Uncertainties in regional climate change

Erasmo Buonomo

Hadley Centre for Climate Change
Met Office, Exeter EX1 3PB, UK
E-mail: Erasmo.Buonomo@metoffice.gov.uk

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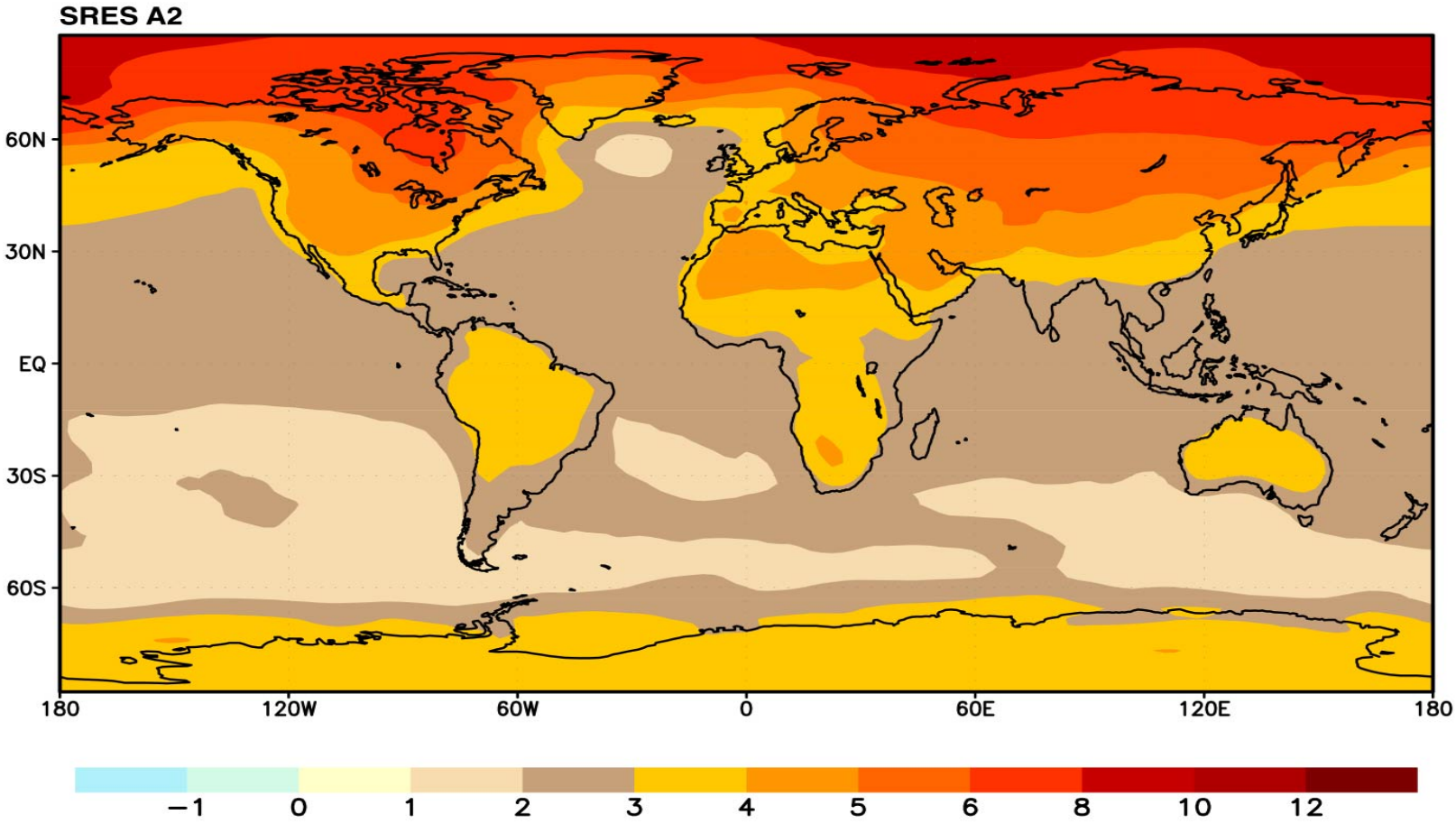
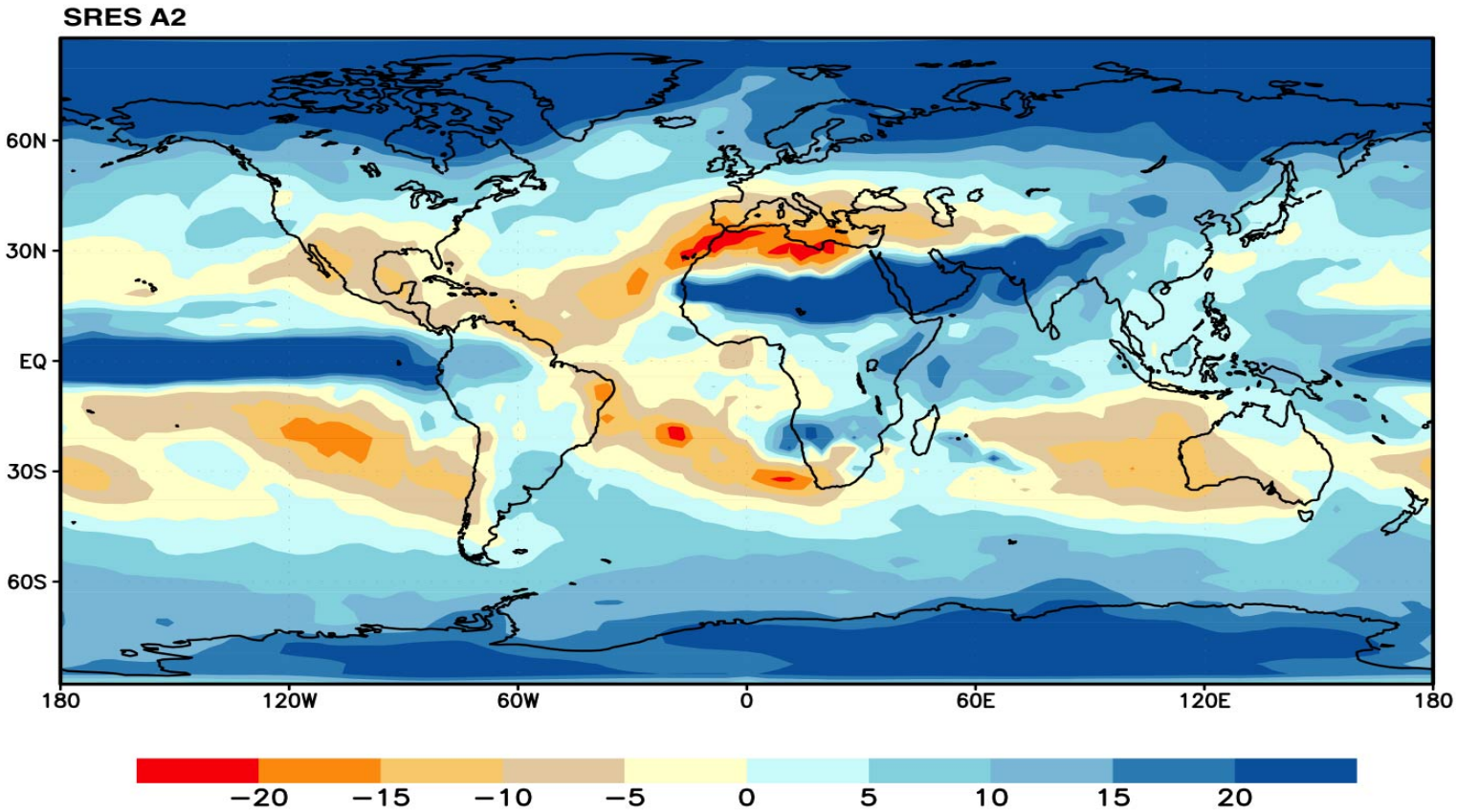
Projecting future climate change given future concentrations - temperature

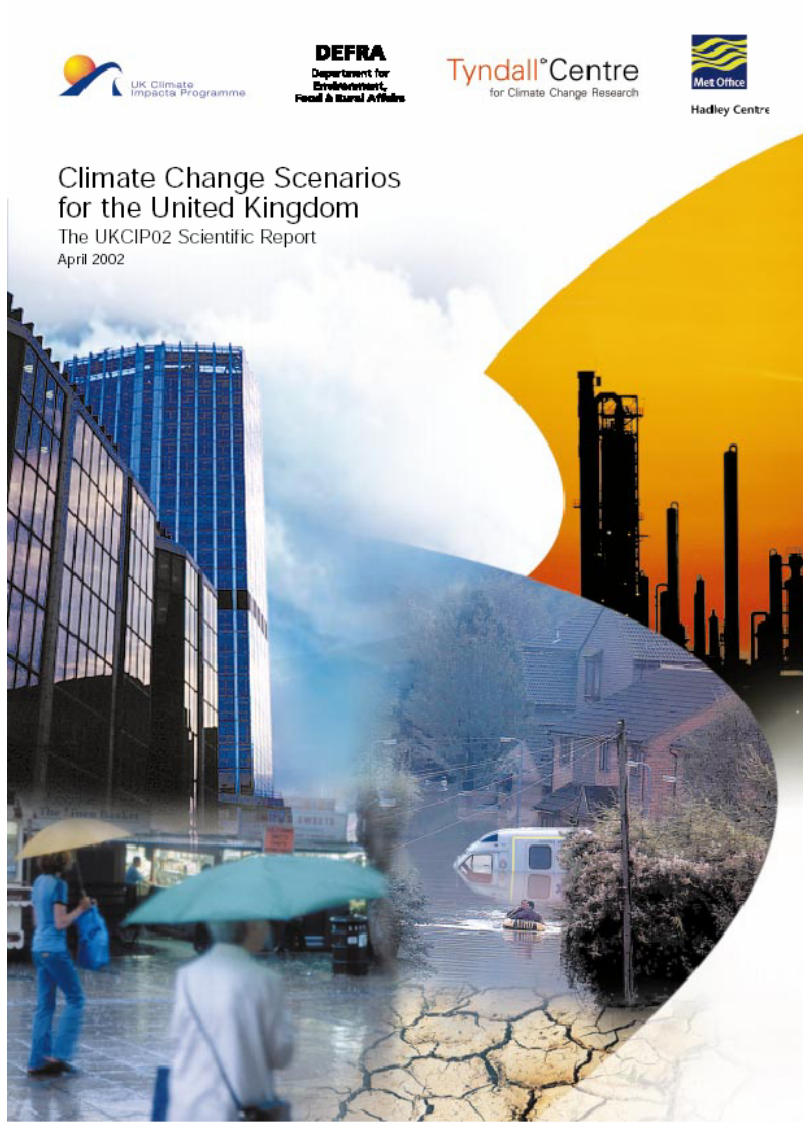


Projecting future climate change given future concentrations - precipitation



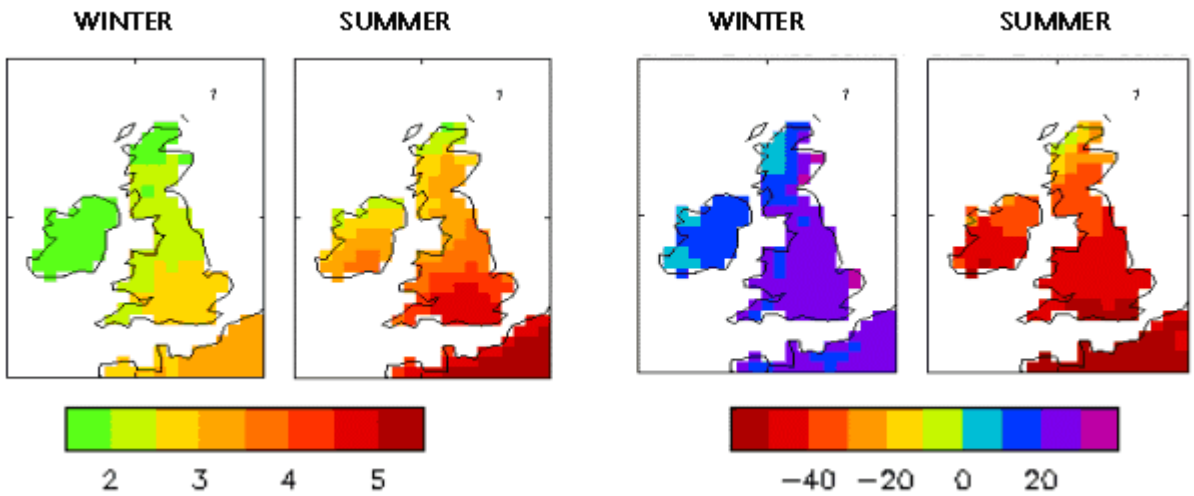
UKCIP '02

- Based on the state-of-the-art at the time - HadCM3, HadAM3H time-slice, 50km HadRM3 experiments
- Used by many private and public-sector organisations to make decisions and spend money
- "Scenario" based with no quantification of uncertainties (although plenty of caveats pointing this out)



UKCIP ‘02

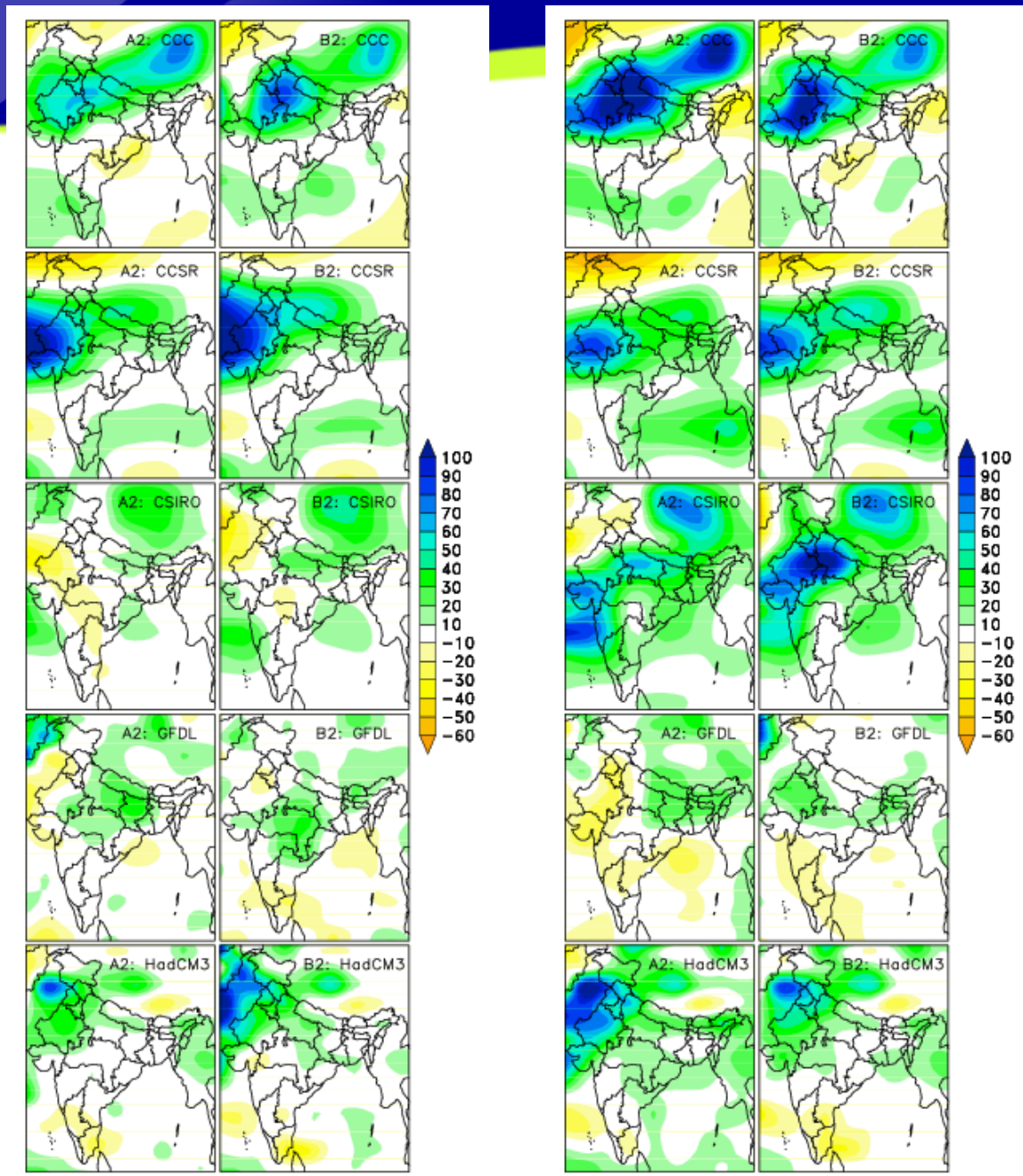
2080 temperature change (K)



2080 precipitation change (%)

We can produce very detailed projections of climate change with no idea of how reliable they might be

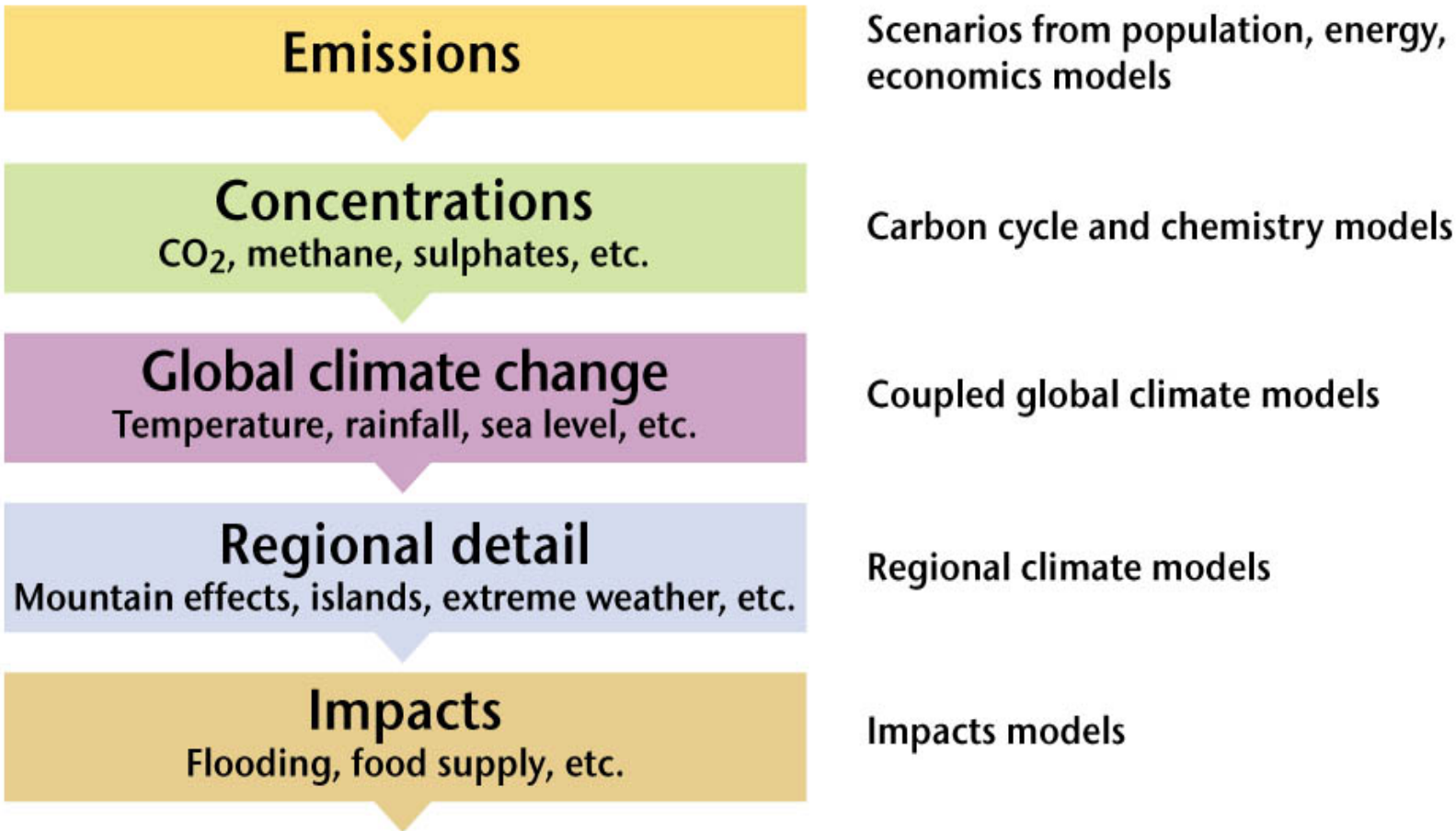
AOGCM
Projected change in summer monsoon rainfall, relative to 1961-90
IPCC TAR



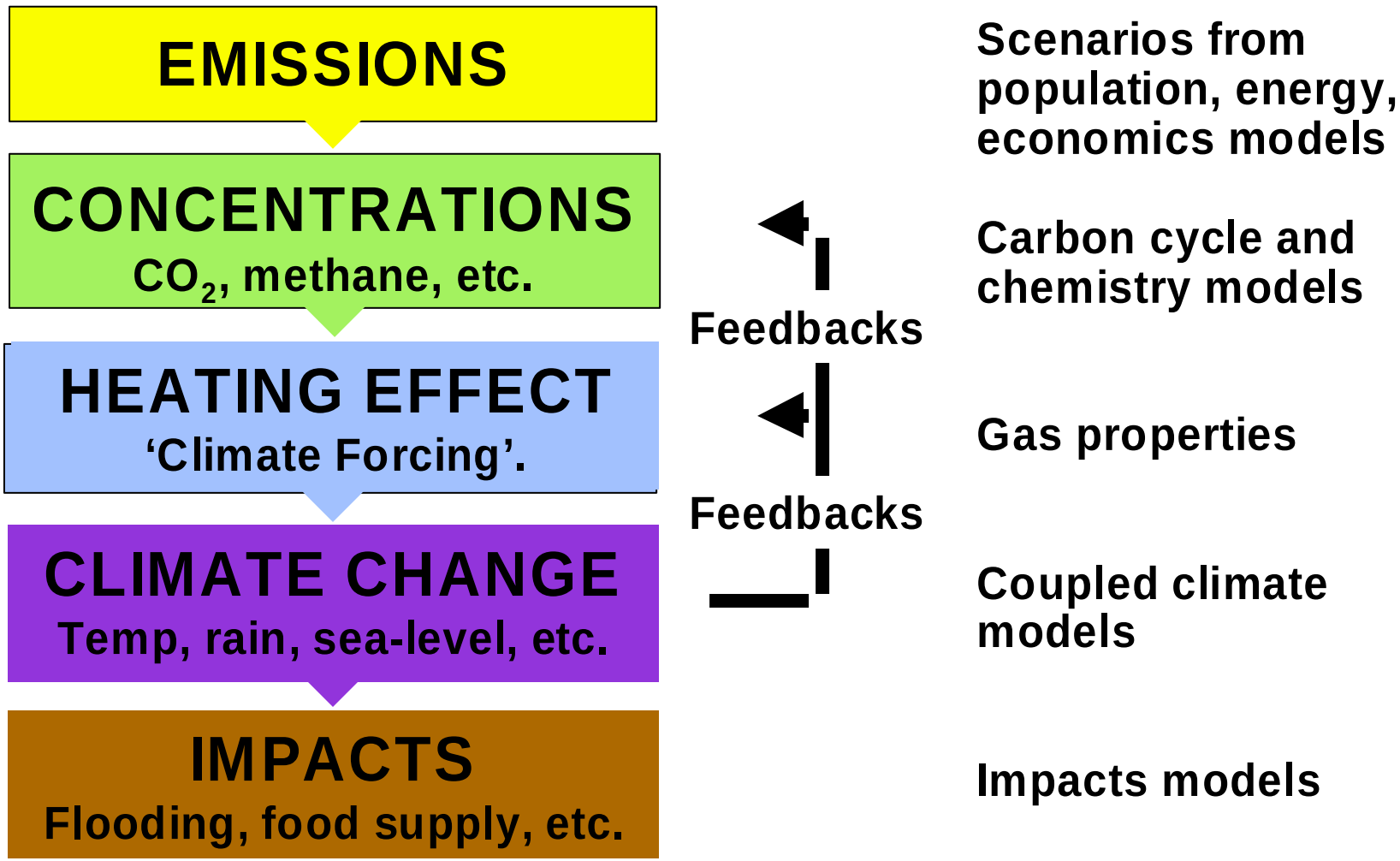
UKCIPnext – Aims and Objectives

- To provide joint probability distribution functions (pdfs) of projected changes in a selection of key UK climate variables at 25km resolution for each decade during the 21st century
- Results will be presented for each variable by month and summarised as quantiles indicating both mean and extreme outcomes
- The set of climate variables will be determined in consultation with stakeholders
- We aim to deliver the final report and the pdfs during the first half of 2008

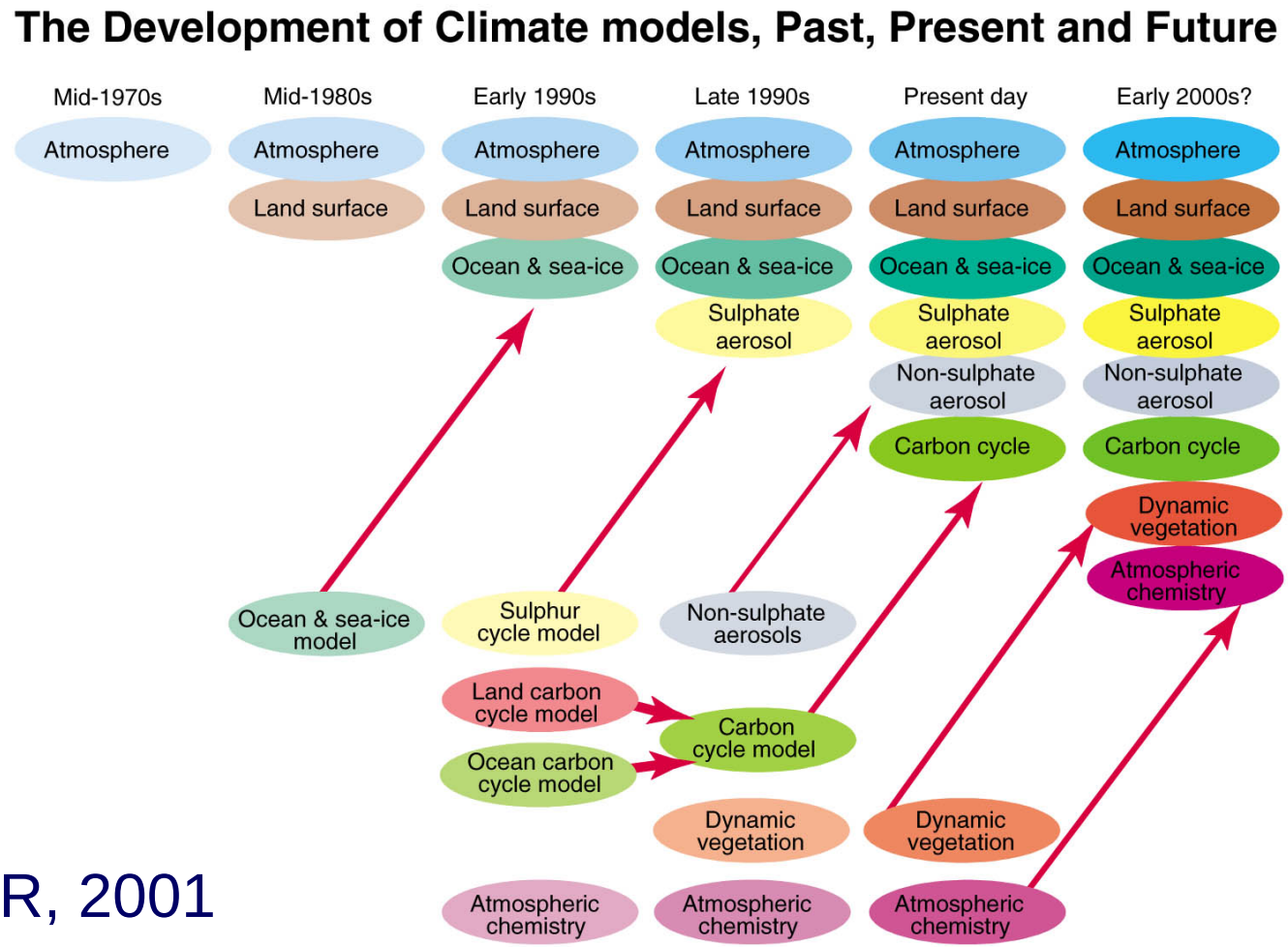
Modelling impacts



Modelling impacts



Development of climate models



From IPCC TAR, 2001

Assessment of model uncertainties

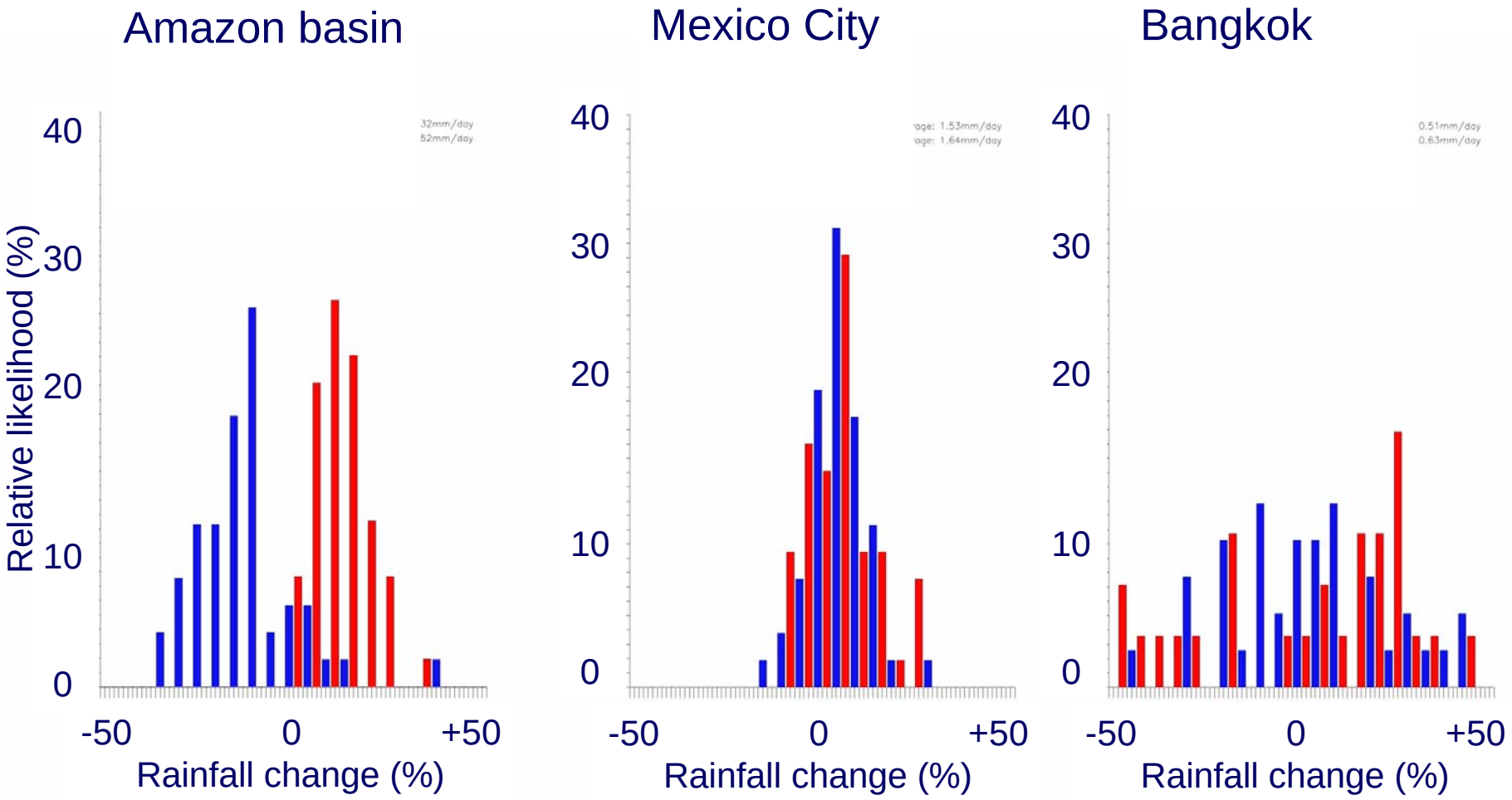
- Uncertainty in representing physical and biological processes in climate models

1. Uncertainties due to different representations of processes (structural)
2. Uncertainties in key parameters in models
3. Omitted processes

The HadCM3 perturbed physics ensemble

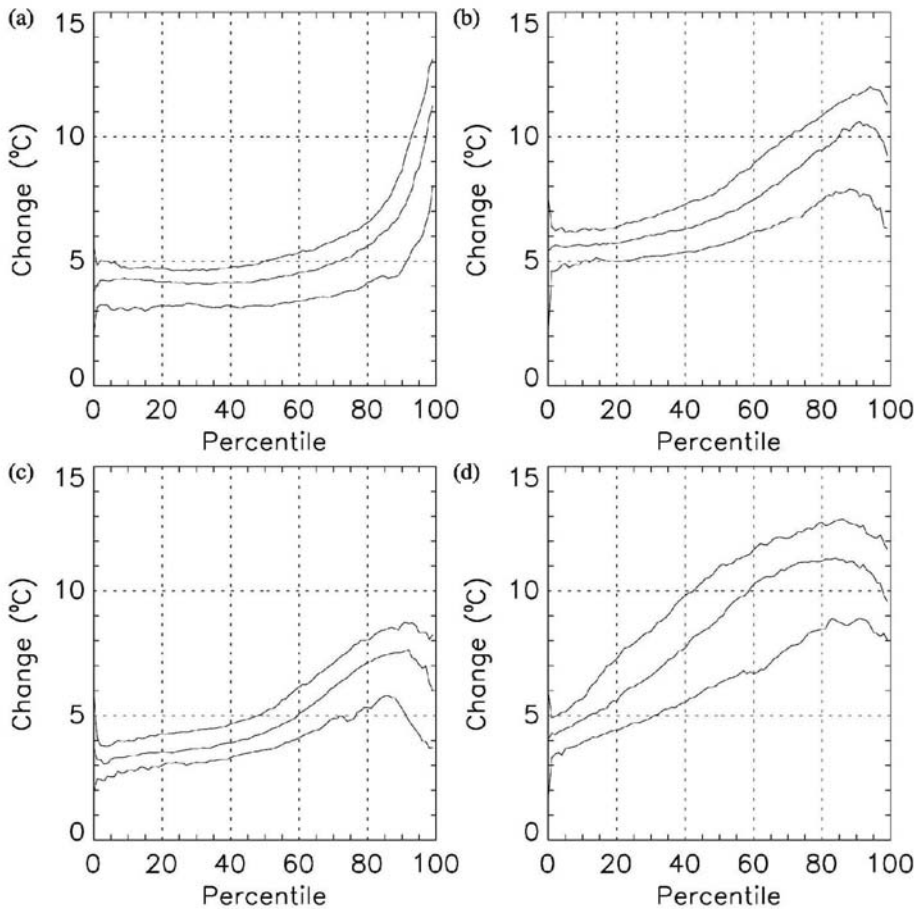
- Assessment of the uncertainty due to the parametrization
- Models built using different values of parameters whose ranges are ill-constrained
- 256 member ensemble with multiple parameter perturbations – atmosphere/slab ocean model, 2xCO_2
- Assessment of model quality and global mean climate response (i.e. climate sensitivity)
- Run a 17 member ensemble of coupled model transient experiments using “high quality” models with range of climate sensitivities – 1860-2100, A1B (flux-adjusted HadCM3)
- Additional perturbed model are *emulated* (Sexton and Rougier, in preparation)
- Transient response generated by pattern-scaling (Harris et al, 2005, EBM based)

The slab ensemble picture: frequencies of projected rainfall changes (DJF)



Blue – mean change: Red – top 95%ile change

Simple uncertainty estimates



Changes in percentiles for T(max) JJA for a) Czech republic, b) Great Lakes (USA), c) eastern China and d) Southern France.

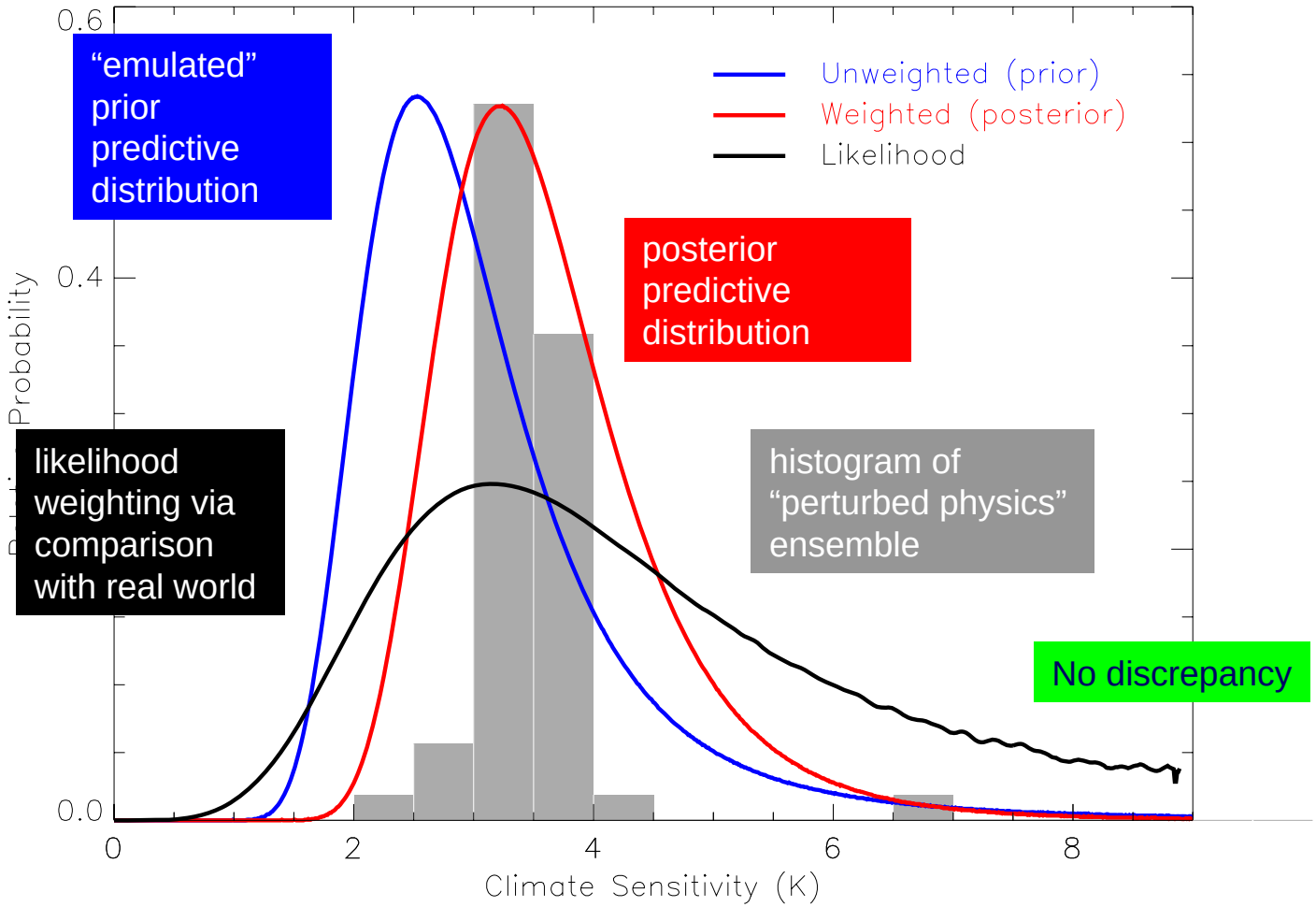
10-90% spread of the 53 members ensembles

from Clark et al, J. Clim, 2006

Use of obs constraints: Bayesian framework

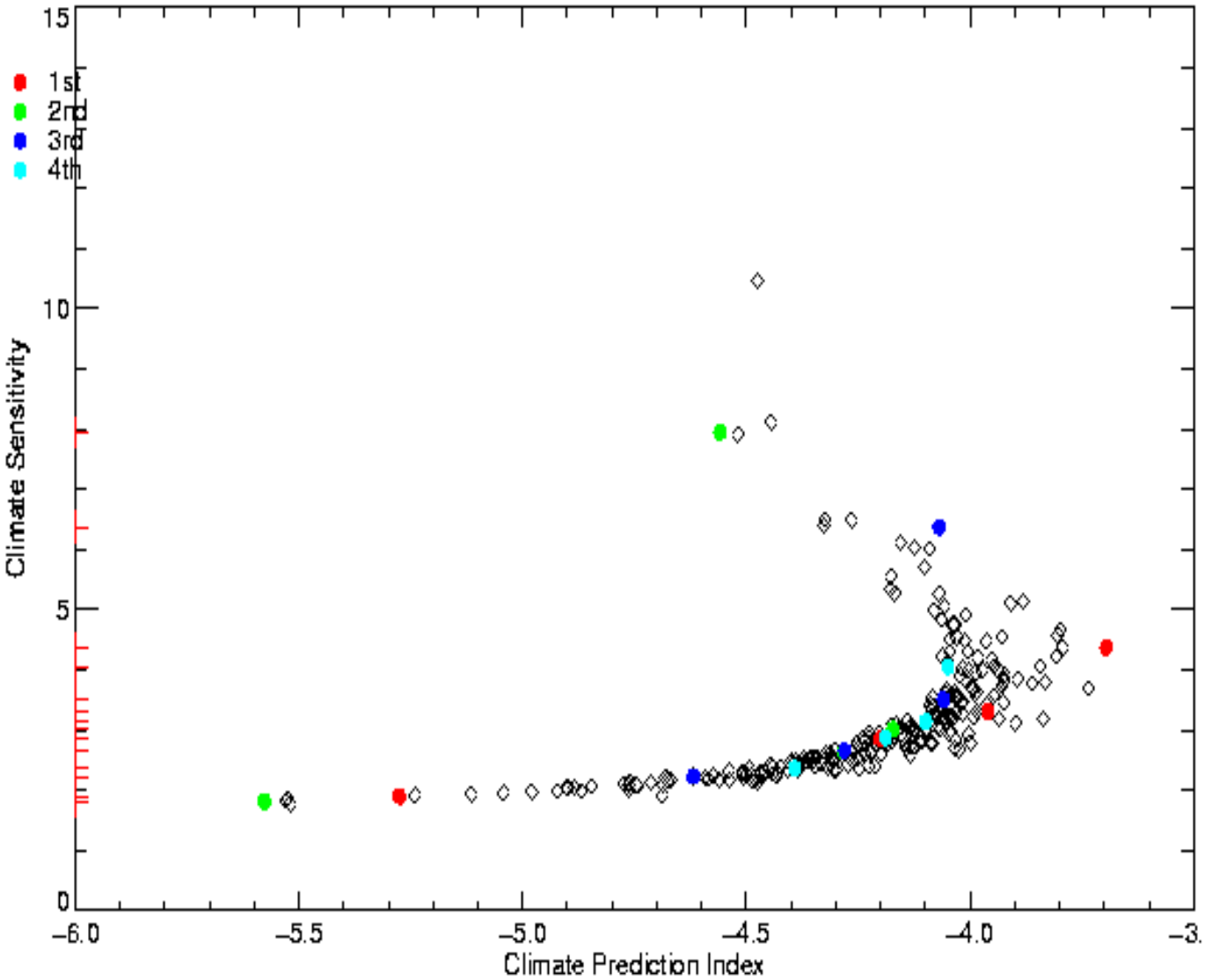
- Perform a limited ensemble of GCM experiments with perturbed input parameters
- Introduce an *emulator* which can estimate the GCM output at untried parameter values
- Introduce a *discrepancy* term derived from the output of other climate models to represent structural uncertainties
- Produce *prior* predictive distributions of climate variables
- Use observations to produce a *likelihood* function and *posterior* predictive distributions

The first example



Murphy et al., 2004, Nature, 430, 768-772

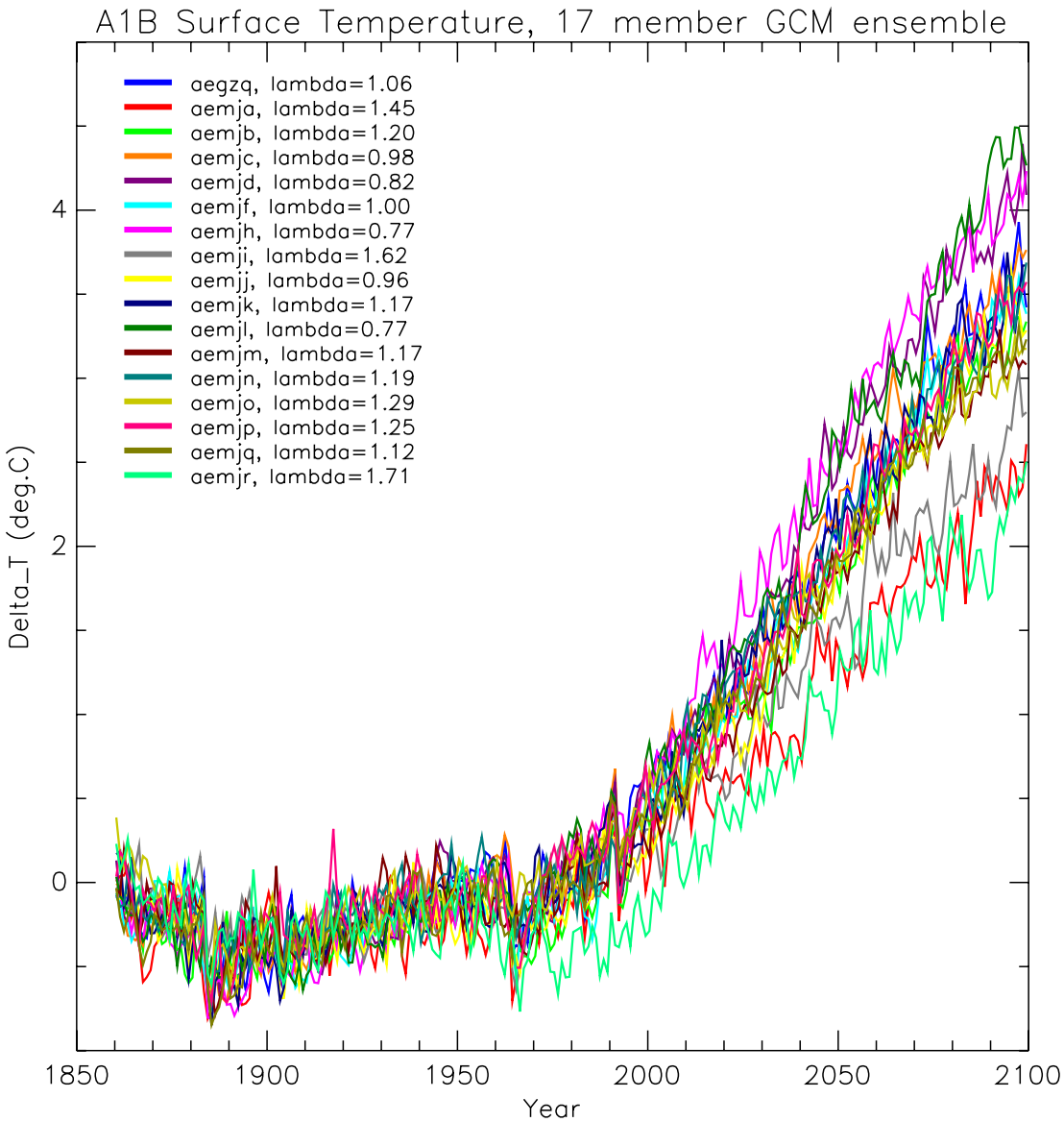
Climate prediction index (CPI) to select AOGCMs



The choice of the models:

- a reasonable spread in climate sensitivity
- a reasonably good CPI
- a spread in model parameter space

Global mean temperature response from HadCM3 ensemble



Multi-model (MM) and parameter perturbation (PP) ensemble ranges

Results for 17 member HadCM3 PP ensemble and 21 member IPCC AR4 MM ensemble

Precipitation and temperature change for Central America (CAM)

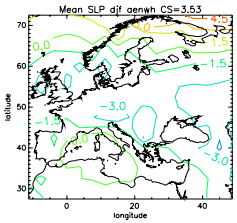
DFJ precipitation change in mm/day						
	5%	5%	Average	Average	95%	95%
	MME	PPE	MME	PPE	MME	PPE
CAM	-0.76	-0.54	-0.27	-0.15	0.23	0.26
JJA precipitation change in mm/day						
	5%	5%	Average	Average	95%	95%
	MME	PPE	MME	PPE	MME	PPE
CAM	-0.99	-1.59	-0.44	-0.59	0.11	0.37
Annual temperature change deg C						
	5%	5%	Average	Average	95%	95%
	MME	PPE	MME	PPE	MME	PPE
CAM	1.8	2.46	3.2	3.58	4.6	5.02

Application of HadCM3 ensemble to climate scenario generation

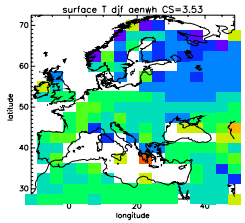
- For UKCIP08: run 17-member HadRM3 ensemble at 25km driven by HadCM3 ensemble and pattern-scale results for the 256 slab ensemble
- For ENSEMBLES (EU project for Europe): run HadRM3 and other RCMs driven by HadCM3.0 and high and low sensitivity members of the full ensemble (i.e. 3 experiments) – ensemble augmented with other GCMs and RCMs
- Application from other groups

ENSEMBLES-EU perturbed physics GCMs

MSLP bias DJF (hPa)



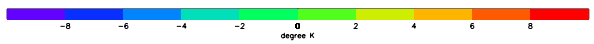
T bias DJF (K)



“unperturbed” HadCM3

high sensitivity

low sensitivity



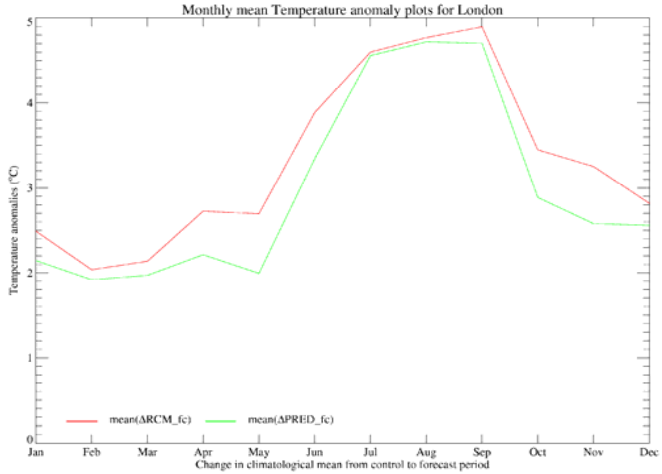
QUMP predictions at RCM scale

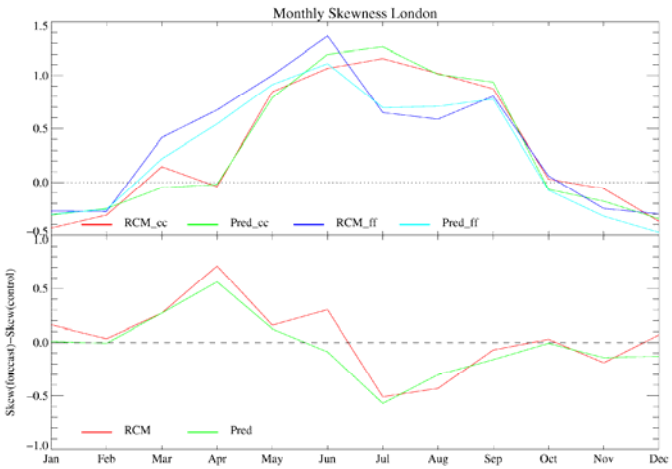
- 17 RCM 150-years transient simulations at 25km horizontal resolution
- RCMs driven from QUMP GCMs (RCM parameters consistent with GCM)
- Variables from other GCMs will be obtained by statistical downscaling from GCM to RCM scale
- Transferability of methods

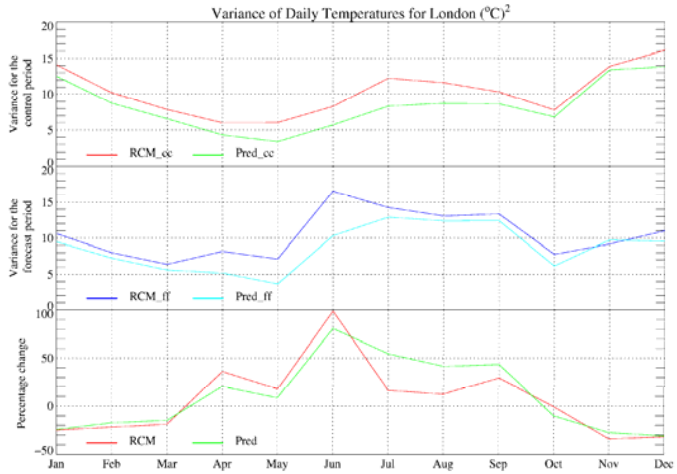
Statistical Downscaling GCM -> RCM

K. Brown (unpublished)

- SDSM (Wilby et al, 2002)
- Daily temperature distribution for UK
- HadAM3P/HadRM3P simulations (1960-1990 and 2070-2100 A2)
- 70% RCM variance explained by GCM temperature
- Preliminary results on precipitation not so good





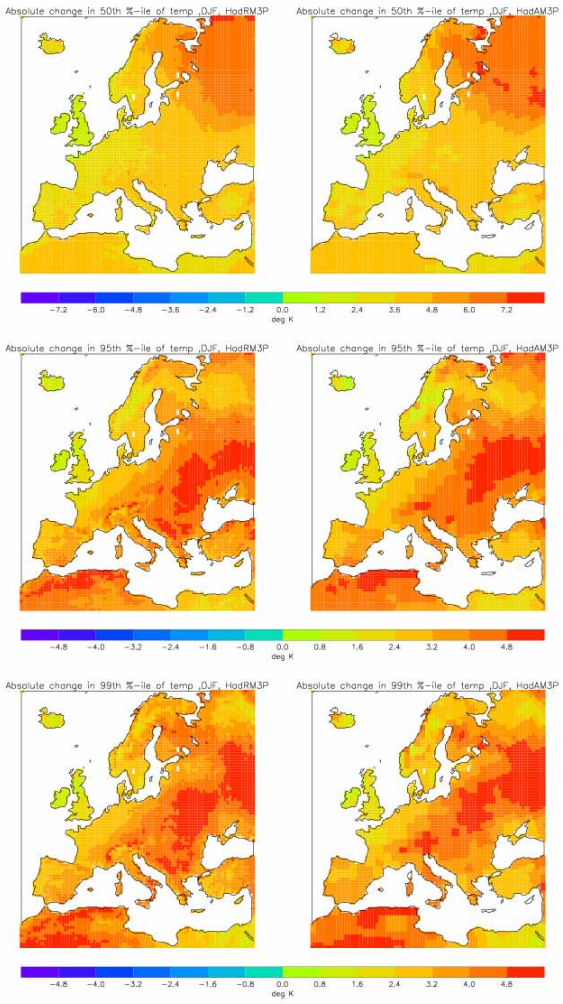


“Local scaling” approach

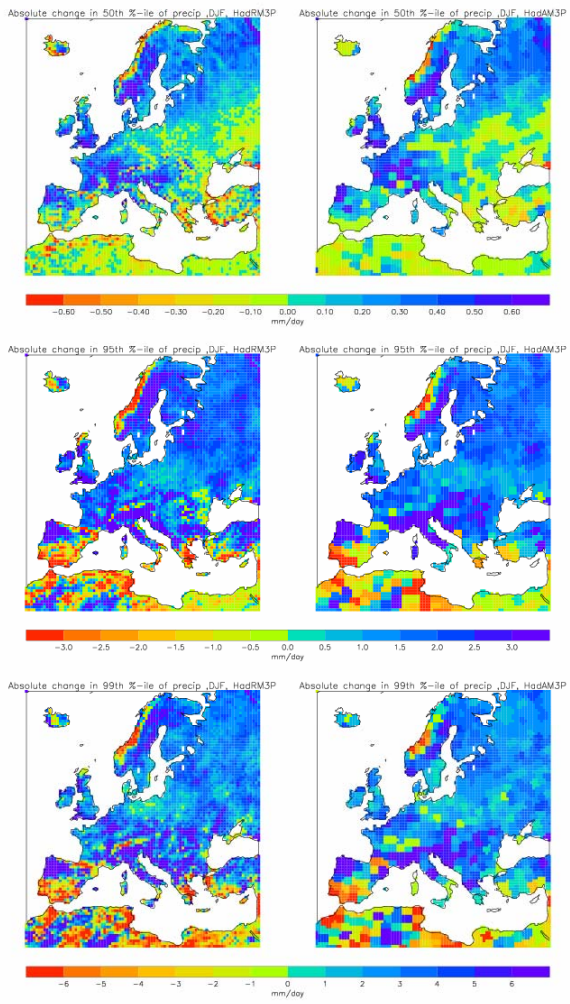
E. Kennett (unpublished)

Met Office

Temperature



Precipitation



50th percent

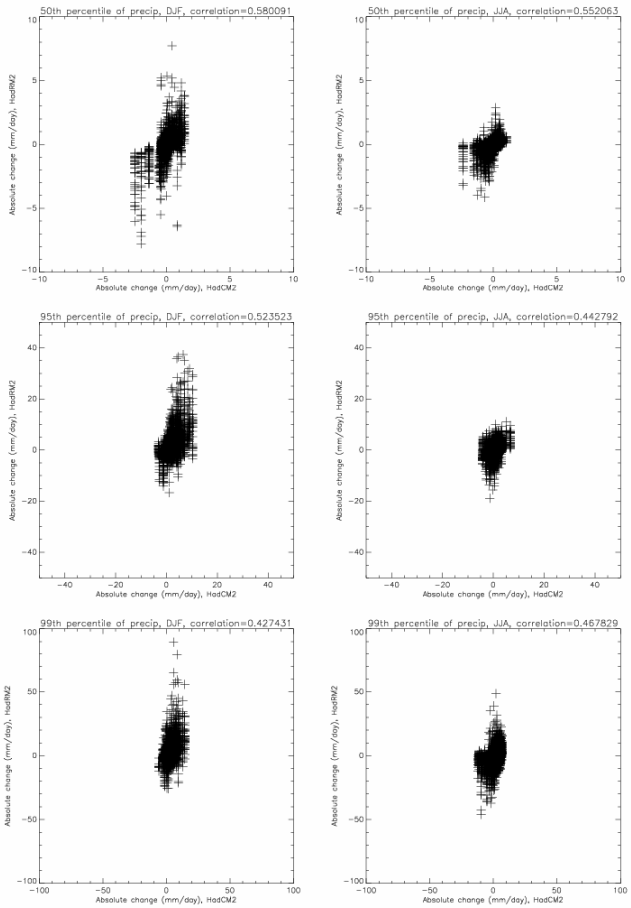
95th percent

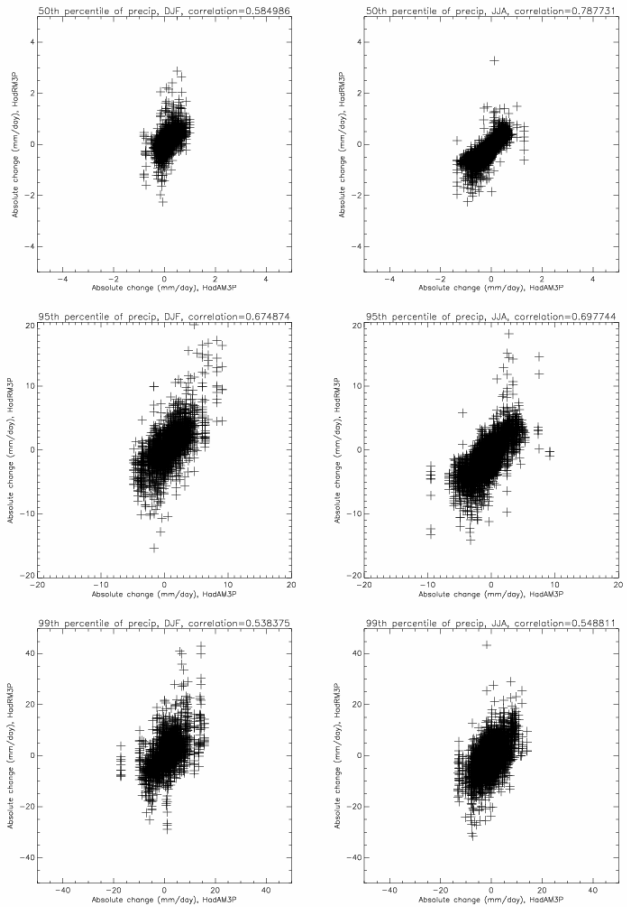
99th percent

“Local scaling” approach: effect of GCM resolution on precipitation - E. Kennett (unpublished)

HadCM2 (~300km)

HadAM3P (~150km)





50th percent.

95th percent.

99th percent.

Summary

- Methods to estimate uncertainty in climate projection are under development.
- Possible problems with the users, impact models not ready for pdfs of climate variables.
- Ensembles of climate simulations require models with low computational costs to maximise the number of perturbed models involved. Sophisticated sampling strategies are also needed.

Thanks!

Erasmo.Buonomo@metoffice.gov.uk