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Hydrology and Earth System Sciences Discussions
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Interactive comment on "Multi-annual droughts in the English Lowlands: a review of their characteristics and climate drivers in the winter half year" *by* C. K. Folland et al.

Anonymous Referee #1

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This paper examines the large-scale climatic drivers of winter drought in south-east England, considering measures of meteorological drought (SPI), groundwater drought (SGI), and hydrological drought (normalized streamflow). Potential drivers include ENSO, sea surface temperature, recurring wind patterns, solar forcing, and the Atlantic Multi-decadal Oscillation (AMO). The authors show that SPI, streamflow, and groundwater droughts are correlated, examining the most relevant lag and accumulation period for the region. They also show that extreme ENSO values have a significant influence on winter droughts in the region, though this effect is small and represents only a fraction of total variability, limiting predictability. Some smaller effects related to

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SST and winds are noted. Ultimately, the authors conclude that the ENSO link is important, but should be evaluated as part of a multivariate, rather than univariate, predictive model.

I recommend publication of this article with minor revisions. It provides a thorough analysis of drought drivers, considering a wide range of both drivers and drought indices. Rather than simply including a pair-wise analysis of each combination, the authors thoughtfully consider the hydrologic and atmospheric processes connecting them, with good support from prior research. Tables and figures are clear and illustrative. My remaining comments are as follows:

Specific Comments

1. I strongly support the decision to not accumulate streamflow or groundwater levels when calculating SGI. I agree with the authors that accumulating streamflow is not necessary because streamflow and groundwater levels have already been integrated by the hydrologic cycle. Applying a accumulation period is therefore arbitrary and only makes sense in the context of accumulating structures, i.e. reservoir storage.

I assume this is why the authors chose not to call normalized streamflow "Standardized Runoff Index (SRI)", which is a term commonly used to describe applying the SPI/SGI methodology to streamflow or runoff. This becomes confusing on Page 12943, lines 8-17 when the authors describe normalized streamflow as “streamflow SGI (standardized groundwater index)”. Please either use the SRI nomenclature or develop a new name for this index.

2. Page 12948, lines 6-14 and Figures 7-10 – In the paper, you link winter rainfall with extreme values of ENSO. Is there concern that results will be confused by testing total precipitation (including snowfall)? If ENSO causes a temperature anomaly, this may shift the balance from rainfall to snowfall, making it seem as though there is a winter rainfall deficit, when in fact total precipitation has remained the same. This may not be a large issue for southeast England, but certainly portion of Europe shown in Figures

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7-10 depends on winter snowfall to replenish water reserves.

3. Page 12959, line 5-6 – Figure 4 is very illustrative in visualizing how different lags and accumulation periods relate to streamflow and groundwater levels. However, in the conclusions and abstract, I suggest being careful when discussing the importance of lags, as the best correlations for streamflow and groundwater are concurrent. This is particularly clear for groundwater.

4. Table 2 – How is a meteorological drought defined for this table? Also, the column of Yes/No is difficult to read. It might be more useful to only show Yes.

5. Figure 7b – This is a very dense figure. I suggest splitting the top row from the bottom two rows, as the top row shows atmospheric pressure for different time periods from left to right, while the two bottom rows show precipitation indices in the same format (storminess on left, precipitation on right).

6. Figures 8, 9, 11 – Similar to the above comment. Please try to be consistent with the figure orientations. Figure 8 shows drought indices organized along the vertical axis with positive and negative drivers organized along the horizontal. Figure 9 flips this, with drought indices organized along the horizontal axis and atmospheric drivers along the vertical. Same for Figure 11. Please pick an orientation and maintain it for all figures.

7. This is not a required change, only a thought for future work. Figure 12 uses a Welch 2-sample t-test to compare differences in the central value (mean) for pairs of drought indices/climate drivers. It appears that QBO does not affect the mean behavior of the drought indices, but greatly changes the variance. You might want to perform a 2 sample test of variance to quantify this. This could have implications in terms of drought variability.

Technical Corrections

Page 12947, Line 6 – It appears part of this sentence is missing.

Page 12947, Line 8 – There is an accidental space in La Nina.

Additional references you may also consider "Fraedrich, K. and Müller, K. (1992), Climate anomalies in Europe associated with ENSO extremes. Int. J. Climatol., 12: 25–31. doi: 10.1002/joc.3370120104" as an original paper that examined anomalies in Europe tied to ENSO

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