CATS CENTRE FOR THE ANALYSIS OF TIME SERIES

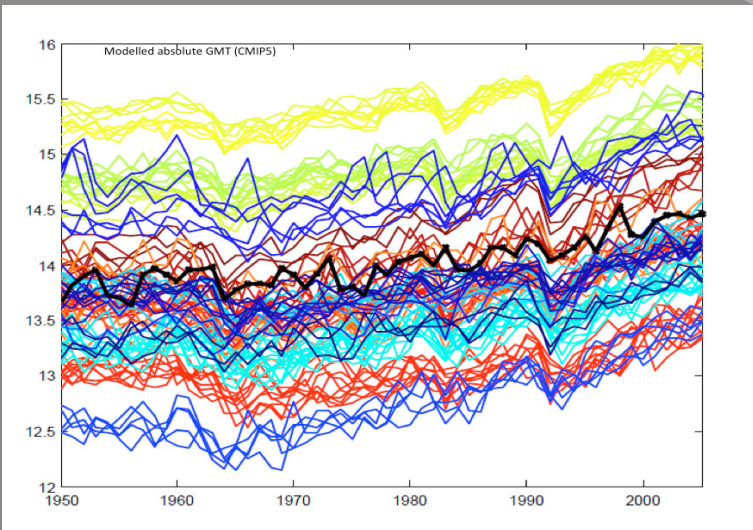
LSE THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

Implications of expert assessment of **climate model (in)adequacy**

Projecting future global mean temperature (GMT) involves expert judgement regarding the chance that the true outcome would be outside the range given by state-of-the-art climate models of the day. The Intergovernmental Panel on Climate Change (IPCC) imply this to be a one-in-four chance for projections of GMT, with a greater probability of model inadequacy for projections of quantities which are more local, shorter-term, or are derived from downscaling or socioeconomic impact models.

The Intergovernmental Panel on Climate Change (IPCC) present headline ranges for global mean temperature (GMT) at the end of the century, derived from state-of-the-art climate models using different forcing scenarios (Representative Concentration Pathways, or RCPs).

The ranges given are an interval covering 90% of model outcomes – if the model runs were independent and drawn from a statistically perfect representation of the real world, this would be a 90% confidence interval. But "accounting for additional uncertainties or different levels of confidence in models", the IPCC assess this to be a 66% confidence interval for the real-world outcome. Known inadequacies of models include biases in the absolute GMT of each model, shown here as per figure 9.8 of the IPCC's 2013 assessment report.



Effectively, the IPCC authors judge that there is approximately a one-in-four chance that the models are so inadequate that the real world GMT will be outside the range of modelled GMT for reasons of which we are currently unaware (in addition to the one-in-ten chance that it is outside the range of modelled GMT due to presently known uncertainties).

The climate model runs which generate these temperature ranges are archived centrally and are a primary source of information about other expected trends in the future climate. They are also used as input into more finely detailed models ("downscaling") and as input into models which assess socioeconomic climate impacts ("impact models" or "damage functions" according to the level of sophistication). We should expect a greater level of uncertainty in these derived results.

IPCC statements on model inadequacy are subjective expert judgements based on discussion between professionals who are very familiar with these models. The judgement is not a free estimate, but is pegged to the IPCC's predefined terminology relating to uncertainty – for instance, there is no uncertainty level between "very likely" at 90% and "likely" at 66%.

Caution should therefore be used in interpreting all projected ranges provided in climate research. In particular, it should be remembered that the upper end of a "likely" range does not reflect a "worst case scenario" or even the 1-in-200-year event of interest to insurers. At best, the chance of exceedance of the higher limit is one-in-six; it may well be considerably larger.

When the outputs of these models are recycled into input for other models to calculate "probabilities" of different outcomes for other impacts, for example flooding in 2100, many uncertainties multiply. The model uncertainty expressed by the IPCC's downgrade of the interval from "very likely" to "likely" applies to GMT, a globally-averaged, annually-averaged variable which is relatively smooth and relatively well-understood. Other physical variables on more local scales, or derived quantities such as flooding incidence, must have greater levels of uncertainty still.

Example: a mid-range warming scenario

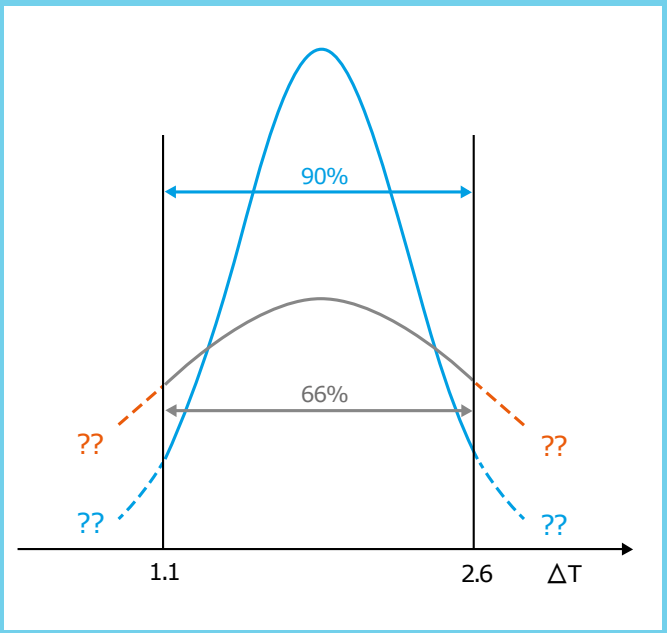
It is **likely** that the change in global mean surface air temperature (ΔT) in 2081-2100 will be **between 1.1 and 2.6°C**, relative to 1986-2005, if RCP4.5 forcings occur (Table SPM.2, IPCC AR5).

This is calculated from projections as a 5-95% model range. The range is then assessed to be a *likely* range, after accounting for additional uncertainties or different levels of confidence in models.

Rephrased:

IPCC experts estimate that there is

- a two-in-three chance of the ΔT being between 1.1 and 2.6°C;
- a one-in-ten chance of the ΔT being outside that range due to presently known and modelled uncertainties;
- approximately a one-in-four chance of the ΔT being outside that range due to unknown or unmodelled uncertainties.



The shape of the probability distribution outside of the 66% range is undefined and may well be asymmetric, with a longer tail of plausible but poorly-modelled higher-warming outcomes.

The Centre for the Analysis of Time Series (CATS) is a research centre of the London School of Economics and Political Science. We focus on nonlinear analysis methods for decision support in situations of economic and physical significance.

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