CMIP5 in review

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- For CMIP5, what were the science questions and what was done?
- What did we learn (scientifically and in terms of practical lessons)?
- What science gaps and systematic model errors remain and what science questions should be addressed?
- For CMIP6, what should be done differently?

- For CMIP5, what were the science questions and what was done?

Aims: provide a multi-model context for :

i) assessing the mechanisms responsible for model differences in poorly understood feedbacks associated with the carbon cycle and with clouds

ii) examining climate "predictability" and exploring the ability of models to predict climate on decadal time scales

iii) determining why similarly forced models produce a range of responses.

The main novelties in CMIP5 design (wrt to CMIP3) were the inclusion of climate prediction and the extension of CMIP runs to ESMs. Due to the **pioneering character of these kind of experiments, the design of some of the simulations suffered from a lack of past experience and knowledge of the processes involved.**

- For CMIP5, what were the science questions and what was done?

  Decadal Predictions (i) **: The documentation on the experimental design was not sufficiently clear. A few aspects were left to the discretion of the modeling groups.** For example, groups were free to select different starting points for individual hindcasts *("Groups are expected to initialize their runs at some point prior to the 10-years…of the forecast period")*. This created some confusion, and made also difficult the intercomparison between different predictions.

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Decadal Predictions (ii) : **The 30-year predictions (for start-dates 1960,1980 and 2005) were extremely expensive, under the computational point of view, and their usefulness is questionable**, as pioneering efforts had already pointed out that there was very limited predictive skill beyond 5-10 years. Also, constraining the mean drift for full-value initialized systems is made difficult due to the low number (3) of 30-year long realizations.

- For CMIP5, what were the science questions and what was done?

  Decadal Predictions (iii) : **Groups were asked to increase the number of start-dates (from every 5-year to – possibly - every year) at a very advanced stage of the production of CMIP simulations.**

- For CMIP5, what were the science questions and what was done?

Earth System Models – Carbon Cycle :The experiment 4xCO2 is flawed, as there is **no knowledge on the parameterization of ocean-atmosphere CO2 gas exchange above 30 deg C**. All groups most likely had to introduce a threshold control to avoid unrealistic numbers because the Wanninkhof (1992) parameterization is not valid outside a certain range.

- What did we learn (scientifically and in terms of practical lessons)?

  We started to assess the potential for making useful decadal predictions in a reasonably large ensemble of state-of-the-art climate models, and we found an encouraging degree of consistence in predictive skill across CMIP models. Most of this skill is still associated with long-term changes in the radiative forcing, but there is a "residual" fraction of this skill which appears to be linked to internal variability processes, particularly evident over some areas (notably, the North Atlantic).

  At this stage, predictability seems to be mostly determined by ocean initialization (a feature common to all CMIP decadal prediction systems). However, **the role of poorly constrained components (cryosphere, land-surface through soil moisture and vegetation, stratosphere and aerosols) on the multi-annual timescale was not adequately addressed in CMIP5**. The future availability of more reliable observations/reanalyses for these components will help us in assessing their role on climate predictability, in the next CMIP effort.

- What science gaps and systematic model errors remain and what science questions should be addressed?

There is an urgent need for **tackling long-lasting "historical" model systematic errors**. The very little advancements in terms of bias reductions (particularly in the tropics – but not only) from AR4 to AR5 should be seriously considered and put at the top of the agenda in the discussions leading to the planning of CMIP6.

We should use the time-frame between CMIP5 and CMIP6 to tackle the long lasting model systematic errors affecting climate models as a community effort.

Setting up coordinated multi-model experiments explicitly designed to tackle model biases (double ITCZ, etc.) could be an option – A BIAS-MIP?: Analyse the transition from an un-biased state to a biased state to assess and understand the "time-evolving" nature of GCM errors. Make use of multi-model ensembles of seasonal and decadal forecast data.

- For CMIP6, what should be done differently?

  The whole CMIP effort could be splitted into several –MIPs tailored around specific targets (types of experiment), so as to allow individual groups to take part only to those experiments which are of interest (e.g., make separate MIPs for centennial scenario runs, decadal, etc.).

  At the end of each individual MIP, a synthesis common paper is produced. **While a Technical Summary for policy makers is routinely produced, there is not an equivalent recommendation report" for scientists, providing guidelines for future model developments in view of the next CMIP**.

  This process may ultimately lead to a decoupling of CMIP from IPCC.

- For CMIP6, what should be done differently?

  Some of the new experiments included in CMIP5 (specifically, near-term predictions, and some of the experiments performed with ESMs) were still at a **pioneering stage**. In CMIP6, we should repeat these experiments, **revisiting the experimental design based on the lessons we learned** (and the errors made) in CMIP5. Freezing the current level of complexity of ESMs, trying to improve our systems without adding new components.