Interactive comment on "Assessment of actual evapotranspiration over a semi-arid heterogeneous land surface by means of coupled low resolution remote sensing data with energy balance model: comparison to extra Large Aperture Scintillometer measurements" by Sameh Saadi et al.

Anonymous Referee #1

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Interactive comment on "Assessment of actual evapotranspiration over a semi-arid heterogeneous land surface by means of coupled low resolution remote sensing data with energy balance model: comparison to extra Large Aperture Scintillometer measurements" MS No.: hess-2017-454. by Sameh Saadi et al.

The Authors present an extensive work (reinforced by experimental data) aimed to assess the operational use of the Soil Plant Atmosphere and Remote Sensing Evapotraspiration (SPARSE) model and its accuracy by a comparison to the Scintillometric technique. I think that Authors address relevant scientific questions within the scope of HESS. Furthermore the paper is generally well organized and well written and there-fore the paper could be taken into account for the final publication after a moderate revision. Particularly, The Authors should improve the part of "Results and discussion" (pag. 16-20) with a better description of the validation of SPARSE model carried out with by comparing H and AE estimations with flux station and XLAS scintillometer (see comments n 7, 11 and 12). My comments and questions are as follow:

1. Lines 33-44: The Authors corroborated "the good correspondence between instantaneous H estimates and large aperture scintillometer H measurements" reporting RMSE values expressed in W m-2. As stated by the Authors (Line 418) "For hydrological applications, daily ET is usually required: : :." and in my opinion this means that for hydrological purposes the accuracy of daily evapotranspiration should be expressed in millimeters for day (mmd-1). Therefore in the abstract and through the paper this aspect should be considered and also critically analyzed. From my calculations the accuracy obtained by SPARSE model application should be around 1.6 mmd-1. Is this value "acceptable" ?

Response:

Indeed, we agree with Reviewer 1 that for hydrological purposes the accuracy of daily evapotranspiration (ET) should be expressed in millimeters for day, however, mentioned RMSE in the abstract and through the paper are instantaneous sensible and latent heat fluxes estimates at the satellite overpass time and are not daily values, therefore, they are expressed in W.m-2. Since, they are instantaneous data, it should not be converted using this formula:
*47.2 W.m-2*0.0864/2.45= 1.66 mm/day*
*43.2 W.m-2*0.0864/2.45= 1.52 mm/day*
Therefore, we get an instantaneous LE error of about 0.1 mm/0.5.hour around the satellite overpass (around midday, at the max. ET rate)
Later (section 6.5), when dealing with daily ET, all values are in mm.day^{-1}, indeed, the model daily ET estimates accuracy (RMSE= 0.7 mm/day) will be added as it was mentioned for instantaneous results.

2. Lines 87-88: Is "irrigation requirements" (generally expressed in mmd-1) a prerogative only "of RS-based SWB models" ? Please, clarify.

Response:

Irrigation requirements are mainly estimated using RS-based SWB models, since irrigation is a component of the water balance equation on which is based SWB models. Indeed, the crop coefficient method (FAO56 method) is currently the main method used for scheduling irrigations around the world (Glenn et al., 2007).
Irrigation requirement was rarely directly estimated using SEB models. Indeed, SEB outputs are generally actual evapotranspiration (its energy equivalent LE) and if Irrigation is estimated, it should be computed as a residual term of the water balance equation. Exception exists, for example, (Courault et al., 1998) used surface temperature derived from NOAA data and a SVAT model called MAGRET to find parameters linked to the irrigation over the agricultural region "la Crau" in South-Eastern France ; the predicted parameters were the beginning and the end of irrigation, frequency and water quantity diverted.

3. Line 108: ": : :at the beginning of the process". Please clarify.

Response:

I did not find this expression in line 108 of the last article manuscript version "hess-2017-454-manuscript-version3_discussion" to which I am referring. Indeed, in this last version, the mentioned phrase was rectified as follows: "at the beginning of the dry down".

4. Lines 111-112: ": : :the lack of information about the actual irrigation scheduling adopted by the farmers is the critical limitation for SWB modeling". I believe that var-ious SWB models (Swap, Cropsyst, FAO56, AcquaCrop) are able to consider both scheduled by farmer irrigation (as input) or predicted irrigation (as output). Please, clarify or modify.

Response:

Indeed, several SWB models such as Swap, Cropsyst, FAO56, AcquaCrop and also the SAMIR model that we have already used (Saadi et al., 2015) are able to consider both methods to take irrigation into account: either an estimated amount provided by the farmer (as an input) or a predicted irrigation with a module to trigger irrigation according to, say, critical soil moisture levels (as an output). We have to clarify this part by saying that the lack of actual irrigation scheduling information does not impact the irrigation estimation by these models, since irrigation could be simulated by SWB models, but rather the validation protocol of irrigation requirements estimates (irrigation data is usually unavailable).

5. Line 123: Insert ". . ." in dual-source models.

Response:

In the version to which I am referring this expression is already put in inverted commas (line 116): "However, separate estimates of evaporation and transpiration makes the "dual-source" models more useful for agrohydrological applications

6. Lines 152-154: Clarify that the "layer" approach of SPARSE is essentially a "dual-source" scheme.

Response:

The paragraph will be modified accordingly:

"In this study, (…) were obtained by the SEB method, using the "layer" approach (a resistance network that relates the soil and vegetation heat sources to a main reference level using a series electrical

branching) of the "dual-source" model; Soil Plant Atmosphere and Remote Sensing Evapotranspiration (SPARSE) (...)."

7. Line 187: The Authors should explain (also under a theoretical point of view) the choice to install Scintillometer at a 20 m height. About the experimental setup it is strange the absence of a "net radiometer" that, on the basis of the footprint analysis, could be installed in the average prevalent source area of footprint. The Authors could explain this fact.

Response:

The choice to install Scintillometer at a 20 m height was based on the XLAS installation principle detailed in the "Kipp & Zonen LAS and XLAS instruction manual", indeed, the minimum installation height of the XLAS as function of the path length and for different surface conditions is graphically explained and shows that for a path length of 4km, the XLAS height of 20m is an adequate height since the XLAS is high enough to minimize measurement saturation and not too high to be representative of the 4km path Boundary Layer.

The absence of a "net radiometer" is explained by the high heterogeneity of the study area vegetation cover; therefore, it is not possible to measure the net radiation (Rn) of all plots or even the Rn of enough "typical" plots (with similar land cover and irrigation practice).This will be explicited in the revised version.

8. Line 280: The terms "incoming solar radiation" and "incoming atmospheric radiation" are correct but could generate a misunderstanding. Please use the more classical "shortwave" and "longwave" terminology in eq. (9) and explain how RS data are generally used to solve balance equation of radiation (eq.9).

Response:

Indeed, in equation (9) the terms "incoming shortwave radiation" and "incoming longwave radiation" are used. This terminology should be also used along all the manuscript, hence, sections 3.3.2, and 4.2.3 should be corrected. This paragraph will be added accordingly:

In Eq. 9, Land surface temperature (LST), surface emissivity and albedo are generally taken from remotely sensed data, whereas, incoming shortwave radiation Rg and incoming longwave radiation Ratm are meteorological data.

9. Line 367: About the "Temporal interpolation of albedo and NDVI" some brief details could be considered.

Response:

Albedo MODIS products (MCD43) are available every 8 days and come from different satellite overpasses over a period of 16 days, the day of interest is central date.. Both Terra and Aqua data are used in the generation of this product, providing the highest probability for quality input data and designating it as an MCD, which means Combined product.

NDVI MODIS products (MOD13A2/MYD13A2 for Terra and Aqua, respectively) come from different satellite overpasses over a period of 16 days, and they are available every 16 days and separately for Terra and Aqua. Indeed, algorithms generating this product operate on a per-pixel basis and requires multiple daily observations to generate a composite NDVI value that will represent the full period (16 days), the 1km/16days MOD13A2 (respectively MYD13A2) product is an aggregated 250m/16 days MOD13Q1 (respectively MYD13Q1) product..

For both products, the data is linearly interpolated over the available dates in order to get daily data. For each pixel, the best data is taken into account (based on the quality index supplied with the product). Therefore, the temporal interpolation was done pixel by pixel.

10. Line 455: Which method has been used to evaluate the "potential conditions", please clarify.

The half hourly potential latent heat flux is computed using the prescribed mode of the SPARSE model (see (Boulet et al., 2015)). Indeed, potential conditions are expressed through the use of the efficiencies βs and βv which are functionally equivalent to surface resistances ("s" for soil, "v" for vegetation). Their range of validity is [0, 1]. If βv= 1, then the vegetation transpires at the potential rate, and if βs= 1, the soil evaporation rate is that of a saturated surface, while βv= 0 or βs= 0 corresponds to a non-transpiring or non-evaporating surface, respectively. Therefore, in full potential conditions, βs= βv= 1, while in fully stressed conditions, βs= βv= 0.

The above paragraph will be added to the SPARSE model description in the manuscript.

11. Lines 491-492: The Authors reported that . . ..."An overestimation of about 15% is found between estimated and measured daily available energy. . ..and the coefficients . . .. . .were applied to remove this bias". If I well understand the above procedure (re- move of bias) is a sort of calibration of the output of modeled on the basis of observed flux station. Please clarify.

Response: see response to comment 12.

12. Lines 526-527: About the estimation of sensible heat flux the authors reported that "This result is of great interest considering that the SPARSE model was run with no prior calibration", but I feel a sort of contradiction with the bias removing procedure described in the above comment. Please clarify. Moreover I think that the Authors should describe the accuracy of model prior and after the bias correction.

<u>Responses to comments 11 and 12:</u>

In fact, bias removal does concern neither the SPARSE model which was run with no prior calibration nor its estimates. Since the model provide a single instantaneous estimate of energy budget components, the global solar incoming radiation Rg was used to scale modeled AE and H from instantaneous to daily values (see section 4.2.3), the same applies to instantaneous available energy (see sections 3.3.1 and 3.3.2) computed using remote sensing and meteorological data (equation9) and measured H by the XLAS.
Indeed, the extrapolation from an instantaneous flux estimate to a daytime flux assumes that the surface energy budget is "self-preserving" i.e. the relative partitioning among components of the budget remains constant throughout the day. However, many studies (Brutsaert and Sugita, 1992; Gurney and Hsu, 1990; Sugita and Brutsaert, 1990) showed that the self-preservation method gives day- time latent heat estimates that are smaller than observed values by 5-10%. Moreover, Anderson et al. (1997) founded that the evaporative fraction computed from instantaneous measured fluxes tends to underestimate the daytime average by about 10%, hence, corrected parameterization was used and a coefficient=1.1 was applied. Similarly, Delogu et al. (2012) founded an overestimation of about 10% between estimated and measured daily component of the available energy thus, a coefficient =0.9 was applied. The Delogu et al. (2012) corrected parameterization were tested, since, in our study case also an overestimation between estimated and measured AE was found, but this coefficient did not give consistent results, therefore, we had to calibrate the extrapolation relationship in order to get accurate daily results of AE and H
Thereby,, the applied extrapolation method was tested using in situ Ben Salem flux station measurements. Indeed, daily measured AE (all the same for H) computed as the sum of half-hourly measured AE, was compared to daily AE computed using the extrapolation method from

instantaneous measured AE at Terra (equation 13) and Aqua (equation 14) over pas time. This comparison gave an overestimation of about 15% (for AE), hence, corrected parameterizations of available energy AE (coefficients summarized in Table 2) were applied to remove the bias between measured and computed AE (see sections 3.3.2 and 6.1).

13. Line 545: (Figure 7). Looking at the scatterplot it is clear a more dispersion for H value greater than 150. Is there an explanation of this?

Response:

Possible explanations are:

- i) *the XLAS measurement saturation; according to the "Kipp & Zonen Las and XLAS instruction manual", for a path length of 4km and a scintillometer high of 20 m, saturation measurement problem starts from H values of about 300 $W.m^{-2}$*
- ii) *Uncertainties on the correction of stability using the universal stability function*
- iii) *Potential inconsistencies between the area average MODIS radiative temperature and the air temperature measured locally at the meteorological station.*

14. Line 604: The Authors reported that "Daily observed and modeled ET over the whole study period were both in the range of 0-4 mm mm.day-1 which is consistent with the land use present in the XLAS pat". In my opinion this is a prosy comment, Trouble if not.

Response:

We agree with the reviewer 1, and the composition of the vegetation cover over the study area (above the scintillometer) with detailed land use percentage should be added to the study area section (section 2.1), in order to show that this area is almost covered by fruit trees spaced by a lot of bare soil, with less herbaceous soil-covering crops; which lead to this range of daily ET. These ET values range was also found in (Saadi et al., 2015) dealing with the same study area.

15. Line 616-617: The Authors reported that "Some points with little to null ET were recorded from May to July 2013 which can be explained by the very dry conditions and scattered vegetation cover with a considerable amount of bare soil". Why this behavior was not observed in the same period of 2014 ?

Response:

This behavior was not observed in the same period of 2014, because 2014 was a rainy year in comparison to 2013 (more rainfall peaks), so, even supposing that the farmers have the same attitude and cultivate the same crop types between the two years (which is not true in the context of our study area and farmers always change crop types), precipitations favor the growth of spontaneous vegetation over fallows which contribute to ET rise. On the other hand, since the year is rainy, hence, piezometrical level of the water table rises, leading to more water in boreholes and wells which encourage farmers to diversify the crop types and vegetation cover is therefore becomes dense, which contribute to an overall increase in ET.

16. Line 863: Please check the (Minacapilli and Ciraolo, 2007) reference.

Response:

This reference should be corrected as follows:

Minacapilli, M., Ciraolo, G., D Urso, G., & Cammalleri, C. (2007). Evaluating actual evapotranspiration by means of multi-platform remote sensing data: a case study in Sicily. IAHS PUBLICATION, 316, 207.

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