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Modelling the runoff regime of the glacierised upper Aconcagua River Basin using a distributed hydrological model: a multi-criteria approach for simulations of glacier and snow melt contributions to streamflow

Silvan Ragettli (1), Francesca Pellicciotti (1), Darcy Molnar (1), Stefan Rimkus (1), Jakob Helbing (2), Fernando Escobar (3), and Paolo Burlando (1)

(1) Swiss Federal Institute of Technology ETH, Institute of Environmental Engineering, Zurich, Switzerland (pellicciotti@ifu.baug.ethz.ch), (2) Swiss Federal Institute of Acquatic Science and Technology (Eawag), Switzerland, (3) DGA, Santiago, Chile

In the Central Andes of Chile the interactions between snow, glaciers and water resources are governed by a distinct climatological forcing. Summers are dry and stable, with precipitation close to zero, low relative humidity and intense solar radiation. During the summer months, water originates almost exclusively from snow and ice melt. Evidence of glaciers retreat and changes in the seasonal snow cover suggests that climate change might have an impact on the water resources in the area.

We use the physically-based, spatially-distributed hydrological model TOPKAPI to study the processes governing the exchange between the climate, snow and ice in the upper Aconcagua River Basin. The model incorporates the melting of snow and ice based on a simplified energy-balance approach (ETI model) and the routing of melt water through the glacial system. The model has numerous empirical parameters used in the computation of the single components of the hydrological cycle, the determination of which might lead to problems of equifinality. To address this issue we set up a rigorous calibration procedure that allows calibration of the main model parameters in three different steps by separating parameters governing distinct processes. We evaluate the parameters' transferability in time and investigate the differences in model parameters and performance that result from applying the model at different spatial scales. The model ability to simulate the relevant processes is tested against a data set of meteorological data, measurements of surface ablation and glacier runoff at the snout of the Juncal Norte Glacier during two ablation seasons. Modelled snow height is compared to snow maps derived from terrestrial photos.

Results show that the magnitude of snow and icemelt rates on the glacier tongue is correctly reproduced, but simulations at higher elevation have a larger uncertainty. Crucial factors affecting model performance are the model ability to simulate the redistribution of the winter snow cover due to wind and gravity, the correct modelling of the temperature fields; and the model ability to reproduce the melt onset. The model was found to be most sensitive to the parameters governing snow and glacier processes, and in particular the parameters governing the extrapolation of air temperature from point measurements to the glacier and basin wide scale. The parameters of the ETI melt model are transferable from one season to the other, despite important differences in terms of meteorological and surface conditions. The parameters governing the extrapolation of the meteorological input data and the routing of glacier melt water, on the contrary, need recalibration.