The importance of sampling multi-decadal variability when assessing impacts of extreme precipitation

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Overview

Context

Quantifying local changes in extreme precipitation under transient climate change

The potential of dynamical downscaling to provide information on extreme precipitation

An(other) application of ACRE/C20R

With thanks to Elizabeth Kendon, Erasmo Buonomo, Dave Rowell

Global context: Regional climate change research – where we are

- Attributing regional-scale temperature (+ some other) changes
- Presenting regional-scale mean temperature and precipitation changes with measures of model consensus and some supporting physical insight
  - Information on emergence time of model signals
  - Temperature change information relative to transient climate sensitivity
  - Provides broad overview of likely sub-continental changes in most regions
- Some general (and a few specific) statements on changes in extremes

Local context: Recent flooding in the UK

- The 2007 June-July period was the wettest on record (since 1766 for England and Wales)
- Heavy rainfall events are expected to re-occur naturally, relatively infrequently.
- Are such events likely to become more frequent or intense under climate change?

Quantifying local changes in extreme precip. under transient climate change: importance of natural climate variability

For a given climate projection …

how confident are we in the anthropogenic component of change in climate extremes?

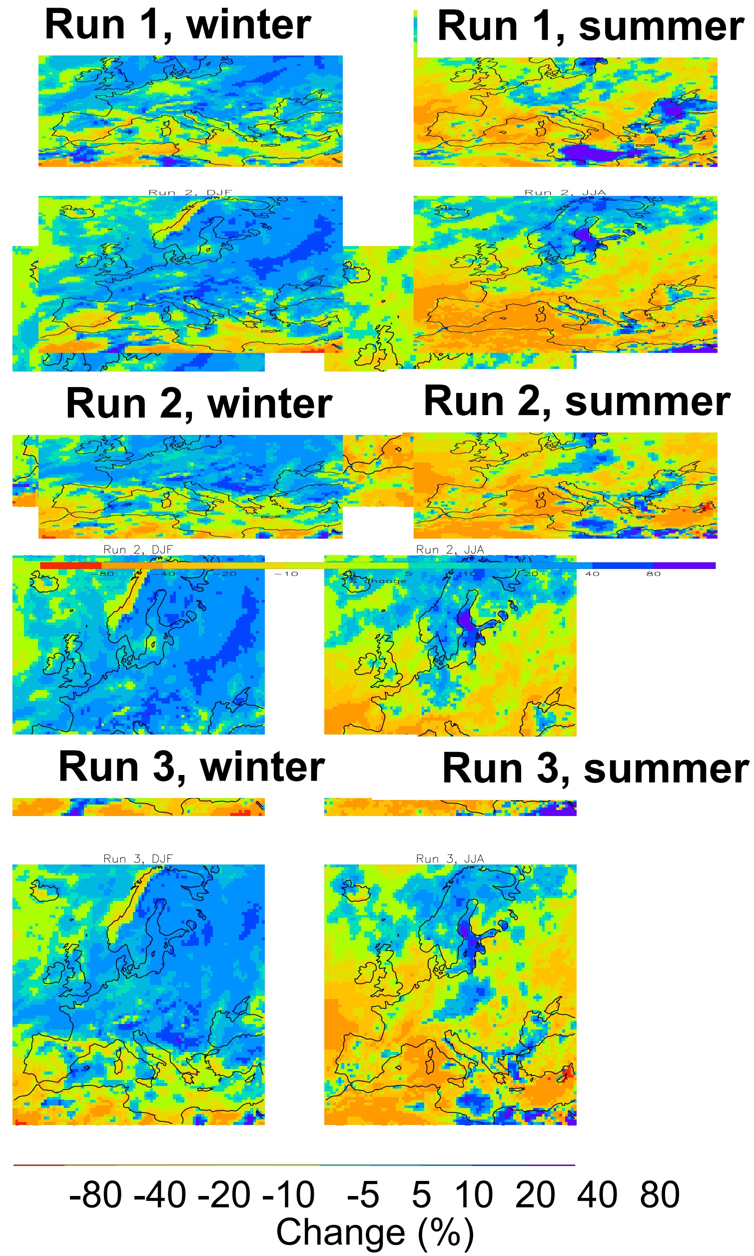
- Full knowledge of natural variability is needed to define extreme behaviour
- Uncertainty in estimate of extreme metric from finite number of years (short timescale + multi-decadal variability)

Ultimately we are less interested in one possible 30 year realisation, than what is the underlying probability of a given extreme event in any future period.

Internal variability of precipitation extremes

3-member UKCIP02 ensemble:

- Many areas of significant change in each ensemble member
- Key point is not demonstrating significant change but reliable changes
- Similarity in projected changes on large-scales
- Locally considerable differences between 3 realisations



Change in upper 5% of wet days by 2071-2100 for SRES A2 scenario

Some key questions

- Over what areas of Europe are changes in extreme precipitation discernible above natural variability?
- Are single 30 year integrations sufficient to infer changes in the extreme tail of the underlying precipitation distribution?
- How effective is spatial pooling in reducing noise due to internal variability, and does robustness increase with spatial scale?

Statistical methodology for initial condition ensemble

Multiple realisations of future climate under given forcing scenario:

- Allows assessment of uncertainty due to full spectrum of natural variability

Assessing significance: t-test

- Allows for wider spread in extreme precipitation estimates from untried ensemble members
- Applicable to ensembles sampling noise with a high degree of 'redness'

Signal to noise ratio

Signal = anthropogenic change in extreme precipitation

Noise = natural climate variability

$$\mathrm{SNR} = \frac{\quad}{\sqrt{(\sigma_x^2 +}}$$

x_i = extreme precip, control

y_i = extreme precip, future

i = ensemble member {1,2, …, n}

$$t = \mathrm{SNR}\sqrt{}$$

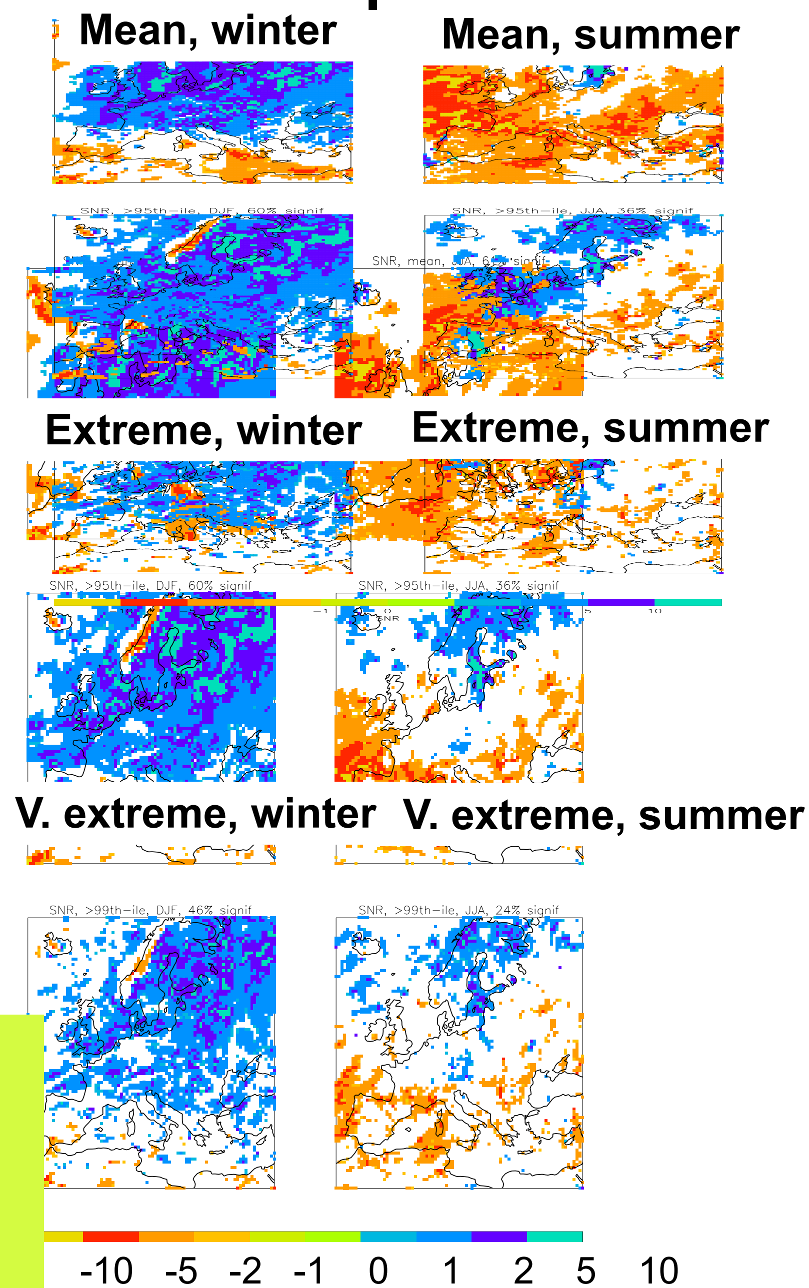
Evidence of ‘redness’ in extreme precipitation data

- Multi-decadal variability in large-scale circulation patterns explains observed change in extreme wintertime precipitation over Europe in recent decades (Scaife et al. 2007)

- Bootstrap resampling shows short time-scale natural variability does not explain ensemble member differences

Need for good sampling of natural variability on all timescales.

Robustness of local precipitation changes

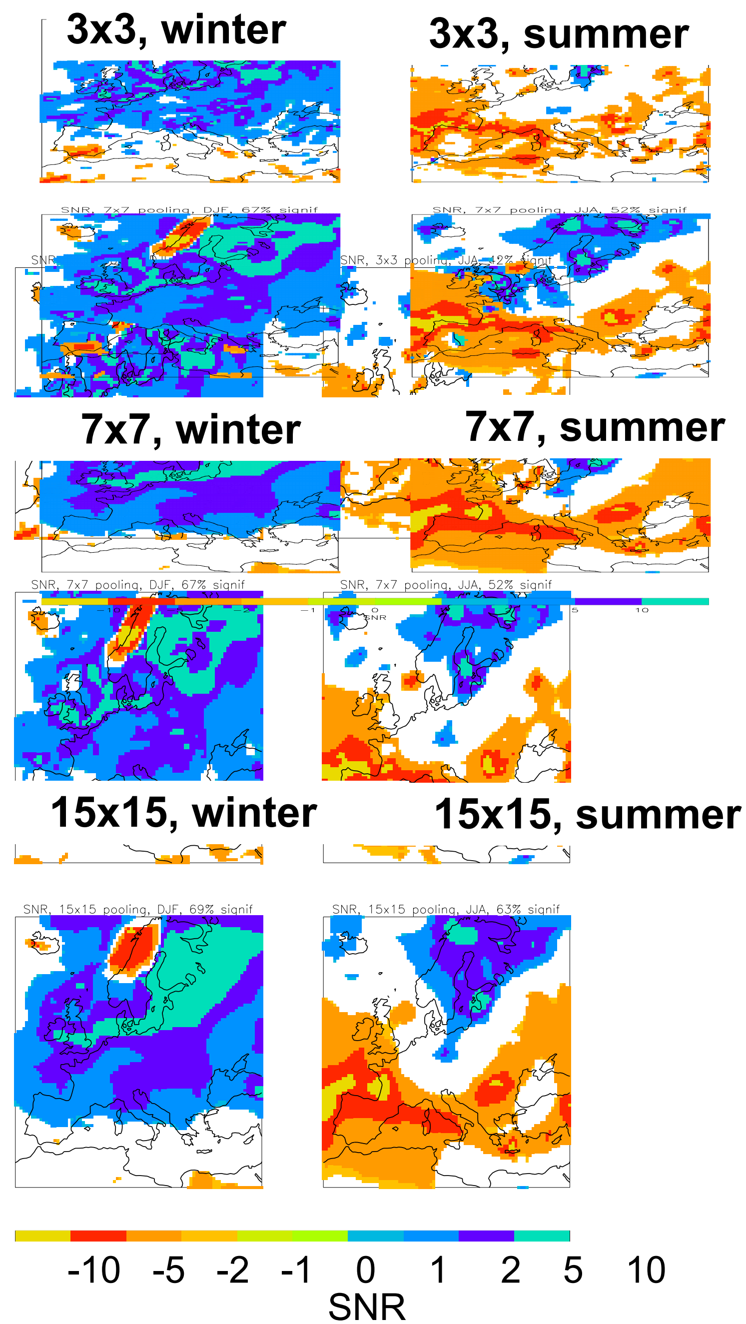


- Can discern significant changes over much of northern and central Europe in winter, and parts of northern and southern Europe in summer.
- Quantify changes with reasonable accuracy where |SNR|>5
- Robustness decreases for increasingly extreme metrics

Kendon, E. J., D. P. Rowell, R. G. Jones, and E. Buonomo, 2008: Robustness of future changes in local precipitation extremes. J. Climate, doi: 10.1175/2008JCLI2082.1.

Benefits of spatial pooling

- Pooling leads to increase in SNR
- Emergence of many more regions with quantifiable changes (|SNR| >5)
- For low amounts of pooling reduction in noise outweighs loss of regional detail (Räisänen & Joelsson 2001)



Some answers – relative to the climate projection analysed

Changes at grid box level discernible over much of northern and central Europe in winter, but less than half of Europe in summer

Changes quantified only in some northern European locations

Single 30 year integrations are insufficient to infer changes in the extreme tail of the underlying precipitation distribution

More than 3x30yr ensemble integrations needed for significant local changes over large parts of Mediterranean in winter and central and eastern Europe in summer

3x3 pooling is effective at reducing grid box noise, but loss of regional detail with further pooling

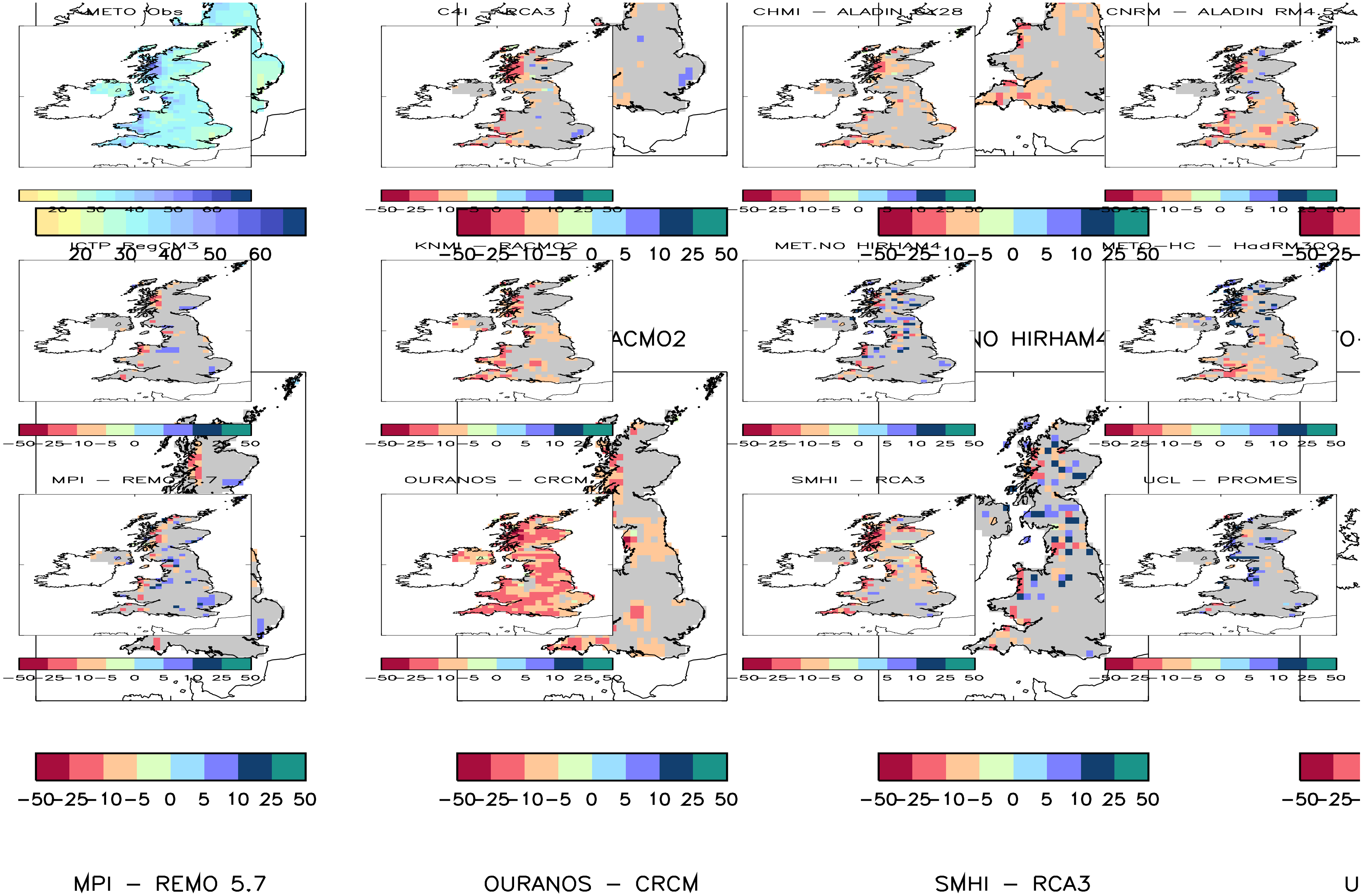
Increasing ensemble size more effective than spatial pooling

The potential of dynamical downscaling to provide information on extreme precip.

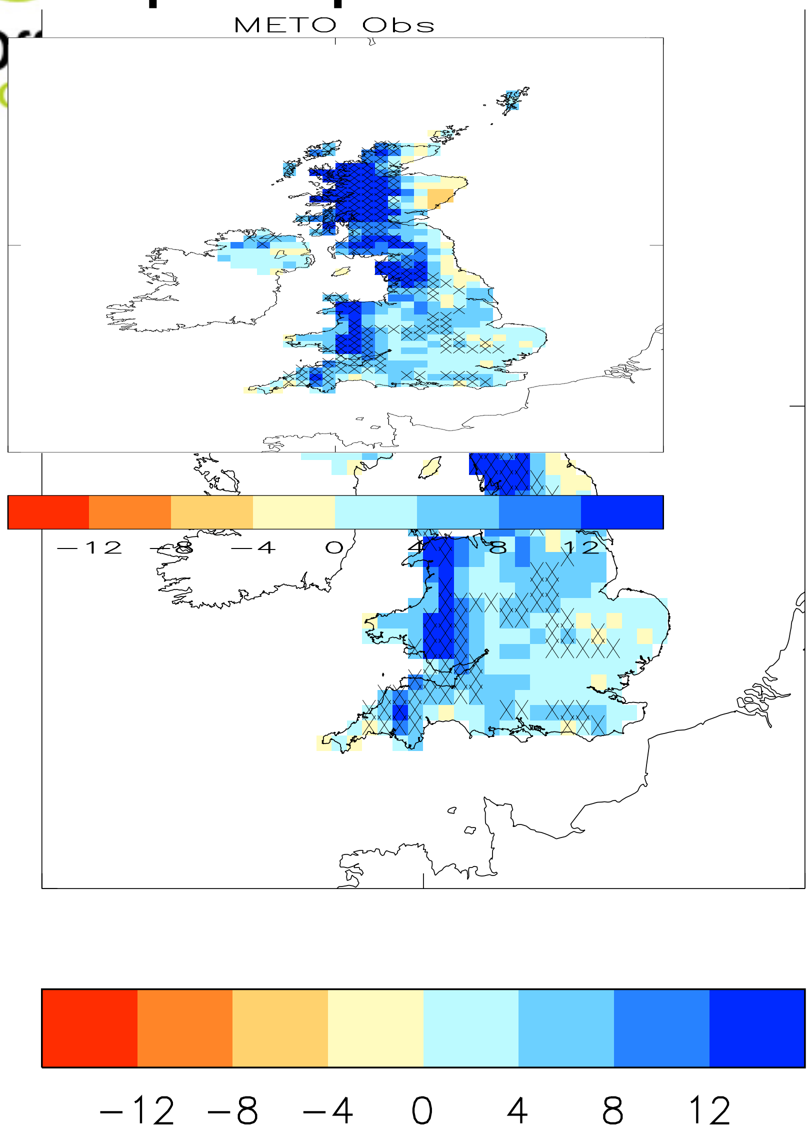
RCM simulations driven by reanalysis boundary conditions demonstrate their ability to:

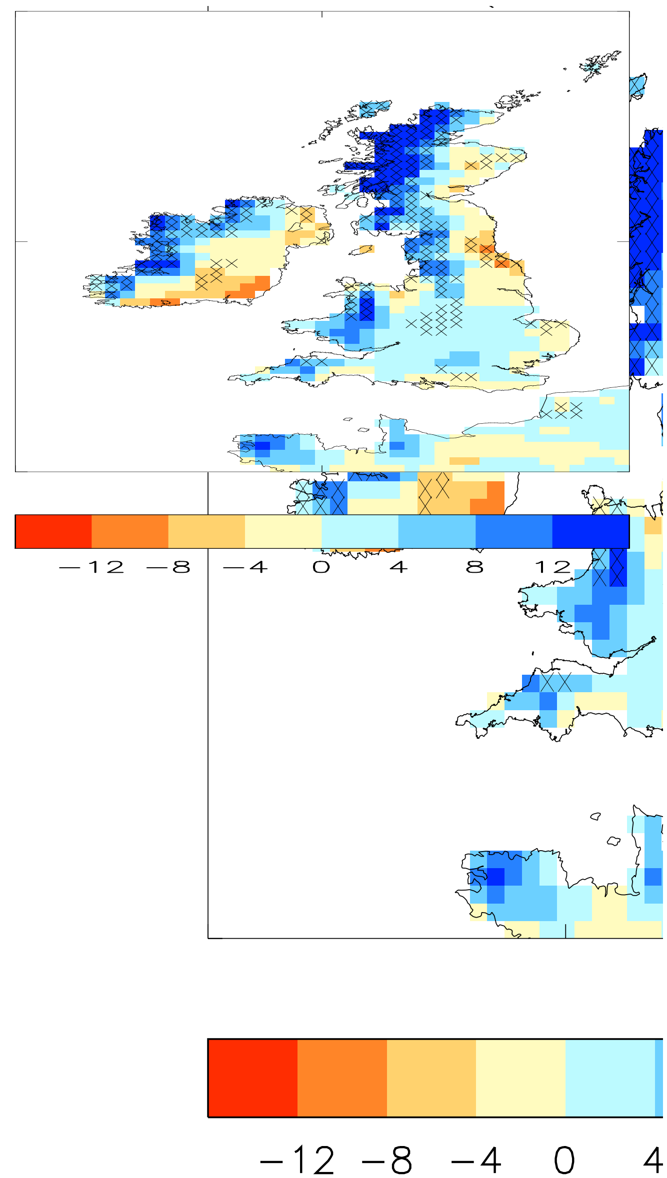
- Simulate extreme precipitation
- Reproduce observed trends
- Provide realistic inputs into models simulating impacts of extreme precipitation

JJA precip 5-year event: obs (mm/day) & bias (%)

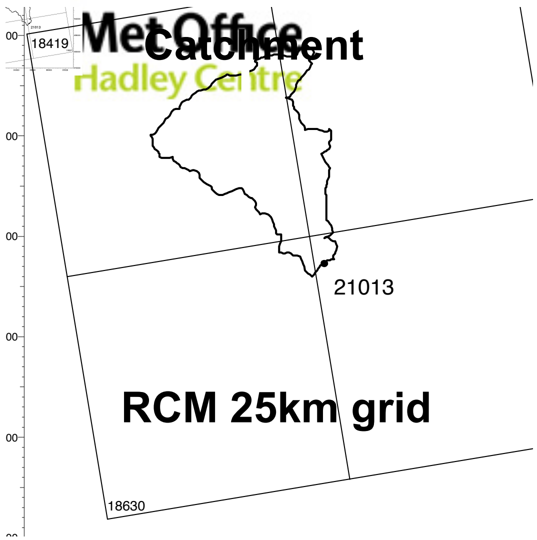


Simulating observed daily extreme precip. trends in an ERA-40 driven RCM

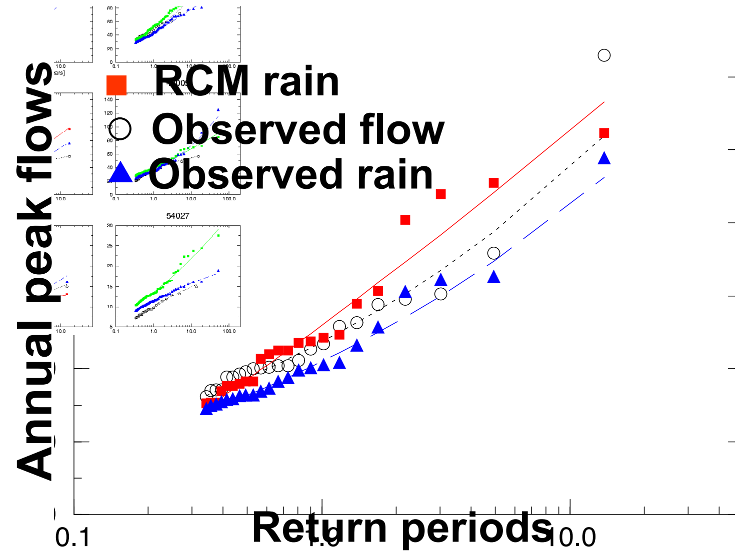


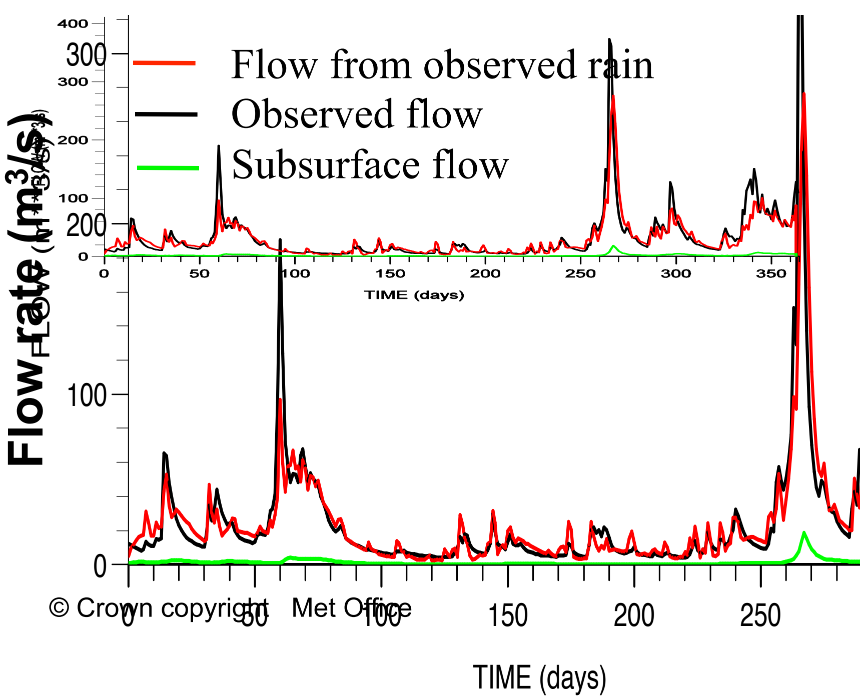


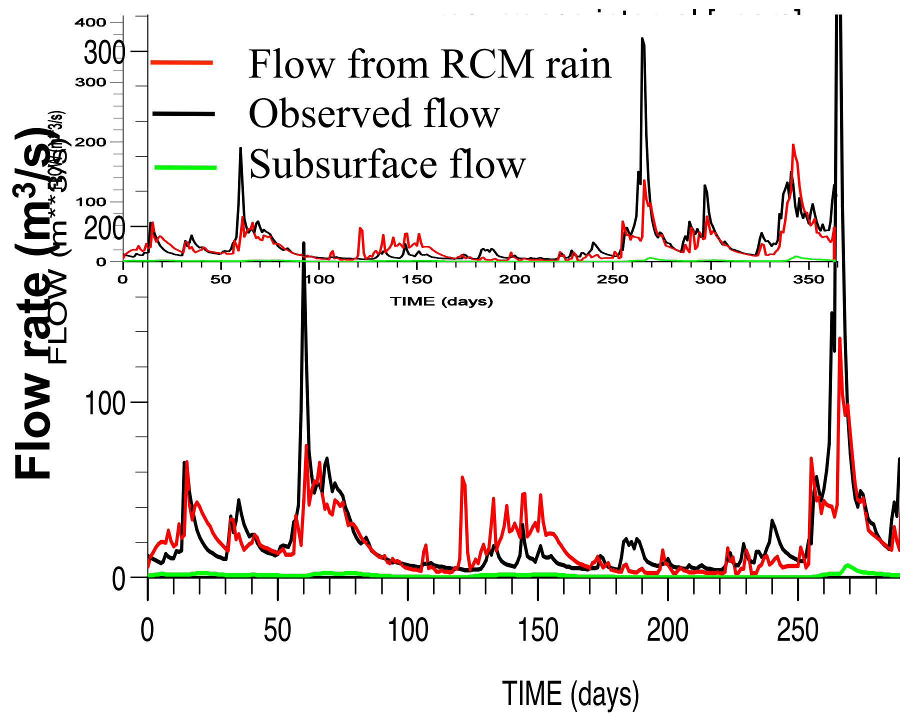
Simulation of extreme river flow via 1km catchment model and RCM data



Statistics of extreme daily flows from observed or RCM rain driving sub-grid river catchment model are the same as observed







An application of ACRE/C20R

Drive Hadley RCM with C20R to provide estimate of multi-decadal variability in European extremes:

- Information to assess vulnerability to past extremes - currently testing system on the 1894 Thames flood
- Good estimate of “noise” to assess emergence of climate change signals

Provide functionality as part of the PRECIS regional climate modelling system (which incorporates Hadley RCMs):

- Enables users in 110 (mainly developing) countries to develop detailed climate reconstructions
- Encourages users to apply local data to assess quality of reconstructed climate (and make available to ACRE?)

Next steps and requirements

Obtain 6 hourly data from a few C20R ensemble members:

- Run downscaling for Europe and Africa (for CORDEX)
- Assess difference in "climatology" of downscaled climate using different ensemble members

Need to assess feasibility of/options for obtaining full dataset:

- Source data need post-processing/conversion to netcdf?
- Local access to data e.g. via CMIP5/CORDEX sites (BADC, DMI, UCT?)

Coordination of wider downscaling activities, both dynamical and statistical