



Modelling the 20th century surface mass balance of Hardangerjøkulen, southern Norway

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A spatially distributed mass and energy balance model has been developed for Hardangerjøkulen, a small ice cap in southern Norway. The model has been used to study surface mass balance variations for the period 1905–2005. In addition, the spatial distribution of surface energy and mass balance has been investigated. Calculations were done on a 50 m rectangular grid to include topographic effects. Parameterizations were calibrated and validated with mass balance data provided by the NVE, Oslo (1963–2005) and measurements from an automatic weather station on Hardangerjøkulen (2001–2005), which is operated by the IMAU, Utrecht University, the Netherlands. Three different meteorological data sets were used as input to the model. Detailed records from synoptic weather stations in the vicinity of the glacier are available from 1958 onwards. Secondly, the model was driven with ECMWF re-analysis data (ERA40: 1959–2001) and operational data (2002–2005). Before 1958, data from Bergen were used. We derived parameterizations to simulate the local climate using the data from Bergen, by comparing the data from Bergen with data from stations near the glacier for the overlapping period (1958–1984). In this way we could reconstruct surface mass balances back to 1905. There is good agreement between modelled winter and summer mass balance and NVE measurements, although interannual variations are somewhat smaller in the model. In precipitation rich years, the winter mass balance is always underestimated with ERA40 input data. The model results show that net mass balance was strongly negative in the 1930's and 40's, then remained in approximate balance until the late 1980's. Around 1990, net mass balance was very positive, but since the year 2000, it has mainly been negative.