

Interactive comment on “Influence of snow water equivalent on droughts and their prediction in the USA” by Daniel Abel et al.

Anonymous Referee #1

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Summary

In this manuscript, Abel et al. examine potential connections between snow water equivalent and drought occurrence in the conterminous United States (CONUS). To this end, they conduct Maximum Covariance Analysis (MCA) – also known as Singular Value Decomposition – between monthly-averaged SWE values for March – obtained from the ERA-Interim reanalysis dataset (1979-2015) – and two drought indices (DIs): (i) the self-calibrating Palmer Drought Severity Index (sc-PDSI), and (ii) the Standardized Precipitation Evapotranspiration Index. The authors also perform Principal Component Analysis (PCA) on each field “to confirm or contradict the results from MCA”. In a final stage, Abel et al. examine possible connections between standard climate indices, and SWE or DIs. MCA results show that connections between SWE and DIs

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do exist, in particular between mountainous areas and downstream domains. Connections between ENSO and DIs are also displayed. Finally, the authors conduct time shifted MCA between march SWE and DIs to demonstrate the utility of the former for drought prediction.

The authors address a relevant problem for both scientific and operational communities. Further, the literature review is sound and the graphical results are nicely presented. Nevertheless, I found this manuscript extremely hard to follow and understand, mainly due to the lack of a coherent methodological flow. Therefore, this manuscript needs a major revision – including the proper use of English – before being considered for publication in HESS.

Major comments

1. Datasets used: In my opinion, using SWE datasets from a reanalysis sounds like a very odd approach, especially considering that the study domain is the US – where hundreds of SNOTEL sites have been operating in real-time for decades. The authors should, at the very least, include a robust evaluation of Era-Interim SWE across the CONUS, since the assessment they refer to (Brun et al. 2013) was conducted in Eurasia. Additionally, the authors should provide a justification of the atmospheric indices included in this study. Did they try including other standard indices? In my opinion, a better approach would be to directly explore interconnections between drought indices and spatial fields of variables such as sea surface temperature or geopotential height – extracted from Era-I. The authors can find many related examples aimed to predict hydrometeorological variables (e.g., Grantz et al. 2005; Block and Rajagopalan 2007; Mendoza et al. 2014; Ionita et al. 2015).

2. Approach: Although Singular Value Decomposition (SVD) has been widely used to understand the joint correlation structure between hydroclimatic fields (e.g., Rajagopalan et al. 2000; Sagarika et al. 2015), I'm not sure whether is the right approach to explore interconnections for prediction purposes. Did the authors consider using

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Canonical Correlation Analysis (e.g., Salas et al. 2011) or Partial Least Squares Regression (e.g., Smoliak et al. 2010)? Also, I don't understand the rationale for including PCA in this study and highlighting those results in many sections (P8-L10; P10-L6). To the best of my understanding, PCA only looks for principal modes of variability in one field, while SVD looks for principal modes while maximizing covariance between two fields. I think the authors need to provide a better justification to include it (otherwise, delete those results from the manuscript). Finally, I think the authors should include, at the very least, a simple demonstration on how they would use their findings for drought prediction. This could be done, for example, by fitting linear regression models between PCs from SWE and DIs, and produce deterministic or ensemble forecasts using a cross-validation framework.

3. Conclusions: The authors state that "SWE influences drought via downstream water/moisture transport from (high) mountain regions". Did they really need to conduct all the analyses presented here to conclude this?

Minor comments

4. P1, L17-18: The first sentence in the introduction reads out of place. I suggest deleting. What do you mean with "high amounts of damage"?

5. I suggest the authors to carefully read Clark et al. (2001).

6. Section 2.1: The first paragraph reads out of place. I suggest deleting.

7. P3, L11: Do the authors mean in situ observations?

8. P3, L18: Reliable snowfall does not necessarily mean that snow depth and density estimates will be accurate.

9. Section 2.2: Is it possible to include sub-annual (i.e., seasonal) sc-PDSI values? How would the results change if 3-month averages of SPEI were used?

10. P5, L28: What do the authors mean with drying conditions? Less runoff?

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11. P6, L10: This is the first and only time where “cross-validation” is mentioned. Did the authors actually conduct it?

12. All figures: Can you please add “a”, “b”, “c”, etc. to the various panels? I think this would greatly improve the readability of this manuscript. Also, do you mean March SWE when referring to ERA-I in your figure titles and captions? If yes, I suggest to be more direct.

13. Figures 1-3: Can you please add a sub-panel with joint total variance as a function of mode?

14. P7, L3: I suggest the authors being more quantitative when reporting trends (e.g., adjust a linear regression, report confidence levels).

15. P9, L6: “Subsequently, the relation between SWE and sc–PDSI, respectively, and the two dominating patterns of the study area is investigated”. I thought the authors were already doing this. Please re-word or delete.

16. Figure 7: It is really hard to distinguish correlations for annual, DJF and Oct-Mar without labels for each time scale. Would it be more logical to go from longer to shorter time periods? Also, are correlation values obtained from pulling together all time steps and points in the domain? Wouldn't it make more sense to plot correlation coefficients between leading modes from PCA (and not MCA) from each variable, and climate indices?

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