Abstract View

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A Model for the Influence of Wind and Oceanic Currents on the Size of a Steady-State Latent Heat Coastal Polynya

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ABSTRACT

This paper presents a model for determining the size and shape of a steady-state latent heat coastal polynya in terms of the following free parameters: 1) the frazil ice production rate (*F*); 2) the wind stress ($\boldsymbol{\tau}$); 3) the surface ocean velocity field (**u**); 4) the offshore consolidated thin ice transport (**T**); 5) the coastline shape; and 6) the intersection of the polynya ice edge with the coastline, all of which must be prescribed. Frazil ice trajectories are determined via the free-drift ice momentum balance. Analytical solutions for the polynya shape are derived for a straight coastline in the special case when **u**, **T**, and $\boldsymbol{\tau}$ are uniform in the alongshore direction and the rotation of the earth is neglected. When the latter constraint is relaxed, an expression for the asymptotic uniform polynya width is obtained. An expression for the alongshore adjustment length scale of the polynya associated with alongshore variations in the coastline shape, **u**, **T**, and $\boldsymbol{\tau}$ is derived, with rotation of the earth included. By considering a wedge-shaped ocean domain in which the ocean velocity is nondivergent and irrotational it is demonstrated that (i) a polynya solution does not always exist and (ii) a point (*S*, say) can exist where the frazil ice and thin ice transports are equal. When *S* exists, all possible polynya ice edge curves will pass through this point. The model is applied to simulate the wind-driven polynya that sometimes forms off the northern Greenland coast during winter and early spring between the Henrik Krøyer Islands and the Ob Bank. Because of fundamental couplings between the free parameters listed above, one should be cautious in drawing inferences on the physical behavior of the polynya. However, the model is useful in revealing the sensitivity of the polynya to variations in the prescribed forcing fields.

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