6 THE ECO-SCALE PROJECT: INTEGRATED HIGH RESOLUTION MONITORING FOR MEDITERRANEAN MAQUIS ECOSYSTEMS

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1. INTRODUCTION

In the Mediterranean environment, reduced water availability, high temperatures, and scarcity of nutrients represent the major limitations to plant growth. In addition to the natural structural and functional complexity of the Mediterranean vegetation, changes induced by climate change (increased temperature, reduced water availability), and due to environmental conditions (increased nitrogen deposition), represent additional constrains (Cleland et al. 2007). However, many physiological and phenological adaptations and specific structural features of the Mediterranean vegetation ensure its survival.

The study of the vegetation features in a complex and highly vulnerable environment requires the use of continuous monitoring systems at high spatial and temporal resolution, which leads to a better interpretation of the mechanisms of regulation of ecosystem processes. Moreover, to overcome the limitation of field observations on single individuals, which implies lack of consistency, continuity and objectivity, and to scale between ground-based sampling and regional-scale satellite sampling, different approaches for vegetation monitoring have been proposed in recent researches (e.g. Jenkins et al. 2007).

Near-surface remote sensing techniques are used to quantify, at high temporal resolution, and with a certain degree of spatial integration, the seasonal variations of the surface optical and radiometric properties. These data provide information on vegetation phenological and ecophysiological responses (Richardson et al. 2009; Sonnentag et al. 2011).

Spectral signatures are acquired using spectroradiometers installed a short distance from the vegetation. The two most commonly used indices are: (1) fAPAR, the fraction of incident photosynthetically active radiation absorbed by the foliage, and (2) the NDVI, Normalized Difference Vegetation Index (Jenkins et al. 2007). These data can be integrated with vegetation brightness indices calculated from digital images and ecosystem carbon and energy fluxes measurements obtained using eddy covariance techniques, for improving the knowledge about the impact of phenology on carbon sequestration and the description of carbon fluxes at site level (Migliavacca et al. 2011; Mizunuma et al. 2013).

For these reasons, in recent decades, the design and implementation of global monitoring networks involved the use of non-destructive and/or cheaper approaches such as (i) continuous surface fluxes measurement stations, (ii) phenological observation networks, and (iii) measurement of temporal and spatial variations of the vegetation spectral properties.

2. THE ECO-SCALE PROJECT

The ECO-SCALE (Integrated High Resolution Monitoring of Mediterranean vegetation) project is aimed to the development and validation of new technologies and methodologies for the identification of structural and functional responses of natural vegetation to environmental and climatic changes in a Mediterranean area (Fig. 1).

Fig. 1. The experimental site located in North-West Sardinia, Italy.

In particular, the project aims to: (i) develop an integrated system for environmental monitoring based on digital photography, hyperspectral radiometry , and micrometeorological techniques, (ii) implement a methodology based on digital images for the automated phenological vegetation monitoring, (iii) develop a phenological model based on hyperspectral reflectance data, (iv) monitor surface fluxes, and (v) analyses an integrated fashion data obtained from different methods and techniques over a Mediterranean ecosystem (Fig. 2) to improve our knowledge of the mechanisms underlying the development processes of plants.

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Figure 2. General view of the experimental site located in North-West Sardinia, Italy.

3. RESEARCH ACTIVITIES

To achieve the specific objectives of the project, the work breakdown structure of this Project includes 3 Work Packages that will be implemented throughout the entire duration of the Project.

WP1 – The first WP will be dedicated to the methodological and technological development of new tools and instrumentations for monitoring Mediterranean ecosystems. In particular, two main tools will be developed: (i) a digital photographic system for the automated detection and recording of vegetation phenology, and (ii) a monitoring system of phenological phases based on spectroradiometric measurements.

WP2 – This WP will be mainly focused on the potential applications of the new tools and systems developed for monitoring the structural and functional changes of Mediterranean vegetation.

WP2 will be directed at (i) developing an application for semi-automated analysis of "phenological" images, and for individuating digital metrics and phenological patterns and biometrics of interest, and (ii) calibrating hyperspectral indices for the estimation of phenological stage of Mediterranean species.

WP3 – Within the third WP the information acquired using traditional techniques will be integrated with data from the novel monitoring systems and results will be analysed. Specific activities will consist in (i) comparing results from near-surface remote sensing techniques with direct phenological observations, (ii) measuring fluxes using eddy covariance technique, (iii) determining nitrogen deposition effects on the optical properties of the Mediterranean systems using spectroradiometric methods, and (iv) performing an analysis of the ecosystem processes based on the integration of the three monitoring systems.

4. CONCLUSIONS

The operational objectives and expected results of ECO-SCALE will provide continuous and high-resolution information on Mediterranean maquis ecosystem, which will be a valuable support for both ecological and environmental studies and for management applications.

Specific fields of application can be: the analysis of phenological plants responses to environmental and climate changes, the validation of data derived from satellite images, the interpretation of data of gross primary productivity obtained from eddy covariance measurements, and the validation of ecophysiological models. In addition, this research can provide useful information for planning adaptation strategies to climatic changes.

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