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Characterizing the Basal Melting Spatio-Temporal Variability of the Ross Ice Shelf using a Regional Ocean Model

Enrico Pochini[1,2], Florence Colleoni[2], Andrea Bergamasco[3], Manuel Bensi[2], Giorgio Budillon[4], Pasquale Castagno[4], Michael Dinniman[5], Pierpaolo Falco[6], Riccardo Farneti[7], Emanuele Forte[1], Vedrana Kovačević[2], and Stefanie Mack[8]
[1]University of Trieste, Trieste, Italy
[2]National Institute of Oceanography and Applied Geophysics, Trieste, Italy
[3]CNR Institute of Marine Sciences, Venice, Italy
[4]Parthenope University of Naples, Naples, Italy
[5]Old Dominion University, Center for Coastal Physical Oceanography, Norfolk, VA, United States
[6]Marche Polytechnic University, Ancona, Italy
[7]The Abdus Salam International Centre for Theoretical Physics, Trieste, Italy
[8]NERC British Antarctic Survey, Cambridge, United Kingdom,

The Ross Ice Shelf (RIS) is one of the biggest Antarctic ice shelves and buttresses ice streams draining both the West and East Antarctic ice sheets. Recent observations indicate that the melting of Antarctic ice-shelves is accelerating with great spatial heterogeneity. However, estimates of basal melting, which rely on indirect methods, are affected by large uncertainties: as for the RIS, the literature includes basal melt rates from 48 to 123 Gt/yr. To improve basal melting predictions we must understand what causes its spatio-temporal variability. Here, we use a regional configuration of the MIT general circulation model (MITgcm) to analyze the interactions between various water masses and the ice shelf, and their connection to local and global climate. The model simulates the ocean circulation in the Ross Sea and inside the RIS cavity from 1993 to 2018. In the actual configuration it does not account for tidal forcing. Basal melting of the RIS is parameterized by the three-equation formulation. The simulated RIS basal averaged melt rate is 78.6 ± 13.3 Gt/yr averaged over 1993-2018.

To better understand which local water mass causes basal melting, we developed a new methodology based on mixing ratios of endpoint-water masses. The endpoints are defined by: the High and Low Salinity Shelf Water (HSSW/LSSW), characterized by high and low salinity respectively and a near-freezing temperature; warm and salty modified Shelf Waters (mSW); warm and fresh Antarctic Surface Water (AASW); and cold and fresh Ice Shelf Water (ISW).

Our analyses show that in the long-term, HSSW causes ~45% of the total basal melting and is found mostly in the Western half of the RIS cavity. It shows a long-term trend due to the increase in the volume of cavity occupied by HSSW at the expense of LSSW. LSSW yields ~20% of the total basal melting and is mostly found in the Eastern half of the RIS cavity. As expected, melting due to mSW (~15% of the basal melting) and AASW (~7% of the basal melting) shows a strong seasonal

cycle. Simulated mSW mostly reaches the Central-Eastern RIS during summer. Similarly, AASW intrudes below the RIS near Ross Island exclusively in summer. Melting attributed to ISW is only ~2%. About 11% of the simulated basal melting cannot be clearly attributed to any of the main water masses due to local mixing.

Finally, RIS basal melting and Ross Sea water masses variability inside the cavity are likely driven by a combination of local forcing (katabatic wind), large-scale wind/pressure systems (Amundsen Sea Low, Southern Annular Mode) and teleconnections (El-Niño Southern Oscillation, Pacific Decadal Oscillation), mediated by ocean-sea ice interactions, in particular by sea ice production in Western Ross Sea polynyas, and sea ice import in the Eastern Ross Sea. Identifying such climatic connections can inform which melting mode will be more important in the future climate and which region of the RIS will be more affected.