Geophysical Research Abstracts
Vol. 18, EGU2016-15732, 2016
EGU General Assembly 2016

Solidification and convective instability during early sea ice growth

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Growing sea ice rejects large amounts of cold, salty water into the underlying ocean which contributes to the formation of Antarctic Bottom Water, North Atlantic Deep Water, and maintaining the cold halocline in the Arctic ocean. This cold, salty water is formed by the partial solidification of sea water to form porous sea ice, which is an example of a mushy layer. Convection within the porous ice interior drives the drainage of dense brine into the underlying ocean. We consider how realistic surface cooling and variations in physical properties affect the time-dependent development of early sea ice growth, and the impact on solidification and convective instability within the ice. Whilst many previous studies of mushy layers have focussed on growth at a steady rate, we here model geophysically-motivated settings where the growth rate evolves with time. We quantify how the onset of convection in sea ice depends on the initial salinity of the sea water and the rate of heat loss to the overlying atmosphere, and show that slower cooling rates can promote the formation of larger convection cells within the ice.