Reply to Referee #2 for "Evaluation of ORCHIDEE-MICT simulated soil moisture over China and impacts of different atmospheric forcing data" on HESSD

Z. Yin on behalf of all co-authors

1 Major comments

1.1 **"The abstract contains some details that cannot be understood by reading the abstract only (it should be avoided). For instance, median R and RMSE are reported at page 1 - line 9 without mentioning with respect to which dataset they are computed. The reference to SB and LSC metrics is given but the reader is not able to understand what these metrics represent. Why are they used? Similarly for the discrepancies metric. I suggest mentioning in the abstract the results in general terms, without referring to metrics not know to the reader."**
A: True. Details of the comparison (value of metrics) are removed from the abstract. Other sentences are also slightly modified to make them more clear and brief.

1.2 **"GLEAM contains several datasets included in the atmospheric forcing datasets. It is not only ERA-Interim but also GPCC through MSWEP product. Therefore, I expect a large agreement between GLEAM and modelled soil moisture, but it does not mean the soil moisture simulations are accurate, they are simply consistent with GLEAM soil moisture (as I expected). The corresponding results should be clarified and put in perspective."**
A: Exactly. Some information is contained in both GLEAM and atmospheric forcing that we used, which may lead to a good agreement between GLEAM and simulated SM. We will discuss this issue in the revised Section of "Discussion and perspective".
However, the GLEAM SM assimilates a set of satellite observations and ground measurements (Martens et al., 2017). In addition, it has high spatio-temporal integrity in comparison to in-situ and remote sensing SM. Therefore, GLEAM is used to evaluate spatial variation of simulated SM in a long time period. In introduction we will explain the aim of using GLEAM SM, as: "Finally the GLEAM SM data (The Global Land Evaporation Amsterdam Model; Martens et al. (2017)) is compared to the simulated SM. Different from other SM datasets, GLEAM SM results from a land surface model constrained with a number of satellite and in-situ observations. This is not a direct observation but GLEAM was shown to reproduce reasonable long period SM dynamics at

global scale (Martens et al., 2017), which is valuable to evaluate ORCHIDEE simulations for both surface and root zone moisture. Furthermore, GLEAM assimilates CCI data, so that evaluation of our model against root zone moisture from GLEAM is consistent with evaluation against surface moisture from CCI. Details of the SM datasets are shown in Sect. 2.3."

1.3 **"Even though it is a satellite-based dataset (therefore, its accuracy might be not good enough), the use of ESA CCI soil moisture dataset is in my opinion good. However, why only 3 years? I agree with authors that ESA CCI soil moisture product is more accurate after 2007, but for modelling assessment, I would prefer to see a long-term comparison (1980-2017). It is highly needed and to me much more appropriate than using GLEAM."**
A: Although ESA CCI has long time coverage, data availability (the fraction of days with available measurements) is very low in China until 2006 (as shown in Fig. R1 and R2 in the reply to Reviewer #1). Moreover, the data availability varies significant in both space and time. Thus we decided to only use the data from 2007 to 2009 for comparison. In the manuscript, we modified as: "The data availability also varies along the period according to the number of instruments available and the increase of their temporal and spatial resolutions. In China, the fraction of days with available records (Figure 4 of Dorigo et al. (2015)) is lower than 20% from 1979 to 2006. More importantly, large spatial variation of gaps exists before 2006 (Fig. A1). ... To provide a reliable validation, we only use the CCI data between 2007-2009."
We suggest to present the long time comparison in online supplementary (as Fig. R3 and Table R1 shown in the reply to reviewer #1). However, if both reviewers were aware the limitation of ESA CCI already and consider the long time period comparison more important, we will present it in the revised manuscript instead of the 2007-2009 comparison.

2 Moderate comments

2.1 **"Too many figures, also by considering the Appendix, have been presented in the paper. I would prefer a lower number of more focused figures that would help the reader to understand clearly the main results the authors want to convey. Please try to reduce the length of the paper, mainly the results section."**
A: True. Section 4.1 will be removed. Section 4.2 (comparison between GLEAM and ORCHIDEE SM), 4.4 and 5.2 will be reduced. Figure 9 will be moved to supplementary. Figure A10, A11, A12 and A13 will be removed.

2.2 **"The sensitivity analysis linking soil moisture and meteorological variables seems to me not robust enough for being published on HESS. I might be wrong, but also the authors acknowledge this problem. I suggest removing or, at least, strongly reducing."**

A: True. The results and discussions related this analysis will be reduced in the revised version. Several related figures will be removed (see reply to the previous comment).

3 Minor comments

3.1 **"Acronyms and symbols should be specified the first time they appear in the text, please check."**
A: Revised. Explanation is given before the first appearance of each symbol.

3.2 **"Page 5, line 3: How is it assessed the quality of ISMN stations? Please clarify."**
A: It should be "availability". Corrected.

3.3 **"Page 5, line 17: I would not say 'only' 203 stations."**
A: True. Corrected.

3.4 **"Page 7, line 19: Soil depths are not different in the four datasets. If I am right, please remove."**
A: Here we talk about the SM datasets, not of forcing datasets or simulation outputs. Revised as: "Because the soil depths, periods and spatio-temporal resolutions are different in the four SM datasets (Sect. 2.2)..."

3.5 **"Page 10, line 16: 'an traditional' should be 'a traditional'."**
A: True. Corrected.

3.6 **"Page 10, line 20: Why the magnitude of soil moisture is systematically underestimated? Please try to find an explanation."**
A: Here we are talking about the comparison at Xuzhou station. To avoid misunderstanding, it is revised as: "However the magnitude of θ_t is systematically underestimated as well (Fig. 4)."

3.7 **"Page 12, lines 2-3: Again, why changes of precipitation regimes are not enough to predict changes in soil moisture? Please comment."**
A: It is confusing. Based on the different trends of θ_s and P, we infer that the trend of precipitation amount cannot well explain the trend of SM. Modified as: "The mismatch of θ_s and P trends suggest that the change of precipitation amount is not the only driver of the trend of SM."

Bibliography

Dorigo, W. A., Gruber, A., De Jeu, R. A. M., Wagner, W., Stacke, T., Loew, A., Albergel, C., Brocca, L., Chung, D., Parinussa, R. M., and Kidd, R.: Evaluation of the ESA CCI soil moisture product using ground-based observations, Remote Sensing of Environment, 162, 380–395, https://doi.org/10.1016/j.rse.2014.07.023, 2015.

Martens, B., Miralles, D. G., Lievens, H., van der Schalie, R., de Jeu, R. A. M., Fernández-Prieto, D., Beck, H. E., Dorigo, W. A., and Verhoest, N. E. C.: GLEAM v3: satellite-based land evaporation and root-zone soil moisture, Geoscientific Model Development, 10, 1903–1925, https://doi.org/10.5194/gmd-10-1903-2017, 2017.