Applying statistical downscaling to environmental management and resource assessment

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Adaptation can involve difficult decisions...

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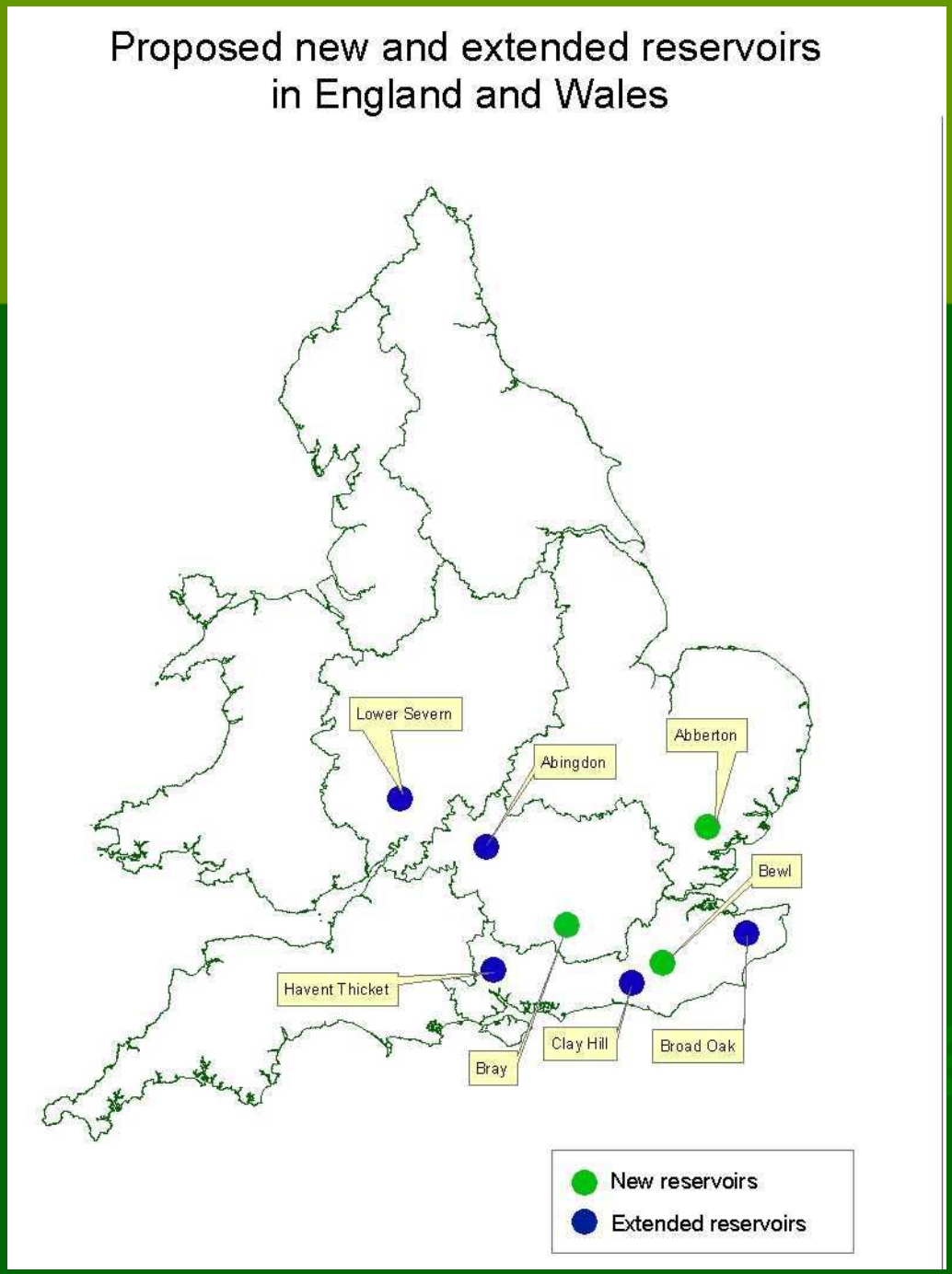

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...and costly investments in major assets

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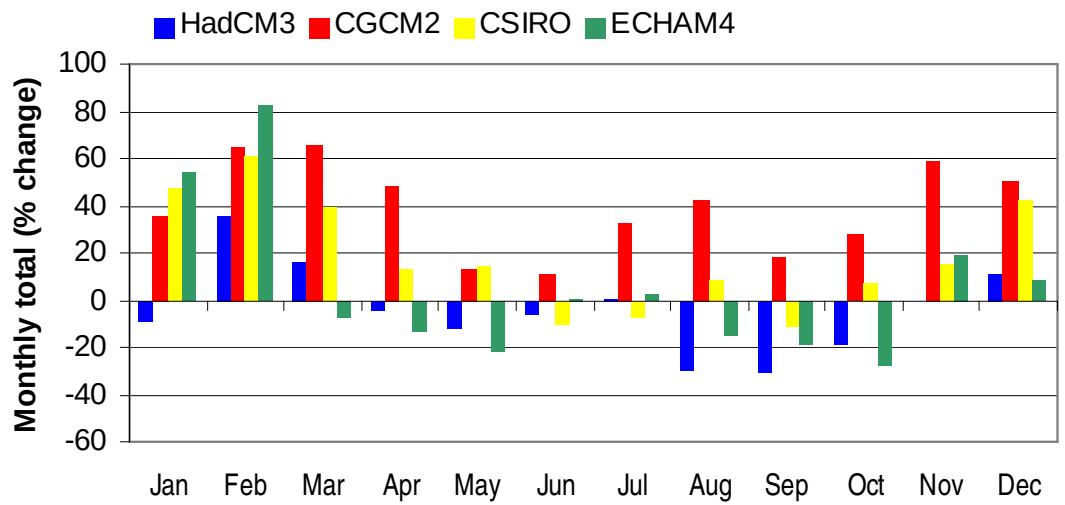

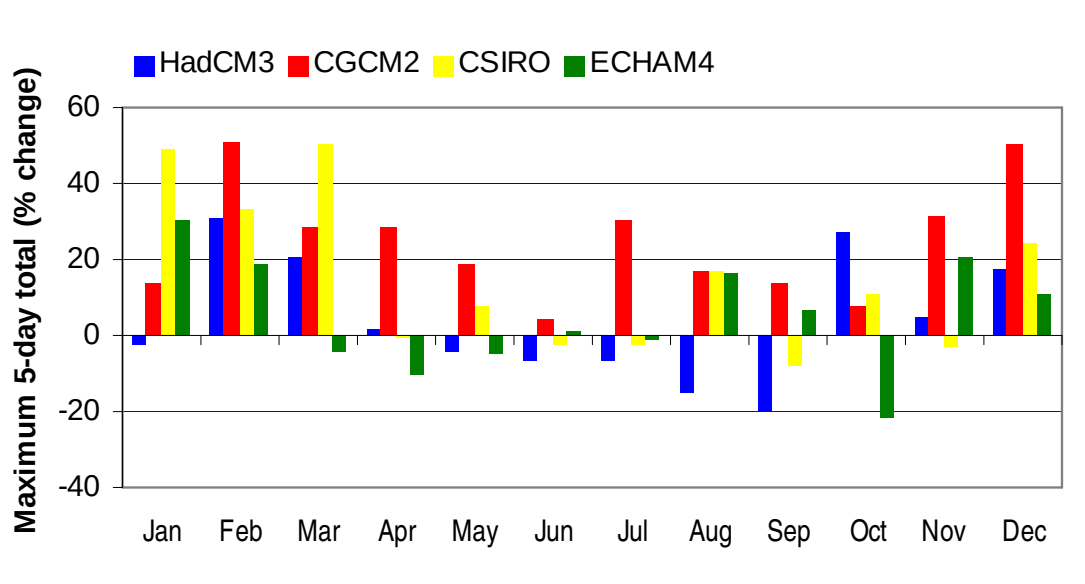

Climate model uncertainty and adaptation response...

Downscaled precipitation scenarios for the River Thames under A2 emissions in the 2050s

Talk outline

Derwent reservoir during the 1995 UK drought. Photo courtesy of Nick Jackoby

Key questions

- *Why are we downscaling?*
- *How should we apply downscaling within a probabilistic framework?*
- *What are the outstanding scientific challenges for the downscaling community?*

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Why are we downscaling?

Appraisal of adaptation options for the River Kennet

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Long-term nutrient enrichment of the River Thames, 1930-2000

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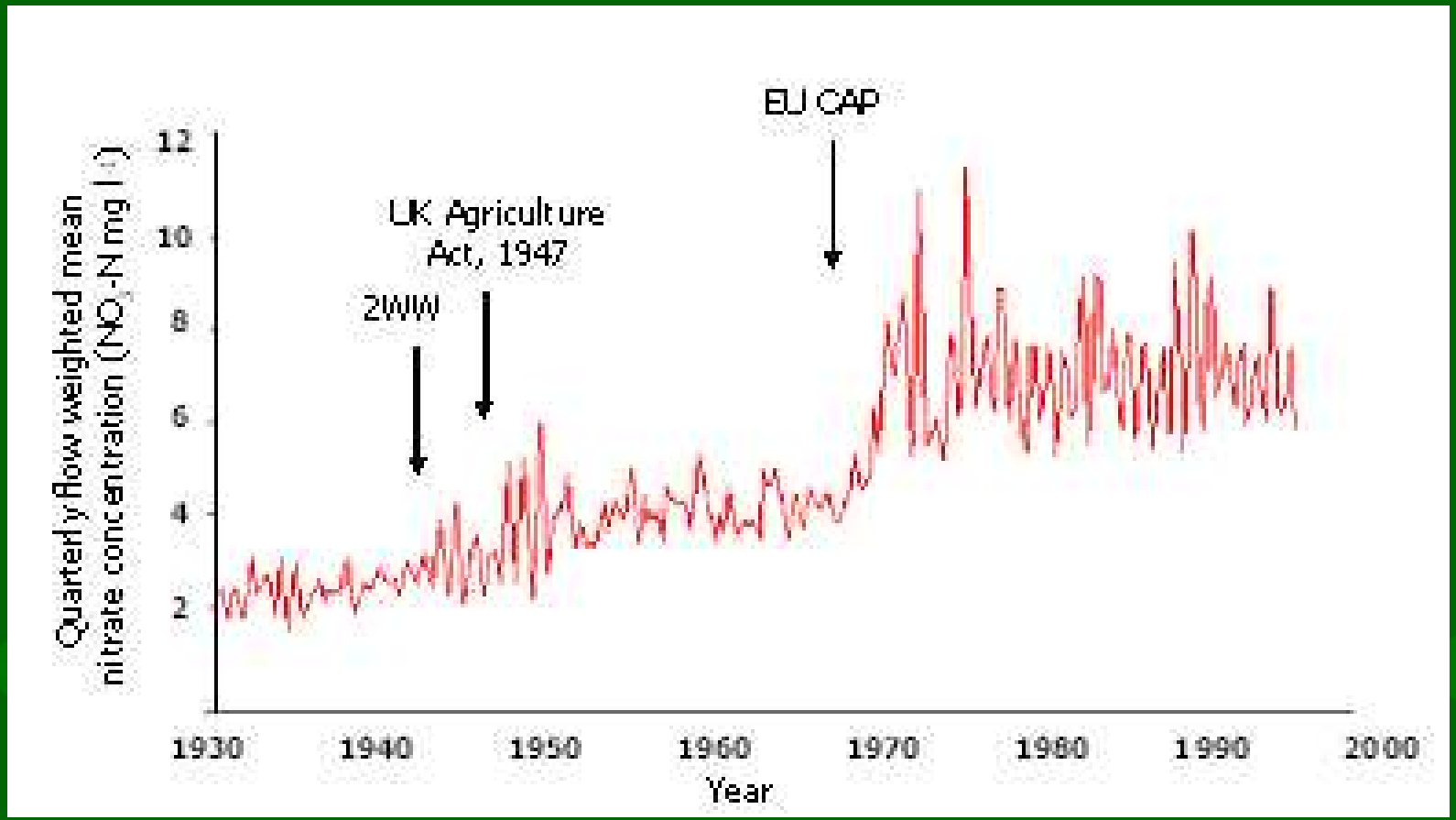


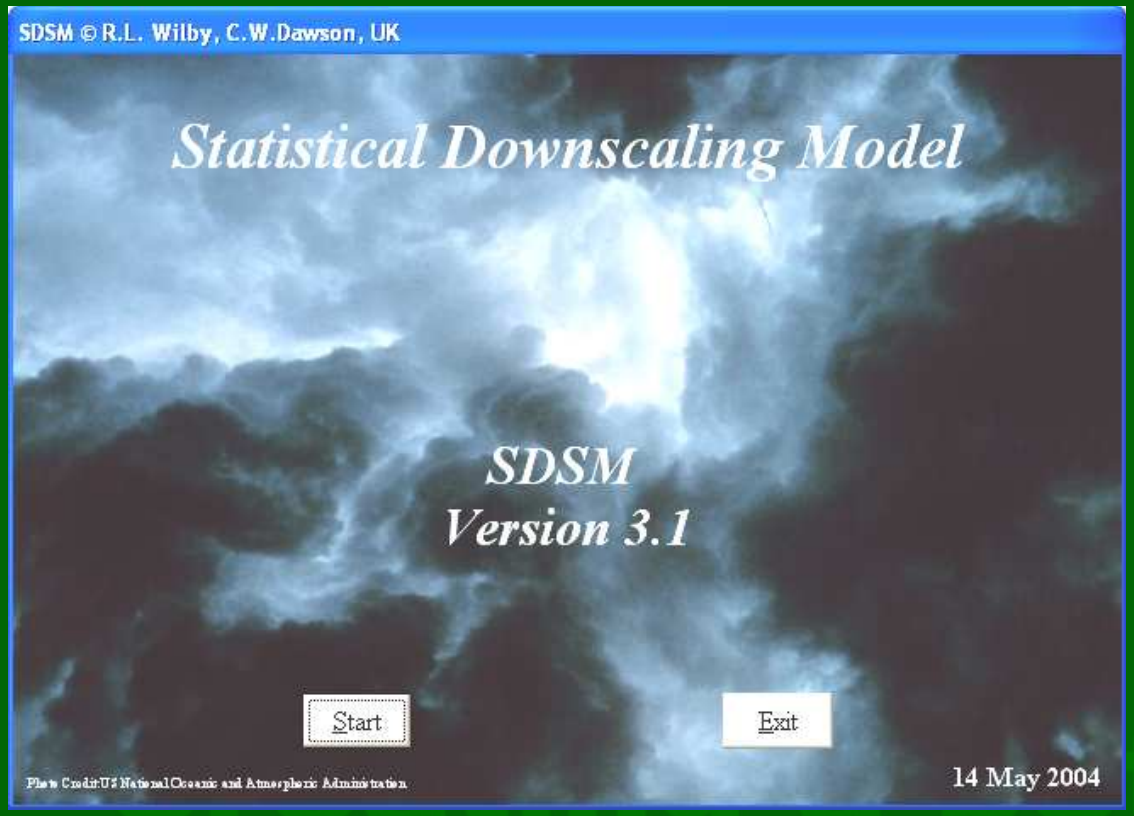
'Luxuriant' macrophyte growth

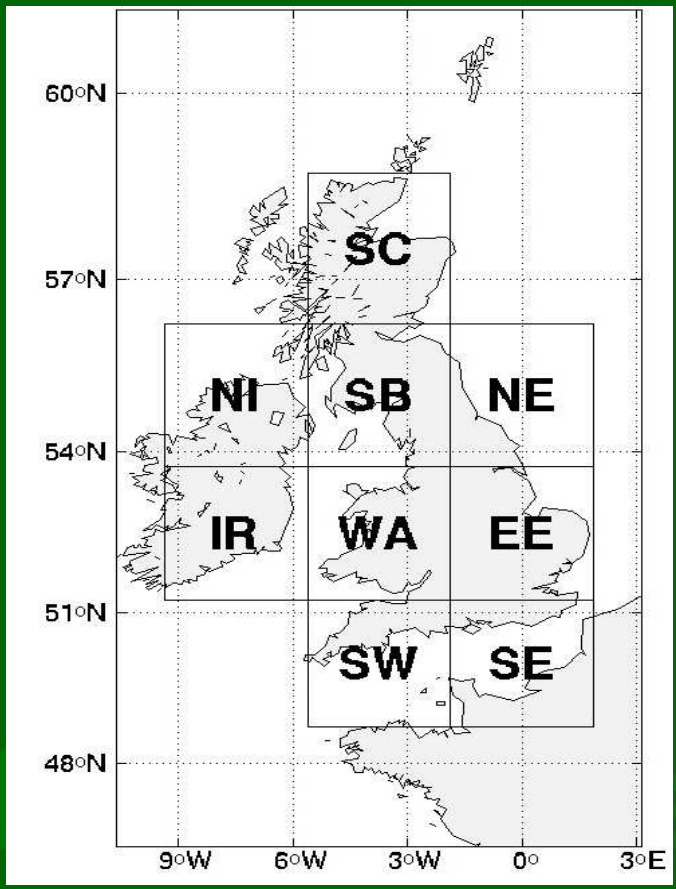
Appraisal of adaptation options

Five scenarios

- *Baseline conditions under HadCM3 A2 emissions*
- *Fertiliser use reduced by 50%*
- *Deposition of atmospheric pollutants reduced by 50%*
- *Water meadow creation (4 x surface area of river)*
- *Combined approach with 25% reduction in fertiliser and deposition, water meadow creation (2 x surface area)*

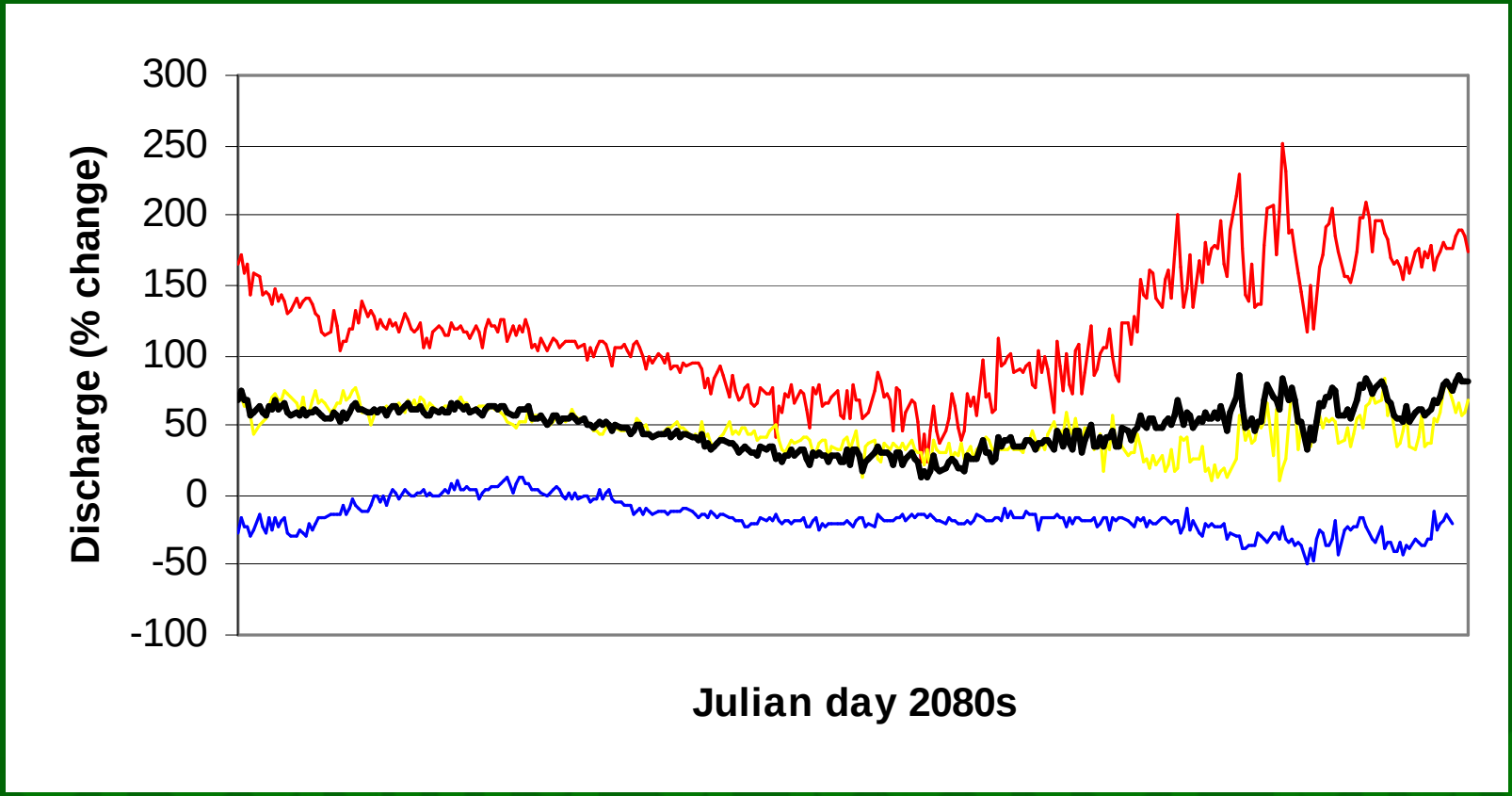
Statistical DownScaling Model (SDSM) and predictor variable archive





http://www.sdsm.org.uk/

CATCHMOD daily river flow changes under A2 emissions



Daily precipitation and PE downscaled for the River Kennet using three GCMs for the 2080s

INCA-N model of soil and instream nutrient concentrations

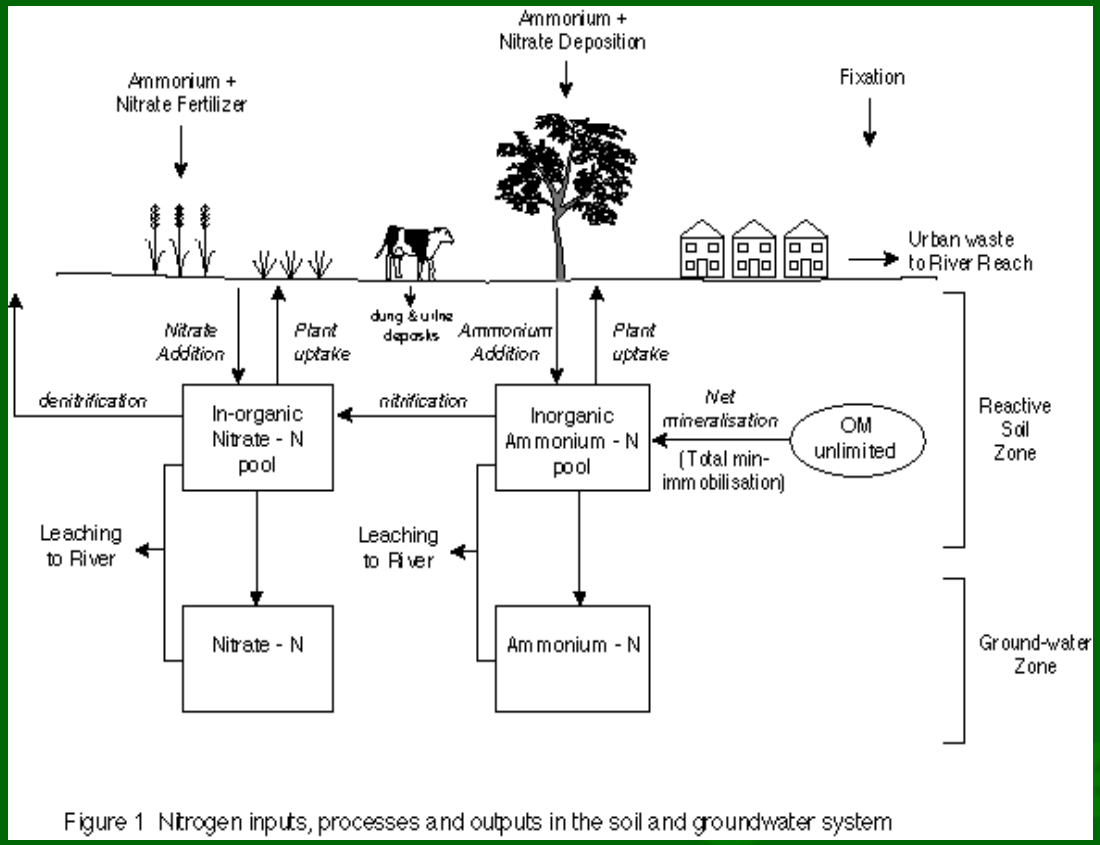
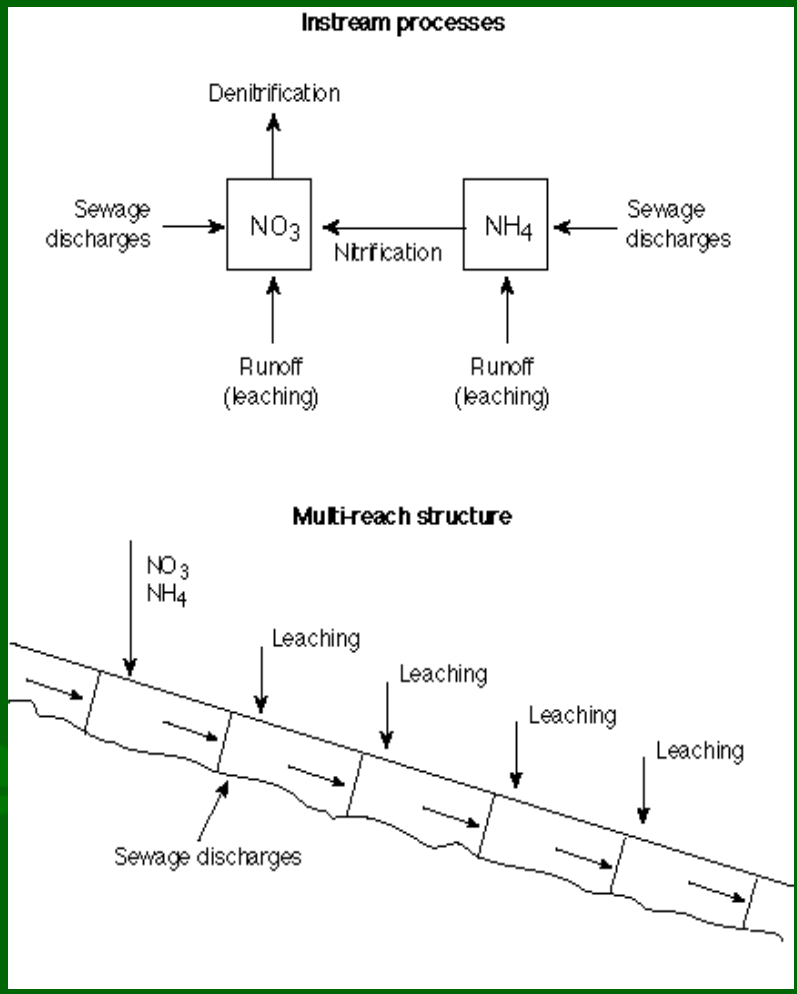
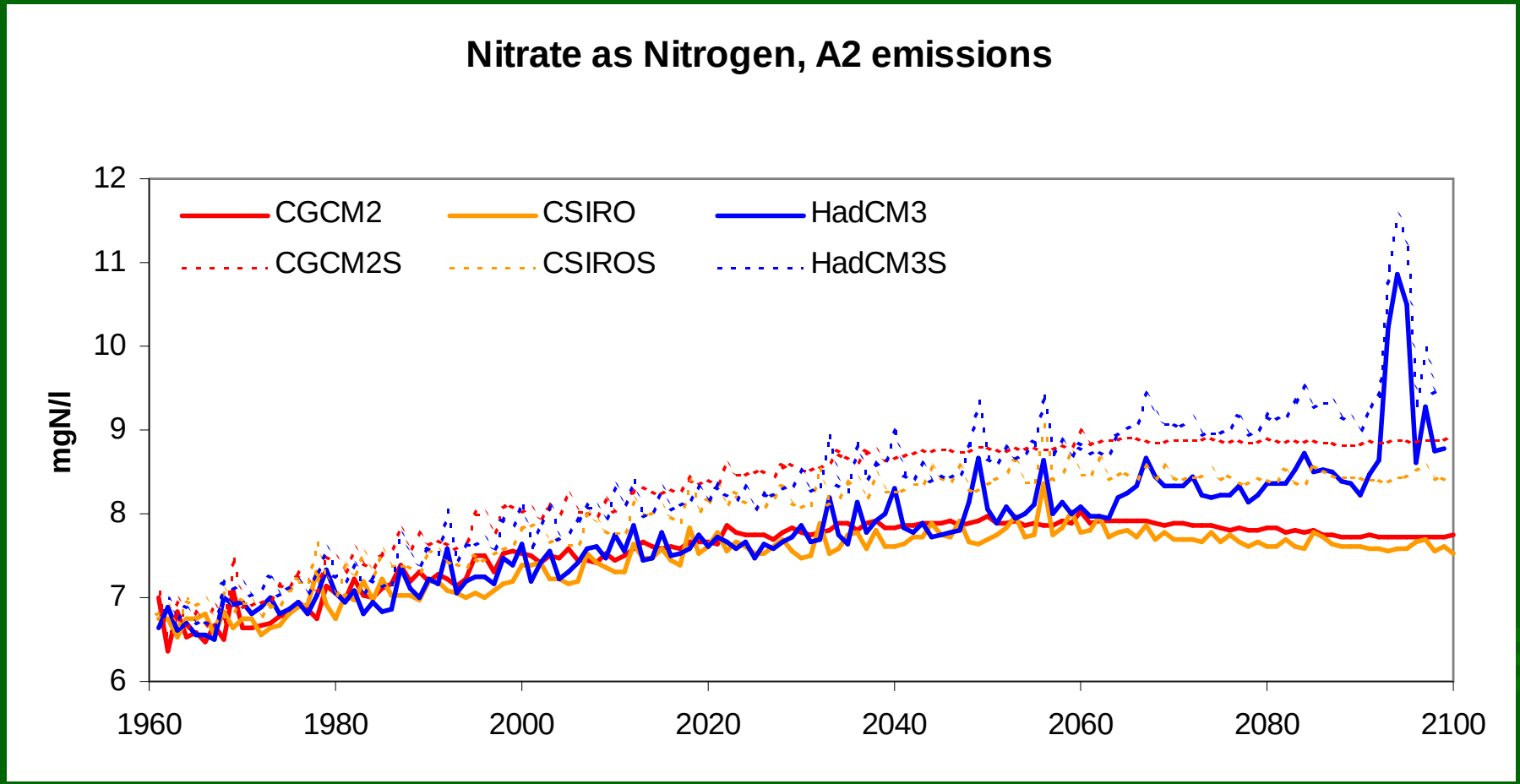


Figure 1 Nitrogen inputs, processes and outputs in the soil and groundwater system

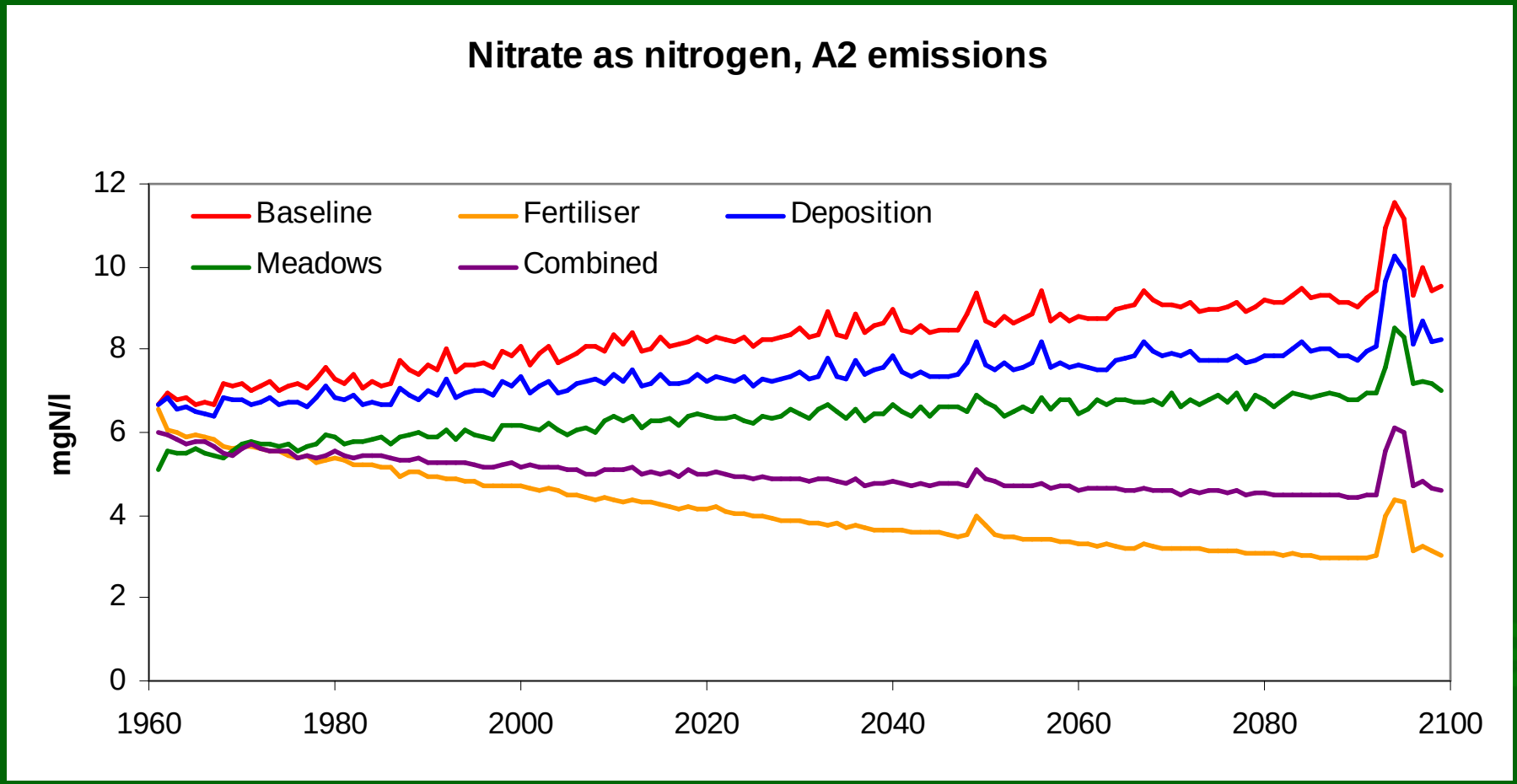


INCA-N simulation of Nitrate-N under A2 emissions: headwater



Concentrations exceeded 5% of the time

Simulation of adaptation outcomes under HadCM3 A2 emissions



Concentrations exceeded 5% of the time

Why downscale?

- *Link scenarios to space-time **scale** of impact model (INCA-N) to explore complex **transient** response at sub-grid scales*
- *Assess the impact of future **extreme** (drought) events*
- *Generate **exotic** predictands (such as PET) that are not directly available from GCMs*
- *Explore **uncertainty** in future (summer) climate due to GCM or the outcomes of mitigation options*
- *Rapid assessment of **adaptation** measures that will be sustainable under climate change*

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How to downscale within a probabilistic framework?

Assessing uncertainties in low flows for the River Thames

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Impacts assessment using mega-model ensembles

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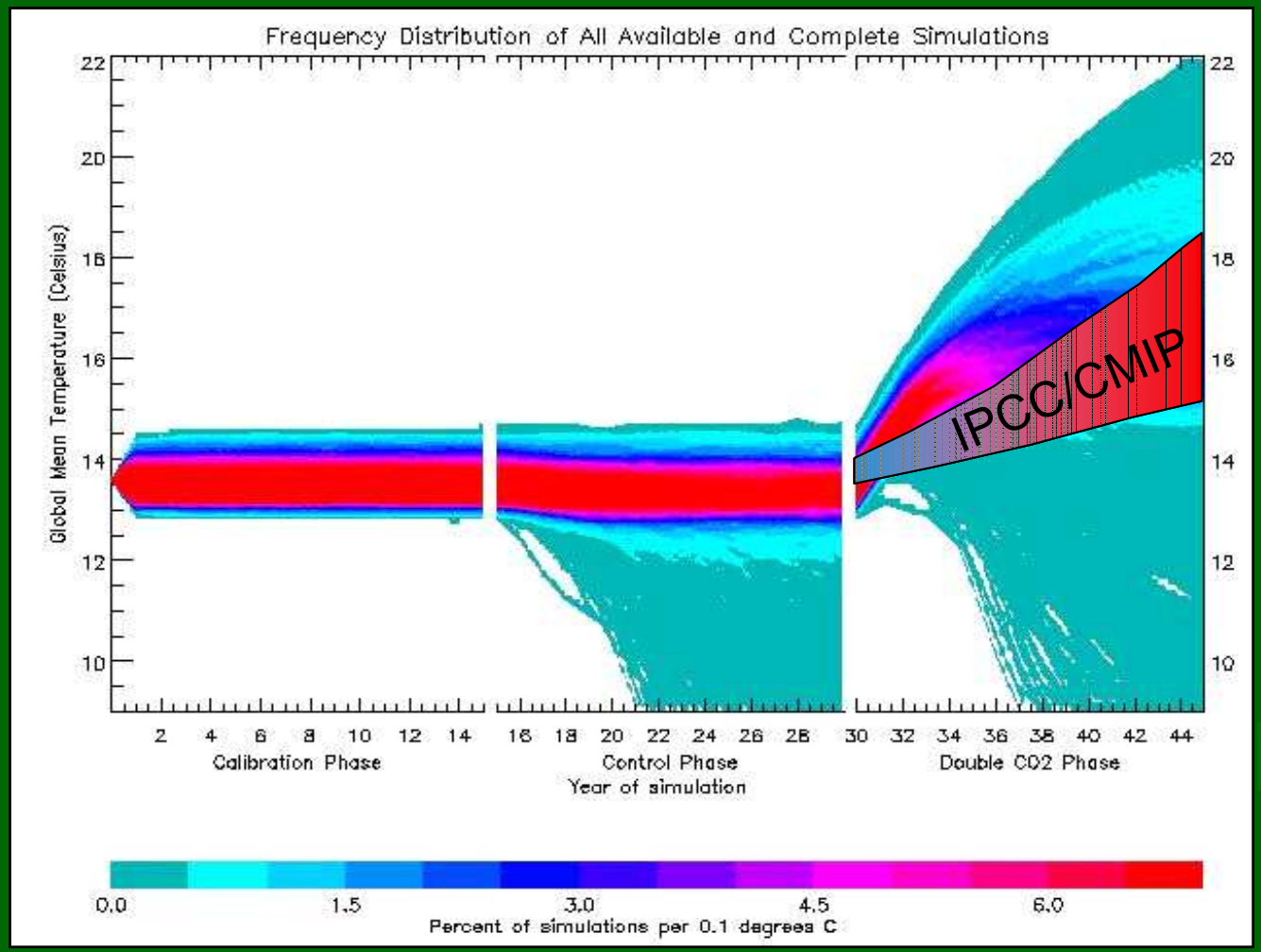
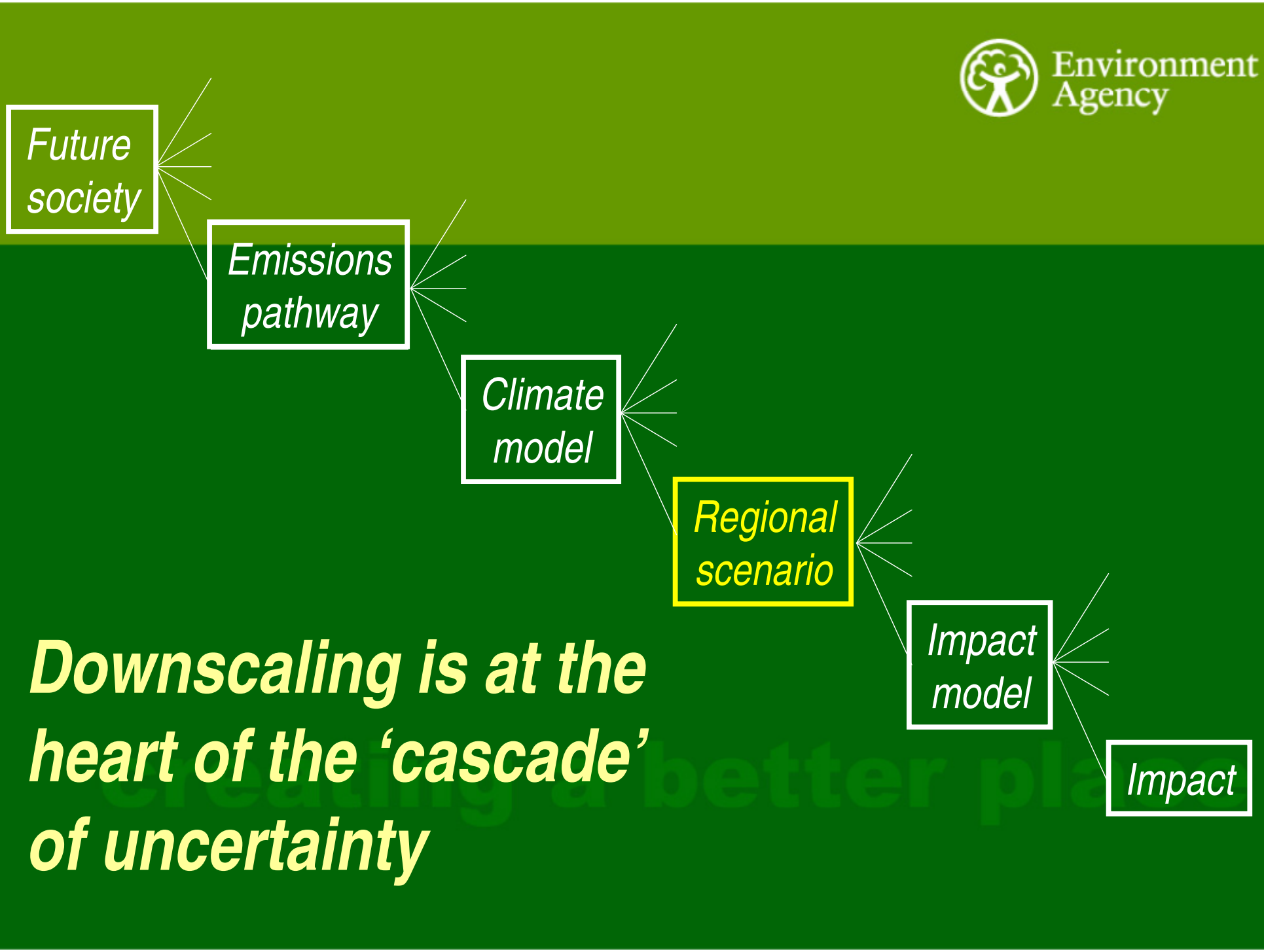
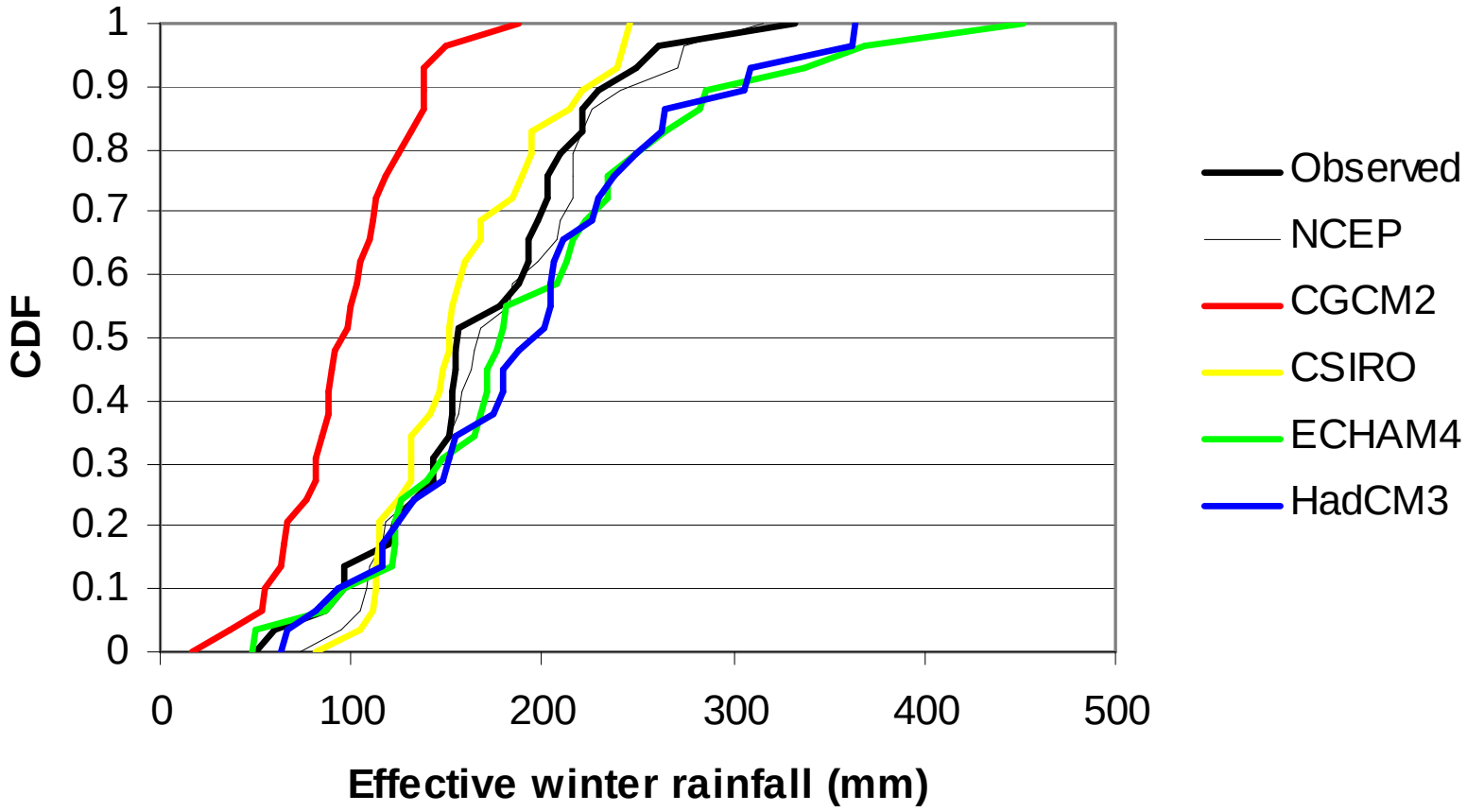


Frequency distribution of global mean temperature response to doubled CO_2 produced by CP.net, compared with IPCC (2001) range.



Downscaling is at the heart of the 'cascade' of uncertainty

Uncertainties due to GCM/ downscaling pair



An Impacts Relevant Climate Prediction Index

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Model	Summer		Winter	
	Bias (%)	*Weight*	*Bias (%)*	*Weight*
CGCM2	52.1	0.138	42.2	0.074
CSIRO	14.3	0.503	6.0	0.522
ECHAM4	49.6	0.145	16.1	0.194
HadCM3	33.6	0.214	14.9	0.210
NCEP	7.6	n/a	4.8	n/a

This IR-CPI is based on the skill of the GCM/downscaling pair for effective rainfall in the Thames basin

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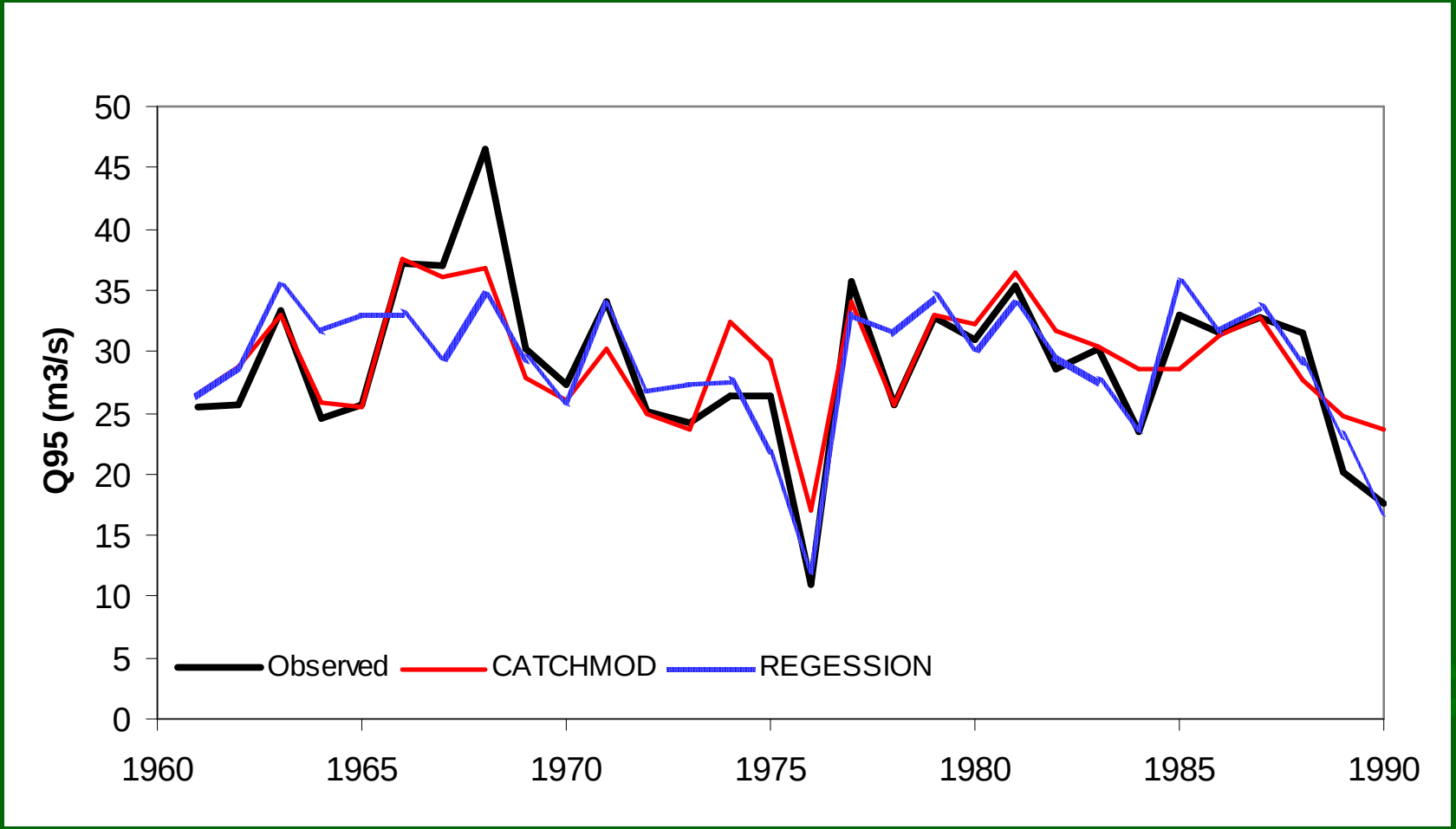
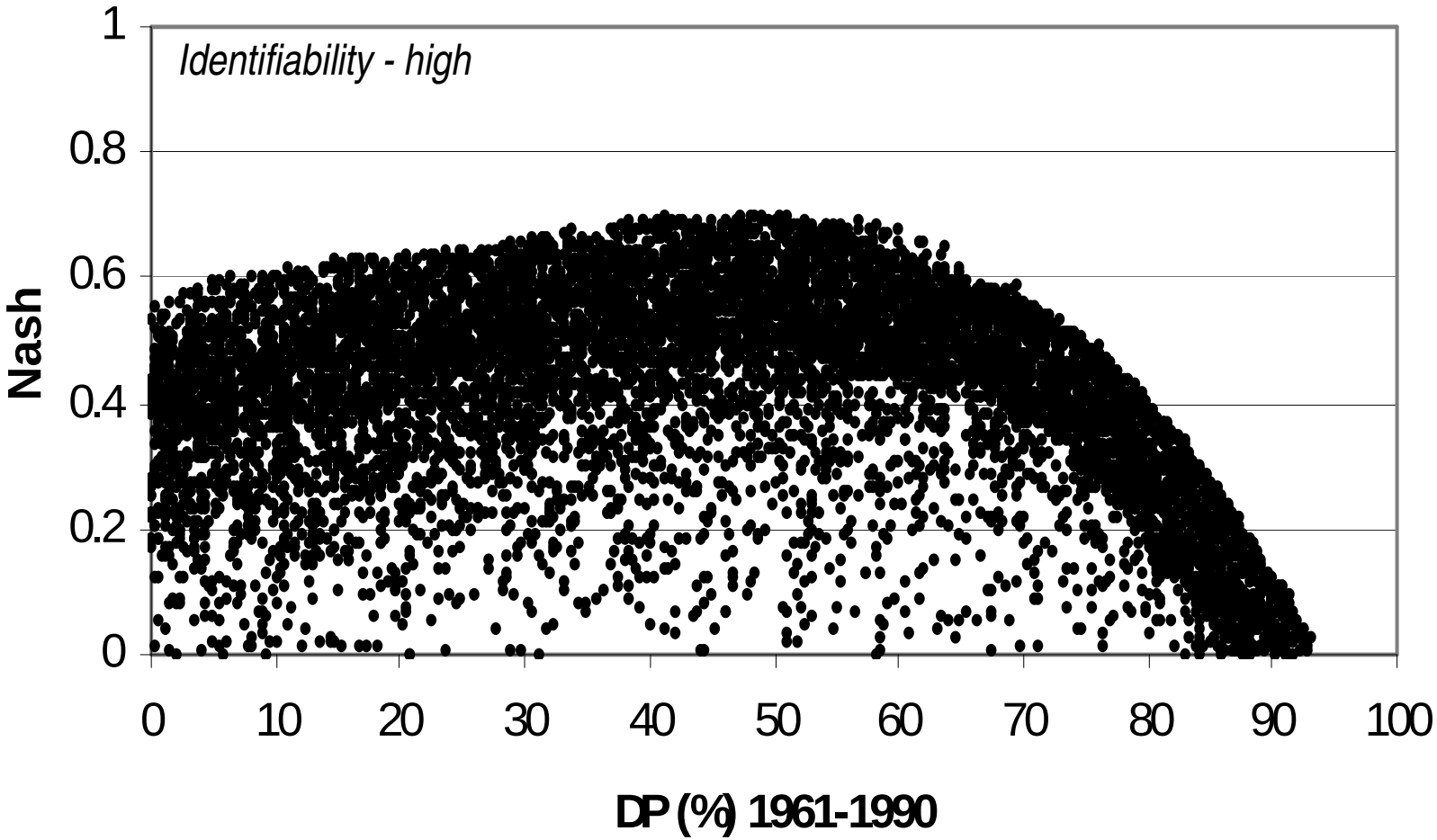
Uncertainty due to low flow model structure



Derived from observed daily rainfall and PE

Uncertainty due to water resource model parameters



An experimental framework for assessing uncertainties

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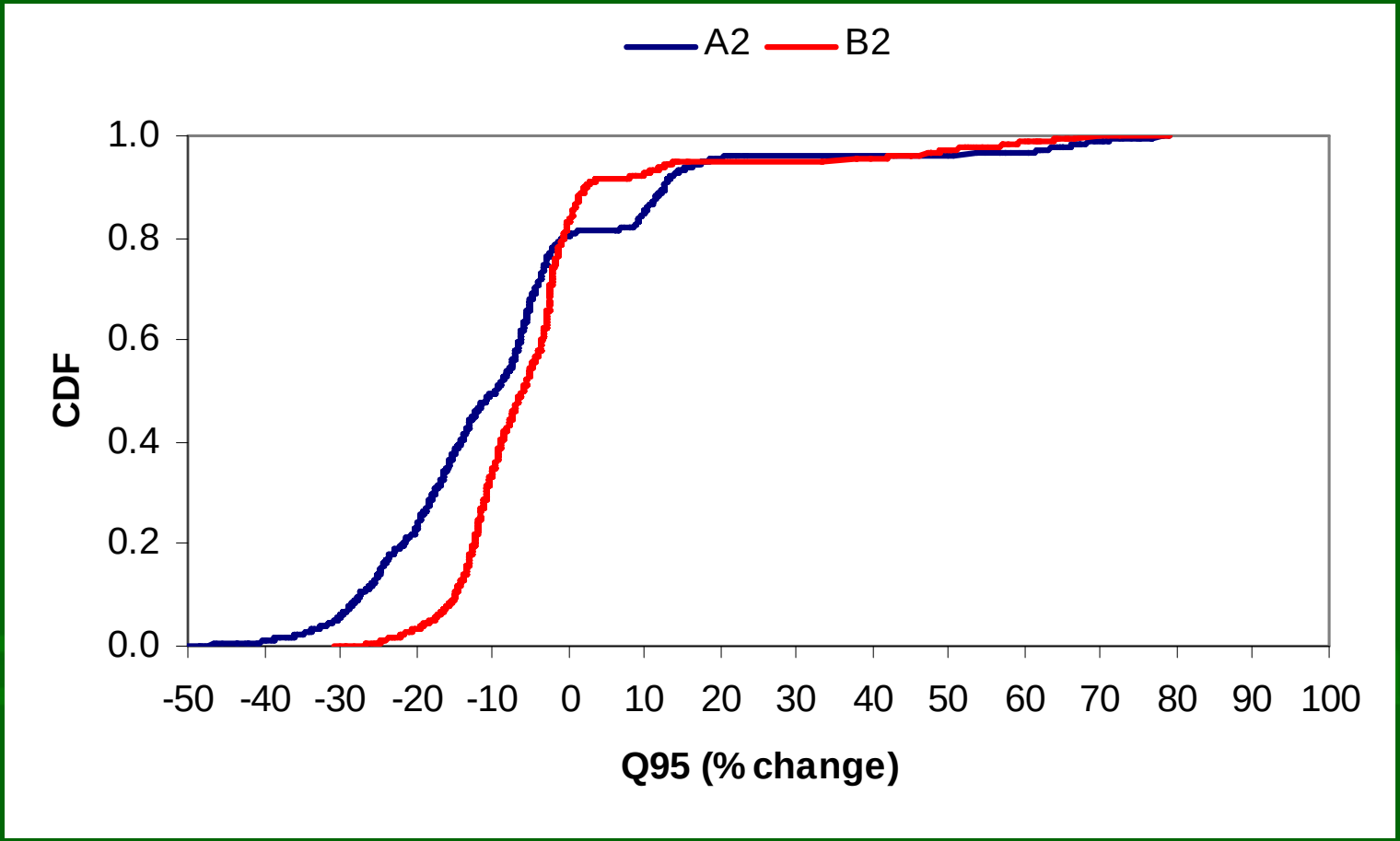
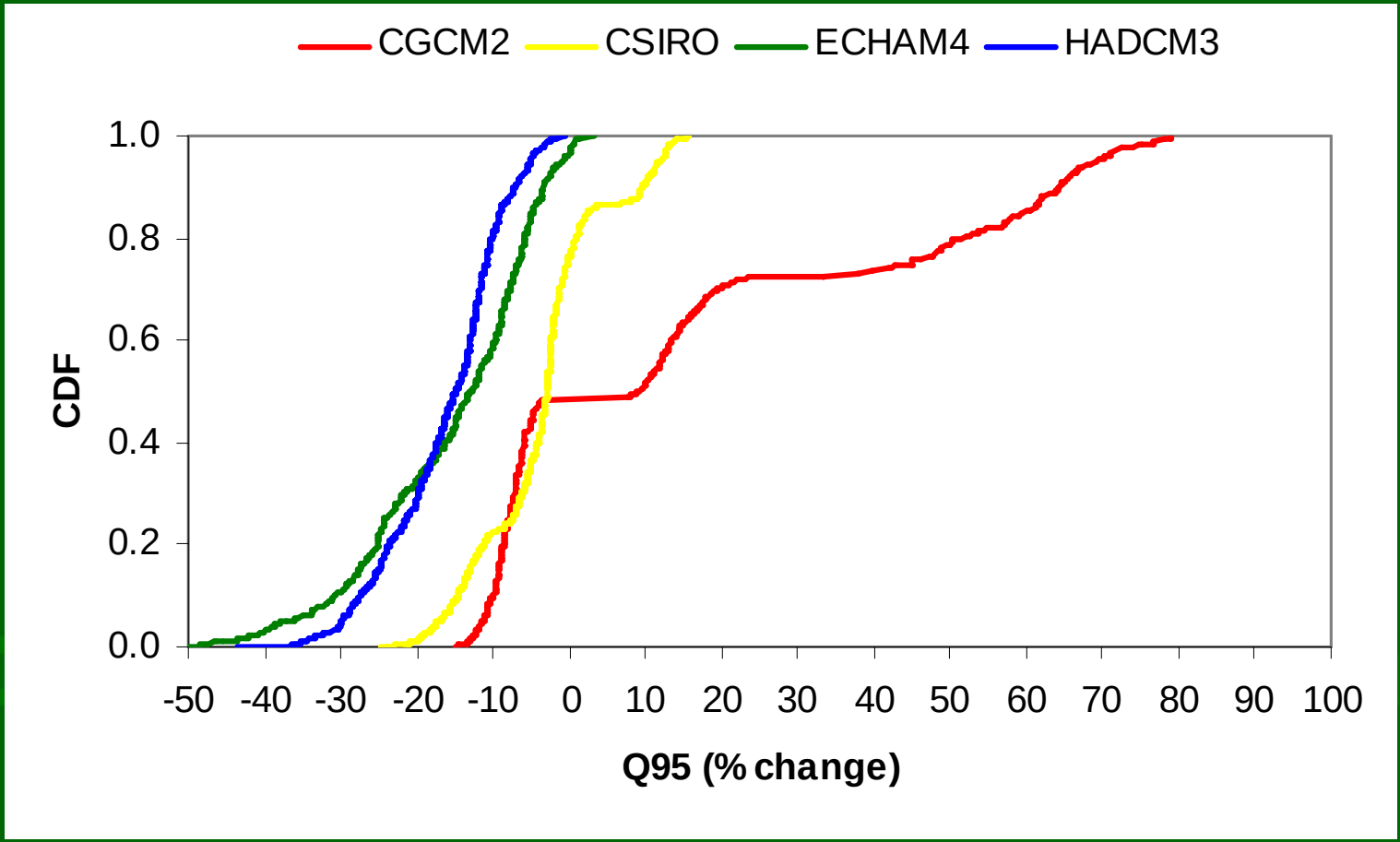
- *4x GCMs, 2x emissions, 2x downscaling methods, 2x low flows models, 100x parameter sets*
- *Weight GCMs by modified Climate Prediction Index*
- *Weight low flow model structures by r_{adj} statistic*
- *Weight low flow model parameters by N-S score*
- *Emissions and downscaling method unweighted*
- *Monte Carlo simulation (2000+ runs)*
- *Evaluate using (Q95) low-flow index for River Thames*

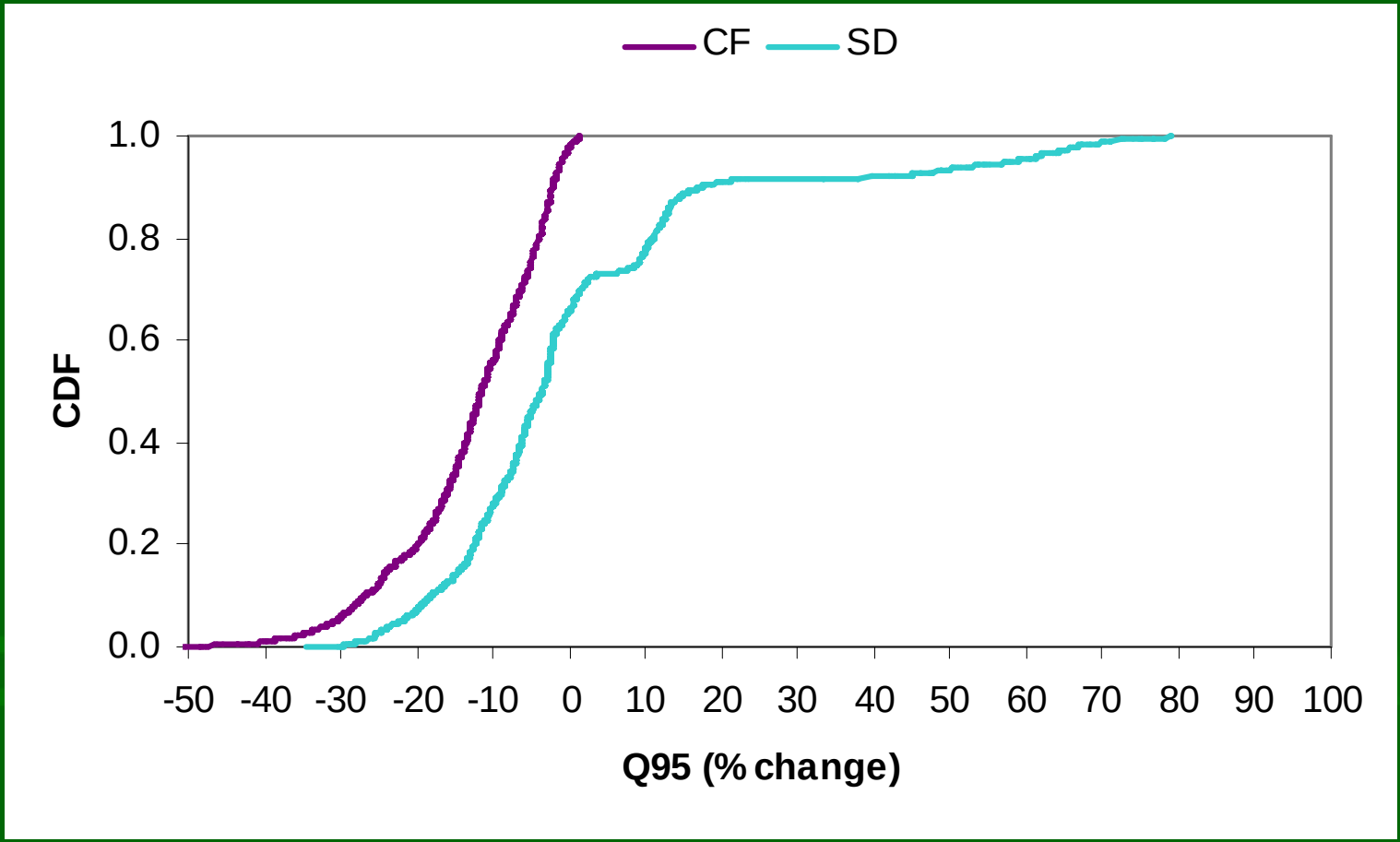
Uncertainties due to emission scenario



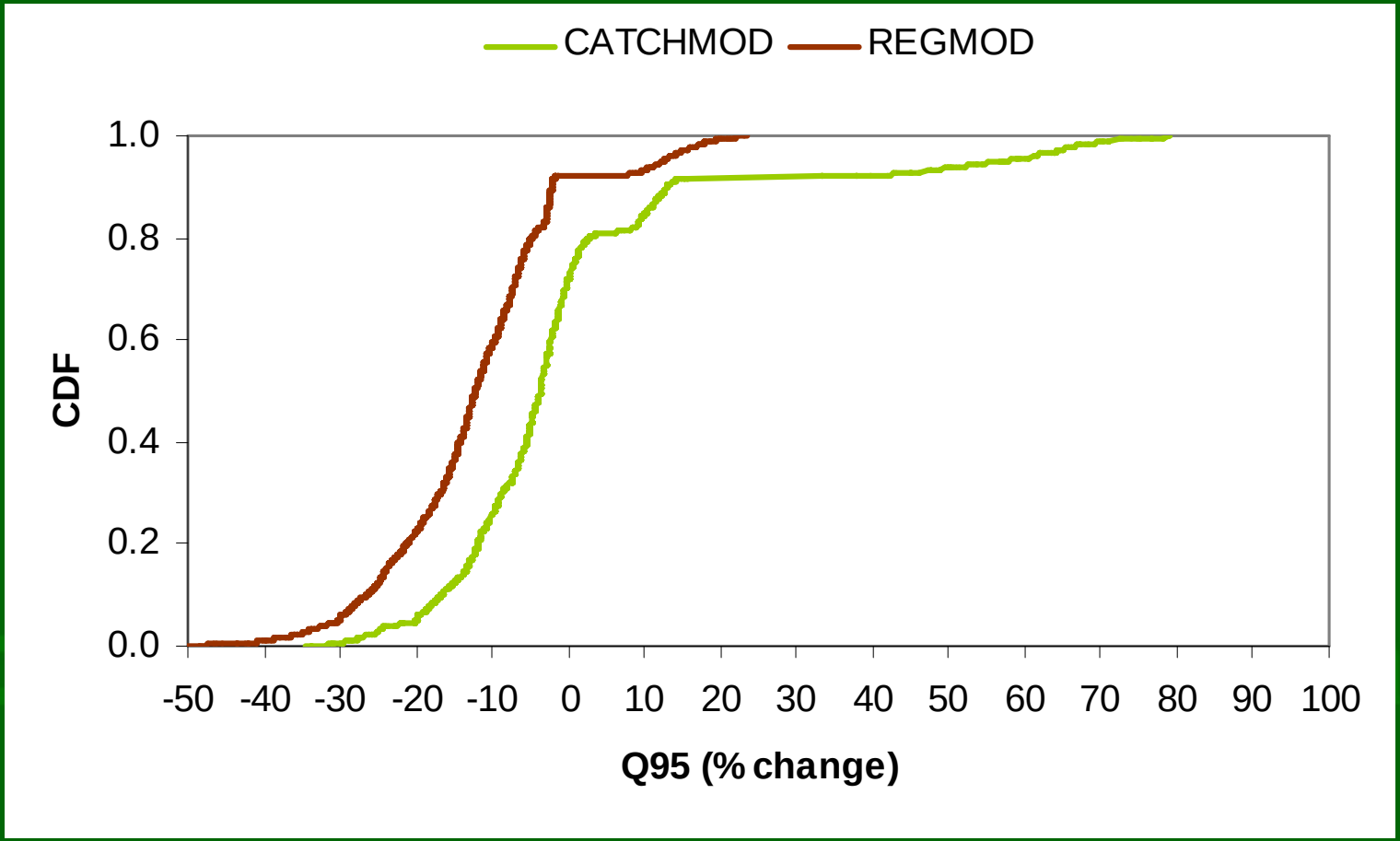
Uncertainties due to GCM



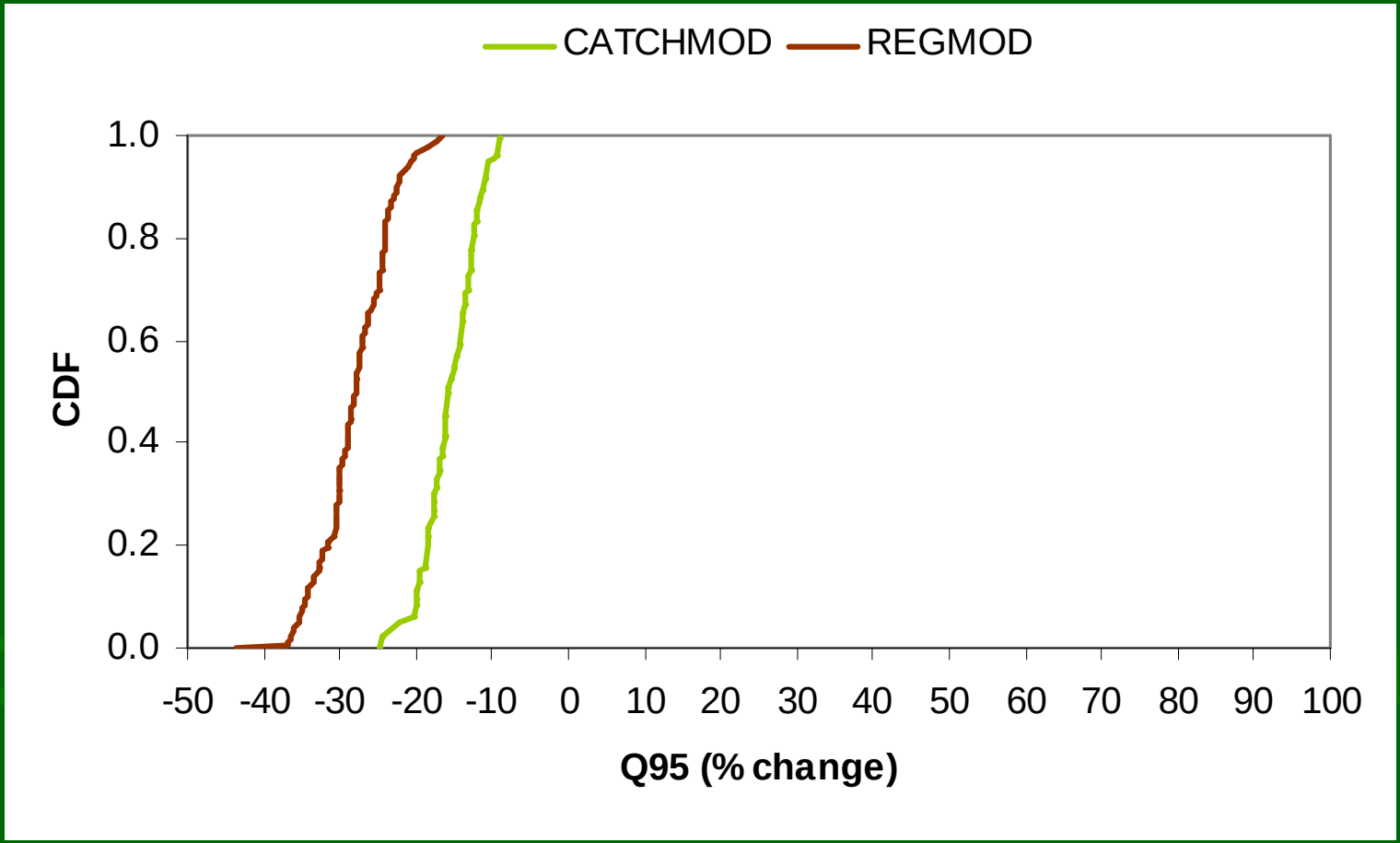
Uncertainties due to downscaling method



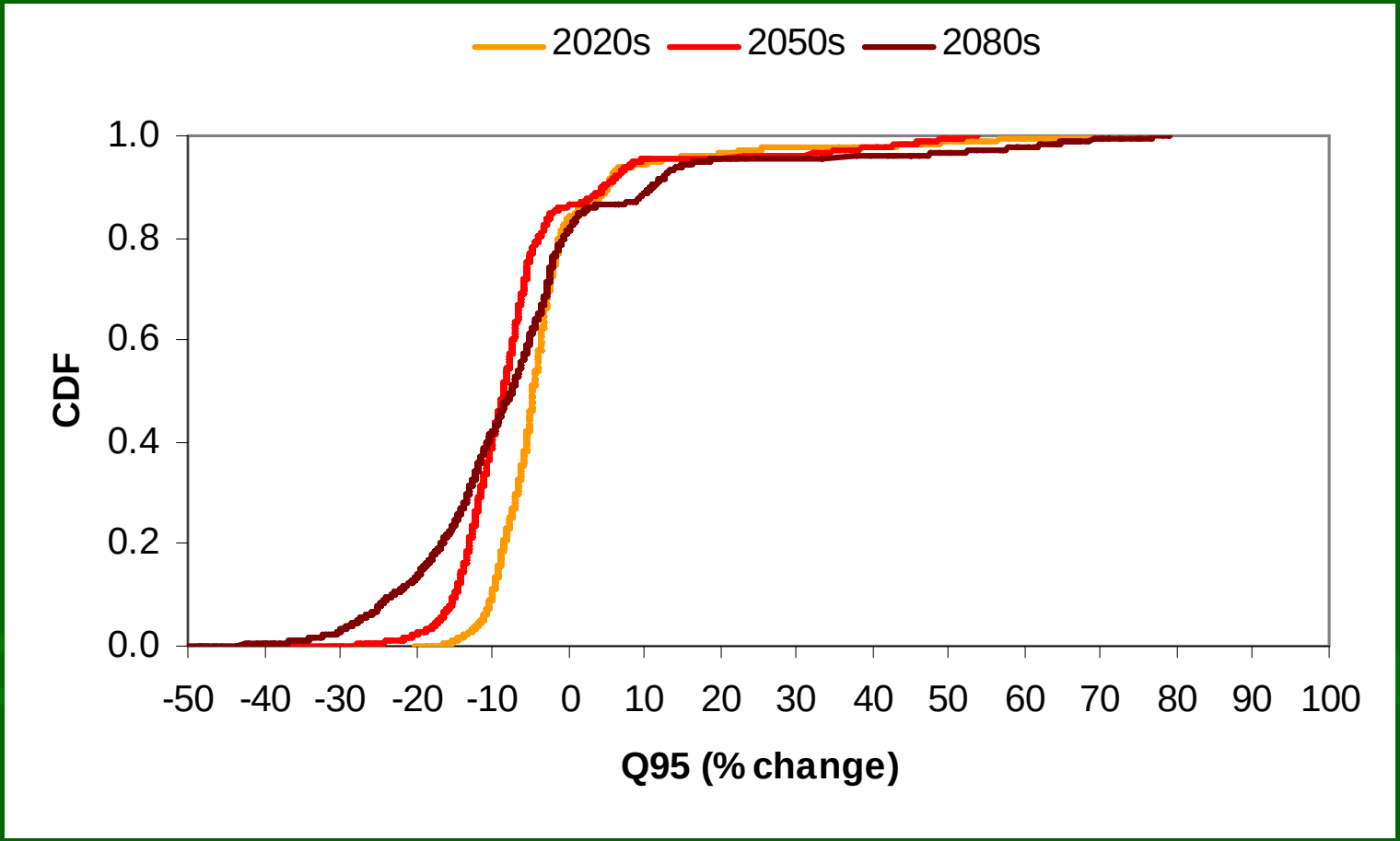
Uncertainties due to low flow model structure



Uncertainties due to low flow model parameters (HadCM3, A2)



Combining all sources of uncertainty



Downscaling is a significant component of uncertainty

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Uncertainty component	Likelihood	
	Min	Max
Emissions	82	83
GCM	47	100
Downscaling	66	100
Hydrological model	72	92
All weighted/ unweighted	76	82

Conditional probabilities of lower summer river flows in the Thames by the 2080s

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What are the outstanding scientific challenges?

A proposed research agenda for the downscaling community

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Please can we have:

- *NO MORE COMPARISON STUDIES!!!*
- *A dossier of best practise and case studies where downscaling has actually shaped decision-making*
- *More physical insight in our downscaling (e.g., local controls, land-surface feedbacks, extreme events)*
- *Incorporation of downscaling in risk-based modelling frameworks to inform adaptations responses*
- *A downscaling community 'Wizard'*

Warmer winters have helped the ring-necked parakeet to establish viable populations in southern England

Thanks!!!

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