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Improving Winter Ensemble Streamflow Prediction in the UK using North Atlantic Oscillation Analogues

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Ensemble Streamflow Prediction (ESP) is a well-established method of predicting streamflow where skilful meteorological forecasts are not available. ESP uses historic climate data as input to a hydrological model to generate an ensemble of streamflow forecasts, and its skill relies upon initial hydrological conditions. The technique has been widely employed around the globe, and is currently one of the methods used in the operational UK Hydrological Outlook. However, ESP has been shown have poor skill over seasonal lead times in winter months in the UK, especially in the north and west where catchments respond quickly to rainfall and are less driven by initial hydrological conditions. Winter months are critical in the UK for groundwater, reservoir and soil moisture recharge, and are often responsible for the onset and termination of significant flood and drought events. Therefore, improving seasonal forecasting skill in the winter is crucial for the management of hydrological extremes.

Continuing research from the UK Drought and Water Scarcity IMPETUS project, and working with the Hydro-JULES project (which seeks to develop an integrated UK and global modelling system in order to, among other things, quantify the risks of hydro-climatic extremes and improve hydrological forecasting) methods of improving the ESP forecasting technique over winter in the UK were explored. ESP does not traditionally use meteorological forecasts, though these are available in the UK. Furthermore, meteorological forecasts of precipitation are more skilful in the UK in winter months (when ESP skill is lowest), when atmospheric circulation patterns are more predictable. Moreover, skill in the predictability of the winter North Atlantic Oscillation (NAO) index further exceeds the skill in precipitation itself. Therefore, NAO index forecasts from Glosea5 were used to produce analogue date sequences for winter 3-month seasonal forecasts, by extracting non-sequential 3-month sequences from the past that provide an average NAO index approximating the forecast values. Precipitation and potential evapotranspiration data were then extracted for these analogue sequences, and applied in the UK Hydrological Outlook Ensemble Streamflow Prediction System.

This research demonstrates the results of a hindcast experiment conducted to determine the potential for improvement in the ESP forecasts by utilising analogue sequences, derived using the NAO index, over winter months in the UK. This method has the potential to significantly improve seasonal forecasting skill, especially in the north and west of the UK, where current ESP skill is limited. This technique could be further exploited by determining alternative dominant circulation patterns during different seasons in the UK, or indeed be employed to improve ESP elsewhere in the world, where the seasonal prediction skill of these key patterns can be demonstrated.