

Modelling to Support the Observations of Surface Temperatures and Soil Water Content in Agrivoltaics

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1. Introduction

Climate change tends to increase the frequency of extreme weather events. As a result, more regions will probably face intense droughts and periods of abnormally high temperatures. Among the various crop services that can be expected from agrivoltaics, there are a reduction in the diurnal surface temperatures [1], [2], [3] and an improvement in the water balance [4], [5]. Although initial studies have shown some trends, there is still a lack of available data of these variables measured during field trials. As experimental trials often have many limitations in terms of resources, modelling can provide additional information for interpreting observations. This work therefore presents an initial attempt to supplement the understanding of surface temperature and soil water content measurements in a vertical agrivoltaic system with a modelling tool, the Python Agrivoltaic Simulation Environment (PASE).

2. Material and method

In 2023 and 2024, spring wheat trial was monitored in the vertical AgriPVplus demonstrator of Wallhausen, Saxony-Anhalt, Germany. Buriable soil temperature and humidity probes (TMS TOMST units) were installed at three depths along a transect in the middle of the demonstrator and in the reference zone in full sunlight. These probes measure the temperature and volumetric water content of the soil. These two years of spring wheat cultivation were reproduced in PASE, in co-simulation with the JavaStics crop model. Data from the weather station installed on the experimental site was used as input for the simulations, and soil analysis and crop management data were used to parameterise the model.

3. Results

Fig. 1 shows the results obtained for the year 2023 in terms of water content and soil temperature for the two zones and three depths. The RMSEs shown on the graphs indicate how accurately the model matched the experimental data. In general, the model underestimated the potential ground temperature reduction offered by PV modules, showing that this formalism needs to be improved. As the formalism used to calculate soil temperature in STICS is based on crop temperature, it is likely that STICS also underestimates the reduction in canopy temperature and the protection against heat stress. Observations showed a very low soil water content in the surface horizon of the reference zone compared with the agrivoltaic zone. Given the variability of these measurements and the lack of repetitions, confidence in them is low. The simulation, initialized to the water content at field capacity on day 1 of the year, did not show such a difference, meaning that the observations could not be confirmed. These results should be analysed in greater detail and using different calculation

formalisms to better understand the shortcomings of the model. Lysimeters should be used to obtain more reliable measurements of soil water content.

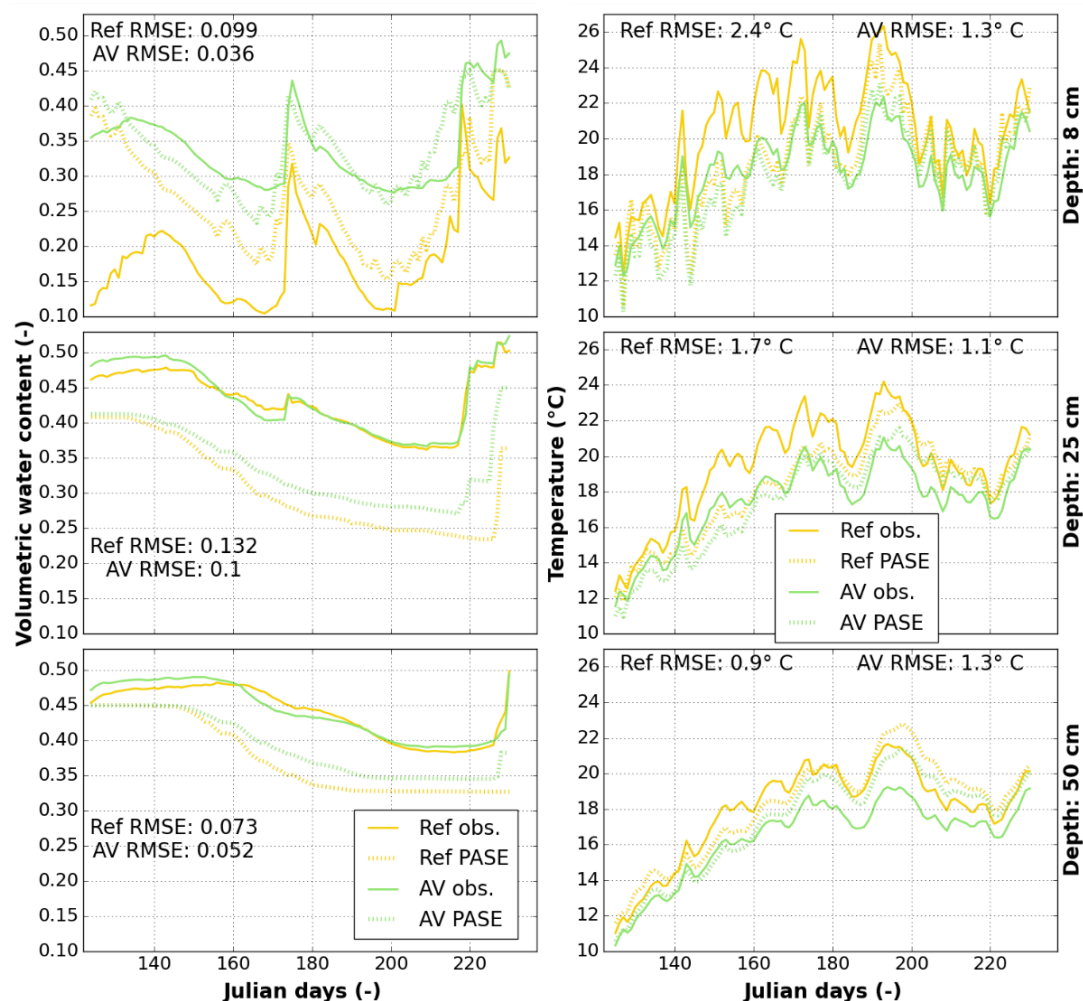


Figure 1. Simulated and observed soil water content and temperature at 3 depths in 2023.

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