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Hydrology and Earth System Sciences Discussions

Interactive comment on "Estimation of Mediterranean crops evapotranspiration by means of remote-sensing based models" *by* M. Minacapilli et al.

M. Minacapilli et al.

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Response to Referee #2

First of all, we would like to thank the Anonymous Referee for his accurate throughout revision of the manuscript. We recognize that the three major criticisms by the Reviewer are relevant and, as matter of fact, there are obscure points in the original manuscript regarding the scientific methods and assumptions made that, probably, were not extensively presented. In view to improve the future version of the manuscript, in present discussion, we will try to give some further details on the three major concerns highlighted by the Reviewer:

1. Reviewer comment: "what is the goal of the research?".

The research focuses on the comparison between two surface energy balance approaches (i.e. the one-source SEBAL model and the two-source TSEB model) to estimate the actual crop evapotraspiration in a spatially distribute way. Estimation of evapotranspiration in Mediterranean tree crop is a crucial emerging issue since these agricultural systems are more and more converted from rain-fed to irrigated conditions, with significant impacts on the management of scarce water resources in the interested regions. The choice of the most appropriate methodology for assessing water use in these systems is still an issue of debating, due to the complexity of tree crops canopy and root systems and for the high land fragmentation. The recently applied two-source approach should be preferred to the one-source approach under typical Mediterranean crops (the canopy structure of these tree crop systems poses doubts about the existence of linearity of the interpolating function used in the SEBAL algorithm), but comparisons are rare in literature and the traditional one-source approach is still the most widely applied. Again, the complexity of tree crop systems under study imposes severe limitations in the application of micrometeorological techniques for the validation of Energy Balance models, due to the canopy heterogeneity and limited fetch conditions for the crop plots extension (of the order of one hectare). In these conditions obtaining representative evapotranspiration measurements for a single crop by eddy covariance or scintillometry instruments is very difficult . The two different approaches have been compared with the results of the soil water balance model, considered as the actual "reference". This definition is based on the following assumptions: 1) the soil water balance approach is the main method to evaluate crop water use in these conditions; 2) the soil water model has been applied with detailed knowledge of most relevant processes and parameters; 3) the soil water balance results have been validated in three locations with in-situ measurements. As such, we consider that the ET estimates obtained by the soil water model are the best picture available of the hydrologic conditions of the tree crop system under study.

2. Reviewer comment: "my major concern when reading this paper is the fact that the spatial SWAP results are used as reference to compare the outcomes of SEBAL and

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TSEB"

The rationale for the choice of SWAP simulated evapotranspiration as a reference one is given above. This assumption will be clearly stated in the "Introduction" section of the revised manuscript. Furthermore, a more detailed description of the validation conducted for the three sites in the study area will be introduced in the "Study area and data collection" section and comments on accuracy of the model prediction will be given.

3. Reviewer comment: "no details are provided how the LAI is linked to Kc"

Given that the crop coefficient, Kc, is the ratio between the crop potential evapotranspiration, ETc, and the grass reference one, ET0, using the Penman-Monteith equation for calculating ETc e ET0, the following functional relationship can be obtained:

Kc = f(Rs, Ta, RH, u, rc, a, LAI, hc)

with Rs incoming short wave radiation, Ta air temperature, RH relative air humidity, u wind speed, rc minimum (non-stessed) stomatal resistance, a albedo, LAI leaf area index and hc canopy height. Meteorological data where collected in a weather station located within the study area and unique values of Ta, RH, Rs and u were considered. Following Allen et al. (1998) a unique value of rc equal to 100 s m-1 was considered. In the original version of the manuscript, we gave details on the procedure for deriving the spatial distribution of a and LAI from remote sensed imagery. The spatial distribution of hc was derived using a forth order polynomial of LAI that was experimentally calibrated for the study area (Anderson et al., 2004). According to this procedure, the spatial distribution of Kc is essentially linked to the spatial variability of a and LAI. Following the Reviewer's suggestion, further details of the procedure will be introduced in the revised version of the manuscript in order to make it clearer.

4. Reviewer comment: "I am not convinced that, if measured soil moisture is in correspondence with SWAP estimations, the estimated/calculated ET values are correct on

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those locations"

In general, we agree with the observation. However, in our application a low permeability layer is located at the bottom of the soil profile that induced us to set up a zero flux bottom boundary condition for our validation sites. Under this hypothesis, the water exchanges occur only through the upper boundary of the profile and the temporal evolution of soil water content in the root zone is mainly governed by rainfall/irrigation and evaporation/transpiration. If the simulated water contents in the root zone are in agreement with the measured ones, one should be confident that the simulated evapotranspiration fluxed are a good approximation of the real ones. To answer to the Reviewer observation, in the revised manuscript, the results of SWAP validation will be presented not only in terms of the scatterplot of figure 4, but also as temporal evolution of measured/simulated water contents for the validation period. Also, as requested, data for citrus field will be presented.

5. Reviewer comment: "I am not convinced that the SWAP model catches the spatial patterns of ET well since the parameterization may not be catched, but I cannot check this since no details are provided on e.g. the soil sampling and interpolation between the points"

Even if this is not well specified in the original manuscript, the following steps were followed for experimental sites selection: i) a detailed soil survey was performed and the soil texture was determined on more than 100 soil samples collected in the entire area; ii) on the basis of spatial distribution of clay, silt and sand, three experimental sites were selected; iii) ditchs were opened and undisturbed soil samples were collected at various depths in the three sites; iv) standard laboratory techniques were performed to determine soil water retention curve and saturated hydraulic conductivity; v) according to the low variability of soil hydraulic properties, unique soil hydraulic characteristics were chosen (Table 1). We are planning to introduce the lacking details in the revised manuscript. The selection of unique soil hydraulic properties for the three sites may seem questionable. In a former study, conducted in a wider area with different pedological characteristics (Minacapilli et al., 2008), simulations performed with SWAP resulted to be more sensitive to spatial variability of vegetation parameters than of soil hydraulic properties. Given the variability of soil hydraulic properties within the study area is far lower, we were confident in using this lumped approach.

6. Reviewer comment: "Thirdly, in section 4.2 the TSEB and SEBAL models are compared and very strong conclusions are drawn"

We agree that the conclusions are too strong considering that the comparison has been carried out only for a single day. Therefore we will modify this part in the revised paper. However it is to point out that we expected a better performances of the TSEB model compared with the SEBAL ones, because it is well known the greater reliability of TSEB in simulating fluxes over sparse canopy. As observed by other Authors (French et al. 2003; Gao and Di Long, 2008; Savige et al. 2005; Timmermans et al, 2007) the TSEB approach ..."provides a more physical framework for estimating spatial variability in aerodynamic surface resistance by directly considering the effects of varying vegetation cover amount on coupling between the soil and atmosphere through the soil resistances" (Timmermans et al, 2007). From this point of view our results, even for only a single day of comparison are in according with these considerations.

7. Reviewer comment: "Starting on Page 5, L25 the authors mention that the SWAP calculations should be taken as reference since no flux instrumentation was installed, since there was a high level of agricultural fragmentation. Firstly, in the study are only three types of vegetation present, I would not call this a high level of fragmentation"

We agree that on Page 5, L25 the term "agricultural fragmentation" not properly justify the difficulties to perform a reliable fluxes measurements. In fact the real problem is that, even if we have only three crop types, the size of the study area is 20 ha and the bigger crop type extension is approx. 10 ha (Olive). This extension is not sufficient to guarantee the appropriate fetch required for a reliable micrometeorological fluxes measurements. Under this point of view we can talk about "agricultural fragmentation".

However in some other part of the paper, the statement "agricultural fragmentation" was used instead of "sparse canopy". We will correct that in the revised version of the paper.

8. Reviewer comment: "Secondly, while mentioning this, is it acceptable to use SWAP, calibrated on soil moisture measured on three locations and upscaled using an LAI image, as a reference?"

See our reply in comments n. 4 and n.5. As mentioned before and considering the difficulties to perform a reliable fluxes measurements the choice to use an hydrologic water balance SWAP model as reference appears reasonable. Furthemore similar approach has been applied by other Authors (Kite and Droogers, 2000; Gao and Di Long, 2008). As explained in comments n. 3 we applied SWAP directly in a spatially distributed way using an approach to compute the spatial distribution of the crop coefficient Kc from remote sensing data. So we did not perform any upscaling procedure.

9. Reviewer comment: On P17, L3-4, the authors conclude from Fig. 7 that SEBAL underestimates ET compared to TSEB. What is shown here is a comparison between two models, and it can easily be argued the other way around that TSEB overestimates daily ET..

As we consider the SWAP results as reference and these outputs are in better agreement with TSEB estimations it is possible to talk about of "underestimation". We will modify the revised manuscript using the suggestion of referee as recommended in the comment "Manuscript organization".

10. Reviewer comment: Some observations regarding the maps of ET in Fig. 5 (SWAP), Fig. 9a (SEBAL), and Fig. 9b (TSEB): 1. ET in olive field O1, appears rather homogenous for SWAP and TSEB, SEBAL, however, shows significant lower ET in the Western part, roughly between citrus fields, C1 and C2. Is there an explanation for this?

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In the western part of O1 field the canopy is slightly sparser than eastern one. This affects the surface temperature spatial distribution values that, as consequence, are slight higher. SEBAL one-source approach consider these temperatures as canopy temperatures according with the "big leaf" scheme and, as a consequence, the computed sensible heat flux is higher that real one. Differently TSEB two-source approach splits the surface temperature values in the two soil/canopy components providing more realistic canopy temperature and then a more realistic ET assessment. Similar considerations can be carried out for the two citrus fields being the C2 field (orangery) sparser than the C1 field (mandarin).

2. Both TSEB and SEBAL depict lower ET values in the two vineyards, compared to SWAT. Can this be due to the way the upper limit of SWAP is determined (Eq. 21)?

No, in this case (pag. 18, lines 14-18) the underestimations of both TSEB and SEBAL models are due to much higher values of radiometric temperatures influenced by the bare soil rather than the canopy. Differently from Olive case, the initial development stage of vineyard on 16/05 with low LAI and a strong row architecture of the plants, does not allows a correct detection of canopy temperature of TSEB approach also in consideration of the pixel dimensions (3m x 3m) that resulted too coarse to capture correctly the raw structure of the plants.

3. Also in both citrus fields, the ET calculated by SWAP is high compared to the results of the energy balance models.

Yes, really ET calculated by SWAP resulted higher of about 1 mm/d respect to SEBAL and 0.5 mm/d respect to TSEB evidencing, also in this case, a better performance of the Two-source approach. Moreover the higher differences resulted in the C2 field where SEBAL underestimated ET of about 2 mm/d due to the sparser canopy. In the next version of the manuscript, as suggest by the reviewer, the results obtained on the two citrus fields will be analysed separately.

4. What explains the difference in ET between both citrus fields. Is there an agediffer-

ence, planting distance?

See the reply to the comment 10.1 and 10.3.

5.The ET in citrus field C2 is largely between 0 and 0.25 mm in the SEBAL calculations. This seems to be too low unless there is severe water stress on this day.

See the reply to the comment 10.1 and 10.3.

11. Reviewer comment: "Regarding Fig. 11: The standard deviations of the energy balance models are rather similar, the SWAP deviations are smaller. What does this say about the three models? Does SWAP catch the spatial variations that are present or do the energy models overestimate? What is the influence of scale?"

The smaller standard deviations values obtained by SWAP ET map reflected the smaller spatial variability of the Kc maps compared to the variability of all inputs parameters used in SEBAL and TSEB, especially the surface temperatures distribution characterized by an higher magnitudo. However, the results obtained in terms of average crop value can be considered reliable and not affect by a scale effect.

12. Reviewer comment regarding "Manuscript organization" and "Specific comment".

We are agree to all suggestions and specific corrections of reviewer. We will take into account in the revised manuscript version.

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