Flooding of Snow-Laden Sea Ice

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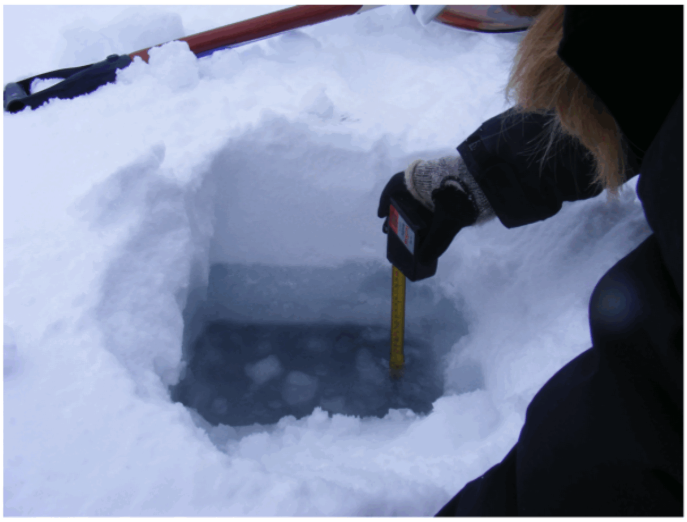

Figure 1: Flooded snow in the Antarctic. The snow above the water level contains a layer of wicked brine.

The upper layer of the polar oceans freeze to form a floating layer of sea ice. Sea ice forms a partial barrier to the transport of heat, moisture, and momentum between the ocean and atmosphere and plays an important role in both local and global climate. In contrast to the high Arctic, the Antarctic sea ice cover is thin and typically supports a relatively thick snow cover. When the snow load is sufficient to depress the ice surface below sea level, seawater and brine percolate up through the porous ice and flood the snow cover, where the resultant slush may refreeze to form snow ice, figure 1. The formation of snow ice results in thickening of the sea ice from above and a thinning of the snow cover, which can further enhance ice growth. Snow ice formation is believed to be pervasive throughout the Antarctic, and may be responsible for much of the thermodynamic thickening of the ice.

Phase change and fluid transport processes alter snow properties, affect nutrient dynamics within the ice and play a role in the buoyancy forcing of the ocean (Lytle and Ackley, 2001). The modified thickness and thermal properties of the snow and ice layers affect air-sea fluxes (Feltham et al., 2006) and provide a negative feedback for sea ice response to climate change. Our knowledge of the importance of snow ice formation is limited because: (a) we do not have an accurate knowledge of the prevalence of snow ice formation in the Southern Ocean, partly due to the effect of brine transport on the isotope signature of snow ice; and (b) our fundamental understanding of how the flooding takes place is limited (Maksym and Jeffries, 2000). This project addresses these uncertainties and will provide fundamental understanding necessary for the construction of physical models that can be included in sea ice and climate models.

This project will investigate the process of flooding and snow ice formation on snow-laden sea ice by means of carefully controlled laboratory experiments in the UCL cold room. The primary goals are:

1) To understand the dynamics and thermodynamics of seawater and brine percolation through sea ice and the role of sea ice microstructure in controlling the flooding process.
2) Investigate the evolution of the freezing flooded layer and its role in controlling snow and sea ice thermodynamics and microstructure.
3) Investigate the process of salt rejection from the freezing flooded layer and its role in buoyancy forcing of the upper ocean.

Experiments will involve the growth of artificial sea ice in insulated Perspex tanks in the UCL cold room. Artificial snow will be placed on the surface and the hydrostatic head will be controlled to force brine upward through the ice and flood the snow and freeze. Percolation processes will be investigated using a combination of dye and chemical tracers (possibly including stable isotope measurements), photography, and microstructural observations post experiment. Thermistor strings and conductivity probes frozen into the ice and snow will continuously monitor temperature and salinity, and hence the evolution of the local solid fraction, and the impact of percolation and freezing on the heat and mass budget of the floe. This process will be investigated for a variety of sample histories and ambient conditions to simulate the various conditions present in the field.

An existing numerical model (Maksym and Jeffries, 2000) capturing the essential processes of percolation and freezing will be improved based on the experimental results. The model will be used to understand and extrapolate the empirical results and investigate the role of flooding and snow ice formation in the heat and mass balance of Antarctic sea ice.

Student Prerequisites

A successful candidate will have a degree (2(i) minimum) in Geophysics, Physics, Earth Sciences, or a similar numerate subject involving the exploration of physical principles, along with an aptitude for experimentation, and mathematical modelling.

Training and support

The student will receive instruction in the physics of the heat and mass budget of snow-laden sea ice, guidance in the development of experimental apparatus, conduction of experiments and analysis of results, and guidance in the development of a numerical model. The student's PhD project is in the context of a coherent research effort at CPOM. UCL has a programme of courses promoting transferable skills such as time management, presentation, and report writing.

Application procedure

If you are interested in this PhD position, contact Dr. Feltham directly dlf@cpom.ucl.ac.uk. In order to apply for Departmental funding for this studentship, an application must be received no later than Monday 13 Feb 2012. If this deadline is missed, there may be other opportunities for funding. NERC funding is only available for UK students.

References

Feltham, DL, N Untersteiner, J S Wettlaufer, and M G Worster, Sea ice is a mushy layer, *Geophys. Res. Lett.*, 33, L14501, doi:10.1029/2006GL026290, 2006.

Lytle, VI, and SF Ackley, Snow ice growth: a freshwater flux inhibiting deep convection in the Weddell Sea, Antarctica, *Ann. Glaciol.*, 33, 45-50, 2001.

Maksym, T, and MO Jeffries, A one-dimensional percolation model of flooding and snow ice formation on Antarctic sea ice, *J. Geophys. Res.*, 105, 26313-26332, 2000.