グリーンランド氷床北西部 Bowdoin フィヨルドにおける氷河融解水流出過程のモデリング

大橋良彦 [1,2]、青木茂 [2]、松村義正 [2]、杉山慎 [2,3]、漢那直也 [3]、榊原大貴 [3]、深町康 [2,3]
[1] *北海道大学大学院環境科学院*
[2] *北海道大学低温科学研究所*
[3] *北海道大学北極域研究センター*

Modeling glacial meltwater runoff process in Bowdoin Fjord, northwestern Greenland

Yoshihiko Ohashi[1,2], Shigeru Aoki[2], Yoshimasa Matsumura[2], Shin Sugiyama[2,3], Naoya Kanna[3], Daiki Sakakibara[3] and Yasushi Fukamachi[2,3]
[1]*Graduate school of Environmental Science, Hokkaido University*
[2]*Institute of Low Temperature Science, Hokkaido University*
[3]*Arctic Research Center, Hokkaido University*

Meltwater runoff from the Greenland ice sheet to the ocean has increased in recent years (Hanna et al., 2008), affecting recent rapid mass loss of the ice sheet (van den Broeke et al., 2009). In addition to the influence on the ice sheet mass budget, meltwater runoff affects fjord circulation and submarine melting of glacier front by enhancing entrainment of ambient warm deep water (e.g. Xu et al., 2012; Straneo and Heimbach, 2013). Despite its importance in the understanding of ice mass loss and fjord circulation, little is known about the behavior of subglacial meltwater plume produced by meltwater runoff. To understand the impact of the subglacial meltwater discharge on water properties in fjord, we carried out field observations in Bowdoin Fjord, northwestern Greenland (77°41'N, 68°35'W), in August 2014 and July 2016. CTD and turbidity observations revealed the presence of a high turbidity layer caused by subglacial discharge at the depth of 20–40 m. Turbid meltwater diffusion observed in Bowdoin Fjord was analyzed by a numerical experiment. The experiment was carried out with a non-hydrostatic ocean model (kinaco; Matsumura and Hasumi, 2008) by changing the mass flux of meltwater runoff (Q_{sg} = 25–2000 m^3 s^{-1}). Bedrock topography is based on previous measurements along the central and transverse lines (Sugiyama et al., 2015) and the initial stratification is based on the results from the field observation in 2014. We assumed subglacial meltwater discharge (T = 0°C, S = 0, Virtualized tracer concentration = 1) from a tunnel-like channel (200 m wide × 50 m high) at the central depth of 210 m.

In the case of large mass flux of meltwater runoff (Q_{sg} = 2000 m^3 s^{-1}; Figure 1a), significantly high tracer concentration (> 0.05) was observed at the depth of 0–40 m within 15 km of the glacier front. On the other hand, in the case of small mass flux of meltwater runoff (Q_{sg} = 500 m^3 s^{-1}; Figure 1b), relatively high tracer concentration (~0.03) was observed only near the subsurface (20–40 m) within 10 km of the ice front. Vertical distribution of tracer concentration obtained with Q_{sg} = 500 m^3 s^{-1} was consistent with that of turbidity observed by the CTD. These results suggest that subglacial meltwater plume reaches the water surface only with a large mass flux of meltwater runoff (Q_{sg} = 2000 m^3 s^{-1}). We will compare the model results with in situ observations and present the details in the presentation.

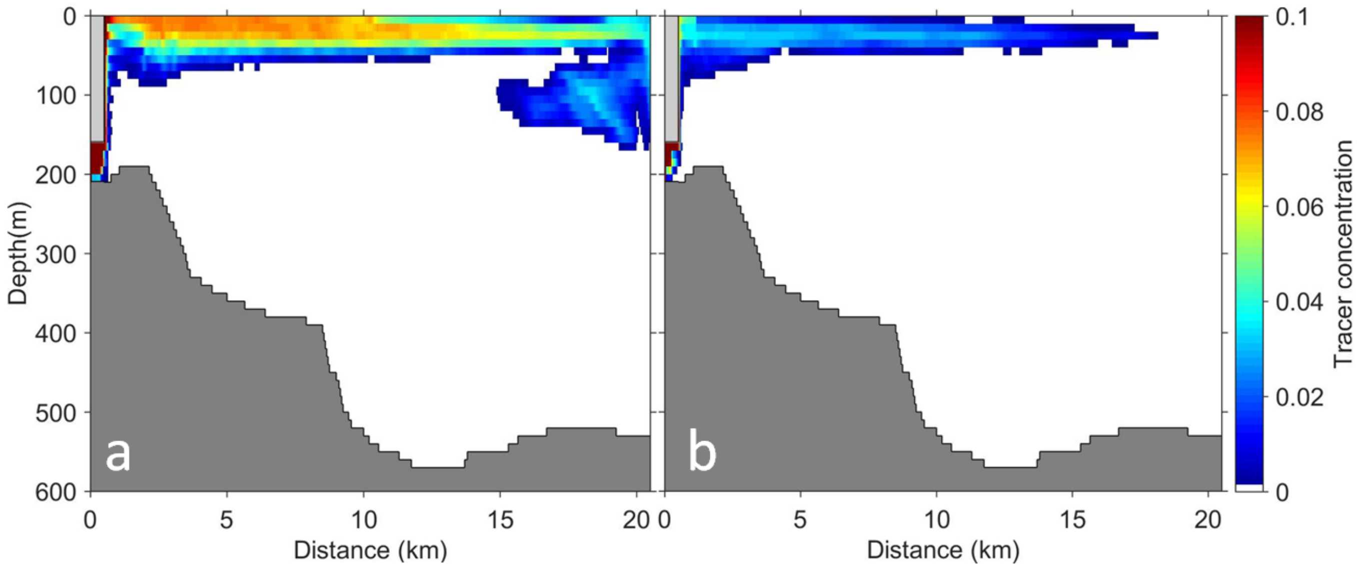

Figure 1. Vertical cross-section of tracer concentration along the centerline of fjord at t = 1 day ((a) Q_{sg} = 2000 m^3 s^{-1} and (b) Q_{sg} = 500 m^3 s^{-1}).

References

Hanna, E., P. Huybrechts, K. Steffen, J. Cappelen, R. Huff, C. Shuman, T. Irvine-Fynn, S. Wise, and M. Griffiths, Increased runoff from melt from the Greenland Ice Sheet: a response to global warming. Journal of Climate, 21 (2), 331–341, 2008.

van den Broeke, M., J. Bamber, J. Ettema, E. Rignot, E. Schrama, W.J. van de Berg, E. van Meijgaard, I. Velicogna, and B. Wouters, Partitioning recent Greenland mass loss. Science, 326 (5955), 984–986, 2009.

Xu, Y., E. Rignot, D. Menemenlis, and M. Koppes, Numerical experiments on subaqueous melting of Greenland tidewater glaciers in response to ocean warming and enhanced subglacial runoff, Annals of Glaciology, 53(60), 229–234, 2012.

Straneo, F. and P. Heimbach, North Atlantic warming and the retreat of Greenland’s outlet glaciers. Nature, 504, 36–43, 2013.

Matsumura, Y. and H. Hasumi, A non-hydrostatic ocean model with a scalable multigrid Poisson solver. Ocean Modeling, 24, 15-28, 2008.

Sugiyama, S., D. Sakakibara, S. Tsutaki, M. Maruyama, and T. Sawagaki, Glacier dynamics near the calving front of Bowdoin Glacier, northwestern Greenland. Journal of Glaciology, 61 (226), 223–232, 2015.