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Exploring fire dynamics with BFAST approach: case studies in Sardinia, Italy

Jamie Quarfeld (1), Biagio di Mauro (2), Roberto Colombo (3), and Jan Verbesselt (4)

(1) Wageningen University, The Netherlands, (2) University of Milan-Bicocca, Italy, (3) University of Milan-Bicocca, Italy, (4) Wageningen University, The Netherlands

The synergistic effect of wildfire and extreme post-fire climatic events, (e.g. droughts or torrential rainfall), may result in long windows of disturbance—challenging the overall resilience of Mediterranean ecosystems and communities. The notion that increased fire frequency and severity may reduce ecosystem resilience has received much attention in Mediterranean regions in recent decades. Careful evaluation of vegetation recovery and landscape regeneration after a fire event provides vital information useful in land management. In this study, an extension of Breaks For Additive Seasonal and Trend (BFAST) is proposed as an ideal approach to monitor change and assess fire dynamics at the landscape level based on analysis of the MODerate-resolution Imaging Spectroradiometer (MODIS, TERRA) time series. To this end, satellite images of three vegetation indices (VIs), the Normalized Burn Ratio (NBR), the Enhanced Vegetation Index (EVI) and the Normalized Difference Vegetation Index (NDVI) were used.

The analysis was conducted on areas affected by wildfires in the Sardinia region (Italy) between 2007 and 2010. Some land surface (LS) descriptors (i.e. mean and maximum VI) and fire characteristics (e.g. pre-fire trend & VI, change magnitude, current VI) were extracted to characterize the post-fire evolution of each site within a fifteen-year period (2000-2015). Resilience was estimated using a classic linear function, whereby recovery rates were compared to regional climate data (e.g. water balance) and local landscape components (e.g.topography, land use and land cover). The methodology was applied according to land cover type (e.g. mixed forest, maquis, shrubland, pasture) within each fire site and highlighted the challenge of isolating effects and quantifying the role of fire regime characteristics on resilience in a dynamic way when considering large, heterogeneous areas. Preliminary findings can be outlined as follows:
I. NBR showed it was most effective at detecting fire occurrence. EVI showed it was more sensitive to the influence of the Savitkzy-Golay smoothing filter than NBR or NDVI;
II. The quantitative assessment of resilience for different land covers (maquis, mixed forest, shrubland) allows discrimination of diverse post-fire dynamics. Mixed forest showed an overall lower resilience compared to maquis and shrubland. Detection of post-fire breakpoints appears to occur in a similar time sequence with respect to both year of fire occurrence and land cover.
III. The combined use of several climate and landscape components enables characterization of different features of post-fire dynamics in a Mediterranean ecosystem.

In summary, the approach used in this study provides useful insight into complex post-fire vegetation dynamics in Mediterranean regions from a remote sensing perspective. Tailoring of the methodologies employed this study can inform a broad spectrum of forest and wildfire management activities, from monitoring and decision support during the fire season to long-term fuel management and landscape planning, with the general goal of reducing fire exposure and losses from future wildfires. Results can be expanded to include additional LS descriptors or soil geological aspects that contribute to a stronger integration of remote sensing data in operational natural resource management plans for ecosystem conservation and natural hazard prevention.