Geophysical Research Abstracts
Vol. 12, EGU2010-12250-1, 2010
EGU General Assembly 2010

Long-term mass- and energy balance of Kongsvegen glacier, Spitzbergen

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We present meteorological and glaciological data from the equilibrium line (ELA) of Kongsvegen glacier (550masl) in Svalbard, covering the period 2000 until 2008. Mean annual air temperatures for the period range from -6.9 to -10.1°C and specific net annual mass balances range from -670 to +281 mm w eq. During some years substantial superimposed ice was formed and even survived the summer. The meteorological data were homogenized and used for input and validation of mass- and energy-balance simulations.

The meteorological regime at the ELA is characterized by a coreless winter and summer temperatures around 0°C. Wind conditions are largely determined by katabatic winds and topgraphically channeled upper-air winds. Net short-wave radiation is determined by cloudiness during the polar day and by the seasonal evolution of glacier surface albedo. Long-wave radiation fluxes withdraw energy throughout the year and the mean annual net radiation is almost negligible. The turbulent sensible heat fluxes constitute a comparatively strong and continuous source of energy. The latent heat flux is characterized by prevailing condensation during winter and evaporation during summer. On average, however, the turbulent fluxes provide only a small amount of heat to the glacier. Most of the energy available from the atmosphere is used for summer melt and a small amount goes into heating the near surface ice layers.

Similar investigations were performed at the tongue of the glacier (170masl) for a shorter period. Here the conditions are characterized by enhanced input from the atmospheric fluxes and correspondingly increased melt rates. In addition, accumulation is usually small (>50 cm snow) and melt can also occur during winter.

We then investigate whether spatially distributed mass balance can be simulated using data measured outside of the glacier. Regression models were developed to derive model input from climate data measured at a nearby research station. These models are based on a two-step approach considering free-atmosphere and along-glacier gradients, respectively. The mass balance model is forced with interpolated data and the results compared to the observations at the glacier and to the locally calibrated simulations.
Verification of these different simulations shows that the long-term evolution of the local mass balance is best reproduced by forcing the model with in-situ measurements. Driving the model with interpolated climate data yields less accurate results, which can mainly be attributed to specific shortcomings in input data.

Finally, we show that while simulated mass balances of the whole glacier can significantly deviate from the stake measurements for individual seasons, the models do reproduce the overall cumulative mass balance of Kongsvegen glacier for the measurement period,