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Using discrete element methods to understand in-plane fragmentation of sea ice floes

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Sea ice floe size can impact several processes that determine the evolution of the Arctic sea ice, including lateral melt volume, momentum exchange, and rheology. Floe size distribution (FSD) models are applied within continuum sea ice models to capture the evolution of the FSD through parameterisations of the processes that modify floe size such as lateral melting and wave break-up of floes. FSD models do not yet adequately resolve in-plane fragmentation processes of floes such as the breakup of floes under wind forcing, through interactions between neighbouring floes, or through thermal weakening. It is challenging to characterise and therefore parameterise these in-plane floe breakup processes due to limited availability of in-situ observations. Discrete element models (DEMs) offer an alternative way to understand the different mechanisms of floe fragmentation. By resolving relevant properties such as shear and normal stress and sea ice strength at the sub-floe scale, it is possible to use DEMs as a virtual laboratory and directly simulate the break-up of floes into smaller fragments.

In this study, we describe how in-situ observations of sea ice can be combined with output from sea ice DEMs to develop parameterisations of in-plane breakup of floes that can then be applied in continuum models. We then discuss the necessary model developments in order to apply a sea ice DEM to floe fragmentation at smaller scales. We will also present results from a series of DEM simulations used to model the fracture of sea ice under different forcing conditions and with varying sea ice states to identify the important sea ice parameters and processes in determining the size of the floes that form from in-plane breakup events.