Geophysical Research Abstracts
Vol. 15, EGU2013-2010, 2013
EGU General Assembly 2013

Mass balance model parameter transferability on a tropical glacier

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The mass balance and melt water production of glaciers is of particular interest in the Peruvian Andes where glacier melt water has markedly increased water supply during the pronounced dry seasons in recent decades. However, the melt water contribution from glaciers is projected to decrease with appreciable negative impacts on the local society within the coming decades. Understanding mass balance processes on tropical glaciers is a prerequisite for modeling present and future glacier runoff.

As a first step towards this aim we applied a process-based surface mass balance model in order to calculate observed ablation at two stakes in the ablation zone of Shallap Glacier (4800 m a.s.l., 9°S) in the Cordillera Blanca, Peru. Under the tropical climate, the snow line migrates very frequently across most of the ablation zone all year round causing large temporal and spatial variations of glacier surface conditions and related ablation. Consequently, pronounced differences between the two chosen stakes and the two years were observed. Hourly records of temperature, humidity, wind speed, short wave incoming radiation, and precipitation are available from an automatic weather station (AWS) on the moraine near the glacier for the hydrological years 2006/07 and 2007/08 while stake readings are available at intervals of between 14 to 64 days.

To optimize model parameters, we used 1000 model simulations in which the most sensitive model parameters were varied randomly within their physically meaningful ranges. The modeled surface height change was evaluated against the two stake locations in the lower ablation zone (SH11, 4760m) and in the upper ablation zone (SH22, 4816m), respectively. The optimal parameter set for each point achieved good model skill but if we transfer the best parameter combination from one stake site to the other stake site model errors increases significantly. The same happens if we optimize the model parameters for each year individually and transfer these combinations to the other year. We show that multi-site and multi-year analyses are crucial before extrapolating ablation modeling to larger glacier areas. So far tested surface albedo schemes and respective parameterizations can obviously not satisfyingly reproduce the dynamics of glacier surface conditions at our study site and new solutions to the problem have to be explored.