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Modelling land-fast sea ice using a linear elastic model

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Land-fast ice is an important component of the Arctic system, capping the coastal Arctic waters for most of the year and exerting a large influence on ocean-atmosphere heat exchanges. Yet, the accurate representation of land-fast ice in most large-scale sea ice models remains a challenge, part due to the difficult (and sometimes non-physical) parametrisation of ice fracture. In this study, a linear elastic model is developed to investigate the internal stresses induced by the wind forcing on the land-fast ice, modelled as a 2D elastic plate. The model simulates ice fracture by the implementation of a damage coefficient which causes a local reduction in internal stress. This results in a cascade propagation of damage, simulating the ice fracture that determines the position of the land-fast ice edge.

The modelled land-fast ice cover is sensitive to the choice of failure criterion. The parametrised cohesion, tensile and compressive strength and the relationship with the land-fast ice stability is discussed. To estimate the large scale mechanical properties of land-fast ice, these results are compared to a set of land-fast ice break up events and ice bridge formations observed in the Siberian Arctic. These events are identified using brightness temperature imagery from the MODIS (Moderate Resolution Imaging Spectroradiometer) Terra and Aqua satellites, from which the position of the flaw lead is identifiable by the opening of polynyi adjacent to the land-fast ice edge. The shape of the land-fast ice before, during and after these events, along with the characteristic scale of the resulting ice floes, are compared to the model results to extrapolate the stress state that corresponds to these observations. The model setting that best reproduce the scale of the observed break up events is used to provide an estimation of the strength of the ice relative to the wind forcing. These results will then be used to investigate the relationship between the ice thickness and the ice strength, the timing of the land-fast ice stabilization, the formation of ice bridges and the seasonal break up.