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

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

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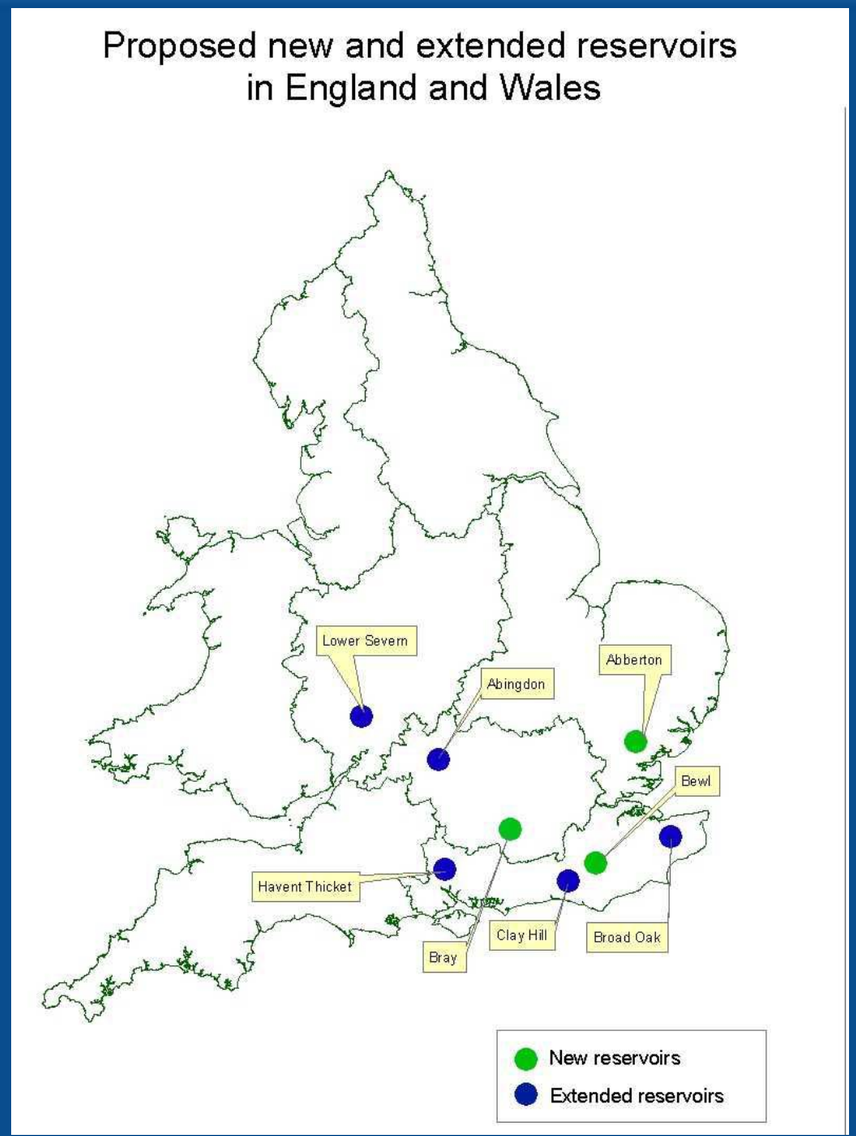

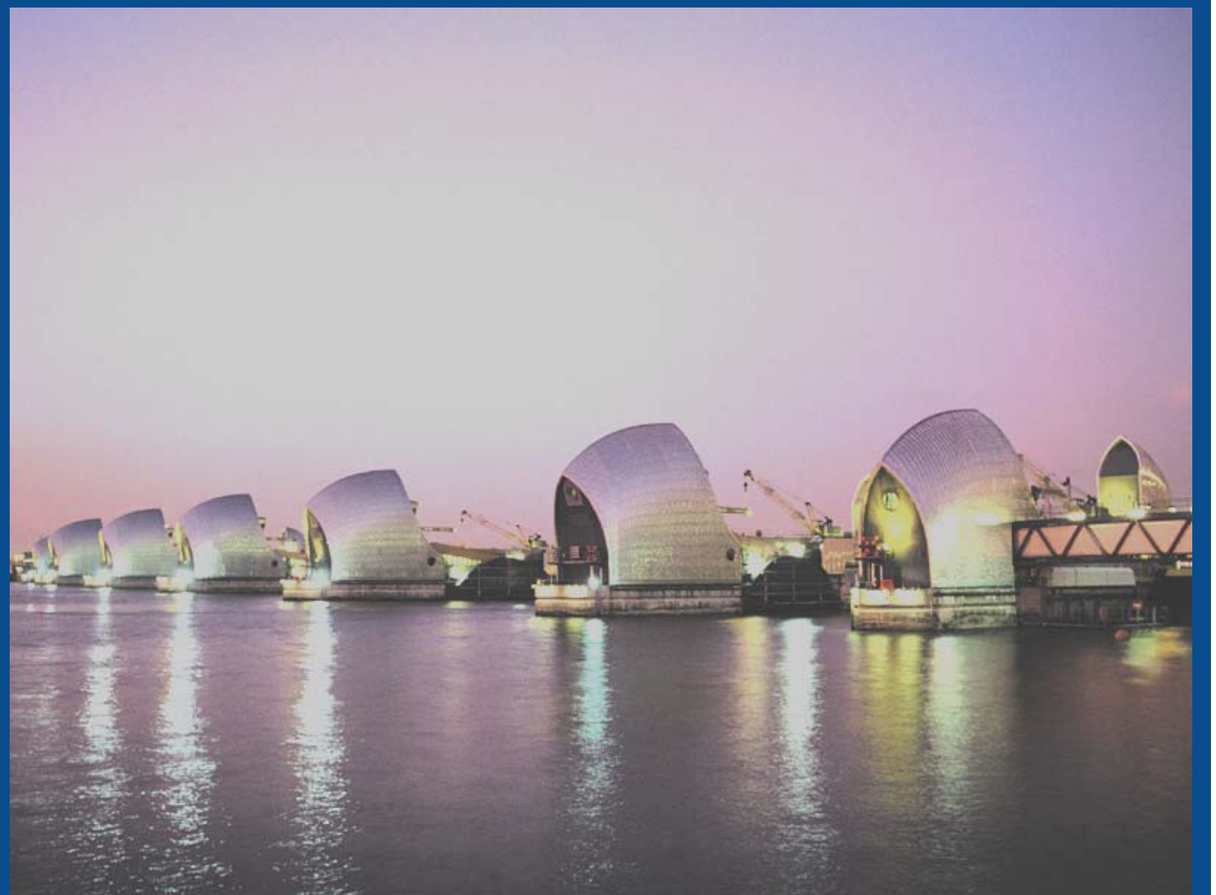

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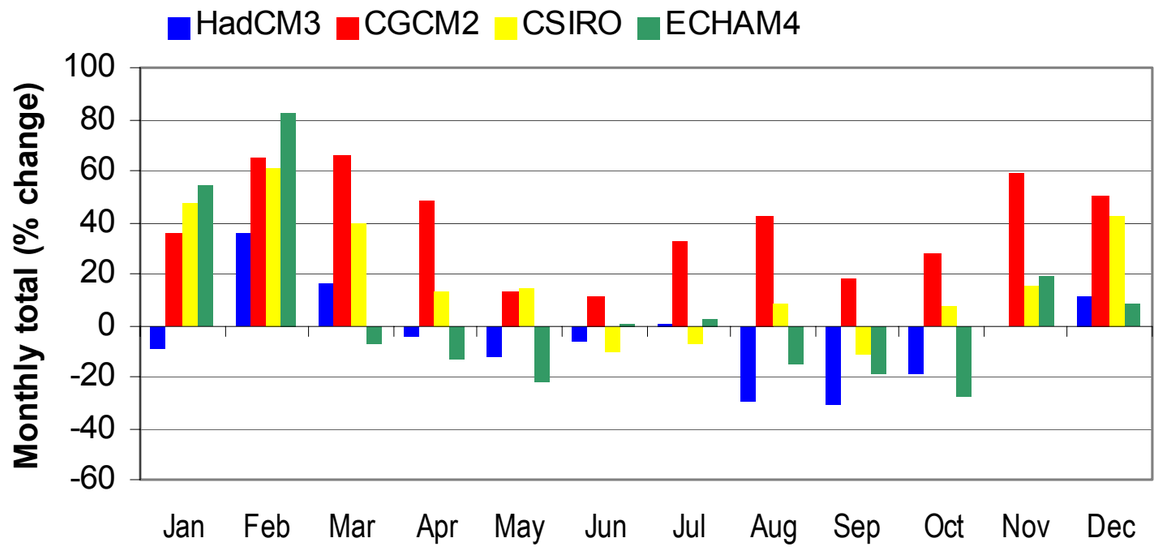
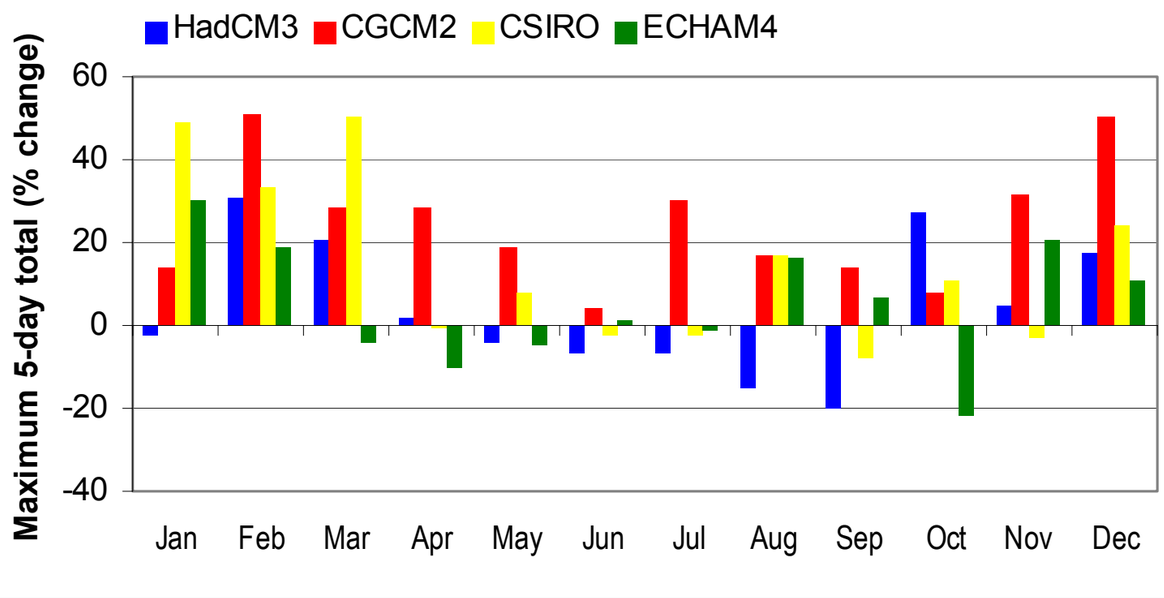
…in the face of much uncertainty...





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

Downscaling is at the heart of the uncertainty cascade

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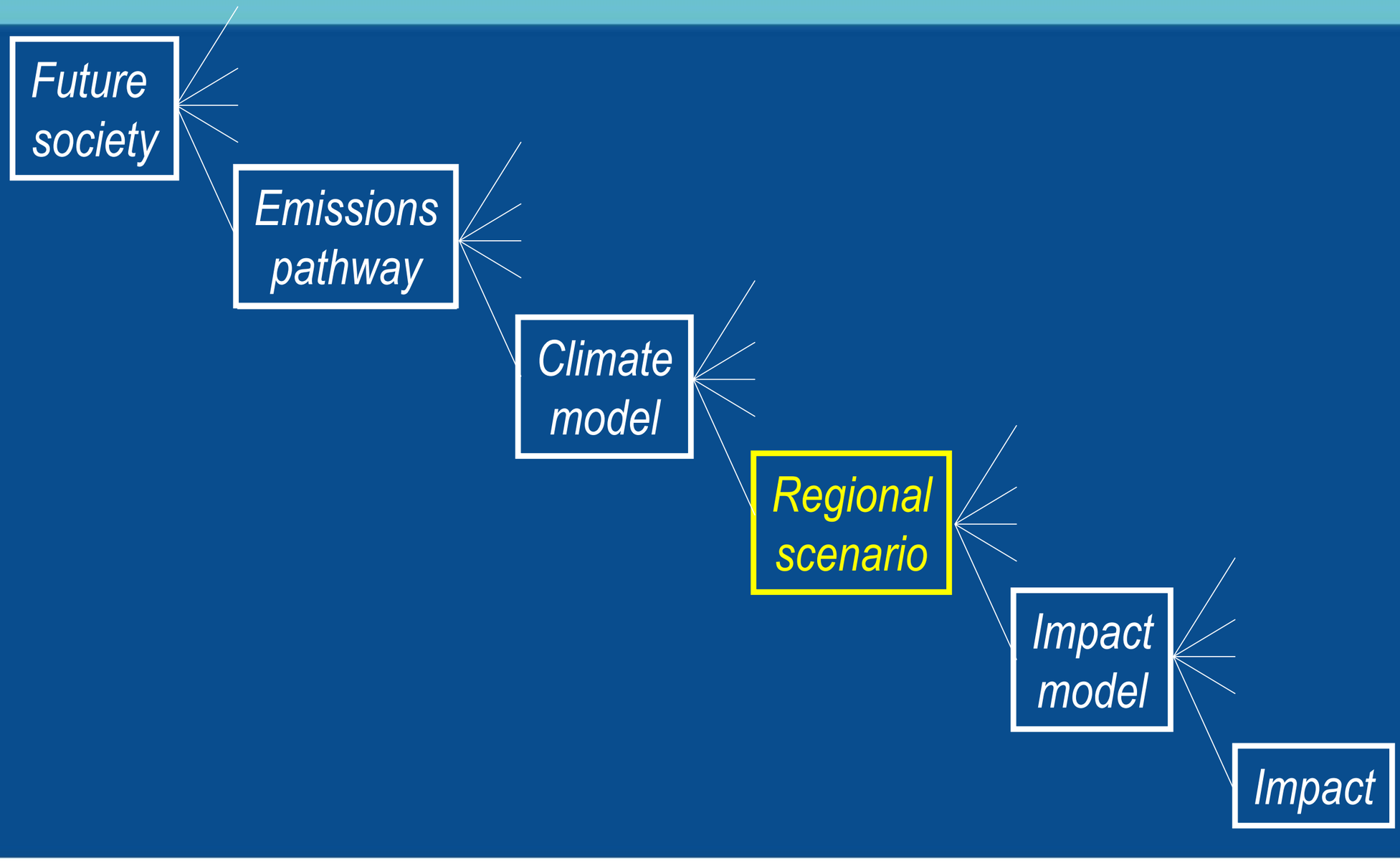

An experimental framework for assessing uncertainties

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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 the River Thames

Uncertainties due to GCM/ downscaling pair

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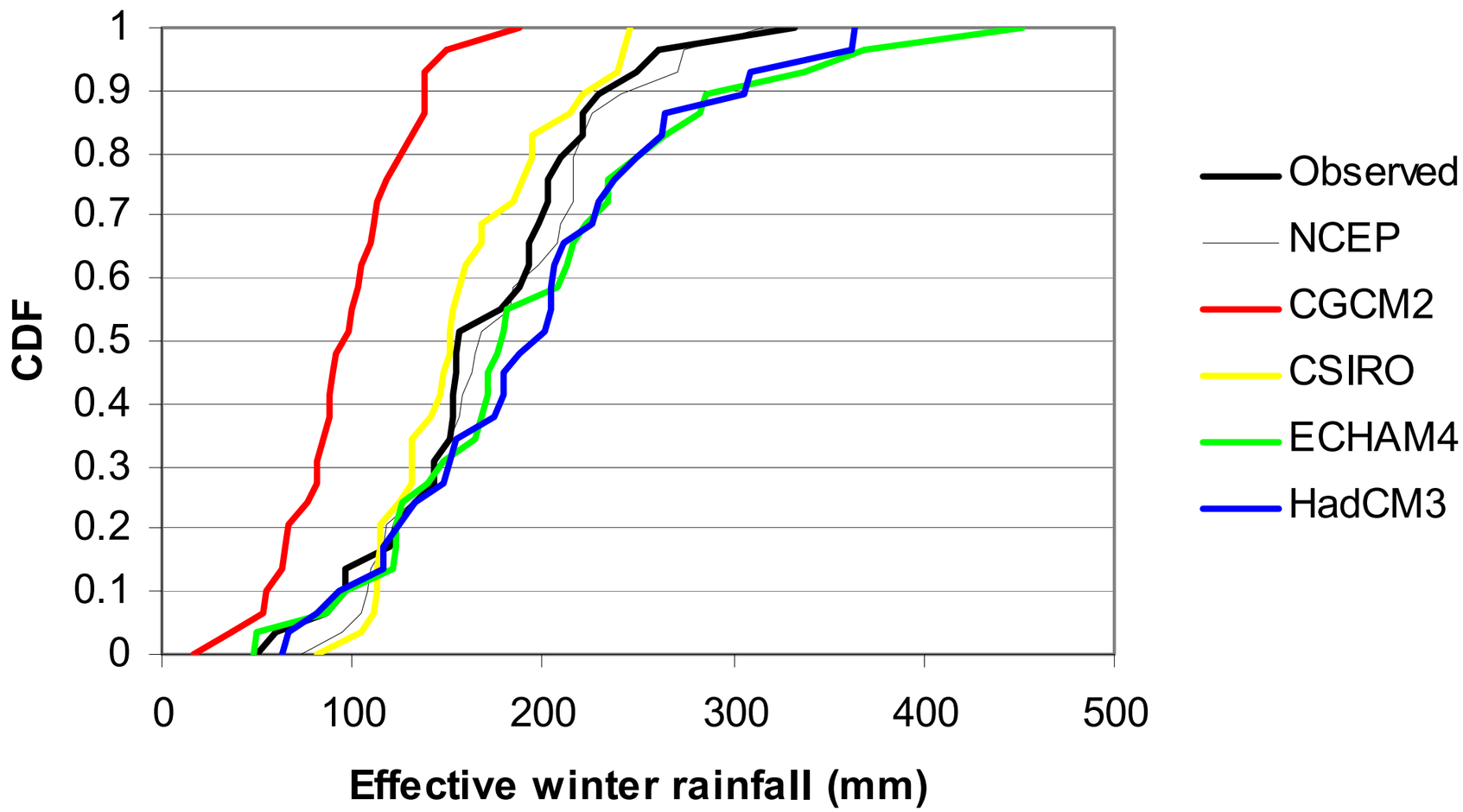

An Impacts Relevant Climate Prediction Index

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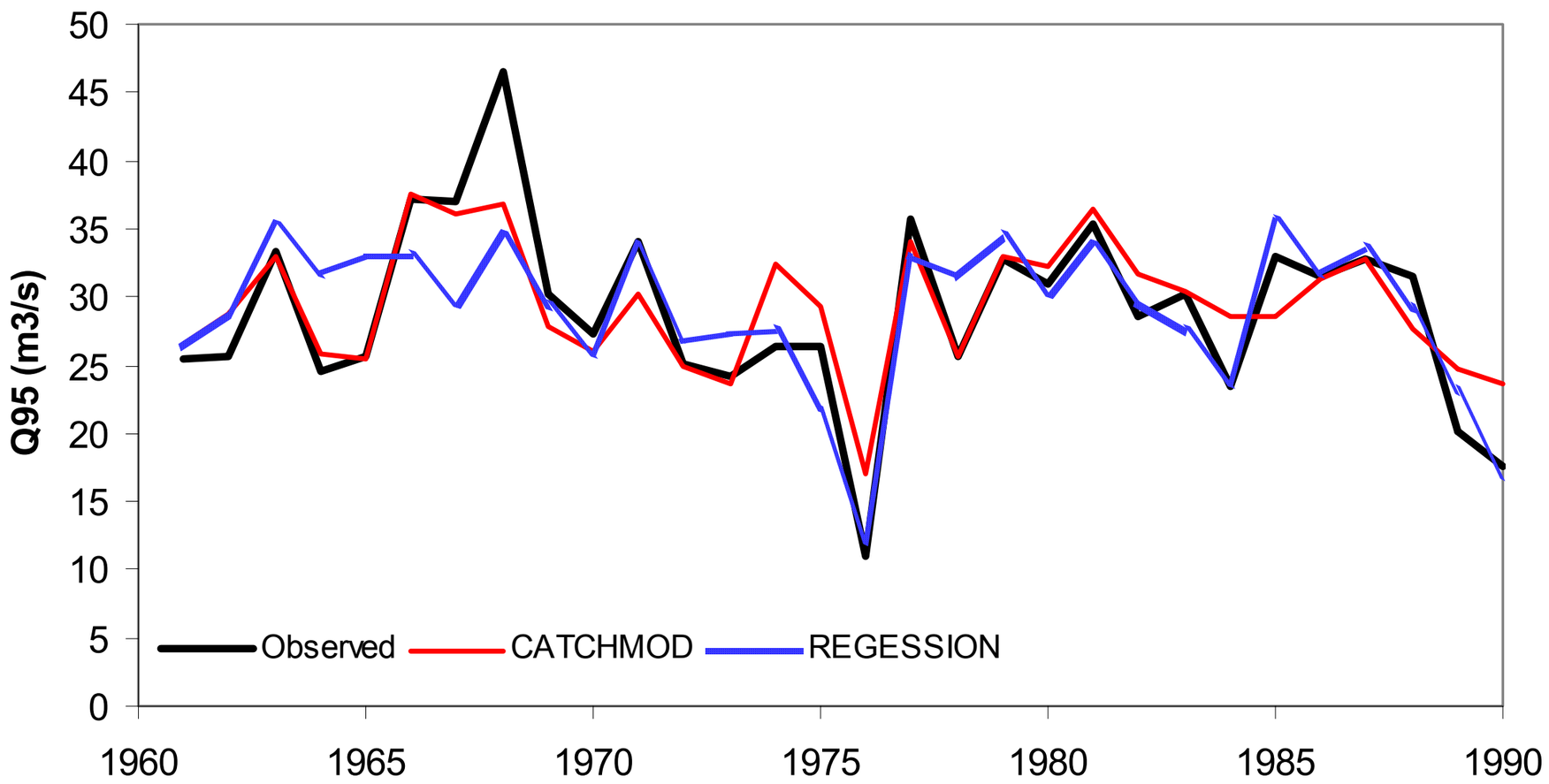
Model	Summer		Winter	
	Bias (%)	*Weight*	*Bias (%)*	*Weight*
CGCM2	52.1	0.138	42.2	0.074
CSIRO	14.3	0.503	6.0	0.522
ECHAM4	49.6	0.145	16.1	0.194
HadCM3	33.6	0.214	14.9	0.210
NCEP	7.6	n/a	4.8	n/a

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

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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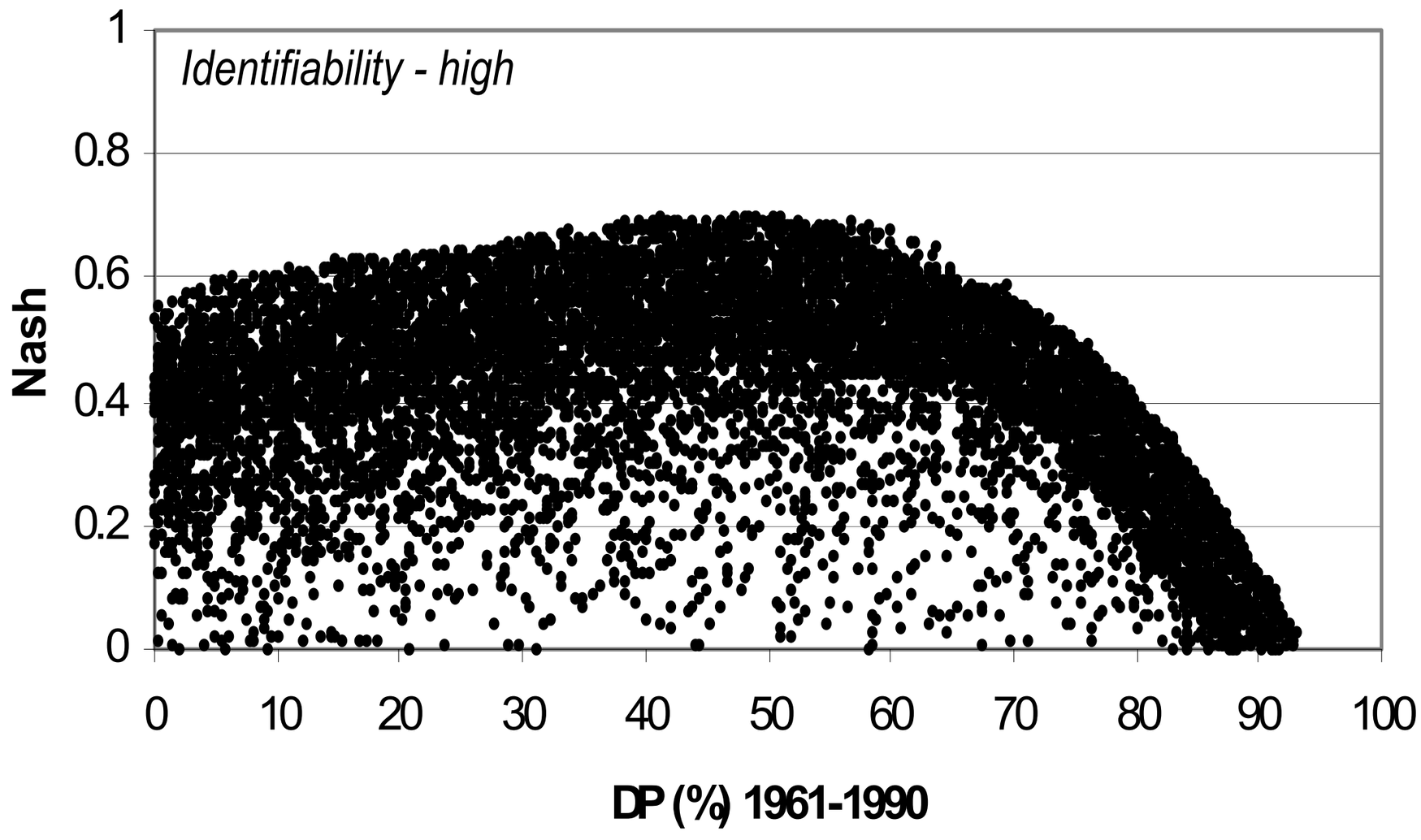
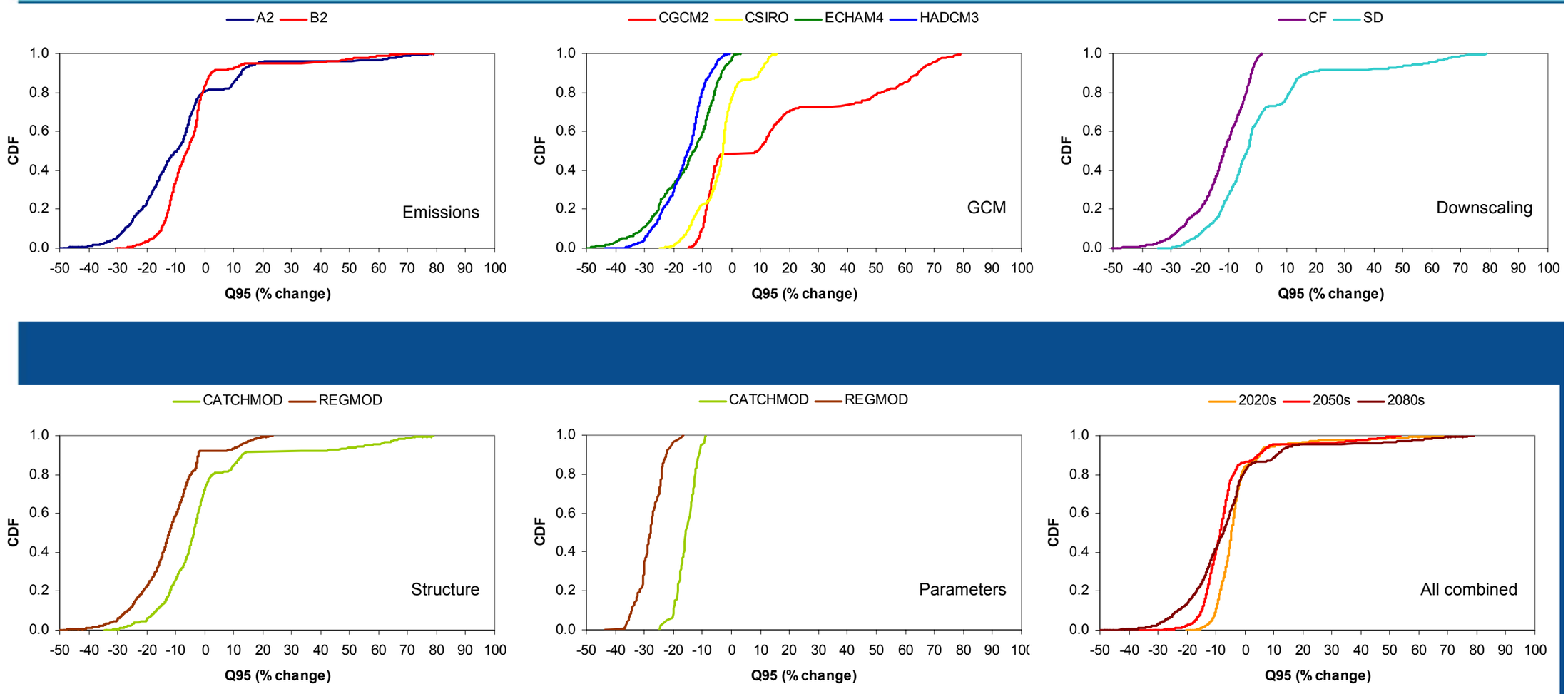


End-to-end uncertainty analysis



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

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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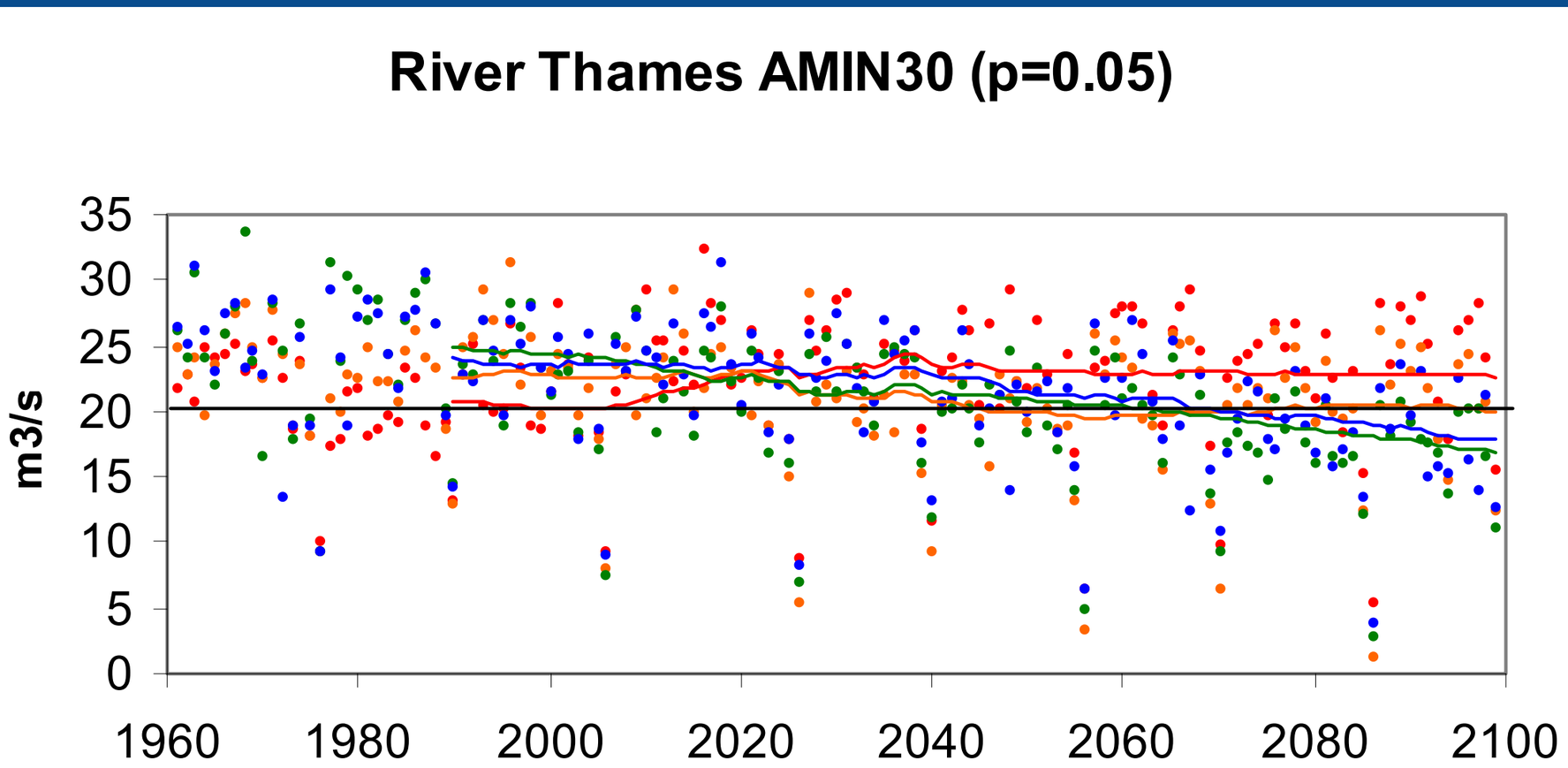

30-day annual minimum flow series in the River Thames
reflecting uncertainty due to GCM boundary forcing 1961-2100

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Downscaling from large ensemble GCM experiments

Impacts assessment using mega-model ensembles...

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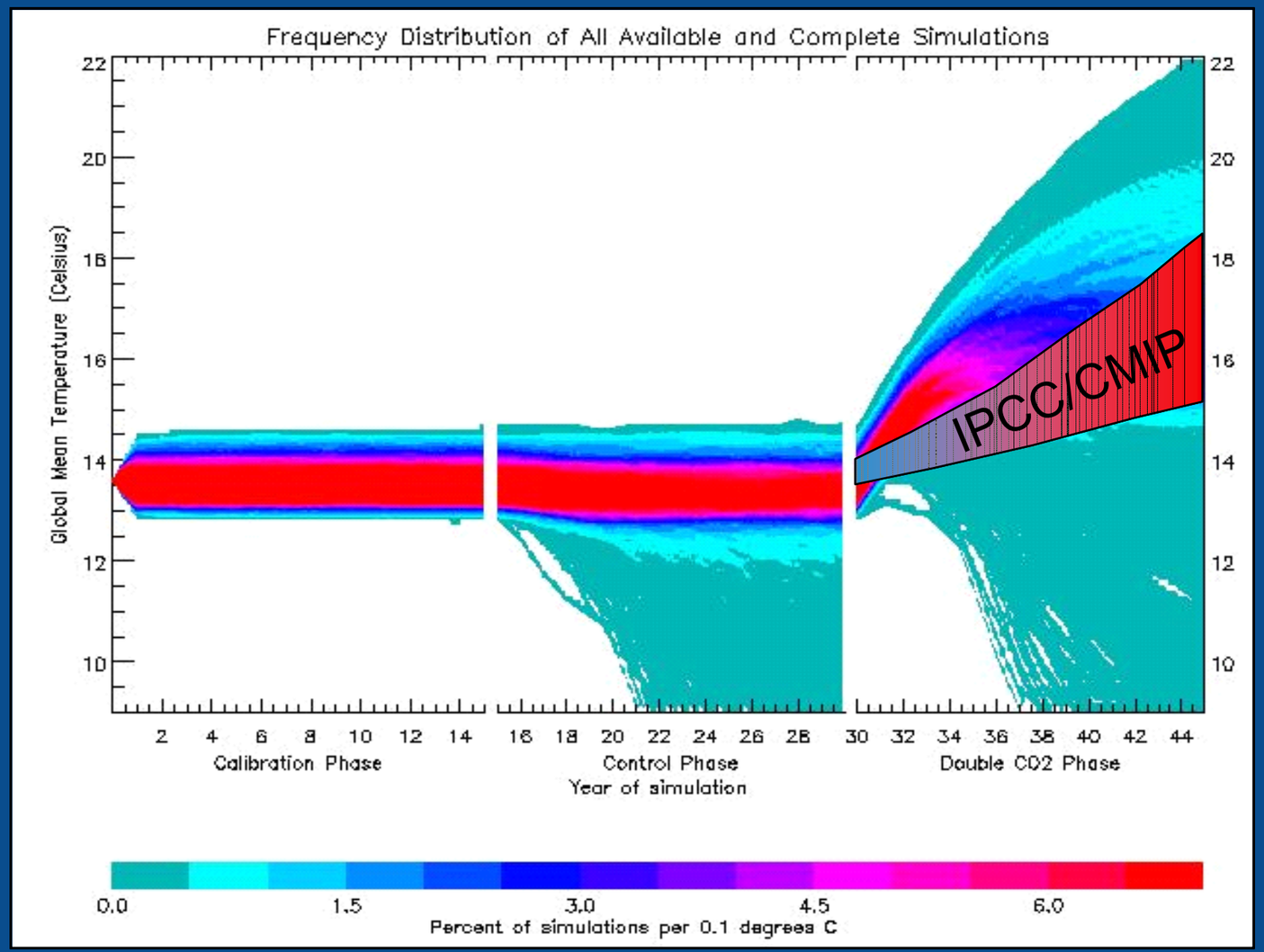
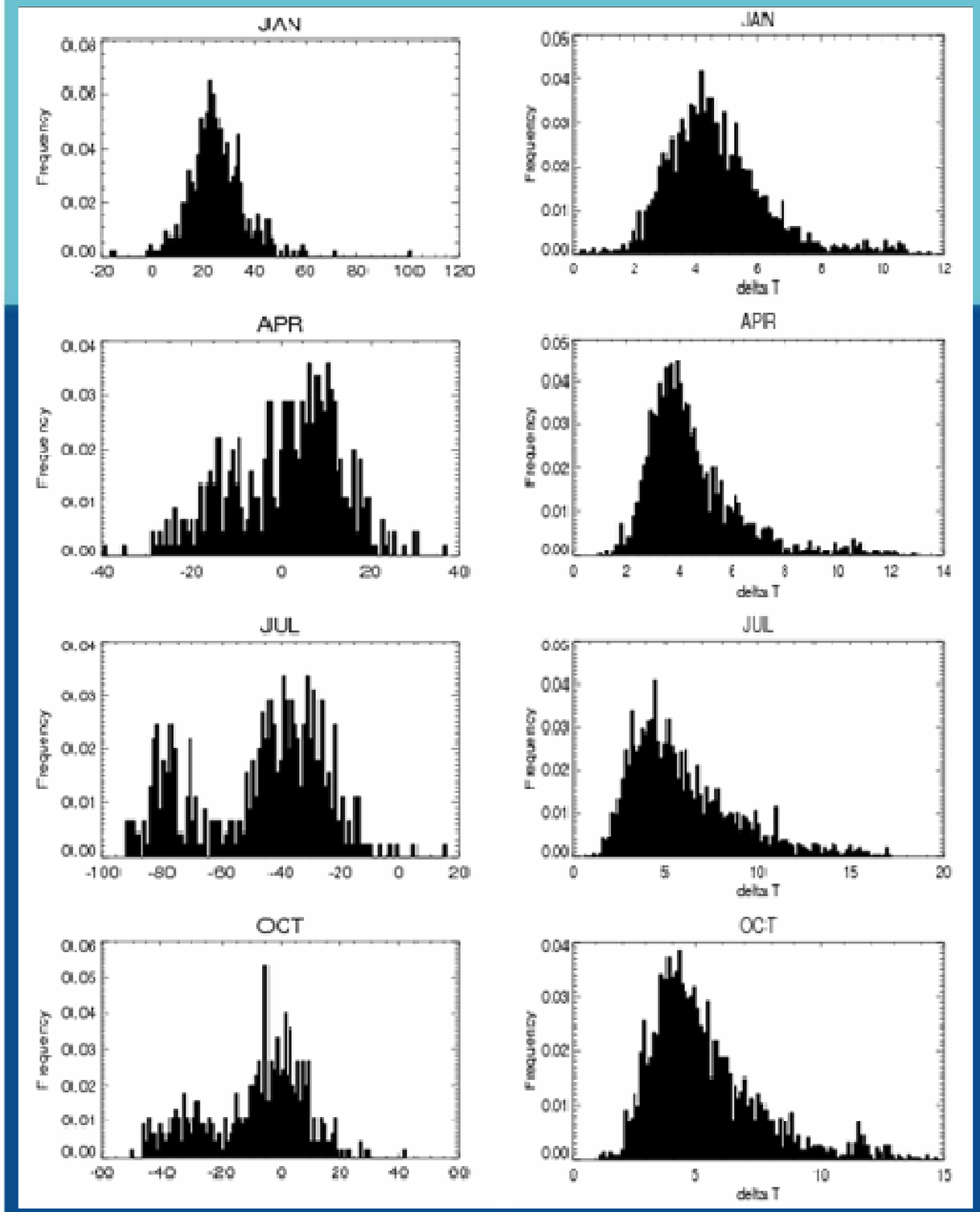


Frequency distribution of global mean temperature response to doubled CO_2 produced by CP.net, compared with the IPCC (2001) range.

Source: Stainforth et al. (2005)



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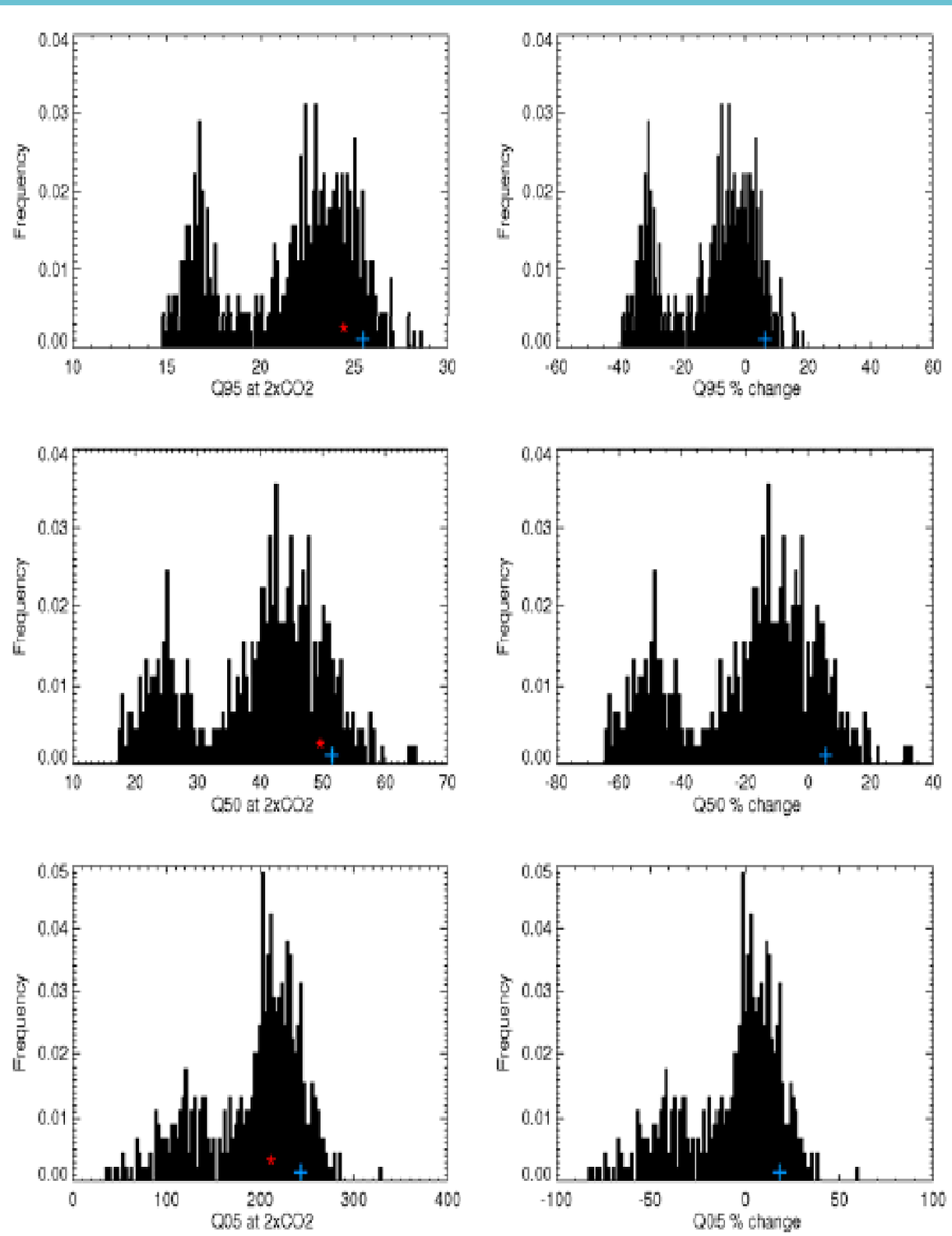
Climate model uncertainty...

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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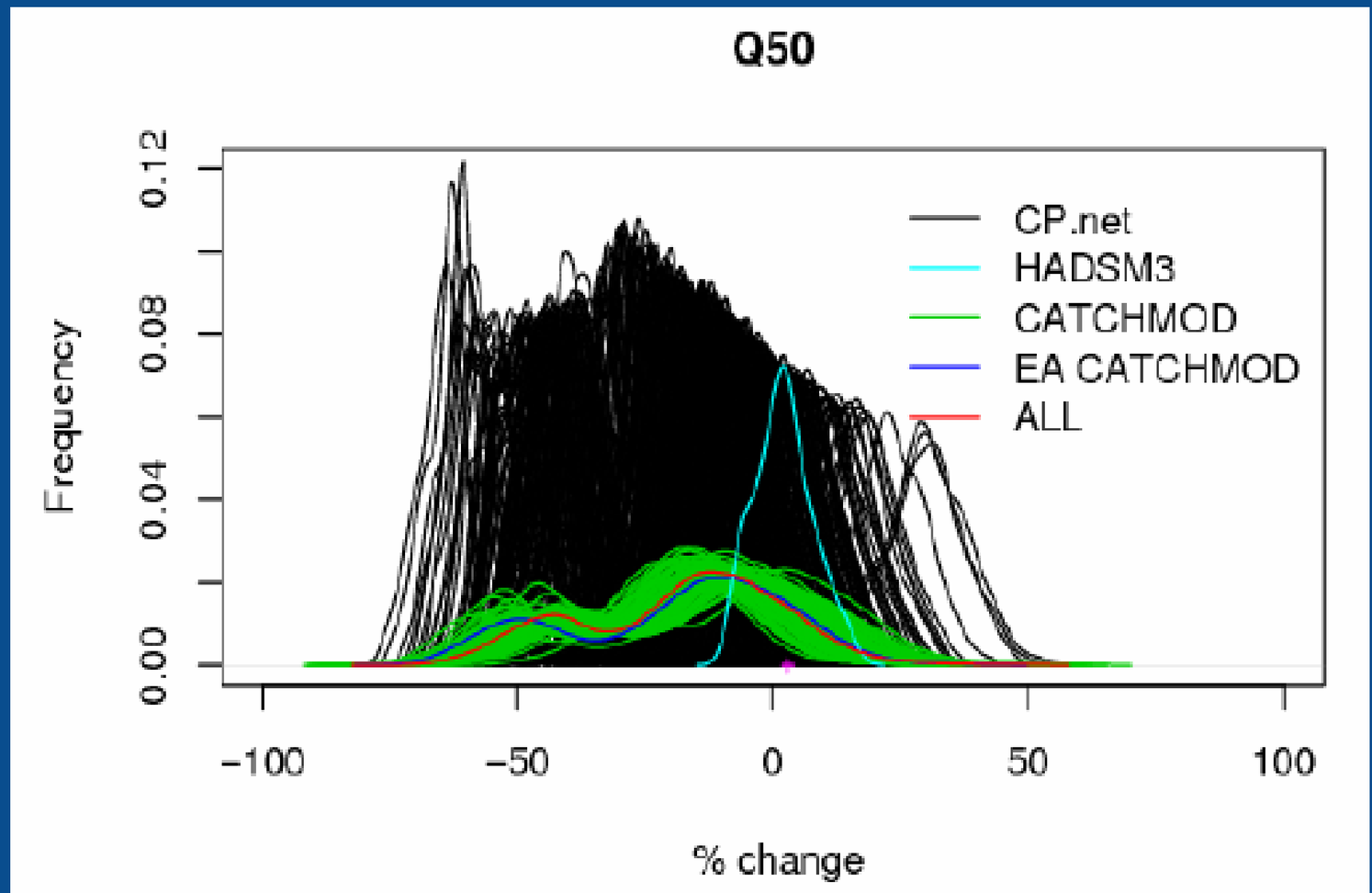
...combining uncertainties...



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)

Expressed in terms of environmental standards

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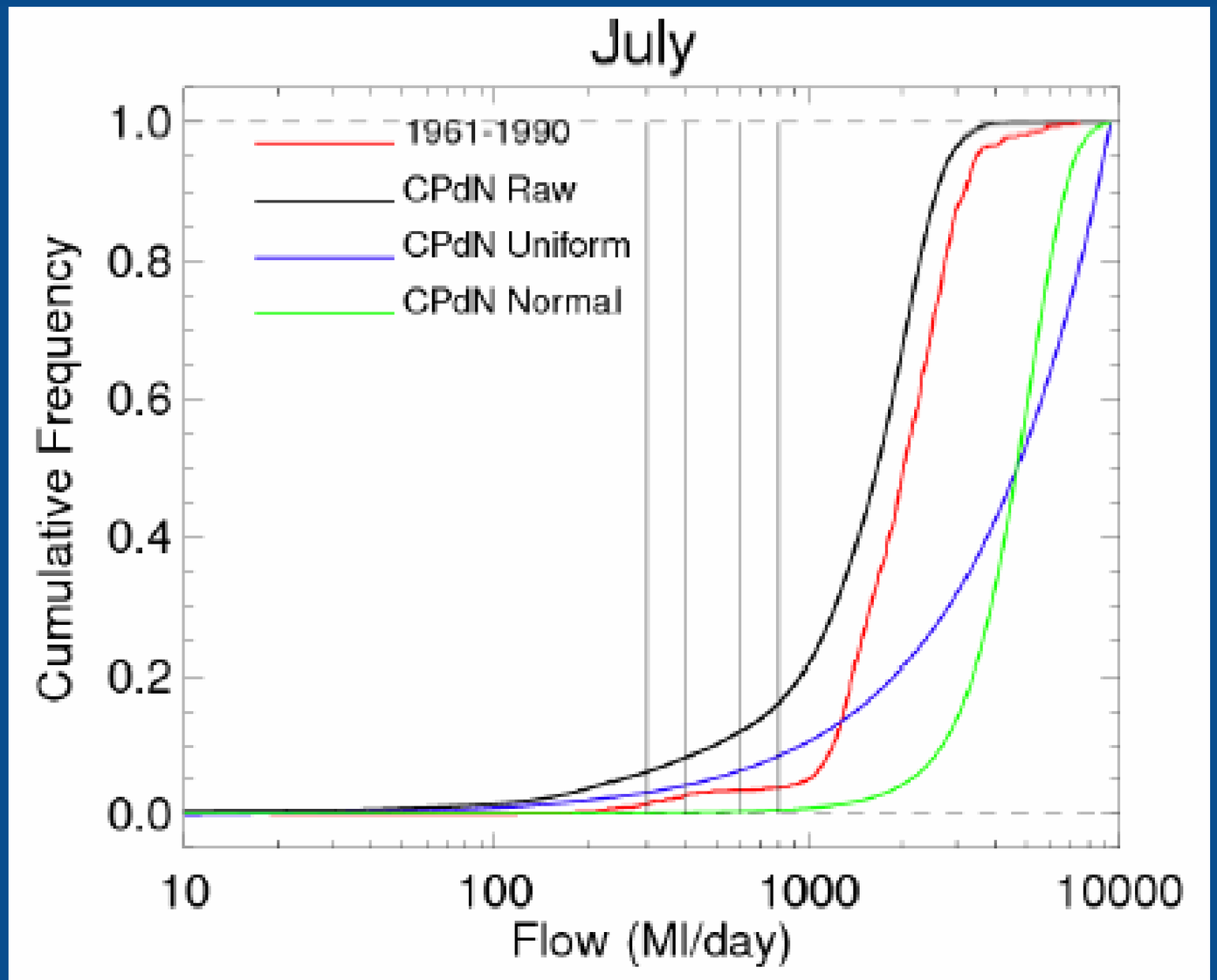

Cumulative frequencies of July monthly discharge for the River Thames in relation to environmental flows (300, 400, 600 and 800 Ml/day) for different reservoir capacities.

Source: New et al. (2006)

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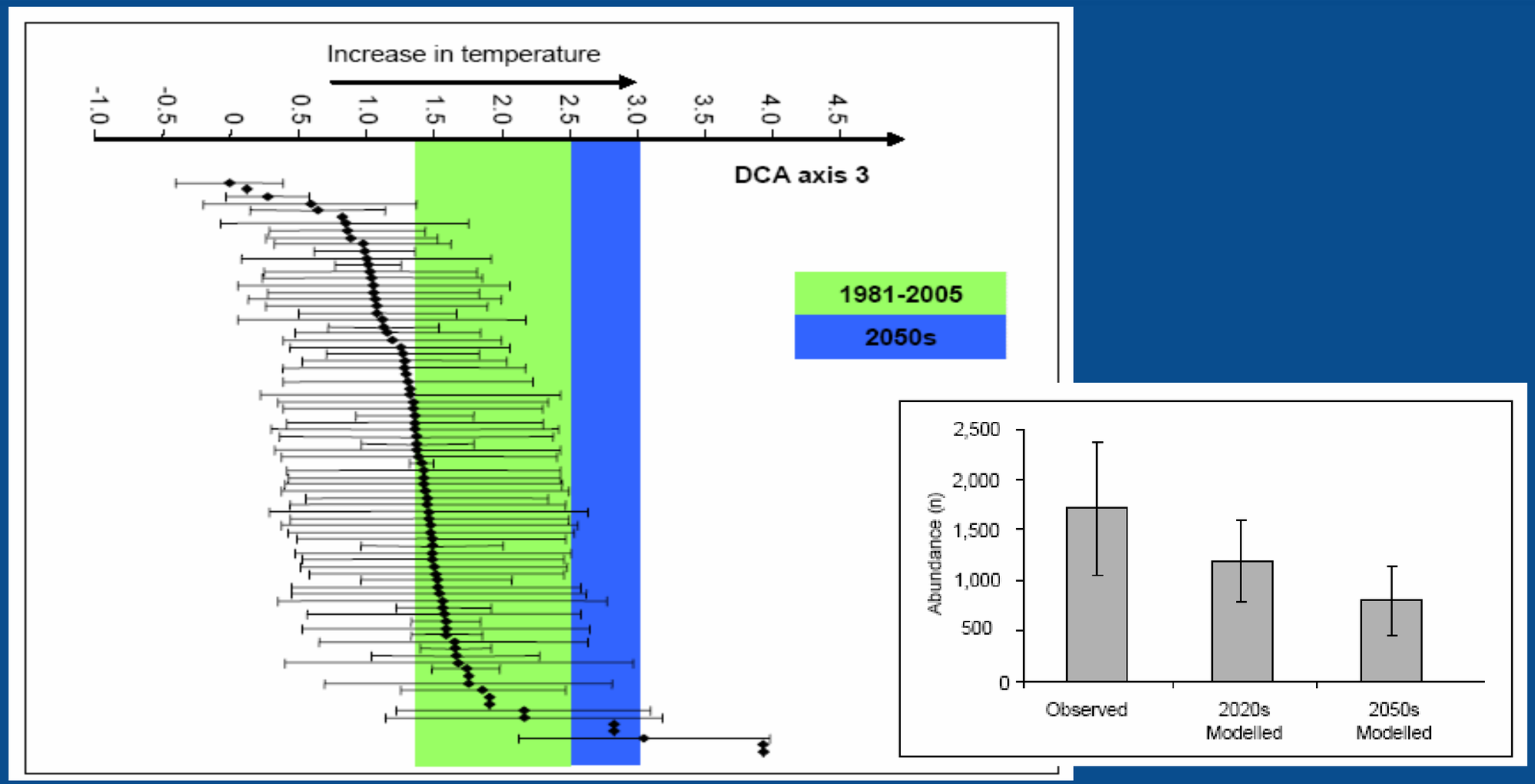
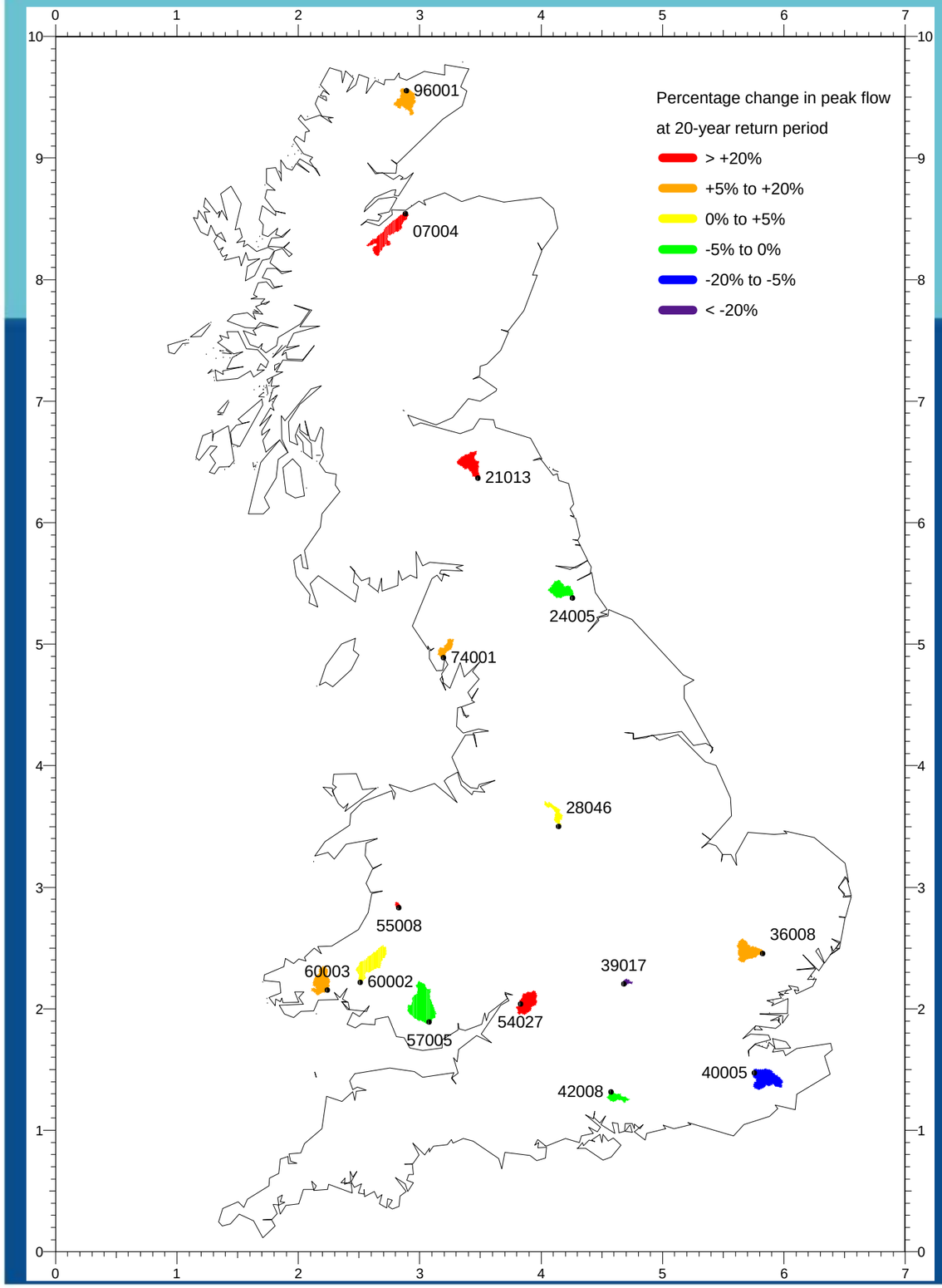
Other examples of downscaling applications

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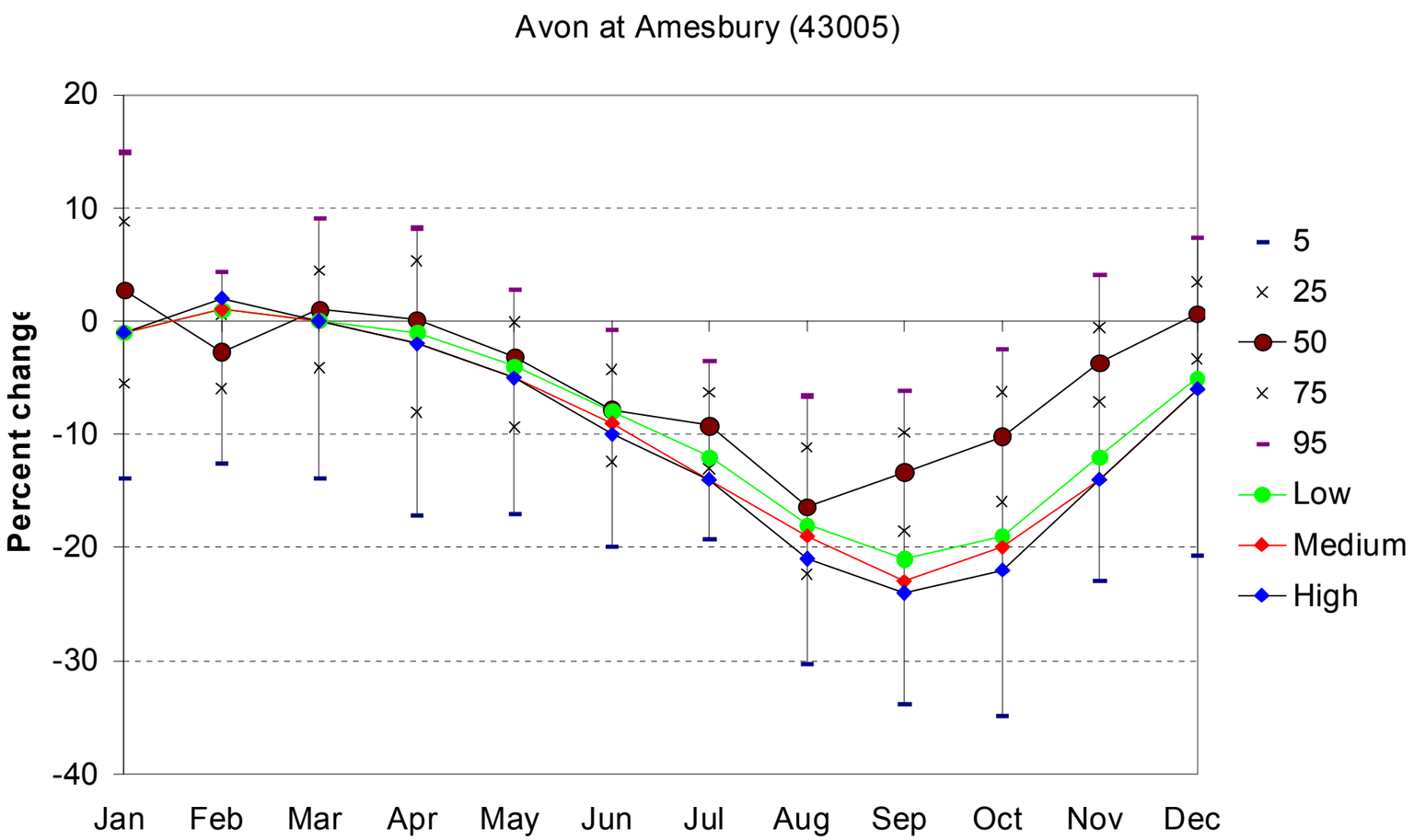
Reviewing Defra's 20% sensitivity test for future flood risk

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

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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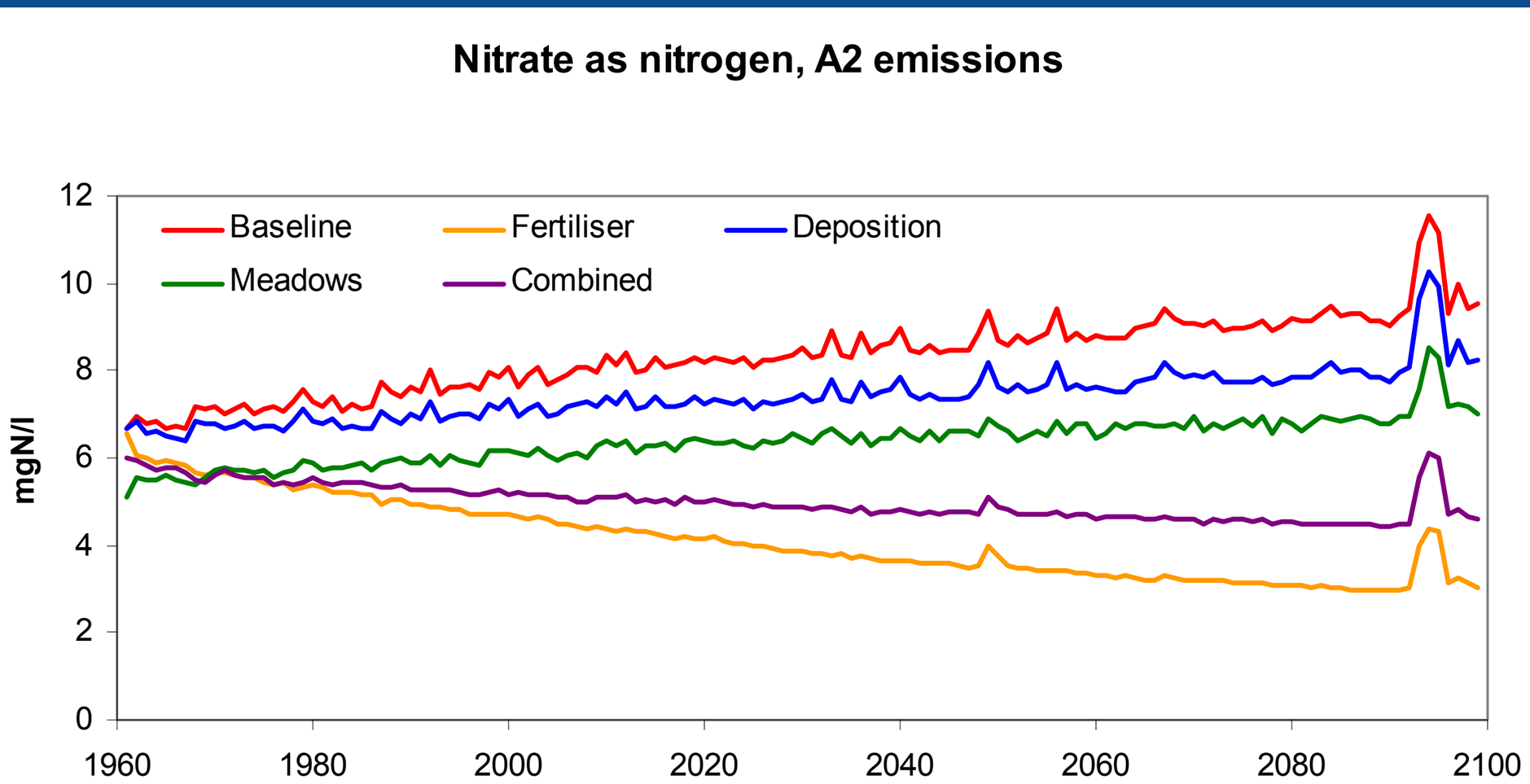
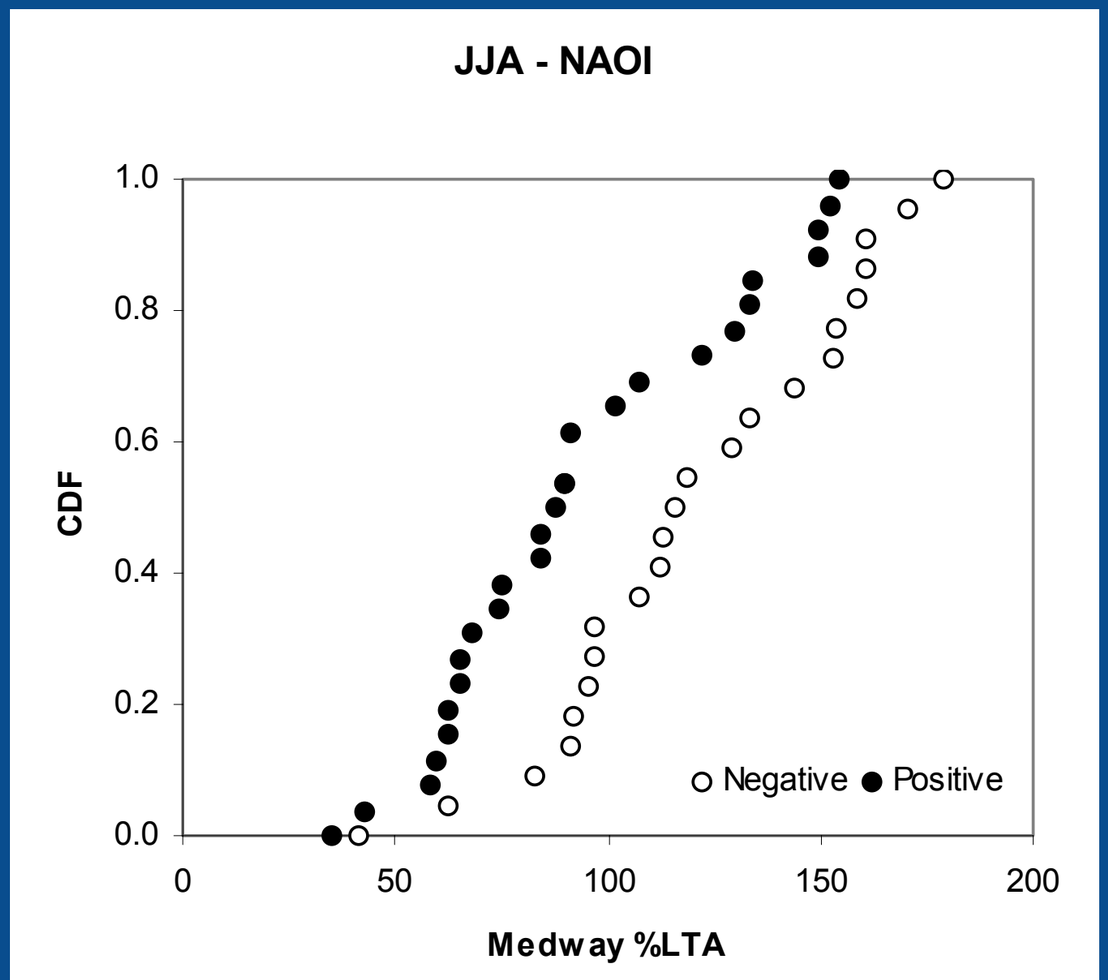
Appraisal of adaptation measures



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

Seasonal forecasting



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

New functionality for downscaling extreme events in SDSM v4.1

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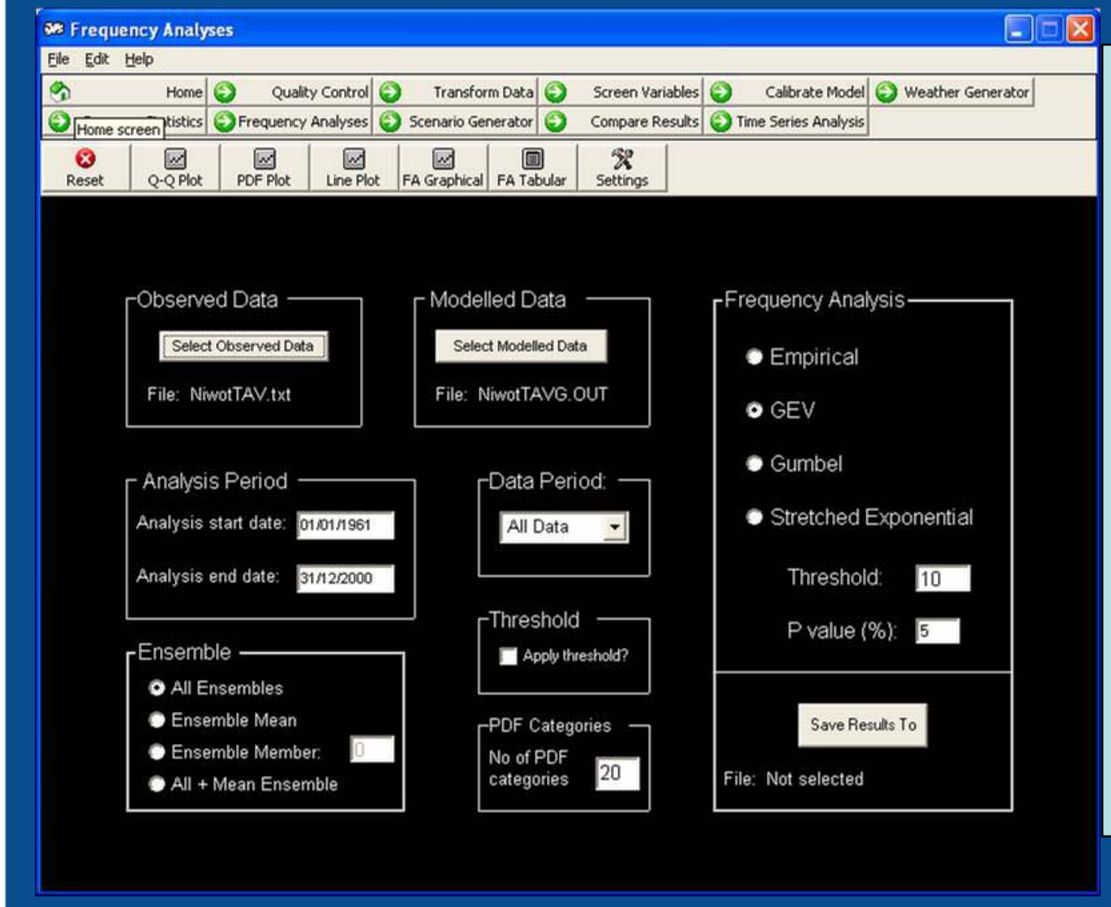

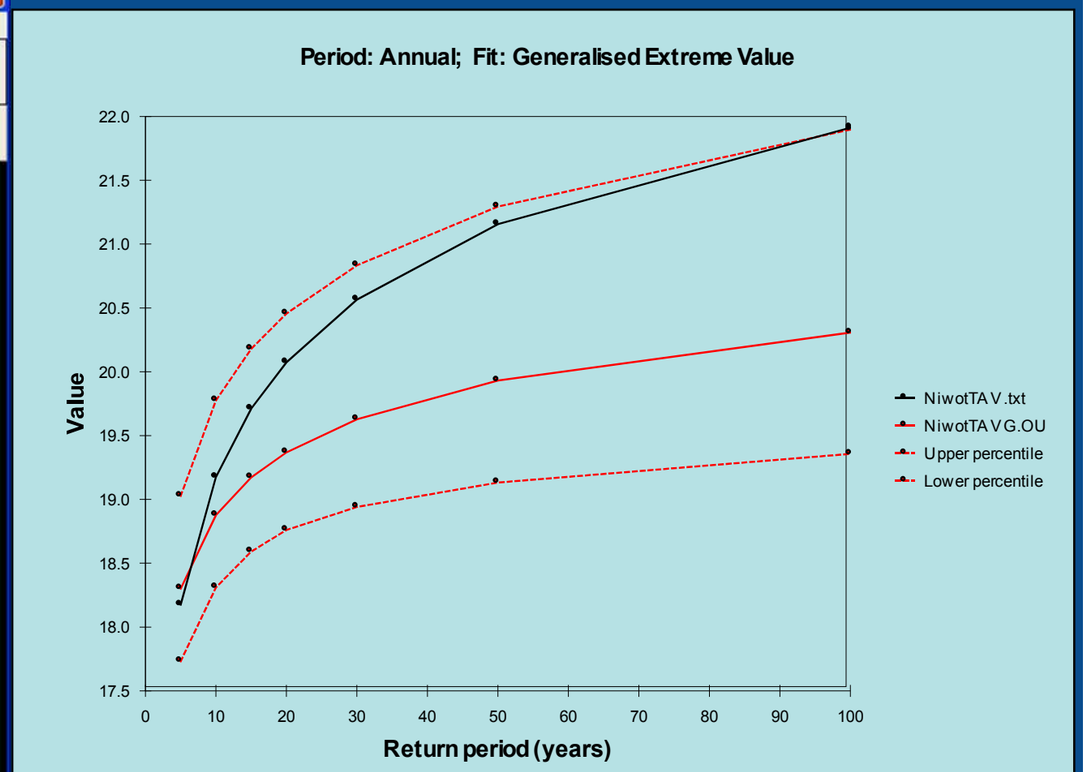

Tools for regional climate change impact assessments

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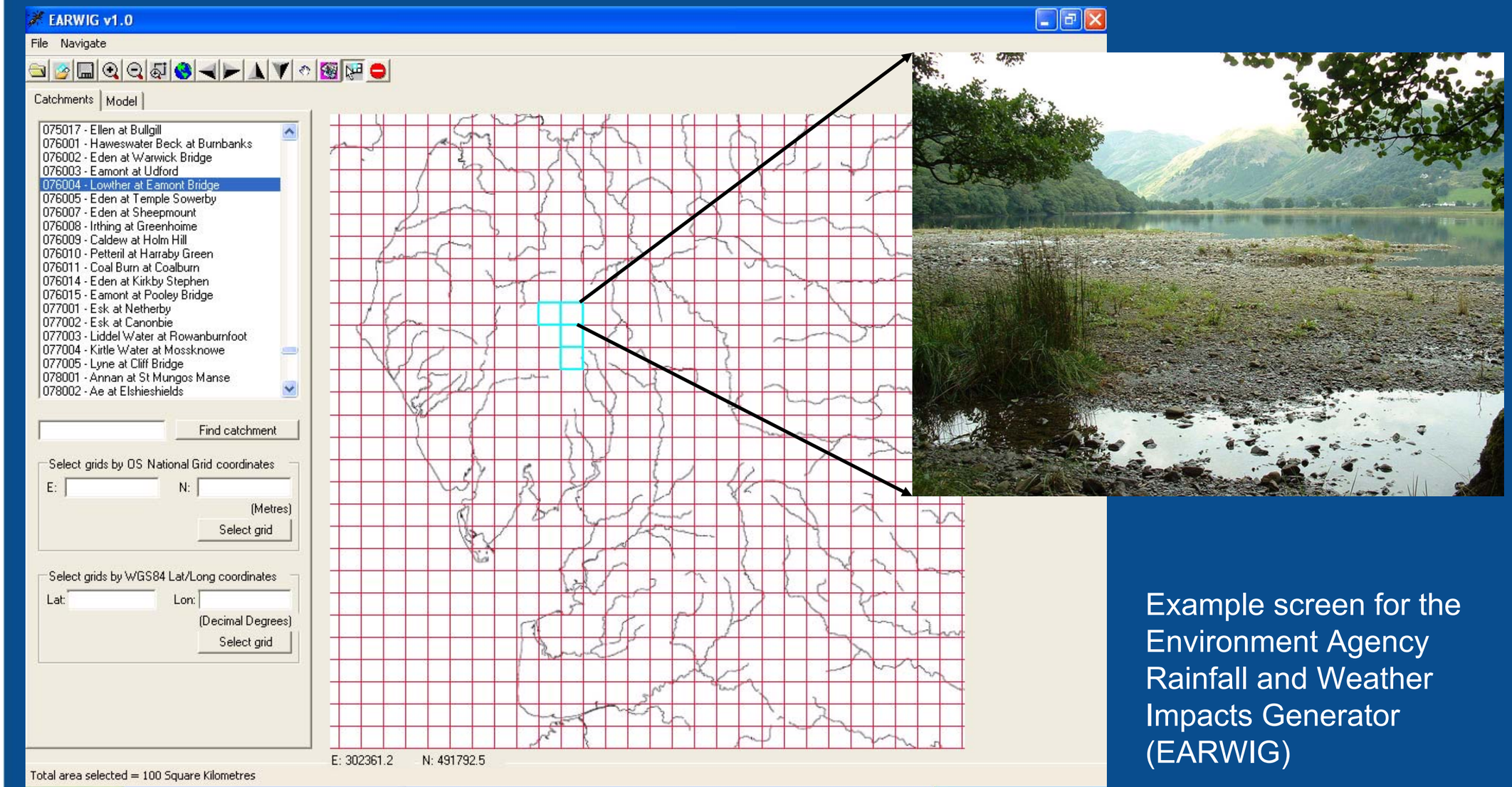

Example screen for the Environment Agency Rainfall and Weather Impacts Generator (EARWIG)

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Concluding remarks

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