

## ***Interactive comment on “The European 2015 drought from a groundwater perspective: estimation in absence of observed groundwater data” by Anne F. Van Loon et al.***

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Please find below the comments of reviewer Miriam Fendekova and our replies (preceded by “»”).

General comments

The problem of groundwater level drought evaluation is still less often studied in comparison to meteorological or streamflow droughts. Evaluation of groundwater drought is complicated because of many factors influencing its development and persistence even within relatively small areas. Therefore the paper of authors van Loon et al. is highly appreciated. The paper is well structured, based on the present-day knowledge

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of the meteorological and hydrological drought evaluation, and techniques of groundwater drought assessment. The input data, methods and results are well described. The discussion and conclusions are clear, well understandable. The concept of accumulation period estimation and its relation to SPI and SPEI indices led to adequate results within two different areas (southern Germany, Netherlands). Use of satellite-based GRACE-TWS and GRACE-GLDAS showed that because of coarse resolution the models were not able to simulate groundwater anomalies realistically.

» Thanks for this positive evaluation of our manuscript.

Scientific questions/comments:

1/ Did the authors think about looking at other groundwater parameters, as baseflow or spring yield from the point of drought occurrence?

» Yes, we did consider alternative sources of data such as baseflow or spring yields. For baseflow, data availability would have been higher, because it is derived from discharge time series. Although discharge data availability has its own issues, especially in near-real time, we could have drawn on the FRIEND community effort described in Laaha et al. (2016). However, there would still have been uncertainties as to which method to use to separate baseflow from the total hydrograph and to how representative baseflow time series are for the local groundwater situation during drought. Spring yields are probably one of the best alternatives for groundwater level data to evaluate the groundwater drought situation, but they can only be used in regions where springs occur (i.e. not in the Netherlands and other lowland areas) and the availability and sharing of spring data is even more problematic than that of groundwater level data. We agree that for future research a comparison with baseflow and spring yield data would be very interesting.

2/ Hydrogeological conditions and recharge-discharge relationships of an aquifer are more purely represented by spring yields and their changes during the meteorological drought periods. Therefore, maybe the next step in groundwater drought research

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should be the spring yields drought study. However, in some hydrogeological conditions (as in the Netherlands) the data availability might be very limited.

» We totally agree. There is very limited research on spring yields as an indicator for groundwater drought. We are not aware of any databases on spring yield for Europe that could be used in such an analysis, but are very interested to explore this option with Prof. Fendekova in the future.

3/ Do the authors recommend the use of SPI index which calculation is easier than the SPEI index giving the comparable good results?

» Yes, if the data for calculating SPEI are not readily available, one could use SPI without any problem in these or similar regions in Europe. Before application in completely different climates, we do recommend testing first, because in other regions potential evaporation might have more influence on the propagation of drought from meteorological drought to groundwater drought. See also our reply to the comments of John Bloomfield about this topic.

Technical comments:

Despite of the reference to Kumar et al. (2016) I would appreciate at least the very short description of major differences in hydrogeological conditions of both areas used in the study. There are not comments to the English language which is excellent, and to figures quality.

» In the revised manuscript we will expand the description of the hydrogeological conditions of the two study regions so that the paper is more stand-alone.

Reference:

Laaha, G., Gauster, T., Tallaksen, L. M., Vidal, J.-P., Stahl, K., Prudhomme, C., Heudorfer, B., Vlnas, R., Ionita, M., Van Lanen, H. A. J., Adler, M.-J., Caillouet, L., Delus, C., Fendekova, M., Gailliez, S., Hannaford, J., Kingston, D., Van Loon, A. F., Mediero, L., Osuch, M., Romanowicz, R., Sauquet, E., Stagge, J. H., and Wong, W. K.: The Euro-

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pean 2015 drought from a hydrological perspective, *Hydrol. Earth Syst. Sci. Discuss.*, doi:10.5194/hess-2016-366, in review, 2016.

Interactive comment on *Hydrol. Earth Syst. Sci. Discuss.*, doi:10.5194/hess-2016-561, 2016.