1. Introduction

Forecasting of river flows at seasonal time scales, defined as lead times of 1 to 6 months, is an area of growing research interest. This is because seasonal forecasts of river flows are of practical use in informing water management decisions and preparing to mitigate hydrological extremes (floods or droughts), which may have major societal and economic impacts. The aim of our work, is to improve the accuracy achieved of the seasonal forecasts of river flows.

The aim of this research is to compare the potential skill of river flow forecasting using (1) Global Climate Models (GCM) output in the form of reanalysis data and (2) downscaled precipitation data from GCMs. This paper explores the comparison of the Probabilistic Distributed rainfall-runoff Model (PDM), and the input of GCM reanalysis data and downscaled reanalysis data into the PDM rainfall-runoff model.

2. The PDM Rainfall-Runoff model

The Probabilistic Distributed Model (PDM) is a lumped rainfall-runoff model (based on probability distributed moisture stores) that transforms rainfall and potential evaporation to river flow at the basin outlet. A schematic of the PDM structure is shown in figure 1 (PDM User Guide, 2005).

3. Data

The River Dyfi basin was chosen as a test case as it has limited anthropogenic influence, hence the climate-flow signal should be stronger than a basin with greater human impact. It is a temperate basin, and relatively small with an area of 473.6 km². A grid of rainfall-runoff models is used to calculate the catchment-averaged rainfall in each grid cell, and the dark brown colour show elevations higher than 600 metres. Daily catchment-averaged rainfall, monthly catchment-averaged potential evaporation (PE) and daily river flow data were used to calibrate the PDM. Precipitation data from both the ERA-40 resolutions resulted in underestimated modelled flows compared to the observed; and this is highlighted by the very large negative biases in the Q5, Q95 and Q98 in table 1.5 (a).

When the ERA-40 rainfall time series is run through the PDM, the simulated flow (green line) is lower than the observed series. The ERA-40 data does not represent the number of wet days (wet day defined as here as > 0 mm) accurately, however, the average rainfall intensity from ERA-40 on the wet days is under half of what the observations suggest. This implies that the bias in the ERA-40 rainfall may be due to the underestimated rainfall that occurs in the wet season, rather than the rainfall occurrence.

The downsampling process generated different daily rainfall time series, and this on average increases the R² value by 0.15 and 0.03 for 1.5° and 2.5° resolution respectively. Figure 1.5 (c) shows the improvement in using downscaled series versus 1.5° resolution ERA-40 data in the flow duration curve. The biases between the percent exceedance flows are reduced substantially for the downscaled ensemble mean in comparison with the direct use of ERA-40 data in the PDM.

6. Conclusions and Future Work

The background to this work was to compare the potential skill of raw and downscaled GCM output for river flow forecasting: a UK case study.

The skill and convective precipitation and snowfall were summed daily for the two grid points nearest the Dyfi catchment (52.5°N 5°W and 52.5°N 2.5°W for 2.5° resolution; 52.5°N 4.5°W and 52.5°N 3°W for 1.5° resolution). These rainfall time series were then run directly through the PDM model, whilst the PE data was left unchanged from the model calibration. The grid point from which the precipitation explained the highest proportion of river flow in the PDM was the westernmost point (52.5°N 5°W and 52.5°N 4.5°W for 2.5° and 1.5° resolution respectively), and these two grid points were used for the downsampling procedure.

The ability of GCM and downscaled GCM rainfall time series to reproduce river flow was assessed through the percent exceedance flow (Q20). For example the Q5 value is the river flow which is equaled or exceeded 5% of the time (high flow index), and the Q85 value is the river flow which is equaled or exceeded 85% of the time (low flow index).

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The results at both tested resolutions highlighted the use of ERA-40 precipitation data as direct input to the PDM rainfall-runoff model, the simulated river flow substantially underestimated the observed river flow in the Dyfi basin. This is likely to be due to the reanalysis data's inability to resolve catchment-scale (or GCM sub-grid scale) atmospheric processes such as orographic enhancement of rainfall over the Welsh Mountains. The direct use of GCM output as input to a rainfall-runoff model is thus not recommended due to its poor ability in reproducing observed river flows.

To address the relatively poor performance of the GCM data, a statistical downsampling technique (SDSM) was used. The downsampling process added skill to the river flow simulations for ERA-40, and more particularly for ERA-40 1.5° resolution. This improvement is significant for all parts of the river regime (from high flows such as Q5 to low flows such as Q95).

This research suggests that much improvement is added to GCM output when combining it with statistical methods. In the future we intend to test the downsampling method used here on seasonal forecasts from GCMs to assess how comparatively dynamical with statistical techniques could forecast river flow in the UK.

7. References

2. The PDM Rainfall/Runoff Model Version 2.2 Centre for Ecology and Hydrology, September 2005

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