FY 2011 First Quarter Department of Energy, Office of Biological and Environmental Research, Climate and Environmental Systems Division GPRA Metric

Title: *Development of a future representative concentration pathway for use in the IPCC 5th Assessment earth system model simulations*

Product Definition/Description

The representative concentration pathway to be delivered is a scenario of atmospheric concentrations of greenhouse gases and other radiatively important atmospheric species, along with land-use changes, derived from the Global Change Assessment Model (GCAM). The particular representative concentration pathway (RCP) that the Joint Global Change Research Institute (JGCRI) has been responsible for is a not-to-exceed pathway that stabilizes at a radiative forcing of $4.5 Wm^{-2}$ in the year 2100.

Product Documentation/Deliverable

The $4.5 Wm^{-2}$ RCP data set has been delivered to the RCP data portal maintained at the International Institute for Applied Systems Analysis (IIASA) and has already begun to be used by the Earth System and Atmosphere-Ocean General Circulation Modeling (AOGCM) communities. The URL for the data portal is at http://www.iamconsortium.org/ under the Scientific Working Group on the RCPs.

Moss et al. (2010) present a summary of the new process by which the scientific communities comprising Earth System and AOGCM modelers and the Integrated Assessment Modelers agreed to produce new sets of climate model runs for both the Climate Modeling Intercomparison Program 5 (CMIP5) exercise sponsored by the World Climate Research Programme (WCRP) and potentially for use in the 5th Assessment of the Intergovernmental Panel on Climate Change (IPCC).

The core of CMIP5 is to begin to understand the carbon cycle feedback to the climate system. As a result, there has been a desire to have endpoints for atmospheric forcings at the end of the 21st century that are widely enough separated to generate expected differences in climate response that will be interesting and diagnostic of differences in the models themselves. At the same time, the IPCC community has been interested in exploring emissions/concentrations scenarios that achieve stabilization targets at the end of the 21st century, as these are thought to be more realistic for the purposes of analysis.

The Integrated Assessment Modeling Consortium (IAMC), an international group of IA modelers, performed a thorough review of the options for new emissions/concentration scenarios and determined that there were examples in the published literature that could serve as a basis for new work for both the WCRP CMIP5 experiments and the Assessment Report 5 (AR5) of IPCC. As a result of their analysis, agreement was reached on four scenarios, and on the modeling groups to do each one:

At 2100, these are 8.5 Wm^{-2} (MESSAGE model of IIASA), 6.0 Wm^{-2} (AIM of Japan), 4.5 Wm^{-2} (GCAM model of the JGCRI), and 2.6 Wm^{-2} (IMAGE model of the Netherlands). Each model was to deliver a complete set of emissions and land-use change data, for both greenhouse gases and other radiatively and chemically important atmospheric species at a 0.5 degree global grid. In order to do this in a consistent way, all the IA groups harmonized their historical data, used the same starting date for the beginning of the simulation, and harmonized their treatment of land-use changes through an interface with the Global Land Model (GLM) of Hurtt et al (2006). The only exception to the 0.5 degree global grid were CO_2 concentrations, which do not require gridding to be used in either atmospheric chemistry models or in the ESMs/AOGCMs to be used in AR5. For IPCC purposes, the emissions data from the IAMs are harmonized using the model MAGIC6, which was calibrated to best estimate values for physical processes, including aerosol parameterizations from the AOGCM's in CMIP3 and from the carbon cycle model used by the Bern group in AR4. Total amounts of aerosols in the atmosphere are scaled to the appropriate industrial activities.

The complete collection of RCPs has been delivered to IIASA in order for the global climate modeling groups to use the data. The base data are also available more broadly to other scientific communities for their potential use as well. Out of the collection of four RCPs, the 4.5Wm-2 example is the only one that all the modeling groups participating in CMIP5 have agreed to run. Therefore, the RCP contributed by JGCRI will be the only emissions/concentration scenario that will be common throughout the climate simulations done for AR5. In addition, the CMIP5 experimental protocols call for doing a "decadal prediction" experiment, in which very high spatial resolution model runs are done for the next several decades. Again, the RCP 4.5Wm-2 has been agreed on to be the basis for that set of experiments.

Examples of the output from RCP 4.5 are shown below:

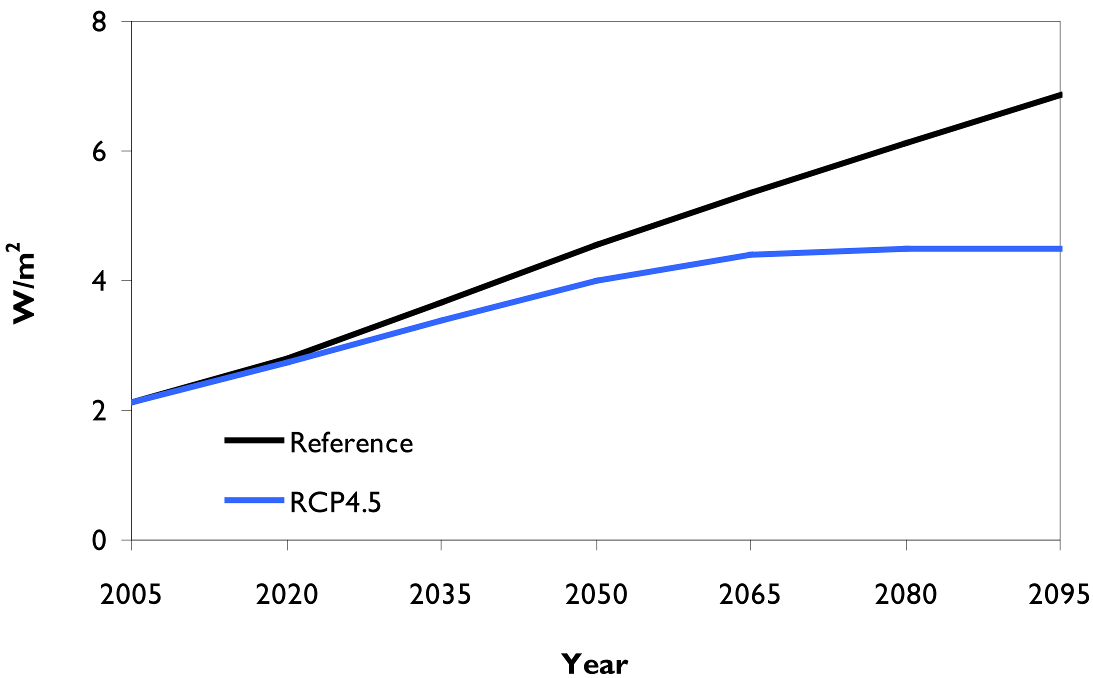

Figure 1: Radiative forcing (W m^{-2}) of the GCAM reference (with no mitigation) and RCP4.5 scenarios over the model simulation period

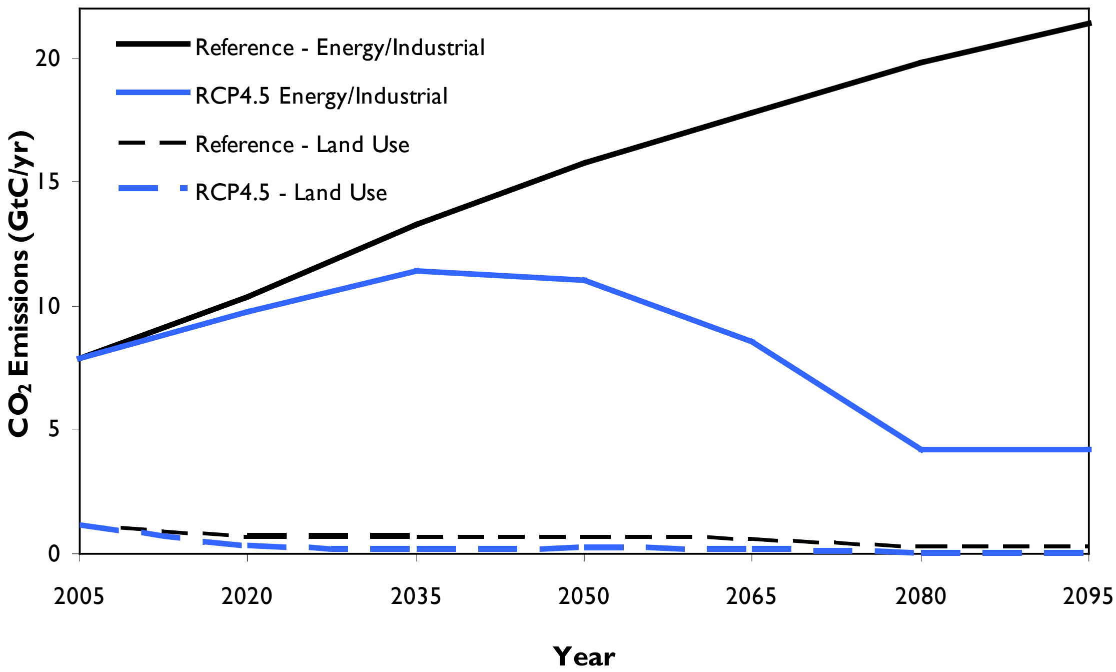

Figure 2: CO_2 emissions from energy and industrial sources and from land use/ land use change in the GCAM reference (no mitigation) and RCP4.5 scenarios

These figures are taken from a major manuscript (Thomson et al 2010) that is in the review process in the journal *Climatic Change*, along with other papers from the IA community, fully documenting all the details of the RCP products. The plan is that *Climatic Change* will publish a special issue devoted to the RCPs, and this manuscript from the GCAM group at JGCRI is just one of several papers from each modeling group describing the RCPs. The Thomson et al manuscript is being revised now in response to review comments, and is attached to this report. We will alert DOE when the paper has been accepted for publication.

Other publications have already been published using the RCP results. Thomson et al (2010) in *PNAS* have shown that the choice of parameters for continued agricultural productivity and for whether terrestrial carbon has a tangible economic value in GCAM make a very large difference in the future landscape of tropical forests. This result is quite important for assessing the relative magnitude of possible changes on the landscape that are not currently captured in GCMs—the fact that land-use can and does change extremely rapidly because of human decisions. Future publications will explore the implications of such rapid change for physical processes (such as changes in albedo and latent heat) that feed back to the physical climate system itself.

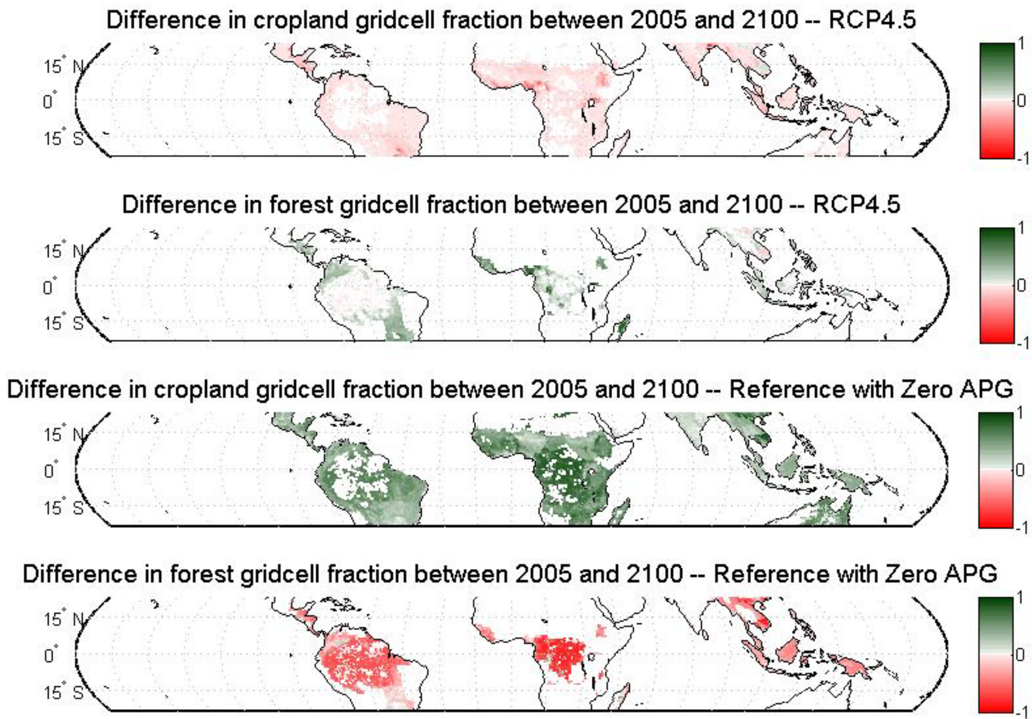

Figure 3: Differences in forest and cropland grid cells depends strongly on assumptions made about continuing agricultural productivity. The two bottom panels assume no intrinsic increase in agricultural productivity during the second half of the 21st century (source: Thomson et al, 2010, PNAS).

References

Hurtt, GC et al. 2006. The underpinnings of land-use history: three centuries of global gridded land-use transitions, wood harvest activity, and resulting secondary lands. *Glob. Change Biol*. 12:1208-1229.

Moss R, et al. (2010) The next generation of scenarios for climate change research and assessment. Nature 463:747-756.

Thomson AM, KV Calvin, LP Chini, G Hurtt, JA Edmonds, B Bond-Lamberty, S Frolking, MA Wise, and AC Janetos. 2010. Climate mitigation and the future of tropical landscapes. *Proceedings of the National Academy of Sciences.* doi/10.1073/pnas.0910467107.

Thomson, AM, KV Calvin, SJ Smith, GP Kyle, AC Volke, PL Patel, S Delgado Arias, B Bond-Lamberty, MA Wise, LE Clarke, JA Edmonds. 2010. RCP4.5: A Pathway for Stabilization of Radiative Forcing by 2100 *Climatic Change (in review)*