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Modelling discrete failure regimes of anisotropic sea ice

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A rheological model of sea ice is presented that incorporates the orientational distribution of ice thickness in leads embedded in isotropic floe ice. Sea ice internal stress is determined by Coulombic, ridging and tensile failure at orientations where corresponding failure criteria are satisfied at minimum stresses. As sea ice traction increases in thinner leads, and cohesion is finite, such failure line angles are determined by the orientational distribution of sea ice thickness relative to the imposed stresses. In contrast to the isotropic case, sea ice thickness anisotropy results in these failure lines becoming dependent on the stress magnitude. While generally a given failure criteria type can be satisfied at many directions, we consider only two at most. The strain rate is determined by shearing along slip lines accompanied by dilatancy, and closing or opening across orientations affected by ridging or tensile failure. The rheology is illustrated by a yield curve determined by combining Coulombic and ridging failure for the case of two pairs of isotropically formed leads of different thicknesses rotated with regard to each other, which models two events of Coulombic failure followed by dilatancy and re-freezing. The yield curve consists of linear segments describing Coulombic and ridging yield as failure switches from one lead to another as the stress grows.