EGU24-894, updated on 19 May 2024
https://doi.org/10.5194/egusphere-egu24-894
EGU General Assembly 2024

On the atmospheric response to idealized freshwater input around Antarctica

Xiaoqi Xu[1], Torge Martin[2], and Rebecca Beadling[3]
[1]Institute of Atmospheric Physics, Chinese Academy of Sciences, State Key Laboratory of Numerical Modelling for Atmospheric Sciences and Geophysical Fluid Dynamics, China (xuxiaoqi@mail.iap.ac.cn)
[2]GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany (tomartin@geomar.de)
[3]Temple University, Earth and Environmental Science Department, Philadelphia, PA, USA (rebecca.beadling@temple.edu)

The enhanced mass loss from the Antarctic ice sheet (AIS) and ice shelves has recently gained greater attention. Most climate models lack an interactive ice sheet and meltwater runoff is prescribed instead. The implications of AIS meltwater are studied most often with a focus on ocean and sea ice. We show that the changing surface conditions trigger an atmospheric response as well with consequences extending into the stratosphere. The release of meltwater into the Southern Ocean has important impacts on the ocean temperature, stratification, currents, and sea ice properties. Remote atmosphere responses tied to a shift in the ITCZ were reported as well, such as changes in (sub-)tropical precipitation.However, patterns and magnitudes of the various responses remain uncertain due to varying ways of freshwater forcing input and model uncertainty. Thus, the Southern Ocean Freshwater Input from Antarctica (SOFIA) initiative has been formed to demonstrate the robustness and quantify the uncertainty of such responses. About a dozen modeling groups participate in running the same 100-year freshwater-release experiment (0.1 Sv distributed uniformly to the ocean surface along the Antarctic coast under preindustrial forcing) with a range of state-of-the-art climate models (Swart et al., 2023, GMD, accepted).

Using the SOFIA multi-model ensemble, we study the atmospheric response to the additional freshwater. First results are based on an 8-member ensemble using GEOMAR's Flexible Ocean and Climate Infrastructure (FOCI) model. Sea level pressure and surface air temperature over Antarctica and the Southern Ocean decline and westerly winds from 40°S to 60°S strengthen. Significant atmosphere cooling, with the maximum zonal-mean anomaly of up to 0.6^{o}C near the surface, extends to 300 hPa. This is accompanied by a weak but significant warming in the lower stratosphere, which is likely associated with a slight lowering of the tropopause or enhanced wave propagation. The zonal winds strengthen on the southern flank of the westerlies belt with a maximum at 300 hPa, the level of the jet stream core. A corresponding intensification of the Ferrell cell is found as well. The circulation changes are caused by near-surface cooling and buoyancy reduction at polar latitudes, enhancing the meridional temperature and pressure gradients. These responses have strong seasonal patterns with strongest tropospheric imprints in austral winter and a stratosphere response in late winter/spring---despite the prescribed freshwater release

being constant in time without seasonal cycle. We suggest that changing sea ice conditions play a key role in creating the seasonal response.

These first results have been confirmed by a parallel study using the GFDL climate model. We will expand our analysis to the SOFIA multi-model ensemble to further prove the robustness and estimate model uncertainty, which we will present in this session.