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Interactive comment on "A baseline probabilistic drought forecasting framework using Standardized Soil Moisture Index: application to the 2012 United States drought" *by* A. AghaKouchak

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Point-by-Point Response to Review Comments

The author would like to thank the reviewer for the constructive and thoughtful comments and suggestions which led to substantial improvements in the revised version of the manuscript. In the following, the issues raised by the reviewer are addressed point-by-point in the order they are asked. Reviewer's comments are shown in italic; author's reply is shown in regular text.

Anonymous Referee 1 *The ESP method is applied to approximate the probability of droughts in the future with rather short lead time. Standardized Soil moisture Index (SSI) is used as agricultural drought indicator. Persistence analysis is conducted on SPI and SSI with 6-month accumulation window. The forecast method is sound; however, it is overrated by a few questionable comparisons. My major concerns are as follow:*

1) Author emphasized on the higher auto-correlation in SSI time series vs SPI and concluded accordingly that SSI is a better indicator for drought forecasting (Page 1954, lines 3-5). Higher persistence is not a basis to choose among drought indicators. In fact, drought type determines the indicator; i.e. SPI for meteorological droughts and SSI or any other soil moisture-based index for agricultural droughts. Thus, this point should be cleared in the manuscript for potential future readers. According to speciïňĄc attributions of SSI and SPI, they give different information about droughts. For example, ïňĆash storms as an important cause in producing flash floods (especially in wet regions with saturated/near-saturated soil) are reflected in SPI. The smooth variation in SSI cannot address sudden storms; and then, it is not appropriate in prediction of hydrological droughts where streamflow (or runoff) is used as drought variable. Flash floods can mitigate ongoing hydrological droughts to some extent. In general, persistency is not always an ideal attribution for a drought indicator. It depends on the application.

Response: The author fully agrees with the Reviewer. Please note that the SSI-based approach is not suggested as an alternative to other indicators such as SPI. Instead, it is suggested as an approach that should be considered along with other indicators. In the revised version this issue is clarified to avoid any confusion (see the last paragraph of the revised version). As the Reviewer correctly mentioned, SSI typically varies less compared to SPI (see also figures in [1]) and hence, may not be suitable for monitoring rapid storms. This issue is discussed in Conclusions Section. Also, in the revised version, it is emphasized that the choice of index depends on the application.

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2) One-month lead time is very short for decision making in agricultural applications. For 6-month SSI with a lead-time of one month, the soil moisture of 5 months is available and the soil moisture of only one month is produced by ESP approach. In a 6-month window, the impact of one month is not as much to affect the total summation (and consequently SSI value). Moreover, the variable (soil moisture) itself is highly persistent as approved by Fig. 1. Hence, the agreement of observed and predicted SSI with 1 or 2 months lead-time cannot confirm the quality of forecast model. Instead, the performance of method can be illustrated in greater lead times (3 or 4 months) as shown in Fig. 5. Comparing Fig. 2 and 5, the forecast results are not encouraging. Majority of droughts are captured with low probabilities (Probability=0.1-0.5). Who might plan for droughts with low probabilities? Moreover, this analysis is conducted for July and August droughts (Fig. 5) when soil moisture is usually at its lowest amount and agricultural droughts are intense. Since the forecast model cannot capture summer droughts well, how it would perform in detecting mild droughts of other seasons. It seems that for a better picture of the performance of proposed model, it needs to be examined for a) greater lead times and b) other seasons with less severe droughts.

Response: The author's team has received funding from the National Science Foundation to interview farmers and understand user needs for drought information. Thus far, we have interviewed over 110 farmers from across the country (project still ongoing). We have learned that for some end-users even few weeks of lead time make a substantial difference (e.g., for purchasing fewer fertilizers and other related services). On the other hand, even very short lead times on drought development are important for commodity investors and investment management. We agree that longer lead predictions will be more useful. In general, longer lead predictions are subject to higher uncertainty and lower predictability (regardless of methodology). In fact, predicting droughts beyond few months is a major challenge highlighted in a recent WCRP report [2] – see also [3] [4]. It is worth highlighting that this method cannot be used for long lead predictions (e.g., 6 months and more). Theoretically, in a persistence based concept, the lead time should not exceed the time scale of the data. For this reason, this method can only be used for prediction with few months lead time (see Section Methodology).

About probabilities; for 3- and 4-month lead predictions of moderate drought threshold, the probabilities are quite high (up to 80

About longer lead times and other seasons; as mentioned above, this method is not really suitable for long-lead prediction (see Figure one and a systematic decrease in autocorrelation versus time). Finally, the results are not limited to July and August. For example, the predictions for May 2012 are shown with 1- to 4-month lead (i.e., January - April), indicating that soil moisture data from winter is used for prediction.

3) In "conclusion", there is a statement saying: "While dynamic models did not predict the 2012 summer drought well in advance, ...". How much were the models weak in predicting 2012 droughts? According to the points in my previous comments, the proposed model could not predict those droughts well either, especially with lead times greater than 2 months. I should mention once again that model performance cannot be revealed by 1 or 2 months lead time in a 6-month accumulation window where the soil moisture of 4 or 5 months are already observed.

Response: In the revised version, Section Conclusions is updated to address the Reviewer's comment. Please note that model simulations did not predict the 2012 summer drought well. See the below quite from an Editorial by Freedman 2012:

"The three-month seasonal drought outlook, which is revised monthly, is the main drought forecasting tool produced by the federal government. It wasn't until June 21 that an outlook showed drought conditions were likely to persist and expand in the Mid-

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west and High Plains, and by that time, the country was rapidly heating up and drying out, destined to record its hottest month on record in July."

As shown, the results indicate relatively high probabilities of drought in most regions prior to June 2012. On the other hand, and as mentioned above, even 1- and 2-month lead times are important to some drought sensitive sectors. Again, this model is not proposed as an alternative to the currently available approaches. Dynamic models are still valuable and should be used. This approach provides an alternative that can be used alongside other methods. This issue is clarified in Section Conclusions.

4) In Fig. 1, please make it clear that what time windows are used for auto-correlation analysis. The boxplots are provided for 4 initial conditions with accumulation window of 6 months. On the other hand, the lag time varies from 1 to 6 months. To my understanding, for example, for SSI with initial condition of March (i.e. accumulation window: Mar, Apr, May, Jun, Jul, Aug), the autocorrelation with 1-month lag time refers the SSI with accumulation window of Apr to Sep. Is this correct? If so, please clarify that "initial condition" refers to the start month in the accumulation window for only one variable. The other variable starts with a lag-time whose initial condition is not the same as the ïňĄrst variable.

Response: The definition of "initial" in Figure 1 is consistent with the one in Section Methodology. For example, initial: March indicates precipitation and soil moisture form Oct. 2011 through March 2012. This would be the initial condition for prediction from March onward. This is clarified in the manuscript (see discussion of Figure 1).

5) It is recommended that Fig. 3 and 5a be updated for SSI<-0.5 (instead of SSI<-0.8). Comparing these figures with "any" observed droughts (SSI<-0.5) is not very reliable

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(Fig. 2a).

Response: Throughout the paper, we have used the thresholds consistent with the so-called D-scale [5]. In this scale, -0.5 is referred to as “abnormally dry”, while -0.8 is defined as “moderate drought”. Note that both observed and simulated are compared for the same thresholds of -0.8 (we have NOT compared predicted SSI<-0.8 with observed SSI<-0.5).

6) It seems that “(Fig. 2b)” in Page 1954-line 28 should be replaced by “Fig. 2a”.

Response: Corrected; Thanks!

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