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Hydrology and Earth System Sciences
Discussions

# *Interactive comment on* "Microwave implementation of two-source energy balance approach for estimating evapotranspiration" *by* Thomas R. Holmes et al.

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Please find below the comments of Anonymous Referee #2 and our replies.

The authors have used diurnal temperature cycle built on available MW sensors to the well-known ALEXI model. The quality of diurnal temperature cycle based on MW sensors is important to ET retrieval. LSA-SAF LST was used to calibrate MW LST.

I am wondering how did they determine or scale MW DTC parameters (especially the diurnal amplitude A) for the regions outside of SEVIRI coverage? Does MODIS ALEXI IR also use LSA-SAF LST to determine DTC parameters? I am confusing with eq.



1 and eq. 2 and 3. A_MW can be derived with equation 1. The diurnal cycle can then be produced with DTC3 model. eq. 2 says A_MW is scaled with TIR-based parameters. Then shouldn't the diurnal temperature cycle will also be changed by the new A_MW? When A_MW equals A_IR, shouldn't dTrad_IR and dTrad_MW be the same or very close? Then ET_MW and ET_IR will certainly have a high correlation. Please compare with other ET dataset, such as the latitudinal transect in Fig. 6, Fig. 7, Fig. 9. Otherwise, comparison between ALEXI_IR and ALEXI_MW is not enough for evaluation of the method. In addition, when they evaluate the ET results with Fluxnet, please do the analysis on a daily scale. A part of the purpose using MW here should be also providing ET at daily scale. So please assess the daily ET not weekly or monthly.

Reply. Thank you for the comments and reflection on the manuscript. In response to these general comments we want to stress that:

- Only the long term mean of the diurnal parameters is scaled to match those of LSA SAF TIR. The entire transfer of information from TIR to MW is contained in three static maps (for amplitude, mean, and timing). This means that the correlation between the diurnal amplitudes of TIR and MW LST is not affected – in terms of short-scale inter-seasonal patterns the two sets remain independent. This point is will be emphasized in the description of Eq2-3 and the process of creating MW-LST: Section 2.3.3: "Because all three parameters are constant with time, Eqs 2-3 preserve their temporal independence of the TIR LST product."

- For the extrapolation of MW to LSA-SAF LST calibration parameters outside the Meteosat domain we used ad-hoc linear regressions with vegetation characteristics (MW vegetation optical depth). It is not an approach we will continue with. For this paper, we use it to bring the dataset in the approximate range of the TIR LST, but only to include it in the analysis of temporal signal with Fluxnet data. Again, the temporal signal is not affected by the calibration.

In light of this, we do think a comparison between MW and TIR ALEXI is a valid test of performance at this point and a strong indication of diurnal information content in MW LST.

I am wondering why don't they use MW and IR signal to build diurnal temperature cycle directly. Could this method get more accurate daily global ET? Xuelong Chen has found MODIS monthly LST products could capture the monthly mean of diurnal LST variation. This means that the ALEXI could be used to MODIS monthly LST products. The authors might be interested to the following figure 1.

Reply. It is certainly possible that we will eventually merge MW and IR to get a better estimate of diurnal temperature. However, this still requires some additional steps to overcome, not least of which is the spatial resolution difference. This paper presents a milestone along the way, reporting on an experiment to test MW LST in an ET retrieval that is itself sensitive to the diurnal information.

Eq1. If possible, please give the equation of DTC3, then the readers could quickly understand what kind of curves were used to fit the diurnal cycle.

Reply. We will add the description of the DTC model as a model that " combines a cosine and an exponential term to describe the effect of the sun and the decrease of surface temperature at night". We think that this level of detail is sufficient for understanding the present paper, and listing the exact equations might distract from the main analysis. For a detailed description, the reader is referred to Holmes et al 2015 and references therein.

Section 2.3.2 now includes this passage: "The DTC model combines a cosine and an exponential term to describe the effect of the sun and the decrease of surface temperature at night and is based on Göttsche and Olesen (2001) with slight adaptations to limit the number of parameters. This implementation (DTC3) is fully described in Holmes et al. (2015). "

Fig. 4 please specify t1 and t2 time for dTrad.



Reply. We added to the caption: dTrad is defined in the ALEXI framework as the temperature rise between 1.5 hr after sunrise to 1.5 hr before noon (see Section 2.1).

Fig. 8 how did the authors cope with different spatial resolution when they calculate Pearson's correlation. ALEXI-IR is 0.05 deg and ALEXI-MW is 0.25 deg. The correlation is at 0.05 deg resolution?

Reply. The correlation in 3-month anomalies (Fig 8) is calculated based on 0.25 degree resolution data. This is now specified in the caption.

Fig. 9 why not calculate monthly anomaly? MW provide the possibility of daily ET. 3 months anomaly will provide more consistent spatial patterns. But the performance at daily or monthly is more interesting. Fig. 7, and 8 also have the same question.

Reply. 3-month anomalies were chosen to represent the larger seasonal patterns in interannual variation. Higher temporal resolution is tested with in situ data's. As can be seen in the attached Figure 1, the correlations are rather similar between the 1-month and 3-month anomalies.

Reply. Thanks for pointing this out, the caption did not specify that these statistics are based on weekly ET values. For ALEXI these weekly values are interpolated from clearsky observations as detailed in Section 2.4. The Fig 10 caption is changed to start with: "Comparison of Pearson correlation () and RMSE between estimates of weekly ET from satellite data and Fluxnet observations."

Describe what is ti in Equation 1.

Reply. The definition of t is given in the preceding sentence, 'ti' is the observation time of the temperature measurement. The index 'i' is used to represent the individual observations within a day.

Table 2 Comparison is based on weekly averages in the period of 2003 to 2011. Why not use daily ET with gaps to calculate R, RMS? This is more useful for the readers to compare other ET products. Surely, weekly averages will give a higher R and low

RMS. But MW provide ALEXI with the possibility for daily ET calculation. AND page 2, 'generated a data record of weekly ET' why not daily? as above comments \

Reply. While the goal of this work is to eventually reduce the temporal interval of consistent ET retrievals to daily, at this moment we followed the existing global ALEXI protocol that allows for evaluation of weekly ET totals. We do look forward to analyzing daily output in future studies, but it was not an option at this stage of the development.

Table 1, MOD43C3 doesn't have gaps? How did they fill albedo gaps? Please specify at what time step (00:00, 06:00: : :) lapse rate profile is used.

Reply. In fact, it should have read MCD43B3 and this is a 16-day product. The updated reference (Schaaf et al. 2002) explains: ".. BRDF parameters are produced (via either full or magnitude inversions) for every land or coastal area which is viewed (and atmospherically corrected) at least once over a 16-day period. Land areas that remain completely cloud covered over this period are designated with fill values."

Schaaf, C. B., Gao, F., Strahler, A. H., Lucht, W., Li, X., Tsang, T., Strugnell, N. C., Zhang, X., Jin, Y., Muller, J.-P., Lewis, P., Barnsley, M., Hobson, P., Disney, M., Roberts, G., Dunderdale, M., Doll, C., d'Entremont, R. P., Hu, B., Liang, S., Privette, J. L. and Roy, D.: First operational BRDF, albedo nadir reflectance products from MODIS, Remote Sens. Environ., 83(1–2), 135–148, doi:10.1016/S0034-4257(02)00091-3, 2002.

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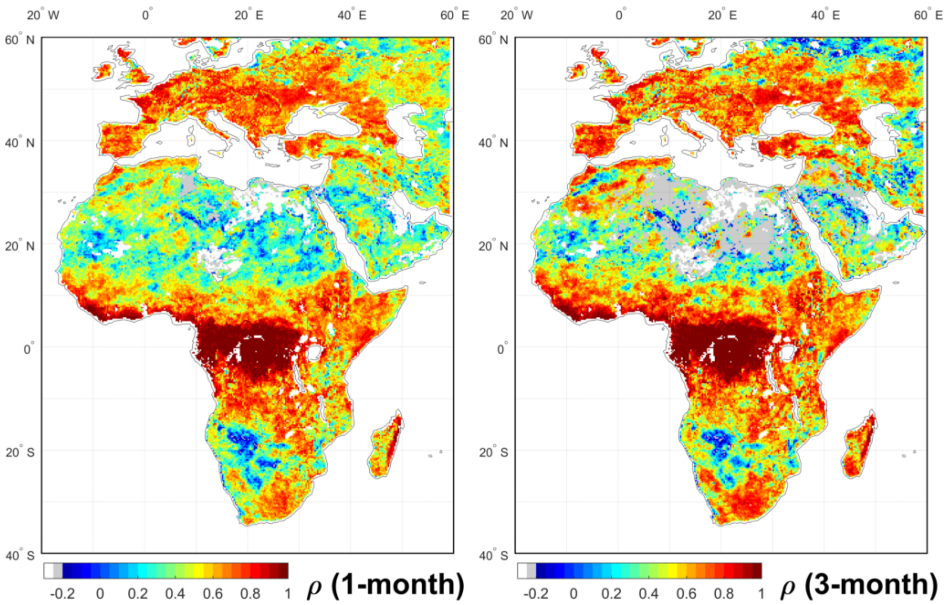


**Fig. 1.** Figure 8: Pearson's correlation between anomaly in 1-month (left) and 3-month (right) ET totals as estimated by ALEXI-IR and ALEXI-MW, calculated at 0.25 degree resolution. White areas have no data, g