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Soil-plant-atmosphere processes along an elevation gradient in a dry alpine valley

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In mountain regions soil-plant-atmosphere processes exhibit rapid changes within short distance due to the complex pattern of topography and atmospheric processes. An elevation transect can be seen as a proxy of climate change (CC), as it affects air temperature, precipitation amount and its partitioning into snow and rain, snow cover duration, and the resulting changing length of vegetation period.

In order to quantitatively investigate the exchange of energy, water and carbon with respect to elevation for mountain grassland ecosystems within an inner dry alpine valley, a transect of three micro-meteorological stations was established since 2009 in the Venosta valley (South Tyrol, Italy). It has been designed with three stations, with an elevation difference among the stations of 500 m, which means an average temperature gradient of 2.7 K.

In this contribution, the GEOtop-dv model was employed to simulate the effects of the elevation gradient on snow, soil moisture, evapotranspiration (ET) and above ground net primary production (ANPP) dynamics in two years with different climatic conditions. Simulations have been validated with observations of soil moisture, snow height, ANPP and eddy-covariance measured ET.

Considering the observed contrasting natural trends of increasing precipitation and of decreasing temperature with higher elevation, numerical simulation results show that, in this type of climate, snow dynamics are highly nonlinear with the elevation due to differential precipitation partitioning in early winter and spring. Despite the relatively cold climatic conditions, soil moisture dynamics indicate that severe drought occurs in the bottom of the valley, while at the higher elevations cold temperatures limit growing season duration, and therefore ET and ANPP. Those contrasting trends result in an optimal altitude at about 1400 m a.s.l., where temperature and water availability are optimal in terms of maximum annual ET and ANPP.

Our results indicate that for this mountain ecosystem, a threshold elevation exists, below which most of the precipitation is used for ET, and irrigation is needed for maximize ANPP, and above which an increasing part of precipitation can become runoff and water infiltration. Therefore, a relevant implication is that only above a certain elevation this mountain area acts as “water tower”. A determination of future trends of this threshold elevations is crucial for stakeholders to assess the impact of climatic changes on water resources for mountain ecosystems.