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Correlation between satellite vegetation indices and crop coefficients

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Accurate estimations of plant evapotranspiration and its spatial distribution are fundamental for the evaluation of vegetation water stress. Satellite remote sensing techniques represent precious tools for the evapotranspiration estimations at large scale. Many studies are based on the use of thermal signals as inputs for energy balance equations that are solved to estimate evapotranspiration (e.g., Bastiaanssen et al., 1998; Ayenew, 2003). This approach requires many inputs and a detailed theoretical background knowledge. Other works (e.g., Calera at al., 2005; Gonzalez-Dugo and Mateos, 2008) explored a second approach based on the FAO method that estimates the plant evapotranspiration by weighting the reference evapotranspiration with a crop coefficient (Kc) derived from satellite based vegetation indices. Such studies mainly investigated the usefulness of high resolution satellite data, such as Quickbird, Ikonos, TM, that in spite of the high spatial sampling, are not suitable for a dense temporal sampling. In order to generate spatially distributed values of Kc that capture field-specific crop development, we investigated the usefulness of vegetation indices derived from a time series (2005-2008) of medium resolution MODIS data. We analyzed the spatial and temporal correlation of different indices (NDVI, EVI, and WDVI) with crop coefficients available in literature for different herbaceous and arboreal cultivations present in the study area (Basilicata region, southern Italy). To take into account the background of the cultivation covers, we weighted the Kc by considering the vegetation fraction within each the pixel. By evaluating altogether the cultivations, we found that the correlation increases during the growing season ($R^2 > 0.80$) whereas it decreases during the winter period ($R^2 < 0.30$). Such a behaviour seems to be directly connected with the dependence of vegetation indices on temperature that showed a specular correlation cycle. The analysis performed for each cultivation highlighted that NDVI provided quite high correlation for all the investigated cultivation with maximum values for wheat (R^2 = 0.89) and vineyards (R^2 = 0.83). For the cultivation with more homogeneous canopy, e.g. kiwifruit, the best performing index was the WDVI showing a determination coefficient of 0.90; whereas its performances for vineyards and mixed olive cultivations were not satisfactory ($R^2 < 0.40$). The EVI showed a behaviour similar to WDVI with slightly lower correlation values. The obtained results highlight the capability of medium resolution satellites for dynamically estimating crop coefficients and so for improving water balance assessment by taking into account the actual status of vegetation instead of expected and tabulated Kc-values.

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