

Interactive comment on “Mapping daily evapotranspiration and dryness index in the East African highlands using MODIS and SEVIRI data” by Z. Sun et al.

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We thank you very much for your comments. Please find below our responses to each of your comments:

“The methodology is clearly described, and the discussion seems correct, . . .”

Thank you!

“ . . .but I think that the analysis of the data lacks depth. Flux sites in Africa are sparse, but unfortunately the authors did not fully exploit the data.”

We have included additional data analysis and additional data, as explained below:

1. We have added a new figure (Fig. 4) that shows a time series of our ET results and observations. We hope this figure presents our ET results more clearly.

2. We have added a new data analysis that shows the relative contribution of the main error sources. Extensive discussion (using four new figures) has now been added on this topic. This discussion is presented in Sections 4 and 5.

3. We have cases where we have actual ET values but missing corresponding reference ET values. In the original manuscript, we removed these cases from the evaluation of the actual ET values to maintain the same sample size between the evaluation of actual ET and evaluation of reference ET. We agree with you that we need to include all available data. In the revised manuscript, we have included all available data for evaluation of actual ET. We have modified Figure 5 (and related results and discussion) accordingly.

“The authors find that remote sensing estimates of daily ET correlate well with ground measurements, but that the remote sensing estimates have a bias of nearly 1 mm d⁻¹. They discuss possible causes of this underestimate. My main concern is that this discussion is only qualitative. For example, they argue that net radiation is underestimated during clouded days. It is not clear if the results presented in Figs 4 and 5 include clouded days. The conclusion is that further research is needed. To my opinion some of this further research should be part of the paper.”

1. We have added new quantitative results showing errors in net radiation (Figs. 7 and 8) and errors in EF (Fig. 9), and testing the assumption of constant EF during the daytime (Fig. 10).

2. We have added a new Figure (Fig. 7) that shows the prevalence of cloudy sky conditions during the study period. We have added the following statements on Page 9 of the manuscript: “In cloudy sky conditions, the radiation and surface temperature

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data are not available, and this leads to underestimation of the daily net radiation on cloudy days. Figure 7 indicates that cloudy or partially cloudy days usually occur in wet seasons.”

“The authors identify net radiation, evaporative fraction (EF), and the mismatch in spatial scale as possible causes for the discrepancy between remote sensing and ground based ET. At least two more could be added here: soil heat flux and the assumption that daily EF equals instantaneous EF at Aqua and Terra overpass time.”

1. The accuracy of soil heat flux depends on that of net radiation, and we have added discussion on the accuracy of net radiation (see Fig. 8). Second, we do not have valid measurements to evaluate soil heat flux estimates at our site. Third, in some prior studies, soil heat flux is ignored in daily ET estimation (e.g., Price, 1982). It is possible that uncertainties in soil heat flux may have minor effect on daily ET estimation.

2. The assumption that daily EF equals instantaneous EF at the Terra overpass time has been added in the revised manuscript (Fig. 10).

“These five possible errors can relatively easily be quantified and evaluated with the available flux site data. The flux site provides net radiation (probably also 4-component radiation), soil heat flux and latent heat flux. With these data, net radiation, soil heat flux, EF and the diurnal variation of EF can all be compared to their remote sensing counterparts individually. If 4-component radiometric measurements are available at the Fluxnet site, then SEVERI radiation products and LST can be evaluated as well. Such an analysis presented in one or two additional graphs would give more weight to the paper, and would also give directions to the priorities for further research.”

1. SEVERI radiation products and LST have been intensively evaluated by the SEVIRI science group (<http://landsaf.meteo.pt/>). We have already included these evaluation results in the Discussion Section.

2. We have added new quantitative results on the evaluation of net radiation (Fig. 8),

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EF (Fig. 9), and assumption of constant EF during the daytime (Fig. 10).

3. We do not have valid ground-based data to evaluate soil heat flux (see above).

Response to specific comments:

“Page 6287, Line 5. “we do not have daily ET maps across the East African highlands available...”. But LandSAF provides these maps (<http://landsaf.meteo.pt/>)”

The LandSAF ET products are still in a pre-operational status, and are not yet available to the public.

“Page 6289, lines 9-16. It would be helpful to add some key information about the site, like the measurement height, footprint area, instrumentation, canopy height and density.”

We have added this information in the last paragraph of Section 2. Note that the footprint area of the flux tower changes with wind speed and direction, and therefore we cannot give exact values.

“Page 6290, Eqs 1 and 2. In the literature, EF is dimensionless (a value between 0 and 1). In this paper it has the units of ($\text{mm m}^2 \text{d}^{-1} \text{W}^{-1}$) (see Eq 2). This is confusing, because it makes it seem like the units in Eq 1 are not consistent. ”

Note that both ETMODIS and QMODIS are instantaneous values with units of W/m^2 in the Eq. 2, and therefore EF is dimensionless, which is consistent with literature.

“The right hand side in Eq 1 still needs to be multiplied by 1800 seconds. ”

Corrected.

“Page 6294, lines 3-6. Is this a general remark, or does it refer to the situation at the flux tower? How much is the space between the trees at the site? See also point 2. ”

It is a general framework. However, we have removed the sentence as it does not add value to our discussion.

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“ Page 6294, lines 3-6, “can be too smaller” -> “can be smaller” ”

Corrected.

“Figs 4 and 5. Why are only 16 points plotted in Figs 4 and 5, if 6 months of data were available (or 4 months if the rainy season is excluded)?”

This is a good point. As we discussed above, we have included additional data points.

References: Price, J.C.: On the use of satellite data to infer surface fluxes at meteorological scales. J. Appl. Meteorol., 21, 1111-1122, 1982.

Please also note the supplement to this comment:

<http://www.hydrol-earth-syst-sci-discuss.net/7/C3450/2010/hessd-7-C3450-2010-supplement.pdf>

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 7, 6285, 2010.

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