Geophysical Research Abstracts,
Vol. 11, EGU2009-12296, 2009
EGU General Assembly 2009

Calculating distributed glacier mass balance for the Swiss Alps from RCM output: Development and testing of downscaling and validation methods

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Climate model output has been applied in several studies on glacier mass balance calculation. Hereby, computation of mass balance has mostly been performed at the native resolution of the climate model output or data from individual cells were selected and statistically downscaled. Little attention has been given to the issue of downscaling entire fields of climate model output to a resolution fine enough to compute glacier mass balance in rugged high-mountain terrain. In this study we explore the use of gridded output from a regional climate model (RCM) to drive a distributed mass balance model for the perimeter of the Swiss Alps and the time frame 1979-2003. Our focus lies on the development and testing of downscaling and validation methods.

The mass balance model runs at daily steps and 100 m spatial resolution while the RCM REMO provides daily grids (approx. 18 km resolution) of dynamically downscaled re-analysis data. Interpolation techniques and sub-grid parametrizations are combined to bridge the gap in spatial resolution and to obtain daily input fields of air temperature, global radiation and precipitation. The meteorological input fields are compared to measurements at 14 high-elevation weather stations. Computed mass balances are compared to various sets of direct measurements, including stake readings and mass balances for entire glaciers. The validation procedure is performed separately for annual, winter and summer balances.

Time series of mass balances for entire glaciers obtained from the model run agree well with observed time series. On the one hand, summer melt measured at stakes on several glaciers is well reproduced by the model, on the other hand, observed accumulation is either over- or underestimated. It is shown that these shifts are systematic and correlated to regional biases in the meteorological input fields. We conclude that the gap in spatial resolution is not a large drawback, while biases in RCM output are a major limitation to model performance. The development and testing of methods to reduce regionally variable biases in entire fields of RCM output should be a focus of pursuing studies.