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Evolution of snow-covered area at hillslope scale using terrestrial photography

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The spatial distribution of snow is conditioned by both meteorological driving processes and topography. Monitoring by remote sensing is a powerful source of data in medium-large areas, but poses some constraints when heterogeneity is significant at scales smaller than the spatial resolution of the GIS-modeling. Such is the case of Mediterranean mountainous watersheds, especially during melting cycles. In these cases terrestrial photography, whose spatial and temporal resolutions can be adapted to the study problem, is an economic and also efficient alternative.

This study uses terrestrial photography to quantify the relationship between the elevation gradient and the presence-absence of snow during the snowmelt cycles. The study was carried out in Sierra Nevada Mountain, southern, Spain, specifically, on a hillside of the Ducal River basin, where terrestrial images were taken with a frequency ranging from 1 to 4 days from May to July, 2009. These images were referenced using a digital elevation model (DEM) and an algorithm based on graphics design principles. The presence of snow was detected using machine learning techniques, a clustering method in which two clusters are selected: pixels with and without snow.

The results of this process are snow map series with the same temporal frequency of the image acquisition and the spatial resolution of the DEM (10 x 10 m). An exponential trend was clearly observed in the behavior of the evolution of snow with elevation, with a high determination coefficient value ($R2>0.98$). Moreover, this trend could be fitted with only two parameters, which were also related to elevation. The trend was validated in another monitored location during a different snowmelt period of 2013, when similar results were obtained ($RMSE<0.15$ m2m-2 in terms of snow cover area). From the results, further assessment was performed in the study site in reference to other hydrological processes with a strong snow influence, such as the recession curve in baseflow.