Quantifying the sources of uncertainty in projections of regional climate change

Ed Hawkins | Rowan Sutton

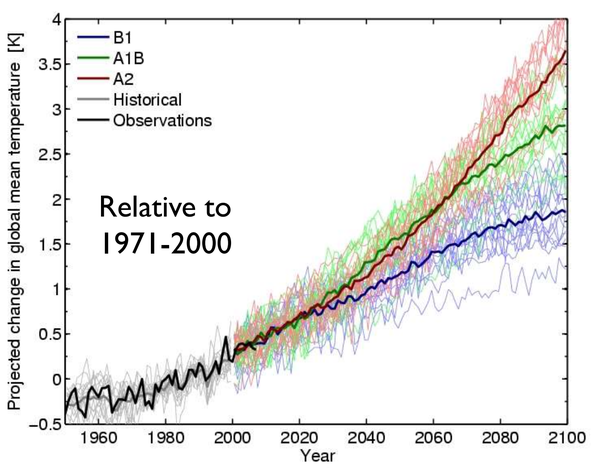
National Centre for Atmospheric Science
NATURAL ENVIRONMENT RESEARCH COUNCIL
Walker INSTITUTE

Summary

- **The total uncertainty in temperature and precipitation projections for the 21st century is separated into its three components and quantified on regional scales.**
- **For both regional temperature and precipitation projections for the next few decades, total uncertainty is dominated by model uncertainty and internal variability.**
- **The potential to reduce uncertainty is high for temperature, but limited for precipitation, especially for the next few decades, because of high internal variability.**

The sources of uncertainty in projections

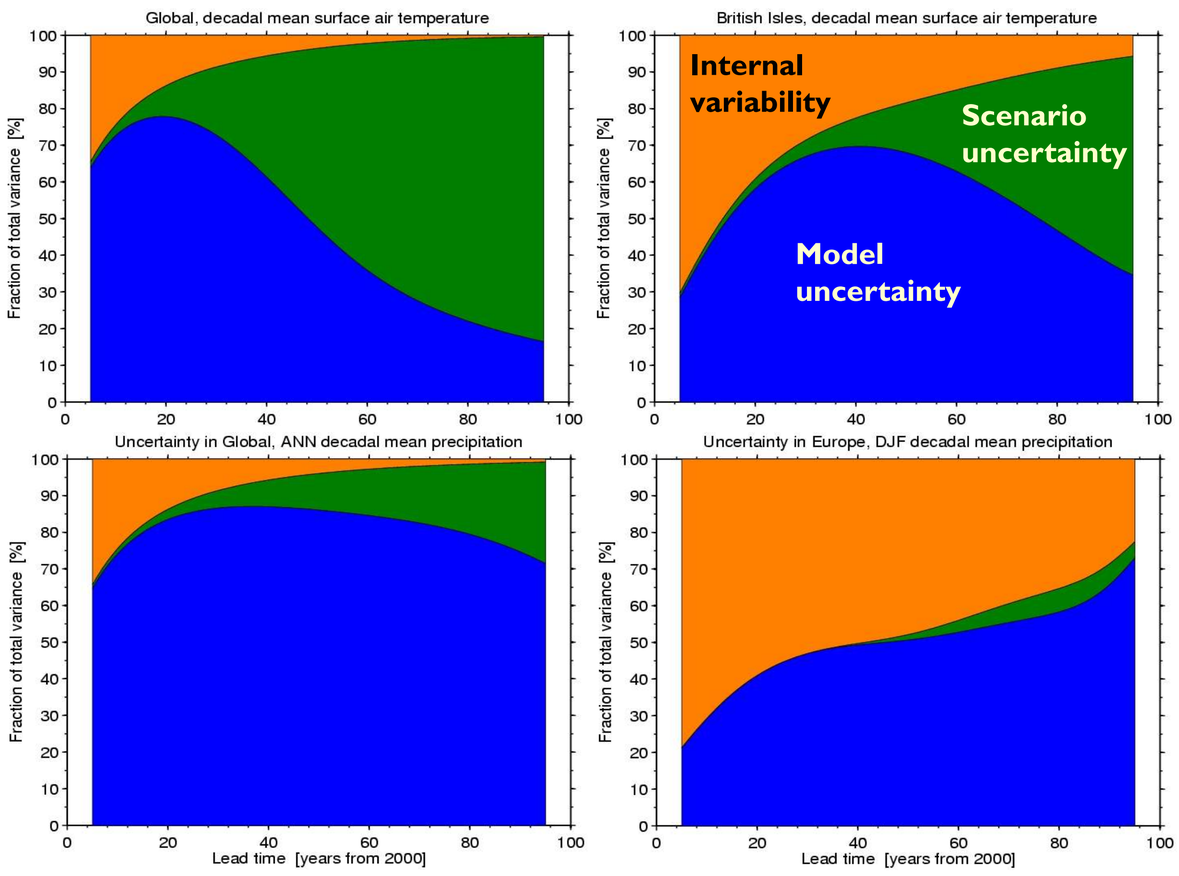
• Scenario • Model • Internal Variability •



Projections of global mean temperature change for a range of IPCC GCMs. The multi-model means for each scenario (thick lines) show how uncertainty in future emissions produces ***scenario uncertainty*** in climate predictions. Each GCM predicts a different response to the same climate forcings, causing ***model uncertainty***. The ***internal variability*** component is shown by the 'wiggles' superimposed on the trend for each individual prediction.

Which uncertainty source dominates?

The dominant source of uncertainty depends on the climate variable, prediction lead time, and region considered. The fraction of the total variance in decadal mean predictions explained by the three components of total uncertainty, as labelled, is shown for **(top left)** global mean temperature, **(top right)** British Isles mean temperature, **(bottom left)** global mean precipitation, and **(bottom right)** European DJF mean precipitation.

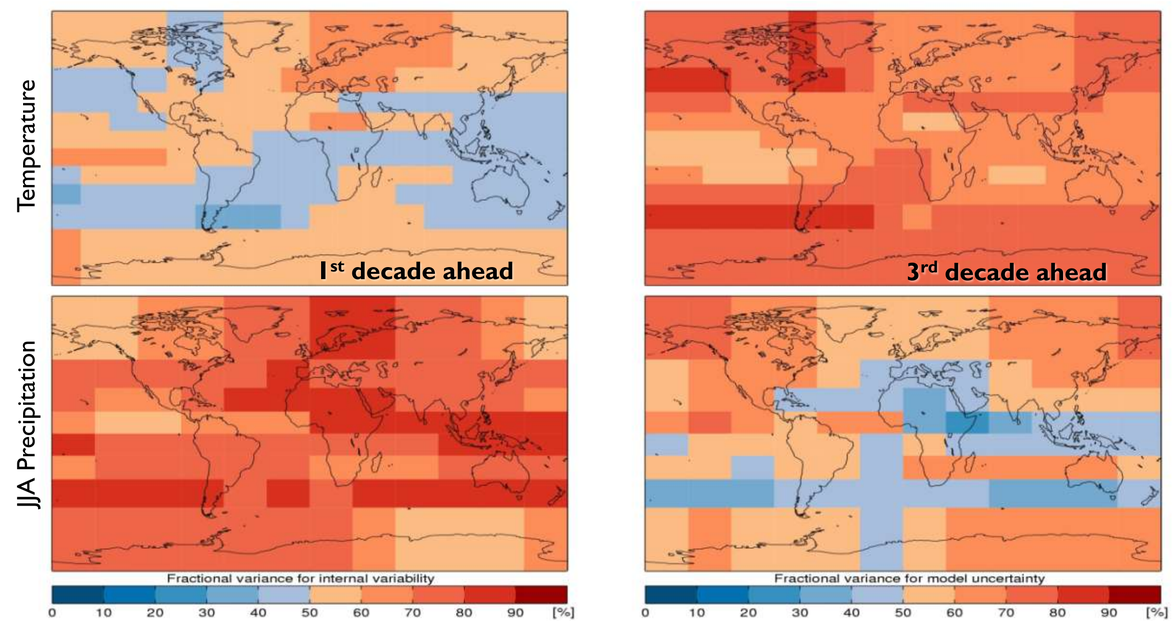


Main points to note:

- As the size of the region is reduced, the relative importance of internal variability increases, especially for precipitation.
- For regional temperature projections, scenario uncertainty generally dominates at multi-decadal lead times. However, for precipitation, scenario uncertainty is usually small or negligible. Model uncertainty is always important.

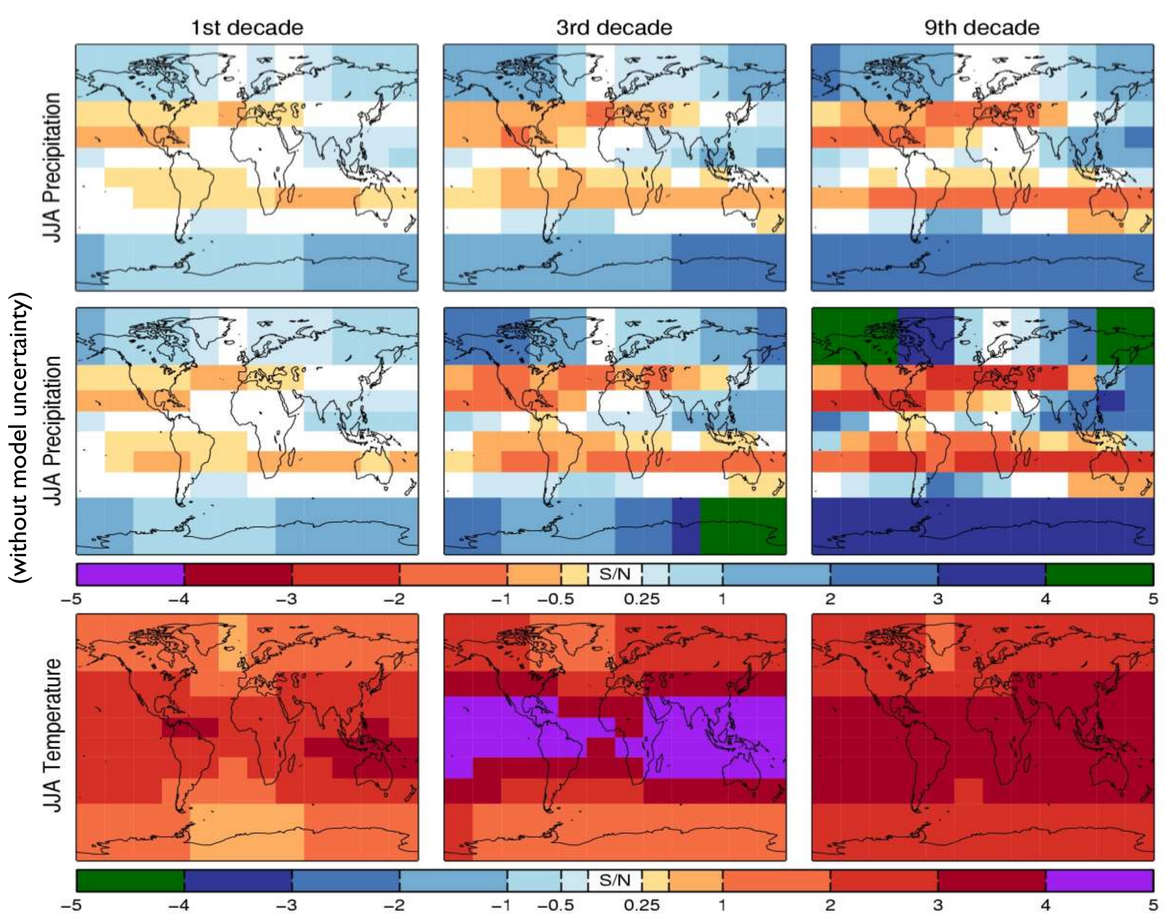
The potential to narrow uncertainty

Maps of the fraction of variance explained in climate projections by different uncertainty sources: (top row) decadal mean annual temperature, and **(bottom row)** decadal mean precipitation in JJA; **(left column)** internal variability for the first decade ahead, and **(right column)** model uncertainty for the third decade ahead.



- For the mean of the next decade, internal variability accounts for about half of the total uncertainty for temperature in most regions, but 60-85% for JJA precipitation. For the third decade ahead, model uncertainty dominates the total uncertainty for temperature for all regions, but is slightly less important for precipitation projections. Thus, improving GCMs would reduce total uncertainty more for temperature than for precipitation.

Measuring the robustness of climate predictions. Maps of the signal-to-noise ratio (S/N) for various lead times are shown for the JJA season for **(top row)** precipitation, **(middle row)** precipitation, assuming zero model uncertainty, and **(bottom row)** temperature. A S/N of 2 equates to a significance level of ~8% that the signal is non-zero.



Main points to note:

- The signal-to-noise (S/N) is far larger for temperature than for precipitation everywhere. The tropics have the highest S/N for temperature, but the lowest for precipitation. For temperature (precipitation), the S/N generally peaks at the middle (end) of the 21st century.
- Even with no model uncertainty, the S/N in precipitation projections for the next few decades is often less than 1, as the internal variability is relatively large compared to the signal. Adaptation decisions may therefore need to be made with high uncertainty for regional changes in precipitation.

Find out more.....

Hawkins & Sutton, 2009, BAMS, in press
Hawkins & Sutton, 2009, GRL, submitted

Contact: Ed Hawkins
(e.hawkins@reading.ac.uk)

Website: http://ncas-climate.nerc.ac.uk/research/uncertainty/

University of Reading