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Statistical modelling of climate related future mass balance changes of maritime mountain glaciers in Norway

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Maritime mountain glaciers are highly sensitive indicators of climate variability and a vital source of sustainable energy in Norway. Because of related natural hazards, the prediction of changes in mass balance and mass accumulation and melting rates also has social relevance. The current research project DYNAMO-KG (Dynamic Statistical Modelling of Climate Related Glacier Mass Balance Changes in the Middle Latitudes) aims to develop a statistical model linking large-scale climate phenomena in the Northern Hemisphere to mass balance changes of selected glaciers in South Norway. It applies deduced statistical transfer functions for observed present-day conditions to global climate model simulations of the fourth IPCC assessment report to give a probabilistic estimate of future glacial mass change for a wider region. Localised disparities are, however, carefully considered.

Sea level pressure, temperature and precipitation data from National Centers for Environmental Prediction (NCEP) re-analyses (1948 - present day) and mass balance data from the Norwegian Water Resources and Energy Directorate (NVE) form the data basis for the statistical model. The first and last year of available mass balance records vary between the glaciers, but are all within the 1948 to present day window. The seven glaciers that proved suitable for this research project cover coastal and inland regions and, therefore, represent both the maritime and the continental glacier regimes in Norway. Data from the WCRP CMIP3 Multi-Model dataset at the Program for Climate Model Diagnosis and Intercomparison (PCMDI) are used in combination with the statistical model to generate the estimate of future mass balance change. Special focus is given to the ECHAM5/MPI OM runs.

The statistical model consists of a cross-validated stepwise multiple regression analysis between large-scale climatic phenomena (predictors), such as the North Atlantic Oscillation (NAO) and the East Atlantic Jet pattern (EA-JP), and glacier mass balance data (predictands). The data from NCEP re-analyses are used to construct predictor time series for each season. Summer and winter mass balances of each glacier are treated as seperate predictands. In order to take into consideration the phase of advance and possible change in glacier regime of some Norwegian glaciers, the analysis is carried out for predictor-predictand temporal overlaps in time periods 1949-1988 (pre-advance phase), 1989-2008 (includes advance phase) and 1949-2008 (total time span). This creates sets of transfer functions for different seasons and glacier regimes. The same predictors are then derived from the CMIP3 Multi-Model data for future time slices within the 21st century and climate scenarios B1, A1b and A2. Finally, the different sets of transfer functions are applied to them to generate probabilistic estimates for future glacial mass balance changes.