Editor’s comments
Dear Authors,

Thanks for the revised version of the manuscript. Could you check the Supplement? In your response you indicate that "To further stress this point, we included results from an alternate CDF scaling method in the supplementary document and provided additional justification as to why a seasonal assimilation methodology would not work for many locations within the study domain" but I was not able to see any difference between the new Supplement and the old version.

Best regards,
JC Calvet.

Author Response
Dear Editor,

Thank you for your comments. This sentence refers to the additions made to the supplementary document during the first round of revisions. We added these results to the supplementary document during the first revision and referred to these updates in the response to comments for the second revision (as well). We apologize for any confusion in how we referred to earlier edits in the supplementary document.

Bias correction via anomaly scaling was attempted. It was found that using the model climatology to correct biases using either CDF-matching or anomaly-scaling methods results in the loss of the irrigation signal from the SMAP soil moisture retrievals. In addition, seasonal assimilation would not yield the desired results as the amount of water contributed by irrigation changes in magnitude during different time periods (higher during some months). However, it cannot be quantified as negligible at any time of the year (Biemans et al., 2016). It would be incorrect to assume that irrigation is only important during the winter. Therefore, seasonal CDF-matching would not result in the removal of all the biases from the SMAP retrievals.

Further details regarding the anomaly scaling results are provided at the following lines in the current supplementary document:

Line 12 to 32:
S2: Anomaly-scaled retrieval assimilation
Assimilation using an anomaly-based approach (DA-Anom.) was also tested. In this approach, the retrieval mean was mapped to the land surface model mean and updates were computed using the resultant anomalies such that:

Observed value (*s, t*) = Mean NoahMP soil moisture(*s*) + Observation anomaly(*s*, *t*)

where, *s*= location in space and *t*= instance in time. Figure S1 shows a sample timeseries for a location that is 80% irrigation-equipped. It is apparent that assimilation estimates (DA-CDF) after anomaly scaling closely mimic the OL estimated soil moisture throughout the year whereas DA-NoCDF is able to update the soil moisture based on the information in the SMAP observations, particularly during the winter months.

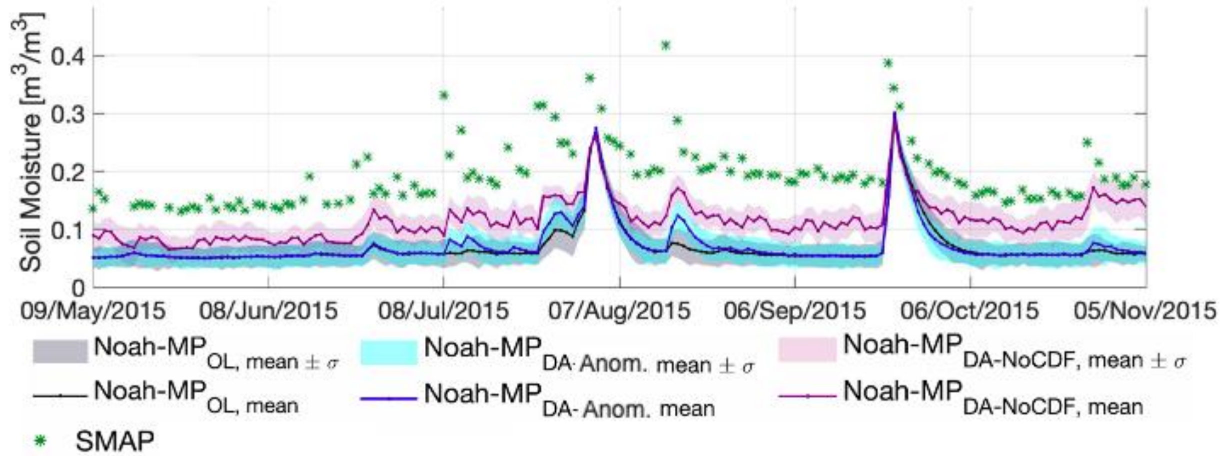

Figure S1. Comparative timeseries of OL and DA estimated surface (top 5 cm) soil moisture at an irrigation-equipped pixel. The solid line represents the ensemble mean whereas the shaded areas represent mean +/- standard deviation across the full ensemble. DA-CDF: anomaly-based assimilation; DA-NoCDF: no CDF-matching based assimilation.

Figure S2 presents the differences between OL versus DA estimated soil moisture for the two main seasons. DA-CDF (subplots (a) and (e)) and DA-Anom. (subplots (b) and (f)) simulations show some spatial similarities during both seasons. During summer, the DA-Anom. simulations (Fig. S2(b)) do not show any visible updates across the Indus, Ganges, and Brahmaputra basins. This signal is, however, apparent in the DA-NoCDF map (Fig. S2(c)). For winter, the DA-Anom. estimates (Fig. S2(f)) show positive updates across the Ganges Basin, however, little influence is seen across the Indus and Brahmaputra basins.

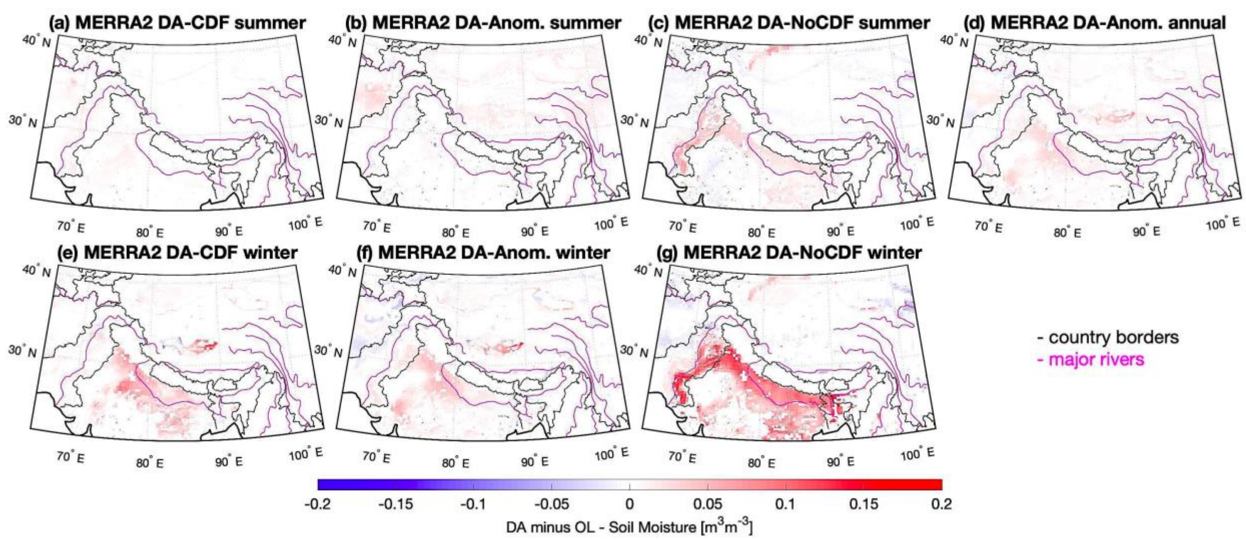

Figure S2. Differences between the mean soil moisture estimated by the OL and DA simulations during the summer (April 2016 to September 2016) versus the winter months (October 2015 to March 2016). DA-CDF= assimilation of CDF-matched SMAP retrievals; DA-Anom.= assimilation of anomaly scaled SMAP retrievals; DA-NoCDF= no CDF-matching of SMAP retrievals.

Figure S2(d) presents the annual mean differences between the OL and DA-Anomaly runs. Positive differences are observed across the Tibetan Plateau, similar to the DA CDF run (Fig. 4). The statistics show that DA-CDF estimates have the lowest accuracy across the Tibetan Plateau (lower than the OL). The performance of the individual runs could be further explored if in-situ measurements were available across the lower part of the study domain. Unfortunately, there are no publicly available soil moisture datasets across the three primary river basins in South Asia, i.e., Indus, Ganges, and Brahmaputra, from 2015 onwards.