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Observation and Modelling of Soil Water Content Towards Improved Performance Indicators of Large Irrigation Schemes

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Irrigation performance may be evaluated for different objectives such as equity, adequacy, or effectiveness. We are using two performance indicators: IP2 measures the consistency of the allocation of the irrigation water with gross Crop Water requirements, while IP3 measures the effectiveness of irrigation by evaluating the increase in crop transpiration between the case of no irrigation and the case of different levels of irrigation. To evaluate IP3 we need to calculate the soil water balance for the two cases. We have developed a system based on the hydrological model SWAP (Soil Water atmosphere Plant) to calculate spatial and temporal patterns of crop transpiration T(x, y, t) and of the vertical distribution of soil water content θ(x, y, z, t).

On one hand, in the absence of ground measurement of soil water content to validate and evaluate the precision of the estimated one, a possibility would be to use satellite retrievals of top soil water content, such as the data to be provided by SMAP. On the other hand, to calculate IP3 we need root zone rather than top soil water content. In principle, we could use the model SWAP to establish a relationship between the top soil and root zone water content. Such relationship could be a simple empirical one or a data assimilation procedure.

In our study area (Doukkala- Morocco) we have assessed the consistency of the water allocation with the actual irrigated area and crop water requirements (CWR) by using a combination of multispectral satellite image time series (i,e RapidEye (REIS), SPOT4 (HRVIR1) and Landsat 8 (OLI) images acquired during the 2012/2013 agricultural season).

To obtain IP2 (x, y, t) we need to determine ETc (x, y, t). We have applied two (semi)empirical approaches: the first one is the Kc-NDVI method, based on the correlation between the Near Difference Vegetation Index (NDVI) and the value of crop coefficient (kc); the second one is the analytical approach based on the direct application of Penman-Monteith equation with reflectance-based estimates of canopy biophysical variables, such as surface albedo (r), leaf area index (LAI) and crop height (hc). The validation of spatial results using the dual crop coefficient approach (kcb) showed that the satellite-based estimates of ETc corresponded well with ground-based ETc i.e, R^2=0.75 and RMSE=0.79 versus R^2=0.73 and RMSE=0.89 for respectively kc-NDVI and analytical approach.

To monitor IP3 (x, y, t) with the SWAP model we mapped soil hydrological properties combining soil maps with grain size analysis of a number of samples, and agricultural crops using multi-temporal classification of NDVI time series.

The assessment of irrigation performance in term of adequacy between requirement and allocation showed that CWR are much larger than water supply for entire area, this mismatch is improved in the beginning of the growing season by means of Irrigation water requirement (IWR) and even more using the net irrigation water requirement (NIWR) estimated using SWAP model. We expect that the availability of SMAP data products will significantly improve the reliability and temporal sampling of our indicators.