Crop water stress detection from remote sensing using the SSEBI-2 algorithm
A case study in Morocco

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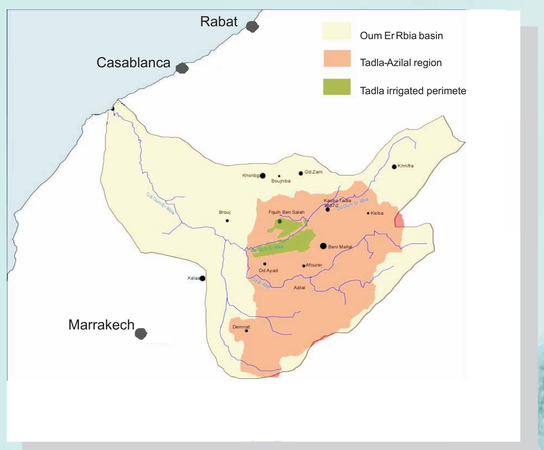
Water stress characterization using remote sensing

Quantification of Actual Evapotranspiration (ETa) at critical growth stages can be used to avoid water stress in crops. For large irrigated areas, remote sensing techniques are important tools for ETa assessments. The SSEBI-2 algorithm is applied to derive time series of actual and potential ET for the Tadla irrigation perimeter in 2006, based on 22 MODIS images.

Tadla irrigation perimeter

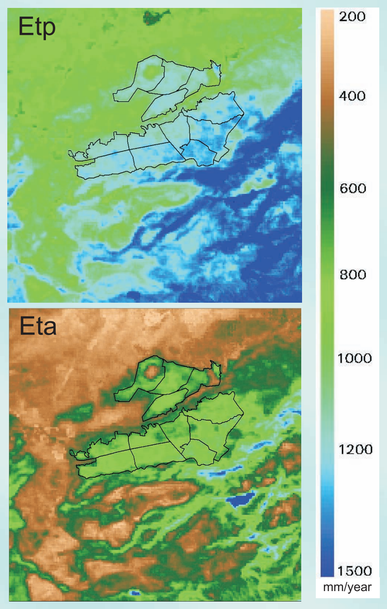
The Tadla irrigation perimeter is part of the Oum Er Rbia basin, some 170 km south of Rabat, Morocco. Tadla irrigates more than 100,000 hectares and is one of the most important agricultural areas in Morocco regarding its contribution to the Gross National Product. The perimeter is composed of two sub perimeters which are hydraulically distinct, Beni Amir and Beni Moussa. The area has an arid to semi-arid climate, receiving about 300 mm of rain annually, most of which is received during the winter rainy season from November to March. The main problems are high losses of irrigation water due to inefficient irrigation techniques, and groundwater over-exploitation, leading to a lowering of the water table in the area.

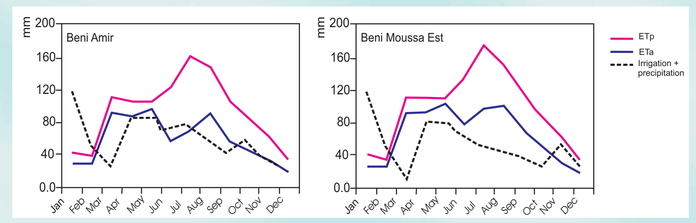


Results

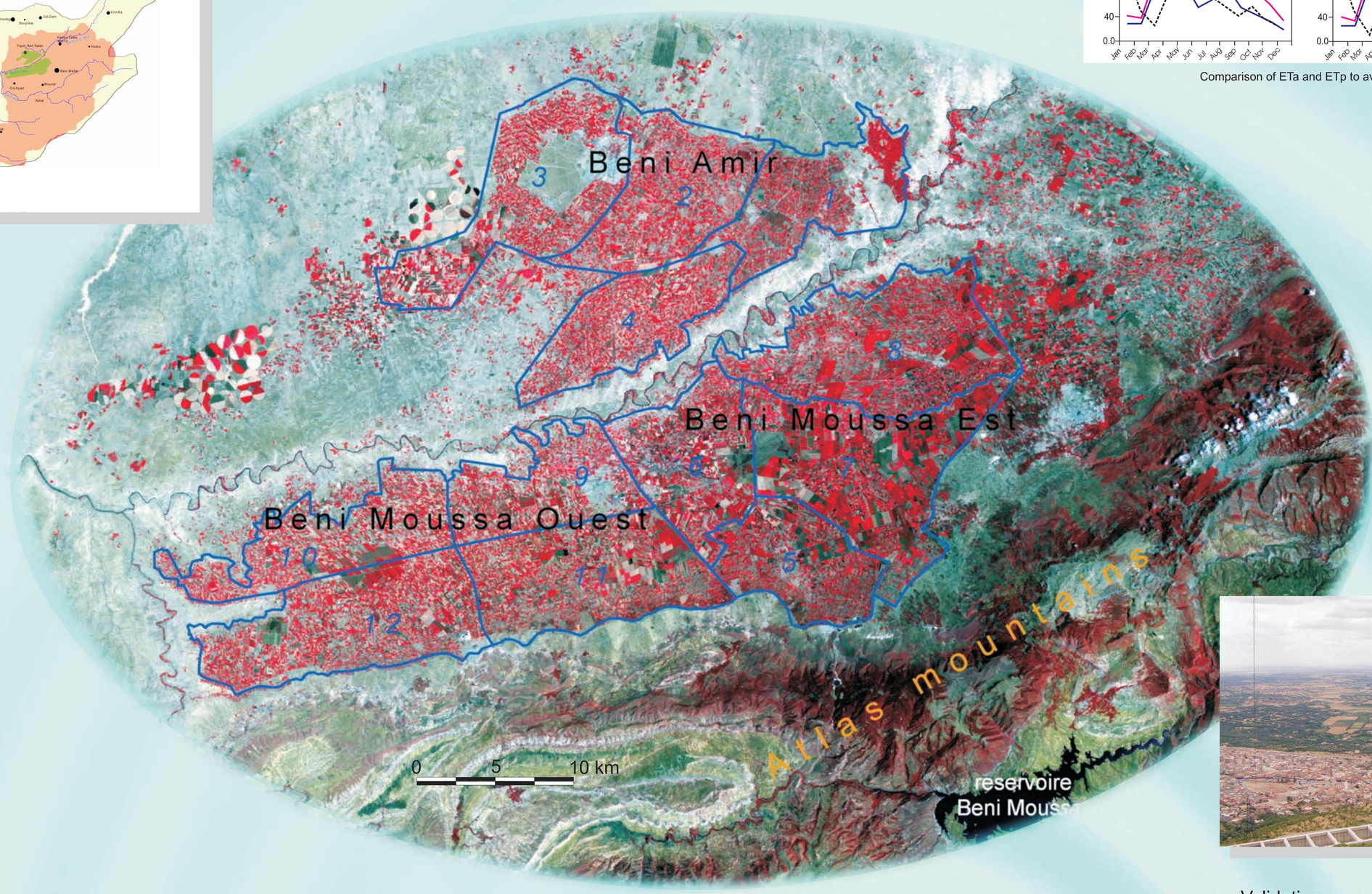
A comparison of monthly ETa and ETp reveals the occurrence of crop water stress in the Tadla perimeter during the summer months (June, July). The Beni Amir sub perimeter shows more severe crop stress than the Beni Moussa Est sub perimeter. This information can be used to improve irrigation strategies or to propose alternative cropping calendars.

Comparing water consumption to water availability, it is clear that more water is evapotranspired than is available from canal irrigation and precipitation. This demonstrates that another source of water is used for irrigation, namely groundwater. Especially in Beni Moussa Est the use of groundwater appears to be substantial; Almost twice the amount available from irrigation and precipitation was consumed in July and August.





Comparison of ETa and ETp to available water (Irrigation + Precipitation)



The SSEBI-2 Algorithm

The Simplified Surface Energy Balance Index (SSEBI-2) algorithm is developed to quantify evapotranspiration on the basis of satellite imagery. SSEBI-2 builds upon the earlier SSEBI model and performs a temporal integration of satellite images into a constant time series of daily ET maps. SSEBI-2 allows a quick temporal and spatial assessment of seasonal water consumption for large river basins or irrigation systems, with a minimum amount of input data required.

In a first step SSEBI-2 calculates the evaporative fraction (= part of the available energy that is used for the evapotranspiration process) from surface albedo and temperature images. Under the precondition that wet and dry areas are present in the images, two boundary lines can be drawn in a scatterplot of surface albedo and temperature, where the evapotranspiration is zero or potential and the evaporative fraction can be calculated as a temperature ratio:

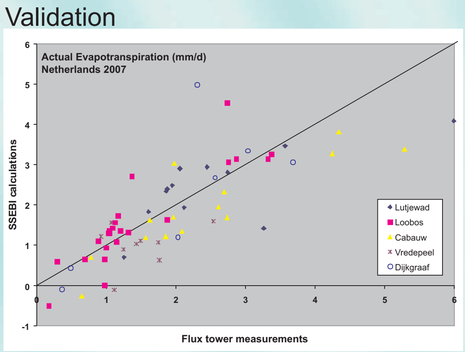
$$\Lambda = \frac{T_{dry} - T_0}{T_{dry} - T_{wet}} \quad \left(= \frac{\lambda E}{R_n - G_0} \; in\ energy\ balance\ terms \right)$$

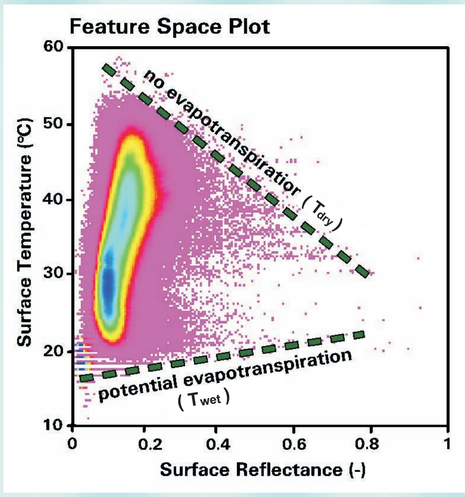
The next step is an interpolation of the available remote sensing maps (evaporative fraction, albedo, temperature) into daily maps. From this the daily evapotranspiration (ETa) is calculated. Since the evaporative fraction behaves constant during the day, ETa is calculated as:

$$ET_a = \Lambda R_n$$

where the daily net radiation (R_n) is calculated from remote sensing (albedo, temperature) and standard meteorological measurements (solar radiation).

Validation





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