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Sea ice dynamics: the role of friction

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Model simulations reveal the importance of sea ice dynamics to the climate system. Experiments with stand-alone models have shown that thermodynamic-only models are more sensitive to changes in thermal forcing than those that include dynamics, while modelling studies show that sea ice rheology has a leading order impact on predictions of the spatial pattern of sea ice thickness in the Arctic basin, ice drift and speed distributions and ice drift. So better models of sea ice dynamics with more realistic ice rheology are required to improve understanding of the inter-annual variability and discern the true climate signal. Here our focus is on sea ice friction because of its importance in floe-floe interactions, rafting and ridging.

Recent research into sea ice friction has focussed on ways to provide a model which maintains much of the clarity and simplicity of Amonton's law, yet also accounts for memory effects. Previously we have adopted the rate- and state- dependent models which are prevalent in rock friction. These are simple two parameter friction models which enable time-dependence to be introduced into dynamical models. In such models it is assumed that there is some fixed critical slip displacement, which is effectively a measure of the displacement over which memory effects might be considered important.

We have undertaken frictional sliding experiments on saline ice, both in large-scale experiments in the Hamburg environmental ice basin and at a small-scale in the laboratory. In both cases, instrumented ice blocks were slid against each under under normal load. Hold time and slip displacement were measured. In the ice basin experiments, the propagation of slip along the interface between blocks was also measured. We show experimentally that a fixed critical slip displacement is not a valid assumption in ice friction, whereas a constant critical slip time appears to hold across a range of parameters and scales. We discuss the implications that the critical slip displacement is not a fixed parameter in relation to modelling sea ice friction and scaling models from micro to macro behavoiour in Arctic Ocean dynamics.