Dear Referee,

Below you will find the answers to the overall and minor comments you made about the manuscript titled "Comparison of measured brightness temperatures from SMOS with modelled ones from ORCHIDEE and H-TESSEL over the Iberian Peninsula" by A. Barella-Ortiz, J. Polcher, P. de Rosnay, M. Piles, and E. Gelati.

OVERALL COMMENTS

1. The description of the methods and the results is fragmented. For example, a mixed introduction of ORCHIDEE and HTESSEL confused me on what configuration exactly used for each LSM? And the discussion of temporal and spatial correlation are not clearly separated and most of time mixed, which hinders the understanding of their studies.
    - Section 2.2.2 does not aim at describing the LSMs, but at showing that each one of them deals with the hydrological scheme and surface and soil temperatures in different ways. This is key to discard the LSMs as the main source of the TB error in the discussion. The information given in this section is supported by Table 1 (page 13053), which, in our opinion, clarifies the configuration of each set of modelled TBs. However, we propose to change the way this information is given to clarify our approach. In particular, we propose to divide the "Data and methods" section into two: "Data" and "Methods". We would like to point out that we also propose to modify the structure of the other sections to clarify the way information is given in the manuscript:

      Abstract

      1 Introduction

      2 Data
      - 2.1 SMOS retrievals of TB
      - 2.2 Modelled TB: CMEM
        - 2.2.1 Input data from Land Surface Models
          - Differences between LSM hydrological schemes and temperature estimation
      - 2.3 Precipitation and Land Surface Temperature

      3 Methods
      - 3.1 Data sampling and filtering processes
      - 3.2 Comparison analysis:
        - Spatio-temporal correlation
        - EOF

      4 Results
      - 4.1 Comparison of measured and modelled brightness temperatures
        - Temporal correlation
        - Spatial correlation
      - 4.2 Temporal and spatial characterization of the TB error
        - 4.2.1 TB error
          - Spatial patterns
          - Expansion coefficients
        - 4.2.2 LST and precipitation errors
          - Spatial patterns
          - Expansion coefficients

4.2.3 Analysis of CMEM assumptions
4.3 Annual cycle of brightness temperatures

5 Discusssion

6 Conclusions

- We will explain the reason why the spatial and temporal correlations appear in several sub-sections of the “Results” section.
  First, these correlations between measured and modelled brightness temperatures are exposed in section 3.1 (page 13030). In this section, the first four paragraphs correspond to the temporal correlation and the other three to the spatial correlation. We believe that it is well structured. Nevertheless, to ease comprehension, we propose to divide this section into two sub-sections without numbering: i) temporal correlation and ii) spatial correlation.
  Second, the results obtained for the temporal and spatial correlations are discussed after the EOF analysis of the TB error is exposed in section 3.2.1 (page 13034, lines 20 to 28). This text relates the seasonality observed in the dominant mode of the TB error (EOF analysis) to the one of the spatial correlation time series (Figure 2). Therefore, it links the inconsistency found between the spatial structures of measured and modelled TBs and their annual cycle. We also higlight that while temporal correlation (Figure 1) is driven by the TB's fast varying component (its quick response to precipitation), spatial correlation is dominated by the slow varying component (the annual cycle): this explains the apparent discrepancy between the relatively larger temporal correlation values and smaller spatial ones. The same conclusion is reached by Polcher et al. (2015) comparing remotely sensed and modelled surface soil moisture.
  Third, further TB temporal and spatial correlations are computed (section 3.2.2) by varying the CMEM configuration (Table 1). The aim of this analysis is to study if the spatial inconsistency found between measured and modelled TBs could be due to assumptions made in the CMEM model. The values obtained for these correlations are compared to those obtained for the original sets of modelled TBs. To clarify the comparison, the text refers to Table 4. To improve the readability of section 3.2.2, we propose to divide it into two: i) 3.2.2 “ LST and precipitation errors” and ii) 3.2.3 “Analysis of CMEM assumptions”.
  Finally, the spatial correlation is also mentioned in section 3.3. It is done after identifying a systematic bias between measured and modelled data during the Winter season. This is related to the previous paragraphs, where we illustrate the spatial inconsistency between measured and modelled TBs due to their annual cycle.
  We would like to note that the temporal and spatial correlation of TBs are also listed in Table 4 (page 13056).

2. The discussion on the precipitation and LST errors is wired to me. First of all, the E-OBS precipitation and LAND-SAF LST were not used in CMEM to derive TBs. However, they were used as the reference to derive the errors of precipitation and LST from ECMWF reanalysis data (e.g. forcing data for LSMs). And, then, the authors try to link such analyzed errors to the TB errors? It seems to me a major flaw in the concept of their studies on this topic.

- Brightness temperatures are defined as the product between the emissivity of the surface and its physical temperature (page 13021, lines 27 to 28). On the one hand, temperature is driven

by the thermodynamics of the surface. Land Surface Temperature (LST) is an independent variable which allows us to verify if the thermodynamics of the models shows biases with spatio-temporal characteristics similar to those found for TB. On the other hand, the emissivity is driven by the hydrological cycle at the surface. It is influenced by soil moisture, which is directly correlated with precipitation and thus, the verification of this forcing variable of the LSMs with indepedent data is essential.
We do not believe that this is a flaw in the concept of the study. We have chosen to validate the two variables which are the prime driver of TB and for which independent observations exist. This allows to exclude the hypothesis that biases in the models (either originating from the forcing data or produced internally) are responsible of the errors found when comparing modelled TB with observed TB.

And i am not surprised that they cannot find the controlling factors for the TB errors over IP.

- We would like to note that the work exposed in the manuscript is not limited to studying only the forcing as the origin of this inconsistency. Certain assumptions made in the CMEM are analysed but are discarded too, as explained in page 13038. Nevertheless, we believe that further research has to be done following this line to find the main cause for the spatial differences between measured and modelled TBs. This is discussed in section 4 (from page 13044, line 17 to page 13045, line 12). LSMs are not likely to explain the TB errors found, because ORCHIDEE and H-TESSEL deal with the soil moisture and the soil temperature in different ways, but both sets of modelled TBs show a similar spatial pattern and temporal evolution of the dominant TB error mode (page 13037, lines 19 to 27). This is the reason why we highlighted the differences between the two LSMs in section 2.2.2.

I stopped further commenting this manuscript due to the perception of a wrongly conducted studies, as indicated from the above comments. Nevertheless, I do also provide the minor comments in the attached PDF

- On the one hand, we would like to thank you for providing both the overall and the minor comments. On the other hand, we hope that after the responses to the previous points you agree with our approach to discard the forcing as the main source of the inconsistency in the TB error. It should be noted that this analysis corresponds to a subsection of the "Results" section and, as explained in the previous point, other analyses were carried out. Therefore, we regret that you stopped commenting the manuscript and would be very grateful if you could provide more insight about the other analyses presented herein.

DETAILED COMMENTS

Page 13021

1. Lines 11 – 18

It is not pretended to attribute the control of soil water flow to pedo-transfer functions. The text refers to them as one way in which the interaction between soil and water is approached. As for the last phrase, we refer to the soil moisture because it is the variable we are interested about in this study. In our opinion the text expresses clearly that soil moisture is interpreted in different ways depending on the hydrological scheme that a LSM considers.

Page 13022

2. Lines 6 - 11

We propose to replace the text by the following: " Therefore, we will refer to Surface Soil Moisture (SSM) instead of soil moisture. Some studies, like Escorihuela et al. (2010) lower the penetration depth to 1–2 cm. However, it should be highlighted that information from thicker layers can also be retrieved due to the action of roots."

Page 13026

3. Lines 2 - 5

This corresponds to the way the CMEM model was development. We did not participate in it, but used it to model brightness temperatures. To know more details about this, we refer to literature [de Rosnay et al. (2009), Drusch et al. (2001)]. In addition, the manuscript provides the ECMWF's website about the CMEM.

4. Lines 2 – 7

We would like to thank the author for providing us this reference. The modelled set TB_{HT} was provided by the ECMWF.

5. Line 10

This information is given in Table 1 (page 13053).

6. Line 19

A similar comment was made by the other referee. The same reply to its comment is given: The main objective of this section is not the description of models, but the difference in their hydrological scheme, as well as in their estimation of land surface and soil temperature. This is key because these differences allow to discard LSMs as the main cause of the spatial inconsistency between measured and modelled TBs. The title of the section may, however, not be clear enough and thus, we propose to change it to "Differences between LSM hydrological schemes and temperature estimation". As exposed in the response to the other referee's "overall comments", we propose to change this section to section 2.2.1 (Input data from Land Surface Models) where both LSMs will be briefly introduced. It will include a subsection without numbering (Differences between LSM hydrological schemes and temperature estimation), where the differences will be explained.

7. Line 27

We agree with the referee´s proposal.

Page 13027

8. Line 14

ORCHIDEE's hydrological scheme is based on the model of the Centre for Water Resources Research (CWRR). In line 14 we refer to the CWRR model, not to ORCHIDEE.

Page 13028

9. Lines 4 - 6

In our opinion the layering information corresponding to ORCHIDEE's soil temperature is not relevant to the study. The reason being that ORCHIDEE's temperature profile was calculated following the same 11 layer soil discretization as the one from the soil moisture profile (page 13028, lines 6 to 7). However, we propose to include a reference to (Hourdin, 1992) where this information can be found.

10. Line 26

We propose to divide the "Data and Methods" section into two. The way the correlation was computed can be detailed in the new "Methods" section.

11. Line 27

TB_{SM} is how measured TB from SMOS (L1C product) is referred to in the manuscript (page 13025, lines 2 to 3).

Page 13029

12. Line 9

To sample modelled data using H-TESSEL's state variables (TB_{HT}), TB data from i) TB_{SM} and ii) TB_{HT} were averaged considering a 3 hour window. Next, TB_{HT} were sampled with TB_{SM}.

Page 13030

13. Lines 22 – 24

In section 3.1 we perform a temporal and spatial correlation analysis to compare the temporal evolution and spatial structures of measured and modelled TBs. The text from the manuscript highlighted in your comment gives two reasons why we expected high values for the mean annual temporal correlations between these TBs: i) quick response to precipitation and, at a lesser extent, ii) strong annual cycle of surface temperature. In our opinion the text does not identify the surface temperature's annual cycle as the main controlling factor of TB calculation. In fact, further on in the same section we refer to the comparison between retrieved and modelled surface soil moisture (Polcher et al., 2015) (page 13031, lines 20 to 24) that shows that temporal correlation measure between remotely sensed, in-situ, and modelled SSM, is mainly driven by the high frequency behaviour of SSM. Therefore, this diagnostic is not very sensitive to the slower variations of the field studied. We believe that this is also the reason why the temporal correlation between measured and modelled TBs is high.

Page 13031

14. Lines 20 – 23

As mentioned in the previous point, Polcher et al. (2015) proves that the temporal correlation between remotely sensed, in-situ, and modelled SSM, is mainly driven by the high frequency behaviour of surface soil moisture. Therefore, this kind of analysis will not diagnose in a reliable way the soil moisture dynamics relative to the low frequency behaviour of surface soil moisture. That includes its annual cycle.

15. Line 24

This comment is analogous to number 10:
We propose to divide the “Data and Methods” section into two. The way the correlation was computed can be detailed in the new “Methods” section.

Page 13032

16. Lines 13 – 14

We have performed two different correlation analyses: temporal and spatial. Each one is computed in a different way and thus, a good agreement in temporal correlation does not imply that there will be a good agreement in spatial correlation.
On the one hand, Figure 1 shows that the mean annual temporal correlation between measured and modelled TBs is high. In our opinion this is due mainly to the measure of the correlation which is more responsive to the high frequency behaviour of temperature (quick response to precipitation) than to its low frequency behaviour (Polcher et al., 2015). On the other hand, Figure 2 shows poor spatial correlation values. So, even though there is a good agreement in the temporal evolution of measured and modelled TBs, their spatial structures are not consistent between them. Figure 2 also identifies a marked seasonality in the temporal evolution of the spatial correlation. This implies that the inconsistency in spatial structures may be related to the slow variation of TBs, and thus their annual cycle. Analysing Figures 1 and 2, the temporal correlation is mainly driven by the high frequency behaviour of TBs, while the temporal evolution of the spatial correlation is more influenced by their low frequency behaviour.

Page 13033

17. Line 12

We propose to divide the “Data and Methods” section into two. The description of the EOF analysis will be moved to the new “Methods” section.

Page 13034

18. Lines 14 – 15

This comment is related to the previous one. The description of the EOF will be moved to the new “Methods” section.

19. Lines 24 – 25

By means of the EOF analysis of the TB error, section 3.2.1 states that the temporal evolution of its main dominant pattern evolves slowly throughout the year. This coincides with the seasonality shown in Figure 2. Therefore, the dominant mode of variability of the TB error is driven by the low varying component of the TB signal and not its fast varying component (as the temporal correlation). We propose to change the phrase to “This is contrary to the temporal correlation analysis, which we believe is driven by their synoptic variability as occurs with surface soil moisture (Polcher et al., 2015).”

Page 13035

20. Lines 4 – 5

We are not sure of having understood your comment. ECMWF mean first guess departure is “the time averaged geographical mean of the difference between measured (SMOS) and modelled (H-TESSEL and CMEM) TBs” (page 13035, lines 5 to 7). In our opinion it is relevant to include this figure because it allows us to confirm the results shown by the EOF analysis of the TB error.

21. Lines 19 – 22

The “Results” section (3) contains 3 subsections

3.1 The temporal and spatial correlation between measured and modelled TBs are exposed.

3.2 An EOF analysis of the TB error (the difference between modelled and measured TBs) is exposed.

3.3 The TB's annual cycle is analysed.

One of the results obtained in section 3.1 is that there is a poor spatial correlation between measured and modelled TBs. Therefore the spatial structures from these TBs are not consistent between them. To understand why this happens, we decided to study the error between TBs using the EOF methodology. As explained in the EOF description, this methodology allows to identify the dominant spatial and temporal modes of variability of a field. In this case the field is the TB error, not the TB itself. Therefore, the results shown in this subsection are referred to the EOF analysis of the TB error. We do not deal with correlations, but with the spatial pattern of the dominant mode of variability of the TB error and with its temporal evolution (the expansion coefficients).

We have identified a dominant spatial structure of this error and we have also shown that this structure evolves during the year, being dominated by the slow varying component of the TB signal, given by its annual cycle. It should be noted that this can explain the behaviour shown in section 3.1 regarding the temporal and spatial correlation:

- The fact that the measure of the temporal correlation is driven by the TB's high frequency behaviour and does not provide reliable information of the annual cycle. Otherwise, the temporal correlation would have shown lower values than the ones observed in Figure 1.
- The marked seasonality shown in the poor spatial correlation (Figure 2).

Page 13036

22. Lines 18 – 22

This is explained in the overall comments (point 2).

We would like to end this document by thanking you for the comments made about the manuscript.

Yours faithfully,

Anaïs Barella-Ortiz