Response to comments from Referee 2

October 26, 2015

Firstly, we would like to thank reviewer 2 for their constructive comments. The corrections for reviewer 2 are shown in blue in the paper.

Response to major comments:

1

1.1

Referee comment

The contribution needs to be more concise and at the same point some of the underlying assumptions needs to be better explained.

Response:

We will clarify these aspects in the revised paper.

1.2

Referee comment The authors have explored a large spectrum of experiments and I have some suggestions on how to improve the first experiments without DA. I would definitely include a map of the 12 SMOMANIA sites with a table listing the main characteristic of each site: without a map and some information about for example the climate variability it is difficult to draw conclusion for example on the critical importance of the soil type (clay soils versus sandy soils for example).

Response:

We will add a map as Figure 1. We will include a bar chart showing the average daily precipitation for the sites (from West to East) as this is arguably the most important climate variable (and the most important variable in our sensitivity study). The characteristics of sand and clay content are given in Table S1.1 of the supplement.

2

2.1

Referee comment Are there other factors that should be considered? I wonder if there is too much emphasis on the soil type characterization and if its importance is really demonstrated in the paper. At a first glance, I would say not really because there are so many other factors that can be considered.

Response:

This is a very good point. We recognise now that we did not investigate the impact of climate on the results, nor did we properly investigate the impact of soil texture over the 12 sites. Therefore, we performed extra experiments to determine whether the differences in the ensemble perturbation bias between the sites can be partly attributed to soil clay content or to precipitation. We suggest adding these results to Section 3.1.2. We clearly demonstrated that precipitation suppresses the bias for the 12 sites, while clay content has little influence. A scatter plot of the average daily precipitation against the normalized bias is shown in Figure 1(a). The linear regression line shows a strong negative correlation between the precipitation amount and the magnitude of the perturbation bias.

We then performed an experiment to determine the impact of clay content on the bias. In this experiment we used the same atmospheric forcing of the wettest site (Sabres) for all the sites. This eliminates the impact of different climate on the results and leaves only differences in soil class. The clay percentage is plotted against the perturbation bias in Figure 1(b). We then repeated the experiment in Figure 1(b) but instead using the same atmospheric forcing of the driest site (Narbonne) for all the sites. The results are shown in Figure 1(c). Neither Figure 1(b) nor 1(c) show a strong correlation between the clay percentage and the bias. On the other hand, the perturbation bias for the drier climate in Figure 1(c) is much greater for all the sites than for the wetter climate 1(b). These results demonstrate that precipitation acts to suppress the perturbation bias, while clay content has little influence on the bias for these 12 sites.

These results contradict the original conclusion we made that clay content was the main factor influencing the size of the bias. We will correct the conclusions of the paper accordingly. We will discuss the reasons for these findings in Section 4.3. We suggest replacing “contrasting soil conditions” with “contrasting conditions” in the title.

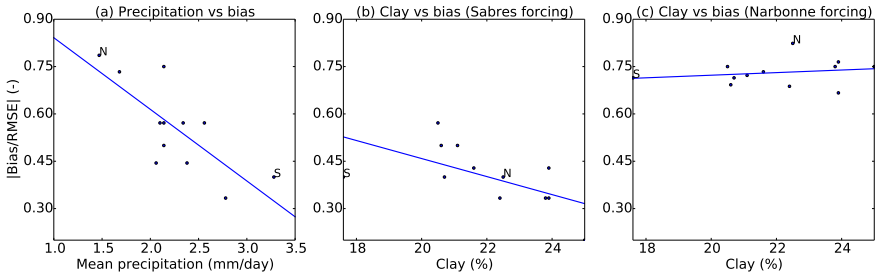

Figure 1: (a Average perturbation bias normalized by the RMSE against average daily precipitation for each site; (b) Average perturbation bias normalized by the RMSE against clay percentage for each site, with the climatological forcing of the Sabres site applied to all the sites; and (c) same as (b) but the climatological forcing of the Narbonne site has been applied to all the sites. The Sabres and Narbonne sites are labelled as 'S' and 'N' respectively. The line of best fit (linear regression) is shown for each plot.

3

3.1

Referee comment I would suggest a better description of the real and synthetic experiment and which observations have been used in each case and how. A summary on a table would be very helpful.

Response:

We will add a new Table 2, which we hope shows a clear description of each experiment, including which observations have been used in each case and how.

4

4.1

Referee comment I have some comments about the structure of the paper: I found the chapter with the methods very confused and some of the equations need to be checked. I wonder if having chapter 2.7 be- fore 2.6 would be beneficial to the reader to understand the whole experimental setup.

Response:

We agree. We will re-structure the paper and split the real and symthetic experiments into separate Sections (2.5 and 2.6 respectively). We will correct the mistakes in the equations, including the ACC equation. We will put the summary of the whole experimental setup before the detailed descriptions.

4.2

Referee comment Finally, a summary of pro and cons of each method with the correspondent computational burden can provide the reader with ideas on the feasibility of these methods.

Response:

We think that the summary of the potential advantages of the EnSRF in the introduction is sufficient. The computational burden of the DA methods was not properly explored in this study.

5 Response to minor comments

Response to minor comments:

1. **Referee comment:** p. 7361 around line 28: it would be interesting to know what was the RMSE value before calibration.
   Response: The RMSE before calibration was approximately $0.063 m^3/m^3$.

2. **Referee comment:** p. 7362, line 1: representivity?
   Response: Could be re-phrased as: "However, other representativeness errors were also likely in this study, since the point observations were assumed to represent 8 times 8 km squared model pixels."

3. **Referee comment:** p. 7382, line 7: sources of errors, such as?
   Response: This Section will be deleted, since the conclusions about soil texture were not valid.