Pathways of freshwater from Greenland Ice Sheet and its impacts on sea ice and ocean

Kazuya Kusahara[1], Yoshiki Komuro[1], Fuyuki Saito[1] and Hiroaki Tatebe[1]
[1]*Japan Agency for Marine-Earth Science and Technology (JAMSTEC)*

As global warming progresses, significant changes in the cryospheres in both polar regions are emerging. In particular, changes in the Antarctic and Greenland ice sheets have become even more pronounced in recent years. The mass loss of these polar ice sheets directly contributes to sea-level rise and freshening of the polar oceans. Because the North Atlantic Ocean is the key region for the Atlantic Meridional Ocean Circulation, the changes in freshwater from Greenland are a vital science topic on a global scale, not just around Greenland.

Observations have shown that freshwater from the Greenland Ice Sheet (GrIS) has increased significantly after 1990. This increase in freshwater supply to the ocean can affect sea-ice and ocean circulation fields through ocean freshening. Recently, a newly developed freshwater dataset has been published by Bamber et al. (2018) that allows researchers to conduct more realistic and detailed numerical ocean modeling of the GrIS meltwater. In this study, we conduct numerical modeling to identify pathways of the GrIS meltwater and its impact on the sea-ice ocean fields.

This study used the ocean-sea ice model (COCO), which has been developed jointly by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) and the Atmosphere and Ocean Research Institute of the University of Tokyo (AORI). The model domain is global. The horizontal resolution is 0.25° degrees south of 63°N and the Arctic region is represented by a tri-polar grid. The coastal regions around Greenland are represented with a resolution of approximately 9–14 km. This resolution allows us to reproduce the Greenland coastline reasonably. The atmospheric surface boundary conditions to force the ocean-sea ice model were derived from ERA5, and the runoff data were calculated from river data from JRA55-do, whose freshwater flux from GrIS was taken from Bamber et al. (2018). We performed a 90-year spin-up integration by repeating 1981–2010 forcing three times to obtain quasi-steady ocean conditions in the Greenland coastal regions. Next, we performed virtual tracer experiments in which the surface flux equals the meltwater flux from the Greenland Ice Sheet to trace pathways of the GrIS meltwater. In this study, the Greenland coastal region was divided into six parts based on ice-sheet basins (Fig. 1), and six independent tracers were released in the tracer experiments.

The model is currently being run, and preliminary results are presented in this abstract. Figure 1 shows the sum of the six regional tracers at the surface layer after five years, which shows the distribution of the meltwater from GrIS. High concentration zones are identified not only in the area surrounding Greenland but also in Baffin Bay, Hadson Bay, and coastal regions along Labrador Current. Although the concentration is relatively small, the virtual tracer spreads over the North Atlantic Ocean. At the time of presentation, we plan to show the results of the tracer experiments with the integration period extended to about 30 years and present a more detailed analysis of the tracer distribution. For example, since we used six independent tracers for the GrIS freshwater, we can calculate the contribution of each tracer to the total meltwater. Furthermore, as a comparison experiment, we also plan to conduct an experiment in which the freshwater supply from Greenland is turned off, and we will discuss the impact of the meltwater on the adjacent sea-ice and ocean conditions.

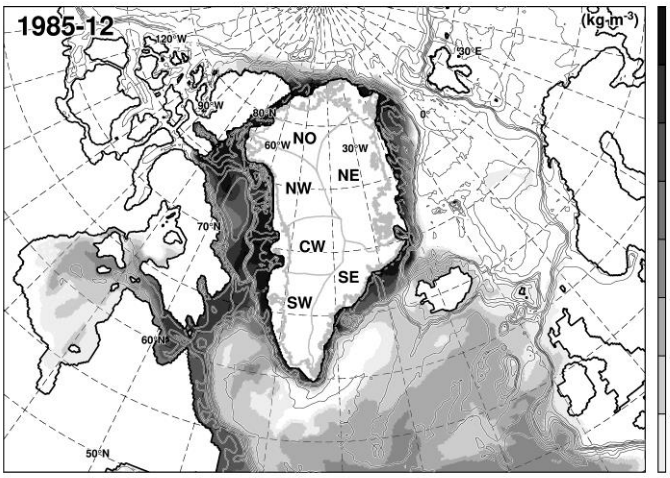

Figure 1: Horizontal distribution of the GrIS meltwater after five years. Labels of NO, NE, SE, SW, CW, and NW represents the ice-sheet basins divided with the gray lines on Greenland. The contours are scaled by log 2 (e.g., value of 1.0 indicating 2.0 kg m^{-3}).

References

Bamber, J. L., Tedstone, A. J., King, M. D., Howat, I. M., Enderlin, E. M., van den Broeke, M. R., et al. (2018). Land Ice Freshwater Budget of the Arctic and North Atlantic Oceans: 1. Data, Methods, and Results. *J. Geophys. Res. Ocean.* 123, 1827–1837. doi: 10.1002/2017JC013605.