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Mapping Wet-Dry Signatures of the North Atlantic Oscillation (NAO) in British Catchments

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The North Atlantic Oscillation (NAO) is one of the primary atmospheric circulations which influence weather patterns in Great Britain. Its two phases (either positive or negative depending on differences in sea level pressure) result in characteristic precipitation patterns, the effects of which cascade down to signatures in streamflow. However, in relation to streamflow response to the NAO, these studies have been spatio-temporally limited as they have been undertaken using a small number of measurement sites with relatively short records.

The release of new historic datasets from the UK Centre for Ecology and Hydrology (CEH) provides a new opportunity to undertake a broad spatio-temporal analysis of the relationship between NAO and streamflow. This research used reconstructed daily flows for 291 catchments and the associated Standardised Streamflow Index (SSI) to explore the relationship between the North Atlantic Oscillation Index (NAOI) for the period January 1900-November 2015. Spearman correlations were calculated at monthly intervals between the NAOI and SSI (with a 1-month accumulation period), and the historic flows dataset was used to explore the variability in flows across the catchments under NAO+ and NAO- phases.

This analysis revealed distinct wet and dry spatio-temporal signatures in streamflow. The winter months are characterised by a north-west and south-east divide in this relationship; catchments in the northern and western regions show strong positive correlations between the NAOI and SSI and NAO+ is associated with higher than normal flows in many north-western catchments, and vice versa under NAO-. While catchments in the south-eastern and central regions are negatively correlated and therefore show an opposite wet-dry response. However, during the summer months, while there are some wet-dry signatures under NAO positive/negative phases - the reverse to that seen in winter, almost all catchments show weak NAOI-SSI negative correlation values.

Finally, we compare the wet-dry responses to the NAO observed in streamflow to NAO-precipitation patterns, measured via correlations between the NAOI and Standardised Precipitation Index with a 1-month accumulation period over the same study period. The two sets of correlations (NAO-SPI and NAO-SSI) were analysed for spatio-temporal similarity through a Geographically Weighted Regression (GWR) analysis and a space-time clustering analysis. This revealed that in winter, as described above, the correlations with SPI and SSI generally behave

similarly during the winter months – i.e. the wet-dry signatures in rainfall cascade down and are identifiable in streamflow patterns. In the summer months the NAOI-SPI correlations for the majority of catchments are negative. In the NAOI-SSI correlations, the summer values, while still negative, are notably weaker. The catchments with the weakest NAOI-SSI correlations are those generally in the central/southern region. These catchments have very slow response times due to their characteristics which may moderate the NAO wet/dry rainfall deviation.