Geophysical Research Abstracts
Vol. 21, EGU2019-19117, 2019
EGU General Assembly 2019

Projecting future sea level rise by coupling models of the Antarctic Ice Sheet, Ice Shelves and the Southern Ocean

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The next assessment report of the IPCC requires reliable projections of future Antarctic ice loss in order to predict global and regional sea level rise under a warming climate. Antarctic ice loss is currently mitigated by the presence of extensive ice shelves, that buttress inland ice and limit its discharge. These shelves also represent the largest and most efficient thermodynamic interface between the ocean and the Antarctic Ice Sheet.

In the last decade model studies of ice sheets and oceans have independently refined the incorporation of relevant geophysical aspects of ice shelves. Many continental-scale ice sheet models parameterize basal melting based on exchange coefficients and simplified ocean temperature maps, and generally lack sophisticated melt/freeze algorithms. Conversely, ocean-ice shelf models compute advective diffusive heat and salt exchange at the ice base but generally don't account for evolving ice shelf and grounding line geometry.

Since small changes in ice shelf cavity geometry can cause significant alterations in ocean circulation and hence heat distribution patterns, a feedback process exists that is currently unresolved in ocean-ice shelf models. On the other hand, non-uniform melting of ice shelves can lead to ice flow instabilities and localized grounding-line retreat. To accurately capture future ice sheet responses to a changing climate, high resolution ice sheet models are therefore required that incorporate a robust depiction of the spatial pattern of ocean driven melt that can only arise from a coupled ocean simulation.

We present initial results from a circum-Antarctic coupled ice sheet - ocean model that includes evolving ice shelf cavities and grounding lines, as well as a dynamic/thermodynamic sea ice model (PISM, ROMS, CICE). Tuning the model by simulating past climate scenarios and constraining our parmeterizations to allow recent mass changes to be reproduced we aim to improve projections of Antarctic Ice Sheet dynamics and ocean behaviour over the current century. Our simulations will form a critical component of the New Zealand SeaRise project enabling regional downscaling for coastal impact assessment.