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Using mid-altitude regions as observatories of change in snow areas: the Natural Park of Cazorla, Segura y las Villas (South Spain) as study case for early snow regression.

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Snow plays a key role at the hydrological cycle in semiarid mountainous areas, modifying the energy and water balances that govern the regime of stored water in the snowpack, a key resource for the spring and summer river flow. The Natural and National Park of Sierra Nevada (SNNP), a coastal mountain range up to 3450 m a.s.l. in southern Spain, is a representative example of snow areas in Mediterranean-climate regions; its high altitudinal gradient results in a wide variety of eco-climatic environments, and it is part of the global monitoring network to study climate change. Both monitoring and modelling efforts have been performed to assess this variability and its significant scales; whereas increasing temperature trends have been found, no significant trends are observed so far regarding the precipitation regime both on a seasonal and annual basis, with a highly variable impact on the snow regime in this area, especially in the mid-altitude range.

In this context, the study of the snow cover in the neighbouring Natural Park of Cazorla, Segura and Las Villas (CSLVNP), with similar climatic conditions but lower altitudes (up to 2107 m a.s.l.) is proposed as a parallel monitoring site for early warning of impacts of climate change on the snow regime. The CSLVNP is the most extensive protected area in Spain and it is located to the north of SNPN, with less influence of the Mediterranean Sea. This study carried out a first quantification of the snow importance in this area, which exhibits a large transitional zone with a dominant alpine environment, and its relationship with the observed local precipitation-temperature trends. For this, the snow cover fraction on a 30x30 m gridded resolution has been studied during a 5-yr period combining on-site meteorological observations and remote-sensing data analysis, and snow modelling by the distributed and physically based approach for Mediterranean regions proposed by Herrero et al. (2009; 2010). The analysis of the available series of satellite images Landsat 8 OLI/TIRS, Landsat 7 ETM+ and Landsat 4-5 TM were used to obtain snow cover fraction maps with 30x30 m resolution. The study period 2010-2015 was simulated with the distributed snow model and the results were compared against these snow map series. Additionally, the annual and seasonal trends of precipitation, mean daily temperature and global radiation were obtained from the available local data sets.

Globally, the simulated results overestimate the snow presence in the study area, very likely due to the estimation of snowfall. However, on a local scale, the model performance improves in the region between 1750 and 2250 m altitude. On the other hand, those zones at lower altitudes, which are a transition of the clearly alpine environment above, present a high variability of results related to the spatial patterns of precipitation, temperature and radiation. Regarding the precipitation-temperature regime, an increasing 0.05 º/yr over the last 30 years (1970-2010) was found, but no significant conclusion can be achieved on precipitation trends. This is also observed in the SNNP, which confirms the potential representativeness of PNCSV as an early warning site. Further work is being carried out to improve the snow modelling at this site and generate longer snow cover fraction maps series and other characteristic variables of the snow in this area.