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Coupling time-lapse photography to weather stations for monitoring snow processes in Mediterranean mountain regions: a case study in Sierra Nevada (Spain)

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One of the main characteristics of the snow cover in Mediterranean regions is its spatial heterogeneity, due to both the high spatiotemporal variability of the climatic agents and the interaction of vegetation and microtopography. Weather monitoring networks do not always cover high altitudes in these areas with the required density to produce skilled maps of weather and snow variables; difficult access and hard working conditions also pose a constraint for the availability of continuous records. Additional issues for reproducing the snow pack evolution are, among others, the threshold temperature for snowfall, the effect of rain-on-snow or fog events during the snow season, wind redistribution, triggering of melting by boundary vegetation or rocks, changes in roughness and cohesion by metamorphism... There is a need for alternative data sources that help to study the snowpack dynamics and to estimate the main drivers under transient conditions. Terrestrial photography has become a very useful tool for monitoring the snow cover evolution in these environments: it is a practical, simple and low-cost measurement method, which is rarely affected by the presence of clouds and allows obtaining continuous series of data.

The objective of this study is to evaluate the potential of terrestrial photography for the analysis of the above-mentioned phenomena at a detailed scale, as a complementary data source for weather station in snow regions. For this, a 30x30m pilot area has been monitored from 2009 with a time-lapse digital camera in the snow-monitoring experimental site Refugio Poqueira in Sierra Nevada (southern Spain), where an automated weather station especially equipped for snow variables has been recording since 2004. The following data sets have been used for the analysis: 1) daily series of terrestrial images from November, 2009 up to April, 2017 (5 images per day); 2) daily series of hourly precipitation and temperature.

After pre-processing of the images, the following variables were assessed from the joint analysis of both time series: a) threshold temperature to partition snowfall and rainfall; b) occurrence of rain on snow. The method proved to discriminate both variables within an adequate range. The resulting time series for these two variables are key for understanding transient regimes in Mediterranean mountain areas and improving the performance of snow models on a local basis. The work shows the added value of coupling terrestrial pictures to advanced weather stations in mountain areas such as Sierra Nevada, where climate variability and topography result in hydrological processes that can be significant on small time scales.