IRRIGATION WATER AMOUNT IN SEMI-ARID CROPLANDS USING TIME SERIES OF FORMOSAT-2 IMAGES

Duchemin B (1) *, Benhadj I (1), Hadria R. (1,2,3), Hagolle O. (1), Kharrou M.H. (4), Mougenot B. (1), Courault D. (3), Chehbouni A. (1)

(1) CESBIO - 18, Av. Edouard Belin (bpi 2801), 31401 Toulouse Cedex 9 – France. *duchemin@ird.fr
(2) Faculté des Sciences Semlalia, BP 2390, Marrakech – Maroc.
(3) UMR EMMAH, INRA, Domaine Saint Paul, Agroparc, F-84914 Avignon Cedex 9, France.
(4) ORMVAH, Avenue Hassan II, BP 2411 Marrakech 40000 Maroc

Semi-arid regions are subjected to strong tensions due to water scarcity. Effective management of this resource requires irrigation water to be known in terms of amount and origin (dam, river, ground). This information is difficult to monitor over large areas as farmers practices are heterogeneous. In this context, satellites designed to provide both high spatial resolution and frequent revisit may offer strong opportunities. Presently, the FORMOSAT-2 Taiwanese satellite is able to acquire every day high spatial resolution (8m in the multispectral mode) images with constant viewing angles.

In this context, the objective of our study was to estimate the amount of irrigation water in semi-arid croplands at a seasonal scale. The experiment - part of the SUDMED project (Chehbouni et al. 2008) - took place in an irrigated area of about 3000 ha located 40 km East of Marrakech in the Tensift plain (Morocco), where irrigated wheat is dominant. The region experiences low and irregular rainfall (on average 240 mm/year) whereas the evaporative demand is very high (around 1500 mm/year). Since rainfall and irrigation are limited hence evapotranspiration is the dominant term of the water balance.

The methodology was founded on the combination of a simple crop/water model and time series of FORMOSAT-2 images. The images were acquired during the 2005-2006 agricultural season with a nominal time step of 4 days with a constant viewing angle around 18° (Duchemin et al. 2008). The processing is based on a four-step procedure. Firstly, all images were co-registered and corrected from atmospheric effects (Hagolle et al. 2008). Secondly, time series of NDVI were analysed to map the land use and to derive vegetation biophysical variables. Thirdly, this information is used to control the SAFY vegetation model (Duchemin et al. 2008); this allowed to both monitor crop maximal evapotranspiration and to evaluate plant water stress. Finally, these terms were introduced into a soil-plant water balance model with the aim to simulate irrigation schedules, from which seasonal irrigation are calculated. The approach offers the advantage to not require any data on agricultural practices. This makes it very attractive for operational application at a regional scale.

The approach was evaluated with data provided by the regional office in charge of irrigation. The data set consists of amounts of dam irrigation water (observed irrigations, collected over 60 irrigation units) and locations of pumping stations (56 forages, for which the amount is not known). On spatial and seasonal averages, simulated irrigations were larger than observed irrigations by about 25%. The correlation between simulations and observations was low if all irrigation units were considered (R^2=0.5), but it was significantly increased when the areas with pumping stations were eliminated (R^2=0.8). In this case, the errors between simulated and observed dam irrigation water was around 10%. These results revealed the potential of the approach to evaluate ground irrigation water.

Chehbouni A., Escadafal R., Duchemin B., et al. (2008). An integrated modelling and remote sensing approach for hydrological study in arid and semi-arid regions: the SUDMED Program. International Journal of Remote Sensing 29:5161-5181

Duchemin B., Hagolle O., Mougenot B., et al. (2008). "Agrometerological study of semi-arid areas: an experiment for analysing the potential of FORMOSAT-2 time series of images in the Marrakech plain". International Journal of Remote Sensing 29:5291-5299.

Duchemin B., Maisongrande P., Boulet G, Benhadj. I (2008). A simple algorithm for yield estimates: evaluation for semi-arid irrigated winter wheat monitored with ground-based remotely-sensed data. Environmental Modelling and Software 23:876-892

Hagolle O., Dedieu G., Mougenot B., Debaecker V., Duchemin B., Meygret A. (2008). Correction of aerosol effects on multi-temporal images acquired with constant viewing angles: application to Formosat-2 images. Remote Sensing of Environment 112:1689-1701