Asociación Argentina
de Mecánica Computacional

Mecánica Computacional Vol XXXVIII, págs. 21-21 (resumen)
H.G. Castro, J.L. Mroginski, R.R. Paz, M.A. Storti (Eds.)
Resistencia, 1-5 Noviembre 2021

MODELING FRACTURE IN ARCTIC SEA ICE

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Abstract. Sea ice regulates heat, moisture and salinity in the polar oceans. In the winter, sea-ice insulates relatively warm ocean water from the colder air, except where fractures allow heat and water vapor to escape from the ocean to the atmosphere. This exchange affects cloud cover and precipitation. Freezing of sea water exposed in fractures also causes brine to be ejected into the ocean. These factors impact worldwide ocean currents, weather patterns and ecosystems. An elastic-decohesive constitutive model for pack ice has been developed that explicitly accounts for fractures. The constitutive model is based on elasticity combined with a cohesive crack law that predicts the initiation, orientation and opening of fractures, and also has a simple closing/refreezing model. The model is constructed to transition from observed brittle failure under tension, to compressive brittle failure under moderate compression, and to a plastic-like faulting under large confinement, as observed in laboratory experiments. The various modes of failure occur in the model, depending on the stress state in the ice. Where the transitions occur in stress space depends on the material parameters and can be adjusted based on empirical data. This model is implemented in the material-point method (MPM), which is based on a Lagrangian set of material points with associated mass, position, velocity, stress, and other material parameters, and a background mesh where the momentum equation is solved. This method avoids the convection errors associated with fully Eulerian methods as well as the mesh entanglement that can occur with fully Lagrangian methods under large deformations. Example calculations using the elastic-decohesive constitutive model are performed for the Arctic, where predictions can be validated against satellite observations.