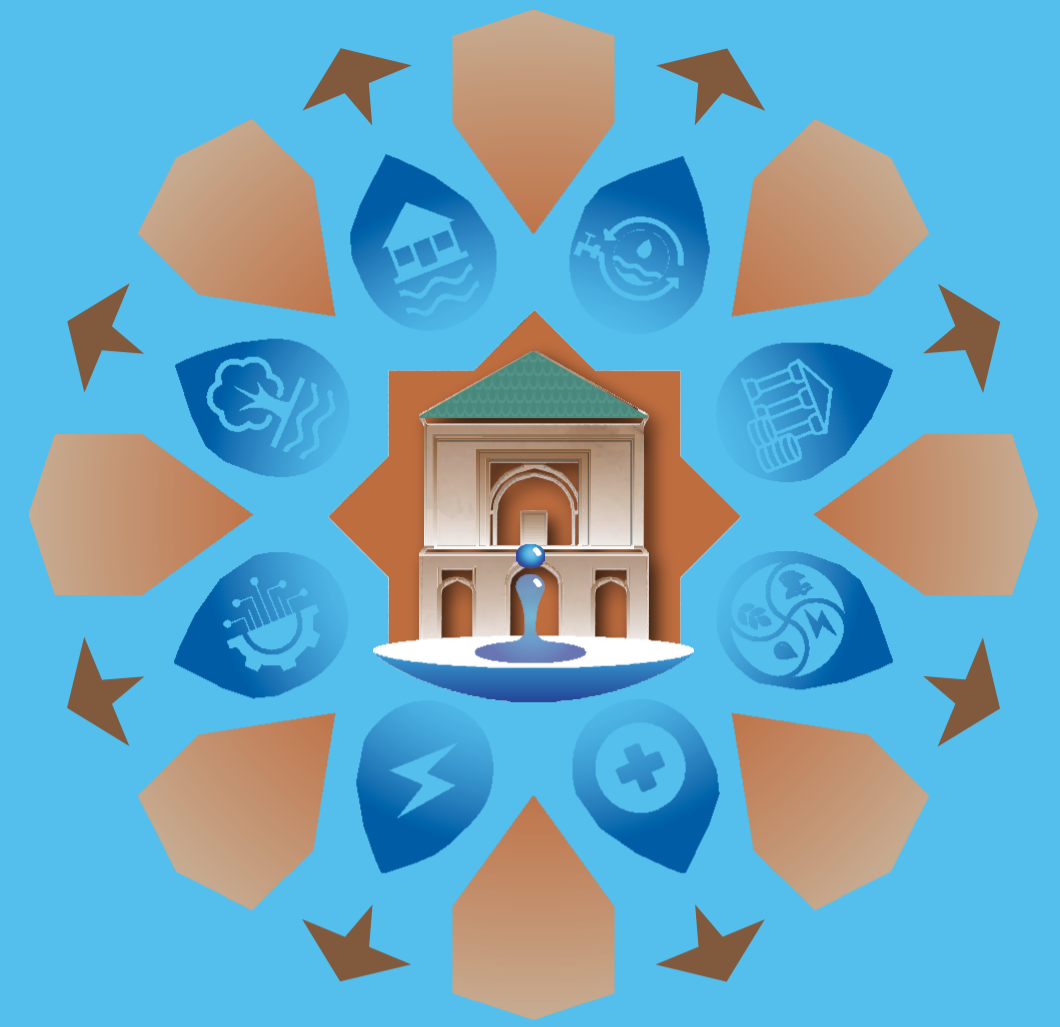


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Author's Name(s): Research Title: METRIC-2S: A Two-Source Model for Enhanced Partitioning of Evapotranspiration in Agricultural Landscapes

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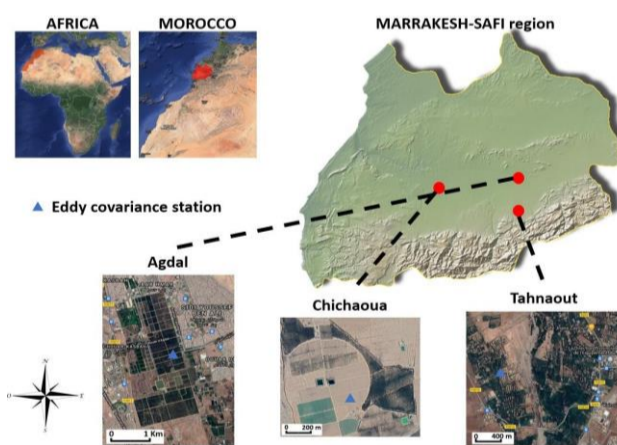
Introduction

Partitioning evapotranspiration (ET) into soil evaporation (E) and plant transpiration (T) is crucial for accurate water resource management. Traditionally, this has been challenging due to the complexity of the underlying processes. In this study, we develop an approach to enhance the Mapping EvapoTranspiration at high Resolution with Internalized Calibration (METRIC) model, enabling better partitioning of landscape-scale flux components. Named METRIC-2S, this approach introduces a two-source scheme into the original single-source model, using soil and vegetation temperatures for partitioning. These temperatures are used by METRIC to calculate two ET components, one for soil and another for vegetation, subsequently weighted by fractional vegetation cover (fc) to compute E and T. Soil and vegetation temperatures are estimated using the hourglass method, driven by surface temperature and fc. ET estimates from both the original METRIC and the revised METRIC-2S models are compared and validated against eddy covariance measurements over three agricultural sites: an olive orchard, a wheat field, and a mixed wheat/olive plantation. METRIC-2S demonstrates significant improvements in accuracy relative to the original METRIC model across all three sites, with reductions in RMSE from 141 to 63 W/m² at the olive site, 102 to 83 W/m² at the wheat field, and 180 to 78 W/m² at the mixed site. To evaluate the performance of the partitioning scheme, transpiration estimates were compared with available sap flow measurements at the olive orchard site on selected dates coinciding with a Landsat overpass, yielding an RMSE of approximately 22.3 W/m². While further verification and assessment of component values are necessary, the results suggest that the METRIC-2S approach strikes a good balance between simplicity and improved accuracy.

Study site

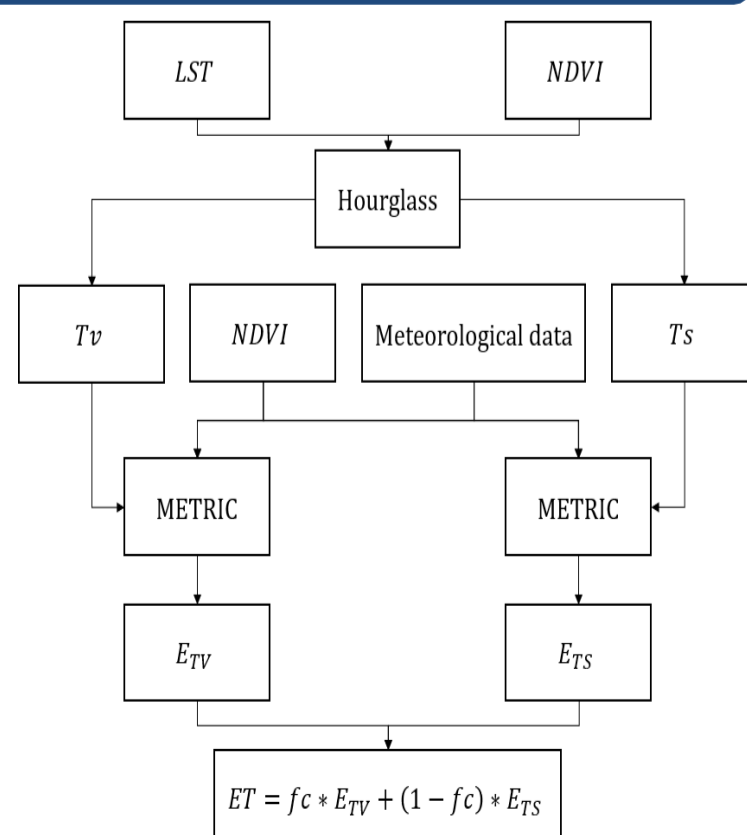
The proposed approach was evaluated over three study sites and covering a range of temporal periods.

- The Agdal experimental site was operated between 2003 and 2004 over an olive orchard situated southeast of Marrakech, Morocco. This field is mostly flat with an area of 275 hectares. Within the orchard, olive tree density averaged approximately 225 trees per hectare, with an approximate tree height of 6 m.
- The Chichaoua experimental site is situated in the Haouz plain in central Morocco, approximately 70 km west of Marrakech. Data collection occurred from November 2016 to May 2017 in a winter wheat field (variety Karim) with an area of around 1.5 ha
- The Tahnaout experimental study site was conducted over the foothills of the High Atlas Mountain neighbouring Marrakech in central Morocco. In this region the climate is semi-arid, characterized by limited and irregular rainfall throughout the study period. Tahnaout is planted with traditional olive trees and an understory of wheat.



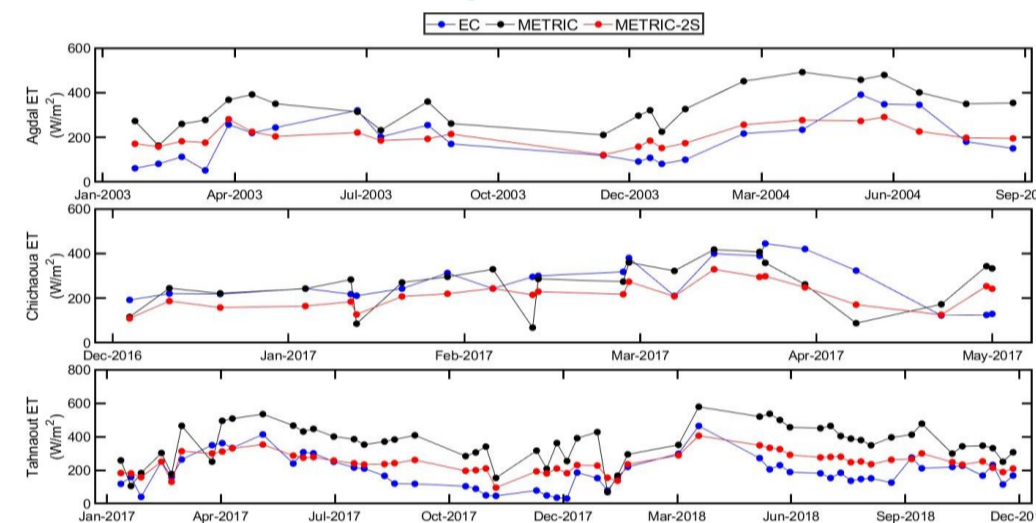
Methodology

The METRIC model forms the basic building block for the new METRIC-2S model presented here. METRIC is a contextual model using LST to compute the sensible heat flux (H) based on the hypothesis that the difference ΔT is linearly linked to LST. ET is then inferred as a residual term of the energy balance. In METRIC-2S, we extend this approach by partitioning ET into its two components E and T. To achieve this, we partition LST into T_s and T_v using the Hourglass method. T_s is used as input into the METRIC model instead of LST to estimate H_s , and ETS is calculated as a residual term of the energy balance. Similarly, T_v is used to compute H_v , and ETV is derived as a residual term of the energy balance. T is calculated by weighing ETV by the fraction vegetation cover (fc), while E is computed by weighting ETS by (1 - fc).



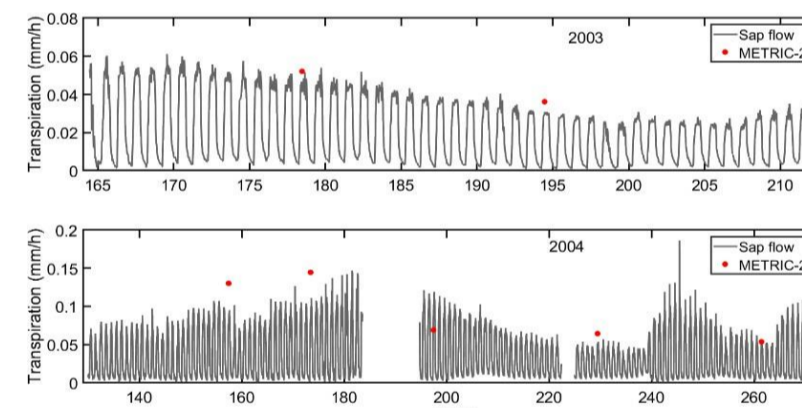
Results

Evaluation and comparison of METRIC and METRIC-2S



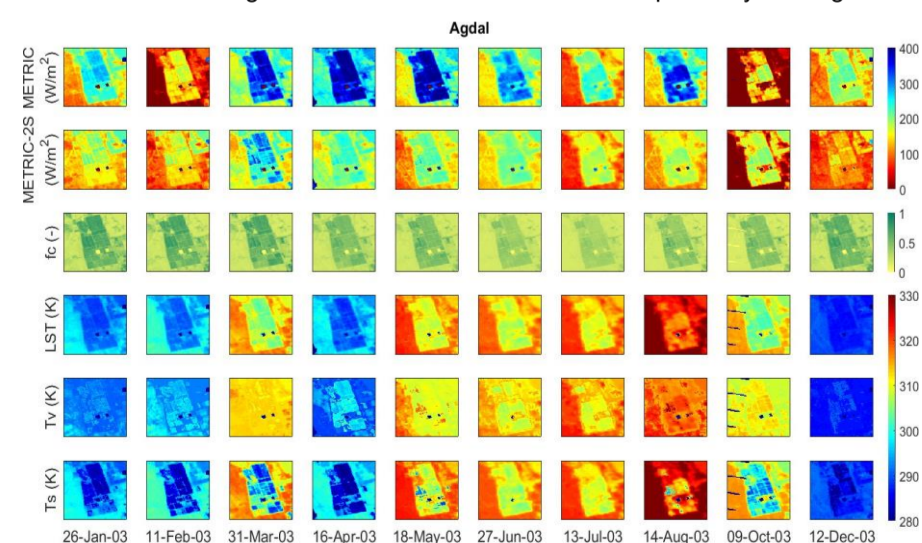
Temporal variation of EC-based ET measurement (blue) and ET estimated using METRIC (black) and METRIC-2S (red) over the three study sites and over satellite pass

Temporal variation of in situ measurements using sap flow superposed with the transpiration estimated using METRIC-2S over Agdal site.

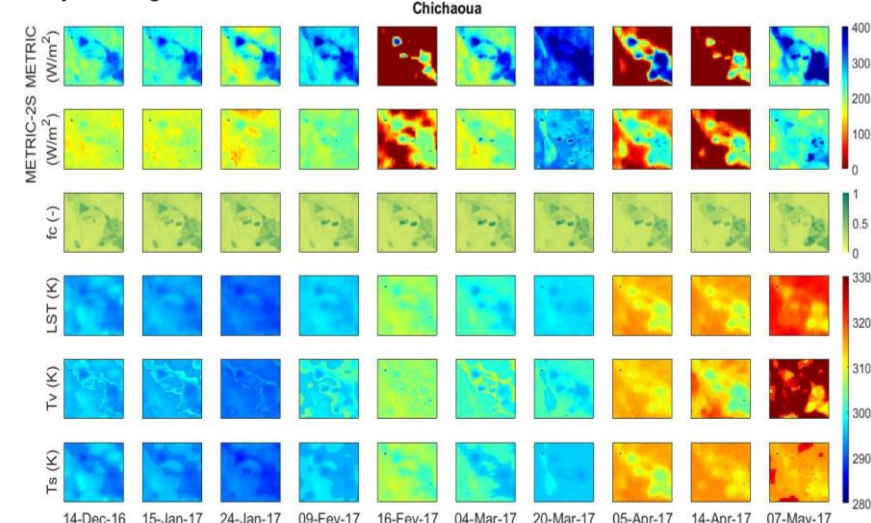


Mapping ET with METRIC and METRIC-2S

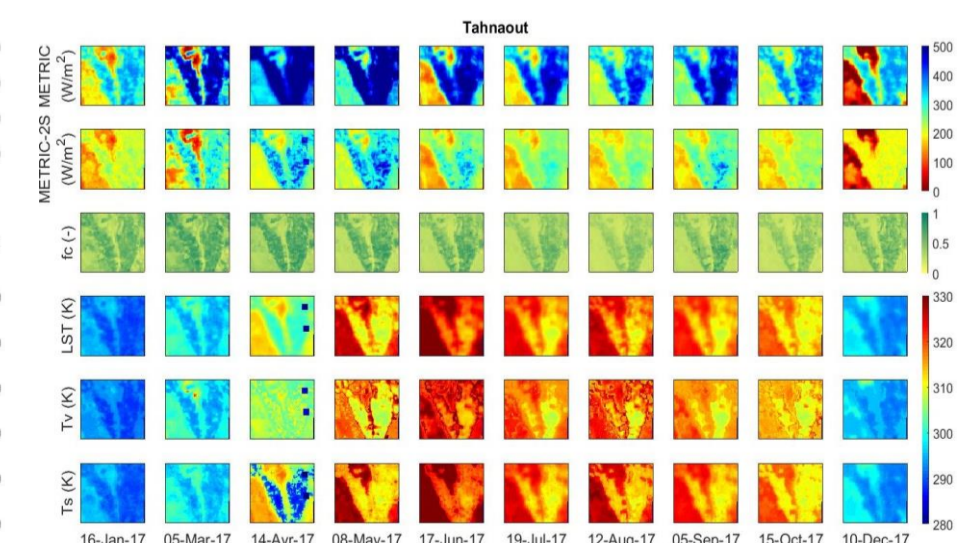
Spatiotemporal variation of fc, LST, T_s , T_v and ET predicted by METRIC and METRIC-2S over Agdal site at ten selected Landsat overpass days during 2003



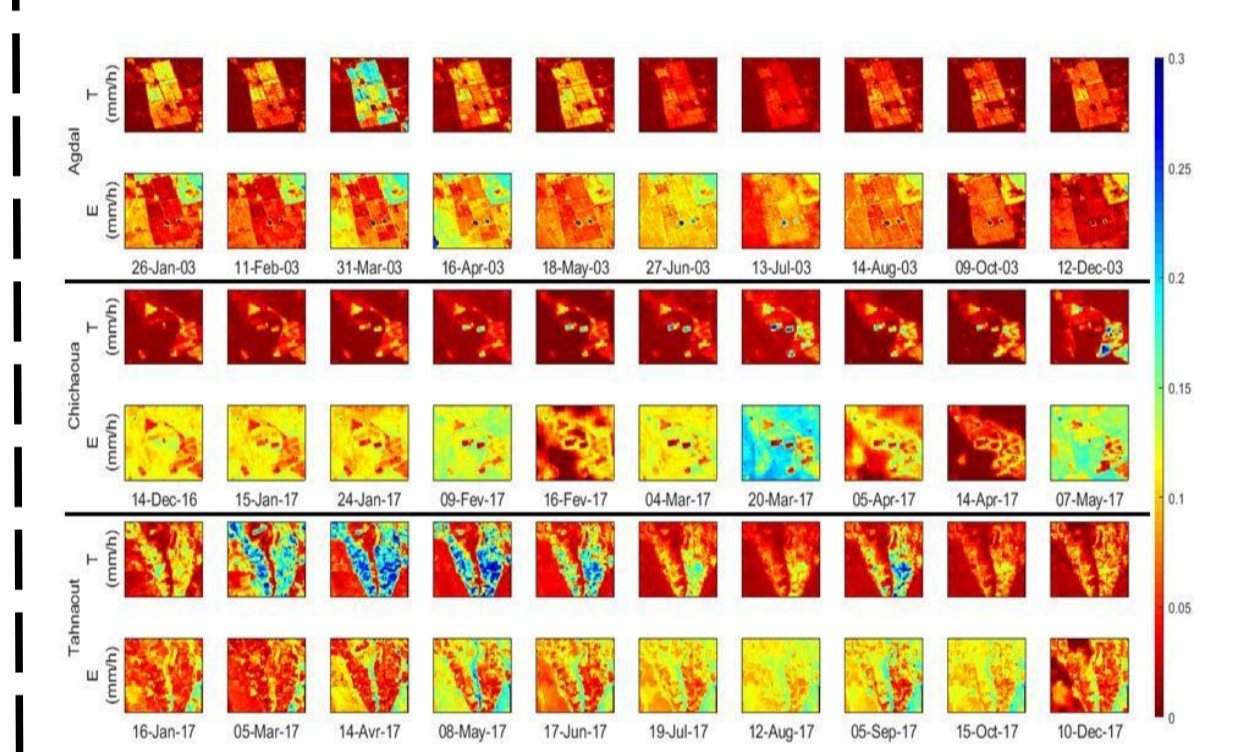
Spatiotemporal variation of fc, LST, T_s , T_v and ET predicted by METRIC and METRIC-2S over Chichaoua site at ten selected Landsat overpass days during 2017 season



Spatiotemporal variation of fc, LST, T_s , T_v and ET predicted by METRIC and METRIC-2S over Tahnaout site at ten selected Landsat overpass days during 2017



Transpiration and evaporation maps using METRIC-2S



Spatiotemporal variation of transpiration (T) and evaporation (E) METRIC-2S estimation over the three sites at Landsat overpass.

Conclusions

This work presents a new evapotranspiration (ET) model derived from the METRIC algorithm, by explicitly partitioning ET into its transpiration (T) and evaporation (E) components. Indeed, there are already energy balance models that provide T and E separately. However, these models are highly sensitive to LST accuracy which is their main input. METRIC is a contextual model that uses the spatial variation of LST and not its actual value, which is an important advantage given the difficulty to compute LST using satellites data. Consequently, to take advantage of the contextual method employed in METRIC, METRIC-2S has been proposed to measure the gain in terms of ET estimates while estimating each ET component separately.

The validation shows that the METRIC-2S model presents an improvement in the ET estimation compared to METRIC over the three sites. The transpiration estimated by the METRIC-2S model was validated using SF measurements performed at the Agdal field. The results for this validation are encouraging but more tests are needed over different crops and with a large number of measurements to ensure the accuracy of the model in the ET partitioning. Overall, METRIC-2S provides good estimations over sparse and heterogeneous vegetation cover. However, it shows less performance over dense vegetation which may be linked to the vegetation cover fraction accuracy. More validation sites are needed to understand the limitation of METRIC-2S and how its performance can be improved over different land cover. Finally, this approach is a good tool to generate accurate ET estimates and its components over different scales from the field to the continent especially, with the high temporal and spatial resolution of the satellites data expected from upcoming thermal missions such as Land Surface Temperature Monitoring (LSTM) and Thermal infraRed Imaging Satellite for High-resolution Natural resource Assessment (TRISHNA).