We thank Luigi Renzullo for the very in-depth review, providing feedback both on major points as well as numerous details. For clarity our responses are added to his original comments and highlighted in colour.

The changes to the manuscript are attached in an extra file, since changes are pretty extensive.

GENERAL COMMENTS

The paper explores a very interesting idea of assimilating brightness temperature observations, as opposed to derived soil moisture products, into a land surface model. However, no compelling argument is provide as to why this might be 'better' than assimilating the derived soil moisture product. Nor is there any real examination to the improvements, or otherwise, to the model performance. Most troubling however is the lack of evaluation against local information about the continental water balance to see if the patterns the authors have identified may be corroborated with either independent data or research. Why choose Australia as a case study but ignore the very many articles about data assimilation for water balance over the country? More detail critique is provided in the following. I recommend major revision and another review.

We have reworked the relevant text passages within the introduction, highlighting the advantages of the assimilation of brightness temperature as opposed to soil moisture products. The CLM land surface model used in this study provides all necessary dynamic information required for the brightness temperature forward simulations, e.g. soil temperature, vegetation temperature etc. Furthermore, the static surface datasets within of the model are also used within the forward simulations. In contrast to this, soil moisture products are based on retrievals using output and surface datasets from other models, thus introducing inconsistencies. However, brightness temperature assimilation does have its own issues, e.g. shortcomings in the forward simulations and biases between simulated and observed brightness temperatures.

We have compared the modelled soil moisture to in-situ stations over Australia and evaluated the assimilation performance in terms of the correlation coefficient R and the Root Mean Square Error (RMSE), as done in other studies. The validation has been expanded, giving some more detail on the in-situ measurements and citing the relevant publications. We have included maps showing the Murrumbidgee basin where most of the in-situ measurements are located as well as the Australian land cover classification used by the model. Spatial patterns for the increments and also quantile evaluation are put into context of the Australian landscape.

We have added some lines in the introduction about why Australia was chosen as a study area and highlighted the main soil moisture assimilation studies that we have found.

MAJOR ITEMS: * Most concerning is that there appears to be no interest in gaining new insight about Australian hydrology or indeed assessing the validity of the model estimates beyond soil moisture. No papers referencing Australian sources on the continent's hydrology or water cycle, so how do you know if the results are any good. There are clearly patterns in the results that may or may not be known to Australian research community. A simple first check is to see if the results accord with those from http://www.bom.gov.au/water/landscape/. The limited evaluation against in situ data in the Murrumbidgee catchment is weak, including no mention of the sites locations, the depth measublue, nor what is measublue (e.g. volumetric water content or wetness, neutron count etc).

Please see above response. Further we would like to add that the study strongly focuses on soil moisture, and therefore the wider Australian water balance has not been discussed. We have compared the spatial patterns of the soil moisture simulations to the above link and now mention this. A quick check did reveal that for instance evaporation fluxes change by roughly 5 %,

* Should mention in the introduction that while L-band on SMOS may be the first 'ded- icated' mission for soil moisture, there has been a long history of data assimilation development in C-band soil moisture retrievals (AMSR-E,-2 and ASCAT for example) and SMAP is yet another L-band mission that is providing global coverage. Moreover you would be wise to cite work from research who have performed assimilation with an Australian focus (you are not the first) and you cannot ignore the

rich legacy of work conducted in understanding Australian hydrology.

We have included example studies on the use of ASCAT and AMSR-E in the introduction as well as studies focusing on Australia.

* Simulations appear to be made for layers 0-9 cm, however the L-band sees emissions from at (at best) 0-5cm. Comment on this disparity and the impact, if any, on simulated brightness temperatures.

For all experiments the forward simulations use model output from the 10 CLM layers. These reach far deeper than where L-band emissions mostly originate from, as stated up to roughly 5 cm. The forward operator accounts for this and the simulations therefore are also only sensitive to model output of 0-5cm. We have clarified this within the description of the experiments.

SPECIFIC ITEMS: P1,L17: Change to ' . . . sensitive to 1.4 GHz electromagnetic emissions, measures . . . multi angular top-of-atmosphere . . .'
We have changed this.

P1,L18: Delete 'influenced by, among others, surface soil moisture.' Sentence is too long and 'among others' doesn't make sense. Among other what?
We have shortened the sentence accordingly.

P1,L22: I suggest including the key reference by Kumar et al. 2009 in the list which describes the mechanisms how top layer soil moisture assimilation can improve root-zone estimates in LSM's. [Kumar, S. V., Reichle, R. H., Koster, R. D., Crow, W. T., & Peters-Lidard, C. D. (2009). Role of Subsurface Physics in the Assimilation of Surface Soil Moisture Observations. Journal of Hydrometeorology, 10(6), 1534–1547. https://doi.org/10.1175/2009JHM1134.1]
The citation has been included.

P2,L11: Suggest rewording the sentence to: ". . . retrievals represent the optimum fits between simulated brightness temperatures and the . . . "
The sentence has been changed.

P2,L19: Modify: "Sources of uncertainty include atmospheric forcing, . . ."
We have changed this.

P2,L32-33: Not clear what is meant here. Elaborate on the link between brightness temperature and 'qualitative' models. Why would this even be a consideration?
We have removed the term 'qualitative' as we agree it was not clear. We simply meant that brightness temperature assimilation should be tested with different land surface models

P3,L2: "Within this" should be the start of a new paragraph.
A new paragraph has been inserted.

P3,L2-35: Very lengthy introduction to what this paper is about. Strongly suggest restructuring to be more clear in the lead up to Section 2 about what the objectives of this paper are. The paragraph should start: "In this paper we . . " and itemise the objectives. This will help the reader link the findings with the objective of the work.
We have revised the introduction and moved some parts to the conclusion part of the paper (relevance of findings for drought monitoring systems, ellaborations on the use of CDFs and quantiles for extreme event characterisations in a shortened form).

P3,L19: Why Australia? This needs to be clearly articulated.
We have added some sentences on the motivation of choosing Australia as a study area.

P3,L26-28: If the results will be evaluated over Australia then you should cite "Smith et al. (2012)". Yes, these data are part of ISMN, but should cite the official source. [Smith, A. B., Walker, J. P., Western, A. W., Young, R. I., Ellett, K. M., Pipunic, R. C., ... Richter, H. (2012). The Murrumbidgee soil moisture monitoring network data set. Water Resources Research, 48(7), 1–6. https://doi.org/10.1029/2012WR011976]
The citation has been included.

P3,L33: Change "avoiding to large" to "minimising the impact of potential large".
The sentence has been altered.

P4,L6: So did you use coupled or uncoupled mode? Why mention these if you're not going to specify here why.
We do not mention the coupled mode anymore

P4,L9: What are these more recent higher resolution data sets? Explain that these will be described in Section 2.1 and 2.2. Why 0.25 degree? What is CLM normally run at? 0.25 degrees is quite coarse for continental studies, makes me think why not extend to the whole world. That way t=you can use the whole ISMN and not just the tiny little southeast corner of Australia?
We have included the reference to the relevant section. The 0.25 degree resolution matches the SMOS observatiosn well, which is now stated in the text. CLM itself can be run at many resolutions, although usually coupled global simulations are quite a bit coarser than 0.25 degrees, e.g. 0.5 or 0.75 degrees. The motivation of using Australia has been included, see above.

P4,L13-32: How do you know if the derived surface information is accurate for Australia? What local information/expertise have you consulted? There is A LOT of research work (none of which are cite here) that shows these MODIS products are not representative of truth in Australia, (let alone the soils information). I would accept that a global study may use inferior information because it is the only data available with global coverage, but because this investigation focuses on Australia, it must be addressed! If accuracy is not an issue for this investigation (because assimilation compensates for the model deficiencies, including parameterisation) than you should state it explicitly here.
We agree we should have consulted more local expertise. However, despite focusing on Australia we did have future global applications in mind choosing the datasets. We have included a study on the validation of LAI within the Murrumbidgee area in the Assimilation and results section, linking visible patterns to possible LAI errors. Selecting MODIS data was also motivated by the fact that a clear rational exists in using these data as CLM Plant Functional Types and LAI values. The soil data used incorporates local information, albeit into a global product. Concerning the forcing datasets, we have consulted local expertise but did not find forcings at the requried spatial and temporal resolution.

P5,L26: Change to '. . . allows the coupling of different . . .'
We have changed this.

P6,L15: Is that "K ensembles" or "K ensemble members"? Clarify.
Changed to "K ensemble members."

P6,L22: I recommend "mapped" instead of "propagated". Propagated is only relevant to mapping through time (or space).
We have changed this.

P7,L29: The UTC to local time conversion may work for eastern Australia but not central or western Australia. How big an impact do you think a 2 hour error in timing will make on simulations?
We have included that the assumed error is justifiable, since the 2 hour mismatch is smaller than the temporal resolution of the forcings. We do agree the approach is not optimal.

P8,L16-17: Modelled brightness temperature can be extremely sensitive to choices in h, the roughness parameter. How have you dealt with this? Perhaps through the bias correction? Explain.

We have included that the roughness parameter is important, but calibrating the forward simulations towards the observations might actually deteriorate the sensitivity towards soil moiture. We therefore keep the original parameters for good variability and remove the bias through CDF-matching.

P8,L24: Is RFI an issue over Australia? If so, where will it be most likely. If not, then say so.
Australia is largely unaffected by RFI, we have added this information

P10,L2-3: You need to be more specific. These are the OzNet network in the southeast of Australian in a catchment called the Murrumbidgee, I presume. If so, confirm and cite the relevant work (Smith et al, 2012). If not, then you need to explaining where the in situ data are located, how deep they measure, etc.
We have added the reference and also added a brief description of the sites location and depths. The OzNet sites location is now shown in a map.

P10,L18-19: I would have thought the innovations would be close to zero on average (in fact that is one of the tests to see if your filter is operating optimally). Do you mean innovation or increment? Clarify. Also, what are the units on the increment? They appear to highlight dryland agricultural areas, e.g. western Australian wheat belt. Can you comment on the patterns and their connection to the surface parameterisation?
We argue that for most parts the increments are close to zero but that deviations do exist. They are given in vol % soil moisture, which has been added to the graphics. Within the text we now refer to the possible error in the LAI values or other possible reasons, such as irrigation for limited areas.

P11,L19: Please comment on the strong positive features in Fig. 6 in the 0.8 - 2.3 m layers. They are clearly linked to features in the landscape. What can you say about them?
We have linked the patterns to Lake Eyre and the Nullarbor plain, they are the result of strong increments accumulating in the lower layers. The Nullarbor plain for instance is very dry, and adding water in the deep layers with low temporal variability will lead to strong quantile changes.

P11,L34-P12,L1: A more relevant way to "place these findings in the context of" hydrological monitoring systems is to compare with actual modelling system output. A simple web search shows you can gain a lot of information about water balance in Australia from http://www.bom.gov.au/water/landscape/ I strongly urge you to consider locally relevant information to assess your results.
We have included the site, stating that CLM output was compared to the AWRA-L simulations to check for consistency.

P12,L10-13: How do you know it was a drought event? What other independent corroborating evidence supports this?
We now refer to the event as being relatively dry, it is to highlight the influence of quantile changes without making any quantitative evaluations on real droughts. This could be interesting for future research.

P12,L23-24: You should mention the coupling to CMEM, as CLM does not estimate brightness temperatures.
We now mention CMEM.

P13,L5-7: Agree with revisiting the use of LAI climatology. Recommend further than you examine the usefulness in Australia.
Quite likely a next study, restricted to a more local area. We will consult local expertise upfront.

Figure 1: Why cant the two panels be compablue? They should be able to be compablue. The point need to be identified, otherwise why have them a s separate shapes and colours?

This has been corrected for.

Figure2 2-8,10: Why no label on the colour bar? Insert units. ('Unitless' is acceptable)
Done

Figure 10: Where are we looking. Consider a location diagram/inset or mention: "central coast of New South Wales." for example.
The proposed text has been added.