CCSM

Community Climate System Model

Proposal for CSL Resources – IPCC

6/1/09 – 11/30/10

PROJECT TITLE: Community Climate System Model: IPCC AR5 Runs

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Request in this Proposal: 450K GAU/month for 18 months, for a total of 8.1M GAU.

Introduction

The fifth assessment report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) is scheduled to be published in early 2013. This report can only assess papers that are either published in reputable journals, or accepted for publication. So, working backwards from this timeline, the CCSM project believes it has to finish the complete suite of AR5 runs by the end of December, 2010. Thus, the period of this CSL allocation, June 2009 through November 2010, almost exactly coincides with the period when the AR5 runs have to be accomplished. The CCSM project has committed to complete two different sets of runs for the AR5, neither of which it has done before. The first will include an interactive carbon cycle, and will consist of longer runs out to 2100, with one or two runs extended to 2300, see Figure 1. These runs will be done with a somewhat modest resolution version of the model: 2° in the atmosphere and land components and 1° in the ocean and sea ice components. The CCSM project aims to complete this set of runs on its CSL allocation at NCAR. The second set of runs will be shorter, decadal forecasts using a higher resolution version of the model: 0.5° in the atmosphere and land components and 1° in the ocean and sea ice components, see Figure 2. Several to many of these runs will involve interactive chemistry, and some will use the Whole Atmosphere version of the CCSM. These runs will require a much larger amount of computer time, and the CCSM project aims to use allocations on Department of Energy computers in order to complete this set of AR5 runs.

Therefore, this proposal will describe briefly the set of IPCC AR5 runs using the carbon cycle. This set of runs is debated and agreed by the WCRP Working Group on Coupled Modeling, and is quite often called the CMIP5 Long-term Experiments. The last meeting of this Panel was in September 2008 in Paris, when the set of runs was agreed on, and a report can be downloaded at http://www.clivar.org/organization/wgcm/wgcm-12/wgcm12.php#reports. This report goes into considerable detail about the rationale behind each of these runs, so that this request will only outline the set of runs and not go into details. The set of carbon cycle runs is divided into three groups: Core, Tier I, and Tier II, and is shown graphically in Figure 1 below. Only a handful of the more sophisticated climate models from around the world will have an interactive carbon cycle, so there is strong pressure on these modeling groups to do the complete set of AR5 runs.

There is a major difference in how future scenarios will be forced in models without and with a carbon cycle. The first are forced by concentrations of CO2 and other greenhouse gases. These concentrations are determined by estimating the future emissions of CO2 and multiplying by a factor of about 0.5 to produce the future concentrations. The factor around 0.5 is determined by the ratio of past emissions that have remained in the atmosphere, and haven't been taken up by either the land or the ocean, which are both estimated to have taken up about 25% of the CO2. In a model with a carbon cycle, the future CO2 emissions will be specified, and the model itself will determine how much will be taken up by the land and ocean and how much will stay in the atmosphere. So, the fraction of CO2 staying in the atmosphere can vary over time. Comparing

future scenarios with an interactive carbon cycle based on emissions with one based on future concentrations can then determine the positive feedback due to the carbon cycle. The size of this feedback is unknown, although the first time a carbon cycle was put into the Hadley Centre model, this feedback was so large that the Amazon rain forest turned into a grassland by 2100.

The set of runs has the standard elements of 1870 control, 20th Century and 21st Century runs for a range of future scenarios. There will be four future scenarios for both emissions and concentrations for 2005-2100. They are called: RCP 2.7, RCP 4.5, RCP 6, and RCP 8.5. The numbers represent the approximate imbalance to the earth's climate in Watts/m^2 caused by the future CO2 emissions, ranging from a low value of 2.7 Watts/m^2 to a high value of 8.5 Watts/m^2. There are two runs that then run further out to 2300, keeping the emissions fixed at their 2100 values, just as in AR4. There is an ensemble of AMIP runs, where the observed sea surface temperatures are used from 1950 to the present. There are also standard runs, such as a 1%/yr increasing CO2 run that is integrated for 150 years, which goes to the quadrupling of the present day value. Another standard CMIP run is to instantaneously increase the CO2 to four times its present day value, and to repeat this keeping the sea surface temperatures fixed. Another set of standard CMIP runs is to repeat the 20th Century run with just the natural forcings and just the greenhouse gas forcings, which answers the question as to which of these caused the observed warming in the late 20th Century. Tier II lists an ensemble of these so called 20th Century detection and attribution runs. Another set of 20th Century runs just uses the observed forcings, such as solar variability, volcanic eruptions, and individual greenhouse gases, one at a time, in order to determine which of these effects is most important at different times.

In addition, three runs are proposed in the suite that will use the CCSM 4 in different epochs. 500 year runs for both the mid-Holocene and the Last Glacial Maximum are listed, as well as a 1000 year run of the last millennium from 1000-2000. These runs test whether the model is capable of reproducing the climates of these epochs, which then gives confidence in the CCSM 4 future climate projections.

Finally, there are three runs using the WACCM version of the model from 1960 to 2050, which have 45 years of the 20th Century runs and 45 years using the RCP 4.5 scenario. These runs will be used to determine whether using the whole atmosphere version of the CCSM changes the results using the standard, tropospheric version significantly. In particular, the WACCM version will be predicting the ozone levels throughout the atmosphere instead of using prescribed values. It is yet to be determined whether this will significantly change the CCSM future climate projections. These are not standard CMIP5 Long-term Experiments. However, the CCSM will probably be uniquely able to answer this important question, because it may well be the only climate model that has an option to be run in a whole atmosphere configuration.

There are a few very short Tier I and II simulations that have not been included; namely sulfate aerosol forcing, aqua planet, and changes to the SSTs to diagnose cloud feedbacks.

Most of these experiments will use the coupled version of the CCSM 4 with a carbon cycle, which is estimated to cost 560 GAU/year. The AMIP and fixed SST runs do not use the active ocean component, but do use active atmosphere, land and sea ice components, so that the cost is estimated to be 200 GAU/year. There are three experiments using the WACCM 70 level version of the fully coupled CCSM 4, which is estimated to cost 1580 GAU/year.

IPCC AR5 or CMIP5 Long-term Experiments with a Carbon Cycle Component

	Years	# Runs	KGAU
CORE			
1870 Control - emissions	1000	1	560
1870 Control - concentrations	1000	1	560
20th Century 1870-2005 emissions	135	5	378
20th Century 1870-2005 concentrations	135	5	378
RCP 4.5 2005-2100 emissions	95	5	266
RCP 4.5 2005-2100 concentrations	95	5	266
RCP 8.5 2005-2100 emissions	95	5	266
AMIP 1950-2009	60	5	60
1%/yr CO2, abrupt 4xCO2	300	2	336
Fixed SST, 1xCO2 4xCO2	300	2	120
Total number of KGAU			3190
TIER 1			
Additional 20th Century runs	135	5	378
Additional AMIP runs	60	5	60
Extend RCP 4.5 from 2100-2300	200	1	112
RCP 2.7 and RCP 6 2005-2100	190	5	532
20th Century with just natural & GHG forcings	270	1	151
1%/yr CO2 & RCP 4.5; but radiation sees 1xCO2	245	1	137
Mid-Holocene & Last Glacial Maximum	1000	1	560
Ensemble of abrupt 4xCO2 runs	5	5	14
Total number of KGAU			1944
TIER II			
Extend RCP 2.7 and RCP 8.5 2100-2300	400	1	224
1%/yr CO2 run; but carbon sees 1xCO2	150	1	84
Ensemble of 20th Century with natural and GHG forcings	270	4	605
20th Century with individual forcings	675	4	1512
Last Millennium	1000	1	560
Total number of KGAU			2985
WACCM (70 levels) 1960-2050 20th Century + RCP 4.5	91	3	431
Grand total of KGAU			8550
KGAU / month over 19 months			450

From the start of the next CSL allocation in June 2009, CCSM has 19 months to complete these runs by the end of December 2010. Thus, our best estimate at this time is that we will need an allocation of 450K GAU/month for the 19 months in order to complete the CMIP5 set of runs. The best present estimate of mass storage for these runs is that the carbon cycle version of the model will produce 30 GB of data per simulated year. The total number of years is 15,000, so that the total data storage will be 450 TB. This amount of storage could be reduced if restart files are not saved every year, but less frequently.

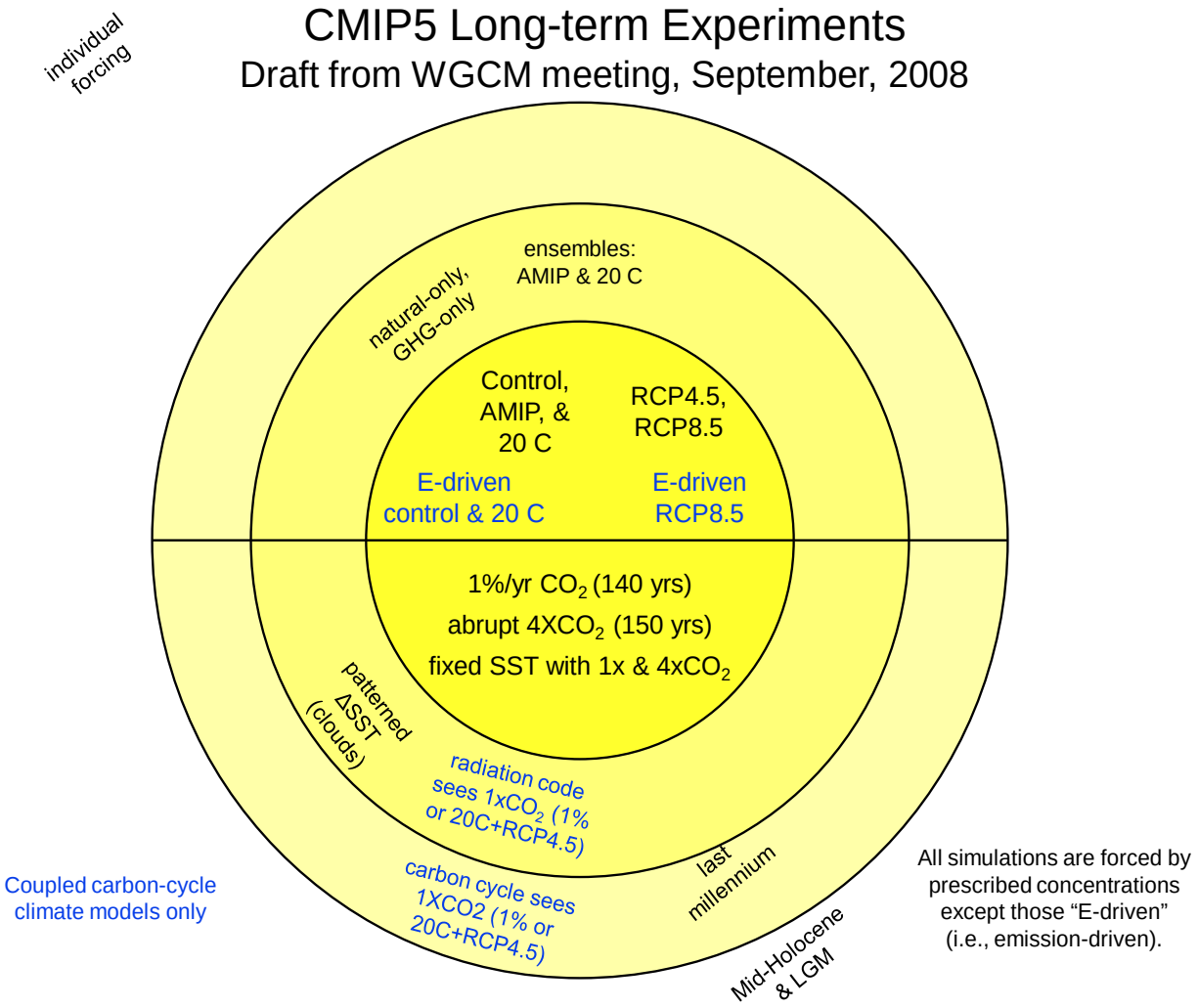

Figure 1. Graphical representation of the CMIP5 Long-term Experiments to be performed by climate models that include an interactive carbon cycle module.

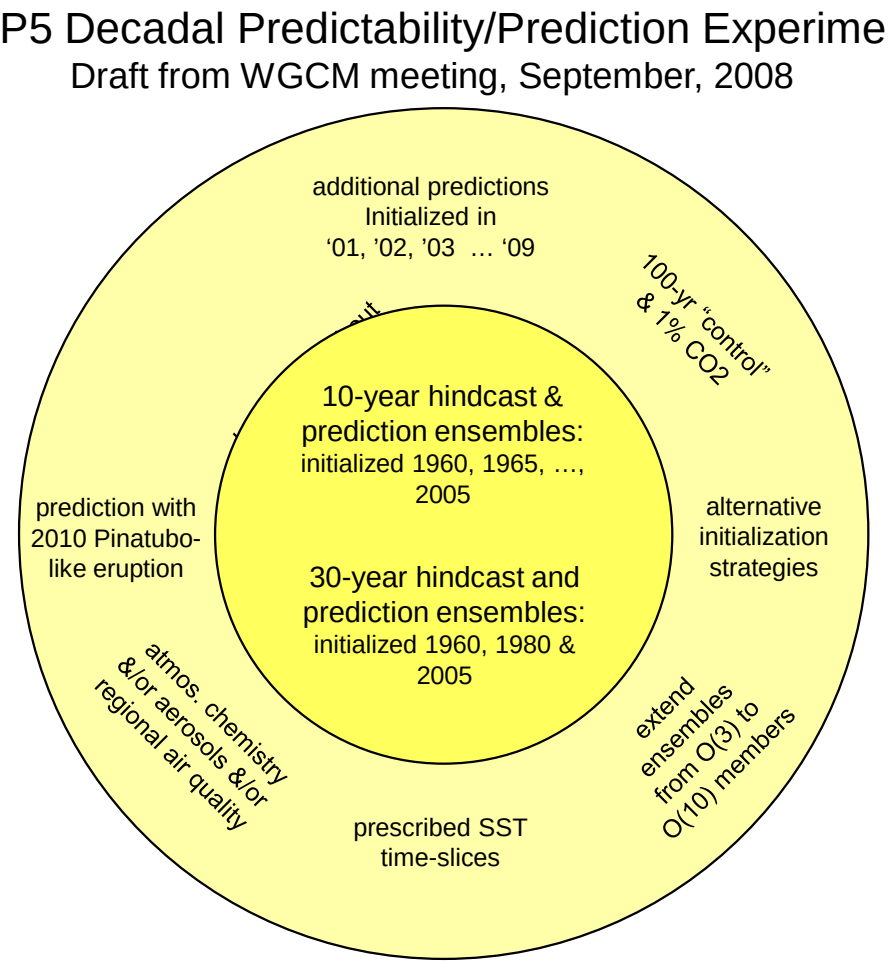

Figure 2. Graphical representation of the CMIP5 Decadal Predictability/Prediction Experiments that will be done with a higher resolution version of the CCSM4 on DOE computer platforms.

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