Hydrol. Earth Syst. Sci. Discuss., 10, C5440–C5449, 2013
www.hydrol-earth-syst-sci-discuss.net/10/C5440/2013/

Hydrology and Earth System Sciences
Discussions

Interactive comment on "FAO-56 dual approach combined with multi-sensor remote sensing for regional evapotranspiration estimations" *by* R. Amri et al.

R. Amri et al.

mehrez.zribi@cesbio.cnes.fr

Received and published: 8 October 2013

The paper "FAO-56 dual approach combined with multi-sensor remote sensing for regional evapotranspiration estimations" by Amri et al. describes an approach to better estimate the ET from vegetated surfaces by including soil moisture information in the FAO-56 method (via a new evaporation component) and to compare it against ISBAAgs model output over a site in Tunisia. This paper is a slightly different model to Er-Raki et al. (2010) and deserves publication. In the current form, this paper requires major revisions, as there are points that will need clarification or more detailed discussion.

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper

Answer: We thank reviewer for these constructive comments. We try to consider all the proposed remarks and comments. We try to clarify the aims of the proposed paper. We don't try to improve Er-Raki et al., 2010 approach, which is well validated. We try just to adapt it to regional scale for ET estimation, by considering remote sensing as input (for vegetation description through optical remote sensing and for soil moisture through active microwave remote sensing). At this regional scale, it is not evident to validate our simulations with flux local measurements. For this reason, we consider just a comparison with ISBA meteo-France SVAT model to illustrate the reasonable quality of simulations proposed by the simple approach considering FAO and remote sensing as input. Our results discussion will be improved (comments answer).

1) The results section is not much longer than the discussion/conclusion. Out of 8 pages of text, only 1 page has any results. The remainder is occupied by the introduction/ background, site/model description and conclusions. This is not sufficient. At the very least I would expect a study on the improvement over the Er-Raki et al. (2010) method. This is not given. All the reader is presented with is a comparison of two models. There is no validation reference other than the land surface model, nor is the said comparison against previous model versions presented. This is necessary in order to understand the level of improvement that may be achieved using the extended methodology, as presented in this paper. Answer: We agree with reviewer, we will add more details for results and particularly a discussion of different figures. Nevertheless, it is important to note that the objective of this paper is not to improve Er-Raki et al., 2010 approach. Er-Raki et al developed the FAO dual approach with an important database, at a local scale. He considered effects of vegetation and soil moisture for modeling of vegetation transpiration and soil evaporation. In this paper, the principal objective is to consider a regional analysis of application of FAO dual approach. Our objective was to illustrate the capacity of the FAO approach to estimate evapotranspiration at regional scale, and not only for irrigation applications. For this reason, we consider remote sensing input. We consider the use of NDVI as discussed in different proposed studies, for a precise estimation of crop coefficient, but we add also soil moisture estimated

HESSD

10, C5440–C5449, 2013

from microwave satellite products. Comparison with ISBA is certainly not sufficient, but it allows to show the coherency of this simple approach with ISBA-A-gs SVAT approach (proposed by meteo-France as an operational tool), and then the capacity of this type of approaches to be used not only for irrigation management. 2) The motivation as to why the Merlin et al (2011) methodology was chosen to be included is not clear. Er-Raki et al. (2010) presented a very well working method, using simply NDVI. The authors need to make a stronger point to include a surface soil moisture product, as well. In particular, as they point out towards the end, that this product only provides 2-3cm of the top soil moisture.

Answer: Er-Raki et al. use only NDVI, but only for estimation of crop coefficient and then vegetation transpiration. If we consider soil evaporation, without considering local moisture measurements or a modeling, remote sensing could be a useful tool. For example, ASCAT and SMOS moisture products are now tested as input for different SVAT models. For our site, considering soil evaporation is essential because of important fraction of bare soil and dispersed vegetation cover. Different studies have proposed relationships between surface soil moisture and evaporation level (Chanzy et al., 1995, Merlin et al., 2011). So, we apply the relationship of Merlin et al., 2011. Soil moisture products are considered for the first 5cm. However, we consider the first 2-3 cm as the most contributive to radar signal. 3) (p. 8119, l. 10-18) I am not clear of your motivation. This is not a strong argumentation to introduce a new index into the model. I think that a better argument could be formed around the more reliable availability of microwave products as opposed to optical ones. Answer: Using soil moisture products, we try just to estimate Ke evaporation index, without considering local measurements or a modeling approach. We consider moisture products to consider the regional aspect through spatial and temporal variations. Nevertheless, the NDVI still indispensable for estimation of Kcb and vegetation fraction parameters. We consider the two products for two different roles. NDVI is considered for vegetation transpiration and moisture products for improving soil evaporation description. We will try to clarify this point in the text.

HESSD

10, C5440–C5449, 2013

4) (p. 8119, l. 26-29): the issue there is with optical data products is that they may saturate. This should not be a problem in semi-arid environments, but the general implications should be discussed. Answer: Yes, optical data products may saturate. This is clearly observed for example for cereals at field scale, with an approximate stabilization of NDVI index for LAI higher than 2. At low resolution scale, saturation is not observed because of mean analysis over areas with different vegetation density. However, it is important to note that saturation of satellite data could induce error for high Kcb values.

5) Introduction: Overall, the introduction lacks some depth. There is no clear distinction at this point that would suggest why the original method by Er-Raki et al. (2010) should be improved. What is also lacking is a broader discussion of other papers that have used the FAO-56 method (or similar PM methods) with remote sensing data. A brief list with suggested references can be found at the end of this review. Answer: Yes, we agree that the first version was not enough clear. First, we will add in introduction a review of proposed scientific approaches using FAO and remote sensing. Second, this paper has not as objective to improve the approach of Er-Raki et al. but as we write before just to propose a simplified approach to estimate regional scale evapotrasnpiration.

6) (p. 8122, l. 7-18): Be more specific about how those parameters were derived. Yes
7) (p. 8124, l. 21): what is the error term in detail, and how did you quantify it for this study? Here we explain the equation 2:

The error term is the squared differences between the assigned signature of NDVI for each class and the NDVI profile observed at the pixel. 8) (p. 8126, l. 15): how did you arrive at those values, as they differ from Er-Raki et al. (2010). We used the same equation made by Er-Raki et al, 2010 but we include values of NDVImin and NDVImax estimated using SPOT-VGT time series over the studied site.

9) (p. 8129) : at this point, I would expect a discussion on the scale discrepancies

HESSD
10, C5440–C5449, 2013

between the remotely sensed data product and the surface conditions/model. There is some hinting at it, when talking about ISBA only representing an average of all contained vegetation types, but using 40km and 1km-resolution data products and a model at probably a different resolution again, raises some questions about scaling of data products, that, at the very least, needs to be discussed. Answer: Yes, ISBA analysis is based on an average of all contained vegetation types. For our analysis, we consider 1km vegetation data products. The effect of scale is limited because of a majority of linear relationships in the tested FAO approach. The effect will be added, by considering an application of FAO at 40 km scale, considering a mean value of different vegetation fractions.

10) (p. 8129, l. 19-25): The relatively high coefficient of determination is - in my view - partially due to not correcting for the dynamics in the models. There is a strong seasonal correlation; however, the more important question is whether the diurnal or even monthly changes are well captured. That cannot be fully answered with those statistics. Also, for me, the SWI products do not compare well after 1997, with the ERS SWI essentially losing all sensitivity. There is no real discussion around any type of actual reference values. Even if there are no in-situ measurements available, Meteo France did some studies comparing ERS & ASCAT with model and in-situ observations (Albergel et al., 2008, Rudiger et al., 2009). At the least you need to discuss the accuracy of either model or remotely sensed product. Answer: Amri et al., 2012 have discussed the validation of ERS and ASCAT products using ground measurements. We retrieve a high agreement between measurements during the period (2010-2011) and satellite products with an RMSE equal to 0.06cm3/cm3 for surface moisture and 0.039 cm3/cm3 for SWI. Zribi et al. (2010) have also proposed a validation of ERS products using GSWP outputs. Concerning difference of behavior after 1997, this is due to the number of surface soil moisture dates used for SWI estimation (Pellarin et al., 2006). For dates before 1997, we consider only ERS1 scatterometer and then number of data was very limited (less than one data per week). So, the proposed products must be less accurate than for the period after 1997, with about two to three data per week.

HESSD

10, C5440–C5449, 2013

SWI products are then a priori more robust after 1997. Nevertheless, we observe less agreement after 1997. ISBA model over-estimates root-zone soil moisture content satellite estimations. 11) (p. 8130, l. 6-8): there is no discussion about the obvious outlayers in Fig. 5. Where, when, and why do they occur? Answer: Yes, we agree with reviewer. The figure 5 illustrates comparison between simulations of evapotranspiration with ISBA and FAO models during the period between 1991 and 2006, over the same studied area. The objective of considering this figure was to illustrate the reasonable agreement between simulations.

12) (p. 8131, l. 2-3): I am not entirely sure whether the root zone product is used at all in this approach (please explain this in more detail with Eq. 7). But if it is then it is not a surprise that FAO-56 method is not working all that well in 2000, given that the ERS SWI is fairly flat and not showing much dynamical range. Answer: The SWI is not used in evaporation estimation. We consider only surface soils moistures. However, we consider comparisons of SWI just to validate the ISBA model over the studied site.

13) Fig. 7: there are large areas with very low ET on the plot. How are those explained? They correlate with the low fractional coverage areas in Fig. 3. Were those not considered at all, or blanked out? Answer: Yes, very low ET areas correspond generally to olive groves with low vegetation cover fraction, as illustrated in figure 3. All areas with water cover (dams, sebkhas) are not considered in our calculation. We consider for them a black mask for all maps. Minor comments: 14) (p. 8118, l. 16-17): Is this a recent development due to climate change or is the statement meant in a broader general term? The semi-arid Mediterranean regions are characterized by a frequent occurrence of long periods of drought (Amri et al., 2011). This figure illustrates variations of NDVI during the last 11 years showing these frequent periods of drought.

Vegetation cycles from 1998 to 2010 (with four dry seasons) 15) (p. 8118, l. 20) : rephrase to " [...] rainfed agriculture in water-limited environments" Yes 16) (p. 8118, l. 23-25) : are you saying that ISBA is the best land surface model there is? I would be careful with strong statements like this! No, here we mean that the most accurate

HESSD

10, C5440–C5449, 2013

models are the SVAT models types. SVAT models (Soil-Vegetation-Atmosphere Transfer models) which may be used for monitoring energy and mass exchanges by using assimilation of remote sensing data procedures ISBA is one of SVAT models. There are several other SVAT models, such as SETHYS, SiSPAT, BIGFLOW. . .

17) (p. 8119, l. 20) : don't use "..." Yes

18) (p. 8120, l. 2) : reference Paloscia et al (2008) is not in the reference list We added it in the reference list. Paloscia, S., Pampaloni, P., Pettinato, S., Santi, E. 2008, A comparison of algorithms for retrieving soil moisture from ENVISAT/ASAR images, IEEE Transactions on Geoscience and Remote Sensing, vol. 46, pp. 3274-328.

19) (p. 8120, l. 1-6) : there are many more (recent) publications both for soil moisture retrieval models and ERS-Scat validation. We are added some recent publications: Calvet, J. C., Wigneron, J. P., Walker, J., Karbou, F., Chanzy, A., Albergel, C. Sensitivity of Passive Microwave Observations to Soil Moisture and Vegetation Water Content: L-Band to W-Band. IEEE Transactions on Geoscience and Remote Sensing, 49(4), 1190-1199. doi: 10.1109/tgrs.2010.2050488, 2011. Das, N. N., Entekhabi, D., & Njoku, E. G. An Algorithm for Merging SMAP Radiometer and Radar Data for High-Resolution Soil-Moisture Retrieval. IEEE Transactions on Geoscience and Remote Sensing, , 49(5), 1504-1512. doi: 10.1109/tgrs.2010.2089526, 2011. Kolassa, J., Aires, F., Polcher, J., Prigent, C., Jimenez, C., Pereira, J. M., Soil moisture retrieval from multi-instrument observations: Information content analysis and retrieval methodology, Journal of Geophysical Research: Atmosphere, 118(10), 4847–4859, 2013 C. Albergel, W. Dorigo, G. Balsamo, J. Muñoz-Sabater, P. de Rosnay, L. Isaksen, L. Brocca, R. De Jeu, W. Wagner, "Monitoring multi-decadal satellite earth observation of soil moisture products through land surface reanalyses"; Remote Sensing of Environment, 138 (2013), 77 – 89 A. Loew, T. Stacke, W. Dorigo, R. De Jeu, S. Hagemann, "Potential and limitations of multidecadal satellite soil moisture observations for selected climate model evaluation studies"; Hydrology and Earth System Sciences, 17 (2013), 9; 3523 – 3542 C. Su, D. Ryu, R. Young, A. Western, W. Wagner,

"Inter-comparison of microwave satellite soil moisture retrievals over the Murrumbidgee Basin, southeast Australia"; Remote Sensing of Environment, 134 (2013).

20) (p. 8120, l. 6): not clear whether you are using the old or new SWI (Albergel et al.,2008) Answer: We consider the new SWI products proposed by Vienna University. As written before, these products are validated over the same site in Amri et al., IEEE TGARS 2012).

21) (p. 8120, l. 21): are those the mean daily extremes or absolute extremes? Those temperatures are the mean daily extremes.

22) (p. 8121, l. 21): here the observation depth is 5cm, later, it is "2 to 3cm" (p. 8129, l.16-17). The satellite observations are validated with 5cm depth ground measurements. Nevertheless, different studies have shown that the highest contribution on radar signal is due to the first two to three centimeters. This is due to the penetration depth of radar waves in C band, generally lower than 5 cm for medium and high moisture values. We add more clarifications in the text.

23) (p. 8123, l. 12): is there a peer-reviewed reference to this data set? Yes, we added here a reviewed reference. Olseth, J.A and Skartveit, A., Solar irradiance, sunshine duration and daylight illuminance derived from METEOSAT data at some European site, Theoretical and Applied Climatology, 69, 239-252, 2001.

24) (p. 8128, l. 9ff): move the paragraph describing the model into Section 3. Why did you not use the diffusive layer model version of ISBA? Answer: As asked by reviewer, we will move the description of the ISBA model into Section 3. ISBA version uses the force–restore method of Deardoff (1977,1978) to calculate the time variation of the surface energy and water budgets (Noilhan and Planton, 1989). The soil hydrology is represented by three layers: a thin surface layer with a uniform depth, a root-zone layer, and a deep soil layer (Boone et al., 1999) contributing to evaporation through capillarity rises. Also, the model simulates the water interception storage and the snow pack evolution based on a simple one layer scheme (Douville et al., 1995). The deep drainage

HESSD

10, C5440–C5449, 2013

is computed according to Noilhan and Mahfouf (1996). This version is proposed for different studies in link with remote sensing assimilation of soil moisture.

25) (p. 8130, l. 3) : what units are the ISBA pixels "0.5 x 0.5"? The ISBA outputs data have the spatial resolution of 0.5° latitude and 0.5° longitude.

26) (p. 8130, l. 20-21): why would the models be more consistent during this season than others? Answer: The comparison show more consistent results for driest season. This is particularly due to limited rainfall events. In this case, soil moisture variations are limited. For dry period, we observe a good agreement between models. It is easier for FAO model to retrieve an ET variation for a limited temporal moisture variation, with one rainfall event between two dry periods.

27) (p. 8131, l. 23): the dual approach was not proposed here, but by Er-Raki (2007, 2010). Yes, certainly, we clarify this point in last answers. It will be clarified in the text.

Figures: Combine Fig. 1 & 2. It's already done.

Figure 3: there are areas that have low fractions on all three plots (SW and NE corners, how can that be?) The areas that have low fractions on all the 3 classes' proportion of the land map use represent areas covered with water (sebkhas, dams). They are masked in all maps. Clarification added to the text.

Figure 6: y-axis should be in mm/d (I assume that the values are monthly averages of total daily ET?!) We changed the y-axis in mm/d of the two figures of each agriculture season. The values are total daily ET.

Overall, the figure captions need to be more descriptive. Yes, descriptions are added.

References : Campos et al., J. Hydrol., 494, 1-9, 2013. Prassad et al., J. Agromet., 15(1), 23-30, 2013. Cammalleri et al., Int. J. Appl. Earth Obs. and GIS, 21, 149-158, 2013. Sanchez et al., Agric. Water Mgt., 98(1), 69-78, 2013. Kamble et al., Remote Sensing, 15(4), 1588-1602, 2013. Torres et al,. Remote Sensing in Hydrology, in: IAHS Publication 352, 401-405.

Answer: We consider all these references

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 8117, 2013.