Submitted Abstract

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Abstract

The Spanish Pyrenees provide a substantial part of the water resources to sustain environmental and human water demands in the semi-arid downstream lowlands, by storing water in winter and releasing it during the dry warm summer season. However, water scarcity is already a widespread problem and climate change is increasing snow droughts and shifting spatio-temporal patterns of snow accumulation and ablation (including a shift from snow to rain, rising snow lines, snowpack decline, earlier snowmelt). These snow distribution changes will likely have serious water supply consequences for multiple sectors (e.g. hydropower, agriculture, tourism, etc.). Understanding spatial heterogeneity of snowpack distribution and temporal variation in snow accumulation and melt dynamics can help us to advance our understanding of the processes controlling streamflow generation across scales and to improve hydrological predictions for various water users. In this context, this study focuses on two main objectives:

Linking hydrological simulations and satellite-derived high-resolution snow estimations in a hybrid model for improved hydrological predictions. Using the Jena Adaptable Modelling System (JAMS), a software framework for component-based development of environmental models, novel satellite-derived high-resolution COSMOS20 snow products (snow cover, snow depth and snow water equivalent) are integrated into the spatially-distributed, physically-based J2000 model.

Assessment of the impacts of snow accumulation and ablation patterns on water availability from a multi-scale perspective. By applying the hybrid model, the response of streamflow to spatio-temporal variations of snow distribution is simulated and runoff components are quantified across scales ranging from small headwater catchments of hydropower reservoirs up to upper meso-scale basins of large reservoirs used for controlling water flows downstream (flood control, irrigation canals, etc.). Thereby, the influence of different proportions of snow-dominated areas on the runoff dynamics is investigated.

The modelling outputs support the development of appropriate climate adaptation and mitigation strategies, aiming to achieve a sustainable water management across all sectors. This study highlights the potential benefits of the synergy between satellite-derived high-resolution snow estimations and hydrological modelling to examine how mountain snow accumulation and ablation patterns vary through space and time and to investigate quantitatively cross-scale effects of snow distribution variations on water resources availability.