Regionalising the influence of the North Atlantic Oscillation (NAO) on seasonal hydrological extremes in Great Britain

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1 CONTEXT

While previous studies [1,2] have shown the influence of the NAO on rainfall in Great Britain, these have focussed on extremes (rather than the flood-drought continuum) and have either been based on analysis of a limited number of stations, undertaken only for particular seasons, or have been based on a relatively short record. Nationally consistent gridded data sets such as the UK CEH Gridded Estimates of Areal Rainfall (GEAR) and the Standardised Precipitation Index (SPI) (1 month accumulation) time series for the UK [3,4] now enable new analysis.

We aim to map the spatial impact of NAO phase on rainfall extremes in Great Britain.

2 METHODS

Monthly NAO phase for 1900-2015 (116 years) was defined [5], based on two NAOI methods (ST - Hurrell Station Based; PC - Hurrell Principal Component Based). Each were correlated against the GEAR and SPI time series, spatially averaged by the 9 Met Office climate regions.

Mean monthly SPI values were subsampled by NAO+/- phase (PC method, NAOI+ 27% , NAOI- 25% of record) and Getis Ord-Gi* hot/cold spot analysis was undertaken. These created areas of spatial significance which served as zones for the calculation of deviation from mean monthly rainfall (% difference) in a neutral state. To provide a context to these values, deviation (mm) from mean monthly neutral values when in a +/- phase was also mapped.

3 RESULTS (a)

Regional correlations in the tables on the right, show both strong negative and positive values - the result being clearly determined by season. Differences between NAOI methods have a significant impact on results - notably the PC method produces much stronger negative correlations during summer. Choice of NAOI therefore has much more of an effect than whether this is correlated against actual rainfall (GEAR) or SPI.

The PC method is considered more accurate during the summer; this is a result of the movement of the NAO system away from the stations on which measurements for the ST method are based [6]. The analysis below is therefore only undertaken using NAOI calculated using the PC method.

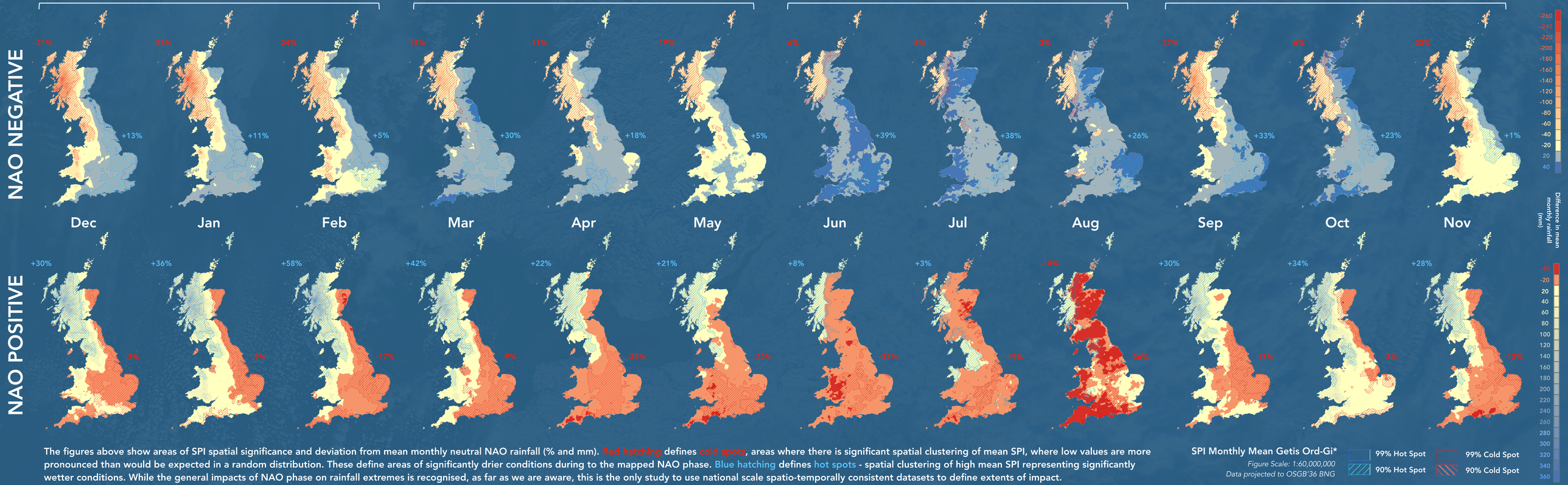
* = 95% sig.

SPI 1 ST Method	D	J	F	M	A	M	J	J	A	S	O	N
Scotland N	*	*	*	*						*	*	*
Scotland E	*	*									*	*
Scotland W	*	*	*	*	*	*				*	*	*
England E & NE							*					
England NW & N Wales	*	*	*				*				*	*
Midlands		*					*					*
East Anglia							*					*
S Wales & England SW	*	*					*				*	*
England SE & Central S		*					*					*

SPI 1 PC Method	D	J	F	M	A	M	J	J	A	S	O	N
Scotland N	*	*	*	*	*	*	*	*	*	*	*	*
Scotland E							*	*	*			
Scotland W	*	*	*	*	*	*	*	*	*	*	*	*
England E & NE							*	*	*	*		
England NW & N Wales	*	*	*				*	*	*	*	*	*
Midlands							*	*	*	*		
East Anglia							*	*	*	*		
S Wales & England SW							*	*	*	*		
England SE & Central S							*	*	*	*		

GEAR ST Method	D	J	F	M	A	M	J	J	A	S	O	N
Scotland N	*	*	*	*						*	*	*
Scotland E	*	*	*								*	*
Scotland W	*	*	*	*	*	*				*	*	*
England E & NE							*					
England NW & N Wales	*	*	*				*				*	*
Midlands		*					*					*
East Anglia							*					*
S Wales & England SW	*	*					*				*	*
England SE & Central S		*					*					*

GEAR PC Method	D	J	F	M	A	M	J	J	A	S	O	N
Scotland N	*	*	*	*	*	*	*	*	*	*	*	*
Scotland E							*	*	*			
Scotland W	*	*	*	*	*	*	*	*	*	*	*	*
England E & NE							*	*	*	*		
England NW & N Wales	*	*	*				*	*	*	*	*	*
Midlands							*	*	*	*		
East Anglia							*	*	*	*		
S Wales & England SW							*	*	*	*		
England SE & Central S							*	*	*	*		



The figures above show areas of SPI spatial significance and deviation from mean monthly neutral NAO rainfall (% and mm). Red hatching defines cold spots, areas where there is significant spatial clustering of mean SPI, where low values are more pronounced than would be expected in a random distribution. These define areas of significantly drier conditions during to the mapped NAO phase. Blue hatching defines hot spots - spatial clustering of high mean SPI representing significantly wetter conditions. While the general impacts of NAO phase on rainfall extremes is recognised, as far as we are aware, this is the only study to use national scale spatio-temporally consistent datasets to define extents of impact.

SPI Monthly Mean Getis Ord-Gi*
Figure Scale: 1:60,000,000
Data projected to OSGB'36 BNG
99% Hot Spot
90% Hot Spot
99% Cold Spot
90% Cold Spot

3 RESULTS (b)

WINTER

- NAO negative phases result in very dry conditions in the north west (up to 31% drier/>150mm lower than NAO neutral in the zone of spatially significant low SPI values). The south and east experience marginally wetter conditions (up to 13%).
- Positive NAO produces extremely wet conditions in the north west (up to 58% wetter than NAO neutral). The south and east experience drier conditions (up to 17%, a ≈20mm reduction).

SPRING

- Negative NAO northern dry conditions start to weaken (up to 19% drier than under neutral NAO). However the south and east start to experience much wetter (up to 30%) conditions.
- Equally the NAO positive driven wet conditions in the north decrease in magnitude across spring. Meanwhile the south and east start to experience significant areas of dryness (up to 25% drier than NAO neutral conditions).

SUMMER

- In summer a negative NAO produces significantly wetter summers (up to 39%/20-40mm increase) for much of Great Britain. Marginally drier conditions (up to 6%) are present in the far north of the country.
- Positive summer NAO results in equally significant extremely dry conditions. Notably in August where the whole country experiences relative dryness (up to 36%/>40mm reduction).

AUTUMN

- In autumn the NAO negative phase summer wetness starts to decrease in magnitude, and drier conditions start to prevail in the north (up to 27% drier than NAO neutral conditions).
- In a NAO positive phase the summer dryness starts to weaken (up to 13% drier) and significantly wetter conditions are found in the north (up to 34% wetter than NAO neutral conditions).

4 SOURCES

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