

Statistical downscaling: applied to the UK

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What have we learnt so far?

- Statistical and dynamical downscaling have similar skill
- Different downscaling methods yield different scenarios
- There are no universally “optimum” predictor(s)
- There is no optimal configuration for predictor domain
- Downscaling extreme events is highly problematic
- Summer rainfall predictability is very low

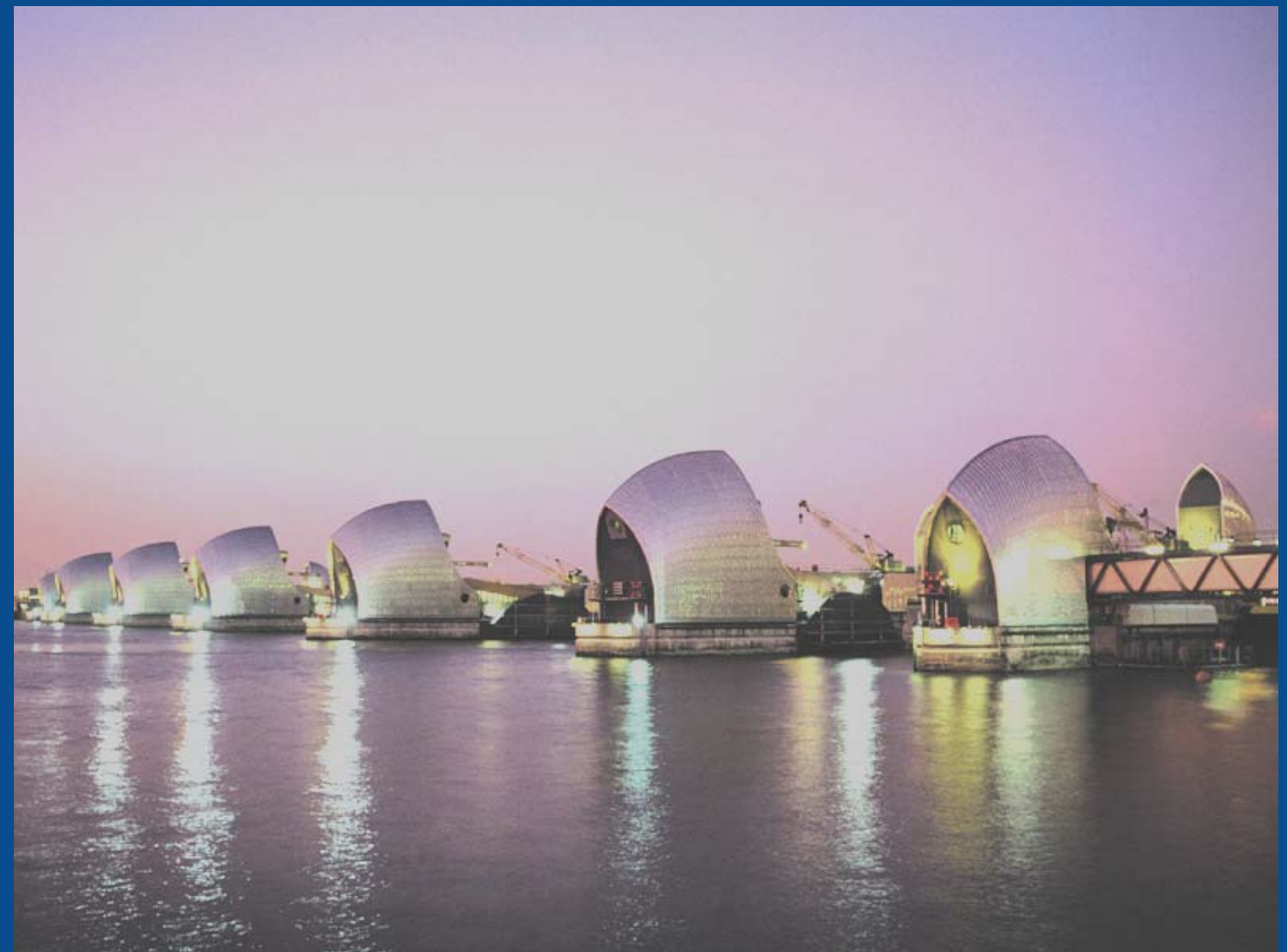
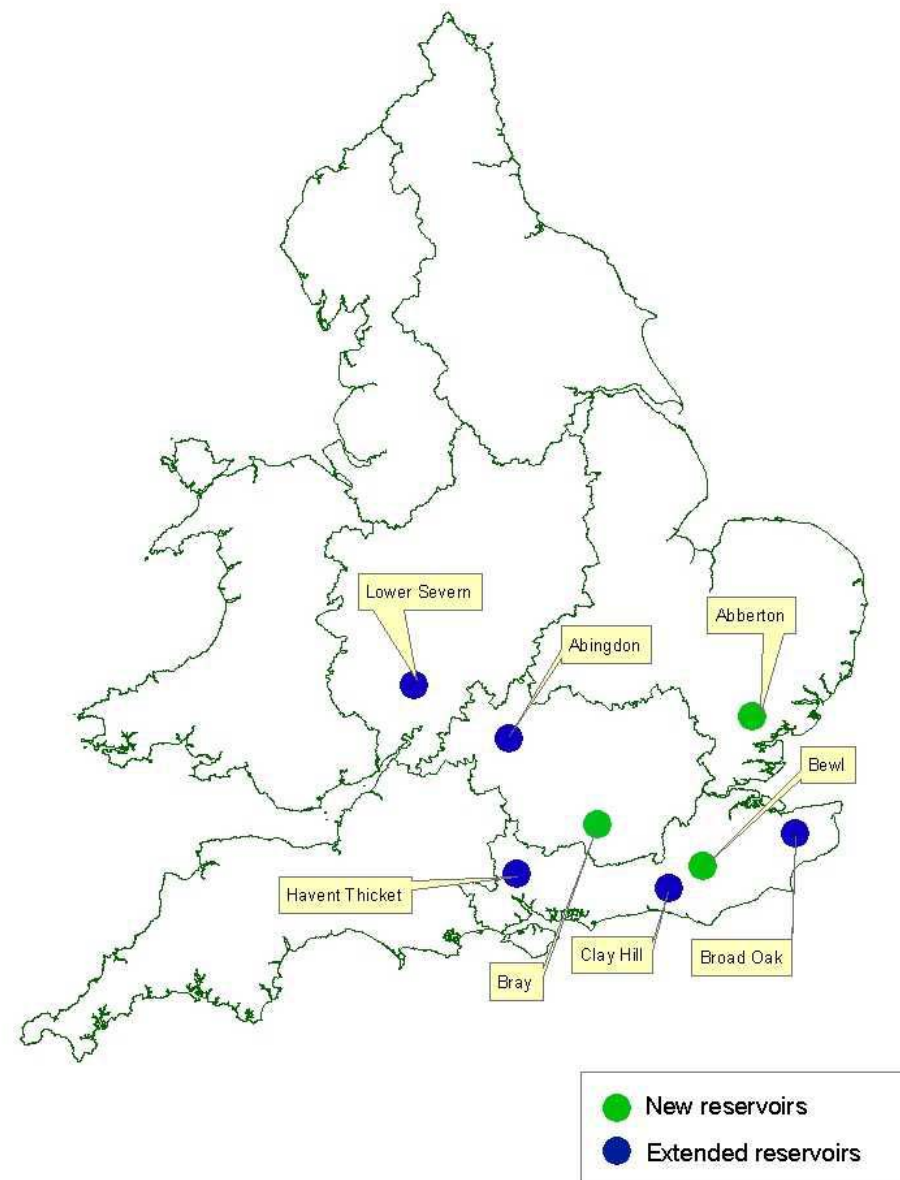
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...but scenarios are needed
to address some big adaptation issues...

Proposed new and extended reservoirs
in England and Wales

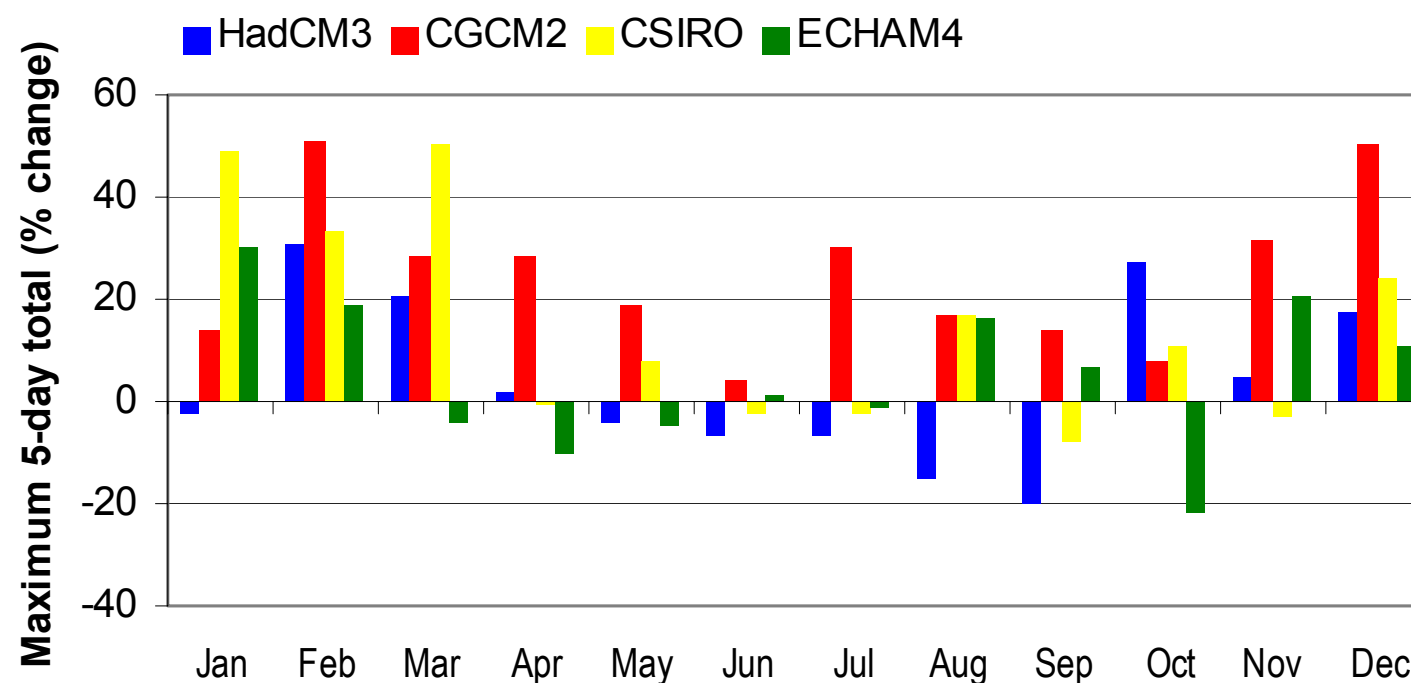
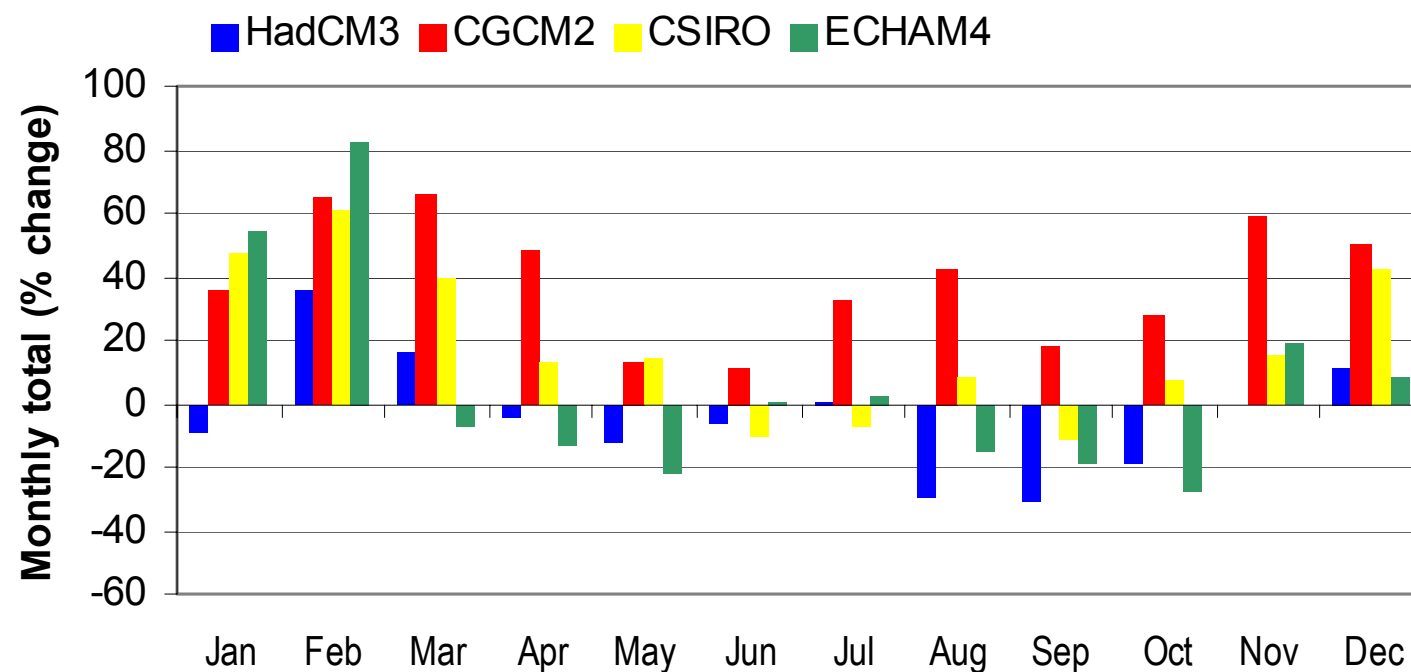


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...in the face of
much uncertainty...



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

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Embedding downscaling within a **probabilistic** framework

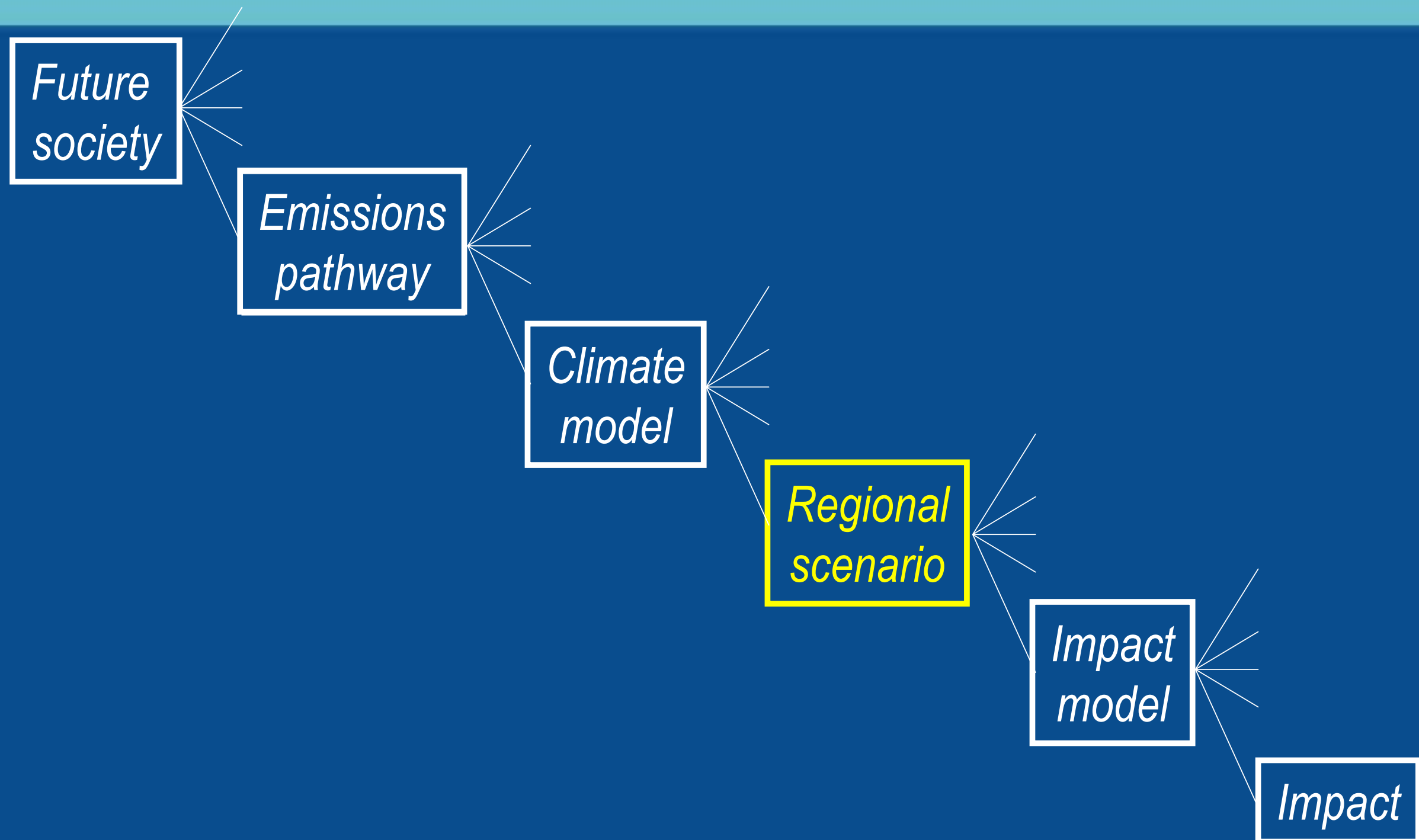
End-to-end uncertainty analysis
of low flows in the River Thames

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Downscaling is at the heart of the uncertainty cascade



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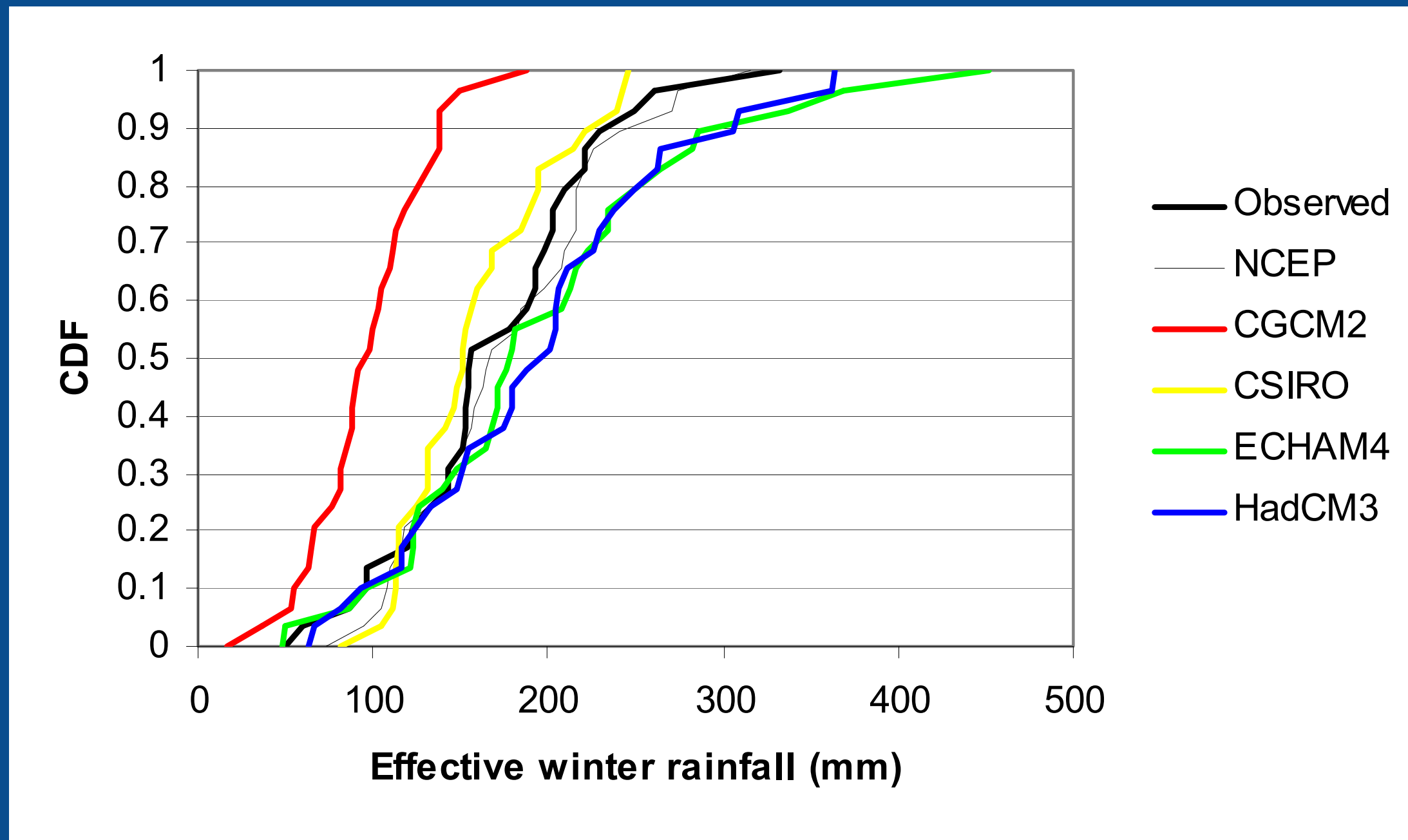
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An experimental framework for assessing uncertainties

- 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 the River Thames

Uncertainties due to GCM/ downscaling pair

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An Impacts Relevant Climate Prediction Index

Model	Summer		Winter	
	<i>Bias (%)</i>	<i>Weight</i>	<i>Bias (%)</i>	<i>Weight</i>
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

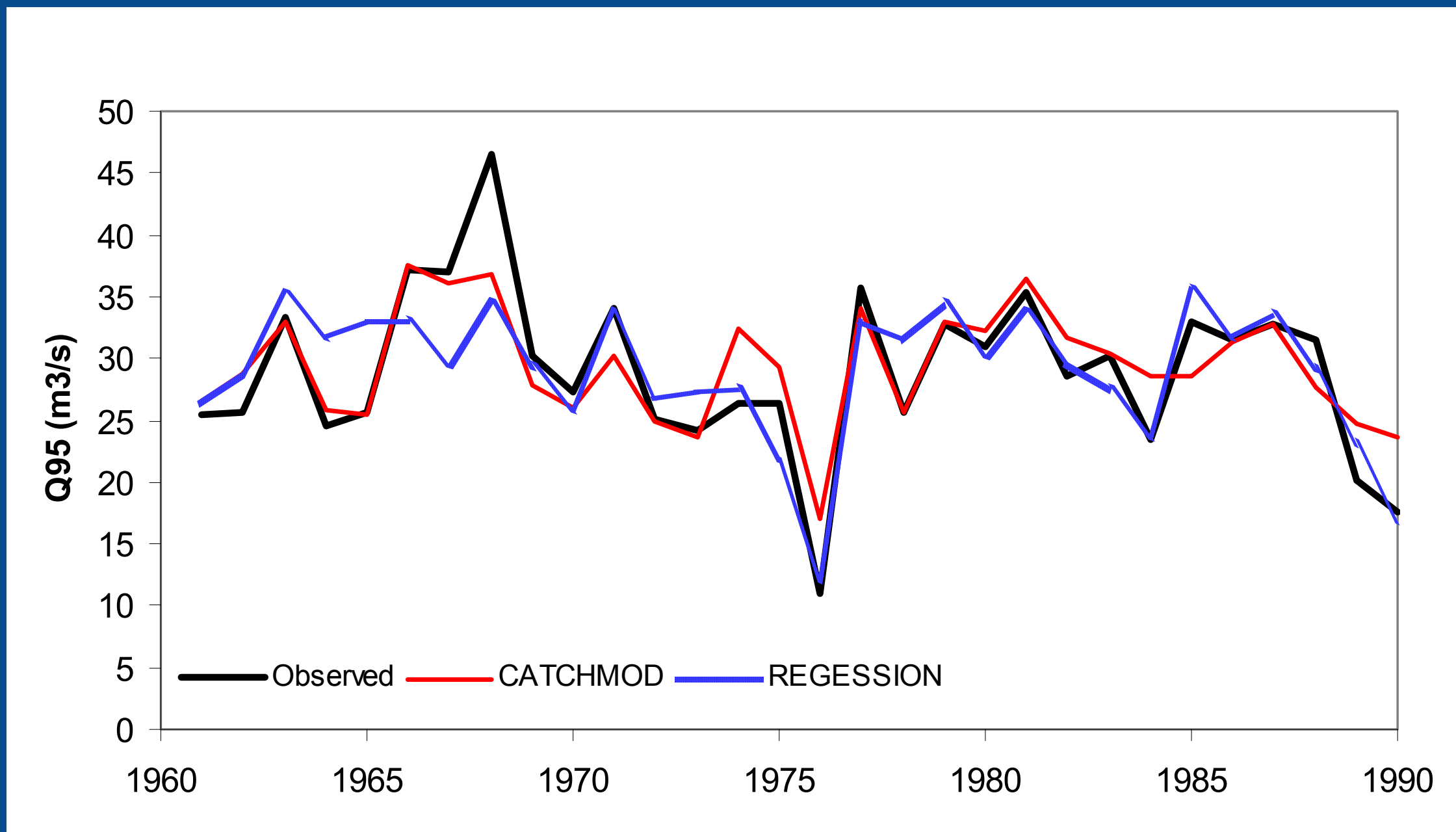
The IR-CPI shows skill of the GCM/downscaling pair at reproducing effective rainfall in the Thames basin

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Uncertainty due to low flow model structure



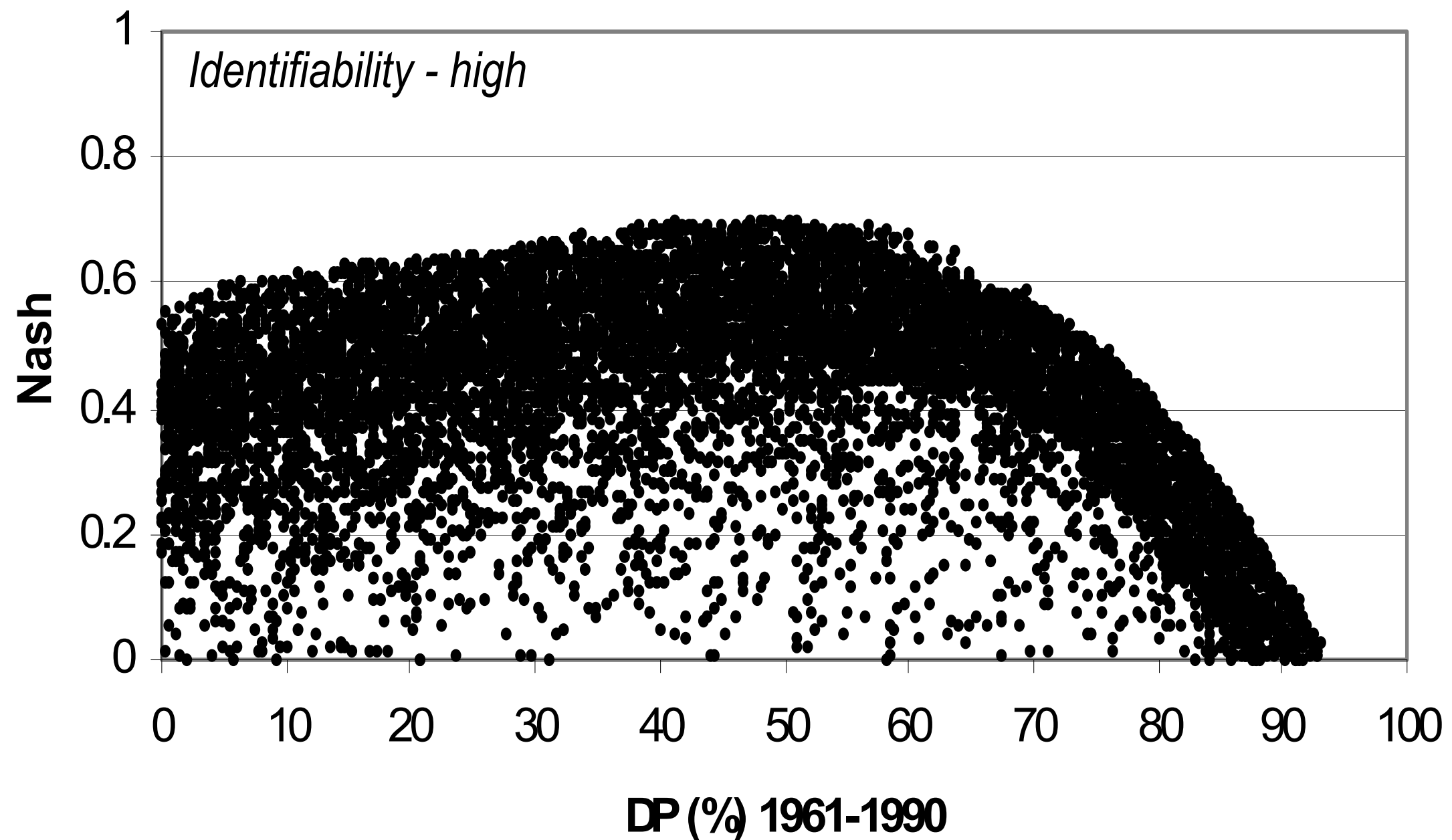
Derived from observed daily rainfall and PE

Uncertainty due to water resource model parameters

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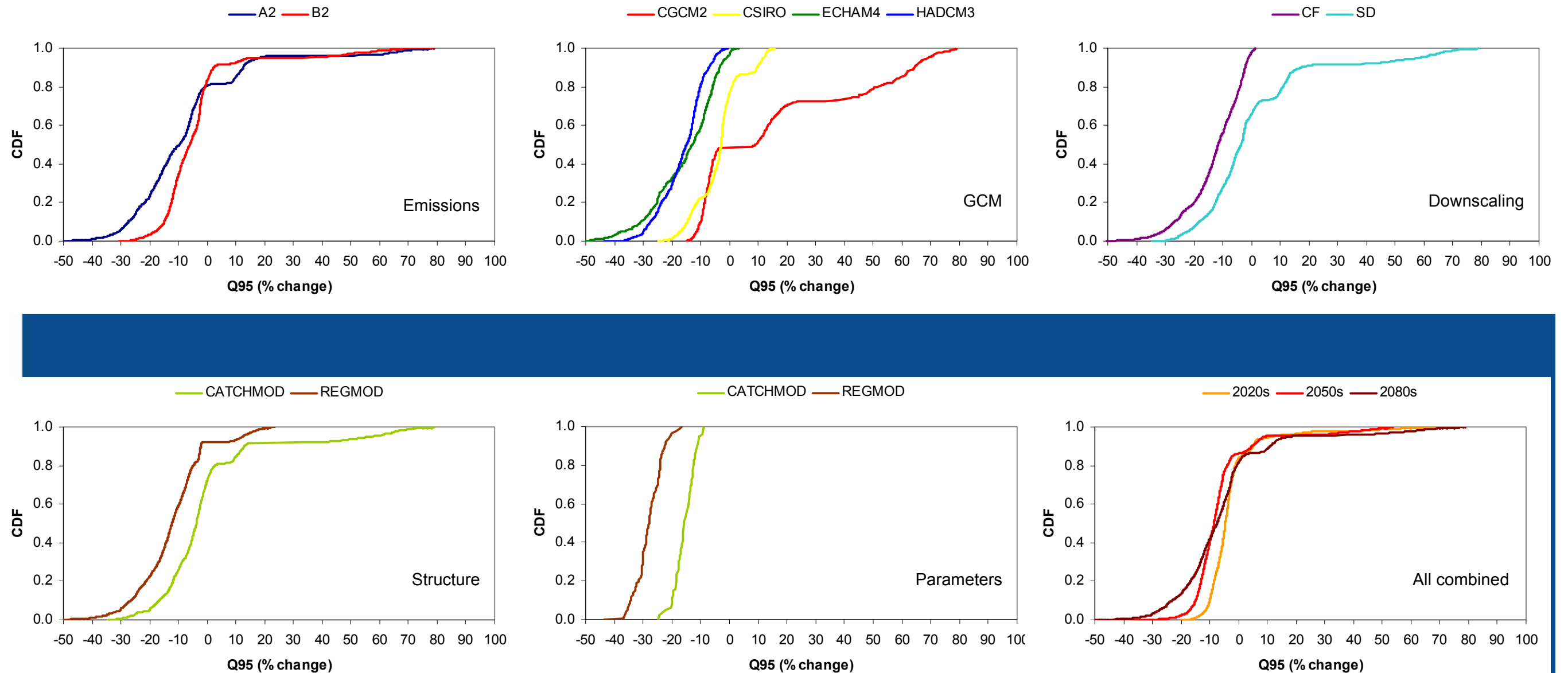


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End-to-end uncertainty analysis



Conditional probabilities of lower summer flows in the River Thames by the 2020s, 2050s and 2080s. Source: Wilby and Harris (2006)

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Downscaling is a significant component of uncertainty

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

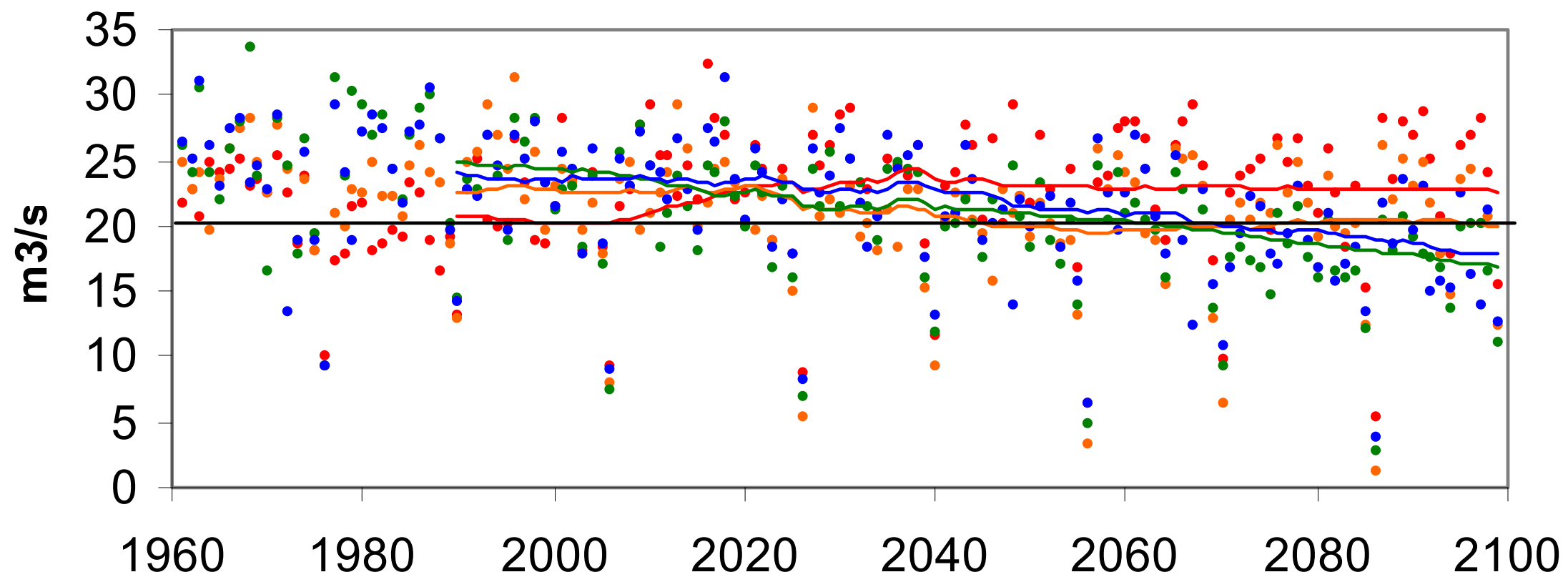
Conditional probabilities of a reduction in summer flows
in the River Thames by the 2080s

Transient data could inform decisions on timing of adaptation

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River Thames AMIN30 (p=0.05)



30-day annual minimum flow series in the River Thames reflecting uncertainty due to GCM boundary forcing 1961-2100

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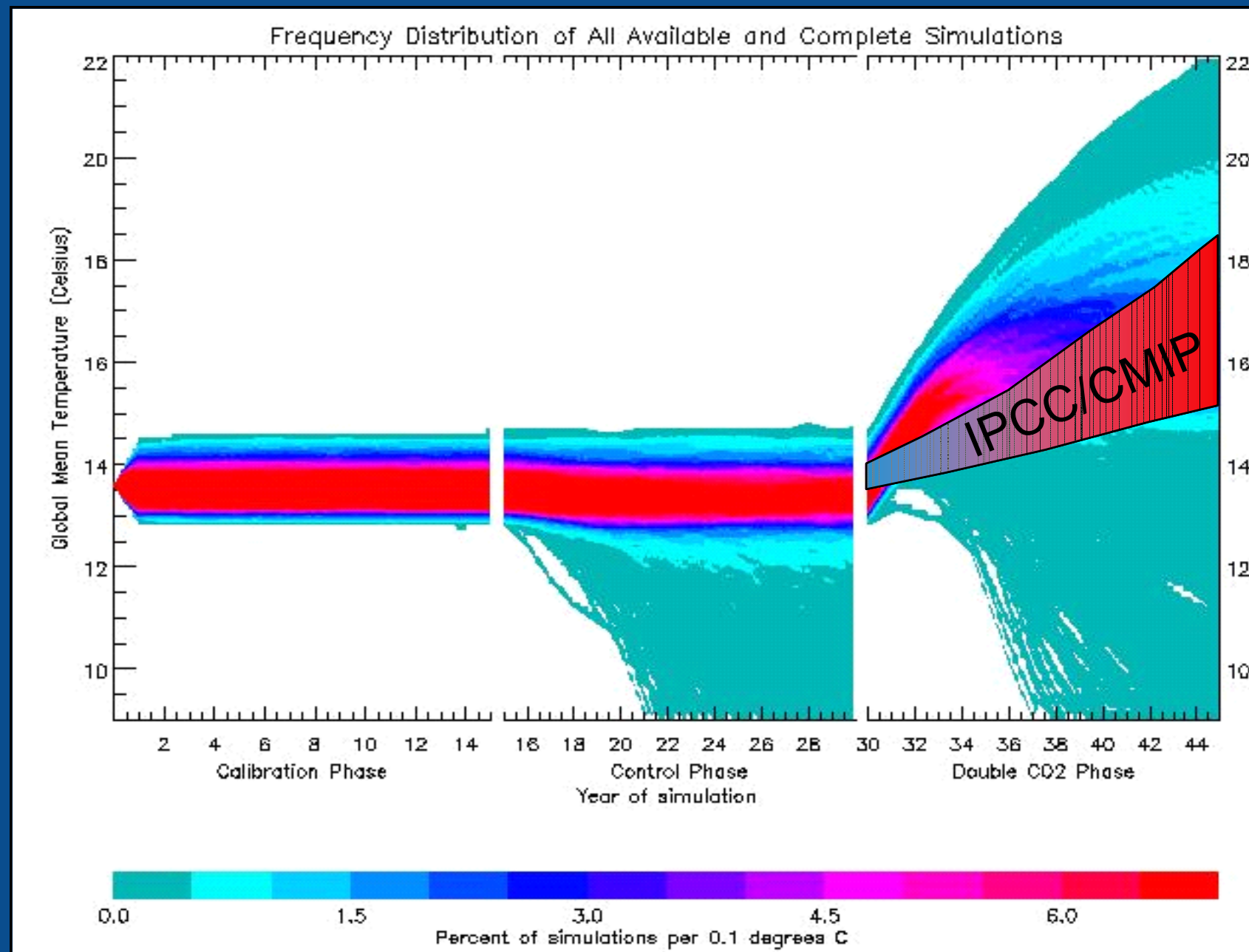
Downscaling from large ensemble GCM experiments

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Impacts assessment using mega-model ensembles...



Frequency distribution of global mean temperature response to doubled CO₂ produced by CP.net, compared with the IPCC (2001) range.

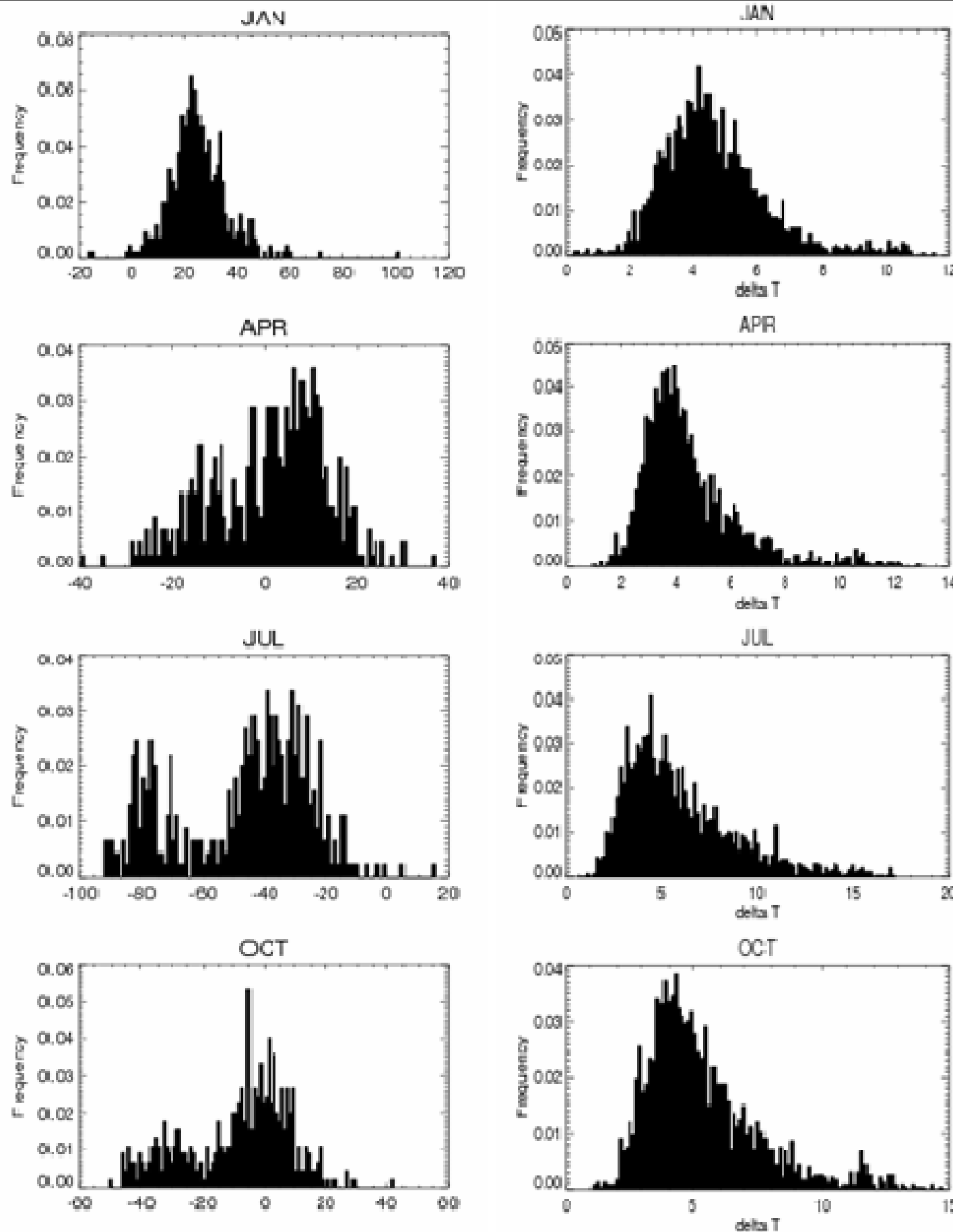
Source: Stainforth et al. (2005)

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Climate model uncertainty...



Precipitation (left) and temperature (right) changes simulated by CP.net for the Thames grid-box between 1xCO₂ and 2xCO₂

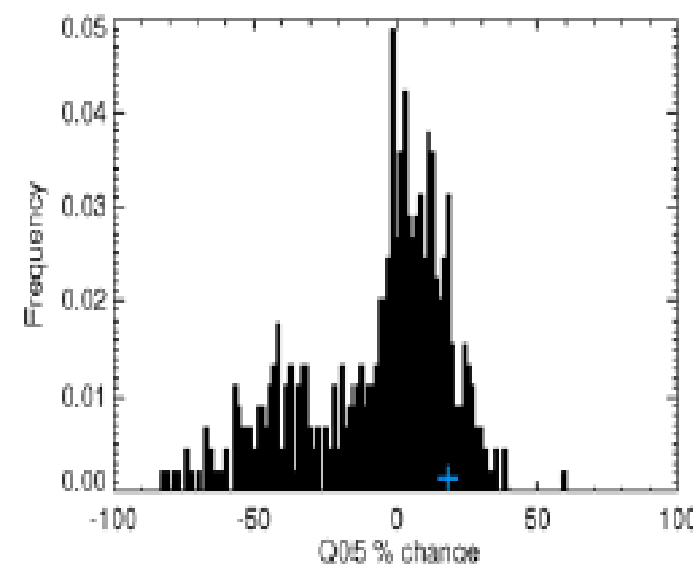
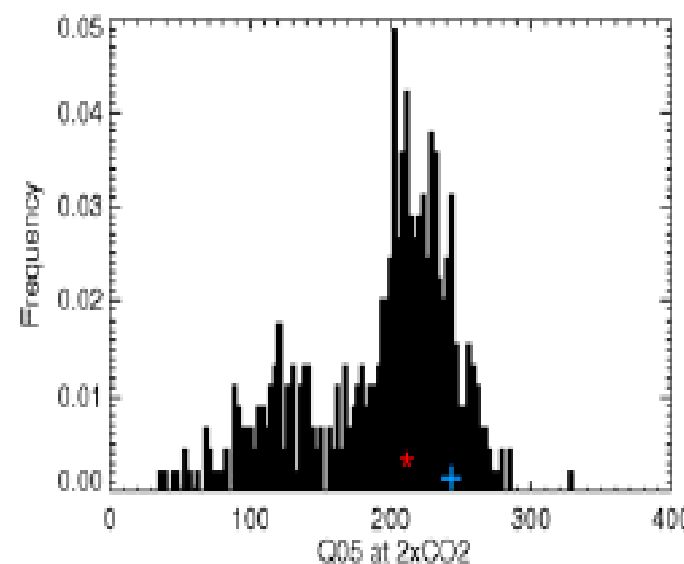
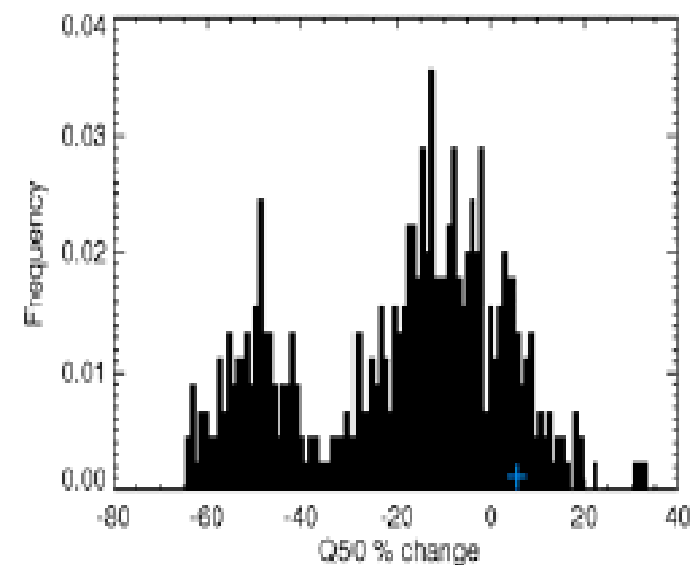
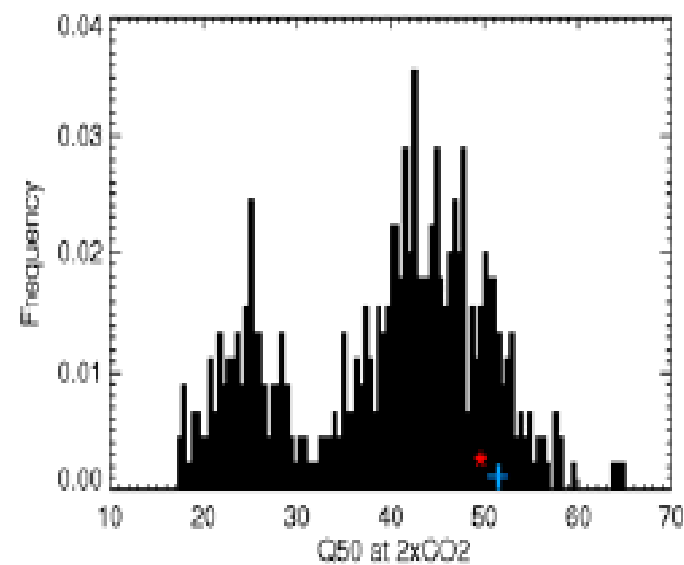
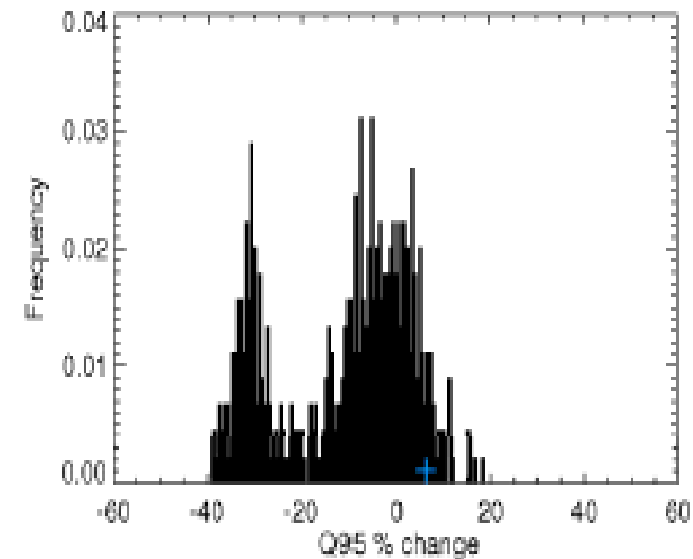
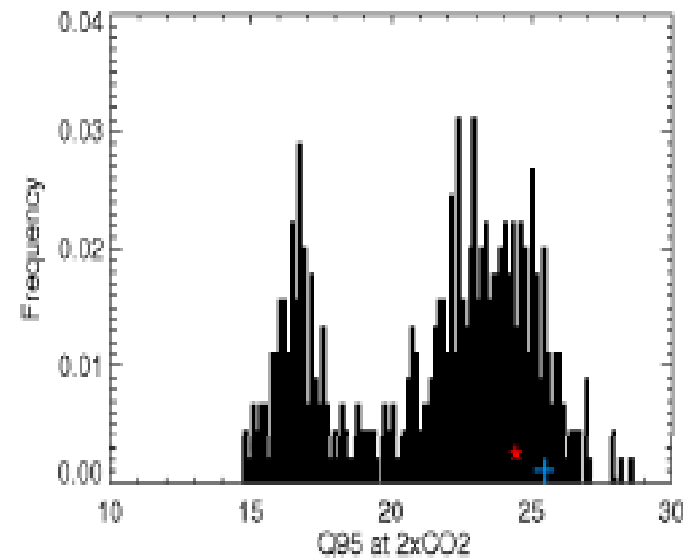
Source: New et al. (2006)

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...to hydrological
uncertainty...



Changes in low (Q95), average (Q50)
and high (Q05) flows simulated by
CATCHMOD given CP.net climate
scenarios for the Thames grid-box

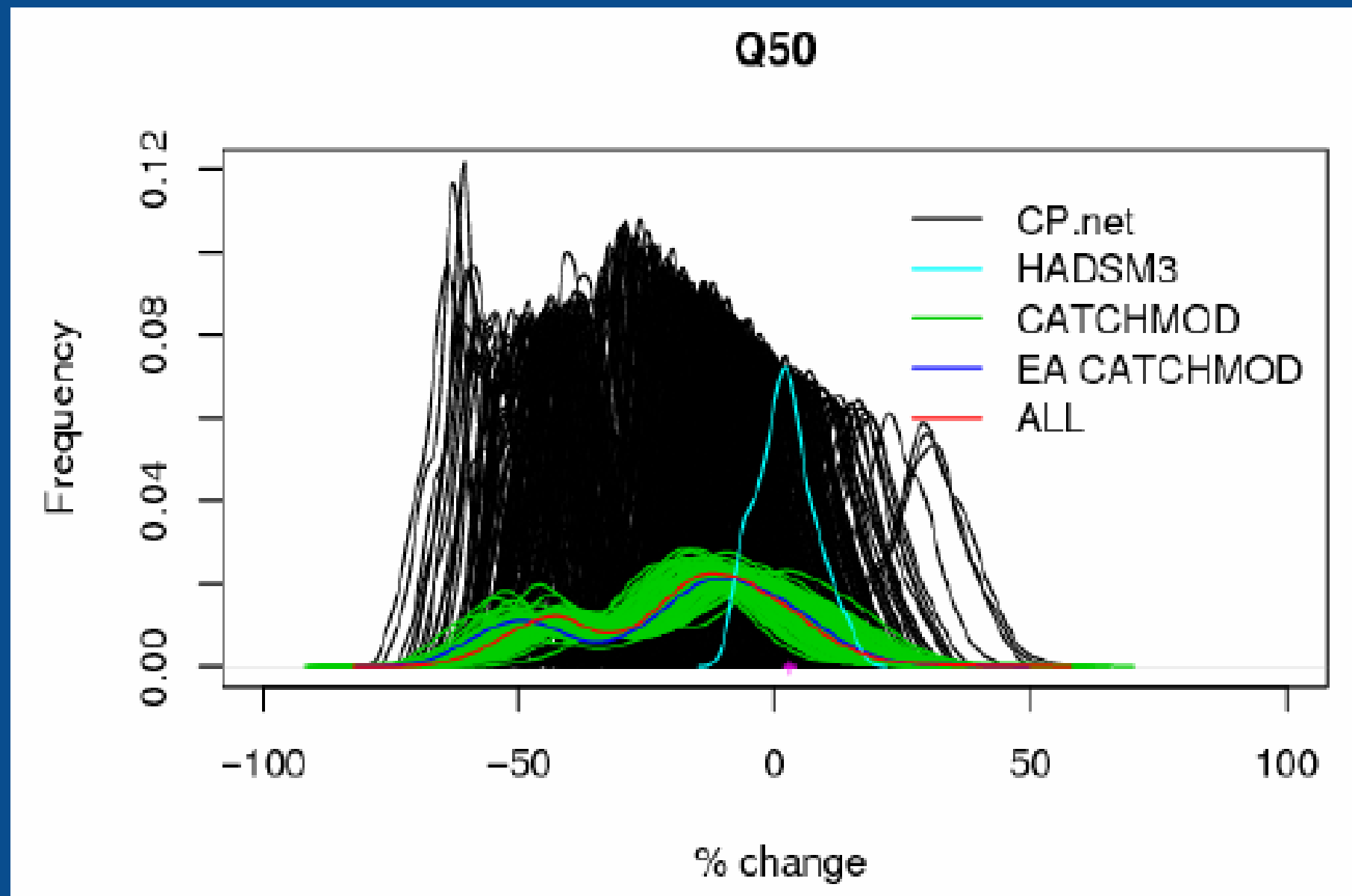
Source: New et al. (2006)

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...combining uncertainties...

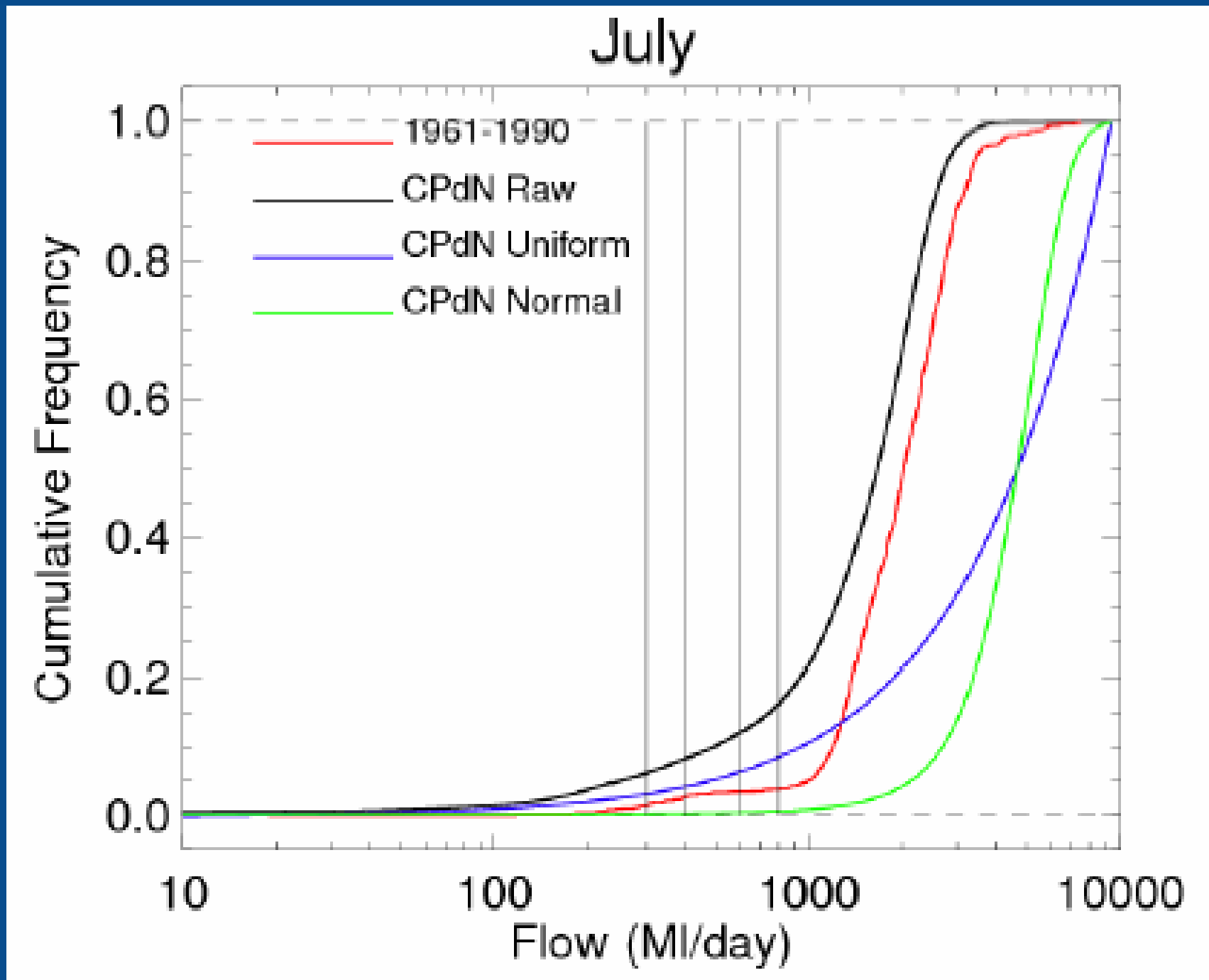


Changes in average (Q50) flows when combining uncertainty in CATCHMOD parameters with CP.net climate scenarios for the Thames grid-box. Source: New et al. (2006)

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Expressed in terms of environmental standards



Cumulative frequencies of July monthly discharge for the River Thames in relation to environmental flows (300, 400, 600 and 800 MI/day) for different reservoir capacities.

Source: New et al. (2006)

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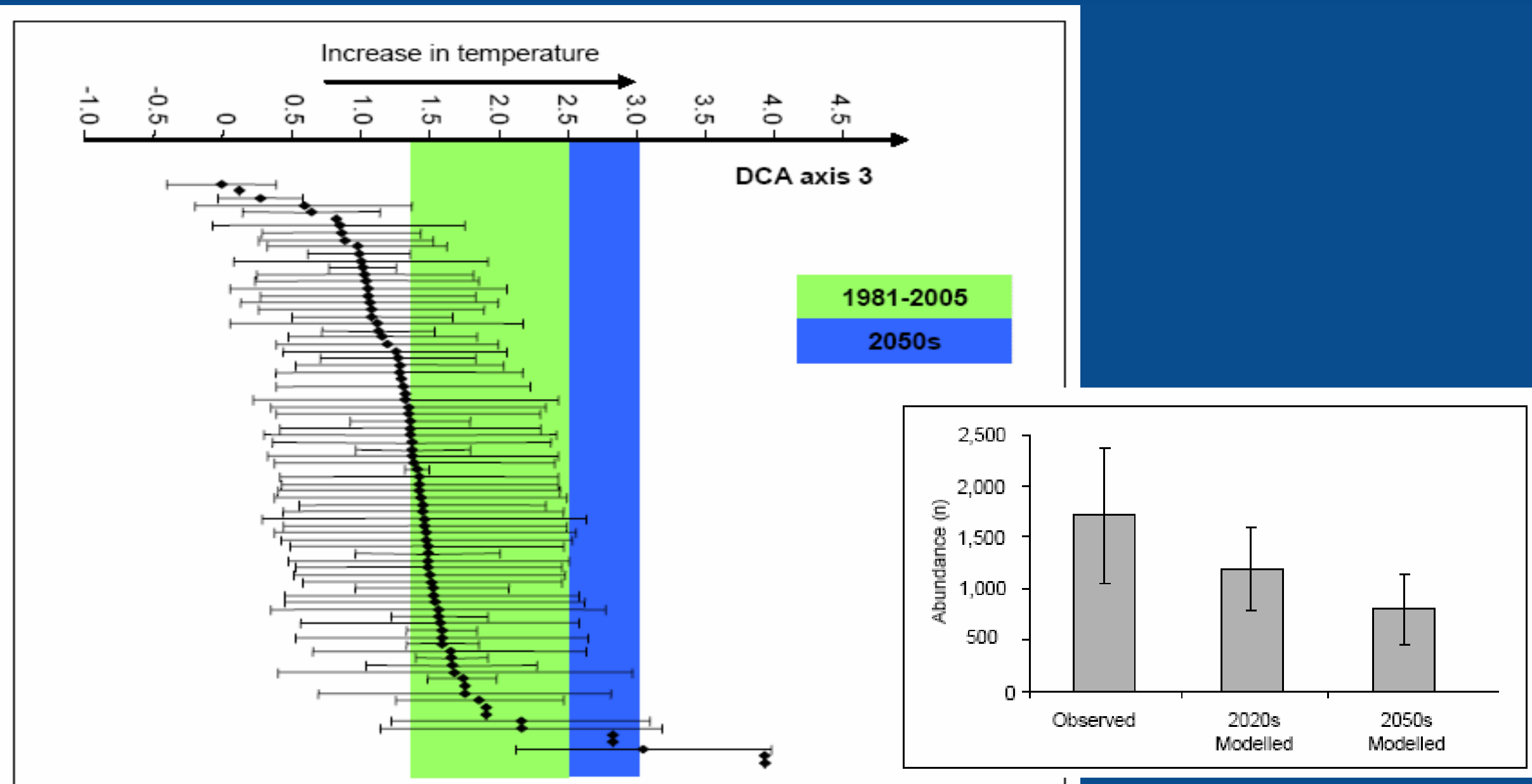
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Other examples of downscaling applications

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'Classic' impact assessments

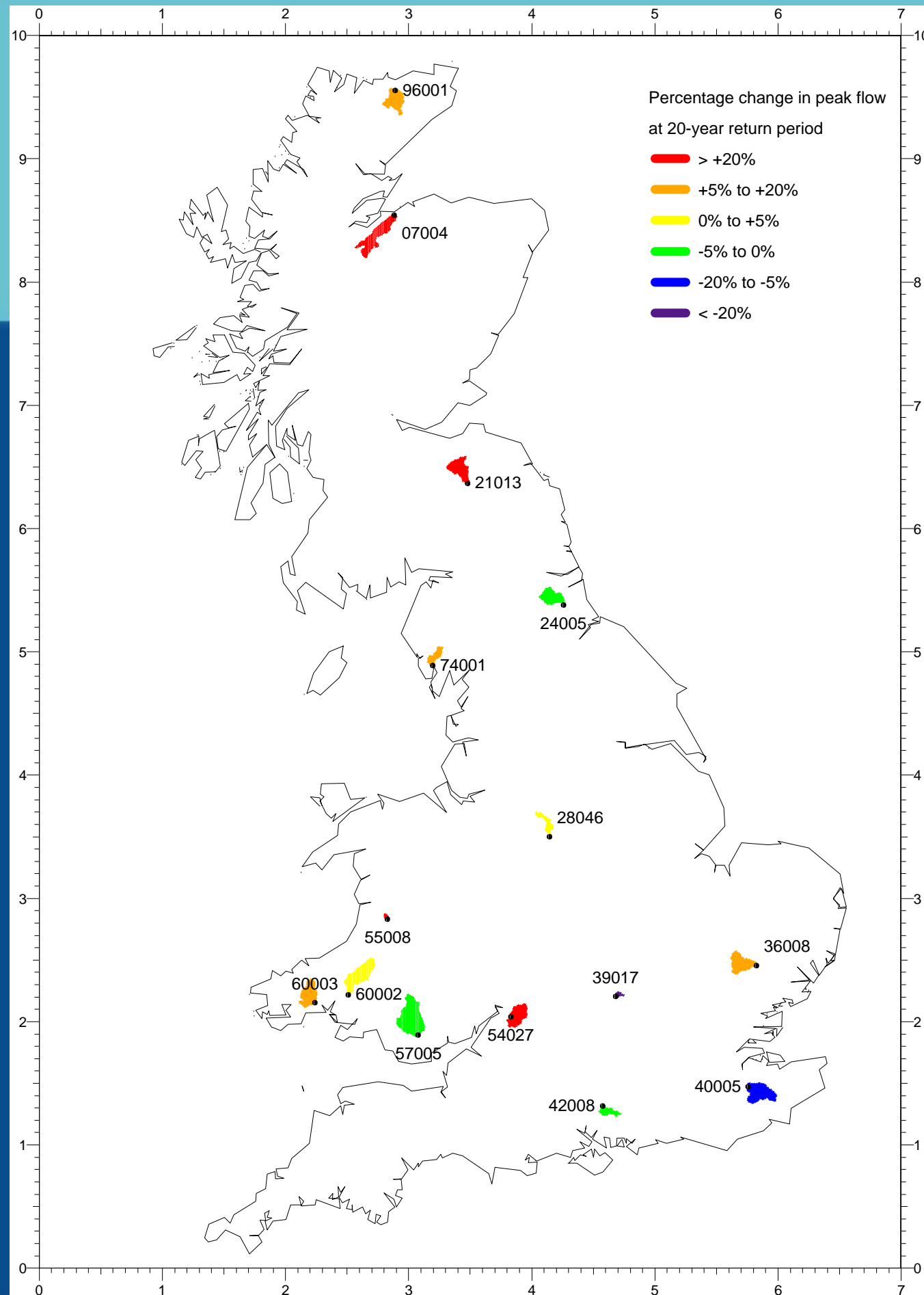


Response of invertebrates in the upper Tywi, Wales to increasing temperatures in terms of preferred ranges (left) and abundance (right). Source: EA (under review)

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Reviewing Defra's 20% sensitivity test for future flood risk

Variations in the 20-year flood by the 2050s under the UKCIP02 Medium-High emissions scenario

Source: Reynard et al. (2004)

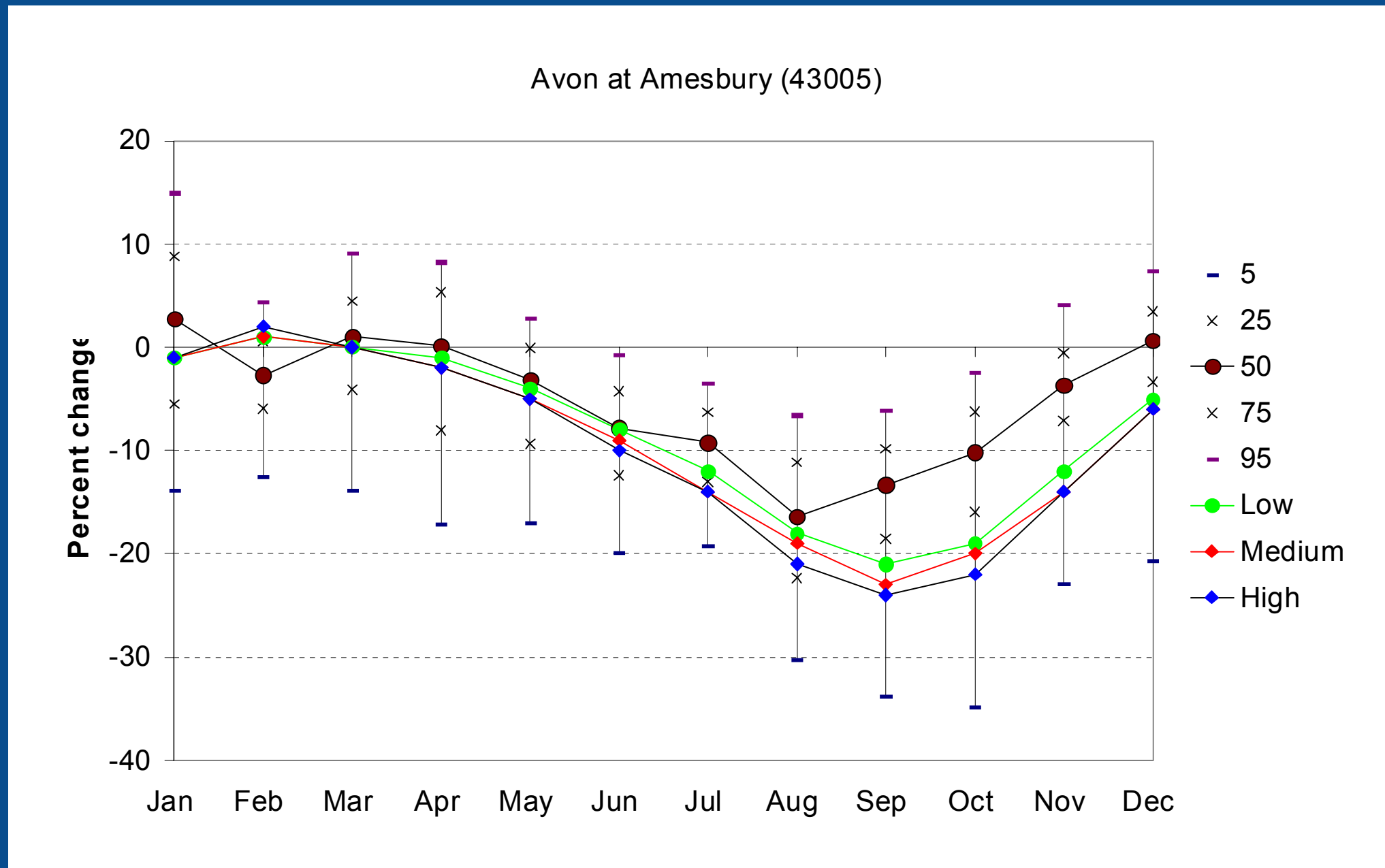
Waves, winds and surge in estuaries



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Practical methodologies for incorporating climate change in water planning



Example climate change factors for river flow by the 2020s. Source: UKWIR/EA. (2006)

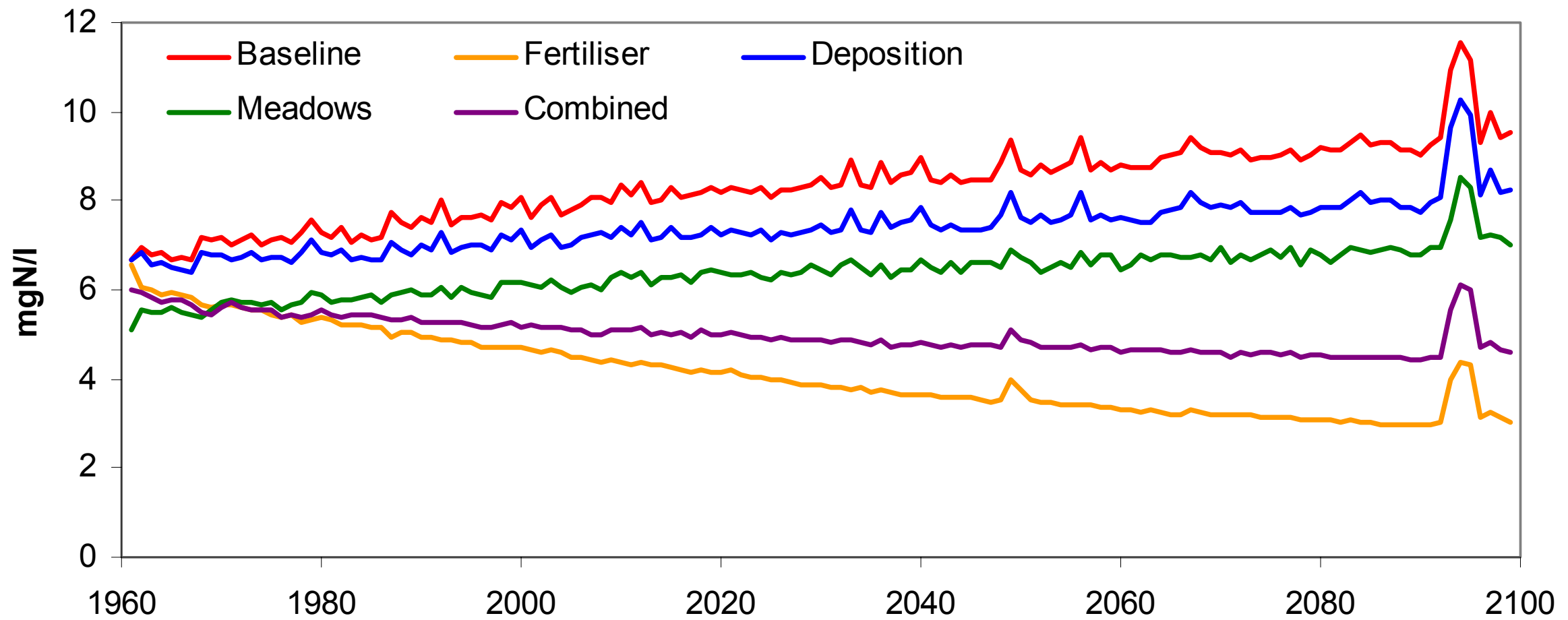
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Appraisal of adaptation measures

Nitrate as nitrogen, A2 emissions



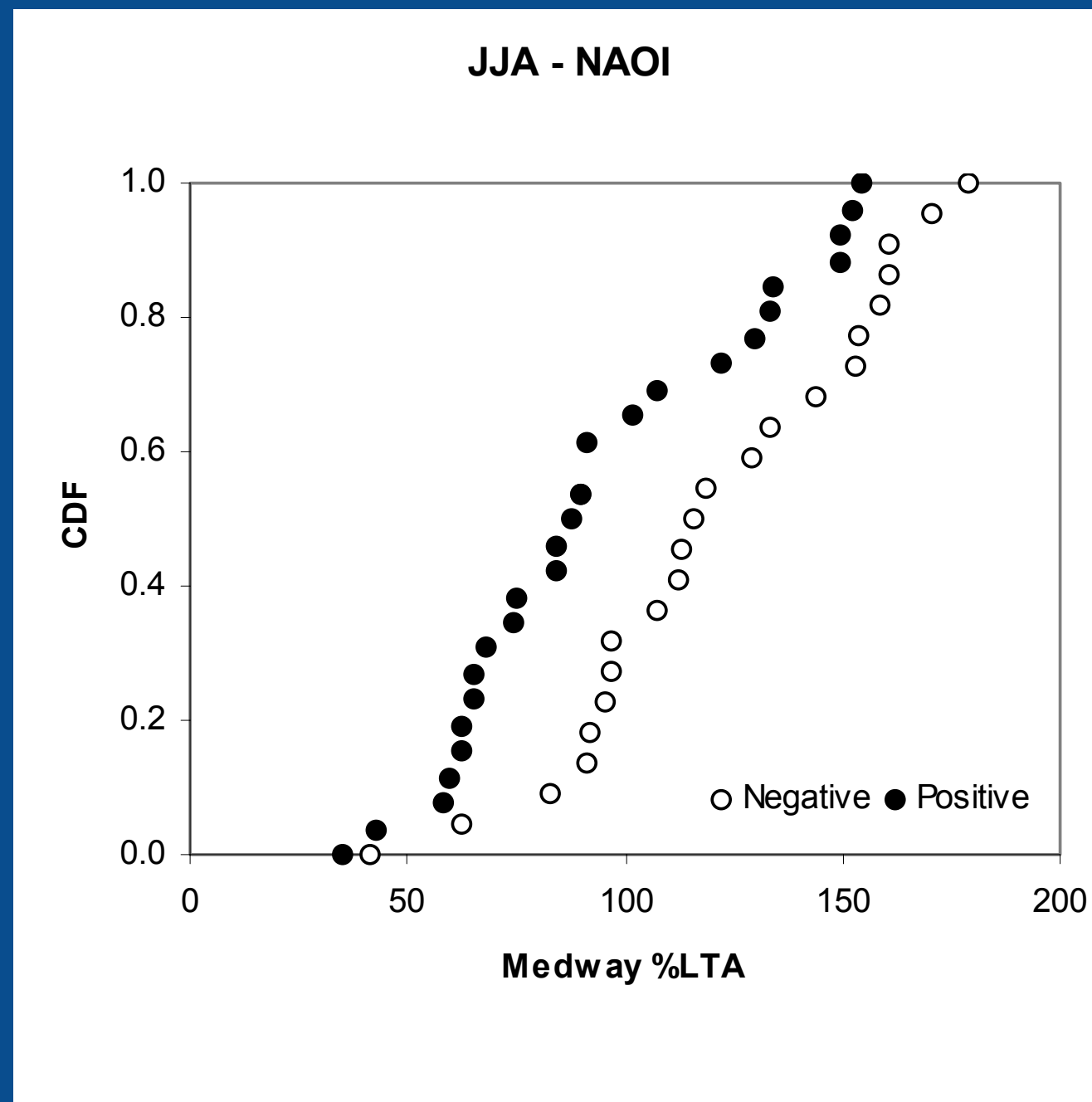
Nitrate concentrations exceeded 5% of the time in the River Kennet under the HadCM3 A2 emissions scenario

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Seasonal forecasting



Summer rainfall (expressed as % long term average) in the River Medway, conditional on winter NAO index.

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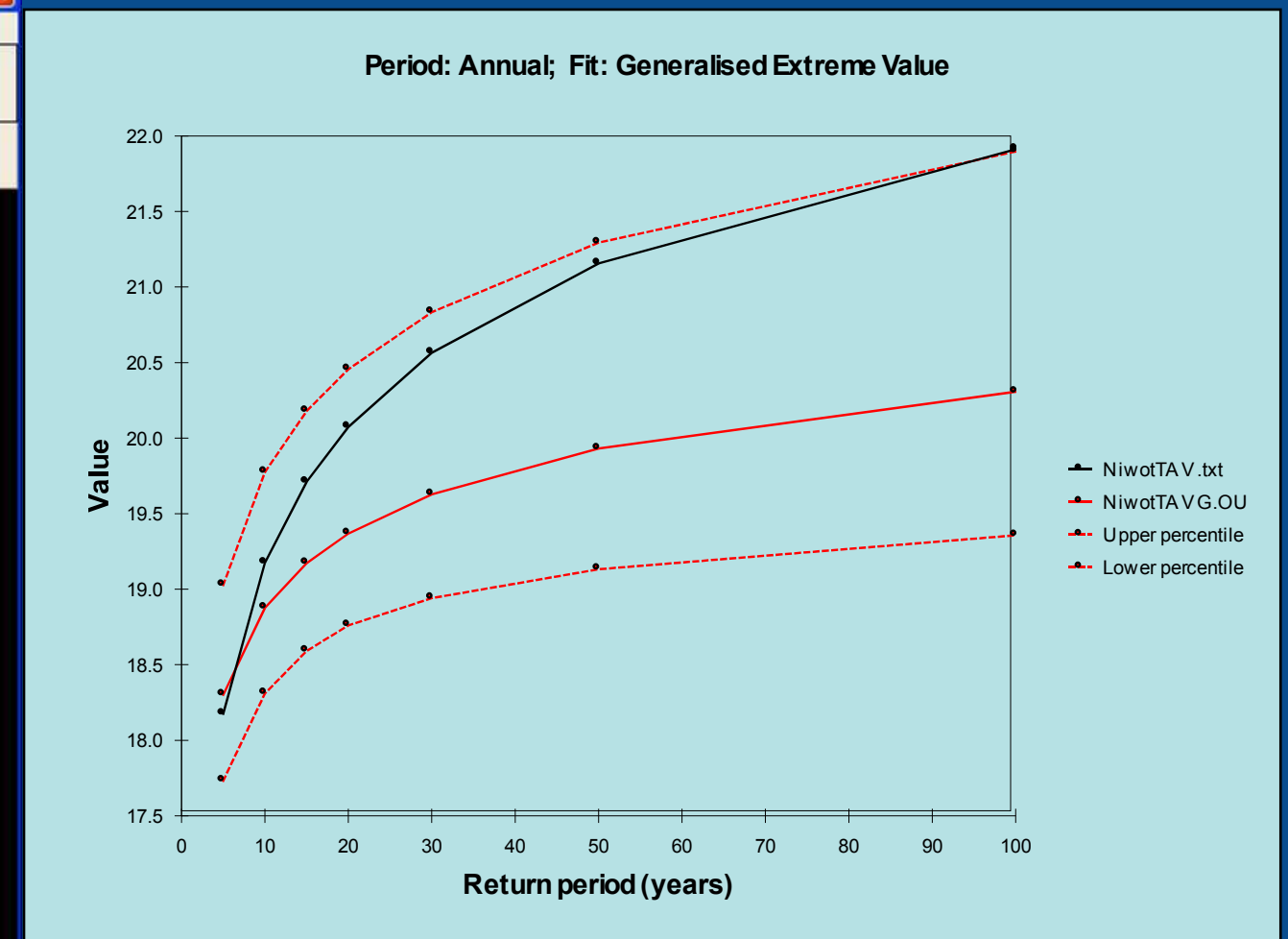


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New functionality for downscaling extreme events in SDSM v4.1

The screenshot shows the 'Frequency Analyses' software window. It features a menu bar (File, Edit, Help) and a toolbar with various analysis options. The main interface is divided into several sections:

- Observed Data:** Includes a 'Select Observed Data' button and a file path 'File: NiwotTAV.txt'.
- Modelled Data:** Includes a 'Select Modelled Data' button and a file path 'File: NiwotTAVG.OUT'.
- Analysis Period:** Fields for 'Analysis start date: 01/01/1961' and 'Analysis end date: 31/12/2000'.
- Data Period:** A dropdown menu set to 'All Data'.
- Ensemble:** Radio buttons for 'All Ensembles', 'Ensemble Mean', 'Ensemble Member: 0', and 'All + Mean Ensemble'.
- Threshold:** A checkbox for 'Apply threshold?'.
- PDF Categories:** A field for 'No of PDF categories' set to '20'.
- Frequency Analysis:** Radio buttons for 'Empirical', 'GEV', 'Gumbel', and 'Stretched Exponential'. Below these are input fields for 'Threshold: 10' and 'P value (%): 5', and a 'Save Results To' button with 'File: Not selected'.



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Tools for regional climate change impact assessments

The screenshot shows the EARWIG v1.0 software interface. On the left, a list of catchments is displayed, with '076004 - Lowther at Eamont Bridge' selected. Below the list are input fields for finding catchments by OS National Grid coordinates (E and N) and WGS84 Lat/Long coordinates. The main area shows a map of the UK with a red grid overlay. A cyan square highlights a specific grid cell, with two black arrows pointing from its corners to a photograph of a river landscape. At the bottom, the status bar shows 'Total area selected = 100 Square Kilometres' and coordinates 'E: 302361.2 N: 491792.5'.



Example screen for the Environment Agency Rainfall and Weather Impacts Generator (EARWIG)

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Concluding remarks

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Six challenges ahead

- Shifting from academic studies to support for climate change adaptation
- Promoting best practise and case studies where downscaling is actually shaping decision-making
- Representing uncertainty in terms of *timing*
- Downscaling within probabilistic frameworks
- Addressing technical challenges of extreme events
- Translating new insights of uncertainty into guidance for practitioners