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Hydrology and Earth System Sciences
Discussions

# *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.

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Reply to Short Comment by R. Wilby

Firstly, we would like to thank Wilby for this very constructive Short Comment which raises a number of important points, which we have answered below. We also thank Wilby for the positive feedback.

One of the main issues raised is the omission of some important background references. We will accommodate these suggestions where appropriate and will mention earlier literature by Fraedrich and colleagues and Wilby. Given these acknowledgments



of earlier work, we will also moderate references to 'first time', although we will highlight the significant differences in scope between earlier work and ours. We note that where the earlier literature shows differences between El Nino and La Nina influences on North Atlantic and European climate, the results suffer not only from inferior data but do not reflect the fact that strong El Ninos have different teleconnections from moderate ones for reasons discussed in our paper and its references. So these papers tend to underestimate the winter climatic signal. Where La Nina results are shown separately, they are qualitatively consistent but lack the accuracy and detail now available. These results are also not for the winter half year but core winter, although there is no critical difference in our own results between these two periods. The Wilby (1993) paper on Lamb types and England & Wales rainfall is a good reference, though the area to which it refers is considerably larger than Lowland England.

Some other comments refer to the other seasons. We have deliberately removed consideration of other seasons from this paper. However we recognise that a full discussion of the drivers of long period droughts requires all other seasons to be included including hydrological persistence between them and influences of climate warming. We will ensure that this is clearer in our discussion and recommendations for further work. This may benefit from research now underway on the drivers of UK and European summer climate variability for instance. We suspect that there is more than one further paper needed to reach this point. Wilby highlights the importance of sequencing between seasons in long droughts, and it is certainly the case that intervening summer half-years will have a significant bearing on the evolution of droughts primed by dry winters (as borne out by a simple comparison of droughts with hot, dry summers such as 1976/1990/2006 with others with damp dull summers or even very wet ones, like the spectacular summer half-year drought termination in 2012). The Markov-chain based approach Wilby highlights is potentially a useful avenue for such research in future, but beyond the scope of our paper.

P 12936: See above points: we will highlight the importance of summer in UK droughts,

particularly in a future climate change context.

P 12940: Amend wording of text, replacing “This series has been naturalised to remove the influence of abstractions” with “This series has been naturalised, i.e. the flows have been adjusted to take account of the major abstractions upstream of the gauging station”. However, no account is taken of inter-basin transfers. The view of the data provider (UK National River Flow Archive, NRFA) is that there are undoubtedly losses/gains (e.g. from consolidation of Sewage Treatment Works around the edges of the Thames basin) but these are unlikely to have a major influence on the Kingston flows. Effluent returns in the catchment are also not accounted for, but again these are deemed unlikely to have major effects on monthly runoff volumes (although will influence timing) relative to the abstractions which the naturalisation accounts for. The Thames is one of the most intensively studied rivers in the world and the Kingston record is one of the most widely used on the NRFA. It has other limitations around homogeneity of low flows which are probably more important – these are detailed at: http://www.ceh.ac.uk/data/nrfa/data/station.html?39001 We will add a link and a brief sentence to point out all these considerations out, but they are not likely to be unduly influential for the drought indicators we are using, aggregated to seasonal scales, when linking with climate drivers.

P 12941: See above points: we will highlight the importance of temperature and evapotranspiration.

P 12949: We agree that as La Nina provides the clearest Lowland England hydrological driver in the winter half year, a diagram like that of Fig 2 in the comments could be added for precipitation over our region. We will probably retain the Tables as there is additional information not easily captured by the proposed Figure.

P 12950: We will add these references. Svensson and Prudhomme (2005) noted a positive concurrent winter (Dec-Feb) correlation between SSTs in the area corresponding to the centre of the SST tripole and river flows in northwest Britain (r=0.36),



consistent with Fig. 8b and d. For river flows in southeast Britain, encompassing the English Lowlands, they found a positive concurrent winter correlation with SSTs slightly further to the south (r=0.43), partly overlapping the southernmost centre of the SST tripole. Both these correlations are significant at the 5% level.

P 12951: We will also add sentences on the main physical causes of the influence of tropical volcanoes and solar variability on N Atlantic and European winter climate

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