Project title: REDOCCA (REgional DOwnscaling of Climate Change in the Antarctic)
Project lead: Tido Semmler (AWI Bremerhaven)
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Report on achievements and results

In 2021, we finished the evaluation of the existing AWI-CM CMIP6 simulations from the DKRZ project DICA (DKRZ project identifier bk0988) in the Weddell Sea. The ocean resolution around Antarctica and in the Southern Ocean generally lies between 10 and 20 km. The mesh that was used for the AWI-CM CMIP6 simulations does not include ice shelf cavities. Nevertheless, current patterns and water masses in the southern Weddell Sea and on the continental shelf capture the main features of known hydrography and circulation.

The Filchner Trough on the continental shelf of the southern Weddell Sea is characterized by a seasonal influx of modified Warm Deep Water (mWDW) from the Weddell Gyre circulation. Observations show an increase in strength and duration of these mWDW pulses in recent years (e.g. Ryan et al. 2020). The historical simulation of CMIP6 reproduces the seasonal signal, as well as an increase in frequency (Phase I and Phase II until 2014 in Fig. 1). For future scenarios SSP3-7.0 and SSP5-8.5, the duration of the seasonal pulses increases to lasting multiple years. In these two scenarios, this leads to a tipping of the Filchner Trough into a warm state, where it is filled with mWDW instead of colder, denser shelf water.

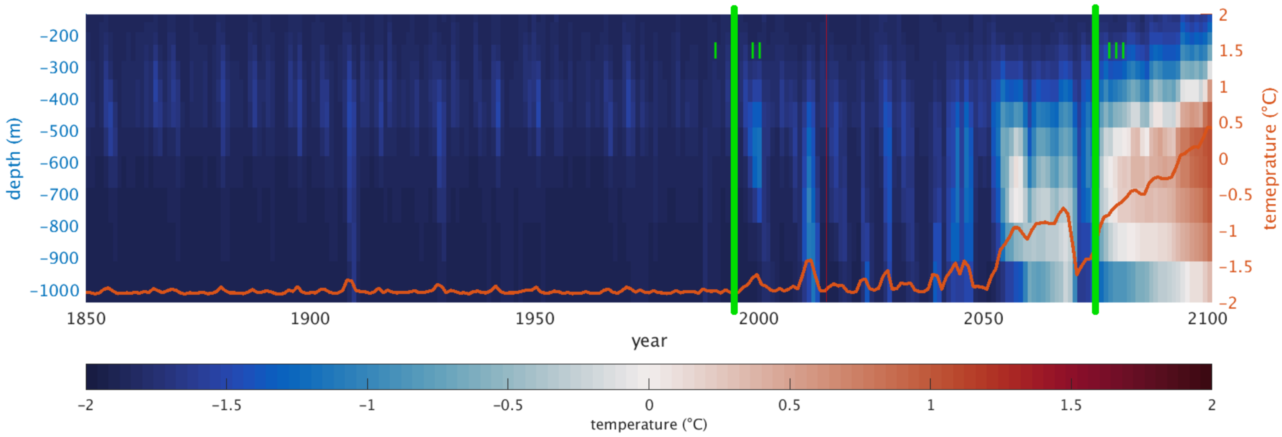

Fig. 1: Hovmöller plot of potential temperature in the Filchner Trough in the historical simulation hist1 (1850 – 2014) and climate scenario SSP5-8.5 (2015 – 2100).

The seasonal signal in the mWDW flux, caused by the seasonal cycle in sea ice formation on the continental shelf and variations in the depth of the thermocline, strongly weakens with the increased inflow of mWDW (Fig. 2). Starting from 2054, the seasonal signal in SSP5-8.5 nearly vanishes, only shortly reappearing between 2065 and 2075 during a phase of stronger sea ice formation in Filchner Trough. The mitigation scenario SSP1-2.6, which does not show tipping of the Filchner Trough into a warm state, also shows no systematic weakening of the seasonal signal of the mWDW flux. It remains to be seen how this warm intrusion on the shelf develops in the FESOM simulations (ocean component of the coupled AWI-CM) planned within this project with a changed geometry in which ice shelf cavities are included.

The computing time and work space in 2022 that we applied for has been used to prepare the atmospheric AWI-CM output and CCLM output so it can be used to drive the planned FESOM simulations, and to run a 20-year spin-up simulation with the created mesh, which now includes ice shelf cavities. The spin-up simulation is forced with the atmospheric AWI-CM output from the years 1980 to 1999 of the historical simulation.

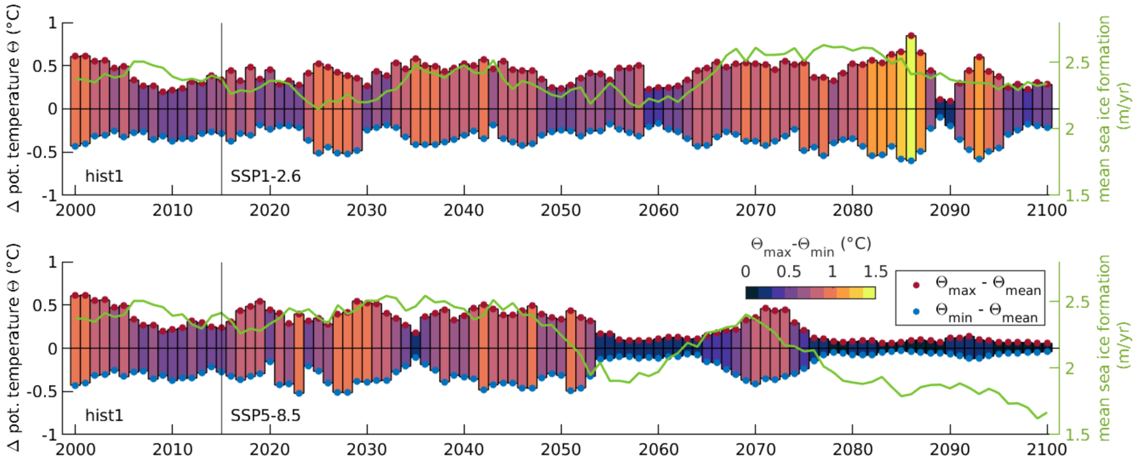

Fig. 2: Development of the seasonality of the yearly maximum temperature in the Filchner Trough in two climate scenarios. Red (blue) dots depict the difference between the temporal and spatial maximum (minimum) to the temporal mean of the spatial maximum along a transect through the trough. The bars illustrate the seasonal variation. The green line represents the sea ice formation in the Filchner Trough region.

Reference

Ryan, S., Hellmer, H. H., Janout, M., Darelius, E., Vignes, L., & Schröder, M. (2020). Exceptionally warm and prolonged flow of Warm Deep Water toward the Filchner-Ronne Ice Shelf in 2017. Geophysical Research Letters, 47, e2020GL088119. https://doi.org/10.1029/2020GL088119