Evaluation of a distributed energy balance model for a high-altitude glacier on the Tibetan Plateau using glaciological measurements and a time-lapse camera system

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In the remote and high-altitude mountain areas of the Tibetan Plateau, climate observations as well as glacier-wide mass and energy balance determinations are scarce. Therefore, the application of models to determine reliable information on mass balance and runoff is important. Simultaneously, these circumstances make it difficult to evaluate the models.

Since 2009, we operate an automatic weather station (AWS) in the ablation zone of Zhadang Glacier (5.665 m a.s.l.). The glacier is situated in the southern-central part of the Tibetan Plateau (30.5°N) in the Nam Co drainage basin and ranges between 5.400 and 5.900 m a.s.l.

Based on these measurements over 2009-2012, we run and evaluate a physically-based, distributed energy and mass balance model. Gaps within the dataset, resulting from the harsh environment, are filled with atmospheric model data from the High Asia Reanalysis (HAR).

The model couples an energy balance to a multilayer snow model and therefore accounts for subsurface processes like refreezing, subsurface melt and densification of the snowpack. First, the model is evaluated at point scale against measurements from the AWS. The results show that modelled accumulation and ablation patterns reproduce the observed changes in surface height very well. To evaluate the distributed model, we use ablation stake measurements since 2009 as well as daily images of a time lapse camera system installed nearby the glacier over 2010-2012. The non calibrated slope images had to be orthorectified using ground control points measured during field campaigns. While the ablation stake measurements are temporally and spatially limited, the camera system obtains highly resolved time series that allow a detailed evaluation of the distributed energy balance model by analyzing the spatial and temporal heterogeneity of the snow line during the ablation season. The results show that the model captures the observed spatial heterogeneity of melt on the glacier surface. It can reproduce the observed mass balance values at individual ablation stakes as well as the glacier wide pattern of the snow line at a reasonable level of accuracy.

Subsequently to the evaluation, the model is applied on several glaciers and small ice caps in remote areas on the Tibetan Plateau to determine the linkages between climate fluctuations and glacier variability using HAR data and remote sensing products for calibration and validation.

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