Neue Studie: Schmelzen des antarktischen Eisschilds führt zu großflächiger Abkühlung und Meereisausdehnung

geschrieben von Chris Frey | 20. Juni 2025

Kenneth Richard

Wissenschaftler haben entgegen der Intuition festgestellt, dass ein schmelzender antarktischer Eisschild die globale Erwärmung abmildern kann.

Das erwartete beschleunigte Abschmelzen des antarktischen Eisschildes (AIS) wird dazu führen, dass in den nächsten hundert Jahren enorme Mengen an Süßwasser in den Südlichen Ozean (SO) gelangen werden.

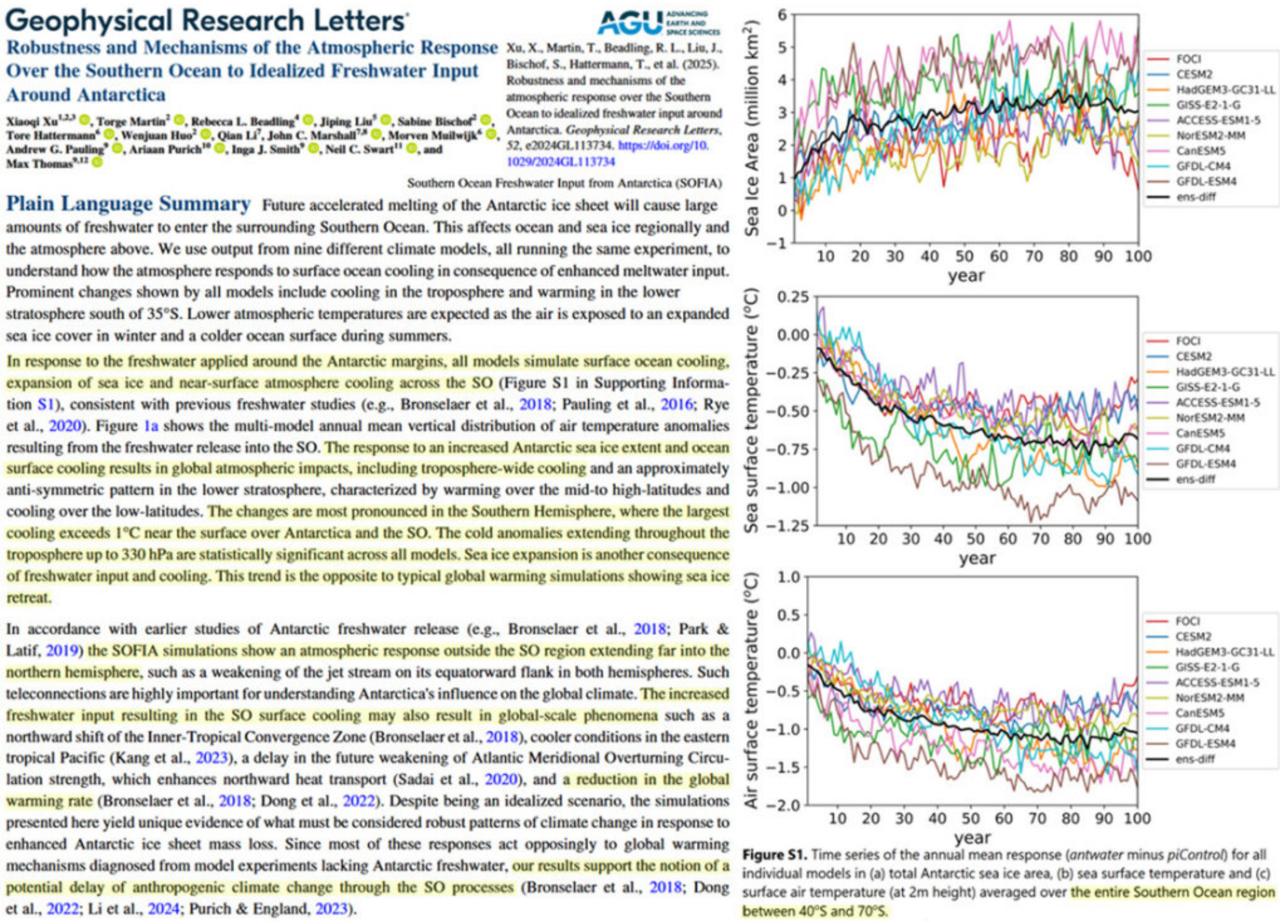
Laut einer neuen Studie, die sich auf eine Reihe von SOFIA-Modellen (Southern Ocean Freshwater Input from Antarctica) stützt, wird ein schmelzender AIS den SO und die Antarktis abkühlen (letztere um 1°C oder mehr) und zu einer weiteren Ausdehnung des Meereises auf der Südhalbkugel führen.

Genauer gesagt wird sich die gesamte Region zwischen 40 und 70°S im nächsten Jahrhundert infolge des Abschmelzens des antarktischen Eisschildes um ~0,7°C abkühlen und das Meereis wird sich um etwa 2 Millionen km² ausdehnen (siehe Abbildung S1 der Studie). Der Hauptautor hat bereits 2022 eine Arbeit veröffentlicht, die belegt, dass „die Meerestemperatur des Südlichen Ozeans (50°S-70°S) im Zeitraum 1982-2020 einen signifikanten und robusten Abkühlungstrend aufweist“, so dass der Abkühlungstrend bereits seit über 40 Jahren anhält.

Die Autoren der vorliegenden Studie behaupten, dass die Reaktion auf die zunehmende Ausdehnung des antarktischen Meereises und die Abkühlung der Ozeanoberfläche globale Auswirkungen auf die Atmosphäre hat, und nicht nur lokale oder regionale Auswirkungen. Die Auswirkungen der SO-Kühlung umfassen insbesondere (a) eine Verringerung der globalen Erwärmungsrate, (b) eine troposphärenweite Abkühlung, (c) eine Abkühlung des östlichen tropischen Pazifiks, (d) eine Verzögerung der erwarteten Abschwächung der AMOC, (e) eine Verschiebung der ICTZ (innertropischen Konvergenzzone) nach Norden und (f) eine „Abschwächung des Jetstreams an seiner äquatorwärts gerichteten Flanke in beiden Hemisphären“.

Mit anderen Worten: Der Schlüssel zur Verringerung des „Problems“ der globalen Erwärmung und ihrer mutmaßlichen Nebenwirkungen könnte darin liegen, ein beschleunigtes Abschmelzen der AIS im nächsten Jahrhundert zu bejubeln (oder darauf zu hoffen).

„Da die meisten dieser Reaktionen entgegengesetzt zu den Prozessen der globalen Erwärmung wirken, die in Modellexperimenten ohne antarktisches Süßwasser diagnostiziert wurden, unterstützen unsere Ergebnisse die Vorstellung einer potenziellen Verzögerung des anthropogenen Klimawandels durch SO [Southern Ocean] Prozesse.“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Robustness and Mechanisms of the Atmospheric Response Over the Southern Ocean to Idealized Freshwater Input Around Antarctica

Xiaoqi Xu[1,2,3], Torge Martin[2], Rebecca L. Beadling[4], Jiping Liu[5], Sabine Bischof[2], Tore Hattermann[6], Wenjuan Huo[2], Qian Li[7], John C. Marshall[7,8], Morven Muilwijk[6], Andrew G. Pauling[9], Ariaan Purich[10], Inga J. Smith[9], Neil C. Swart[11], and Max Thomas[9,12]

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Southern Ocean Freshwater Input from Antarctica (SOFIA)

Plain Language Summary Future accelerated melting of the Antarctic ice sheet will cause large amounts of freshwater to enter the surrounding Southern Ocean. This affects ocean and sea ice regionally and the atmosphere above. We use output from nine different climate models, all running the same experiment, to understand how the atmosphere responds to surface ocean cooling in consequence of enhanced meltwater input. Prominent changes shown by all models include cooling in the troposphere and warming in the lower stratosphere south of 35°S. Lower atmospheric temperatures are expected as the air is exposed to an expanded sea ice cover in winter and a colder ocean surface during summers.

In response to the freshwater applied around the Antarctic margins, all models simulate surface ocean cooling, expansion of sea ice and near-surface atmosphere cooling across the SO (Figure S1 in Supporting Information S1), consistent with previous freshwater studies (e.g., Bronselaer et al., 2018; Pauling et al., 2016; Rye et al., 2020). Figure 1a shows the multi-model annual mean vertical distribution of air temperature anomalies resulting from the freshwater release into the SO. The response to an increased Antarctic sea ice extent and ocean surface cooling results in global atmospheric impacts, including troposphere-wide cooling and an approximately anti-symmetric pattern in the lower stratosphere, characterized by warming over the mid-to high-latitudes and cooling over the low-latitudes. The changes are most pronounced in the Southern Hemisphere, where the largest cooling exceeds 1°C near the surface over Antarctica and the SO. The cold anomalies extending throughout the troposphere up to 330 hPa are statistically significant across all models. Sea ice expansion is another consequence of freshwater input and cooling. This trend is the opposite to typical global warming simulations showing sea ice retreat.

In accordance with earlier studies of Antarctic freshwater release (e.g., Bronselaer et al., 2018; Park & Latif, 2019) the SOFIA simulations show an atmospheric response outside the SO region extending far into the northern hemisphere, such as a weakening of the jet stream on its equatorward flank in both hemispheres. Such teleconnections are highly important for understanding Antarctica's influence on the global climate. The increased freshwater input resulting in the SO surface cooling may also result in global-scale phenomena such as a northward shift of the Inner-Tropical Convergence Zone (Bronselaer et al., 2018), cooler conditions in the eastern tropical Pacific (Kang et al., 2023), a delay in the future weakening of Atlantic Meridional Overturning Circulation strength, which enhances northward heat transport (Sadai et al., 2020), and a reduction in the global warming rate (Bronselaer et al., 2018; Dong et al., 2022). Despite being an idealized scenario, the simulations presented here yield unique evidence of what must be considered robust patterns of climate change in response to enhanced Antarctic ice sheet mass loss. Since most of these responses act opposingly to global warming mechanisms diagnosed from model experiments lacking Antarctic freshwater, our results support the notion of a potential delay of anthropogenic climate change through the SO processes (Bronselaer et al., 2018; Dong et al., 2022; Li et al., 2024; Purich & England, 2023).

Figure S1. Time series of the annual mean response (*antwater* minus *piControl*) for all individual models in (a) total Antarctic sea ice area, (b) sea surface temperature and (c) surface air temperature (at 2m height) averaged over the entire Southern Ocean region between 40°S and 70°S.

Quelle: Xu et al., 2025

Denjenigen, die behaupten, dass ein beschleunigtes Abschmelzen des antarktischen Eisschildes in Zukunft zu einem Anstieg des Meeresspiegels führen wird, halten Wissenschaftler entgegen, dass sich dieses „Problem“ auch selbst korrigieren könnte.

Laut IPCC und Klimamodellen würde die Erwärmung der Antarktis (die in den letzten 70 Jahren nicht stattgefunden hat) dem antarktischen Eisschild mehr Niederschlag und damit Eismasse zuführen (IPCC AR4, Krinner et al., 2007, Palerme et al., 2017). Die wärmungsbedingte Ausdehnung der Eismasse trägt zu einer Verringerung des Beitrags der Antarktis zum Anstieg des Meeresspiegels bis 2100 bei. Genauer gesagt, verringert eine Erwärmung der Antarktis den Meeresspiegelanstieg um -1,2 mm/Jahr.

Eine Erwärmung der Antarktis führt also zu einer Zunahme der Eismasse und einer Verringerung des Meeresspiegelanstiegs, während ein schmelzender Eisschild zu einer weit verbreiteten Abkühlung und einer Zunahme des Meereises führt. In beiden Fällen verliert die alarmistische Darstellung.

ipcc INTERGOVERNMENTAL PANEL ON climate change WMO UNEP

With rising global temperature, GCMs indicate increasingly positive SMB for the Antarctic Ice Sheet as a whole because of greater accumulation (Section 10.6.4.1). For stabilisation in 2100 with SRES A1B atmospheric composition, antarctic SMB would contribute 0.4 to 2.0 mm yr^{-1} of sea level fall (Table 10.7). Continental ice sheet models indicate that this would be offset by tens of percent by increased ice discharge (Section 10.6.4.2), but still give a negative contribution to sea level, of –0.8 m by 3000 in one simulation with antarctic warming of about 4.5°C (Huybrechts and De Wolde, 1999).

However, discharge could increase substantially if buttressing due to the major West Antarctic ice shelves were reduced (see Sections 4.6.3.3 and 10.6.4.2), and could outweigh the accumulation increase, leading to a net positive antarctic sea level contribution in the long term. If the Amundsen Sea sector were eventually deglaciated, it would add about 1.5 m to sea level, while the entire West Antarctic Ice Sheet (WAIS) would account for about 5 m (Vaughan, 2007). Contributions could also come in this manner from the limited marine-based portions of East Antarctica that discharge into large ice shelves.

Weakening or collapse of the ice shelves could be caused either by surface melting or by thinning due to basal melting. In equilibrium experiments with mixed-layer ocean models, the ratio of antarctic to global annual warming is 1.4 ± 0.3. Following reasoning in Section 10.6.4.2 and Appendix 10.A, it appears that mean summer temperatures over the major West Antarctic ice shelves are about as likely as not to pass the melting point if global warming exceeds 5°C, and disintegration might be initiated earlier by surface melting. Observational and modelling studies indicate that basal melt rates depend on water temperature near to the base, with a constant of proportionality of about 10 m yr^{-1} $°C^{-1}$ indicated for the Amundsen Sea ice shelves (Rignot and Jacobs, 2002; Shepherd et al., 2004) and 0.5 to 10 m yr^{-1} $°C^{-1}$ for the Amery ice shelf (Williams et al., 2002). If this order of magnitude applies to future changes, a warming of about 1°C under the major ice shelves would eliminate them within centuries. We are not able to relate this quantitatively to global warming with any confidence, because the issue has so far received little attention, and current models may be inadequate to treat it because of limited resolution and poorly understood processes. Nonetheless, it is reasonable to suppose that sustained global warming would eventually lead to warming in the seawater circulating beneath the ice shelves.

Because the available models do not include all relevant processes, there is much uncertainty and no consensus about what dynamical changes could occur in the Antarctic Ice Sheet (see, e.g., Vaughan and Spouge, 2002; Alley et al., 2005a). One line of argument is to consider an analogy with palaeoclimate (see Box 4.1). Palaeoclimatic evidence that sea level was 4 to 6 m above present during the last interglacial may not all be explained by reduction in the Greenland Ice Sheet, implying a contribution from the Antarctic Ice Sheet (see Section 6.4.3). On this basis, using the limited available evidence, sustained global warming of 2°C (Oppenheimer and Alley, 2005) above present-day temperatures has been suggested as a threshold beyond which there will be a commitment to a large sea level contribution from the WAIS. The maximum rates of sea level rise during previous glacial terminations were of the order of 10 mm yr^{-1} (Church et al., 2001). We can be confident that future accelerated discharge from WAIS will not exceed this size, which is roughly an order of magnitude increase in present-day WAIS discharge, since no observed recent acceleration has exceeded a factor of ten.

Another line of argument is that there is insufficient evidence that rates of dynamical discharge of this magnitude could be sustained over long periods. The WAIS is 20 times smaller than the LGM NH ice sheets that contributed most of the melt water during the last deglaciation at rates that can be explained by surface melting alone (Zweck and Huybrechts, 2005). In the study of Huybrechts and De Wolde (1999), the largest simulated rate of sea level rise from the Antarctic Ice Sheet over the next 1 kyr is 2.5 mm yr^{-1}. This is dominated by dynamical discharge associated with grounding line retreat. The model did not simulate ice streams, for which widespread acceleration would give larger rates. However, the maximum loss of ice possible from rapid discharge of existing ice streams is the volume in excess of flotation in the regions occupied by these ice streams (defined as regions of flow exceeding 100 m yr^{-1}; see Section 10.6.4.2). This volume (in both West and East Antarctica) is 230,000 km^3, equivalent to about 0.6 m of sea level, or about 1% of the mass of the Antarctic Ice Sheet, most of which does not flow in ice streams. Loss of ice affecting larger portions of the ice sheet could be sustained at rapid rates only if new ice streams developed in currently slow-moving ice. The possible extent and rate of such changes cannot presently be estimated, since there is only very limited understanding of controls on the development and variability of ice streams. In this argument, rapid discharge may be transient and the long-term sign of the antarctic contribution to sea level depends on whether increased accumulation is more important than large-scale retreat of the grounding line.

Quelle: IPCC AR4

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Simulated Antarctic precipitation and surface mass balance at the end of the twentieth and twenty-first centuries

G. Krinner, O. Magand, I. Simmonds, C. Genthon & J. -L. Dufresne

Climate Dynamics **28**, 215–230(2007) | Cite this article

The aim of this work is to assess potential future Antarctic surface mass balance changes, the underlying mechanisms, and the impact of these changes on global sea level. To this end, this paper presents simulations of the Antarctic climate for the end of the twentieth and twenty-first centuries. The simulations were carried out with a stretched-grid atmospheric general circulation model, allowing for high horizontal resolution (60 km) over Antarctica. It is found that the simulated present-day surface mass balance is skilful on continental scales. Errors on regional scales are moderate when observed sea surface conditions are used; more significant regional biases appear when sea surface conditions from a coupled model run are prescribed. The simulated Antarctic surface mass balance increases by 32 mm water equivalent per year in the next century, corresponding to a sea level decrease of 1.2 mm $year^{-1}$ by the end of the twenty-first century. This surface mass balance increase is largely due to precipitation changes, while changes in snow melt and turbulent latent surface fluxes are weak. The temperature increase leads to an increased moisture transport towards the interior of the continent because of the higher moisture holding capacity of warmer air, but changes in atmospheric dynamics, in particular off the Antarctic coast, regionally modulate this signal.

Quelle: Krinner et al., 2007

Springer Link

Evaluation of current and projected Antarctic precipitation in CMIP5 models

Cyril Palerme, Christophe Genthon, Chantal Claud, Jennifer E. Kay, Norman B. Wood & Tristan L'Ecuyer

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Antarctic snow accumulation is expected to increase in a warming climate (Gregory and Huybrechts 2006; Frieler et al. 2015), moderating the future contribution of the Antarctic ice sheet to sea level rise.

Between the periods 1986–2005 and 2080–2099, the CMIP5 models predict, on average, a precipitation increase from 5.5 % (scenario RCP2.6) to 24.5 % (scenario RCP8.5). These changes in Antarctic precipitation correspond to a negative contribution to sea level between −19 mm (scenario RCP2.6) and −71 mm (scenario RCP8.5) between 2006 and 2099.

Quelle: Palerme et al., 2017

Link: https://notrickszone.com/2025/06/16/new-study-antarctic-ice-sheet-melt-will-lead-to-widespread-cooling-sea-ice-expansion/

Übersetzt von Christian Freuer für das EIKE