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Anisotropic rheology of sea ice as a collection of diamond-shaped floes

A. V. Wilchinsky (1) and D. L. Feltham (1),(2)

(1) Centre for Polar Observation and Modelling, University College London, UK (aw@cpom.ucl.ac.uk), (2) British Antarctic Survey, Cambridge, UK

In polar oceans, seawater freezes to form a layer of sea ice of several metres thickness that can cover up to 8% of the Earth's surface.The modelled sea ice cover state is described by thickness and orientational distribution of interlocking, anisotropic diamond-shaped ice floes delineated by slip lines, as supported by observation. The purpose of this study is to develop a set of equations describing the mean-field sea ice stresses that result from interactions between the ice floes and the evolution of the ice floe orientation, which are simple enough to be incorporated into a climate model. The sea ice stress caused by a deformation of the ice cover is determined by employing an existing kinematic model of ice floe motion, which enables us to calculate the forces acting on the ice floes due to crushing into and sliding past each other, and then by averaging over all possible floe orientations.We describe the orientational floe distribution with a structure tensor and propose an evolution equation for this tensor that accounts for rigid body rotation of the floes, their apparent re-orientation due to new slip line formation, and change of shape of the floes due to freezing and melting. The form of the evolution equation proposed is motivated by laboratory observations of sea ice failure under controlled conditions. Finally, we present simulations of the evolution of sea ice stress and floe orientation for several imposed flow types.Although evidence to test the simulations against is lacking, the simulations seem physically reasonable.