

former method is converted to the form of a frequency operator for comparison with the latter. Because the magnitudes of $2G$ and T depend on the wavelength of the averaging scale, it is argued that for our case the digital low-pass filter is more appropriate. This method has the additional advantage that high-frequency noise in the data, predominantly a result of measurement errors, is more effectively removed.

Both operators are applied to the data to test the ability of $2G$ to correct τ_g for averages of $\frac{1}{4}$, 1, 2, 4, and 10 km. The average depth of the glacier is 270 m, and T is neglected in all cases. Remnant high frequency in the data arithmetically averaged interferes with any attempt to judge the effectiveness of $2G$ as a correction. For no averaging length does the correction seem to be effective, although an averaging scale of 4 km appears to be the least poor. Comparison is easier with the frequency-filtered data. The agreement is best for the 4 km filter, where $2G$ accounts for a large fraction of the difference between τ_b and τ_g over most of the filtered region. However, for large-scale filters, most data are only partially filtered. For the 4 km filter, these edge effects eliminate 75% of the data field.

The conclusion is that in this analysis, $2G$ does not provide an effective means of improving the calculation of base shear stress on Variegated Glacier. This contrasts with the agreement found by Budd (1970) using Wilkes Ice Cap data. Possible explanations of this discrepancy include: errors in the field data or the shape factor may be too large to permit meaningful evaluation of a small correction term; T may be significant over some regions of this glacier; the relation used to evaluate $2G$ may be inappropriate for this valley glacier.

REFERENCE

- Budd, W. F. 1970. The longitudinal stress and strain-rate gradients in ice masses. *Journal of Glaciology*, Vol. 9, No. 55, p. 19-27.

DISCUSSION

W. F. BUDD: Can you use your results to calculate an effective "viscosity" parameter for longitudinal stress?

R. A. BINDSCHADLER: Yes, I foresee no difficulty.

TESTING NUMERICAL MODELS OF GLACIER FLOW

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ABSTRACT. The recent glaciological literature contains a number of numerical simulations of ice-mass flow based on the mass conservation equation. Although rather complex ice masses have been modelled, there has been little discussion of the necessary tests for correct response time and amplitudes in the models. The analytical work of J. F. Nye (1960, 1963[a], 1963[b], 1965[a], 1965[b]) on the response of a steady-state glacier to perturbations in its mass balance provides an excellent test of model dynamics. Only when properly verified can the numerical model be used to extend knowledge of glacier response to more general cases where analytical solutions are unavailable. The model in this paper is checked against Nye's calculations of response to a step increase in mass balance. It is then used to extend Nye's results by finding the time constants for diffusion parameters other than 0 and 1.

REFERENCES

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DISCUSSION

W. D. HIBLER III: Would it be possible to use a complete explicit scheme rather than iterating, or is this too slow?

E. D. WADDINGTON: A forward time-differencing scheme with no iteration for the velocity would require small time steps and could still be subject to numerical instability. Time steps in the model in this paper can be an order of magnitude larger than in such a scheme, while using only two or three iterations. I have not investigated the use of an (explicit) leap-frog scheme.

W. F. BUDD: Nye's flux equations are based on a flow law of the form of the flow law of ice and a sliding law of the Weertman type. The problem is that when applied to different glaciers, different values of the parameters are found for best fit. Another approach is to use flow and sliding relations which give better fit to real glaciers, in which case the comparison with the Nye equations may be inappropriate. For example, have you considered how to handle double-valued sliding relationships?

WADDINGTON: Examination of double-valued sliding relationships is certainly a problem worth doing. I have been using the Nye equations strictly as a quantitative test of the numerical aspects of the model.

WAVE OGIVES AS SECOND-ORDER EFFECTS IN THE CREEP OF LARGE ICE MASSES

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ABSTRACT. This paper presents a mathematical analysis of the steady-state motion of a large ice mass. The purpose of the study is to determine the parameters which govern the motion of the ice and to establish the relationships between these parameters and the observable features of the motion. The study considers both land-based glaciers and floating ice shelves as different cases of the same problem. The particular features of the motion which are considered in this study are the surface waves or ogives which appear on both glaciers and ice shelves.

Previous studies have obtained useful information on the behaviour of the glacier by assuming very simple distributions of the stress and strain in the ice, but these analyses cannot account for some of the interesting surface features. In the present paper it is shown that a