The CONVEX project - Using Observational Evidence and Process Understanding to Improve Projections of Extreme Rainfall Change

Stephen Blenkinsop[1], Hayley Fowler[1], Elizabeth Kendon[2], Steven Chan[1], Chris Ferro[3], Nigel Roberts[4], David Stephenson[3], Pat Sessford[3]

[1] Newcastle University [2] UK Met Office Hadley Centre [3] University of Exeter [4] Met Office@Reading

For more details visit: http://research.ncl.ac.uk/convex/ or email: stephen.blenkinsop@newcastle.ac.uk

What is CONVEX?

It is predicted that climate change will bring about changes to the intensity and frequency of climatic and hydrological extremes which will in turn have large impacts on communities through increased risk of flooding.

A key focus of the CONVEX project is the representation of the **CONV**ective **EX**tremes that are important contributors to flood generating events, a deficiency of current climate models. Its aims therefore ultimately include the provision of better guidance on using climate models and better information on future UK flood risk.

AN HOURLY RAINFALL CLIMATOLOGY FOR THE UK

CONVEX has combined observations of hourly rainfall from the UK Met. Office Integrated Data Archive System (MIDAS), the Scottish Environmental Protection Agency (SEPA), and tipping bucket rain gauge (TBR) data from ~1,300 gauges across England and Wales from the UK Environment Agency (EA). The data was subjected to quality control checks including for accumulated totals, periods of non-operation of TBRs and unrealistic high-frequency tipping in the TBRs.

- A climatology of sub-daily extremes has been produced for the period 1992-2011 comprising ~200 gauges depending on season (e.g. see Fig 1). For most of the UK, summer produces the greatest 1-hr totals.

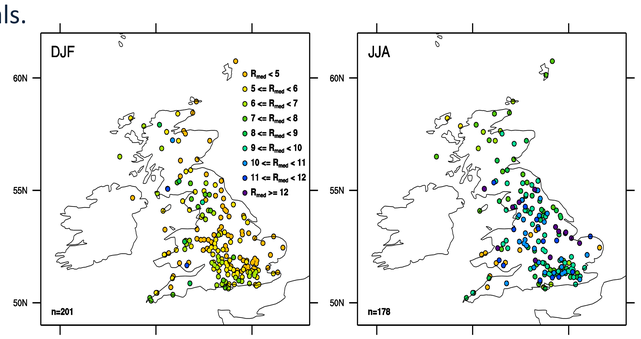

Fig 1. Seasonal 1-hr annual maxima (R_{med}; mm) for the period 1992-2011 for winter (left) and summer (right), n denotes the number of gauges.

- Additional metrics/indices of extremes analysed include (i) POT data for different seasons; (ii) return period estimates derived from extreme value analysis; (iii) number of Extreme Rainfall Alert thresholds to identify flood risk hotspots.

VERY HIGH RESOLUTION CLIMATE MODELLING

- First climate change experiments with a very high resolution (1.5km) "convection permitting" model have been carried out for a region of the southern UK.
- The 1.5km model simulates realistic hourly rainfall characteristics including extremes, unlike coarser resolution climate models (Fig 2).

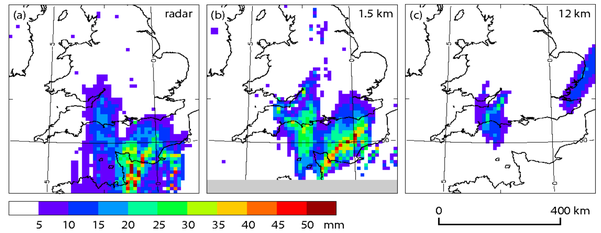

Fig 2. Rainfall accumulations for 5h period 13-18 UTC on 27th July 2013 for (a) radar, (b) 1.5km forecast model, (c) 12km forecast model. The improvement at 1.5km in rainfall structure and intensity is typical for convective storms.

- JJA return levels estimated from 1.5km and 12km resolution RCMs are presented in Fig 3.
- The 1.5km RCM tends to overestimate return levels uniformly, but the 12km RCM struggles with long return periods (Fig 3, upper panels).

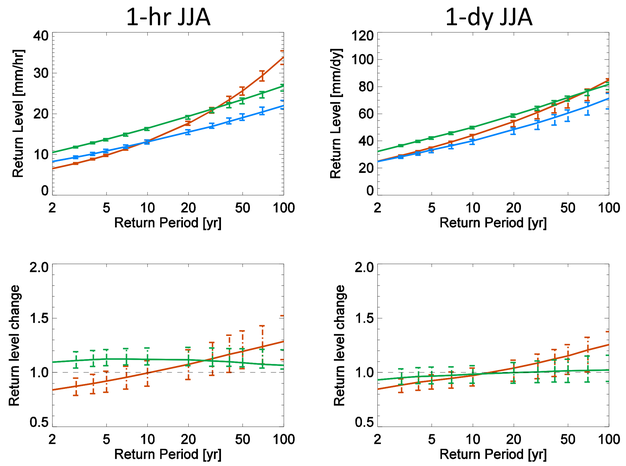

Fig 3. Simulated 1-hr (left) and 1-dy (right) return level amounts for reanalysis driven simulations (upper) and climate change simulations (lower). Blue – radar, green – 1.5km RCM, orange – 12km RCM).

- For 1-hr precipitation, uniform return level increases are projected by the 1.5km RCM, but the 12km RCM projects decreases at low return periods and increases at long return periods (with large uncertainty). No change for return levels for 1-day totals is expected from the 1.5km RCM (Fig 3, lower panels).

SPATIAL PATTERNS OF CHANGE

- Simulations indicate evidence of a future intensification of hourly rainfall in summer in the 1.5km model, which is not seen in a coarser 12km resolution model (Fig 4).
- The benefits of the 1.5km model are largely confined to summer, with the 1.5km and 12km models showing similar future changes in hourly rainfall in winter.

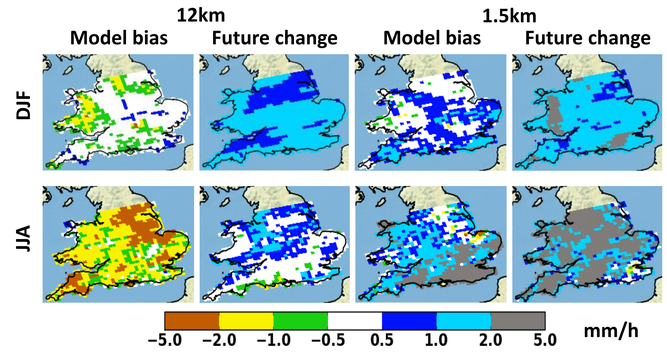

Fig 4. Model biases and future changes in heavy rainfall at the hourly timescale in the 12km (left) and 1.5km (right) models, for winter (top) and summer (bottom).

LINKING OBSERVATIONS, MODELS AND PROCESSES

CONVEX has identified that extreme hourly precipitation intensities for the UK are found to increase according to the Clausius-Clapeyron (CC) relationship (Fig 5, left). Furthermore, for the first time, using the 1.5km RCM this process has been identified in a climate model (Fig 5, right).

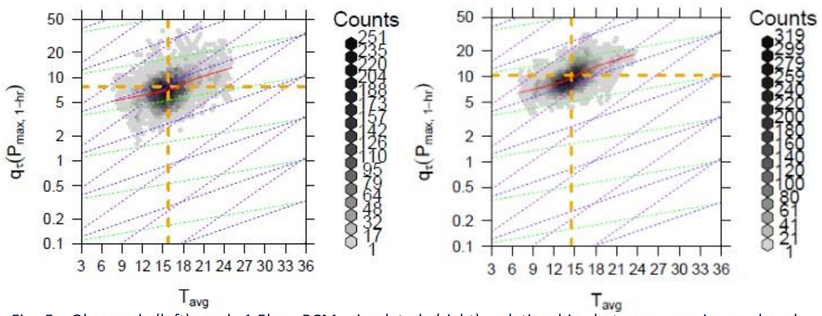

Fig 5. Observed (left) and 1.5km RCM simulated (right) relationship between maximum hourly precipitation intensities ($q_t(P_{max}, 1\text{-hr})$ and mean daily temperature (T_{avg}) Blue diagonal lines denote CC scaling, red line denotes LOESS estimated relationship for all grid cells in the southern UK RCM domain. Orange dashes denote mean values.

By analysing observations and models at different spatial and temporal scales the CONVEX project is improving our understanding of key atmospheric processes and their representation in climate models.