Author response to R1

We thank the reviewer for their kind comments which have helped to strengthen this manuscript. Below are our responses:

1) The reviewer noted that the DA framework in this study is very similar to previous studies.

We agree that the method is similar to the studies noted, we have updated the text to clarify this. P7L3:

"This is a similar framework to that introduced in Yang et al. (2007, 2009) for data assimilation with the Simplified Biosphere model 2 (SiB2) (Sellers et al., 1996), …"

2) The reviewer asked if we had optimized soil porosity.

Soil porosity is updated implicitly via the pedo-transfer functions we use for the JULES model. We have updated the text to make this clear. P7L4:

"…with the exception that the soil porosity parameter of JULES is updated implicitly within the pedo-transfer functions rather than explicitly included in the optimisation."

3) The reviewer asked for more explanation of the reference to *Maidment et al. 2017* P6L28-29.

We have updated the texted with more explanation. P8L25:

"This finding is consistent with the comparisons of precipitation between v3.0 and v2.0 presented by Maidment et al. (2017), where TAMSATv3.0 was shown to reduce a dry bias present in TAMSATv2.0 when compared to ground station data."

4) The reviewer disagreed that we were overfitting to the data at some grid cells P8L3-4.

We agree that "overfitting" is not the right terminology here. We believe that missing processes within the model and deficiencies of our pedo-transfer functions may cause us to retrieve unrealistic soil texture values for some grid cells. We have updated the text to remove the previous explanation. We have also included a comparison to in-situ soil texture observations from the African Soil Profile Database. P11L4:

"The inability of our data assimilation to improve soil texture estimates at certain points is most likely due to issues of spatial representativity between the modelled soil map and the in-situ data. It is also possibly impacted by errors in our pedo-transfer functions, which may perform better if specifically calibrated for Ghanaian soils (Patil and Singh, 2016)."

5) The reviewer didn't agree with our discussion on P8L10-13.

We agree with the reviewer that discussion about the biases was not meaningful and have removed this discussion from the text.

6) The reviewer commented that the CCI soil moisture observations are believed to be representative of a depth of less than 10cm P12L23-25.

Reviewer 3 also thought that 10cm was too deep a layer for comparison with the CCI soil moisture. We have therefore updated the JULES model to run with a top layer of 5cm depth and re-run our experiments. P3L15:

"JULES is typically run with 4 soil layers, with the top layer being 10 cm deep. In this paper we have updated JULES to run with a top layer of 5 cm to be more representative of the ESA CCI soil moisture observations. Another option to deal with the issue of representativity would be an exponential filter (Albergel et al., 2008) which has been used in sequential data assimilation studies previously (Massari et al., 2015; Alvarez-Garreton et al., 2016)."