MANAGEMENT PLAN

A Scalable and Extensible Earth System Model for Climate Change Science

otherwise known as the

SciDAC2 CCSM Consortium Project

Department of Energy

Office of Biological and Environmental Research

Scientific Discovery through Advanced Computing

Scientific Application of the Climate Change Prediction Program (Dr. Anjuli Bamzai, program manager)

Principal Investigators

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1 Introduction[†]

This project employs multi-disciplinary teams to accelerate development of the Community Climate System Model (CCSM), based at the National Center for Atmospheric Research (NCAR). A consortium of eight Department of Energy (DOE) National Laboratories will collaborate with NCAR and the NASA Global Modeling and Assimilation Office (GMAO). The laboratories are Argonne (ANL), Brookhaven (BNL) Los Alamos (LANL), Lawrence Berkeley (LBNL), Lawrence Livermore (LLNL), Oak Ridge (ORNL), Pacific Northwest (PNNL) and Sandia (SNL). The proposed work focuses on scalablity for petascale computation and extensibility to a more comprehensive earth system model.

Key objectives are to develop, integrate and evaluate the CCSM (through comparison with observed data), enhance the performance of the CCSM, making it the leading comprehensive earth system model on scalable computer architectures. This management plan defines roles and responsibilities to assure that the proposed work remains coordinated, focused, and compatible with the objectives of the CCSM Scientific Steering Committee, while supporting the DOE Climate Change Prediction Program (CCPP).

As part of the DOE Scientific Discovery through Advanced Computing (SciDAC) program, the "CCSM Consortium" must also work collectively with applicable parts of the whole SciDAC infrastructure development efforts, namely the Centers for Enabling Technologies (CETs) the Scientific Application Projects (SAPs), and SciDAC Institutes. The project acts as a focal point for collaborations with related efforts sponsored by other agencies, such as the NASA Earth System Modeling Framework (ESMF), NASA Carbon Assimilation projects within the GMAO at Goddard Space Flight Center, and NOAA atmospheric model development projects at the Geophysical Fluid Dynamics Laboratory (GFDL). The project also has a collaborative relationship with the DOE Climate Change Research Division programs. As part of the Climate Change Prediction Program we work with researchers from the Atmospheric Science Program (ASP), the Atmospheric Radiation Measurement (ARM) and the Terrestrial Carbon Program (TCP).

2 Objectives

The overarching objective of the SciDAC2 CCSM Consortium project is to work in collaboration with NCAR to develop and maintain the CCSM as a state-of-the-art climate model optimized for performance, portability, and climate change science application on a range of parallel computer architectures. The project seeks to facilitate the CCSM's use to gain the best possible scientific understanding of climate variability and global change on decadal to century time scales. This project works to implement scalable algorithms and conform to modern software engineering practices and modular, open development of each component of the CCSM and of the coupled system as an Earth System Model. Efficient parallel execution for high-throughput climate simulations at multiple resolutions will be achieved through flexible model configurations and optimized utilities and algorithm libraries. The completeness of the model will also be extended through the

[†] A complete list of acronyms is given in Appendix A.

development of new physical parameterizations, with particular focus on the global carbon cycle and terrestrial land and ocean ecological processes and atmospheric chemistry and aerosol coupling with climate. With collaborative links to the DOE Climate Change Research Divisions programs in Aerosol Science (ASP) and Terrestrial Carbon (TCP) we seek to advance the capability of the CCSM in conjunction with the latest developments in process modeling and with the benefit of DOE's extensive measurement campaigns in the Atmospheric Radiation Measurement (ARM) program.

3 Multiple levels of coordination*

Coordination of the SciDAC2 project must take place at several levels.

- It is necessary to coordinate contributions from several DOE labs in each of many topic areas (see Tasble 1 below).
- SciDAC activities must follow DOE OBER's Climate Change Prediction Program (CCPP) objectives.
- Activities in DOE labs must be coordinated with related activities at NCAR and NASA and NOAA, to avoid duplication of effort and to insure that DOE contributions are both timely and relevant to the overall CCSM goals.
- SciDAC activities ultimately must be compatible with the overall vision for CCSM determined by the collection of CCSM Working Groups (WGs) and the CCSM Scientific Steering Committee (SSC).
- As part of the DOE SciDAC program, this SciDAC Consortium project is expected to interact with and benefit from research and development activities in the rest of the SciDAC program, namely, the other SciDAC Computer Science and Mathematics projects of the Centers for Enabling Technology (CETs) and SciDAC Institutes.
- Finally, we are expected to be responsive to the US Climate Change Science Plan and to participate and support Assessment activities such as the U.N. Intergovernmental Panel on Climate Change (IPCC).

Clearly, for DOE laboratory scientists to be effectively involved in so many aspects of CCSM, it is imperative that they participate actively in relevant activities. Most important is involvement in the Working Groups as members or, if possible, as co-chairs. This is where alternative approaches are evaluated and compared prior to making recommendations to the SSC. Attendance at the annual summer CCSM Workshops provides a unique opportunity to see the "big picture" of CCSM's progress. Obviously, if the opportunity arises, it can be very helpful to serve as a member of the CAB or SSC.

3.1 Coordination among DOE Labs

This SciDAC Consortium project involves different subsets of eight DOE laboratories contributing to different aspects of CCSM development and evaluation (see Table 1). The nomenclature used to describe different managerial responsibilities is explained here.

Coordination will take place by means of weekly teleconference calls, periodic project working meetings. Problems will be dealt with via email, telephone and mini-teleconference calls. Semi-annual meetings will be held. One will take place in conjunction with the annual CCSM Workshop on the Monday immediately preceding

* Full names, affiliations, and primary interests and roles of individuals referred to in this document are listed in Appendix B.

late June meeting. The second will be held in conjunction with the periodic CCPP program review and Science team meeting. A project web page will be maintained at http://www.scidac.org/CCSM.

3.1.1 Principal Investigators

The PIs, John Drake (ORNL) and Phil Jones (LANL), will coordinate all aspects of the project among the participating DOE laboratories and corresponding activities at NCAR and NASA and NOAA. The PIs are responsible for (a) monitoring progress of SciDAC tasks, (b) negotiating the roles of the DOE labs relative to one another and NCAR, and (c) insuring through discussions with CCSM management that SciDAC contributions are compatible with CCSM objectives. The PIs will provide semi-annual reports on the progress of the project to the DOE program sponsors. These will include highlights of the project and status of scheduled tasks and milestones. Drake and Jones will also be liaisons to NCAR and CCSM management for the coordination of the project.

3.1.2 Laboratory Site Contacts

Each participating DOE lab has a designated Site Contact for the project, whose purview cuts across all topics being pursed at that laboratory. It is the responsibility of the Site Contacts to communicate issues to the PIs, help manage ongoing activities at their labs and to monitor progress within the lab, and oversee budgets. Site Contacts and their NCAR and NASA and NOAA counterparts are listed (italicized) in the second row of Table 1. Generally speaking, the Site Contacts are the PIs and co-PIs listed on the title page.

Topic	NCAR	NASA	NOAA	ANL	BNL	LANL	LBNL	LLNL	ORNL	PNNL	SNL
Site Contacts	Gent	Rood	Lin	Jacob	McGraw	**Jones**	Wehner	Cameron -Smith	**Drake**	Ghan	Taylo
Biogeochemistry	Mahowald					Elliott			**Hoffman**		
Aerosols and Atm Chem	Lamarque				McGraw	Elliott		Cameron -Smith	Erickson	**Ghan**	
Integration	Vertenstein	Sawyer		**Jacob**		Lipscomb		Mirin	Worley		Taylo
Evaluation	Collins			Jacob		Maltrud	**Wehner**	Cameron -Smith	Erickson	Ghan	
Scalability	Craig		Kerr	Loy				Mirin	**Worley**		Taylo
Performance	Wolfe			Loy					White		

Table 1. Laboratory Site Contacts are responsible for overseeing all activities at their respective institutions and high-level coordination among institutions. Major topic areas are listed in the first column, (in bold) Team Coordinators.

3.1.3 Topic Leaders

In each topic area, the PIs have appointed one of the Topic Leaders to coordinate and provide input to the periodic progress reports. The role is to monitor progress and coordinate work among the DOE labs, NCAR, NASA and NOAA.

3.2 Coordination with CCSM

The management structure of the CCSM project at NCAR has three parts: the Scientific Steering Committee (SSC), the CCSM Advisory Board (CAB), and a collection of Working Groups, each devoted to a component model, scientific research area, or other aspect of CCSM. Detailed information about the CCSM management structure and scientific plans is available on-line at http://www.cgd.ucar.edu/csm.

3.2.1 Working Groups

The topic areas listed in Table 1 fall within the scope of the CCSM Working Groups (WG). Each working group consists of scientists who come together to work on topics in which they share common interest. Membership in any WG is open to all persons having an interest in the topic. The WGs allow scientists to participate in cooperative research, compare different approaches, and minimize unnecessary duplication. The WGs present their research and recommendations, preferably based on consensus, to the SSC, which has the authority to accept or reject any recommendation. The SSC may also call for further research before any decision is made. Thus, it is imperative that SciDAC personnel be involved closely in the activities of relevant WGs.

At present, there are ten WGs, each co-chaired by one or more non-NCAR scientists and zero or more NCAR-based scientists. The topic areas and co-chairs of each WG are displayed in Table 2. DOE laboratory scientists appear in italics.

Working Group	Co-chairs	Affiliations
Atmosphere Model	Phil Rasch	NCAR
	Leo Donner	Geophysical Fluid Dynamics Laboratory
Ocean Model	Bill Large	NCAR
	Steven Jayne	Woods Hole Oceanographic Institute
Land Model	David Lawrence	NCAR
	Steven Running	U. Montana
Polar Climate	Marika Holland	University of Washington
	Elizabeth Hunke	Los Alamos National Laboratory
Paleoclimate	Jeff Kiehl	NCAR
	Zhengyu Liu	University of California-Santa Cruz
Climate Variability	Clara Deser	NCAR
	Sumant Nigam	U. Maryland
Biogeochemistry	Natalie Mahowald	NCAR
	Scott Doney	Woods Hole Oceanographic Institute
	James Randerson	U. Calif, Irvine
Climate Change And Assessment	Warren Washington	NCAR
	Gerald Meehl	NCAR
	Ben Santor	Lawrence Livermore National Laboratory
Chemistry-Climate	Michael Prather	U. Calif, Irvine
	Peter Hess	NCAR

Working Group	Co-chairs	Affiliations
Software Engineering	Mariana Vertenstein	NCAR
	Pat Worley	ORNL
	Ceclia Deluca	NCAR

Table 2. Names of CCSM Working Groups and Co-chairs, 2006.

Communications with the WGs occurs only through participation by DOE scientists and managers in relevant WGs. In several cases, DOE scientists are co-chairs of WGs. Active involvement is the most effective way to influence the direction taken by WGs. We have chosen not to specify liaisons to the working groups as many of our tasks involve multiple WGs. We have strong participation with Software Engineering with the tasks *of integration, scalability and performance*. The biogeochemistry task overlaps with the Land, Chemistry-Climate and Biogeochemistry WGs.

3.2.2 Scientific Steering Committee

The CCSM Scientific Steering Committee (SSC), is chaired by Dr. Peter Gent, who is also an investigator on the SciDAC team. Steve Ghan, Bill Collins and Mariana Vertenstein are also members of the SSC and Co-Investigators on this project. The SSC provides scientific leadership for the CCSM project, including oversight of activities of working groups, coordination of model experiments, decision making on model definition and development, and encouragement of external participation in the project. The SSC determines what working groups should be organized and oversees the activities of these working groups. The co-chairs for each working group are appointed by the SSC. The major scientific responsibility of the SSC is to decide which components and/or parameterizations should be included in future versions of CCSM. Proposals for new components and/or parameterizations should come from the appropriate working groups, together with appropriate reasons for the recommended changes and documentation of the results.

The CCSM SSC members consist of the Director of NCAR's Climate and Global Dynamics (CGD) Division plus eight additional scientists. The present membership of the SSC is given in Table 3.

Peter Gent, Chair	NCAR
Chris Bretherton	University of Washington
Steve Ghan	PNNL
Bill Collins	NCAR
Bill Large	NCAR
Jim Hurrell	NCAR
Julia Cole	U. Arizona
Daniel McKenna	NCAR
Gordon Bonan	NCAR
Ben Santor	LLNL

Scott Doney	Woods Hole
Mariana Vertenstein	NCAR

Table 3. Membership of the CCSM Scientific Steering Committee, 2006.

It is worth noting that most SciDAC scientists have no access to the SSC as a unit, so the only mechanism that presently exists for communication between SciDAC and the SSC is conversations with individual members of the SSC. That seems sufficient for now.

3.2.3 CCSM Advisory Board

In addition to the SSC, CCSM has an Advisory Board (CAB) that meets twice annually to review the progress and status of the CCSM program. The CAB then writes a report (letter) to the President of UCAR, the Director of NCAR, and the Leader of the Climate and Global Dynamics Division. In January, 2002, John Drake became a member of CAB, taking over from Bob Malone, who served a three-year term starting in 1998.

3.3 Coordination with CCPP

In its present form, the DOE Climate Change Prediciton Program (CCPP) comprises numerous university grants plus three major projects: the climate change project at NCAR (Warren Washington, PI); the Program for Climate Model Diagnosis and Intercomparison (PCMDI) at LLNL (David Bader, Director); and the Climate, Ocean and Sea Ice Modeling (COSIM) project at LANL (Phil Jones, PI). PCMDI is playing an important role in evaluation and validation of CCSM. Thus strong ties already exist between CCPP, CCSM, and the SciDAC CCSM Consortium. Progress Reports to the CCPP program director, Dr. Anjuli Bamzai, will be provided semiannually by the PI's, utilizing information from the Topic Coordinators. In addition, we anticipate a review in the second or third year of the program. The PI's will keep the present management plan updated and provide periodic highlights to Dr. Bamzai.

Within the DOE Climate Change Research Division that sponsors the CCPP, there are three other programs with which we have collaborative links. The Terrestrial Carbon Program sponsors measurements and process model development for terrestrial carbon cycle. Mac Post (ORNL) is a collaborator and advisor to this project regarding biogeochemical developments. In addition, the Aerosol Science Program sponsors work in Robert McGraw (BNL)'s group who is a Co-Investigator for this project. The Atmospheric Radiation Measurement program (ARM) is also important for providing data and validition of the Single Column Radiation Model that is a unit in the atmospheric physics model of the CCSM.

3.4 Coordination with SciDAC Program Elements

The full SciDAC program within DOE spans a wide range of applications, of which climate modeling is the largest. Cross-cutting activities in numerical methods, adaptive grids, mathematical libraries, data management, and computational performance optimization are supported by Centers for Enabling Technology (CETs) as well as SciDAC Institutes which are lead by University collaborations. Collaborations between

the SciDAC CCSM Consortium and several of the SciDAC CETs and Institutes have been established. Table 4 lists those most pertinent to the SciDAC CCSM Consortium project, along with the lead investigators at each institution; the Principal Investigator of each CET or Institute is in bold. Tasks in collaboration with other SciDAC projects are tracked along with other project tasks. Note that the Geodesic Climate Model project led by David Randall (CSU) is another SciDAC Climate project funded by OBER. The Earth System Grid is a CET.

ISIC/NC	NCAR	ANL	LANL	LBNL	LLNL	ORNL	Other
Earth Sys Grid	Middleton	Foster			**Williams**	Bernholdt	
PERI				**Lucas**		Worley	
SDM CET		Ross		**Shoshani**		Samatova	
ITAPS CET					**Diachin**		
TOPS CET					Woodward		**Keyes** (Columbia)
APDEC CET				**Colella**	Brown		

Table 4. SciDAC projects pertinent to CCSM Consortium. PI names in **bold**.

3.4.1 Scientific Application Partnerships

Two SAP's have been funded by the DOE ASCR Office in conjunction with this project. These are of three year duration and focused on a particular mathematical or computer science task within the proposal. Bob McGraw (BNL) leads the SAP on Aerosol Dynamics and Pat Worley (ORNL) leads the SAP on Scalability. These are tightly integrated with our project and will be considered members of the Consortium, though they will have reporting requirements in addition those requested by OBER program director Anjuli Bamzai. The DOE OASCR program manager for the SAPs is Anil Deane. The PI's will be accountable and assist in responses to both program managers.

Appendices

A. Acronyms

ANL	Argonne National Laboratory
CCSM	Community Climate System Model (NCAR and other institutions)
CET	Center for Enabling Technology (SciDAC program element)
CICE	Sea ice model (LANL)
DAO	Data Assimilation Office (NASA)
DOE	Department of Energy
ESMF	Earth System Modeling Framework (NCAR and other institutions)
HPCC	High Performance Computing and Communications (multi-agency program)
ISIC	Integrated Software Infrastructure Center (SciDAC)
LANL	Los Alamos National Laboratory
LBNL	Lawrence Berkeley National Laboratory
LLNL	Lawrence Livermore National Laboratory
MCT	Model Coupling Toolkit (ANL)
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NSF	National Science Foundation
ORNL	Oak Ridge National Laboratory
PCMDI	Program for Climate Model Diagnosis and Intercomparison (LLNL)
POP	Parallel Ocean Program (LANL)
PNNL	Pacific Northwest National Laboratory
SAP	Scientific Application Partnership
SciDAC	Scientific Discovery through Advanced Computing (DOE program)
SCRIP	Spherical Coordinate Remapping and Interpolation Package (LANL)
SSC	CCSM Scientific Steering Committee

B. Names, affiliations, and primary interests

The following table contains the full names, affiliations, primary interests and roles (in the context of this management plan) of individuals referred to in this document. Names in italics identify people *not* funded under the SciDAC CCSM Consortium project.

Last name	First name	Laboratory	Primary Interest	Primary role
Atherton	Cyndi	LLNl	Chemistry, aerosols	Co-I: Constortium, ASP
Bader	*David*	LLNL	Global modeling	CCPP Chief Scientist
Bernholdt	*David*	ORNL	SW Engineering	CCA and ESG
Bonan	*Gordon*	NCAR	Land-surface model	Co-Ch: Land WG
Cameron-Smith	Philip	LLNL	Chemistry, aerosols	Co-I: Consortium
Chung	*Cathy*	LLNL	Aerosols	Co-I: Consortium, ARM
Collela	*Phil*	LBNL	Applied math	PI: APDEC CET
Collins	Bill	NCAR	Aerosols, Evaluation	Co-I: Consortium
Connell	Peter	LLNL	Chemistry, aerosols	Co-I: Consotrium
Craig	Tony	NCAR	SW Engineering	Co-I: Consortium

Last name	First name	Laboratory	Primary Interest	Primary role
Doney	*Scott*	NCAR	Biogeochemistry	Co-Ch: Biogeo WG
Drake	John	ORNL	Atmospheric dynamics	PI: Consortium
Diachin	*Lori*	LLNL	Meshing software	PI: SciDAC ITAPS CET
Elliott	Scott	LANL	Ocean biogeochemistry	Co-I: Consortium
Erickson	David	ORNL	Chemistry, Evaluation	Co-I: Consortium
Fung	*Inez*	Berkeley	Biogeochmistry	Collaborator, advisor
Gent	Peter	NCAR	Ocean model	CCSM Chief Scientist
Ghan	Steve	PNNL	Atmospheric model	Co-I: Consortium
Hoffman	Forrest	ORNL	Land-surface model	DOE lead: Land
Hunke	*Elizabeth*	LANL	Sea-ice model	Co-Ch: Polar Cli WG
Jacob	Rob	ANL	Coupler, SWE	Co-I: Consortium
Keyes	*David*	Old Dominion	Applied math	PI: TOPS ISIC
Lamarque	Jean-Francios	NCAR	Chemistry	Co-I: Consortium
Larson	*Jay*	ANL	Coupler, SWE	Collaborator
Lin	*S. J.*	NASA/DAO	Atmospheric dynamics	Collaborator
Lipscomb	William	LANL	Ice sheet	Co-I: Consortium
Loy	Ray	ANL	Scalability on BG/L	Co-I: Consortium
Lucas	*Bob*	LBNL	Performance	PI: SciDAC PERI
Malone	Robert	LANL	Hydrologic cycle	Co-PI: Consortium
Maltrud	Mat	LANL	Ocean analysis	Co-I: Consortium
McGraw	Bob	BNL	Aerosol dynamics	PI: SAP
Middleton	*Don*	NCA*R*	Earth system grid	Co-I: Earth Sys Grid
Mirin	Art	LLNL	Atmospheric model	Co-I: Consortium
Post	*Mac*	ORNL	Carbon land processes	TCP, advisor
Randall	*David*	CSU	Coupled model	PI: Geodesic Grid CM
Rood	*Ricky*	UMich-NASA	Global modeling	advisor
Sawyer	*Will*	NASA/GMAO	SW Engineering	Co-I: Consortium
Shoshani	*Ari*	LBNL	Data grid	PI: SciDAC SDM CET
Taylor	Mark	SNL	Scalability	Co-I: Consortium
Washington	Warren	NCAR	Coupled model	Co-I: Consortium, CCWG
Wehner	Michael	LBNL	Performance, evaluation	Co-I: Consortium
Williams	*Dean*	LLNL	Diagnostic tools	Co-PI: ESG
White	Trey	ORNL	Performance	Co-I: Consortium
Woodward	*Carol*	LLNL	Solvers	Co-I: TOPS CET
Worley	Pat	ORNL	Scalability, integration	Co-I: PERF ISIC