Reviewer: Anonymous Referee #2

We thank the anonymous reviewer for the constructive comments and suggestions (plain text), which significantly improved our paper. Our response is bold text.

This article evaluates 2 soil moisture dataset; derived from microwave remote sensing (ESA CCI soil moisture) and model simulations (CLM 4.5) using in-situ measurements over China. While the article is not particularly original and mostly a validation paper, it is certainly useful to document this effort. Some information is redundant with respect to recent literature and the analysis could have been more detailed.

Comments:

1) My main concern is about the choice of the metrics used for the evaluation. On the ESA CCI soil moisture website (http://www.esa-soilmoisture-cci.org/node/136, FAQ), one can read: "Before merging the active and passive merged products into a combined active+passive product we first scale both datasets into the dynamic range of the GLDAS-Noah surface soil moisture fields. We perform this processing step to obtain a final product in absolute volumetric units [m^3/m^3]. Even though the original dynamics of the remote sensing observations are preserved, this step imposes the absolute values and dynamic range (min-max) of the GLDAS-Noah product on the combined product. As a consequence, the combined product CANNOT be considered an independent dataset representing absolute true soil moisture. Hence, the statistal comparison metrics like root-mean-square-difference and bias based on our combined dataset are scientifically not meaningful. However, the CCI SM prodcuts can be used as a reference for computing correlation statistics or the unbiased root-mean-square-difference." So the choice of the metrics in this paper doesn't seem to be appropriate (or need to be further discussed).

Response: Based on this comment, the statistical metrics used in the old manuscript, including the mean bias error (BIAS), root mean square difference (RMSD), normalized standard deviation (SDV), and centered normalized RMSD (E), have been removed; and we mainly focused on the analysis about correlation coefficients and unbiased RMSD (ubRMSD) in the revised manuscript. Please see Section 2.4 (Pages 9−10, Lines 219−237). In addition, the Pearson correlation coefficient was instead by the Spearman rank correlation coefficient (Dorigo et al., 2015), please see Page 10 Lines 235−237; both the ESA CCI SM and CLM4.5 soil moisture datasets were scaled into the dynamic range of the in situ observations using a linear rescaling method (Brocca et al., 2013; Dorigo et al., 2015) prior to computing the ubRSMD (new Eq. 2), please see Page 10 Lines 230−235. Old Fig. 8 (Taylor diagram) and Table 3 have been removed; other old figures and tables related to these metrics were also revised. Please see new Figs. 3−11 and Table 2.

2) Slide 5153, Introduction. "[...] moisture using remote sensing techniques (Njoku et al., 2003; Owe et al., 2008; Kerr et al., 2012) and land surface modeling (Dirmeyer et al., 2006; Wang et al., 2011; Liu and Xie, 2013)." Could be : "[...] moisture using remote sensing techniques

(Njoku et al., 2003; Owe et al., 2008; Kerr et al., 2012), land surface modeling (Dirmeyer et al., 2006; Wang et al., 2011; Liu and Xie, 2013) or a combination of both through land data assimilation system (e.g. Dharssi et al., 2011, de Rosnay et al., 2013)."

Dharssi, I, K. J. Bovis, B. Macpherson, and C. P. Jones: "Operational assimilation of ASCAT surface soil wetness at the Met Office". Hydrol. Earth Syst. Sci., 15, 2729- 2746, 2011.

de Rosnay P., M. Drusch, D. Vasiljevic, G. Balsamo, C. Albergel and L. Isaksen: A simplified Extended Kalman Filter for the global operational soil moisture analysis at ECMWF, Q. J. R. Meteorol. Soc., 139(674):1199-1213, 2013, doi: 10.1002/qj.2023.

Response: Revised as suggested. Please see Page 2 Lines 39−43.

3) L.20-21: "[...] was intended to extend the valuable heritage of AMSR-E and provide improved spatial resolution [...]" could be: "[...] was intended to extend its valuable heritage [...]".

Response: Revised as suggested. Please see Page 3 Lines 59−60.

4) Slide 5154, Introduction L.11: "[...] than that of the most recent re-analysis [...]" L.22: Dorigo et al., 2014

Response: Revised as suggested. Please see Pages 3−4 Lines 77−78.

5) Slide 5155, Introduction L.1-5: "[...] has proven to be an effective tool to complement the commonly use of in-situ measurements [...]".

Response: Revised as suggested. Please see Page 4 Lines 96−98.

6) Slide 5156, Material and methods L.13, please add reference for MODIS

Response: The reference for MODIS is Lawrence and Chase (2007), which has been moved to the back of MODIS, as suggested. Please see Page 6 Lines 133−135.

7) Slide 5157, Material and methods L.1-2, so it is the same dataset used for the evaluation (?), please clarify.

Response: In response to the comment, we revised the description to make it clear. Please see Pages 6−7 Lines 149−153: "*The soil moisture simulations of CLM3.5, an old version of CLM4.5, forced by four different atmospheric forcing datasets were compared against a common set of in situ observations and results showed that, over most regions of China, the soil moisture estimations forced by the ITP forcing dataset had closer correlations with ground-based observations than did the three other simulations (Liu and Xie, 2013)*".

8) Slide 5159, Material and methods I am confused by the equations here, Eq.5 looks like the formula of the unbiased RMSD but you call it the centred normalised RMSD (?) and latter in the text, slide 5164, L.26 you called unbiased RMSD the RMSD on soil moisture anomalies. Please clarify.

Response: In the revised manuscript, the centered normalized RMSD (E) has been

removed and the formula of the ubRMSD has been added (see new Eq. (1), Page 10 Line 227). The RMSD of soil moisture anomalies, called ubRMSD in the old manuscript (slide 5164 L.26), was also removed as suggested.

9) Slide 5162, Results How do your correlations compare with existing literature? Did you account for significance? Do you think that le rather low level of correlation could be linked to the fact that the in-situ measurements are not taken at the same place (destructive measurements)?

Response: In response to the comments, we added a detailed description of in situ soil sampling method and a discussion of its potential effect on the comparison results.

1. We compared the statistical metrics used in this study with those of the existing literature (Page 12 Lines 293−295): "*In the current study, the averaged R_{sp} value of the ESA CCI SM is 0.37, which is slightly higher than that (R_{sp} = 0.32) from 34 sites over China in Dorigo et al. (2015)*".

2. In the revised manuscript, the Spearman correlation coefficients and ubRMSD values for all 306 sites were all shown in Figs. 3 and 4, respectively. The sites with a significant positive Spearman's correlation ($p < 0.05$) have been marked with cycles while the other sites marked with points (Figs. 3 and 4). The related analysis was presented in Section 3.2, please see Pages 12−13 Lines 282−317. However, it should be noted that only the sites having significant positive Spearman's correlations ($p < 0.05$) were used in the following analysis (Sections 3.3, 3.4, and 3.5) and discussion (Section 4) for both the ESA CCI SM product and CLM4.5 simulation.

3. According to the user guide of in situ soil moisture measurements from agricultural meteorological stations of China Meteorological Administration (in Chinese, http://cdc.nmic.cn), soil moisture observation method is summarized as follows: (1) the observation field of each station is divided to four parts and four soil samples would be collected each time; (2) their soil moisture contents in dry weight basis (the ratio of water mass to dried soil's weight) are determined by drying the soil, respectively; (3) the average value from the four samples are recorded as mass percentage for this station. It is noted that the horizontal distance between two successive samples at the same part of each station is no more than 2 meters, which leads to almost the same meteorological and soil conditions. Moreover, to reduce the effect of soil moisture heterogeneity, the station was usually chosen to be over flat surface. However, the original observations from four samples at each station were not available and we could not investigate the effect of destructive sampling on the comparison results in this study. Previous studies (Brocca et al., 2014a, b) showed that soil moisture had enormous variability even at local scales, in particular in absolute terms. These methods will be used in our future work to discuss the impacts of spatial variability and destructive sampling method. Please see Pages 18−19 Lines 439−455.

10) Slide 5167, Discussion Looks more like a summary/conclusion (at least to me) L.26, I do not feel necessary to mention that data assimilation is beyond the scope of the study.

Response: In response to the comment, we added some discussions to Section 4, including (1) a detailed description of in situ soil sampling method and a discussion of its potential effect on the comparison results, (2) the potential effect of in situ precipitation measurements on the comparison results for the CLM4.5 simulation; (3) the impact of the mismatch in soil depths on the statistical metrics. Furthermore, some descriptions of potential uncertainties derived from in situ observations, model simulation and remote sensing product were also presented in the discussion section. Please see Pages 18–21 Lines 428–520. In contrast, the summary showed main conclusions of this work and potential directions for future research. In addition, the sentence (Page 5167 Lines 26–27 in old manuscript): "*However, data assimilation is beyond the scope of the present study*" has been removed, as suggested.

11) Slide 5168, Discussion L.6-9, information that could be useful earlier in the manuscript.
Response: In response to this suggestion, the reason why we evaluated the ESA CCI SM product and CLM4.5 simulation at the monthly timescale was added to Section 2.4. Please see Page 9 Lines 208–213: "*Given the low temporal frequency of the in situ datasets, the validation of the ESA CCI SM and CLM4.5 was conducted at the monthly timescale to reduce the effect caused by the mismatch between actual observation and model time (Wang and Zeng, 2011; Liu and Xie, 2013)*". However, the information was still remained in the discussion section, which was used to discuss possible potential uncertainties of the statistical metrics for the ESA CCI SM product and CLM4.5 simulation. Please see Page 21 Lines 511–520.

12) Slide 5176, Table 2 An averaged value of number of valid measurements might be more useful (?)
Response: Based on the suggestion, the average value of number of valid measurements per station was added to Table 2 instead of the number of total valid measurements. Please see Page 33.

13) Figs. 6 - 7 - 9: having the same y-axis might help.
Response: We revised Figs. 6 and 7 by adding the same y-axis for each sub-plot, as suggested. Fig. 9 was revised by adding the same y-axis as Fig. 5. In addition, to distinguish the discrepancies of statistical metrics at different soil depths, the y-axis of new Fig. 11 is different from that of Figs. 5 and 9. Please see Pages 41–47.

References

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