Evaluation of an irrigation scheduling tool using spatial remote sensing

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Irrigated agriculture is facing new challenges as water resources become increasingly scarce, which is exacerbated by the threat of climate change. As a result, efficient irrigation water use, combined with reduced agricultural water demand, represents a significant challenge. Understanding crop water requirements is therefore critical to achieving this goal.

The main objective of this work is the study of an irrigation scheduling tool using spatial remote sensing; by conducting an evaluation on two levels: a socio-economic level through a field survey of potential users of the tool, confirming that the latter is a crucial or even preliminary stage in the development or evaluation of a new product, and a technical level through an evaluation of two approaches to estimating actual crop evapotranspiration, including the tool in question.

The socio-economic survey conducted on the Haouz plain was a part of a larger investigation focusing on all private and public stakeholders in agricultural water management; with the aim of complementing the technical expertise based on scientific information with a survey based on popular knowledge. Our study's main objective was to assess Moroccan farmers' desirability and perception of an irrigation management tool.

By conducting a qualitative survey through semi-structured interviews, we tried to identify all of the unfulfilled needs of a small sample of farmers, their practices concerning irrigation management, and their expectations regarding using a scientific irrigation scheduling tool.

The needs were multiple, but a need for more water resources was the most expressed. There seems to be a real awareness of the water table decline in the Haouz, but no individual responsibility for this decline.

Most farmers were very satisfied with their observational approach to irrigation decision-making, which explains the low interest in irrigation management assistance. Moreover, the need for irrigation control was expressed by a minority of respondents, but it seems that there is a possibility of opening up to greater irrigation management with an irrigation scheduling technology like Sat'Irr, and thus inverting the pyramid of needs, which requires even more water resources.

The second part of the study consisted of evaluating and validating two models for estimating actual evapotranspiration on a corn plot under drip irrigation and a semi-arid climate.

The two models use two different approaches, a surface energy budget approach (TSEB) fed by a radiometric surface temperature observation and which gives indirect information on the surface water status, and a surface water budget model (Sat'Irr) which is based on the FAO-56 double coefficient approach and the NDVI to predict the crop water status, but requires in return an exact knowledge of the water inputs, a quantity that can be achieved at the plot level but with difficulty on a larger scale.

The two models' simulations were run with local observations of rainfall and irrigation amounts for Sat'Irr, and Land Surface Temperature (LST) derived from the local net radiometer for TSEB. The results of both models were then compared to an eddy-covariance station's observation; installed during the 2021 winter agricultural season. Indeed, both models simulate ET quite well; the RMSE is always less than 1 mm/day, whether evaluated over the whole season or by phenological stages.

Slight deviations were observed under specific conditions, including a small overestimation of Sat'Irr during vegetation development and after water inputs (Bias=0.38mm/day), and a slight underestimation of TSEB (Bias=-0.37mm/day) during development related to the surface temperature measurement, which has high values as measured on bare soil, and this underlines the requirement for representative in-situ temperature measurements with high spatial resolution.

The results of the TSEB and Sat'Irr models remain remarkable, as they were obtained with parameter values that were not significantly adjusted from the literature; in addition to the specific growing conditions that affected the corn such as the weeds' spread throughout the entire season.

Finally, the performance of TSEB was evaluated when forced by the LST product of Landsat 8 and 9. With a significant difference of 3K between in situ and Landsat LST; a strong underestimation of the Latent Heat flux (ET) was noticed by TSEB. This issue is related to the nominal pixel's resolution of the Landsat surface temperature product (100m), which is considered big for our small corn plot; and therefore, could include nearby areas where the fraction of bare soil is more important.

In addition, it should be noted that due to the malfunction of the second Landsat-8 temperature sensor, the LST product is only available within 15 days, making it unusable for a near real-time approach.

Despite the small number of farmers who were surveyed; and some discrepancies in the TSEB modeling results, this work remains useful to

improve “Sat’Irr” as it’s being the tool in question, and here are the main suggestions:

To begin, a more extensive survey with larger sample size is required to better understand the needs of farmers who are considered the most important category of demanders of the tool; and their perception of this type of technology. Improving the survey’s methodology, particularly the questionnaire and data collection technique, will also be beneficial.

From a technical point of view, the TSEB model could help overcome the constraint of lack of data or uncertainty concerning water supply by irrigation at the plot scale, in particular by integrating the LST into the Sat'Irr model by assimilation. Last but not least, the result of the simulation of TSEB forced by the Landsat 8 and 9 LST highlights the importance of good spatial and temporal resolution, as well as the rapid availability of finalized products for use in near-real time. To date, the Landsat missions do not meet these criteria for the Haouz small area, but the future TRISHNA (CNES/ISRO) and LSTM (ESA) space missions may be able to meet them.