Integration of Remote Sensing based Energy Balance Modelling with Soil Water Balance Modelling in Morocco

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[Soil Moisture modelling]

Topsoil moisture and its spatial and temporal distribution over the landscape is an important input variable in various landscape process simulation models e.g. evapotranspiration, crop growth, soil erosion, surface runoff and groundwater recharge.
Conventional models, however, are not able to accurately predict soil moisture patterns in space and time as they are calibrated and validated with point measurements with limited spatial support.
In this study a 3 layer spatial soil water balance model, using unsaturated gravity driven drainage and Penman evapotranspiration, is constructed with the PCRaster Python library (fig. 1) in order to predict soil moisture patterns in time for the 55 km² Sehoul study area, Morocco.

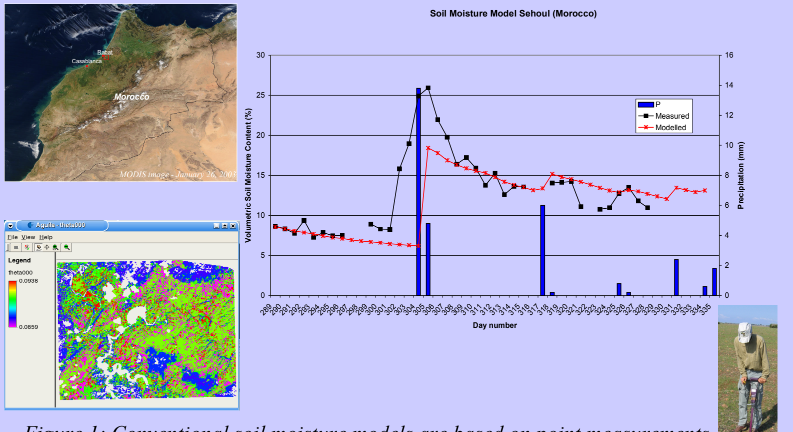

Figure 1: Conventional soil moisture models are based on point measurements

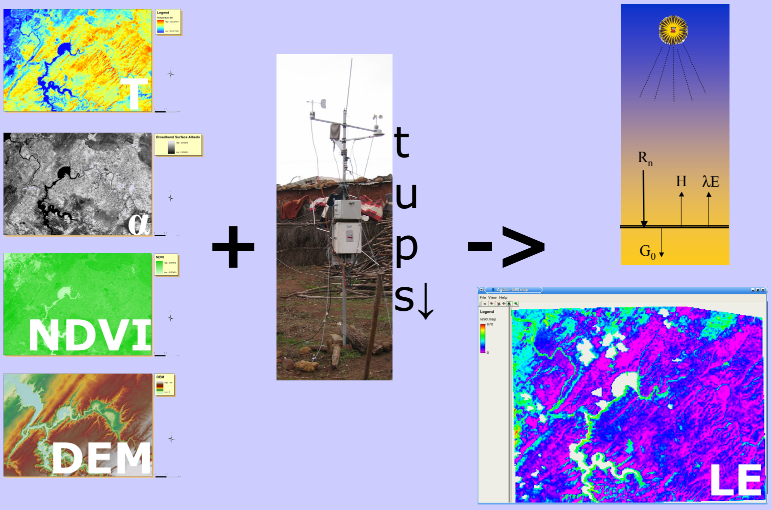

Figure 2: With SEBS, surface energy fluxes can be modelled from satellite imagery

[Remote Sensing]

In this study it is anticipated that the combined use of a GIS based simulation model and earth observation techniques will yield an improved prediction of top soil moisture.
The Surface Energy Balance System (SEBS) (Su, 2002) is used to estimate the evapotranspiration flux (fig. 2). SEBS requires three sets of input data: (1) Data derived from remote sensing (albedo, emissivity, temperature, fractional vegetation cover, Leaf Area Index, height of vegetation (or roughness height); (2) Meteorological parameters at reference height (air pressure, temperature, relative humidity, wind speed); (3) Radiation data (downward solar radiation, downward longwave radiation). Radiance and reflectance data acquired by the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) were combined with field measurements to derive the input parameters. In addition, a digital elevation model from the Shuttle Radar Topography Mission (SRTM) was used in the model. The model was validated with flux measurements from the ESA funded SPARC/EAGLE field campaign in Barrax (Spain) (Timmermans et al., 2005). In the study area no validation flux measurements were available.

[Integration]

The actual evapotranspiration modelled by the soil moisture model will be optimized by assimilating the actual evapotranspiration from SEBS during a satellite overpass (fig. 3). A simple optimal interpolation algorithm will be used first:

$$ET_{act,new} = ET_{act,sm} + \left(\frac{\sigma^2_{ETm}}{\sigma^2_{ET_m} + \sigma^2_{ET_0}} \right) \times \left(ET_{act,SEBS} - ET_{act,sm} \right)$$

This algorithm will be used to update the relative evapotranspiration factor in the soil moisture model:

$$\alpha_{E,new} = \frac{ET_{act,new}}{ET_{pot,sm}}$$

Later, more sophisticated data-assimilation algorithms will be applied. The resulting soil moisture predictions will be validated with TDR measurements in the study area.

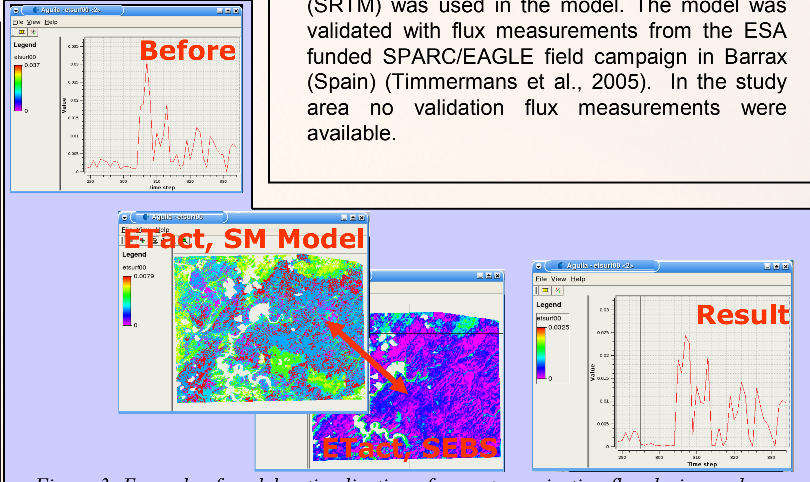

Figure 3: Example of model optimalization of evapotranspiration flux during and after satellite overpass

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