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Improving winter river flow forecasts for the UK

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Winter is the main season for recharge of groundwater and reservoirs in the United Kingdom (UK), and therefore influences the water availability during the rest of the year. Whereas hydrological predictions on timescales of days are comparatively successful, predictability on a seasonal scale is still limited and is mainly a result of the strong dependence of the flow on initial water storage conditions in the catchments. Seasonal river flow and groundwater predictions on a national, year-round scale have recently become available for the UK through the Hydrological Outlooks (http://www.hydoutuk.net/). For winter (December to February) mean river flows, these forecasts tend to be less skilful in the northwest than the southeast. Here we demonstrate new methodologies which take advantage of the remarkable geographical complementarity between the regional geological variations and regional meteorology, enabling increased skill in long range forecasts of winter river flows across the UK. Forecasts made at the start of winter show significant skill, which derives mainly from the geological memory of antecedent conditions in southern and eastern parts of the UK and from greater long range predictability of seasonal rainfall in northern and western areas of the UK. Many river catchments in lowland (southern and eastern) UK have a permeable geology and therefore a runoff regime dominated by slowly released groundwater. In contrast, catchments in the northwest are generally less permeable and therefore faster responding to rainfall events, making good seasonal rainfall forecasts essential for successful river flow forecasts. Winter rainfall in this region is primarily controlled by the North Atlantic Oscillation (NAO), and forecast methods are presented which take advantage of recent improvements in the predictability of the sea level pressure field over the North Atlantic by the GloSea5 seasonal climate prediction system. Two river flow forecast methods are presented. The first consists of at-site linear regression forecasts using the preceding November's river flow and the December-February forecast of the NAO index as predictors. Second, a grid-based hydrological model is run using NAO-adjusted rainfall forecasts from GloSea5 as input. These rainfall forecasts lead to improved river flow forecasts in the northwest compared to using non-adjusted rainfall forecasts. Results for groundwater modelling are mixed, partly because most aquifers are located in the south and east rather than the northwest, and are therefore less affected by the NAO. But the slow response times of groundwater stores also mean that the resulting groundwater levels are complex aggregates of rainfall, evaporation and soil moisture over a longer time period than just the forecast period.