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Use of an automated digital images system for detecting plant status changes in response to climate change manipulations

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The importance of phenological research for understanding the consequences of global environmental change on vegetation is highlighted in the most recent IPCC reports. Collecting time series of phenological events appears to be of crucial importance to better understand how vegetation systems respond to climatic regime fluctuations, and, consequently, to develop effective management and adaptation strategies. However, traditional monitoring of phenology is labor intensive and costly and affected to a certain degree of subjective inaccuracy. Other methods used to quantify the seasonal patterns of vegetation development are based on satellite remote sensing (land surface phenology) but they operate at coarse spatial and temporal resolution. To overcome the issues of these methodologies different approaches for vegetation monitoring based on "near-surface" remote sensing have been proposed in recent researches.
In particular, the use of digital cameras has become more common for phenological monitoring. Digital images provide spectral information in the red, green, and blue (RGB) wavelengths. Inflection points in seasonal variations of intensities of each color channel can be used to identify phenological events. Canopy green-up phenology can be quantified from the greenness indices. Species-specific dates of leaf emergence can be estimated by RGB image analyses.
In this research, an Automated Phenological Observation System (APOS), based on digital image sensors, was used for monitoring the phenological behavior of shrubland species in a Mediterranean site. The system was developed under the INCREASE (an Integrated Network on Climate Change Research) EU-funded research infrastructure project, which is based upon large scale field experiments with non-intrusive climatic manipulations. Monitoring of phenological behavior was conducted continuously since October 2012. The system was set to acquire one panorama per day at noon which included three experimental plots for climate manipulations: control (no manipulation), warming (overnight cover), and drought (interception of the periodic precipitation) treatments (36 shots x panorama (3 rows x 12 columns) with a degree of overlapping equal to 30%). On each panorama, ROIs (Regions of Interest) focusing major species of the shrubland ecosystem were identified. Then, image analysis was performed to obtain information on vegetation status (i.e. color signals and phenology). The color channel information (digital numbers; DNs) were extracted from the RAW file. The overall brightness (i.e. total RGB DN, green excess index) was also calculated. Finally, the RGB value was correlated with the pattern of phenological development. Preliminary results of this study show that the use of digital images are well-suited to identify phenological pattern of the Mediterranean species.
Results of digital images analysis can be a valuable support for ecologists, environmental scientists, and land managers providing information useful to interpret phenological responses of plants to climate change, to validate satellite-based phenology data, and to provide input to adaption strategies plans to climate change.