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Spatial coherence and large-scale drivers of drought

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Drought is a potentially widespread and generally multifaceted natural phenomenon affecting all aspects of the hydrological cycle. It mainly manifests itself at seasonal, or longer, time scales. Here, we use seasonal river flows across the climatologically and topographically diverse UK to investigate the spatial coherence of drought, and explore its oceanic and atmospheric drivers. A better understanding of the spatial characteristics and drivers will improve forecasting and help increase drought preparedness.
The location of the UK in the mid-latitude belt of predominantly westerly winds, together with a pronounced topographical divide running roughly from north to south, produce strong windward and leeward effects. Weather fronts associated with storms tracking north-eastward between Scotland and Iceland typically lead to abundant precipitation in the mountainous north and west, while the south and east remain drier. In contrast, prolonged precipitation in eastern Britain tends to be associated with storms on a more southerly track, producing precipitation in onshore winds on the northern side of depressions. Persistence in the preferred storm tracks can therefore result in periods of wet/dry conditions across two main regions of the UK, a mountainous northwest region exposed to westerly winds and a more sheltered, lowland southeast region. This is reflected in cluster analyses of monthly river flow anomalies. A further division into three clusters separates out a region of highly permeable, slowly responding, catchments in the southeast.
An expectation that the preferred storm tracks over seasonal time scales can be captured by atmospheric airflow indices, which in turn may be related to oceanic conditions, suggests that statistical methods may be used to describe the relationships between UK regional streamflows, and oceanic and atmospheric drivers. Such relationships may be concurrent or lagged, and the longer response time of the group of permeable catchments in the southeast also introduces lags in the statistical relationships. Three-month aggregations of the data were used to investigate potential oceanic and atmospheric drivers of streamflow drought in the three UK regions. Significant concurrent relationships were found for different parts of the year for several indices of northern hemisphere airflow patterns, including the North Atlantic Oscillation, the Arctic Oscillation, the East Atlantic, the East Atlantic/West Russia, and the Scandinavia patterns. Significant relationships with oceanic and atmospheric indices representing the El Niño/Southern Oscillation were found for both concurrent and lagged analyses.