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Discussion

On Modeling the Energetics of the Ridging Process[1]

R. S. Pritchard.[2] Hopkins and Hibler (1991) described ridge formation using a particle simulation model. They found that energy dissipation by inelastic contact and frictional sliding exceed changes in potential energy by a factor of 2 to 3 times. This result was compared with the energy dissipated in the AIDJEX model (Rothrock, 1975), where dissipation by frictional sliding was found to be about the same as changes in potential energy. In addition to large-scale modeling references cited by the authors, other modeling studies have addressed the energetics of ridging. Specifically, the AIDJEX model was modified and extended to describe large-scale strength (which is equivalent to describing energy dissipation in these models) more accurately. The purpose of this brief note is to point out that continuum models that reproduce the strength necessary to describe observed ice behavior have existed for some time.

Post-AIDJEX Model Development. The first simulations using the AIDJEX model showed that model strength of the order of 10^3 N/m was too low (e.g., Coon et al., 1976; Coon, 1980). Later simulations assumed perfect plasticity, confirming that strengths of the order of 10^5 N/m are needed to approximate observed ice motions in the Beaufort and Chukchi Seas (e.g., Pritchard, 1977; Pritchard et al., 1979). Subsequently, the AIDJEX model was modified (Pritchard, 1981) by changing parameter values to increase strength, and extended by introducing a shear ridging energy sink. This new model retained the physical basis of the AIDJEX model, strength increased to order 10^5 N/m for typical winter ice conditions, and energy dissipated by frictional sliding increased to about 5 times the potential energy change. The additional energy sink relaxed a constraint between the yield surface and opening coefficient, allowed nonzero unconfined compressive strength to be introduced, and reduced weakening during shearing deformations. Kollé and Pritchard (1983) found the model simulated observed ice motions to within 3 km/day. This model was later used by Pritchard, et al. (1990) to forecast Bering Sea ice behavior accurately. Recently, Pritchard (1991) described this model with a new yield surface, and recommended that it be used to study low-frequency, under-ice ambient noise.

These independent studies are confirmed by the results of Hopkins and Hibler (1991), and in turn confirm that their assumptions are reasonable. That similar results have been obtained by the extended-AIDJEX model, by parametric model studies, and now by the particle simulation model suggests strongly that we are indeed making progress in understanding sea ice behavior. We can now have reasonable confidence that both the continuum model and the particle simulation model can describe ice behavior accurately in a wide range of conditions.

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[1]By M. A. Hopkins and W. D. Hibler III, published in the 1991 issue of JOURNAL OF OFFSHORE MECHANICS AND ARCTIC ENGINEERING, Vol. 113, pp. 105–108.

[2]IceCasting, Inc., Seattle, WA 98125-5846

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Author's Closure

The work by Hopkins and Hibler (1991a), cited by Dr. Pritchard, discusses results of an early numerical model of ridging of a rubble-filled lead using disk-shaped rubble. A similar, more recent ridging model (Hopkins et al., 1991b) using polygon-shaped rubble predicts ratios of dissipation to change of potential energy of 3:1 to 4:1, depending on friction.

Preliminary studies (Hopkins and Hibler, 1991c) of ridging of an intact ice sheet yield values of 7:1 to 14:1, depending on the amount of ridged ice.

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