Feedbacks Between the Labrador Sea Dynamics and Freshwater Runoff in the Regional Arctic System Model

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The oceanic forcing of a marine terminating glacier may rapidly destabilize the inland outlet glacier. In turn, the regional ocean circulation can be affected through coastal freshwater inputs. In order to realistically model ice sheet - ocean interactions, heat and buoyancy exchanges between a sub-ice cavity or fjord and the adjacent open ocean need to be accurately simulated. These exchanges and the ocean circulation are controlled by the overall climate state, synoptic atmospheric forcings, such as mesoscale storms, and air-sea interactions. Thus, large-scale coupled earth system models (ESMs), including atmosphere, ocean, sea/land ice, and other components of the climate system are required to better understand such feedbacks.

While there are still many challenges to modeling physical processes at the ice sheet – ocean interface, especially in narrow Greenland fjords, regional climate models exist and can be used to study the ocean circulation upstream of fjords and downstream of glacial origin runoff. In this study, we evaluate the skill of the Regional Arctic System Model (RASM) in simulating the hydrography and dynamics of the Labrador Sea due to varying magnitudes of land runoff, including the local source from the Greenland Ice Sheet.

RASM is a fully coupled regional ESM, however here we use a subset of RASM, where the ocean and sea ice components (Los Alamos Sea Ice – CICE and Parallel Ocean Program – POP, respectively) are active while the atmosphere (Weather and Research Forecasting – WRF) and land (Variable Infiltration Capacity – VIC) components are replaced with realistic atmospheric data from the Common Ocean Reference Experiment version 2 (CORE2) reanalysis for 1948-2009. POP/CICE models use the same grid configured at 1/12° in the horizontal and 45 levels in the vertical direction.

We analyze RASM's sensitivity to the surface salinity conditions by comparing two simulations, one using surface salinity restoring to monthly climatology and the other with monthly mean runoff fluxes from land prescribed from CORE2. We find that the run with prescribed freshwater fluxes yields more realistic simulation, including coastal currents, a stronger boundary current, and sharper shelf-basin density gradients. In addition, the sea ice extent in the Labrador Sea follows observations more closely, and the spatial distribution and temporal evolution of mixed layer depth are more accurate in this model run compared to the run with salinity restoring. Finally, eddy generation and distribution also differs between the two simulations, which we argue plays an important role in preconditioning or inhibiting deep-water formation in the region. On the other hand, we also find warmer and more salty water penetrating the west Greenland's continental shelf region and getting advected further north in the model run with realistic runoff forcing. Thus, our study shows that freshwater runoff plays an important role in the region, acts to communicate potential feedbacks between the ocean and marine terminating glaciers, and that such feedbacks need to be accounted for in ESMs.

Theme: Ice-ocean interaction *(Surfin' USA)*: everywhere else (*Promised Land)*