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Hydrology and Earth System Sciences Discussions

Interactive comment on "Determining irrigation needs of sorghum from two-source energy balance and radiometric temperatures" *by* J. M. Sánchez et al.

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First, we would like to thank the reviewer for his/her comment/suggestion since they have contributed to improve the paper. Appropriate changes have been made following each one of the reviewer's comments/suggestions. In the following, detailed and justified responses, as well as the corresponding modifications into the manuscript (with appropriate reference to particular page and line numbers) are given.

Answer to Comments:

Although the manuscript is clearly written, it falls short on meeting these objectives. In the first instance, there is insufficient supporting material to describe what has already been done for the simplified approach, and what is still needed. In the second instance there is scarce information about variable weather conditions aside from two illustrative cases (DOY 185, 236). What would be more significant would be an assessment of ET modeling accuracies for different weather cases.

Thanks to this referee comments we realized that some ideas had not been clearly expressed, supported or stated in the original version of the manuscript. For this reason, we have modified and completed some sections of the paper, but principally the introduction. From the beginning the objective has been set to the real aim of this work (page 3, line 30): "The main objective of this study is to present this method as a simple and feasible technique to determine short and long-term crop water use from thermal infrared radiometry and ancillary meteorological data, under clear and cloudy sky conditions and covering different stages of the crop development, that could be further used as an alternative to weighing lysimeters required to determine irrigation needs or to calibrate crop coefficient based algorithms."

The referee was totally right that scarce information about variable weather conditions was present. The study has been expanded and two additional examples have been considered. Now, the paper shows (page 9, line 17) "four examples…representative of a variety of cloud cover conditions: one cloud-free day (DOY 236), one fully overcast day (DOY 229), and a couple of partially cloudy days (DOY 184, 185)." Further assessment of modelled ET for different weather conditions has been added (page 10, line 18): "STSEB estimations of ET match the measured ET values under a wide range of vegetation cover fractions and cloudy sky conditions. Note that energy balance models yield ET values also under rainfall or irrigation conditions when the lysimeter measure is compromised. Two examples of this effect can be observed in plots 5b and 5c, where ET measured drops as a consequence of an irrigation event after 22 hours DOY 185 and due to a rainfall event between 12 and 15 hours DOY 229, respectively. Also, the quick response of the energy balance models to changes in environmental conditions can be observed in DOY 184, in which after a cloudy morning the sky clears between 12 and 14 hours before getting cloudy again (Fig. 4a). Figure 5a shows how modelled ET values peak for this interval, consequence of the increase in available net radiation, whereas measured ET does not."

"A significant shortcoming that can be corrected is the insufficient detail and motivational material for the study. There are now quite a few surface energy balance studies in the literature spanning a range of spatial resolutions. The case that needs to be made is why thermal infrared data are superior to what one can do with approaches such as FAO-56. Notably missing is the prime rationale for thermal data: detection of water stressed vegetation. If your vegetation canopies are not water stressed, simpler assessments of canopy cover , coupled with Penman-Monteith modeling ought to predict water use reasonably well. Thermal monitoring is now used in at least one commercial product, this needs some recognition."

Following this referee comment, some additional material has been added to the introduction section, stressing the utility of the surface temperature to detect water stress: (page 2, line 19) "The utility of the crop surface temperature to detect crop water stress has long been recognized, based on the fact that under stress conditions, the water transpired by the plants evaporates and cools the leaves, whereas in a water deficit situation, transpiration is scarce and canopy temperature increases (González-Dugo et al. 2006; Pinter et al. 2003; Gardner et al. 1992; Jackson et al. 1981). This theory has been used to develop indices that combine meteorological data with thermal remotely sensed information to provide relative measure of plant water status and health. The agricultural remote sensing literature abounds with examples of the application of thermal indices to schedule irrigations in various crops (e.g., Moran et al. 1994; Hatfield, 1983; Wang and Gartung, 2010)." Also (page 2, line 15): "...generic crop coefficients will not fulfill the need for precise irrigation applications, since they lack flexibility to account for temporal and spatial variation in crop water needs (Pinter et al. 2003), and specific crop coefficients need to be developed (López-Urrea et al. 2009a,b,c). This can be a limitation for providing spatially distributed regional ET information."

The authors are aware of many other recent studies, dealing with energy balance from remote sensing techniques, not included in this bibliographic review, but we tried to avoid overload distracting the reader from the main aim of this work. However, any additional study that the referee considers that should be included would be welcome.

The manuscript title suggests that irrigation scheduling is a background goal, but there is nothing in this study that discusses forecasting; this is all retrospective, or at best near real time.

We agree with the referee that forecasting is not really discussed in this paper. We just focus on the estimation of actual ET and thus crop water use. For this reason, the title has been changed: "Determining water use of sorghum from two-source energy balance and radiometric temperatures". We only mention in the conclusions that (page 12, line 24): "The presented methodology could be then used to estimate ground-truth ET values, as an alternative to weighing lysimeters, required to determine irrigation needs..."

Use of a crop growth regression model is not very satisfactory, you'd be better off using crop coefficients or heat units (easily measured).

The authors assume that the referee refers to plots in Figure 2. Both crop height and vegetation coverage are the two vegetation parameters required as inputs in the presented methodology. From the beginning of the paper this method is presented as an alternative to the FAO-56 and the use of the crop coefficients, so the authors do not understand the point of using crop coefficients? Also, the authors do not understand what the referee exactly means with heat units?

Details: Abstract: l 13: resulted in Last sentence too vague and uninformative.

This sentence has been changed: "Total accumulated crop water use during the campaign was underestimated by 5%."

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Introduction: L 21: particularly important

This has been corrected.

L 25: ‘energetic crops’ is awkward, how about crops with high biofuel potential?

This particular sentence has been removed, but the term “energetic crops” has been changed to “biofuel crops” in other parts of the manuscript.

L 26: change relevant to alternative

This sentence has been removed from the new version of the manuscript.

P3939, L1: Production of biofuel crops. . .that might compromise water conservation strategies.

Corrected.

L 4: crop is key to providing growers

Corrected.

P 3940, L 4: models may solve some of these limitations (I think J. Norman claims it is in fact solved, but current experiments indicate otherwise)

Changed.

L 6: No segue into this section? Why do we want to use STSEB? What are the alternatives?

This section has been modified and some additional explanation has been added for a better understanding of this idea (page 3, line 17): “. . .Sánchez et al. (2008) and (2009) showed the potential of a simplified version of the two-source energy balance model (STSEB), when direct measurements of radiometric surface temperature are available, in a corn crop and a forest ecosystem, respectively. In this paper, the STSEB model will be used together with thermal radiometry to determine ET values in a sorghum crop. . .”

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Probably we could have tried some other methods, but in this particular work we wanted to apply the methodology that we have been recently using with good results (Sánchez et al. 2008, 2009).

Study site and materials: L 24: how does this yield compare with typical values for the region/globally for forage sorghum?

A new sentence, and an online reference, has been inserted to answer this question (page 5, line 2): "According to MARM (2009), the average yield in Spain for irrigated forage sorghum results 3.8 kg m-2.". Unfortunately, no specific records are available for Castilla-La Mancha region.

P 3942, L 6: scale's beams?

This has been changed to the technical term "The balance-beam weighing system"

L 14: The resulting data were compiled..

Corrected.

L17: an older thermocouple model? Please verify field of view, newer models have half-angles of 18 and 22 degrees.

Yes, for this work we used an older model of Apogee. We have double checked and field of view is correct. For this version of Apogee (SI-211) field of view is 28°.

Model description: Eq. 2: what isn't mentioned (but should be) is that you can't get Tc and Ts uniquely from one view angle without an additional assumption. That assumption is critical to whether or not the resulting temperature provides any stress related information. The original Norman/Kustas model uses Priestley Taylor.

According to this referee comment, a new paragraph has been added after equation (2) (page 6, line 22): "Using equation (2), values of Tc and Ts can be retrieved from a system of two equations with 2 unknowns if measures of TR are available at two different view angles. However, an additional assumption is required when measures

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from the second view angle are missing (Norman et al. 1995; Sánchez et al. 2008).”

P3944: L 8: resistance units inverted

Corrected

Modelled ET A big reason for remote sensing for ET estimation is detection of early season water use. By the time the crop is at full cover the amount of water needed for the crop is known quite well. So missing the early season is a big drawback.

We agree with the referee at this point, but unfortunately for this experiment measurements of radiometric surface temperature started on DOY 174. But as stated at the end of section 4 (page 12, line 7): “This study will be further completed with the application to other biofuel crops such as sunflower and maize, with particular emphasis on their sparse growth phase.“. In fact we are right now carrying out a similar experiment in a sunflower field, where early season will be also captured, and hope to include these new results for a future work.

L 23: compromised

Corrected

P 3948, L 9: where are the predictions?

We agree with the referee that “predict” was not the right verb in this context, so it has been changed to “estimate”.

Fig. 6: If you intend to do regression analysis, the deterministic component needs to be on the x-axis, the stochastic component on the y-axis. As shown here, they are reversed and need to be switched.

Following this referee comment, x-axis and y-axis have been switched.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 8, 3937, 2011.

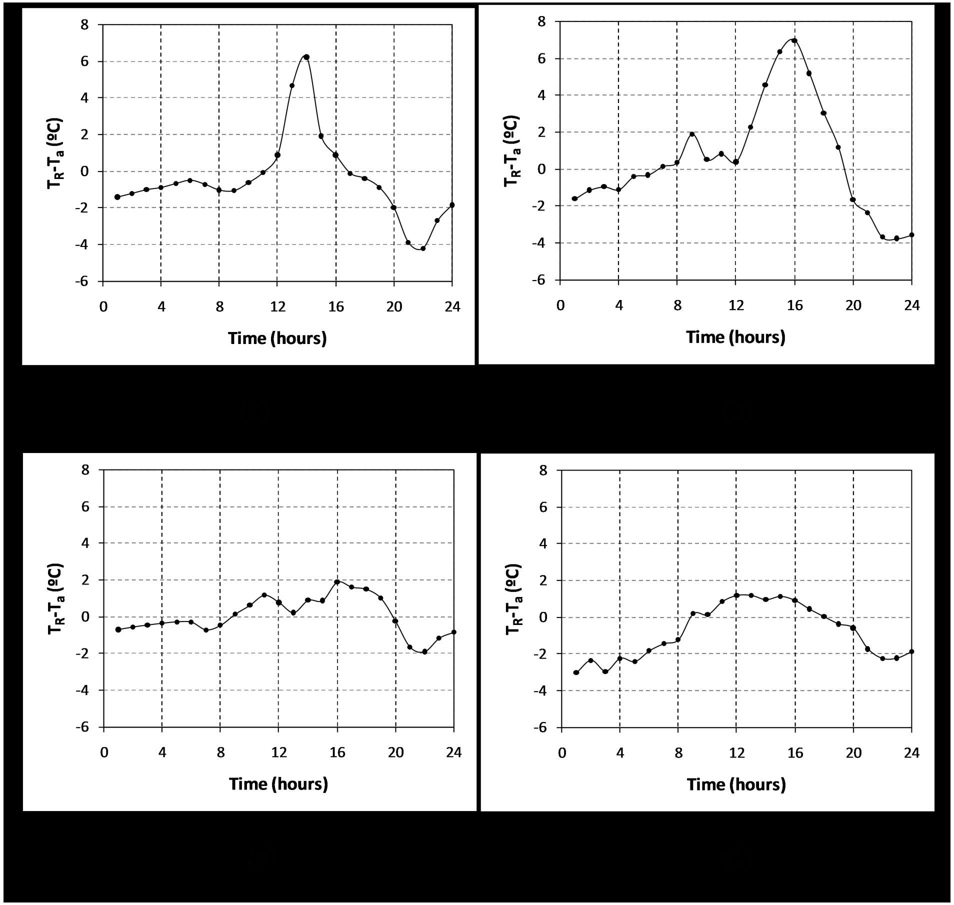

Fig. 1. New figure 3

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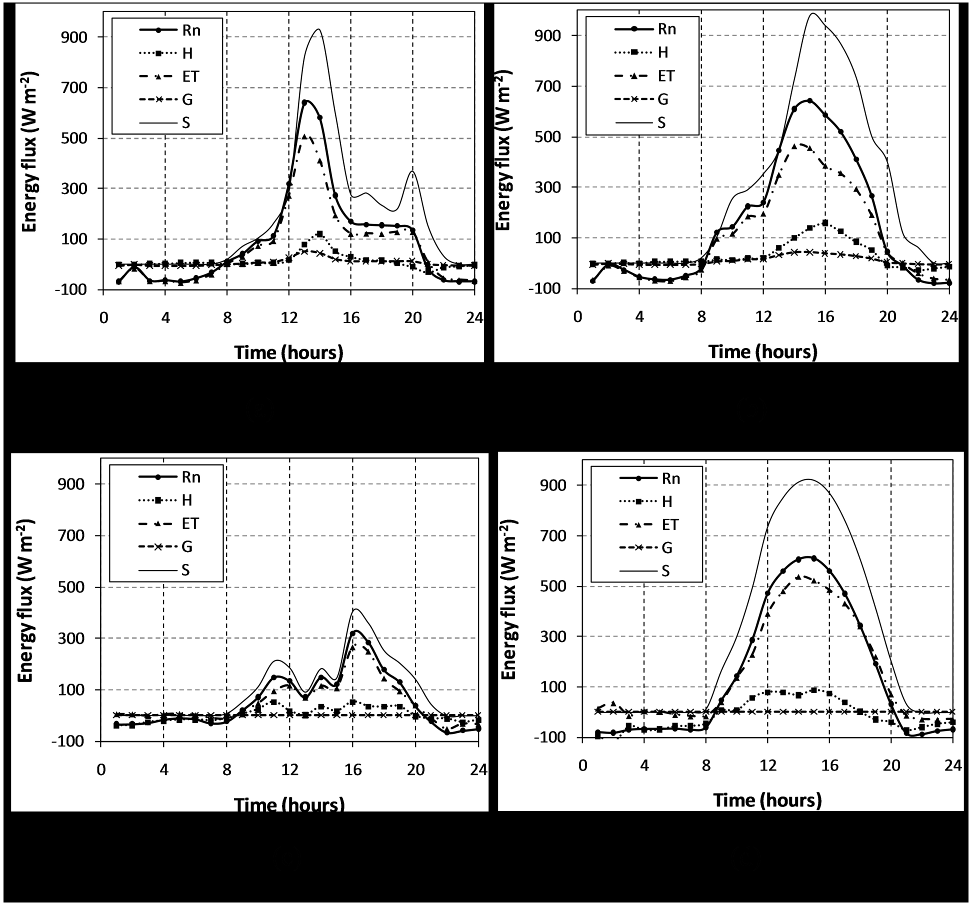

Fig. 2. New figure 4

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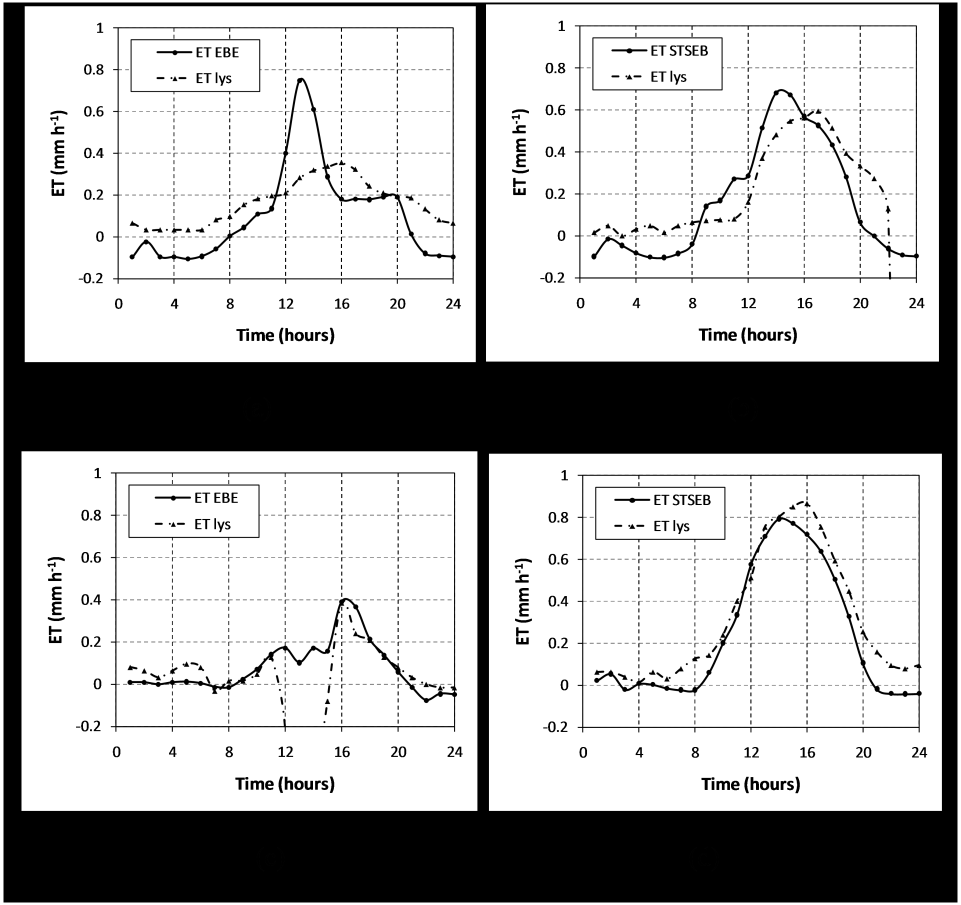

Fig. 3. New figure 5

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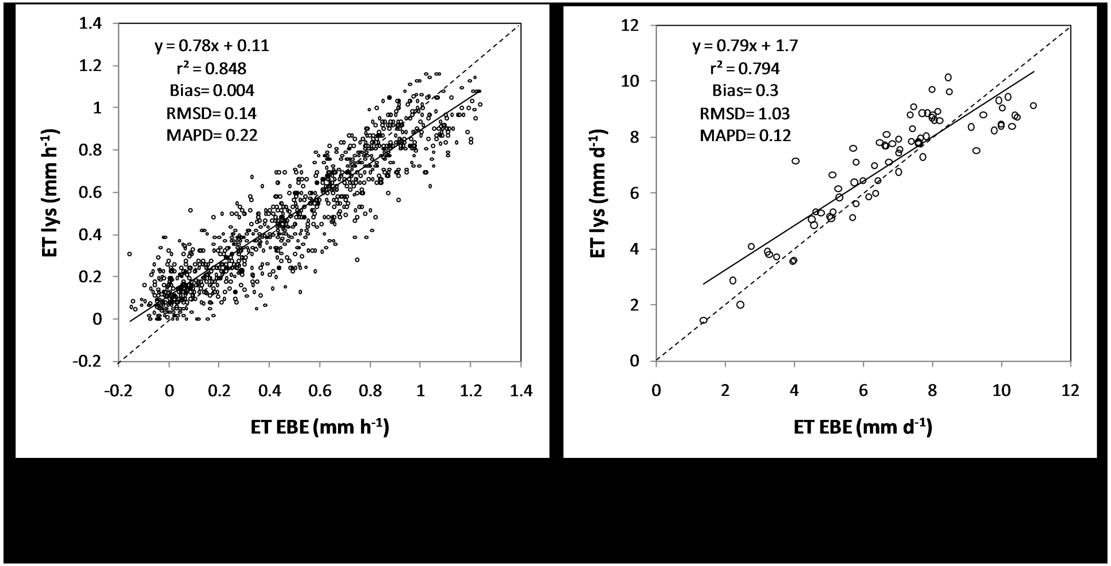

Fig. 4. New figure 6