

## **Earth System Models: The Next Generation**

Aspen Global Change Institute Summer Session

### **Executive summary points**

Status of carbon cycle and dynamical vegetation to be incorporated in AOGCMs

Empirical evidence indicates that the carbon cycle responds to climate change, and first generation coupled carbon cycle model indicate the possibility of a large positive carbon cycle feedback to global warming. This makes the challenge of achieving any particular stabilization target harder to achieve. Therefore, the community is moving towards including aspects of the carbon cycle and dynamical vegetation in emerging earth system-type models.

Some models already include a closed carbon cycle, but none have yet consistently included the impacts of land use change and land management, wild fires, and this will be a priority for models to be used for the AR5

We also expect models to include some simple representation of ocean biology for the AR5

Although all models won't include other potentially important processes such as micronutrient limitations on ocean ecosystems, ocean bottom chemistry, nitrogen limitations on terrestrial ecosystems, impact of anthropogenic management on fires and increases in trop ozone, it is anticipated that some models may be implementing some or all of these

Modeling groups are also implementing various strategies for biogeography and successional processes, and re-growth in their core models

Status of aerosols and chemistry to be incorporated in AOGCMs

Aerosols and chemistry need to be considered in earth system-type models for a number of reasons. A new consideration for IPCC is the ability of the ESM to study air quality trends, to be used by the impacts community and scenario community.

For the AR5, most models will have a representation of the indirect effect of aerosols. Using more comprehensive schemes than for the AR4, and they will treat the temporal change from the past to the future.

The representation of aerosols and chemistry is likely to be more comprehensive for the near-term (2005-2030) than for the long term (2100 and beyond) experiments partly due to computational limitations

The expectation is that effects from aerosols and chemistry would be particularly important over this near-term time frame.

Mixed phase and ice phase cloud-aerosol interactions are likely to be handled rather crudely in the AR5 simulations. This is a subject of ongoing research.

Experimental design: to 2030

A prime goal of projections for the next 25 years is to provide better guidance as to the likelihood of changes in extremes on the regional scale. A research task will be to determine the feasibility of this goal.

To produce such regional scale predictions will require finer resolution models (horizontal and increased vertical resolution and domain) with the inclusion of simple chemistry, aerosols, and dynamic vegetation. Both improved process representation and higher resolution are important and compromises will be required to make the simulations computationally feasible.

Such simulations will also require accurate ocean data initialization which is currently problematic, particularly the lack of observed salinity data. Improved initialization datasets such as observed soil conditions and sea ice may be required.

Given that scenarios of long-lived greenhouse gases do not differ substantially prior to 2030, only one such scenario is anticipated to be used in model predictions for this time period.

A number of scenarios for pollutants (aerosols and short-lived gases) should be provided for low, medium and high emission projections as perturbations around the standard scenario.

To provide statistically significant assessments on the regional scale will likely require ensemble simulations of at least 10 members for each scenario.

To incorporate past climate forcings, for model verification, and for the coupled assimilation/initialization process, simulations should start some time during the latter half of the 20<sup>th</sup> century.

Experimental design: to 2100 and beyond

Advantages of proposed experimental design and scenarios:

Relatively few future climate projection simulations would be required of the ESMs using two new benchmark stabilization scenarios (for high and low forcing). For the AR4 there were three future climate projection simulations. For the proposed new coordinated experiments, there are four for groups with ESMs, and two for groups with AOGCMs.

Non-ESM results can be directly compared with the ESM results for the physical climate system.

Using benchmark scenarios allows the WG3 community to provide these scenarios to the WG1 community in a timely manner. The development of a complete new set of scenarios would take several years.

The process involved with this experimental design establishes pathways for necessary interactions between WG1 and WG3 communities

## Recommendations

An integrated effort is needed to produce past/current/future emissions of aerosols and ozone precursors would ensure the use of consistent and documented data relevant to climate/carbon cycle/aerosol/chemistry communities

To assess regional climate change effects will require gridded emission data for aerosols and short-lived trace gases. A concerted effort will be necessary to produce these datasets.

The WG2 and WG3 IPCC reports need to be lagged about 2 years behind the WG1 report. At present the WG2 and WG3 use relatively outdated (up to six years) model simulations from the previous assessment. It would be more desirable if all three working groups are using as close to current generation model projections as possible. An alternative would be for the modeling groups to make new climate change projection simulations as soon as possible (about the 2009-2010 time frame), and delay the next full assessment by about 2 years (e.g. target publication in 2015).

There is a need for a PCMDI-equivalent for WG2 and WG3 communities, or an expanded role for the IPCC DDC, and a WGCM-type community organization mechanism for WG2 and WG3 communities

WG2 and WG3 need to have input to the selection of fields to be archived for analysis in the new integrations for the AR5, in particular a list of fields related to the carbon cycle