## Review of Parinussa et al.

Anonymous Referee #1 Received and published: 17 August 2011

Firstly, the authors of the manuscript would like to thank the anonymous reviewer for their helpful comments. Secondly, this document is structured similar to the reviewer's document as presented online in HESSD. Each reviewer's comment (*italic*) is followed by the author's response.

## **General comments:**

I think this is a good paper dealing with an important issue concerning soil moisture retrievals from the current SMOS satellite and the future SMAP satellite. It compares two recent techniques to evaluate soil moisture retrievals, and assesses their performance. Results from this comparison and the attendant discussion will be of interest to the hydrological sciences community. I recommend eventual acceptance and publication in HESS, but once the authors address a number of general and specific issues, itemized below.

From a general point of view, the paper needs a number of improvements, namely: (i) quantification of statements; (ii) clarification of statements; and (iii) clarification of technical points. Details are provided in the specific comments. A number of style comments also need to be addressed (see below).

## **Specific comments:**

**P. 6684, L. 15:** I would have thought that as well as re-analysis data, analysis data from operational centres could also be used. If so, please amend here and elsewhere in the paper.

Yes, analysis data from operational weather prediction centres could also be used for soil moisture retrievals from the SMOS and SMAP missions. This was indicated in the abstract of the manuscript, however the authors agree that this could be stated more clearly throughout the entire manuscript. For this reason, we use the term 'ancillary data' and refer to 're-analysis or near real time data from weather prediction centres' in the revised manuscript.

**P. 6684, L. 25, 26 and 28:** Please quantify the statements made regarding improvement in retrieval quality. This should be done elsewhere such statements are made (e.g. in conclusions and outlook section).

Statements made regarding the improvement in retrieval quality were quantified in the abstract and conclusions and outlook section of the revised manuscript. The abstract reads as follows:

'Results demonstrate that under sparsely vegetated conditions, the use of MERRA land surface temperature instead of Ka-band radiometric land surface temperature leads to a relative decrease in skill (on average 9.7%) of soil moisture anomaly estimates. However the situation is reversed for highly vegetated conditions where soil moisture anomaly estimates show a relative increase in skill (on average 13.7%) when using MERRA land surface temperature. In addition, a pre-processing technique to shift phase of the modelled surface temperature is shown to generally enhance the value of MERRA surface temperature estimates for soil moisture retrieval. Finally, a very high correlation ( $R^2$ = 0.95) and consistency between the two evaluation techniques lends further credibility to the obtained results.'

**P. 6685, L. 1:** The statement about "high degree of consistency" is vague. What do you mean? Good agreement in the patterns and/or magnitudes of the fields compared?

The statement about 'high degree of consistency' was replaced by 'a very high correlation ( $R^2 = 0.95$ ) and consistency between the... []'

P. 6685, L. 13: I suggest the Kerr et al. (2001) reference could be updated to:

Yann H. Kerr, Philippe Waldteufel, Jean-Pierre Wigneron, Steven Delwart, François Cabot, Jacqueline Boutin, Maria-José Escorihuela, Jordi Font, Nicolas Reul, Claire Gruhier, Silvia Enache Juglea, Mark R. Drinkwater, Achim Hahne, Manuel Martín-Neira, and Susanne Mecklenburg, 2010: The SMOS Mission: New Tool for Monitoring Key Elements of the GlobalWater Cycle, Proceedings of the IEEE, Vol. 98, No. 5, May 2010, 667-687.

Reviewer's suggestion to replace this reference was followed

**P. 6685, L. 15:** Given the history of delays in the launch of satellites, would it be better to say: "and currently scheduled"?

Reviewer's suggestion to replace this word was followed

P. 6692, L. 4: Provide a reference for ASCAT.

The reference Figa-Saldana et al. (2002) is inserted to provide readers more detailed information on ASCAT.

**P. 6687, L. 22:** I think you are discussing "CDF-matching". If so, mention this term, as it would help the reader identify what you are talking about.

The text was adapted in an attempt to clarify this section and reads as follows:

'The skill to capture a high degree of temporal variability of soil moisture was the main driver to select LPRM soil moisture retrievals for this study. For the majority of the applications and/or data assimilation techniques that use remotely sensed soil moisture data the temporal correlation coefficient is arguably the most important indicator of utility. Especially for data assimilation it is a prerequisite to minimize systematic differences (Reichle and Koster, 2004), often by removing the climatology and scaling the anomalies to match the models climatology (e.g. by cumulative distribution function (CDF)-matching).'

**P. 6692, L. 21:** If I understand correctly, the time periods for the TC and Rvalue methods are different. Could you comment on the likely effects of this difference on results?

A short section about the potential differences was inserted into the revised manuscript and reads as follows:

'The analysis period of the TC method is limited due to the availability of the ASCAT SSM dataset (2007-2010) and differs from the period used for the  $R_{value}$  method (2003-2010). For both methods the climatology was calculated based on their analysis periods. A consequence of these different analysis periods is that the calculated anomalies for the longer period of the  $R_{value}$  method are more statistically robust. On the other hand, the outcomes from the  $R_{value}$  method depend on the amount of precipitation events during the analysis period, both differences may result in spatial inconsistencies of evaluation results. It is likely that the number of precipitation events made available for the  $R_{value}$  method is the dominant factor in arid areas, since evaluation results from the  $R_{value}$  verification technique appear unreliable and highly spatially heterogeneous in desert areas (figure 4).'

**P. 6694, L. 20:** I understand the calculation of soil moisture errors as Psat – Pgauge comes from Crow et al. (2007). Is this result empirical or based on theory? Could this be identified in the paper? In my view, this would help clarify this part of the paper.

The  $R_{\text{value}}$  method is based on calculating the Pearson correlation coefficient ( $R_{\text{value}}$ ) between rainfall errors ( $P_{\text{sat}}$ - $P_{\text{gauge}}$ ) and Kalman filter analysis increments realized during the assimilation of remotely sensed soil moisture products into an antecedent precipitation index (*API*). A higher  $R_{\text{value}}$ indicates high-quality soil moisture retrieval and increased efficiency in the filtering of errors in the *API* predictions resulting from random error in  $P^{\text{sat}}$  used to generate *API*. The approach is based on the simple assumption that  $P_{\text{gauge}}$  is relatively more accurate than  $P_{\text{sat}}$  and can therefore be subtracted from  $P_{\text{sat}}$  to provide an estimate of absolute rainfall errors. This is clarified by new text added to Section 3.1.1 of the revised manuscript.

*P.* 6695, *L.* 17: It is not clear to me from the text what version of the Rvalue algorithm you use. Is it the one adapted by Crow et al. (2010)?

In this paper we only use the adapted version of the  $R_{\text{value}}$  verification technique as presented in Crow et al. (2010a). This is stated more clearly in the revised manuscript (e.g. Introduction and Section 3.1.1).

P. 6696, L. 9: What method is used to do the rescaling?

The description of this rescaling has been completely redone in the revised manuscript. As clarified in the new text - it is based on the application of techniques used in previous TC studies. In particular, Scipal et al. (2008) and Stofellen et al. (1998) provided detailed information about rescaling approaches which are necessary for getting reliable error estimations using the TC verification technique. In the revised manuscript we followed the rescaling steps as described in these papers, leading to scaling factors (3) and (4).



*P. 6697, L. 25:* I understand "vertical support" means the variation in the vertical. Is this correct? If so, could this be mentioned to help the reader?

Yes, the term 'vertical support' means the variation in the vertical. To prevent misinterpretation/-understanding we use 'vertical depth of the soil layer' in the revised manuscript.

P. 6698, L. 9: Why are these standard deviations used?

These levels are chosen to represent realistic error levels of various LST products. Holmes et al. (2011) analyzed the MERRA surface temperature product with the focus on the implementation for soil moisture retrievals and found errors on this order of magnitude.

**P. 6701, L. 3:** I suggest you comment that as shown by Fig. 7, the TC and Rvalue results are roughly inversely correlated.

Reviewer's suggestion was followed.

P. 6702, L. 10-11: Does decreased vegetation water content imply increased vegetation density?

In general for the majority of vegetation species the dry wood density is smaller than the density of water leading to a decrease in vegetation bulk densities when vegetation water content

decreases. This particular issue needs more research and therefore we are conservative in the statements regarding this.

P. 6705, L. 17: I suggest you write: "...their validity to evaluate soil moisture retrievals".

Reviewer's suggestion was followed.

P. 6708, L. 32: Is there an update for the Parinussa et al. Reference?

The current status of Parinussa et al. (2011) is accepted for publication with minor revisions in IEEE Transactions on Geoscience and Remote Sensing.

## **Style comments:**

For all style comments (below) the reviewer's suggestion was followed.

**P. 6684, L. 4:** I suggest you use "current" instead of "modern" when referring to SMOS. This should be changed in other places as well.

**P. 6686, L. 20:** I do not think you need "unfortunately". I suggest you use something like "Because the newly designed...are single frequency and lack an instrument band...".

P. 6687, L. 7: I think it would be better to say: "As a result of this feedback...".

*P.* 6688, *L.* 3: To help the reader, remind them that the first technique under discussion is that of *Rvalue verification*.

**P. 6689, L.** 7: It would be helpful if at the end of section 1 you indicate what each section of the paper deals with.

**P. 6690, L. 19:** I suggest these references should be introduced earlier in section 2.1, when you first introduce the AMSR-E and Windsat sensors.

**P. 6691, L. 16:** To help the reader, I suggest you write: "...are also utilized: Psat and Pgauge. Psat is based...".

P. 6693, L. 1: To help the reader, identify the lowest resolution.

P. 6693, L. 7: Identify the 6 classes or refer to Table 1.

P. 6698, L. 11-12: Are words missing? Should it be: "...radiation as it originates..."?

**P. 6700, L. 21:** I suggest you replace "strikingly" with "very" (and suggest the same should be done elsewhere in the paper).

P. 6702, L. 23: I suggest you replace "number" by "values" in both instances.

P. 6704, L. 9: Do you need the words "resulting changes in"?

P. 6705, L. 6: I think this should be: "Since the MERRA LST estimates do not...".

**P. 6705, L. 13-14:** I suggest you replace the term "novel" with "recent" and identify the techniques as TC and Rvalue. Perhaps replace the term "traditional" with "commonly-used"?

**P. 6712, Fig. 2 caption:** I suggest you indicate that red/blue colours indicate low/high values of optical depth.

P. 6713, Fig. 3 caption: I suggest that reference be made to Table 1.

**P. 6714, Fig. 4 caption:** I suggest you indicate that blue/red colours indicate low/high values of the Rvalue output.

**P.** 6715, Fig. 5 caption: I suggest you indicate that blue/red colours indicate low/high values of the TC output.

**P. 6716, Fig. 6 caption:** I understand different phase-shifts relate to different depths in the soil. If so, please indicate in the caption. Also, I suggest you identify the line styles/colours in the caption.

P. 6718, Fig. 8 caption: I suggest you identify in the caption the different symbols used.

**P. 6719, Fig. 9 caption:** I suggest you identify in the caption the different MERRA scenarios. I suggest that reference is made to how the positive values/negative values are measured, i.e., how are improvement/degradation identified.