Local processes determine global ocean climate

Ice sheet - ice shelf - ocean interaction in the marginal seas of the Southern Ocean

T. Kanzow, R. Timmermann, M. van Caspel, S. Ryan, L. Stulic, *University Bremen and Alfred-Wegener-Institut für Polar- und Meeresforschung*

Kurzgefasst

- ocean - sea ice - ice shelf - ice sheet interaction
- finite-element global ocean model
- marginal seas in the center of our research

Melting of glaciers, ice caps, and ice sheets contributes to changes in global sea level. Most of the Antarctic Ice Sheet drains into floating ice shelves which serve as buttresses to the ice flow. Ice shelf basal melting has been shown to be an important component in the southern hemisphere's ice mass budget and its variability. In order to explore mechanisms of ice-ocean interaction and the potential of substantial changes in ice shelf basal mass loss in a warmer climate, we use the global Finite Element Sea ice–ice shelf–Ocean Model FESOM (Timmermann et al., 2012) with a high resolution in the Antarctic marginal seas. Simulations are performed with prescribed cavity geometries and with a dynamic ice shelf as part of a coupled ocean–ice shelf–ice sheet model (Timmermann and Goeller, 2017). Next to the implications for the Antarctic ice sheet mass budget (which is relevant to global sea level), we are interested in the role of meltwater input for Southern Ocean hydrography and the formation and properties of Antarctic Bottom Water (AABW), one of the driving components of the ocean's global thermohaline circulation.

In the recent project phase, we have implemented and tested modules for tidal-induced mixing at the ocean bottom and the ice-shelf base and added a signature of tidal velocities to the friction velocity used in the computation of ice shelf–ocean heat and freshwater fluxes. Results indicated a strong sensitivity of local melt rates, but cavity hydrography (distribution of temperature and salinity and production of Ice Shelf Water) proved to be surprisingly robust. For a fully consistent study, however, it is necessary to run the tidal model as part of the ocean/ice shelf model, i.e. with a dynamic response to evolving cavity geometries. This is currently beyond our capabilities but is envisaged for the next phase of the project.

An important driver for shaping cavity hydrography is the distribution of sea ice net growth rates on the continental shelf off the ice shelf front. A calving event in 1986 released a giant tabular iceberg from Filchner Ice Shelf, and a large piece of this iceberg (A-23A) has remained grounded on the eastern slope of Berkner Bank. A mélange of sea ice and icebergs tends to fill in the area south of this iceberg, affecting ocean circulation and increasing sea ice concentration to the eastern (luv) / decreasing sea ice concentration on the western (lee) side of the ice tongue (Fig. 1, top left). We use MODIS ice-surface temperature data to get the best possible information about existence, location, and extent of the fast-ice bridge. In order to mimic the blocking of sea ice movement by the fast-ice bridge in the model, zero sea ice velocities were prescribed in these areas. Results were then compared to a reference run without data assimilation and thus no fast-ice bridge developing.

We find that position and shape of the fast-ice bridge in the sensitivity experiment affect interannual variability of polynya sea ice production, and increase sea ice production westward of the ice bridge and suppress it eastward of it (Figure 1, top right). Bottom salinity anomalies (Figure 1, bottom left) reveal a similar pattern with reduced salinities in the region covered by the fast ice bridge. Changed density gradients in the presence of the fast ice bridge affect the ocean circulation leading to decreased basal melt rates below the Filchner Ice Shelf (Figure 1, bottom right). Compared to MODIS-based estimates of sea ice net growth rates in various sectors of the southwestern Weddell Sea continental shelf, the simulation considering the fast ice bridge gives more realistic results. A paper reporting on these findings is currently being prepared.

We have used eddy-resolving simulations to assess the sensitivity of hydrography in the Filchner Trough to the properties of the slope current. Analysis has shown that an eddy-resolving grid improves the representation of the Antarctic Slope Front and the related westward flowing slope current / coastal current system considerably, with strong implications on the longterm behaviour of Weddell Gyre transport. We plan to utilize a further improved configuration of this model with an optimized set of parameters (see below) to investigate characteristics and dynamics of Weddell Gyre in- and outflow in strong conjunction with long-term observations obtained through CTD sections and moored instruments. First results based on observations indicate a surface-intensified inflow at the area of Greenwhich Meridian, and a bottom-intensified outflow near the Antarctic Penin-

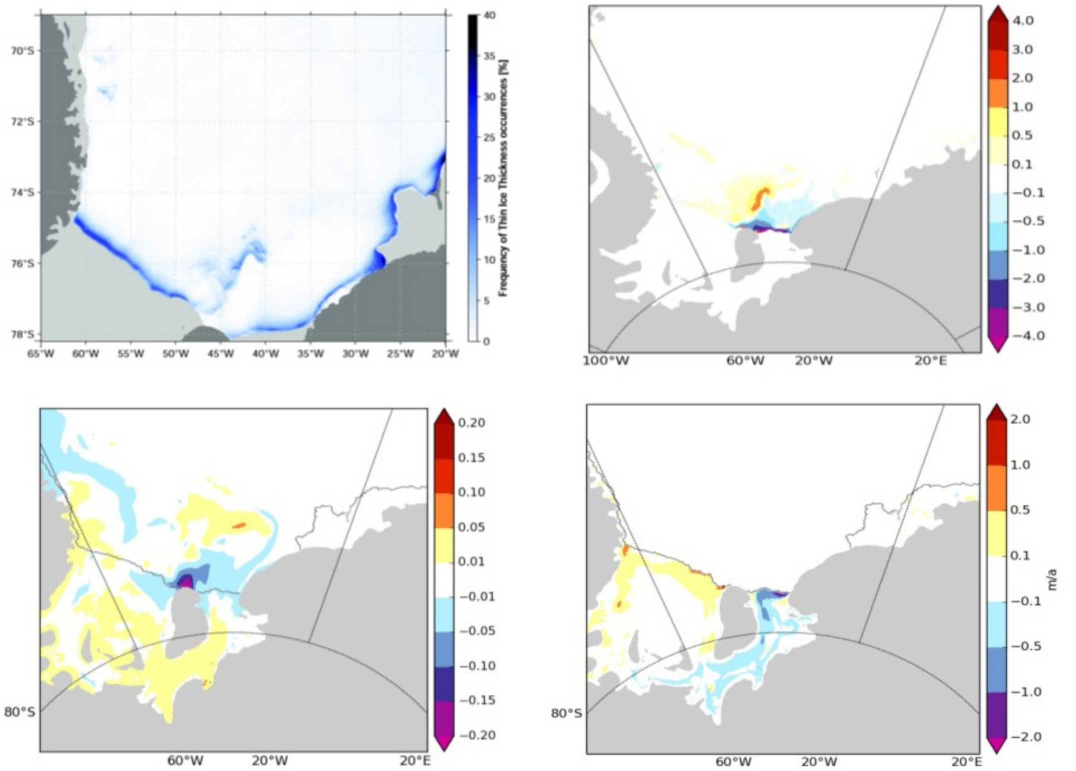

Figure 1: *Occurence of thin ice 2002-2014 derived from MODIS data (Paul et al., 2015; top left); and simulated differences in sea ice net growth rate (cm/day, top right), September 2002-2014 mean bottom salinity (bottom left), and 2002-2014 mean ice shelf basal melt rate (m/a). Differences are simulation "with ice tongue" minus reference run. Modified after Stulic et al. (in prep.)*

sula. Variability, seasonality and possible long-term trends will be assessed through model simulations.

Last but not least, sea ice production and associated High Salinity Shelf Water (HSSW) formation in the southern Weddell Sea are drivers of the global thermohaline circulation. Processes in coastal polynyas are essential here and therefore need to be represented in a realistic way. The main hypothesis for our new workpackage is that it is possible to achieve an improved representation of not only sea ice production but also hydrography and water mass modification in this polynya-active region by systematically optimizing sea ice model parameters. The Green's functions method provides an effective way to quantify model and data errors and to correct model biases by optimizing the model parameters. It involves the computation of sensitivity experiments to obtain a new set of parameters. Green's functions are then used to linearize the model, and an inverse method is employed to estimate uncertain parameters. Control parameters can be estimated by minimizing the cost function, which is a measure of the model-data misfit. As a first step, our optimization will focus on the values for ice/snow albedos, drag coefficients, ice strength parameter, lead closing parameter and sea ice salinity. Ocean model parameters will be included at a later stage.

WWW

`http://www.awi.de`

Weitere Informationen

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