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Interannual tidal signatures in iceshelf melt in a new NEMO-LIM3 configuration of the southwestern Weddell Gyre, its shelves and sub-iceshelf seas

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Realistic high-resolution simulations of the southwestern Weddell Gyre are prepared using a state-of-the art z-coordinate ocean model (NEMO). One of the novelties of the proposed configuration consists in the explicit resolution of the Weddell sub-iceshelf seas, including the cavity between the Filchner-Ronne iceshelf (FRIS), while also resolving the adjacent Weddell shelves and large parts of the open gyre, in presence of interannually varying atmospheric forcing and coupled to a dynamic thermodynamic sea ice model (LIM3), and moreover including tides. The new configuration is designed to enable exploration of the mechanisms of iceshelf basal melting, as well the latter's impact on the ocean's state in and beyond the cavities, thus of the communication between the open Weddell Gyre and its sub-iceshelf seas, and the roles played therein by water mass (trans-)formations on the Weddell shelves and the oceanic circulation including tides. First simulations are spun up from a 1/4 degree NEMO simulation, carried out at an isotropic horizontal resolution ranging from about 4.5 km at the northern boundary of the gyre, 4 to 2 km over the gyre's shelves, to less than 2 km in the FRIS cavity.

A reference experiment including tides shows a water mass population overall close to what is observed, in all, the open gyre, shelves and the FRIS cavity. Weddell iceshelf melting reveals large seasonal and year-to-year variability in response to the interannual variations in atmospheric forcing and eastern boundary inflow conditions.

Using a no-tide sensitivity experiment, tides are shown to enhance net iceshelf melting in the Weddell cavities but by less than a factor two. Locally tides enhance the intensity of both melting and refreezing where each occurs, which follows a pattern close to what is known observationally. Whereas refreezing is small under the shallow iceshelves, it reflects a quarter of the meltwater produced underneath FRIS, a fraction that enhances to more than a third in presence of tides, reflecting a tidally driven enhancement of the icepump, acting on top of the net increase of FRIS melting by about fifty percent.

The mechanisms of these tidally-driven signals in basal melt are shown to be mechanical, a response to enhanced kinetic energy in the surface boundary layer underneath the icedraft. Water mass changes in the cavity are revealed to be primarily a response to this mechanically driven enhancement of the melt/freeze pattern, and thereby to damp the tidally driven melt signals, which would be a factor 7-9 times greater in the absence of thermodynamic adjustments in the cavities, or equivalently in presence of an infinitely fast flushing timescale.