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Assessing global warming impacts on the phenology of selected vegetation covers in Mediterranean mountain areas from terrestrial photography

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Changes in both distribution and phenology are some of the major impacts of global warming on the vegetation; they also constitute an indirect tracer of the significance of the climate variables shifts in remote areas. Whereas the spatial pattern of vegetation covers can be easily estimated by remote sensing, with high-resolution sensors available nowadays, phenology requires in-situ field campaigns costly in time and human resources. Mountain areas in Mediterranean regions are highly valuable biodiversity reservoirs due to the variability of the climatic and hydrological regime; at the same time, the study of trends in ecological variables is specially critical due to the usually difficult access and the reported observed trends towards an enhanced torrentiality and, sometimes, aridity.

This work presents the use of terrestrial photography for monitoring selected phenological states in two Mediterranean mountain systems in South Spain: a “dehesa” (an oak-savanna), site in northern Andalusia (Natural Park of Sierra-Cardeña and Montoro), and a high mountain site in south-eastern Andalusia (National Park of Sierra Nevada). Specifically, the results show how useful this technique is, coupled to conventional weather stations, in the study of phenological changes; for this, two plant species, holm oak in the Natural Park Cardeña y Montoro and the Spanish broom in the National Park of Sierra Nevada, have been selected as representative of each kind of environment.

The workflow at each site included i) pre-analysis of the scenes covered by the terrestrial photography to generate the best masks to monitor the phenological states of the selected cover; ii) analysis of the RGB bands in the available terrestrial pictures to identify the expected changes associated to different phenological states; iii) multivariate analysis of the day of the year (DOY) associated to each state and different climate indicators from the weather datasets, including accumulated heat and coldness units ; iv) reconstruction of time series of the resultant phenology states during the historical period 1962-2017; v) trend analysis of the most relevant phenology states.

Particularly, bud formation, blooming and fruiting were satisfactorily monitored by the RGB analysis from the terrestrial pictures in both species, being this result one of the few systematic characterization of the phenology of the Spanish broom in high mountain conditions. The trend analysis resulted in an earlier bud formation and blooming during the last decades, with an increased risk of damage in years with colder springs.

The results show how useful terrestrial photography is in the study of phenological changes and trends, provided that good-quality weather datasets are available on-site. Both the flexibility of the automated cameras to fix snap frequency and the possibility of automated treatment of the images make this method a cost-effective approach to complement the field campaigns and help to further understand the reasons behind the observed changes in the ecohydrological regime in these areas on different time scales, and confirm the suitability of terrestrial photography as a relevant instrumentation in standard monitoring networks.