WCRP
World Climate Research Programme

WCRP Community-wide Consultation on Model Evaluation and Improvement

Please complete the following template by writing your answers into the boxes below the questions, sending any supplementary material such as clearly labeled figures in a separate file. Please submit your response electronically by ***15 September 2009*** to Anna Pirani at apirani@princeton.edu.

Q1: Please state your particular area of interest, e.g. global or regional climate or NWP modeling, seasonal prediction, sea-ice feedbacks, monsoons, troposphere-stratosphere exchanges, etc.

The Met Office Hadley Centre has a very broad interest including global and regional climate modelling, sesonal prediction, understanding and modelling of key processes and variability on seasonal-centennial timescales (monsoons, ENSO, MJO, troposphere-stratosphere exchanges, teleconnections, blocking and many others); climate feedbacks processes (clouds, sea-ice, water vapour, the hydrological cycle and many others).
The Met Office has interests also in NWP modelling and Ocean modelling as well and these will be addressed in separate replies to this questionnaire.

Q2: Given your interest, what would you consider/identify as the KEY uncertainties/deficiencies/problems of current models? What do you think should be evaluated/improved as a priority in models in terms of parameterization and/or interactions among processes? (Give references and/or one key figure where possible)

Our interest is in improving model predictions across a range of space and timescales. A specific aim is to reduce errors in models at regional scales and for extremes and to improve predictions on seasonal-decadal timescales. To deliver on this we believe that we need to evaluate processes in the models utilising the best possible observations. Key uncertainties in 'physical' models remain associated with tropical phenomena and variability (ENSO, monsoons, MJO, the hydrological cycle,…) and with clouds and aerosols (low clouds are a major source of uncertainty (Webb et al 2006, Bony and Dufresne, 2005) but other cloud types may have bigger feedbacks). Linking these model deficiencies to parameterizations is difficult, but studies have suggested the role of convection in many of these aspects. Hence a focus on improved understanding, modelling and evaluation of convective schemes would seem a priority.

The sensitivity of predictions on all timescales to model resolution (horizontal and vertical) and model domain is also a key issue. For example, on seasonal to decadal timescales, the role of the stratosphere on tropospheric climate has been shown to be important (e.g. Ineson and Scaife, 2009) but this is mostly not included in future projections. Key modes of variability (e.g. ENSO) are influenced by resolution in both the atmosphere and ocean models and probably by the relative resolution of one component to the other.

Increasingly we are modelling earth-system feedbacks and the biogeochemical feedbacks (e.g. atmospheric chemistry, ecosystems, carbon cycle, methane and nitrogen cycle, …) have significant and/or in some cases not well quantified uncertainties associated with them. In addition we need to better understand and evaluate regional interactions between physical and earth system feedbacks. Some aspects of Earth System modelling are also required to reduce uncertainties on climate impacts and plan adaptation policies accordingly.

Q3: Do you see a particular gap (in knowledge, in observations or in practice) that would need to be filled, or a particular connection between different modeling communities or between modeling, process studies and observations that should be made a priority?

There has been a joining up of effort in some communities to cover the gap between observations, small scale and large scale modelling. A good example is the CFMIP-GCSS link. Modelling efforts to produce diagnostics that allow acurate comparison to up-to-date EO or in-situ datasets has been very effective in highlighting model deficiences (e.g. COSP; Bodas-Salcedo et al, 2009). Mirroring this in other communities (e.g. hydrological modelling, …?) would enable greater progress to be made. There is also a gap between data assimilaton research for short to medium range weather prediction and that used for initialising seasonal and decadal climate predictions.

Bridging the gap between observations, process studies and large-scale modelling also needs to happen in the field of Earth System modelling, especially in areas where parametrisations are still very crude (e.g. dynamic vegetation).

Q4: Do you see any particular resource or opportunity within the modeling/process study/observational/theoretical community (e.g. new results, new observations) that would be particularly useful and should be exploited to tackle this problem?

In the Met Office we are utilising a seamless approach to model development and evaluation using the MetUM (Met Office Unified Model) framework. We will run the same physical model at all timescales from 1-5 day forecasts to centennial prediction. This allows study of errors at the shortest timescale (e.g. a few hours or less for fast physical processes such as clouds or seasonal timescales for coupled modes of variability such as ENSO). Hence we are able to evaluate processes in a strongly dynamically constrained environment focussing on errors in the physical mechanisms and compare in real-time to the most up-to-date observations.

However, observations of certain key quantities are still lacking across the range of timescales. For example, although there is a relatively large number of research stations around the world that make measurements of soil moisture, these are limited to certain areas of the globe and a reliable long-term global record is lacking. This is being addressed through the development of a number of satellite-based measurements such as ASCAT. Detailed information about cloud processes, ice and water contents and their conversion to precipitation is lacking - an area which experiments such as CloudSat are aiming to address. A number of global precipitation products exist which use multiple sources of observations (rain gauges, radar, and multiple satellite measurements), but there is some disagreement between such products, both over land and sea. Thus, verification of global precipitation distribution on all timescales is problematic. This is being addressed through measurement projects such as the Tropical Rainfall Measuring Mission (TRMM; see http://trmm.gsfc.nasa.gov) and, in the future, the Global Precipitation Measurement mission (GPM; see http://gpm.gsfc.nasa.gov).

Q5 What would best accelerate progress on the topics raised in questions 1-4? Do you have suggestions for new initiatives (new process studies, field campaigns, or new collaborative approaches, eg international Working Groups, Climate Process Teams)?

We are strongly supportive of initiatives such as CAPT (Phillips et al, 2004) and Transpose-AMIP (Williamson et al, 2008) which aim to set up frameworks for evaluating climate models run in NWP mode (where they are not routinely used for NWP forecasting) so they can exploit the advantages described above. Coordinated experiments such as the Climate Historical Forecast Project and experiments around it also help to direct the development of models and forecast systems.

Q6: Any other suggestions/issues to be raised?

There is a requirement for systematic and objective techniques to prioritise areas for model development and improvement.

In the past it has commonly been the case that the setting of priorities has been relatively obvious. If you want to make model-based predictions of, for example, the MJO, then you need to ensure your model actually simulates organised MJO activity. On a more basic level, you might even need to develop a parameterisation of a new process such as vegetation in order to simulate the carbon cycle.

We are now getting to a stage where models can simulate phenomena like ENSO with some basic level of fidelity. Then we start to ask questions like "how good does my model's simulation of ENSO have to be in order for me to be confident that its sensitivity to increasing greenhouse gases is correct?" or "what aspects of ENSO do I need to get right and what aspects can I afford to neglect in order to concentrate on some other aspect of model improvement?" How do I know when my model is fit-for-purpose?

There is a need to further develop techniques which relate how model deficiencies and errors impact on the prediction problem of interest: to define the mapping between model-error space and prediction-error space. Some will prefer approaches which seek to understand those mappings from a fundamental or process point of view. Others will favour more statistical approaches, perhaps involving collections of metrics. We need both types of approaches.

The mapping between model-errors and prediction-errors is central to the concepts of weighting/ranking different model versions, quantifying uncertainty and probabilistic climate prediction. This is an emerging area (subject to a special IPCC meeting http://www.ipcc-wg1.unibe.ch/meetings/boulder/boulder.html) but, as yet, these techniques have not been coordinated or consistently extended to inform the model development processes and help prioritise effort.