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Hydrology and Earth System Sciences
Discussions
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Interactive comment on "Improving Soil Moisture Prediction of a High–Resolution Land Surface Model by Parameterising Pedotransfer Functions through Assimilation of SMAP Satellite Data" *by* Ewan Pinnington et al.

Anonymous Referee #1

Received and published: 25 August 2020

The study describes results of a data assimilation experiment, assimilating soil moisture data of the Soil Moisture Active Passive mission into the UK land surface model JULES. The assimilation updates states and parameters. Resulting soil moisture is compared to SMAP data and data of an independent network of cosmic ray neutron probes.

The title and general content of the manuscript are promising, while the manuscript itself exhibits lack of detail which would be required for following the study and reproducing the results. Below, my concerns, starting with the general ones, and followed

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by detailed comments.

1. Well known bias in the SMAP satellite product and impact on pedotransfer functions is not discussed (e.g. Reichle et al. https://doi.org/10.1029/2019MS001729 or Colliander et al 2017 https://doi.org/10.1016/j.rse.2017.01.021). This would be a key asset of the paper.

2. Which SMAP level data was used. It will help the reader in understanding the results. Please point this out in the introduction and methods sections. What are the implications?

3. Discussion is not based on literature but merely on own postulations. A good guide is located here: https://www.biosciencewriters.com/How-to-Write-a-Strong-Discussion-in-Scientific-Manuscripts.aspx

4. Please add conceptual details on how the 4DEnVar (an optimization method) is combined with EnKF (optimization) (see page 7 lines 159-164). I imagine this can be done by text or together with a figure. Also address why are both optimization methods combined at all?

5. Please add how is the state vector in Appendix A is composed in the present case (variables, parameters, IenKS posterior?) and which units do the variables in Appendix A have.

6. Please clarify, what are prior and posterior with respect to two data assimilation methods? How can posteriors be worse then priors considering that the results are optimized using the evaluation data? Please plot as well the data assimilation performance over time with regard to RMSE and parameter convergence as for example in Poterjoy et al. 2017 https://doi.org/10.1175/MWR-D-16-0298.1 , Botto et al. 2018 https://doi.org/10.5194/hess-22-4251-2018 and Baatz et al. https://doi.org/10.5194/hess-21-2509-2017 .

7. Please add results after the 4DEnVar assimilation in order to demonstrate what an

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additional assimilation yields in terms of skill.

8. Please expand on why to add another 1% SWC error to SMAP (from 0.04 to 0.05 cm3/cm3, page 6 line 123) and multiply by four (20cm3/cm3 error?) for observation inflation, a rather seldomly used method. Inflation is rather used for covariance inflation during the run time of the data assimilation experiment (e.g. Jamal and Linker 2020, https://doi.org/10.1002/vzj2.20000 or Whitaker et al. 2011 DOI: 10.1175/MWR-D-11-00276.1). Please cite more studies were observation inflation is directly used and discuss why a bias aware data assimilation method was not used (e.g. Ridler et al. 2018 https://doi.org/10.2166/nh.2017.117)

9. Please add legend to the graphs (Figure 6, 7 etc.).

10. Please discuss cross-correlation among the parameters of pedotransfer functions. From Equation 1 in the author's paper, it is clear that many parameters cross-correlate. Take for example Phi a and Phi c crosscorrelate strongly. What is the impact on saturated soil hydraulic conductivity?

11. Please expand on the JULES hydrologic water components (ET, ground water, surface water flow, overland flow, infiltration, snow). How exactly was the 4 year spin up done? Was it done in ensemble mode? How were parameters perturbed? Please provide groundwater and soil moisture development over time at four cosmic ray neutron probe locations during the spinup period to elucidate the reader about the spinup performance.

12. In this realm, a discussion of main characteristics, limitations and specifics of the study area with regard to SMAP data is essential to understand the manuscript. This would include addressing topography, land cover, other factors.

13. Equation 1 – please list the units of the parameters in these physical equations.

14. Page 7 line 145 – why did the authors chose 10% standard deviation when it is well known that many van Genuchten parameters and soil hydraulic conductivity is

logarithmic scale. What does 10% standard devation mean? Does it mean 0.63+/-0.063 for phi a and 0.0003 +/-0.00003 for phi c for example?

15. Why did the authors not use a known weighting function for JULES soil moisture to compare with cosmic ray neutron sensors. Köhli et al. 2014 https://doi.org/10.1002/2015WR017169 Baatz et al. https://doi.org/10.5194/hess-21-2509-2017 or Shuttleworth et al. 2014 doi:10.5194/hess-17-3205-2013 provide already well tested methods. How does the author's method compare with these results?

16. Aside, Desilets and Zreda, 2013 doi:10.1002/wrcr.20187, 2013 consider the diameter being 600 meter, not the radius.

17. Figure 2: please add a map of soil textures. Please discuss the sharp light blue – dark red gradient at 0.9°E. Is this an artifact from data assimilation?

18. Page 9 line 196 – adding London in all maps for the non UK citizens would be a great asset.

19. Page 10 line 206 – please define observation operator and outline the details on how this operator was developed, calibrated and validated. There are existing operators already (see point 13).

20. Page 13: Please separate discussion and outlook clearly. The authors use repeatedly phrases on future work e.g. 'work is being undertaken' (line 238), 'we will' (line 241), 'is possible' (line 244) 'could be' (line 245) 'it may' (line 247) and so on... Also references to e.g. GRACE are missing.

21. Also, a discussion on literature with previous published assimilation experiments on soil hydraulic parameters will be useful. Here, the paper can give a valuable contribution to exhisting literature. Especially considering the authors going the extra step to assimilate often cross correlated parameters of pedotransfer functions.

22. Figure 11: Symbols with a center point are more precise and clearer than circles. Please use smaller dots, or even better symbols with a center point such as +,*, x

and use different symbols for Cosmic Ray Calibration data and SMAP data points. Also please add SMAP soil moisture to the plots with cosmic ray neutron probe data, although these are not the equivalent depths as cosmic ray neutron probe soil moisture.

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