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SNOWCOVER ABLATION AND RUNOFF

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INTRODUCTION

In many countries snow constitutes a major water resource; its release in the form of melt water can significantly affect agriculture, hydro-electric energy production, urban water supply and flood control. The ablation of a snowcover or the net volumetric decrease in its snow water equivalent is governed by the processes of snowmelt, evaporation and condensation, the vertical and lateral transmission of water within the snowcover and the infiltration of water to the underlying ground. In turn, water yield and streamflow runoff originating from snow are governed by these same processes as well as the storage and the hydraulics of movement of water in channels. In recent years it has become apparent that a better understanding of the physics of the ablation process is central to improving techniques of forecasting the time of melt, the quantity and rate of water released, the volume of water entering the soil and the amount of evaporation.

Regular forecasting of runoff from snowmelt in North America was first attempted at Lake Tahoe, Nevada, in 1909. Engineers of the local power company correlated changes in the lake water levels during the spring with the water content of the snow on Mount Rose (as determined from snow surveys made by Dr. J. E. Church). This correlation allowed the company to regulate releases from the lake to prevent spring flooding and to use the melt water more efficiently for power production. From this early beginning, research into the snow ablation phenomenon has increased significantly. Most studies have been concerned with the prediction of floods and peak discharge rates for

designing hydraulic structures and flood control works, and melt water flow to optimize its use for hydro-electric power generation, recreation and irrigation. Recently, there has been a greater emphasis on studies of the impact of snow on the agricultural industry (crop production) and the environment. The interactions between human activities (for example, deforestation, urban development) and the snowmelt regime are receiving increasing emphasis.

The most comprehensive study of snowmelt published to date is *Snow Hydrology* prepared by the U. S. Army Corps of Engineers (1956). Although the investigations summarized in this report were conducted in mountainous regions in the United States their findings have served as a foundation for many subsequent studies undertaken in other parts of North America. In particular, the results and methods described in this publication form the basis for many of the snowmelt runoff models currently used to forecast streamflow. The major Soviet publication on snowmelt is that by Kuz'min (1961) and deals primarily with conditions on the Russian Steppes. This work contains a thorough discussion of the physical processes influencing snowmelt, and an excellent summary of empirical methods for estimating melt rates suitable for incorporation in streamflow forecasting procedures and for other water management purposes.

PHYSICS OF SNOWMELT

General Considerations

Seasonal snowcovers normally develop from a series of winter storms and are modified by the action of freezing rain, wind and diurnal melting and refreezing at the surface. As a result, both deep snowpacks in the mountains and the shallow covers in regions of low relief develop a characteristic layered structure (Gerdel, 1948; Langham, 1974) with "ice" layers or relatively-impermeable, fine-textured high-density layers alternating with coarse-textured, low density and highly permeable layers. Early in the melt sequence vertical drainage channels develop in the snow contributing further to its heterogeneity. The internal structure significantly influences the retention and movement of melt water through the snow, making a detailed analysis of the transmission process extremely difficult. However, during most of the melt period the total melt water produced is governed by the energy exchanges at the upper and lower snow surfaces.

When the pack is primed to produce melt it is at a temperature of 0°C throughout and its individual snow crystals are coated with a thin film of water; also, small pockets of water may be found in the angles between contacting grains, normally amounting to 3 to 5% of the snow by weight