EGU24-16331, updated on 15 Mar 2024
https://doi.org/10.5194/egusphere-egu24-16331
EGU General Assembly 2024

Deciphering the impact of future individual Antarctic freshwater sources on the Southern Ocean properties and ice shelf basal melting

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The Antarctic ice sheet is losing mass. This mass loss is primarily due to ice shelf basal melting and the subsequent acceleration of glaciers. The substantial freshwater fluxes resulting from ice shelf and iceberg melting affect the Southern Ocean and beyond. As emphasized by some studies, they slow down the decline of Antarctic sea ice and hinder mixing between surface water and Circumpolar Deep Waters, further intensifying ice shelf basal melting. In this context, most studies so far have neglected the impact of surface meltwater runoff , but recent CMIP6 projections using the SSP5-8.5 scenario challenge this view, suggesting runoff values in 2100 similar to current basal melt rates. This prompts a reassessment of surface meltwater future impact on the ocean. We use the ocean and sea-ice model NEMO-SI3 resolving the sub-shelf cavities of Antarctica and including an interactive iceberg module. We perform thorough sensitivity experiments to disentangle the effect of changes in the atmospheric forcing, increased ice shelf basal melting, surface freshwater runoff and iceberg calving flux by 2100 in a high-end scenario. Contrary to expectations, the atmosphere alone does not substantially warm ice shelf cavities compared to present temperatures. However, the introduction of additional freshwater sources amplifies warming, leading to escalated melt rates and establishing a positive feedback. The magnitude of this effect correlates with the quantity of released freshwater, with the most substantial impact originating from ice shelf basal melting. Moreover, larger surface freshwater runoff and iceberg calving flux contribute to further cavity warming, resulting in a noteworthy 10% increase in ice shelf basal melt rates. We also describe a potential tipping point for cold ice shelves, such as Filchner-Ronne, before the year 2100.