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Modeling impacts of climate change on evapotranspiration and soil moisture spatial patterns in an alpine catchment

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A climate change impact study on spatial pattern of evaporation and soil moisture was performed in the Venosta/Vinschgau valley (South Tyrol, Italy). Locating hot spots of future changes for these main components of the water cycle is essential for the development of mitigation and adaptation strategies in this dry inner alpine valley, which is already affected by water scarcity issues.

The GEOtop hydrological model was used for 1-dimensional simulations, resulting in soil water content, evapotranspiration and snow water equivalent for 300 locations within the valley. Simulation locations were chosen by means of a multidimensional sampling (K-means clustering) of the most important aspects of land surface heterogeneities of the complex, mountainous topography, and land use cover, based on 20m grid maps. This approach reduced considerably computational time with respect to a full 3-dimensional simulation. An ensemble of 7 regional climate models (RCM) was downscaled using the Δ-change approach, to drive the hydrological model for the scenario periods 2040-2059 (scen2060) and 2080-2099 (scen2100). A baseline simulation is covering the period 1990-2009. Calibration and validation studies were successfully carried out for three locations along an elevation transect (station B10: 1000m a.s.l., station B15: 1500m a.s.l., station B20: 2000m a.s.l.), where detailed observations of meteorological inputs, evapotranspiration, snow cover and soil moisture were available.

The annual cycle of the Δ-change signal for temperature and precipitation reveals explicit differences between the 7 RCMs. Especially precipitation patterns exhibit high uncertainty, but, nevertheless, they show an average increase of $17\%(\pm 36\%)$ in autumn and a decrease of $13\%(\pm 23\%)$ in summer (scen2100). Temperature pattern are more homogenous, reaching a maximum increase in summer (4.2±0.9°C, scen2100). Decreasing temperatures are not projected.

Simulations show a strong impact of increasing temperature on snow and ice storage. Besides decreasing snow water equivalent and summer precipitation, enhanced evapotranspiration rates were simulated, especially for high elevation (e.g. station B20). Only small changes in soil moisture occurred for sites below 1000 m a.s.l., whereas high elevation sites show a clear decrease, with maximum changes in summer months. Changes are more pronounced for scen2100, but results for the two scenario periods do not differ qualitatively. Comparing the ensemble members, strongest effect occurred with HadRM3Q0 (UK Met Office), as it is the model predicting the warmest climate with the lowest summertime precipitation.

The results suggest that a warmer climate with less summertime precipitation may lower the seasonal mean soil water content during the vegetation period significantly. In particular, south faced pastures and woodlands within the elevation band of 1000 – 1500 m a.s.l. seem to be the most sensitive locations and may be exposed to more frequent water stress conditions in future.