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Seasonal river flow forecasting using multi-model ensemble climate data

D.A. Lavers (1, 2), **D.M. Hannah** (2), C. Prudhomme (1), A. Troccoli (3)

(1) Centre for Ecology & Hydrology, Maclean Building, Wallingford, Oxfordshire, OX10 8BB, UK (2) School of Geography, Earth and Environmental Sciences, University of Birmingham, Edgbaston, Birmingham, B15 2TT, UK (3) European Centre for Medium-Range Weather Forecasts, Shinfield Park, Reading, RG2 9AX, UK (d.m.hannah@bham.ac.uk),

Developing skilful seasonal forecasting of river flows is important for many societal applications. Long-lead forecasts have potential to aid water management decision making and preparation for human response to hydrological extremes. The seasonal prediction of river flows has been a topic of increasing interest due to the recent 2004-06 drought and 2007 floods experienced in the UK.

We compare the relative skill of predictions of river flow using: (1) a multi-Global Climate Model (GCM) ensemble data set and (2) downscaled multi-GCM data as input to a hydrological model. The period considered is 1980-2001. The River Dyfi basin in West Wales, UK is the focus of this research. This basin is near natural, hence the climate-flow signal should be clearer. The DEMETER project is the source of the multi-model climate data, and this consists of 7 GCMs each with 9 ensemble members. Hindcasts with lead times up to 6 months are available from 1st February, 1st May, 1st August and 1st November initial conditions. Each hindcast was split into the first 3 and last 3 months, and the subsequent concatenation of the split hindcasts produced 2 time series (total of 7x9x2 ensemble series), which were run through the Probability Distributed Model (PDM). PDM is a lumped rainfall-runoff model that transforms rainfall and potential evaporation data to river flow at the basin outlet. PDM was calibrated with observations from 1980-1990, and then validated from 1991-2001.

The coarse resolution of the DEMETER data (standardised to 2.5° x 2.5° resolution)

means that the atmospheric motions at sub-grid scales are not captured by the models. The large spatial disparity between the GCM grids and the scale of the study (471.3 km^2) lead to underestimation of precipitation by DEMETER models. This difference is addressed through the use of a statistical downscaling tool, the Statistical Downscaling Model (SDSM). The SDSM was calibrated on the ERA-40 re-analysis data set (from the ECMWF), as it provides one of the best estimates of the real atmosphere (a spatial resolution comparable to that of DEMETER models was used for this calibration). Multiple linear regression models (one per month) were used to link DEMETER predictors with basin scale rainfall, and a stochastic weather generator produced downscaled rainfall time series. These new downscaled series are designed to more closely represent catchment rainfall. DEMETER precipitation data and downscaled data are inputted to the PDM to determine their relative river flow modelling skill.

Preliminary results show that simulated river flows driven by DEMETER do underestimate the observed flow. The downscaled series improves the hindcast skill, and little reduction in skill is seen when using a longer lead time hindcast. The results drawn from this research will have major implications for assessing (1) the potential skill expected from large scale GCM output, and (2) the relative improvement in skill of using downscaled versus non-downscaled precipitation data. Also, it will be possible to ascertain any degradation in the seasonal hindcast skill when using longer lead times.