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Sea Ice Ridge Modelling: A Comparison of Approaches in a Continuum Model for the Arctic

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Sea ice grows thermodynamically until heat flux from, and conductive heat loss to, the ocean are balanced. In the Arctic this equilibrium thickness reaches 2-3 m. Thicker ice and especially morphological features are the product of dynamic deformation. About 70% of the Arctic sea ice volume evolves from deformation processes. These need to be represented in a dynamical sea ice model in order to cover dynamical growth and lead opening. Due to convergent and shear drift ice floes collide and raft on top of each other or pile up in broken blocks, so-called ridges.

Here two different ways to incorporate ridge build up and development of a deformed ice class into a numerical sea ice model for the Arctic are compared. The simulations are based on a dynamic thermodynamic model with a rotated, regular grid of 1/4 degree horizontal resolution and a six hour time step. First, a redistribution term in the balance equations of two ice classes, level and ridged ice, is used. The redistribution function relies on the internal forces being calculated from components of the strain rate tensor. Then ridge density and height are derived as diagnostic variables with the help of a geometric ridge cross-section model. The second method introduces ridge density and height as prognostic variables, which finally also results in the development of two ice classes. Parameters needed for the geometric ridge model and for statistical distribution models are derived from surface profiles of helicopter-borne laser measurements undertaken on expeditions to the Arctic between 1995 and 2004.

The advantage of the first method is a reliable redistribution of ice volume from level to ridged ice class depending only on physical relations. Ridge parameters are then calculated from statistical assumptions based on parameterisations. However, the second method allows a fairly free development of ridge density and height although

source terms also depend on given parameters. In this case level ice volume is used up by deformation and is redistributed to a ridged ice class. The development of the deformed ice class and ridging parameters within one winter season are shown, comparing results of both methods. The differences will be presented considering special situations, like a low pressure system in the wind forcing field, as example.