Hydrol. Earth Syst. Sci. Discuss., 11, C1272–C1278, 2014
www.hydrol-earth-syst-sci-discuss.net/11/C1272/2014/

Hydrology and Earth System Sciences
Discussions

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

AA AghaKouchak

amir.a@uci.edu

Received and published: 7 May 2014

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 2

This paper presents a nonparametric statistical baseline approach for drought prediction using standardized soil moisture index. To the best of my knowledge, previous studies have primarily focused on precipitation for persistence-based statistical drought prediction. This study highlights the fact that given the higher persistence of soil moisture compared to precipitation, a baseline forecasting using soil moisture would improve drought prediction. The methodology is proposed as an additional model that can be used alongside with the currently available techniques. The framework is novel and given the importance of the topic, I believe the article is suitable for publication pending a revision. Also, the study focuses on the 2012 drought, a major recent event that has not been explored in the literature yet. I have included some comments and suggestions below:

-In Equations 1 to 3, it is not clear whether the initial conditions can obtained from one year before the target month year (for example, for predicting January, February drought). This needs more explanation.

Response: We agree with the Reviewer. In the revised version, we have addressed this issue (see Explanation of Figure 3). In summary, for the first few month of a year, the initial values will be from the previous year.

-While the difference between precipitation and soil moisture persistence is shown, it would be good to include the improvements in using soil moisture in terms of drought probabilities (either showing them side by side, or showing the differences).

Response: Technically, it is possible to provide the differences between precipitation- and soil moisture-based predictions (see the below example). Figure 1 (in this document) shows locations where soil moisture indicates higher probability of drought for July 2-month lead (left), and August 3-month lead (right). As shown, in most regions, soil moisture leads to higher probability of drought relative to precipitation. However, soil moisture responds to precipitation with some delay and such comparison does not necessarily provide additional information. Also, this behavior may change from event to event. I believe the two methods should be evaluated as presented in Figure 1 in the main manuscript (the overall behavior over a certain region, rather than pixel based assessment).

-While this approach probably improves drought prediction, ideally, soil moisture should be combined with other variables for a more robust statistical prediction. Can this model be extended to higher dimensions (e.g., using precipitation or runoff)? Given that both precipitation and soil moisture data are available, it is worth exploring this issue.

Response: Theoretically, this methodology can be extended to a multivariate form with more than one variable used for prediction. One can use different variables independently and then combine them for composite drought assessment. Alternatively, using the nonparametric form of the Multivariate Standardized Drought Index (MSDI; [1]), one can combine multiple data sets for multi-index drought prediction (this issue is currently under investigation by the author's team).

-Discuss uncertainties associated with the input variables. Acknowledge the limitations of the available soil moisture data sets.

Response: Per Reviewer's suggestion, a discussion is added on the uncertainty of input data sets (see Section Data). A couple of publications that evaluated input data set are cited (see Section Data). Furthermore, limitations of the input data and modeling framework are acknowledged in the manuscript.

- SSI is a relatively new index and has not been used for drought prediction before. The description of the suggested nonparametric approach needs to be discussed in more details. Why a nonparametric approach?

Response: The discussion on computation of SSI is extended and all the governing equations are provided. In a recent paper on drought monitoring, derivation of empirical SSI is discussed in detail (see [1]). For this reason, the discussion is concise and provided only to make the paper standalone.

- What is the advantage of using SSI over the other soil moisture-based indices?

Response: The main advantage of SSI over other soil moisture indices is that it can be computed for different time scales consistent with SPI. This has been discussed in the revised version.

-Is there an opportunity to integrate the upcoming satellite soil moisture data sets (e.g., SMAP) and the currently available SMOS data? It is worth to include a discussion on this topic.

Response: Yes; in fact, one of the main motivation of this study is to develop a platform for near real-time drought monitoring using satellite soil moisture data. In a recent study, an algorithm has been developed for near real-time drought monitoring by combining real-time satellite precipitation data with long-term climate data records using a Bayesian framework (see [2]). A similar algorithm can potentially be used with the upcoming SMAP satellite data combined with long-term data sets. This issue, however, requires extensive research and validation. A brief discussion is added to the revised manuscript (see last paragraph in Section Results).

-Would it be possible to condition forecasts on large scale climatic oscillations? For example, sampling from historical data with a certain condition (e.g., ENSO pattern).

Response: The ESP modeling concept can be conditioned to one or more covariates. However, the main limitation is that one needs a long record of observations. That is, for different ENSO conditions, sufficient precipitation and soil moisture observations would be necessary for probabilistic drought prediction. Unfortunately, long-term observations of soil moisture is not available and hence, conditioning the methodology on ENSO would reduce the sample size significantly.

-The fact that the drought probabilities drop at longer lead times worth a discussion.

Response: The Reviewer is right. In this model concept (and other similar probabilistic concepts), probabilities reduce as the lead time increases. This is mainly due to the nature of the persistence-based prediction (see also Figure 1 and the decreasing autocorrelations with increasing time lags). In the revised version, we have acknowledged this issue (see Section Conclusions).

-Can this model be used for drought recovery too (i.e., probability of drought recovery)? Discuss.

Response: Yes; theoretically, this methodology can be used for probabilistic assessment of drought onset as well as recovery. In a recent study, Pan et al. 2013 used a similar methodology to describe drought recovery probabilistically using precipitation

data. Given that this issue is addressed in Pan et al., this study does not focus on drought recovery.

-Conclusions should be extended with a discussion on limitations of the methodology and data sets.

Response: Conclusions have been extended and a discussion on limitations of the methodology and input data sets is added to the revised manuscript.

References

1. Hao Z., AghaKouchak A., 2014, A Nonparametric Multivariate Multi-Index Drought Monitoring Framework, Journal of Hydrometeorology, 15, 89-101, doi:10.1175/JHM-D-12-0160.1.

2. AghaKouchak A., and Nakhjiri N., 2012, A Near Real-Time Satellite-Based Global Drought Climate Data Record, Environmental Research Letters, 7(4), 044037, doi:10.1088/1748-9326/7/4/044037.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 11, 1947, 2014.

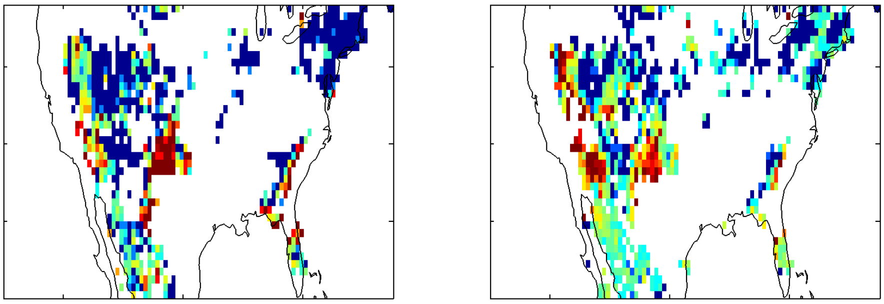

Fig. 1. July 2-month lead (left), and August 3-month lead (right)