Assessment of HadRM3 Extreme Precipitation in the UK

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Introduction

Climate change impacts on extreme rainfall in the United Kingdom (UK) present a major concern regarding their effects on water resources and hydrology. Climate model output gives some guide to the magnitude of future changes. However, the modelling involves many parameterisations of sub-grid processes. Validation of model estimates with observed data is therefore essential to assess the reliability of modelled rainfall extremes. This study compares return period magnitudes in rainfall based on the Hadley Centre regional model (HadRM3) data and on observed data for the period 1961-1990.

Data and Methodology

- *Observed data*: 105 rainfall stations covering the UK (Figure 1a).
- *UK Climate Impacts Programme (UKCIP)*: 5-day rainfall totals for a 5 by 5 km grid over the UK (this is the only extreme rainfall variable available for comparison).
- *Regional model data*: the Hadley Centre model HadRM3, 0.44° latitude by 0.44° longitude (Hulme *et al.*, 2002) (Figure 1b).

Return period magnitudes were estimated for the following data sets:

- Annual maxima
- Seasonal maxima (spring, summer, autumn and winter)
- Multi-day totals (2, 5 and 10 days).

The magnitudes were estimated for 5-, 10-, 20- and 50-year periods by fitting data to a Gumbel distribution. All data sets were re-gridded to a common regular grid (0.5° latitude by 0.5° longitude) to aid the comparison (Figure 1c).

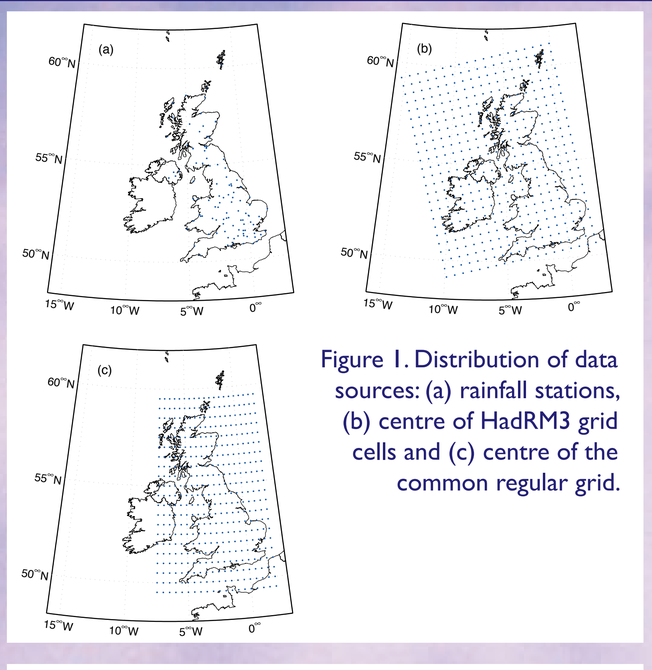

Figure 1. Distribution of data sources: (a) rainfall stations, (b) centre of HadRM3 grid cells and (c) centre of the common regular grid.

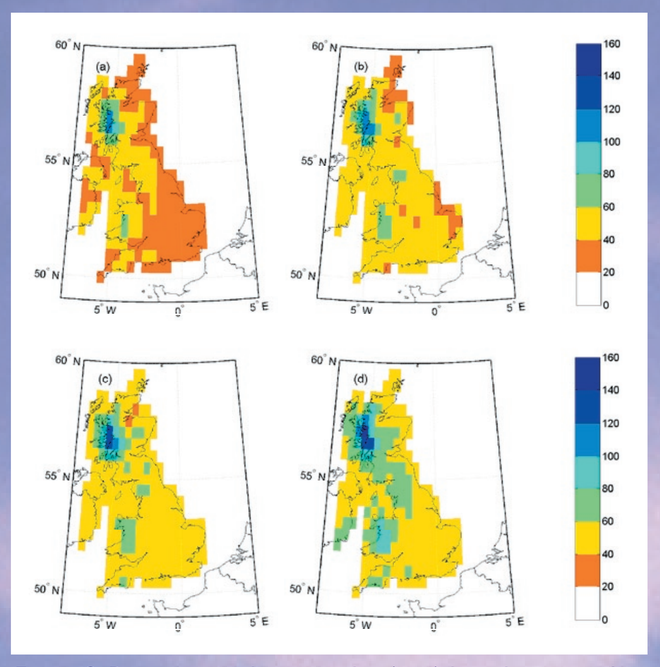

Figure 2. Return period magnitudes (mm) based on annual maxima: (a) 5-year period, (b) 10-year period, (c) 20-year period and (d) 50-year period.

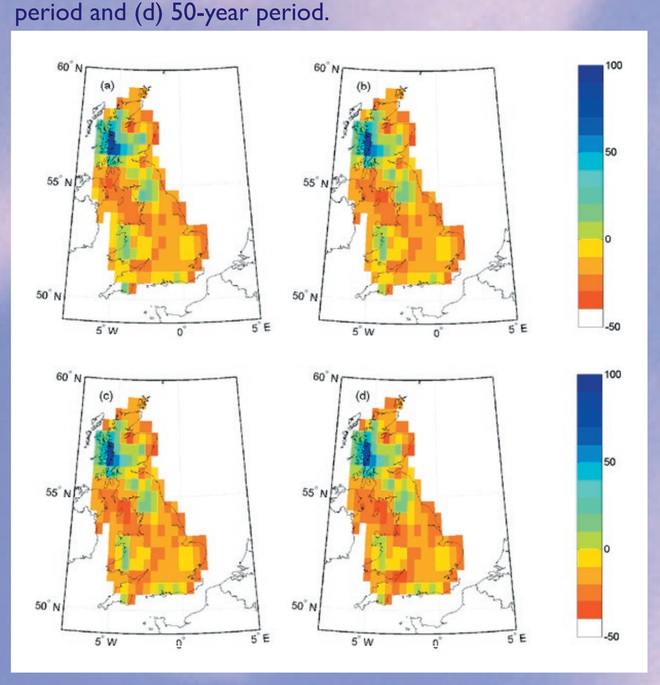

Figure 3. Relative difference (HadRM3 - observed) in return period magnitudes (%) based on annual maxima: (a) 5-year period, (b) 10-year period, (c) 20-year period and (d) 50-year period.

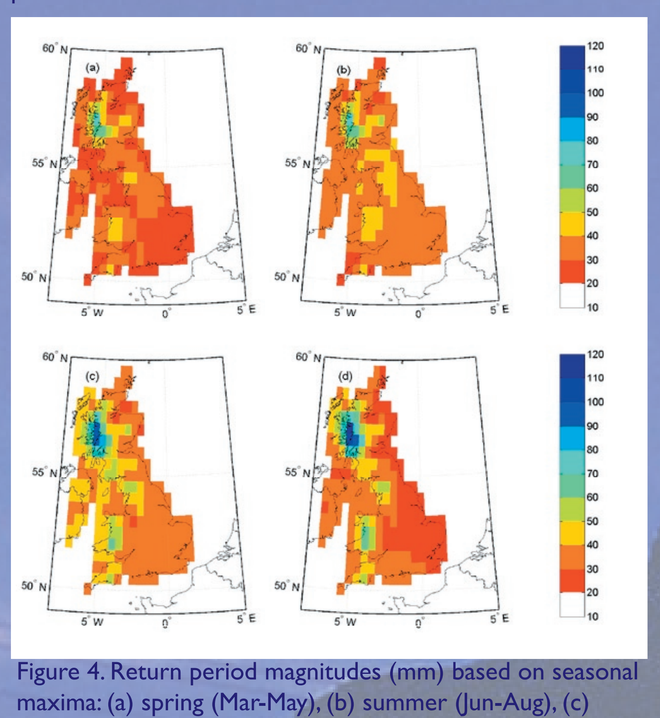

Figure 4. Return period magnitudes (mm) based on seasonal maxima: (a) spring (Mar-May), (b) summer (Jun-Aug), (c) autumn (Sep-Nov) and (d) winter (Dec-Feb).

Results

Results for all return periods are only shown for the annual maxima. For the remaining data sets only the 10-year return period is shown.

Annual maxima

Spatial patterns of return period magnitudes based on HadRM3 data show a clear west to east trend over the UK, with high magnitudes in western Scotland, northern England and Wales (Figure 2). Lowest magnitudes are found in eastern England and eastern Scotland. The maximum values range from about 110 mm (5-year return period map) to about 150 mm (50-year return period map).

Maps of percent difference between HadRM3 and observed data have similar spatial patterns and magnitudes (Figure 3). The largest overestimation (> 40 %) is usually associated with the high magnitudes. On average the discrepancy is about -20 %, but there are regions with larger underestimation (up to -40 %), mainly along the coasts, but also inland.

Seasonal maxima

The main differences between the seasons are found in the magnitudes rather than in the spatial patterns (Figure 4). The strongest west-east gradient is found in winter, where the high magnitudes in Scotland are combined with low values over much of eastern England. Similar low values in eastern England are also found in spring, however, during this season the magnitudes in Scotland are much smaller. Summer and autumn have similar patterns and magnitudes. Their main difference is the larger magnitudes of return period magnitudes in western Scotland during autumn.

Relative differences to the observed seasonal patterns are shown in Figure 5. With the exception of western Scotland the spring, autumn and winter patterns show on average a +/- 20 % difference between the model and observations. Larger differences are found in the summer pattern where the HadRM3 data have underestimated the return period magnitude by up to 40 % over large parts of central and eastern England.

Multi-day totals

The maps are expected to have similar spatial patterns with increases in magnitudes to match the increase of days included in the totals (Figure 6). Relative differences to observed data are shown in Figure 7. The maps show that while the 2-day totals are generally underestimated (-25 %), the 5-day and 10-day totals are overestimated (25 %). Relative differences between HadRM3 5-day totals and that of the UKCIP data show similar patterns to those found in differences with observed data.

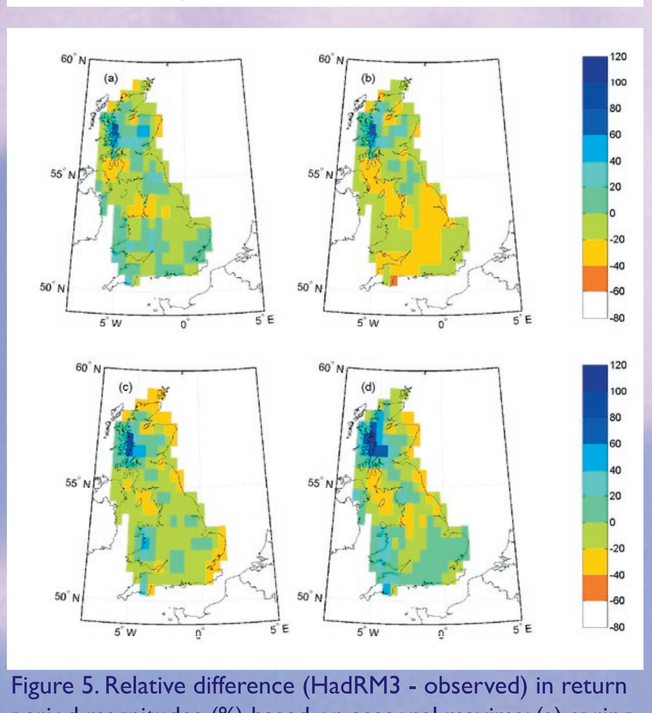

Figure 5. Relative difference (HadRM3 - observed) in return period magnitudes (%) based on seasonal maxima: (a) spring (Mar-May), (b) summer (Jun-Aug), (c) autumn (Sep-Nov) and (d) winter (Dec-Feb).

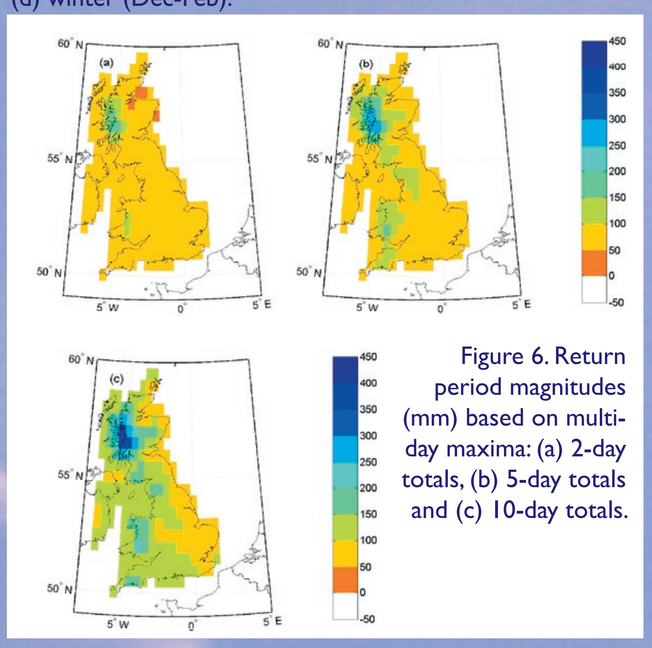

Figure 6. Return period magnitudes (mm) based on multi-day maxima: (a) 2-day totals, (b) 5-day totals and (c) 10-day totals.

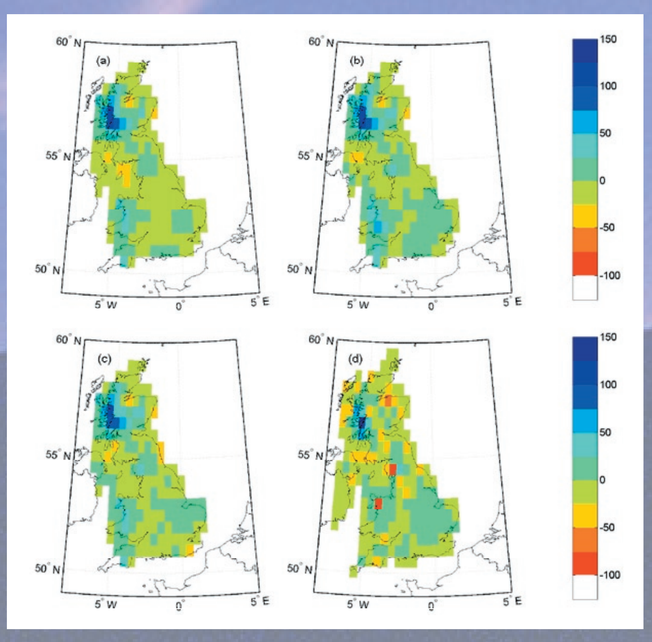

Figure 7. Relative difference (HadRM3 - observed) in return period magnitudes (%) based on multi-day maxima: (a) 2-day totals, (b) 5-day totals, (c) 10-day totals and (d) relative difference (HadRM3 - UKCIP) in return period magnitudes based on 5-day totals (%).

Summary

HadRM3 provides reasonable patterns of extreme rainfall over UK, with an average difference of about +/- 20 % compared with gridded observed data. The large overestimation in western Scotland is probably partly a result of the sparse data coverage in this region.

Acknowledgements

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Reference

Hulme, M., Jenkins, G. J., Lu, X., Turnpenny, J. R., Mitchell, T. D., Jones, R. G., Lowe, J., Murphy, J. M., Hassell, D., Boorman, P., McDonald, R. and Hill, S., 2002: Climate Change Scenarios for the United Kingdom: The UKCIP02 Scientific Report, Tyndall Centre for Climate Change Research, School of Environmental Sciences, University of East Anglia, Norwich, UK, 120 pp.

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