Response to Reviewer #4 comments

This study reconstructed past droughts over India using multiple land surface models (LSMs). Standardized Precipitation Index (SPI) and Standardized Soil moisture Index (SSI) were used for detection and characterization of meteorological and agricultural drought, respectively. In this study, root-zone soil moisture was estimated from VIC, Noah, and CLM. The parameters of each LSM were calibrated. This study found that there are larger uncertainties in agricultural droughts over a large part of India during crop growing seasons than during monsoon seasons. This study concluded that different persistence of soil moisture from the three LSMs are caused by the difference in model parameterization. Overall, the manuscript is written well but some words and sentences are necessarily revised due to misuses and grammatical errors. The topic is a good-fit to Hydrology and Earth System Sciences (HESS), but I have several major comments on the method and findings. Also, there are several minor comments on the scientific representations, especially figures. More details of the major comments are listed below. Due to the major issues, the current version of the manuscript is not publishable in the HESS. Therefore, I recommend major revision.

We thank the reviewer for his/her insightful comments. We have addressed the reviewer's comments in the revised manuscript.

General Major Comments:

It has been very popular to compare the estimated hydro-climate variables from different climate or land surface models (e.g. CMIP3 and CMIP5). One of the lessons from the previous inter-comparison studies is that it is hard to understand what really happens in the models (more likely a black box) unless common parameters (e.g., infiltration capacity or vegetation fraction) across the models and their impacts on the interest estimate (herein, root zone soil moisture (down to 60 cm) are evaluated. In this study, there is a missing section for evaluations of simulated soil moisture, before converting soil moisture to SSI, which give valuable information for how different soil moisture dynamics are across the models. Also, there is a missing for comparisons of the common parameters, which can bring a fundamental understanding of the sensitivity of root-zone soil moisture to the common parameters even though this study discussed that soil water holding capacity (a common parameter) plays an important role in soil moisture dynamics. Therefore, adding sections for root-zone soil moisture analysis and parameter comparison is strongly recommended.

Thank you. We will include a section on "Soil moisture analysis and parameter comparison" in the revised manuscript. Here we will check the correspondence of different model simulated root-zone soil moisture along with characteristics like persistence and seasonal behaviors. Apart from this, we will evaluate the modeled soil moisture estimates against some proxy (satellite-based) soil moisture that could further shed some lights on individual modeled soil moisture simulations. We will also include an analysis depicting the similarity/differences among the common model parameters related to soil moisture simulations – this could be root-zone soil water holding capacity, across India.

In addition, the output from three LSMs are not able to provide a full distribution of the root-zone soil moisture estimates due to different model structures and parameters. The method introduced in this study might be appropriate for a sensitivity test of the simulated root-zone soil moisture to different land surface model structures and parameters. In Figure 2, the spreads of areal extents from three models were represented as the envelope but they are actual three points in each year. Or, the authors need to clarify the definition of uncertainty.

We agree with the reviewer on the aspect that three chosen LSMs may not cover the full uncertainty of the root-zone soil moisture estimates. There are number of factors that need to be considered in understanding the full distribution of root-zone soil moisture estimates that include among other things, the uncertainty in forcing variables (precipitation, temperature, etc), land-surface variables (soil textural information and soil hydraulic parameters like porosity, field capacity and permanent witling point), as well as, model conceptual parameters.

Nevertheless with the application of three models, our aim in this paper was to show the differences in soil-moisture simulations and resulting drought characteristics over India. We term these differences to soil moisture simulations uncertainty to convey the main message that the application of a single model to study soil moisture droughts over India may not be adequate.

Furthermore, we will provide a note in the concluding paragraph of the revised manuscript on future efforts on including other LSMs or hydrological models for analyzing soil moisture drought analysis; as well as for conducting analysis to recognize the contribution from other sources of uncertainty.

Minor comments:
Abstract: Page 1 Line 13: “higher uncertainty” should be replaced with “higher sensitivity.”

Thank you. We will revise the text as suggested.

Page 1 Line 18: “multi-model ensemble” should be replaced with “multi-model average.” The ensemble is often used for different perturbed physics, initial condition, and forcing within one model.

Thank you. We will incorporate your suggestion in the revised manuscript.

Page 1 Line 23: “severity” should be replaced with “intensity” for consistency with the later section.

Thank you. We will revise it as suggested.

Page 2 Line 29-30: What are the temporal coverage of precipitation from 6995 gage stations from IMD? Have the IMD precipitation products compared with the CRU and GPCC (even though they are 0.5 degree)? It is worth to understand how large the uncertainties in precipitation from different sources are.

A detail description of the methodology and underlying dataset used to create the gridded IMD field is provided Pai et al (2014). In this study, we restricted to use the IMD dataset, which uses much more underlying station dataset than used in CRU or GPCC. As said earlier, our goal here is to understand the uncertainty in soil moisture due to usage of different LSMs; we restrict ourselves to use a single set of forcing dataset for all three LSMs.

As a side note, in our recent study, we have compared the IMD based precipitation product with the CRU ones for drought analysis (see Mishra et al., 2016b). On a long-time period the two products agree on showing similar basic features, but they do differ (sometime substantially) on a short-time period (see a recent paper by Jing and Wang (2017) Nature CC).

Page 4 Line 15-18: Zilintikevich coefficient and its explanation should be placed at the end of the sentence.

We will add a sentence on the coefficient as suggested.

Page 5 Line 10-11: Is a Gamma (parametric) distribution appropriate in computing a agricultural (soil moisture) drought index? What about using percentiles (nonparametric) as a drought index?

We have tested the appropriateness of the distribution function. We used here the parametric (Gamma) form for the agricultural drought so to be consistent with the precipitation based drought index (SPI). We, however, agree with the reviewer of using a more robust non-parametric based drought index (like percentile) – we adopted for such approach in the recent past (see Mishra et al, 2016b) – but here in this study we do not find big differences in our modeling results due to different approach of estimating drought indices (the main results and conclusions however remain unaffected).

Page 5 Line 17: Why this study uses the 4-month SSI? I assume that it was matched with Rubi seasons but there is no explanation about it. Please clarify it.

Yes, the reviewer is right in his/her interpretation. We will add a sentence to clarify this in the revised manuscript.