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Glacier energy and mass balance modelling in High Mountain Asia

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Knowledge of the development of glacier mass balances and resulting seasonal and interannual runoff patterns is crucial for irrigation, flood risk management and hydropower generation in the whole High Mountain Asia (HMA) region. The newly-developed physically-based coupled snowpack and ice surface energy and mass balance model in Python (COSIPY) is used to investigate energy and mass fluxes of glaciers in HMA in greater detail. COSIPY is an updated version of the former model COSIMA (Huintjes et al. 2015) with updated physics and optimized computational performance.

Despite considerable advancements in our understanding of the response of HMA glaciers to changing climate conditions and climate variability, there are still remarkable knowledge gaps regarding physical processes and spatial patterns. Particularly glaciers with accumulation seasons in spring or summer are extremely sensitive to changes in temperature and variable precipitation patterns.

For the Zhadang glacier, located in the western Nyainqêntanglha range (Tibetan Plateau), the model has been run as point model, and the results are compared and classified with data of an automatic weather station (AWS), which was operated from May 2009 until June 2012 on the glacier.

As a distributed version, the model is applied to Halji glacier, located in Humla district in northwest Nepal (Himalayas). Close to the Halji glacier, an AWS was installed in April 2018. The data are used to evaluate the modelled results. Especially, separate measurement of solid and liquid precipitation proves to be useful to tackle uncertainties in precipitation data from global and regional gridded precipitation data sets. Total precipitation and its solid fraction are key input variables, but unfortunately affected by considerable uncertainties.

Results for Zhadang glacier show the overall good similarity of modelled and measured variables. Nonetheless, results reveal strong model sensitivity to precipitation input and other parameters and constants of the various parameterizations concerning the energy balance at the surface. This emphasizes the importance of precipitation measurements at elevations above 4500 m a.s.l., where most glaciers are located.

Huintjes, E., Sauter, T., Schröter, B., Maussion, F., Wei, Y., Kropáček, J., Buchroithner, M., Scherer, D., Kang, S., and Schneider, C. (2015): "Evaluation of a coupled snow and energy balance model for Zhadang glacier, Tibetan Plateau, using glaciological measurements and time-lapse photography". In: Arctic, Antarctic, and Alpine Research 47.3, S. 573–590. DOI: http://dx.doi.org/10.1657/AAAR0014-073