and compactness. The thickness and compactness, in turn, evolve according to continuity equations which include thermodynamic source and sink terms. The simulations with the rigid-plastic law reproduce reasonable geographical ice-thickness variations, ice outflow, and ice-velocity characteristics. The viscous simulations (especially the Newtonian viscous case) produce less satisfactory geographical ice thickness variations, and near-shore velocity characteristics. In addition the Newtonian-viscous simulation produces highly unrealistic ice-edge effects in summer. The results are discussed in terms of the relative magnitudes of the shear and compressive strengths, and in terms of the non-linear versus linear dependence on deformation in the ice rheology. The portion of this study employing a plastic constitutive law is published in full in *Journal of Physical Oceanography*, Vol. 9, No. 4, 1979, p. 815–46.

DISCUSSION

W. F. Budd: How well have you simulated the ocean heat and salt exchanges under the ice and in the basin as a whole?

W. D. Hibler III: These effects are crudely incorporated by using ice growth-rates dependent on ice thickness and season. The growth-rates in turn were largely based on Maykut and Untersteiner's calculations where these exchanges were parameterized by a constant upward oceanic heat flux. Clearly improvements in the treatment of such oceanic effects are needed.

V. R. Neralla: What is the grid distribution used for your numerical simulation? I wonder how your model responds if one applies it to real-time, short-range, small-scale prediction problems?

Hibler: The grid size used in the simulation was 125 km. I have not applied it to smaller time and space scale problems. However, the comparisons done here between linear-viscous, Newtonian-viscous, and plastic rheologies, strongly suggest that the non-linear plastic rheology is substantially better; a statement that I expect will also hold up on finer scales. Moreover, using my numerical scheme, the momentum balance with a non-linear rheology can be solved almost as simply and efficiently as with a linear-viscous rheology.

R. S. Pritchard: What unconfined compressive strength causes arching across the Greenland Strait under typical loads?

Hibler: The reduction of outflow in the Greenland–Spitsbergen passage is not a question of arching, but simply a reduction of flow due to using a rheology which allows higher shear stresses to develop. For the plastic case, doubling the shear strength (i.e. the deviatoric stress allowable for pure shearing deformation) reduces the outflow by 30%. You might get at the problem analytically by assuming a typical outflow velocity field and then plotting the stress state.

PREDICTING THE MOTIONS OF DRIFTING OPEN PACK ICE

By Uri Feldman

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Abstract. Methods based on remotely-sensed data are needed to predict motions of drifting open pack ice and to determine sea-ice parameters associated with these motions. The method presented here is able:

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(a) to predict the motions of groups of wind-driven detached ice floes over periods of 12, 36, and 60 h;

(b) to determine sea-ice thickness and the surface and sub-surface drag coefficients associated with these motions.

Wind stress, water drag, and Coriolis force were assumed to be at equilibrium for a drifting group. Surface wind speed and ice motion velocity were obtained from three-day sequences of surface weather charts and Landsat-1 MSS images. The angle of sea-ice deflection, the cross-isobar angle, sea-ice thickness, and the surface and sub-surface drag coefficients were determined by solving the equilibrium equation of motion. Weather data from a fourth day were used to predict the motions for this day.

If used in conjunction with data from microwave sensing systems, these predictions and parameters could be applied to support marine traffic and exploration of natural resources in the Polar Oceans. Sea-ice parameters, which were formerly practically unavailable, can now be derived by the method.

DISCUSSION

O. H. Løken: To what extent are the results of your study being used in the preparation of operational ice forecasts for the Beaufort Sea?

U. Feldman: This method is not yet operational because the MSS images of Landsat-1 provide useful data only if the images are cloud free. The method may be applied in the future with remotely-sensed data from microwave systems.

J. B. Mercer: How many tests of your method have you made? You mentioned two in your talk. What is the success rate?

Feldman: Out of approximately 3 000 Landsat-1 MSS images recorded during the period 1972–76 over the study area, 35 images, belonging to 6 cycles, were found suitable for analysis. From the 6 cycles tested 4 were successful.

SURGING GLACIERS—THE DILEMMA CONTINUES

By M. F. Meier

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Abstract. A glacier surge, according to most definitions, is a short-lived phase of unusually rapid glacier flow, after which the glacier returns to more normal behavior, with the surge–non-surge phases recurring on a regular or periodic basis. Recent interest is largely directed toward analyzing the effect of water at the bed on the periodic change in flow regime and on the rapid flow during a surge phase. For instance, study of a local depression of basal shear stress that depends on a "friction lubrication factor" which becomes important as the ice velocity increases, is one promising phenomenological approach. An important physical approach focuses on a water "collection zone" that occurs where and when the longitudinal pressure gradient in the subglacial water film approaches zero. The data necessary for properly verifying these and other similar theories do not yet exist. Computer modeling of rapidly-surging glaciers based on a "friction lubrication factor" has been quite successful in duplicating their major features. Once rapid movement (10^2–10^3 m a^{-1}) has begun, sufficient water is generated at the bed, from ice melted by heat dissipated in sliding, to produce some

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