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A continuum anisotropic model of sea-ice dynamics

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Abstract

We develop the essential ingredients of a new, continuum and anisotropic model of sea-ice dynamics designed for eventual use in climate simulation. These ingredients are a constitutive law for sea-ice stress, relating stress to the material properties of sea ice and to internal variables describing the sea-ice state, and equations describing the evolution of these variables. The sea-ice cover is treated as a densely flawed two-dimensional continuum consisting of a uniform field of thick ice that is uniformly permeated with narrow linear regions of thinner ice called leads. Lead orientation, thickness and width distributions are described by second-rank tensor internal variables: the structure, thickness and width tensors, whose dynamics are governed by corresponding evolution equations accounting for processes such as new lead generation and rotation as the ice cover deforms. These evolution equations contain contractions of higher-order tensor expressions that require closures. We develop a sea-ice stress constitutive law that relates sea-ice stress to the structure tensor, thickness tensor and strain rate. For the special case of empty leads (containing no ice), linear closures are adopted and we present calculations for simple shear, convergence and divergence.

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Keywords

Anisotropic, Flawed continuum, Plastic, Rheology, Sea ice