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FURTHER WORK OF THE IPCC ON NEW EMISSION SCENARIOS

(Letter by John Mitchell regarding the integrated TGNES proposal concerning new IPCC emission scenarios)

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Dear Patchy

Re the integrated TGNES proposal concerning new IPCC emission scenarios

The proposal by TGNES for scenario development is a big improvement over the current situation. In particular, this integrated approach will allow better use of the expensive and time consuming simulations carried out by Working Group I, as these no longer need to be rerun each time the emission scenarios are changed. The proposal also has the potential to allow new scenarios to be evaluated more quickly across working Groups I and II.

Producing model runs for IPCC assessments is both time consuming and expensive.
Even though SRES been available since around 1998/99, still only a limited number of scenarios are run by GCM groups. The AR4 is probably the first time there have been enough models and scenario runs to produce regional changes which can be distinguished from natural variability and start to the define the range of model uncertainty, and give some indication of changes in extreme events. The changes in emissions scenarios from assessment to assessment mean that it is difficult to separate the effects of improvement in models form the effect of changes in scenario, unless the old scenarios are rerun with the new model.

In order to serve impacts modellers well, it would be better to run fewer scenarios but in larger ensembles and higher resolution to better define changes in regional climate and extreme events.

There is limited added value in having more than two or three scenarios to cover the range of forcing in IPCC (and other credible) emission scenarios

- in the TAR, there is little separation in global mean temperature series for the different SRES scenarios in the first thirty to forty years (Figure 1). It is even less likely that regional changes (especially precipitation) that form the different scenarios are distinguishable at this level due to the range of natural variability alone.

- on a timescale of forty to a hundred years, at most two or three scenarios are distinguishable at the global mean temperature level once model uncertainty is taken into account

Note that there are some substantial drawbacks to the sequential approach that has been used by IPCC up to now:

1. The time from developing scenarios, through having them approved, used in GCM simulations and the results analysed by inputs, adaptation and vulnerability groups is long, so the scenarios can get of date long before the related IA studies are made
2. The GCM simulations are “hard-wired “ to the socio-economic scenarios, and hence the science may be discredited on socio-economic arguments
3. If the socio-economic scenarios are modified, one has to rerun all the models again.
4. Although the approach is easy to explain it is not as clear as is always supposed. Some modelling groups have not included all the forcings in their scenario runs, especially for non well mixed forcing agents and for indirect effects.

The TGNES proposal

Given the large level of uncertainty in regional climate change relative to the overall range of climate change from past emission scenarios, there is little scientific justification for running more than 2 or 3 separate “benchmark” emission scenarios which span the range of uncertainty. Scenarios with intermediate emissions could then be obtained through interpolation. The interpolation would be carried out using simple models which have been calibrated to give comparable results to the full three-dimensional climate models. (This approach has already been used WG I assessments for global mean temperature and sea-level). In this way, the “benchmark” scenarios would be independent of the socio-economic scenarios used in the full assessments.

Advantages

1. It will decouple climate science from the issues of socio-economics. This link is only made when the climate scenario is constructed from the benchmark scenarios.
2. New models would be run against the same scenarios, allowing one to isolate the effects of scientific changes
3. New scenarios and impacts could be evaluated immediately — there would be no need to rerun models, and in many cases, no need to rework the detailed impact calculations.
4. The saving in computing time could be used for bigger ensembles/higher resolution leading to better simulations of regional change/extreme events, and better definition if uncertainties/probabilities.

Risks and their mitigation

1. It may take time to set up and agree the benchmark scenarios as this is a new approach. However, if the approach is agreed quickly enough, it may actually save time — model runs can start earlier and then interpolated to the new emission scenarios for impact assessment immediately. The timescale can be set by calling for a technical paper (or an expert meeting) to deal with this after the completion of AR4.

2. Any change in approach may be seen as a risk, especially if there are technical issues involved. This will require careful definition of the process and management by IPCC.

3. The benchmark scenarios may be perceived as official IPCC emissions scenarios. This can be managed through the normal IPCC processes (e.g. defining the benchmark scenarios in a technical paper)

4. The approach assumes to first order that the climate response can be scaled by the forcing/global mean temperature response. Aerosols, changes in land use and other feedbacks complicate these issues. Note that this is also an issue for the traditional approach, as current models do not all include the same forcing and feedbacks. The interpolation would be carried out by "simpler models" calibrated against the full climate models, as done in previous IPCC assessments. One could also recommend additional runs (for example with well mixed GHGs only, and all forcings or selected forcings, as I believe was done for the second assessment), which would allow a broad benchmarking of non-well mixed species.

Yours sincerely

John Mitchell

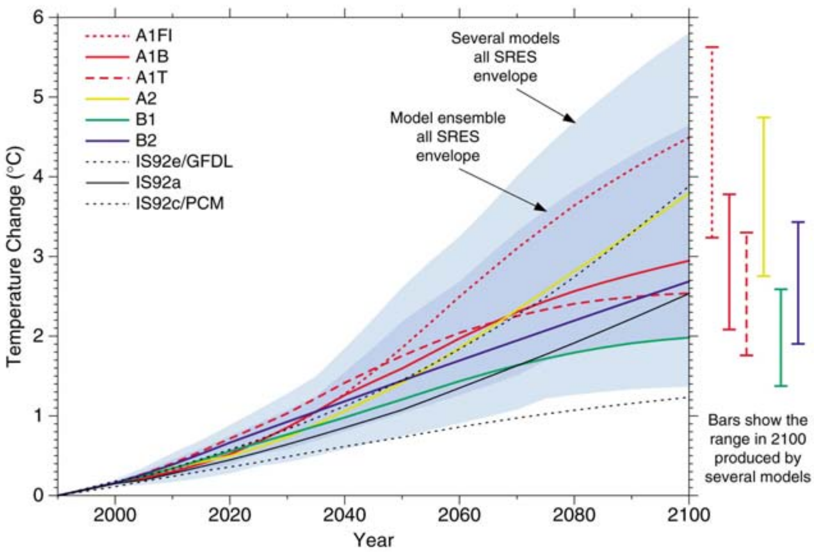
Cc Dr Renate Christ (IPCC Secretariat)

Appendix: Ranges of climate change uncertainty associate with IPCC emission scenarios.

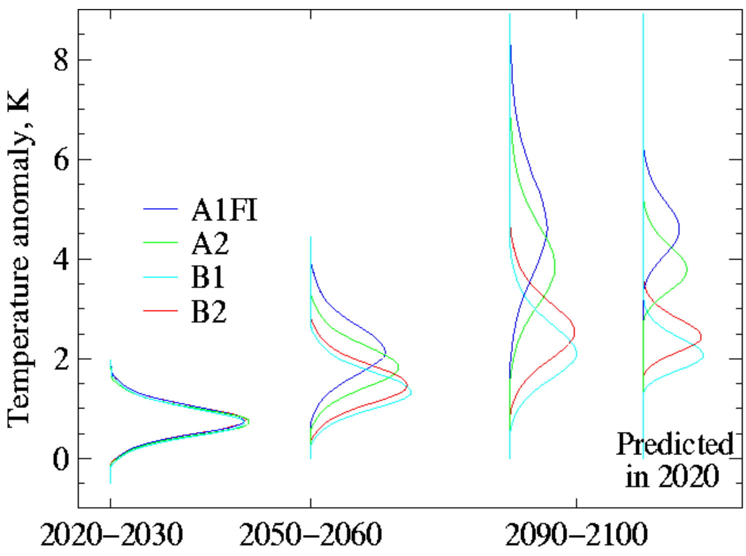
This appendix illustrates the range of uncertainty in simulated climate change for individual emission scenarios.

The range of global mean temperature change over all scenarios is about 4 °C (Mean model parameters, Figure 1) whereas the spread in model results for a given scenario is about 1.5 to 2 °C by 2100 (Figures 1, 2)

- *Figure 1 - range of uncertainty in global mean temperature response for different scenarios, from the 3rd assessment of Working Group I. The bars on the right hand side give the model range of uncertainty at 2100 for each scenario, and are likely to be an underestimate of the full range of model uncertainty.*

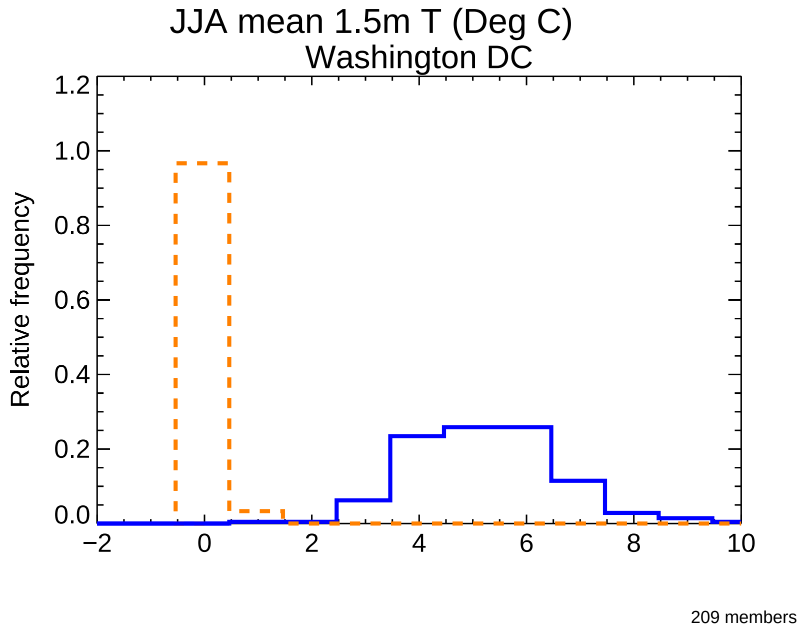


- *Figure 2 - From Stott and Kettleborough (2002). This shows the uncertainty distribution of global mean temperature change for selected IPCC scenarios at given periods based on model simulations and observational constraints*



- At a regional level, the spread of results is even larger. In Figure 3 is shown the frequency distribution of simulated changes especially for precipitation

Figure 3 – Temperature change range and natural variability range from an ensemble of versions of a Hadley Centre model (Washington DC, summer). The blue histogram outlines the range of uncertainty due to varying parameters around "plausible" values in a version of the Hadley Centre model- the uncertainty across models is likely to be greater. The red dotted line is an estimate of the uncertainty due to natural fluctuations. Based on Murphy et al, Nature, 2005)



Note that the uncertainty in temperature change in Figure 3 is over 6 °C for a mean change over models of about 5 °C. The range would be about 30% less for a transient experiment, but larger for a full multi-model ensemble than a single model physics ensemble. The interdecadal range for natural temperature change is estimated to be about 1-2 °C. Detail will vary with location and season, but the model uncertainty in other variable, such as rainfall, is likely to be larger than for temperature.

In conclusion, the uncertainty in regional changes for a given scenario is often comparable to the range of global mean change over all scenarios. This makes distinguishing between the finer variations of emissions scenarios at a regional level very difficult and brings into question the value of running more than a few scenarios that span the range of all emission scenarios.

Murphy, J M, David MH Sexton, David N. Barnett, Gareth S. Jones, Mark Webb, Matt Collins and Dave Stainforth, 2005. Quantification of modeling uncertainties in large ensemble of climate change simulations, Nature, 430, 768–772; 2004

STOTT, P.A. and Kettleborough, J.A., 2002: Origins and estimates of uncertainty in predictions of twenty first century temperature rise. Nature, 416, 723-726.