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The fast-ice growth and freezing of the bottom in the Braganzavagen Gulf (Van Mijenfjorden, Svalbard)

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The results of oceanographic and sea ice studies in the shallow Braganzavågen Gulf (Van Mijenfjorden, Svalbard) in March 2016 are presented. These studies are a continuation of observational efforts initiated by UNIS (Svalbard, Norway) in 2014. 2016 field campaign includes instrumental measurements of snow and ice properties in the fjord (e.g., ice thicknesses, temperatures, and salinities), as well as high-resolution CTD measurements within the under-ice water column.

Collected observations were accompanied by freezing simulations of adjacent water and bottom ground layers performed with a one-dimensional thermodynamic model (Bogorodskii and Pnyushkov, 2015). The model uses two methods to reproduce phase transition areas - a “classic” (frontal) method for the fast ice, and transition in the continuous media (mushy zone) for the bottom sediments. Meteorological observations during the winter 2015-16 at Sveagruva (northwest coast) were used in these simulations as the atmospheric forcing. Numerical experiments were carried out for the initial salinity of 35 psu and 2 m water depth. The simulations start with the beginning of water freezing determined by a steady air temperature transition through the freezing point. The start of freezing was also verified by comparison with sea ice charts available for the Van Mijenfjorden for the period of simulations.

Model simulations showed that the growth of sea ice in shallow (<1 m) areas of the basin significantly increases water salinity in the under-ice layer. For instance, at a 0.5 m depth the salinity in the under ice water layer exceeds $\sim$160 psu, which corresponds to the freezing temperature below –9 [U+F0B0] C. In fact, the water salinity does not reach high values because of the horizontal mixing. However, available hydrological observations showed relatively small (0.2-0.5 m) amplitudes of tides – the major contributor to the horizontal exchange in this area. These small amplitudes likely suggest small advective salt fluxes induced by tides, and thus their little effect on the rate of ice formation at seasonal time scales. As expected, substantial water cooling in the under-ice layer leads to freezing of the bottom ground, mostly evident in areas with small depths. For example, during the cold season this freezing may be as large as $\sim$1 m at a fjord part with typical depths of $\sim$0.5 m. In general, the model shows a relativity good agreement with direct observations of fast ice properties. However, due to uncertainty in the thermodynamic properties of the ground, the quantitative description of the heat transfer processes in this layer is still incomplete and required additional clarification in the specially targeted field experiments.