ESTIMATING GROSS PRIMARY PRODUCTION IN A MEDITERRANEAN TREE-GRASS ECOSYSTEM WITH TIME SERIES OF HYPERSPECTRAL AIRBORNE IMAGES: THE IMPACT OF SPATIAL HETEROGENEITY

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Abstract: Biosphere–atmosphere carbon exchanges are continuously registered in ground stations by the Eddy Covariance (EC) systems. Remote Sensing (RS) provides spatialized information about vegetation phenology and physiology. The combination of both brings new opportunities for the development of predictive models of vegetation productivity. However, since, flux footprints vary rapidly in time and space, spatial heterogeneity hinders this modeling. This is the case of Mediterranean tree-grass ecosystems, whose complex structure makes difficult their study from both, EC and RS approaches.

The aim of this work is analyzing the impact of spatial heterogeneity on the parametrization of optically based models of Gross Primary Production (GPP) in a Mediterranean tree-grass ecosystem.

In the Mediterranean tree-grass ecosystem of Las Majadas del Tiétar (Cáceres Spain), up to three EC towers record carbon exchanges from areas with different fertilization treatments. Time series of hyperspectral images have been acquired over each EC tower using the Compact Airborne Spectrographic Imager operated by the Instituto Nacional de Técnica Aeroespacial. Digital classification of the CASI images allowed to discriminate different vegetated and non-vegetated ecosystem components and optical information was extracted from each class using half-hourly footprint Probability Distribution Function (PDF). Intra-day variability produced by the dynamic PDFs on the optical signal was assessed. Different GPP predictive models based on the Normalized Difference Vegetation Index (NDVI) and the Photochemical Reflectance Index (PRI) were fit using only grass, trees or all the pixels together; and also different sampling schemes: footprint PDF and squared 250 and 500 m pixels.

Footprint dynamics produced large changes in the optical signals of the areas contributing to fluxes. In the case of the NDVI, the maximum coefficient of variation found was 6.09%, and for the PRI it was 7.91%. In all the cases, the variability of grass and trees classes separately was lower. The adjusted GPP models reached $R^2 > 0.78$ in all the cases. The lower differences in R^2 between different sampling strategies were found when all the pixels were used, and the largest differences were found for the grassland.

Footprint analysis showed significant variability in the optical signal. This is mostly due to changes in the contribution of the different components of the ecosystem. Daily GPP estimates varied when different sampling strategies and covers were used. Intra-pixel heterogeneity still allows an acceptable estimation of GPP (RRMSE < 7.3 %). Any improvement is limited by the uncertainties in the prediction of the footprint PDF.

Keywords: Mediterranean tree-grass ecosystem, Airbonre hyperspectral imagery, Carbon flux, Spatial heterogeneity, Gross Primary Production

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