Geophysical Research Abstracts
Vol. 14, EGU2012-5483, 2012
EGU General Assembly 2012

Alpine snow cover in a changing climate: A regional climate model perspective

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We present an analysis of an ensemble of regional climate model experiments from the ENSEMBLES project in terms of mean winter snow-water equivalent (SWE), the seasonal evolution of snow cover, and the duration of the continuous snow cover period in the European Alps. Two sets of simulations at a horizontal resolution of 25 km are considered, one driven by GCMs for the period 1951-2099 and assuming the SRES A1B greenhouse gas emission scenario, and the other driven by the ERA-40 reanalysis for the recent past. The simulated SWE for Switzerland for the winters 1971-2000 is validated against an observational data set derived from daily snow depth measurements. Model validation shows that the climate models are capable of simulating the general spatial and seasonal variability of snow cover, but generally underestimate SWE in altitudes below 1000 m asl and overestimate SWE above 1500 m asl. Model biases in snow cover can partly be related to biases in the atmospheric forcing (temperature and precipitation).

The analysis of climate projections for the 21st century reveals high inter-model agreement on the following points: The strongest relative reduction in winter mean SWE is found below 1500 m asl, amounting to between 40 and 80% already by mid century, relative to 1971-2000 and depending upon the model considered. At these elevations, mean winter temperatures are close to the melting point. At higher elevations the decrease of mean winter SWE is less pronounced but still a robust feature. For instance, at elevations between 2000-2500 m asl, SWE reductions amount to between 30 and 80% by the end of the century. The duration of the continuous snow cover season shows an asymmetric reduction with strongest shortening in springtime when ablation is the dominant factor for changes in SWE. We also find a substantial ensemble-mean reduction of snow reliability relevant to winter tourism at elevations below about 1700 m by mid century, and at elevations below about 2100 m by the end of the century.