Climate Insights

High quality, robust, defensible, actionable, climate physical assessment and risk ranking platform

Climate Model Ensembles

Ensemble Guidance

Ensembles are increasingly recognised in the climate change adaptation and risk assessment literature as an appropriate method for managing uncertainty in GCM impacts on climate change risk analysis, i.e. the range of possible outcomes based on the choice of GCM pattern in one's analysis. The convergence of future climate simulations by different models for a given emissions scenario must be assessed. For the purpose of sensitivity analysis, a super ensemble approach whereby no favouritism in model selection is applied and this permits the selection of low and high percentiles as an ensemble option and thus provides a transparent method for determining the range of uncertainty and hence risk that is reflected in the range of individual GCM and RCM models of future climate change. The robustness of such a method in the context of risk assessment of the type requested by end users is well documented in the report of Knutti et al. (2011). An ensemble approach to modelling was followed in all cases when GCM and RCM data was applied to assessment of future change. The application of ensembles permits the development availability of quantified confidence limits for extreme value estimates.

Climate model results provide the basis for projections of future climate change. Previous assessment reports included model evaluations but avoided weighting or ranking models. Projections and uncertainties were based mostly on a 'one model, one vote' approach, even though models differed in terms of resolution, processes included, forcings and agreement with observations.

Projections in the IPCC's Fifth Assessment Report (AR5) were based largely on CMIP5 of the World Climate Research Programme (WCRP), a collaborative process in which the research and modelling community has agreed on the type of simulations to be performed. While many different types of climate models exist, the following discussion focuses on the global dynamical models included in the CMIP project.

Uncertainties in climate modelling arise from uncertainties in initial conditions, boundary conditions

(e.g., a radiative forcing scenario), observational uncertainties, uncertainties in model parameters and structural uncertainties resulting from the fact that some processes in the climate system are not fully understood or are impossible to resolve due to computational constraints. The widespread participation in CMIP provides some perspective on model uncertainty.

Nevertheless, inter-comparisons that facilitate systematic multi-model evaluation are not designed to yield formal error estimates and are in essence 'ensembles of opportunity'. The spread of a multiple model ensemble is therefore rarely a direct measure of uncertainty, particularly given that models are unlikely to be independent, but the spread can help to characterise uncertainty. This involves understanding how the variation across an ensemble was generated, making assumptions about the appropriate statistical framework, and choosing appropriate model quality metrics. Such topics are beginning to be addressed by the research community (e.g., Randall et al., 2007; Tebaldi and Knutti, 2007; Knutti, 2008; Reichler and Kim, 2008; Santer et al., 2009; Annan and Hargreaves, 2010; Knutti, 2010; Knutti et al., 2010).

Climate Model Ensembles

When analysing results emanating from the application of Climate Insights multi-model ensembles, the following points should be considered:

(1) Forming and interpreting ensembles for a particular purpose requires an understanding of the variations between model simulations and model set-up, and clarity about the assumptions.

(2) The distinction between 'best effort' simulations (i.e., the results from the default version of a model submitted to a multi-model database) and 'perturbed physics' ensembles must be recognized. Perturbed physics ensembles can provide useful information about the spread of possible future climate change and can address model diversity in ways that best effort runs are unable to do.

(3) In many cases it may be appropriate to consider simulations from CMIP3 and combine CMIP3 and CMIP5, recognizing differences in specifications (e.g., differences in forcing scenarios). IPCC assessments should consider the large amount of scientific work on CMIP3, in cases where lack of time prevents an in-depth analysis of CMIP5. It is also useful to track model improvement through different generations of models.

(4) Consideration needs to be given to cases where the number of ensemble members or simulations differ between contributing models. The single model's ensemble size should not inappropriately determine the weight given to any individual model in the multi-model ensemble. In some cases, ensemble members may need to be averaged first before combining different models, while in other cases only one member may be used for each model.

(5) Ensemble members may not represent estimates of the climate system behaviour (trajectory) entirely independent of one another. This is likely true of members that simply represent different versions of the same model or use the same initial conditions. But even different models may share components and choices of parameterizations of processes and may have been calibrated using the same data sets.

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