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Hydrology and Earth System Sciences
Discussions
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Interactive comment on "Estimation of hydrological drought recovery based on GRACE water storage deficit" *by* Alka Singh et al.

Anonymous Referee #3

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1 Summary

The authors devise a novel method for estimating intradecadal drought recovery periods using GRACE and precipitation data globally. The total water storage estimates from GRACE are used to determine the deficit and the precipitation data is used for estimating the drought recovery periods using an empirical forecasting model. The issue is an important one in the context of ongoing climate change. Furthermore, the subject matter is also relevant for the journal and its audience. Having said that there are methodological issues in the data analysis which I will point out in the subsequent section, and the manuscript requires improvement in its narrative.

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2 General Comments

1. The title does not fully reflect the content of the manuscript. Firstly, the work only looks at short-term (intradecadal) droughts and secondly it uses precipitation in addition to GRACE to estimate the drought recovery times. These two aspects of the manuscript should be reflected in the title. Currently, going by the title, the drought recovery time is solely estimated from GRACE, which is incorrect.

2. The central goal of the manuscript seems to be to determine drought recovery times and that is facilitated by precipitation forecasts, and the majority of the manuscript is dedicated to figuring out an empirical way to predict precipitation. However, in the conclusions there is hardly any mention of precipitation and the empirical forecast model, and their role in drought recovery times. Rather it is concluded that the one of the findings is that GRACE can be used to derive drought indices, which appears to have been established by Thomas et al (2014).

3. Throughout the manuscript it is not clear as to what type of drought the authors are trying to quantify. In the title it is indicated that the authors are concerned about hydrological droughts, but nothing much is said in the manuscript. In the introduction they specify there are multiple definitions of droughts, but beyond that there is no indication on what sort of droughts the authors are interested in and which sorts will be sensitive to the method developed in the manuscript. It would be beneficial if the authors clarify this for the readers.

4. For the data the authors use GRACE JPL mascons for total water storage and GPCP for precipitation. Given the wide variety of data available both for total water storage (CSR mascons, GSFC mascons, CSR, GFZ, JPL, ITSG spherical harmonics, COST-G combined solutions) as well as precipitation (GPCC, CRU, Delaware), it would be interesting to know how different the drought recovery times would be if we were to choose a different pair of datasets. At least

in the case of GRACE it should be tested, because it is the starting point for the method proposed in the manuscript. Given the lack of consensus on which GRACE flavour is to be used, or how to reconcile the data, it is worthwhile to perform this test.

5. The GRACE and the GPCP datasets are represented on 3° spherical cap and $2.5^\circ \times 2.5^\circ$ equi-angular grid. After indicating that the area of the unit representations are comparable, they represent the two datasets on a $0.5^\circ \times 0.5^\circ$ grid to perform the analyses. There a couple of issues here. Firstly, the difference between the areas of the unit representations are at best $\approx [10,000] km^2$ (at the equator) and at worst $\approx [80,000] km^2$ (close to the poles). Secondly, by regridding them to a smaller grid size, they are only making map a bit smooth, but there is no change in the information content. The best way to bring them to a commensurate resolution to perform the data analysis would have been to filter them with a common filter either a Gaussian or any other contrast preserving filter, and then regrid them to any other grid size they wanted. It is essential that the authors discuss the impact of these data processing choices on the final results.

Based on these comments I recommend a major revision.

3 Technical comments

30 Please provide references for the events you have described

32 Please provide standard references for the drought definitions, for e.g., Wilhite and Glanz (1985). Water International

33 It is not clear what you want to convey by indicating the different indices.

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38 Similar is the case for remote sensing data based drought indicators. Please clarify to the reader what their benefits and shortcomings are in order to get a perspective.

51 "This method can improve ..." until end of line 55. Please corroborate the statement, if it is not a conclusion of Thomas et al (2014).

59 "... are still a few" Please cite some of those studies

63 successive –> next

74 "However, above average ..." until end of line 77. Please clarify whether it is your opinion or a conclusion of Pan et al (2013)

84 In general, the introduction lacks a cogent narrative. It is hard to identify what issue you are trying to address

88 "... global and regional water cycle." Please provide a reference for the same.

104 When you say comparable, please indicate the numbers.

135 Please clarify to the reader why you need to integrate the precipitation time-series.

142 The variability of precipitation intensity can be checked. It is unclear why this needs to be assumed.

189 The paragraph reads like the caption of Figure 5. Please interpret the figure for the reader as to what you want to convey through that figure.

199 Is the NSE performed on the full signals or after removing the climatology signal? It is well known that the climatology will dominate the metric if it is retained. Please clarify.

204 In Figure 6, please indicate the regions of weak association.Also, instead of a continuous scale, it would be better to use a discrete scale colorbar, i.e., one colour for a range of values. It is more convenient for the human eye to interpret such images.

265 stimulated –> simulated?

299 "hydrological compartments" – Do you mean storage compartments?

342 "independency from other drought indices" – Do you mean to say that SPI depends on other drought indices? Please clarify the "independence" argument.

343 "spatial coverage" – Indices based on NDVI also cover much of the globe. How is this an advantage specific to the GRACE method?

Apart from the specific comments, I would like to indicate that it was rather frustrating to read such a methodology-heavy manuscript devoid of any equations. Even if the equations involved are simple and straight-forward I believe they will provide clarity for the reader. Please consider incorporating equations.

Your results largely fall into the sequential and diverging types of data for which colorbrewer2.org provides very good advice on choosing colorbars. Typically, sequential data require only one colour with varying intensity to indicate the sequences and diverging data requires two colours of varying intensities. Furthermore, the standard colorbars are not color-blind friendly. I strongly recommend that you follow the rules indicated in the website to improve the graphics in the manuscript.

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