Geophysical Research Abstracts
Vol. 21, EGU2019-11250, 2019
EGU General Assembly 2019

Frazil ice growth and convection driven by double-diffusive supercooling in the Arctic ocean mixed layer

Andrew Wells (1), Margaret Lindeman (2), and Mary-Louise Timmermans (3)

(1) Dept of Physics, University of Oxford, Oxford, United Kingdom (andrew.wells@physics.ox.ac.uk), (2) Scripps Institution of Oceanography, UC San Diego, La Jolla, CA, USA , (3) Yale University, New Haven, CT, USA

Much of the sea ice growth in the polar oceans is driven directly by surface heat losses to the atmosphere. We here assess a mechanism for secondary ice growth controlled by double diffusive heat transfer in the ocean interior, generation of supercooling, and the nucleation of frazil ice crystals. Leads or openings in the ice pack are sites of rapid sea ice growth and intense brine rejection, forming cold salty water masses which can intrude beneath the comparatively fresh mixed layer below the neighbouring pack ice. Motivated by Ice-Tethered Profiler measurements from the Canada Basin, which show the persistence of such conditions, we develop a hierarchy of models of frazil ice growth in the ocean mixed layer due to double-diffusive supercooling. If thermal diffusion exceeds the diffusive transport of salt, there is a tendency for supercooling in a boundary layer near the base of the mixed layer. The supercooling is relieved by nucleation of frazil ice crystals which buoyantly rise and can precipitate onto the overlying sea ice cover. Two dynamical regimes are identified. Large ice crystals rise individually relative to the background fluid and into the ocean mixed layer. Alternatively, if many small ice crystals nucleate, then the buoyancy of a mixture of ice crystals and water drives convective instability of the boundary layer and rise of parcels of ice-laden fluid into the mixed layer. We use a linear stability analysis to show that the latter regime can allow convection in the mixed layer even when the underlying temperature and salinity gradients are statically stable. We then develop a one-dimensional mixed layer model to quantify the resulting ice crystal growth, accumulation of granular ice on the surface sea-ice cover, and evolution of mixed-layer temperature and salinity.