

## ***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.***

**C. K. Folland et al.**

jaha@ceh.ac.uk

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We thank MacDonald for the positive comments on our paper and the helpful suggestions for improvements to the text. We have answered the minor comments as follows.

General:

“I would though encourage the authors to tone down the ‘aims and novelty’ section on P12937 L1-18, as others have discussed a number of these aspects (e.g. Lloyd-Hughes 2002; Todd et al., 2013).”

In line with the comments from Wilby, regarding precursors to our work, we will tone  
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down claims of novelty in relation to ENSO in our paper, and such a revision partly deals with this comment. With regards to the section highlighted by MacDonald, we do not feel we are making any undue claim to novelty. Here, we simply highlight that there has been a wealth of work on drivers of meteorological drought, but that studies have rarely examined links to hydrological drought; and that while some papers have looked at the NAO, there have been few attempts to look at the factors that force the NAO itself. Lloyd-Hughes and Todd both focus on meteorological/soil moisture droughts (SPI and sc-PDSI); the latter paper has some linkage with NAO. We will moderate this section in line of the comments from Wilby and MacDonald, but we feel this paragraph is a fair reflection of several important gaps in research we have aimed at.

“A little more discussion of temperature and its role in drought even within the winter months would be beneficial within a paper considering so many potential drivers”.

Agreed, as also noted in responses to Wilby and Reviewer #1 we will highlight the role of temperature, through evapotranspiration and snowfall.

Suggested Amendments:

P12936 L17, see Lennard et al., (2014 - ref below) linking drought management and water resources

We will add this reference, thank you.

P12941 L21-25, consider revising the sentence

We are not sure exactly what the reviewer means here, but suggest a change to clarify our point. The original was: “We also conducted an analysis to examine how spatially coherent these major long 20 droughts are relative to the rest of the UK. Rainfall tends to be influenced differently in northwest Britain when the English Lowlands suffer drought. To show this, Fig. 3 shows correlations between rainfall in the ten climatological rainfall districts covering the UK defined by the UK Met Office and gridded NCIC rainfall data elsewhere in UK for both winter and summer half years based on the 15

drought periods listed in Table 1”.

Will be modified to: “We also conducted an analysis to examine how spatially coherent these major long 20 droughts are relative to the rest of the UK. There is a strong rainfall gradient between the English Lowlands and northwest Britain (an order of magnitude between the wettest parts of the Scottish Highlands and driest parts of East Anglia); given the predominance of westerly airflows interacting with uplands in the west, lowland areas are often in rainshadow so periods of very wet or very dry conditions in the lowlands do not necessarily conform to those in the northwest. The atmospheric drivers of lowland droughts are therefore likely to be somewhat different to those in the northwest. To demonstrate this, Fig. 3 shows correlations between rainfall in the ten climatological rainfall districts covering the UK defined by the UK Met Office and gridded NCIC rainfall data elsewhere in UK for both winter and summer half years based on the 15 drought periods listed in Table 1”.

P12943 L15-21, I am not convinced this adds to the argument or shows anything particularly beneficial

We agree this is treated rather cursorily at present, although we do use the correlation between SPI and SGI to inform the approach in section 4 of the paper. We agreed to add more coverage of the significance of lags and attenuation (see response to reviewer 1) here, which will hopefully make this section fit the narrative better.

P12951 L10, consider removing 3.2.3 as it does not really add to the discussion – up to the authors/editor?

We keep this for completeness of considered drivers (see also Section 4). The coverage is weak at present but we agreed to add this in our response to Wilby, so will add material here.

P12971 Add an inset map to Figure 1, showing location in UK, then focus the map closer on the study area, consider adding London and Oxford for reference.

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We will add these suggestions.

P12975/6, a number of the curves (Figures 5 and 6) in the most extreme drought events are cut so they appear to have a flat bottom, show the full curves if possible, as these illustrate the severity of the event

The truncated parts of the series are a product of the non-parametric approach underlying the SGI. The behaviour at the extremes is always hard to model because -by their very nature - we don't observe many examples of them). The flat portions of a non-parametric transform are a big hint that all we know about the most extreme drought is that it is the biggest one we see within our data record. A parametric transform might well lead to a smoother curve in the extremes but it only does that because it makes an untestable assumption about the shape of the tail of the distribution. These limits to the SGI do not make a difference to the identified droughts.

P12934 L2 remove 'very', quantifiable

We will do this.

P12935 L16 provide a reference to the 'English Lowlands' being the driest part.

We did not feel this statement needed a reference. We could add reference to the NCIC climate averages we use in this paper.

P12935 L17 reference to support rainfall levels.

will be the same reference as above.

P12935 L17 population density statement needs a reference as a large portion of the catchment is semi-rural, SE is more densely populated I suspect than the define EL.

Agreed that parts within this region are more densely populated. The problem here is that we are referring to a region that we have defined ourselves, using the NRFA regional outflow series, which can't really be compared with other widely used UK regions (e.g. administrative). We will modify “contains some of the most densely pop-

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ulated areas of the UK and, correspondingly, the highest concentrations of commercial enterprise and intensive agriculture; many parts of the region....”

P12936 L3, given ‘anticipated’ increases in pop and urban development

Agreed.

P12936 L15, remove ‘dry’ EL

Agreed.

P12936 L27, reconsider ‘modulating’

We think this is fine.

P12941 L21 ‘are’ available

Agreed (presumably this refers to 12942, L11)

P12943 L12, clarify ‘accumulation’

We think this follows from the preceding discussion but we will modify “As with groundwater levels, monthly river flows were not accumulated over a range of periods in producing the SGI” (also note for clarity will be referred to as Standardized Flow Index – see reviewer #1 response)

P12944 L5 are rather than is

Agreed

P12947 L17, 20CR - twentieth century

This is defined on the previous page.

P12974, ensure font size is same across a-b

We will do this.

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 11, 12933, 2014.

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