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SPECIAL ISSUE

PARADIGMS IN CLIMATE RESEARCH

Guest Editor: Arthur Rörsch

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GUEST EDITORIAL

Over recent decades the social-scientific infrastructure of climatology has been dominated by scientists organised under the banner of an UN-sponsored political body, the Intergovernmental Panel on Climate Change (IPCC). These scientists - and even more so their governments-proclaimed as 'scientific' consensus that increasing amounts of CO_2 in the atmosphere will strongly affect the 'global' that is averaged climate. This was the immutable truth. At the presentation of the last Summary for Policymakers of the IPCC reports (2007) it was proclaimed: "the science is settled" The voices of well-known scientists opposed to this dominant paradigm (e.g. Lindzen, Spencer, Singer, Christy McIntyre, Pielke, Khandakar), and backed by their own research, have been less clearly heard. They have been least heard by governments who are considering reducing of the use of fossil fuel -itself a laudable effort for many of them.

Doubts about the mainstream "CO_2-paradigm" arise because there is so little evidence from direct observations to support the framework that has been constructed from computer model studies/experiments. This alone should be a sufficient reason for the scientific world to consider alternative paradigms. The one described in this issue could be called the weather/water thermostat paradigm and originates from long-held views in classical climatology and meteorology.

It must be emphasized that the two opposing frameworks: the CO_2-paradigm and the *weather paradigm*, lead to very different consequences for climate variability. The CO_2-paradigm does not recognize the regulatory function of weather events on surface temperature and even predicts the possibility of a 'run-away effect': i.e. continued temperature rise with CO_2 increase in the atmosphere. The weather paradigm, in contrast, is far less alarming and predicts an equilibrium state that is near to the current state. Observations increasingly point to the alternative, weather paradigm as correct.

This would indicate that the reductionist approach of the numerical-model approach used in the CO_2 paradigm may amount to a fundamental methodological error. A consideration of alternatives to the dominant CO_2 paradigm is therefore essential for scientific progress in the field of climatology.

However, so far, we can see no sign that the protagonists of the IPCC line on expected Dangerous Anthropogenic Global Warming (AGW) are willing to consider any alternative to the CO_2 paradigm. Scientific worldwide discussions between protagonists and antagonists have been limited. No IPCC critics are invited to participate at official international scientific deliberations, though they have organized their own large conferences and issued invitations to IPCC supporters. With few exceptions these invitations were not accepted. Nevertheless, at theinformal level, e.g. in e-mail exchanges, opposing thoughts and intensive discussions continue about the basic principles of the earth's greenhouse effect. This is especially true for opponents of the officially sanctioned AGW hypothesis

The authors in this issue participated in these discussions – together with others in different areas of scientific expertise. I joined these debates but in most cases only as

moderator rather than expert. This activity was noticed by the editor of Energy & Environment, and was the reason I was invited to be guest editor for this special issue. The fields that I have chosen for consideration by the scientific community are presented in outline below, preceded by an introduction to the general concept of paradigms.

The first paper by *R. Clark* presents the arguments that a further increase of CO_2 in the atmosphere may not lead to an enhanced greenhouse effect. Especially the processes of radiation transfer in the atmosphere and the mass- and heat transfer at the surface are being reconsidered. The next paper by *W. Eschenbach* deals with thermostat hypothesis, that is the regulatory function of weather events.

N. van Andel then further quantifies the effect of wind speed on mass transfer by water vapour and heat transfer by evaporation. In the fourth paper *W. Kininmonth* notes that current computer models of the climate system appear to underestimate the rate of increase of surface evaporation (and latent heat exchange) with temperature – leading to a gross exaggeration of the surface temperature response to radiative forcing. *D. Thoenes* then deals with the stabilising effect of the oceans on climate, a topic of major importance based on calculations supported by experience with salt evaporation pools on Bonaire. *P. Siegmund* comments briefly on the papers by Thoenes and in N. van Andel's paper this issue is also considered. The paper by *F. Miskolczi* explores basic physics and could be subtitled "A new interpretation of weather balloon observations". It leads the author to deduce new relationships between the energy fluxes in and out of the atmosphere, which has become known as the 'Miskolczi theory'. *W. Gilbert* explores the relationship between surface temperature and water vapour concentration and augments the Miskolczi paper with respect to the thermodynamic forces driving the hydrological cycle. The title of the last paper *by van Andel* expands on the consequences of the Miskolczi Theory".

The manuscripts were sent for critical review to several members of the discussion groups from which they originated, though consensus was not always reached among those participating in this internal peer review system. Next, each paper was submitted to criticism by two external referees. If one of them felt inclined to recommend rejection of the paper, a third referee became involved. If the third reaction was positive, it was left to the author himself to weigh the criticism. Thus the conclusions in each paper remain the sole responsibility of the author. In the opinion of the guest editor this is the proper way to handle 'peer review'. However, the guest editor does not claim that the papers presented here falsify the AGW hypothesis. In the spirit of the journal's regular "Fuel for Thought", they provide much evidence that the cry "the science is settled" remains - at very least - premature.

Guest editor Arthur Rörsch
Former Vice President Board of Management of the
Netherlands Organisation for Applied Research. (TNO)
Leiden, The Netherland.,

INTRODUCTORY PAPER ON PARADIGM SHIFT SHOULD WE CHANGE EMPHASIS IN GREENHOUSE-EFFECT RESEARCH?

Arthur Rörsch Ph.D.
Pieterskerkhof 40c
2311 ST Leiden, The Netherlands
Arthur@keykey.nl

ABSTRACT
A paradigm is a set of scientific and metaphysical beliefs that provide a theoretical framework within which scientific theories can be tested. Replacement of an existing paradigm by another is called a paradigm shift. Most of the following papers in this issue argue that an alternative paradigm is needed for the functioning of the so-called greenhouse effect of the Earth and hence for the explanation of observed climatic change. Some others contest it. The observed coincidence between global warming and rise of CO_2 in the atmosphere over the last century - more accurately measured over the last 30 years of it - need not indicate a causal relationship, and it certainly need not give rise to global catastrophe. An assumed correlation is based on the expectation that the infrared radiation from CO_2 contributes significantly to the greenhouse effect of the Earth. However, irregularities in the trends raise doubts of such a simple causal relationship and, at least, considerable doubt about the magnitude of such an expected effect.

1. THE MEANING OF A PARADIGM SHIFT

Thomas Kuhn[1] introduced the concept of paradigms into philosophical discussion on the progress of science. The present definition of a paradigm[2] is: a set of scientific and metaphysical beliefs that make a theoretical framework within which scientific theories can be tested, evaluated, and if necessary revised. Kuhn says a scientific revolution occurs when the beliefs change drastically. This is accompanied by a strong change in how scientific knowledge is interpreted. Not every observation that contradicts a ruling paradigm leads to a revolution or to a rejection of that paradigm as a whole. Such an observation may merely lead to a revision of the paradigm.

At present, a dominant concept prevails concerning the role of CO_2 in the Earth's greenhouse effect. An important consideration is whether there is a need to replace or extend this paradigm with a different insight of how the greenhouse effect is maintained. This consideration is of importance for the progress of science because this may be seriously hampered if a possible revision is suppressed by influential scientists for whatever reasons.

2. THE WATER PLANET

The surface of the Earth is mostly covered by water (H_2O) that is present in three aggregation phases: gas, liquid and solid. Indeed, the Earth can be viewed as 'water planet'. Subject to the influence of local variations these phases can be transformed into each other, even vapour into ice.

Radiation energy – e.g. from the sun – is received at locations on the water surface, and this leads partly to production of sensible heat. The temperature rises. Part of the energy induces evaporation and is thus transformed into latent heat, which is not accompanied by temperature rise near the surface. The produced vapour condenses in the atmosphere so the latent heat is transformed to sensible heat at high altitudes, where the air temperature rises. The condensation produces clouds, which return liquid water, snow or ice, to the Earth's surface. Hence, this water cycle has a global dimension as well as an associated heat cycle. The most important primary effect is that radiative energy from the sun received at the surface is redistributed as sensible heat over surface and atmosphere.

Not all of the radiation received by the Earth's surface is from the Sun, and not all of it stays associated with the water cycle. Some radiation from the sun is reflected from the surface back to space, so is not involved in the water cycle. More importantly, water in the atmosphere exists in its three (aggregation) phases and, the atmosphere therefore, functions as a radiation source that produces (exclusively) infrared radiation. This infrared is emitted in all directions and partly into the direction of space, so this radiation to space too is not involved in the water cycle. But this infrared radiation is also partly directed towards the Earth's surface and thus adds to the radiation received by this surface.

The average global surface temperature shows only small variations over time. Thus, the heat content of the atmosphere remains apparently rather constant. Therefore, a radiation balance seems to exist: i.e. the radiation energy received from the Sun in Joules/year equals the energy the atmosphere emits to space as infrared over a year. (However, it should be remembered that during each year there is no radiation balance because the average global surface temperature varies by several degrees Celsius during each year[3]).

3. THE GENERALLY ACCEPTED PARADIGM OF THE NATURAL GREENHOUSE EFFECT

As mentioned, the atmosphere is a radiation source that emits its energy in all directions. A part of this radiation is to space, another part is towards the surface. As a result the surface receives more radiation energy than it would receive from the sun alone. The sun produces insufficient Joules/year to maintain the average surface temperature above freezing point, but the back radiation from the atmosphere adds to the heat which raises the surface temperature. If we start from the virtual situation that the Earth originally was an ice ball, then from that beginning some water vapour would have been put into the atmosphere by sublimation. This atmospheric moisture would have increased the back radiation. And the enhanced radiation from the H_2O in the atmosphere would have caused the surface temperature to rise with resulting evaporation of H_2O that would provide more H_2O in the atmosphere. How long would

this process continue with continued increase of the H_2O concentration in the atmosphere? Clearly, the seas exist and, therefore, increase to evaporation would cease before the ultimate situation that all the water from the seas becomes evaporated. Hence, we have to assume that a global equilibrium state is established under the influence of the water circulation. The colder atmosphere returns rain water (or snow and ice) to the surface. As a result the global balance between radiation received from the Sun and radiation emitted to space stays functional.

4. THE CO_2 PARADIGM

Water is not the sole infrared emitting molecule in the atmosphere. Importantly, there is a small amount of CO_2 which absorbs and produces infrared at specific wavelengths. As a result one can expect that the CO_2 concentration influences the functioning of the water greenhouse effect. In the CO_2 paradigm it is assumed that the increase of CO_2 results in a rise of the temperature throughout the whole atmospheric column and that this induces the surface temperature to rise. In model calculations this can be made plausible on physical grounds but is difficult to prove *in situ*. It was given additional credibility: an average global temperature rise occurred at the surface of almost 0.7 degree Celsius over the previous century when the CO_2 concentration increased. However, the rate of temperature rise varied with time and was not always in proportion to CO_2 concentration. Also, the rate of temperature rise differed between locations: for example, since precise temperature measurements by satellites have been available (1980), no or very little temperature rise has been observed on Antarctica.

Thus there must be 'complicating factors'. We can assume these arise from the complexity of the system itself. The earth rotates around its own axes with an inclination and orbits the Sun. This produces the diurnal and the seasonal cycles. In addition this mechanical system produces complex air and ocean currents that continuously redistribute the uneven distribution of radiation energy received from the Sun over the Earth's surface. This is discussed further in the section on the weather paradigm.

As an extension of the assumption that CO_2 will influence the heat flow to – and the heat absorption at the surface, there is the assumption that enhanced evaporation will occur, so the humidity of the atmosphere will rise, and this will enhance the greenhouse effect caused by the water vapour. This is named a positive feedback of the CO_2 rise on the temperature rise.

5. A REVISED CO_2 PARADIGM

However, increased back radiation from CO_2 will also result in latent heat removal from the surface by the evaporation. This latent heat removal will cool the surface, and this cooling is a negative feed back. Infrared is less effective at warming a water layer than the sunlight because the infrared penetrates only a few millimetres into the layer but sunlight penetrates to tens of meters. Therefore, the latent heat removal induced by infrared is expected to be larger than by the sunlight because the infrared directly heats the surface water that evaporates. The question is, what are the magnitudes of the positive and negative feedback mechanisms for a particular surface temperature and humidity near the surface when the surface receives more radiation? Scientists working

on such model studies do not agree as yet, although current models all predict a global mean surface warming of several degrees as a response to a doubling of the CO_2 concentration. (See the various papers in this issue and commentaries.) The problem is complex because one cannot consider only radiation transfer and evaporation processes: local influences of vertical air flows (convection and turbulence) also act as very effective heat removers from surface to atmosphere at particular locations (e.g. near the equator), and there exists a strong vertical thermodynamic coupling between temperature variations at different altitudes, the so-called most adiabatic.

6. THE PARADIGM OF THE WEATHER THERMOSTAT

An important point with respect to the global radiation balance is that at any location there is not an equilibrium state between light received from the sun and infrared radiated to space. This makes model calculation on a specific atmospheric column at a specific location at a particular time less meaningful to an understanding of how the global radiation budget is established.

In the equatorial zone (between 30° South and 30° North) the top of the atmosphere radiates less radiation to space than it receives from the Sun: the energy budget for export to space is negative. The opposite is true in regions near the poles (from South pole to 30° South and from 30° North to the North pole) where the top of the atmosphere radiates more radiation to space than is received from the Sun: the energy budget is positive. Consequently, to reach a global energy balance over a certain period of time, the energy exchange between the equatorial zone and the near polar regions must be very important. This is strongly influenced by the weather events. Particular events on different latitudes influence each other strongly by the complex movements of air masses that are illustrated on weather charts by the flows around the high and low pressure areas (i.e. the anticyclones and cyclones). These air movements can be seen as 'machines' which influence the horizontal and vertical heat transport. And they can be considered as being heat or Carnot engines[4] which function according to the laws of thermodynamics.

According to classical climatology the climate in the different climate zones is determined by these machines[5] that are strongly influenced by horizontal temperature gradients. These temperature regulators themselves determine to a great extent the radiation capacity of the atmosphere by its water content and the cloud coverage. And at the bottom of them is the uneven illumination of the surface by the Sun.

This paradigm has the weather events as the global temperature regulator. And it raises the question as to whether any change of the CO_2 in the atmosphere can influence the global temperature regulation of the water covered planet provided by the weather events.

7. SUMMARY OF THE CONFLICTING PARADIGMS

The basis of the CO_2 paradigm is a 'forcing model'. The major actors in the radiative processes (radiation from the sun, from H_2O and CO_2 in the atmosphere), and their intensity changes are attributed to have an influence on the greenhouse effect. This is a reductionist consideration which is useful to get some insight about the forces which are active. But it is debateable as to whether the effects of these radiative processes -

as deduced from model systems - are unaffected by other actors in the complex climate system.

The basis of the weather paradigm is that the greenhouse effect is kept within borders by the water cycle which establishes the heat cycle.

The essential difference between those who support the idea that CO_2 strongly influences the greenhouse effect, and those who doubt the size of this effect, is as follows: the first group is of the opinion that the climate system is very sensitive to changes in the composition of the atmosphere, the second that our water planet has developed adequate regulatory mechanisms to keep the surface temperature within certain limits. In other words, the climate system is rather robust and cannot easily be pushed out of balance.

Weighing the evidence, the major question remains as to thet extent to which recent observations support these differing views. This is the issue on which the scientific discussion on climate change should focus. The answer has major consequences for energy policy and natural resource use, and especially for the continued reliance on energy intensive carbon (fossil) fuels for heating, lighting, cooling and transport. Support for the alternative second paradigm, that the Earth possesses its own regulatory mechanism, has so far denied by the IPCC and its supporters. It would also indicate that the reductionist approach relying on computer modelling was fundamentally an error of methodology.

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A NULL HYPOTHESIS FOR CO_2

Roy Clark, Ph.D.
Ventura Photonics
1336 N. Moorpark Road #224
Thousand Oaks, CA 91360 USA
805-701-3705, rclarkres@aol.com

ABSTRACT
Energy transfer at the Earth's surface is examined from first principles. The effects on surface temperature of small changes in the solar constant caused by the sunspot cycle and small increases in downward long wave infrared (LWIR) flux due to a 100 ppm increase in atmospheric CO_2 concentration are considered in detail. The changes in the solar constant are sufficient to change ocean temperatures and alter the Earth's climate. The surface temperature changes produced by an increase in downward LWIR flux are too small to be measured and cannot cause climate change. The assumptions underlying the use of radiative forcing in climate models are shown to be invalid. A null hypothesis for CO_2 is proposed that it is impossible to show that changes in CO_2 concentration have caused any climate change, at least since the current composition of the atmosphere was set by ocean photosynthesis about one billion years ago.

Keywords: Carbon Dioxide, Global Warming, Greenhouse Effect, Maunder Minimum, Meteorological Surface Air Temperature, Milankovitch Cycles, Ocean Warming, Radiative Forcing, Radiative Transfer, Sunspot Cycle.

1. INTRODUCTION

Over the last 50 years, the atmospheric CO_2 concentration has increased by 70 ppm to 380 ppm and the average annual sunspot index has been 70% above its historical mean from 1650.[1-3] During this time, ocean temperatures have increased, Arctic sea ice extent has decreased and the average meteorological surface air temperature has increased.[4-8] Under ideal 'clear sky' conditions, the 70 ppm increase in CO_2 increases the downward atmospheric long wave infrared (LWIR) surface flux by 1.2 $W.m^{-2}$. This goes up to 1.7 $W.m^{-2}$ for the full 100 ppm increase over the last 200 years. These numbers are derived from radiative transfer calculations using the HITRAN database and are used as 'radiative forcing constants' in the IPCC climate models.[9,10] SOHO/VIRGO satellite radiometer data show that the solar constant increased by 1 $W.m^{-2}$ during the last solar sunspot cycle from a baseline of 1365 $W.m^{-2}$.[11] The corresponding annual sunspot index minimum and maximum were 8.6 to 120. The index has now decreased to a minimum of 2.8.[3] These variations may be used to relate the change in the annual sunspot index to changes in the

solar constant. An increase of 100 in the sunspot index produces an increase in the solar constant of approximately 1 $W.m^{-2}$. This means that the solar constant over the last 50 years (6 sunspot cycles) has been 0.3 $W.m^{-2}$ above its historical average from 1650. The basic physics question is a simple one. How do these small changes in solar and LWIR flux influence the energy transfer process that occur at the Earth's surface and produce the observed climate changes? Since the air-ocean and air-land interfaces behave differently, it is convenient to consider them separately, starting with the air-ocean interface and some climate history. Atmospheric energy transfer, the greenhouse effect and the validity of the radiative forcing assumptions used in global warming predictions are then addressed.

2. THE AIR-OCEAN INTERFACE

During the last Ice Age, the solar constant was reduced by approximately 1 $W.m^{-2}$ because of changes in the ellipticity of the Earth's orbit due to Milankovitch cycles.[12] At the glacial maximum, sea level was 120 m lower than it is today.[13] This ocean water was stored as fresh water ice at high latitudes. Over a 10,000 year period, the heat needed to melt this ice and warm the resulting water to 15 C requires an increase in the solar constant of 0.4 $W.m^{-2}$. As the oceans warmed, the solubility of CO_2 decreased and the atmospheric CO_2 concentration increased from 200 to 280 ppm.[14,15] This was an effect, not a cause of ocean warming. The Maunder Minimum was the period between 1645 and 1715 when there were almost no sunspots observed on the sun. This coincided with the 'Little Ice Age', a period of very cold winters. As the number of sunspots has increased since 1715, the Earth's climate has warmed up, as indicated by glacier melting, increases in sea level and other proxies.[16,17] However, the atmospheric CO_2 concentration did not even begin to increase until after 1800.

The sun is the heat source for the Earth. Half of the solar energy is incident within the ±30° latitude band and 70% is incident within ± 47°. The heating of the atmosphere in the tropics sets up the Hadley cell circulation and the trade winds. The trade winds in turn drive the large scale ocean gyres and the ocean currents such as the Gulf Stream that transport warm ocean water to higher latitudes. Under 'pristine' conditions, the sun can penetrate and warm the oceans to depths of 100 m. The ocean cools through a combination of evaporation and LWIR emission processes that are limited at most to a 1 mm surface layer. This evaporation is the primary heat source for the atmosphere above the ocean as the latent heat is released by condensation and cloud formation. The First Law of Thermodynamics only requires conservation of energy at the air-ocean interface. There is no local conservation of flux on any time scale. The solar heating of the ocean follows Beer's law. Sunlight is attenuated exponentially along the path length, depending on the local absorption/scattering coefficient. As the sun warms the ocean during the spring and summer, the upper layers heat up and a stable thermal gradient develops. As the ocean starts to cool in the fall, the upper layers cool first and a uniformly mixed layer develops that extends to lower depths as the temperature decreases. Two distinct solar heated layers form. Close to the surface, the ocean is mixed by the diurnal variation in thermal density gradients and wave action. The depth and time scales here are nominally 10 to 25 m and 24 hours. At lower depths, mixing occurs more slowly through thermal/salinity density gradient changes, since surface motions are only weakly coupled to these depths. The mixing scales are 25 to 100 m and a 'seasonal' 90 days or longer.

Historically, data on subsurface ocean temperatures, mixing and transport has been sparse. This situation has changed recently with the implementation of the Argo float program. High quality subsurface ocean temperature, salinity and density data are now available from a fleet of 3000 submersible floats that are distributed throughout the world's oceans.[18] The floats are designed to sink to a depth of 1000 or 2000 m, drift at that depth for ten days, then return to the surface, acquiring data during the ascent. At the surface, the data are transmitted via satellite to a series of ground monitoring stations. The floats then repeat the descent/ascent cycle. The floats are not tethered and drift with the ocean currents. The principal features of the solar heating of the ocean at various latitudes through the year may be understood by examining the results from selected Argo floats. Figure 1 summarizes a year of data from 5 Argo floats covering a range of latitudes from the equator to the Antarctic Circle in the southern central Pacific Ocean. The temperatures at 5 depths, 5, 25, 50, 75 and 100 m are shown as a time series for the year. The latitude drift of the floats is also shown. Because of variability in the float actuators, the depths are averages for each float with a standard deviation of approximately 0.2 m. The average latitude, longitude, depths and temperatures for each float are given in Table 1. The average temperatures show the expected decrease in temperature at higher latitudes.

Table 1. Argo float summary data.

Float 1							
Serial No.	34250						
Av: Latitude	–1.5	Av. Depth m	4.6	23.4	49.5	74.4	99.3
Av: Longitude	126.2	Av. Temp. C	24.5	24.1	21.9	18.0	15.1
Float 2							
Serial No.	59033						
Av: Latitude	–20.9	Av. Depth m	4.4	24.3	52.2	75.2	99.2
Av: Longitude	105.2	Av. Temp. C	23.0	22.9	22.8	22.4	22.0
Float 3							
Serial No.	35605						
Av: Latitude	–42.4	Av. Depth m	4.6	24.3	52.3	75.2	99.3
Av: Longitude	153.5	Av. Temp. C	12.9	12.9	12.2	11.1	10.6
Float 4							
Serial No.	26893						
Av: Latitude	–52.7	Av. Depth m	4.4	27.3	51.1	75.2	99.2
Av: Longitude	146.5	Av. Temp. C	7.4	7.4	7.3	7.1	6.9
Float 5							
Serial No.	35987						
Av: Latitude	–63.4	Av. Depth m	4.8	23.6	50.8	73.2	96.5
Av: Longitude	140.7	Av. Temp. C	–0.5	–0.5	–0.6	–0.9	–1.0

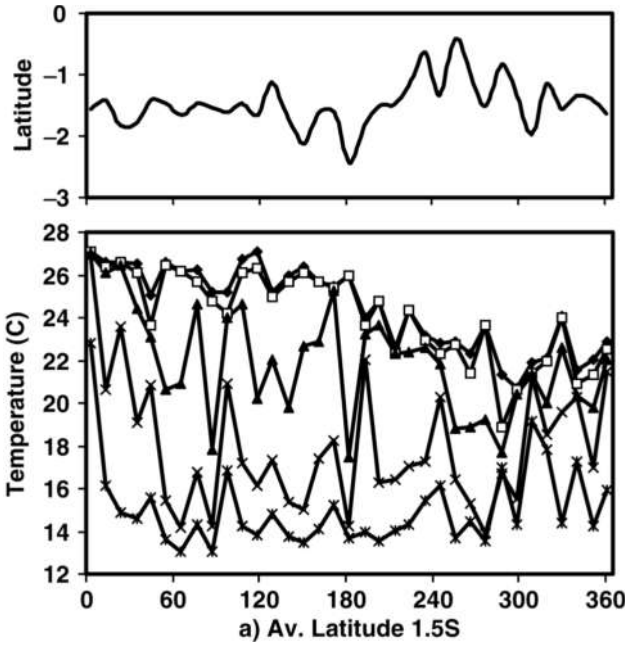
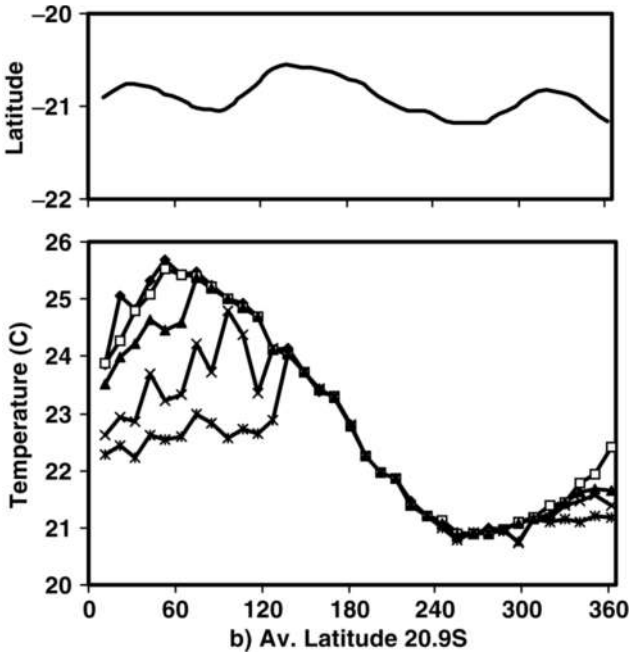


Figure 1. Argo float data. Annual temperature profiles at 5, 25, 50 and 100 m depths for 5 selected floats in the S. Pacific Ocean. (See text for further discussion).

Figure 1a shows the results from a float drifting near the equator. The average temperature at 5 m is 24.5 C. There is no obvious seasonal peak in the data. The temperatures at the 5 and 25 m levels are similar, so these levels are usually mixed. Mixing down to the 50 m level occurs approximately half of the time. However, the 75 and 100 m levels have temperatures that are on average 4 and 7 C below the 50 m level. These lower levels are rarely coupled to the surface. Figure 1b shows the results from a float drifting near 21.5° S. There is a distinct seasonal peak in March with the 5 m temperature reaching 25.5 C. (Seasons are opposite in the southern hemisphere). The distinct temperature layers then merge together as the ocean cools. All of the levels down to 100 m are fully mixed for 6 months. Figure 1c shows the results from a float drifting near 42.4° S. The temperature profiles show a similar pattern to the float at 21.5° S, but the temperatures are lower because of the higher latitude. The maximum 5 m temperature is 16 C. Figure 1d shows the results from a float drifting near 53° S. The overall temperatures are reduced compared the 42.4° S float. The maximum 5 m temperature is now 10 C and the duration of the summer separation of the subsurface layers is reduced to approximately 3 months. This float also drifted about 6° S from March to December, so there is an overall cooling from this drift superimposed on the seasonal variation. Figure 1e shows the results from a float drifting near 63.4° S, close to the Antarctic Circle. The average temperatures at all depths are below 0 C. The summer mixing depth pattern is similar to the previous 3 floats, but the



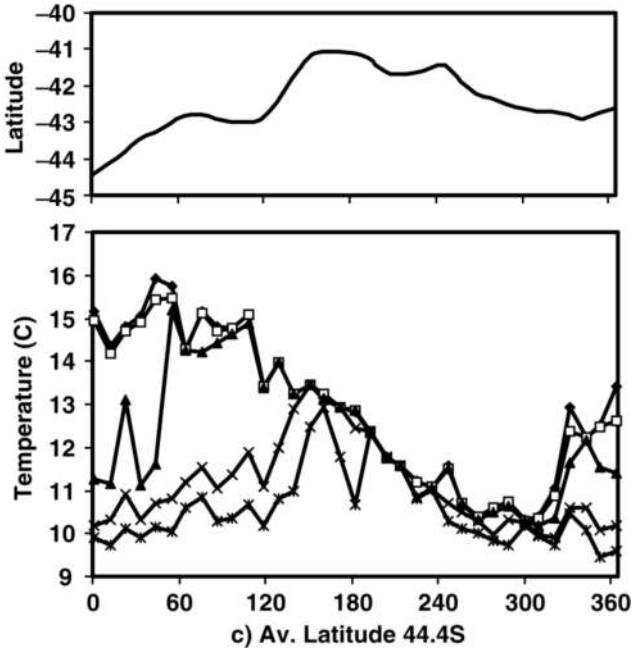


Figure 1. *(continued)*

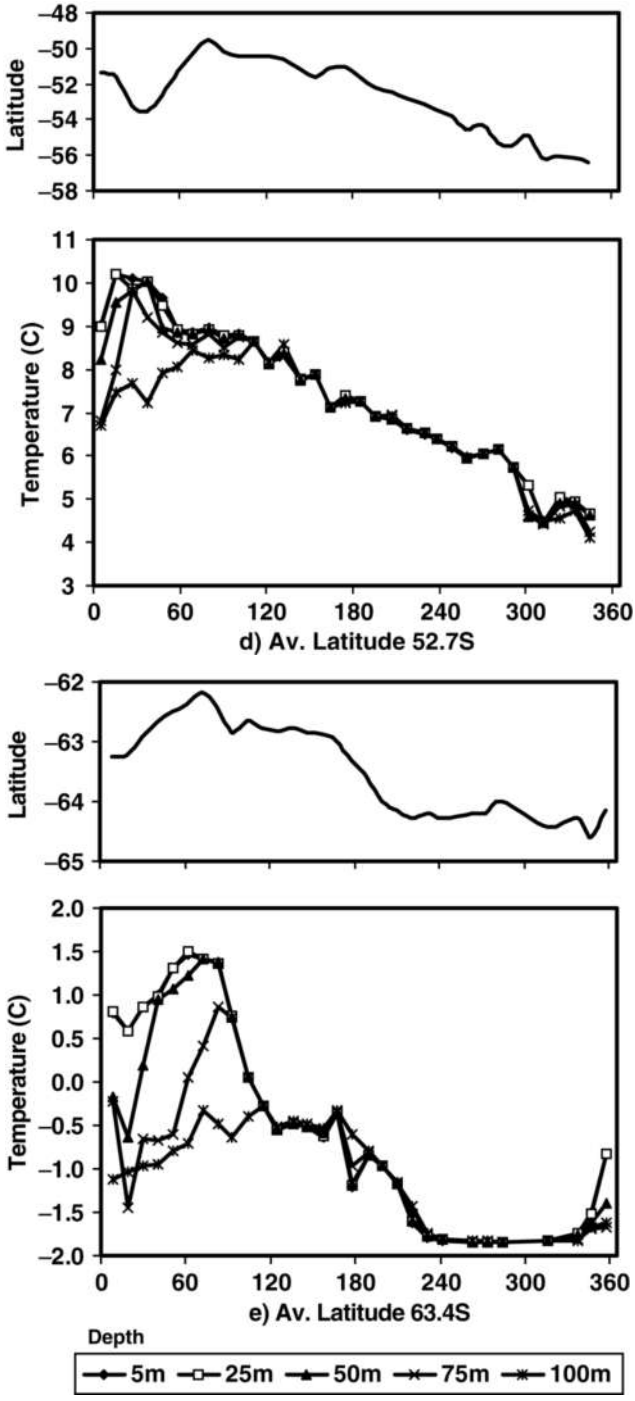


Figure 1. *(continued)*

temperature range is reduced. At all depths, the temperatures reach a minimum of −1.8 C from September to November. This is the freezing point of sea ice.

The float data presented here illustrate the seasonal trends in subsurface ocean temperatures. During the summer, the lower subsurface layers are not coupled to the surface while they are warmed by solar illumination. Heat from these layers may be transported or re-circulated over long distances by wind driven ocean currents. At low latitudes, the diurnal and seasonal temperature variations may not be sufficient to mix these subsurface layers at all and heat may accumulate at these depths for extended periods. At higher latitudes, the ocean cools and the subsurface layers are coupled to the surface during the winter months. The ocean has to cool to −1.8 C for ice to form. It is also important to note that at high latitudes, the surface area of a spherical zone decreases significantly. This geometric factor increases the depth of ocean currents as they flow to higher latitudes, further limiting their interaction with the surface. Small changes in subsurface ocean temperatures can therefore result in large changes in polar ice formation. No interaction with the atmosphere is required and changes in atmospheric CO_2 concentrations can have no effect on this process.

The solar heating of the ocean may be simulated using a simple Beer's law model as illustrated in Figure 2. This was used to determine ocean solar heating and cooling as a function of depth over a 1 year period at 30° latitude with the solar constant set

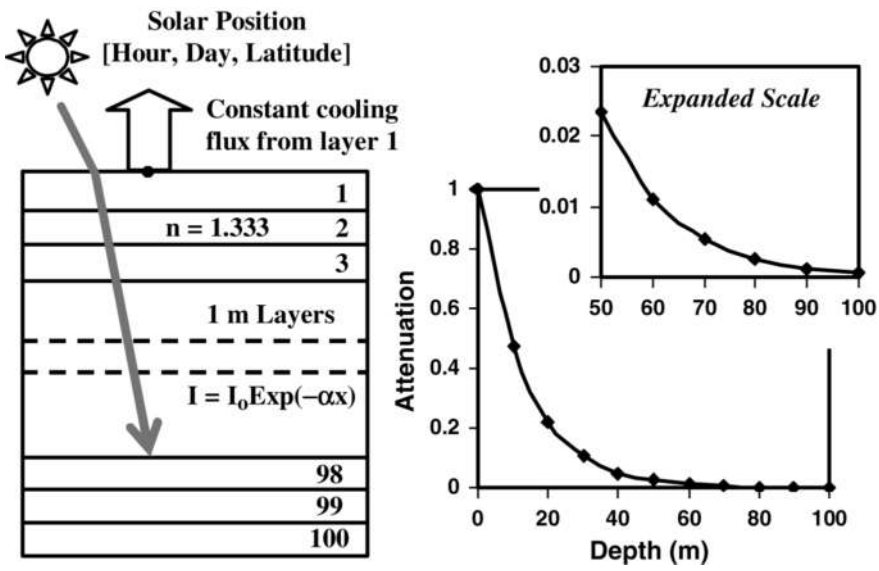


Figure 2. Simple ocean solar heating model. The solar heating of the first 100 m of the ocean is calculated every 0.5 hr and the 1 m layers are mixed according to temperature. The solar intensity algorithm was adapted from IEEE Standard 738 (1993). A constant LWIR cooling flux was used so that the model repeats each year. The solar attenuation for $\alpha = 0.075\ m^{-1}$ as used in the model is also shown.

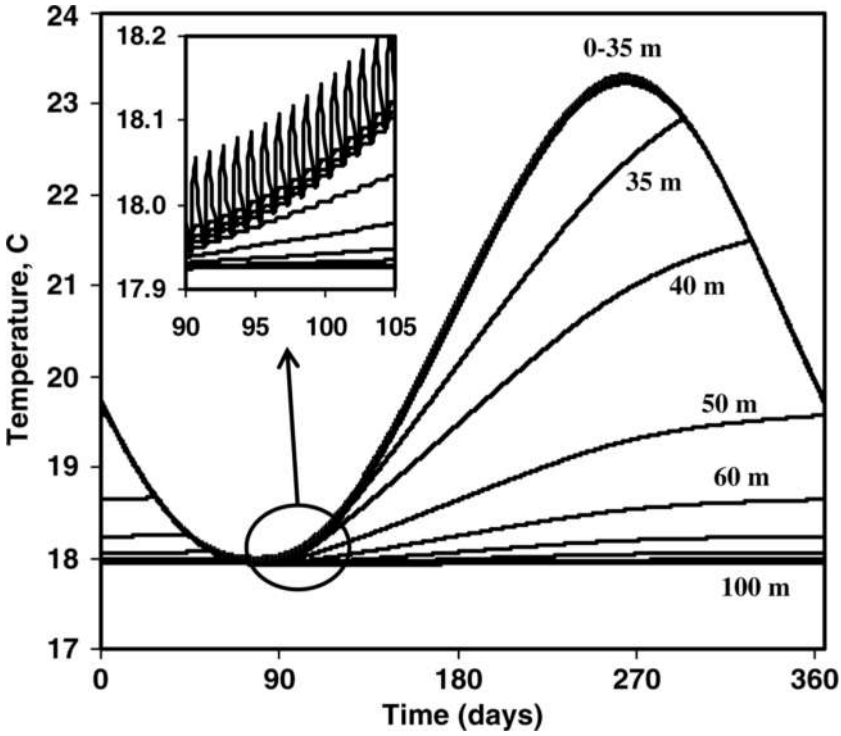


Figure 3. Ocean layer solar heating model results. Ocean layer solar heating to 100 m depth calculated over a 1 year period for 30° latitude. As the ocean heats up in the spring and summer, stable layers form. As the ocean cools in the fall and winter, the heated layers cool from the surface down. Inset shows the diurnal mixing layer and the initial heated layer separation.

to 1365 $W.m^{-2}$. The model depth resolution was 1 m and the time step was 0.5 hours. The calculated results are shown in Figure 3. They are consistent with Argo Float data such as the examples shown in Figure 1. The model was then extended to simulate changes in the solar constant due to the sunspot cycle from 1650 to 2000 using a scale factor of 1 $W.m^{-2}$ per 100 change in the annual sunspot index.[11] The calculated change in ocean temperatures at 90 m depth is shown in Figure 4. There is a distinct decrease to the end of the Maunder Minimum followed by an overall increase of almost 0.5 C from 1750 to 2000. This simple model clearly demonstrates that small changes in the solar constant influence ocean temperatures and cause climate change. Subsurface ocean layers are transported over long distances by wind driven ocean currents without any interaction with the surface. The average global ocean temperature increase for the 0 to 300 m depth level from 1953 to 2003 was 0.17 C and the average increase in flux needed to heat the oceans was 0.2 $W.m^{-2}$.[4] This is consistent with Figure 4 over the same time period. However, there was also

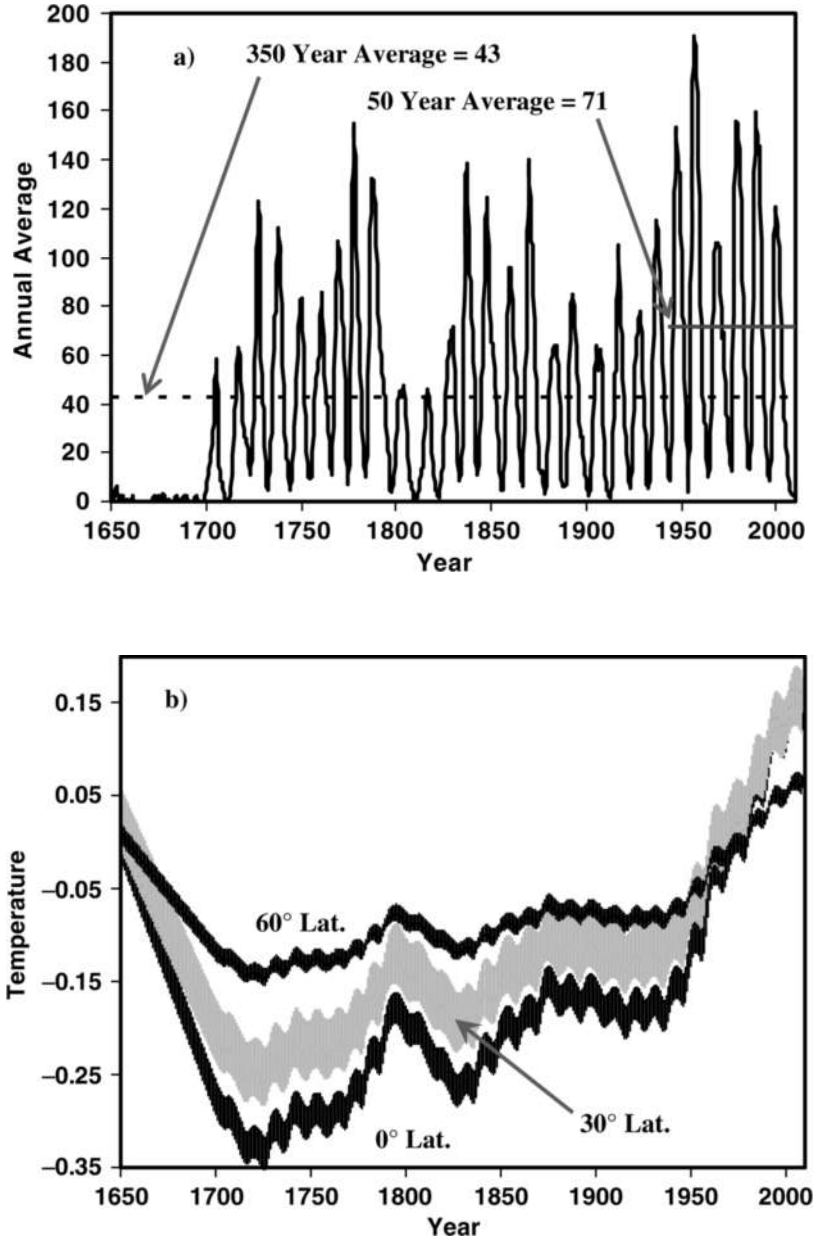


Figure 4. Calculated change in ocean temperatures at 90 m depth using the sunspot index to set the solar constant. a) The sunspot index from 1650. b) Calculated ocean temperature changes. Mean solar constant was 1635 $W.m^{-2}$. A 1 $W.m^{-2}$ increase in solar constant for a 100 increase in index was used in the model. The Maunder Minimum cooling and the current warming period are clearly demonstrated.

significant variation in temperatures between ocean basins. The N. Atlantic warmed by 0.35 C, the N. Pacific by 0.09 C. These fluctuations are caused by differences in ocean circulation, mixing and wind speed.[5]

It is also straightforward to show that a 1.7 $W.m^{-2}$ increase in downward LWIR flux at the ocean surface cannot cause measurable changes in ocean temperatures. Water is almost completely opaque to LWIR radiation.[19] The LWIR absorption/emission depth is less than 1 mm, so the interaction volume is at most 10 cm^3. Following the Kirchoff Exchange Law, an increase in downward LWIR flux at the ocean surface of 1.7 $W.m^{-2}$ reduces the ocean LWIR cooling flux by a corresponding amount.

This heats the surface layer at an initial rate of at least 2.4 C per minute. The ocean responds by rapidly increasing the surface evaporation rate, although the level of evaporation produced depends on local micro scale ocean mixing effects which are difficult to estimate. A flux of 1.7 $W.m^{-2}$ represents a water evaporation rate of 2.7 $g.hr^{-1}m^{-2}$ for ideal 'clear sky' conditions. This corresponds to a 2.4 $cm.yr^{-1}$ increase in evaporation rate since 1800, with 1.7 $cm.yr^{-1}$ of this increase occurring over the last 50 years. Global estimates of ocean evaporation rates show that between 1977 and 2003 the global ocean evaporation rate has increased from 103 to 114 $cm.yr^{-1}$ with an uncertainty of ± 2.72 $cm.yr^{-1}$.[20] This was caused by a 0.1 $m.s^{-1}$ increase in average wind speed. The 'clear sky' upper limit for the CO_2 induced increase in evaporation is below the measurement uncertainty bounds. Long term averages of surface air temperatures are approximately 2 C below the corresponding ocean surface temperatures.[21] This means that there is usually no direct heating of the ocean by the atmosphere, as required by the Second Law of Thermodynamics. As discussed below (Figure 15), any slight increase in atmospheric H_2O vapor concentration will produce atmospheric cooling through increased upward LWIR emission under these conditions. Latent heat of evaporation is not released until the water condenses, which is generally at altitudes above 1 km. It is therefore impossible for an increase in downward atmospheric LWIR flux of 1.7 $W.m^{-2}$ to heat the ocean. The increase in flux is converted by the ocean surface into an insignificant change in evaporation rate. This is buried in the noise of wind induced fluctuations in evaporation and changes in LWIR flux caused by variations in solar illumination, aerosols, clouds and near surface humidity.

3. THE AIR–LAND INTERFACE

The ground is heated by the sun during the day and convection and the increase in LWIR flux from the warm surface heats the air above. It is important to distinguish clearly between the actual ground surface temperature and meteorological surface air temperature. The surface temperature needed for energy transfer analysis is the ground surface temperature. The meteorological surface air temperature is the air temperature measured in an enclosure placed 1.5 to 2 m above the ground.[22] There is no obvious or simple relationship between these two temperatures. Solar radiation is absorbed and reflected by the ground. The resulting surface temperature

depends on the absorption coefficient, the thermal conductivity and heat capacity of the ground, the surface area and angles of incidence, the balance of the upward and downward LWIR flux and the direct air convection. If the ground is moist, latent heat effects also have to be included. The meteorological surface air temperature depends on the origin of the bulk air mass of the local weather system, surface LWIR flux heating, air convection and wind speed. As for the air-ocean interface, the First Law of Thermodynamics imposes energy conservation, but there is no requirement that the flux be conserved on any time scale. The Second Law of Thermodynamics requires that the heat transfer follow the thermal gradient.

Basic surface heating effects may be investigated using a simple thermal conduction model analogous to the ocean heating model. This is illustrated in Figure 5. The results for summer and winter illumination of a dry concrete surface are shown in Figure 6. The calculated daily temperature excursions for summer and winter solar heating are 40 and 20 C at 35° latitude. A 1% increase in solar flux produces peak summer and winter temperature increases of 0.34 and 0.17 C. The

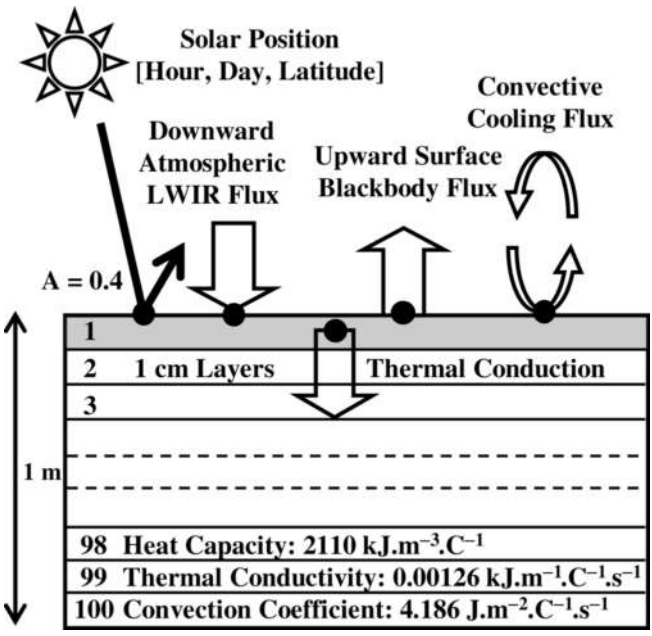


Figure 5. Simple model used to calculate land surface temperature. The thermal balance from solar heating, LWIR flux, convection and conduction is used to calculate the change in surface temperature. This is then used in the thermal conduction model to calculate the subsurface temperature profile. In the example shown, concrete was selected as the surface material.

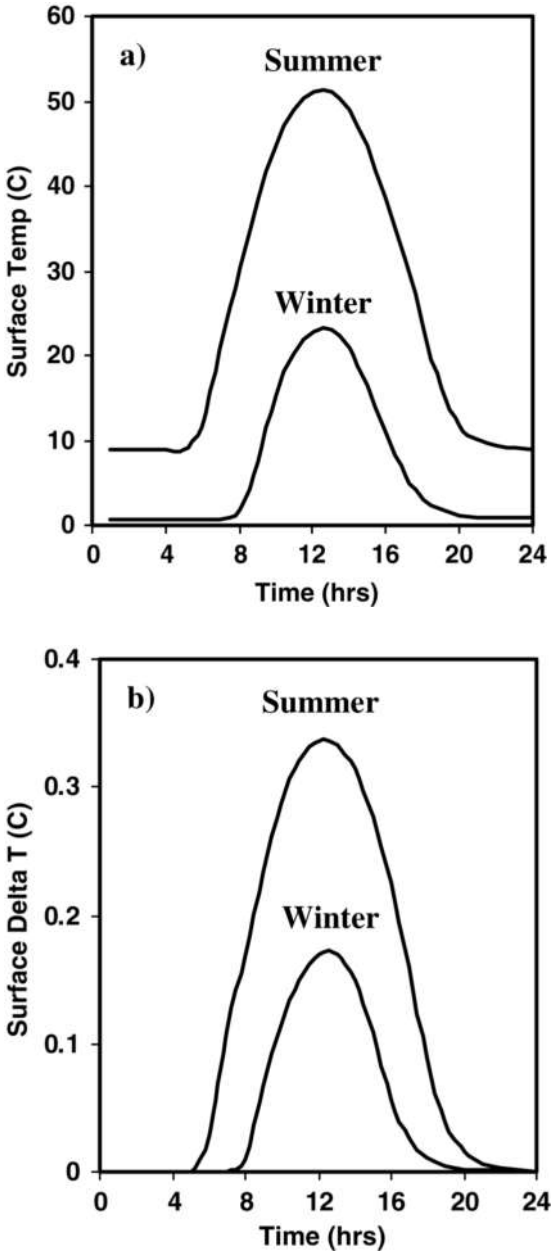


Figure 6. Land heating model results: a) Daily summer and winter ground surface temperature variations, 35° latitude. Summer change is 40 C, winter is 20 C. b) A 1% increase in solar flux increases peak summer temperature by 0.34 C and peak winter temperature by 0.17 C. c) A 1.7 $W.m^{-2}$ increase in downward LWIR flux (+100 ppm CO_2) increases peak summer temperature by 0.32 C and winter temperature by 0.34 C. Maximum change occurs at night. Daytime increases are less, 0.14 and 0.17 C.

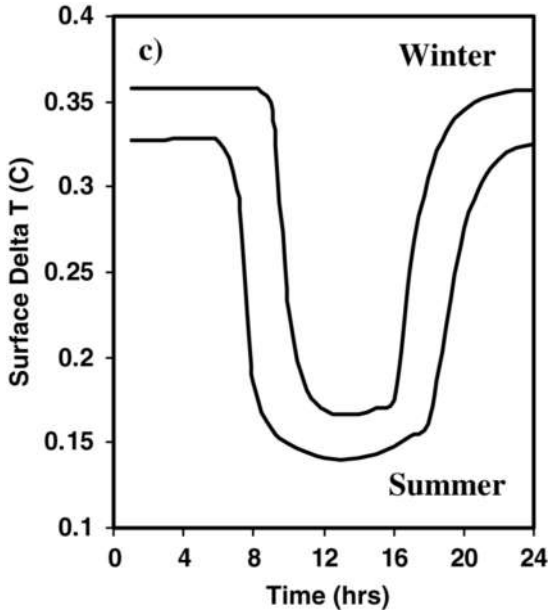


Figure 6. *(continued)*

increases in surface temperature due to a 1.7 $W.m^{-2}$ increase in LWIR flux vary between 0.14 and 0.36 C, with higher temperature increases observed at lower surface temperatures. These changes are for ideal 'clear sky' conditions over a period of 200 years. Variations in cloud cover, aerosols and humidity will produce fluctuations in LWIR flux that are much larger than 1.7 $W.m^{-2}$, so the effects of CO_2 on ground surface temperature are not measurable. However, no historical record of surface temperature is available, so the meteorological surface air temperature has been substituted for the surface temperature without any consideration of the differences between the two.

During the day, the air is heated both by convection and the excess LWIR radiation from the ground. Figure 7 shows the spectrally resolved flux absorbed by H_2O and CO_2 as a function of height above the ground and Figure 8 shows the total flux absorbed vs. height derived from a high resolution (0.01 cm^{-1}) radiative transfer model.[9] The radiative transfer calculations are described in more detail in Appendix A. The surface temperature difference was set to 30 K with the surface temperature at 325 K and the air temperature at 295 K. In this case at 2 m above the ground, a total of flux of 16 $W.m^{-2}$ is absorbed. Of this, only 1.6 $W.m^{-2}$ or 10 % is absorbed by CO_2. The radiative transfer model was also used to simulate the effect of changes in temperature difference, CO_2 concentration and humidity on the heat transfer at 2 m above the ground. These are summarized in Figure 9. For a 30 K temperature difference, the change in flux produced when the CO_2

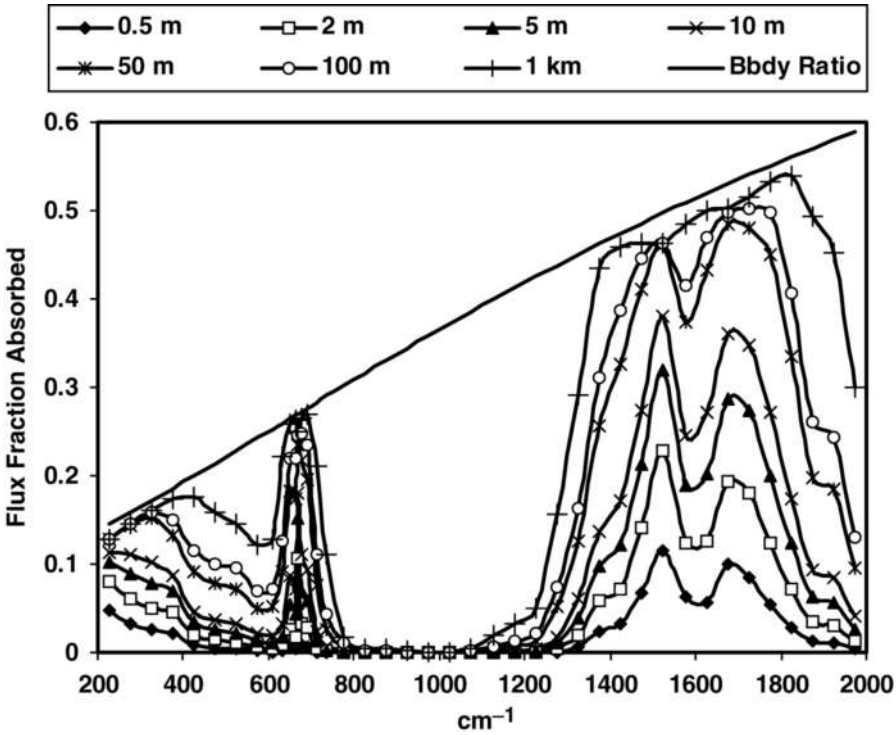


Figure 7. Spectrally resolved fraction of the LWIR flux absorbed by air layers near the ground. Surface temperature is 325 K, air temperature is 295 K, CO_2 concentration is 380 ppm, RH is 50%. Path lengths are from 0.5 m to 1 km. Flux fractions shown are derived from high resolution (0.01 cm^{-1}) radiative transfer calculations, H_2O and CO_2 only, truncated data sets.

concentration is increased from 280 to 380 ppm is only 0.25 $W.m^{-2}$. As the humidity is changed from 10 to 90% for this case, the total absorbed flux changes from 8 to 20 $W.m^{-2}$. These flux changes are more than 50 times larger than any changes due to CO_2. The meteorological surface air temperature records the effect of the surface heating (and cooling) of the air 2 m above the ground superimposed on the bulk air temperature of the local weather system. Based on the results presented in Figures 6 to 9, it is impossible to detect the effect of a 100 ppm increase in CO_2 concentration on the meteorological surface air temperature. This may also be illustrated by examining the so called US surface temperature anomaly as shown in Figure 10.[23] There is a distinct peak in the temperature anomaly in the 1930s due to the dust bowl drought. This is an indication of increased surface solar absorption and lower moisture levels. There is no relationship between the measured temperature anomaly and the calculated increase in 'clear sky' surface temperature due to anthropogenic CO_2.

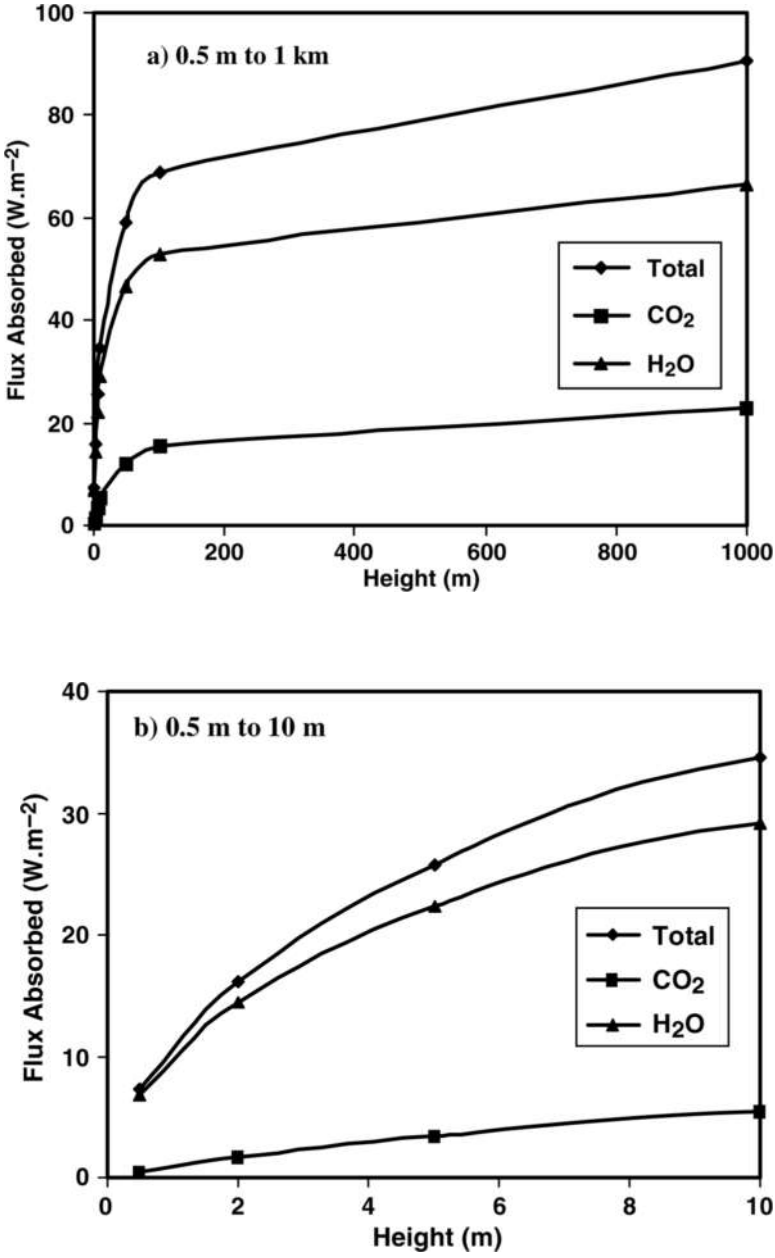


Figure 8. a) Total (cumulative) flux absorbed up to 1 km from the ground. The contributions to the absorption from H_2O and CO_2 are also shown separately. b) The absorption from 0.5 to 10 m on an enlarged scale. Data derived from Figure 7. At 1 km, H_2O absorbs 75% of the flux. This increases at shorter path lengths to 90% at 2 m and 96% at 0.5 m.

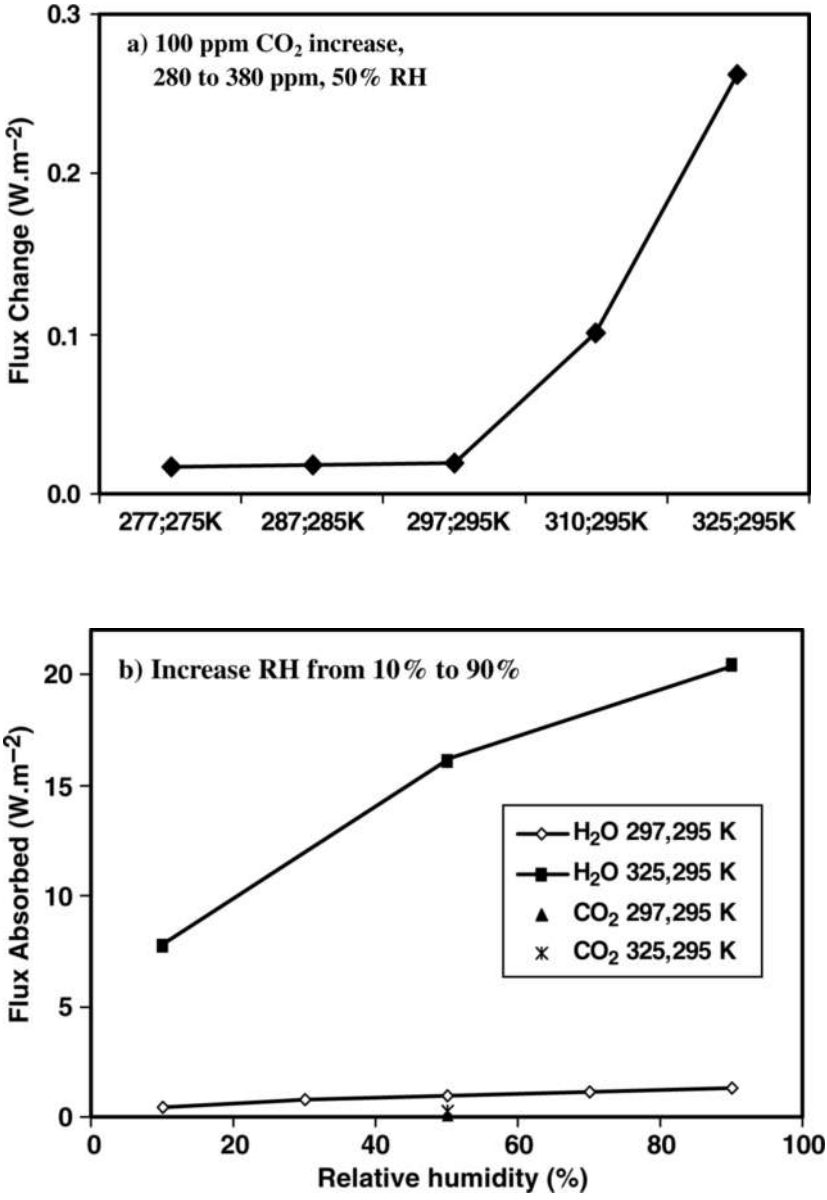


Figure 9. Effect of a 100 ppm increase in CO_2 concentration and changes in RH on the LWIR flux absorbed at 2m above the ground. a) There is a slight increase in the absorbed flux at 2 m above the ground when the CO_2 concentration is increased from 280 to 380 ppm. For a 30 K surface-air temperature difference it is still only 0.25 $W.m^{-2}$. (b) The corresponding change in flux for a change in RH from 10 to 90 % is 12 $W.m^{-2}$. For a thermal gradient of 2 K the RH flux change is reduced to 0.8 $W.m^{-2}$. For comparison, the flux changes due to a 100 ppm increase in CO_2 at 50% RH are 0.25 and 0.02 $W.m^{-2}$.

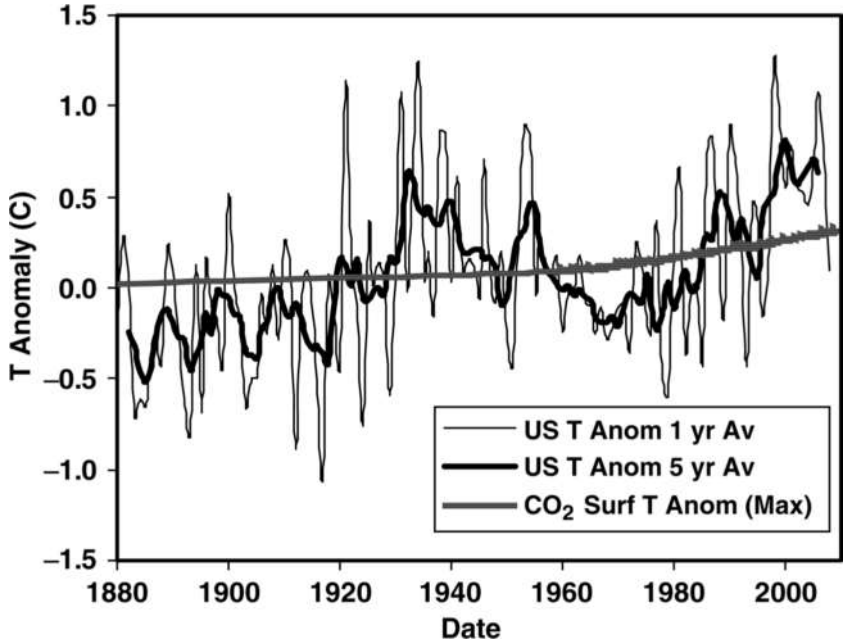


Figure 10. U. S. temperature anomaly from 1880, 1 year and 5 year averages. The calculated increase in surface temperature for a 292 K blackbody surface due to the increase in CO_2 is also shown. This is a cloud and aerosol free upper limit. There is clearly no relationship between the measured temperature anomaly and the calculated change in surface temperature.

4. ATMOSPHERIC ENERGY TRANSFER

The IR active gases in the Earth's atmosphere absorb and re-emit LWIR radiation. The downward LWIR flux keeps the Earth's average surface temperature surface about 33 K warmer than it would be without this flux.[24] However, the full explanation of this so called greenhouse effect requires careful consideration of the detailed energy transfer processes involved. Atmospheric energy transfer is of course constrained by the First and Second Laws of Thermodynamics and by the Kirchoff Exchange Law. It is also important to understand that the thermal gradient in the troposphere is set by the lapse rate. This depends on the surface temperature and the humidity. It is not changed by variations in the concentration of the permanent greenhouse gases such as CO_2. The molecular collision rate is also very fast in the troposphere ($>10^9$ s^{-1}), so that the excited state lifetime of an IR active molecule is very short. This means that the absorbed IR radiation is rapidly converted to molecular kinetic energy and the IR active molecules are always at the local air temperature. The atmospheric absorption bands consist of a large number of overlapping lines due to transitions between specific rotation-vibration states of the IR molecules involved. The individual lines are quite narrow with line widths of a few tenths of a wavenumber. The line profiles are Lorentzian and the line widths decrease with altitude as the pressure decreases. This means that the upward and downward LWIR

fluxes are not equivalent. Any atmospheric energy transfer analysis must explicitly consider these linewidth effects and any approximations made to simplify the lineshape calculations have to be properly validated using high resolution results.

Figure 11a shows the lapse rate for moist air calculated for various conditions of surface air temperature and humidity.[25-28] Figure 11b shows the corresponding concentration profiles for H_2O. The concentration profiles for 200, 380 and 500 ppm

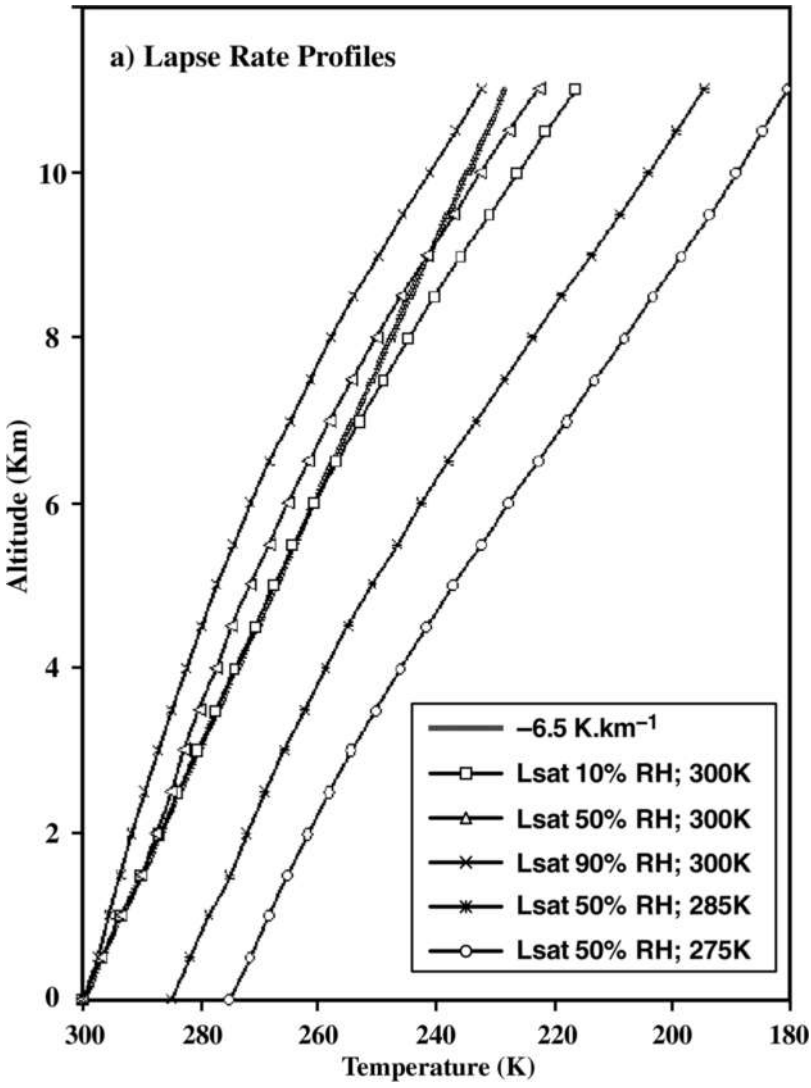


Figure 11. a) Moist lapse rate profiles for selected surface air temperatures and humidities. b) The corresponding concentration profiles for H_2O. The concentration profiles of CO_2 for 200, 380 and 500 ppm and 285 K surface air temperature are also shown. The concentrations for H_2O decrease much faster with altitude than those of CO_2.

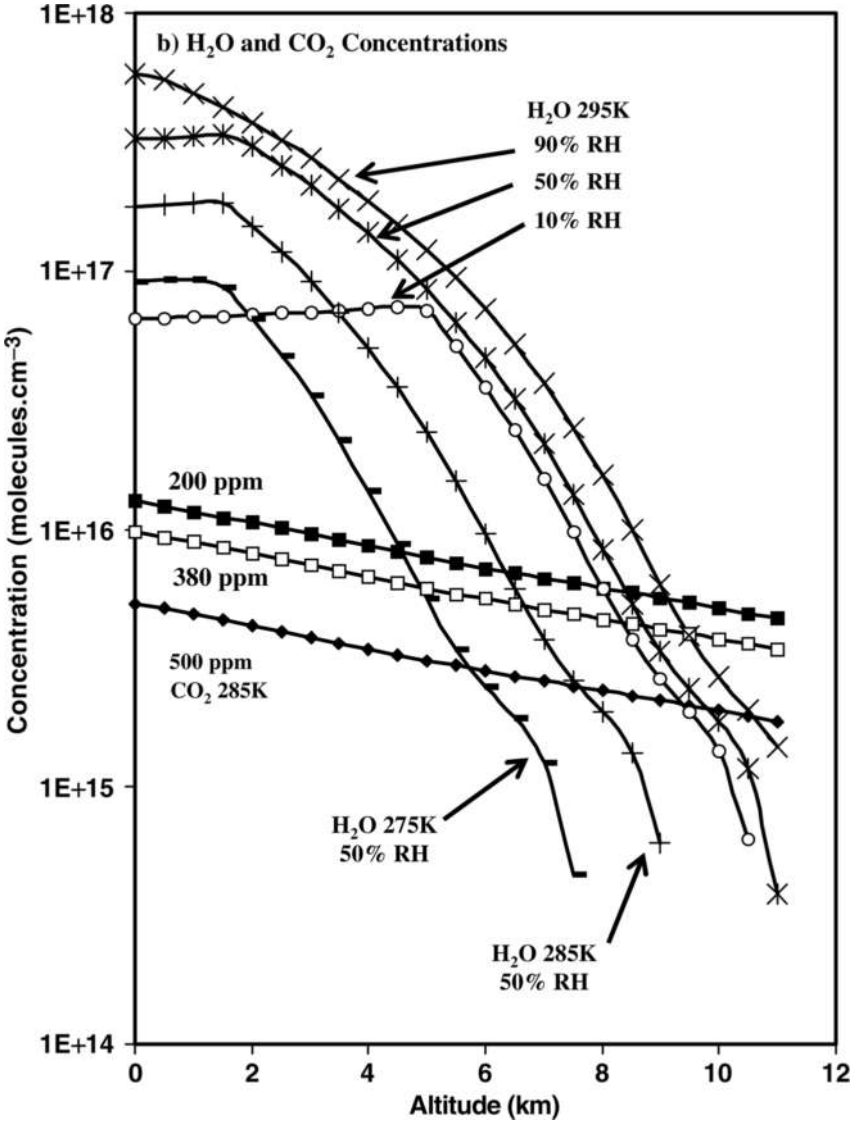


Figure 11. *(continued)*

of CO_2 are also shown. The concentration of H_20 in the troposphere decreases by 3 orders of magnitude with altitude because of the decrease in vapor pressure with decreasing temperature. The concentration of CO_2 decreases by less than a factor of three. The line width profiles of the H_2O spectral lines therefore decrease much faster that those of CO_2. The means that there is less absorption and re-emission of LWIR

radiation within the H_2O bands as the altitude increases. The radiation from the wings of the broader H_2O lines in the lower troposphere is not reabsorbed at higher altitudes and simply escapes into outer space. H_2O is therefore more effective at cooling the atmosphere than CO_2. These changes in line width with altitude are shown in Figure 12.

Changes in absorption and emission of LWIR radiation are the basis of the greenhouse effect. In general, an air parcel in the troposphere emits equal amounts of LWIR flux in the upward and downward directions. The air parcel will also absorb LWIR radiation from the air layers above and below. Usually the downward emitted

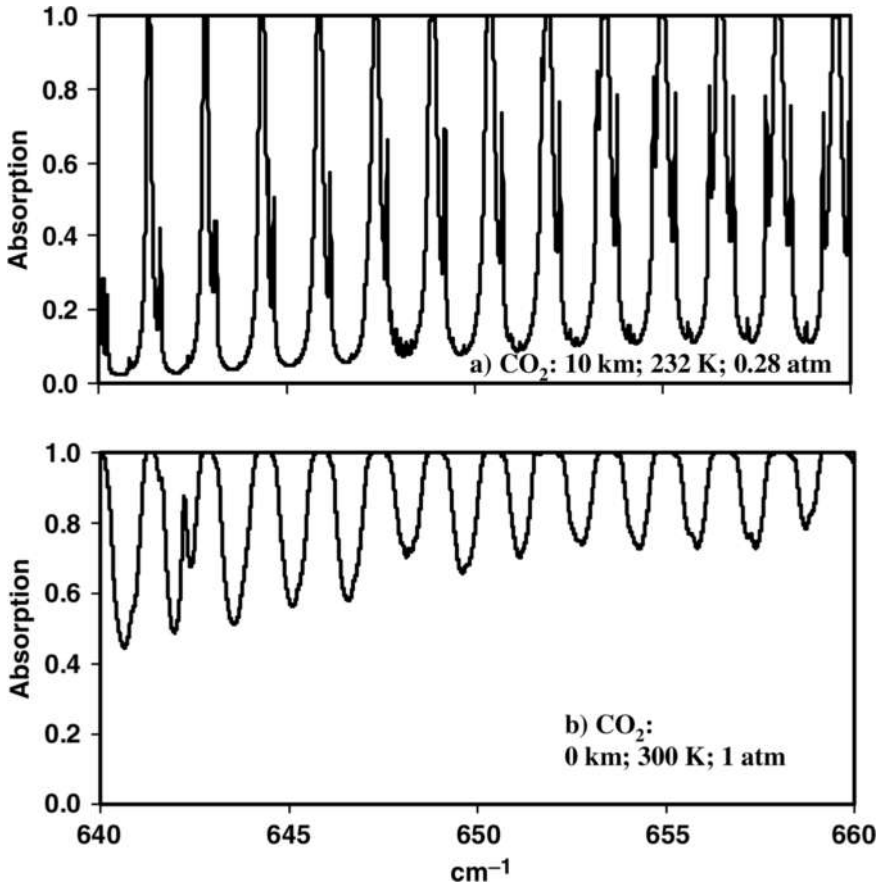


Figure 12. The effect of altitude on the line shapes and intensities of CO_2 and H_2O: a) CO_2 lines from 640 to 660 cm^{-1} at 10 km. b) Same CO_2 lines at 0 km. c) H_2O lines from 400 to 450 cm^{-1} at 10 km. d) Same H_2O lines at 0 km. Path lengths are 100m. The spectral lines are much narrower at 10 km. This effect is more pronounced for H_2O because of the decrease in concentration.

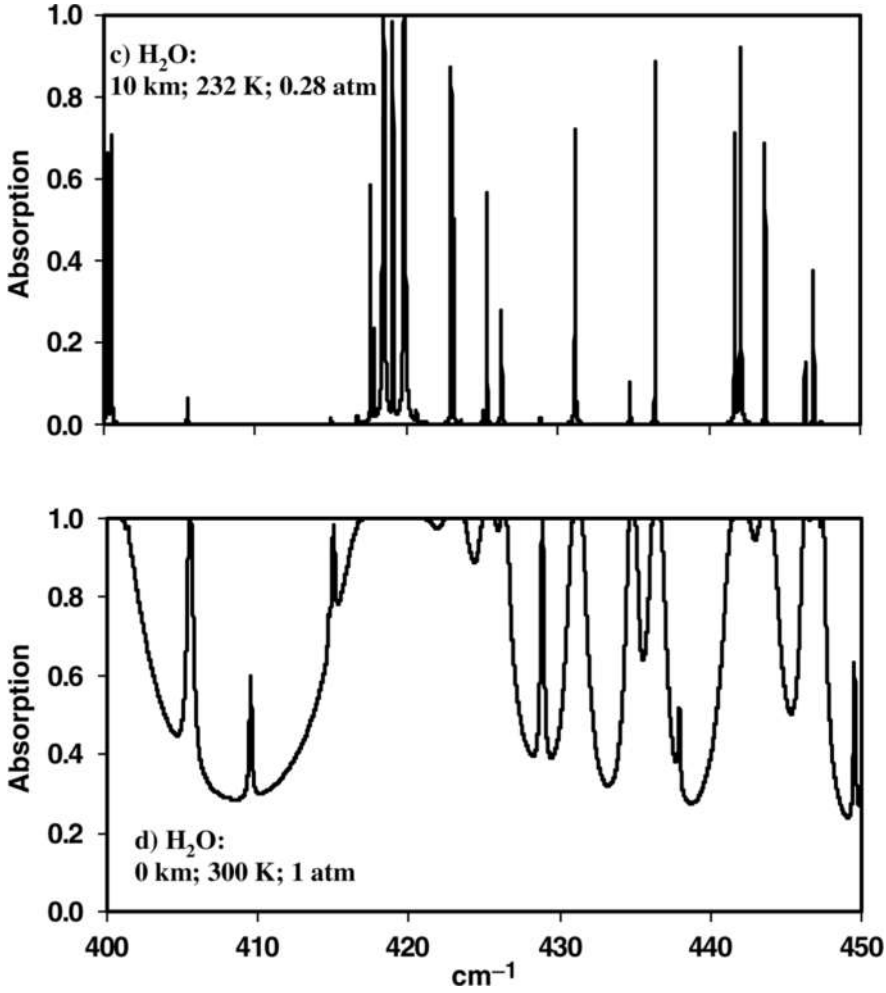


Figure 12. *(continued)*

flux and the upward absorbed flux are similar, whereas the absorbed downward flux from the cooler air layers above will be less than the upward emitted flux. The net effect is therefore a cooling of the atmosphere. This is illustrated in Figure 13. Over the oceans, almost all of the LWIR radiation lost to cooling is replaced by the latent heat flux from the condensation of water that has evaporated from the ocean. Over land, the most of the LWIR radiation lost to space is replaced by excess thermal radiation emitted by the ground as it is heated by the sun during the day. However, there may also be a significant latent heat flux if the ground is moist. It is also important to note that the air is re-circulated by convection and that as the air rises, it cools at the local lapse rate.

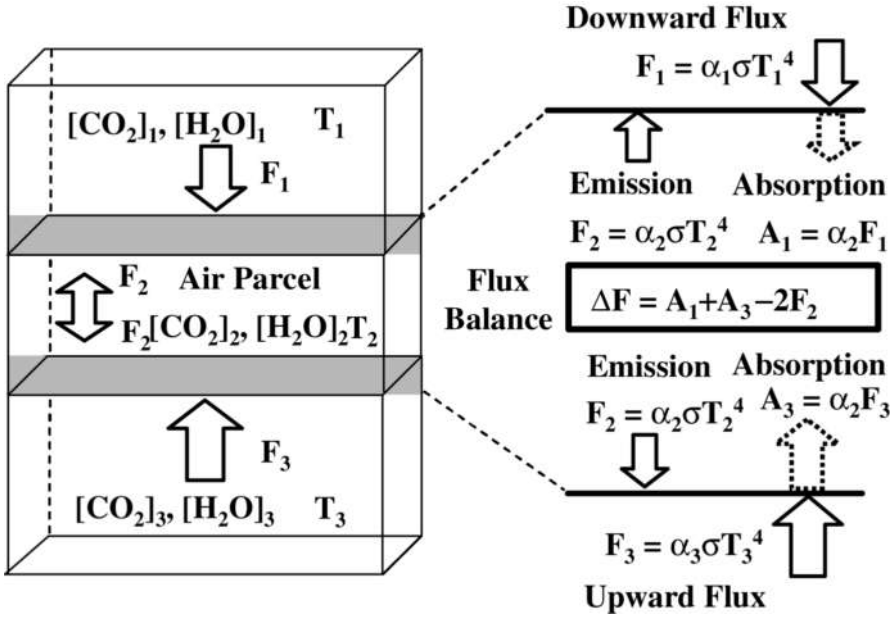


Figure 13. The flux balance underlying the greenhouse effect. The greenhouse gases in the air parcel emit flux F_2 in both directions. They also absorb part of the downward flux F_1 and the upward flux, F_3 from the surrounding air. The net balance of these terms determines the heating or cooling produced by the greenhouse effect. In general, the net balance leads to cooling, unless the air parcel is close to a warmer ground surface.

Figure 14 shows the spectrally resolved net absorption as a function of altitude due to the greenhouse effect. The ground surface temperature is 325 K and the surface air temperature is 295 K with 50% RH. These are the same conditions as Figure 7. 75% of the surface radiation is absorbed within the first 100 m above the ground and cooling dominates above 1 km. Most of the cooling occurs in the H_2O rotational band below 600 cm^{-1}. Figure 15 shows the variation in the upward LWIR cooling flux emitted at 7.5 km as the CO_2 concentration and RH are changed. H_2O is at least five times more effective in cooling the atmosphere than CO_2. Furthermore, the cooling flux increases with RH because of linewidth and condensation effects. The decrease in cooling flux produced by a 100 ppm increase in CO_2 concentration from 280 to 380 ppm has an insignificant effect on the atmospheric cooling rate.

This rather brief discussion of atmospheric radiative energy transfer clearly shows that water vapor is the dominant greenhouse gas for both cooling and warming the atmosphere. A 100 ppm increase in CO_2 concentration to 380 ppm has a negligible effect on the overall atmospheric heating and cooling rates. An increase in RH leads to an increase in atmospheric radiative cooling. Atmospheric energy transfer simulations must be derived from detailed high resolution radiatative transfer calculations. Empirical ‘radiative forcing constants’ and ‘water vapor feedbacks’ are unrealistic simplifying assumptions.

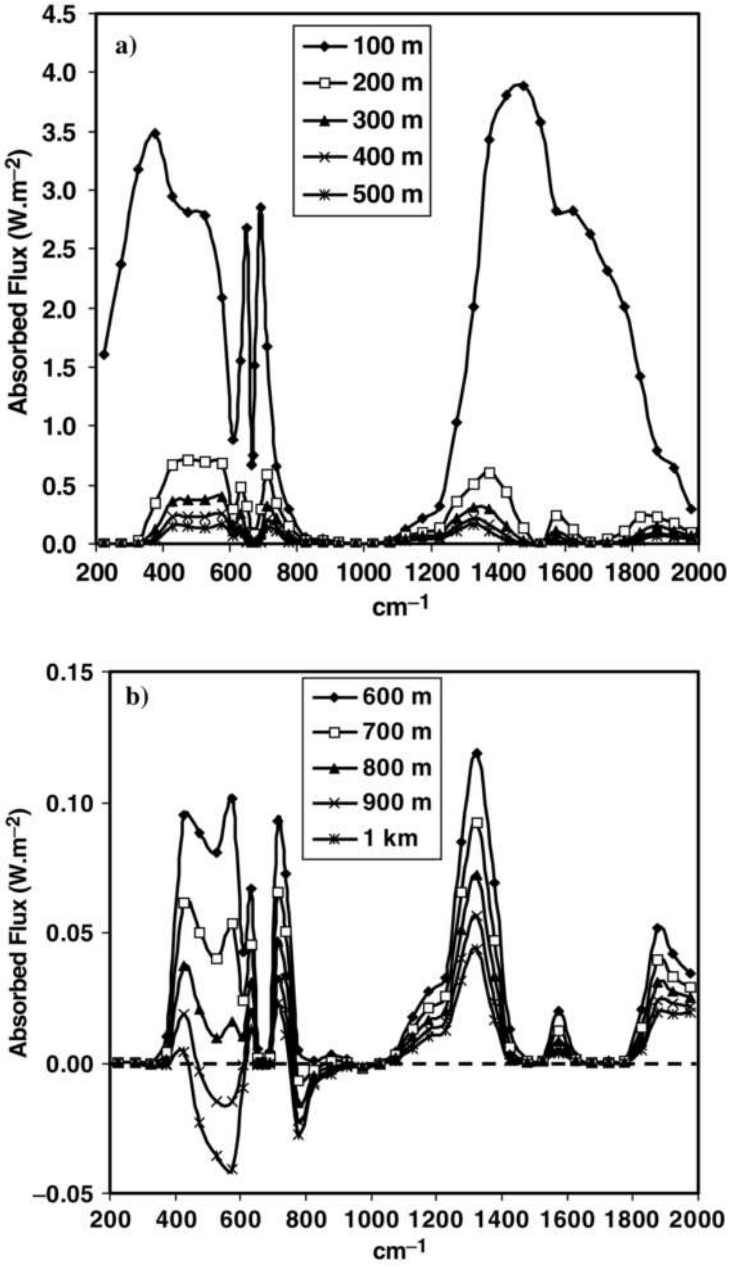
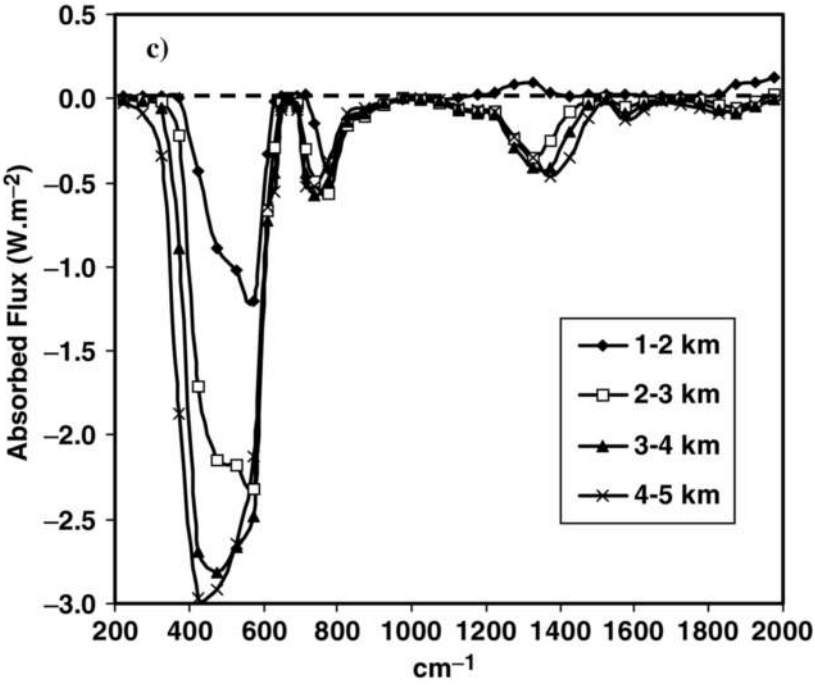
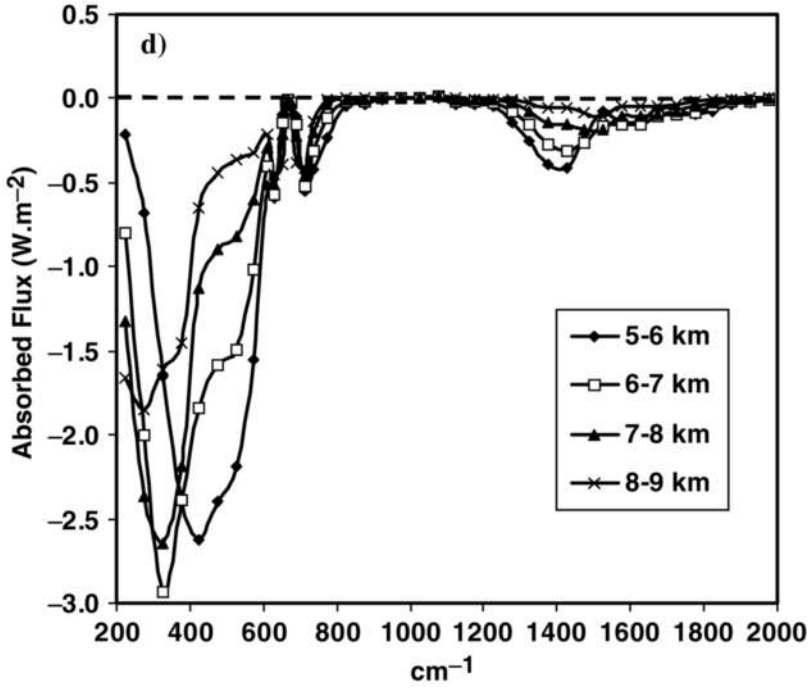


Figure 14. Spectrally resolved absorbed flux vs. altitude: a) 100 to 500 m, b) 600 m to 1 km, c) 1 to 5 km, d) 5 to 9 km. The ground temperature is 325 K and the surface air temperature is 295 K at 50% RH. Most of the surface LWIR flux is absorbed in the first 100 m. Above 1 km, radiative cooling is dominant and occurs mainly from the water rotational band below 600 cm^{-1}.





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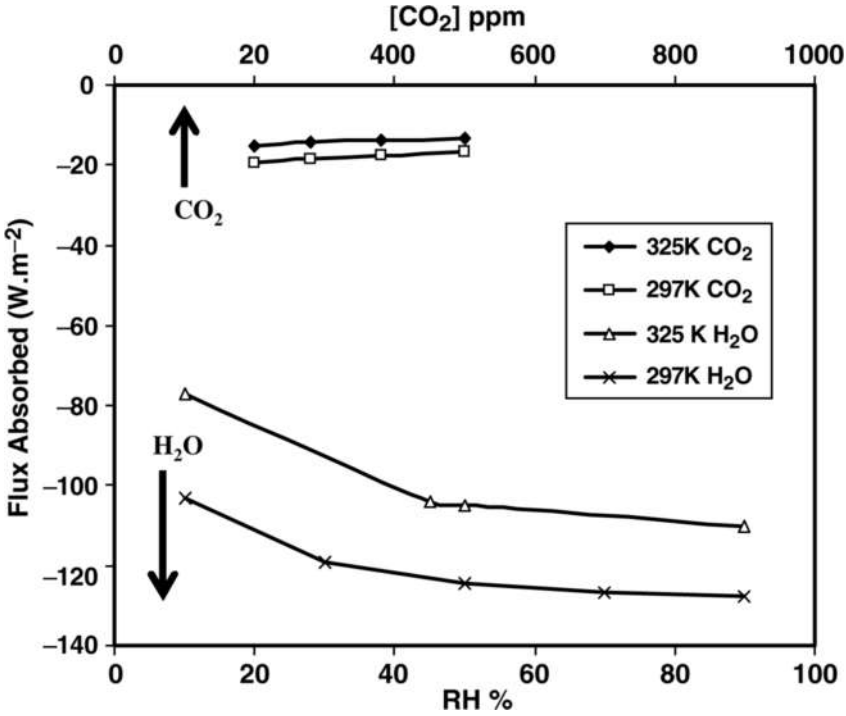

Figure 15. The effect of RH and CO_2 concentration changes on the total upward cooling flux at 7.5 km. The surface temperatures are 325 and 297 K and the air temperature is 295 K. There is a slight decrease in the cooling flux as the CO_2 concentration is increased. However, there is a significant increase in the cooling flux as the RH is increased. H_2O dominates the atmospheric cooling caused by the greenhouse effect.

5. RADIATIVE FORCING

Most of the large scale climate models used to predict global warming use an approach known as radiative forcing.[10, 29-32] This assumes that long term averages of dynamic, non-equilibrium climate variables such as radiative flux and surface temperatures can be analyzed using perturbation theory as though they were in radiative equilibrium. Small changes in 'average equilibrium flux' through an artificial boundary such as an 'average tropopause' are assumed to influence 'average equilibrium surface temperatures'. Although the mathematical derivation is correct and may even appear elegant, the underlying physical assumptions are incorrect. The troposphere is an open thermodynamic system so heat and flux are not conserved. The temperatures in the upper troposphere are near 220 K. Small changes in LWIR flux in the upper troposphere or stratosphere cannot influence surface temperatures of 288 K. Heat does not flow from a cooler to a warmer body. Molecular line widths also vary with altitude because of pressure broadening, so the upward and downward LWIR fluxes are not equivalent, as illustrated in Figure 12. At the Earth's surface, radiative flux is not

conserved, especially over the oceans. The calculated 'equilibrium surface temperature' produced by radiative forcing calculations is not even a physically measurable climate variable. Surface temperatures are determined by the cumulative daily and seasonal heat flux coupled into a surface volume with well defined thermal properties.

However, in the mid 1980's, a slight increase in the 'average' meteorological surface air temperature was found.[8] This was immediately linked by empirical speculation to the increase in anthropogenic CO_2 concentration. It was assumed that a 1 $W.m^{-2}$ increase in downward LWIR flux due to an increase in atmospheric CO_2 concentration produced an increase in meteorological surface air temperature of 2/3 C.[10] Water vapor feedback effects were invoked to explain model inaccuracies. These feedback assumptions have now been shown to be incorrect.[33] The change in the Kirchoff exchange flux was converted into an empirical 'radiative forcing constant'. This 'calibration factor' was then applied to other greenhouse gases such as methane and even to aerosols. The 'radiative forcing constants' used in climate simulation models have no physical meaning. The results derived from climate simulations that use the radiative forcing approach may be of limited academic interest in assessing model performance. However, such results are invalid and have no relationship to the physical reality of the Earth's climate.[34] Radiative forcing by CO_2 is, by definition a self-fulfilling prophesy, since the outcome is predetermined by the empirical modeling assumptions.

6. CONCLUSIONS

Application of Beer's law to the propagation of solar and LWIR flux through the ocean clearly shows that only the solar radiation can penetrate below the ocean surface and heat subsurface ocean layers. It is impossible for a 1.7 $W.m^{-2}$ increase in downward 'clear sky' atmospheric LWIR flux to heat the oceans. Similarly, the changes in land surface temperatures produced by this flux increase are too small to detect in measured diurnal and seasonal surface temperature variations. Furthermore, a 100 ppm increase in CO_2 concentration is not detectable in the meteorological surface temperature record. The assumptions underlying the use of radiative forcing and the 'prediction' of meteorological surface temperature in climate simulation are invalid. Based on these arguments, a null hypothesis for CO_2 is proposed:

It is impossible to show that changes in CO_2 concentration have caused any change to the Earth's climate, at least since the current composition of the atmosphere was set by ocean photosynthesis about one billion years ago.

A1. APPENDIX A

The IR absorption and emission spectra used in this work were calculated using the spectral data from the HITRAN database.[9] To facilitate the calculations, only the data for the principal isotopologues $^{1}H_2{}^{16}O$ and $^{12}C^{16}O_2$ were used and only lines with linestrengths above 10^{-23} cm^{-1}/molecule.cm^{-2} were selected. This slightly

underestimated the overall emission and absorption, but did not significantly alter the calculated flux differences for changes in absorption and emission due to changes in temperature and concentration. The changes in the downward LWIR flux due to changes in CO_2 concentration from 200 to 1000 ppm calculated in this work agree with the equivalent 'forcing constants' used by Hansen et al.[10]

To calculate the absorption profile of a single line, the linestrength is multiplied by the concentration and the linewidth is calculated as a Lorentzian profile from the air broadening pressure and temperature coefficients. The linestrengths in the HITRAN database are given for a reference temperature of 296 K. At other temperatures the linestrengths must be scaled by the Boltzmann factor and the partition function. The line by line spectral data for the line position, linestrength, lower state energy level, pressure and temperature broadening coefficients are available from the HITRAN database.[9] The calculations are described in detail in the related literature.[35-41] The absorption and emission spectra used in this work were calculated using Excel worksheets automated by using Excel VBA macros to cycle through the calculations. Most of the spectra were calculated from 200 to 2000 cm^{-1} using 0.01 cm^{-1} resolution for the spectral linewidths and 100m steps for the altitude. The use of a minimum spectral resolution of 0.01 cm^{-1} eliminates any uncertainty in the calculated lineshape.[42] Line by line HITRAN data for CO_2 and H_2O were merged and divided into 50 cm^{-1} increments. At 0.01 cm^{-1} resolution, this requires 5000 lines in an Excel worksheet. A singe column in the worksheet was used to calculate each line absorption profile. The rows were summed to obtain the spectral absorption profile. This was multiplied by the blackbody emission for the lapse rate temperature used in the absorption profile calculation to obtain the emission profile. The temperature, CO_2 and H_2O concentrations were calculated from the lapse rate profile. The calculated spectral data was written to a second worksheet and processed to generate summary absorption and emission profiles for the upward and downward fluxes at 1 km intervals. Because of the higher line density near the CO_2 Q branch, the spectral interval was decreased and the resolution was increased to accommodate the 5000 line worksheet calculation. Interval/resolution ranges of 25/0.005; 20/0.004, 10/0.002 and 5/0.001 cm^{-1} were used as needed to span the 600 to 750 cm^{-1} spectral region.

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THE THUNDERSTORM THERMOSTAT HYPOTHESIS: HOW CLOUDS AND THUNDERSTORMS CONTROL THE EARTH'S TEMPERATURE

Willis Eschenbach
Independent Climate Researcher
16869 Lauri Lane, Occidental, CA 95465 USA
willis@taunovobay.com

ABSTRACT
The Thunderstorm Thermostat Hypothesis is the hypothesis that tropical clouds and thunderstorms actively regulate the temperature of the earth. This keeps the earth at an equilibrium temperature regardless of changes in the forcings. Several kinds of evidence are presented to establish and elucidate the Thermostat Hypothesis – historical temperature stability of the Earth, theoretical considerations, satellite photos, and a description of the equilibrium mechanism.

1. AUTHOR'S NOTE

I am aware that this study is not written in the normal scientific format. However, it is not a normal scientific study. It is the theoretical investigation of a new paradigm for understanding the climate system. In addition, it is my own small protest against the idea that scientific papers need to be written in a dense, hard-to-read format. One of the results of the Internet is that many more people are interested in, and have access to, scientific papers. It is my belief that it is in everyone's interest to have scientific papers that are accessible to a much wider audience.

This is particularly true in climate science, which ranges over a very wide variety of disciplines (oceanography, atmospheric chemistry, geology, statistics, meteorology, solar physics, biology, and many more). As such, it is important that scientific papers in the field be accessible to scientists in one of those disciplines who may not be as well versed in the other disciplines.

2. INTRODUCTION

Why Do We Need A New Paradigm?

In 1896, Svante Arrhenius speculated that an increase in CO_2 in the atmosphere would increase the global surface temperature (Arrhenius 1896). He postulated that the relationship between the two was given by the equation:

$$\Delta T = \alpha \log2(C/C0)$$

where ΔT = temperature, C = CO_2 concentration, C0 = original CO_2 concentration, log2 is logarithm to the base 2, and alpha = climate sensitivity.

Arrhenius initially estimated that a doubling of CO_2 would result in a temperature increase of 4–5 °C. In 1906 he reduced the estimate to 2.66° per doubling. By 1988, using computer models, the result of a doubling of CO_2 was estimated at 1.5–4.5 °C.

In 1988, computer models were slow and crude. Since then, a large number of improvements have been made in both the speed and the complexity of the computer models. But despite all of these improvements, we have been unable to improve this estimate in any significant way. The most recent IPCC report estimates a temperature increase of 2–4.5 °C from a CO_2 doubling, which is only a slight increase over the accuracy of the 1988 estimate.

Thus, over a century, we have made very little improvement on the initial estimate made by Arrhenius. Despite a century of advances, despite the advent of computer models, despite huge increases in the speed and complexity of those models, despite years of increases in our understanding of climate phenomena, our estimates are not improving in any significant way.

The most reasonable explanation of this inability to improve our estimate of the climate sensitivity is that we are using the wrong paradigm to understand the climate.

The Current Paradigm

The current paradigm of climate is that the temperature of the earth is a one-dimensional problem. That is to say, the surface temperature is ruled by CO_2, and everything else averages out over time. The paradigm does not allow for the possibility that there are any preferred temperatures. The paradigm does not include any temperature regulating systems. The paradigm does not include any limits on temperature variation. The paradigm does not include any acknowledgment of the effects of the Constructal Law on flow systems (Bejan 1997, 2005). It claims that CO_2 is what governs global temperatures. Everything else is assumed to average out over a period of thirty years or more.

After all, the proponents argue, it is simple physics. Increased $CO_2 \rightarrow$ increased greenhouse effect $\rightarrow$ increased temperature. How can you argue with simple physics?"

The difficulty with this single-variable paradigm is that the climate is an almost unimaginably complex dynamic system. It has five major intricate, interrelated, and incompletely understood subsystems – atmosphere, hydrosphere, biosphere, cryosphere, and lithosphere. (And that's not counting the extra-terrestrial system, involving solar radiation, the complex interaction of helio- and geo-magnetism, solar wind, cosmic rays, coronal mass ejections, and the like.)

Each of these subsystems has a host of known and unknown forcings, interactions, phase transitions, limitations, resonances, couplings, response times, feedbacks, natural cycles, emergent phenomena, constructal constraints, and control systems. Finally, climate is affected by things occurring on spatial scales from the molecular to the planetary, and on temporal scales from the instantaneous to millions of years.

To illustrate what this complexity means for the current "simple physics" paradigm, consider a similar "simple physics" problem in heat transfer. Suppose we take a block of aluminum six feet long and put one end of it into a bucket of hot water. We attach a thermometer to the other end, keep the water hot, and watch what happens. Fairly soon, the temperature at the other end of the block starts to rise. It's a one-dimensional problem, ruled by simple physics.

To verify our results, we try it again, but this time with a block of iron. Once again the temperature soon rises at the other end, just a bit more slowly than the aluminum. We try it with a block of glass, and a block of wood, and a block of copper. In each case, after time, the temperature at the other end of the block rises. This is clearly simple physics in each case.

As a final test, I look around for something else that is six feet long to use in the investigation. Finding nothing, I have an inspiration. I sit down, put my feet in the hot water, put the thermometer in my mouth and wait for the temperature of my head to start rising. After all, heat transmission is simple physics, isn't it? So I just sit with my feet in the hot water and wait for the temperature of my head to rise.

And wait.

And wait ...

The moral of the story is that in dealing with complex systems such as the climate or the human body, the simplistic application of one-dimensional analyses or the adoption of a simple paradigm based on simple physics often gives results that have no resemblance to real world outcomes. It is this inability of the current paradigm to lead us to any deeper understanding of climate that underlines the need for a new paradigm. The current paradigm is incapable of solving many of the puzzles posed by the variations in global climate.

Historical Stability

The stability of the earth's temperature over geological time has been a long-standing climatological puzzle. The globe has maintained a temperature of ± ~ 3% (including ice ages) for at least the last half a billion years during which we can estimate the temperature. During the Holocene (since the last Ice Age), temperatures have not varied by ±1% (±3 °C). And during the ice ages, the temperature was generally similarly stable. Figure 1 shows the variations of temperature over the last half billion years.

First, maximum temperature for a blackbody at our distance from the sun is less than the earth's temperature. This warming above the theoretical maximum possible temperature is a result of the so-called "greenhouse effect".

Second, although it has gotten cold at times, at no time has the temperature gone below freezing. Currently, we are at the cold end of the variation over geological time.

Third, the earth's temperature has only varied about ±3% during the last half billion years. And for much of that time, the variations have been much smaller, in the range of ±1%.

Fourth, the earth appears to have limits beyond which the temperature does not venture, although it spends long periods of time at those limits.

In contrast to Earth's temperature stability, solar physics has long indicated (Gough, 1981; Newman et al., 1977) that the sun is warming at a rate of about 10% per billion years. The warming from this is shown by the gray line in Figure 1. In early geological times, however, the earth was not correspondingly cooler. Temperature proxies such as deuterium/hydrogen ratios and 16O/18O ratios show no sign of solar driven warming of the earth over this time. Why didn't the earth warm as the sun warmed? Why didn't the earth freeze when the sun was much cooler than it is now?

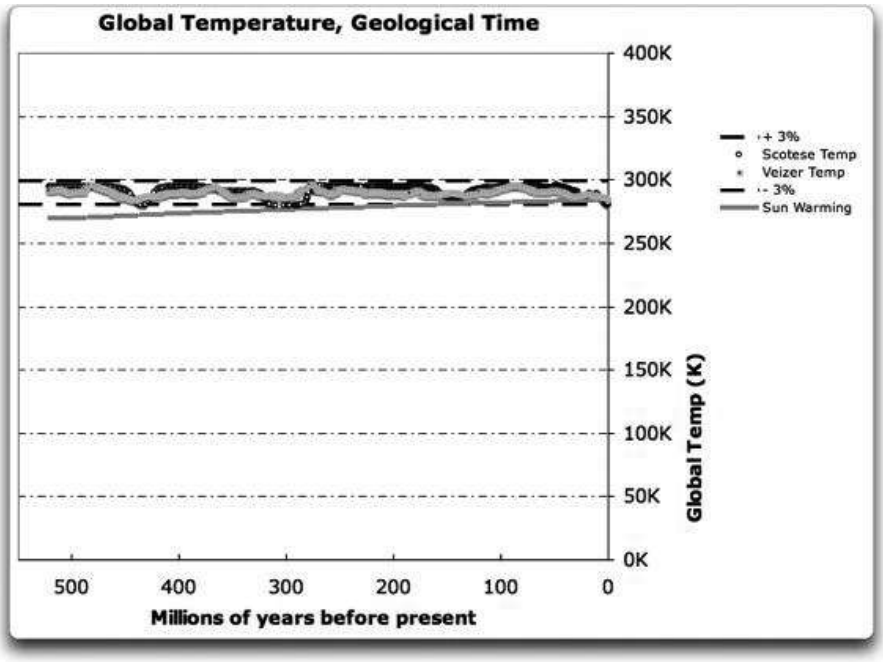

Figure 1. Variation of temperature over the last half a billion years. Two different temperature estimates are given, with data sources listed in References. Temperatures are given as anomalies around 290°. The gray line shows the warming expected from the increased strength of the sun. Warming due to the change in solar strength is calculated at the IPCC value of 3 °C per 3.7 W/m^2.

This is called the "Faint Early Sun Paradox" (Sagan et al., 1972), and is usually explained by positing an early atmosphere much richer in greenhouse gases than the current atmosphere. However, this would imply a gradual decrease in GHG forcing which exactly matched the incremental billion-year increase in solar forcing to the present value. This seems highly unlikely.

Why has Earth's temperature stayed so stable? Global temperature has stayed within a narrow band for at least the last half billion years. During that time the planet has seen meteor strikes, and millennia long widespread volcanic eruptions, and huge forest fires, and oceans disappearing as continents were lifted out of the sea, and huge changes in the land cover, and all manner of good, bad, and ugly events. Each of these events had a large effect on the forcings. Despite all of that, despite all of the variation in the forcings and the changes in the losses during all of that geological time, the earth's temperature hasn't moved around much at all. A few percent. And the variation over the last 10,000 years has been less than ±1%. For a system as complex as the climate, this is amazing stability.

So I began looking for some natural governing mechanism that was strong enough to hold the Earth's temperature within such narrow bounds.

3. THE CLIMATE GOVERNING MECHANISM

Bejan (Bejan 2005) has shown that the climate system can be robustly modeled as a heat engine, with the ocean and the atmosphere as the working fluids. The tropics are the hot end of the heat engine. Some of that tropical heat is radiated back into space. The system transports the rest of that tropical heat to the Poles. There, at the cold end of the heat engine, the net flow of heat is from earth to space. Fig. 2 shows the entire system.

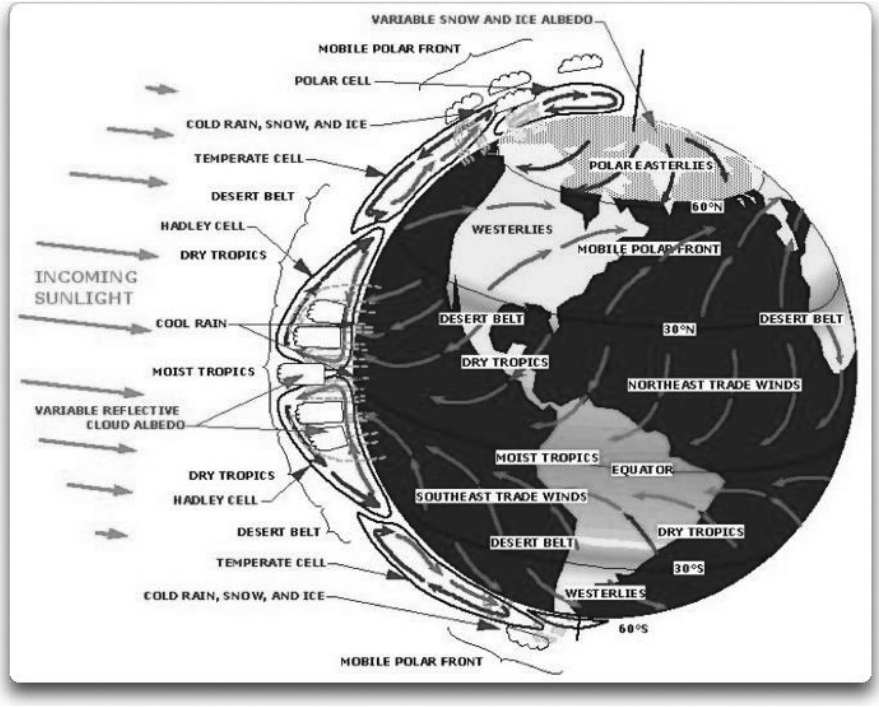

Figure 2. The Earth as a Heat Engine. The equatorial Hadley Cells provide the power for the system. Over the tropics, the sun is strongest because it hits the earth most squarely. The length of the arrows labeled "Incoming Sunlight" shows relative sun strength. Warm dry air descends at about 30N and 30S, forming the great desert belts that circle the globe. Heat is transported by a combination of the ocean and the atmosphere to the poles. At the poles, the heat is radiated to space.

Since the climate can be modeled as a heat engine as shown in Fig. 2, what might be regulating the temperature to keep it within such a narrow band? Heat engines usually have a throttle. The throttle is the part of the engine that controls how much energy enters the heat engine. A motorcycle has a hand throttle. In an automobile, the throttle is called the gas pedal. It controls how much energy (fuel) enters the car's engine.

While all heat engines have a throttle that controls incoming energy, not all of them have a governor. In a car, a governor is called "Cruise Control". Cruise control is a governor that controls the throttle (gas pedal). A governor adjusts the energy going to the car engine to maintain a constant speed regardless of changes in internal and external forcing (e.g. hills, winds, engine efficiency and losses).

A governor uses both negative and positive feedback to control a system so that it maintains a steady state. An example of negative feedback is the effect of air friction on a car. As you increase your speed, the friction goes up, reducing your speed. It is a negative feedback affecting your speed. However, it is only a negative feedback. Air friction can never speed the car up.

In the climate heat engine, the throttle is the clouds that reflect solar energy back to space. Clouds control how much energy enters the system. However, a throttle is not enough. The stability of the earth's temperature over time (including alternating bi-stable glacial/interglacial periods), as well as theoretical considerations, indicates that this heat engine we call climate must have some kind of governor controlling the throttle.

We can narrow the candidates for this climate governor by noting first that a governor controls the throttle (which in turn controls the energy supplied to a heat engine). Second, we note that a successful governor must be able to drive the system beyond the desired result (overshoot). For a governor to control a lagged system, it must be capable of overshoot.

A governor is different from a simple linear negative feedback. A linear negative feedback can only reduce an increase. It cannot maintain a steady state in the face of differing forcings, variable loads, and changing losses. Only a governor can do that. A governor must perforce be able to increase as well as decrease the overall speed. Regarding the climate, when the earth gets too cold, the governor must be able to actively warm it up. When the earth gets too hot, the governor must cool it down. A simple negative feedback cannot do that.

In order to maintain a steady climate state, a governor must be able to cool the system down below the starting point (overshoot). In terms of temperature, it must be able to more than just reduce the size of an increase. It must actively cool the earth down to a temperature cooler than the starting point.

I propose that two inter-related but separate mechanisms act directly to regulate the earth's temperature – cumulus and other reflective clouds provide the throttle, and cumulonimbus clouds (thunderstorms) are the governor.

Cumulus clouds are the fluffy "cotton ball" clouds that abound near the surface on warm afternoons. Thunderstorms start life as simple cumulus clouds. Both types of clouds are part of the throttle control. Globally, clouds reflect about 20% of the incoming solar energy. Locally, of course, the effect is far greater. Both cumulus and cumulonimbus clouds are part of the throttle system. In addition, the cumulonimbus clouds are active heat engines that provide the necessary overshoot to act as a governor on the system.

The majority of the earth's absorption of heat from the sun takes place in the tropics. This is due to a combination of factors that reduce insolation as we move towards the poles. These include increasing tilt of the surface, increasing depth of atmosphere to traverse, increasing reflection from clouds, increasing albedo due to the

angle of incidence, and increasing albedo from snow and ice. Combined, these mean that very little solar energy heats the poles, and most of it is absorbed at the tropics.

The tropics, like the rest of the world, are mostly ocean; and what land is there is wet land. The steamy tropics, in a word. The entire global heat engine we call climate is spun into motion by the ascending air and thunderstorms at the tropics, as shown in Fig. 2. The tropics are the hot end of the heat engine, where the majority of the solar energy enters the system. It absorbs much more heat than it can radiate to space. This heat is exported from the tropics and transported pole wards. There the heat is eventually radiated to space. Because they regulate incoming energy, the tropics play a huge part in the thermal balance of the earth. There is little ice there, so the clouds are the throttle that controls how much energy enters the climate heat engine. And the thunderstorms are the governor.

A pleasant thought experiment shows how this thunderstorm governor works. I call it "A Day In the Tropics".

I live in the deep, moist tropics, at 9°S, with a view of the South Pacific Ocean from my windows. Here's what a typical day looks like. In fact, it's a typical summer day everywhere in the Tropics. The weather report goes like this:

> *Clear and calm at dawn. Light morning winds, clouding up before noon. In the afternoon, increasing clouds and wind with a chance of showers and thundershowers as the storms develop. Clearing around or after sunset, with an occasional thunderstorm after dark. Progressive clearing until dawn.*

That's the most common daily cycle of tropical weather, common enough to be a cliché around the world.

It is driven by the day/night variations in the strength of the sun's energy. Before dawn, the atmosphere is typically calm and clear. As the ocean (or moist land) heats up, air temperature and evaporation increase. Warm moist air starts to rise. Soon the rising moist air cools and condenses into clouds. The clouds reflect the sunlight. That's the first step of climate regulation. Increased temperature leads to clouds. The clouds close the throttle slightly, reducing the energy entering the system. They start cooling things down. This is the negative feedback part of the cloud climate control.

The tropical sun is strong, however. Despite the negative feedback from the cumulus clouds, the day continues to heat up. The more the sun hits the ocean, the more warm, moist air is formed, and the more cumulus clouds form. This, of course, reflects more sun, which is to say the throttle closes a bit more. But despite that the day continues to warm.

The full development of the cumulus clouds sets the stage for the second part of temperature regulation. This is not simple negative feedback. It is the climate governing system. As the temperature continues to rise, as the evaporation climbs, some of the fluffy cumulus clouds suddenly transform themselves. They rapidly extend skywards, thrusting up to form pillars of cloud thousands of meters high in a short time. These cumulus clouds are transformed into cumulonimbus (thunderstorm) clouds. The columnar body of the thunderstorm acts as a huge vertical heat pipe. The thunderstorm sucks up warm, moist air at the surface and shoots it skyward. At altitude the water condenses, transforming the latent heat into sensible heat. The air is re-warmed by this release of sensible heat, and continues to rise.

At the top, the air is released from the cloud up high, way above most of the CO_2. In that rarified atmosphere, the air is much freer to radiate to space. By moving inside the thunderstorm heat pipe, the air bypasses most of the greenhouse gases and comes out near the top of the troposphere. During the transport aloft, there is no radiative or turbulent interaction between the rising air and the lower and middle troposphere. Inside the thunderstorm, the rising air is tunneled through most of the troposphere to emerge at the top.

In addition to reflecting sunlight from their top surface as cumulus clouds do, and transporting heat past the greenhouse gases to the upper troposphere where it radiates easily to space, thunderstorms cool the surface in a variety of other ways, particularly (but not exclusively) over the ocean.

1. Wind driven evaporative cooling. Once the thunderstorm starts, it creates its own strong wind around the base. This self-generated wind increases evaporation in several ways, particularly over the ocean.
   a) Evaporation rises linearly with wind speed. At a typical squall wind speed of 10 metres per second (mps) (20 knots), evaporation is about ten times higher than at "calm" conditions (conventionally taken as 1 mps).
   b) The wind increases evaporation by creating spray and foam, and by blowing water off of trees and leaves. These greatly increase the evaporative surface area, because the total surface area of the millions of droplets is evaporating as well as the actual surface itself.
   c) To a lesser extent, ocean surface area is also increased by wind-created waves (a wavy surface has larger evaporative area than a flat surface).
   d) Wind created waves in turn greatly increase turbulence in the boundary layer. This increases evaporation by mixing dry air down to the surface and moist air upwards.
   e) As the spray rapidly warms to air temperature, which in the tropics is often warmer than ocean temperature, evaporation also rises above the sea surface evaporation rate.
2. Wind driven albedo increase. The white spray, foam, spindrift, changing angles of incidence, and white breaking wave tops greatly increase the albedo of the sea surface. This reduces the energy absorbed by the ocean.
3. Cold rain and cold wind. As the moist air rises inside the thunderstorm's heat pipe, water condenses and falls. Since the water is originating from condensing or freezing temperatures aloft, it cools the lower atmosphere it falls through. It also cools the surface when it hits. In addition, the falling rain entrains a cold wind. This cold wind blows radially outwards from the center of the falling rain, cooling the surrounding area.
4. Increased reflective area. White fluffy cumulus clouds are not tall, so basically they only reflect from their tops. On the other hand, the vertical pipe of the thunderstorm reflects sunlight along the sides of its entire height. This means that thunderstorms shade an area of the ocean out of proportion to their footprint, particularly in the late afternoon.
5. Modification of upper tropospheric ice crystal cloud amounts (Lindzen 2001, Spencer 2007). These clouds form from the tiny ice particles that come out of

the smokestack of the thunderstorm heat engines. It appears that the regulation of these clouds has a large effect, as they are thought to warm (through IR absorption) more than they cool (through reflection).

6. Enhanced nighttime radiation. Unlike long-lived stratus clouds, cumulus and cumulonimbus generally die out and vanish as the night cools, leading to the typically clear skies at dawn. This allows greatly increased nighttime surface radiative cooling to space, particularly in the early morning.
7. Delivery of dry air to the surface. The air being sucked from the surface and lifted to altitude is counterbalanced by a descending flow of replacement air emitted from the top of the thunderstorm. This descending air has had the majority of the water vapor stripped out of it inside the thunderstorm, so it is relatively dry. The dryer the air, the more moisture it can pick up for the next trip to the sky. This increases the evaporative cooling of the surface.

In part because they utilize such a wide range of cooling methods, cumulus clouds and thunderstorms are extremely good at reducing the surface temperature of the earth. Together, they form the governing mechanism for the tropical temperature.

But where is that mechanism?

The problem with my thought experiment of describing a typical tropical day is that it is always changing. The temperature goes up and down, the clouds rise and fall, day changes to night, the seasons come and go. Where in all of that unending change is the governing mechanism? If everything is always changing, what keeps the temperature within a narrow range month-to-month and year-to-year? If conditions are always different, what keeps the temperature from going off the rails?

In order to see the governor at work, we need a different point of view. We need a point of view without time. We need a timeless view without seasons, a point of view with no days and nights. And curiously, in this thought experiment called "A Day In the Tropics", there is such a timeless point of view, where not only is there no day and night, but where it is always summer.

The point of view without day or night, the point of view from which we can see the climate governor at work, is the point of view of the sun. Imagine that you are looking at the earth from the sun. From the sun's point of view, there is no day and night. All parts of the visible face of the earth are always in sunlight; the sun never sees the nighttime. And it is always summer under the sun.

If we accept the convenience that north is up, then as we face the earth from the sun, the visible surface of the earth is moving from left to right as the planet rotates. So the left hand edge of the visible face is always at sunrise, and the right hand edge is always at sunset. Noon is a vertical line down the middle. From this timeless point of view, morning is always and forever on the left, and afternoon is always on the right. In short, by shifting our point of view, we have traded time coordinates for space coordinates. This shift makes it easy to see how the governor works.

The tropics stretch from left to right across the circular visible face. We see that near the left end of the tropics, after sunrise, there are very few clouds. Clouds increase as you look further to the right. Around the noon line, there are already cumulus clouds. And as we look from left to right across the right side of the visible face of the earth, towards the afternoon, more and more cumulus clouds and increasing numbers of thunderstorms cover a large amount of the tropics.

It is as though there is a graduated mirror shade over the tropics, with the fewest cloud mirrors on the left, slowly increasing to extensive cloud mirrors and thunderstorm coverage on the right.

After coming up with this hypothesis that as seen from the sun, the right hand side of the deep tropics would have more cloud than the left hand side, I realized this was a testable proposition to support or demolish my hypothesis. So in order to investigate whether this postulated increase in cloud on the right hand side of the earth actually existed, I took an average of 24 pictures of the Pacific Ocean taken at local noon on the 1st and 15th of each month over an entire year. I then calculated the average change in albedo and thus the average change in forcing at each time. Fig. 3 shows the changes in the clouds and the albedo.

The graph below the image of the earth in Fig. 3 shows the albedo and solar forcing in the rectangle that contains the Pacific Inter-Tropical Convergence Zone. Note the sharp increase in the albedo between 10:30 and 11:30. You are looking at the

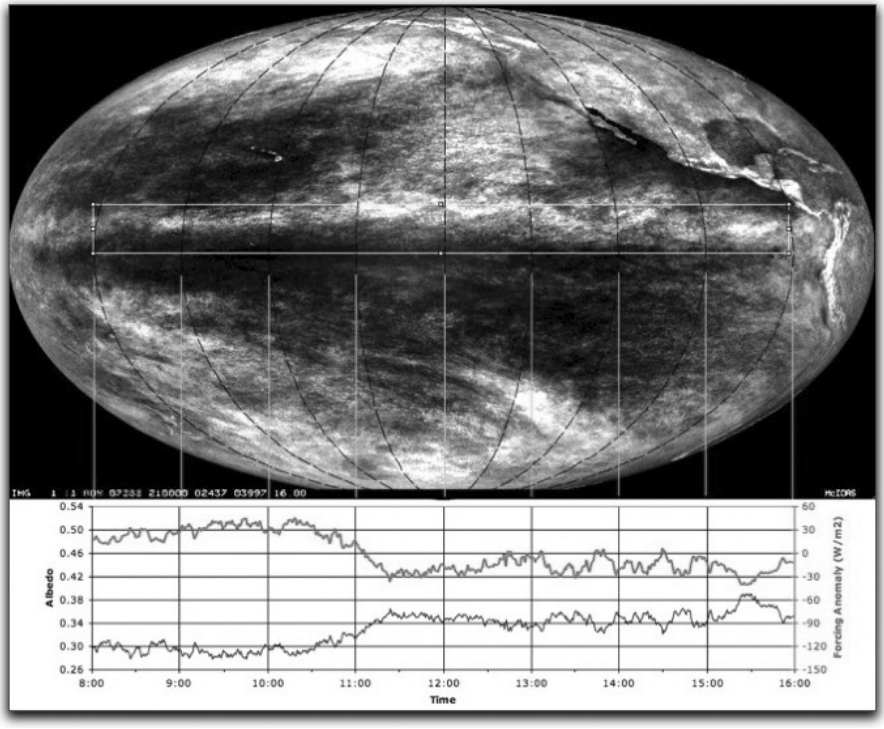

Figure 3. Average of one year of GOES-West weather satellite images taken at satellite local noon. The Intertropical Convergence Zone is the bright band in the gray rectangle. Dashed black lines on the image show local time on earth. Time values are shown at the bottom of the attached graph. Upper line on graph is solar forcing anomaly (in watts per square meter) in the area outlined by the rectangle (right scale). Lower line is albedo value in the area outlined by the rectangle (0°–15°N).

mechanism that keeps the earth from overheating. It causes a change in insolation of -60 W/m^2 between ten and noon.

Now, consider what happens if for some reason the surface of the tropics is a bit cool. The sun takes longer to heat up the surface. Evaporation doesn't rise until later in the day. Clouds are slow to appear. The first thunderstorms form later, fewer thunderstorms form, and if it's not warm enough those giant surface-cooling heat engines don't form at all.

And from the point of view of the sun, the entire mirrored shade shifts to the right, letting more sunshine through for a longer time. The 60 W/m^2 reduction in solar forcing doesn't take place until later in the day, increasing the local insolation.

When the tropical surface gets a bit warmer than usual, the mirrored shade gets pulled to the left, and clouds form earlier. Hot afternoons drive thunderstorm formation, which cools and air-conditions the surface. In this fashion, a self-adjusting cooling shade of thunderstorms and clouds keeps the temperature within a narrow range. A change in albedo of a mere 2%, from say 30% albedo to 32% albedo, is equivalent to two doublings of CO_2 (from the current 380 ppmv to 1,520 ppmv!) . . . so a tiny, undetectable change in cloud cover is more than enough to offset any conceivable variation in CO_2.

One of the unexpected findings in Fig. 3 above is the nature of the change in albedo from early morning to late afternoon. Albedo runs level at ~ 0.30 from eight am to ten-thirty AM. In the next hour, it takes a very quick jump to ~ 0.34. From there it stays roughly level until 16:00.

My interpretation of this is that once the cumulus starts to form, it forms in an hour or so. At the end of that time, it has covered the maximum area possible. Remember that a cumulus cloud is not a "thing". It is a flag marking an area of rising air. What goes up must come down. So these areas of rising air have to be surrounded by areas where the air is descending. Fairly quickly, the limit of cumulus growth is reached. At that point the uprising and descending areas have reached their full growth balance. Fig. 3 shows that cumulus growth ends around 11:30. The growth limit is where cloud cover starts to seriously cut into the area available for descending air. That ratio of cumulus area to area of descending air appears to be maintained for the rest of the day. To me, this is a sign of a system that is fully developed. The clouds are not able to stop the temperature rise, much less drive the temperature down below the starting point. As evaporation increases and more water vapor condenses, the clouds are forced to grow vertically rather than horizontally. The lapse rate decreases over a larger vertical area and the effective heat capacity of the formation increases dramatically relative to its surroundings. More energy is available but temperature changes more slowly. And as the temperatures continue to rise, at some point, the thunderstorms begin to form. They begin cooling the surface immediately, stopping the temperature increase.

It is this daily regulation of tropical temperature that governs the temperature over millennia. I used to think that the governor system would have to operate over geological timescales. I wasted a lot of time trying to imagine what that hugely slow, long timescale system might be. But one day, after years of looking, I realized that since on average the cloud/thunderstorm combo keeps the daily tropical temperature

on average within say a 6° range, then the million year average would also be within the same 6° range. I smote my forehead in frustration over wasted time ...

4. HOW THE GOVERNOR WORKS

Tropical cumulus production and thunderstorm production are driven by air density. Air density is a function of temperature (affecting density directly through air parcel expansion/contraction) and the water content of the air (water vapor is lighter than air).

A thunderstorm is both a self-generating and self-sustaining heat engine. The working fluids are moisture-laden warm air and liquid water. Self-generating means that whenever it gets hot enough over the tropical ocean, which is almost every day, at a certain level of temperature and humidity, some of the fluffy cumulus clouds suddenly catch fire. The tops of the clouds streak upwards, showing the rising progress of the moisture laden surface air. At altitude, the rising air exits the cloud, replace by more moist air from below. Suddenly, in place of a placid cloud, there is an active thunderstorm.

Self-generating means that the thunderstorms arise spontaneously as a function of temperature and evaporation. Above the threshold necessary to create the first thunderstorm, the number of thunderstorms rises rapidly. This rapid increase in thunderstorms limits the amount of temperature rise possible.

Self-sustaining means that once a thunderstorm gets going, it no longer requires the full initiation temperature necessary to get it started. This is because the self-generated wind at the base, plus dry air falling from above, drive the evaporation rate way up. The thunderstorm is driven by air density. It requires a source of light, moist air. The density of the air is determined by both temperature and moisture content (because curiously, water vapor at molecular weight 18 is a third lighter than air, which has a weight of about 29). This means that a thunderstorm is a "dual-fuel" engine. It runs off of combination of temperature or water vapor. A lack of one fuel can be made up by more of the other fuel. (Chang 2009)

Evaporation is not a function of temperature alone. It is governed by a complex mix of wind speed, water temperature, air temperature, and vapor pressure. Evaporation is calculated by what is called a "bulk formula", which means a formula based on experience rather than theory. One commonly used formula is:

$$E = VK(es - ea)$$

where

E = evaporation
V = wind speed (function of temperature difference [ΔT])
K = coefficient constant
es = vapor pressure at evaporating surface (function of water temperature in degrees K to the fourth power)
ea = vapor pressure of overlying air (function of relative humidity and air temperature in degrees K to the fourth power)

Regarding thunderstorms, the critical thing to notice in the formula is that evaporation varies linearly with wind speed. This means that evaporation near a thunderstorm can be an order of magnitude greater than evaporation a short distance away.

In addition to the changes in evaporation, there at least one other mechanism increasing cloud formation as wind increases. This is the wind-driven production of airborne salt crystals. The breaking of wind-driven waves produces these microscopic crystals of salt. The connection to the clouds is that these crystals are the main condensation nuclei for clouds that form over the ocean. The production of additional condensation nuclei, coupled with increased evaporation, leads to larger and faster changes in cloud production with increasing temperature.

Increased wind-driven evaporation means that for the same density of air, the surface temperature can be lower than the temperature required to initiate the thunderstorm. This means that the thunderstorm will still survive and continue cooling the surface to well below the starting temperature. (Chang 2009).

This ability to drive the temperature lower than the starting point is what distinguishes a governor from a negative feedback. A thunderstorm can do more than just reduce the amount of surface warming. It can actually mechanically cool the surface to below the temperature required to start the thunderstorm. This is the overshoot that allows it to actively maintain a fixed temperature in the region surrounding the thunderstorm.

A key feature of this method of control via clouds and thunderstorms is that *the equilibrium temperature is not governed by changes in the amount of losses or changes in the forcings in the system*. The equilibrium temperature is set by the response of wind and water and cloud to increasing temperature, not by the inherent efficiency of, or the inputs to, the system.

In addition, the equilibrium temperature is not affected much by changes in the strength of the solar irradiation. If the sun gets weaker, evaporation decreases, which decreases clouds, which increases the available sun. This is the likely answer the long-standing question of how the earth's temperature has stayed stable over geological times, during which time the strength of the sun has increased markedly. The answer is that if there is extra heat in the ocean from any source, the cloud cover increases. The thunderstorms increase. This is visible in the course of each day. As the sea heats, clouds increase. A change in albedo of 2% is equivalent to two doublings of CO_2 (from the current 380 ppmv to 1,520 ppmv!) . . . so a tiny, undetectable change in cloud cover is more than enough to offset any conceivable variation in CO_2.

Some climate modelers say that the clouds are not a response to the warmer weather. The models all predict positive cloud feedback, that is to say, as clouds increase it makes the earth warmer. This, they say, is the reason that warm temperatures are correlated with increased clouds.

However, there is a simple way to show that for the Tropics the causation is the other way around, that the increased tropical clouds are a result of increased temperatures. This is to look at the difference in the cloud cover in the Northern and Southern Tropics summer and winter. The equatorial cloud cover is shown in Fig. 4. In the NH summer, we see greatly increased cloud cover north of the equator in Colombia and the Sahel, and decreased clouds south of the equator. In the SH summer, the reverse is true, with the Amazon and southern Africa seeing increased cloudiness, and the areas north of the Equator seeing less clouds. Since the clouds are not causing the seasonal changes in insolation leading to warming, it is clear that the warming is

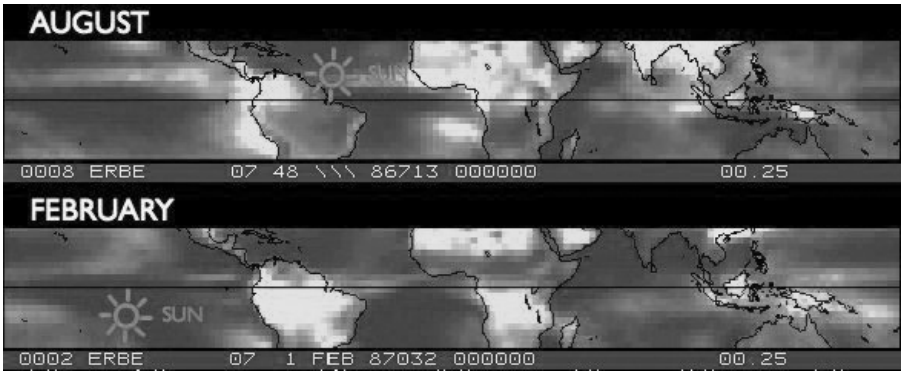

Figure 4. Tropical albedo during the Northern and Southern Hemisphere summer from the ERBE data. Upper panel shows NH summer. Lower panel shows SH summer.

causing the increase in clouds. Fig. 4 also shows that because the land warms more than the ocean, the increase in clouds is greater over the land than the ocean. Clearly, temperature is driving the clouds, and not vice-versa.

5. GRADUAL EQUILIBRIUM VARIATION AND DRIFT

If the Thunderstorm Thermostat Hypothesis is correct and the earth does have an actively maintained equilibrium temperature, what causes the slow drifts and other changes in the equilibrium temperature seen in both historical and geological times?

As shown by Bejan, one determinant of running temperature is how efficient the whole global heat engine is in moving the terawatts of energy from the tropics to the poles. On a geological time scale, the location, orientation, and elevation of the continental landmasses is obviously a huge determinant in this regard. That's what makes Antarctica different from the Arctic today. The lack of a landmass in the Arctic means warm water circulates under the ice. In Antarctica, the cold goes to the bone.

In addition, the oceanic geography which shapes the currents carrying warm tropical water to the poles and returning cold water (eventually) to the tropics is also a very large determinant of the running temperature of the global climate heat engine. Continents drift together and apart, volcanoes build the Isthmus of Panama and close off the Central American Seaway. These large-scale gradual changes from volcanism and tectonic drift are responsible for some of the historical temperature swings that the Earth has experienced.

On a shorter term, there could be slow changes in the albedo. The albedo is a function of wind speed, evaporation, cloud dynamics, and (to a lesser degree) snow and ice. Evaporation rates are fixed by thermodynamic laws, which leave only wind speed, cloud dynamics, and snow and ice able to affect the equilibrium.

The variation in the equilibrium temperature may, for example, be the result of a change in the worldwide average wind speed. Wind speed is coupled to the ocean through the action of waves, and long-term variations in the coupled ocean-atmospheric momentum occur. These changes in wind speed may vary the equilibrium temperature in a cyclical fashion.

Or it may be related to a general change in color, type, or extent of either the clouds or the snow and ice. The albedo is dependent on the color of the reflecting substance. If reflections are changed for any reason, the equilibrium temperature could be affected. For snow and ice, this could be e.g. increased melting due to black carbon deposition on the surface. For clouds, this could be a color change due to aerosols or dust.

Finally, the equilibrium variations may relate to the sun. The variation in magnetic and charged particle numbers may be large enough to make a difference. There are strong suggestions that cloud cover is influenced by cosmic rays (Svensmark 2000). And since cloud cover is the throttle on solar energy entering the system, this could affect the climate.

6. CONCLUSIONS AND MUSINGS

1. Since we only use 70% of the sun's energy, it is clear that the sun puts out more than enough energy to totally roast the earth. It is kept from doing so by the clouds reflecting about 20% of the sun's energy back to space, and the surface reflecting back another 10%. As near as we can tell, this system of cloud formation to limit incoming solar energy has never failed.
2. A reflective shield of clouds forms in the tropics in response to increasing surface temperatures passing a critical threshold.
3. As tropical temperatures continue to rise, the reflective shield is assisted by the formation of independent heat engines called thunderstorms. These cool the surface in a host of ways. In addition, they can drive the temperature down below the temperature at which they form (overshoot). This is a requirement for controlling any lagged system.
4. Like cumulus clouds, thunderstorms also form in response to increasing temperatures passing a second threshold. The number that form is temperature driven. Once past the threshold, many storms form quickly in response to any local temperature increase.
5. Because they are temperature driven, as tropical temperatures rise, both tropical thunderstorms and cumulus production increase. These combine to regulate and limit the temperature rise. When tropical temperatures are cool, tropical skies clear and the earth warms rapidly. But when the tropics heat up, cumulus and cumulonimbus put a limit on the warming. This system keeps the earth within a fairly narrow range of temperatures.
6. The earth's temperature regulation system is based on the unchanging response of wind, water, and cloud to changes in temperature. It is not based on losses or forcings.
7. This is a reasonable explanation for how the temperature of the earth has stayed so stable for hundreds of millions of years.

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TROPICAL RAINSTORM FEEDBACK

Dr (hc) Noor van Andel
Fiwihex bv.. In sustainable energy innovation
Burgemeester Stroinkstraat 341,
7547 RH Twekkelo The Netherlands
noor@xs4all.nl

ABSTRACT
In the set of radiative feedbacks to global warming due to a doubling of the CO_2 concentration, from all the models the increase in latent heat transfer as a consequence of an increase of [sea] surface temperature is left out. Starting from measurements of increased evaporation and increase of wind speed as a function of sea surface temperature increase, I derive a large global feedback of –20 $Wm^{-2}K^{-1}$. This negative feedback is much larger than the balance of feedbacks, range +0.8 to +2 $Wm^{-2}K^{-1}$, included in the climate models. If the latent heat transfer feedback, i.e. tropical rainstorms, would be included in the models, the local climate sensitivity would decrease from 1.5 to 4 ºC for a doubling of CO_2 to less than 0.2 ºC. This is lower than the temperature variations due to solar magnetic, ocean current and volcanic aerosol effects

1. INTRODUCTION

In many recent reactions to the feedback factors and the large climate sensitivity of 1.5 to even 4 ºC per doubling CO_2 concentration assumed in the most recent IPCC literature, an extra negative feedback is brought up, at least qualitatively.

- Willis Eschenbach (this issue) shows that in the tropics, every day clouds form as a consequence of solar heating of the surface, that these clouds develop into rainstorms as soon as the surface temperature exceeds a limit, so a "governor" is in place that shuts off the solar heating and even can cool the surface to temperatures lower than hours before.
- Kyoji Kimoto (1) shows that λ_0, the denominator for the feedback factors should be more than twice the value commonly taken in the climate models. $\lambda_0 = -6.8(W/m^2)/K$ when all heat transfer modes inclusive latent heat transfer are incorporated, while $\lambda_0 = -3.21(W/m^2)/K$ for CO_2 doubling when only lapse rate, water vapor, surface albedo and cloud feedbacks are included. This 3.21 value overestimates the threat of carbon dioxide by 4–6 times.
- Satellite data from the ERBE instrument (Barkstrom, 1984, Wong et al, 2006) (2) show that the feedback in nature is strongly negative-strongly reducing the direct effect of CO_2 (Lindzen and Choi, 2009) (3) in contrast to the model behavior, where feedback is positive.
- William Kininmonth writes: The peak pole-ward transport of energy by the

atmosphere is known with confidence from satellite and other direct observations. A decrease in the transport by only one percent would allow the volume of Arctic sea ice to more than double in ten years. It is surprising, therefore, that the gross underestimation of pole ward energy transport by the computer models is not reflected as cooling and expansion of the ice sheets over the polar regions. The computer models have compensating gross errors in the latitudinal distribution of net long wave radiation at the surface. There is too much radiation loss over the tropics, thus cooling the surface, and not enough radiation loss over Polar regions, thus retaining energy in the surface. The magnitude of the radiation errors in the computer models is up to five times the expected radiation forcing from doubling carbon dioxide concentration.

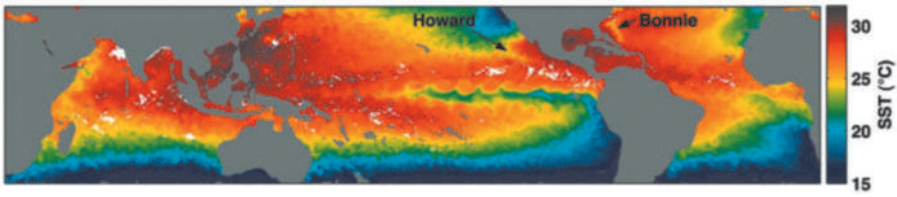


Fig 1a The SST field for 25 to 27 August 1998, as seen by TMI from 40^0 S to 40^0N. Area for persistent rain are indicated by white. The equatorial cold tongue in the eastern Pacific is border on the north and south by TIW's propagating from South America westward to about 160^0E. Also discernible are the cold wakes of Hurricane Bonny in the west Atlantic and of cyclone Howard in the east Pacific as well as strong monsoonal upwelling of the coast of Arabia and Somalia.

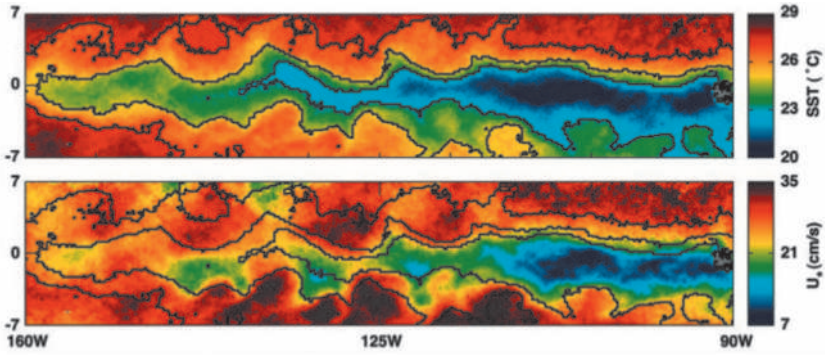


Fig. 1b. SST and surface wind in the vicinity of the eastern Pacific equatorial cold tongue during the first week in October 1998. The surface wind is given in terms of the friction velocity U. The black contour lines show the isotherms for 23^0, 25^0 and 27^0 C derived from the SST image. These contour lines are superimposed on the U imagine to highlight its correlation with SST. Both SST and wind clearly delineate the TIW's to the north and south of the cold tongue. Over warm water turbulent mixing increases the exchange of momentum from winds aloft to the surface. As a result, higher surface winds are associated with warmer water.

Figure 1. Temperature and wind speed over the Eastern Pacific.

My discussion partners at the Dutch KNMI have the opinion that "what comes up must go down", meaning that heat transferred upwards must come down elsewhere. But this conflicts with the second law of thermodynamics: heat flows from warm to cold. Heat transferred to the top of the troposphere radiates away into space.

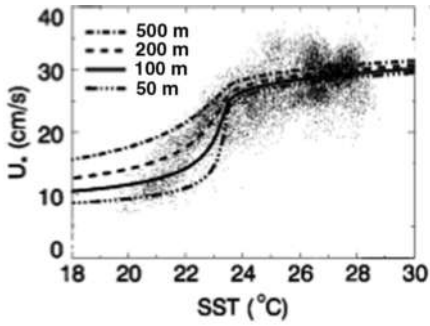
Can we, just by using data of wind speed and vapor pressure of water over the ocean, deriving mass transfer and thus latent heat transfer from the sea surface, **quantify** this negative feedback? I will treat this derivation in the next sections.

2. WIND SPEED

The relation between wind speed and sea surface temperature has been measured by Chelle Gentemann & al (4), see fig.1:

We see that the wind speed chart is a true reflection of the sea surface temperature chart. The large eddies in the westward Humboldt Sea current are faithfully expressed in lower local wind speeds. We all know form experience that in a warm summer afternoon, when a thunderstorm nears, the wind suddenly becomes stronger, caused by the updraft of the thunderstorm, and taking the moist air from the surface into the storm.

These storms are of their own making, they keep themselves in form by sweeping up the warm moist air, and are driven by the moist adiabat inside the cloud, where water condenses. In the tropics, the moist adiabat lapse rate can be less than 4 K/km, while the dry adiabat, in the down-flowing cold and dry air between the clouds, has an adiabatic lapse rate of about 10 K/km. The rainstorms are very local, and are impossible to simulate in a climate model with a cell dimension larger than 10 km across.



A scatter ploy of the weekly averaged values of U versus SST shown in figure 1. The spatial resolution of each value is 50 km. The four curves show the U versus SST relation given by a boundary layer model having a thickness of 50 to 500 m. The air temperature and wind speed at the top of the boundary layer are assumed to be 24^0 C and 9 m/s respectively.

Figure 2. Wind speed as a function of SST.

We see in fig. 2 that the heat received from the sun speeds up the convection along the surface onto the tropical rain clouds and convection zone, and that this increase is far from linear. We see that the SST is nowhere higher than 30 ºC, and we see that the average trade wind speed, in terms of the friction velocity, increases a factor of 3/2

when the SST rises from 23 ºC to 26 ºC. The friction velocity is $U^* = [\tau/\rho]^{0.5}$, where τ [N/m^2] is the shear force at the interface sea-air and ρ [kg/m^3] the air density.

3. MASS TRANSFER OF WATER VAPOR

Our interest here is the mass transfer of water vapor as a function of sea surface temperature. Mass transfer and friction or momentum transfer in turbulent flow regimes are described by homologous differential equations. Both the Fanning friction

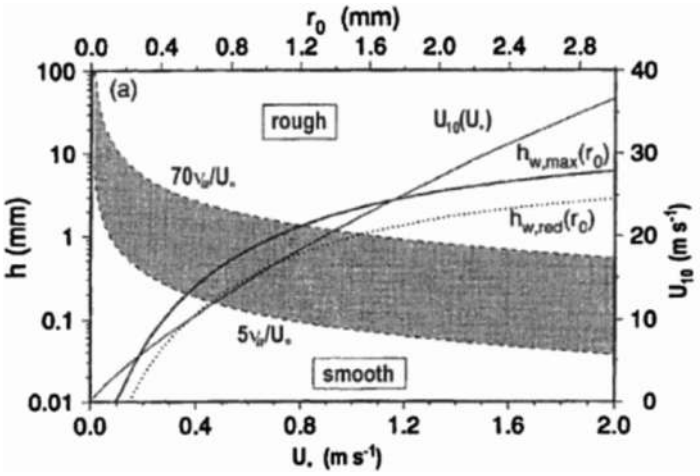


Figure 3. Wind friction as a function of wind speed.

factor, $f = \tau/\rho.v^2/2$, and the Sherwood number, kd/D, are, theoretically as well as empirically, proportional to the .8th power of the flow speed in highly turbulent regimes. k [m/s] here is the mass transfer coefficient, D [m^2/s] is the molecular diffusion coefficient of water vapor in air, d [m] is the characteristic dimension of the turbulent flow boundary layer. When U* rises from 12 cm/s at a SST of 21 ºC to 30 cm/s at a SST of 25 ºC, then Sh rises[1] also with a factor of 30/12 going from SST 21 ºC to SST 25 ºC.

In fig.3 from: "The near surface of the ocean: structure, dynamics and applications", by Soloviev & Lukas, p. 133, we see that a U* of 12 respectively 30 cm/s relates to a wind speed at 10 m height U_{10} of 3 respectively 8 m/s. We see that indeed *f* is proportional to $Re^{0.8}$ or U* is proportional to $U_{10}^{0.8}$ in this graph.

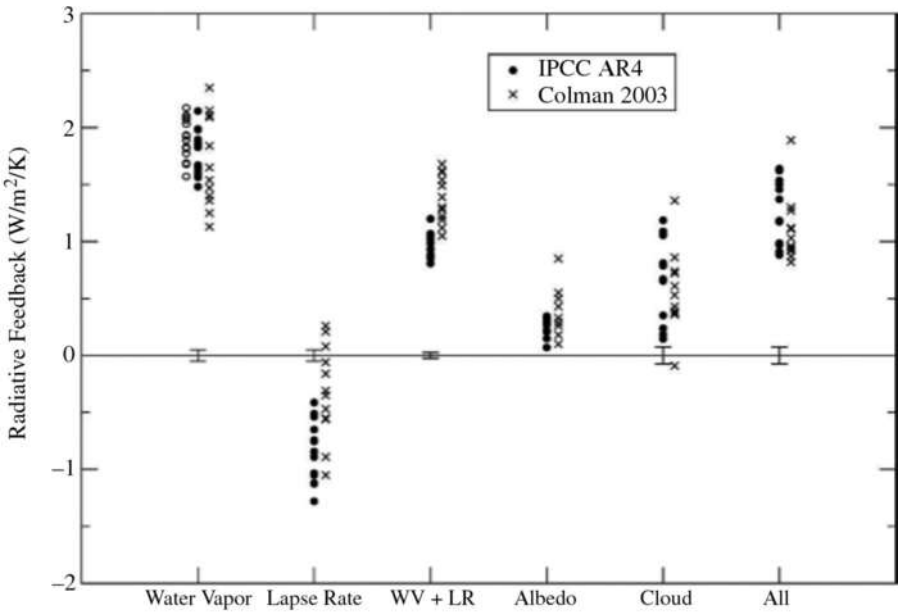
[1]The Sherwood number for water mass transfer over a water surface is anomalously high. That comes from the fact that usually the surface of the sea is broken on the wave tops. A fine spray develops, that can evaporate completely. For a flat surface, one can prove that $Sh = U10^2/U^*/Sc^{2/3}$ where the Schmitt number Sc is the ratio between kinematic viscosity and diffusion constant of air, Sc is close to 1. That would mean a mass transfer coefficient of only 0.01 m/s at U* = 8 m/s. For gases such as CO_2, this is close tot the measured value, because the small drops contain only minute quantities. The measured Sh value for water is at least 10 times higher.

We conclude that the mass transfer, and therefore also the latent heat transfer, rises with a factor of [30/12] per 4 ºC or a factor of **1.3 per ºC**, quite apart from the fact that the sea surface becomes rougher with increasing wind speed.

4. HEAT TRANSFER BY WATER EVAPORATION

Water vapor saturation pressure rises from 2488 Pa at 21 ºC to 3169 Pa at 25 ºC, and, when the relative humidity stays constant, as is observed in a warming world, this ratio of $[3169/2488]^{[1/4]}$ = **1.0624/ºC** is also the relative increase of partial water vapor pressure over the tropical ocean.

Now the latent heat transfer K is the amount of water vapour that is taken from the surface, in mol/m^2.s, multiplied by the latent heat of evaporation, L in J/mol. The driving force for the mass transfer is c•[1-rH], where rH = 0.7, the relative humidity, and c the saturated water vapour pressure. The mass transfer coefficient k is the mass flow in mol/m^2.s divided by the driving force: K = L•k•c•[1-rH]. At the mean global



Comparison of the climate feedback parameters for water vapor (λ_w), lapse rate (λ_T), the combined water vapour + lapse rate, surface albedo (λ_a) and clouds (λ_c) in units W m-2 K-1. All represents the combined feedback from water vapour, lapse rate, surface albedo, and clouds. Filled circles represent results from this study using the IPCC AR4 model archive. Crosses are previously published results taken from the survey of Colman (2003). Open circles for water vapour represent the water vapour feedback computed for each of the IPCC AR4 models assuming no change in relative humidity. Vertical bars depict the estimated uncertainty in the calculation of the feedbacks for each parameter.

Figure 4. Climate feedback parameters, [5].

temperature of 15 ºC, and a mean wind speed of 5 m/s, K = 77.5 W/m^2, the latent heat flow of the global mean precipitation.

So we can take K = L•k•c•[1-rH] = 77.5 W/m^2 at the mean global temperature of 15 ºC and a mean wind speed of 5 m/s and, correcting for higher vapor pressure and lower wind speed for the tropics we find a K at 23 ºC and 4 m/s, 2.81/1.70•[4/5]$^{0.8}$ = 107 W/m^2.

This is a more or less theoretical derivation, and needs a check. The evaporation rate [latent heat flow] has been measured as a function of wind speed and water surface temperature in the Lake Hefner Study, 1952. When we take their formula and multiply with the 44 kJ/mol latent heat of evaporation of water we arrive at 109.6 W/m^2 for 23 ºC and 4 m/s, almost the same value.

Now we can determine the rise in latent heat transfer in the tropics due to the rise in SST: [δK/δT] = [1.0624•1.3 – 1]/ºC • 107 W/m^2 = 40 W/m^{2}K.

This is a much larger increase of heat transfer per ºC than the 4.98 W/m^{2}K that can be derived from global mean temperature and global mean latent heat flow values.

5. FEEDBACK FACTORS & CLIMATE SENSITIVITY

The following synopsis of feedback parameters in the climate models is taken from Soden and Held (5)

We see that the negative feedback resulting from the increase of latent heat transfer to the top of the troposphere is not included in any of the models. All included feed backs with exception of the lapse rate feedback are positive, the total feedback resulting has a range of +0.9 to +1.8 W/m^{2}K. To get the dimensionless feedback factor β, we must divide these feedback heat transfer coefficients by the heat transfer coefficient to space; 4 W/m^{2}K = dR/dT_{eff}, the increase of the outgoing radiation per ºC increase in effective OLR temperature, $4\sigma T_{eff}^3$ at T_{eff} = 260 K.

We assume with the IPCC that without any feedback, a doubling of the CO_2 concentration [IPCC scenario SRS A1B] causes a forcing of 4.3 W/m^{2}K and thus increases the surface temperature with Δ_0 = 1.08 ºC. The climate sensitivity in ºC/log$_2$$CO_2$ then becomes Δ_0/[1-β]. As β = 1, we have the famous "runaway greenhouse effect". IPCC assumes β = 0.4

6. THE RIGHT FEEDBACK FACTOR

With the IPCC range of total feedback fluxes, the range in climate sensitivity Δ_0 / [1-β] becomes 1.08/[1 – 0.9/4] = **1.4 ºC** to 1.08/[1 – 1.8/4] = **1.96 ºC** per doubling of CO_2.

When we include the negative feed back value of δK/δT = 20 W/m^{2}K, the value of β becomes [1.8 – 20]/4 = –4.55, and the climate sensitivity becomes 1.08/[1 – (–4.55)] = **0.19 ºC per doubling of CO_2**. A runaway greenhouse effect becomes impossible.

Of course, this large negative feedback, occurring mainly as the SST reaches 23 ºC, is acting against every "forcing", be it greenhouse gases, or changes in solar forcing, and acts as a thermostat. The set point is fixed mainly by the vapour pressure and the heat of vaporization of water.

7. COMPARISON: THE PALEOCENE-EOCENE THERMAL EXCURSIONS

From climate history it is known that during large temperature excursions the tropics

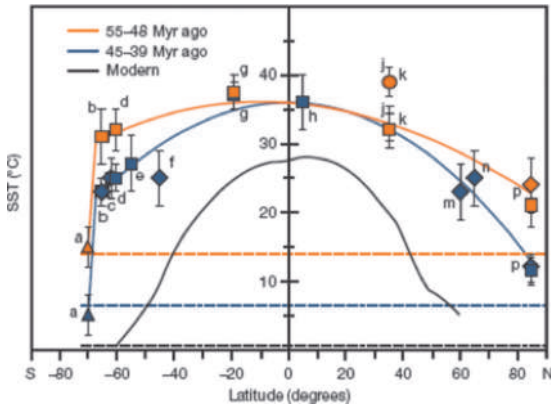


Figure 5. Temperature distribution during the PETM , Bijl et al (6).

were not much warmer, but the polar regions were much warmer, even above freezing during the dark polar winter.

In a recent publication the following graph is presented; describing the hottest recent climate excursion that is known to us, about 50 million years ago, based on geological and paleobiological proxies:

We see that during this excursion, compared to the modern climate, the tropical sea surface temperature only rose about 8 ºC, while the temperature at the poles rose 25.30 ºC. The Arctic Ocean was a big sweet water lake then, with Azolla ferns floating on the surface, the fossil remains of which are still to be found in the North Sea. The mammals found in this period their maximal species diversity.

It is clear that the heat transfer from the tropical sea to the temperate and polar regions is very dependent on the temperature, due to the fast increase in water vapour pressure, and therefore the latent heat transfer.

Would the thermal excursion be due to an increased "greenhouse gas", the warming would be global. We do not know the cause of the excursion, but we clearly see a tropical thermostat.

8. CONCLUSION

Modern ground based and satellite measurements, climate history data and geological data all point to the fact that when it becomes warmer, the high latitudes rise much more in temperature than the tropics. This can only be the result of increased heat transfer from the tropics pole ward. Established physical transport phenomena science lets us quantify this heat transfer and its dependence on surface temperature. The result is a much larger negative feedback than the positive sum of feedbacks incorporated in the known climate models. This large negative feedback should be incorporated into these models. The result would be that the climate sensitivity is reduced tenfold. A doubling of the CO_2 concentration has such a small temperature effect, that this is indiscernible from all other effects.

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A NATURAL CONSTRAINT TO ANTHROPOGENIC GLOBAL WARMING

William Kininmonth
Australasian Climate Research
23 Holroyd Street
Kew, Victoria 3101
Australia
w.kininmonth@bigpond.com

ABSTRACT
Computer model projections suggest that unconstrained emissions of carbon dioxide and other greenhouse gases by human activity will cause the global average temperature to rise by at least 2 ^{o}C and possibly as much as 4.5 ^{o}C toward the end of the 21st century as equivalent concentrations of carbon dioxide in the atmosphere nearly double. A well-specified analysis of the surface temperature response to global warming presented here suggests that global average surface temperature is unlikely to rise beyond 1 ^{o}C. This analysis identifies the rate of increase of evaporation (and latent heat exchange) with temperature at the surface as a critical restraining factor that damps surface temperature response to radiative forcing. It is noted that current computer models of the climate system apparently underestimate the rate of increase of surface evaporation with temperature leading to a gross exaggeration of the surface temperature response to radiative forcing.

1. INTRODUCTION

The burning of fossil fuels and related activities of modern industrial and agricultural economies contribute to the build-up of carbon dioxide (CO_2) and other so-called greenhouse gases into the atmosphere. The build-up in concentration of the greenhouse gases will enhance the greenhouse effect, causing global warming.

The claims that unregulated greenhouse gas emissions will cause dangerous climate change have their foundation on three premises:

1. The climate was stable prior to industrialisation and the Earth then was in radiation balance, emitting to space as much infrared radiation as the solar radiation being intercepted and absorbed.
2. The previous climate stability is now being disrupted as infrared radiation to space in wavelengths characteristic of CO_2 and other human-caused greenhouse gases is reduced. In order to return to radiation balance it is necessary for the Earth to warm so that there is additional compensating infrared radiation emitted to space across all wavelengths.

3. There is a direct and linear relationship between the reduction of infrared radiation loss from the troposphere[1] (the so-called radiation forcing, ΔF_{Tr}) and the increase in surface temperature, ΔT_s

$$\Delta F_{Tr} = \lambda \, \Delta T_s$$

The explanation for the relationship between radiative forcing and surface temperature response is largely empirical and does not have rigorous theoretical underpinning. For practical purposes the sensitivity factor, λ is generally estimated from computer models although the correlations between past global CO_2 concentration and temperature has also been the basis for sensitivity estimates. The value of λ given by different computer models varies over a relatively broad range but there is no way *a priori* of assessing whether λ should have a low value or a high value. The IPCC claims that, based on its assessment of a range of computer models, for a doubling of CO_2 concentration there will be a rise in global temperature in the range of 2.0 ^oC to 4.5 ^oC, with a most likely value of 3.0 ^oC[i].

Here we will discuss the physical basis of Earth's response to increasing concentrations of CO_2 (and equivalent greenhouse gases) and identify those factors that regulate the temperature sensitivity to changing concentrations.

2. CARBON DIOXIDE AND RADIATION

CO_2 absorbs and emits radiation within selected bands of the infrared spectrum. That is, within these bands and according to their absorptivity spectra, the CO_2 molecules absorb radiation that has been emitted from the earth's surface and surrounding clouds and greenhouse gases. Also, within these bands the CO_2 molecules emit radiation in all directions but with intensity that is dependent on the gas temperature and their characteristic wavelength emissivity spectrum.

The infrared radiation emission to space is of much less intensity than the radiation emitted from the surface. This is because the earth's surface is warmer and its emissivity is greater than the higher and colder layers of the atmosphere from whence the radiation to space from clouds and greenhouse gases emanates. However, the lowest warm layer of the atmosphere is also emitting radiation back to earth. What is of importance in this discussion is the change in radiation intensities as the concentration of CO_2 varies.

Table 1 illustrates how the changing concentration of CO_2 typically affects the radiation intensity at various levels in the atmosphere. These data have been derived using the MODTRANS[ii] radiation transfer model and the US Standard Atmosphere temperature and moisture profiles under clear sky conditions. As the CO_2 concentration increases, more of the upwelling infrared radiation is absorbed while the emission to space from across the CO_2 wavelengths emanates from a higher and colder altitude; thus the intensity to space decreases. At the surface, the downward infrared

[i]The intergovernmental Panel on Climate Change (IPCC) refers to the 'radiation forcing' as the reduction in upward directed infrared at the tropopause due to the increase in CO_2 concentration.

[ii]MODTRANS is a medium resolution radiation transfer model and is accessible through the University of Chicago at http://geosci.uchicago.edu/~archer/cgimodels/radiation.html

radiation emanates from a lower, warmer altitude; as the CO_2 concentration increases the downward infrared radiation intensity also increases.

The IPCC has introduced the concept of Radiative Forcing to link the change in radiation intensities with changes to greenhouse gas concentrations resulting from human activities:

> *"The radiative forcing of the surface-troposphere system due to the perturbation in or the introduction of an agent (say, a change in greenhouse gas concentrations) is the change in net (down minus up) irradiance (solar plus longwave; in wm^{-2}) at the tropopause AFTER allowing for stratosphere temperatures to adjust to radiative equilibrium, but with surface and tropospheric temperatures held fixed at the unperturbed values".*[2]

According to this construct, immediately a small greenhouse gas perturbation is introduced there is an impact on the radiation intensities at all levels but there is no change in temperature, either at the surface or through the troposphere. There is a resulting change to the magnitude of net radiation loss from the stratosphere (In Table 1 the tropopause of the US Standard Atmosphere is 10.5 km and the stratosphere is from 10.5 to 70 km). The stratospheric temperature is allowed to come to a new (cooler) thermal equilibrium that further alters the downward infrared radiation intensity at the tropopause. Note that in Table 1 the infrared radiation intensities at 10.5 km and 70 km are before adjustment of the stratospheric temperature but for this discussion the difference following adjustment is negligible.

For each of the listed concentrations of CO_2 there is a net loss of IR radiation energy from the stratosphere and the troposphere. The tendency of the radiation processes associated with the greenhouse gases is to cool each layer. However, as CO_2 concentration increases the reduction in net upward infrared radiation at the tropopause is greater than the reduction in IR emission to space; the tendency for radiative cooling of the stratosphere increases and that of the troposphere diminishes.

Table 1. Upward and downward clear sky infrared (IR) radiation at the surface, 10.5 km (tropopause) and 70 km (top of the atmosphere) computed by MODTRANS for the US Standard Atmosphere and changing carbon dioxide concentration, together with net infrared radiation loss from the troposphere and stratosphere. Upward infrared emission from the surface (360.5) is constant. Units: Wm^{-2}.

CO_2 Conc. (ppmv)	Upward IR 70 km	Upward IR 10.5 km	IR Down 10.5 km	IR Down Surface	IR Loss Troposphere	IR Loss Stratosphere
0	286.2	294.5	13.8	23.0	150.2	5.5
50	267.0	276.9	21.9	249.7	144.3	12.0
100	264.2	273.8	23.7	252.7	142.4	14.0
200	261.4	270.7	25.4	255.8	140.6	16.1
400	258.6	267.4	27.1	259.0	138.8	18.3
800	255.8	264.0	28.4	262.2	137.3	20.2

IPCC argues that, if all other energy exchange processes of the troposphere remain unchanged, then the reduction in cooling of the troposphere will result in warming of the troposphere-Earth system. However, as will be demonstrated, the troposphere does not warm directly.

The conditional instability of the troposphere that is essential for convective overturning and vertical distribution of heat and latent energy from the surface is maintained by radiative cooling. As the radiation cooling diminishes the conditional instability of the atmosphere also decreases; there is reduced convective overturning and reduced exchange of heat and latent energy between the surface and the troposphere. The tendency is not for the troposphere to warm but for energy to be retained in and directly warm the surface. By taking the US Standard Atmosphere (a good approximation for the global average atmospheric temperature and humidity profiles) and a realistic radiation transfer model (MODTRANS) we can see how infrared fluxes vary with different CO_2 concentrations. The CO_2 concentration is currently at just under 400 ppmv so we can use 400 as the starting point (Note that 185 ppmv was the concentration at the last glacial maximum 20,000 years ago and 280 ppmv was the concentration pre-industrialisation). Doubling to 800 ppm reduces the IR to space by 2.8 Wm^{-2} but increases the down infrared at the surface by 3.2 W^{-2} to give an increasing rate of infrared energy loss from the atmosphere layer of 0.4 Wm^{-2}. However the atmosphere loss is partitioned such that there is an increase in net loss from the stratosphere of 1.9 Wm^{-2} but a reduction in net loss from the troposphere of 1.5 Wm^{-2}.

The significant process changes that result from the increase in CO_2 concentration are:

1. The increased rate of radiative cooling of the stratosphere giving a tendency to lower stratospheric temperature;
2. A decrease in the rate of radiative cooling of the troposphere that will tend to increase the tropospheric temperature. However, immediately there is a reduction in the radiative cooling of the troposphere there will be a reduction in convective instability causing a reduction in convective overturning and associated transfer of heat and latent energy from the surface; and
3. An increase in the downward infrared radiation at the surface and a tendency to warm the surface.

In practical terms it is the sum of the increased downward infrared radiation at the surface and the reduction of surface energy exchange that will force the surface to a new steady state temperature. The warming surface temperature, and the convective overturning linked to it, will regulate the tropospheric temperature and humidity profiles. The surface temperature does not, as implied in some discussions, respond to the tropospheric temperature changes. It is the excess of absorbed solar radiation over net infrared radiation loss at the surface that is the energy source for ongoing transfer of energy (by way of conduction and heat and evaporation of latent energy) from the surface to the atmospheric boundary layer. In the context of global energy budgets it is the surface temperature and rate of convective overturning that regulates the tropospheric temperature profile.

3. CARBON DIOXIDE AND SURFACE ENERGY EXCHANGE

The surface energy balance has been widely studied and is well understood. For example, Priestley (1966)[3] has used the surface energy budget to explain the variations in land temperature with surface wetness and the limitations of ocean surface temperature by evaporation. The energy inputs to the surface energy budget are solar radiation and the downward infrared radiation from the atmosphere (the downward emissions of infrared radiation from the greenhouse gases, principally water vapour and CO_2, and clouds). The surface energy losses are primarily by way of: a) direct heat exchange between the surface and the atmosphere; b) evaporation of surface water to give latent energy exchange between the surface and the atmosphere, and; c) the emission of infrared radiation from the surface. There is also an exchange of energy to storage (in the land surface or ocean surface mixed layer) but when a new steady state is achieved these energy fluxes are likely to be little changed and are neglected here.

The increase in downward radiation, ΔF_{CO_2} due to increased CO_2 concentration will vary the magnitudes of the surface energy exchange processes and cause an increase in surface temperature, ΔT_s given by:

$$\Delta F_{CO_2} = [dF_u/dT + dLH/dT + dH/dT - dS_o/dT - dF_d/dT] * \Delta Ts \qquad (1)$$

where:

dS_o/dT is the rate of change of solar radiation absorbed at the surface with temperature;
dF_d/dT is the rate of change of downward infrared radiation at the surface with temperature;
dF_u/dT is the rate of change of surface infrared radiation emission with temperature;
dH/dT is the rate of change of direct surface heat exchange with temperature; and
dLH/dT is the rate of change of latent energy exchange with temperature.

The magnitude of solar radiation at the surface will vary with cloudiness changes but not significantly with variation of CO_2 concentration. Cloudiness may change with surface temperature of the earth (cloud feedback) but *a priori* we do not know the direction or magnitude of any potential change. For the purposes of this discussion solar radiation is treated as a constant that does not change with temperature.

The downward infrared radiation at the surface varies directly with greenhouse gas concentration and temperature of the air near the ground. The main greenhouse gases are water vapour and CO_2; water vapour concentration varies with temperature and CO_2 concentration varies with fossil fuel usage. In the context of anthropogenic global warming CO_2 is the forcing process; atmospheric temperature and water vapour concentration are response processes. As a consequence, the downward infrared radiation at the surface will be treated as two components: a) ΔF_{CO_2} (the forcing through changing CO_2 concentration) and b) dF_d/dT (the response to changing temperature and water vapour concentration rise).

The direct exchange of heat between the surface and atmosphere varies with the vertical gradient of air temperature at the surface[iii]. However the atmosphere has a relatively low thermal capacity and the temperature of the air near the ground responds rapidly to surface temperature changes. Consequently, like surface storage, the rate of heat exchange between the surface and atmosphere will not vary appreciably as the surface temperature changes; it is ignored in this discussion.

The infrared radiation emission from the surface varies with emissivity and the fourth power of absolute temperature according to the Stefan Boltzman Law[4]. The emissivity varies with the nature of the surface (land, vegetation or ocean) but not with temperature.

The evaporation of water that exchanges latent energy between the surface and the atmosphere can be represented by a bulk aerodynamic formula where evaporation varies with the wetness of the surface (water body, moist soil, evapotranspiration from plants, etc), wind speed, and the vapour pressure gradient near the surface. The IPCC suggests that atmospheric relative humidity does not vary with temperature[5] and this constraint leads to the conclusion that the vapour pressure gradient will vary as the rate of change of saturated vapour pressure with temperature, the Clausius Clapeyron[6] relationship[iv]. More than 70 percent of the Earth's surface is water and ice and there is no *a priori* information on how the wetness and vegetation of land surfaces will vary with temperature. It is a reasonable assumption that the rate of evaporation and latent energy exchange will vary approximately according to the Clausius Clapeyron relationship.

Recognising that solar absorption and direct heat exchange vary little with temperature then equation 1 can be reduced to:

$$\Delta F_{CO_2} = [dF_u/dT + dLH/dT - dF_d/dT] * \Delta T_s \tag{2}$$

and rearranged to:

$$\Delta T_s = \Delta T_{CO_2}/(1 - r) \tag{3}$$

where

$$\Delta T_{CO_2} = \Delta F_{CO_2}/[dF_u/dT + dLH/dT] \tag{4}$$

and

$$r = dF_d/dT/[dF_u/dT + dLH/dT] \tag{5}$$

Here ΔT_{CO_2} is the direct surface temperature response resulting from CO_2 forcing and $1/(1 - r)$ is the feedback amplification due to atmospheric temperature and water vapour increase.

[iii]More specifically, potential temperature gradient but over the few metres near the surface these are considered to be identical.

[iv]The vapour pressure gradient (VPG) at the surface is $(q_s - q_r)$, where qs is the saturated vapour pressure at the surface temperature and qr is the vapour pressure at a reference level. The reference level is close to the surface and hence the temperature at the two levels is similar; the vapour pressure gradient can be equated to $(q_s - RH.q_s)$ where RH is the relative humidity. That is VPG = $(1 - RH)\ q_s$ where $(1 - RH)$ is constant.

It is important to note that the rate of surface energy loss with temperature, given by [$dF_u/dT + dLH/dT$], is an important factor in damping both the direct surface temperature response to radiation forcing (equation 4) and the magnitude of the feedback amplification factor (equation 5). The surface temperature increase for CO_2 forcing is less if the rate of surface energy loss with temperature is large.

At Figure 1 are plotted the magnitudes of the major surface energy exchange processes across a range of temperatures typical of the Earth's surface. The surface emission (upward infrared radiation) varies according to the Stefan Boltzman Law (emissivity = 1) while the back radiation (downward infrared radiation) is computed using the MODTRANS radiation transfer model for the US Standard Atmosphere (approximately average global temperature and moisture) under clear sky conditions and constant relative humidity. Latent energy exchange is according to the Clausius Clapeyron relationship (approximately 7 percent change with each degree Celsius variation: ~7% C^{-1}) scaled to the global average latent heat exchange of 78 Wm^{-2} at 15 ^oC estimated by Kiehl and Trenberth (1997)[7].

It is clear from Figure 1 that the magnitudes of surface emission and the back radiation increase in near parallel as temperature increases. This is because both parameters are dependent on the fourth power of absolute temperature; any rise in surface temperature will increase the surface emission but there will also be corresponding increase in downward infrared radiation because of a similar rise in air temperature of the boundary layer. As a consequence, across the temperature range near the Earth's average temperature there is little change in the magnitude

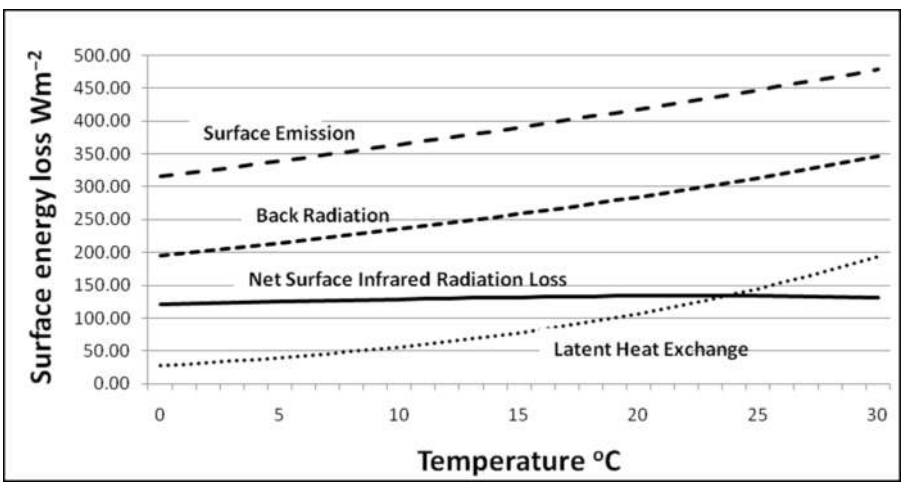

Figure 1. Changing magnitudes of the major surface energy exchange processes over the range of typical temperatures of the Earth's surface. (The Back Radiation is computed for the US Standard Atmosphere under clear sky conditions using the MODTRANS model; the surface emission is computed from the Stefan Boltzman law; and the latent heat exchange (between the surface and the atmosphere) is according to the Clausius Clapeyron relationship scaled to 78 W/m^2 at 15 ^oC).

of net infrared radiation loss from the surface. It is the latent energy exchange, about 78 Wm^{-2} at the global average temperature of 15 °C and approximately doubling in magnitude with every 10 °C temperature rise, which dominates the changing surface energy loss with temperature. The importance of evaporation for limiting surface temperature in hot climates has previously been explained by Priestley (1966)[8].

When the magnitude of the net surface energy loss (net infrared radiation plus latent energy) is plotted against temperature and scaled for steady state at the average temperature of the Earth, as in Figure 2, it is found that the surface temperature is relatively stable. A small change in surface temperature, either to a lower or a higher value, causes the net surface energy loss to be out of balance with the constant energy input and there is a strong tendency to return to the steady state temperature.

A change in the atmospheric CO_2 concentration will cause a shift to a new steady state surface temperature. This is because the additional CO_2 will enhance the downward radiation at the surface, thus reducing the net surface energy loss.

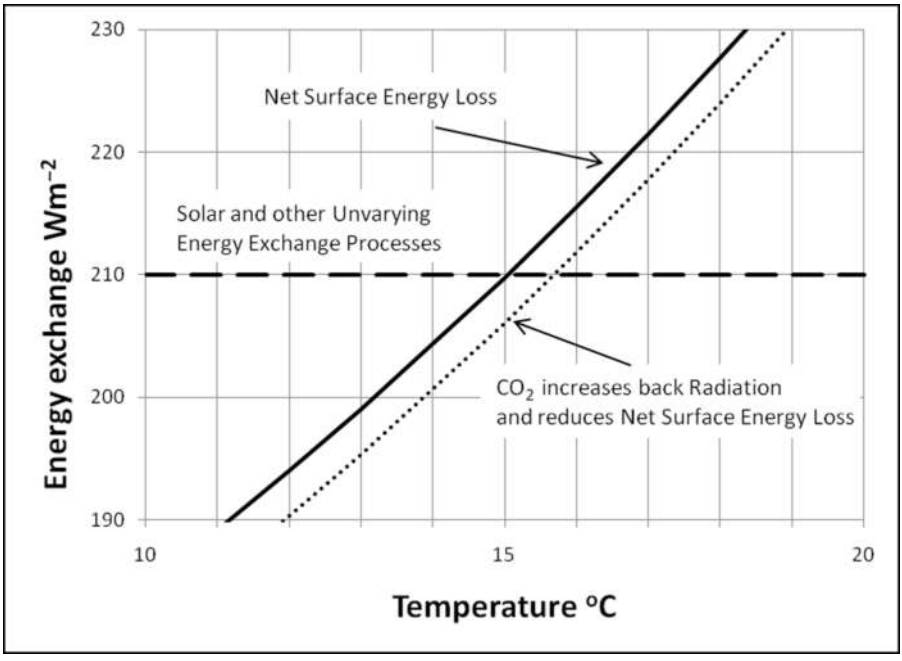

Figure 2. The magnitude of the net surface energy loss (net infrared radiation plus latent energy) plotted with the solar absorption and other energy exchange processes that do not vary with temperature (clouds are omitted from the calculations and the sum of the constant energy exchange processes is scaled to be in steady state at the Earth's mean temperature of 15 °C). As CO_2 concentration increases the back radiation also increases, thus reducing the net surface energy loss. The surface temperature rises to a new steady state for energy balance with the near constant energy processes.

The reduction in net energy loss allows the surface temperature to rise to a new steady state.

Table 1 and Figure 2 give approximate global average values for the various energy exchange components. It is possible to estimate an approximate impact on surface temperature for a doubling in CO_2 concentration from the present value near 400 ppmv to 800 ppmv. The downward infrared radiation at the surface will increase by about 3.2 Wm^{-2}. If the reduction in convective instability from net troposphere infrared radiation loss is included with increased downward infrared radiation (both factors increase the energy imbalance at the surface) then the CO_2 radiative forcing equates to 4.7 W/m^2 at the surface. Figure 2 suggests a new steady state is achieved if the surface temperature rises by about 0.7 ^oC.

It should be noted that this estimated adjustment to surface temperature is independent of changes that might be wrought by changing atmospheric circulation and distributions of cloud and moisture patterns. The estimate only takes account of the CO_2 forcing and the water vapour feedback arising from the assumption of constant relative humidity. Unlike the tenuous connection made by the IPCC between the change in the net infrared radiation at the tropopause and surface temperature, it is shown that the change in downward infrared radiation at the surface has a direct impact on surface temperature and the effect is mathematically tractable. Moreover, because of the rapid increase of latent energy exchange with temperature, the surface temperature rise is constrained to a relatively small response that is significantly less than the IPCC estimates.

4. THE EXAGGERATED RESPONSE OF COMPUTER MODELS

There is nearly an order of magnitude difference between the relatively small 0.7 ^oC surface temperature response to a doubling of CO_2 concentration (above) and the projected responses of between 2.0 ^oC and 4.5 ^oC estimated by the IPCC using complex computer models. A key difference can be found in the representation of changing rate of latent energy exchange with temperature.

Over a water surface with constant relative humidity the rate of increase in evaporation (and latent energy exchange) with temperature will equate to the Clausius Clapeyron relationship (about 7% C^{-1}), other factors such as relative humidity and mean wind speed being constant. Held and Soden (2006)[9] have reported that on average the rate of increase of evaporation with temperature rise for the computer models used in the IPCC fourth assessment was only about one-third this value. These low values were confirmed by Wentz et al (2007)[10], who reported across the models a range of 1% C^{-1} to 3% C^{-1} for the global average evaporation increase with temperature.

The apparently anomalous low values for the rate of evaporation increase with temperature, as specified in computer models, has significant consequences for the sensitivity of surface temperature response to CO_2 forcing. The slope of the net surface energy response curve of Figure 2 is reduced, the tendency to return to the steady state temperature is weakened, and surface temperature must rise by a larger magnitude to recover from the same radiative forcing of a doubling of CO_2.

More importantly, analysis of equations 3, 4 and 5 shows that, under CO_2 forcing, the surface temperature response is very sensitive to the rate of increase of evaporation

with temperature when it is reduced below the Clausius Clapeyron relationship. The reduction in latent heat exchange with temperature means that the offsetting energy loss necessary to arrive at a new steady state from downward infrared radiation forcing must come from additional infrared radiation emission. That is, the new steady state energy exchange will be at a much higher surface temperature than if the evaporation was following the Clausius Clapeyron relationship.

The sensitivity of surface temperature response to rate of increase of latent energy exchange with temperature can be demonstrated through application of typical values of the component factors to equation 3. At the average temperature of the Earth (15 ^{o}C) the rate of increase of surface infrared emission with temperature change given by the Stefan Boltzman Law is 5.4 $Wm^{-2}C^{-1}$. The rate of increase of downward infrared radiation at the surface with temperature under the condition of constant relative humidity can be assessed, for example using the MODTRANS radiation transfer model. With the assumptions that the US Standard Atmosphere approximates the mean profile of the atmosphere, that relative humidity is constant (that is, the atmospheric water vapour increases with temperature in accordance with the Clausius Clapeyron relationship) and ignoring any potential change in cloudiness and its impact, it is estimated from MODTRANS that the natural rate of increase in back radiation at the surface is about 4.8 $Wm^{-2}C^{-1}$.

Table 2 has been calculated from equation 3 using the equivalent radiative forcing from Table 1 for a doubling of CO_2 concentration. That is, a direct increase in downward infrared emission of 3.2 Wm^{-2} and the reduction of convective instability equivalent to 1.5 Wm^{-2}, for a total forcing of 4.7 Wm^{-2}. The Table sets out indicative values for the sensitivity and response of surface temperature to radiative forcing using a range of values of rates of latent energy exchange with temperature. The value of 6% C^{-1} for dLH/dT is the global average estimate by Wentz et al (2007) based on satellite estimates of changing precipitation during the global warming of recent decades. It is less than the Clausius Clapeyron relationship but this is not unexpected given, as they explained, the existence of some arid and semi-arid land areas across Earth's surface. The other values of dLH/dT are typical ofr computer models (GCM) used in the IPCC fourth assessment of 2007.

Table 2 indicates that surface temperature response to CO_2 forcing is very sensitive to specification of the rate of increase of evaporation, and hence latent energy

Table 2. Indicative values of surface temperature increase from a doubling of CO_2 concentration ($2 \times CO_2$) and with a range of rates of increase of evaporation with surface temperature. The rates of surface latent energy exchange, dLH/dT correspond to global values assessed from satellite analysis, and values corresponding to computer models (GCM) used in the 2007 IPCC fourth assessment.

dLH/dT	$\Delta Ts/\Delta FCO_2$	ΔTs ($2 \times CO_2$)
6% C^{-1} (satellites)	0.19 °C/Wm^{-2}	0.9 °C
2% C^{-1} (Average GCM)	0.46 °C/Wm^{-2}	2.2 °C
1% C^{-1} (Low-end GCM)	0.72 °C/Wm^{-2}	3.4 °C

exchange, with temperature increase. Correct specification of the rate of change of evaporation (and latent heat exchange – see equations 3, 4 and 5) with surface temperature change is fundamentally important for estimating the magnitude of global surface temperature response to anthropogenic greenhouse gas forcing. The analysis at Table 2 also points to a high likelihood that the computer models used as the basis for the IPCC estimates of anthropogenic global warming are significantly exaggerating the projected global temperature response from a doubling of atmospheric CO_2 concentration.

If we accept that surface evaporation will increase at a rate near the Clausius Clapeyron relationship, as assessed by Wentz et al (2007), then an increase of CO_2 concentration from the current level to near 800 ppm by the end of the 21st century is not likely to cause a global temperature rise exceeding 1 ^{o}C. Such a rise is well within the range of natural variability and should not be construed as dangerous.

5. CONCLUSION

Carbon dioxide is a greenhouse gas and interacts with the Earth's infrared radiation, especially the emission to space and the downward radiation at the surface. There is little disagreement that additional CO_2 in the atmosphere will enhance the greenhouse effect. What is at issue is the reason for the enhancement and the magnitude of Earth's temperature sensitivity as CO_2 concentration increases.

Water vapour is important in regulating the magnitude of the enhanced greenhouse effect in two ways: increased water vapour in the atmosphere has an amplifying effect on the CO_2 forcing because it further increases the downward infrared radiation at the surface as temperature rises; and, more importantly, any increased evaporation and latent heat exchange between the surface and atmosphere constrains the surface temperature response. It is evaporation that is shown to be the dominant factor.

Contrary to popular explanations, it is not the reduction in radiation to space across the CO_2 bands that is important for enhancing the greenhouse effect; it is the increase in downward infrared radiation at the surface compounded by the reduction in convective instability that is important because these directly lead to an adjustment of the surface temperature. An increase in the concentration of CO_2 will enhance the greenhouse effect but the magnitude remains controversial. This analysis suggests that, because of the role of surface evaporation, the sensitivity is significantly less than that estimated by the IPCC using computer models.

The computer models on which the IPCC based its fourth assessment projections significantly underestimate the rate of increase of evaporation with temperature when compared to both theoretical and observational estimates. The indicative analysis presented here suggests that projections of global temperature rise made by these contemporary computer models are nearly an order of magnitude too large. A better representation in computer models of the response of evaporation and surface latent heat exchange with temperature is a primary requirement if the uncertainty about anthropogenic global warming is to be reduced. Without this improvement the projected temperature response to anthropogenic forcing will likely continue to be exaggerated.

This indicative analysis suggests that a doubling of CO_2 concentration from current levels by the end of the century is expected to cause a modest global temperature rise

not exceeding 1 ^{o}C. This value is significantly less than the 2.0 ^{o}C to 4.5 ^{o}C projected by computer models.

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THE STABILISING EFFECT OF THE OCEANS ON THE CLIMATE

Dick Thoenes
Prof (em) of chemical engineering, Eindhoven University of Technology
Home address: Mozartlaan 55, 2555 JC Den Haag, Netherlands,
e-mail adress dthoenes@gmail.com

ABSTRACT
Based on some simple calculations and a few estimates, it is demonstrated that the oceans have a stabilising effect on the earth's climate. Any additional incoming infrared radiation will be compensated by evaporation of water followed by infrared irradiation from high clouds into space and by heat flow into the deep sea.

1. INTRODUCTION

The average surface temperature of the oceans remains remarkably constant during years and even decades, despite considerable variations in both the solar irradiation and the back radiation from the atmosphere. The most likely cause is the rapid variation in the evaporation rate of water. A large part of the radiation energy that is absorbed by the water is used for evaporation.

2. BASICS

The evaporation rate of surface water is mostly determined by the irradiation rate, the humidity of the air and the wind velocity. The transfer of sensible heat between the air and the water cannot be neglected. The surface temperature will attain a value so that the heat balance is fulfilled. When all factors are known, the surface temperature can be calculated. Obviously, when the irradiation rate is increased, the surface temperature of the water will rise. We are interested in the quantitative relationship between these two factors.

3. CALCULATION

The heat balance for the surface layer of the water can be written as:

$$Q = r\,k\,(C^* - C_0) + h\,(T^* - T_0) \tag{1}$$

(irradiation rate = heat of evaporation + heat transfer water to air or vice versa)

We assume a steady state, which is realistic if we want to consider averages. We also assume that the air temperature is given and that downward heat transfer can be neglected. This is only true for shallow waters. Later we will consider the consequences of downward heat transfer to deep waters.

We choose an air temperature of 15 °C, which is an approximate average for the globe.
Explanation of symbols:

Q = irradiation rate W/m^2 (independent variable)
r = heat of evaporation of water = 2.47 10^6 J/kg
(this and all other physical constants are valid for temperatures around 15 °C)
k = mass transfer coefficient (m/s) between water surface and air.
C^* = water vapour concentration (kg/m^3) corresponding to vapour pressure at T^*
C_0 = water vapour concentartion (kg/m^3) in the air.

The vapour pressue curve is approximated by a simple linear relationship of the form

$C^* = a\ T^*$, and $C_0 = \eta\ a\ T_0$, where a = 0.85. 10^{-3} kg/m^3 °C.
η = relative humidity of the air (independent variable)
h = heat transfer coefficient between water surface and air (W/m^2 °C) (independent variable)
T^* = water surface temperature (dependent variable)
T_0 = air temperature which is assumed constant (15 °C).

We make use of the so called "complete analogy of heat and mass trasnfer" (named after Chilton and Colburn) (Bird et al., 1960),
so that the following approximation applies:

$k/h = D/\lambda$
D = diffusion coefficient of water vapour in air = 2.43. 10^{-5} m^2/s
λ = thermal conductivity of air = 2.54. 10^{-2} W/m °C

At increased wind speeds (above a certain minimum) k and h will increase proportionally, so their ratio remains constant ($= D/\lambda$)

We substitute $\beta = r\ k\ a/h$, $\beta = 2.01$ (dimensionless).

The heat balance in eqn. (1) can be simplified to:

$$T^* = Q/h\ (\beta + 1) + T_0\ (\beta\eta + 1)/(\beta + 1) \tag{2}$$

For wind velocities of 4 and 8 m/s, the heat transfer coefficient h appears to be approximately 18 and 31 W/m^2 °C, respectively (Ferguson, 1952)

The results of some calculations are shown in the Table 1. This gives the dependent variable T^* (surface temperature) (°C) for two values of h, three values of η and five values of Q, for an air temperature of 15 °C.

It follows from these calculations that the water surface temperature can become lower than the air temperature, particularly at lower values of Q (irradiation) and η (relative humidity) and higher wind speeds, as is to be expected.

The first column gives the surface temperature of water when there is no irradiation. This is the so called "wet bulb temperature" (used in a technique to determine the relative humidity of air).

We also see that for higher values of Q (irradiation) the surface temperature is more dependent on wind speed.

Table 1.
Surface temperature T^*(°C) calculated for various values of Q, h and η

Q (W/m^2)	0	100	160	200	300
h = 18 W/m^2 °C					
η = 0,6	11,0	12,9	14,0	14,7	16,6
η = 0,7	12,0	13,9	15,0	15,7	17,6
η = 0,8	13,0	14,9	16,0	16,7	18,6
h = 31 W/m^2 °C					
η = 0,6	11,0	12,1	12,8	13,2	14,3
η = 0,7	12,0	13,1	13,8	14,2	15,3
η = 0,8	13,0	14,1	14,8	15,2	16,3

If we want to estimate an average effect, we can choose as average realistic values Q = 160 W/m^2, η = 0.7, and a wind speed of 8 m/s. We find then a value for the surface temperature of 13.8 °C, that is about 1 °C lower than the temperature of the air.

4. DISCUSSION

The most important conclusion from these calculations is the effect on surface temperature of an increase of the irradiation Q. We see that when Q is raised by 100 W/m^2, the surface temperature would be increased by 1 to 2 °C., Around the average conditions, the increase is about 1 °C. We may conclude that the increase would be approximately 0.01 – 0.02 °C for each increase of 1 W/m^2 of the irradiation received by the oceans. This would indicate a strong stabilizing effect of the oceans on climate.

However, this is an oversimplification. There are two additional effects that would affect the surface temperature of the oceans. One is caused by the latent heat that is released on condensation of extra water vapour at a height of several kilometers. This would raise the local temperature to make the increased irradiation into space possible. On the basis of the Stefan Boltzaman equation, one finds that this would raise the local temperature 0.3 °C for each 1 W/m^2 of additional irradiation. Because of the redistribution of heat in the atmosphere, this would raise the surface temperature by the same amount.

However, this temperature rise may be compensated, at least partially, since the increased evaporation will lead to a slight increase of the cloud cover. If the increase of the cloud surface would be proportional to the amount of evporated water, the irradiation into space would increase proportionally, so that no temperature rise woud occur. At the same time, the heat flux from the sun to the surface of the earth would be reduced, which amounts to a negative feedback. At the same time, the net irrdiation from lower layers into space is reduced, but this effect is smaller, so that there remains a negative feedback. As far as I am aware, these effects are not precisely known.

Another effect is the heat transfer from the surface of the oceans into deep water. One can estimate the magnitude of this heat flow as follows: It is known that the total evaporation of water from the surface of the earth (equal to the total precipitation) is on the average about 1000 mm of water per year. This corresponds

to an enthalpy flow of 80 W/m^2. Since most of the water evaporates from the oceans, one can estimate that the evaporation from the oceans corresponds to about 100 W/m^2. This means that only 100/160 parts or roughly two thirds of te solar irradiation is used for evaporation, and the remaining one third for heat transfer to the deep sea. This would reduce the temperature rise at the surface by approximately one third, so that it would become 0.2 °C (instead of 0.3 °C) for each 1 W/m^2 of additional irradiation.

5. CONCLUSION

There appear to be several effects that determine the surface temperature of the oceans, that are not exactly known. However it is shown by the above estimates, that the oceans have a considerable stabilising effect on these temperatures and consequently on the temperature of the atmosphere.

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WHAT GOES UP MUST COME DOWN (A COMMENTARY)

Peter Siegmund
Royal Netherlands Meteorological Institute (KNMI)
Postbus 201
3730 AE De Bilt
The Netherlands
siegmund@knmi.nl

In 'The stabilising effect of the oceans on the climate', Dick Thoenes has modeled that on an aquaplanet an increase in irradiation of 1 W/m^2 gives an increase in surface temperature of 0.01 – 0.02 °C. The modeled temperature increase is so small, because it gives an increase in evaporation rate that is sufficiently large to compensate the increase in irradiation. However, in reality the surface temperature increase will be much higher because of the following process that is neglected by Thoenes. The increase in evaporation will lead to an increase in the release of latent heat in the atmosphere, at several kilometers height where the condensation takes place. The increase in release of latent heat will heat the atmosphere up to approximately a temperature where the increase in radiative cooling by the atmosphere compensates the increase in latent heat release. We use the word 'approximately', because a part of the extra latent heat release might be compensated by an increase of the poleward heat transport by the atmosphere and oceans, thus leading to a temperature increase in the poleward regions. As follows from Stefan-Boltzmann's law, assuming a temperature of 240 K at the level of condensation, an atmospheric temperature increase of about 0.3 °C is required to give an increase in radiative cooling of 1 W/m^2 that would compensate the same amount of increase of latent heat release. This temperature increase will occur not only at the levels of condensation, but as a result of vertical redistribution of heat by the induced vertical motions, it will occur at all levels, including the surface level. In other words, what goes up must come down, or, more precisely, the upward flux of latent heat will heat the atmosphere at all levels, due to the heating of condensation and the vertical redistribution of this heating. In Thoenes' model the evaporation goes up, but the down story is neglected. Such a neglect would be correct in case of a small (compared to the earth's surface) evaporative area, such as a salt exploration area. However, for the present, global case the atmospheric dynamic and thermodynamic processes should be part of the game. Three-dimensional climate models do include a description of these processes, which explains why these models give a surface temperature increase due to the enhanced greenhouse effect that is at least one order of magnitude larger than the value modeled by Thoenes.

THE STABLE STATIONARY VALUE OF THE EARTH'S GLOBAL AVERAGE ATMOSPHERIC PLANCK-WEIGHTED GREENHOUSE-GAS OPTICAL THICKNESS

Ferenc M. Miskolczi
3 Holston Lane, Hampton VA 23664, USA

ABSTRACT
By the line-by-line method, a computer program is used to analyze Earth atmospheric radiosonde data from hundreds of weather balloon observations. In terms of a quasi-all-sky protocol, fundamental infrared atmospheric radiative flux components are calculated: at the top boundary, the outgoing long wave radiation, the surface transmitted radiation, and the upward atmospheric emittance; at the bottom boundary, the downward atmospheric emittance. The partition of the outgoing long wave radiation into upward atmospheric emittance and surface transmitted radiation components is based on the accurate computation of the true greenhouse-gas optical thickness for the radiosonde data. New relationships among the flux components have been found and are used to construct a quasi-all-sky model of the earth's atmospheric energy transfer process. In the 1948-2008 time period the global average annual mean true greenhouse-gas optical thickness is found to be time-stationary. Simulated radiative no-feedback effects of measured actual CO_2 change over the 61 years were calculated and found to be of magnitude easily detectable by the empirical data and analytical methods used. The data negate increase in CO_2 in the atmosphere as a hypothetical cause for the apparently observed global warming. A hypothesis of significant positive feedback by water vapor effect on atmospheric infrared absorption is also negated by the observed measurements. Apparently major revision of the physics underlying the greenhouse effect is needed.

INTRODUCTION

A key parameter in the study of the planetary greenhouse effect is the absorbed amount, A_A, of the surface upward infrared radiation, S_U. Greenhouse gas molecules absorb and emit the infrared radiation of the atmosphere. It has been proposed (Hansen et al. [1]; Ramanathan [2]; Bony et al. [3]) that increase of atmospheric CO_2 concentration causes persistent increase of the greenhouse effect, because proposed increase in absorption of surface upward radiation outweighs possible increase in emission of atmospheric radiation to space, with particular reference to water vapour feedback, which they say is positive.

The relevant physical quantity necessary for the computation of the accurate atmospheric absorption is the true greenhouse-gas optical thickness τ_A. The definition and the numerical computation of this quantity for a layered spherical refractive atmosphere may be found in Miskolczi [4]. Note that this quantity is conceptually different from the Planck mean optical thickness as usually defined for thin gray atmospheres; see Collins [5], Mihalas and Mihalas [6]. The fundamental difference arises from the fact that τ_A is computed from the Planck-weighted spectral hemispheric transmittance and therefore represents the true spectral feature of the infrared absorption coefficient. In short, τ_A may be expressed as:

$$\tau_A = -\ln\left[\frac{1}{\sigma t_A^4}\sum_{j=1}^{M}\pi B(\Delta\nu_j, t_A)\sum_{k=1}^{K} w^k\,\bar{T}_A(\Delta\nu_j,\mu^k)\right], \tag{1}$$

where $M = 3490$ is the total number of spectral intervals, $K = 9$ is the total number of streams, t_A is the surface temperature, B is the Planck function, σ is the Stefan-Boltzmann constant, and w^k is the hemispheric integration weight associated with the kth direction (stream). $\bar{T}_A(\Delta\nu_j,\mu^k)$ is the directional mean transmittance over a suitable short wave number interval:

$$\bar{T}_A(\Delta\nu_j,\mu^k) = \frac{1}{\Delta\nu_j}\int_{\Delta\nu_j}\exp\left[-\sum_{l=1}^{L}\sum_{i=1}^{N}\left[c^{i,l}+k_\nu^{i,l}\right]\frac{u^{i,l}}{\mu^{l,k}}\right]d\nu, \tag{2}$$

where $\mu^{l,k} = \cos(\theta^{l,k})$ and $\theta^{l,k}$ is the local zenith angle of a path segment, $c^{i,l}$ and $k_\nu^{i,l}$ are the contributions to the total monochromatic absorption coefficient from the continuum type absorptions and all absorption lines relevant to the ith absorber and lth layer respectively. $N = 11$ is the total number of major absorbing molecular species and $L = 150$ is the total number of the homogeneous atmospheric layers (shells). In eqn (2) the wavenumber integration is performed numerically by 5th order Gaussian quadrature over a wavenumber mesh structure of variable length. At least $\Delta\nu_j \approx 1\ \mathrm{cm}^{-1}$ spectral resolution is required for the accurate Planck weighting. From eqn (1) follows the usual form of the transmitted and absorbed part of the surface upward radiation:

$$S_T = S_U\exp(-\tau_A), \tag{3}$$

$$A_A = S_U - S_T = S_U(1-\exp(-\tau_A)) = S_U(1-T_A) = S_U A. \tag{4}$$

In eqns (3-4) S_T is the transmitted surface upward flux, $S_U = \sigma t_A^4$ is the total surface upward flux, A_A is the absorbed part of S_U within the atmosphere, T_A is the flux transmittance of the whole air column, and $A = 1 - T_A$ is the flux absorptance. The other radiative flux components of interest are the upward and downward atmospheric emittances, E_U and E_D, subsequently, and the outgoing longwave radiation, $OLR = E_U + S_T$. Except for OLR, E_D, and S_U, the above radiative quantities cannot be directly measured. Unfortunately no computational results of E_U, S_T, A, T_A and τ_A can be found in the literature, and therefore our main purpose is to give realistic estimates of their global mean values, and investigate their dependence on the atmospheric CO_2 concentration. The accurate estimates can only be obtained by using a line-by-line radiative transfer

code and real weather balloon observations. Fig. 1. shows the definitions of the involved flux components. It is explicitly assumed that temperatures t_A and t_G are equal, the surface is black, and therefore, $S_U = S_G = \sigma t_A^4 = \sigma t_G^4$.

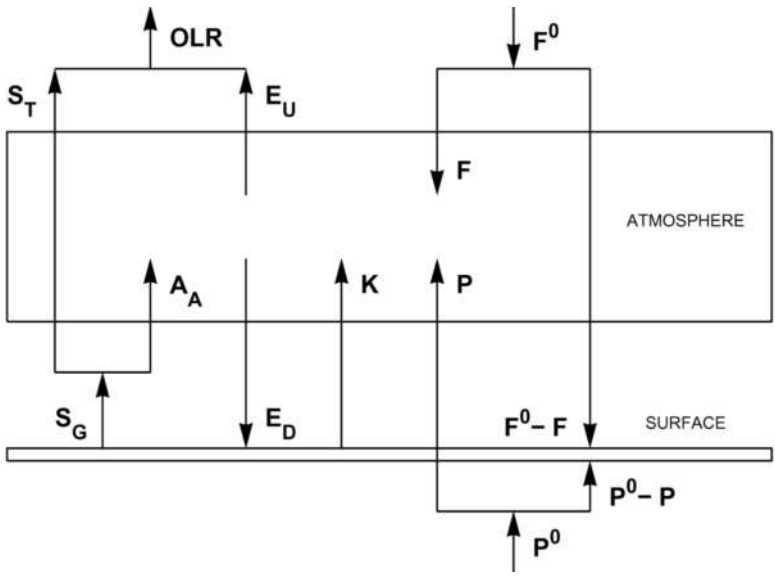

Figure 1. Semi-transparent clear sky planetary atmospheric model. F^0 is the total absorbed SW radiation in the system, F is the part of F^0 absorbed within the atmosphere, S_G is the LW upward radiation from the ground: $S_G = \sigma t_G^4$, where t_G is the ground temperature and σ is the Stefan-Boltzmann constant. The total thermal energy from the planetary interior to the surface-atmosphere system is P^0. P is the absorbed part of P^0 in the atmosphere. The net thermal energy to the atmosphere of non-radiative origin is K.

In this study the spectroscopic computations were performed by using the High-resolution Atmospheric Radiative Transfer Code, HARTCODE, Refs. 7, 8, 9, 10, 11,12. In all calculations of A, T_A, τ_A, and of the radiative flux components, the presence or absence of clouds was ignored; the calculations refer only to the greenhouse gas components of the atmosphere registered in the radiosonde data; we call this the quasi-all-sky protocol. It is assumed, however, that the atmospheric vertical thermal and water vapor structures are implicitly affected by the actual cloud cover, and that the atmosphere is at a stable steady state of cloud cover; the present quasi-all-sky protocol refers to dynamic cloud processes only by implicit assumption.

All radiative quantities mentioned hereafter, unless specifically noted to the contrary, are radiosonde data assessed in terms of the above-defined quasi-all-sky protocol. In effect, the various cloudy conditions of the actual atmosphere are regarded as maintaining their established average state, which forms a stable steady background for the present analysis.

The weather balloon observations were taken from the TIGR2 archives, Chedin and Scott [13], and from the NOAA NCEP/NCAR Reanalysis data, http://www.cdc.noaa.gov [14]. The TIGR2 dataset is used to show empirically that new relationships hold amongst certain global variables of the earth's atmospheric energy transport process. The NOAA 61-year dataset is used to demonstrate that the global average annual infrared optical thickness of the atmosphere has been unchanged for 61 years, with a value of 1.87. It will be inferred that CO_2 does not affect the Earth's climate through the greenhouse effect. In Fig. 2 the temperature and H_2O volume mixing ratio profiles of the USST76 Standard Atmosphere are compared to the global average profiles obtained from the TIGR2 and NOAA archives.

TIGR2 SIMULATIONS

1 Profile Selection Strategy

The TOVS Initial Guess Retrieval, (TIGR2), database consists of 1761 weather balloon observations. The pressure, temperature, H_2O and O_3 mixing ratio profiles are specified at 40 pressure levels between 0.05 and 1013 hPa. The soundings were collected over both hemispheres and over all seasons from 1976. For practical reasons, the number of the profiles was reduced to a reasonably small number, suitable for detailed line-by-line calculations. The TIGR2 profiles were classified according to their geographical latitudes and the seasons. Based on the latitudinal and annual distribution, 5 latitudinal belts were selected, and in each belt, one, two or three 'seasons' were established, roughly based on the solar climate. This classification of profiles resulted in 11 groups with a minimum of 57 profiles during the northern midlatitude summer, and a maximum of 332 profiles during the northern midlatitude winter. The selection of the individual TIGR2 profiles was based on the total precipitable water, u, effective H_2O temperature, T_e, and effective H_2O pressure, p_e. The final set was reduced to 228 profiles. In Table I. the characteristics of the original data set are summarized. The selected subset of the 228 profiles has a similar statistical pattern. Further details on the selection strategy and the computational parameters of the line-by-line simulations may be found in Ref. 10.

2 Analysis of the Observations with the Quasi-All-Sky Protocol

In Table 2 the ranges and the global means of some basic quantities are summarized. Global mean values were computed as the weighted average zonal means with a 5 degree latitudinal resolution. The global average TIGR2 (GAT) profile was computed similarly from the selected 228 profiles. Notice that global averaging introduces slight nonlinearity. For reference, the global average clear sky *OLR* from the ERBE Monthly Scanner Data Product is 268 Wm^{-2}, ERBE [15]. The reason of the 17 Wm^{-2} higher ERBE global average clear sky *OLR* is not yet clear. In Kiehl and Trenberth [16] the clear sky *OLR* was computed for the USST76 atmosphere and their 265 Wm^{-2} is much closer to the ERBE data. Since their water vapor column amount is much less than the global average we may speculate that the source of the discrepancy could be traced back to the anisotropy corrections of the ERBE measurements.

The data are here described in terms of three relationships between various empirically measured quantities. The three relationships are referred to here as (1) radiative exchange

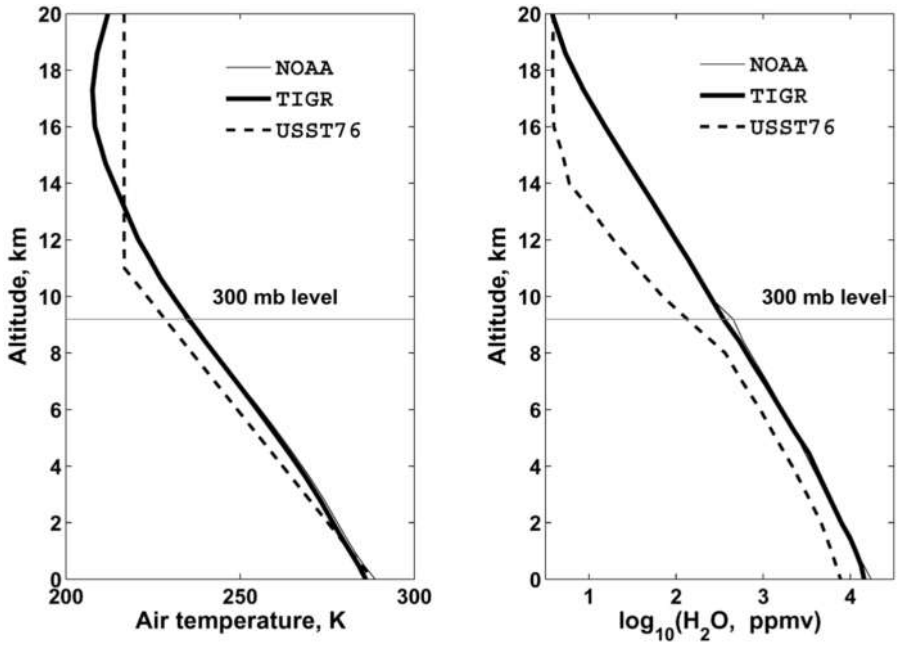

Figure 2. Temperature and H_2O profile comparisons. The NOAA and TIGR2 global average profiles are in good agreement, while the USST76 atmosphere significantly differs both in thermal structure and water vapor column amount. The NOAA and TIGR2 H_2O column amount is 2.6 precipitable cm (prcm) while the USST76 atmosphere contains only about half of this amount. Since H_2O is the most important greenhouse gas, apparently the USST-76 Atmosphere is not suitable for global radiative balance studies.

equilibrium between land-sea surface and atmosphere, (2) quasi-radiative transfer coefficient from land-sea emittance to *OLR*, and (3) global average atmospheric up-down emittance ratio.

Because the radiative exchange equilibrium and the quasi-radiative transfer coefficient relationships fit the individual radiosonde ascents from the wide variety of sampled climate conditions, they cannot in principle provide explicit direct information about the global average energy transfer, which is the object of interest for this work. The third relationship, the global average up-down emittance ratio, on the other hand, has no explicit information about single radiosonde ascents, but does complete a simple model of the global average energy transport process, which we here call the quasi-all-sky model.

RELATIONSHIPS AMONG THE RADIATIVE FLUXES IN THE QUASI-ALL-SKY MODEL

1 Radiative Exchange Equilibrium Between Land-Sea Surface and Atmosphere

One of the first and most interesting discoveries was the relationship between the absorbed surface radiation and the downward atmospheric emittance. According to

Table 1. Average characteristics of the TIGR2 subset containing 1761 profiles in 11 classes. M is the number of profiles, u is the H_2O column amount in prcm, T_e is in K and p_e is in hPa.

Class	Region and season	M	u	T_e	p_e
1	Arctic - summer	112	1.0	263	795
2	Arctic - winter	295	0.3	250	779
3	North - midlat. - summer	57	2.7	281	797
4	North - midlat. - fall /spring	88	1.1	266	804
5	North - midlat. - winter	332	0.9	263	804
6	North/South - tropical	114	3.6	285	816
7	South - midlat. - summer	131	1.6	271	808
8	South - midlat. - fall/spring	155	1.0	264	805
9	South - midlat. - winter	151	1.1	269	823
10	Antarctic - summer	157	0.5	255	783
11	Antarctic - winter	169	0.3	250	774

Ref. 4, for each radiosonde ascent the

$$E_D = A_A = S_U - S_T = S_U(1-\exp(-\tau_A)) = S_U(1-T_A) = S_U A \tag{5}$$

relationships are closely satisfied. The concept of radiative exchange was the discovery of Prevost [17]. It will be convenient here to define the term *radiative exchange equilibrium* between two specified regions of space (or bodies) as meaning that for the two regions (or bodies) A and B, the rate of flow of radiation emitted by A and absorbed by B is equal to the rate of flow the other way, regardless of other forms of transport that may be occurring.

Table 2. Ranges and the global averages of the different physical quantities. Fluxes are in Wm^{-2}, u is in prcm, t_A is in K.

Quantity	Minimum	Maximum	Global Average	GAT
t_A	**232.25**	**309.62**	**285.34**	**286.04**
S_U	**164.98**	**521.10**	**381.88**	**379.64**
u	**0.0507**	**6.836**	**2.533**	**2.637**
E_U	**83.74**	**256.71**	**188.94**	**192.7**
E_D	**103.35**	**429.69**	**308.70**	**310.49**
T_A	**0.0497150**	**0.391204**	**0.173344**	**0.15422**
$S_T = S_U T_A$	**22.246**	**111.92**	**61.094**	**58.54**
$OLR = E_U + S_T$	**150.64**	**297.62**	**250.05**	**251.25**
$\tau_A = -\ln(T_A)$	**0.9385**	**3.0014**	**1.8736**	**1.8693**

In Miskolczi [4] the relationships in eqn (5) were ascribed to Kirchhoff, but as noted above, radiative exchange equilibrium was first understood and described in 1791 by Ref. 17. Here we shall refer to the equality $E_D = S_U A$ as radiative exchange equilibrium between land-sea surface and atmosphere. Apparent violations of this law are due to

the anisotropy in the E_D radiation field, and may be corrected by an empirical hemispheric emissivity factor. From the TIGR2 data the global average hemispheric emissivity is $\bar{\varepsilon} = 0.967$. The mechanism of the equality $A_A = E_D$ is shown in Fig.3. Here the contribution density functions are plotted for the E_D and A_A fluxes. The two plots show that up to about 2 km altitude the source density of E_D and the destination density of A_A match precisely at each altitude.

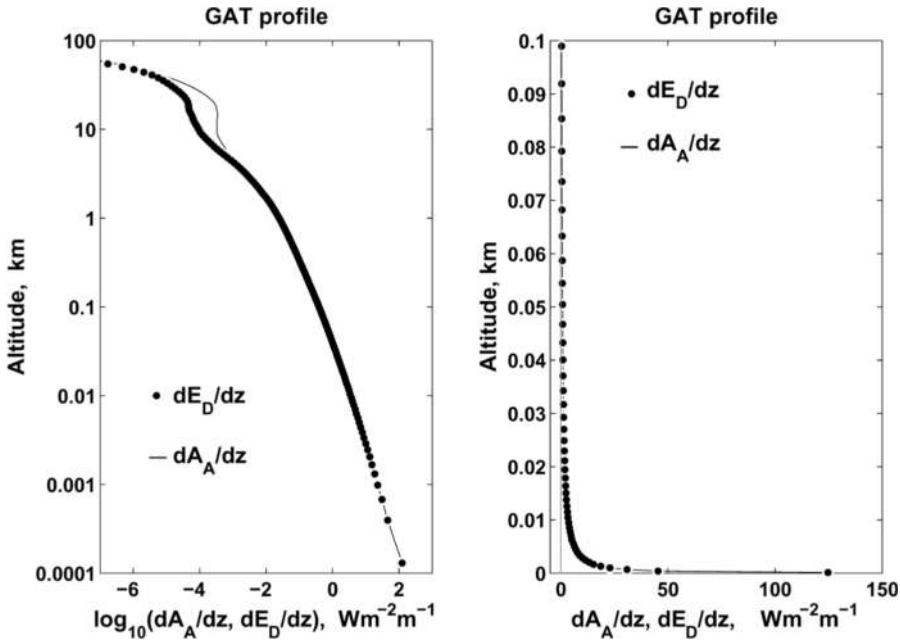

Figure 3. The law of radiative exchange equilibrium. The $E_D = S_U A$ relationship holds because the contribution of a layer to the downward emittance is equal to the absorbed surface upward radiation in the same layer. This law turned out to be valid for any cloud layer in the atmosphere and even holds true in the cloud free Martian atmosphere (see Fig. 4).

From eqn (5) follows the

$$\tau_A = -\ln(1 - E_D/S_U) \tag{6}$$

relationship which gives an independent estimate of τ_A through the surface-based observations of the E_D and S_U fluxes. Using the numerical data in Table 2 and $\bar{\varepsilon}$, the global average optical thickness for the GAT profile is $\tau_A = -\ln(1 - E_D/(\bar{\varepsilon}\,\mathrm{S_U})) = 1.869$. This is in good agreement with the direct computation using the $\tau_A = -\ln(T_A)$ definition. We may look in another way at the radiative equilibrium between the land-sea surface and the atmosphere. We imagine that the surface that upwardly emits A_A, and the upward facing detector surface for E_D, are lifted to various altitudes. The simulations are plotted in Fig. 4, and we see that the virtual A_A and E_D at all altitudes are equal.

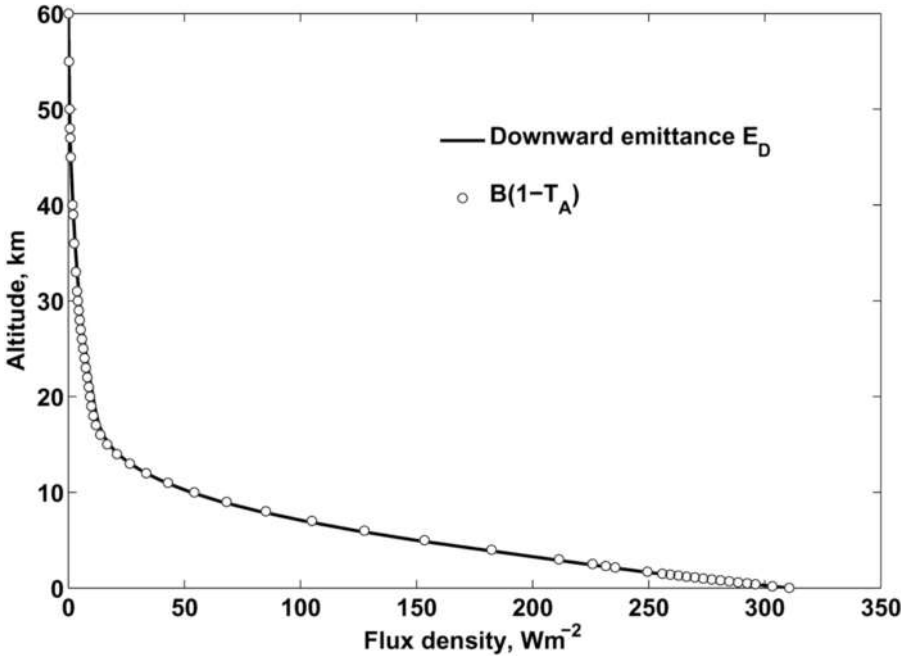

Figure 4. Radiative exchange equilibrium at altitudes above the surface. The plot shows that, independently of the altitude z, $A_A(z)$ from an upward emitting surface at z and E_D (z) from the atmosphere above are equal. Here we used the GAT atmosphere, $A_A(z) = B(z)(1 - T_A(z))$, $B(z) = \bar{\varepsilon}\,\sigma\, t_A^4(z)$, and $t_A(z)$ is the temperature profile. $E_D(z)$ may be measured by an up-looking detector at altitude z.

Another aspect of the radiative exchange equilibrium between land-sea surface and atmosphere is their spectral contents. For a hypothetical atmosphere in isothermal equilibrium with the surface $(S_U \equiv B(\mathrm{z}) \equiv B$ and $S_U^\nu = B^\nu(\mathrm{z}) = B^\nu)$ the spectra of atmospheric and surface radiations would match exactly. Then, with the monochromatic A_A^ν, E_D^ν, S_U^ν, τ^ν, T^ν and B^ν obeying the Beer law, we may write:

$$A_A - E_D = \int_0^\infty [A_A^\nu - E_D^\nu]\, d\nu = \int_0^\infty [S_U^\nu (1 - e^{-\tau_A^\nu}) - \int_{T_A^\nu}^1 B^\nu\, dT^\nu]\, d\nu = 0. \tag{7}$$

Fig. 5 shows the spectral A_A^ν and E_D^ν for four example radiosonde ascents. The spectral $A_A^\nu - E_D^\nu$ differences (shaded areas) in the relatively transparent spectral regions are related to the differences in the close-to-surface thermal structure of the atmosphere.

In the Antarctic summer case $A_A - E_D = 15.8$ Wm^{-2}, (5.2 % of S_U). In the Antarctic winter A case $A_A - E_D = -9.3$ Wm^{-2}, (–5.5 % of S_U). Here the strong temperature inversion resulted in the rare situation where $A_A < E_D$. These two cases are the observed maximum violations of the radiative exchange equilibrium law. In many cases the spectral differences compensate each other resulting in negligible differences

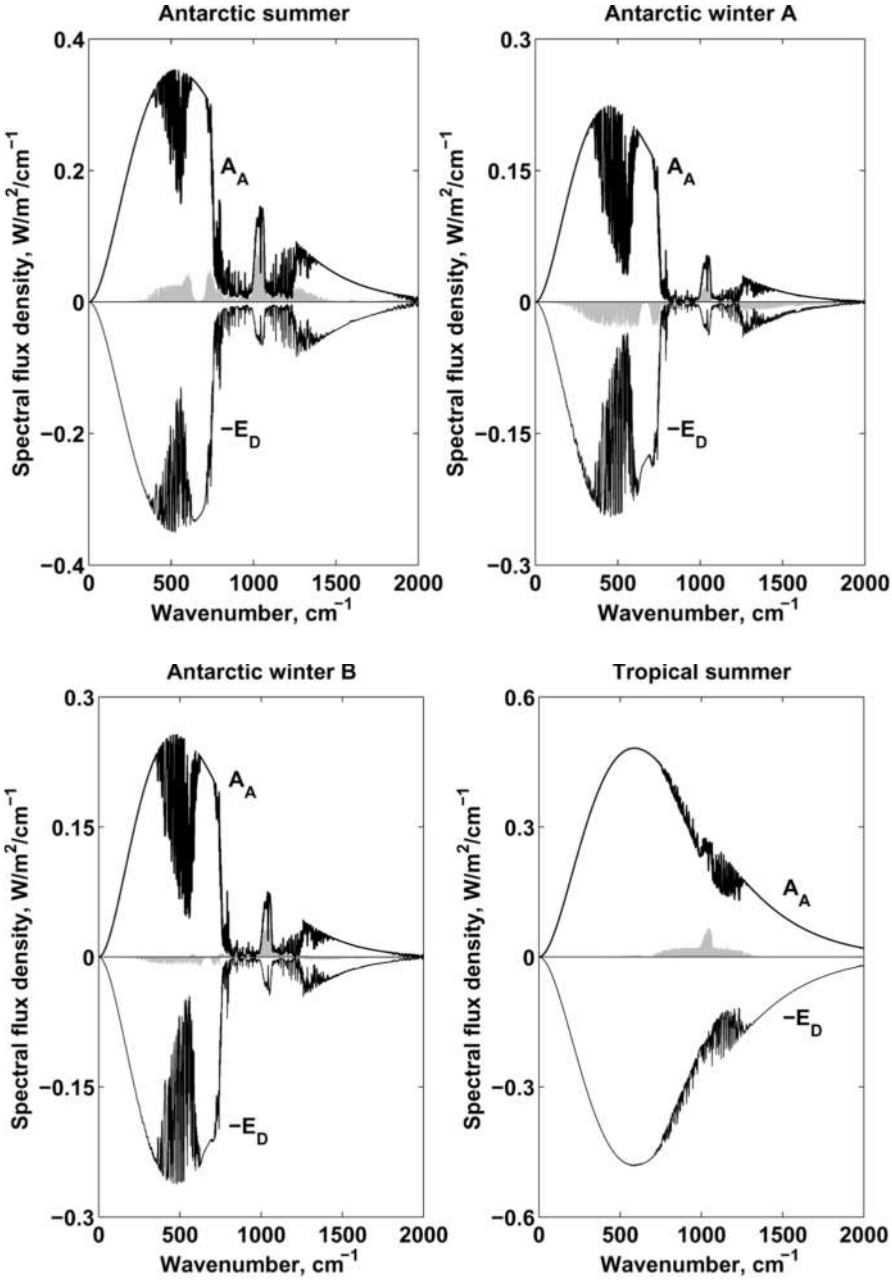

Figure 5. Violation of the radiative exchange equilibrium law. In each plot the negative spectral E_D^ν is plotted for clarity. The gray shaded area indicates $A_A - E_D$. The global average bias is about 3 % of S_U.

in $A_A - E_D$. For example, in the Antarctic winter B case $A_A = E_D$. As a general rule, the warm and humid atmosphere follows the radiative exchange equilibrium law better. In the Tropical summer case the bias is 11.1 Wm^{-2}, 2.5 % of S_U.

The zero dimensional energy balance model presented in Fig. 1 shows that the radiative exchange equilibrium requires the $S_U - (F^0 + P^0) = E_D - E_U$ and $E_U = P + K + F$ relationships among the fluxes. Total radiation to space from the bulk of the atmosphere is here called E_U. The source contribution profile of E_U is shown as d$Eu(z)$/dz in Fig. 6. This shows a local removal of local internal energy from the body of the atmosphere by radiation to space. Maintaining local thermodynamic equilibrium, and the steady state of the local internal energy, energy is locally dissipatively supplied by P and K and F for such radiation. Since $E_D = A_A$, on average the atmosphere does not cool radiatively to the land-sea surface, and the land-sea surface does not warm radiatively from the atmosphere. In this model, radiative surface cooling occurs only to space, by the S_T flux term. On average, atmospheric heating and cooling of the land-sea surface occurs only by non-radiative transfer.

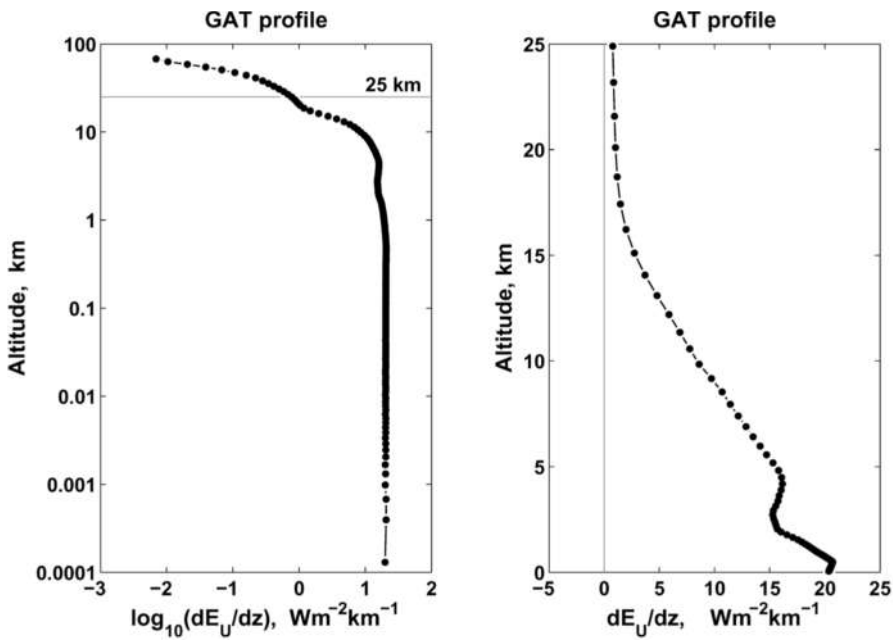

Figure 6. Contribution density function to the upward emittance. The significant part of E_U comes from the lower 25 km altitude range. About half of E_U comes from below 6 km. The dots indicate the levels where dE_U / dz was computed.

2 Quasi-Radiative Equilibrium Model

Let us consider the earth's atmospheric energy transport process in a heuristic one-dimensional abstraction in which radiative and material transport are abstracted into a single total energy transport. Now let us model that abstraction by a quasi-radiative

equilibrium. This model has been detailed in Ref. 4. In brief, it supposes that solar energy is absorbed at the land-sea surface, and from there it is radiated to space through and by a finite partially transparent atmosphere. The quasi-radiative model is expressed as a relationship between important overall energy transport variables. $S_A = \pi B(\hat{\tau}_A)$ is the source function at the bottom of the atmosphere; S_G is the upward emitted flux from the land-sea surface; τ_A is the model quasi-radiative flux optical thickness of the atmosphere: and, *OLR* is the total outgoing longwave (infrared) radiation. The quasi-radiative equilibrium defines a quasi-radiative transfer coefficient: $f(\hat{\tau}_A) = 2/\left(1 + \hat{\tau}_A + \exp(-\hat{\tau}_A)\right)$. The relationship is

$$OLR = (S_A A + S_G T_A) f(\hat{\tau}_A). \tag{8}$$

In the case in which the land-sea surface and the atmosphere in contact with it are at the same temperature, then we may think of a common upward flux S_U and set the land-sea surface emissivity to unity, so that we have $S_U = S_G = S_A$ and eqn (8) takes the following simple form:

$$OLR / S_U = f(\hat{\tau}_A). \tag{9}$$

The relationship of eqn (9) gives a fair but not perfect fit to the individual radiosonde ascents and a very good fit for the global average, see Fig. 7. The measured optical thicknesses, τ_A, in the Earth's atmosphere lie mostly in the range $1 < \tau_A < 3$. That the three global average optical thicknesses lie close to $\tau_A \cong 1.87$ is an indication that the global average atmosphere has a preference in setting its infrared optical properties.

While the fit to the individual radiosonde ascents is far from exact, the main interest of the quasi-radiative equilibrium model is in what it says about the global averages of the components of energy transfer. That it fits the data, and has a simple rationale and no arbitrary constants, is enough recommendation for the present purposes.

3 Global Average Atmospheric Up-Down Emittance Ratio

Further investigation of the meridional distribution of the fluxes revealed another simple relationship between the global average $\bar{E}_D$ and $\bar{E}_U$ (in the following equations the 'bar' over the variables denotes the spatial averaging over the globe):

$$\bar{E}_D / \bar{E}_U = 5/3. \tag{10}$$

This relationship was empirically validated for the GAT profile and by the averages of the individual TIGR2 simulations, see Fig. 8. From eqn (5) and eqn (10) we obtain the $\overline{OLR} / \bar{S}_U$ flux density ratio as:

$$\overline{OLR} / \bar{S}_U = \frac{3 + 2\bar{T}_A}{5}. \tag{11}$$

We note, that based on the empirical $\bar{S}_U = 2\bar{E}_U$ and $\bar{S}_U = 3\overline{OLR}/2$ relationships and some theoretical considerations eqns (10–11) were already predicted in Ref. 4.

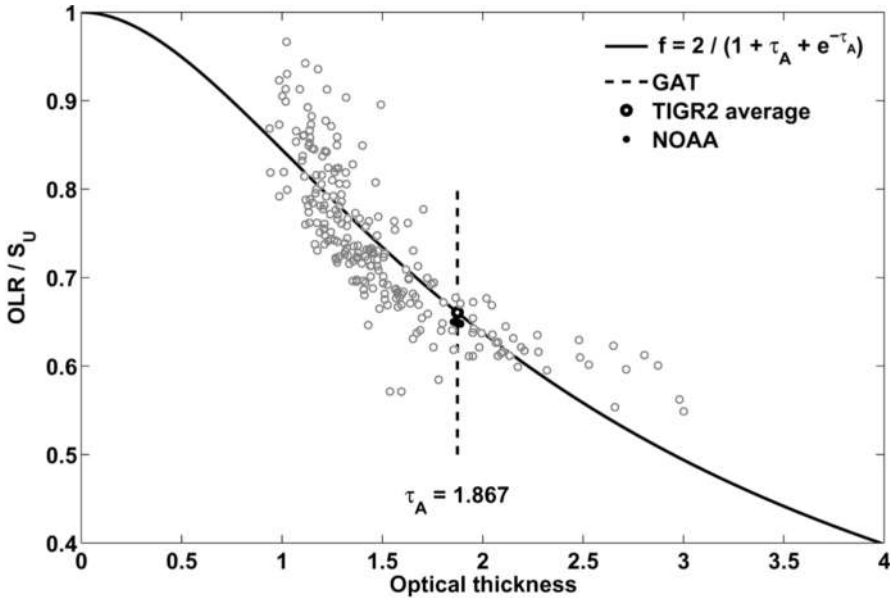

Figure 7. The gray open circles are the 228 TIGR2 ascent data, and the 61 black dots, not visibly resolved in this diagram because they are so nearly coincident, are the NOAA annual averages. The black open circle is the average of the 228 ascent data and dashed line is the GAT optical thickness.

4 Quasi-All-Sky Model of the Earth's Global Average Atmospheric Energy Transport Process

We can now consider an atmosphere which follows the three relationships, namely radiative exchange equilibrium between land-sea surface and atmosphere, the quasi-radiative transfer coefficient, and the global average atmospheric up-down emittance ratio. As noted above, these relationships are found by analysis of the empirical observations with the quasi-all-sky protocol, and the model they provide is called here the quasi-all-sky model. The three relationships mathematically imply an equation for the global average true greenhouse-gas optical thickness of our quasi-all-sky atmospheric model. Eqn (9) and eqn (11) combine to make an equation that can be solved numerically for τ_A:

$$\frac{3+2\exp(-\tau_A)}{5} = \frac{2}{1+\tau_A+\exp(-\tau_A)}. \tag{12}$$

The solution of eqn (12) is τ_A = 1.86756, in good agreement with the observed TIGR2 and NOAA averages and the GAT results presented in Fig. 7.

The three relationships of the quasi-all-sky model provide a logical structure in terms of which we can consider the possible stability of the Earth's greenhouse effect. This model is characteristic of the Earth's atmosphere. A different model is needed for Mars, where eqn (10) is replaced by the relation $\bar{E}_D / \bar{E}_U = 3/2$. For the Earth, eqn

(12) suggests that as long as the $3\overline{E}_D = 5\overline{E}_U$ and $\overline{OLR} = \overline{S}_U \overline{f}$ conditions hold there may not be any change in the surface greenhouse temperature. According to the IPCC's standpoint the anthropogenic global warming (AGW) is due to increased CO_2 emission, therefore, the possible empirical constancy of the annual global average τ_A in the Earth's atmosphere, or its variation around the $\tau_A = 1.86756$ theoretical value, is of particular interest. In the next section this question will be discussed.

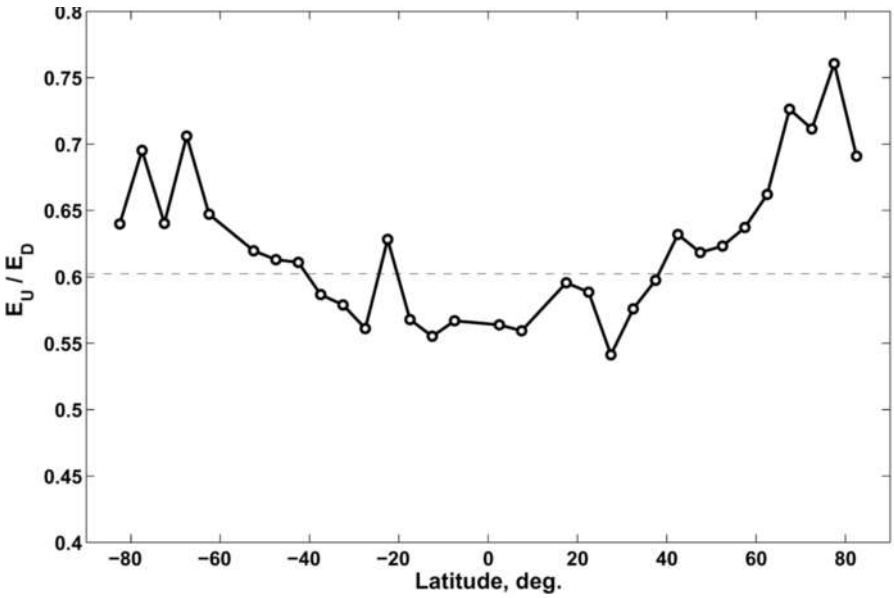

Figure 8. Meridional distribution of the E_U / E_D flux density ratio. The thin horizontal line is the global average. Open circles are averages for latitudinal belts of 5 degree width. The $\overline{E}_U / \overline{E}_D \cong 3/5$ global relationship is evident.

NOAA SIMULATIONS

1 IPCC View of Climate Sensitivity to Greenhouse Gas Increase

The IPCC has been using a special formalism for discussion of the long term response of the climate system to greenhouse gas perturbations. Their formalism states a virtual no-feedback effect of CO_2 on land-sea surface temperature, and thence states an after-feedback predicted eventual effect on that temperature. The sequence of the IPCC calculations is (1) spectroscopic simulation of the primary virtual no-feedback effect of CO_2 doubling, as it increases the greenhouse-gas optical thickness of the atmosphere, not allowing for any response of the atmosphere at this stage of the procedure; (2) estimation of how much this primary virtual no-feedback effect leads to a primary virtual increase in the surface temperature; (3) based on the entire long-term dynamics of the system, all the diverse feedback effects from the surface temperature change are then calculated, so as to yield a calculated eventual after-feedback effect. The difference between the primary virtual increase (2) in the surface temperature and the calculated eventual after-feedback effect (3) is formally regarded as a virtual feedback effect.

The main argument of the IPCC is stated in terms of this formalism: it is that there is strong positive feedback by water vapor effect on the greenhouse-gas optical thickness.

This IPCC formalism is not used in the present article, because it is considered here that taking the calculations through the primary no-feedback virtual surface temperature increase is far too indirect and complicated and fraught with un-assessable risk of error, and is utterly superfluous and apparently physically misleading. Here the eventual after-feedback effect of CO_2 on the greenhouse-gas optical thickness is assessed directly without intervening virtual surface temperature calculations.

2 Input Radiosonde Observations

About a year ago Ken Gregory suggested to test the constancy of the global average τ_A using the NOAA Earth System Research Laboratory (Ref. 14) time series data archive, and he kindly supplied me with the atmospheric profile information for the 1948–2008 (61 years) time period. In Fig. 9 the observed temperature, H_2O and CO_2 trends are presented.

A quick look at the data immediately shows that the range of the variations in the annual mean over the 61 years are very small: 58.87 atm-cm$_{STP}$ in CO_2, –0.0169 prcm in H_2O, and 0.687 K in surface temperature. The related year-to-year changes are also very small, 0.35 %/year in c, 0.0106 %/year in u, and 0.0039 %/year in t_A. Obviously, there is strict and high requirement on the sensitivity and numerical accuracy of the computed fluxes and flux optical thicknesses.

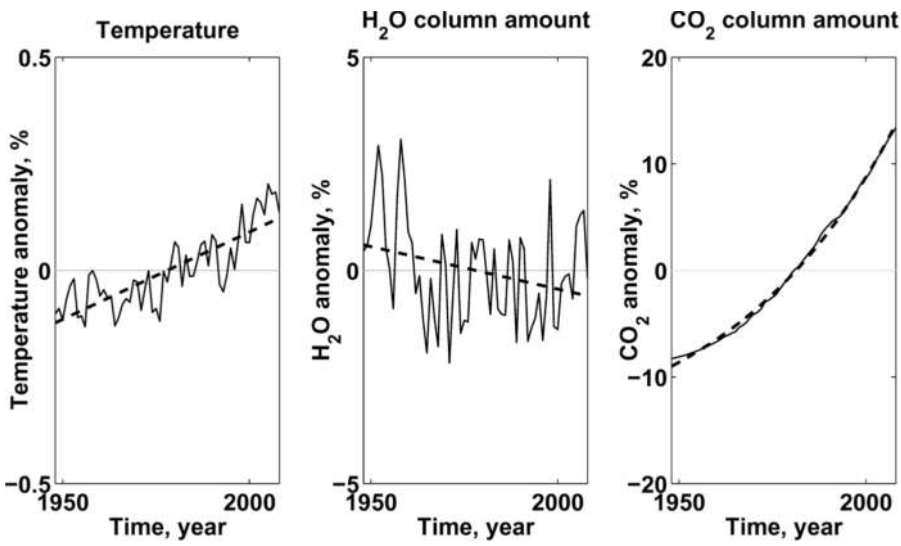

Figure 9. Temperature, t_A, H_2O, u, and CO_2, c, trends in the annual global mean reanalysis time series. The reference u, c, and t_A, are 2.61 prcm, 272.1 atm-cm$_{STP}$, and 288.9 K. The thin solid lines are the annual mean values. We should note, that recently there is an unsettled debate about the accuracy of the early upper tropospheric water vapor observations, see for example Paltridge at al. [18].

The NOAA time series optical depth computations were based on a slightly modified version of HARTCODE, i.e. it was set up to meet with the above mentioned

strict requirements of the computational accuracy. A short sensitivity summary is presented in Table 3. At these sensitivity runs the 61 year NOAA average atmospheric profile, (NAV) was used. Regarding the relative importance of the CO_2 and H_2O it was found that 1 ppmv increase in CO_2 concentration (equivalent with 0.8 atm-cm$_{STP}$ increase in column amount) can be compensated by 0.3 atm-cm$_{STP}$ (2.4×10^{-4} prcm column amount) decrease in H_2O. In other words, CO_2 doubling would virtually, with no feedback, increase the optical thickness by 0.0246. Calculations here show that an equivalent amount of increase can be caused by 2.77 per cent increase in H_2O. There is also a direct no-feedback effect of temperature on the greenhouse-gas optical thickness and calculations here show that a virtual no-feedback equivalent increase could alternatively be caused by 2.65 K decrease in the temperature at each atmospheric level. As we mentioned earlier such virtual sensitivity tests are made without dynamic feedback changes in other atmospheric profile variables. According to Table 3 HARTCODE adequately responds to the extremely small changes of the most important input parameters.

Table 3. HARTCODE sensitivity tests using the NAV profile. Fluxes are in Wm^{-2}, Δu is in prcm, Δc is in atm-cm$_{STP}$ Δt_A is in K. The transmittance ΔT_A is dimensionless, ΔE_D, ΔOLR, ΔS_T, ΔE_U, and ΔS_U are in Wm^{-2}. The reference u, c, and t_A, are 2.61 prcm, 272.1 atm-cm$_{STP}$, and 288.9 K. All numerical data are multiplied by10^4.

Δu	Δc	Δt_A	ΔE_D	ΔOLR	ΔS_T	ΔE_U	ΔS_U	ΔT_A
0	0	1	3.9	3.7	1.4	2.4	5.4	1.4E-3
0	0	–1	–3.9	–3.8	–1.3	–2.4	–5.3	–1.4E-3
2.6	0	0	56.4	–19.5	–52.8	33.4	0	–1.4E-1
–2.6	0	0	–56.5	19.4	52.9	–33.4	0	1.4E-1
0	272	0	2.2	–3.7	–1.9	–1.7	0	–4.9E-3
0	–272	0	–2.2	3.6	1.9	1.8	0	4.9E-3

While the dependence of the optical thickness on the absorber amount originates from the spectral or monochromatic Beer law, it is not feasible to express this by a summary explicit analytical function. The reason is the spectral overlapping of the absorption bands of the individual absorbers. The dependence of the optical depth on the temperature is also extremely complex and again cannot feasibly be described by an explicit analytical expression. The above dependences can only be diagnosed by using the LBL method for the transmittance computation in conjunction with a realistic properly stratified spherical refractive real (or model) atmosphere which is subjected to temperature and absorber amount perturbations.

3 Investigation of the Proposed Constancy of the Global Average Value of τ_A

To investigate the proposed constancy with time of the true greenhouse gas optical thickness, we now simply compute τ_A every year and check the annual variation for possible trends. In Fig. 10 we present the variation in the optical thickness and in the atmospheric flux absorption coefficient in the last 61 years.

According to Fig. 10 the trend in τ_A is 1.5×10^{-3} % year^{-1} and the total absolute change in the 61 years is $\Delta\tau_A = 0.0018$. The trend in A is 5.4×10^{-4} % year^{-1} and the total absolute change in the 61 years is $\Delta A = 0.00028$.

Here we have to make a fine point. In a hydrostatic atmosphere, given a constant pressure range, the top altitude is a function of the profile of the virtual temperature. However, the layer absorber amount is proportional to the layer thickness, therefore the observed warming trend of the atmosphere may introduce an unwanted effect in the optical thickness trend through the technical computation of the absorber amount. The correlation between τ_A and the top altitude is rather weak. Correcting our results for the above effect by subtracting the trend in the top altitude (7.6750×10^{-4} km/year) the final trend and the absolute change are reduced to $\Delta\tau_A / \Delta t = 8.08\times10^{-4}$ %/year and $\Delta\tau_A = 0.0009213$, respectively.

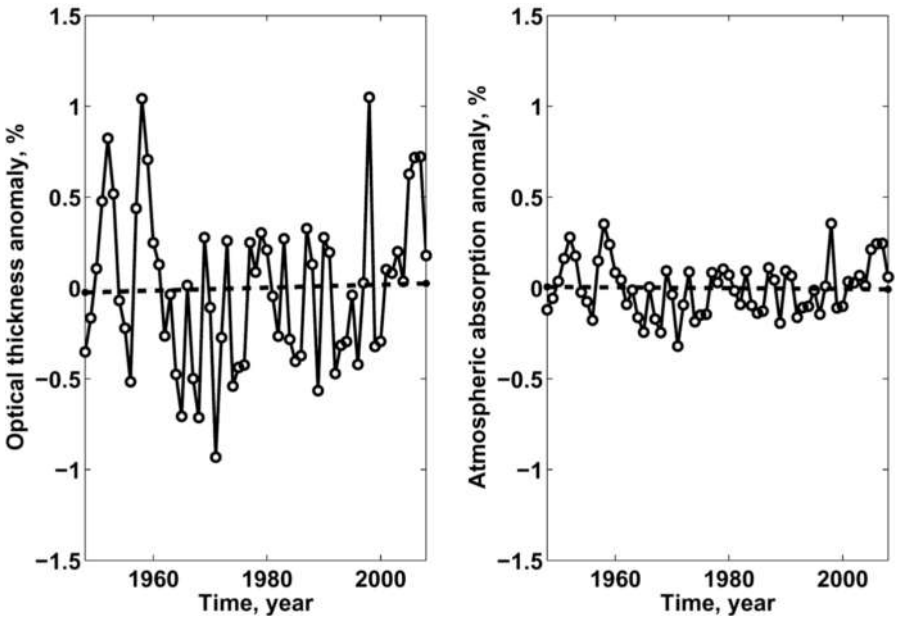

Figure 10. Time dependence of τ_A and A in the NOAA NCEP/NCAR annual global mean reanalysis time series. The thick dashed lines are the linear trend lines. The reference values (61 year means) of τ_A and A are 1.868754 and 0.84568, respectively.

One may already conclude that using the more conservative $\Delta\tau_A = 0.00179$ value for about 21 % increase in CO_2, and assuming that the atmosphere would behave similarly for CO_2 doubling, the predicted change in τ_A is $\Delta\tau_A = 100\times0.00179/21.63 = 0.00827$. This is one third of the no-feedback change of $\Delta\tau_A = 0.0246$ for CO_2 doubling. In other word, GCMs or other climate models, using a no-feedback optical thickness change for their initial CO_2 sensitivity estimates, they already start with a minimum of 200 % error (overestimate) just in $\Delta\tau_A$.

4 Virtual Primary No-Feedback Effect

For comparison with the empirical observations above, we also compute theoretically a virtual reference signal, the primary no-feedback effect of the actually measured increase in atmospheric CO_2 over the 61 years. The virtual effect is the difference between the actual signal and the computed virtual reference signal. The virtual effect is not stochastically affected by the year-to-year fluctuations, because it is a virtual change, defined conceptually and mathematically, not empirically.

Fortunately here we are dealing with very small changes and the optical thickness response of the system for the perturbations may reasonably be assumed to be linear, that is to say, the incremental response is directly proportional to the incremental perturbation. The minimum and maximum optical thicknesses are 1.8513 and 1.8884 respectively. The optical thickness of the average profile is $\tau_A(\bar{c},\bar{u},\bar{t}_A) = 1.86877$, and the average of 61 optical thicknesses is $\overline{\tau_A(c,u,t_A)} = 1.86875$. The bar over the variable vectors now indicates averaging over the 61 years. The effect of changes in c, u, and t_A may be computed by two different ways. One way is to compare the actual $\tau_A(c,u,t_A)$ to the ones where one variable is kept at the average value, and the other way is to compare the average $\tau_A(\bar{c},\bar{u},\bar{t}_A)$ to the ones where one variable vector is replaced with the actual one. These two methods are termed as dual or single profile perturbations, and they result in the same changes in τ_A. We may write:

$$\Delta\tau(c) = \tau_A(c,u,t_A) - \tau_A(\bar{c},u,t_A) = \tau_A(c,\bar{u},\bar{t}_A) - \tau_A(\bar{c},\bar{u},\bar{t}_A), \tag{13a}$$

$$\Delta\tau(u) = \tau_A(c,u,t_A) - \tau_A(c,\bar{u},t_A) = \tau_A(\bar{c},u,\bar{t}_A) - \tau_A(\bar{c},\bar{u},\bar{t}_A), \tag{13b}$$

$$\Delta\tau(t_A) = \tau_A(c,u,t_A) - \tau_A(c,u,\bar{t}_A) = \tau_A(\bar{c},\bar{u},t_A) - \tau_A(\bar{c},\bar{u},\bar{t}_A). \tag{13c}$$

In Fig. 11 we present the annual variations in $\Delta\tau(c)$, $\Delta\tau(u)$ and $\Delta\tau(t_A)$. As it was expected the cumulative changes in τ_A are simply the arithmetic sum of the changes due to the individual variables. Clearly, the variation in the annual mean optical thickness anomaly is largely caused by the H_2O, $\Delta\tau \cong \Delta\tau(u)$, the linear correlation coefficient between $\Delta\tau(u)$ and $\Delta\tau$ is 0.9948. The $\Delta\tau(c)$ and $\Delta\tau(t_A)$ works into the opposite direction and neither of them has significant correlation with the $\Delta\tau$. The numerical values are 0.131 for CO_2, and –0.494 for the temperature.

As a final conclusion of this perturbation study, we can safely state that the dynamic stability of the stationary value of the true greenhouse-gas optical thickness of the atmosphere is mediated mainly by the amount and distribution of the water vapor in the atmosphere, and by the surface and atmospheric temperatures. For a recent reference, applying eqn (6) and the Earth's long wave global average surface radiation budget data (from Table 1b in Ref. 19), the global average all-sky true optical thickness is 1.8779. This value was computed as the average from four independent groups. Radiation budget data from Ref. 16 were not included. Apparently, the global average cloud cover must not have a dramatic effect on the global average clear-sky optical thickness, and the effective altitude of the global average cloud cover must be around 2 km, as it was theoretically predicted in [4].

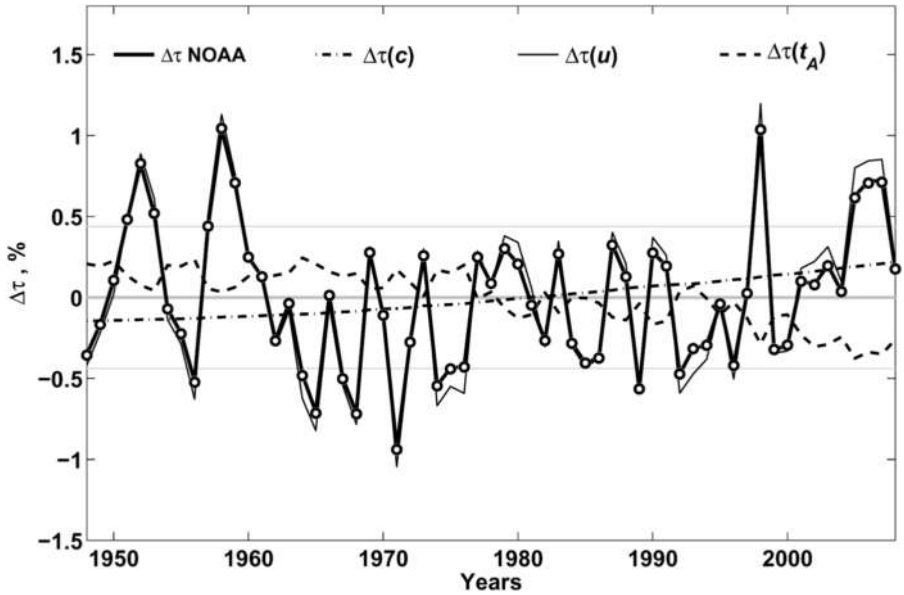

Figure 11. Summary of the perturbation study with the NOAA annual mean time series data. Here the normalized variability is plotted for the CO_2, H_2O and temperature perturbations. The reference value (61 year mean) of τ_A is 1.868754. The open circles indicate the sum of the $\Delta\tau(c)$, $\Delta\tau(u)$, and $\Delta\tau(t_A)$ curves. The thick black $\Delta\tau$ curve is the unperturbed anomaly in the original τ_A. Obviously, the fluctuations of global average $\Delta\tau$ are very largely explained immediately and directly by variations in water vapor column amounts.

5 Statistical Testing

The linear regression coefficient of the actual values of τ_A against time has a Student *t* value of 0.499. This is not even nearly statistically significantly different from zero. The Student *t* value that would correspond to the theoretically calculated virtual effect of actual CO_2 is 1.940. This would be statistically significant on a one-sided test at the 0.05 significance level. The statistical power of the Student *t* test for these data at a one-sided significance level of 0.05 is 0.6. That is to say, the data are well enough behaved to detect at the one-sided significance level 0.05, with a probability of 0.6, an uncompensated effect of CO_2 of the magnitude of the theoretically calculated virtual effect, supposing the same degree of variability in the data, if it were present in them. For putative data with this degree of scatter, there is a probability of 0.4 that such an effect, though putatively present, would not be considered statistically significant at the one-sided significance level of 0.05.

CONCLUSIONS

The greenhouse effect is here monitored without the superfluous complications of AOGCM climate models. The present method shows directly whether the global average infrared absorption properties of the atmosphere are changing or not. In general, if there has been global warming due to any cause, its possible correlation with

infrared absorption properties of the atmosphere will be directly apparent from accurate observations assessed by calculations of the absorption properties. The present results show an apparent warming associated with no apparent change in the absorption properties. Change in absorption properties cannot have been the cause of the warming.

The results show that the theoretical CO_2-induced virtual increase in true greenhouse-gas optical thickness greatly exceeds the actual empirically measured change over the 61-year dataset. The fact that the virtual change is about four times the actual change is strong empirical evidence that there is a very strong dynamic compensation that stabilizes the atmospheric energy transport process against a potential perturbation by CO_2 change. This means that the empirically estimated virtual feedback of water vapor effect on the greenhouse-gas optical thickness is not significantly positive contradicting the IPCC doctrine of it being strongly positive. It is clear from these data that the increase in surface temperature shown in Fig. 9 cannot in the least be accounted for by any effect of CO_2 on greenhouse gas optical thickness, with or without positive feedback by water vapor. Merely empirical evidence does not necessarily justify predictions of the future: for them, in addition to empirical evidence, some logical warrant of generality is needed. Such a warrant of generality is usually called a physical theory. In order to predict the future, we need a principled physical theory to explain our empirical observations. The present paper has restricted its attention to the empirical observational testing of the quasi-all-sky model, and has avoided theoretical analysis. These empirical results could well be challenged by a comparable empirical method.

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THE THERMODYNAMIC RELATIONSHIP BETWEEN SURFACE TEMPERATURE AND WATER VAPOR CONCENTRATION IN THE TROPOSPHERE

William C. Gilbert
170 Weston Road, Arden, North Carolina 28704 USA
wgilbert@bellsouth.net

ABSTRACT
The theoretical and empirical thermodynamics discussed in this paper explain the physics behind the observed reduction in relative humidity in the upper troposphere as surface temperature and surface humidity increase. This contradicts the physics embedded in current GCM models commonly used by the climate science community. The key to the physics discussed in this paper is the understanding of the relationship between water vapor condensation and the resulting PV work energy distribution under the influence of a gravitational field. New analyses of empirical, observational radiosonde data are presented which show the relationship between thermal energy and PV work energy resulting from this water vapor condensation process.

INTRODUCTION

There has been much discussion in the literature concerning the role of water vapor in the thermodynamics of the atmosphere. In the past two decades or so, this discussion has focused on the role of water vapor as a positive feedback for the radiative forcing supposedly caused by increasing CO_2 in the atmosphere. A key assumption in this argument is that the relative humidity in the atmosphere will remain constant as the atmosphere heats or cools [1, 2]. In the case of atmospheric heating, this means that the specific humidity (g water vapor/kg air) or mixing ratio (g water vapor/kg dry air) will increase as the surface/atmosphere warms. This is based on the Clausius-Clapeyron equation which defines the increase in water evaporation as surface temperature increases. This is one of the algorithms that is included in all Global Climate Models (GCM) currently in use. There are various model and empirical estimates that range from 3% to 7% of increased evaporation for every degree Celsius increase in surface temperature [1, 2, 8].

Unfortunately the actual observational data contradict this core rational of AGW. While specific humidity levels in the lower troposphere do increase with increasing surface temperature, the specific humidity levels in the mid to upper troposphere have shown a decreasing trend over the past few decades even though surface temperatures (and tropospheric temperatures) are thought to be increasing. This is illustrated in Figures 1 and 2.

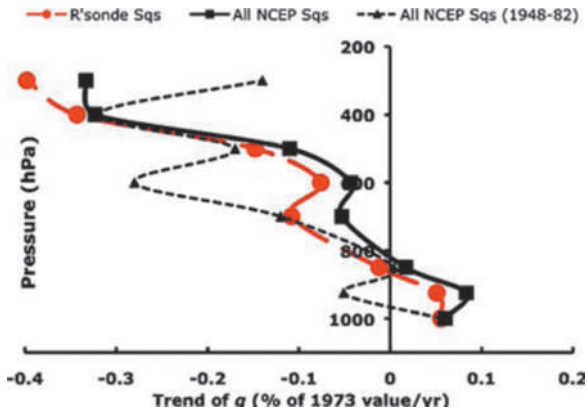

Figure 1. Comparison of the profile of the specific humidity trends obtained as an average of all National Centers for Environmental Prediction (NCEP) tropical grid squares and the profile obtained as an average only of those tropical squares in which there is an input of actual radiosonde data for the full 35-year period. Also shown is the profile obtained as an average of all tropical NCEP grid squares but for the period 1948 to 1982 (Partridge, et al. Theor Appl Climatol, February 2009).

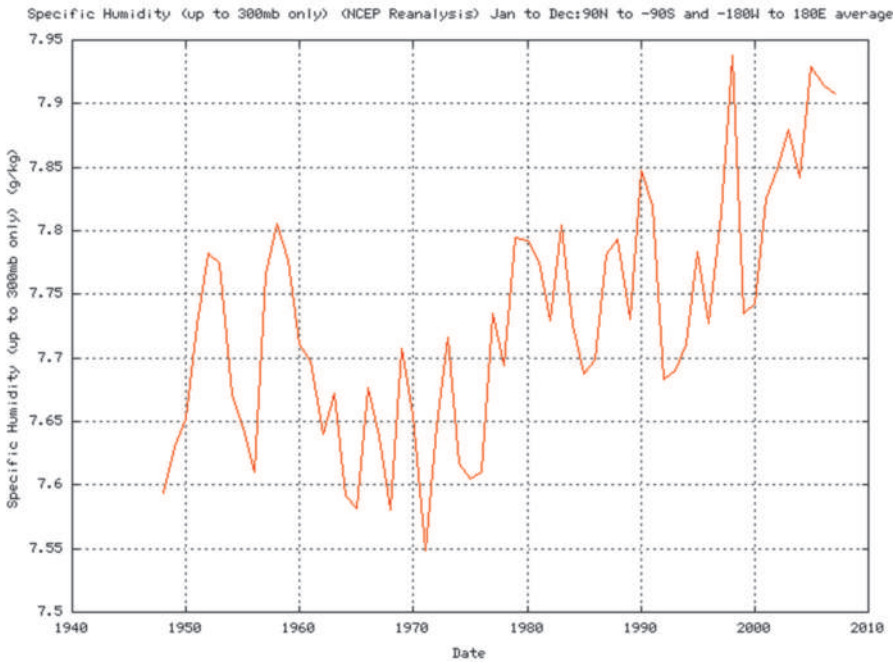

Figure 2a. 1000 mb (surface).

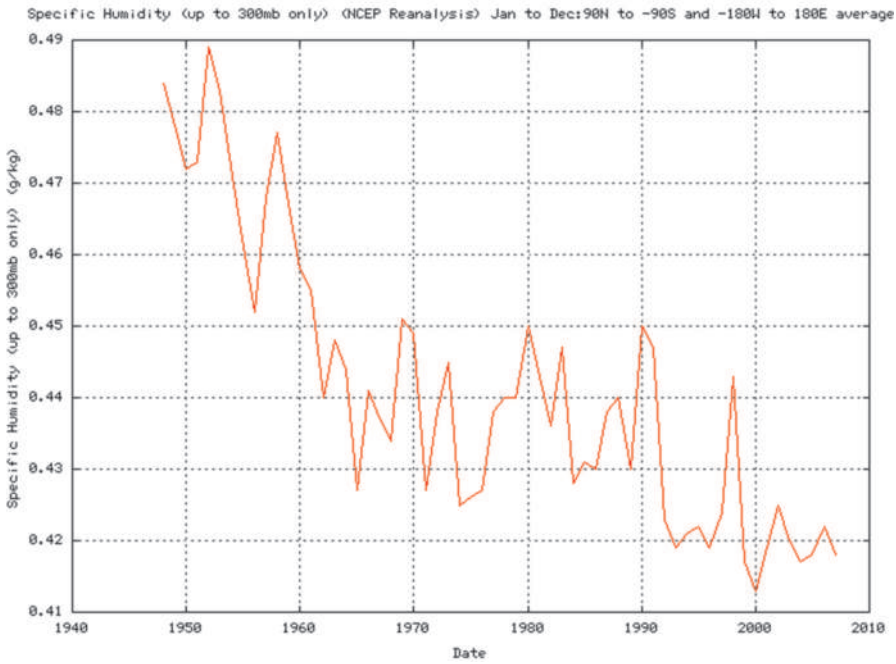

Figure 2b. 400 mb (7 Km).

Figures 2a. and 2b. From NOAA Earth System Research Laboratory database (ESRL) for surface and 7 km elevations. (Note: the reference to 300mb at the top of each chart refers to the maximum elevation available for the ESRL humidity measurement database)

As stated in the abstract of Partridge, et al, 2009 [3]: "The upper-level negative trends in q are inconsistent with climate-model calculations..... Negative trends in q as found in the NCEP data would imply that long-term water vapor feedback is negative—that it would reduce rather than amplify the response of the climate system to external forcing such as that from increasing atmospheric CO_2". Thus, there is something amiss in the physics embedded in the climate models. Solomon et al., 2010 [4] have also noted a drop in water vapor concentrations in the stratosphere over the last decade. This may or may not be related to the water vapor decline in the troposphere outlined by Partridge.

The rest of this paper will 1) outline the pertinent classical thermodynamics/meteorology and 2) present new, empirical, observational radiosonde data analyses that explain this humidity profile phenomenon.

THE PHYSICS BEHIND THE HUMIDITY PROFILE IN THE TROPOSPHERE

The physics/thermodynamics that describe the empirical findings in this paper have long existed in the classical texts of thermodynamics/meteorology. But it should be worthwhile to review them prior to looking at the observational radiosonde data analysis that explains the humidity profiles we see in the troposphere.

First let's start with the basic process equation for the first law of thermodynamics (Note that all units of measure for energy in this discussion assume intensive properties, i.e., per unit mass):

$$\mathbf{dU = dQ - PdV} \tag{1}$$

where **dU** is the change in total internal energy of the system, **dQ** is the change in thermal energy of the system and **PdV** is work done to or by the system on the surroundings.

But equation (1) applies to a system that is not influenced by external fields. Since the atmosphere is under the influence of a gravitational field the first law equation must be modified to account for the potential energy portion of internal energy that is due to position:

$$\mathbf{dU = dQ + gdh - PdV} \tag{2}$$

where **g** is the acceleration of gravity (9.8 m/s^2) and **h** is the mass particle vertical elevation relative to the earth's surface.

The thermal energy component of the system (**dQ**) can be broken down into two distinct parts: 1) the molecular thermal energy due to its kinetic/rotational/ vibrational internal energies (**CvdT**) and 2) the intermolecular thermal energy resulting from the phase change (condensation/evaporation) of water vapor (**Ldq**). Thus the first law can be rewritten as:

$$\mathbf{dU = CvdT + Ldq + gdh - PdV} \tag{3}$$

where **Cv** is the specific heat capacity at constant volume, **L** is the latent heat of condensation/evaporation of water (2257 J/g) and **q** is the mass of water vapor available to undergo the phase change.

The relationship between **T**, **P** and **V** is also defined in the ideal gas law which is applicable in the predominately diatomic gaseous composition of the troposphere:

$$\mathbf{PV = nRT} \tag{4}$$

Since the troposphere has been repeatedly shown in various meteorological texts to very closely approximate adiabatic behavior, we can, for the purposes of this discussion, equate **dU = 0** in equation (3). Thus while any of the various components of internal energy in any given air parcel can vary, any variation in any given component must be offset by a corresponding inverse change in other components. The total internal energy will remain constant. As we shall see, PV work energy is very important to the understanding of this thermodynamic behavior of the atmosphere, and the thermodynamic role of water vapor condensation plays an important part in this overall energy balance. But this is unfortunately often overlooked or ignored in the more recent climate science literature. The atmosphere is a very dynamic system and cannot be adequately analyzed using static, steady state mental models that primarily focus only on thermal energy.

If we begin with an air parcel at the surface at a given surface temperature, there is an equilibrium relation between liquid water at the surface and water vapor concentration in the air parcel. The water vapor concentration (**q**) will depend on the

surface temperature, the air temperature and the air pressure. The value of **q** is established at this point.

If the surface temperature is greater than the air temperature, the surface air parcel will increase in temperature. As the air temperature increases the air parcel will respond according to equation (4) and **PV** will also increase. But since the atmosphere is not physically constrained, the system behaves as a constant pressure system and the increase in **PV** will all be primarily embodied as **ΔV**. The increase in **V** will immediately result in buoyancy of the air parcel and it will begin to rise. At this point the air parcel is for all practical purposes in adiabatic isolation (no exchange of energy with its surroundings except for PV work) and equation (3) is now operable (remember that **dU = 0**). Due to the existence of the gravitational field, there is a natural, vertical, decreasing pressure gradient from the surface to the tropopause. As a result, **dV** will increase as the parcel rises (decreasing **P**) resulting in PV work on its surroundings. But since energy is conserved in equation (3), any increase in **PdV** (a negative term when work is done on the surroundings) will result in a decrease in parcel temperature (thermal energy, **CvdT**, is expended to provide the PV work) and a corresponding increase in potential energy (**gdh**) due to the parcel vertical displacement (PV work is exchanged for potential energy). This exchange of internal energy components (thermal energy to PV work energy to potential energy) will continue as long as the parcel has positive buoyancy and rises. Thermal energy (**CvdT**) will decrease and potential energy (**gdh**) will increase.

We have now accounted for 3 of the 4 independent variables in equation (3) in describing the process known as convection. Heat has been transferred from the surface to the mass particles in the air parcel and the heated air/mass parcel is being transported vertically. Convection is both a heat and mass transfer process. Once heat is transferred, the driving force for the mass transfer is the gravity induced decreasing ΔP profile with altitude. (Note: the larger scale meridional distribution (advection, zonal temperature gradient, Equator-to-poles heat transfer etc.) is not being covered in this analysis but these can also be explained via classical thermodynamics/ meteorological treatments).

Now we can deal with the latent heat component of equation (3). The baseline value of **q** (specific humidity) is established at the surface where the parcel may or not be in steady state equilibrium with the surface liquid and saturated. If saturated, some of the water vapor will almost immediately begin to condense during convection due to the decreasing temperature (offset somewhat by the decreasing pressure). If not saturated, condensation will begin at a higher altitude. Condensation releases a very large quantity of heat as compared to other heat transfer processes. Compare the value of latent heat, 2257 J/g, to the heat capacity of water vapor, 2.1 J/g-K. Condensation can alter the convection process (heat and mass transfer) by orders of magnitude. When condensation occurs, heat is immediately transferred to the air parcel mass, dramatically increasing **T**. **Ldq** decreases and **CvdT** increases. But as we saw at the surface, any increase in **T** must result in a corresponding increase in **PV** (equation (4)). Thus the thermal energy transferred from **Ldq** to **CvdT** must also result in a transfer of thermal energy from **CvdT** to work energy **PdV**. This whole process will result in an increase in temperature but possibly an even larger increase in PV work. Thus

understanding this PV/thermal energy ratio profile is critical in understanding the thermodynamics of the troposphere.

This ratio of thermal energy released versus PV work energy created is the crux of the physics behind the troposphere humidity trend profile versus surface temperature. But what is it that controls this energy ratio? It turns out that the same factor that controls the pressure profile in the troposphere also controls the tropospheric temperature profile and the PV/thermal energy ratio profile. That factor is gravity. If you take equation (3) and modify it to remove the latent heat term, and assume for an adiabatic, ideal gas system CpT = CvT + PV, you can easily derive what is known in the various meteorological texts as the "dry adiabatic lapse rate":

$$\mathbf{dT/dh = -g/Cp = 9.8\ K/km} \tag{5}$$

Thus the temperature profile of a steady state dry troposphere is solely a function of the heat capacity of the troposphere and the gravitational constant. This profile is independent of the temperature of the troposphere itself. This is also the equilibrium lapse rate for a steady state dynamic flow where no latent heat is involved. Thus the atmosphere tries to reach a dynamic equilibrium or an equilibrium rate of change [5, 9]. This lapse rate is established by the physics surrounding the convective flow process that was described at the beginning of this section. As an air parcel expands and rises, thermal energy (**CvdT**) is converted to PV work energy (**PdV**) which results in an increase in potential energy (**gdh**). Thermal energy is traded off for potential energy (conservation of energy). Without the internal input of latent heat the temperature declines at a rate of 9.8 K/km. Take a thermal snapshot of the dry ascending parcel every km and you will see this temperature profile or very close to it.

Keeping this gravitational steady state equilibrium in mind, let's look again at what happens when latent heat is released (condensation) during air parcel ascension. Latent heat release immediately increases the parcel temperature. But that also results in rapid PV expansion which then results in a drop in parcel temperature. Buoyancy results and the parcel ascends and is driven by the descending pressure profile created by gravity. The rate of ascension, and the parcel temperature, is a function of the quantity of latent heat released and the PV work needed to overcome the gravitational field to reach a dynamic equilibrium. The more latent heat that is released, the more rapid the expansion/ascension. And the more rapid the ascension, the more rapid is the adiabatic cooling of the parcel. Thus the PV/thermal energy ratio should be a function of the amount of latent heat available for phase conversion at any given altitude. The corresponding physics shows the system will try to force the convecting parcel to approach the dry adiabatic or "gravitational" lapse rate as internal latent heat is released.

For the water vapor remaining uncondensed in the parcel, saturation and subsequent condensation will occur at a more rapid rate if more latent heat is released. In fact if the cooling rate is sufficiently large, super saturation can occur, which can then cause very sudden condensation in greater quantity. Thus the thermal/PV energy ratio is critical in determining the rate of condensation occurring. The higher this ratio, the more complete is the condensation in the parcel, and the lower the specific humidity will be at higher elevations.

Empirical Observations to Verify the Physics

Figures 3, 4 and 5 represent an analysis of three sets of radiosonde soundings taken at Miami, Florida in 2009. I downloaded this data last year as part of another project. (Radiosonde sounding raw data are courtesy of the University of Wyoming, College of Engineering, Department of Atmospheric Science). The soundings were taken on the morning and evening of 6/18/09 and on the morning of 6/27/09 approximately one month later. The soundings represent three varying levels of both surface temperature and specific humidity (mixing ratio). As surface temperature increases so does the specific humidity, as would be expected from the Clausius-Clapeyron equation.

The bold solid line curve in each graph is the actual temperatures recorded during the radiosonde sounding. The dotted line curve (Dry Adiabat) represents the theoretical

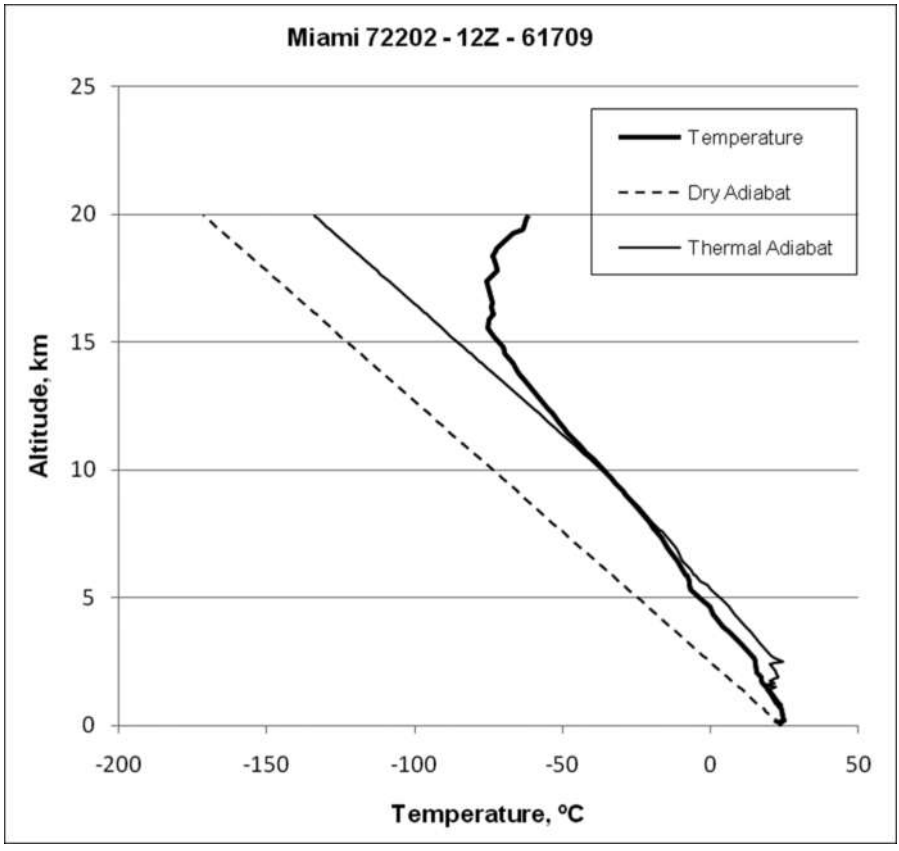

Figure 3. Miami 72202 – 12Z – 61709

- Date/Time: 6/18/09 7AM
- Surface Temperature (1000 hPa) = 23.6 °C
- Surface Mixing Ratio (g water vapor/kg dry air at 1000 hPa) = 17.07
- Lower Troposphere Lapse Rate (ºC/km) = 7.0

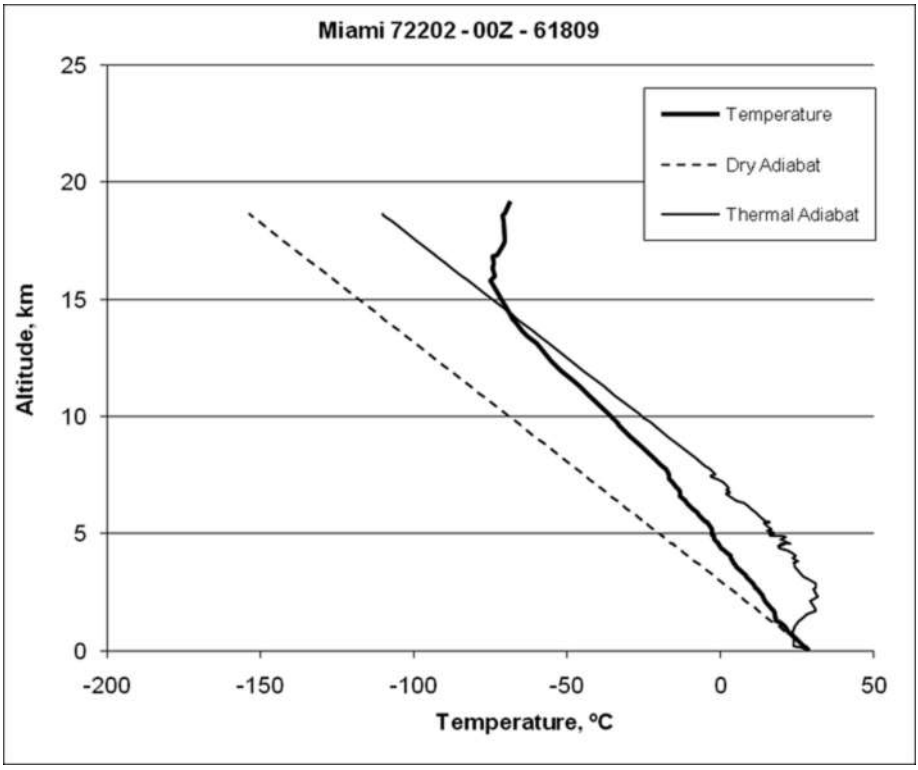

Figure 4. Miami 72202 – 00Z – 61809
- Date/Time: 6/18/09 7PM
- Surface Temperature (1000 hPa) = 27.8 °C
- Surface Mixing Ratio (g water vapor/kg dry air at 1000 hPa) = 20.06
- Lower Troposphere Lapse Rate (ºC/km) = 5.9

dry adiabatic lapse rate of 9.8 °C/km. The thin solid line curve (Thermal Adiabat) is the temperature profile that would occur if all latent heat released at all altitudes were converted 100% to thermal energy (temperature). This is calculated based on the reduction in mixing ratio at each reading at altitude and is added to the temperature of the Dry Adiabat at that altitude. This is cumulative beginning at the surface. Thus the ΔT between the Dry Adiabat and the actual temperature represents the latent heat that was released and converted to thermal energy. The ΔT between the actual temperature and the Thermal Adiabat represents the latent heat that was released and converted to PV energy. The Dry Adiabat is the baseline since it is the theoretical temperature profile if **Ldq** = 0.

There are several general observations that should be noted:

- The surface temperature differential between the maximum and minimum soundings is 4.2 °C with the 7PM temperature being the highest.

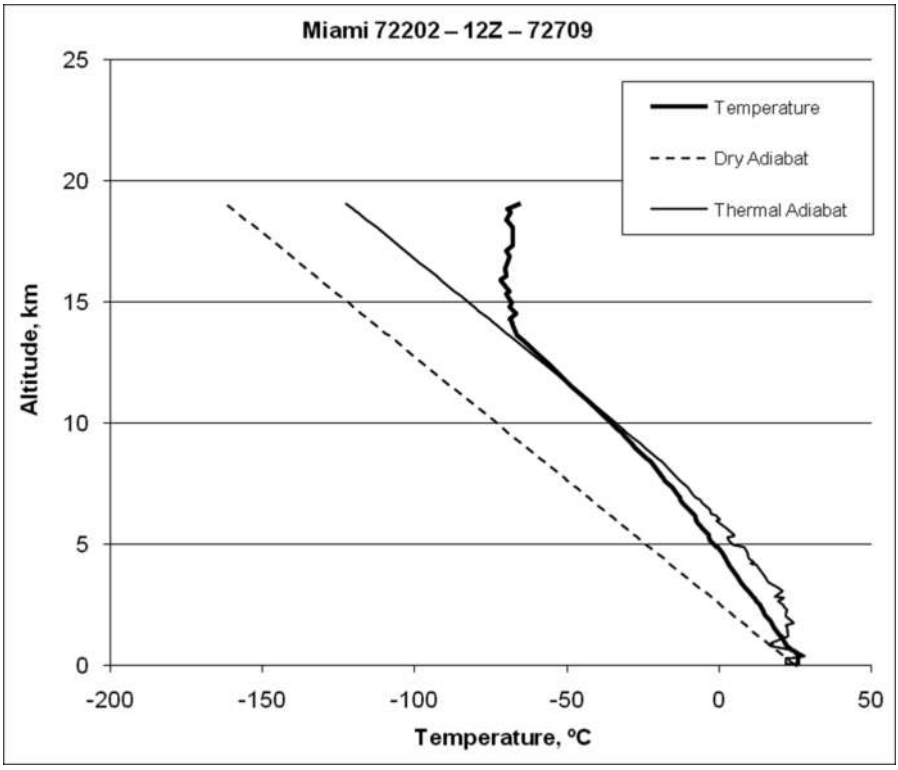

Figure 5. Miami 72202 – 12Z – 72709
- Date/Time: 7/27/09 7AM
- Surface Temperature (1000 hPa) = 25.8 °C
- Surface Mixing Ratio (g water vapor/kg dry air at 1000 hPa) = 18.17
- Lower Troposphere Lapse Rate (ºC/km) = 6.3

- The surface mixing ratio differential between the maximum and minimum soundings is 2.99 g/kg with 7PM being the highest. This roughly represents ~4.2% increase in specific humidity for every degree increase in temperature, but this varies between the soundings.
- The lower troposphere lapse rate decreases (slower rate of cooling) with increasing system surface humidity levels, as expected. But the differences in lapse rate are far less than expected based on the relative release of latent heat occurring in the three systems.
- The amount of PV work that occurs during ascension increases markedly as the system surface humidity levels increase, especially at lower altitudes. This is quantified below.
- PV work energy (and thus latent heat release) is at a maximum between 2.0 km and 2.5 km.

- Latent heat release is effectively complete at 7.5 km for the highest surface humidity system (20.06 g/kg) but continues up to 11 km for the lower surface humidity systems (18.17 and 17.07 g/kg). The higher humidity system has seen complete condensation at a lower altitude, and a significantly higher temperature (−17 ºC) than the lower humidity systems (~ −40 ºC) despite the much greater quantity of latent heat released.

This leads to the following conclusions:

- Due to the existence of the gravitational field and the resulting pressure profile, the system will always try to approach a dynamic equilibrium represented by the dry adiabatic lapse rate (black curve).
- When a higher concentration of surface water vapor exists, which subsequently condenses thus releasing more latent heat, more work energy (**PdV**) will be needed to convectively cool the parcel and move the temperature profile closer to the dry adiabatic lapse rate.
- The wetter system will convert a greater portion of the released latent heat towards work energy (**PdV**) versus thermal energy (**CvdT**). The *rate* of expansion/convective flow will increase and the *rate* of condensation will increase.
- Note that the wet adiabatic lapse rate does not reach the dry adiabatic lapse rate even after condensation ceases. This is partly, if not primarily, due to subsiding air that is converting potential energy to thermal energy via adiabatic heating which is mixing with the upward convecting air. The subsiding air is increasing temperature at +9.8 ºC/km, the dry adiabatic lapse rate).

Now, if we look more closely at the distribution of latent heat conversion to thermal and PV energy, the difference between the three soundings becomes striking (Figure 6). For the lower surface humidity systems (7AM), the percentage of latent heat energy that is converted to thermal energy is always greater than that which is converted to PV work energy. The latent heat conversion to PV energy reaches a maximum at ~40%. The maximum PV/Thermal energy ratio is 0.8 for these two systems. However in the higher surface humidity system (7PM) the latent heat conversion is overwhelmingly directed to PV work energy at the lower elevations, exceeding 80% at its maximum. The maximum PV/Thermal energy ratio is 4.3, more than five times that of the lower surface humidity systems. This results in a marked increase in the rates of expansion, convection and adiabatic cooling and thus a marked increase in the rate of condensation for the higher surface humidity system.

If we look at the cumulative latent heat release for the three systems, the thermodynamic behavioral differences become clearer (Figure 7). The higher the surface humidity in a system, the more latent heat it has to release and it releases it at a much faster rate. The 7PM weather system (20.06 g/kg) has released as much latent heat at approximately 5 km as the lower humidity systems have released at 7 km and 10 km respectively. This reflects the much larger PV/thermal energy ratio and suggests a much more intense convective expansion and velocity. Condensation occurs much more rapidly and efficiently as surface humidity of the system increases.

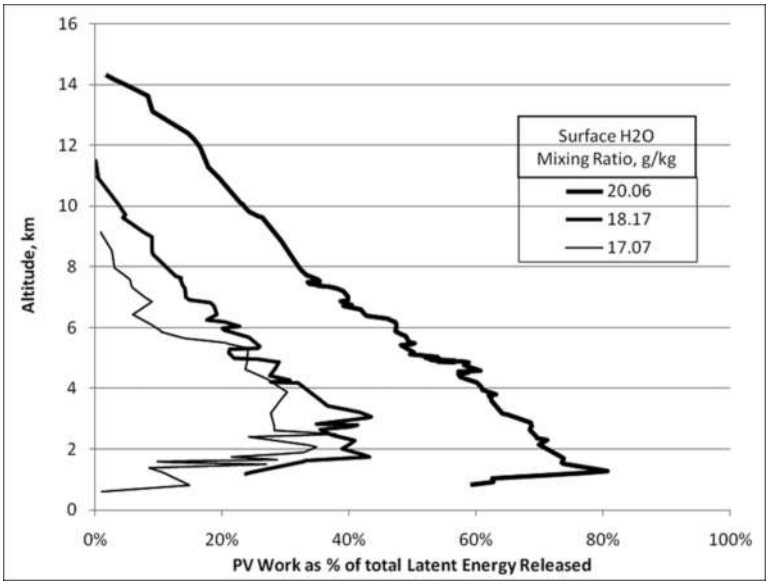

Figure 6. PV Work Energy as a Percentage of Latent Heat Energy Released.

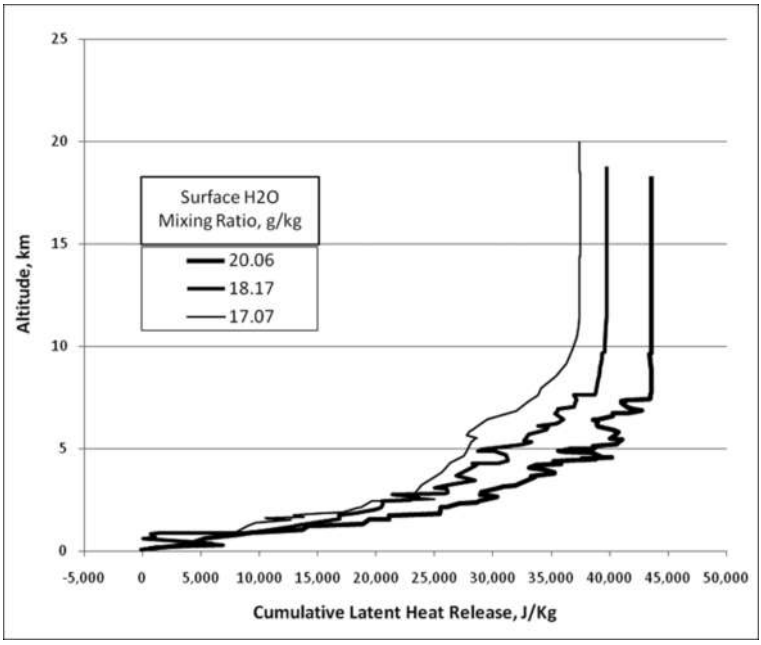

Figure 7. Cumulative Latent Heat Release.

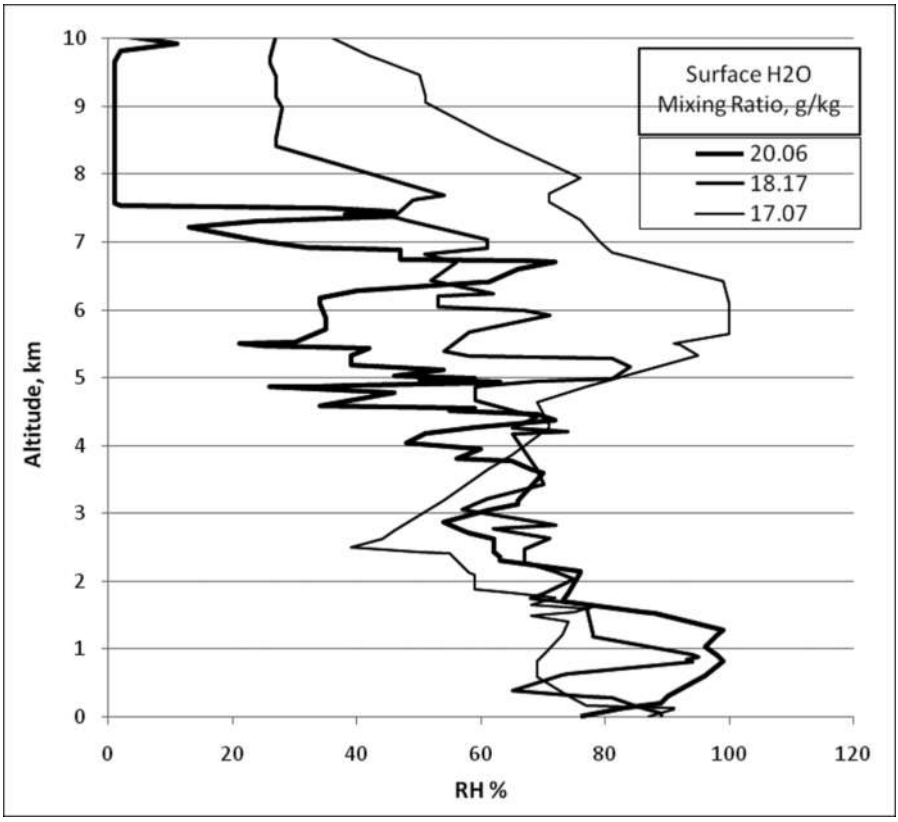

Figure 8. Relative Humidity vs. Altitude.

But how does all this translate into humidity profiles at different altitudes? This is illustrated in Figure 8. At lower altitudes (below 4 km), all three systems show a gradual but erratic decline in RH with increasing altitude. But at higher altitudes (above 4 km) the three systems begin to diverge with the higher surface humidity systems showing a higher rate of RH decrease. In contrast the lowest surface humidity system (17.07 g/kg) shows an actual increase in RH at middle troposphere elevations. At higher elevations, the differences in RH between the three systems become more and more pronounced. The wettest system at the surface actually approaches zero RH in the upper troposphere.

CONCLUSION

The theoretical and empirical physics/thermodynamics outlined in this paper predict that systems having higher surface temperatures will show higher humidity levels at lower elevations but lower humidity levels at higher elevations. This is demonstrated in the empirical decadal observational data outlined in the Introduction, in the daily radiosonde data analysis discussed above and explained by classical thermodynamics/meteorology relationships. This theoretical and empirical analysis contradicts the current GCM

computer models. The physics embedded in the GCM models predict a constant relative humidity throughout the troposphere as surface temperature increases. As a result, these models imply a positive feedback from water vapor as surface temperature and specific humidity increase. The key to understanding the actual observed atmospheric humidity profile is to properly take into account the physics/thermodynamics of PV work energy in the atmosphere resulting from the release of latent heat of condensation under the influence of the gravitational field. The current physics underlying the GCM models appear to be incorrect. If anything, the actual behavior of water vapor with increasing surface temperature as outlined in this paper would imply a negative feedback. The observational data leaves little room for doubt

The contents of this paper may also have relevance for the work of Ferenc Miskolczi [6, 7] in that his radiosonde analysis shows that over the decades, as CO_2 concentrations have increased, water vapor concentrations at higher elevations have decreased yielding offsetting IR absorbance properties for the two greenhouse gases. That offset results in a constant Optical Depth in the troposphere. The results in this paper, while supporting the decadal decreasing water vapor concentration in the upper atmosphere, apply to any increase in surface temperature for whatever cause. It is not specific to CO_2 forcing. The same physics/thermodynamic processes will dominate whether the increasing surface temperature is due to CO_2, solar variability, PDO, AMO, cosmic rays, etc...

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NOTE ON THE MISKOLCZI THEORY

Dr (hc) Noor van Andel
Fiwihex bv.. In sustainable energy innovation
Burgemeester Stroinkstraat 341,
7547 RH Twekkelo The Netherlands
noor@xs4all.nl

ABSTRACT
The Miskolczi theory of our atmosphere is summarized. The main relations of the radiative and non-radiative heat fluxes are derived. The physical control mechanisms that keep the atmospheric fluxes bound to these relations are described. The physical mechanisms of climate change that are published and that are compatible with this theory are mentioned. In an appendix the main analytical derivation of Miskolczi is explained.

1. INTRODUCTION

I have written this note in answer to a question from the KNMI, the Dutch weather institute. The new theory is so different from the usual stream of thought on climate change, that many are either confused, or revolt or embrace this theory without really having penetrated it.

2. FIXED ENERGY FLUX RATIOS

Neglect P^0: in a period much longer than the one-month time constant of heating the 100 m top mixed ocean layer, P is very small. $S_G = S_U$ when the surface radiates as a black body. See flux diagram below from [1]; the theory is published in [1,2].

Overall balance: F^0 = OLR. Atmosphere balance: $F + K + A_A - E_U - E_D = 0$. Surface: $F^0 - F + E_D - K - S_G = 0$. Arrow joints: $OLR = S_T + E_U$, $S_U = A_A + S_T$.

Measurements: $A_A = E_D$; $2E_U = S_G$; $3E_D = 5E_U$. See the two lines in the graph taken from [2]; surface temperatures range here from –40 ºC to + 37 ºC. There is no "standard atmosphere", these three relations hold for all climates, from the polar night to the tropical ocean afternoon.

Every point is the result of Hartcode line-by-line calculations of upward E_U and downward E_D energy fluxes from one of hundreds of radiosonde measurement series of humidity, temperature and pressure. With these three relations, together with the energy balances over atmosphere and surface and the known value for the net insolation F^0, there is only one degree of freedom left that is the ratio F/K. This ratio is not at all constant; during the polar night or winter F = 0, but K is relatively large; there is a large horizontal non-radiative heat flux from the tropics to higher latitudes, dominating the climate. The 3 points on the extreme right are from desert climates where there is no water to evaporate and K is limited to sensible heat transfer.

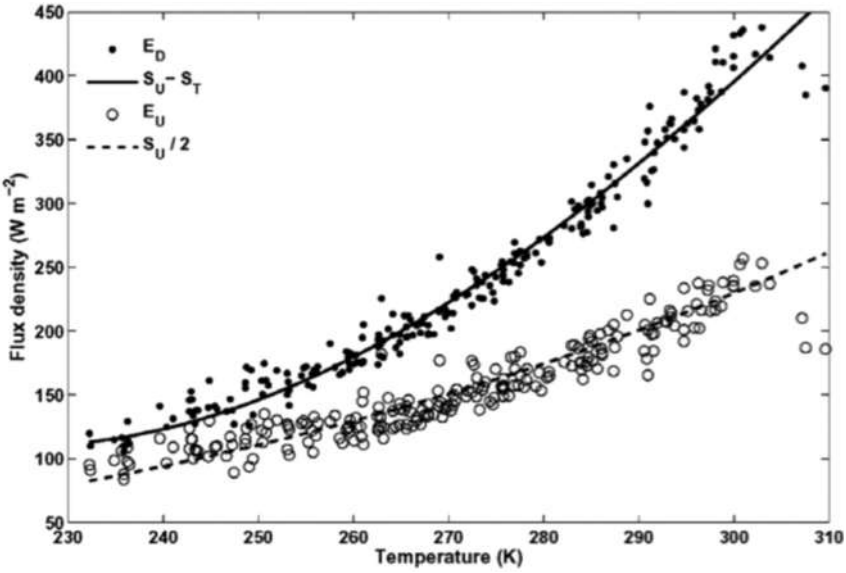


Figure 1. Dependence of E_D and E_U fluxes on surface temperature. The solid line is a parabolic fit to the absorbed fluxes and the dashed line is the fit to the half of the surface upward fluxes.

Putting a value on the F^0 of 12, in units of 21 W/m^2 in order to get simple numbers, we can solve the 8 equations: 3 balances, 2 arrow joint relations of the diagram below from [2] and the 3 measurement relations of the graph above. We get 8 values for the fluxes:

$F^0 = 12$, OLR = 12, F + K = 9, $E_D = 15$, $A_A = 15$, $E_U = 9$, $S_G = 18$, $S_T = 3$. [$P^0 = 0$]

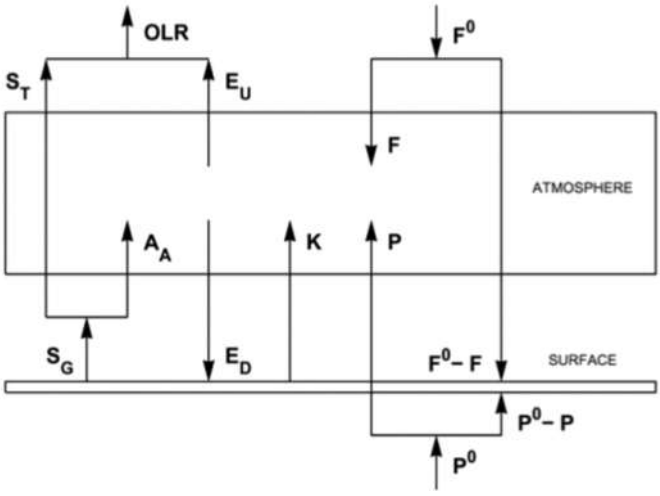


Figure 2. Radiative flux components in a semi-transparent clear planetary atmosphere. Short wave downward: F^0 and F; long wave downward: E_D; long wave upward: OLR, E_U, S_T, A_A, and S_G; Non-radiative origin: K, P^0 and P.

This is a remarkable result. It means that the greenhouse factor is not a free variable: OLR is 2/3 of S_U. The optical density is $\ln[S_U/S_T] = \ln[18/3] = 1.8$. This value, see appendix, is the same as the theoretical value resulting from Miskolczi's new solution [different from the 1922 Eddington approximation] of the Schwarzschild-Milne radiation equation for a bounded semi-transparent atmosphere, with 1] the bottom boundary condition that the surface temperature is equal to the air temperature just above it, and 2] the top boundary condition that the downward radiation is zero, and further the assumption that 3] the radiation energy loss from the top of the atmosphere is maximal with given S_G. It is equal to the long-time measured value in the NOAA-NCEP database. It is equal to the aggregate value in the TIGR radiosonde database.

To summarize the main features of Miskolczi's theory:

- The heat transfer from surface to atmosphere is only by convection, not by radiation.
- We do not need to know the composition of the atmosphere.
- We do not need to subdivide atmosphere into troposphere and stratosphere
- We do not need to differentiate between low and high latitudes; the theory holds everywhere.
- We do not need to differ between low & high clouds, only their total albedo effect matters.
- The surface temperature T_S is only coupled by $S_U = T_S^4 = 1.5\ F^0$ to the net SW absorption F^0.
- There is no "greenhouse gas", no "forcing", no "feedback", no "climate sensitivity".
- The cloudy sky moves to that equilibrium effective optical density whereby the net absorbed solar heat can be reradiated out into space with the minimum greenhouse effect, minimum surface temperature or maximum entropy production.

3. PHYSICAL MECHANISMS

Now there are three questions that arise:

1 What is the mechanism that makes $A_A = E_D$?
2 What is the mechanism that makes $E_U = S_U/2$?
3 What are the mechanisms that cause large climate changes such as ice ages, notwithstanding this fixation of flux relations, and notwithstanding an almost constant extraterrestial solar flux?

3.1. The Mechanism Behind $A_A = E_D$

This is a consequence of the atmosphere being everywhere at LTE or Local Thermodynamic Equilibrium. We can measure a real temperature at least up to 60 km height. Because of the fact that IR absorbing gases are minor components of our atmosphere and the maximum thermal emission intensity is the emission from the surface that is in thermal contact with the atmosphere, the frequency of collisions of excited molecules that quench the excited state is many orders of magnitude higher

than the inverse of the life time of the excited state. So, any emission is of purely thermal origin, any absorption cross section is therefore equal to the emission probability.

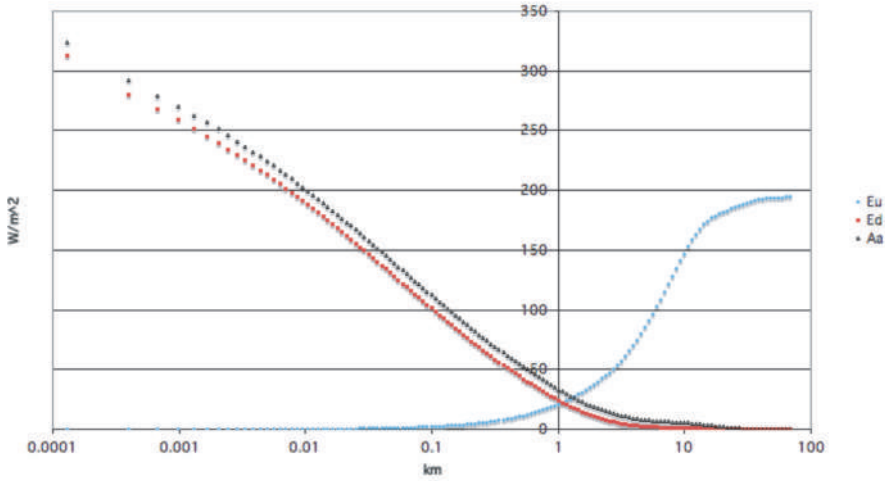


Figure 3. Eu, Ed, Aa as function of height, linear / logarithmic scale

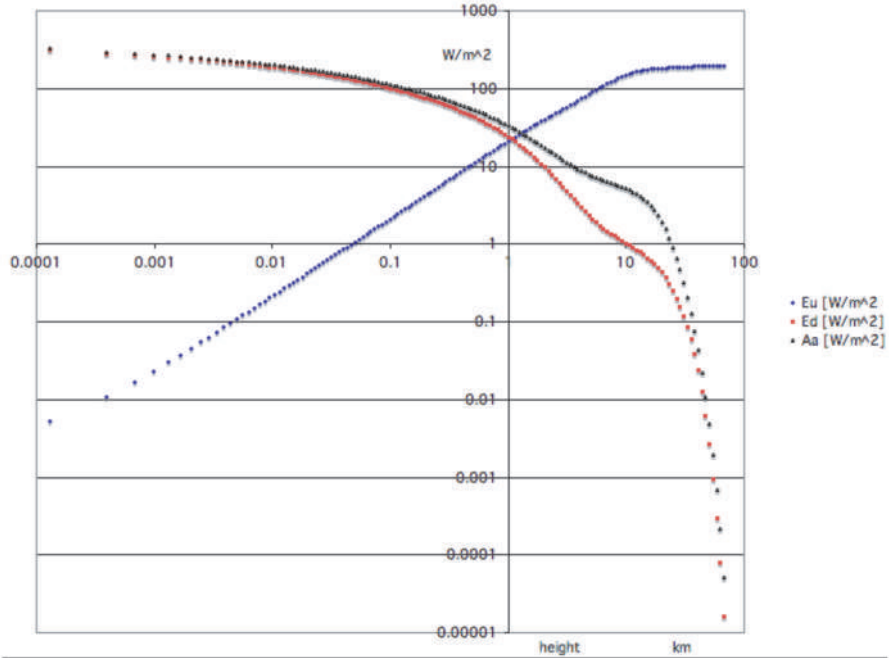


Figure 4. Eu, Ed, Aa as function of height, log / log scale

3.2. The Control Mechanism for $E_U = S_U/2$

The answer can only be that the main "greenhouse gas", i.e. water, is available in unlimited supply and finds its way into the atmosphere to control the flux relations.

We know from measurements; TOGA-COARE-IOP in this case, that increased latent heat flux, the main component of K, goes along with drying the atmosphere above the cloud base, or over the turbulent boundary layer. In the period between 1973 and 1997 in the tropical West-Pacific the sea surface temperature rose with only 0.4 ºC, the latent heat flux increased 15 W/m^2, or about 9%, the water content changed +1.3% at 1000 mB, –6.8% at 925 mB, –10% at 850 mB, and –29% at 500 mB, causing a large decrease of local atmospheric optical density. Both effects caused an increase of $E_U = F + K$ and therefore of the $OLR = S_T + E_U$. In this way the surface temperature is tightly controlled: If S_U would rise with 15 W/m^2, then Ts would rise with 2.5 ºC, 6 times more as it did. The measured differentials, albeit local in nature, are larger than can be related to increased CO_2 concentration that rose in this period from 330 to 380 ppmv, or 8.6%. A relative change in upper tropospheric humidity [UTH] has a 10 times larger relative IR transparency effect as an equal relative CO_2 change has: d [OLR]/d [UTH] = 0.4 W/[m^2%]. d [OLR]/d [CO_2] = 0.04 W/[m^2%]. Paltridge et al. [3] find that the climate sensitivity for a CO_2 doubling changes from 1.6 ºC with unchanging relative humidity, onto 0.4 ºC when the currently observed drying trend, i.e. the numbers above cited, is taken into account.

We have an idea how the control mechanism works, as long as the water partial pressure is able to influence the optical density. Now we come to the attractor, or "set point" of the control that point whereby $E_U = S_U/2$. The fluxes are controlled so that the conversion of F^0 into OLR proceeds with the lowest surface temperature possible,

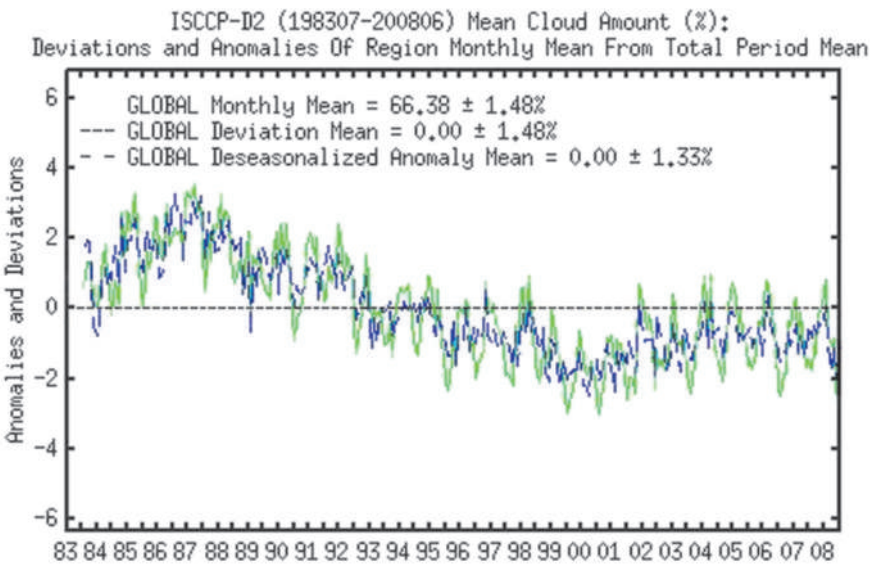


Figure 5. Cloud cover time series 1983-2008

i.e. with the highest entropy production, as with all thermal dissipation. We find maximal entropy production [MEP] in all thermal dissipation processes: The temperature distribution over successive radiation screens, the turbulent flow in boiling fluids and in thermal convection all cause MEP.

3.3. Climate Change Mechanisms

3.3.1. The recent climate change

We have 9 fluxes constrained by 8 relations, so there is only one degree of freedom.

In the long run, the only way to change the climate is to change F^0, the net absorbed solar shortwave energy. P and P^0 can be neglected on a global scale over years.

Now $F^0 = S^0/4*[1-]$ where S^0 is the solar constant, 1368 W/m^2, and is the Earth albedo, 30%, and = /2, where is the global cloud cover, 60%. So, when decreases 4%, from 68 to 64%, decreases from 34% to 32%, 1− increases from 76 to 78%, and F^0 grows by 78/76 = 2.6%. All fluxes scale by F^0 so the surface flux has to increase also 2.6%, this needs a surface temperature increase of 2.6%/4 = 0.65%, or from 288 K to almost 290 K. And the mean cloud amount **has** changed 4% in the warming period 1986–2008:

Albedo has been measured independently by Earthshine on the Moon to have decreased indeed about 2% from 1985 to 2004. This decrease explains all warming in this period [4].

On the shorter run, P and P^0 can influence the climate there where heat is transferred horizontally by sea currents. The sun heats with 147 W/m^2 a 100 m deep column of water, the time constant is the heat capacity, 4.2e6*100 J/m^{2}K, divided by the power density, 147 W/m^2, yielding 2.8e6 seconds or one month. Indeed, we see in the Pacific "Intra Seasonal Oscillations" with double this period, just like a process controller tends to oscillate with a period equal to twice the main integration time.

3.3.2. Ice ages and the PETM

The "dissipative structure" of our atmosphere is defined by that amount of sensible & latent heat transfer from surface to the TOA, E_U, that together with the IR radiation S_T from surface through the IR window can transfer the net incoming flux F^0 to the OLR with the lowest surface temperature, that is, with the highest entropy production. The rest of the solar flux is reflected without entropy production. During an ice age, the Earth is much whiter. More sunlight is reflected. The surface temperature is lower, and along the surface dissipation path the entropy production is higher. The flux relations stay the same, but F^0 and therefore all the other fluxes are smaller, and in case the solar constant has not changed, the surface temperature is lower by a relative amount of $[1-]^{1/4}$. An increase, or cloud cover increase, of 13% corresponds with a 10 ºC lower surface temperature, an ice age whereby land ice in Europe reaches 50º latitude and covers the Netherlands.

During the Paleocene-Eocene Thermal Maximum the polar temperature was 20 ºC, the tropical SST 36ºC. This would be the result of a 13% lower albedo due to less cloud cover, a stronger trade wind, drier deserts, more sensible heat transfer horizontally to the poles. We do not know what caused the low cloud cover. What we know is a large-scale anaerobic sequestration of sulphur as FeS or pyrite during this period.

4. CLOUD COVER CHANGE

So our question changes into the following one:

What causes such large cloud cover changes of +/– 13%?

Converting latent heat or water vapor content by condensation into clouds & into sensible heat requires cloud condensation nuclei [CCN]. For deep convection [**K**], the efficiency of this conversion or condensation is essential. When there are more CCN, the atmosphere becomes more opaque and the heat transfer mode in the lower atmosphere shifts more into the convective mode. F^0–F, the part of the insolation that reaches the surface, decreases. Both effects bring a cooling of the surface.

CCN are particles have at least the critical dimension, about 80–120 nm, from which a cloud water droplet can grow. Smaller droplets evaporate. There are not enough CCN for the condensation to reach equilibrium everywhere. Supersaturation is ubiquitous

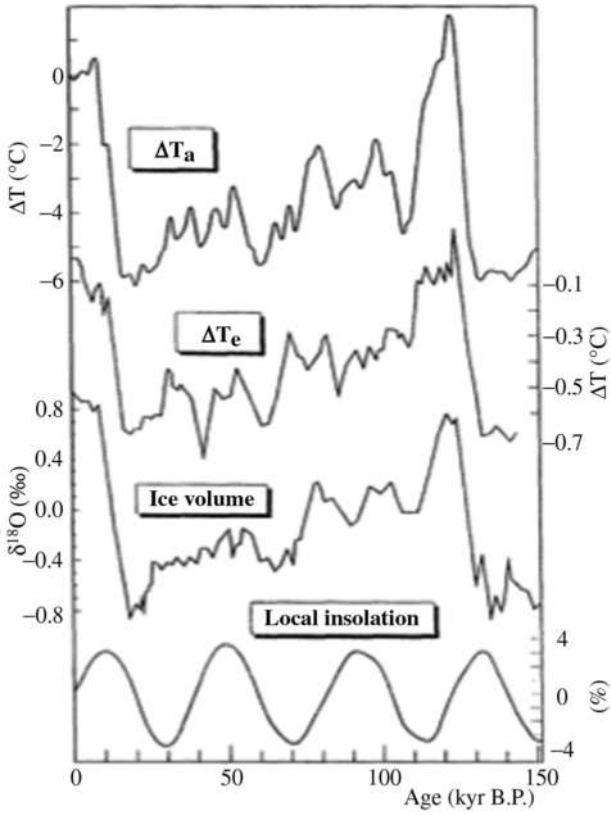


Figure 6(a). Time series of the Vostok climatic record and of climatic forcings used in the multivariate analysis: (a) atmospheric temperature change over Antarctica (Vostok record), ΔT(ºC); (b) the direct greenhouse radiative forcing accounting for CO_2 and CH_4 variations, ΔT(ºC); (c) the Δ18O SPECMAP record taken as a proxy of ice volume change (normalized value from Martinson et al., 1987) (d) percentage change in total insolation at the Vostok latitude (78ºS) during the entire year. Vostok derived curves (a and b) have been redated for the period before 110 kyr B.P. in such a way as to put in phase the Vostok temperature and the marine record.

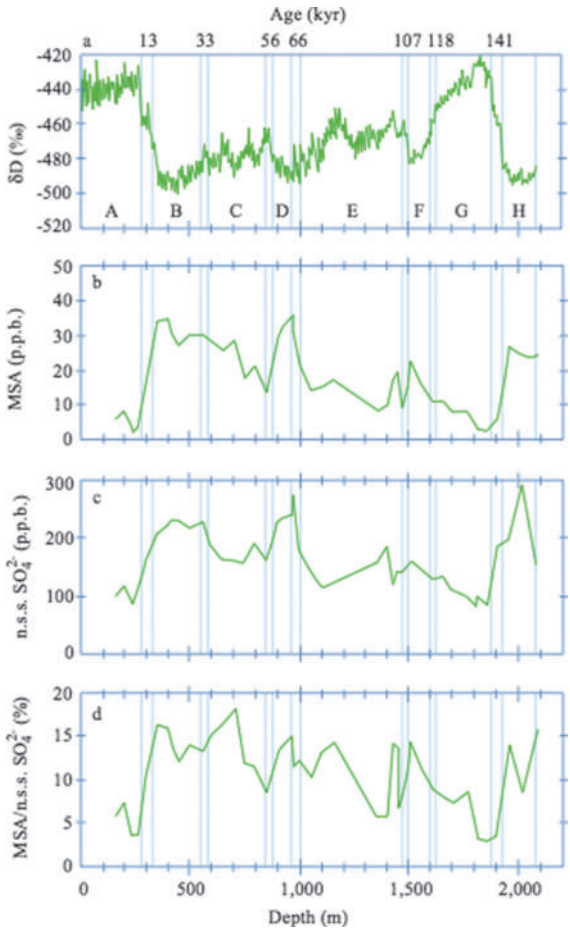


Figure 6(b). Depth profiles of a, δD, b, MSA, c, non-seasalt sulphate and d, the ratio of MSA to non-seasalt sulphate in the Vostok ice core. Upper and lower stage boundaries are marked by vertical lines. (δD is deuterium isotope profile)

above the cloud base and away from clouds. Conversion of latent into sensible heat has a wide range of efficiencies, between 95 and 5%, due to more or less CCN availability.

4.1. Sulphuric Acid

The main factor for growing CCN from the large supply of much finer particles is sulphuric acid.

When atmospheric sulphuric acid increases as a result of a volcanic eruption the global temperature decreases often several tenths of a ºC within a year.

There is a Nobel-prize-winning atmospheric chemist who proposed in earnest to inject millions of tons of sulphur into the stratosphere to replace the feared anthropogenic global warming by anthropogenic global cooling. http://www.cogci.dk/news/Crutzen_albedo enhancement_sulfur injections.pdf

If non-sea salt sulphate [sulphuric acid, not sodium sulphate] lowers the temperature, we should find more non-sea salt sulphate in ice cores during ice ages than during interglacial periods. Around 1990 we were most interested in the CO_2 content in polar ice cores, to prove that variations in the concentration of this gas caused ice ages, and moreover to suggest that there is a large amplification, almost ten times, going from the radiation forcing temperature increase to the total temperature increase. See the left graph below, iahs.info/redbooks/a208/**iahs_208_0029.pdf** that was used for this purpose. And indeed, there is a good correlation between CO_2 and the temperature proxy, here ice mass or heavy oxygen isotope ratio.

Later it turned out that the CO_2 concentration *followed* the temperature change by about 600 years, the deep mixing time of the oceans, and therefore could not be the causal factor but an effect of changing temperatures. In the left graph with its low time resolution we cannot see this lag. We see that the insolation variation, following the 41 ky Milankovitch cycle, indeed starts the first and the last of the four thawing periods, indeed preceding them with a kiloyears lead.

The right graph, due to Legrand 1992, much less widely published, from the same time and the same ice core, concentrates on **sulphate** instead of on CO_2:
http://ocw.mit.edu/NR/rdonlyres/90E02A75-CAB2-4211-9764-BF347CA8F27A/0/lec08.pdf

We see that sulphate varies almost a factor of three, high in cold and low in warm periods. In the upper graph with the Deuterium isotope ratio as a temperature proxy, we see the same temperature time series. With this resolution we cannot see if the sulphate decrease is preceding or following the temperature increase. The delay should be short however, because the sulphate dissolved in the oceans does not interact here, and is even subtracted as Na_2SO_4 to get the n.s.s. value that is relevant for the CCN production. MSA stands for [di-]methylsulphonic acid, a gaseous product from marine biota that is known to increase with temperature. Its concentrations however are more than one order of magnitude lower.

We know from experience that a major volcanic eruption causes a few years of global cooling, and that this cooling is directly connected to SO_2 emission, that oxidizes into sulphuric acid and cools by increasing albedo and cloud cover. The "year without summer", 1816, with a 3 K temperature fall in Europe, snowstorms in June, an 8-fold increase in grain prices and a hundred thousand deaths from famine, was caused by mount Tambora's 1815 explosion on the island of Sumbawa. Sulphate content of Greenland ice in 1816 was measured to be 4 times higher than in preceding and following years. Journal of Geophysical Research, Vol. 100, p. 26105, determines the maximum forcing at 97% relative humidity to be 2000 W/gSO_4^{2-}. The accepted forcing of $2xCO_2$ in the literature is $4W/m^2$ or $16W/gCO_2$ or $4^oC/[gCO_2/m^2]$. From the graphs hereunder we can derive a sulphate forcing of 6^oC/125 ppm SO_4^{2-} or 7500 $^oC/gSO_4^{2-}$. Almost 2000 times the supposed CO_2 effect.

It is remarkable that the sulphate content of ice cores correlates so well with the temperature proxy and that hydrosulphuric acid is a proven cause of climate change, but receives so little attention in the literature. During the Paleocene-Eocene Thermal Maximum, we see a strangely large sulphur isotope abundancy change, a ^{34}S minimum, the implications of which, presumably anaerobic pyrite sequestration, remain unclear.

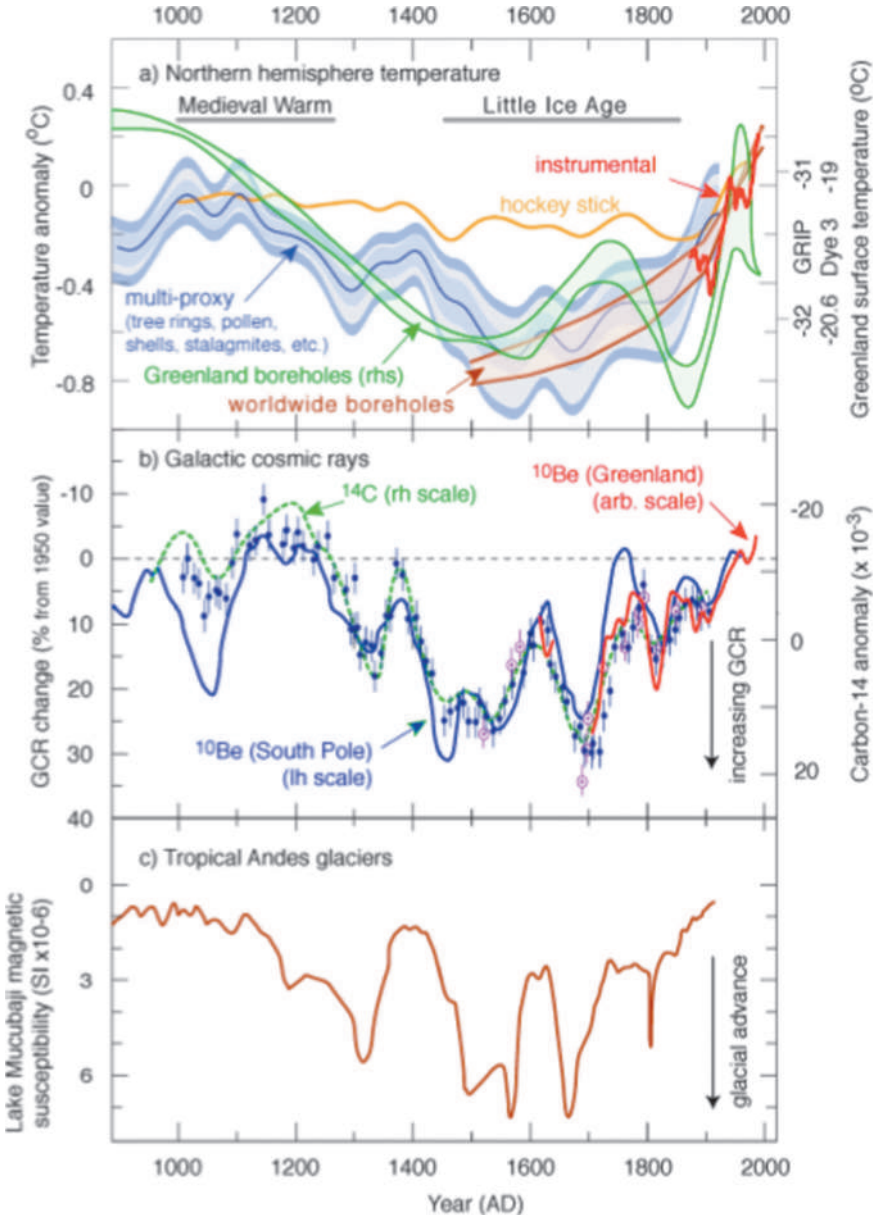


Figure 7. Climate proxies correlated with Galactic Cosmic rays proxies

4.2. Galactic Cosmic Rays

There is another remarkable correlation with temperature that has been recognized already in 1975, [5]. That is the large variation in time of galactic cosmic ray [GCR] intensity, the atmospheric production of ^{10}Be and ^{14}C, correlated with the variation of the number of sunspots and change of climate. The hypothesis is that charged electric particles created by these very energetic protons in the lower atmosphere charge and

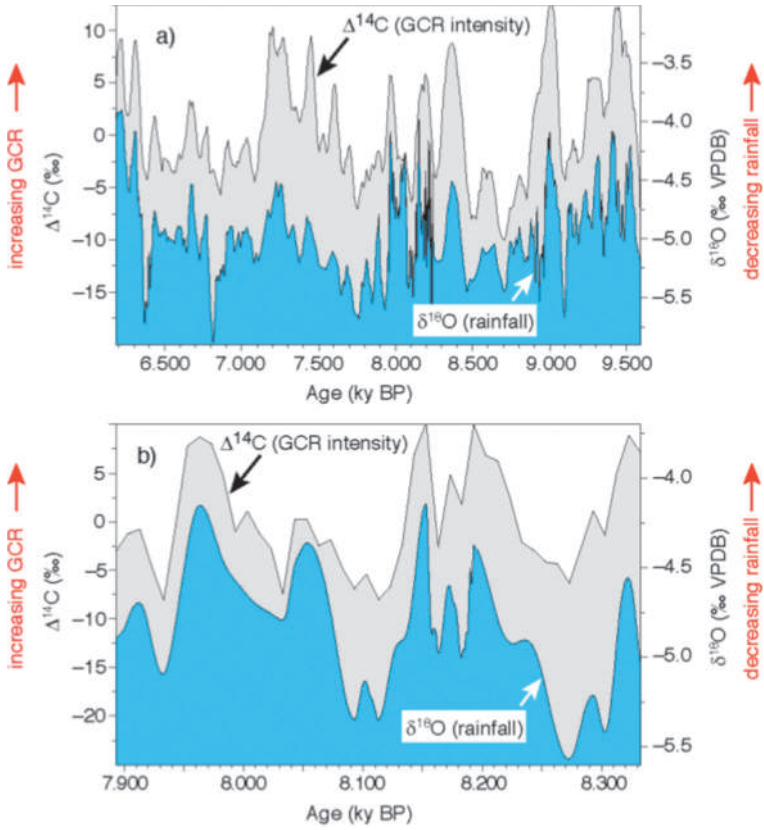


Figure 8. Profiles of δ^{18}O from a U-Th-dated stalagmite from a cave in Oman, together with Δ^{14}C from tree rings in California bristlecone pines and elsewhere, for a) the 3.4 ky period from 9.6 to 6.2 ky BP (before present) and b) the 430 y period from 8.33 to 7.9 ky BP [65].

therefore enhance the coalescence of H_2SO_4 pre-condensation nuclei. The correlation with climate is extraordinary on any time scale, see the three following graphs from CERN-PH-EP/2008-005: We see that only one curve does not correlate well, i.e. the infamous "hockey stick", prominent in the IPCC TAR.

Lake Mucubaji is on 3500 m altitude in the Venezuelan Andes, where an extensive paleoclimate study has been made; *www.geo.umass.edu/climate/theses/polissar-thesis.pdf*

The lower graph is blewn-up part of the upper one to expand on the Dryas event 10 kY ago. Less ^{18}O means, like the temperature proxy in the ice cores, a higher temperature, as long as the ^{18}O stems from precipitation, snow or cave stalagmites. Fossil ^{14}C content of organic material has been measured frequently to gauge the dating curve.

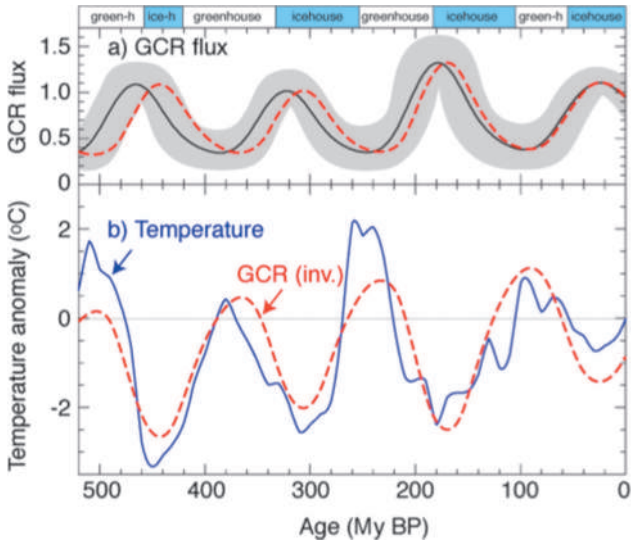


Figure 9. Correlation of cosmic rays and climate over the past 500 My [90]: a) GCR mean flux variations as the solar system passes through the spiral arms of the Milky Way, reconstructed from iron meteorite exposure ages [89], and b) ocean temperature anomalies reconstructed from $\delta^{18}O$ in calcite shells found in sediments from the tropical seas [88]. Panel a) shows the nominal reconstructed GCR flux (black curve) and the error range (grey band). The dashed red curves in panels a) and b) shows the best fit of the GCR flux to the temperature data (solid blue curve in panel b), within the allowable error (note inverted GCR scale in panel b). The data are de-trended and smoothed. The dark bars at the top represent cool climate modes for Earth (icehouses) and the light bars are warm modes (greenhouses), as established from sediment analyses elsewhere.

5. CONCLUSION

We have seen that the Miskolczi theory, very different from what is the basis of current complicated climate models, and much more fundamental, excludes any temperature influence of increasing greenhouse gases, their only effect being a small rise in rainfall and upper atmospheric drying. We have seen that the large climate changes in the past can be explained by changes in net insolation due to changes in cloud cover c.q. Earth albedo. These changes in cloud cover are perfectly correlated with changes in the cloud condensation nuclei change due to sulphuric acid and to galactic cosmic rays.

6. APPENDIX

The derivation of the correct greenhouse function, obtained by solving the Schwarzschild/Milne radiation equations with only the surface temperature as lower boundary condition and only zero upward radiation as higher boundary condition, and as further constraint that the radiation out of the atmosphere itself is maximized according to the general principle of maximum entropy production, in this case the lowest greenhouse effect, is due to Ferenc Miskolczi [2]. The main parts of the

derivation follow here in facsimile, to allow me to make some remarks on the main points: dependence of the surface air temperature and the ground temperature on the total flux optical depth, (*Goody* and *Yung*, 1989; *Stephens* and *Greenwald*, 1991; *McKay et al.*, 1999; *Lorenz* and *McKay*, 2003):

$$t_A^4 = t_E^4(1+\tau_A)/2, \tag{16}$$

$$t_G^4 = t_E^4(2+\tau_A)/2, \tag{17}$$

where $t_A^4 = \pi B(\tau_A)/\sigma$, $t_G^4 = t_A^4 + t_E^4/2$ and $t_E^4 = H/\sigma = OLR/\sigma$ are the surface air temperature, ground temperature, and the effective temperature, respectively. At the top of the atmosphere the net IR radiative flux is equal to the global average outgoing long wave radiation. As we have already seen, when long term global radiative balance exists between the SW and LW radiation. OLR is equal to the sum of the global averages of the available SW solar flux and the heat flux from the planetary interior.

We have seen that in a semi-transparent atmosphere the surface upward radiation is $B_G = \varepsilon_G \sigma t_G^4/\pi$, and the upper boundary condition at the top of the atmosphere is the zero downward IR radiance. The upward and downward hemispheric mean radiance at the upper boundary using the general classic solution of the plane-parallel radiative transfer equation and the isotropy approximation are:

$$\bar{I}^+(0) = B_G e^{-\frac{3}{2}\bar{\tau}_A} + \frac{3^{\bar{\tau}}}{2}\int_0^A B(\bar{\tau}) e^{-\frac{3}{2}\bar{\tau}} d\bar{\tau}, \tag{B1}$$

and

$$\bar{I}^-(0) = 0 \tag{B2}$$

Putting Eq. (Bl) and Eq. (B2) into the $H(\bar{\tau}) = \pi(\bar{I}^+ - \bar{I}^-)$ equation, and substituting the source function with $B(\bar{\tau}) = 3H\bar{\tau}/(4\pi) + B_0$ in the upward hemispheric mean radiance we get:

$$\frac{H}{\pi} = B_G e^{-\frac{3}{2}\bar{\tau}_A} + \frac{3^{\bar{\tau}}}{2}\int_0^A \frac{3H}{4\pi}\bar{\tau} e^{-\frac{3}{2}\bar{\tau}} d\bar{\tau} + \frac{3^{\bar{\tau}}}{2}\int_0^A B_0 e^{-\frac{3}{2}\bar{\tau}} d\bar{\tau}. \tag{B3}$$

The two definite integrals in the second and third terms of the right hand side of Eq. (B3) must be evaluated:

$$\frac{3^{\bar{\tau}}}{2}\int_0^A \frac{3H}{4\pi}\bar{\tau} e^{-\frac{3}{2}\bar{\tau}} d\bar{\tau} = -\frac{H}{4\pi}\left(2e^{-\frac{3}{2}\bar{\tau}_A} - 2 + 3\bar{\tau}_A e^{-\frac{3}{2}\bar{\tau}_A}\right) \tag{B4}$$

$$\frac{3^{\bar{\tau}}}{2}\int_0^A B_0 e^{-\frac{3}{2}\bar{\tau}} d\bar{\tau} = B_0\left(1 - e^{-\frac{3}{2}\bar{\tau}_A}\right) \tag{B5}$$

After putting back Eqs. (B4) and (B5) into Eq. (B3) we get:

$$\frac{H}{\pi} = B_G e^{-\frac{3}{2}\bar{\tau}} + \frac{H}{4\pi}\left(2e^{-\frac{3}{2}\bar{\tau}_A} - 2 + 3\bar{\tau}_A e^{-\frac{3}{2}\bar{\tau}_A}\right) + B_0\left(1 - e^{-\frac{3}{2}\bar{\tau}_A}\right). \tag{B6}$$

Rearranging Eq. (B6) and using the $\tau_A = (3/2)\bar{\tau}_A$ notation for the total flux optical depth. πB_0 can be expressed as:

$$\pi B_0 = \frac{\frac{H}{2}\left[1+\tau_A e^{-\tau_A}+e^{-\tau_A}\right]-\pi B_G e^{-\tau}}{1-e^{-\tau_A}}. \tag{B7}$$

This B_0 in the $B(\overline{\tau}) = 3H\overline{\tau}/(4\pi)+B_0$ equation will give the general form of the source function profile:

$$\pi B(\tau) = \frac{\frac{H}{2}\left[1+\tau+\left(\tau_A-\tau+1\right)e^{-\tau_A}\right]-\pi B_G e^{-\tau_A}}{1-e^{\tau_A}}. \tag{B8}$$

Applying the $T_A = \exp(-\tau_A)$, $A = 1-T_A$, and $f = 2/(1+\tau_A+T_A)$ notations, Eq. (B8) will become identical with Eq. (21). The semi-infinite solution may be obtained exactly in the same way, but substituting τ_A with infinity in Eq. (Bl), or simply by making these substitutions in Eq. (B8).

The most efficient cooling of the clear atmosphere requires a total optical depth that maximizes B_0. The derivative of Eq. (B7) with respect τ_A may be expressed as:

$$\pi\frac{dB_0(\tau_A)}{d\tau_A} = \frac{d}{d\tau_A}\left[\frac{\frac{OLR}{2}\left[1+\tau_A+e^{\tau_A}\right]-\pi B_G}{e^{\tau_A}-1}\right]. \tag{B9}$$

From Eq. (B9) follows that:

$$\frac{\pi B_G e^{\tau_A}-\frac{OLR}{2}\left[1+e^{\tau_A}+\tau_A e^{\tau_A}\right]}{\left(e^{\tau_A}-1\right)^2} = 0. \tag{B10}$$

From Eq. (B10), assuming $\tau_A > 0$ we get:

$$\pi B_G = OLR\frac{1+\tau_A+e^{-\tau_A}}{2} = \frac{OLR}{f}. \tag{B10}$$

Classical Solution

Equations 16 & 17 are the classic 1922 Eddington solutions of the Schwarzschild-Milne equations, originally conceived to explain the enormous "greenhouse effect" in the Sun's atmosphere, where the inside temperature is a thousand times the surface temperature. The Sun has no surface, and the sun's atmosphere is a plasma; its optical density is many orders of magnitude higher than that of our atmosphere, therefore an infinite approach does not bring large errors. But on Earth it cannot use infinity, otherwise τ_A would be infinite. So it uses an artificial upper boundary, that is the effective height with temperature t_E where the OLR radiates from. This is at about 5 km height. This is not the top of the atmosphere, not the height whereby the downward radiation is zero, and therefore not a physically correct boundary condition. Another unphysical result is that the surface temperature t_G becomes about 20 ºC higher than than the air temperature t_A just above it. The Keith-Trenberth scheme, or "US standard atmosphere" shows this discrepancy in that the absorbed part A_A of the

upwelling radiation from the surface is some 25 W/m^2 more than the downwelling radiation E_D. This unphysical assumption helps to come to a 5 W/m^2 forcing at the surface due to a CO_2 doubling, but it is physically not correct, and is probably a main cause of error in the derivation of the "climate sensitivity" from the climate models. It leads to a 25 W/m^2 unacceptable underestimation of the window radiation. The K/T scheme only holds for the "mean global" temperatures and fluxes. There exists nowhere on Earth a "mean" and consistent set of temperatures and fluxes. We need a solution that describes the atmospheric physics correctly from the polar winter all the way to the equatorial afternoon. Only then we can take a mean value.

Miskolczi's Solution

Equation (B1) has only one surface temperature and radiation flux: $S_U = S_G = t_G^4 = t_A^4$ as lower boundary condition, assuming correctly that the surface has an emittivity near to one and there is a temperature continuity between air and surface.

Equation (B2) has no infinity problem at the top of the atmosphere, so needs no artificial assumption for an upper boundary, but can use the real the boundary condition, $I^- = 0$, zero downward flux, and therefore zero absorbed upward flux.

The derivation now proceeds the classic way, described in many handbooks. From equation (B8) we can derive directly that $E_U = \pi B^0/A$ where $A = 1\text{-}e^{-A}$, the absorption of the semi-transparent atmosphere. This is the value that implies the equilibrium greenhouse effect. Note that E_U is brought into the atmosphere by absorption of shortwave radiation and by non-radiative heat transfer from the surface, and not by surface radiation!

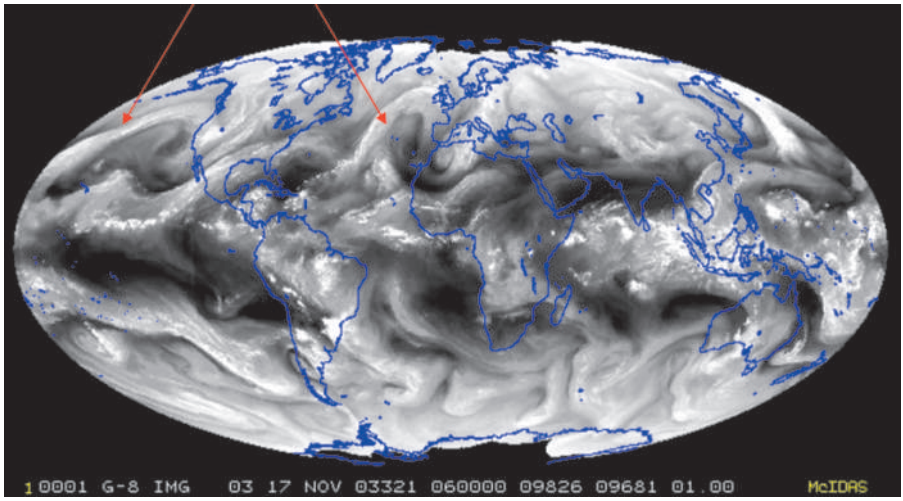
Equation (B9) sets the derivative of B^0 to τ_A to zero. This is an important extra condition. It assumes that our atmosphere, as all thermal dissipative structures do, organizes itself for minimal temperature difference given the flux, or for maximal flux given the temperature difference, or for maximal entropy production [$flux/T_{low} - flux/T_{high}$]. In the derivation, it is not important how the atmosphere does this, only that there are enough degrees of freedom available, such as the supply of water into the atmosphere that has a large influence on τ_A and therefore can control τ_A.

With this condition the greenhouse factor is determined: $OLR/S_G = 2/[1 + \tau_A + \exp(\tau_A)]$.

The strong point for this purely theoretical derivation, that uses no climate parameters and no material constants at all, gives a τ_A derived from S_G and OLR values that is exactly equal to the measured τ_A, either the TIGR value or the completely independent NOAA/NCEP value, with a precision into the third decimal. τ_A has the value of 1.86. This **is and must be** a global effective value, because it implies essential atmospheric water vapor transport and heat transport by horizontal convection from equator to poles that keeps global τ_A on this value!

We see that if τ_A becomes large, $2/[1 + \tau_A + \exp(-\tau_A)]$ becomes the old solution $2/[1 + \tau_A]$ in equation (16). This is correct for the Sun. If τ_A goes to zero, we have no greenhouse effect, $S_U = S_G = OLR$, correct for the Moon.

Below a visual reminder: All this algebra is but a terrible simplification. All physics is. White is atmospheric *water vapor emission* as seen by a satellite. τ_A is very much a local variable indeed!



We see our atmosphere wrestling with water vapor to reach maximum entropy generation.

7. REFERENCES

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FUEL FOR THOUGHT:

Mid-March to mid April 2010

EPILOGUE
SCIENCE AND SCIENCE POLICY
CLIMATE AND ENERGY POLICY
CARBON FINANCE
DECARBONISING TECHNOLOGY
CARBON FUELS PROSPER
CARBONPHOBIA PEAKING?
NUCLEAR GROWTH
FACTS AND EVENTS

Science News

- Pre 1940 warming is generally agreed to be non-anthropogenic; 1979–1997 satellites show little if any warming. The fundamental, unanswered question: Is the reported global mean surface warming (1979–1997) real*?* (Fred Singer 10 March 2009)
- The March 2010 monthly mean CO_2 concentration at Mauna Loa was 391.06 ppmv, an increase of 2.27 ppmv compared to March 2009 (Jack Barrett 15 April)
- There is no evidence that the mean temperature in New Zealand has ever altered to a measurable extent since records began. (Vincent Gray 31 April 2010)
- The world is warming, it is observed on every continent, and there is no natural explanation that can account for it. (UK Met Office cited in Independent 5 March)
- Radiation and convection are complementary processes, not competing processes. (William Kininmonth 9 March) Convection distributes 102 W/m^2 and radiation distributes 26 W/m^2.
- February data – CO_2 concentration is up by 2.5 ppmv since last February, more than usual.

Temperature anomalies:

	Global	NH	SH
HADCRUT3	0.461	0.464	0.457
UAH Satellite	0.62	0.73	0.52

- Global temperature has been falling for the last 8 years (R Courtney 21 March)
- Global temperature is now similar to that of 1990. But atmospheric carbon dioxide concentration has increased at a near constant rate and by more than 30% since 1940. It has increased by 8% since 1990 . . . There has been no significant warming since 1995, and global temperature has fallen since the high it had in the El Nino year of 1998. (Richard Courtney 20 March)

- The emission intensity rises with temperature according to the formula: $I = 2\pi hc^2 v^3/[\exp(hcv/kT) - 1]$ when h = Planck's constant, c = speed of light, v = wave number, k = Boltzmann's constant. The extent of absorption of CO_2 photons decreases logarithmically with increasing concentration, so successive additions of CO_2 have smaller and smaller effects, but there are also emission changes to be included, it's not simple. (Jack Barrett 5 April)
- Last month's combined global land and ocean surface temperature made it the sixth warmest February ever recorded. Additionally, the December 2009 – February 2010 period was the fifth warmest on record averaged for any similar three-month Northern Hemisphere winter-Southern Hemisphere summer season, according to scientists at *NOAA's National Climatic Data Center*.
- Aboriginals could walk from Papua New Guinea 60,000 years ago because of lower sea level. (James Buckee) (13 April 2010)
- The Guardian's Online forecaster *Positive Weather Solutions* predicts Britain will have a summer to match or exceed that of 1976, i.e. very hot.
- In a recent poll (*BBC 4*, February 2010) only 34 % of those asked now believe that global warming is a scientific fact.
- During the Jurassic CO_2 content of atmosphere was above 2000 ppm; during the Cambrian around 7000. It fell throughout the Cretaceous to below 1000 ppm. (Berner 2001)
- 40 million years ago (Eocene) the average global temperature was higher than now – not at the equator, but at the poles. The earth was a warm ball instead of a snow ball. The CO_2 content of the atmosphere was much higher than now. (William Kininmonth)
- Methane is not intrinsically any stronger than CO_2 as a ghg. It is much lower down on the logarithmic curve being three orders of magnitude rarer than CO_2. If concentrations were reversed it would be CO_2 that appeared the more powerful. (Max Beran 19 March 2010)
- The heat content of the atmosphere is actually quite small: equivalent to the top 4 metres of the ocean . . . Steady state is achieved by energy exchange between the surface and the atmospheric boundary layer (direct heat and evaporation) and then convective transport through the atmosphere (William Kininmonth 17 March)
- Convection is a major way to move heat within the earth's atmosphere, but it does not work in a vacuum and therefore cannot transfer heat out of the earth system. Radiation of course works perfectly well in a vacuum. (Jack Barrett)
- A shell from 130 BC recorded the highest temperature in the entire 2,000-year dataset. (*The GWPF Observatory, 10 March 2010*)
- No unadjusted climate data is available, thus we have no idea if the Earth has warmed or cooled in the last 25 years. (Roy Spencer http://www.drroyspencer.com/2010/01/)
- Is now the time to get frightened? [of methane leaks] No. CO_2 is plenty to be frightened of, while methane is frosting on the cake. *(RealClimate* 10 March)
- In its latest report, the IPCC predicted *up to* 59cm of sea level rise by the end of this century. According to *RealClimate,* a number of broadly based assessments

have appeared since the last IPCC report, which all conclude that global sea level rise by the year 2100 *could* exceed one meter.

- The 'outside' assessment of the IPCC by Dijgraaf (see below) is to be completed by late August so that the findings can be used at the 5 October 5 meeting to start the next report. The last two reports (TAR in 2001, and AR4 in 2007) have their climate projections (to 2100) underpinned by the non-sensical IIASA economic scenarios. (Bob Foster 11 March 2010)

Emissions News

- National average per capita footprints vary from 1 tCO_2e/y in African countries to ~30t/y in Luxembourg and the USA. (http://pubs.acs.org/stoken/beta/select/abs/10.1021/es803496a)
- History suggests every billion extra human mouths increases CO_2 by 40 ppm. (Max Beran 11 March 2010)
- Human activities account for about 3% of CO_2 emitted into atmosphere. Global population (and therefore population density) has increased by a little over 50% in the three last decades of 20th century. Effect on temperature? (Max Beran 10 March)
- UK emissions are estimated to have fallen by 1.9 % during 2008, with CO_2 responsible for about 85% of the total, with overall decline mainly due to fuel switching from coal to natural gas. UK emissions are down by 19.4% below the 1990 value, thus 'clearly exceeding our Kyoto target of 12.5% below 1990 levels.' With emission trading, the decline is 22%. (*Energy World* April 2010)
- Gordon Brown's Government has been accused of using the economic downturn to gain green plaudits after new figures showed the recession has led to record cuts in greenhouse gases by almost 10% between 2008 and 2009. The Tory energy spokesman: "It is disappointing that it took the longest and deepest recession since World War II for Labour to achieve any noticeable fall in UK carbon emissions. . . . Ministers should be embarrassed that their green claims are based on our broken economy." (*Reuters* 26 Mar 2010)
- Europeans import twice as much CO_2 per capita than US citizens, but the USA remains the biggest emitter, according to the Carnegie Institute for Science in Stanford, California. In 2004, they tell us, 23% of global emissions were due to internationally traded products, many from China. Unlike Europe, America exports many emissions – intensive goods that offset its imports. Official national inventories so far only count emissions produced in national territories, ignoring trade. (*New Scientist* 13 March)
- EU governments should intervene in the bloc's flagship emissions trading scheme to drive prices high enough to spur low-carbon investments, said a UK Member of Parliament. (*EF* 11 March)
- UN farm experts will look at links between meat-eating and greenhouse emissions amid claims they have been exaggerated.<http://news.bbc.co.uk/go/em/fr/-/1/hi/sci/tech/8583308.stm
- The UN has admitted a report linking livestock to global warming exaggerated the impact of eating meat on climate change. (*Telegraph* 29 March)

- The US Government has announced that it will try to cut its own emissions by 28% by 2020. (*Energy World* April 2010)

Policy and Politics

- Climate negotiators from more than 175 countries meeting in Bonn on 9–11 April struggled to agree an agenda for discussions ahead of the next UN climate conference in Cancun, Mexico.
- Jeffry Sachs, (director of the Earth Institute at Columbia University and advisor to Bi Moon), joined George Osborn, UK's shadow chancellor, in advocating recovery through private sector employment and investment in next generation technologies, pre-commercial innovation and 'a decent regard for long-term investment', both taking a stand against the Keynesians in national debate. [A strange alliance?] (*EF* 15 March)
- Only 28% of Americans worry 'a great deal' about global warming — Water and air pollution, extinctions, deforestation, toxic waste, all rank among higher concerns. (2010 Gallup Poll) Von Storch and Pielke have called for the resignation of Pachauri.
- Protesters in Kyrgyz demanded reductions in energy prices and the reversal of privatisations. (*FT* 18 March 2010)
- Unemployment, not cap&trade legislation will be the primary issue now facing the Obama administration
- By early April 12 USA states had joined petitions filed by Virginia, Alabama and Texas against the EPA for ruling that greenhouse gases like carbon dioxide endanger human health.
- The heads of the Transportation Department and the EPA signed final rules setting fuel efficiency standards for model years 2012–2016, with a goal of achieving by 2016 the equivalent of 35.5 miles per gallon combined for cars and trucks, an increase of nearly 10 mpg over current standards. (*FoxNews.com* 2 April 2010)
- Arnold Schwarzenegger is now the least popular Governor in California's history. The latest Field Poll pegged his approval rating at 23%.
- The Climate Science Coalition has been formed in the USA with Roy Spencer as chairman.
- The US government distinguishes between climate change and human – induced climate change, though the distinction remains vague. However, there is now more reference to adaptation. (http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts)
- A desert preservation bill banning solar power has been introduced in California by a Democrat senator, supported by Republicans.
- American farmers plan to seed huge areas of soya bean and corn this year, leading already to marked falls in grain prices.
- The UK claims to lead the world on carbon budgets and has set up 2,500 apprenticeships in wind energy to close the 'skills gap', part of it low carbon industrial strategy.
- Judged simply by the number of mentions of key words, the Conservative party's manifesto is the greenest of the three main parties, according to an *ENDS Report* analysis. (15 April)

- The UK has set up a green investment bank backed by £1 bn of public money to encourage alternative energy (*FT* 24 March); but has been dismissed as 'paltry' and unrealistically low in comparison to other EU efforts where job creations seems to have been the main motive (*Letters, FT* 29 March).
- UK Local government councils will have to identify opportunities for district heating schemes under a new planning policy.
- New homes being built now (in UK) must be designed to cope with the inevitable changes in climate we will see over the next 50–80 years. [Says the Environmental Audit Committee)
- The hostility surrounding the healthcare debate in the US is expected to complicate efforts by a tri-partisan group of senators to develop a compromise energy and climate bill, observers have warned, but some remain optimistic a deal will be reached this year nonetheless. (*EF* 23 March)
- In Germany, only 42 % of population still fear global warming. Every fourth person believes that Germany is likely to profit from climate change. (*Der Spiegel* 27 March 2010)
- German government talks of '*nachhaltigem Klimaschutz*' – sustainable climate protection. – but the new coalition faces a challenge. Coalition negotiations accepted a target of reducing CO_2 emission cuts of 40% by 2020, irrespective of the efforts made or not, by others.
- EU claims to be on track for meeting its 2020 renewable target of 20%.
- Rajendra K. Pachauri, Director General, TERI (The Energy and Resources Institute), India is to address the World Energy Congress in Montreal in September this year.
- Sarkozy has called on the World Bank to reverse its 50 year abstention from funding nuclear power in developing countries. The UN should also extend carbon credits to nuclear investments. (Another example of global salvationism or is France acting in self-interest?) The World Bank considers nuclear still not the least cost option there. (*FT* March 9 2010)
- Italy and France have agreed on cooperation when 'Rome relaunches nuclear power from 2013.' But last year Abu Dhabi opted for South Korean reactor technology. (*FT* 9 April 2010)
- The Chinese government has outlawed property development by state–owned enterprises.
- Australia green job creation/emission cutting house insulation programme (part of the stimulus) has turned into a national fire disaster. The former pop star Peter Garrett, now environment minister, was stripped of his responsibilities for energy efficiency.

Carbon Fuels and Nuclear Power

- The US imports some 10 million barrels of oil per day.
- Oil prices fluctuated around $80 a barrel in early March reflecting 'risk' appetite and credit ratings. By mid April they to over $85 with some forecasting further rises. Overall, however, the stability of oil prices is striking. However, the share prices of the large western integrated oil companies have not recovered. (Ed Crooks *FT* 29 March)

- The "light" regulation of oil markets should be replaced by "more comprehensive regulations aimed at dealing with the traditional risks of fraud and abuse of dominant positions, as well as systemic risks," according to a report written for the French Finance Minister.
- BP defeated a shareholder resolution challenging its investments in Canadian oil sands. (*FT* 15 April 2010)
- China has become a coal importer of both thermal and coking for first time as until now neglected coal industry struggles to keep up with domestic demand. Domestic oil production is about one third of consumption. "The battle to secure mines to supply China has already begun. (*FT* 14 April 2010)
- Indonesia is now the world's second largest coal exporter India and China are expected to consume two thirds of world coal. *FT* 14 April 2010)
- China has won the contract to build and operate a coal railway for Indonesia, adding to similar contracts in America, Africa and Australia
- Iran has started gasoline hoarding with experts "divided over whether fuel starvation will unite the nation or bring it to its knees." (*FT* 8 March 2010)
- Gazprom supplies more than 25% of Europe's gas with Bovanencovo on the Yamal Peninsula the largest field now requiring a pipeline beneath icy waters, tundra and permafrost, but faced with competition from within and a glut in the world market. (FT 26 March) However, it has had to re-negotiate long term gas export contracts with EU energy companies, a move aimed at offsetting the influx of LNG which is threatening Gazproms as supplier of 25% of gas imports to the EU. *(FT* 29 March 2010)
- Federal proposals in US would increase the influence of environmental objectors over oil and gas exploration on public land.
- The next step in Britain's nuclear clean-up will cost £2,8 bn and is to be generated by the Nuclear Decommissioning Authority's power stations and reprocessing activities. £1.5 bn will go to Sellafield to reduce the amount of highly active liquids stored on site.
- EDF Energy is preparing to build four new EPRs, with the first electricity to be generated in 2017 'subject to the right investment framework'. (*Energy World* April 2010)
- Over thirty countries are actively considering embarking upon nuclear power program**s.** (*WNA* April 2010)
- Russia has announced a 15% increase in uranium reserves during 2009. (WNA 7 April)
- James Hansen has become an advocate of nuclear power: more research is urgently needed for fourth generation reactors. He has written a detailed letter on this to Obama. http://www.kernenergie-wissen.de/nextgeneration.html.
- "Hybrid reactor, combining fusion with fission 'deserve wider understanding and support." (*New Scientist* 5 March 2010)
- 52 nuclear power stations are currently being built in 14 countries. Of eleven newly started in 2009, nine are in China and one each in Russia and South Korea. The Chinese government is planning 30 more nuclear power stations during its 5th economic plan. (*FA* 16 February 2010).

Finance, Renewables and Green Technology

- According to the World Bank, turnover of carbon trading reached *$126 billion* in 2008. PointCarbon estimates trading in 2009 was about *$130 billion*. This is turnover, not specifically profits, but every major finance house stands to profit as brokers of a paper trade. It doesn't matter whether you buy or sell; the bankers take a slice both ways. The bigger the market, the more money they make shifting paper.
- EU finance ministers approved on 16 March a directive to clamp down on VAT fraud in carbon markets by allowing member states to shift the levy to the end user. Earlier this year, Internet fraudsters robbed companies of their emission allowances by obtaining the access codes to their accounts through a rogue website. This prompted the Commission to revise rules governing the emissions registries, allowing national administrators to close user accounts or to refuse would-be fraudsters permission to open new ones (*EurActiv* 18 March). Alister McFarquhar
- The Bermuda based Lloyd's of London, and Munich Re face major losses from recent Earthquakes and European storm, but last year's 'benign hurricane season' helped to treble profits. Global warming was not mentioned, only that 'Mother Nature was kind' according to Hiscox chairman (Lloyd's specialist insurer). Shares fell nevertheless. (*FT* 17 March)
- The uncertainty in future carbon prices is likely to delay or deter investment in low-carbon technology (UK Ofgem), one of four key issues representing an 'unprecedented challenge to current energy arrangements [in UK]. (*Energy World* April 2010)
- The US Department of Energy is encountering numerous obstacles to releasing funds for clean energy projects from last year's economic stimulus package. (*EF* 11 March)
- Thanks to stimuli and other support, wind power capacity grew by 31% in 2009, according to the Global Wind Energy Council. (*Energy World* April 2010) The USA remains top in installed capacity, followed by Germany and China.
- Because of "insatiable" demand in India, and in China, coal prices may double this year, but In the UK, energy-intensive companies where energy is a hefty chunk of their overheads, are paying about 20 % of their energy bill as climate taxes, green taxes or renewable obligations. (Benny Peiser *Financial Chronicle,* 8 March 2010 *CCNet* 17)
- New investment in clean energy is set to recover to at least $175 billion-200 billion this year, according to projections from Bloomberg New Energy Finance.
- WWF earns £400 million a year. (*Sunday Telegraph* 21 Mar 2010)
- 1.23million people out of 7 million living in Hong Kong live below the poverty line, earning less than half of a desperately low median wage. The city's Gini coefficient being the worst in Asia, and worse than that of Mainland China. (*FT* 18 March 2010)
- Apart from the biofuels, which are a mess, the renewables don't save or replace oil; they do save and replace coal and natural gas!

- South Korea is trying to extract lithium from seawater by 2015, an important material in the manufacture of lithium ion batteries for electric cars. Bolivia remains the main source of this metal. (*FT* 9 March 2010)
- Electric cars are to be the basis of industrial revival in NE England and will be built by Nissan with government loans and grants. The dawn of a new industrial era? Locals see this as putting the Sunderland area at the centre of the global automotive industry. The new plant is called Leaf – leading environmentally friendly affordable car' and is accompanied by a lithium-ion battery plant. Cars to be for sale by 2013.
- The international race for the 'green' car has started according to this year's Geneva Motor show . . . both hybrid and battery powered, allegedly to reduce carbon emission. Porsche's 918 Spider hybrid car does 78 miles per gallon. [But how much energy is used in making it?]
- One forecast from Geneva is that by 2020, about 19% of cars will be electric. (*FT* 9 March 2010), and the centre of gravity of the global car industry will be moving east, with China already the world's largest auto market. (*FT* 9 March).
- According to the UK Carbon Trust, by 2020 marine energy will be ready for mass-scale deployment and an important new British industry. (*Energy World* April 2010)
- Speaking on March 11, 2010, the Chinese vice minister for Industry and IT, Miao Wei, described massive wind farms in China as essentially "vanity projects". (From Andrew Mckillop)

SCIENCE AND SCIENCE POLICY

If we want to reorganize IPCC we need to adhere to a basic principle in reorganisation practice. The staircase is cleaned from the top. If an organization shows malfunction, the top is the first to be replaced. (Arthur Rorsch 19 April 2010)

"Many scientists now realize they are facing a crisis of public confidence and have to fight back. Tentatively and grudgingly, they are beginning to engage their critics, admit mistakes, open up their data and reshape the way they conduct their work. . . . ." (Walter Russell Mead, Council on Foreign Relations; Staff Member, Foreign Affairs March 3 2010)

There is a need to demonstrate that the outputs of GCMs are exaggerated because the physics are amiss . . . . the representation of convection is crude and does not adequately represent the vertical non-radiative transfers of energy . . . . the AGW atmosphere has no convection. So "the science" may be indisputable but it is woefully and fatally incomplete. (William Kininmonth 30 March)

Non-believers don't have to prove anything. Skeptics are not asking the world for money or power. Believers need to explain their case. . . ." (http://jonova.s3.amazonaws.com/sh1/the_skeptics_handbook_2-3_lq.pdf

IPCC Science to be Reviewed by Inter-Academy Council

The UN and IPCC have jointly asked for an independent review of IPCC procedures and processes, to be completed by 31 August 2010. The review will be undertaken by

the InterAcademy Council, representing national science academies from the UK, US and China and other states. It will address the IPCC's use of 'grey' literature that has not been peer-reviewed, the way in which it handles dissenting viewpoints, its review process and procedures for correcting errors. The IPCC leadership structure will also be analysed. It is not a review of climate science. (*ENDS Report Bulletin* 11 March 2010) Robert Dijkgraaf, Co-chair, InterAcademy Council, Amsterdam and President, Royal Netherlands Academy of Arts and Sciences president of the Royal Netherlands Academy of Arts and Sciences and professor of mathematical physics at the University of Amsterdam, said to the UN: ". . . Together with my colleague Lu Yongxiang, president of the Chinese Academy of Sciences, I co-chair the InterAcademy Council, a multinational organization of the world's science academies. . . . The InterAcademy Council is ready to take on the challenge of this important review of the IPCC. Our goal will be to assure nations around the world that they will receive sound scientific advice on climate science with which governments and citizens alike can make informed decisions. . . . The board of the InterAcademy Council is currently composed of presidents of 15 national academies of science – representing Argentina, Australia, Brazil, China, France, Germany, India, Indonesia, Japan, South Africa, Turkey, the United Kingdom, and the United States. . . . In fact, our first report *Inventing a Better Future – A Strategy for Building Worldwide Capacities in Science and Technology* was released in 2004. Our second IAC study, *Realizing the Promise and Potential of African Agriculture,* was commissioned by UN Secretary-General Kofi Annan . . . . When we are asked to provide advice on a particular issue, the IAC assembles an international panel of scientific experts. Serving on a voluntary basis, panel members meet, investigate relevant questions, and prepare a draft report with their findings, conclusions, and recommendations. . . . We enter this process with no preconceived conclusions. Specifically, we have been asked to address the following:

1. Data quality assurance and data quality control at the IPCC
2. Guidelines for the types of literature appropriate for inclusion in IPCC assessments, with special attention to the use of non peer reviewed literature
3. Procedures for expert and governmental review of IPCC material
4. Handling of the full range of scientific views
5. Procedures for correcting errors identified after approval, adoption and acceptance of a Report

We have also been asked to analyze the overall IPCC process, including the management, administration, and transparency of the IPCC and the way in which it handles possible errors and communicates them to policymakers and the public. We will look at how the UN Environment Programme, the World Meteorological Organisation, and how the UN system and other relevant stakeholders relate to the IPCC — this with a view to strengthening and improving assessments as well as ensuring consistent application of IPCC procedures. Finally, we have been asked to analyze appropriate communication strategies and examine how the IPCC interacts with the public and the media. . . . And because work on the IPCC's Fifth Assessment Report has already begun, the IAC will endeavor to submit its report by the end of August 2010. . . . . Climate change is one of the most significant scientific and public

policy questions of our time. As scientists, we have a responsibility to assure the best scientific practices are in place . . .” (http://www.interacademycouncil.net/Object.File/Master/12/875/DIJKGRAAF%20STATEMENT.pd)

Reminder: IPCC Limits

“The IPCC does not conduct any research nor does it monitor climate related data or parameters. Its role is to assess on a comprehensive, objective, open and transparent basis the latest scientific, technical and socio-economic literature produced worldwide relevant to the understanding of the *risk of human-induced climate change*, its observed and projected impacts and options for adaptation and mitigation.” This means that the IPCC is not really considering natural climate change. Its full mandate is: “The IPCC was established to provide the decision-makers and others interested in climate change with an objective source of information about climate change. The IPCC does not conduct any research nor does it monitor climate related data or parameters. Its role is to assess on a comprehensive, objective, open and transparent basis the latest scientific, technical and socio-economic literature produced worldwide relevant to the understanding of the risk of human-induced climate change, its observed and projected impacts and options for adaptation and mitigation. IPCC reports should be neutral with respect to policy, although they need to deal objectively with policy relevant scientific, technical and socio economic factors. They should be of high scientific and technical standards, and aim to reflect a range of views, expertise and wide geographical coverage.” Source: http://www1.ipcc.ch/about/index.htm

NB: The ‘producer’ of IPCC science is therefore that handful of countries with governments interested and wealthy enough to fund the relevant research, and hence of those research lobbies and disciplines with the best access to these funds.

More Dutch-based Effort to Sort Out IPCC

- “The world’s biggest scientific guns are being called in to mop up after a trickle of unsettling errors in the authoritative reports written by a global warming panel. . . . A panel of experts created by the council will try to figure out how better to catch and correct errors, Dijkgraaf said. It will also consider whether the climate panel should use non-peer reviewed literature, how governments review IPCC material, and even how the IPCC communicates with the public . . . Dijkgraaf said the review is “a forward-looking report” but will examine the errors already found as “case studies.” He said it will not be a comprehensive review of the “vast amount of data that has already been obtained.” The review will involve a mix of outside experts and climate scientists who have worked with the IPCC before but are “far enough removed to be truly independent,” Dijkgraaf told The Associated Press in a telephone interview before a briefing at the U.N. The idea is to have expertise and insight into how IPCC works without including current leaders, he said. . . . . The InterAcademy has done science reviews before for the United Nations. “The (review) panel will have great liberty to function and work and write a report with an open mind,” Dijkgraaf said. And the conclusions of the panel itself will be peer-reviewed by outside scientists. Both critics and

supporters of the IPCC process cheered the outside review. "The idea sounds fine. I hope people like me have input. Otherwise it's just the usual members of the establishment defending to themselves what's been done," said researcher John Christy of the University of Alabama, Huntsville, a prominent IPCC critic and warming skeptic." (Excerpt: Seth Borenstein *AP* Washington 10 March 201; from Paul Ashton 10 March)

- In the Netherlands, climate scepticism is making progress, (http://climategate.nl/). The Standing Commission on Environment of the Second Chamber of Parliament is preparing a public hearing (19 April) where both protagonists and antagonists of AGW will testify. The focus is not only on 'Climategate' and subsequent 'gates', but allows for a broader discussion of the functioning of the IPCC. As far as I know, this is the first official hearing of its kind in Europe. Participants are all Dutch, with one exception: John Christy, who will be invited to present his views on the future of the IPCC.
- The Royal Netherlands Academy of Sciences (KNAW) will organise a climate conference at the end of April. "After seeing the KNAW President (Robbert Dijkgraaf) being appointed by the UN to co-chair an international examination into the IPCC's way of doing things, and after the announcement of a one day hearing into climate science by the Environment Committee of the Netherlands Parliament, the Royal Netherlands Academy of Sciences has now acceded to requests from both sides of the climate change issue to hold a seminar of many scientific protagonists and antagonists of the human greenhouse hypothesis, with emphasis on the scientific aspects. Foremost will be the matter of measurements ('facts'), such as CO_2, temperature, sea ice cover, glacial retreats; then the explanation of these measurements in terms of the assumptions of rapid temperature rise and the human role therein. The question of temperature reconstructions will be examined as well as the question of sun- versus CO_2-driven climate change. Finally models will be discussed, as well as their usefulness in climate science. Missing from the program is a discussion of climate sensitivity, but it is still an admirable attempt to achieve some common sense, civilised intercourse and scientific discussion. One could only hope that other National Academies and Royal Societies would see it as a good example to follow. (Arthur Rorsch)
- Similar good news from the Swedish front, where a climate seminar took place at the 'Riksdag' in Stockholm on 24 March. The seminar was organized by the MPs . . . The panel included Professor Michael Tjernström, Stockholm University (How can confidence in the IPCC restored?), Professor Göran Petersson, Chalmers, (the IPCC's role in an environmental science perspective), Professor Sten Bergström, SMHI (SMHI's perspective on the climate issue and IPCC), Professor Peter Stilbs, KTH, (How does the IPCC do climate science?). The views of the panel on various issues can be seen and heard in a video recording on the Stockholm Initiative website. http://stockholmsinitiativet.se/. (From Hans H.J. Labohm)

NB "I tried for years to obtain the data that the IPCC was based on a claim that the climate in the Nordic region has become warmer, "says Wibjörn Karlén. who is Professor Emeritus of Physical Geography at Uppsala. This did not agree with my own

calculations show that the Nordic countries have not undergone any unusual warming, but both Philip Jones and Kevin Trenberth simply refuses to hand over the data." (Hans Jelbring 6 March)

According to Jelbring: ". . . The Swedish raw data is mostly gathered every 3 hour and is then processed into average daily temperature, average daily pressure, average cloud cover, average monthly temperature etc. The methods to collect and to do the initial processing are very strict. The instructions to the collectors and SMHI people cover about 100 pages. Only one organization is responsible for this initial processing and that is SMHI. It is very hard for SMHI to cheat about the raw station data. Omission to publish data publicly has been one method to avoid too much focus on reality. Pure station data sets are what researchers should base their work on and I consider the SMHI station data sets free from intentional contamination for 300 years (although they contain UHI-effects, mistakes etc). All information about moving instruments etc is available. We now have data from 52 stations. For some reasons Phil Jones mentioned about 30 and at least one is no longer in use. Phil Jones and co-workers then have to process data further for the purpose of calculating "gridded" data which might be claimed to be at sea level (a model correction needed). However "homogenization" including complex factors as UHI effects effects, assumed carbon dioxide effect, etc does not belong to the "raw" data category.

There is much to be said about this and it is very understandable that SMHI did not want CRU to claim that SMHI should be responsible for the CRU product, especially since CRU has "lost" it and nobody can check what it looked like and how it was processed. It is too simple to say that "Sweden held tightly to the AGW line". Yes, the leaders Bert Bolin (now dead), Henning Rodhe (retired dean of Stockholm University but still very active) and the former CEO of SMHI quit some years ago, and the successor of Bert Bolin, Professor Erland Källen left his work at Stockholm University last July and is now working in UK. It should now be easier to reintroduce better science into climate research in Sweden." (Hans Jelbring 8 March 2010)

For a German view of the same story, see *Der Spiegel,* http://www.spiegel.de/international/world/0,1518,686697-3,00.html

Comments from Australia:

- After regretting the weak questioning of Jones, Warwick Hughes, the scientist who first requested data from CRU says: ". . . nothing less than a Royal Commission type of setting with key players questioned under oath, by experts. But it will not happen that I can see, unless the current mess leads to further outcry later on. " (March 4 2010)
- "Nobody should listen to recent attempts by Jones / UKMO/UEA officials as they muddy the waters by saying, ". . . do not waste time asking us for station data, go get the GHCN station data yourselves . . ." Just a giant obfuscation. Studying GHCN station data will tell you very little about what Jones et al / CRU / UKMO have done. (Warwick Hughes 12 March 20)
- The real peer review in science takes place after a study has been published when it is subject to open ongoing examination by the entire scientific community. Pre-publication peer review is of necessity restricted and subject to bias. It is more an editorial aid than it is a guarantee of quality. The attempt by proponents of

catastrophic climate change to turn pre-publication peer review into a form of censorship and sanctification speaks volumes of the bankruptcy of their science. (Walter Starck 24 March 2010)

And from the Radical Wing in UK

"Some will celebrate the results of the UK House of Commons Science and Technology Committee's investigation into the furore surrounding the University of East Anglia's Climate Research Unit as a vindication of the reputation of climate science, the work of the unit, and of all the academics involved. After all, the investigation found that the CRU academics did not 'distort data'. Others, however, will be astounded by the complacent tone of the committee's report and its reluctance to ask any difficult questions. But the real question we should be asking is this: what was the point of the investigation? The House of Commons committee self-consciously refused to pose any probing questions, and its main aim seemed to be to ensure that the moral status of the current consensus on climate change remained intact. What is most remarkable about the committee's report is that it openly acknowledges that it is not the product of a serious investigation. It claims that the reputation of Phil Jones, director of the CRU, 'remains intact' – but it doesn't make this claim with very much conviction. What it actually says is that 'within our limited inquiry and the evidence we took, the reputation of Professor Jones and the CRU remains intact'. That's another way of saying: we did not look very hard at the details of this scandal but here's what we decided anyway. . . So what was the purpose of this stage-performed investigation? The answer, to me, seems fairly obvious. As Labour MP Doug Naysmith indicated, he hoped that the report would serve as a 'corrective' to climate-sceptic hysteria. Investigations that are meant to serve as a 'corrective' to people's misguided or immoral sentiments used to be called rituals. And that is what the House of Commons Science and Technology Committee's 'limited inquiry' was mostly about: a ritualised pseudo-investigation aimed at correcting people's allegedly backward views." (Frank Furedi, *Spiked* 31 March 2010) http://www.spiked-online.com/index.php/site/article/8368/)

Citability Leads to Clubability – On the Ignored Question of Peer Review

- "The same few authors dominate top journals. Selflessly and shamelessly, they boost the impact factor by self-citing, co-citing and group-citing. Reference lists grow ever longer, but not with new citations. Papers were once cited less with age; now they are cited into eternity. Important advances in management thinking are rarely announced in its top journals. Academics are desperate to publish in top journals. Little else matters. They envy and admire those who do, but not as experts. Academics rely on their personal networks to identify experts. Politicians, who created this distorting system, still see it as the cornerstone of evidence-based policy. A system to measure and reward academic performance, the Research Excellence Framework is replacing the RAE. It is thought its greater emphasis on citation metrics and academic impact will make identifying academic expertise more certain. Our research finds that academics are already accomplished at tactical citation. As for impact – consider what the recent media reports will have done for the REF impact of the

University of East Anglia." (Stuart Macdonald, Professor of Information and Organisation, Sheffield Management School *FT* March 2010)

National Academy of Sciences on Warpath?

As for the vaunted objectivity of scientists, last week, a leaked series of emails between leading academics at Stanford University revealed a plan to mount "an outlandishly aggressively partisan" attack on climate skeptics. The emails were full of paranoid demonization of "well-funded, merciless enemies." Renowned alarmist (and close buddy of Al Gore) Stephen Schneider invoked McCarthyism. In fact, it is skeptics who have been subjected to a witch hunt. The Stanford emails compared them to those who "would deny the reality of the law of gravity." Those involved in this email exchange are all members of the U.S. National Academy of Sciences. The notion of "official" climate reviews has already been tainted by the U.K.'s Stern Review, which emerged as a blatantly skewed political document designed to support U.K. policy. . . . Still, there is some small humour in this, as befits a Wonderland-ish situation. The IAC is headquartered at the Royal Netherlands Academy of Arts and Sciences in Amsterdam. One of 2007 IPCC report's "very small number or errors" was to double the amount of the Netherlands that lies below sea level. At Wednesday's press conference, neither Mr. Pachauri nor Mr. Ban took questions. It was not reported whether they subsequently disappeared down a rabbit hole. It will be fascinating to see how long the IPCC's house of cards survives this scandal, which grows ever "curiouser and curiouser." (Peter Foster: Alice In UN Land *Financial Post* 12 March 2010)

More Responses to 'CRUGate'

- *The Royal Society of Chemistry* (RSC) and the Royal Statistical Society (RSS) have both issued statements declaring that it is essential that scientific data and evidence compiled by researchers be made publicly available for scrutiny. Their comments come after the Institute of Physics said that emails sent by Professor Phil Jones, head of the CRU, had broken "honourable scientific traditions" about disclosing raw data and methods. (Richard Gray, *The Sunday Telegraph*, 7 March 2010)
- From *Swedish Meteorological and Hydrological Institute*: " Dr. Jones asserted that the weather services of several countries, including Sweden, Canada and Poland, had refused to allow their data to be released, to explain his reluctance to comply with *Freedom of Information* requests. This statement is false and misleading in regards to the Swedish data. All Swedish climate data are available in the public domain. As is demonstrated in the attached correspondence between SMHI (Swedish Meteorological and Hydrological Institute), the UK Met Office and Dr. Jones (the last correspondence dated yesterday March 4), this has been clearly explained to Dr. Jones. What is also clear is that SMHI is reluctant to be connected to data that has undergone "processing" by the East Anglia research unit.
- From UK Physicists: This body represents 36,000 UK physicists and called for a wider enquiry into *the Climategate affair* which raises issues of scientific corruption. "The Institute of Physics doesn't pull any punches in the submission, one of around 50 presented to the Commons Select Committee

enquiry into the Climategate archive. . . The IOP says the enquiry should be broadened to examine possible "departure from objective scientific practice, for example, manipulation of the publication and peer review system or allowing pre-formed conclusions to override scientific objectivity." It deplores the climate scientists' "intolerance to challenge" and the "suppression of proxy results for recent decades that do not agree with contemporary instrumental temperature measurements." The physics institute observes that "unless the disclosed emails are proved to be forgeries or adaptations, worrying implications arise for the integrity of scientific research in this field and for the credibility of the scientific method as practised in this context". (Andrew Orlowski Columnist, *The Register* March 1, 2010: Courtesy Cornwall Alliance, Calvin Beisner.)

- For some people, 'the use of a specialist extremist intelligence unit in investigating the hacked UEA emails is part of a disturbing trend in policing.' (http://www.guardian.co.uk/commentisfree/henryporter/2010/apr/15/climate-change-terrorist-policing-unit)

Codes Ready to be Tested: Data Sources Compared

"The two big issues I have recently been reading about. . . The first is that at GHCN high quality station counts are being trimmed pretty drastically over the last decade or so and there is some concern that stations are being cherry picked to keep only those that show warming; i.e. those at airports are kept in the high quality series, rural are removed from that group. The data is not being deleted, just no longer included in the high quality station data set. If the stations removed were the ones Anthony Watts review showed to be problematic, the sceptic community would cheer. That seems not to be the case. The second big issue is how GISStemp takes the GHCN data for its input and adjusts that for final use. There are a few major/suspicious issues in how that code works. The code is available and the ClearClimateCode project has re-implemented it totally I believe. They are now in the process of instrumenting the code so that more precise questions can asked and answered. I fully expect people like Willis to find major errors in the way it works and now that the code is readily available, the audit/critique can be very specific as to why the code is wrong. The code is released under the BSD license which means it can be edited and re-released to behave the way a sceptic audit team would prefer and a new temp series can be produced. I truly hope that happens. Maybe some of the participants in this list will be part of that process. I, myself, suspect the GISS series shows about twice the actual warming. If true, that makes it even easier for natural forcings to be 100% responsible for the warming. (9 March)

GISS I know fairly well. The full data and source code was released via Freedom of Information request over a year ago. It does not get any of its source information from HADcrut. The Clear ClimateCode project is taking a very detailed look at the GIS temperature program which is used to create the final GISS series. I suspect the GIS temp program has fundamental statistical processing errors which the detailed review will identify." GHCN is a core land-based temp series. It purports to hold the raw unadjusted temp measurements from a large number of stations in as complete a way as it can. GHCN is the primary source of raw data for both GISS and HADcrut. I have

read nothing about GHCN data values being adjusted inappropriately. I have read about the potential cherry icking of "high-quality stations" as I discussed previously. Given that both HADcrut and GISS use GHCN as their foundation it is not surprising that the general shape of their graphs is the same. Most of the upward trend over the last 100 years seems not to be present in GHCN raw data. It is introduced via the adjustment processes that HADcrut and GISS use. As to the last 35 years, I believe it is widely accepted that warming has occurred, but each of the series shows different rates, with UAH showing the least. And many sceptics in particular feel the 1975–2000 warming just restored temperatures to where they were in the 1930 timeframe. ie. the earth is continuously cycling through warming and cooling periods, so a 25 year warming period is just nature, not man. (Greg Greg Freemyer 10 March 2010)

Adds Roy Spencer: "What I believe this demonstrates is that after known, natural modes of climate variability are taken into account, the primary period of supposed CO_2-induced warming during the 20th Century – that from about 1970 onward – does not need as strong a CO_2-warming effect as is programmed into the average IPCC climate model. This is because the natural variability seen BEFORE 1970 suggests that part of the warming AFTER 1970 is natural! Note that I have deduced this from the IPCC's inherent admission that they cannot explain all of the temperature variability seen during the 20th Century." (http://www.drroyspencer.com/2010/01/)

Fred Singer on the Codes

1. We have yet to discover just how Jones et al managed to produce a substantial surface warming [between 1979 and 1997] when satellites showed practically none in the troposphere — in conflict with all GH models.
2. I suspect that it had to do both with the SELECTION of weather stations and with the applied CORRECTIONS to the trends
3. Further, I note that the Mann analysis of proxy data [Nature 1998] conveniently stops in 1979. When I questioned him on this matter, I got the very unsatisfactory reply that there were no suitable data available — suggesting to me that he was hiding such info.
4. Accordingly, one needs to procure and analyze post-1980 proxy data to see if they support CRU or satellite trends (9 March 2010)

UK Enquiry: Science&Technology Committee Report Out But Not Over Yet

This Committee of the British Ouse of Commons concluded that Phil Jones was 'not guilty of dishonesty. **'**The HC committee report claimed "We believe that the focus on CRU and Prof. Phil Jones. . . has largely been misplaced. Whilst we are concerned that the disclosed e-mails suggest a blunt refusal to share scientific data and methodologies with others, we can sympathise with Professor Jones, who must have found it frustrating to handle requests for data that he knew – or perceived – were motivated by a desire simply to undermine his work." (1 April 2010)

NB: The important issue of peer review and pressure on journals was raised but handed on to the Russell enquiry (which also largely ignored this issue).

CRU Scientific Assessment Panel Announced to Augment Russell Review

"Lord Oxburgh FRS, a former chair of the Lords Select Committee on Science and Technology, is to chair an independent Scientific Assessment Panel to examine

important elements of the published science of the Climatic Research Unit (CRU) at the University of East Anglia. His appointment has been made on the recommendation of the Royal Society, which has also been consulted on the choice of the six distinguished scientists who have been invited to be members of the panel. The panel will have access to any publications or materials it requests, and all information considered will be listed in the Report. The University, in consultation with the Royal Society, has suggested that the panel looks in particular at key publications, from the body of CRU's research referred to in the UEA submission to the Parliamentary Science and Technology Committee.

Announcing the appointment, Prof Trevor Davies, the University's Pro-Vice-Chancellor for Research, said: "CRU's scientific papers have been examined by scientists from other institutions through the peer review process before being accepted for publication by international journals. We have no reason to question the effectiveness of this process. Nevertheless, given the concerns about climate research expressed by some in the media, we decided to augment the Muir Russell review with an independent assessment of CRU's key publications in the areas which have been most subject to comment. "We are delighted that a renowned scientist of the standing of Lord Oxburgh has agreed to chair this very strong independent panel. . . .

The panel members are: Prof Huw Davies, Professor of Physics at the Institute for Atmospheric & Climate Science at ETH Zürich; Prof Kerry Emanuel, Professor of Meteorology at Massachusetts Institute of Technology; Prof Lisa Graumlich, Director of the School of Natural Resources and the Environment at The University of Arizona; Prof David Hand, Professor of Statistics in the Department of Mathematics at Imperial College; Prof Herbert Huppert, Professor of Theoretical Geophysics at the University of Cambridge; and Prof Michael Kelly, Prince Philip Professor of Technology at the University of Cambridge. "The shadow hanging over climate change and science more generally at present makes it a matter of urgency that we get on with this assessment. We will undertake this work and report as soon as possible," said Lord Oxburgh.

The panel will meet in Norwich in April and will have the opportunity to see original data and speak to those who did the work. . . Prof Davies said: "Our concern has been to bring together a distinguished group of independent scientists. . . The panel members have the right mix of skills to understand the complex nature of climate research and the discipline-based expertise to scrutinise CRU's research; how they do this will be entirely down to the panel.

"The choice of scientists is sure to be the subject of discussion, and experience would suggest that it is impossible to find a group of eminent scientists to look at this issue who are acceptable to every interest group which has expressed a view in the last few months. Similarly it is unlikely that a group of people who have the necessary experience to assess the science, but have formed no view of their own on global warming, could be found. . . ." (UEA information)

Controversy Surrounds the Second Scientific Enquiry into CRU/East Anglia

- Controversy over committee member of the 'independent' group around Muir Russell continued, with The Lord Oxburgh, former non-executive chairman of Shell reported to head up a team of leading scientists looking at claims fossil fuels cause global temperatures to rise. Other controversial names on the panel include Prof

Kerry Emanuel, professor of meteorology at the Massachusetts Institute of Technology where the infamous "hockey stick" graph was first created. He is best known for a paper that suggested hurricanes are getting fiercer with global warming, immediately causing sceptics on the internet to start questioning the appointment. . . . . Already there are various ongoing inquiries into the behaviour of the scientists involved and legal implications. But Lord Oxburgh is leading the first inquiry to look at the science being discussed in the emails. "The shadow hanging over climate change and science more generally at present makes it a matter of urgency that we get on with this assessment," he said. "We will undertake this work and report as soon as possible." Lord Oxburgh trained as a geologist and has been chief scientific adviser for the Ministry of Defence and Rector of Imperial College and chairman of the Lords Select Committee on Science and Technology. His past working in the fossil fuels industry will make environmentalists cautious, but he has also shown an interest in the environment and is currently president of the Carbon Capture and Storage Association and Falck Renewables. (*Daily Telegraph* 22 Mar 2010)

- Lord Oxburgh, the climate science peer, 'has a conflict of interest' .A member of the House of Lords appointed to investigate the veracity of climate science has close links to businesses that stand to make billions of pounds from low-carbon technology. Lord Oxburgh is to chair a scientific assessment panel that will examine the published science of the Climatic Research Unit at the University of East Anglia. . . . CCS Association has stated that carbon capture could become a "trillion dollar industry" by 2050, but this would happen only if governments made reducing emissions a top political priority. In an interview in 2007, Lord Oxburgh said that the threat from global warming was so severe that "it may be that we shall need . . . regulations which impose very severe penalties on people who emit more than specified amounts of greenhouse gases into the atmosphere". (Ben Webster *The Times* March 23, 2010)
- Professor Geoffery Boulton worked full-time at the UEA from 1968 to 1980 and part time from 1980 to 1986. Russell insisted he stay on the team with the claim that, *"I am completely confident that each member of the Review team has the integrity, the expertise, and the experience to complete our work impartially."* Boulton had told *The Times*: "I may be rapped over the knuckles by Sir Muir for saying this, but I think that statement needs to be clarified. I think the committee needs someone like me who is close to the field of climate change and it would be quite amazing if that person didn't have a view on one side or the other." Boulton stated that: *"I declared my current view of the balance of evidence: that the earth is warming and that human activity is implicated. These remain the views of the vast majority of scientists who research on climate change in its different aspects. They are based on extensive work worldwide, not that of a single institution." http://www.timesonline.co.uk/tol/news/environment/article7026932.ece*

The Oxburgh Conclusions: Predictable 'Whitewash'?

1. We saw no evidence of any deliberate scientific malpractice in any of the work of the Climatic Research Unit and had it been there we believe that it is likely that we would have detected it. Rather we found a small group of dedicated if slightly disorganised researchers . . .

2. We cannot help remarking that it is very surprising that research in an area that depends so heavily on statistical methods has not been carried out in close collaboration with professional statisticians. Indeed there would be mutual benefit if there were closer collaboration and interaction between CRU and a much wider scientific group outside the relatively small international circle of temperature specialists.
3. It was not the immediate concern of the Panel, but we observed that there were important and unresolved questions that related to the availability of environmental data sets. It was pointed out that since UK government adopted a policy that resulted in charging for access to data sets collected by government agencies, other countries have followed suit impeding the flow of processed and raw data to and between researchers. This is unfortunate and seems inconsistent with policies of open access to data promoted elsewhere in government.
4. A host of important unresolved questions also arises from the application of Freedom of Information legislation in an academic context. We agree with the CRU view that the authority for releasing unpublished raw data to third parties should stay with those who collected it. (12 April 2010; http://www.uea.ac.uk/mac/comm/media/press/CRUstatements/SAPannounce)

NB: Professor *Arthur Rorsch* was of the opinion that the above judgements shows that CRU exhibited 'incompetence' (not fraud) and that the 'team' acted as a pressure group in the IPCC by keeping scientific papers off the record in WG1, that is intended to deceive. The Oxburgh conclusions 3 and 4 indicate that we are dealing with 'politics' not with 'science'. In all fundamental, natural sciences, there is a free exchange of data to allow for reproducibility. The statement "We agree with the CRU view that the authority for releasing unpublished raw data to third parties should stay with those who collected it," can be contested because I suppose the work was performed with public funds. In general, from the point of view of professional investigation of scientific misconduct, the work of the Oxburgh committee looks very amateurish. Most probably none of the members of the committee have had previous experience with allegations of fraud and they do not know about the pitfalls. (Arthur Rörsch 14 April 2010)

NB: The judgement of the Daily Telegraph (Louise Gray 14 April 2010) is significant:

"The 'hockey stick' that became emblematic of the threat posed by climate change exaggerated the rise in temperature because it was created using 'inappropriate' methods, according to the head of the Royal Statistical Society. Professor David Hand said that the research – led by US scientist Michael Mann – would have shown less dramatic results if more reliable techniques had been used to analyse the data. . . . Lord Oxburgh said the scientists at the research unit arrived at their conclusions ''honestly and sensibly''. But the reviewers found that the scientists could have used better statistical methods in analysing some of their data, although it was unlikely to have made much difference to their results.

That was not the case with some previous climate change reports, where "inappropriate methods" had exaggerated the global warming phenomenon. Prof Hand

singled out a 1998 paper by Prof Mann of Pennsylvania State University, a constant target for climate change sceptics, as an example of this. He said the graph, that showed global temperature records going back 1,000 years, was exaggerated – although any reproduction using improved techniques is likely to also show a sharp rise in global warming. He agreed the graph would be more like a field hockey stick than the ice hockey blade it was originally compared to. . . . The "hockey stick" was used to warn the world of the threat of global warming by numerous individuals and organisations, including Al Gore in his oscar-winning film an Inconvenient Truth and UN body the Intergovernmental Panel on Climate Change. . . .

Prof Hand praised the blogger Steve McIntyre of Climate Audit for uncovering the fact that inappropriate methods were used which could produce misleading results. . . [But] Prof Mann, who is Professor of Earth System Science at the Pennsylvania State University, said the statistics used in his graph were correct. "I would note that our '98 article was reviewed by the US National Academy of Sciences, the highest scientific authority in the United States, and given a clean bill of health," he said. "In fact, the statistician on the panel, Peter Bloomfield, a member of the Royal

Statistical Society, came to the opposite conclusion of Prof Hand." http://www.telegraph.co.uk/earth/environment/climatechange/7589897/Hockey-stick-graph-was-exaggerated.html

On CRU and Peer Review

"But apart from Acton [Vice-Chancellor of UEA], the person who will read this report with most gloom, may be Sir *Muir Russell, the Scottish grandee appointed by Acton to review the activities of Jones and his colleagues*. The MPs agree with the sceptic Lord Lawson, who gave evidence, that Russell's inquiry should conduct his interviews and hearings "in public wherever possible". Unless Russell has spoken to nobody in the past four months, he evidently is not doing that. They say his inquiry should "publish all written evidence on its website as soon as possible". Yesterday, a month after the deadline for submissions closed, none had been posted. Worse, the MPs have given him long list of things to investigate or rule on, such as deciding whether emails were deleted in breach of FOI law. Or coming up with rules for CRU on sharing data. And such as deciding whether Jones "subverted the peer-review process". They also suggest that a test of how truly independent the Russell inquiry is will be whether it gives the UEA an advance copy. This story is far from over yet." (Excerpt: Fred Pearce *The Guardian* 31 March 2010)

From Der Spiegel "Most climatologists still believe [East Anglia professor Phil] Jones' contention that he did not intentionally manipulate the data. However, that belief will have to remain rooted in good faith. Under the pressure of [Steve] McIntyre's attacks, Jones had to admit something incredible: He had deleted his notes on how he performed the homogenization. This means that it is not possible to reconstruct how the raw data turned into his temperature curve. For Peter Webster, a meteorologist at the Georgia Institute of Technology in Atlanta, this course of events is "one of the biggest sins" a scientist can commit. "It's as if a chef was no longer able to cook his dishes because he lost the recipes." On the importance of verifying the data to regain public trust: German climatologist Hans von Storch now wants to see an independent institution recalculate the temperature curve, and he even suggests that the

skeptics be involved in the project. He points out, however, that processing the data will take several years. (http://www.spiegel.de/international/world/0,1518,686697-4,00.html: from Paul Ashton 3 April 2010)

Editor's comment: The S&T report was completed in a hurry because of the end of the present Parliament in May, also largely exonerates the scientists involved and blames the University for lack of help with freedom of information issues. Both enquiries now expects a deeper investigation, hopefully in public, from the Muir Russell enquiry, whose independence has already been damaged by the resignation of one member – the Chief Editor of *Nature* – and doubt expressed about several other members as to their scientific 'neutrality'. It remains doubtful, given the people on the bodies set up in the UK that IPCC critical scientists will accept their conclusions. No sceptical scientists were invited to comment.

IPCC Too Close to Greenpeace

"The expert reviewers who had input into just one portion (Working Group III) of the IPCC report are listed *in this 8-page PDF*. They include three Greenpeace employees, two Friends of the Earth representatives, two Climate Action Network reps, and a person each from activist organizations WWF International, Environmental Defense, and the David Suzuki Foundation. One of these expert reviewers is Gabriela von Goerne – who holds a PhD in geology and works as a climate and energy campaigner for Greenpeace Germany. Von Goerne is co-author of a 2008 *report* that employs colourful, less-than-clinical language. Carbon capture and storage "will arrive on the battlefield far too late to help the world avoid dangerous climate change" it declares on page six.

(Incidentally, although this Greenpeace report begins with a declaration that it is "based on peer-reviewed independent scientific research," footnotes 48 and 53 cite only a non-peer-reviewed source to support statements of fact:

- Hannegan, B, 2007. Testimony for Hearing of the Science, Technology and Innovation Subcommittee of the Committee on Commerce, Science, and Transportation. 110th Cong., 1st Sess. 7 November 2007.

Moreover, footnote 153 cites a Greenpeace-published document authored by von Goerne herself. Greenpeace, it would appear, has a definition of "peer-reviewed" that is as elastic as the IPCC's."

(Extract: Much more at http://nofrakkingconsensus.blogspot.com/2010/01/greenpeace-and-nobel-winning-climate_28.html) (From Martin Cohen March 2010)

A Null Hypothesis

"My null hypothesis: are the factors that controlled earth's climate in the past the same factors that control it today and will continue to do so into the future? In other words are the processes that have affected climate (i.e., the forcings – the sun, volcanic eruptions, greenhouse gases, etc.) in the past affecting climate today and will they continue to do so in the future? A basic premise of any science with an historical aspect (e.g., geology, evolution, etc.) is that the past is the key to the future. "(Walt Meier 8 April 2010; http://wattsupwiththat.com/2010/04/08/nsidcs-walt-meier-responds-to-willis/)

Don't Forget the Oceans

"Until we understand the oceans better we simply don't know anything of the future of the climate. They may model the atmosphere as much as they want, without the oceans it is meaningless and if they include the oceans the models will be so complicated that they will be useless anyhow. (Sten Kaijser 20 March 2010)

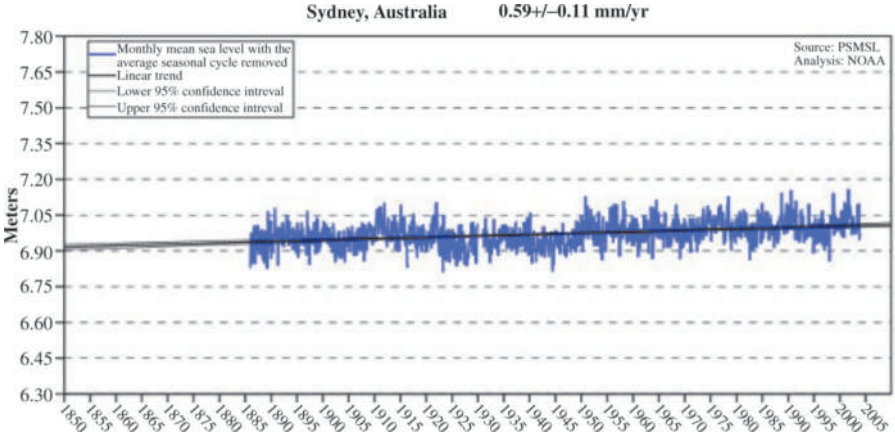
No Rise In Sealevel

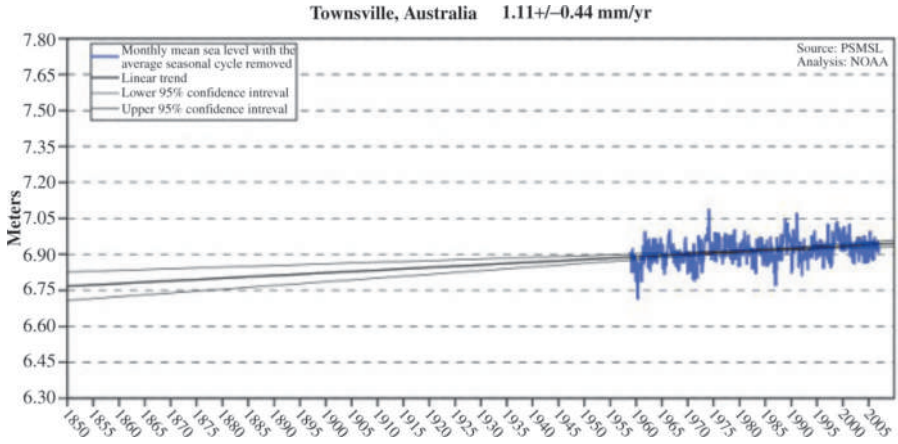
The IPCC and 'warmists' claim that global average mean sea level is rising 3 mm/year, up from 1.7 or 1.8 mm/year in the last century, and that the rate of sea level increase is accelerating. They predict a rate of 10 mm/year by the end of the 21st century. This is all non-sense. The truth is that the best and longest coastal tide gauge records indicate that:

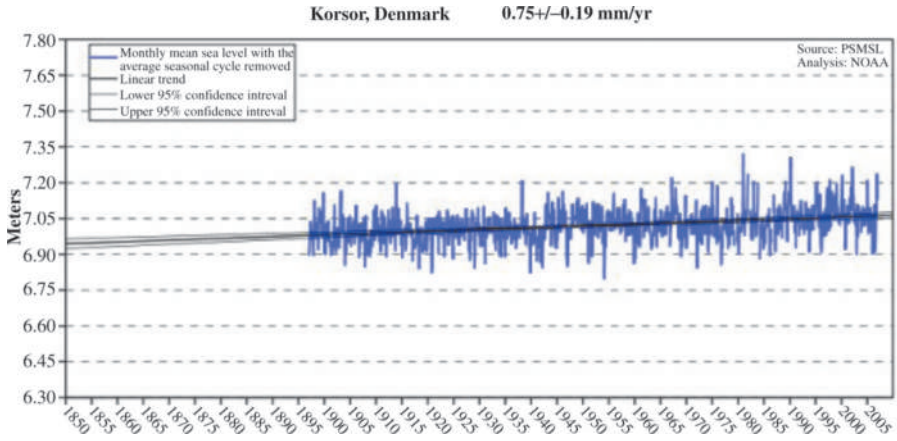
- global average mean sea level has been rising at a rate of less than 1.2 mm/year (not 1.8 or 3); and that
- it was rising at that rate long before there was a major anthropogenic contribution to atmospheric CO_2; and that
- there has been no sign of sustained acceleration in the rate of sea level rise either recently or at any other time in the last century.

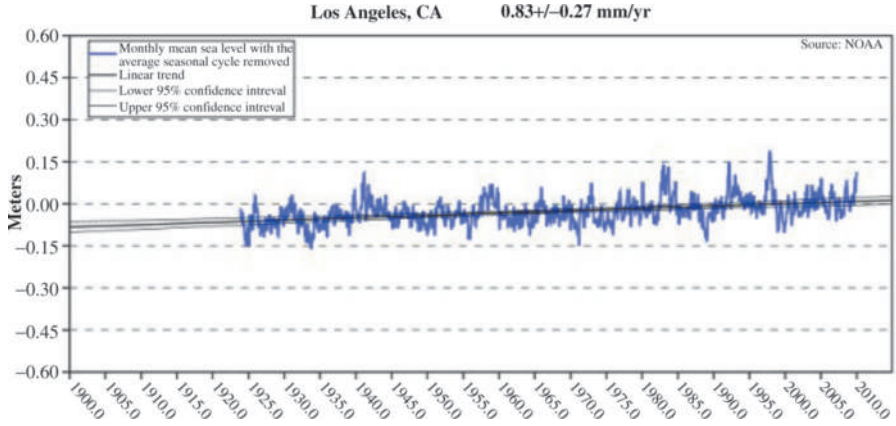
Cf. IPPC's AR4 says: "Sea level indicators suggest that global sea level did not change significantly from [between 3,000 to 2,000 years ago] until the late 19th century. The instrumental record of modern sea level change shows evidence for onset of sea level rise during the 19th century. Estimates for the 20th century show that global average sea level rose at a rate of about 1.7 mm/yr. . . . . "Satellite altimetry. . . shows that since 1993, sea level has been rising at a rate of around 3 mm/yr, significantly higher than the average during the previous half century. Coastal tide gauge measurements confirm this observation. . ." They're wrong. If you view the Mean Sea Level graphs for the GLOSS-LTT tide stations you can't help but notice that there has been no upward in MSL trend since 1993, nor any sustained increase in MSL trend at any other time in the last 120 years.

Here are some samples.




Townsville, Australia 1.11+/–0.44 mm/yr
Monthly mean sea level with the average seasonal cycle removed
Linear trend
Lower 95% confidence intreval
Upper 95% confidence intreval
Source: PSMSL
Analysis: NOAA
Meters
7.80
7.65
7.50
7.35
7.20
7.05
6.90
6.75
6.60
6.45
6.30
1850 1855 1860 1865 1870 1875 1880 1885 1890 1895 1900 1905 1910 1915 1920 1925 1930 1935 1940 1945 1950 1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005


Korsor, Denmark 0.75+/–0.19 mm/yr
Monthly mean sea level with the average seasonal cycle removed
Linear trend
Lower 95% confidence intreval
Upper 95% confidence intreval
Source: PSMSL
Analysis: NOAA
Meters
7.80
7.65
7.50
7.35
7.20
7.05
6.90
6.75
6.60
6.45
6.30
1850 1855 1860 1865 1870 1875 1880 1885 1890 1895 1900 1905 1910 1915 1920 1925 1930 1935 1940 1945 1950 1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005


Los Angeles, CA 0.83+/–0.27 mm/yr
Monthly mean sea level with the average seasonal cycle removed
Linear trend
Lower 95% confidence intreval
Upper 95% confidence intreval
Source: NOAA
Meters
0.60
0.45
0.30
0.15
0.00
–0.15
–0.30
–0.45
–0.60
1900.0 1905.0 1910.0 1915.0 1920.0 1925.0 1930.0 1935.0 1940.0 1945.0 1950.0 1955.0 1960.0 1965.0 1970.0 1975.0 1980.0 1985.0 1990.0 1995.0 2000.0 2005.0 2010.0

The IPCC's claim that "coastal tide gauge measurements confirm" an accelerating rate of MSL rise is nonsense. If the global MSL trend had actually accelerated since 1993 as the IPCC claims, that fact would be apparent at these tide stations, as a doubling or tripling of the measured rate of MSL rise. But there is no evidence of any such acceleration. The global average Mean Sea Level has been rising at a slow, steady rate of less than 1.2 mm/year for 120 years — i.e., since long before there was a major human contribution to atmospheric CO_2 levels. The fact that the rate of sea level rise now is about the same as it was when anthropogenic CO_2 emissions were very low, before there were any automobiles or coal-fired electric power plants, leads to the obvious conclusion that anthropogenic CO_2 does not appear to cause a significant increase in sea level. (Extracts from communication by Dave Burton 13 March 2010)

The Disappearing Island in the Sunderbans

"New Moore Island in the Sunderbans has been completely submerged, said oceanographer Sugata Hazra, a professor at Jadavpur University in Calcutta. Its disappearance has been confirmed by satellite imagery and sea patrols . . . "What these two countries could not achieve from years of talking, has been resolved by global warming," said Hazra. A map in Wikipeda shows that the island was a river estuary . . . made out of mud and sand. "The island was situated only two kilometers from the mouth of the Hariabhanga River. The emergence of the island was first discovered by an American satellite in 1974 that showed the island to have an area of 2,500 sq meters (27,000 sq ft). Later, various remote sensing surveys showed that the island had expanded gradually to an area of about 10,000 sq meters (110,000 sq ft) at low tide, including a number of ordinarily submerged shoals. The highest elevation of the island had never exceeded two meters above sea level." . . . The island was claimed by both Bangladesh and India, although neither country established any permanent settlement there because of the island's geographical instability." (http://www.climatechangefraud.com/climate-reports/6662-bengal-island-succumbs-to-global-warming-nonsense-ap-gets-nutty-over-the-loss-of-a-sandbar)

Himalayan Glaciers and the Medieval Warm: Subject to Natural Cycles

"The Kedarnath temple and the engravings on its boundary wall confirm that there was no glacier around the temple till AD 850. Lichenometric evidences in the Chorabari glacier dated the Little Ice Age maximum to around AD 1748. After the peak of the Little Ice Age, the recession of the glacier started, followed by three major stages of its advance and retreat during AD 1766, 1827 and 1878 (retreat) respectively, as indicated by the largest lichen on the boulders of four loops of terminal and lateral moraines of the glacier. If we consider that glaciations in the region started during the mid-fourteenth century, i.e. the beginning of the Little Ice Age and continued till around AD 1748, (see: Climate change and its impact on the Himalayan glaciers – a case study on the Chorabari glacier, Garhwal Himalaya, India. (Ravinder Kumar Chaujar, Wadia Institute of Himalayan Geology, Dehra Dun 248 001, India, *Current Science* vol. 96, No. 5, 10 March 2009).

Similarly four cycles of retreat and advance were noticed in Chota Shigri, Himachal Himalaya and Dokriani Glacier, Garhwal Himalaya (Papers published). This confirms that a Medieval warm period before the 'Little Ice Age' (LIA), during the LIA and

various periods of warm and cold when different stages of retreat and advance are noticed in the Himalayan Glaciers. . . . . there is no effect of industralisation, CO_2, Greenhouse gases etc in global warming. It is the natural cycle that is playing its role in warming and cooling." (Message from Ravinder Chaujar March 2010)

Indian Scientists on Himalayan Glaciers

Senior scientists at the Wadia Institute of Himalayan Geology (WITG) have rejected the Global Warming [scare] and told that the Himalayas are quite safe zones on earth, where Global Warming has no role in controlling the conditions. In an exclusive chat with HT, Director WIHG Dr AK Dubey said that the conditions of the Himalayas are controlled by the winter snowfall rather than external factors like much hyped Global Warming. "Our glaciers are giant high altitude glaciers above 4000 m altitude with a permanent temperature below 20 degrees [sic] Celsius," he said. (Ashwani Maindola *Hindustan Times* 7 March 2010, Courtesy CCNet 16 8 March)

Fudged Cloud Problems Long Known

Ron Miller and Gavin Schmidt, both of NASA GISS provide an evaluation of the leading US GCModels. They are U.S. climate modellers who use the NASA GISS GCM and they strongly promote the AGW hypothesis. Their paper titled 'Ocean & Climate Modeling: Evaluating the NASA GISS GCM was updated in October 2005. (http://icp.giss.nasa.gov/research/ppa/2001/oceans/) Written by strong proponents of AGW, it is admitted that the NASA GISS GCM has "problems representing variables in geographic areas of sea ice, thick vegetation, low clouds and high relief."

The Abstract says; ". . . . the representation of cloud cover in the model has been brought into agreement with the satellite observations by using radiance measured at a particular wavelength instead of saturation" but this adjustment is a 'fiddle factor' because both the radiance and the saturation must be correct if the effect of the clouds is to be correct. There is no reason to suppose that the adjustment will not induce the model to diverge from reality if other changes – e.g. alterations to GHG concentration in the atmosphere – are introduced into the model. Indeed, this problem of erroneous representation of low level clouds could be expected to induce the model to provide incorrect indication of effects of changes to atmospheric GHGs because changes to clouds have much greater effect on climate than changes to GHGs**.** Low level clouds reflect solar heat and a mere 2% increase to low level cloud cover would more than compensate for the maximum possible predicted warming due to a doubling of carbon dioxide in the air. Good records of cloud cover are very short because cloud cover is measured by satellites that were not launched until the mid 1980s. But it appears that cloudiness decreased markedly between the mid 1980s and late 1990s. Over that period, the Earth's reflectivity decreased to the extent that if there were a constant solar irradiance then the reduced cloudiness provided an extra surface warming of 5 to 10 Watts/sq metre. This is a lot of warming. It is between two and four times the entire warming estimated to have been caused by the build-up of human-caused greenhouse gases in the atmosphere since the industrial revolution. " (The UN's Intergovernmental Panel on Climate Change says that since the industrial revolution, the build-up of human-caused greenhouse gases in the atmosphere has had a warming effect of only 2.4 W/sq metre).

Comments Richard Courtney, the fact that the NASA GISS GCM has problems representing clouds must call into question the entire performance of the GCM. And if another GCM model Team had found a solution to modelling clouds then it could be expected that the NASA GISS GCM model Team would have adopted that solution. So, it can be confidently stated that parametrization of clouds is an imperfect 'fudge' in all the GCMs. (22 March 2010)

Are CO_2 and Temperature Interactive?

Why does change to atmospheric carbon dioxide concentration follow change to global temperature at all time scales?

Jack Barrett argues: "Changes in the atmospheric CO_2 concentration due to changes in ocean temperature occur to an extent of about 10 ppmv per degree Celsius. The change since 1900 is ~102 ppmv that would require a temperature increase of ~10 C. The observed temperature change has been ~0.8 C and that would account for an increase of 8 ppmv in atmospheric CO_2 concentration. [Henry's law temperature coefficients are well documented.] In past times recoveries from ice ages were not initiated by changes in CO_2 concentration, but the changes that brought about recoveries were followed by increases in CO_2 concentration and those produced more warming as a positive feedback to the principal mechanism of change. Thermally produced changes in CO_2 concentration should not be confused with radiative effects of CO_2 changes upon temperature. [See for instance, W. F. Ruddiman, Orbital changes and Climate, *Quaternary Science Reviews*, 25, 3092, (2006)]. The changes in CO_2 concentration since pre-industrial times are mainly due to fossil fuel emissions. [*Introduction to Isotope Hydrology* by Willem G. Mook, Chapter 5, Taylor & Francis, 2006, *Stable Isotopes and Biosphere-Atmosphere Interactions* eds. Flanagan, Ehleringer & Pataki, Elsevier, 2005 provide explanations and many references to the original literature.] (21 March 2010)

Truth from the UK Met Office?

"Day after day we are bombarded with images of polar bears on ice bergs and collapses of ice sheet into the ocean with apocalyptic headlines that the Arctic ice will vanish within a few years. It is of particular interest that, according to Dr. Vicky Pope, head of Climate Change at the UK Met Office:

> "Recent headlines have proclaimed that Arctic summer sea ice has decreased so much in the past few years that it has reached a tipping point and will disappear very quickly. The truth is that there is little evidence to support this. Indeed, the record-breaking losses in the past couple of years could easily be due to natural fluctuations in the weather, with summer sea ice increasing again over the next few years."(http://www.metoffice.gov.uk/corporate/pressoffice/2009/pr20090211.html)

On the Arctic Oscillation: A Prophesy

"As the time line of these measurements grows to many decades, it should gradually become possible to distinguish long-term trends caused by greenhouse warming from short-term natural variations of climate. If these indications of warming continue or accelerate in future decades, the judgment of those who now argue that a substantial

greenhouse warming is already under way will be confirmed. But if the trends reverse direction or simply slow significantly, the judgment of those scientists who argue for a relatively negligible global warming effect will be vindicated. "(Bill Ruddiman, Earth's Climate: Past and Future (2001) According to our result, the rapid warming during 1970–1990 contains a large fraction of unpredictable natural variability due to the AO. The subsequent period of 1990–2010 indicates a clear trend of the AO to be negative. The global warming has been stopped by natural variability superimposed on the gentle anthropogenic global warming. The important point is that the IPCC models have been tuned perfectly to fit the rapid warming during 1970–1990 by means of the ice-albedo feedback (anthropogenic forcing) which is not actually observed. IPCC models are justified with this wrong scientific basis and are applied to project the future global warming for 100 years in the future. Hence, we warn that the IPCC models overestimate the warming trend due to the mislead Arctic Oscillation." (http://pielkeclimatesci.wordpress.com/2010/03/30/guest-post-by-hiroshi-l-tanaka-on-the-new-paper-data-analysis-of-recent-warming-pattern-in-the-arctic-by-ohashi-and-tanaka/)

A New Paper on Recent Warming Pattern in the Arctic – its Natural

The paper by Masahiro Ohashi and H. L. Tanaka, 2010: Vol. 6A (2010) : *Data Analysis of Recent Warming Pattern in the Arctic*. Special Edition -Special Edition of the Fourth Japan China Korea Joint Conference on Meteorology was published on 13 March 2010. The abstract reads

"In this study, we investigate the mechanism of the arctic warming pattern in surface air temperature (SAT) and sea ice concentrations over the last two decades in comparison with global warming since the 1970s. According to the analysis result, it is found that the patterns of SAT and sea ice before 1989 are mostly determined by the Arctic Oscillation (AO) in winter. In contrast, arctic warming patterns after 1989 are characterized by the intensification of the Beaufort High and the reduced sea-ice concentrations in summer induced by the positive ice-albedo feedback. It is concluded that the arctic warming before 1989 especially in winter was explained by the positive trend of the AOI. Moreover the intensified Beaufort High and the drastic decrease of the sea ice concentrations in September after 1989 were associated with the recent negative trend of the AOI. Since the decadal variation of the AO is recognized as the natural variability of the global atmosphere, it is shown that both of decadal variabilities before and after 1989 in the Arctic can be mostly explained by the natural variability of the AO not by the external response due to the human activity."

Professor Tanaka on the Implications: "According to our result, the rapid warming during 1970–1990 contains a large fraction of unpredictable natural variability due to the AO. The subsequent period of 1990–2010 indicates a clear trend of the AO to be negative. The global warming has been stopped by natural variability superimposed on the gentle anthropogenic global warming. The important point is that the IPCC models have been tuned perfectly to fit the rapid warming during 1970–1990 by means of the ice-albedo feedback (anthropogenic forcing) which is not actually observed. IPCC models are justified with this wrong scientific basis and are applied to project the future global warming for 100 years in the future. Hence, we warn that the IPCC models

overestimate the warming trend due to the mislead Arctic Oscillation." (From Chris de Freitas March 30, 2010)

Lysenko Invoked by Bob Carter

A group of 300 ivory tower scientists, economists and planners in the UK, led by the British Government's scientific advisor, have come up with a new apocalypse scenario, still based on the belief in catastrophic man-made global warming (February 27–28). They probably felt they had to do this because Climategate and the revelations of serious errors in the IPCC report have fatally exposed the man-made-global-warming scam. Their vision lacks any scientific credibility and totally ignores human nature. Their action is nothing more than a rear-guard action. Parliament should defer consideration of the CPRS bill and institute a fully independent Royal Commission of enquiry into the evidence for and against a dangerous human influence on climate. We add . . . . . that the scientific community is now so polarised on the controversial issue of dangerous global warming that proper due diligence on the matter can only be achieved where competent scientific witnesses are cross-examined under oath and under strict rules of evidence". (Excerpt, Bob Carter "Lysenkoism and James Hansen" at http://www.quadrant.org.au/blogs/doomed-planet/2010/03/hansenist-climate-alarmism)

Some claim that the Obama administration is trying to achieve its 'global warming ambitions by 'quietly incorporating climate change considerations into a variety of other policies: national security and the oceans.. without congressional action. The oil and gas people are worried that their offshore activities might be controlled by another sector of government less in tune with their objectives. (*Environment&Climate News* March 2010)

A Comment from South Africa

"The total collapse of climate change science is a direct consequence of the knowledge cage within which climate change scientists chose to operate. The principal constraint is the universal assumption that global climate is a steady-state phenomenon. The natural processes including temperature, rainfall and river flow vary on all time scales from seasonal through to annual, multi-decadal and multi-centuries such as the well-known global cold and warm periods. Consequently, the assumption in climate change science that these phenomena are in a steady-state is fundamentally in error. It was the attempt by the CRU to prove that global temperatures were a steady-state phenomenon by suppressing the irregularities that brought about its downfall. This accusation is unfair because this assumption is widespread within the climate change community. The second knowledge constraint is fundamental. All scientific cause-effect studies have two components. These are studies of the causes in the first instance followed by the prediction of the consequences. The final proof is whether or not the consequences agree with the predictions. It is simple high school logic that the best place to search for signals of changes is in the consequences and not in the causes. If signals of change cannot be found in the consequences then searching for signals in the causes will be an exercise in futility. Even if they are found in the causes, they are obviously too weak to result in detectable changes in the consequences. Yet this is the route that the climate change scientists have followed. (From a memo by Will Alexander 5 April 2010)

Post-Normal Science – Blame the Marxists!

"In 1991 a Marxist philosopher called Jerome R. Ravetz had helped to invent a seductive and dangerous new concept called 'post-normal science'. No longer was it considered essential that scientists strive after objectivity. Their new duty, Ravetz held, was not to 'truth' but to what he called 'quality'. And by 'quality' he meant something more akin to rhetoric – the ability to manipulate evidence and present it in such a way as to achieve particular political ends. Post-normal science and the AGW movement were made for one another. . . ." (Extract J. Delingpole, http://blogs.telegraph.co.uk/news/author/jamesdelingpole/February 27)

Editorial Comment: The merging of values with science is surely nothing new but its dangers need to be explored more fully.

MET Office on UKCIP: Research Analysis Confirms Consensus

"A Met Office review of the latest climate research confirms our planet is changing rapidly and man-made greenhouse gas emissions are very likely to be the cause. Long-term changes in our climate system have been observed across the globe, from shifts in rainfall patterns to a decline in Arctic sea-ice. The changes follow the pattern of expected climate change and bear the 'fingerprint' of human influence, providing the clearest evidence yet that human activity is impacting our climate. (http://www.metoffice.gov.uk/corporate/pressoffice/2010/pr20100305.html)

But Fred Singer concludes: As to natural causes of temperature increases in the past 50 years, the IPCC Summary for Policy-Makers (SPM) claims that: "The observed widespread warming of the atmosphere and ocean, together with ice mass loss, support the conclusion that it is *extremely unlikely* that global climate change of the past 50 years can be explained without external forcing, and *very likely* that it is not due to known natural causes alone. (4.8, 5.2, 9.4, 9.5, 9.7 in SPM 1-30-07 p 10).

Put differently, it is only 5% probable that the surface temperature increases can be explained by changes within the earth and its internal climate system, and only 10% probable that they can be explained by all natural changes including changes in solar activity, etc. This leads to one of nature's delicious ironies. This winter when much of the inhabited part of the Northern Hemisphere was suffering from extreme cold and snow. . . satellite measurements show that the atmosphere was unusually warm due to a strong El Niño. Yet, the IPCC excludes natural influences for warming, specifically mentioning El Niños, which it considers too short to have an influence. It also excludes the established oscillations of the oceans such as the Pacific Decadal Oscillation and the Atlantic Multi-decadal Oscillation. Adding to the irony, on March 6 the Houston Chronicle published an op-ed written by climate scientists. . . titled "On global warming, the science is solid." The scientists claim that the January high temperatures (now February as well) support the IPCC science. Others have made similar claims. Thus, to defend IPCC science some advocates are reduced to attacking IPCC's scientific findings! (*TWTW* March 20)

***Nature* Remains Hopeful in spite of Street Fight with 'Deniers'**

"The integrity of climate research has taken a very public battering in recent months. Scientists must now emphasize the science, while acknowledging that they are in a street fight. Climate scientists are on the defensive, knocked off balance by a re-energized

community of global-warming deniers who, by dominating the media agenda, are sowing doubts about the fundamental science. Most researchers find themselves completely out of their league in this kind of battle because it's only superficially about the science. The real goal is to stoke the angry fires of talk radio, cable news, the blogosphere and the like, all of which feed off of contrarian story lines and seldom make the time to assess facts and weigh evidence. Civility, honesty, fact and perspective are irrelevant.

Worse, the onslaught seems to be working: some polls in the United States and abroad suggest that it is eroding public confidence in climate science at a time when the fundamental understanding of the climate system, although far from complete, is stronger than ever. Ecologist Paul Ehrlich at Stanford University in California says that his climate colleagues are at a loss about how to counter the attacks. "Everyone is scared shitless, but they don't know what to do," he says. "Scientists must not be so naive as to assume that the data speak for themselves." Researchers should not despair. For all the public's confusion about climate science, polls consistently show that people trust scientists more than almost anybody else to give honest advice." (Extract, Editorial *Nature* 464, 141, 11 March 2010. Courtesy *TWTW* 13 March)

It is a travesty!

"We are not close to balancing the [Earth's] energy budget. The fact that we cannot account for what is happening in the climate system makes any consideration of geo-engineering quite hopeless as we will never be able to tell if it is successful or not! It is a travesty!" (Leaked CRU email from Kevin Trenberth (NCAR) to Tom Wigley, October 2009) quoted in *Environment & Climate News* March 2010)

CLIMATE AND ENERGY POLICY

> *It will be very difficult to get a treaty this year* (Connie Hedegaard, EU Commissioner for Climate Change, to FT 9 March 2010)
>
> *To a significant extent, the issue of climate change revolves around the elevation of the commonplace to the ancient level of ominous omen. In a world where climate change has always been the norm, climate change is now taken as punishment for sinful levels of consumption. In a world where we experience temperature changes of tens of degrees in a single day, we treat changes of a few tenths of a degree in some statistical residue, known as the global mean temperature anomaly, as portents of disaster.* (Richard S Lindzen, Gazette Xtra, 8 April 2010)

The Top UN Job on Climate Change Open

This is likely to go to a developing country. South Africa, India and Indonesia are vying for the job to replace the Dutchman de Boer. South Africa has nominated its tourist minister, a former environment minister; India Vijay Sharma, also an environment official, and Indonesia has not yet decided.

Global Climate Deal Impossible in 2010

"The world cannot agree a final climate deal this year, outgoing U.N. climate chief Yvo de Boer told Reuters. . . saying the focus should be on practical steps to help the poor and save forests.

De Boer was speaking on the sidelines of the first U.N. talks since a bad-tempered summit in Copenhagen in December fell short of agreeing the full legal treaty many nations had wanted.

Negotiators at the April 9-11 talks in Bonn struggled to find a formula to revive negotiations on a pact to combat global warming and agree a schedule before the next annual ministerial meeting in Cancun, Mexico in November and December. "I don't think Cancun will provide the final outcome," said de Boer. . . "I think that Cancun can agree an operational architecture but turning that into a treaty, if that is the decision, will take more time beyond Mexico. I think that we will have many more rounds of climate change negotiations before the ultimate solution is arrived at."

. . . . . De Boer said many scientists were advocating a halving of world greenhouse gas emissions by 2050. "Even in my wildest dreams I don't think that Cancun in detail is going to define exactly how that will be achieved," he said. . . . . The mood in Bonn was also soured by Bolivia's claim that the United States and Denmark had withdrawn funding to the Latin American nation, which opposes the accord. De Boer said the most needy should get funds to help adapt to the impacts of a changing climate. (Excerpts: Gerard Wynn and Alister Doyle BONN, Reuters Sunday, April 11 201) http://www.washingtonpost.com/wp-dyn/content/article/2010/04/11/ AR2010041101468.html

Confidential Document Reveals US Climate Strategy

A document outlining key messages the Obama administration wants to convey in the run-up to UN climate talks in Mexico in November was accidentally left on a European hotel computer and passed to the Guardian. It reveals the US government's increasingly controversial strategy in the global UN climate talks. Titled Strategic communications objectives and dated 11 March 2010, it outlines the key messages that the Obama administration wants to convey to its critics and to the world media in the run-up to the vital UN climate talks in Cancun, Mexico in November. Top of the list of objectives is to: "Reinforce the perception that the US is constructively engaged in UN negotiations in an effort to produce a global regime to combat climate change." It also talks of "managing expectations" of the outcome of the Cancun meeting and bypassing traditional media outlets by using podcasts and "intimate meetings" with the chief US negotiator to disarm the US's harsher critics. But the key phrase is in paragraph three where the author writes: "Create a clear understanding of the CA's [Copenhagen accord's] standing and the importance of operationalising ALL elements."

This is the clearest signal that the US will refuse to negotiate on separate elements of the controversial accord, but intends to push it through the UN process as a single "take it or leave it" text. The accord is the last-minute agreement reached at the chaotic Copenhagen summit in December. Over 110 countries are now "associated" with the accord but it has not been adopted by the 192-nation UN climate convention. The US has denied aid to some countries that do not support the accord.

. . . . Jonathan Pershing, lead US negotiator at the Bonn talks, said he "had no knowledge" of the document. But he endorsed one of its key messages. "We are not prepared to see a process go forward in which certain elements are cherry-picked. That was not the agreement we reached in Copenhagen," he said. Excerpts from leaked

document: . . . . . Reinforce the perception that the US is constructively engaged in UN negotiations in an effort to produce a global regime to combat climate change. This includes support for a symmetrical and legally binding treaty. . . . . Advance the narrative that while a symmetrical legally binding treaty in Mexico is unlikely, solid progress can be made on the six or so main elements. . . . . Create a clear understanding of the CA's standing and the importance of operationalising ALL elements. . . . . Build and maintain outside support for the administration's commitment to meeting the climate and clean energy challenge despite an increasingly difficult political environment to pass legislation. . . . . Deepen support and understanding from the developing world that advanced developing countries must be part of any meaningful solution to climate change including taking responsibilities under a legally binding treaty. "Media outreach and Key outreach efforts were also outlined. (http://www.guardian.co.uk/environment/2010/apr/12/us-document-strategy-climate-talks or http://tinyurl.com/y762y6o; from Paul Ashton 14 April 2010)

EU Support for Renewables in Doubt

Renewable energy projects are set to receive "peanuts" from the planned sale of 300 million carbon allowances from the EU Emissions Trading Scheme, with the vast majority of proceeds likely to fund carbon capture and storage projects, according to Green MEP Claude Turmes. He said the European Commission had promised a "fair balance" when it unveiled its plans in February to fund "innovative" energy technologies from the ETS' new entrants' reserve – a quantity of allowances set aside for newly built installations – from 2013. He said that if the 300 million allowances were sold at about 15 ($20) per tonne of carbon dioxide – above the current spot price of 13.35 – this would only amount to 4.5 billion. If the final eight CCS demonstration projects agreed by the Commission each received 500 million, this would leave only 500 million to be divided between the planned 34 renewable projects. (*EF* 8 April)

UK Climate Planning Well Advanced – On Paper

From the Government's response to the House of Environmental Audit Committee's report published on 11 January 2010: "The UK Government has the world's first long-term legally binding national framework to reduce emissions in order to tackle the dangers of climate change. The Climate Change Act 2008 put in place a system of five year 'carbon budgets' to set the trajectory towards our long term target to reduce greenhouse gas emissions by at least 80% by 2050 below 1990 levels.

The UK's first three carbon budgets, which cover the periods 2008–12, 2013–17 and 2018–22, came into force on 31 May 2009. These require emission reductions of just over 22%, 28% and 34% respectively, compared to 1990 levels. The UK is committed to tightening its carbon budgets in the light of a comprehensive global agreement, and the sharing out of a new EU target.

Last summer, the Government published *The UK Low Carbon Transition Plan*. The Transition Plan sets out how we will meet our first three carbon budgets and represents the step-change in emissions reductions that the Committee on Climate Change rightly says is needed. The Plan also announced that we will pilot a system of departmental carbon budgets covering every central government department. The sharing of the UK

budget represents a commitment from all parts of government to taking action to reduce emissions.

At the time the EAC's report was published the Chair of the Committee rightly pointed out that setting carbon budgets involves making a series of difficult political judgments that balance what science is telling us with what is affordable, feasible and politically acceptable. We welcome the fact that he feels that on balance the Government has got these judgments right. We share the view that delivery is equally important as we enter this critical phase in acting on the ambitious commitments set out in the Transition Plan. Indeed, since the Plan was published last summer we have already taken a number of actions, including amongst other things:

- setting out the world's most ambitious plans for clean coal; publishing for consultation the draft energy National Policy Statements;
- working to ensure that access to the electricity grid is not a barrier to low carbon generation;
- trialling new community-based and whole-house approaches to ramp-up delivery of energy efficiency measures in the home;
- looking at policy options to realise the significant potential for emissions reductions from small businesses;
- developing new ways to encourage and support local authorities to increase their role in the transition to the low carbon economy;
- providing from 2011 an incentive of between £2,000 and £5,000 to people who buy an ultra-low emission car; and
- increasing funding to support cycling to £140 million over three years.

The global objective

1. We accept that the Government is broadly right to use the objective of limiting the rise in average global temperature to no more than 2°C as the backbone for its targets and budgets. (Paragraph 12) The Government welcomes this conclusion and also notes the need for an international consensus for setting a temperature limit. The Copenhagen Accord which was agreed by a broad range of developed and developing country leaders at the United Nations Framework Convention on Climate Change (UNFCCC) climate summit in December 2009 includes agreement to take action with a view to holding global temperature increases to below 2°C relative to pre-industrial temperatures. The UK is seeking to broaden, deepen and strengthen the commitments made in the Copenhagen Accord, and to achieve a legal treaty as soon as possible.
2. The Government must be ready, if needed, to establish credible emissions reduction pathways that go well beyond what is currently regarded as politically possible. (Paragraph 12)
3. The Government must shape and inform public opinion so that the UK will be able, if needed, to reduce its emissions at rates in excess of what is possible currently. . .

From Government Response: The Government agrees that to support the UK's transition to a low-carbon economy and meet its long-term target of at least an 80%

reduction in greenhouse gases (GHGs) by 2050, a credible and ambitious emissions reduction pathway has to be in place. To ensure that it is credible the Committee on Climate Change is required by the Climate Change Act to provide advice on what the carbon budgets should be to be consistent with that long term target. In providing that advice and in setting the budgets, the Act requires that a range of matters are taken into account including scientific knowledge and economic, fiscal and social circumstances.

The Low Carbon Transition Plan published last summer sets out a credible pathway to deliver the Government's first three carbon budgets. It includes the policies and measures which are projected to deliver emission reductions of 36% below 1990 levels by 2020, 2% higher than our binding target for that period. The budgets set are consistent with the advice from the CCC and we have made it clear that we will tighten our carbon budgets once an ambitious international deal is reached, once there is agreement within the EU on effort sharing of a tighter target between Member States and following further advice from the Committee on Climate Change (CCC).

The Government is also considering emissions reduction pathways out to 2050. As described in the Transition Plan, the Government is working with key stakeholders to better understand the scale and nature of the changes required in the medium to long term. As part of this "2050 Pathways" work, we are investigating the range of possible contributions to decarbonisation from all sectors, including both energy supply and demand. From this analysis we will better understand which combinations of action in different sectors would enable us to meet our emissions and energy security goals out to 2050. We intend to publish the findings of this work in March.

The Government agrees that it has a key role in shaping and informing public opinion on the need for the UK to reduce its emissions significantly over the coming years consistent with the budgets it sets. This involves not only communicating information but also proactively engaging with people—we recognise that if we are to tackle climate change successfully we need the commitment, energy, ideas and campaigns of a vibrant civil society." (Extract from 'Carbon budgets: Government Response to the Committee's Third Report – Environmental Audit Committee http://www.publications.parliament.uk/pa/cm200910/cmselect/cmenvaud/479/47904.htm)

The UK Post-Copenhagen Action Plan

Energy and climate secretary Ed Miliband has set out the UK's position following the failure to agree international climate treaty at the UN climate summit in Copenhagen last December. The government's preference is for a single international agreement from 2012 to include the USA, but Mr Miliband said the UK could be prepared to sign up to a second commitment period under the Kyoto Protocol. A separate treaty to include non-Kyoto parties would avoid the continuing dispute over the format of the new framework *DECC press release Foreign and Commonwealth Office press release Beyond Copenhagen: The UK Government's International Climate Change Action Plan Consultation Oxfam press release Friends of the Earth press release* (31 March Press Release – Government Kick-Starts Renewed Push for Global Climate Deal)

Summary:

- PM co-chairs first international climate finance meeting
- New international climate action plan published

- Co-funding the delivery of up to 2,500 apprenticeships in the wind energy sector, in line with the sector's ambition for the size of its workforce in 2017
- Further £4.75m for renewables development . . . The Government has also outlined more support for the UK's own low carbon transition with funding for renewables development and a consultation to ensure workers and businesses are prepared to take advantage of the growing need for green skills.

The Government is also setting out its plans to breathe new life into efforts to get a legally binding global treaty.

More on the UK's International Climate Change Action Plan

"We've got to dust ourselves down and kick-start efforts to get a global deal, get the climate finance flowing and make sure the cuts promised by countries happen. . . We need to do this, not just for environmental reasons, but also for economic ones. In the UK, strategic intervention by the Government is unlocking green investment and generating jobs for the future. Low carbon growth will be stronger, and businesses will have greater certainty, when the world agrees to a legally binding deal." (Ed Miliband) The announcements included the new action plan (see above) which shows what must be done to build on the progress made at Copenhagen. The plan sets out the Government's belief that the low carbon transformation can be a major driver of economic growth and job creation – in the UK, in Europe and globally. In it the UK Government makes clear that:

- It wants to build on the strengths of the Kyoto Protocol, and is open to extending that agreement as a way of getting the legal deal we need.
- It is in favour of strengthening the UN decision making process that was so frustrating at Copenhagen.
- It is pushing for the EU to increase its plans to cut emissions in line with comparable moves elsewhere, which is why we are supporting the European Commission's work to identify the practical steps that would be required to implement a 30% target. (From 31 March Press release)

NB After perusing the action plan, Andrew Killop comments: The UK Government makes clear that:

- It wants to build on the strengths of the Kyoto Protocol, and is open to extending that agreement as a way of getting the legal deal it needs.
- It is in favour of strengthening the UN decision making process that was so frustrating at Copenhagen.
- It is pushing for the EU to increase its plans to cut emissions in line with comparable moves elsewhere, which is why we are supporting the European Commission's work to identify the practical steps that would be required to implement a 30% target.

The Action Plan builds on the Copenhagen Accord, in which countries have put forward actions that, if delivered in full, would see global emissions peak before 2020, a key step towards achieving the 2 degrees goal. The real question is who still believes in this junk policy built on junk science, or is there a life after carbon tax ? "(Andrew

Mckillop Former Expert-Policy & Programming, DG XVII-Energy, European Commission; April 2010)

UK Met Office Team Tries to Replace IPCC?

An international team led by the UK Met Office spent last year analysing more than 100 scientific papers to update the last IPCC assessment. It concluded, as one may expect, that the case for man-made warming is even stronger than suspected, thus marking "a resumptions of the campaign by mainstream scientists to show that man-made releases of greenhouse gases are causing potentially dangerous global warming." It mainly deals with so-called fingerprint evidence [discredited by some]. An increase in salinity in the sub-tropical Atlantic and changing rainfall patterns, are reported though it is admitted that natural variability interacted with man-made warming. (*FT* March 5 2010)

[Editor: The media is surely confusing civil servants with scientists. The UK Met Office is very much a government institution, and they surely selected their papers most carefully]

The White House Response to CRUGate?

A task force representing more than 20 federal agencies reported in response: "Climate change is already having "pervasive, wide-ranging" effects on "nearly every aspect of our society."

Fred Singer comments: This is in response to: "the raft of climate change deniers who have been having a field day of late trying to rally an assault on science with a handful of stolen e-mails and a couple of minor errors in a 2,800-page report by the International Panel on Climate Change, according to Reuters alertnet.org, Mar 18, 2010.

But DEFRA Opts for Adaptation

Defra, that is the climate bit left inside this former environment ministry of the UK, now mainly deals with food and rural affairs, but is funding work to bring together a collection of over 40 case studies about local authorities that have acted to adapt to climate change. The case studies cover 24 service areas and includes headings such as risk management, spatial planning and partnership working. Online at www.ukcip.org.uk/casestudies

House of Lords for Adaptation?

The House of Lords European Union Committee has published its report 'Adapting to Climate Change: EU Agriculture and Forestry'. A key recommendation is that governments must ensure that accessible, practical advice is given to EU farmers and foresters to enable adaptation to take place.http://www.parliament.uk/hleud/

Environmental Audit Committee: Adaptation as Important as Emission Cuts

Adapting to climate change needs to become as much of a priority as cutting emissions, MPs on the Environmental Audit Committee argue in a report out today. Climate projections show that Britain can expect wetter winters, drier summers and a higher likelihood of flash-floods, heat waves and droughts. The report concludes that

Government must do more to raise awareness of the need to prepare for a changing climate. Tim Yeo, Chair of the Environmental Audit Committee said:

"For a long time the climate change debate has focused on reducing carbon emissions, but adapting to the inevitable impacts of rising global temperatures is equally critical." . . . "The Government must be imaginative and establish new and sustainable sources of funding and support for adaptation."

Adapting infrastructure and homes will be expensive. More intense rainfall will make flash flooding more likely and the risk of coastal erosion will increase as climate change causes sea levels to rise. To maintain current levels of flood protection for homes, real terms spending on flood defences will need to increase from its current level of around £6oo million per annum to around £1 billion in 2035. Estimates in 2009 suggest that by the end of the century around £7 billion may be needed to improve the Thames flood barrier and tidal defences. New homes being built now must be designed to cope with the inevitable changes in climate we will see over the next 50–80 years. The Government must make adaptation and mitigation more central to the planning system. New developments should only be permitted if they are suited to future climates. . ." (25 March 2010 The report was published by the Environmental Audit Committee and is its Sixth Report of Session 2009–10, HC 113. Details of all the Committee's press releases together with its Reports, oral evidence and other publications, are available on the Committee's website at: www.parliament.uk/eacom)

UK Energy Policy for 80% Emission Cut 'Nowhere Near Ready'

According to the British Royal Academy of Engineering, and irrespective of official announcements, British energy policy is 'nowhere near ready' to delivers the promised investments and jobs, not to mention emission reductions. The Engineers considered policy up to 2050 and agreed that fundamental restructuring was needed if blackouts are to be prevented and emission to be cut by 80%. Also promising lots of new jobs from low carbon technologies, the group warned that market mechanisms and the fragmented energy sector would not provide the needed investments. Massive investments in renewables would be required, such as 38 wind farms the size of the world's largest (the London Array) and one new onshore turbine would have to be erected for 25 years to make up the needed 9000. Huge investment in nuclear power and gas- or coal fired power stations with CCS would also be needed. New nuclear and CCS plants could be kept to 30–49 only if energy efficiency in houses improved greatly. Currently the government is planning for 10 new nuclear plant and four CCS pilots. Without a serious cut in energy demand, 80 new plants would be needed. All this would probably only be achievable only by 'monopolising most of the national wealth and resources." And a significant rise in energy costs to end users would be needed. Wind mill maintenance was identified as the main job creator! (Summarised from *FT 1*8 March)

UK 'Lacks Skills' to Decarbonise

According to a report by the Aldersgate Group, a coalition of businesses, NGOs and think-tanks believing in high environmental standards, the UK does not yet have the necessary skills to make the transition to a low-carbon economy, in spite of the official commitment to this economy – there are not enough engineers for the desired

development of wind farms, CCS, nuclear power, high speed trains and flood defences. And about 20% of the relevant work force are due for retirement within ten years, importing expertise is not likely to be satisfactory or even possible More 'green training' will be required. (www.aldersgategroup.org.uk; *Energy World January 2010*)

The UK Carbon Reduction Commitment/Energy Efficiency Debacle

In early March it was reported that government had underestimated by six times the number of businesses covered by new GHG emission regulation. About 30,000 rather than 6000 firms will now be covered, causing consternation among small and medium-sized businesses. They all have to comply with the newly renamed CRCEnergy Efficiency scheme, with efficiency added to carbon reduction commitment, presumably to sweetening the pill. The government funded Carbon Trust is the source of these rules, with registration required by April 1 this year and compliance by September. The Environment Agency is in charge of implementation. Retailers, banks, large offices and hotels are included, as well as hospitals, schools and universities who all have to register voluntarily and report details of their energy use, to be ranked by officials according to their energy efficiency. Those at the bottom will be penalised with fines that are handed as rewards to firms at the top. All energy use, no matter whether green or not, is included. The scheme remains controversial. (*FT* 5 March 2010) See http://www.opsi.gov.uk/si/si2010/uksi_20100768_en_1.

German Advisory Committee Suggest Adaptation and Going it Alone

On March 12, according to the *Frankfurter Allgemeine* paper 'Wirtschaft', the scientific advisors (that is economists) to finance minister Wolfgang Schäuble (CDU) recommended adaptation rather than mitigation for the German economy. Instead of subsidising wind turbines and solar power in order to reduce emissions to slow down global warming, the German government should make all possible efforts to ameliorate the negative impacts of climate change. Adaptation was more likely to enhance the national economy and create jobs. Emission reduction would only work through a world government, which as Copenhagen suggested, was not likely. The results of this enquiry were not expected to be popular, and the paper was not indeed merely published on the ministry's web site. This official advice was also directed against attempts at going it alone and seeking national leadership roles with respect to emission reduction efforts. ('*gegen nationale Alleingänge und eine Vorreiterrolle einzelner Staaten in der Emissionsvermeidung*'. Summary, *F.A.Z.*, no.61 13 March 2010)

New Touches in Obama's Climate Policy?

The US Administration in its 'Global Climate Change Impacts in the United States -Home report ((http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts), described as "the most comprehensive and authoritative report of its kind. The report summarizes the science and the impacts of climate change on the United States, now and in the future. It focuses on climate change *impacts in different regions of the U.S.* and on various aspects of society and the economy such as energy, water, agriculture, and health. It's also a report written in plain language, with the goal of better informing public and private decision making at all levels.

Some Key findings include:

- Climate changes are underway in the United States and are projected to grow. Climate-related changes are already observed in the United States and its coastal waters. These include increases in heavy downpours, rising temperature and sea level, rapidly retreating glaciers, thawing permafrost, lengthening growing seasons, lengthening ice-free seasons in the ocean and on lakes and rivers, earlier snowmelt, and alterations in river flows. These changes are projected to grow.
- Crop and livestock production will be increasingly challenged. Agriculture is considered one of the sectors most adaptable to changes in climate. However, increased heat, pests, water stress, diseases, and weather extremes will pose adaptation challenges for crop and livestock production.
- Threats to human health will increase. Health impacts of climate change are related to heat stress, waterborne diseases, poor air quality, extreme weather events, and diseases transmitted by insects and rodents. Robust public health infrastructure can reduce the potential for negative impacts.

It concludes that the "amount and rate of future climate change depend primarily on current and future human-caused emissions of heat-trapping gases and airborne particles. Responses involve reducing emissions to limit future warming, and adapting to the changes that are unavoidable. (http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts/key-findings)

NB: Six months after introducing a sweeping climate change bill that flopped in the Senate, Democrat John Kerry is preparing to offer a compromise measure that seeks to reel in reluctant senators. Kerry, collaborating with Republican Senator Lindsey Graham and independent Senator Joseph Lieberman, might introduce a new bill promoting clean energy early next week, just days before the 40th anniversary of Earth Day, environmental sources said. Aides to Kerry, Graham and Lieberman toiled over legislative details of their climate bill during a two-week recess that ends on Monday. Its center piece will be a 2020 deadline for reducing greenhouse gas emissions by 17 % from 2005 levels. Oil and coal, cheap and dirty energy sources, gradually would be replaced with more expensive, but cleaner alternative fuels. The 17 % target lines up with the House of Representatives' target and commitments made by Obama at Copenhagen. (Andrew McKilliop 12 April 2010)

New Regulatory Risks from EPA

A more activist US Environmental Protection Agency (EPA), in trying to curb greenhouse gas (GHG) emissions, is creating regulatory risks for companies that could trigger disclosure obligations, legal experts warned this week. Under the leadership of President Barack Obama, the EPA has moved aggressively to establish GHG rules, including limits on GHG emissions from motor vehicles to be finalised this month and proposed regulation of stationary sources beginning in 2011.

One regulation already imposing risk is the EPA's GHG reporting rule, which took effect 1 January and applies to about 13,000 facilities in the US, said . . . director of the Center for Climate Change Law at Columbia University in New York. The EPA will begin publicly disclosing the emissions data in March 2011, which will create

lists of the top polluters in the country and individual states. Companies on these lists will find themselves targets of citizen activism, shareholder resolutions and toxic tort litigation, which could create material risks that need to be disclosed under recent guidance from the Securities & Exchange Commission (SEC), he said. . .Under the SEC guidance, formally issued in February, companies will have to consider whether the risks created by the new EPA regulations are material and warrant disclosure. "A lot of the things that are happening on the regulatory front could impact the company's bottom line because it's going to increase the cost of business," said Michael Myers, chief of the affirmative litigation section of the environmental protection bureau of the New York Attorney General's office. . . . . In addition to the regulatory risks, companies will have to consider whether public nuisance lawsuits pose material risks that need to be disclosed, he said. For example, the lawsuit Connecticut v. AEP, to which New York State is a party, seeks to force the five largest GHG emitters in the US to cap and reduce their emissions. ..Conservative members of Congress have discussed a potential legislative attempt to retract the SEC guidance since the commission approved it by a 3–2 vote along party lines. "The SEC will stay the course unless November flips things around in Washington very dramatically," Gerrard said, referring to the mid-term elections that month. (New York *EF* 18 March 2010)

EPA Endangerment Finding – Republicans 'Disapprove' and Row Continues
House Energy and Commerce Committee – Republicans introduced disapproval.

The Resolution of Disapproval will prevent the implementation of the economy-killing regulations posed by this administration because:

- "The EPA's endangerment finding is a back-door attempt to institute a national energy tax that will cap our economy and trade jobs.
- The Resolution of Disapproval would prevent the EPA from engaging in job-killing behavior. The resolution would prevent the cascade of anti-growth rules and requirements that flow from the EPA administrator's controversial endangerment finding.
- The endangerment finding, rushed by this administration and the EPA without regard to its overall economic impacts despite EPA's acknowledgement that the finding will cause job losses in the United States, represents a clear-and-present danger to our economy and to all of our efforts to provide the conditions for job growth and prosperity.
- Under the endangerment finding – and the regulatory and legal red tape that flow from this expansion of government into our economic lives – the pace of U.S. economic growth will be stifled by the EPA and its controversial enforcement of environmental laws. The American public, its business owners and workers, want a clear and quick path to a robust, growing economy, not a thicket of new job-destroying regulations . . ."

NB: EPA climate rules will identify targets for litigation, lawyers warn. (From E. Calvin Beisner National Spokesman, *Cornwall Alliance for the Stewardship of Creation* March 20, 2010)

Petitions Against EPA

Eight petitions for reconsideration have been filed demanding that the EPA reconsider and reverse its endangerment finding. They're filled with damning information about the process that yielded the information on which she and her agency relied. And she must know that if EPA refuses to back down, these are going to become the basis of lawsuits that will put her and her agency in court in front of judges who aren't going to be bamboozled quite so easily as the world's environmental journalists have been. From the *EPA's own web page*, is a list of the petitions for review filed thus far–by members of Congress, state attorneys general, scientists, specific businesses, industry associations, think tanks, and more. The granddaddy of them all is the one by Peabody Energy Company, but those eager to know the basis of complaints against the endangerment finding will find plenty of good information on the EPA's legal and scientific failings in any of these. (Source: Cornwall Alliance E. Calvin Beisner 26 March 2010)

Comments on EPA Ambitions

Jeff Kueter, the Marshall Institute's President . . . writes that a "troublesome outcome of the Supreme Court's action is to put the judicial system squarely in the middle of evaluating the validity of the scientific conclusions on global warming and assigning economic accountability to individual emitters of greenhouse gases." He discusses whether the courts are equipped to reconcile legal standards for cause and effect when the underlying state of knowledge about global warming continues to change and evolve. Furthermore, the ability to assign damages to specific entities for a specific weather event, like Hurricane Katrina, is beyond the current capacity of both science and the courts to adequately answer. Kueter writes: "If one accepts the logic presented, anyone could sue anyone. It is suggested that we are all feeling the impact of anthropogenic global warming every day. Where does this litigation end? Will residents in Tornado Alley have standing to sue the coal plant down the road if their property suffers damage in this summer's storms? Do drought-stricken farmers in the Great Plains have the right to claim damages from refineries along the Gulf Coast? Will Alaskans or Hawaiians be able to sue residents/companies in the lower 48 for sea level rise? One would hope not. However, the ease of which plaintiffs have satisfied the traceability standard in the Second and Fifth Circuits leads easily to these absurd scenarios." The total cost of proposed climate change legislation, both in the United States and worldwide, is unknown, but by all accounts it will be extremely high. But are we buying a pig in a poke bonnet? (*Marshall Institute* Jeff Kueter 1April 2010)

EPA Allow States to Address Ocean Acidity

The U.S. Environmental Protection Agency said it will consider ways the states can address rising acidity levels in oceans, which pose a serious threat to shellfish and other marine life. The agency's decision was announced in a legal settlement with the Center for Biological Diversity. The environmental group sued the EPA last year for not requiring Washington state to list its coastal waters as impaired by rising acidity under the Clean Water Act. . . . "It's one of the most important threats to water quality right now," said Miyoko Sakashita, a senior attorney at the group's San Francisco

office. "It's affecting waters around the world, and it's particularly stark in the waters off the West Coast." Oceans are becoming more acidic as they absorb excess carbon dioxide from the atmosphere – a problem Sakashita referred to as "global warming's evil twin." . . . "Protection of the nation's water quality, including the health of our ocean waters, is among EPA's highest priorities," the agency said in a statement. "EPA is interested in learning more about how to protect our ocean and coastal waters from acidification." Previously, states have taken steps to address rising acidity levels in lakes and streams under the Clean Water Act, but this is the first time the EPA has agreed to consider ocean acidity . . ." (Gene Johnson AP 11 March) From Marc Morano, ClimateDepot.com .

'Black Carbon' in US Policy Debate: Blame Asia

"Lawmakers, scientists and advocates in the U.S. intensified calls to immediately cut emissions from climate-warming soot – also known as black carbon – as deadlock continues in Congress over far more complicated regulation of carbon dioxide. "Black carbon is an important, fast-action tool in mitigating long-term warming," said Veerabhadran Ramanathan, one of the world's leading climate scientists, in testimony before the *House Select Committee for Energy Independence and Global Warming*. Although not a greenhouse gas, soot has emerged as a leading contributor to rising temperatures worldwide, scientists say. Limiting these emissions is seen as a relatively cheap and quick way to reign in warming in the short term. Black carbon causes up to 600 times the warming of CO_2 and lasts just a few weeks in the atmosphere, whereas CO_2 lingers for a century or more. Because of black carbon's short lifespan, the impact of efforts to knock out the potent, heat-absorbing particle would be near immediate. "Reducing black carbon emissions by 50 % today will lead to a 50 % reduction in the heat trapped by them within a few months," said Ramanathan, a professor at the Scripps Institute of Oceanography. "Policymakers will witness the success of their actions during their tenure," he told the panel yesterday. . . . The solutions are "pretty simple" and "could be implemented without delay," said Conrad Schneider, advocacy director of the Boston-based Clean Air Task Force, during the hearing. Still, "relatively little is being done in the U.S. or globally to attack this problem," he said." (http://tinyurl.com/ykurvo6 ; from Paul Ashton)

French Change Carbon Policy?

The French government has signalled that it is dropping a plan for a tax on domestic carbon dioxide emissions. Jean-Francois Cope, parliamentary leader of the governing UMP party, was quoted as saying the tax "would be Europe-wide or not (exist) at all". Prime Minister Francois Fillon told parliament that the government should focus on policies that increased France's economic competitiveness. France had been rethinking the tax after a court rejected it last year. The Constitutional Council said there were too many exemptions for polluters in the tax plan, and that a minority of consumers would bear the burden. . . . Had the plan been approved, France would have been the largest country to impose a carbon tax as part of efforts to tackle climate change Environmental agencies expressed dismay, while the head of the French business federation expressed relief. The European Commission said earlier this month that it

was planning an EU-wide minimum tax on carbon as part of the EU's green energy agenda – though the UK opposes such a move. (http://news.bbc.co.uk/1/hi/world/europe/8583898.stm)

Oil Palm Company Guilty

More than twelve years after going to court, the Kayan native community of Long Teran Kanan on the Tinjar river in the Malaysian part of Borneo have won an important legal battle against the Sarawak state government and IOI Pelita, a subsidiary of the controversial Malaysian oil palm producer IOI. . . . the Miri High Court declared the land leases used by IOI "null and void" as they had been issued by the Sarawak state government in an illegal and unconstitutional way. . . Last December, a BBC News investigation had uncovered that vast tracts of former rainforest were being bulldozed in the disputed IOI operations area and had found "a scene of absolute devastation: a vast scar on the landscape". Local landowners had complained that their paddy fields and fruit trees had been destroyed by the company. (Miri / Malaysi April 1, 2010, —/WORLD-WIRE/—)

CARBON FINANCE

*Even if you fully and squarely accept the science, the policy approach advocated by the West is wrong. (*Benny Peiser, Financial Chronicle, 8 March 2010)

A Conservative Party policy document has proposed shifting the burden of the Climate Change Levy (CCL) from industrial energy consumers onto fossil fuel energy producers. (ENDS Report Bulletin 25 March)

Securing Low-Carbon Growth is the title of one section of the UK 2010 budget.

Tax land or carbon emission, but not hard work. (Phillippe Legrain LSE FT 9 April 2010*),*

What has Happened to the Green Stimulus?

Very little in 2009 so far – "with only a fraction of the money for environmental projects spent. (16% of the pledged amount). According to a study from HSBC, the Bank:" Most of this money promised by rich countries was spent in China. However, better results are expected in 2010, as dispersing all this money ($82 billion) is time consuming. (*FT* 10 March 2010)

China Delays Energy Stimulus Indefinitely

"China's new energy stimulus plan – expected to include additional policy support for renewable energy development – has been delayed indefinitely, according to a high-ranking government official.

The New Energy Stimulus Plan, as the policy package is now known, was first rumored as an addition to China's $585 billion stimulus package in May 2009. . . . Most recently, the official Chinese press announced that the plan – said to increase the country's capacity targets for solar, wind and nuclear power – would be revealed in late February. But the deputy director general with the National Energy Administration,

told the Chinese newspaper *21st Century Business Herald* on 7 April that the plan will not be released in the near future. It was expected to provide a comprehensive policy and subsidy support package for renewables and nuclear power. Officials have said that particular emphasis would be placed on policies to expand China's domestic solar power generation capacity, which today consists only of a handful of demonstration projects. In early 2009, the launch of modest rooftop and utility-scale project subsidies marked the start of China's efforts to develop solar installations and domestic demand for photovoltaic (PV) modules. The expectation of additional stimulus led to speculation that the build-out would be rapid. The unofficial 2020 target for solar power generation capacity is 20GW, from less than 500MW today.

But with China's export-dependent PV producers having increased their global market share over the past year, government officials will likely wait for PV prices, which fell 40% during the same period in a climate of gross oversupply, to drop closer to coal-generated power before further stimulating the sector." (Excerpt: *EF* 15 April 2010)

US Renewables Prosper Largely Due to Grants

The US renewable energy grant programme has driven a shift in the number of wind developers using debt financing rather than tax equity to fund their projects, financing experts have said. A change in the tax code by Congress allows wind, biomass and other renewable energy projects to temporarily elect to receive an investment tax credit (ITC) normally reserved for solar projects instead of the production tax credit (PTC). In the economic stimulus package in February 2009, the US also allowed project developers to receive cash payments in lieu of the tax credits. The energy and treasury departments have received 1,749 applications for the grant programme and have given 698 cash grants to the grant programme manager for the treasury department. More than 85% of the grant programme dollars have gone to wind projects, as applications are relatively simple compared with other renewable technologies. Government officials have not rejected a single wind application, Neubauer told attendees of the American Wind Energy Association's Wind Power Finance & Investment Workshop in New York. . . . . More than 10,000MW of wind capacity was installed in the US in 2009, increasing total capacity to more than 35,000MW, largely due to the grants, according to AWEA. (Excerpt: *EF* 15 April)

Money from the CIF?

Around $40 billion could be mobilised for low-carbon growth in developing countries via the Climate Investment Funds (CIF), according to Katherine Sierra, vice-president for sustainable development at the World Bank (*TWTW* 20 March) Kenneth Haapala

UN Recruits George Soros for Climate Financing

On March 4, the UN announced that Secretary-General Ban Ki-Moon had picked a panel of "high-level experts" to form a UN "Advisory Group on Climate Change Financing." Their assignment is to help "mobilize" the funding promised at the Copenhagen Climate Carnival this past December.

The list includes an interesting mix of public and private officials, ranging from the prime minister of Ethiopia, the president of Guyana, and Larry Summers of the Obama

administration; to a vice-chairman of Deutsche Bank and financier George Soros. According to the UN press release, this group will hold its first meeting this Monday, March 29, in London. One might hope that their discussion would take into account the catering of any scientific "consensus" on the UN's sweeping pronouncements about climate change. But since this movement is ever more clearly about money, not science, my bet is that this will amount to yet another bid to scavenge yet more money out of your low-level pocket — and funnel it to wherever these "high-level" folks think it should go. Just one more sign of the times. (Claudia Rosett Pajamasmedia, March 27th, 2010) http://www.pajamasmedia.com/claudiarosett/un-recruits-george-soros-to-help-with-climate-financing/

IMF Seeks $100bn/year Climate Finance Plan?

The International Monetary Fund (IMF) has published proposals for raising the $100 billion/year called for in the Copenhagen Accord to tackle climate change in developing countries – proposals it says could help forge an international climate change deal. In a staff position note – which is explicitly not a formal IMF policy document – deputy director Hugh Bredenkamp and advisor Catherine Pattillo propose the creation of a $120 billion Green Fund, financed with industrialised world currency reserves held by the IMF. This would issue 'green bonds' up to the value of $40 billion a year by 2020, which would be lent to developing countries to help finance climate change mitigation. Meanwhile, the paper proposes that $60 billion/year of grants and subsidies be raised via carbon markets and carbon taxes, mostly directed towards climate change adaptation investments.

In the Copenhagen Accord, drawn up at the UN climate talks in Copenhagen last December, signatories committed to raising $100 billion/year by 2020 to finance climate change adaptation and mitigation in developing countries. It also proposed $30 billion in 'quick start' financing by the end of 2012. However, the accord provided few details on where the money would come from, although commentators such as George Soros have proposed that IMF shareholder reserves – known as 'Special Drawing Rights' – be used to create a $100 billion climate fund. But such proposals have fallen far short of the volume of financing required.

In January in Davos, and earlier this month, IMF managing director Dominique Strauss-Kahn floated the idea of the IMF helping to raise the finance. Strauss-Kahn emphasised that the IMF would not manage such a fund, ... Instead, contributors to the fund would create its governance structure. The advantage of such a fund would be that it would offer a "unified resource mobilisation framework", with burden-sharing agreed in advance (possibly in proportion to the contributions industrialised countries make to the IMF). . . . The proposal completes the IMF's work in this area, with the hope that the idea is adopted by, for example, the UN's High-Level Advisory Panel on Climate Change Financing, set up in February, and co-chaired by UK Prime Minister Gordon Brown and Ethiopian President Meles Zenawai. "Launching a scheme along the lines described here would require a major political effort up front by all participating countries," the paper says. "The potential payoff, however, is enormous. Once created, the Green Fund could provide a unified resource mobilisation framework capable of meeting the financing needs identified at Copenhagen for

decades to come . . . The creation of a Green Fund could also help move the world closer to a binding global agreement on reducing greenhouse gas emissions. "Finally, the scheme could allow developing countries to begin scaling up their adaptation and mitigation efforts sooner (perhaps years sooner) than might otherwise be possible, to the benefit of the entire world." (*EF* Mark Nicholls 25 March 2010)

OECD: Nuclear Power Only Competitive IF CO_2 Trades at $30

The 2010 edition of Projected Costs of Generating Electricity . . . . shows nuclear power as being very competitive at $30 per tonne CO_2 cost, despite the well-publicised increases in plant costs. However, at 10% discount rate the advantage moves to coal and gas in some EU countries but not in USA or East Asia. Renewables are more expensive in most scenarios, except for wind in USA. . . . . The head of IEA commented: "To bolster competitiveness of low-carbon technologies such as nuclear, renewables and CCS, we need strong government action to lower the cost of financing and a significant CO_2 price signal to be internalised in power markets." (*WNN 25/3/10, OECD report: Economics of Nuclear Power*)

Stern Backs $100bn IMF Climate – Sustainable Growth – Fund Plan

A climate fund proposed by the International Monetary Fund (IMF) to raise $100 billion a year by 2020 has won support from climate change economics guru Nicholas Stern. Speaking in Nairobi on Sunday, IMF managing director Dominique Strauss-Kahn said: "Sustainable growth in developing countries will require large-scale, long-term investments for climate change adaptation and mitigation. The Copenhagen Accord suggests that $100 billion a year is needed by 2020, over and above existing aid commitments. This will be difficult to do with the standard approach – a series of 'pledging conferences' for decades to come." He said that, ultimately, financing will come from "budgetary transfers from developed countries, drawing on scaled-up carbon taxes and expanded carbon trading mechanisms". However, these revenue sources will take time to be put in place, so an IMF 'Green Fund' could "act as a bridge to large-scale carbon-based financing in the medium term". . . . . Stern, chair of the Grantham Research Institute on Climate Change and the Environment at the London School of Economics, said: "The 'Green Fund' is a creative and constructive idea which shows that the International Monetary Fund recognises clearly the very serious risks that climate change creates for future global economic growth and development." Late last year, George Soros, the former hedge fund manager and now billionaire philanthropist, suggested that such a fund tap 'Special Drawing Rights', the international reserve assets held by the IMF to supplement its members' official currency reserves. However, Soros' proposal was for a modest $100 billion over 25 years, rather than the $100 billion per year by 2020 apparently on the table from the IMF. In January, Strauss-Kahn floated the idea of an IMF-led green fund, at the Davos meetings in Switzerland. (*EF* London, 11 March 2010)

Other Potential Winners Exert Pressure?

Deutsche Bank's objective is to ensure that "governments continue their climate protection initiatives systematically." Lord Oxburgh (see above) sits on its advisory board together with Dr. R.K. Pachauri, Chairman of the IPCC, as does Lord Browne

former CEO of BP who met with Al Gore, Bill Clinton and Ken Lay, CEO of Enron, in the White House in 1997 to arrange the carbon credit market. (Andrew McKillop March 2010)

On a Green Road to Hell?

"Don't give way to petrol pump rage. . . If you don't like paying 120p for a litre of road fuel, get used to it. Get used to 130p per litre. It is now policy that you should be gouged. It is not just government policy but universal public policy. Everyone (meaning everyone who matters, and that excludes you) agrees that the cost of energy must rise and keep on rising. I am not talking about fuel taxes but the fuel itself — the liquid that goes in your car, the electricity that powers your washer/dryer. It is required to be expensive by legislation. The fuel you pump into your motor this weekend must contain 3.25 per cent biofuel, rising this month to 3.5 per cent. Biofuels are typically more expensive than ordinary petrol or diesel. According to Argus Petroleum, the wholesale price of fatty acid methyl ester, a biofuel used widely in the UK, is 28 % more expensive than cargoes of diesel sold in the Rotterdam spot market. . . . The folly of this strategy was recently exposed by the European Commission, the body that has promoted the drive to biofuels. An EU directive requires that, by 2020, 10 % of our road fuel should come from renewable sources. A study by the Commission on the land use implications of sourcing only 5.6 % of Europe's transport fuel from biofuels concluded that any significant rise beyond 5.6 % would "rapidly" increase carbon emissions and "erode the environmental sustainability of biofuels". In other words, as the percentage of biofuel in your tank increases, the risk of penetration by sugar cane and palm oil plantations into virgin rainforest sharply increases. Like most political diktats, the figure of 10 % was plucked out of the air and no one at the Commission had a clue, when the policy was adopted, how the fuel industry was to meet the one in ten mandates without a huge rise in biofuel planting in the tropics. Britain, however, has taken the renewable command on the chin: the Government is assuming that ordinary biofuels will make up 9.5% road fuel. To hell with the rainforest. . . What are we doing? Where is the debate? In order to prop up the failed European carbon trading system, we will soon have a minimum carbon price — a threshold that will ensure a very cheap form of fuel, natural gas, will be priced out of the market in favour of more expensive ones, such as nuclear and wind power. Have the politicians done their sums? Do we want to make our energy supply so expensive? And if we do, how will our industries remain competitive against rivals in the Middle East and China. Asia will never impose such cost burdens on businesses that employ millions of people. This is what happens when politicians set policy on the basis of ideology. . . . ." (Carl Mortished *The Times* April 10 2010)

Green Investment Bank for UK?

". . . . Support for the low-carbon economy is central to this as it will provide new opportunities in key growth industries of the future. In the past year, the Government has announced £1.8 billion of extra support for low-carbon sectors. This will enable £15 billion of additional low-carbon investment, providing new opportunities for business growth, boosting innovation and creating new high skilled jobs. The Government has an important role to play in enabling the investment needed for the

transition to a low-carbon economy – particularly in the energy sector, where the scale of the investment challenge is unprecedented. To support the financing of low-carbon investment and new low-carbon jobs, Budget 2010 announces: The Government will:

- bring forward proposals this autumn, with a White Paper by spring 2011; and in the shorter term, a summer consultation on mechanisms to provide greater certainty for low-carbon investment;
- address emerging equity finance gaps, the Government intends to create a Green Investment Bank, with a mandate to invest in low-carbon infrastructure. The Government will start by investing up to £1 billion from the sale of infrastructure-related assets and will seek to match this with at least £1 billion of private sector investment;
- launch UK Finance for Growth to streamline the Government's SME finance support – including to help businesses seeking to commercialise low-carbon technologies;
- spend up to £60 million for the development of port sites to support offshore wind turbine manufacturers looking to locate new facilities in the UK and secure low carbon manufacturing jobs;
- make a commitment to reduce government departments' carbon emissions by at least 30 per cent by 2020, and enabling energy efficiency finance to help millions of homes save money and energy by developing Pay As You Save arrangements; and
- halve company car tax for ultra-low carbon cars for five years from April 2010, to contribute to making the UK one of the best places in the world to design and build low-carbon vehicles. . . . .
- increase the main fuel duty for 2010 in stages, with an increase of one penny per litre on 1 April and one penny per litre on 1 October 2010, then 0.76 pence per litre on 1 January 2011. Fuel duty will also rise by one penny per litre in real terms on 1 April each year from 2011 to 2014; and
- an £8 per tonne increase in the standard rate of landfill tax on 1 April 2014, to encourage alternatives to landfill. . . . . ." (shortened from http://www.hm-treasury.gov.uk/d/budget2010)

Comments: Ed Miliband spoke to the *FT* about energy market reform in order to provide returns for low-carbon generation "We don't think doing simply something about carbon price is enough." Reforms are to be implemented as proposed by a government energy review. The Conservatives have proposed taxing generators' carbon emissions below a certain carbon price. Others argue that the budget measures are insufficient to ensure energy security. . . . . In addition a £2 billion green investment bank is to be set up but its effect on investments remains disputed. One of its stated aims, however, is to shift energy generation towards low carbon sources; private sector investment is to be encouraged, with offshore wind and CCS being mentioned especially. (*FT* 25 March)

Climate Change Act Biggest Ever Bill

The Energy Minister, Ed Miliband, at the opening of a wind farm revealed one of the best-kept secrets of British politics – although it is there for all to see on a Government

website – the cost of what is by far the most expensive piece of legislation ever put through Parliament. Every year between now and 2050, according to Ed Miliband's Department for Energy and Climate Change (DECC), the Climate Change Act is to cost us all up to £18.3 billion – £760 for every household in the country – as we reduce our carbon emissions by 80 %. (Excerpt, Christopher Booker *Telegraph* 3 April 2010; http://www.telegraph.co.uk/comment/columnists/christopherbooker/7550164/Climate-Change-Act-has-the-biggest-ever-bill.html)

CER Market Grinds to Halt, Exchanges Suspend Trading

"The market for secondary certified emission reductions (CERs) seized up today, following confirmation that credits previously used for compliance in the EU Emissions Trading Scheme (ETS) have been sold back into the market – prompting two exchanges to suspend CER trading. Traders told *Carbon Finance* that even in the over-the-counter market, very little CER volume has gone through today, while the European Climate Exchange (ECX) – which today changed its rules to preclude such CERs being delivered into its contracts – has not seen any activity in its CER futures.

"We're talking about confidence and trust in the market," said Michael Uzzan, an emissions trader at Geneva-based Gunvor. "It's very, very bad for the market," agreed Eric Boonman, head of environmental markets origination at Fortis Bank in the Netherlands. "The credibility of the market is at stake." Both Paris-based BlueNext and Nasdaq OMX – which owns Nord Pool's spot carbon platform – have today suspended trading on CERs, following confirmation from the French exchange that some of the 2 million CERs resold by the Hungarian government had been delivered via its platform yesterday to an EU ETS participant." . . . . "Some people are talking about the end of the CER market, but I wouldn't say anything that drastic," Uzzan said. "But the European Commission needs to do something. We know the short-term damage . . . but we need to think about the long-term credibility of the market." The Commission said in January that CERs previously used for EU ETS compliance could not be used again in the programme; however carbon market lawyers told *Carbon Finance* that the EU ETS Directive does not state anything specifically on this matter and warned that planned checks by the Commission on CERs surrendered for compliance may not be legally enforceable. The Commission is planning to meet with member states tomorrow to discuss the matter. (*EF Online News* 18 March 2010)

Hunt for 'Rogue Trader' over Recycled Carbon Credits

"A tiny London trading firm is at the centre of a shadowy chain of international deals involving the carbon market's first "rogue trader". A mystery investor made a £1.8m profit last week by selling invalid carbon permits to unwitting buyers in Europe — which caused a temporary trading freeze at two of the main carbon trading exchanges. Microdyne, a firm registered in Cyprus but based in Edgware, northwest London, confirmed this weekend that it bought and sold the permits to the mystery trader. Bluenext, the exchange where the permits were sold has launched an investigation.

The scandal is the latest to damage the credibility of the 100 billion (£90 billion) carbon trading market and is expected to lead to a shakeup of rules governing Europe's flagship pollution reduction scheme. The story began in Hungary, where the government sold 800,000 carbon credits known as CER's, or carbon emission

reduction certificates, to a trading firm called Hungarian Energy Power. The company, whose website was set up only two weeks ago, bought them for 9 each, or about 7m. HEP then immediately transferred them to Microdyne, which in turn sold them to a trading firm in Hong Kong, which sold them via Bluenext to a number of European brokers and banks at about 11.50 to 12 each, generating a quick profit of 2m. The problem was that the credits were no longer valid for European buyers. . . . Patrick Birley, head of the European Climate Exchange in London, another carbon trading platform, said: "It's important to realise that this is an evolving market. When these things happen the rules need to be reviewed and they will be. We don't know who [the trader] is but they're looking for him and hopefully he'll be arrested." Bluenext said yesterday that no law had been broken but it would introduce new mechanisms to prevent recycled permits from leaking back into the system. . .". (Danny Fortson and Jonathan Leake *The Sunday Times* March 21 2010; from: Alister McFarquhar)

NB: Owing to the recession Europe's industry used far less energy than expected and hence had a surplus of permits. (ETS is now worth about $93 bn annually). Buying cheap carbon credits from abroad is a legal company game, but Hungary went too far in March when it recycled carbon credits that had already been used to fulfil obligations". (*FT* 8 April 2010)

Robert's Carbon Wealth?

"If true, then a certain Robert Napier, has a significant say in, or control over pension funds reportedly amounting to over 55 trillion dollars. He makes Peter Dunscombe (IIGCC chair, and head of BBC pensions) look like "small fry". There may also be strong links between Napier and Dunscombe. This posted last August in the "blogosphere" does not seem to have received the attention or raised the concerns (for so many people's pensions) it seemingly warrants. Reportedly Robert Napier, as of August 2009 held positions of, chairman of the Met office, Chairman of the Green Fiscal Commission, Director of the Carbon Disclosure Project, Chairman of the Trustees of the World Centre of Monitoring of Conservation, Chairman of the Homes and Communities Agency. He recently has also held positions including, Chief Executive of WWF-UK, Director of The Climate Group, Director of the Alliance of Religions and Conservation. (From Derek Alker 23 March 2010; http://buythetruth.wordpress.com/2009/08/24/eco-imperialism-every-environmentalists-dream/)

Money for the Climate Industry

"The US government spent $79 billion on climate research and technology since 1989 .., this funding paid for things like satellites and studies, but it's 3,500 times as much as anything offered to sceptics. It buys a bandwagon of support, a repetitive rain of press releases, and includes PR departments of institutions like NOAA, NASA, the Climate Change Science Program and the Climate Change Technology Program. The $79 billion figure does not include money from other western governments, private industry, and is not adjusted for inflation. In other words, it could be. . .a lot bigger. For direct PR comparisons though, just look at "*Think Climate Think Change*": the Australian Government put *$13.9 million* into just one quick advertising campaign. There is no

question that there are vastly more financial rewards for people who promote a carbon-made catastrophe than for those who point out the flaws in the theory. Ultimately the big problem is that there are no grants for scientists to *demonstrate that carbon has little effect*. There are no Institutes of Natural Climate Change, but plenty that are devoted to UnNatural Forces. It's a monopsony, and the main point is not that the scientists are necessarily corrupted by money or status (though that appears to have happened to a few), but that there is no group or government seriously funding scientists *to expose flaws*. The lack of systematic auditing of the IPCC, NOAA, NASA or East Anglia CRU, leaves a gaping vacuum. It's possible that honest scientists have dutifully followed their grant applications, always looking for one thing in one direction, and when they have made flawed assumptions or errors, or just exaggerations, no one has pointed it out simply because everyone who could have, had a job doing something else. In the end the auditors who volunteered — like Steve McIntyre and Anthony Watts — are retired scientists, because they are the only ones who have the time and the expertise to do the hard work. . . . . Banks are doing what banks should do (for their shareholders): they're following the promise of profits, and urging governments to adopt carbon trading. Banks are keen to be seen as good corporate citizens (look, there's an environmental banker!), but somehow they don't find the idea of a *non-tradable carbon tax* as appealing as a trading scheme where financial middlemen can take a cut. (For banks that believe in the carbon crisis, taxes may well "help the planet," but they don't *pay dividends*.) (Joanna Nova, ABC 4 March 2010; http://www.abc.net.au/unleashed/stories/s2835581.htm)

House of Lords: Carbon Tax Bad for Real Industry

A carbon "tax" could hit the North East's industrial heartland with companies going bust or moving abroad, a minister has signalled. Energy Minister Lord Hunt made the apparent admission as he came under pressure over the European Union emissions trading scheme in the Lords. Northumberland peer Nigel Vinson asked if ministers had assessed the scheme's impact on carbon dioxide generating industries such as steel, aluminium, glass and cement production. All of these industries have major bases in the region and Lord Vinson, a former businessman, warned of "massive" job losses if the next phase of the EU scheme goes ahead. . . Lord Vinson said: "If the next phase of the tax is fully applied our heavy industries like Corus, Alcan and cement manufacturers will either go bust or go overseas to countries like India, which don't have this inappropriate tax." (William Green, *The Journal* , 10 March 2010; Courtesy CCNet 17, 12 March 2010)

WWF Enrichment

The carbon credits scheme would make WWF and its partners much richer, but with no lowering of overall CO_2 emissions. . . If the world's largest, richest environmental campaigning group, the WWF – formerly the World Wildlife Fund – announced that it was playing a leading role in a scheme to preserve an area of the Amazon rainforest twice the size of Switzerland, many people might applaud, thinking this was just the kind of cause the WWF was set up to promote. . . If it then emerged, however, that a hidden agenda of the scheme to preserve this chunk of the forest was to allow the WWF and its partners to share the selling of carbon credits worth $60 billion, to enable firms in the industrial world to carry on emitting CO_2 just as before, more than a few

eyebrows might be raised. The idea is that credits representing the CO_2 locked into this particular area of jungle – so remote that it is not under any threat – should be sold on the international market, allowing thousands of companies in the developed world to buy their way out of having to restrict their carbon emissions. The net effect would simply be to make the WWF and its partners much richer while making no contribution to lowering overall CO_2 emissions. WWF, which already earns £400 million yearly, much of it contributed by governments and taxpayers, has long been at the centre of efforts to talk up the threat to the Amazon rainforest – as shown recently by the furore over a much-publicised passage in the 2007 report of the UN's Intergovernmental Panel on Climate Change. The IPCC's claim that 40 % of the forest is threatened by global warming, it turned out, was not based on any scientific evidence, but simply on WWF propaganda. . ." (Christopher Booker *Sunday Telegraph* 21 Mar 2010)

Follow the Money: Sceptics Poorly Paid

Greenpeace has searched for funding for sceptics and found $23 million paid by Exxon over 10 years (which has stopped). Perhaps Greenpeace missed funding from other fossil fuel companies, but you can be sure that they *searched*. I wrote the *Climate Money* paper in July last year, and since then no one has claimed a larger figure. Big-Oil may well prefer it if emissions are not traded, but it's not make-or-break for them. If all fossil fuels are in effect "taxed", consumers will pay the tax anyhow, and past price rises in crude oil suggest consumers will not consume much less fuel, so profits won't actually fall that much. But in the end, everyone spends more on carbon friendly initiatives than on sceptics—even Exxon: (how about $100 million for Stanford's Global Climate and Energy Project, and *$600 million for Biofuels* research). Some will complain that Exxon is massive and their green commitment was a tiny part of their profits, but the point is, what they spent on sceptics *was even less*.

DECARBONISING TECHNOLOGY

> *Clean energy and 'green' jobs were a mantra for politicians across the developed world before the financial crisis struck, and the effects of the recession served only to intensify the rhetoric*. (Fiona Harvey FT 29 March 2010)
>
> *Siting mega (wind power) projects on cheap land in China's dusty deserts is likely to cut their useful lifetimes to 20 years or less*.) (Miao Wei Chinese Vice-Minister for Industry, quoted by Andrew McKillop)

World Nuclear Association on Renewables: Spot the Self-Interest

- There is unprecedented interest in renewable energy, particularly solar and wind energy, which provide electricity without giving rise to any carbon dioxide emission.
- Harnessing these for electricity depends on the cost and efficiency of the technology, which is constantly improving, thus reducing costs per peak kilowatt.
- Utilising electricity from solar and wind in a grid requires some back-up generating capacity due to their intermittent nature. Policy settings to support renewables are also generally required, and some 50 countries have these.

- Utilising solar and wind-generated electricity in a stand-alone system requires corresponding battery or other storage capacity.
- The possibility of large-scale use of hydrogen in the future as a transport fuel increases the potential for both renewables and base-load electricity supply.

Technology to utilise the forces of nature for doing work to supply human needs is as old as the first sailing ship. But attention swung away from renewable sources as the industrial revolution progressed on the basis of the concentrated energy locked up in fossil fuels. This was compounded by the increasing use of reticulated electricity based on fossil fuels and the importance of portable high-density energy sources for transport – the era of oil.

As electricity demand escalated, with supply depending largely on fossil fuels plus some hydro power and then nuclear energy, concerns arose about carbon dioxide emissions contributing to possible global warming. Attention again turned to the huge sources of energy surging around us in nature – sun, wind, and seas in particular. There was never any doubt about the magnitude of these, the challenge was always in harnessing them. Today we are well advanced in meeting that challenge. Wind turbines have developed greatly in recent decades, solar photovoltaic technology is much more efficient, and there are improved prospects of harnessing tides and waves. Solar thermal technologies in particular (with some heat storage) have great potential in sunny climates. With government encouragement to utilise wind and solar technologies, their costs have come down and are now in the same league as the increased costs of fossil fuel technologies due to likely carbon emission charges on electricity generation from them.

There is a fundamental attractiveness about harnessing such forces in an age which is very conscious of the environmental effects of burning fossil fuels and sustainability is an ethical norm. So today the focus is on both adequacy of energy supply long-term and also the environmental implications of particular sources. In that regard the near certainty of costs being imposed on carbon dioxide emissions in developed countries at least has profoundly changed the economic outlook of clean energy sources. A market-determined carbon price will create incentives for energy sources that are cleaner than current fossil fuel sources without distinguishing among different technologies. This puts the onus on the generating utility to employ technologies which efficiently supply power to the consumer at a competitive price. (*World Nuclear Association*. org/ April 2010)

Solar Power Remains Too Expensive But Research Remains Hopeful

Abstract: Solar photovoltaics have great promise for a low-carbon future but remain expensive relative to other technologies. Greatly increased penetration of photovoltaics into global energy markets requires an expansion in attention from designs of high-performance to those that can deliver significantly lower cost per kilowatt-hour. To evaluate a new set of technical and economic performance targets, we examine material extraction costs and supply constraints for 23 promising semiconducting materials. Twelve composite materials systems were found to have the capacity to meet or exceed the annual worldwide electricity consumption of 17000 TWh, of which nine have the potential for a significant cost reduction over crystalline silicon. We identify

a large material extraction cost (cents/watt) gap between leading thin film materials and a number of unconventional solar cell candidates including FeS_2, CuO, and Zn_3P_2. We find that devices performing below 10% power conversion efficiencies deliver the same lifetime energy output as those above 20% when a 3/4 material reduction is achieved. Here, we develop a roadmap emphasizing low-cost alternatives that could become a dominant new approach for photovoltaics research and deployment. (see Wadia et al, Energy and Resources Group University of California; *Full Text HTML Environ. Sci. Technol.*, 2009, *43* (6), pp 2072–2077, Publication Date (Web): February 13, 2009

ENEL Selling Renewables But Warning against Tighter CDM Rules

The Italian electricity group is to sell its renewables business worth $13 bn by June, its dividend having halved and capital spending cut in April. By 'floating' renewables, Enel is following other companies 'to benefit from higher stock market ratings enjoyed by fast growing 'green' technologies, particularly wind power.' Enel also warmed European ministers against changes in the rules for carbon permits arguing that tighter restrictions would hit investment in projects meant to cut GHG emissions. Enel is the world's largest investor in the UN CDM with credits earned usable inside the EU to comply with ETS, the emission trading scheme. Environmentalist have been critical of the kind of projects thus financed in developing countries, urging Enel to invest at home rather than waste money abroad. Most emission credits earned by Enel came from HFC reduction in China. Endsa, the Spanish power company owned by Enel was the EUs heaviest user of CDM credits , largely to compensate for emissions from its own coal-fired power stations The UN FCC is discussion tough standards for the post 2012 period. (*FT* 18March)

NB: Engyco, the firm seeking to become the first listed utility-scale solar power generator in Europe, has appointed new directors as it bids to raise 1 billion ($1.3∞billion) from a listing on the London Stock Exchange.This comes as Italian electricity utility Enel last week outlined plans to sell a minority stake in its renewable energy business, Enel Green Power (EGP), which may involve raising 4 billion via an initial public offering (IPO) in Italy and Spain before the end of this year. The business would be a world leader in terms of installed renewable energy capacity. . . . Engyco's initial strategy is to buy debt-laden solar plants in Spain that were built prior to September 2008, when the country had an extremely favourable 25-year feed-in tariff. (*EF* 25 March)

On Geo-engineering: From Asilomar to the Oxford Principles

Dealing with climate change might mean tinkering with the oceans and the atmosphere. Those who could do so would like the regulations to be clear. "In 1975 scientists expert in a new and potentially world-changing technology, genetic engineering, gathered at Asilomar, on the Monterey peninsula in California, to ponder the ethics and safety of the course they were embarking on. The year before, they had imposed on themselves a voluntary moratorium on experiments which involved the transfer of genes from one species to another. . . . . Another bunch of researchers, accompanied by policy experts, social scientists and journalists, gathered in Asilomar between March 22nd and 26th 2010, hoped for a similar outcome to their deliberations.

This time the topic under discussion was not genetic engineering but geo-engineering-deliberately rather than accidentally changing the world's environment. Geo-engineering is an umbrella term for large-scale actions intended to combat the climate-changing effects of greenhouse-gas emissions without actually curbing those emissions. Like genetic engineering was in the 1970s, the very idea of geo-engineering is controversial. ..Like the biotechnology of the 1970s, geo-engineering cannot be treated just as science-as-usual. There are, however, important differences between the subjects. One is that in the 1970s it was clear that the ability to move genes between creatures was going to bring about a huge change in the practice of science itself, and biologists were eager for that to happen. Modern climate scientists, by contrast, usually see geo-engineering research as niche, if not fringe, stuff. Many wish it would go away completely. ..There are two broad approaches to geo-engineering. One is to reduce the amount of incoming sunlight that the planet absorbs. The other is to suck carbon dioxide out of the atmosphere and put it somewhere else. The second of these approaches is not particularly in need of new regulation. . . . Reducing incoming sunlight, by contrast, is fraught with danger. . . . . overarching principles for the regulation of the field that were presented recently to the British Parliament by Steve Rayner, a professor at the Saïd Business School, in Oxford. The "Oxford principles", as they are known, hold that geo-engineering should be regulated as a public good, in that, since people cannot opt out, the whole proceeding has to be in a well-defined public interest; that decisions defining the extent of that interest should be made with public participation; that all attempts at geoengineering research should be made public and their results disseminated openly; that there should be an independent assessment of the impacts of any geoengineering research proposal; and that governing arrangements be made clear prior to any actual use of the technologies." The conference's organising committee is now working on a further statement of principles, to be released later. Meanwhile Britain's main scientific academy, the Royal Society, and the Academy of Sciences for the Developing World, which has members from around 90 countries, are planning further discussions that will culminate at a meeting to be held this November." (From Tom Addiscott 3 April 2010)

A System Model for Geologic Sequestration of Carbon Dioxide

Abstract: In this paper we describe CO_2–PENS, a comprehensive system-level computational model for performance assessment of geologic sequestration of CO_2. CO_2–PENS is designed to perform probabilistic simulations of CO_2 capture, transport, and injection in different geologic reservoirs. Additionally, the long-term fate of CO_2 injected in geologic formations, including possible migration out of the target reservoir, is simulated. The simulations sample from probability distributions for each uncertain parameter, leading to estimates of global uncertainty that accumulate through coupling of processes as the simulation time advances. Each underlying process in the system-level model is built as a module that can be modified as the simulation tool evolves toward more complex problems. This approach is essential in coupling processes that are governed by different sets of equations operating at different time-scales. We first explain the basic formulation of the system level model, briefly discuss the suite of process-level modules that are linked to the system level, and finally give an in-depth example that describes the system level coupling between an injection

module and an economic module. The example shows how physics-based calculations of the number of wells required to inject a given amount of CO_2 and estimates of plume size can impact long-term sequestration costs. (Philip H. Stauffer et al, Los Alamos National Laboratory, Earth and Environmental Sciences, *Environ. Sci. Technol.*, 2009, *43* (3), pp 565–570)

US Federal Policy on Wind

This " is still geared toward giving tax breaks to the wind industry whenever it can, especially if there is a green jobs component to it. Most states are on board with similar jobs focus or at least a renewable energy promotion. But recent moves in a couple states, while hardly "anti-wind," are moving against type. . . Are these isolated incidents or the start of a trend? It's probably too soon to tell, but two western states are willing, in one case, to tax wind energy output, and in another case, put the brakes on the breaks. I'm talking about Wyoming and Oregon, which enacted these recent changes. . . . Oregon is limiting the amount of money it will subsidize renewable energy development and cutting subsidies to attract "green" manufacturing companies. That bill was passed in February . . . Some key provisions that might affect renewable energy include the eventual elimination of a tax credit. The reduction in the maximum tax credit for wind energy projects is from $10 million to $3.5 million in 2010, $2.5 million in 2011 and $1.5 million in 2012, after which it is eliminated. It also sets a cap of $300 million every two years for renewable energy projects and $200 million for manufacturing plants. As renewable energy development becomes more prolific, it will be interesting to see if other states follow Wyoming's or Oregon's lead, or decide to press their no-tax or tax subsidy advantage.

East England Innovation Awards

The Innovation Awards handed out by East of England Energy Group (EEEGR) in March 2010 were for an Advanced Slug Detector for offshore oil production platform instrumentation and for Enhanced Equipment Competence Online (E2CO) System.. The Low Carbon Innovation Award went to a firm's new LED (SMD) lighting technology. (From March Newsletter)

Environmental technologies are a main focus expected to make the NE 'a significant player in the low-carbon economy', including the world's largest concentration of offshore wind turbines' and waiting to to install and service them is an offshore gas industry that can also store captured carbon in Europe's largest carbon sink." Oil, gas and automotive industry are to be combined into a hybrid supply chain for offshore wind and larger projects, sites fir=or new nuclear power stations are also in the region. (*FT Special Report* 26 March 2010)

Europe Plans to Build 'Super Grid' – by Packaging Green Bonds?

"Europe will not meet its targets on renewable energy without building a massive 'super grid' to connect offshore wind and solar farms, said a lobby group this week. More than 1,500GW of wind and solar farms are due to be built in Europe over the next 40 years, but electricity from these resources is unpredictable and a new grid is needed to ease trade across the continent, said the Friends of the Supergrid (FOSG), a group of 10 companies that would build or benefit from such a grid."We see it as

the most important infrastructure project for the next 50 years," said John Sturman, business development director at infrastructure engineering firm Parsons Brinckerhoff. "We look forward to the day when someone in Scotland makes their tea powered by electricity from solar panels in Africa." The concept has support from European countries and the FOSG will lobby to define common standards to construct a high-voltage DC grid. The group – which includes Areva, Siemens and Hochtief Construction – is looking to appoint a chief executive later this year. The International Energy Agency has estimated that around 200 billion ($270 billion) will have to be invested in upgrading existing transmission assets in Europe through 2030. But infrastructure investors – such as pension funds and sovereign wealth funds – should feel comfortable financing the assets longer term, via the bond market, as the grid connections will likely be a regulated asset that would produce regulated returns. "That's what makes it attractive to infrastructure investors," Whelan said. . . . Bonds sold by super grid holding companies could be packaged as 'green' bonds, which are additionally appealing to investors, said a researcher in climate policy and conservation finance at the University of Oxford. Mainstream's CEO Eddie O'Connor emphasised that the grid would not just connect offshore wind and solar farms, but also open up trading opportunities that would help finance grid installation. With just renewable energy flowing, the cables would essentially be idle 60% of the time; but with energy trading between countries, usage could increase to 90% and this would cut the installation cost per megawatt by more than half. Whelan expressed frustration with the way that offshore wind farms are currently connected "point-to-point" rather than as part of a network. "A lot of your investment [in grid connection] is stranded. You get 40% maximum usage when it could be maxed out," he said. (*EF* Updated 11 March 2010)

CARBON FUELS PROSPER

Now people think nothing of paying more for a gallon of bottled water than for a gallon of gasolene. Interesting commentary on our society. (Al Pekarek, St. Cloud State U, 22 March 2010)

. . . it will be hard to shake off the impression that he and other big oil CEOs are in the business of managing decline. (Ed Crook interviewing the CEO of ConocoPhillips, FT 26 March 2010)

The end of fossil fuels is greatly overplayed. (Laurence Rosenblatt CEO MA Gales)

Oil Demand Moving East

Reporting a meeting of the world' energy sector in Mexico, the FT stresses that green energy sources are attracting more official support 'in the west', with demand, OPEC included, moving eastward. While demand in OECD is stagnating China and to a lesser extent India, are replacing demand, with Saudi Arabia having already doubles its exports to India. Oil consumption of Saudi oil during last 3 years, with the USA relying increasingly on Africa and Canada, and demand for oil actually decreasing last year in Europe., and the IEA expects oil demand to fall in the USA by 0.7 1% a year for next 20 years. The reason for the oil prices remaining around $80 are given as rising demand from China and production restraint by OPEC itself. OPEC again

agreed to restrict output, creating 6m/b a day of unused capacity. (*FT* 29 March 2010)

NB: The IEA has requested China to become a member, fearing loss of its own relevance as demand shifted to Asia. Half the world's energy consumption is already outside OPEC. However, Beijing has been wary of joining developed country organisations. But mid-ranking officials have already participated in discussions on energy security and energy technologies. (*FT* 31 March 2010)

Shell Growing Unconventionally

Shell is now likely to be the fastest growing company having moved into 'unconventional sources' and invested heavily in Qatar (GTL) gas and Canada (tar sands) these projects are coming on stream and net reserves having increased from 11.9 bn barrels of oil equivalent in 2008 to 14.1 bn in 2009. The oil price has already recovered sufficiently to make most Alberta oil sands profitable. Shell is one of the biggest investors, but many environmental concerns are being expressed, e.g. relating to the fracking or fracturing process induced in the shale in order to release the hydrocarbon. Currently there are thousands of operating sites, but 'the industry wants hundreds of thousands'. Buffer zones and strict control of chemicals used would be needed. (*FT* 8 March 2010)

China Remains Major Coal User

For decades to come, China will depend on coal. "Even with all the investments in solar, wind and biomass [the former two having been called 'vanity projects' elsewhere]China will still get nearly two thirds of its energy from coal in two decades time."Cleaner coal technologies rather than renewables will limit emissions, with China having as marked presence in the field of patenting for clean coal. Nevertheless, China hopes to invest more in a 'smart' grid able to absorb the more fluctuating supply form renewables. (*FT* 29 March)

Natural Gas Supplies Plentiful

The search for natural gas only started about 10 years ago [in USA] and now 'new fields are cropping up across the country and the hunt is on for them around the world.' But the demand for new pipelines has fallen with the economic crisis, with Nabucco slowing down and the number o pipeline being needed in Europe having declined from 5 or 6 to three to four. Consumption of gas in EU declined by 10% between 2008 and 2009, and future growth expectation have been reduced, even the high profile Shtockman development of liquefied natural gas by Gazprom has been delayed and sourcing supplies from Central Asia to Europe may become difficult. (Carola Hoyos *FT* 29 March).

Vast Amounts of Gas Wasted

At least 300 billion cubic metres a year, well over 50% of the total delivered and consumed gas in either Europe or USA, is flared. The true amount is not known and could be higher. Simply for gas flaring in oil production, the rate is about 175 bn cu metres a year (World Bank estimate).

East African Pipeline Dreams

Toyota is considering to spend $1.5 bn to extend existing pipelines in Southern Sudan through Kenya to the coast at Lamu, 1,400km, 'the boldest project yet ' by a Japanese company in Africa. An oil export terminal would have to be constructed. Geopolitical considerations, the future of the Sudan, are surely playing a role. The South wants a new pipeline. Current exports reach the Red Sea at Port Sudan in the North China has the largest stake in the Sudanese oil industry and has expressed an interest in the pipeline to Kenya. (FT 4 March 2010)

New Battles with Environmental Lobby Unavoidable

- An international energy ministers' meeting in Mexico urged a review of existing biofuel policies, with ambitious target for the latter causing uncertainties for future oil demand and risked persuading oil exporters to cut investments into projects 'needed to ensure sufficient oil supply once the world emerges from recession." (*FT* 4 March 2010)
- Thanks to melting Arctic ice, the Russians are preparing to sail a large oil tanker along their entire Arctic coast 'opening a strategic energy trading bridge between European and Russia and east Asia'- 'a floating pipeline'. (*FT* 2 March 2010).
- XTO Energy, the shale gas specialist has been bought by ExxonMobli for $41 bn but it would be allowed to walk away from the contract 'if the threat of regulation makes the key technology used to tap the gas uneconomical'.
- The combination of hydraulic fracturing and horizontal drilling promises 100 year supply of natural gas from shale rock to the USA.(*FT* 2March 2010)
- Australia is about to 'secure its path' to became the world's biggest exported of unconventional gas, mainly from Queensland and involving coal-bed methane extraction that is liquefied and would be exported, mainly to Asia. Western Canada and Indonesia could also become methane gas exporters but current low prices are preventing development. In the US, national output has already led to a glut of gas. (*FT* 8 March 2010)
- Oil prices continued fluctuation above $81 but in UK and elsewhere rose more sharply due to changes in currency values and taxation; but the usually volatile US natural gas market has remained 'calm'. (*FT* March 24 2010)
- As the hunt for new oil and gas resources continues, more attention is paid to 'unconventional' oil and gas, widely scattered around the globe, with largest deposits in USA, Canada, Venezuela, China and Latin America, in that order. Relatively small deposits are known of in Middle East and Russia and Africa. Shale beds thousands of metres below are being explored, with Americans beginning to believe that they have supplies to last them for a century 'a remarkable turn -around'. (*FT* 8 March 2010)
- Venezuela announced a large natural gas fund, now claiming to possess 30% more gas, the max, mentioned is 1.85bn barrels of oil equivalent. (*FT* 12 April 2010) Good news for a country that 'heads debt default list'. (*FT* 8 April)
- Tullow Oil, the UK largest independent oil explorer is selling a large part of its oil assets in Uganda to China and France and shifting emphasis to exploration elsewhere in Africa, especially Ghana and continuing its 'winning drilling streak'. (*FT* 11 March)

- Oil production in Colombia is increasing thanks to government intervention and new discoveries, boasting 20 years of reserves. (*FT* April 6 2010)
- Old oil and gas fields in the North Sea are difficult to sell though multinationals seek to offload them to cash-strapped independent explorers Eni, Shell Noble Energy and GDF Suez are all trying to sell. The difficulties select large decommissioning liabilities. At current rates of investment, the North Sea will produce for only another 6 years, the association representing North Sea companies has warned. (F*T* 6 April)
- The 156th OPEC meeting in Vienna decided to keep oil production quotas flat, but the oil price rose above $81; with the FT speculating that OPEC has long lost the clout to shape prices: with technological developments, increased output in developed countries and growing supplies from unconventional sources, including biofuels, responsible. Opec is described as 'rich but largely irrelevant'. (*FT* 18 March 2010) Iraq is its only member without a production quota.
- According to Carola Hoyos, about $80 a barrels oil prices are what 'OPEC's members want them to be," low enough to allow economic recovery and provide for producers' national budgets. But Iran, Angola, Nigeria and Venezuela risk oversupplying and hence falling prices, especially if stimulus packages end. (*FT* 16 March 2010)
- Under pressure from USA, oil traders are reducing the supply of crude and petrol to Iran as sanctions related to nuclear matters are being implemented, While a major oil producer, Iran's refining capacity is poor and demand is for petrol is rising because of generous subsidies. Chinese traders now supply up to a third of the imports, (*FT* 8 March 2010)
- India still imports 75% of its crude, but its local state-owned oil industry is demanding the setting up of a sovereign wealth fund from foreign exchange reserves so that they can better face competition from Chinese energy groups, in particular to secure off-shore energy deals. India lags far behind the Chinese in securing energy resources abroad. (*FT* 18 March 2010)
- The Kurd's demand that oil rich Kirkuk becomes the capital of an autonomous regions risk civil war in Iraq: between the Kurdish minority and the central government in Baghdad.
- Algeria has called for gas production cuts in order to maintain higher prices as 'exporters bear the cost of oversupply'. Other exporters, especially Russia and Qatar are not likely to agree. Qatar, now the world's largest exporter of liquefied natural gas by tanker, is increasing supplies.

Shale Oil Development in North Dakota

The Bakken shale that underlies the western third of the state is estimated to contain over 500 billion barrels. Yes that is billion – not a typo. For comparison, Saudi Arabia has proven reserves of 25 billion and Alaska has perhaps the same in Anwar. Experts tell me that current technology . . . should be able to recover about 20% of the oil which means that recoverable oil is four times greater than what is in Saudi Arabia. That is a lot of oil!

Oil Tanker to Take Arctic Route

The Northern passage along Russia's Northern coast would provide a short cut between Europe and many routes using the Suez Canal and carrying oil as well as NLG. A journey from the White Sea to Japan is planned for this summer by shipping company Sovcomflot led by an ice breaker. Expected to take 18days, this can be seen as a part of the beginning hydrocarbon bonanza in this polar area. This 'floating oil pipeline hopes for further 'global warming'. (*FT* 14 April)

Coal Comeback in Britain?

Energy from remaining rich coal seams in the UK, in Cumbria, is planned . No mining would be involved – a traditional industry that disappeared several decades ago, but gasification in situ underground would be the new technology. Investigative work is to start early in 2011. Nuclear power is generated nearby, and a return to coal would add new lustre to England's 'energy coast', especially as the underground coal fields are abundant and stretch across the Solvay. Similar projects already exist in Australia and South Africa.

The Impact of Closing Coal Fired Power Station is USA

Abstract: Large numbers of proposed new coal power generators in the United States have been cancelled, and some states have prohibited new coal power generators. We examine the effects on the U.S. electric power system of banning the construction of coal-fired electricity generators, which has been proposed as a means to reduce U.S. CO_2 emissions. The model simulates load growth, resource planning, and economic dispatch of the Midwest Independent Transmission System Operator (ISO), Inc., Electric Reliability Council of Texas (ERCOT), and PJM under a ban on new coal generation and uses an economic dispatch model to calculate the resulting changes in dispatch order, CO_2 emissions, and fuel use under three near-term (until 2030) future electric power sector scenarios. A national ban on new coal-fired power plants does not lead to CO_2 reductions of the scale required under proposed federal legislation such as Lieberman-Warner but would greatly increase the fraction of time when natural gas sets the price of electricity, even with aggressive wind and demand response policies. Near-Term Implications of a Ban on New Coal-Fired Power Plants in the United States.((Adam Newcomer and Jay Apt, Carnegie Mellon Electricity Industry Center, Tepper School of Business and Department of Engineering and Public Policy, Carnegie Mellon University, Pittsburgh, Pennsylvania 15213, *Environ. Sci. Technol.*, 2009, *43* (11), pp 3995–4001)

CARBONPHOBIA

> *"I think you have to accept that the sceptics have kept us sane – some of them, anyway," he said. "They have been a breath of fresh air. They have kept us from regarding the science of climate change as a religion. It had gone too far that way. There is a role for sceptics in science. They shouldn't be brushed aside. It is clear that the angel side wasn't without sin."* (James Lovelock, reported The Sunday Times March 14 2010)

Humans must be to blame for climate change, say scientists. No possible natural phenomenon could have caused the huge rise in temperatures experienced in last half-century. (By Steve Connor, Science Editor Independent 5 March 2010)

The methane is oxidized to CO_2 within ten years too. Some time ago cows were blamed for contributing to global warming and some of them went mad! (Jack Barrett 29 March 2010)

An Old Promise. . . .

In *1997* the UK Labour Party Manifesto promised "A new environmental internationalism: "Labour believes that the threats to the global climate should push environmental concerns higher up the international agenda. A Labour government will strengthen co-operation in the European Union on environmental issues, including climate change and ozone depletion. We will lead the fight against global warming, through our target of a 20 % cent reduction in carbon dioxide emissions by the year 2010.[!] Labour believes the international environment should be safeguarded in negotiations over international trade. We will also work for the successful negotiation of a new protocol on climate change to be completed in Japan in 1997."

Easter Message from Greenpeace: Break the Law!

Extract:-"Emerging battle-bruised from the disaster zone of Copenhagen, but ever-hopeful, a rider on horseback brought news of darkness and light: "The politicians have failed. Now it's up to us. We must break the law to make the laws we need: laws that are supposed to protect society, and protect our future. Until our laws do that, screw being climate lobbyists. Screw being climate activists. It's not working. We need an army of climate outlaws." (http://weblog.greenpeace.org/climate/2010/04/will_the_real_climategate_ plea_1.html)

And Worse – Create Ecocide by One Country One Vote System

The proposal for the United Nations to accept "ecocide" as a fifth "crime against peace", which could be tried at the International Criminal Court (ICC), is the brainchild of British lawyer-turned-campaigner Polly Higgins. The radical idea would have a profound effect on industries blamed for widespread damage to the environment like fossil fuels, mining, agriculture, chemicals and forestry.

Supporters of a new ecocide law also believe it could be used to prosecute "climate deniers" who distort science and facts to discourage voters and politicians from taking action to tackle global warming and climate change."Ecocide is in essence the very antithesis of life," says Higgins. "It leads to resource depletion, and where there is escalation of resource depletion, war comes chasing behind. Where such destruction arises out of the actions of mankind, ecocide can be regarded as a crime against peace." Higgins, formerly a barrister in London specialising in employment, has already had success at the UN with a Universal Declaration for Planetary Rights, modelled on the human rights declaration. "My starting point was 'how do we create a duty of care to the planet, a pre-emptive obligation to not harm the planet?'" After a successful launch at the UN in 2008, the idea has been adopted by the Bolivian government, who will propose a full members' vote, and Higgins has taken up her campaign for ecocide.2 (Excerpt J Jowit *The Guardian*

9 April 2010) http://www.guardian.co.uk/environment/2010/apr/09/ecocide-crime-genocide-un-environmental-damage)

The Sceptics' PR Coup?

A marketing firm employed by Oxfam concluded that " A small group of dedicated people coming from a diverse range of positions and perspectives but working together as a loose federation held together by shared values and beliefs succeeded in accomplishing the most impressive PR coup of the 21st century. The climate change sceptics did this by significantly influencing public perception of anthropogenic global warming by single-mindedly applying concerted and consistent pressure at critical junctures in the media ecology here in the UK and abroad. (March 23, 2010) (http://tomnelson.blogspot.com/2010/03/marketing-group-paid-by-oxfam-analyzes.html)

Dissident Shareholders Attack BP

Possible investments in Canada's oil sands were attacked as potentially catastrophic to climate by UK investors. . . . including public pension funds and public sector workers unions. BP quoted IEA forecast demand increases in reply. (*FT* 29 March) However, the protestors were defeated as local authority investors and a leading advisor recommended the investments in Canadian oil sands. The sunrise development is to serve a refinery in Ohio

World Bank Attacked over South African Coal Loan

"The World Bank will vote this evening on a controversial $3.75 billion loan application to build a massive supercritical coal-fired power station in South Africa. Construction work began in 2007 on Eskom's Medupi Power Station, which is expected to have a capacity of 4,300MW and cost 175 billion South African rand ($24 billion). The first phase is due to be commissioned in 2012.

However, on Tuesday local residents filed a complaint with the World Bank in a bid to block the project, while local and international environment groups urged the bank to reject the loan.

South African and international civil society organisations signed a statement calling for governments with voting power in the World Bank to veto the loan, slamming Medupi as a "bad project, contributing to energy poverty and environmental destruction". The organisations also argue that World Bank financing is inappropriate for South Africa, based partly on the bank's history of financing apartheid-era loans. Erich Pica, president of Friends of the Earth US, said: "This coal loan is not about alleviating poverty or supporting sustainable development and the World Bank has no business making it. The World Bank should listen to the voices of communities in South Africa and cut the coal. "Multinational corporations will be the big winners if this loan moves forward. Big corporate polluters cut secret deals with Eskom under apartheid. They receive cut-rate electricity and won't have to pay their fair share of the cost of building the coal plant. Poor households will be stuck with much of the bill. This is unjust and unacceptable."

"This project is to secure uninterrupted electricity for large corporations, such as smelters and mining houses under secretive special pricing agreements. It is not for the

millions of poor people who cannot afford or do not have access to electricity. South Africa does not need this loan," said Bobby Peek, director of ground Work, part of Friends of the Earth in South Africa.

However, Eskom argues that the power station will be a "significant improvement in overall thermal efficiency compared to the existing power stations in South Africa, resulting in better utilisation of natural resources, such as coal and water, and a reduction in emissions of carbon dioxide per unit of electricity produced". (*EF* 8 April)

NB: The World Bank decided to lend South Africa's ESKOM $3.7bn but controversy continues. (9 April 2010)

Nature on Denialism: Sceptics and Deniers of Climate Change Not to be Confused

Climate-change denial could have disastrous consequences, if it delays global action to cut carbon emissions. Denialism is gaining popularity because people have difficulty differentiating deniers' twisted arguments from the legitimate concerns of genuine sceptics. We must stop deniers presenting themselves as the rightful regulators of scientific debate. Denial of the science of climate change is eroding public understanding of the issue and seems to be undermining trust in scientists (see http://go.nature.com/BAhVYp). This loss of public confidence – after a cold winter in Europe and elsewhere, and the 'Climategate' e-mails controversy – was highlighted at February's meeting of the American Association for the Advancement of Science in San Diego, California (R. J. Cicerone Science 327, 624; 2010). Denialism is motivated by conviction rather than evidence. It has been applied to a wide range of issues, including evolution and the link between HIV and AIDS. Deniers use strategies that invoke conspiracies, quote fake experts, denigrate genuine experts, deploy evidence selectively and create impossible expectations of what research can deliver. They rely on misrepresentation and flawed logic (P. Diethelm and M. McKee *Eur. J. Public Health* 19, 2-4; 2009). By contrast, scepticism starts with an open mind. . . (Extract Jeremy Kemp, Richard Milne & Dave S. Reay *NATURE*, vol. 464, page 673

Eating Meat Increases the Heat?

A 2006 report concluded meat production was responsible for 18% of greenhouse gas emissions – more than transport. . . . Leading figures in the climate change establishment, such as Intergovernmental Panel on Climate Change (IPCC) chairman Rajendra Pachauri and Lord (Nicholas) Stern, have also quoted the 18% figure as a reason why people should consider eating less meat. The report has been cited by people campaigning for a more vegetable-based diet, including Sir Paul McCartney. But a new analysis, presented at a major US science meeting, says the transport comparison was flawed. . . ." Producing less meat and milk will only mean more hunger in poor countries." (http://news.bbc.co.uk/1/hi/sci/tech/8583308.stm)

It All Started Along Time Ago

It appeared as global warming in the second publication of the Club of Rome, which Strong, Martin Sr and Martin Jr were both members. Here is the quote from, *Mankind at The Turning Point* in 1974. *"It would seem that humans need a common motivation. . .either a real one or else one invented for the purpose. . .In searching*

for a new enemy to unite us, we came up with the idea that pollution, the threat of global warming, water shortages, famine and the like would fit the bill. All these dangers are caused by human intervention, and it is only through changed attitudes and behavior that they can be overcome. The real enemy then, is humanity itself." (Tim Ball 16 March) !

Coal Industry A Drug Dealer?

James Hansen must be loved by Australians. Just give up the basis of your economy or be considered an equivalent to "drug dealers", is his message. "And exporting coal, and increasing exports of coal, is almost equivalent to being a drug dealer to the world." (http://www.theage.com.au/environment/climate-pioneer-backs-tax-on-carbon-nuclear-power-20100304-pjaw.html)

Hansen's Latest Book

". . . it's the final chapter, "Storms of My Grandchildren," that will really grab your attention. It is here that Hansen puts all the pieces of the previous chapters together into one nightmarish narrative. He paints a frightening portrait of the 21st century should we continue on a business-as-usual path. It is a time of supercell storms with wind speeds of 80 miles per hour. It's a time when 100-year floods occur more often than implied. It is a time of cyclonic blizzards on the East Coast, F5 tornados through the Midwest, and sea-level rise measured in meters, possibly displacing people living in coastal areas. "The strongest hurricanes and other tropical storms will become stronger," he warns. Think Katrina. Think Hugo. "Storms of My Grandchildren" could possibly be the most important scientific manifesto of our time. It is a book that climate – change believers and climate-change deniers alike should pick up and read. As Hansen himself puts it, "Without a well informed public, humanity itself and all species on the planet are threatened." Become well informed. As Hansen says, "It is our last chance." (Extract from message by Hans Jelbring March 2010)

IPCC Not Alarmist Enough Says RealClimate

"In its latest report, the IPCC has predicted up to 59 cm of sea level rise by the end of this century. But *RealClimate* soon revealed a few problems. First, although the temperature scenarios of IPCC project a maximum warming of 6.4 ºC (Table SPM3), the upper limit of sea level rise has been computed for a warming of only 5.2 ºC – which reduced the estimate by about 15 cm. Second, the IPCC chose to compute sea level rise up to the year 2095 rather than 2100 – just to cut off another 5 cm. Worse, the IPCC report shows that over the past 40 years, sea level has in fact risen 50% more than predicted by its models – yet these same models are used uncorrected to predict the future! And finally, the future projections assume that the Antarctic ice sheet gains mass, thus lowering sea level, rather at odds with past ice sheet behaviour. Some scientists within IPCC warned early that all this could lead to a credibility problem, but the IPCC decided to go ahead anyway. Nobody cared about this. I mention this because there is a lesson in it. IPCC would never have published an implausibly high 3 meter upper limit like this, but it did not hesitate with the implausibly low 59 cm. That is because within the IPCC culture, being "alarmist" is bad and being "conservative" (i.e. underestimating the potential severity of things) is good.

Energy Minister Ticked Off

The UK Advertising Standards Authority has ruled that adverts commissioned by Ed Miliband, the energy secretary, are to be banned for exaggerating the potential harm from climate change. The ASA has ruled that the claims made in the newspaper adverts (based on nursery rhymes) were not supported by solid science and has told the Department of Energy and Climate Change that they should not be published again. It has also referred a television commercial to the broadcasting regulator, OFCOM, for potentially breaching a prohibition on political advertising. (Wilson Flood 15 March)

UKCP09 Data Archive Available

An archive of UKCP09 data is now available from the UKCP09 User Interface (UI). The archive makes for more rapid download of large amounts of data, and contains data on the following: probabilistic projections over land (sampled data of projections of both change and absolute future climate, for all time periods, temporal averages, spatial averages and emissions scenarios); probabilistic projections over marine regions (sampled data of projections of climate change, for all time periods, temporal averages, and emissions scenarios); sea level rise projections (both absolute and relative sea-level rise projections are available for all three emissions scenarios, and all grid cells); storm surge projections (projections are available for all grid cells); global mean annual temperature change (these data provide the change in global mean annual temperature associated with each of the 10,000 samples in the sampled data and a cumulative distribution function (CDF) data set is also available). CDF data for the probabilistic projections over land and marine regions is expected in the near future. These are available through the User Interface (UI) – http://ukclimateprojections-ui.defra.gov.uk. There are links on the UI home page to more information and guidance.

Government departments recently launched their climate change plans, which include action they are taking to adapt to a changing climate. As well as adaptation plans for each department, a single summary document describes the Government's overall approach to both adaptation and mitigation. Press release – http://www.defra.gov.uk/news/2010/100331c.htm (From UK Climate Impacts Programme April 2010)

Ian Plimer Rejected by Buckingham Palace

Having been invited to give the 2010 Prince Philip Lecture to the RSA on 5 May 2010 and having accepted to do so in late 2009, the invitation was withdrawn in March. This apparently happened at the request of Buckingham Palace because of his political involvement in Australia.

NUCLEAR GROWTH : Early March 2010 – mid April 2010

> *The world will increasingly rely on civil nuclear power as an energy source.*
> (Editorial FT 29 March 2010)

International

IEA and EU to cooperation 9 April 2010 The International Atomic Energy Agency and the European Commission's Joint Research Centre are starting to roll out joint projects after signing a major cooperation deal late last year.

Nuclear 'roadmap' in latest Russia-India accords: 15 March New agreements between Russia and India include a new cooperation agreement on the peaceful uses of nuclear energy and a roadmap for this year's work by the two countries. Meanwhile, the Indian government has deferred a bill that could be vital to opening nuclear trade with the USA.

China expands nuclear influence to Belarus and Pakistan 31 March 2010 Officials have conducted talks on Chinese involvement in civil nuclear power projects in both Belarus and Pakistan, where Chashma 3 and 4 now look closer to reality.

Kazakhstan signs cooperation deal with Japan 3 March 2010 Japan and Kazakhstan have signed an agreement to cooperate in the peaceful uses of nuclear power. Meanwhile, Romania's president has said the country is open to cooperation with Kazakhstan, including in nuclear energy.

Training support for emerging nuclear energy nations 22 March 2010 While US organizations have agreed to help the United Arab Emirates establish an institute for training its nuclear energy workers, Russia has signed an agreement to help Vietnam train its nuclear workforce.

Powers at odds on Bushehr 19 March While Iran's Bushehr nuclear power plant continues long-running commissioning tests, the USA and Russia have clashed on whether the plant should start up at all.

India and Russia firm up nuclear agreements. The Russian prime minister's visit to India provided the occasion to sign a number of agreements taking forward plans to build further Russian nuclear power capacity in India. As well as a nuclear power cooperation agreement, a 'roadmap' for building six more reactors at Kudankulam by 2017 (where two are almost complete) and four more at Haripur after 2017 was agreed, bringing the total to 12. The number may be increased after 2017, in India's 13th 5-year plan. A Russian fuel fabrication plant is also under consideration

Go-ahead for nuclear fuel reserve: 29 March 2010 A reserve of low-enriched uranium is to be set up in Russia, according to an agreement the country made with the International Atomic Energy Agency today

MOX fuel contract for Hokkaido reactor: 30 March 2010 France's Areva has signed a contract to supply mixed-oxide (MOX) fuel for use in unit 3 of Hokkaido Electric Power Co's Tomari nuclear power reactor in Japan.

Europe, Middle East and Russia

Nuclear Interim Storage: A conference eon this subject chaired by the Director of projects of ANDRA and the President of the European Nuclear Society tt will place 18-19 May in London, with subject anign from interim storage in Sweden and materials and monitoring cjallenges, R&D reports from several countries to issues related to nuclear fuel leaks and the goals of the UK Integrated Project Team to the 100+ years storage of nuclear waste are to be discussed. Decommissioning and Legacy waste in the UK will be discussed 30 June to 1 July in Manchester.

European nuclear safety training institute: 11 March 2010 Four national technical safety organizations have announced the creation of a European Nuclear Safety Training and Tutoring Institute (ENSTTI) to help strengthen European research and assessment know-how in the fields of nuclear safety and radiation protection.

French Nuclear Review: The French government is reviewing the structure and organisation of is large nuclear sector to make it more competitive internationally. The industry is 'an important tool of French foreign policy' especially in the Middle East and Asia. Having lost the contract to build four new reactors in Abu Dhabi acted as wake-up call for a fiercely competitive sector (Areva, EDF and GDF-Suez suffering from government interference). The chief executive is expected to leave. (*FT* 18 March 2010)

Cooperation deals for French, Italian nuclear companies 12 April A raft of nuclear cooperation agreements between French and Italian companies were signed at a forum jointly chaired in Paris by French president Nicolas Sarkozy and Italian prime minister Silvio Berlusconi. According to FT 8 April 'Italy is becoming a nuclear battleground with France and the US competing for a slice of the nuclear revival. Italy is planning to adopt the French EPR new generation reactor for the first stage, (4 plants or half the targeted capacity) with tenders for the second round likely to go to Westinghouse. (*FT* 8 April)

***UK* government prodded to resolve carbon price:** 2 March Two of the three proponents of building new nuclear power reactors in the UK have told the government that it needs to give clearer incentives to low-carbon generation before there will be investment. They called the current price under the EU emissions trading scheme unsustainably weak, and suggested that the government introduce a UK floor price for carbon emissions. The government's own utterances and the market regulator Ofgem were quoted in support of radical action. For EdF Energy, that needs to be soon. The government much earlier ruled out any subsidies for nuclear, and the Conservative opposition agrees with this, but the Climate Change Levy, meant to dissuade generators from using fossil fuels, currently penalises nuclear energy as if it were as carbon-intensive as fossil fuels.

UK Waste Plans ready by Await Implementation: According to one expert witness to the House of Lords enquiry into nuclear waste management: ". . .active research facilities where intermediate level and high level waste can be properly studied are relatively limited in availability in the United Kingdom, and where they do exist it is quite difficult for many researchers to gain access to those facilities. Also when asked about waste disposal sited for new build, currently the concern of CoRWM, whether he could "you identify any gaps in our knowledge which could cause serious delay to actually designing and constructing a (waste disposal)facility? *Professor Pickard replied:* There are huge uncertainties. We have a mining engineer who is a member of the Committee and he is constantly pointing out the need initially to look at alternatives of an engineering and technical nature and not simply to put all the eggs in one basket and put all the effort into one particular engineering solution because it may turn out that that particular solution may be inappropriate when we actually get down to looking at the rock and the characteristics of the geology. . ., if you put too much money into a process of engineering development that turns out not to be successful, it is very, very difficult to work your way backwards to redesign a whole concept." One issue for CoRWM was that "the security of storage of radioactive wastes, spent fuels and nuclear materials is assured (CoRWM, 2009d). The issue arose again in the autumn of 2009 in connection with the British Energy plan to build a dry store for spent fuel at Sizewell B and with the possibility that spent fuel from new

nuclear power stations may have to be stored at the stations for about 160 years before it can be placed in a geological disposal facility. A particular concern for stakeholders is whether new spent fuel stores will be designed to withstand the impact of a large commercial aircraft that has been hijacked by terrorists, ”and while the current UK process for siting a geological disposal facility (GDF) for HAW is sound, it is at an early stage. “ (From (http://www.publications.parliament.uk/pa/ld200910/ldselect/ldsctech/95/95.pdf)

Nuclear press confirmed for Sheffield Forgemasters: 17 March 2010 A UK manufacturer will be able to supply ultra-heavy forgings for nuclear power plants after a strategic government loan announced today. Sheffield Forgemasters said it could supply pressure vessels within three years of installing the press.

Britain looks for reprocessing strategy: 18 March The UK has begun to weigh up its options with respect to reprocessing or directly disposing of used nuclear fuel as its main reprocessing plant ages.

Horizon picks its first nuclear site: 30 March, The Wylfa site has been picked as the first for new build by Horizon Nuclear Power, while the choice of reactor design is still being made.

Decommissioning milestones for UK plants: 30 March Decommissioning work at two of the UK’s oldest nuclear power plants has reached major milestones with the final removal of uranium from Chapelcross and the removal of asbestos cladding from Calder Hall.

The task of the UK Nuclear Decommissioning Authority: The Nuclear Decommissioning Authority (NDA) is a non-departmental public body established in 2005 by the Energy Act 2004. . . . It was established “in order to deliver the Government’s commitment to deal effectively with the nuclear legacy and are responsible for driving substantial change to improve delivery and cost efficiency in a large and complex industry.” Its mission is to: *Deliver safe, sustainable and publicly acceptable solutions to the challenge of nuclear clean up and waste management. This means never compromising on safety or security, taking full account of our social and environmental responsibilities, always seeking value for money with the taxpayer and actively engaging with stakeholders*. In June 2008 the UK Government set out a framework to implement the geological disposal policy in the Managing Radioactive Waste Safely White Paper.

UK on target for low-carbon future: 25 March 2010 UK greenhouse gas emissions continued to decline in 2009, partly thanks to increased use of nuclear power. Meanwhile, the latest budget by the country’s government announced a Green Investment Bank to support the move to a low-carbon economy

New partner for potential Polish nuclear build: 8 March 2010 Poland’s largest power group, Polska Grupa Energetyczna (PGE), has signed a second cooperation agreement with a potential builder of the country’s first nuclear power plant, this time with GE-Hitachi.

Poland’s nuclear site study 16 March 2010 A nationwide survey has selected Poland’s best sites for nuclear power plants, two of which are planned for 2020.

Exploration to resume at German repository site: 22 March 2010 German federal environment minister Norbert Röttgen has lifted a 10-year moratorium on exploratory work at the Gorleben salt dome, a potential repository for Germany’s radioactive waste.

German reactor restarts after lengthy outage: 23 March 2010 RWE's Biblis A pressurised water reactor – Germany's oldest operating nuclear power unit – has restarted after over a year offline for ?68 million ($92 million) of upgrades and modernisation work.

Approval for Myhhra: 5 March 2010 Belgian nuclear scientists have been given the go-ahead to work towards an advanced new research reactor system with a role in researching the transmutation of wastes.

Swedish parliament to vote on nuclear bills as one: 19 March The Swedish parliament has decided to consider two separate nuclear energy-related bills introduced last month by the government as a single bill, the Stockholm News reported. The first bill would allow the construction of new reactors to replace Sweden's ten existing units, while the second would quadruple the financial liability of nuclear power reactor owners in the event of an accident.

Court ruling confirms nuclear plant stays Dutch: 3 March A Dutch appeals court has confirmed that the Netherlands' only operating nuclear power plant must remain in Dutch ownership. The ruling upholds an earlier ruling prohibiting Germany's RWE from acquiring Essent's 50% stake in the plant.

Siting study licence issued in UAE: 8 March 2010: The first licence to be issued by the United Arab Emirates' nuclear regulator will enable the Emirates Nuclear Energy Corporation (Enec) to study potential sites for the country's first nuclear power plant.

Jordan opens storage facility: 22 March 2010 Jordan has inaugurated a national interim storage facility for the country's radioactive waste and nuclear materials. The facility was partly funded by the US Department of Energy.

Russia commits to suite of fast reactor technologies. The Russian government has confirmed a multi-track development to embrace fast neutron reactors as a technological priority in the next decade. The existing sodium-cooled fast reactor program with units of about 800 MWe will continue, a lead-bismuth-cooled SVBR fast reactor of 100 MWe will be built by 2015, and then a lead-cooled BREST fast reactor of 300 MWe will be built by 2020. In addition, a 150 MWt multi-purpose fast research reactor (MBIR) is to be built by 2020. The total fast reactor budget to 2020 is about RUR 60 billion (US$ 2 billion), largely from the federal budget. The program is intended to result in a 70% growth in exports of high technology equipment, works and services rendered by the Russian nuclear industry by 2020.

Consolidation of Russian nuclear industry continues: 7 April The transfer of shares in the Engineering Centre "Russian Gas Centrifuge" from Techsnabexport to Rosatom subsidiary AtomEnergoProm is the latest development in the process to consolidate Russia's state-owned conversion, enrichment and fuel fabrication companies into a new fuel company based on TVEL.

North America

End of the line for Yucca Mountain? 4 March 2010 The withdrawal of its licence application yesterday marked the official end of the Yucca Mountain repository project. The landmark means that efforts under the 1982 Nuclear Waste Policy Act resulted only in $10 billion of spending on a project now described as "not an option."

US regulator challenges political edict: Dale Klein of the Nuclear Regulatory Commission (NRC) challenged the US government's political decision to revoke the license application for the Yucca Mountain waste repository project in Nevada. "The administration's stated rationale for changing course does not seem to rest on factual findings, and thus does not bolster the credibility of our government to handle this matter competently," he said. "Those who would distort the science of Yucca Mountain for political purposes should be reminded that it was a year ago today that the president issued his memorandum on scientific integrity, in which he stated that 'The public must be able to trust the science and scientific process informing public policy decisions'. Under the law, that licensing determination – and the technical evaluation of the science – is the NRC's responsibility."

Sixteen utilities and the main US industry association have filed a lawsuit against the US Department of Energy to suspend the government's collection of nuclear waste disposal fees, on the basis that the country no longer has a disposal plan after ruling out Yucca Mountain, Nevada, as a repository site. The utilities jointly pay about $750 million a year – at 0.1 cent per kilowatt hour – into the fund which now stands at about $24 billion and earns about $1 billion annually in interest. The DOE has pointed out that the fee is legally mandated and will be applied eventually to the purpose intended. Meanwhile the Blue Ribbon Commission on America's Nuclear Future is under way, charged with developing a new strategy for nuclear waste management in the USA. This is likely to include reprocessing and recycling of used fuel, which will greatly reduce but not eliminate the need for a deep geological repository. According to a recent Areva estimate, a 2500 t/yr US reprocessing plant and associated 300 t/yr mixed-oxide fuel fabrication plant could cost $25 billion, which would work out at less than the present 0.1 c/kWh levy.

US utilities, regulators sue DoE over waste fund: 6 April Sixteen electricity utilities, together with US nuclear industry organisation the Nuclear Energy Institute (NEI), have filed a lawsuit against the Department of Energy (DoE) seeking a suspension of payments into the country's nuclear waste fund.

Americans wary of nuclear waste, safety issues: 4 March 2010 Almost half of Americans are in favour of new nuclear power plants being built in the USA, but the majority said they are concerned about radioactive waste management, plant safety and nuclear material falling into the wrong hands, a new public opinion poll shows.

US government pushes ahead with new reactor concept: 11 March The US Department of Energy (DOE) has awarded grants for conceptual design and planning for its Next Generation Nuclear Plant (NGNP). This is to be a small advanced high-temperature gas-cooled reactor usable for electricity or hydrogen production. A $2 billion pilot plant demonstrating technical feasibility is envisaged by 2021 at Idaho National Laboratory but with international collaboration. Three companies were awarded DOE contracts for pre-conceptual NGNP design: General Atomics, Areva, and Westinghouse (with PBMR). DOE has now awarded $40 million to two teams for conceptual designs in six months: Westinghouse, with South Africa's Pebble Bed Modular Reactor Ltd, Shaw, Toshiba, Doosan and others; and General Atomics with General Dynamics, URS Washington, Korea Atomic Energy Research Institute, and Fuji.

Illinois Senate votes to overturn nuclear ban: March16 The Illinois state Senate has voted overwhelmingly to remove a 23-year-old moratorium on the construction of

new nuclear power plants in the state. However, the bill stills need to be approved by the House.

Teams compete for NGNP design: 9 March The USA has asked for more reactor design work from two technology teams led by General Atomics and Westinghouse. One of the designs could be picked for construction as the Next Generation Nuclear Plant (NGNP).

ESP application for new Texan plant: 26 March 2010 Exelon has submitted an application to the US nuclear regulator for an early site permit (ESP) for the construction of a new nuclear power plant in Victoria County, while withdrawing its application for a combined construction and operating licence (COL) for the plant**.**

USEC, DoE reach $90 million cost share agreement: 24 March In a move suggesting growing confidence in USEC's American Centrifuge technology, the US Department of Energy (DoE) has agreed to provide the company with $45 million in funding for its ongoing technology demonstration and manufacturing activities.

New York thwarts reactor relicensing over water: 8 April New York state's Environment Department has told Entergy that its Indian Point nuclear power plant can no longer use water from the Hudson River for direct (once-through) cooling**,** whereby a relatively large volume of water is drawn from the river and discharged back into it, a few degrees warmer. The Indian Point plant withdraws 9.5 gigalitres per day through screens, which kills some aquatic life. Last month the Environment Department introduced a draft policy requiring certain industrial facilities – including nuclear and other power plants – to recycle and reuse cooling water through "closed cycle cooling" technology with large evaporative cooling towers. Water use from the river is then much lower, to replace that evaporated (3-5% per cycle) and allow some discharge to maintain quality.

Entergy has applied to renew the operating licences for the two reactors for 20 years from 2013 and 2015. It estimates that building new cooling towers would cost some $1.1 billion and involve shutting down the reactors for 42 weeks. It has proposed a new $100 million screening system for the water intake which it says would be more effective than cooling towers (which still need some water input). Currently, of the USA's 104 nuclear power reactors, 60 use once-through cooling from large rivers, lakes or the sea, while 35 use wet cooling towers. Nine units use dual systems, switching according to environmental conditions. Cooling towers reportedly reduce the overall efficiency of a power plant by 3-5% compared with once-through use of water from sea, lake or large stream. A 2009 US DOE study says they are about 40% more expensive than a direct, once-through cooling system. Utilities challenge US waste levy

Strong pushback on US waste program: The US Energy Secretary and Department of Energy have come under strong pressure to maintain some work on the Yucca Mountain waste repository rather than just close it down. The House energy and water appropriations committee has strongly criticized DOE's plans to shut down the project and keep it off the agenda of the new panel appointed to reconsider nuclear waste policies. The legality of DOE's plans to abolish the Office of Civilian Radioactive Waste Management (OCRWM), which has long overseen the project, has been called into question, and a bipartisan group, including the chairman of the House

budget committee, has introduced a resolution of disapproval to "compel the Department of Energy to cease its efforts to pull the license application for a nuclear waste repository at Yucca Mountain." Also a group of state utility regulators has filed a motion with the Nuclear Regulatory Commission to oppose the DOE move to abort the project and walk away from the investment of some $10 billion in utility customers' money to settle a political debt. (*Energy Daily, Reuters 25/3/10)*

Study to focus on cancer risk near US nuclear plants: 8 April 2010 A new study by the US National Academy of Sciences on cancer risk for people living close to nuclear power plants is likely to begin this summer, the US Nuclear Regulatory Commission has announced.

Canada's uranium production back on track:.11 March After a couple of lean years due to low ore grades at McClean Lake and various equipment and process problems at the Key Lake mill, Canada's uranium production is returning towards previous levels last seen in 2005, with a total of 11,997 tonnes U3O8 (10,173 tU) for 2009. This is about 22% of world production and makes Canada second to Kazakhstan's 13,900 tU production, but ahead of Australia's 7982 tU.

Enhanced Candu gains approval: 9 April The Canadian Nuclear Safety Commission has said that the overall design intent of Atomic Energy of Canada Ltd's Enhanced Candu 6 is compliant with its requirements. This is the first milestone in licensing the design for actual deployment in the country and comes at the end of the first phase of assessment.

South and East Asia

First Japanese reactor life extension: JAPC's 341 MWe Tsuruga-1 reactor, which started commercial operation in March 1970, has been given a 6-year life extension by local government. It is Japan's oldest operating nuclear power reactor, and the first to get a life extension. Last year JAPC issued a technical evaluation of the reactor with a plan for its ongoing maintenance. The government approved this, so that JAPC then applied for life extension to 2016 in order to bridge the gap until units 3 & 4 at Tsuruga come on line. They will be the first Mitsubishi APWR types, of 1538 MWe, and costing some JPY 770 billion (US$ 8.65 billion). Their construction is now due to start later in 2010 and commissioning of the first is due in March 2016. They have been delayed by revision of seismic safety standards.

South Korea's nuclear technology advances: 30 March 2010 Korea Atomic Energy Research Institute (Kaeri) and Korean steelmaker Posco have signed an agreement to jointly study technologies for advanced nuclear reactor systems. Korean researchers have developed software to ensure optimal operation of power reactors.

Chinese projects place orders: 11 March Orders for waste management systems and valves for new nuclear reactors under construction in China have been placed with US-based suppliers Energy Solutions and Flowserve.

Chinese Candu reactor trials uranium reuse: 24 March The first re-use of nuclear fuel in a Candu reactor has started at a Chinese nuclear power plant. Atomic Energy of Canada Ltd announced that fuel bundles containing recovered uranium from used fuel had been inserted into Qinshan Phase III unit 1.

China plans 28 more' reactors by 2020: 23 March 2010 China has approved the construction of a further 28 new nuclear reactors by 2020 under revised targets to meet

rising energy demand and accelerate the development of the industry, according to media reports.

Human resources critical to Indian nuclear plans: 5 March 2010 India's nuclear industry is preparing for a major expansion after assuring international cooperation with a round of cooperation deals, but the limited supply of human resources in the sector remains a concern.

Computing boost for Japanese research: 3 March 2010 The fastest supercomputer in Japan has been put to use for nuclear energy research by the Japan Atomic Energy Agency (JAEA). The new system has a performance over 12 times greater than its previous systems.

High-level waste returned to Japan: 10 March 2010 The first consignment of solid high-level waste belonging to Sellafield's Japanese customers has safely arrived in Japan from the UK following a journey by ship of over six weeks. The waste arose from the reprocessing of those customers' used nuclear fuel at Sellafield.

Southern Hemisphere

PBMR chief steps down: 9 March Jaco Kriek has resigned as CEO of PBMR Pty Ltd. The announcement comes weeks after South African government funding for the development of the pebble bed modular reactor (PBMR) was withdrawn, leaving the company facing major cuts.

EPILOGUE

Martin Wolf's list of 'limited range of urgent tasks' for the world;

Maintaining an open and dynamic world economy
Fixing the financial system
Balancing the world economy

- Managing climate change and pressure on natural resources while sustaining growth
- Containing nuclear proliferation
- Bringing rising new powers, particularly China, into the heart of global political discussions
- Reforming international institutions to reflect the changed political realities . (Report from Davos, *FT* 26 January 2010)

Question from Sonja B-C: Do international carbon trading and emission targets – does the 'managing of climate change' via regulation, emission trading, taxation and large subsidies – help or hinder the achievement of other societal objectives in the short and the long term?

Sonja Boehmer-Christiansen