

AREAL AND TEMPORAL VARIATION OF PERCOLATION OF WATER THROUGH A SNOW-PACK

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ABSTRACT. Snow melt water that is uniformly generated over the upper surface of the snow-pack does not percolate homogeneously through the snow. Consequently, the rate of arrival of melt water at a single collector at the lower surface does not give a true measure of the melt rate. The experiment described here measures the spatial variability of flow rate and the temporal variation of this two-dimensional pattern. Data are collected from an array of 64 sensors under control of a microprocessor. The microprocessor checks the consistency of the data, calculates the flow rate for each sensor and transfers the results to a recorder. These mean flow rates are calculated at regular intervals for the duration of the experiment. In this way the temporal and spatial variations of flow rate may be related to variations in meteorological conditions and the evolution of the structure snow-pack as the melting progresses.

DISCUSSION

S. C. COLBECK: The placing of collectors in a snow-pack may result in their being frozen even if the snow-pack is isothermal. Location of collectors at the ground surface would seem even more risky. When you record a different flow from different collectors how will you be able to separate the variations due to true spatial variations and those which are the result of different amounts of freezing in different collectors?

E. J. LANGHAM: There is some heat generated from the electrical circuits of the order of 1–2 W and I do not consider the freezing problem a serious one.

R. LIST: The collector funnel size of 8 cm × 8 cm appears rather small as compared to the height of the snow cover. Have you any comments?

LANGHAM: The funnel size that was chosen is compatible with the snow-pack size.

P. M. B. FÖHN: I wonder what kind of parallel measurements could be made related to free-water content and water input. I think that the water outflow can be measured with a large-size lysimeter quite accurately. I think the major problems are still those concerned with the flow of water in the pack.

THE SHORT-RANGE FORECASTING OF DISCHARGE FROM A GLACIATED REGION AND ITS USE FOR OPTIMIZING THE GRANDE DIXENCE S.A. PUMPING PLANTS

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ABSTRACT. The economical operation of the Grande Dixence S.A. pumping plants involves an optimal utilization of the electrical energy for pumping the discharges of five glacierized basins. For each basin, a short-range forecasting model (3 d) has been implemented in order to determine, at any time, the future evolution of the hourly discharge curve. The

forecasting model is based on multiple regressions and involves following variables: discharge, air temperature, global radiation, precipitation and the altitude of the snow-cover limit. The selection of the variables not only depends on the physical laws of the melting of glaciers but also on the possibilities of measuring them accurately. The melt-water run-off is not a stationary process, but this difficulty can be by-passed by introducing the altitude of the snow-cover limit and by subdividing the melt season into intervals. The model must automatically choose the equations corresponding to the actual interval. The quality of the forecasts essentially depends on the weather forecast; some difficulties, such as the precipitation in the forecasted period, have not yet been resolved. The utilization of discharge forecasts in an optimizing model for the operation of a pumping plant with a compensation basin is compulsory and, further, enables the maximum usage of low-price electrical energy, limits water losses, and guarantees operational security.

ICE AVALANCHES

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ABSTRACT. Our knowledge of ice avalanches is very limited in comparison to snow avalanches, for obvious reasons. Ice avalanches are restricted to remote areas with glaciers, whereas snow avalanches may occur in the middle of inhabited regions. Consequently, the economic importance of the two types of avalanches is quite different. Also the efforts and expenditure required to study them are different.

Two classes of ice avalanches may be discerned (with no sharp dividing line between them). A common form occurs on steep glacierized slopes below ice cliffs, from which ice breaks off at intervals. The avalanche debris remains on the glacier and can either be reincorporated or can form a regenerated glacier tongue. This is the type of ice avalanche primarily noticed by mountaineers because of the hazards involved, although little seems to have been done in the way of glaciological studies. A second class of ice avalanches consists of events more akin to landslides where a considerable portion of a glacier falls off a steep part of the bed and moves beyond the original position of the glacier onto ice-free ground, sometimes with disastrous effects. Through such glacier catastrophes, which are fortunately very scarce, more intensive glaciological studies have been initiated. The individual case histories serve best to illustrate the various problems related to ice avalanches.

The *Altels avalanche* of 11 September 1895, thoroughly documented by Heim (1896), can be regarded as a slab of ice sliding off a uniform inclined plane. It is remarkable for its size of $4.5 \times 10^6 \text{ m}^3$, its simple geometry at the origin, its equally simple trajectory involving a jump through the air, and the fact that in 1782 a similar avalanche had occurred. The slope of the bed at the origin was 30° to 32° , the mean ice thickness was 25 m (with a maximum of 40 m). No apparent signs had been noticed in the days preceding the catastrophe. The *Altels avalanche* provides one of the few sources of reliable empirical parameters in relation to ice stability and ice-avalanche dynamics.

The *Allalngletscher avalanche* of 30 August 1965 hitting the Mattmark construction site was of a very different origin. It occurred when about 10^6 m^3 of ice broke off at the snout of the glacier during a surge-like active phase of a larger mass of some $3 \times 10^6 \text{ m}^3$. Since this event, it has been established that such active phases occur periodically at Allalin once every 1–3 years, alternating with quiescent periods. During the active phase, the fast motion sometimes starts in summer or autumn and comes to a halt in November or December. The