Direct measurement and indirect estimation of unsaturated soil hydraulic properties in Tunisian soils.

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1. ABSTRACT

The hydrological cycle is strongly affected by climate changes causing extreme weather events with long drought periods and intense rainfall events. To predict the hydrological functioning of Tunisians catchments, modelling is an essential tool to estimate the consequences on water resources and to test the sustainability of the different land uses. Soil physical properties describing water flow, are therefore essential to feed the models and need to be determined all over the watershed.

In order to complete this task, lightweight, cost effective but robust methods are needed. In the present study, both physically based and empirical models or pedo-transfer functions (PTF) have been used to estimate unsaturated soil hydraulic properties based on particles size distribution (PSD), and straightforward in-situ infiltration experiments.

The specific Pedo-Transfer Functions (PTFs) embedded within the Rosetta model, the physically grounded Arya-Paris model, and the Beerkan Estimation of Soil Transfer parameters (BEST) have been specifically developed to gauge soil hydraulic parameters based on soil texture, bulk density, and, eventually, outcomes from single-ring infiltration experiments. These models were applied to a diverse array of soil types from both Northern and Central Tunisia, with a subsequent comparative analysis aimed at evaluating their potential applicability and individual performances.

2. STUDY AREA

This study is part of a wider regional research program about water management in Mediterra-nean agricultural hydro-systems. It is located in two distinct Tunisian watersheds in Cap Bon and in Central Tunisia. The area experiences hot, dry summers accompanied by mild, humid winters.

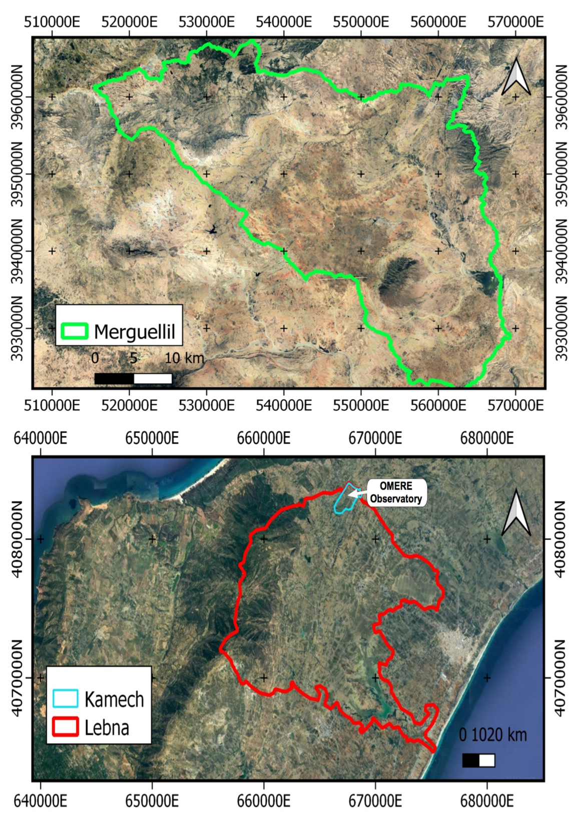

Figure 1. Location of the study area

3. METHODOLOGY

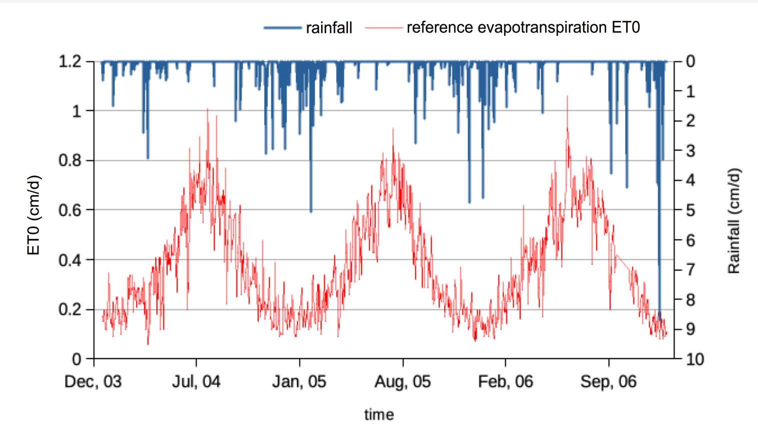

Figure 2. Daily rainfall and potential evaporation ET0 measured in Kamech weather station, used for modelling in HYDRUS-1D

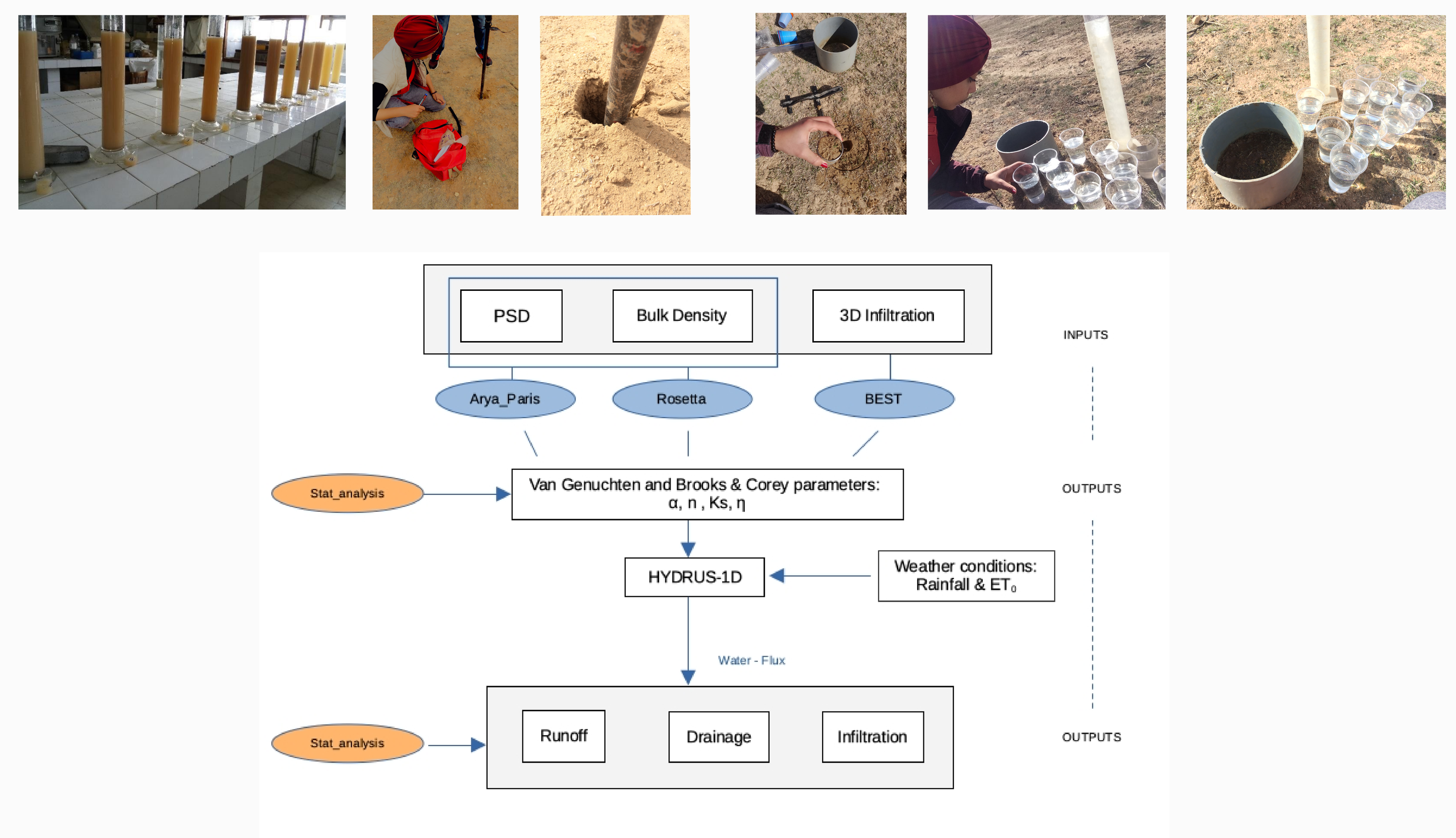

Figure 3. Experimental design plan. PSD is the particle size distribution and ET0 is the reference evapotranspiration

The estimated parameters derived from these models were incorporated into Hydrus to compute water flow in the vadose zone under the actual weather conditions prevailing in Tunisia. The resultant effects on the calculated water balance, encompassing infiltration, drainage, and runoff, were systematically compared for a comprehensive understanding of their implications.

4. RESULTS

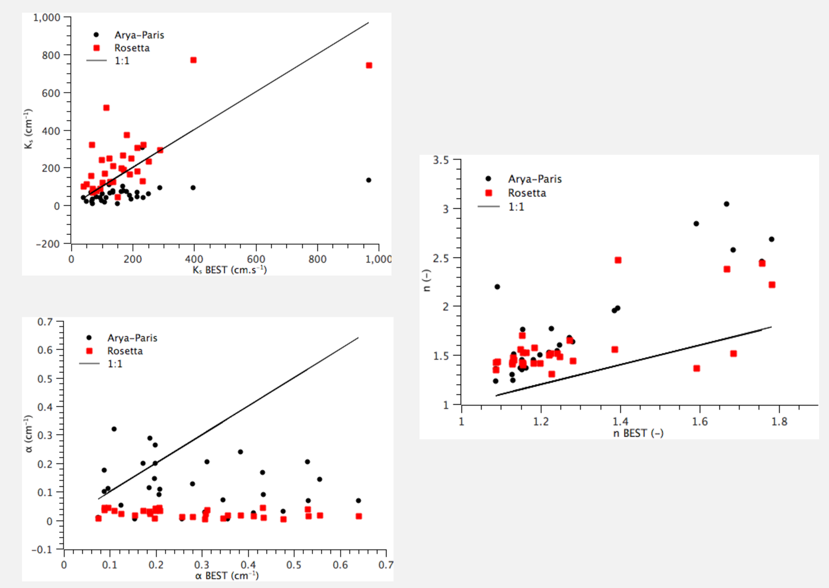

Figure 4. Soil hydraulic parameters determined by Arya & Paris and Rosetta methods versus same parameters determined by BEST method: a. scale parameter α, b. shape parameter n, c. saturated hydraulic conductivity Ks. The straight line represents equality

The calculated soil hydraulic parameters exhibited noteworthy variances across the various methods utilized, notably regarding the scale parameter α. There was no apparent correlation among the results from different methods, illustrating their independence. However, it remains challenging to assert the superiority of any specific method over another.

The secondary components, including evaporation and drainage, revealed slight discrepancies between the BEST and Arya-Paris methods, while Rosetta starkly delineated differences between physically based models and statistical models. Although it is not possible to establish a hierarchical classification, the modelling results demonstrate different behaviours depending on whether the parameters were derived from physically based methods or purely statistical approaches.

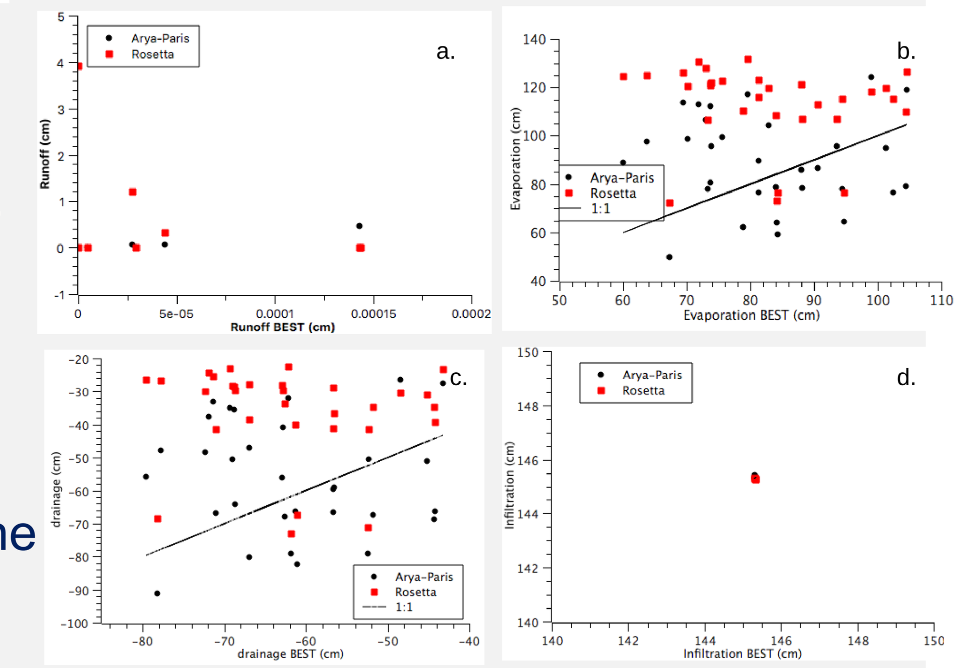

Figure 5. Modelling results for cumulative a. runoff, b. evaporation, c. drainage and d. infiltration for the different soil samples.

5. CONCLUSIONS

The sensitivity of soil hydraulic parameters for the three tested methods did not show the expected pronounced impact. In instances where various parameter evaluation methods were examined, the differences in the computed water balance with HYDRUS-1D did not consistently manifest substantial variations. In the context of this study, which relies on a dataset of smaller scale, the sensitivity of the parameters was found to be less pronounced. In contrast to many of other studies that predominantly relied on purely pedotransfer functions (PTFs), the BEST method employed in this work incorporates experimental infiltration measurements. Consequently, it likely encompasses a broader spectrum of influential factors that govern water flow in soil, such as soil structure derived from agricultural practices, usually not considered by PTFs.

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