Minutes of the CCSM Advisory Board
27 and 28 February 2006
NSF, Room 1235

CAB and Ex-Officio Attendees: Michele Rienecker (acting chair for Jacob), Jay Fein, Peter Gent, David Griggs, Tim Killeen, Rick Anthes, Paola Malanotte-Rizzoli, Jim Hurrell, Eric Sundquist, Tom Crowley, Ricky Rood, Isaac Held, John Drake, David Rind, Paul Dirmeyer, Anjuli Bamzai, Dave Bader

Guests: Bill Collins, Don Anderson, Ming Ji, Pam Stephens, Jim Hack, Jim Kinter, Neil Swanberg, Eric Itsweire, Jarvis Moyers, Steve Meacham, Steve Lord, Sumant Nigam, Bill Wiseman, Lydia Shiver

1. **Introductions and Welcome**. Jay Fein welcomed everyone, especially the new CAB members David Rind, Paola Rizzoli, and Scott Denning, who was unable to attend because he is on sabbatical. He also stated that Daniel Jacob would not be able to attend due to illness and asked Michele Rienecker to act as chair.

2. **Status of the CCSM**. Peter Gent reported on recent science highlights:

- Arrival of the *International Journal of High Performance Computing Applications* issue that describes software engineering for climate models and documents performance and portability. It includes 13 papers with 32 external authors and 9 NCAR authors.
- Printing in progress of the special issue of the *Journal of Climate* on CCSM that includes 26 papers with 51 NCAR authors (22 lead authors) and 48 external authors. It is estimated it will be 570 pages.
- Contributions to the IPCC 4th Assessment (FAR) by CCSM described as output of 10 GB/simulated year, data volume of approximately 100 TB, largest contribution of any model, eight ensemble members at T85 for some experiments, data available online at PCMDI and ESG, original history tapes available from SCD, and diagnostics available via the Web.
- Total requests of 37,285 (10.25 TB of data) downloaded of CCSM3 data from NCAR via the ESG in 2005.
- Late Permian research done by Kiehl and Shields using the T31 x 3 ocean model with runs going out 2700 years and using a forcing of 10x CO_2 and Permian paleogeography. Rind commented that parameters still must be specified and asked if help was available from NCAR. Held said that the quality of the low-resolution CCSM model is a success. He stated that the GFDL model cannot be used in this way. Hurrell reported that Huber spent time at NCAR using SGER funds to help the paleo community be able to use the paleo model more easily. Crowley stated that geologists are very interested in the paleo work being done.
- Polar Climate Working Group research using hosing experiments.

Gent then reported on some near-term scientific priorities:

- Get a good coupled simulation using the finite volume (FV) dynamical core and get a good sea-ice distribution that is comparable to, or better than, the CCSM3 simulation. Anderson stated that NASA/GSFC, NOAA, and NCAR are working together to get a standard FV dycore model using NASA funding. The FV dycore model is needed to be able to add chemistry to the model, so it is on a critical path for CCSM4, and there will be a paleo FV version also.
- Improve the simulation in the tropical Pacific region, especially the double ITCZ and the frequency of ENSO. The biases in the tropical Pacific are being worked on using two approaches: 1) computer time was given to WRF to run at 36 km resolution and 2) CAM3 was run at T170 resolution. The collaboration with MMM has been stimulating to both divisions. Also, a Tropical Pacific Biases Workshop was held at COLA, and six projects were identified. This group will meet again this summer to continue the collaboration. Griggs stated that the UKMet Office has been working on ENSO for the last year and there are still problems, so it continues to be a high focus for them.

Gent discussed some major issues in CCSM simulations, including biases in mid-latitude continental temperature and precipitation; SSTs in coastal stratus regions; semi-annual cycle in SST for the east Pacific; polar temperature bias and tropical tropopause biases; and double ITCZ in the Pacific, and representation of major modes of variability, such as ENSO and MJO.

Gent reported that the longer-term scientific priorities are:

- Including biogeochemistry and the ocean ecosystem model for the carbon/nitrogen cycle.
- Including dynamic vegetation and land use changes in the land component.
- Including both the direct and indirect effects of aerosols.
- Including the effects of tropospheric ozone when the atmospheric chemistry component is added.
- Including a land ice sheet model.

Gent showed a potential configuration for CCSM4, and then stated that if the timeline for AR5 follows the precedent in AR4, CCSM4 has to be ready for production in 2009 and ready for testing in 2008. He also reported that CCSM received a significant increase in computer time from the CSL and DOE's Climate End Station. Sundquist asked if the human resources issue had been alleviated, and Gent stated that funding support must be found in FY07 to maintain and increase the software engineering group and liaisons.

Kinter presented information to the CAB regarding CCSM's CSL proposal and allocation. He stated that CCSM's requested 1.8 million GAUs for Production and was allocated 1.6 million GAUs. CCSM requested 1.0 million GAUs for Development and was allocated 0.9 million GAUs. Kinter said that the CCSM proposals were found to be generally very good.

Gent responded to the report by asking for continued funding that is needed to support the software engineer who is working on flexibility and scalability, and Collins stated that funding is needed for a person to work to understand the efficiency issues. The CAB members agreed that expectations for performance increases have to be tempered with realism. They noted that in a Report of the High-End Computing Revitalization Task Force (HECRTF) it was stated that although climate models "stand to benefit significantly from factors of 10 to 100 increases in MPP scale, in general they will not be able to capture more than 3% to 20% of the peak processor performance on these systems."

3. **Scientific and Technical Plans for IPCC AR5**. Bill Collins, with input from Lawrence Buja and Jerry Meehl, reported that CCSM's major objective should be to develop, characterize, and understand the most realistic and comprehensive model of the observed climate system possible. Subsidiary objectives are to analyze and reduce the principal biases in CCSM's physical climate simulations using state-of-the-art theory and observations; simulate the observed climate record with as much fidelity as possible; and simulate the interaction of chemistry, biogeochemistry, and climate with a focus on climate forcing and feedbacks.

Collins then discussed the open issues related to the configuration of CCSM4, which are what improvements will be ready to address long-standing biases? What major modifications will be included in CAM? What resolutions will we use? What can we afford? What terrestrial ecosystem model will we use? What mechanism for gaseous chemistry will we use? What representation of aerosols will be adopted? What lid will be adopted for the upper atmosphere? Will dynamic vegetation be compatible with the simulated climate? What changes can we make to the numerical formulation to increase scaling by 10x? by 25x?

Collins outlined the lessons learned from IPCC AR4 as

- The need to start with an experimental plan.
- The need to develop forcings early in the process of experimental design and model development.
- The need to design and test methods for equilibration of CCSM with present-day and pre-industrial conditions.
- The need to plan and test data processing to ensure timely data transfer to IPCC archive(s).
- The need to develop scientific requirements for model capabilities, e.g., chemical processes, etc.; spatial resolution of the CCSM component models; and the size of the ensembles for 20th century and scenario runs.

Collins outlined the goals of the design exercise as

- Identifying major scientific objectives, such as what do we want to explore using 20c3m simulations?, what hypotheses are we testing with scenario runs?, and what can we learn about CCSM and the climate from the multi-model ensemble?
- Identifying subsidiary scientific objectives, for example, testing of new methods for understanding climate sensitivity and climate feedbacks and developing state-of-the-art emissions data sets and simulations of forcing agents.
- Mapping/integrating these objectives into the CCSM Science Plan.
- Designing the simulations including spin-up process and ensemble size.
- Creating an implementation plan.

Collins then discussed the draft outline of an IPCC plan as

- Introduction: The interaction of CCSM and IPCC
- Scientific objectives for the IPCC AR5
- Description of the forcing agents
- Description of the experiments
- Description of the model spin-up procedure
- Implications for the CCSM program
- Resource requirements (computer, human resources, and post-processing, archival, and data transfer)
- Timelines and a decision tree
- Distribution and analysis of IPCC simulations

Collins advised that the product of the WGCM workshop in summer 2006 for modeling groups and scenario developers for IPCC AR5 should be recommendations for AR5 scenarios, and also that CCSM should present its plans and AR5 configuration at the meeting of WGCM and AIMES in September 2006. He also advised that the CCSM model should be frozen in late 2008, public release should be in summer 2009, initiation of historical simulations should begin in spring 2010, and scenario integrations should be completed in spring 2011, which gives three years for model development. Also, we should consider a coordinated process to resolve open issues for the configuration of CCSM4, and this process should stem from our experimental objectives for studies of the coupled Earth system.

Held asked if there were so many problems in the AR4 simulations, why should CCSM couple the carbon/nitrogen cycle and would it be useful. Sundquist asked what is the best way to communicate the improvements in climate modeling science to society. Crowley stated that a Plan B must be formulated in case the new model is not useable or not improved. Anderson stated that critical questions to be answered should be identified and then science driven research should go forward.

Collins also reported on the status of ESMF Phase 1, saying that CAM has been re-engineered so it has better scalability and that standalone CAM will be eliminated if the same performance is achieved. ESMF will allow a single executable, sequential

CCSM. Griggs reported that the UK is not using an ESMF-type system. They are using a perturbed physics ensembles system.

4. **Agency Program Manager Updates Related to CCSM**

- Randy Dole, NOAA, informed the CAB members of the Climate Variability and Change Interagency Working Group's proposal "Toward Development of an Integrated Earth System Analysis Capability." Dole stated this is a Grand Challenge Project, and the goal is to unify analysis. This project also directly supports the CCSP Goal 1, which is to "Improve knowledge of the earth's past and present climate and environment, including its natural variability, and improve understanding of the causes of observed variability and change. NOAA, NASA, NSF, DOE, DOD, and universities would collaborate, and they would involve other CCSP program elements such as Observations, Water Cycle, Atmospheric Composition, Ecosystems (marine and land), and Land Use Change elements with direct linkages to GEOSS and other major modeling and observing system-related national and international activities.
- Jay Fein, NSF, discussed the President's FY 2007 budget request, which includes a healthy 7.9% increase for NSF. It is estimated that the GEO budget will be up 6% and ATM's budget will be up 5%. Fein stated that the reason there is a 30% decrease in dollars from the top down to ATM is two high priorities that took $50 million each (Polar Programs and Cyberinfrastructure).
- Anjuli Bamzai, DOE, reported that the Climate-Science Computational End Station (CES) Development and Grand Challenge Team was awarded 2 million CPU hours on DOE's Cray X1E and 3 million CPU hours on DOE's Cray XT3. She stated that the mission of the CES is to deliver simulations that improve the scientific basis, accuracy, and fidelity of climate models and perform climate change simulations that address national concerns and contribute to the DOE science mission. CCSM is the primary model that will be developed, maintained, and supported at the CES. The CES coordination process is a CES Executive Body, resources allocated to CES projects via a proposal process, priority given to projects that fulfill DOE climate science mission goals, require dedicated leadership-class supercomputing capacity, has significant publications in peer-reviewed journals, and support of and coordination with SciDAC-2, which is being competed now. SciDAC-2 awards will be made late summer 2006, includes an anticipated 10 NSF-DOE SGER awards, and computing resources at DOE facilities, e.g., NERSC/LBL. Bamzai also reported that NASA, NOAA, and DOE have all received budget cuts.
- Don Anderson, NASA, reported that he is expecting a 20% cut in budgets. He stated that NASA is observation driven due to its satellite programs, and that NASA needs to step up and do re-analysis of all data. He also stated that 10-15% of his research budget would go to software

engineering interactions and visualization projects. NASA will continue to fund ESMF and provide computer facilities for projects such as WACCM and the GFDL hurricane model. Anderson said that the NASA Earth System Science mission needs to have input about what observations will be needed for further modeling projects. NASA is also holding a meeting on data systems, and Bader stated that Tom Karl at NOAA NESDIS is also involved in planning for data systems.

- Ming Ji, NOAA, stated that his budget has been cut by 40%. Short-term seasonal-to-interannual prediction projects will look at a next generation operational climate forecast system, and long-term stable models (CCSM, GFDL, GMAO model) need to be supported to be used for the NCEP forecast model. NOAA does not expect these stable models to be operational models, but they want them to continue to improve using data assimilation and other approaches for seasonal-to-interannual forecasting. He stated improving the physical model is also important, especially improving ENSO and tropical biases. He stated that planning for budgeting and computing resources needs to be done, and it could be done across agencies.
- Isaac Held, GFDL, reported that they are doing a postmortem on IPCC and suggested CCSM do one also. He said that the GFDL model is very distinctive in Africa, and one strength of the model is in the Southern Ocean and the ENSO is high caliber. Future plans for the GFDL model are to use the FY dycore with cubed sphere, physics options, and a more comprehensive model. GFDL's science themes are earth system, hurricanes, global warming, and variability in the Atlantic Ocean. They also are trying to simulate it better than the current model and develop a way to look at climatology of tropical storms. He also stated that the GFDL/CCSM collaborations will not be going ahead this year due to no funding to hire postdocs. The CPTs are ongoing though, as is the tropical model biases work. Held stated that GFDL pruned away options (different development branches) for IPCC AR4 and chose the best one and went ahead with that one, so the constraints for IPCC AR4 were different for GFDL than for CCSM.
- David Griggs, UKMetOffice, stated that you cannot compare models because they are too complex, so their approach is to compare one process and understand it by model, such as cloud feedbacks.
- Jim Hurrell, NCAR, stated that the seamless prediction project includes all major U.S. modeling centers. A White Paper is being prepared to define a seamless prediction paradigm and identify major research challenges and opportunities. Fein stated that a meeting of NSF, DOE, NASA, and NOAA program managers will be held and comments would be sent to this committee, then a small, invited workshop would be held to discuss the White Paper and set a focus. Then a community workshop should be held. Griggs said that the practical and technical considerations should be looked at as climate models are updated on the order of every 5 years and operation models are updated on the order of every few months.

- Steve Meacham discussed Cyberinfrastructure planning at NSF. A new Director of the Office of Cyberinfrastructure, Dan Atkins, will start in June 2006. The OCI budget requested in FY07 is $182 million. The plans include $200 million over 4 years for a petascale system, together with efforts in data management, virtual organizations, and education. The scope of the petascale system will be defined by the nature of the research for which the science and engineering community wish to use it. Meacham also encouraged use of the NSF shared-use HPC systems at Pittsburgh, NCSA, and UCSD for climate modeling to supplement the capacity available at CSL.
- Jim Kinter, COLA, discussed the tropical biases workshop that was hosted by COLA, with the outcome that 6 modeling groups would run the same experiments and then review the results at the CCSM Workshop in Breckenridge. After that meeting a workshop on analysis will be planned. COLA is also involved in the seamless prediction project, and they are collaborating with Joe Tribbia and Jeff Anderson at NCAR.
- Steve Lord, NCEP, reviewed its Climate Forecast System (CFS), which uses T62/64-layer version of GFS, MOM3, GODAS, and direct coupling (no flux correction), and possible upgrades (resolution increase to T126, MOM4, etc.). He noted their challenges for the next upgrade cycle are improving forecasts for ENSO and North America predictions and reducing biases for ocean and precipitation; self consistent system forcing requiring reanalysis of atmosphere, ocean, land surface, and sea ice; reforecasts for calibration and production development; reforecasts forced by reanalysis; resources such as CPUs, disks, tape, and people; and acceleration of model improvements through the NOAA Climate Test Bed.
- Michele Rienecker, NASA GMAO, discussed the GEOS-5 structure. She also stated that collaborations with CCSM are the FVcore synchronization, gravity wave drag development, CPT for tropical boundary layer clouds, and potential for much more, such as aerosol impacts on weather and climate, chemistry-climate feedbacks, and coupled atmosphere-ocean-sea ice model.

5. **Topics for Next CAB Meeting**. The CAB requested a report on NCAR plans for a new Data Center.

6. **Beyond Scenarios**. Eric Sundquist said the CAB should encourage IPCC to draw some sort of line between production and model experiments. A production scenario would be coupled models with best known feedbacks, such as prescribed GHG concentrations, that will give information about adaptation, biases, and regional climate change. A model experiment would be coupled models with less known feedbacks, such as prescribed GHG emissions that will give information for mitigation and forcing. Rind said that experiments must be run to 2100 to see differences. Crowley said that experiments only need to be run to 2050 to be used for adaptation and then run to 2100 also. Rind said that IPCC will not go backward and only ask for runs to 2050. Collins

stated that we must simulate very well the historical record to start, which will give us direction to biases reduction or adding new elements.

The CAB recommended that CCSM have a goal to write a plan with decision points (project management) to simulate current climate and historical record well.