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LAI estimation in a Mediterranean grassland by in situ radiometric measurements and MODIS satellite data

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Leaf Area Index (LAI) is one of a key variables in studying and understanding biogeochemical cycle mechanisms and ecosystem functionalities and, then, one of a main inputs for ecological modeling. Leaf area surface is related to the main interactions between leaves and the atmosphere as water interception, radiation extinction, energy, mass and gas exchange. Therefore LAI reduction, consequently the loss of productivity, is expression of any physiological and biochemical change of plant status due for example to summer water stress in Mediterranean areas. A good knowledge of seasonal trend and spatial variability of LAI can helps not only modelers but also local farmer to manage grasslands in a sustainable way (grazing, harvesting).
In situ LAI measurements are often limited to relatively small areas whit a small number of samplings that can be sporadic, destructive and time-consuming. Nowadays an interesting alternative to estimate LAI is provided by a large variety of radiometric sensors (ground, airborne and satellite based) whit several spatial, temporal and spectral resolutions. However, few studies shown the effect of different radiometers set-up on VIs-LAI relationships that are also differently sensible to different ranges of LAI, management and to which method is used for LAI measurements.
In this work, we analyzed the relations between several spectral vegetation indexes (VIs) and LAI for the Mediterranean grassland of Amplero, in the Abruzzo Region, Italy. In situ measurements were carried out in 2005 and 2006. Contemporaneously to destructive LAI measurements, radiometric measurements over the grass herbage were made by two different radiometric sensors: by hyperspectral Hand Held ASD spettroradiometer (HYS) field samplings and by broad band measurements (BNR) of incoming and outgoing global (shortwave) solar radiation components and of incident and reflected photosintetically active radiation (PAR). In addition we included in this analysis VIs calculated from MODIS Surface Reflectance (MOD-09) bands and MODIS Vegetation Indexes (MOD-13) product. Among all calculated spectral indexes, NPVI (Normalized Parabolic Vegetation Index), a new index that we proposed, showed best fit with LAI for HYS (R2 = 0.81), BNR (R2 = 0.79) and MOD-13 (R2 = 0.63) while MOD-09 correlates better with NDVI (R2 = 0.65). Moreover LAI-NPVI relationship seams not to be affected by saturation at LAI values higher than 1.5 m2 m-2 as it happens for other indexes as hyperspectral NDVI. LAI shows also a significant exponential relation with GPP (Gross Primary Production)(R2 = 0.69) saturating for LAI values higher than 1 m2 m-2. Moreover several studied vegetation indexes appear to correlate whit GPP offering thus the possibility to predict gross productivity both continuously by BNR radiometer and over a large area by MOD-09 and MOD-13 data. Finally, up-scaling the best LAI-VI relations we created LAI maps that can be helpful to local farmers to understand yield productivity and to modelers to assimilate in their models indirect estimation of leaf area index.