Geophysical Research Abstracts
Vol. 19, EGU2017-15115, 2017
EGU General Assembly 2017

A model of sea ice formation in leads and polynyas

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Cracks in the sea ice cover break the barrier between the ocean and atmosphere, exposing the ocean to the cold atmosphere during the winter. These cracks are known as leads within the continuous sea ice pack and polynyas near land or ice shelves. Sea ice formation starts with frazil ice crystals in supercooled waters, which grow and precipitate to the ocean surface to form grease ice, eventually consolidating into a layer of solid sea ice that grows downwards. In this study a numerical model is formulated to simulate the formation of sea ice in a lead or polynya from frazil ice to a layer of new sea ice.

Our simulations show the refreezing of a lead within 48 hours of its opening. Grease ice covers the lead typically within 3 - 10 hours and consolidates into sea ice within 15 - 30 hours. We use our model to simulate an observed polynya event in the Laptev Sea showing the vertical distribution of frazil ice and water supercooling. Sensitivity studies are used to investigate the dependence of ice growth on the ambient environment with the surface wind speed shown to be of greatest importance to lead exposure time and total ice growth. The size and distribution of frazil crystals and the time taken for the lead to freeze over is shown to be highly dependent upon the ambient forcing and lead geometry.