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THE SPATIAL SIGNATURE OF THE NORTH ATLANTIC OSCILLATION IN MONTHLY RAINFALL PATTERNS IN GREAT BRITAIN (1899/1900-2014/2015)

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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 in Great Britain.

2 METHODS

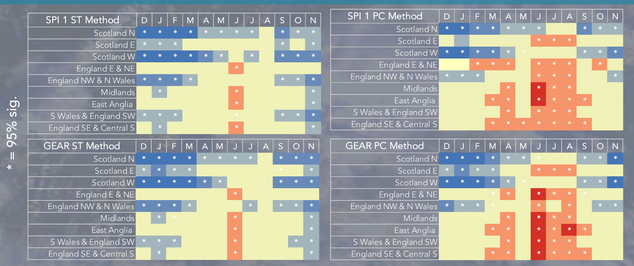
Two different NAO indices (NAOI) were used in this investigation NAOI ST - Hurrell Station Based, and NAOI PC - Hurrell Principal Component Based. These indices represent the phase and provide an indication of strength of the NAO at a national scale. Each were correlated against the GEAR and SPI time series, spatially averaged by the 9 Met Office climate regions.

Months for water years 1899/1900 - 2014/2015 were classified into a state of NAO positive, neutral, or negative based on the method of Berton *et al.* [5] . NAO positive phase was defined as NAOI >0.502. NAO negative was defined as NAOI <-0.503. Months falling between these two thresholds were classified as NAOI neutral. Based on this classification mean monthly rainfall in each phase was calculated and deviation from neutral NAO was mapped.

3 RESULTS (a)

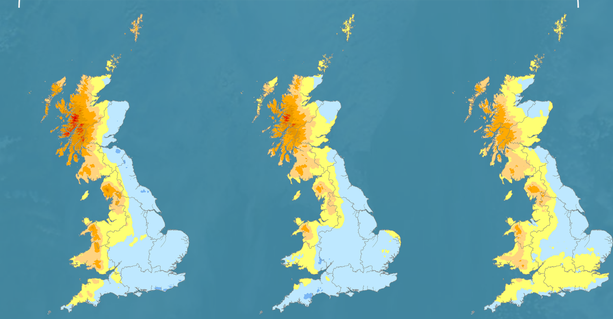
Regional correlations in the tables on the right, show both strong negative and positive values - the result being clearly determined by season. Differences between NAOI methods have a significant impact on results - notably the PC method produces much stronger negative correlations during summer. Choice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

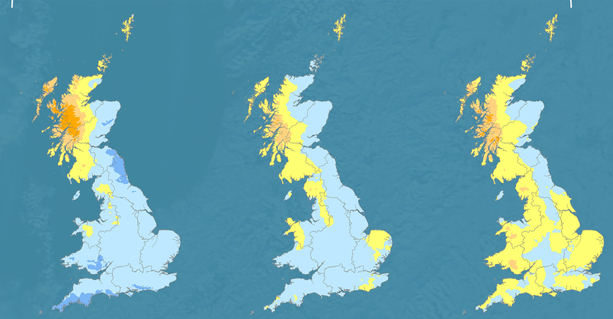
The PC method is considered more representative during the summer; this is a result of the movement of the system away from the stations on which measurements for the ST method are based [6]. The analysis below is therefore only based on NAOI calculated using the PC method.

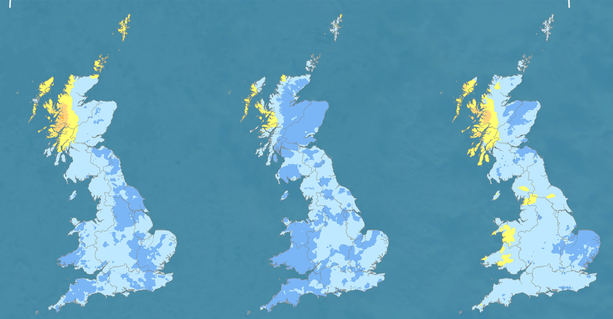


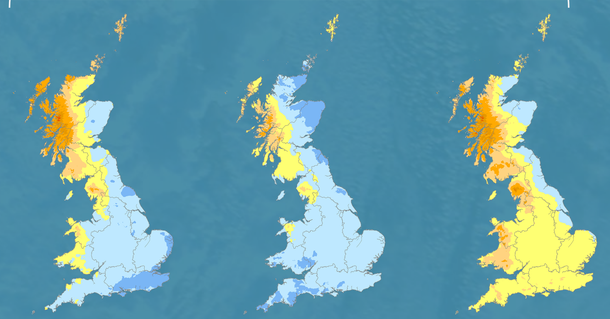
WINTER | SPRING | SUMMER | AUTUMN

NAOI NEGATIVE



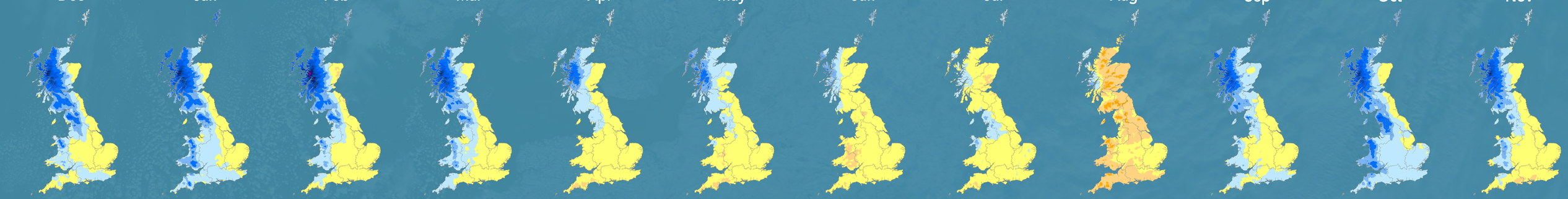






Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov

NAOI POSITIVE



In the figures above, the yellow to red scale shows an increasing reduction in monthly rainfall. When NAOI is negative, the west, and particularly the northwest, show reductions in rainfall. In contrast, during NAOI positive periods this occurs on the opposite side of the northwest/south east axis and the southeast is generally drier most for months, apart from summer when drier conditions are more widespread. The blue to purple scale shows where the NAO enhances monthly rainfall and when NAOI is positive, this occurs predominantly in the northwest during winter, spring and autumn.

Difference in mean monthly rainfall (mm)

Figure Scale: 1:60,000,000
Data projected to OSGB'36 BNG

3 RESULTS (b)

WINTER

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

SPRING

- Negative NAOI northern dry conditions start to weaken (up to 19% drier than under neutral NAOI). However the south and east start to experience much wetter (up to 30%) conditions.
- Equally the NAOI 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 NAOI neutral conditions).

SUMMER

- In summer a negative NAOI 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 NAOI 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 NAOI negative phase summer wetness starts to decrease in magnitude, and drier conditions start to prevail in the north (up to 27% drier than NAOI neutral conditions).
- In a NAOI 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 NAOI neutral conditions).

4 SOURCES

[1] Burt, T.P. & Howden, N.J.K. (2013), North Atlantic oscillation amplifies orographic precipitation and river flow in upland Britain, *Water Resources Research*, Vol.49, 3504-3515.
[2] Kosanic, A., Harrison, S., Anderson, K. & Kavcic, I. (2014), Present and historical climate variability in South West England, *Climatic Change*, Vol.124, 221-237.
[3] Tanguy, M., Dixon, H., Prosdocimi, I., Morris, D.G. & Keller, V.D.J. (2016), Gridded estimates of daily and monthly areal rainfall for the United Kingdom (1890-2015) [CEH GEAR], *NERC Environmental Information Centre*, DOI:/10.5285/33604ea0-c238-4488-813d-0ad9ab7c51ca.
[4] Tanguy, M., Fry, M., Svensson, C. & Hannaford, J. (2017a), Historic gridded standardized precipitation index for the United Kingdom 1862-2015 (generated using gamma distribution with standard period 1961-2010) v4, *NERC Environmental Information Centre*, DOI:/ 10.5285/2339090b2-1d14-4eb9-9ff9c-3923aa2350ff.
[5] Berton, R., Driscoll, C.T. & Adamowski, J.F. (2017), The near-term prediction of drought and flooding conditions in the northeastern United States based on extreme phases of AMO and NAO, *Journal of Hydrology*, Vol.553, 130-141
[6] Pokorná, L. & Huth, R. (2015), Climate impacts of the NAO are sensitive to how the NAO is defined, *Theoretical and Applied Climatology*, Vol.119(3-4), 639-652.