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Thermal evolutions of two kinds of melt pond with different salinity

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Melt ponds are water pools on sea ice. Their formation reduces ice surface albedo and alter surface energy balance, by which the ice melting and freezing processes are regulated. Thus, better understanding of their radiative characteristics has been vital to improve the simulation of melting/freezing of sea ice in numerical models. A melt pond would preserve nearly fresh water if it formed on multi-year ice and no flooding of sea water occurred, whereas a melt pond would contain more salty water if it formed on thinner and porous first-year ice, if there were an inflow of sea water by streams or cracks. One would expect that the fluid dynamic/thermodynamic properties (e.g., turbulence, stability, etc.) of pond water are influenced by the salinity, so that the response of pond water to any heat input (e.g., shortwave radiation) would be different. Therefore, better understanding of the salinity-dependent thermal evolution also has significant potential to improve the numerical simulation of the sea ice melting/freezing response to radiative thermal forcing.

To observe and understand the salinity-dependent thermal evolution, two ice mass balance buoys (IMBs) were deployed in two kinds (fresh and salty) of melt pond on a same ice floe on 13 August 2015 during Araon Arctic cruise. The thermistor chain, extending from the air through the pond and ice into the sea water, was deployed through a drilled borehole inside the pond. Besides, the IMBs were also accompanied with three broadband solar radiation sensors (two (up and down) in the air over melt pond and one upward-looking under sea ice) to measure the net shortwave radiation at the pond surface and the penetrating solar radiation through ice. Also, the web camera was installed to observe any updates in the conditions of equipment and surrounding environment (e.g., weather, surface state, etc.). On the date of deployment, the fresh pond had salinity of 2.3 psu, light blue color, lots of slush ice particles which increased opacity, and under-pond ice thickness of 219 cm, whereas the salty pond had salinity of 20 psu, dark blue color, only transparent water, and under-pond ice thickness of 100 cm.

Temporal evolutions of mean water temperature of the two ponds are contrasted and showed that the fresh pond had about 1degC warmer temperature than the salty pond. The existence of slush ice particles in the pond seems to be responsible for this temperature difference. Multiple scattering by slush ice particles could lead to more absorption of shortwave radiation. A comparison of vertical profiles of water temperature shows that there existed an internal maximum heating layer in the fresh pond. Possibly, this profile might indicate the the below layer unstable, which might have efficient thermal propagation to the ice surface. On the other hand, the vertical temperature profile of the salty pond had internal thermocline near the pond bottom, but so that the upper heating may not efficiently propagate downward to the ice surface.