

## ***Interactive comment on “Cloud Tolerance of Remote Sensing Technologies to Measure Land Surface Temperature” by T. R. H. Holmes et al.***

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A methodology has been developed by Holmes et al. to produce LST diurnal cycle from the collection of available passive microwave observations on board satellite imagers. It is anchored to infrared LST estimates. In the present study, the authors evaluate the sensitivity of the microwave to the clouds, using in situ LST measurements along with in situ estimate of the cloudiness at the station locations. With the infrared LST estimates highly limited by clouds, there is today a strong interest in using microwave observations for LST retrievals to complement the IR. This study provides a valuable contribution in this field, with a quantification of the cloud impact on the microwave LSTs. The paper is well structured and well written. It deserves publication. However, before this study can be published, some issues need to be clarified.

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Major points:

1) In this study, the microwave estimates of the LST diurnal cycle strongly rely upon the IR estimates. One expects the LST diurnal cycle to be impacted by clouds, even under partial cloud coverage along the day. The shape of the LST diurnal cycle (Holmes et al., 2015) will be affected if clouds are present at some time during the day. Can you clarify how these potential cloud effects are taken into account in the modelling / parameterization of the diurnal cycle? Two products are used in this study, the continuous MW-LST product and the MW-LST sparse product. It would be very interesting to see also results without any adjustments for the diurnal cycle. Would that be possible?

2) The number of MW-LST estimate is rather low as compared to what could be expected (50% with respect to 36% for the IR). Can you confirm that this is related to the need to have a very limited cloud coverage during the day, to anchor the microwave retrieval to the IR estimates? Would it be possible to relax this constraint, with modified assumption about the LST diurnal cycle (Holmes et al., 2015) under cloudy sky conditions?

3) The statistical metrics need to be better defined. The mean, the standard deviation, and the root mean square error are common statistical parameters that do not need to be explained. However, the ubRSME or the SEE need to be clarified. For instance, it was first understood that the SEE was the standard deviation, but from Table 4, it is obvious it is not the case (otherwise we would have  $RMSE^2 = STD^2 + BIAS^2$ ). The advice is to use the standard and commonly accepted statistical metrics (mean, std, rmse), to avoid any ambiguity, or define clearly the metrics used.

4) Clouds do affect the 37 GHz (p.10 | 31 sec. 4). The sentence ‘Therefore. . . Ka-band emission process’ has to be removed or modified. Cloud particles do not scatter the radiation at 37 GHz (because of the small size of the particle with respect to the 37 GHz wavelength) but they do absorb and emit radiation. This is actually how the cloud water content is estimated over ocean from observations at 37 GHz. Over land, cloud

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water retrieval is nevertheless very difficult, because of the lack of contrast between the cloud and the surface contribution to the signal (with an emissivity of the land surface close to 1 compared to the low emissivity of the ocean that provide a good contrast with the cloud emission).

Minor points:

- P.2 I.27. 'Well validated TIR-LST'. Not that sure... Our recent experiences show significant differences between TIR-LST products that are all supposed to be well validated...
- P.2. I.27-28. Could you provide more information about the sources of these biases?
- P.3. I.23-24. How are the IR pixels handle within each  $0.25^\circ$  pixels? There are approximately 64 3km pixels in each  $0.25^\circ$  pixel. Do they all need to be clear to aggregate the data?
- P.4. I.5-6. Can you specify here if the inter-calibration is in TB or LST space. The information might be available in other papers, but it needs to be reminded here.
- P.5. eq. 4. It is not obvious here to realize how different is the MW-LST-Sparse from the 'raw' microwave LST. Can you comment on this point? Examples of the three MW-LST (continuous, sparse and 'raw') would help.
- P.7. I.10-11. Neighbouring daytime information taken for nighttime hours. That looks very uncertain. Information every 6 hours or every 3 hours as specified I9, but not used in I12-13? Did you try the analysis with only the daytime data?
- P.7. I.29. The 55% is after removal of the subfreezing temperatures? It will be good to give also the percentage only related to cloudiness.
- P.8 I.20. ThAn, not then
- P.9. I.1-2. Not that clear. MSG stations B,D,C are close to 1:1, as GOES stations J, H, M, G, E. Only K and J (GOES) are worse than D (MSG).

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- P.9. I.29-30. How do the scaling of the MW-LST to the TIR-LST play a role here? It would be nice to see how the 'raw' MW-LSTs behave?
- P.11. Discussion. It would be nice to see the linear regression of Table 4 also discussed in Figure 3, to see if the MW-LST cloudiness dependence (even small) changes by not having the MW-LS somehow depending on the IR diurnal cycle.
- P.11 I.9. What is the spatial heterogeneity of the land surfaces for these two locations? That could be assessed with the std of the IR LST within the large  $0.25^\circ$  pixel.
- Table1. Something missing for station L. US-? What is the meaning of column W?
- Table 2. CloudY not clouded.
- Fig1. When the situation is almost clear (i.e. on July 26 on the upper panel), several IR values were expected, with a good description of the diurnal cycle. This is not the case (lower panel). Can you explain?
- Fig1. For the A calculation, in the top figure, it looks like a full diurnal cycle of SW is available. In the text, only 6 hour information and/or 3 hour information are mentioned.
- Fig1. What is the meaning of the dashed black lines on July 29?
- Fig2. Avoid the use of the ubRMSE or define it. Can you comment on the differences between stations in terms of their soil moisture (or a proxy of the soil moisture if not available)? The amplitude of the diurnal cycle could actually be used.
- Fig3. The indication of the cloud conditions with the circles is not straightforward. It would be helpful to add more explanation in the caption.
- Fig3. The spatial standard deviation of the IR LST information at each station might help explain some of the differences between stations, in terms of surface heterogeneity.

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