The potential to narrow uncertainty in regional climate predictions

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Interactive online analysis tool: www.met.reading.ac.uk/ ~ed/ ipcc/

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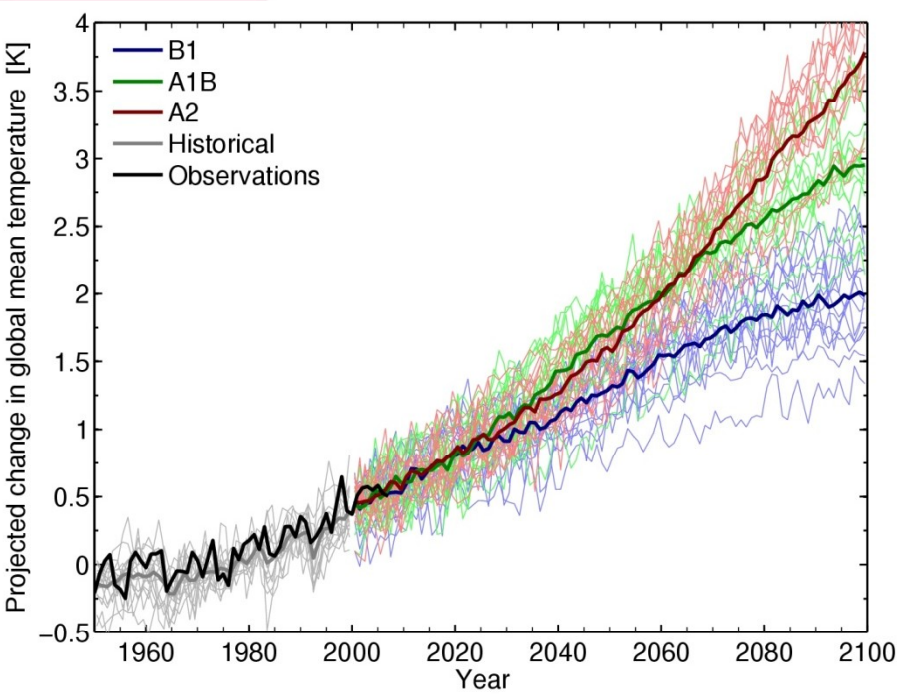
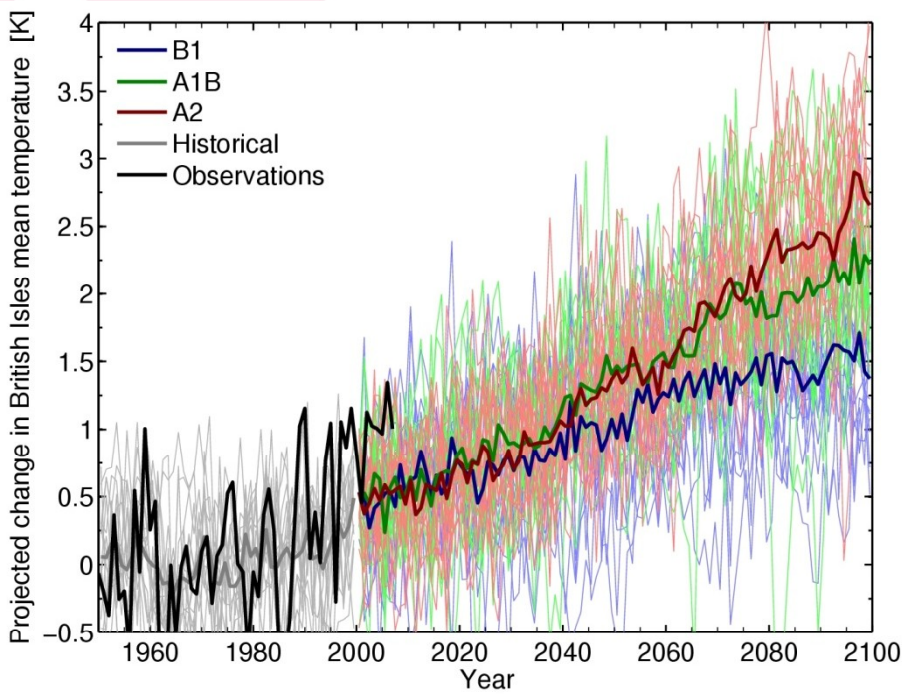
The challenge

To develop quantitative, risk-based, predictions of future climate, and climate impacts, on regional and local scales, especially for the next few decades. (NERC Strategy)

Global mean temperature



British Isles mean temperature



IPCC AR4 surface air temperature (SAT) projections

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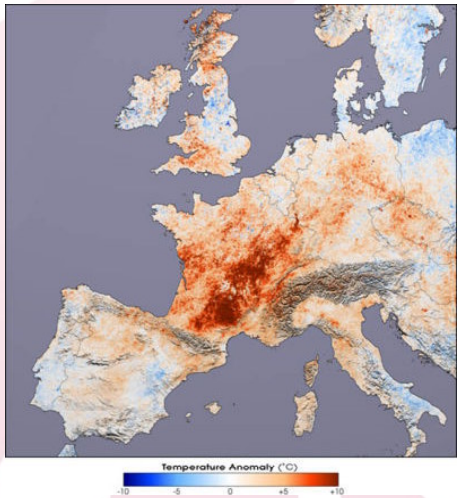

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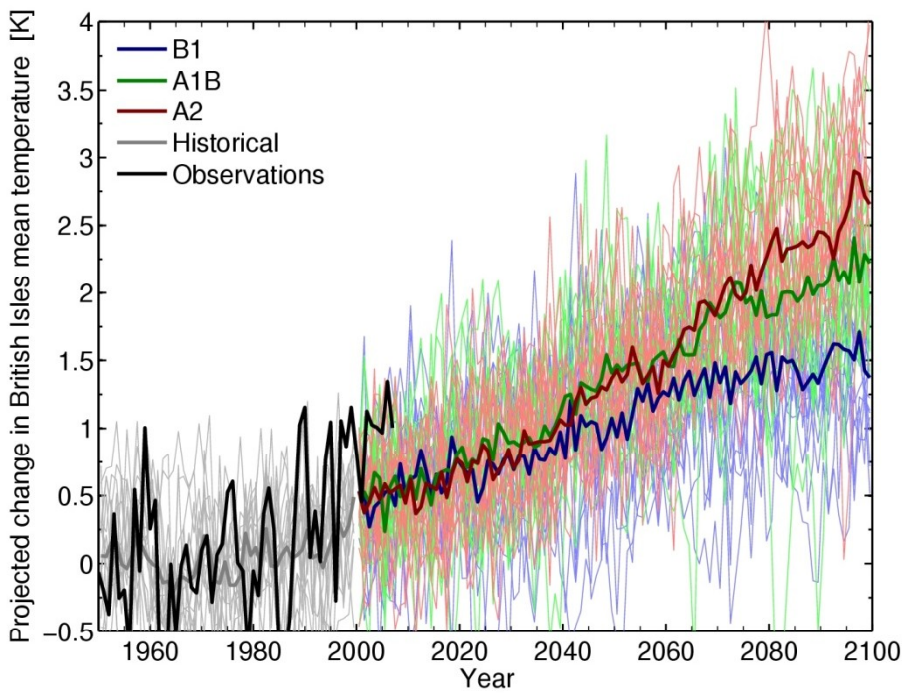
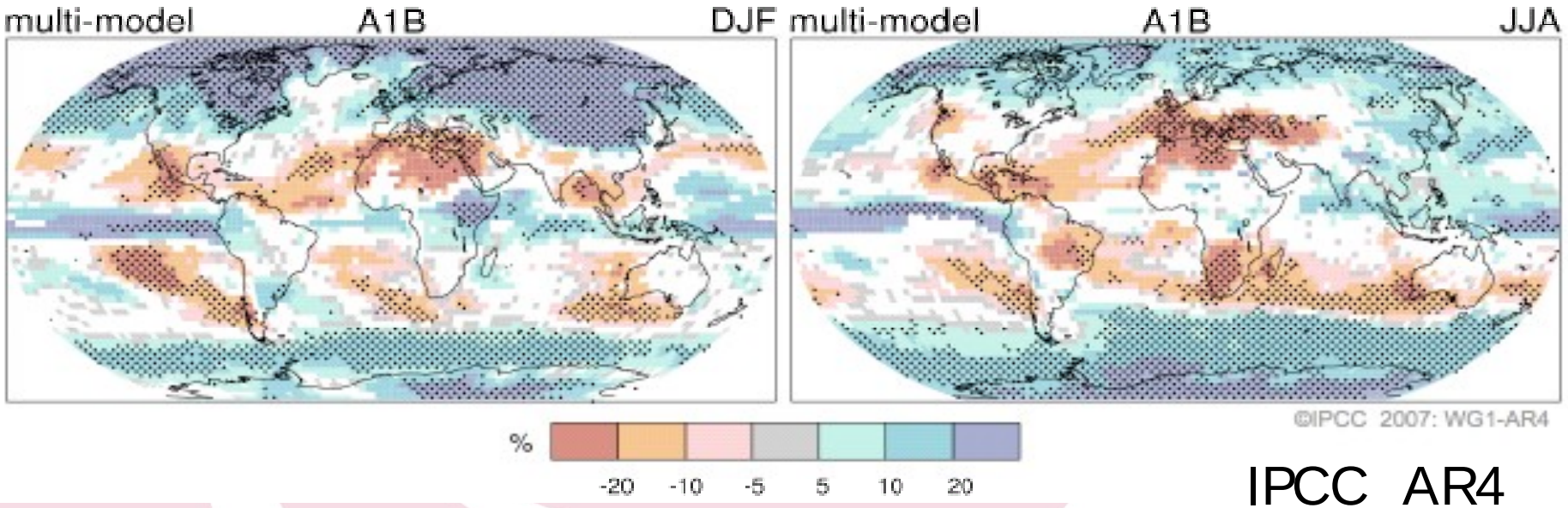


Need to reduce uncertainty on *regional* scales

The challenge

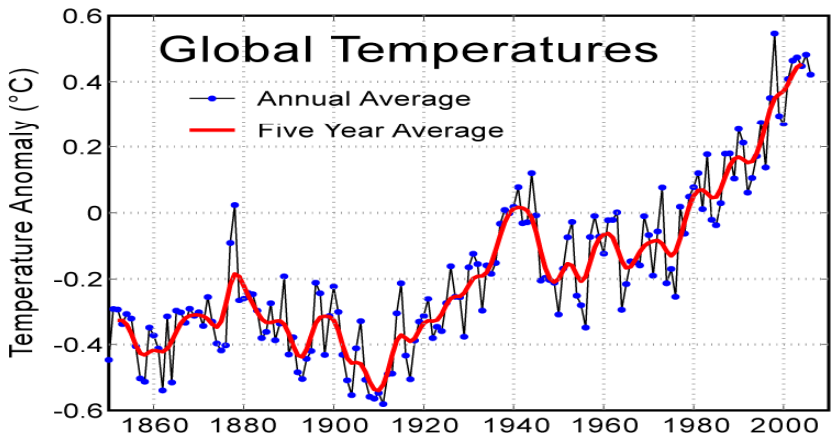
Dominant source of uncertainty in climate impacts is the uncertainty in future climate

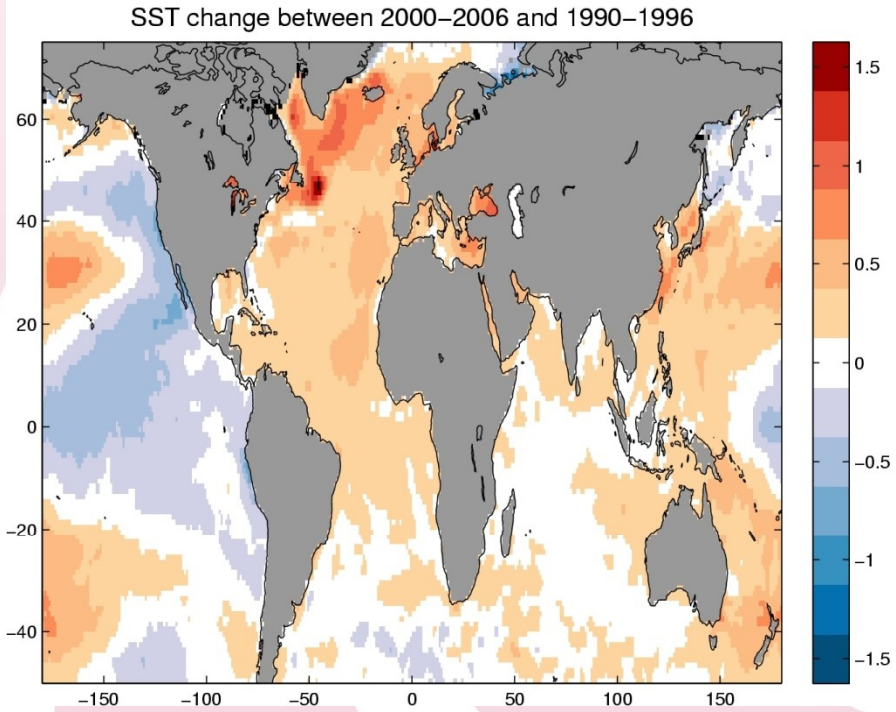
Projected patterns of precipitation change in 2080s



IPCC AR4

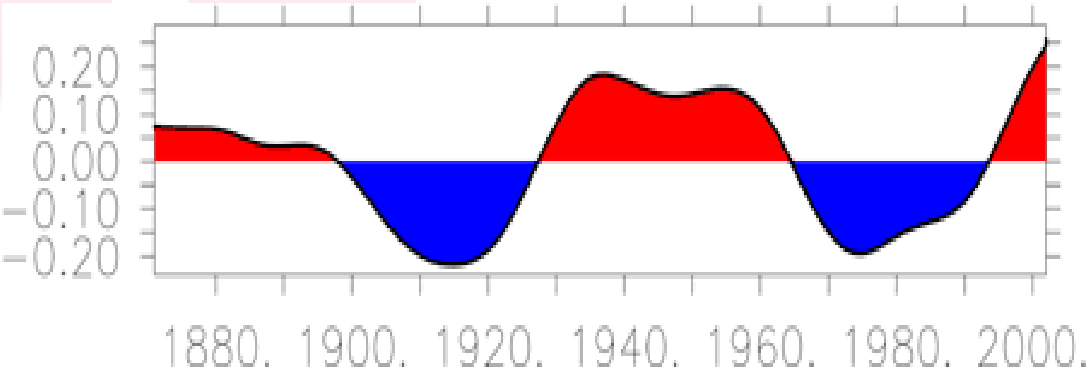
The role of natural variability





Recent SST warming pattern

Smoothed North Atlantic sea surface temperature (long term trend removed)



Sutton & Hodson, 2005

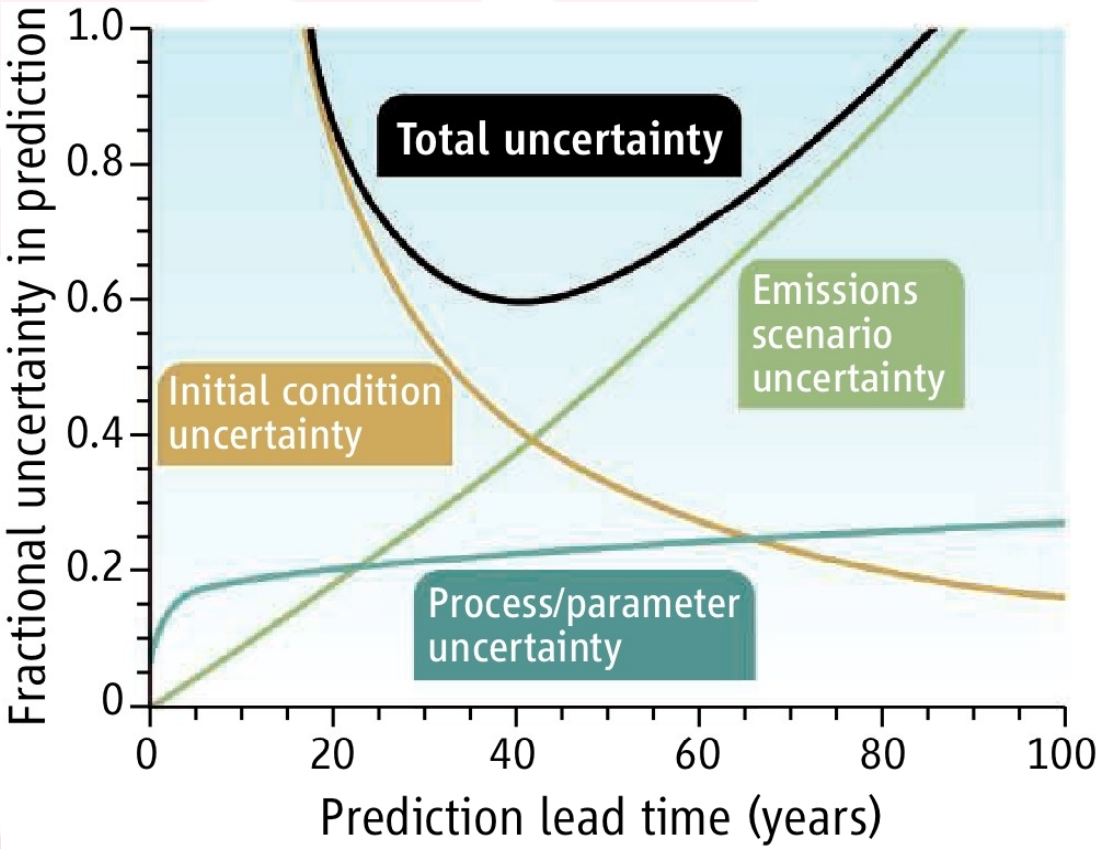
Potential predictability of Atlantic SST, and hence impacts

Sources of uncertainty in climate projections

1. Model (or “response”) uncertainty
   - Models simulate different changes in climate in response to the same radiative forcing
2. Scenario uncertainty
   - Future emissions of greenhouse gases
   - Volcanoes
3. Natural internal climate variability
   - e.g. ENSO, Atlantic Multi-decadal Oscillation
   - Some predictability

Sources of uncertainty in climate projections

uncertainty / mean SAT increase



Cox & Stephenson, Science, 2007

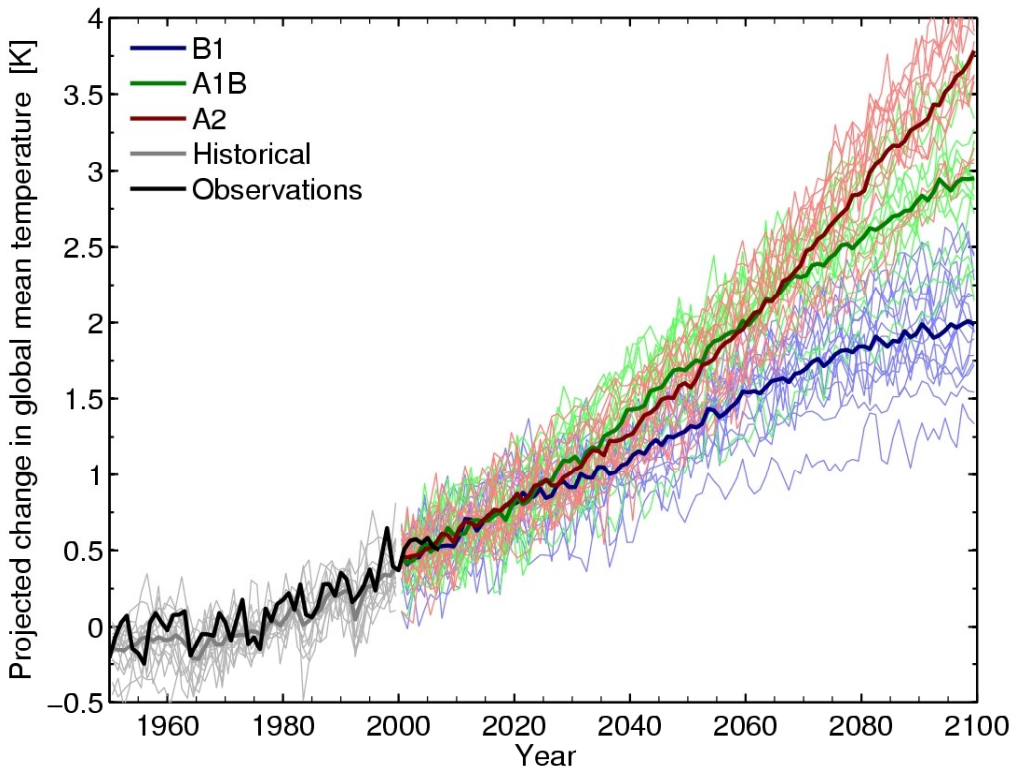
– using simple 1d climate model for **global, decadal mean, surface temperatures**

- Is this really correct? Is model uncertainty unimportant?
- What about on regional scales? (which are much more relevant for decision making)

Methods for IPCC data

- Fit polynomial to individual projections
  - Standard deviation of the residual is the internal variability component, assumed constant in time
- Scenario uncertainty is estimated as the standard deviation of the multi-model means (3 scenarios)
- Model uncertainty is mean of the standard deviation in each scenario (15 models)
  - models weighted by ability to reproduce global mean temperature increase at year 2000 above 1961-1990 baseline

Global temperature projections from IPCC AR4

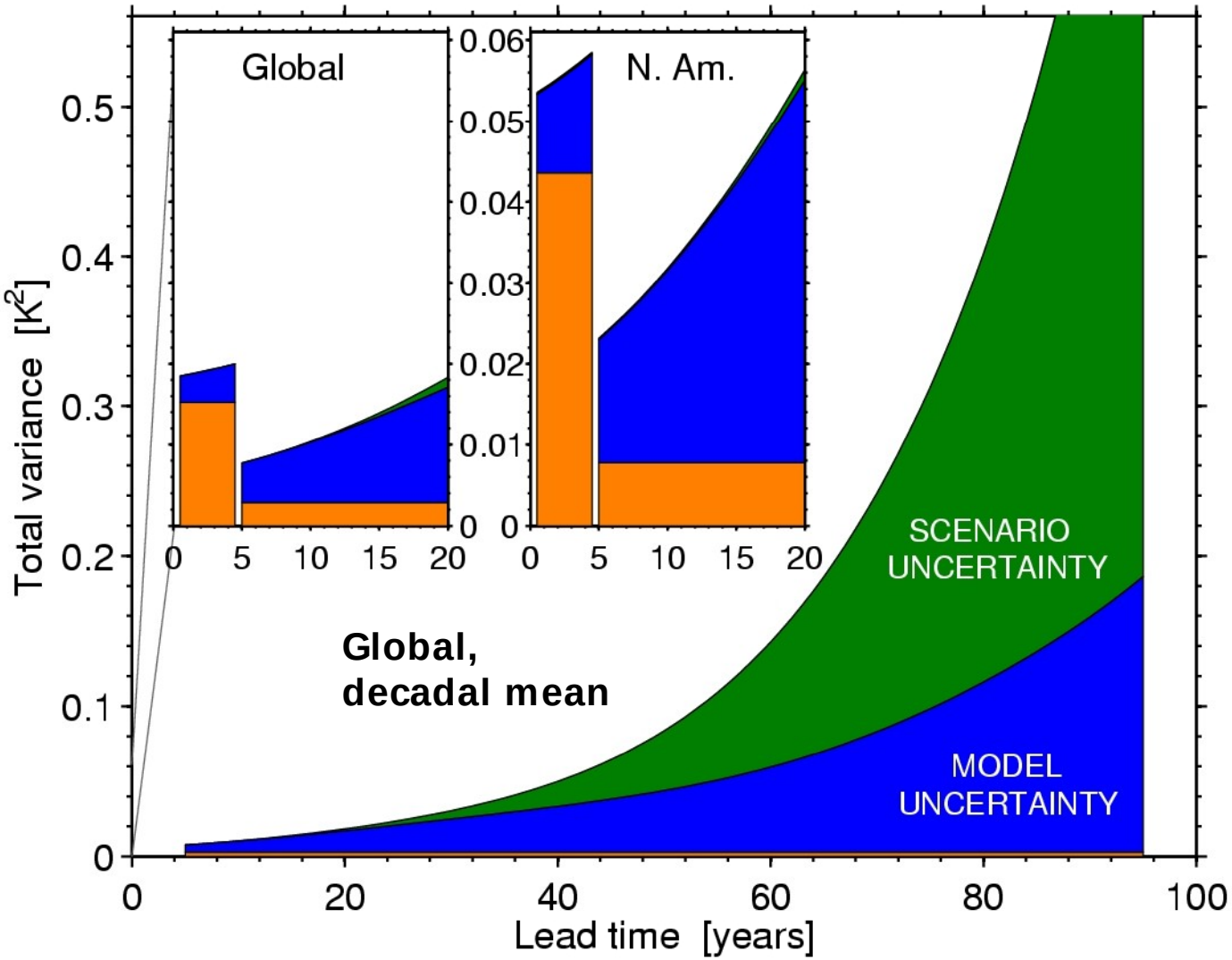


Can be repeated for different regions and temporal means

Hawkins & Sutton, submitted to BAMS, 2008

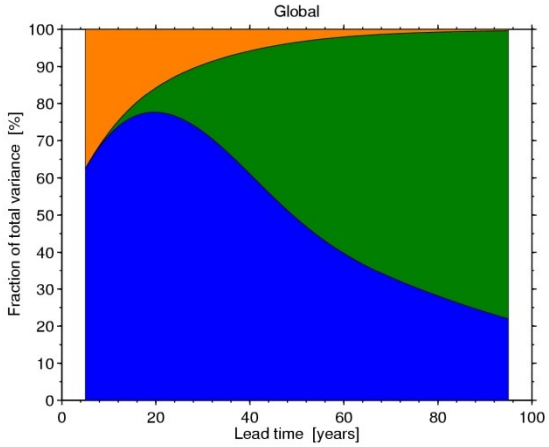
Uncertainty varies with spatial and temporal averaging, and lead time

Variance in temperature projections

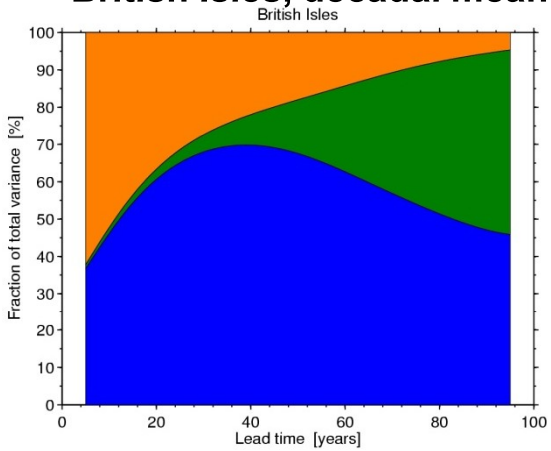


Fraction of total variance

Global, decadal mean



British Isles, decadal mean

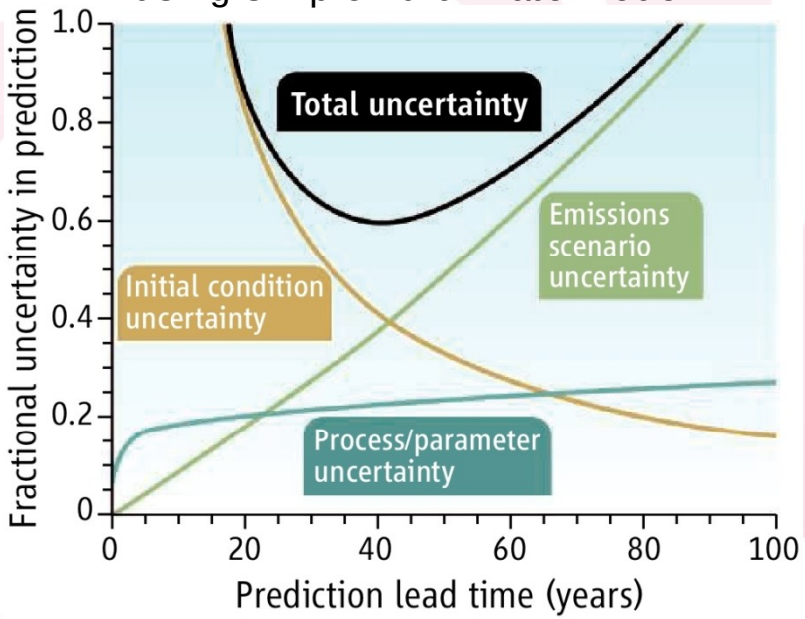


orange = internal variability

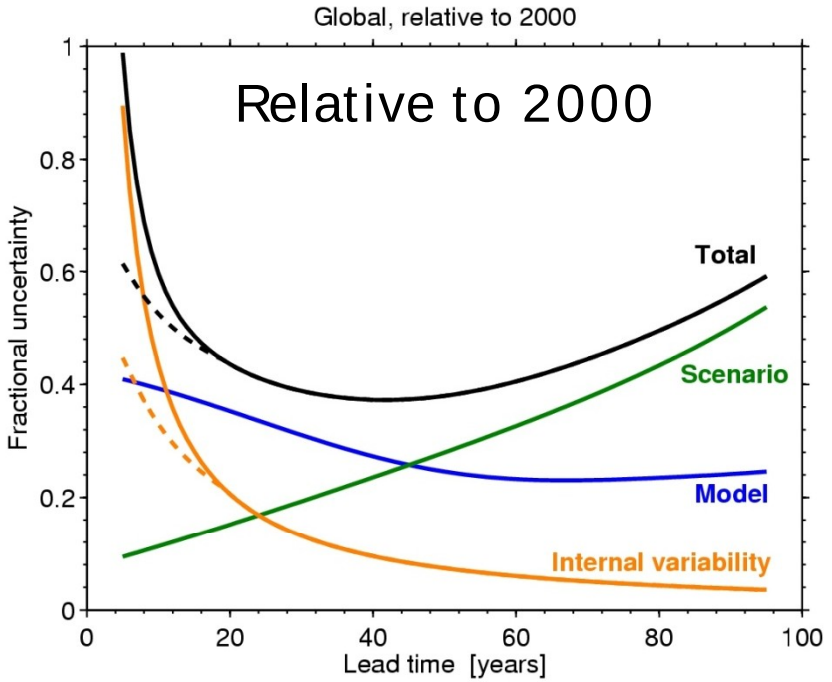
Fractional uncertainty in projections of global mean, decadal mean temperature

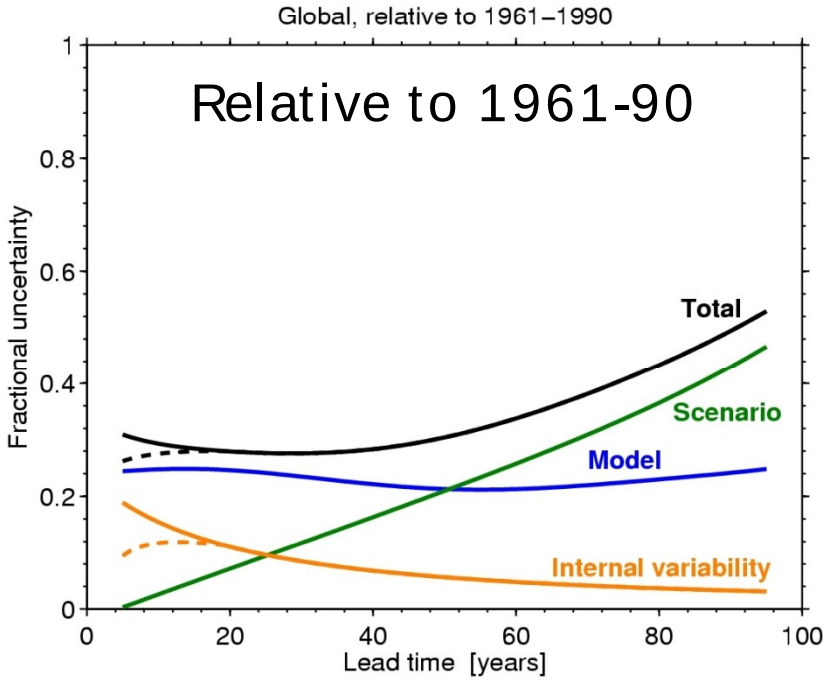
Cox & Stephenson, 2007 – using simple 1d climate model

uncertainty / mean SAT increase



Hawkins & Sutton, submitted – using IPCC data

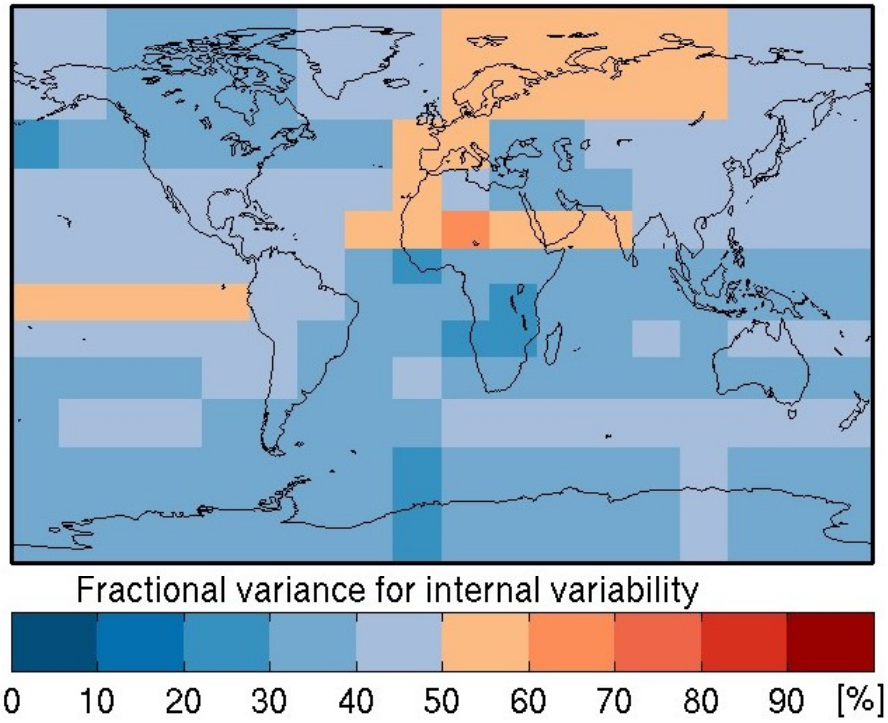




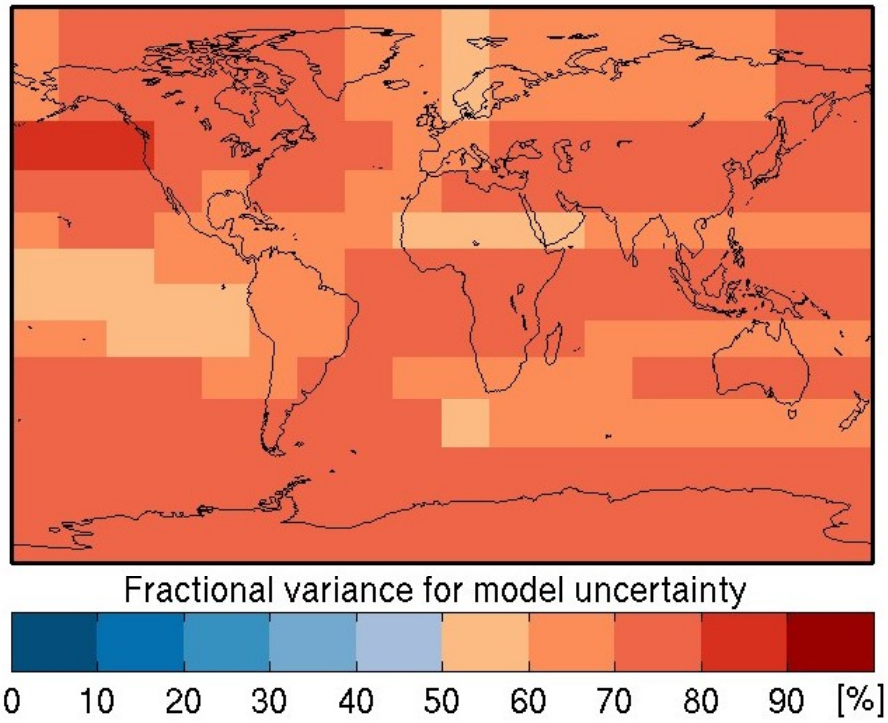
- Using IPCC data, model uncertainty is clearly the dominant contribution for adaptation timescale predictions
- Importance of initial condition uncertainty likely overestimated by Cox & Stephenson
- Existence of any minimum in total uncertainty is sensitive to choice of reference period

Sources of uncertainty in projections of *regional* decadal mean temperature

Fraction of total variance explained by internal variability for predictions of the first decade ahead



Fraction of total variance explained by model uncertainty for predictions of the second decade ahead



- For projections of the first decade ahead internal variability and model uncertainty account for a similar fraction of the total variance
- For projections of the second or third decade ahead, model uncertainty is by far the dominant contribution

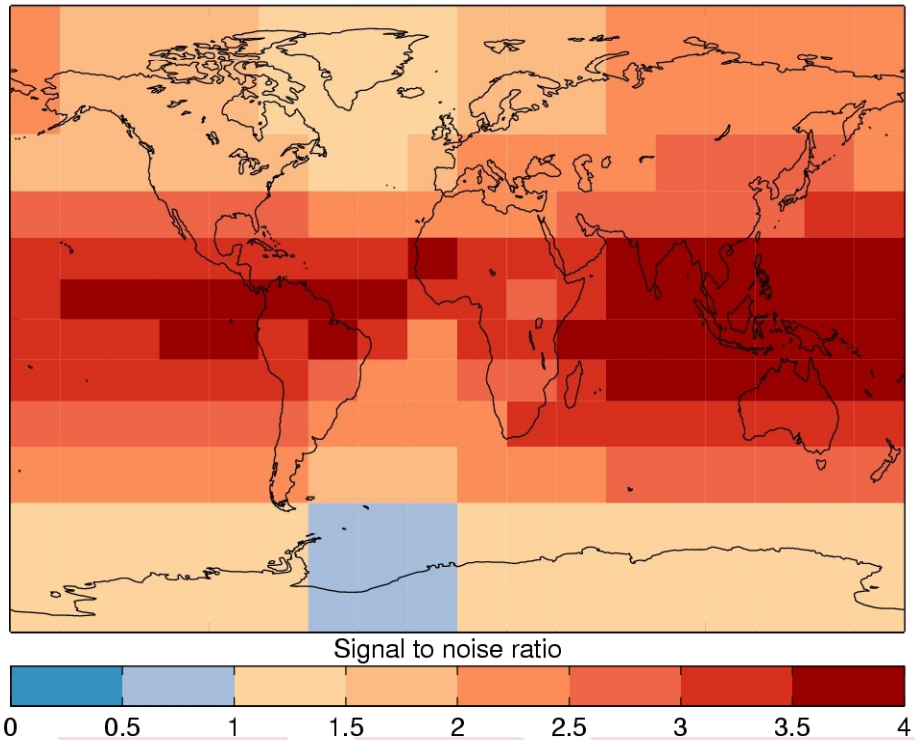
Hawkins & Sutton, submitted to BAMS

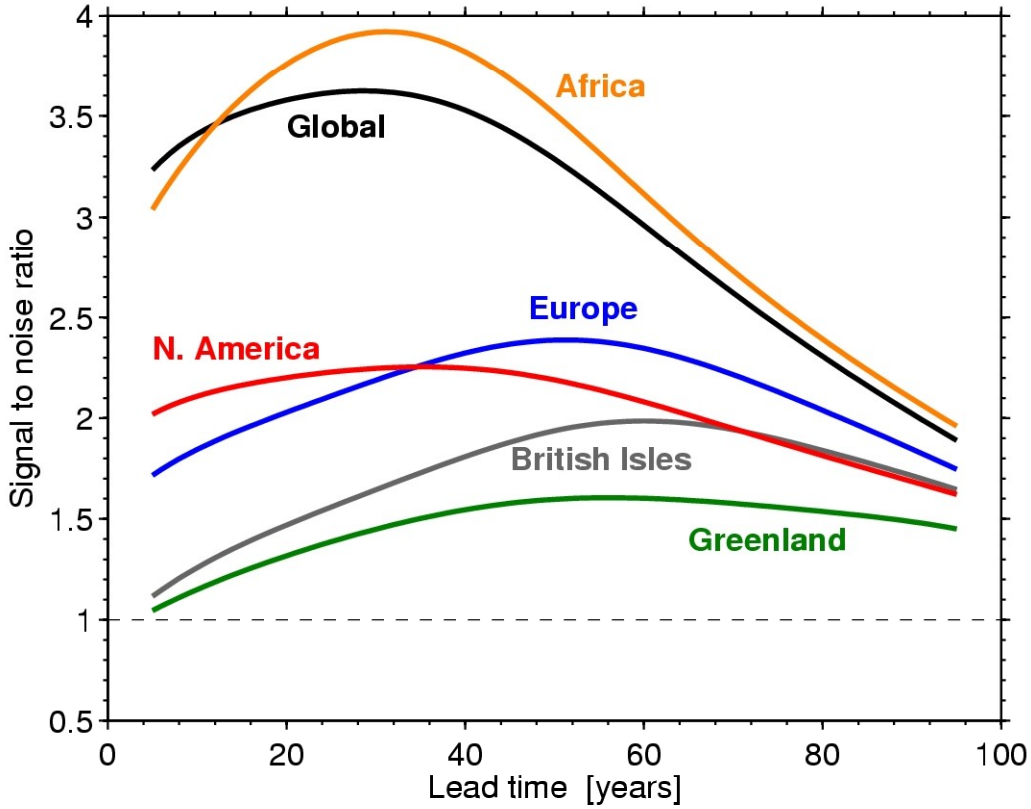
Signal-to-noise ratio

Signal = change in *decadal mean* temperature relative to 1961-90

Noise = total prediction uncertainty

Third decade ahead





- Signal-to-noise is consistently highest in tropics, and larger than 1 almost everywhere for all lead times
- Almost all regions show a maximum in signal-to-noise at a lead time of some decades

Hawkins & Sutton, submitted to BAMS

Conclusions: Opportunities to improve regional decadal predictions

- Reducing model related uncertainty is the top priority
- Reducing the uncertainty from predictable components of internal variability is important for the first decade ahead
- Both these components of uncertainty should be reducible through progress in climate science
- Initialisation of climate predictions could contribute to reducing both these components of uncertainty
- The economic value of reducing uncertainty in predictions is potentially very large (cheaper adaptation), and offers an important motivation for the necessary investments

Interactive online analysis tool at: www.met.reading.ac.uk/~ed/ipcc/