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Interactive comment on "Reconstruction of droughts in India using multiple land surface models (1951–2015)" *by* Vimal Mishra et al.

Anonymous Referee #4

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Review for "Reconstruction of droughts in India using multiple land surface models (1951-2015)" by Mishra et al. in Hydrology and Earth System Sciences

RECOMMENDATION A major revision

SUMMARY: 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

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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.

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.

Uncertainties from a different combination of parameter sets even within one model can bring certain uncertainties in drought estimates, which can question the relative importance of calibration methods or physics (representation of important processes in a model) on soil moisture estimation.

In addition, the output from three LSMs are not able to provide a full distribution of the

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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.

Minor comments:

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

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.

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

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.

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

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

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.

Page 5 Line 20: Drought severity is defined as the total area (intensity x duration) from initiation through recovery. "for each year, mean severity of droughts" is confusing. Please change the sentence as "for each year, mean 4-month SSI value was . . ."

Page 6 Line 7: "the ensemble mean streamflow" should be replaced with "the multi-model averaged streamflow."

Page 7 Line 11-12: What is the definition of uncertainty in area extent of drought? Please clarify it either here or in the method section.

Page 8 Line 32-33: How can higher persistence of CLM soil moisture can be attributed to its higher water holding capacity and thicker soil column? Please explain the possible physical processes. The explanation will be beneficial for readers.

Page 9 Line 21-22: This study finds that regardless of seasons, precipitation is a major driver for drought and temperature is a minor. If then, uncertainties in meteorological forcings, especially precipitation might be more important than uncertainties in soil moisture. Why didn't this study investigate uncertainties in precipitation?

Page 11 Line 1-15: Please discuss the potential implementation of the findings in the section 3.5.

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