Newcastle University

School of
Civil Engineering and Geosciences

Regional climate change projections: A UK perspective

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Assessing future scenarios of global change, impacts and adaptation measures in water resource systems.

International Workshop,
Universidad de Granada,
25th June 2013

OUTLINE

Introduction

- Regional climate models – strengths & limitations

High Resolution regional climate model projections

- Can they improve projections and what can they tell us about how to use climate models?

Downscaling with the UKCP09 weather generator

- Dealing with uncertainty in climate model projections

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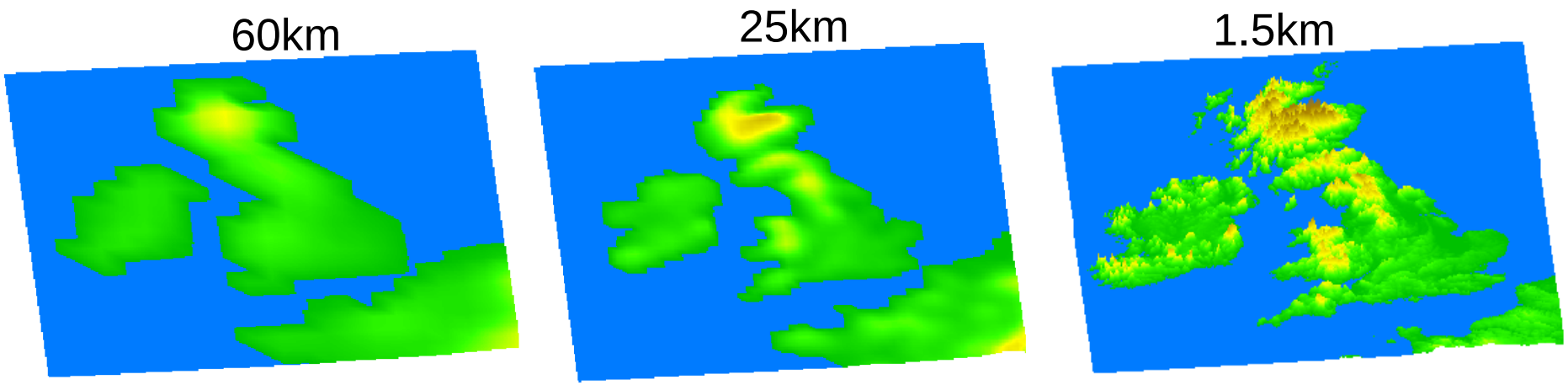
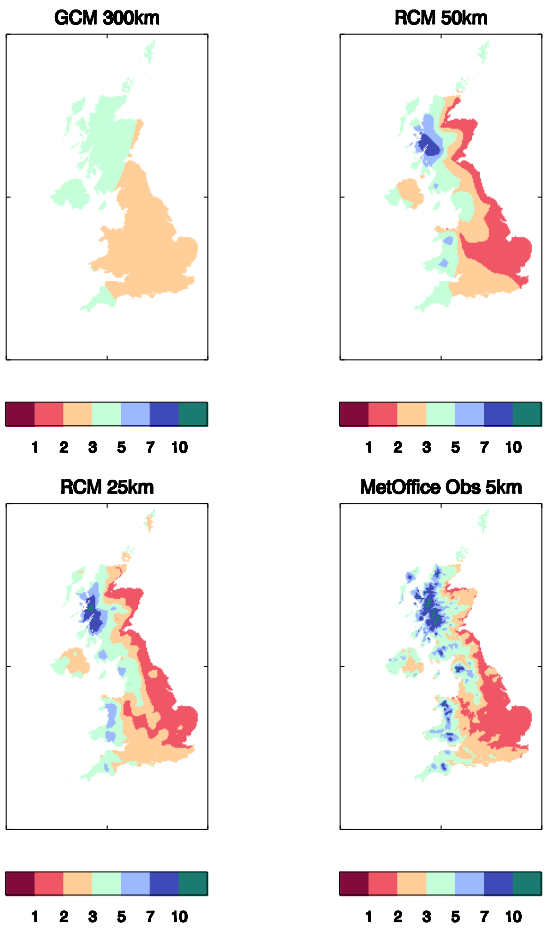
Known deficiencies in current climate models

- Small scale processes are parameterised
  - Convective parameterisation scheme aims to represent the average effects of convection on the grid-scale, but is known source of model deficiencies

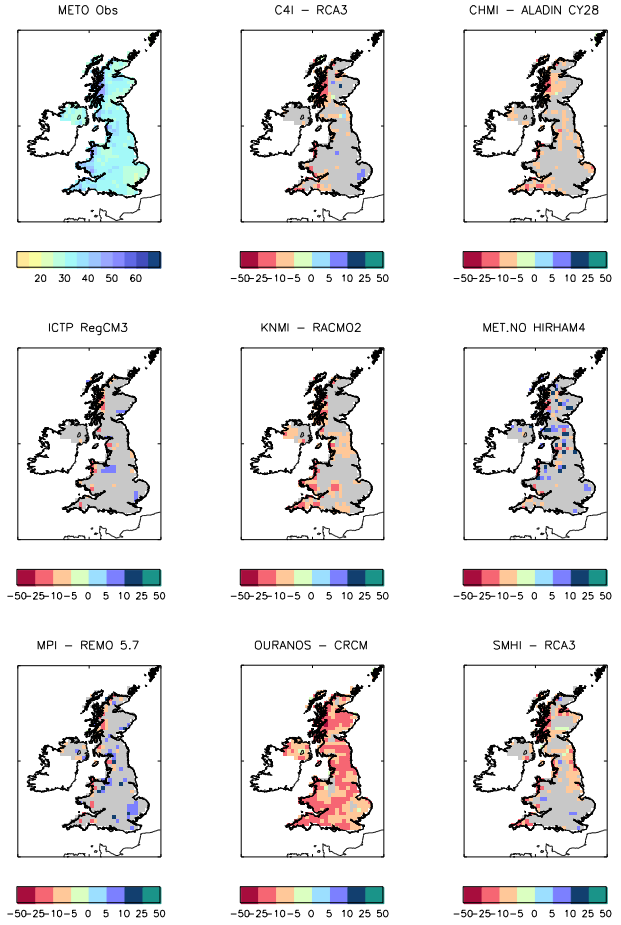
- Representation of complex topography limited by model grid scale



How good are climate models at representing UK rainfall?

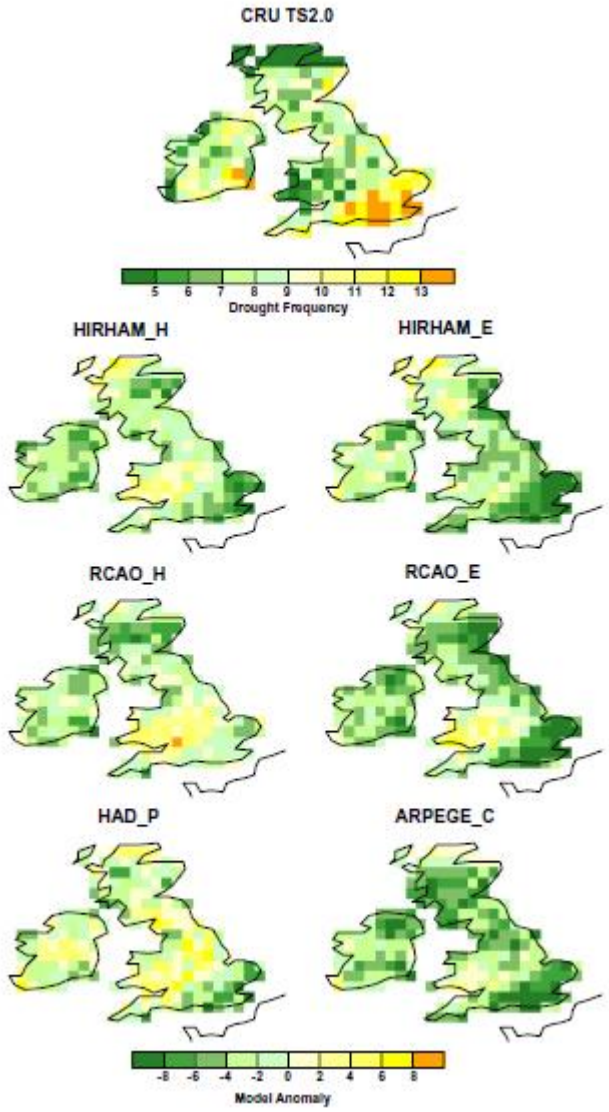


Average UK winter precipitation (mm/day) for 1961-2000



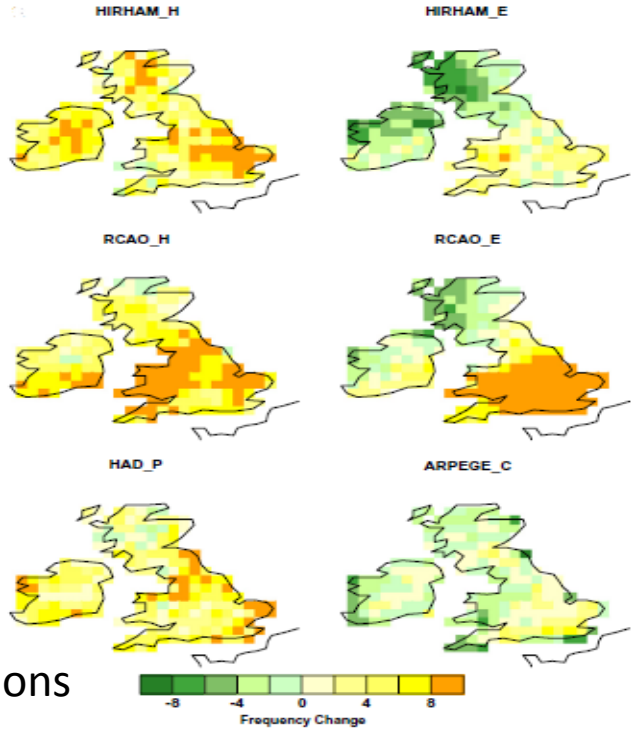
JJA precipitation
5-year return level (mm/day)

… and from a water resources perspective



RCM control experiments

- Drought Severity Index (DSI3) – based on accumulated monthly precipitation anomalies.
- How should we use projections based on these models?



RCM projections

Confidence in model projections

- Greater confidence in ability of models to represent large-scale precipitation extremes on daily timescales or longer.
- There are deficiencies in representation of convective rainfall – particularly in summer for UK. For these events, we have low confidence in current model projections.
- Skill for the present day climate is a necessary but not sufficient condition for reliable future projections.
- **In addition we need to have confidence that models are representing the key processes responsible for future change.**

Reliability of projected changes in heavy rainfall

From understanding of key processes …

- We can make confident statements about the *sign* of change on *large spatial scales* only.

- Uncertainty remains regarding the magnitude of changes, and more generally in changes at local scales. In winter, increasing heavy precipitation over Europe as a whole is reliable.

- For localised extreme events, processes which are not well represented in current climate models could dominate.

CONVEX: CONVective EXtreme rainfall

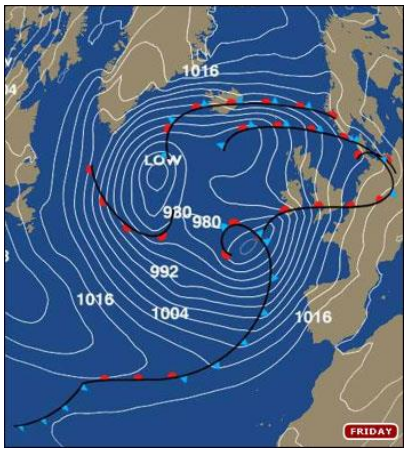
PI: Prof. Hayley Fowler, Newcastle University

Due to potential increases in **flood risk** CONVEX is seeking to improve understanding of extreme rainfall and its representation in climate models and includes the following objectives:

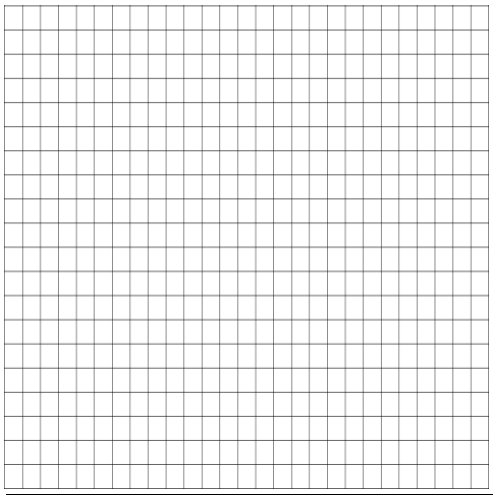
1.Explore observed rainfall – especially sub-daily timescales

3. Assess the deficiencies of climate and weather models - what are their strengths and weaknesses, particularly in terms of the mechanisms of extreme rainfall

2. Better understand the causes of extreme rainfall

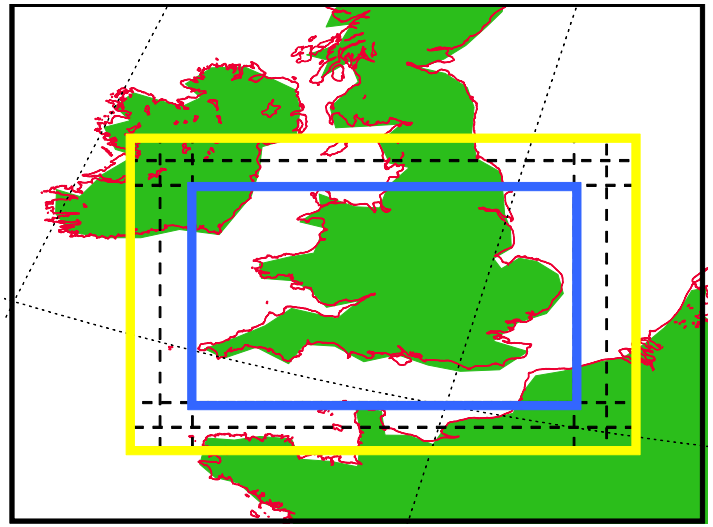


4. Assess the influence of model resolution – running climate model experiments at 50 km, 12 km and 1.5 km scale



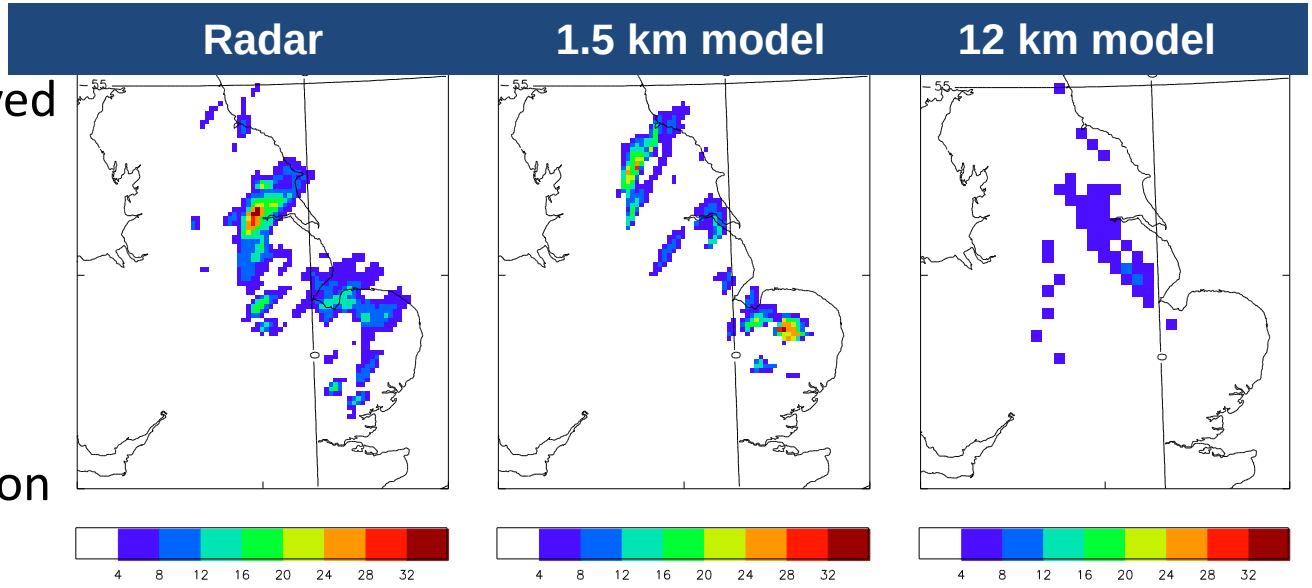
NATURAL ENVIRONMENT RESEARCH COUNCIL

New high resolution climate modelling

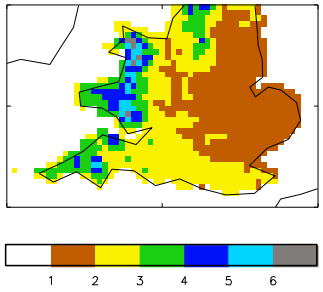
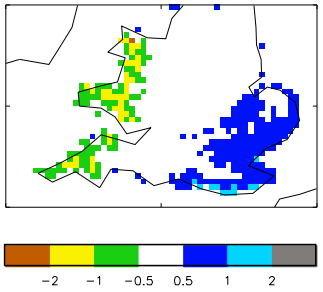
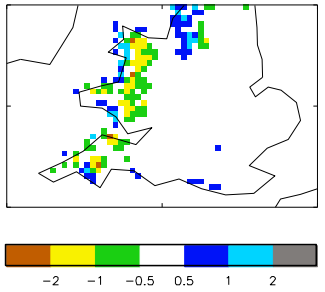
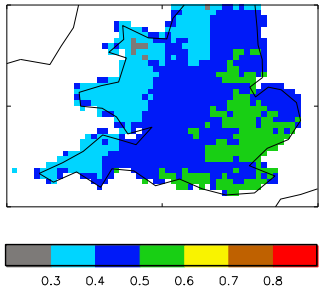
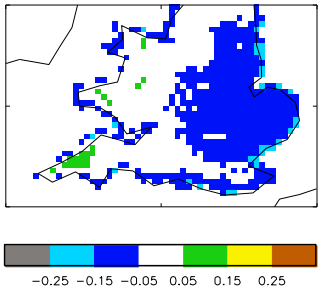
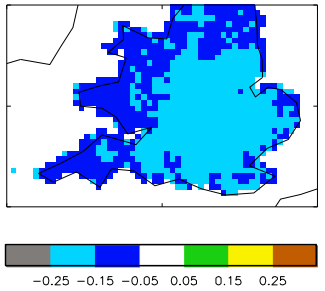
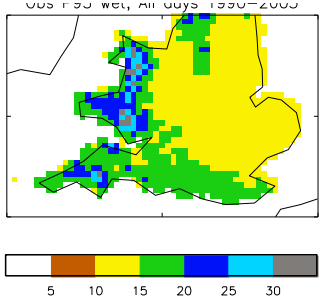
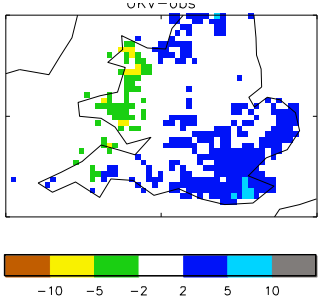
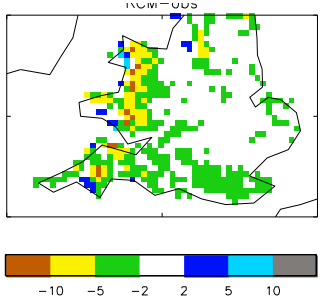


- An ERA-interim driven 1.5km model (1989-2008) better represents *some* characteristics of extreme rainfall events than coarser resolution models.
- The 1.5 km model more realistically represents whether it rains or not.

- Heavy rain is shorter-lived and more localised, in better agreement with radar than for coarser models. (4h rainfall accumulations (mm) across a larger domain on 3 August 2011)



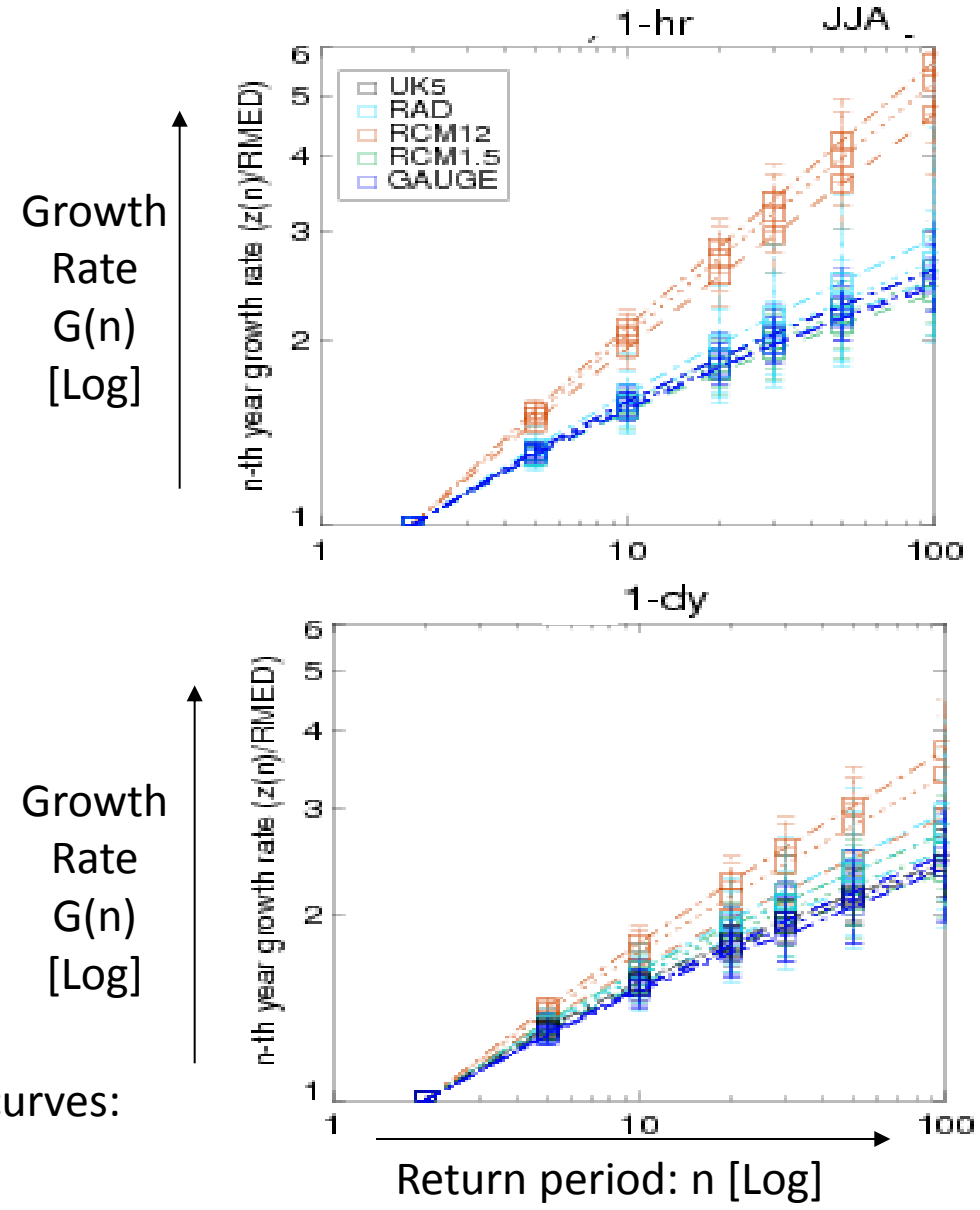
Simulation of daily precipitation

	Obs	Bias	Bias
	Rain gauge	1.5km-gauge	12km-gauge
Mean precipitation			
	Rain gauge	1.5km-gauge	12km-gauge
Dry day occurrence			
	Rain gauge	1.5km-gauge	12km-gauge
Heavy precipitation			

Comparing model resolution

- A way to include gauge data for comparisons

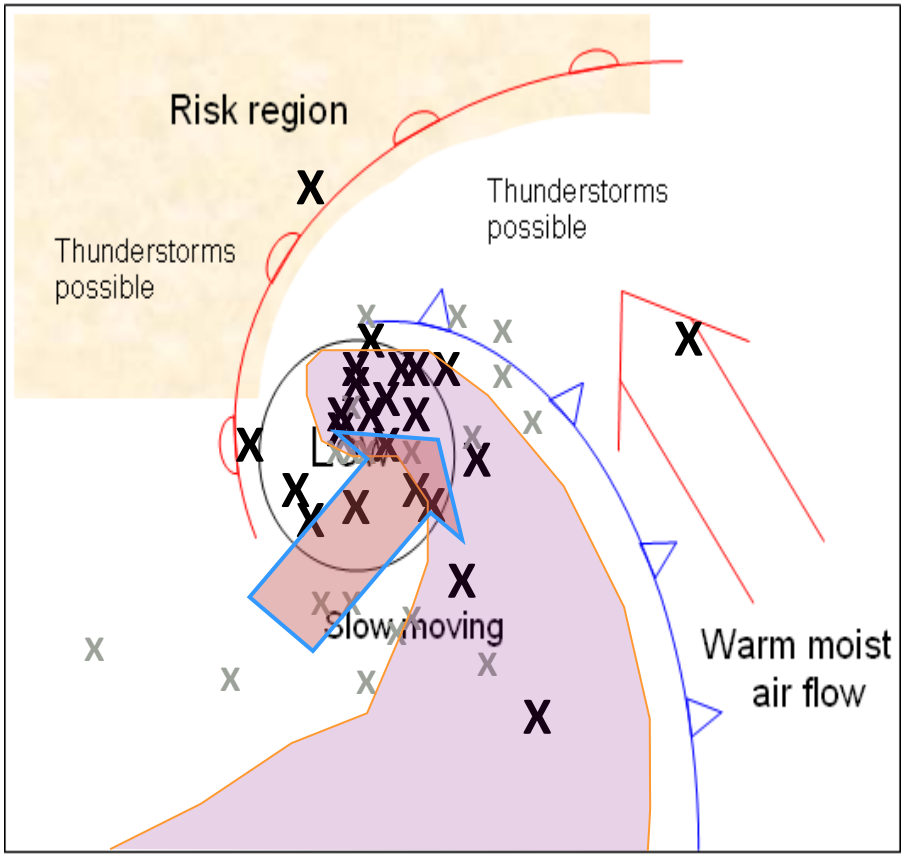
$$G(n) = \frac{z(n)}{z(2)}$$

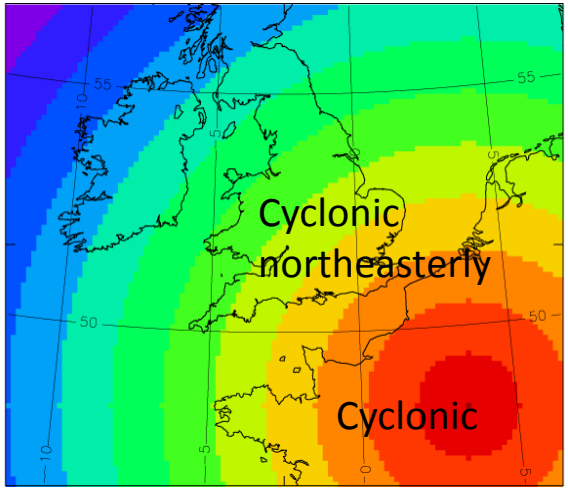


Summer (JJA) growth curves:

Where does flood-producing rainfall occur? - Will Hand

- Must relate storms to larger scale influences
- Low centres seem crucial





Courtesy: Nigel Roberts

- Fractions Skill Score can be used to determine the spatial differences between idealised and simulated pressure fields.

Coming up in CONVEX…

- 1.5km model climate change experiment recently completed.
- Developing a methodology to relate flood-producing rainfall to larger scale flows.
- Providing recommendations in use of climate models at different resolutions.

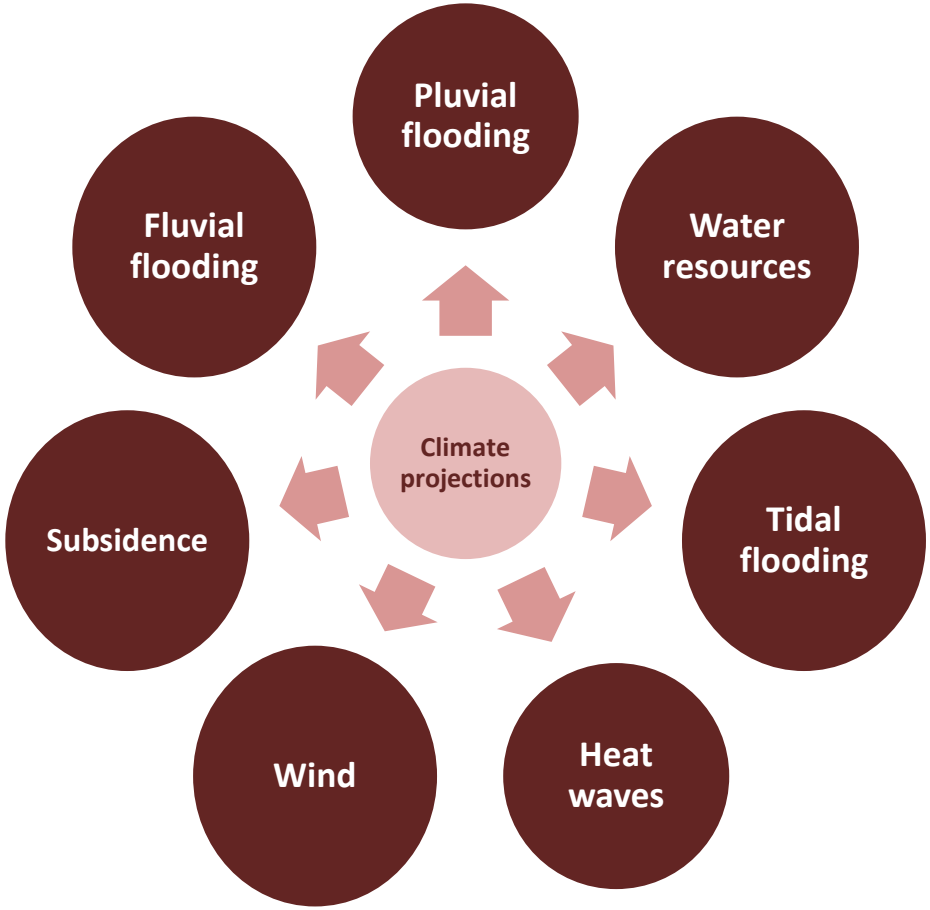
Uncertainty in climate projections

- Natural climate variability
  - Superimposed on long-term changes due to man's activity
  - Greater at smaller scales and for extremes
  - More significant for precipitation than temperature

- Imperfect representation of processes in climate models
  - Sampled by different model variants to some extent
  - Deficiencies/missing processes common to all current models cannot be sampled

- Uncertainty in future emissions

Downscaling climate projections with the UKCP09 weather generator (The CREW Project)



- Aim to assess current and future hazards by looking at the **baseline (1961-90)** and the **2020s** and **2050s**.

- Only considered the medium emissions scenario.

EPSRC Engineering and Physical Sciences Research Council
University of Exeter
University of Birmingham
Cranfield University
University of Wolverhampton
Newcastle University

The UK Climate Projections (UKCP09) & weather generator

- UKCP09 provides projections of changes at 25km scale (HadSM3, downscaled using the regional climate model HadRM3).
- Uses a probabilistic method (primarily a multi-model ensemble) at 25km RCM resolution – this provides pdfs but no time series.
- A weather generator provides the time series users want at the spatial scales (5km) users want.

The UKCP09 Weather Generator

Observed rainfall data
(+ RCM change factors)

NSRP
RAINFALL MODEL

Multiple Simulated
Rainfall Series

Inter-variable
relationships
(**IVRs**)

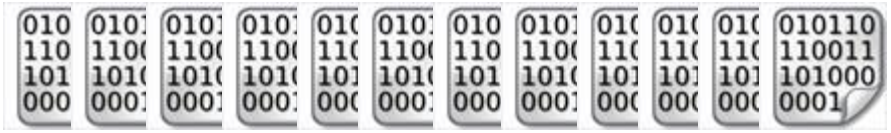
(1) Primary variable:
Precipitation (mm)

(2) Secondary variables:
Mean temperature (°C)
Daily temperature range (°C)
Vapour pressure (hPa)
Wind speed (ms^{-1})
Sunshine duration (hours)

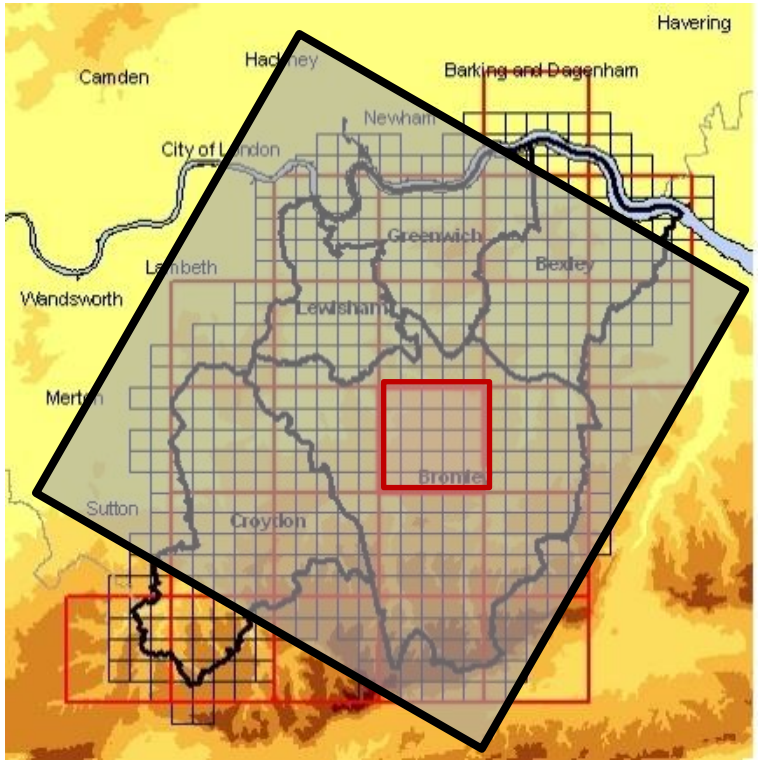
Observed daily weather data
(+ RCM temperature change
factors)

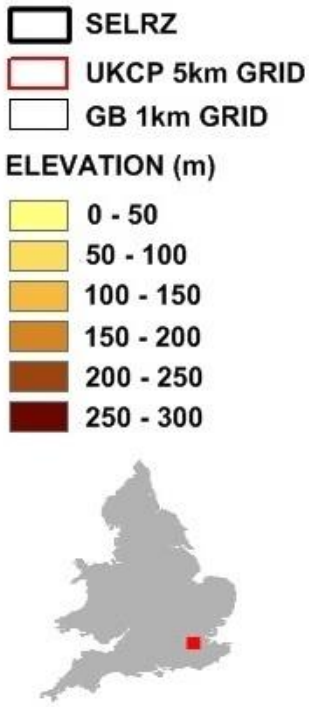
Climatic Research Unit
WEATHER GENERATOR

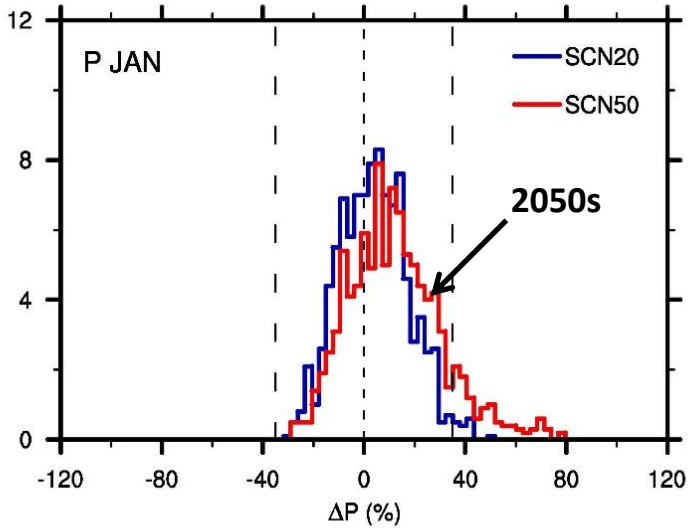
Multiple series of simulated weather variables + PET + direct and diffuse radiation

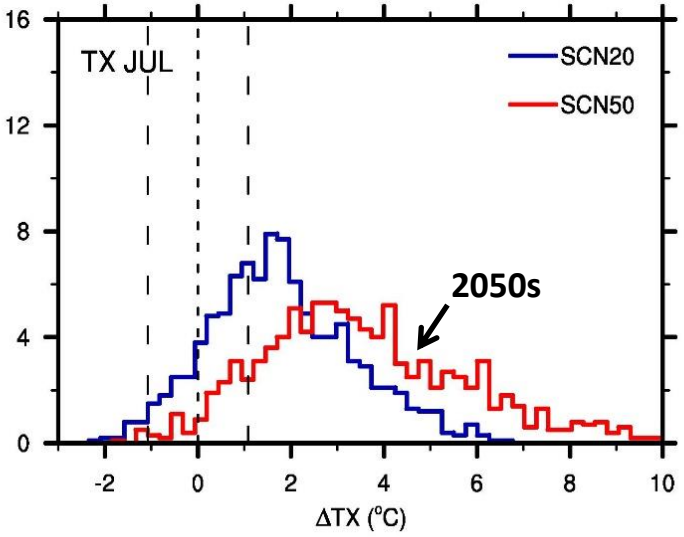


Applying theUKCP09 Weather Generator: The South East London Resilience Zone (SELRZ)

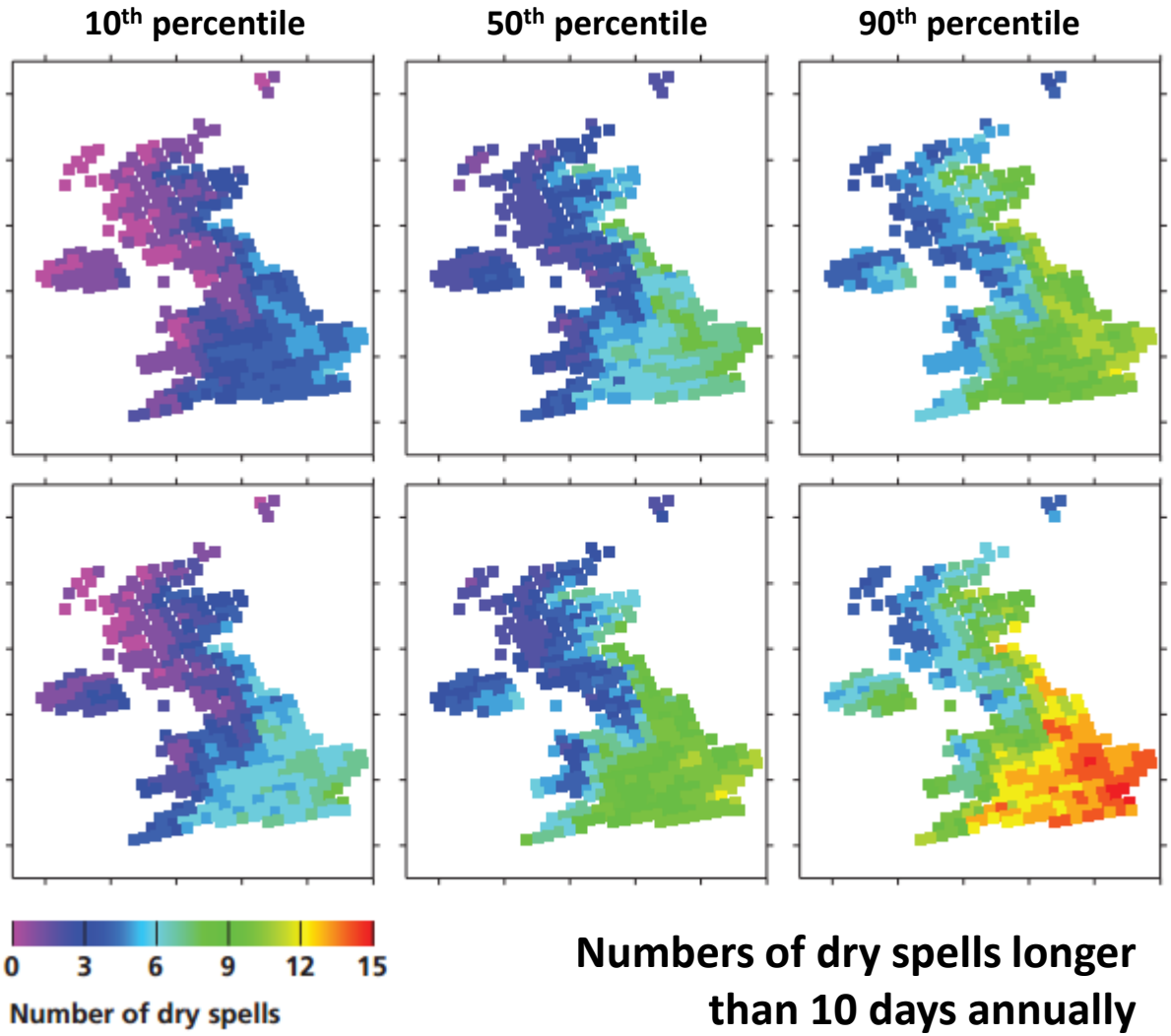








Applying theUKCP09 Weather Generator: A national example



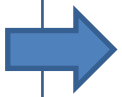
Numbers of dry spells longer than 10 days annually

Using the UKCP09 WG Projections: Water Resources

Rainfall series using a spatial version of the weather generator (rainfall WG only)

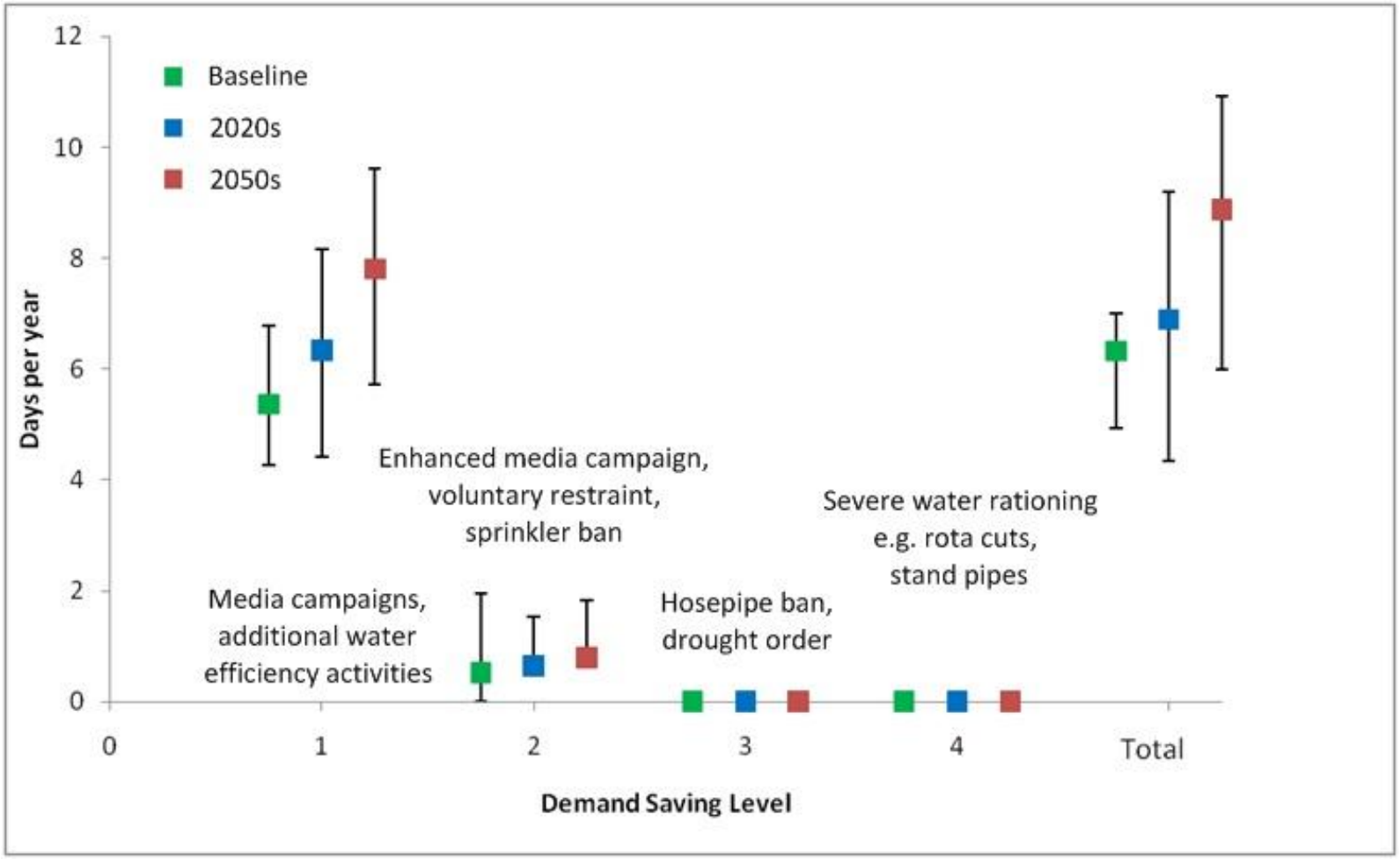
Associated **river flows** (CATCHMOD)

UK Environment Agency's **London Water Resource Zone model** (AQUATOR).

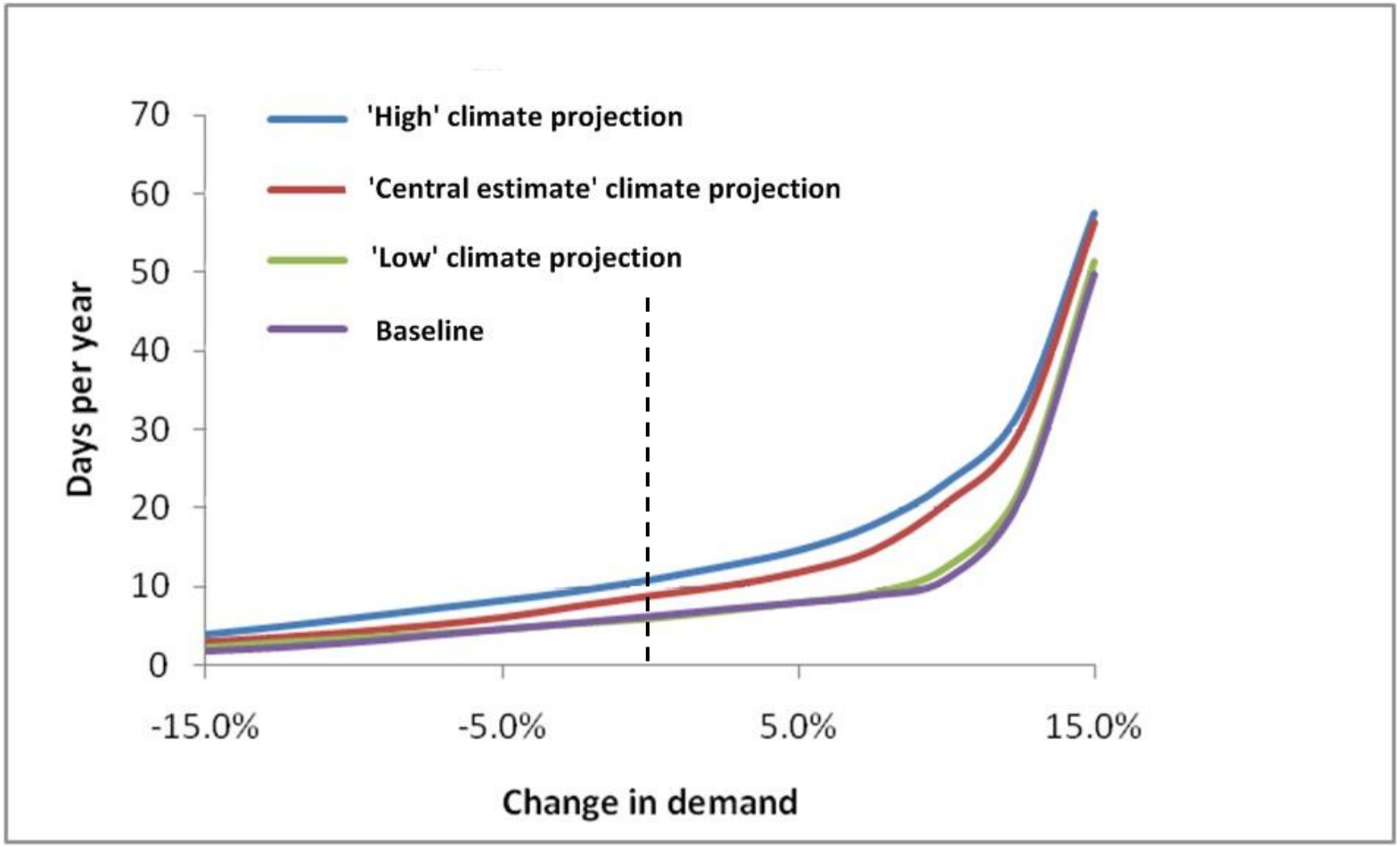


Level of service	Action
1 (1 in 5 y)	Media campaigns, additional water efficiency activities
2 (1 in 10y)	Enhanced media campaign, customer choice/voluntary constraint, sprinkler ban
3 (1 in 20y)	Hosepipe ban, non-essential use ban, drought order
4 (never)	Severe water rationing e.g. rota cuts, stand pipes

Future demand saving day levels (climate change only)



Total demand saving days: 2050s (climate change & demand)



Using the UKCP09 WG Projections: Subsidence Hazard

Underground Foundation Stability' (UFS) model:
combines soil characteristics (1km) and PSMD

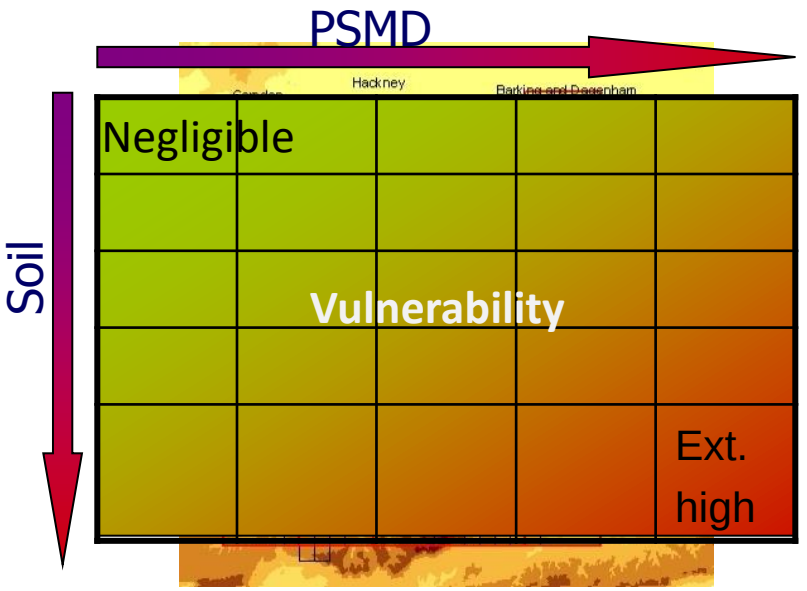
ability of the soil to shrink and swell

*the likely, or potential, soil moisture deficit (**PSMD**) building up during the year that can lead to the realisation of the potential a soil has to shrink and swell*

PSMD = Σ(Rainfall – Potential Evaporation)

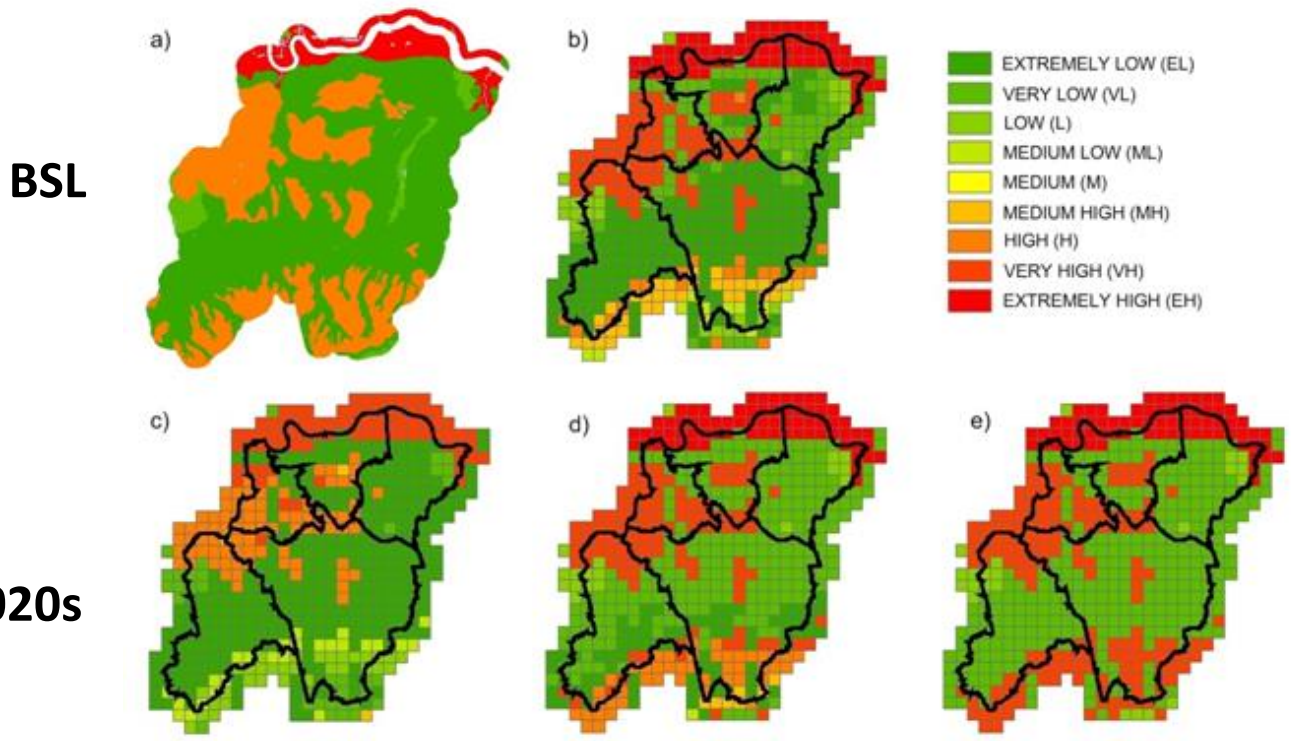
- Define subsidence classes based on PSMD, soil shrink swell and depth of effect

- Gives 9 classes of combined vulnerability



Projections of subsidence hazard

9 classes of vulnerability



VERY UNLIKELY TO BE LESS THAN

10th percentile

50th percentile

CENTRAL ESTIMATE

90th percentile

VERY UNLIKELY TO BE MORE THAN

Conclusions

- There is still a need to understand current extremes of weather and associated vulnerabilities

- Higher resolution climate models do not provide all the answers – new questions

- Understanding and reproducing processes is important

- Demand for “climate services” means the projections must be used appropriately – how should guidance be given?

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Finding out more:

- The **CONVEX** project website:
  http://research.ncl.ac.uk/convex/

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Follow us on twitter: #CONVEX_PROJECT
Newsletters – twice annually

- The **CREW** project website:
  http://www.extreme-weather-impacts.net/twiki/bin/view

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