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A distributed energy balance snow and glacier melt model as a component of a flood forecasting system.

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Snowmelt is an important contribution to Alpine runoff and to the generation of floods in Alpine rivers. Thus, a snow and glacier melt model has been developed as a component of an operational flood forecasting system which is under development for the Inn river in Tyrol.

The model is based on a fully distributed energy balance approach, and internal processes are parameterized. Because radiation energy input is the most important factor for snowmelt in high Alpine regions special attention is paid to the temporal variability of albedo during snow melt. In contrast to many snowmelt models, the decrease of albedo during melt is not modelled as a function of time with the well known aging curve approach of the US Army Corps of Engineers (1956) but as a function of the total energy input the snowpack has received since the last snowfall. This approach seems to meet the physical background of the process better than the aging curve: Alpine skiers know that on the same day snow conditions (e.g. density or albedo) can be totally different on north or south facing slopes, respectively. This difference can be traced back to the different energy consumed by the snow on the two slopes. The point snowmelt model was calibrated and checked against data collected at the research plot of the Commission for Glaciology of the Bavarian Academy of Sciences and Humanities near the Vernagtferner (Ötztal, Tyrol). The model is then applied for fully distributed snowmelt simulations in the headwater reaches of the great southern tributaries of the Inn river.

A distributed model needs to be calibrated and evaluated with distributed data. Distributed measurements of data suitable for verifying such a model type, e.g. continuous measurements of snow water equivalent or of snowpack outflow, usually do not exist. The only distributed information on melt is the existence or non existence of snowcover on the ground. This information can be derived from a series of photographs taken from a definite point in the catchment and rectifying them to a map scale. These depletion patterns can then be compared to the results of the depletion simulations performed by the model. This procedure could be performed making use of photos taken from the Schwarzkögele above the Vernagtferner. They were rectified, and the depletion patterns were identified manually, which was complicated due to the fact that snow and firn had to be distinguished. Corresponding to the observations the model was upgraded to simulate the water balance of the firn as well.

At the present state, the model is driven with parameters calibrated and evaluated with photos of the Vernagtferner and applied to other headwater catchments in the Ötztal region where no photos but runoff measurements of the streams exist. These runoff observations can be seen as an overall performance check of the melt model. On the whole, the model shows reasonable results. For better simulations of the runoff dynamics, however, it was necessary to implement routing algorithms based on cascades of linear reservoirs that allow the routing of meltwater trough the snowpack and along the river reaches to the gauging stations.

Coupling the snow and glacier melt model with a soil moisture accounting hydrological model is on the way.