



# SAMIR, "Satellite Monitoring of Irrigation"

*A tool for irrigation monitoring using remote sensing for landcover mapping and evapotranspiration estimation*

Simonneaux V. <sup>1</sup>, Métrel J. <sup>1</sup>, Kharrou H. <sup>2</sup>, Cherkaoui M. <sup>2</sup>, Duchemin B. <sup>1</sup>, Chehbouni G. <sup>1</sup>

(<sup>1</sup>) CESBIO (UMR 5126 CNES-CNRS-UPS-IRD), Toulouse, France, simonneaux@ird.fr

(<sup>2</sup>) ORMVAH – Office Régional de Mise en Valeur Agricole du Haouz, Marrakech, Maroc

**ABSTRACT** : The *sdmed* project, carried out by CESBIO (Toulouse, France) and University Cadi Ayyad (Marrakech, Morocco), is studying the hydrological functioning of the Tensift semi-arid Watershed (Marrakech, Morocco), to help monitoring its hydrological resources. The evapotranspiration (ET) of the irrigated crops of the plain is one of the major fluxes of this watershed, as it uses 85% of the total available water. To assess the evapotranspiration at the plain level (10000 km<sup>2</sup>), the « FAO » model is used (Allen et Al. 1998), because of the good trade off it makes between data requirements and results accuracy. ET estimation requires 3 types of data : (1) climate (to compute reference E<sub>T0</sub>), (2) land cover and (3) vegetation development stages (= K<sub>c</sub>). We describe here a software dedicated to the testing of various types of data input for ET assessment.

## Introduction

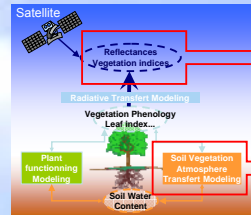
Irrigation is the world major water consumer, using about 65% of the resources. As more and more arid areas are facing water shortage problems, the design of tools providing with spatialized estimates of crop water balance is useful to ensure for a sparing water management. Evapotranspiration (ET) of the irrigated crops is one of the major fluxes conditioning the water budget. ET assessment basically requires information about climate, vegetation state and soil water content. Remote sensing is a major data source for vegetation study, including crop identification and development monitoring. High resolution remote sensing time series are now or will be soon available (SPOT, FORMOSAT-2, see Duchemin et al. in this issue, Venus (2009)). This type of data allow the monitoring of vegetation stages over large areas, giving access to development stage of vegetation, which are usually the critical point in estimating ET.

## Study area

The Haouz plain has a **semi-arid climate** : 240 mm annual rainfall, 1400 mm potential evapotranspiration (ET). Covered with about 150000 ha of irrigated crops (wheat and olive trees mainly), whose **evapotranspiration** is one of the main part of the water cycle of this watershed.

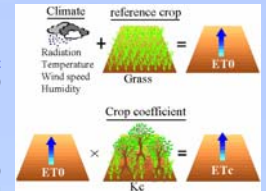


The **FAO method** (Allen et Al. 1998) was chosen here as it appears to better suit than complex physical based models, because of the better trade off it makes between data requirements and results accuracy.



FAO method is based on the multiplication of :

- a climatic component (E<sub>T0</sub>)
- a crop coefficient (K<sub>c</sub>) obtained from satellite data



## Objectives of the SAMIR tool

- Estimation of **evapotranspiration and water balance** of the crops
- Estimation of the **water needs, from daily to annual forecast**
- **Spatialization** of water balance

This tool was designed through a dialog with the office in charge of irrigation management (ORMVAH), and thus lead to a better understanding and a refinement of their needs regarding water management.

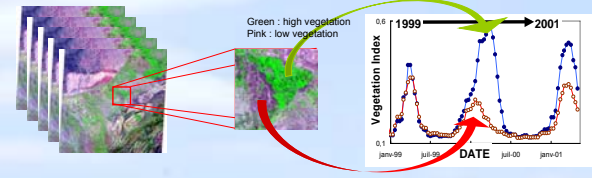
The **climatic data** is obtained from ground measurements or from meteorological model outputs, and is used to compute the reference evapotranspiration E<sub>T0</sub>.

The **land cover** in the area is complex, including trees plantations and annual crops, the latter being often associated as understories of trees. Thus, spectral confusions are frequent and specific remote sensing data analysis techniques were used to discriminate between 4 main crops types based on NDVI time profile analysis and also on very high resolution images texture analysis to identify trees.

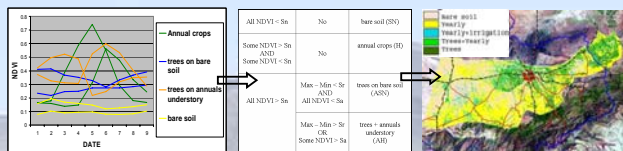
The **crop development** coefficients used by the FAO method (K<sub>c</sub>) were derived from NDVI time profiles using calibrated relations, and considering the land cover class of each pixel.

**Satellite images** provides with a regular synoptic view of the vegetation.

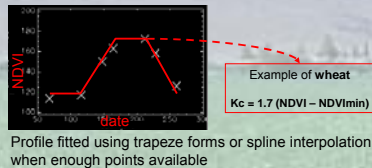
**Step 1 - Vegetation indexes** (e.g. NDVI) can be related to vegetation coverage



**Step 2 - Classification of NDVI time profiles** allows identification of 4 broad land cover classes

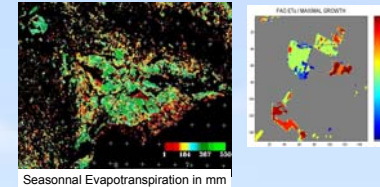


**Step 3 - Knowing landcover type**, the NDVI time profile from satellite can be related to the time evolution of the **crop coefficient** of the FAO method

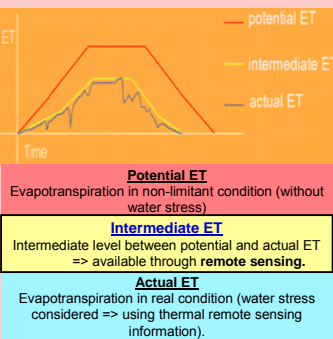


## Outputs

**Evapotranspiration maps** at the plain or plot scale

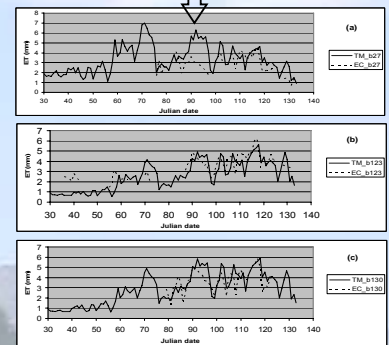


What kind of evapotranspiration is measured ?



## Validation

using ground measurements of water fluxes physical parameters (scintillometers and Eddy correlation systems)



Comparison of ET from Satellite and Eddy correlation measurements in 3 wheat fields.

Average difference is 27% at the daily scale but decrease to 18% at the weekly scale. The overall difference was 5% for the whole set of measurements (including 3 plots, total of 160 days)

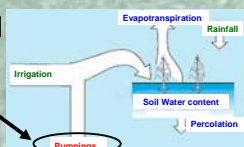
## Example of Application

$$ET + Percolation + \Delta \text{ Soil} = \text{Rainfall} + \text{Irrigation} + \text{Pumpings}$$

**Application to estimation of pumping**

The Haouz aquifer is overexploited

=> The spatialized estimation of pumping is one key information for managers of water



## Ongoing Developments

Towards a full water budget

=> Introducing a **soil module and irrigation / rainfall inputs**, for an improved accounting of water stress and soil evaporation

Developing **forecasting capabilities**

=> phenology extrapolation, based on statistical or model based extrapolation of crop development