Strategic and Implementation Plan: *Center for Multi-Scale Modeling of Atmospheric Processes (CMMAP)*

Lead Institution: Colorado State University

Partner Institutions:

University of California at Los Angeles
University of California at San Diego
Hampton University
University of Washington
University of Maryland
City College of New York
University of Utah
Colorado College
University of Colorado
Catamount Institute
National Center for Atmospheric Research
Pacific Northwest National Laboratory
Lawrence Livermore National Laboratory
Meteorological Service of Canada
Frontier Research Center for Global Change, Japan
Center for Climate System Research, University of Tokyo
Bureau of Meteorology Research Center, Australia
Apple Computer

Collaborating Institutions:

European Centre for Medium Range Weather Forecasting
Scripps Institution of Oceanography
International Business Machines
Goddard Space Flight Center (NASA)
Langley Research Center (NASA)
Geophysical Fluid Dynamics Laboaratory (NOAA)
National Centers for Environmental Prediction (NOAA)
Atlantic Oceanographic & Meteorological Laboratory (NOAA)
University Corporation for Atmospheric Research
Poudre School District
Thompson School District

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Executive Summary

The Center for Multi-Scale Modeling of Atmospheric Processes (CMMAP) will focus on improving the representation of cloud processes in climate models. The need for such improvements has been one of the most important limitations on the reliability of climate-change simulations. CMMAP will address this problem through a revolutionary new approach called the "multi-scale modeling framework" (MMF). Whereas conventional parameterizations are based on statistical theories involving uncertain closure assumptions, MMFs represent cloud processes on their native scales, and include the cloud-scale interactions among the many physical and chemical processes that are active in cloud systems. A very important strength of an MMF is that the results produced can be evaluated by comparison of simulated and observed cloud-scale processes.

A key part of the proposed research consists of further development of the MMF concept. This very challenging, multi-disciplinary task, will be the central, organizing activity of CMMAP's research. The lead time needed for model development will be "buffered" through continuing use of an existing prototype MMF, which is already a very useful research tool.

The performance of the model will be evaluated through exhaustive and elaborate comparisons with observations. These will include surface observations, such as those collected by the ARM program; and satellite observations, such as those that will flow from the newly launched CloudSat and Calypso missions .

Further development of statistical cloud parameterizations will be accelerated through the analysis of MMF results.

The MMF is much more expensive to run than a conventional GCM, and so CMMAP includes a strong computational focus. Research issues include performance optimization, visualization of the MMF results, and management and distribution of large datasets.

CMMAP's education and human-resource goals are to provide first-rate graduate education in Atmospheric Science; to interest undergraduates in graduate education and careers in climate science; and to develop and disseminate teaching materials designed to inform K-12 students (and their teachers) about the nature of the climate system and the career opportunities in climate science. In each of these areas, CMMAP will make a special effort to include students from groups that are under-represented among climate-science professionals. Naturally, CMMAP will support the educations of numerous graduate students in Atmospheric Science. Our undergraduate educational activities include the development of new trans-disciplinary courses, support for undergraduate research experiences, and outreach to under-represented groups through the SOARS (Significant Opportunities in Atmospheric Research and Science) program. We propose a K-12 curriculum development program; delivery of instructional materials to K-12 schools, in part through a television program; K-12 teacher training through workshops; and K-12 classroom visits by CMMAP scientists. CMMAP's educational activities will lead to an increased awareness of Earth science research as a possible career choice, especially for young people from under-represented groups.

CMMAP's Knowledge-Transfer goals are of two types. First, we will work with our research partners to transfer CMMAP research results and technologies into our national atmosphere-modeling "infrastructure," for both climate simulation and weather prediction. Second, CMMAP will undertake two publishing projects that will significantly enhance scientific communication in our field: the creation of a new and unique online technical journal devoted to global modeling, and the production of an edited book on the history of global climate modeling, including transcripts of interviews with the key participants.

Introduction

The purpose of this Strategic and Implementaion Plan is to document the vision, mission, goals and objectives of the Center for Multiscale Modeling of Atmospheric Processes, the strategies by which the Center will accomplish its mission, and the organizational structure of the Center. The Plan is deliberately concise. It will evolve over time.

Research Plan

1. Vision Statement for Research

Cloud processes are central to the Earth Sciences. Changes in cloudiness can either amplify or damp climate change. Cloudiness is a key element of any weather forecast. Clouds are central components of the water cycle. Chemical transformations occur inside clouds and feed back to affect the properties of the clouds. Last but not least, the biosphere is highly dependent on cloud processes. Progress in all of these disciplines is being held back by our limited ability to understand and predict global cloudiness.

Over the past several decades, progress towards improved predictions of the effects of clouds on weather and climate has been unacceptably slow. *CMMAP's vision is to take advantage of rapidly increasing computer speed to achieve major advances in our ability to understand and predict the effects of clouds on weather and climate.*

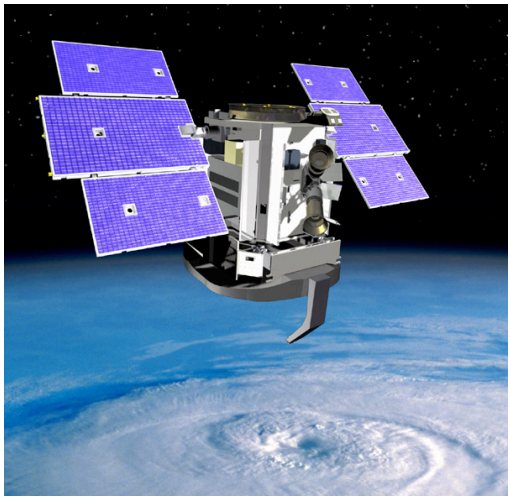
2. Mission Statement for Research

The research mission of CMMAP is to develop a new kind of global atmospheric model that can represent the effects of clouds on weather and climate with greatly improved realism; to evaluate the new model by comparison of model results with observations; and to apply the model to understand the interactions of clouds with other components of the Earth system, including the atmosphere, the vegetated land surface, and the oceans.

3. Opportunities and Challenges

Opportunities

1. The CMMAP team is very strong.
2. Amazing increases in computer performance are enabling new research approaches.
3. CMMAP is starting up with a well defined research strategy already in hand.
4. Because CMMAP's research strategy is very new, many important results are ripe for the taking.
5. Important new observations, just becoming available, are ideally suited to testing our models.
6. CMMAP provides very real and natural opportunities for global modelers, global observationalists, cloud-scale modelers, and cloud-scale observationalists to collaborate over an extended period of time within a highly focused research framework with centralized management. CMMAP will foster scientifically productive interactions among these diverse and historically disjoint communities.



Challenges

1. The CMMAP team is geographically far-flung.
2. CMMAPS's central scientific focus is highly interdisciplinary within the atmospheric sciences.
3. CMMAP's modeling work will require very large amounts of computer time.
4. Members of the CMMAP team need to share enormous amounts of data, both model output and observations.

4. Goals and Objectives

Goals

A. Create a radically new class of models that take advantage of petascale computers to produce dramatically improved simulations of the interactions of clouds with the global circulation of the atmosphere.

B. Identify, analyze, and understand the strengths and weaknesses of the new models using a variety of state-of-the-art observational datasets, derived from in situ observing systems, as well as both ground-based and satellite-borne remote sensors.

C. Apply the new models to develop an improved understanding of the role of clouds in the Earth system.

Objectives

1. Extend, evaluate, and apply the prototype MMF. *Relates to Goal A.*
2. Develop of a second-generation MMF. *Relates to Goal A.*
3. Develop improved parameterizations of microphysics for use in MMFs and GCRMs. *Relates to Goal A.*
4. Develop improved parameterizations of turbulence for use in MMFs and GCRMs. *Relates to Goal A.*
5. Test sensitivity of CSRMs to more detailed radiation calculations *Relates to Goal A.*
6. Analyse, evaluate, and interpret MMF results using emerging datasets. *Relates to Goal B.*
7. Accelerate improvement of conventional parameterizations. *Relates to Goals A and C.*
8. Optimize use of computational and data storage resources. *Relates to Goal A.*

5. Strategies

A. Aggressively develop the Quasi-3D MMF and the global cloud-resolving model, while simultaneously continuing research with the prototype MMF. *Relates to Goals A and C.*

B. Create “Research Themes” on the MJO, low-cloud feedbacks on climate change, development of the Quasi-3D MMF and global cloud-resolving model, and interactions between deep and shallow convection. Use these Themes to foster collaboration among scientists at various CMMAP partner institutions. *Relates to all Goals.*

C. Submit requests for supercomputer resources, including Petascale computing resources.

6. Implementation Plan for Research

Table 2: For each Research Objective, we list "Actions Required," with a time-frame, and identify a Team Leader who assumes responsibility for the Objective as a whole. Appendix A lists the Objectives associated with each CMMAP participant.

Objective	Actions Required	Time-frame	Team Leader	Location	Supports Goal #
1. Extensions, evaluations and applications of the prototype MMF	Perform and analyze AMIP (Atmospheric Model Intercomparison Project) simulations with the prototype MMF	Year 1	Khairoutdinov	CSU	A
	Perform and analyze coupled ocean-atmosphere simulations with the prototype MMF	Year 2			
	Create and test a geodesic version of the prototype MMF	Year 2			
2. Development of a second-generation MMF	Develop and test improved numerical representation of cloud-scale dynamics	Year 2	Arakawa/ Randall	UCLA	A
	Develop and test a global cloud-resolving model	Year 2			
	Develop and test Quasi-3D MMF	Year 3			
3. Develop and test improved microphysics parameterizations for MMFs and GCRMs	Develop new microphysics parameterization and test in CSRM	Year 3	Krueger/ Kreidenweis	UU	A
	Test new parameterization in MMF and GCRM	Year 4			
4. Develop improved parameterizations of boundary-layer clouds and turbulence for use in MMFs and GCRMs	Develop new boundary-layer cloud and turbulence parameterization and test in CSRM	Year 3	Bretherton/ Moeng	UW	A
	Test new parameterization in MMF and GCRM	Year 4			
5. Test sensitivity of CSRMs to more detailed radiation calculations	Develop new radiation parameterization and test in CSRM	Year 3	Barker	MSC	A
	Test new parameterization in MMF and GCRM	Year 4			
6. Innovative analysis, evaluation and interpretation of MMF results using emerging datasets	Acquire and adapt in situ and ground-based remotely sensed datasets for use in evaluating the MMF	Ongoing	Rossow	CCNY	B
	Acquire and adapt satellite datasets for use in evaluating the MMF				
	Develop and apply advanced, non-linear, multivariate analysis methods to enable diagnosis of multi-scale atmospheric processes.				
7. Accelerating improvement of conventional parameterizations	Develop and test improved parameterizations of cumulus convection	Ongoing	Stevens	CSU	A & C
	Develop and test improved parameterizations of stratiform clouds				
	Develop and test improved parameterizations of the boundary layer				
8. Optimal use of computational and data storage resources	Port the MMF and GCRM to a variety of computing platforms including those associated with NSF's petascale initiative	Ongoing	Helly	UCSD	A
	Efficiently distribute model output and observational datasets to users				

7. Metrics for Research

- Number of refereed journal articles published.
  Addresses Objectives 1 - 5.
- Number of simulations performed with the MMF.
  Addresses Objectives 1, 2, and 4.
- Number of simulations performed with the global cloud-resolving model.
  Addresses Objective 2.
- Number of conference and workshop presentations made.
  Addresses Objectives 1 - 5.
- Creation of observation-based datasets designed to facilitate model evaluation.
  Addresses Objective 4.
- Use of observational datasets to evaluate the performance of models.
  Addresses Objective 4.
- Community computational resources allocated Addresses Objective 8.
- Annual reviews of progress and plans by the External Advisory Panel, including an assessment of how many tasks have completed on schedule and within the budget.
  Addresses all Objectives.

8. Management Plan for Research

The research agenda of CMMAP will be managed by the Center Director, who will rely on advice from the other members of the Executive Committee, as well as the External Advisory Panel. A key goal will be to maintain an extremely tight focus on CMMAP's research objectives.

The Center Director will appoint lead scientists for each of the Research Objectives listed above, and will receive quarterly progress reports from each of them.

Education Plan

1. Vision Statement for Education

A climate science workforce enhanced by CMMAP's inspiration and education of students of all levels, policymakers, and the public.

2. Mission Statement for Education

Educate and train a diverse population in climate and Earth System Science by enhancing teaching and learning at all educational levels; disseminating science results through multiple media; engaging stakeholders, policymakers, and the general public; and improving science pedagogy.

3. Opportunities and Challenges

Opportunities

1. Importance of climate to society
2. World class research institutions with a history of leadership in science education
3. Partnerships with successful and well-established leaders in science communication and outreach at multiple levels,e.g., the Little Shop of Physics (LSOP), UCAR (University Corporation for Atmospheric Research) , and CIPP (Colorado Institute of Public Policy)
4. Strong partnerships with programs for recruiting and retaining students from underrepresented groups,e.g., SOARS, CO-AMP, (Colorado Alliance for Minority Participation), and AGEP (Alliance for Graduate Education and the Professoriate)
5. Expertise in formal academic assessment studies

Challenges

1. Distributed nature of Center across many partner institutions
2. Typically poor communication among graduate research, K-12 education, and the public
3. Inadequate pedagogical training of Ph.D. students
4. Inadequate K-12 teacher training
5. Pool of new climate science Ph.D.s is much less diverse than the population at large

4. Goals and Objectives

Goals

A. Enhance the climate science workforce of the future

B. Enhance teaching and learning of Earth System Science at all levels

C. Disseminate CMMAP science results to the public and to climate stakeholders

Objectives

1. Develop, implement, disseminate and evaluate improved Earth System Science curricula for middle and junior high schools
2. Improve teaching and learning of climate science at the high school level
3. Disseminate CMMAP science to the broad public via the World Wide Web
4. Disseminate research results and explain climate science to stakeholders and policymakers
5. Improve undergraduate climate education
6. Enhance graduate education and research in climate science
7. Teach next generation of leading climate scientists to be better teachers

5. Strategies

A. Provide opportunities for students at all levels to engage in active learning of Earth Science and Climate by experimentation

B. Work with successful and well-established partners in curriculum development, science communication, and multimedia for maximum impact

C. Intervene early to draw from the whole range of our diverse population

D. Link Education, Outreach, and Diversity elements of the Center, thereby leveraging investments in all three

E. Use structured mentoring interactions to bring science content from higher education levels downward, to help future educators learn to be better teachers, and to provide strong role models of a motivated, diverse population of young scientists

F. Provide opportunities for current and future leading scientists to learn to be better teachers, both formally (through pedagogical instruction) and informally (through mentoring)

G. Combine curriculum development and implementation with classroom evaluation and formal assessment

H. Maintain active communication across Center components through an ED Committee, summer institutes, and twice-yearly meetings

I. Collaborate with professional societies to disseminate CMMAP innovations.

6. Implementation Plan for Education

Table 3: For each Education Objective, we list "Actions Required," and identify a Team Leader who assumes responsibility for the Objective as a whole. Appendix A lists the Objectives associated with each CMMAP participant. All of the Actions Required for CMMAP's Education activities are ongoing continuously during the life of the project. For this reason, we do not include a "Time-fame" column in the table.

Objective	Actions Required	Team Leader	Location	Supports Goal #
1. Implement, disseminate and evaluate improved Earth System Science curricula for middle and junior high schools	Develop and test curriculum enhancement kits for local schools	Jones	CSU	B
	Develop atmospheric science content for LSOP & TV show			
	Teacher training course			
	Evaluation/assessment			
2. Improved climate education at high school level	SEE-ME web-based modeling tools	Denning	CSU	B
	Teacher training course			
	UCAR levelizers			
	Classroom evaluation			
	Formal assessment			
	Climate summer program			
3. Dissemination of CMMAP science to public via web	Windows to the Universe web site	Foster	UCAR	C
	Science communication analysis			
4. Outreach to climate stakeholders & policymakers	Climate white papers for stakeholders Summer workshops	Kathlene	CIPP	C
	Short course on policy for CMMAP grad students			
5. Improved undergraduate climate education	New atmospheric science courses at Colorado College, taught by CMMAP graduate students	Drossman	CC	A
	Minority recruiting and retention			
6. Graduate education and research	Recruiting excellent and diverse students	Denning	CSU	A
	Improved atmospheric science coursework			
	Direct involvement with research			
7. Teaching future teachers	Teacher training course	Denning	CSU	B
	Mentoring interactions			
	LSOP internships			

7. Metrics for Education

- *Quantity and quality of enhanced materials, teacher training, and outreach*
  Addresses Objectives 1 and 2. Develop science curricula for middle and high schools

  Includes:

  - Number of new curriculum kits and DVD sets developed through LSOP and tested in PSD classrooms
  - Number of science teachers trained through CSU course
  - Number, duration, and quality of visits to SEE-ME web tools
  - Formal assessment of classroom effectiveness and student performance, with publication of findings through national conferences and peer-reviewed journals
- *Evaluation of CMMAP-enhanced Windows on the Universe.*
  Addresses Objective 3. Dissemination of results to public via web site

  Includes:

  - Number of visits, length of visits, which pages viewed
  - Breakdown of usage statistics in Spanish and English
- *Evaluation of outreach to stakeholders and policymakers.*
  Addresses Objective 4. Dissemination of results to stakeholders and policymakers

  Includes:

  - Participation by stakeholders and scientists in working groups
  - Production of climate science whitepapers for stakeholder communities
  - Attendance at summer short courses to learn about policy process
- *Evaluation of enhanced undergraduate education in climate science.*
  Addresses Objective 5. Improve undergraduate climate science education

  Includes:

  - Number of new courses developed and implemented in the classroom
  - Student evaluations of same
  - Number of students from underrepresented groups participating in climate presentations through CO-AMP
- *Evaluation of CMMAP graduate education in climate science.*
  Addresses Objective 6. Improve graduate education and research climate science

  Includes:

  - Number and diversity of graduate students supported by CMMAP
  - Participation of CMMAP-supported graduate students in summer research institutes
  - Peer-reviewed publications led by CMMAP graduate students
- *Evaluation of CMMAP graduate education in climate science.*
  Addresses Objective 7. Teach scientists to be better teachers

  Includes:

  - Number of student interns in LSOP programs
  - Participation of CMMAP-supported scientists and students in pedagogical instruction and mentoring programs
  - Number of CMMAP-supported Ph.D.s who go on to teach

8. Management Plan for Education

The Associate Director for Education and Diversity, Prof. Denning, reports to the Center Director, and provides direction and oversight to these components of the Center. Fig. 2 shows the management structure for the ED part of the Center.

Management of ED activities in CMMAP is facilitated by a full-time Science Education Manager, and is advised by the ED Committee, whose members are CMMAP scientists. The ED Committee serves in part to ensure that CMMAP scientists are actively engaged in CMMAP's ED activities.

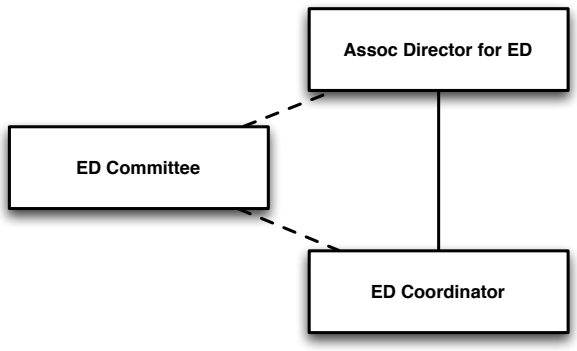


Figure 2: Interactions of the Education and Diversity Committee.

Science Education Manager:

An education professional will be hired, via a nation-wide search, to take responsibility for daily management and implementation of Education and Diversity activities of the Center. Duties will include

- Working with the STC's Administrative Director and ED partners to track performance of component activities
- Organizing twice yearly progress reports from ED partners
- Managing communications among ED partners, and between CMMAP scientists and ED resources, to facilitate dissemination of science results to students, educators, stakeholders, policymakers, and the public
- Organizing monthly teleconferences with ED partners and management
- Organizing and scheduling ED component of twice-annual CMMAP meetings

ED Committee

A committee of CMMAP scientists will oversee planning and implementation of ED activities. The committee is chaired by the Associate Director for ED, Prof. Denning, with membership changing through regular rotation, plus representatives from LSOP, UCAR, and public schools. Committee will host two full-day meetings per year for all CMMAP scientists and students to review ED activities, train participants in ED processes, and solicit content. ED Committee meets monthly by telecon, and ensures that ED content for all levels reflects the full range of CMMAP science and engages all the Center's scientific talent.

Diversity Plan

1. Vision Statement for Diversity

A climate science workforce enhanced through CMMAP's diversity of culture and life experience which draws from the whole US population.

2. Mission Statement for Diversity

Increase the number of women, underrepresented minorities, and individuals with disabilities in climate science by aggressively recruiting these groups as CMMAP graduate students and staff members, helping them become excellent scientists and educators, and placing them in leadership positions. Enhance the science and engineering pipeline through mentoring and recruiting at earlier academic levels. Study diversity problems and solutions, and disseminate results.

3. Opportunities and Challenges

Strengths and Opportunities

1. World class research institutions with a history of placement of Ph.D. graduates in leadership positions in climate science.
2. Partnerships with successful and well-established programs for promoting diversity in science (e.g., SOARS, CO-AMP, AGEP).
3. Center faculty include experts in gender issues and in academic assessment studies.
4. One of CMMAP's partner institutions (Hampton University) is a minority serving institution.

Challenges and Weaknesses

1. Historically poor representation of women and ethnic minorities in climate sciences.
2. Progressive loss of female students from science and engineering in academics beginning in middle-school.
3. Pervasive media imagery in society that portrays scientists as white men.
4. Very low population of African Americans in region of CMMAP home institution.
5. Women, ethnic minorities, and individuals with disabilities are underrepresented on CMMAP faculty relative to US population.

4. Goals and Objectives

Goals

A. Support and matriculate graduate students whose gender and ethnic makeup reflect those of the US population.

B. Improve understanding of the structural barriers to gender and ethnic balance in science.

C. Encourage participation in science and engineering by women, minorities and persons with disabilities, at all academic levels.

Objectives

1. Recruit, retain, and matriculate a cadre of CMMAP Ph.D. students with gender and ethnic makeup representative of the US population.
2. Improve recruitment of underrepresented groups into Earth science at the undergraduate level.
3. Improve the retention of women in the science and engineering "pipeline" from middle school through graduate school.
4. Understand and explain persistent underrepresentation by women and ethnic minorities in science, evaluate solutions, and disseminate results nationally.

5. Strategies

A. Aggressively recruit CMMAP graduate students from underrepresented groups, teach them to be great researchers, and place them in leadership faculty positions in climate science.

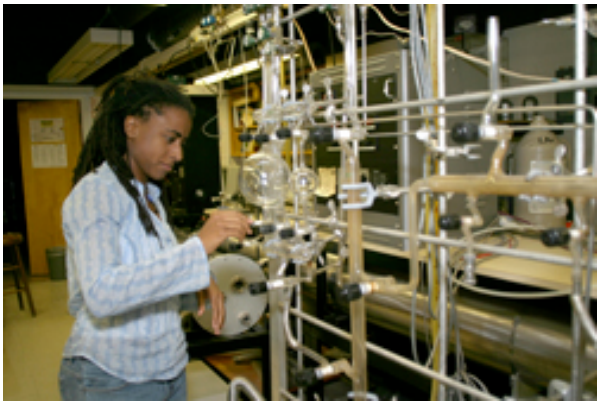
B. Work with successful and well-established programs for promoting diversity in science and engineering.

C. Introduce students from underrepresented groups to climate science early, provide them with opportunities to engage in real research before graduate school, and provide strong community support to encourage participation.

D. Use structured mentoring interactions to provide strong role models of a motivated, diverse population of young scientists.

E. Link Education, Outreach, and Diversity elements of the Center, so leverage investments in all three.

F. Invest in academic research on the persistent problems of diversity in science, study potential solutions, and disseminate the results in peer-reviewed literature and national conferences.



6. Implementation Plan for Diversity

Table 4: For each Diversity Objective, we list "Actions Required," and identify a Team Leader who assumes responsibility for the Objective as a whole. Appendix A lists the Objectives associated with each CMMAP participant. All of the Actions Required for CMMAP's Education activities are ongoing continuously during the life of the project. For this reason, we do not include a "Time-fame" column in the table below.

Objective	Actions Required	Team Leader	Location	Supports Goal #
1. Recruit and matriculate representative Ph.D. students from CMMAP	2 Ph.D. students at HU	Pandja	UCAR	A & C
	2 grad students and 3 summer interns per year through SOARS			
	3 summer internships for HU undergrads			
	2 CSU minority scholarships in Atmospheric Science			
2. Improved recruitment of ethnic minorities to undergraduate science and engineering programs	Present climate science to 400 minority high school students per year through CO-AMP and the Catamount Institute	El-Hakim	CSU	A & C
3. Better retention of women in the science pipeline	Mentoring program pairing female grad students in Atmospheric Science with female high-school students	Denning	CSU	A, B, & C
	Women in LSOP			
4. Study diversity problems and solutions, and disseminate results	Study of media portrayal of gender in science	Canetto	CSU	B
	Longitudinal study of women in science careers			
	Assessment of McNair mentoring program			

7. Metrics for Diversity

- *Degree to which CMMAP graduate students represent US demographics.*
  Addresses Objective A. Recruit and matriculate representative Ph.D. students

  Includes:

  - Number of women and underrepresented minority students supported by CMMAP, and comparison to demographic data
  - Number of SOARS protégés placed in Ph.D. programs
  - Number of CMMAP-supported women and minority Ph.D.s obtaining faculty positions

- *Recruitment of high school students from underrepresented groups to climate science.*
  Addresses Objective B. Improved recruitment of ethnic minorities to undergrad science and engineering programs

  Includes:

  - Number of students attending CO-AMP presentations on climate

- *Evaluation of mentoring programs targeting female students.*
  Addresses Objective C. Improve retention of women in science pipeline

  Includes:

  - Number of female high school students paired with female Atmospheric Science grad students for mentoring
  - Number of women assisting in LSOP program

- *Evaluation of academic studies of diversity in science.*
  Addresses Objective D. Study diversity problems and solutions, and disseminate results

  Includes:

  - Number of publications and presentations by Canetto, McPhee, and their students
  - Citations of these papers
  - Number of CMMAP-supported Ph.D. students conducting these studies

8. Management Plan for Diversity

The Diversity component of the Center is managed jointly with the Education component in order to better realize opportunities for synergy between the two. Please see the Management Plan under the Education section.

Knowledge Transfer Plan

1. Vision Statement for Knowledge Transfer

To create an internationally recognized resource for research and education in climate simulation, numerical weather prediction, and scientific publications dealing with global environmental modeling.

2. Mission Statement for Knowledge Transfer

CMMAP will engage in two-way knowledge transfer that benefits the Center, the public , and the academic and research communities. This will occur through the transfer of modeling technology to other modeling centers, and through the creation of new publications channels for work on global environmental modeling.

3. Opportunities and Challenges

Strengths and Opportunities

1. Capabilities of the prototype MMF
2. Need for a history of global atmospheric modeling
3. Need for a new journal dedicated to global environmental modeling

Challenges and Weaknesses

1. Inertia of established modeling centers
2. Arranging interviews with "legacy modelers"
3. Establishment of the new journal as a recognized venue for high-quality scientific publications

4. Goals and Objectives

Goals

A. Enable improved climate models

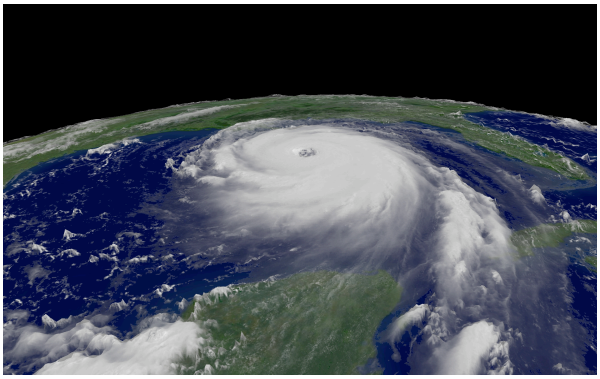
B. Enable improved weather forecasts

C. Capture and record the history of global modeling

D. Create an appropriate venue for the publication of scientific papers on global environmental modeling

E. Create an appropriate venue for the publication of review articles directed toward policy planners and the scientifically informed public

F. Create an appropriate venue for the dissemination of CMMAP results to both the scientific community and the general public



Objectives

1. Provide to climate modeling centers improved tools for the simulation of global cloudiness, as well as innovative tools for the analysis of such simulations. *Relates to Goal A.*
2. Provide improved cloud parameterizations to numerical weather prediction centers. *Relates to Goal B.*
3. Create an edited book on the history of global atmospheric modeling. *Relates to Goal C.*
4. Create a new all-electronic open-access journal for the publication of research on global environmental modeling, including a section of the new all-electronic journal for publication review article. *Relates to Goal D.*
5. Create and maintain a website containing a section designed to make CMMAP results easily available to the scientific community, and a section designed to increase public understanding of issues in global climate modeling. *Relates to Goals E and F.*

5. Strategies

CMMAP's Knowledge-Transfer goals are of two types. First, we will work with our research partners to transfer CMMAP research results and technologies into our national atmosphere-modeling "infrastructure," for both climate simulation and weather prediction. Second, CMMAP will undertake two publishing projects designed to significantly enhance the scientific communication that is so essential to the progress of our field.

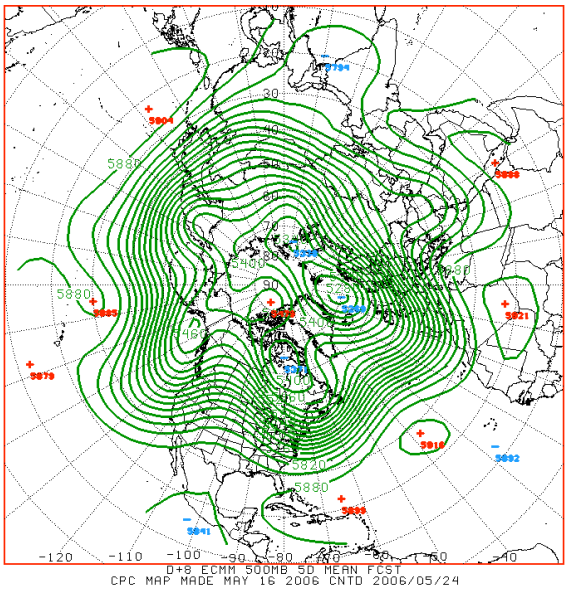
A. *Scientific applications of the MMF*

Task: Climate change

Although we do not claim that a future quasi-3D MMF will immediately solve the cloud-climate problem, we do claim that it will represent a new and faster avenue towards that goal. CMMAP is therefore obliged to contribute in an appropriate way to our society's ongoing search for reliable climate-change predictions. Accordingly, CMMAP will participate in exploratory simulations of climate change, in order to explore the physical processes that lead to cloud feedbacks on climate change. In addition, although CMMAP will not undertake "formal" climate-change simulations designed for use by policy makers, IPCC and others, we will work to influence such simulations and their interpretation through interactions with our partner institutions. We therefore list these activities under "knowledge transfer."

The CCSM is arguably the closest thing we have to a U.S. national climate model. Through the research activities of many of its participants, the CMMAP team has a close and long-standing relationship with the CCSM (Community Climate System Model), and especially its atmosphere submodel, the CAM (Community Atmosphere Model). CMMAP will make use of the CCSM Working Groups to transfer to the CCSM the fruits of CMMAP's research, including scientific understanding, model results, source codes, and diagnostic methods. Many CMMAP scientists are already strongly participating in those Working Groups.

Scientists from the U. S. Department of Energy (DOE) national laboratory system have proposed an MMF-based project within DOE. This project is designed to run in parallel with CMMAP and will be critically dependent on CMMAP's model development efforts. The purpose of the proposed DOE project is to use a tested version of the MMF to investigate the climate sensitivity to a broad range of cloud feedbacks, and then run climate change simulations through the current century. Obviously there is the potential for terrific synergy between CMMAP and the proposed DOE project.



Task: Numerical weather prediction

The MMF has the potential to produce more skillful weather forecasts, especially for precipitation, and makes it possible to assimilate observed statistics characterizing the mesoscale and microscale spatial structures of cloud fields. Assimilation of such data has the potential to produce more realistic analyses of large-scale weather systems, which can then lead to improved forecasts. Finally, NWP is an excellent way to evaluate the performance of a model. For these reasons, CMMAP will perform exploratory NWP, in cooperation with our partner institutions, in a knowledge-transfer mode. In addition, the U.S. National Centers for Environmental Prediction (NCEP) will test new cloud parameterizations developed by MMF research. We will also collaborate on forecasting research with the European Centre for Medium Range Weather Forecasts (ECMWF), the Meteorological Service of Canada, and the Bureau of Meteorology Research Centre in Australia.

B. *Publications initiatives*

Task: Creation of a new scholarly journal

CMMAP will create a new all-electronic peer-reviewed non-profit journal, published by CSU's Department of Atmospheric Science, that will serve the global modeling community. The (provisional) name of the new journal is the "*Journal of Advances in Modeling for the Earth Sciences*" (*JAMES*). Nothing comparable to *JAMES* cur-

rently exists. Research results on global modeling are scattered in a large number of meteorology, oceanography, mathematics, and physics journals. *JAMES* will be a focus for modeling research involving the global system, including the atmosphere, the oceans, the cryosphere, and the land surfaces. *JAMES* will also encourage submissions dealing with numerical techniques for modeling these systems and with the analysis of observational data for critical evaluation of modeling results. Although CMMAP scientists will publish their research results in many different journals, *JAMES* will be designed so that it will be a highly suitable venue for virtually any CMMAP research publication.

Online access to *JAMES* will be free to all. This approach has recently been championed by SPARC, the Scholarly Publishing and Academic Resources Coalition, and demonstrated by PLoS, the Public Library of Science. The costs of publishing *JAMES* will be covered through a combination of page charges and direct funding from multiple agencies. The latter will be obtained via proposals. The business plan for *JAMES* will be developed based on the ideas developed by SPARC, PLoS, and other open access advocates (see, e.g., Crow and Goldstein, 2003).

The costs will be kept to a minimum by the all-electronic nature of the journal and by shifting many of the technical editing aspects of production to the authors, through the use of modern (standardized) electronic publishing methods. CMMAP will oversee and partially fund the start-up of *JAMES*, over a period of five years. During this period, *JAMES* will also solicit and publish "high-profile," value-added review articles designed to attract readers to the *JAMES* web site and to aid scientists who are branching into new areas of research. Our intention is that after five years *JAMES* will have assumed a life of its own, and become financially self-supporting. It can then become independent of CMMAP.

During its start-up phase, *JAMES* will be directed by a small group: the chief editor, two editors, and an editorial assistant, all of whom will be CMMAP project members and will have previous experience in the journal publication process. As *JAMES* grows we will appoint additional Editors in new research areas and also establish a group of Associate Editors.

To encourage communication between CMMAP's partners in the operational community and those in the research community, *JAMES* will establish a section of the journal devoted to problems faced in operational numerical weather prediction. Particularly encouraged will be articles concerning operational model performance and comparisons of reanalysis products with newly-acquired research data sets.

Some CMMAP scientists have the skill and interest to communicate advances in global environmental science to the general public. To take advantage of this, *JAMES* will establish a section of the journal devoted to "popular science" articles. The development of this section of *JAMES* will draw heavily on the expertise of Prof. Denning, CMMAP's Associate Director for Education and Diversity, and on our partner organizations involved in education.

CMMAP's budget provides for personnel and a digital server that will be needed for the start-up phase of *JAMES*. To fill the position involved with knowledge transfer, CMMAP will seek an individual with skills in both of the two areas, i.e., to work with our research partners to transfer CMMAP research results and to help initiate and complete the publication projects.

Task: Production of a book on the history of global modeling

The pioneers of atmospheric general circulation modeling, including those involved with early work on cloud parameterization, are at or near the ends of their careers. To capture their stories for posterity, we will create an edited book that will include chapters written by scientists with important past or present involvement with cloud parameterization. The book will also include transcripts of interviews with key modeling pioneers, including those who initiated global atmospheric modeling at GFDL, NCAR, UCLA, and LLNL.

6. Implementation Plan for Knowledge Transfer

Table 5: For each Knowledge-Transfer Objective, we list "Actions Required," and identify a Team Leader who assumes responsibility for the Objective as a whole. Appendix A lists the Objectives associated with each CMMAP participant.

Objective	Actions Required	Time-frame	Team Leader	Location	Supports Goal #
1. Provide to climate modeling centers improved tools for the simulation of global cloudiness, as well as innovative tools for the analysis of such simulations	Make the prototype MMF available to climate modeling centers	Year 1	Collins	NCAR	A
	Make improved conventional parameterizations available to climate modeling centers	Year 3			
	Make advanced diagnostic tools available to climate modeling centers	Year 3			
2. Provide improved cloud parameterizations to numerical weather prediction centers	Make the prototype MMF available to numerical weather prediction centers	Year 1	Jakob	BMRC	B
	Make improved conventional parameterizations available to numerical weather prediction centers	Year 3			
3. Create an edited book on the history of global atmospheric modeling	Recruit chapter authors	Year 1	Donner	GFDL	C
	Interview modelers	Years 1-3			
	Choose publisher	Year 2			
	Deliver manuscript to publisher	Year 4			
4. Create a new all-electronic open-access journal for the publication of research on global environmental modeling, including review articles and a semi-popular section	Create a business plan for the journal	Year 1	Schubert	CSU	D
	Explore possible affiliations, e.g., PLoS	Year 1			
	Develop a plan for the submission-to-publication process	Year 1			
	Solicit contributions	Year 2			
	Develop a plan for publicizing the new journal	Year 2			
	Begin publication	Year 3			
5. Create and maintain a website containing a section designed to make CMMAP results easily available to the scientific community and a section designed to increase public understanding of issues in global climate modeling	Design and create web site	Year 2	KT Manager	CSU	E & F

7. Metrics for Knowledge Transfer

- Number of climate modeling centers collaborating.
  Addresses Objective 1.
- Number and quality of publications from CMMAP scientists incorporating MMF concepts into climate change simulations.
  Addresses Objective 1.
- Number of numerical weather prediction centers collaborating.
  Addresses Objective 2.
- Number and quality of publications from CMMAP scientists incorporating MMF concepts into operational NWP.
  Addresses Objective 2.
- Number of authors recruited for book.
  Addresses Objective 3.
- Number of interviews conducted.
  Addresses Objective 3.
- Submission of book to publisher.
  Addresses Objective 3.
- Enthusiasm of the reviews of the book.
  Addresses Objective 3.
- Development of end-to-end journal design.
  Addresses Objective 4.
- Beginning of journal publication.
  Addresses Objective 4.
- Review of journal design by the External Advisory Panel.
  Addresses Objective 4.
- The number and quality of submissions of the new electronic journal.
  Addresses Objective 4.
- Number of hits on the journal's web site.
  Addresses Objective 5.

8. Management Plan for Knowledge Transfer

The Associate Director for Knowledge Transfer, Prof. Schubert, reports to the Center Director, and provides direction and oversight to these components of the Center. Fig. 3 shows the management structure for the KT part of the Center.

Management of KT activities in CMMAP is facilitated by a full-time KT Manager, and is advised by a committee of CMMAP scientists.

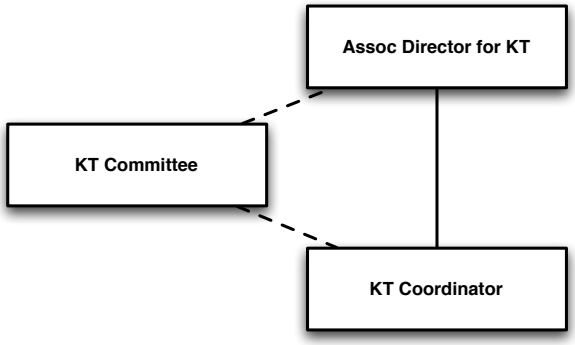


Figure 3: Interactions of the Knowledge Transfer Committee.

KT Manager

A knowledge-transfer professional will be hired via a nation-wide search, to take responsibility for daily management and implementation of the KT activities of the Center. Duties will include:

- Working with the CMMAP EC to track performance of component activities
- Organizing twice yearly progress reports
- Managing communications among KT partners, and between CMMAP scientists and KT resources, to facilitate dissemination of science results to students, educators, stakeholders, policymakers, and the public
- Organizing monthly telecoms among KT partners and management
- Organizing and scheduling KT component of twice-annual CMMAP meetings

KT Committee

A committee of CMMAP scientists will oversee planning and implementation of KT activities. The committee is Chaired by the Associate Director for KT, with membership changing through regular rotation. Committee will host two full-day meetings per year for all CMMAP scientists and students to review KT activities. The KT Committee meets monthly by teleconference, and ensures that KT activities make optimal use of the Center's scientific talent.

Cyberinfrastructure Plan

1. Introduction

Because CMMAP's research is so computationally intensive, it depends critically on the use of cyberinfrastructure. We have therefore developed the cyberinfrastructure plan outlined in this section, which includes an explicit discussion of data management policies. The effective utilization of national computational resources is an integral part of this plan and we will have a formal management process to organize and prioritize this effort.

The plan offered here will form the basis of a System Description Document (SDD) which will be developed and maintained over the lifetime of CMMAP in order to accurately reflect the evolving configuration, conventions and procedures of CMMAP's computing environment.

2. Working Group

Computing policies will be overseen by a Cyberinfrastructure Working Group (CIWG) of interested researchers in coordination with the Associate Director for Computing. The CIWG will have two primary responsibilities: 1) to review and recommend procedures relating to all aspects of CMMAP computing and 2) to coordinate the submission and utilization of CMMAP computing allocations.

3. Personnel

Staffing for cyberinfrastructure management is provided by San Diego Supercomputer Center (SDSC) personnel. The team is led by Dr. John Helly, Director of the Laboratory for Earth and Environmental Science (LEES) and CMMAP's Associate Director for Computing. The other partially funded team members include Dr. Don Sutton and John Weatherford; both programming staff within LEES and full-time staff at the SDSC. CMMAP also provides full-time support for a graduate student beginning in the second year and continuing throughout the lifetime of CMMAP. SDSC resources are also available to CMMAP for consultation and assistance.

4. Computing Allocations

In order to accomplish its research goals, CMMAP must obtain and manage large comput-

ing allocations from the HPCC resources available to United States researchers. These resources primarily include the NSF-supported centers including SDSC, the National Center for Supercomputer Applications, and the National Center for Atmospheric Research. Secondarily, other resources will be utilized on an as-available basis, including those at NASA Ames, the Lawrence Livermore National Laboratory, National Energy Research Scientific Computing Center, and Oak Ridge National Laboratory.

At SDSC, startup and testing allocations are immediately accessible through the Teragrid and eventually the Petascale environment as it is deployed. CMMAP will immediately begin developing and submitting allocation proposals in the normal proposal cycles of the Teragrid and CyberInfrastructure Partnership, as well as the national laboratories.

As NSF begins to implement its petascale computing initiative, presently planned for award in 2010 with incremental advances between now and then, CMMAP will utilize these resources to the best advantage possible. SDSC staff are currently discussing the utilization of the CMMAP models as strategic applications and for potential use in benchmarking the new petascale architecture(s). By the time the Petascale infrastructure is ready for deployment, CMMAP applications will be well-characterized and suitable for benchmarking on the new machines that are, as yet, awaiting definition by the vendors.

5. Data Policy

The CMMAP data policy addresses the maintenance and release of CMMAP data products, user registration for accessing data, and the licensing agreements specifying the conditions for access to CMMAP-produced data. This policy will be the under the care of the CIWG. It will be accessible via the CMMAP web site. Further discussion is given in Appendix B.

6. CyberInfrastructure

The cyberinfrastructure for CMMAP will evolve, but a preliminary configuration is depicted in Fig. 4. This architecture integrates national resources for the benefit of the CMMAP research program and exhibits challenges in managing the resources across different federal organizations and national centers. This will be a key management function.

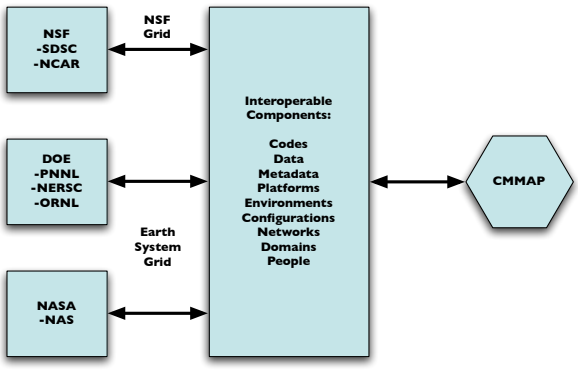


Figure 4: Cyberinfrastructure elements, emphasizing external interfaces.

Backup and recovery will be accomplished using the HPSS storage system at SDSC as well as the dedicated disk resource of 15 TB committed to CMMAP. Off-site storage of data, including software, will be stored in the CMMAP facilities at CSU on an appropriate medium. Backups will be run regularly on a schedule that will be developed as the project evolves. The schedule will be documented in the SDD.

Supported products will include codes, documentation and data that will be maintained by CMMAP for the benefit of the community. Access to supported products will be through the Internet using appropriate methods for the task. There will be a central web-portal to provide "one-stop-shopping" through the resources of CMMAP, and this site will integrate and re-direct users to appropriate secondary servers for access to supported products.

Quality control of data and software will be the responsibility of the developers and the science team using them. CMMAP will develop procedures for assessing data and software quality commensurate with current best practices in the open-source community and statistical analysis.

Interoperability

As indicated in Fig. 3, interoperability will a key feature of the CMMAP cyberinfrastructure. We will support efforts to interoperate with the

Earth System Grid, as well as existing community resources such as those provided and supported by NCAR. We will develop and maintain the necessary interface descriptions to enable effective use of the supported products and computing resources.

Quality Control

Quality control of data and software will be the responsibility of the developers and the science team using them. CMMAP will develop procedures for assessing data and software quality commensurate with current best practices in the open-source community and statistical analysis.

Maintenance

Maintenance of the cyber-resources is the responsibility of the home institutions housing the resources.

Management Plan

1. Organizational Overview

The lead institution for CMMAP is Colorado State University (CSU), which will carry out a wide range of research and educational activities. In addition to CSU, CMMAP has 18 partner institutions and 11 collaborating institutions; here the distinction is that partners cost-share, while collaborators do not. CMMAP has 13 subcontractors, who are funded through CSU; of these, 11 are partners and 2 are collaborators. A summary is given in Table 1.

CMMAP will be governed by an Executive Committee (EC), which will consist of the Center Director, a Deputy Director, three Associate Directors, and an Administrative Director.

Fig. 1 summarizes CMMAP's management structure, which is designed to be minimally hierarchical, to enhance the flow of information throughout the Center, and to minimize bureaucratic bottlenecks. The lines in the figure are intended to show the primary channels of communication, but not the only channels.

The Center Director, Prof. David Randall of CSU, has overall management responsibility for the Center, but delegates to and relies heavily on the other members of the management team. This structure makes it possible for the Center Director to continue to function as a scientist, which is necessary if he is to provide scientific leadership to the Center.

The research activities of CMMAP will be led by the Center Director. They will be organized around the central activities of model development, model evaluation, and the use of the models to improve our understanding of the Earth system.

The Executive Committee will include a Deputy Director, Dr. Chin-Hoh Moeng of NCAR (the National Center for Atmospheric Research), who will assist the Director in management of the Center, in part through special assignments. The Deputy Director will represent the Director as necessary in various meetings and official functions. She will also lead special projects, at the request of the Director.

The EC will include an Associate Director for Education and Diversity (ED), Prof. A. Scott

Denning of CSU, who will be responsible for the overall leadership of the Center's ED activities. The Associate Director for ED will be assisted by a full-time Science Education Manager, who will be responsible for managing the interactions of CMMAP with the ED Partners. The Science Education Manager will be in residence at CSU, but will make frequent visits to CMMAP's ED Partners. Each ED partner institution will have a designated single point of contact for CMMAP activities. An ED Committee, consisting of CMMAP scientists, will work with the Associate Director for ED.

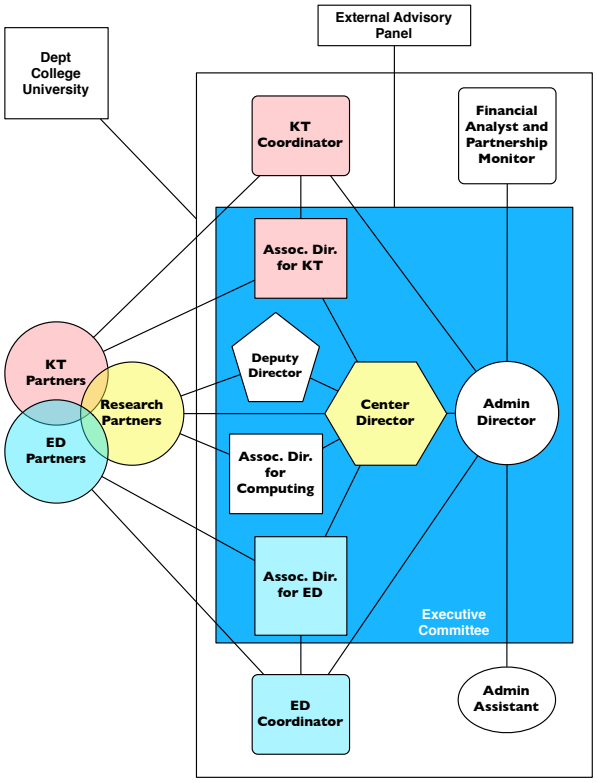


Figure 1: CMMAP's management structure.

The EC will include an Associate Director for Knowledge Transfer (KT), Prof. Wayne Schubert of CSU, who will be responsible for the overall leadership of the Center's KT activities. The Associate Director for KT will be assisted by a full-time KT Manager, who will be responsible for managing the interactions of CMMAP with the KT Partners. The KT Manager will track the progress of CMMAP's newly created academic journal towards the goal of financial independence from CMMAP. The KT Manager will also collect and organize materials for reports to NSF on CMMAP's progress and accomplishments, and will make much of this same information available on the CMMAP web site. A KT Committee, consisting of CMMAP scientists, will work with the Associate Director for KT.

The EC will include an Associate Director for Computation, Dr. John Helly of the San Diego Supercomputer Center, who will be responsible for planning and managing CMMAP's computational resources, both in-house and at supercomputer centers, as well as management of CMMAP data.

CMMAP will employ an Administrative Director (AD), Cindy Carrick of CSU, as the senior administrative position in the Center. The AD will serve as a "Chief of Staff." She will coordinate CMMAP's daily activities, and facilitate interactions among center personnel and with external entities. She will supervise the Financial Analyst, as well as a full-time support Coordinator. As indicated in Fig. 1, the AD will also co-supervise the KT and Science Education Managers, in cooperation with the Associate Directors for ED and KT, respectively. The AD will track ongoing CMMAP activities against this plan, make sure that CMMAP meets the NSF reporting requirements in a timely fashion, and ensure the Center's compliance with university and Federal policies.

The Associate Directors, Deputy Director, and Administrative Director will report to the Center Director. The Associate Directors will provide to the Director quarterly written progress reports, which will be reviewed by the entire EC.

CMMAP will employ a full-time Financial Analyst (FA) and Partnership Monitor, in residence at CSU. The FA will be responsible for tracking the financial operations of CMMAP, including those associated with the various subcontracts, and for collecting and maintaining records on the progress of partner institutions towards fulfilling the terms of their subcontracts, including information about staff diversity. The FA will also track cost-sharing across all partners.

The EC members orchestrate CMMAP's overall scientific direction; recruit new partners and collaborators as appropriate; enforce the highest

standards in ethics and research quality; develop diversity; monitor progress relative to established milestones; and promote broad dissemination of results.

The EC will teleconference at least twice per month, to maintain tight communications across the project. The Center Coordinator and other CMMAP personnel will participate in the teleconferences as appropriate. The EC will also meet face-to-face in conjunction with each of the twice-yearly CMMAP Workshops. Each of the partner institutions will be required to provide twice-yearly written summaries of progress to the EC.

CMMAP's graduate education activities are by their nature highly integrated with the research work. Undergraduate and K-12 educational activities will be organized as "feeders" of future CMMAP scientists.

Finally, CMMAP's knowlege-transfer activities are focused on model applications and publications, both of which are natural extensions of CMMAP's research.

As discussed later in this document, several Objectives have been identified for Research, Education, Diversity, and Knowledge Transfer. A Team Leader is assigned to each Objective. In this way, management responsibilities are delegated within each of the major components of the Center. The Team Leaders will, in most cases, change over time, at the discretion of the EC. Each Team Leader will organize a team of CMMAP participants who will carry out the required actions.

Table 1: A summary of CMMAP's participating institutions. "Partners" cost-share. "Collaborators" do not.

Institution/Organization	Subaward	Partner	Collaborator
Colorado State University (Lead)		X	
University of California, Los Angeles	X	X	
University of California, San Diego	X	X	
Hampton University	X	X	
University of Washington	X	X	
University of Maryland	X	X	
City College of New York	X	X	
University of Utah	X	X	
Colorado College	X	X	
University of Colorado	X	X	
Catamount Institute	X	X	
National Center for Atmospheric Research	X	X	
Pacific Northwest National Laboratory		X	
Lawrence Livermore National Laboratory		X	
Meteorological Service of Canada		X	
Frontier Research Center for Global Change, Japan		X	
Center for Climate System Research, University of Tokyo		X	
Bureau of Meteorology Research Center, Australia		X	
Apple Computer		X	
European Centre for Medium Range Weather Forecasting			X
Scripps Institution of Oceanography	X		X
International Business Machines			X
NASA Goddard Space Flight Center			X
NASA Langley Research Center			X
NOAA Geophysical Fluid Dynamics Laboratory			X
NOAA National Centers for Environmental Prediction			X
NOAA Atlantic Oceanographic and Meteorological Laboratory			X
University Corporation for Atmospheric Research	X		X
Poudre School District			X
Thompson School District			X

2. Cohesion of the Center

The research activities of CMMAP will be organized around the central activities of model development, model evaluation, and the use of the models to improve our understanding of the Earth system.

CMMAP's graduate education activities are by their nature highly integrated with the research work. Undergraduate and K-12 educational activites will be organized as "feeders" of future CMMAP scientists.

Finally, CMMAP's knowledge-transfer activities are focused on model applications and publications, both of which are natural extensions of CMMAP's research.

CMMAP involves dozens of scientists at widely separated institutions. Communication within the team will be a key to CMMAP's success. To foster this communication, we plan two CMMAP meetings per year, each lasting two or three days. The meetings will be conducted as "Workshops," with presentations focusing on recent results and near-term plans, and a lot of discussion time. Each Workshop will also include several longer, invited talks, including some by scientists who are not part of CMMAP. Half of the Workshops will be held in Fort Collins, and half elsewhere.

We will use the "away" Workshops to expose a diverse population of students to CMMAP research and educational opportunities. This can be done, e.g., by organizing poster sessions that are open to or even targeted at the local communities.

Scientific visitors will be hosted at CMMAP Headquarters at Colorado State University. Student interns and teachers undergoing training will also be in residence at CSU.

In addition, we have budgeted for an "Access Grid" teleconferencing system, starting in CMMAP's second year. This system will permit more frequent and effective communications than can be achieved through Workshops alone.

3. Succession Plan

In the unlikely event that Prof. Randall is unable to continue as the Center Director, he will be replaced by Prof. Graeme Stephens of CSU. Prof. Stephens has the required expertise in the area of cloud-climate research, and has experience in leading large multi-institutional research activities. His time has been very heavily committed in his role as the P.I. on CloudSat, but following the successful launch of CloudSat in April 2006 this burden is diminishing. He has agreed to be designated as "next in line" for the CMMAP directorship.

If the Deputy Director, the Administrative Director, or one of the Associate Directors steps down, a successor will be chosen by the EC.

4. Resource Allocation

Resources will be allocated by a consensus of the CMMAP EC. The goal is to use approximately 1/3 of the available funding to support Education, Outreach, and Diversity activities, 1/2 to support Research activies, and 1/6 to support Knowledge Transfer activities. These percentages may evolve as the Center matures and external circumstances change.

5. External Advisory Board

CMMAP will create an External Advisory Panel (EAP) that meets at least once per year. The EAP will consist of six members, including a Chair. The members will include representatives of academia, atmospheric science research centers, a computing center or company, and the education sector. The EAP will monitor CMMAP's progress, and make recommendations to the EC.

The members of the EAP will serve three-year

terms, and the Chair will change every two years.

Prof. Kerry Emanuel of the Massachusetts Institute of Technology has agreed to be the first Chair of the EAP. The other initial members of the EAP will be chosen through discussions between the EC and Prof. Emanuel.

6. Accountability to NSF

CMMAP will provide annual progress reports to NSF, and additional progress updates as requested. The KT Manager will be responsible for maintaining an up-to-date record of accomplishments, ongoing activities, and plans, for use in these reports.

7. Refinement of this Strategic Plan

This Strategic Plan will be reviewed and revised as necessary by the EC at least once per year, through the lifetime of the STC. After each revision, the updated Strategic Plan will be emailed to the CMMAP participants, and posted on the CMMAP web site.

8. Management Goals and Objectives

Goals

A. Create and nurture a new community of researchers and educators with a strong focus on the Research, Education, Diversity and Knowledge Transfer goals of the Center.

B. Foster collaborative relationships between the Center and other institutions.

C. Create synergistic relationships with non-NSF funding sources and national and international partners.

Objectives

1. Organize CMMAP's activities so that the diverse tasks being worked on in widely separated locations feed coherently and efficiently towards the Center's Goals. *Relates to Goal A.*
2. Create productive interactions among the researchers and educators involved in CMMAP, so that the researchers and educators function together as a team. *Relates to Goal A.*
3. Attract and retain highly qualified staff for key CMMAP positions. *Relates to Goal A.*
4. Communicate CMMAP's activities and accomplishments to the outside world. *Relates to Goal B.*
5. Manage the CMMAP budget from year to year so as to maximize productivity across the whole range of the Center's activities. *Relates to Goals A and C.*
6. Attract STC funding, including but not limited to cost-share. *Relates to Goals B and C.*
7. Attract non-STC but CMMAP-synergistic funding that enhances the impact of CMMAP. *Relates to Goals B and C.*

9. Management Strategies

A. Organize research work around a small number of broadly defined "Research Themes," designed to foster collaboration among CMMAP's research participants.

B. Conduct informal climate science classes for non-scientist participants.

C. Comprehensively review and re-think the CMMAP budget at least once per year.

D. Create and maintain a web page designed to be useful and interesting for a wide range of visitors.

E. Revise this Strategic Plan at least once per year.

F. Recruit CMMAP scientists to participate in CMMAP EDucation and Diversity activities.

G. Seek supplementary CMMAP support from non-NSF sources.

H. Submit proposals for CMMAP-relevant research to funding agencies, as opportunities arise.

10. Implementation Plan for Management

Table 6: For each Management Objective, we list "Actions Required," with a time-frame, and identify a Team Leader who assumes responsibility for the Objective as a whole. Appendix A lists the Objectives associated with each CMMAP participant. The Executive Committee has responsibility for achieving these objectives, so "Team Leaders" are not listed.

Objective	**Actions Required**	**Supports Goal #**
1. Organize CMMAP's activities so that the diverse tasks being worked on in widely separated locations feed coherently and efficiently towards the Center's Goals.	Hold "all hands" meetings twice per year, with half of the meetings hosted away from CSU.	A
	Define "Research Themes" that foster collaboration that will lead to progress on CMMAP's research Objectives.	
2. Create productive interactions among the researchers and educators involved in CMMAP, so that the researchers and educators function together as a team.	Create ED and KT Committees, with participation by CMMAP scientists.	A
	Recruit CMMAP scientists to provide content to ED "translators."	
3. Attract and retain highly qualified staff for key CMMAP positions.	Create position descriptions, initiate formal search process, and recruit qualified applicants.	A
4. Communicate CMMAP's activities and accomplishments to the outside world.	Create and maintain CMMAP web page.	B
	Publish review articles that provide overviews on topics highly relevant to CMMAP.	
5. Manage the CMMAP budget from year to year so as to maximize productivity across the whole range of the Center's activities.	Adjust funding levels as appropriate to achieve objectives.	A and C
	Add or delete funded program elements to optimize progress towards the Center's goals.	
6. Attract STC funding, including but not limited to cost-share.	Monitor and adjust cost-share agreements as required.	B and C
	Seek private donations.	
7. Attract non-STC but CMMAP-synergistic funding that enhances the impact of CMMAP.	Submit proposals for CMMAP-related research as opportunities arise.	B and C

11. Management Metrics

- Number of "all hands" meetings held
  Addresses Objectives 1 - 5.
- Number of publications authored by CMMAP participants from more than one institution
  Addresses Objectives 1 - 5.
- Number of EC telecons conducted
  Addresses Objectives 1 - 5.
- Fraction of key staff positions filled
  Addresses Objectives 1 - 5.
- Number of hits on CMMAP web page
- *Addresses Objectives 1 - 5.*
- STC funding attracted, including cost-share
  Addresses Objectives 1 - 5.
- Synergistic non-STC funding attracted
  Addresses Objectives 1 - 5.
- Participation in annual STC Directors' meeting
  Addresses Objectives 1 - 5.
- Professional development of CMMAP staff
  Addresses Objectives 1 - 5.
- Progress towards completion of CMMAP building planned by CSU
  Addresses Objectives 1 - 5.
- Interactions with External Advisory Panel

- Annual reviews of progress and plans by the External Advisory Panel, including an assessment of how many tasks have completed on schedule and within the budget.
  Addresses all Objectives.

Appendix A:
Center Personnel

Table 6: Primary CMMAP personnel and their roles. Under "Objectives," the prefixes R, E, D, and KT denote Research, Education, Diversity, and Knowledge Transfer, respectively.

Name	Institution	Role(s) in CMMAP	Objectives
James Abeles	IBM	Technical consultant for HPC application development and system enablement	R8
Thomas Ackerman	PNNL	Model evaluation using ARM data	R1, 3, 5, 6
Akio Arakawa	UCLA	Development of improved MMF, GCRM, and conventional parameterizations	R2, 7
Robert Atlas	AOML	Use of MMFs for assimilation of cloud and precipitation data	R1, 6 & KT 2
Howard Barker	MSC	Development of improved radiation parameterizations	R1, 5
Chris Bretherton	UW	Development of improved cloud parameterizations	R1, 3, 4
Antonio Busalacchi	UMd	Use of satellite data to evaluate MMF results	R 1, 3, 6
Silvia Canetto	CSU, Psychology	Studies of diversity	E 3, 7, & D 3, 4
Cindy Carrick	CSU/ATS	Administrative Director	All
William Collins	NCAR	Developer of radiative transfer parameterizations; Liaison to CCSM	R 5, 6, 7 & KT 1
Charlotte DeMott	CSU/ATS	Model evaluation	R 6
Allan Scott Denning	CSU/ATS	Associate Director for ED; use of MMFs to study the carbon cycle	E & D All, & R 2, 6
Leo Donner	GFDL	Development of improved MMFs and improved conventional parameterizations	R 7 & KT 3
Howard Drossman	CC and CI	Liaison to the CC Environmental Studies Program and CI	E 5
Philip Duffy	LLNL	Role of MMF in high-resolution climate modeling	R 1, 6
Omnia El Hakim	AGEP & Co-AMP	Liaison to AGEP and Co-AMP	D 2
Susan Foster	UCAR	Lead developer of SEE-ME	E 3
Steven Ghan	PNNL	Research on aerosols and cloud microphysics in climate change	R 1, 3
Wojciech Grabowski	NCAR	Development of improved CSRMs and MMFs	R 1, 3
James Hack	NCAR	Development of cloud parameterizations; Liaison to CCSM	R 1, 7
John Helly	UCSD/ SDSC	Associate Director for Computation, and liaison to SDSC	R 8
Andrew Heymsfield	NCAR	Parameterization of ice microphysics	R 3, 6, 7
Christian Jakob	BMRC	Model evaluation, especially based on ARM data	KT 2
Brian Jones	CSU, Physics	Director of Little Shop of Physics; K-12 education	E 2
Joon-Hee Jung	CSU/ATS	Development of the next-generation MMF	R 2
Lyn Kathlene	CIPP	Director of the Colorado Institute of Public Policy	E 4
Marat Khairoutdinov	CSU/ATS	Development of CSRMs and MMFs	R 1 ,2, 3, 4, 6
Masahide Kimoto	CCSR	Development of improved MMFs	R 2, 6 & KT 1
Sonia Kreidenweis	CSU/ATS	Development of aerosol and microphysics parameterizations for MMFs and GCRMs	R 3

Name	Institution	Role(s) in CMMAP	Objectives
Steven Krueger	UU	Development of improved microphysics and turbulence parameterizations for MMFs	R 3, 4
Christian Kummerow	CSU/ATS	Liaison to TRMM and GPM; model evaluation	R 6
Michael Lacy	CSU, Sociology	Assessment of Little Shop of Physics	E 1, 2
Cara-Lyn Lappen	CSU/ATS	Development of improved turbulence parameterizations for MMFs and conventional GCMs	R 4
Stephen Lord	NCEP	Potential of MMFs and GCRMs to improve weather forecasts	R 6 & KT 2
Jan Lanting	TSD	Liaison to TSD; development and evaluation of SEE-ME	E 1, 2
David MacPhee	CSU/HDFS	Study of diversity	E 3, 7, & D 3, 4
Patrick McCormick	HU	Use of satellite data to evaluate MMF results	R 6 & D 1
Donald MIddleton	NCAR	Data management and high-speed networking strategy	R 8
Martin Miller	ECMWF	Model evaluation through NWP	R 6 & KT 2
Hiroaki Miura	FRCGC	Development of GCRM	R 2
Chin-Hoh Moeng	NCAR	Deputy Director; development of boundary-layer parameterizations for use in the MMF	All, but especially R 4, 7
Mitchell Moncrieff	NCAR	Development of the MMF	R 1, 6
Teriyuki Nakajima	CCSR	Development of improved MMFs, and climate simulation	R 3 & KT 1
Tomoe Nasuno	FRCGC	Development of improved CSRMs	R 3
Rajul Pandya	UCAR	Director of SOARS	D 1
Robert Pincus	CU	Development of conventional cloud parameterizations	R 3, 4
Gerald Potter	LLNL	Model evaluation, in part using CAPT	R 6 & KT 2
David Randall	CSU/ATS	Director; Development of improved MMF, GCRM, and conventional parameterizations	All
William Rossow	CCNY	Model evaluation, especially using ISCCP data	R 6
Steven A. Rutledge	CSU/ATS	Model evaluation, especially using radar data	R 6
Masaki Satoh	FRCGC	Development of improved CSRMs	R 2 & KT 1
Wayne Schubert	CSU/ATS	Associate Director for Knowledge Transfer; further development of the MMF with an emphasis on the choice of governing equations	R 2 & KT All
Richard Somerville	SIO	Further development of the MMF	R 5
Graeme Stephens	CSU/ATS	Model evaluation, especially based on CloudSat data	R 5, 6
Bjorn Stevens	UCLA	Development of conventional parameterizations	R 3, 4, 5
Akimasa Sumi	CCSR	Development of improved MMFs	R 1, 2, 3
David Swartz	PSD	Liaison to PSD; development and evaluation of SEE-ME	E 2
Wei-Kuo Tao	GSFC	Development of improved MMFs, and application to data assimilation	R 1, 3 & KT 2
Michelle Kolb	Apple Computer	Liaison to Apple Computer	R 8
Bruce Wielicki	LaRC	Model evaluation using space data	R 6
Kuan-Man Xu	LaRC	Development of turbulence parameterizations for use in the MMF	R 4

Appendix B: Protecting Intellectual Property

CMMAP's research is highly academic in character and is not expected to produce any patentable items. Our plan is to share data, software, and scientific results *with the maximum possible openness*, but with appropriate respect for the right of CMMAP scientists to priority in the publication of their own work.

CMMAP's scientific results will be promptly published in the peer-reviewed literature. CMMAP's modeling techniques, including source codes, will be made freely available to the academic community immediately after publication by the scientists involved in their development. For these reasons, issues associated with intellectual property rights are expected to be very minimal.

A process for identifying, evaluating, protecting and preserving proprietary information and/or intellectual property generated in the course of research conducted by CMMAP has been established through a memorandum of understanding (MOU) executed among the CMMAP collaborators. The MOU includes provisions intended to identify background proprietary information of the collaborators that may be required to conduct the plan of research and to allow each of the collaborators to use that background proprietary information in connection with the conduct of the research. The MOU:

- defines confidential and/or proprietary information,
- details the obligations of the party (ies) to whom such information is disclosed,
- assures that appropriate mechanisms are in place to disclose any and all proprietary information,
- articulates understandings about the disclosure, ownership, and licensing of intellectual property,
- defines the handling of publications related to emerging intellectual property (and potential need to temporarily delay publication to prevent premature disclosure),
- defines how patent prosecution will be managed (if jointly held or not via local technology transfer offices),
- addresses the granting of licensing rights to the sponsor and CMMAP collaborators, and
- defines treatment of "background technology."

In general, each collaborator will retain all right, title and interest in intellectual property created solely by its employees; collaborators jointly own all right, title and interest in intellectual property that is created jointly by employees of multiple collaborators.

CMMAP does not presume to subvert or take precedence over the roles and responsibilities of the individual technology transfer offices at collaborating institutions. Rather, CMMAP provides coordination across those entities.

As part of its regular business, the CMMAP Executive Committee monitors ongoing and proposed CMMAP activities to detect any emerging issues in connection with intellectual property rights or unethical behavior, and will take action to deal with such issues as they arise.

To formalize these ideas, CSU and the CMMAP subaward institutions are jointly signing an Intellectual Property Agreement, the text of which can be found at *http://www.cmmap.org/members/*.

Other CMMAP partners and collaborators are not asked to sign the Intellectual Property Agreement. However, in the event that matters of a proprietary nature are discussed at a CMMAP meeting, the participants in the discussion will be asked to sign a Non-Disclosure Agreement, text of which can be found at the same web site with the Intellectual Property Agreement, as mentioned above.

Appendix C: Ethics Plan

CMMAP personnel must recognize that their personal conduct reflects on the integrity of the Center, and should take care that their actions have no detrimental effect on the institution. Therefore, each CMMAP staff member is expected to:

a. Perform their duties in a courteous and professional manner.

b. Use CMMAP funds, facilities, equipment, supplies, and staff only in the conduct of CMMAP duties, exceptions to be made only under specific CMMAP policies.

c. Maintain a high level of discretion and respect in personal and professional relations with research colleagues, students, educators, and the public.

d. Compensate CMMAP personnel (including students) fairly for work performed that is related to professional activities beyond one's CMMAP assignment.

e. Recognize fairly and accurately the extent of the contribution of others to one's professional work.

f. Avoid non-CMMAP activities that could significantly interfere with carrying out assigned CMMAP responsibilities.

g. Refrain from disclosing confidential information that was acquired by nature of one's activities within CMMAP.

h. Abide by CMMAP policies pertaining to patents, publication, copyrights, consulting, off-campus employment, and conflict of interest.

i. Eschew misconduct such as fabrication, falsification, and plagiarism, in proposing, conducting, and reporting research or in scholarly or creative endeavors, or in identifying one's professional qualifications.

CMMAP will set up an online ethics training course, and will require all Center and subawardee staff and students to complete the course. The training will cover the nature of CMMAP's research as it relates to intellectual property issues, CMMAP's policies and expectations with respect to intellectual property rights, and the code of ethical behavior outlined above.

Shared values and understandings among the collaborators of CMMAP serve as important underpinnings for CMMAP, and form the foundation from which more formal training, such as the planned CMMAP-developed on-line ethics-training course, will occur. Models from the other successful programs and on-line training resources, including the National Society of Professional Engineers (NPSE), will be utilized where possible.

The CMMAP on-line training course will complement other resources such as traditional course offerings, focus sessions related to specific topics, participation in special lecture events, and integration of ethics training, adjusted to appropriate audience levels, into outreach materials. Access to formal coursework exists through courses like "Science and Ethics" taught by Dr. Bernard E. Rollin, Colorado State University Distinguished Professor of Philosophy, and a leading scholar and author in the areas of ethics and bioethics, and/or "Managing a Career in Science" co-taught by Drs. Katherine Partin and Ed Dudek, Biomedical Sciences. These courses cover topics ranging from the traditional (ethical theories and/or ethical issues that arise from scientific activity, nature of the research, methodologies used, ownership of research and ideas, roles and responsibilities regarding intellectual property) to the contemporary (supervisor to trainee relationship, time management, life balance, personal integrity, scientific integrity and misconduct in science, preparing for the academe). Similar course examples are available from each of the CMMAP institutions, and we recognize the opportunity to maximize the quality of training by offering interaction among the respective institutional science and ethics experts.

Focused discussions of "ethical considerations" will be a routine component of CMMAP meetings, thus allowing for further exploration of issues with a variety of faculty. Modules addressing social and ethical considerations will be a

component included in the content of outreach materials. Communication among the CMMAP personnel will include notification of special lecture series and/or campus activities that provide additional exposure to relevant topic areas.

CMMAP's Education and Diversity activities include research involving human subjects. The Regulatory Compliance Office at CSU provides assistance to researchers in obtaining required approvals, and administration of faculty oversight committees, for research activities involving human subjects, animals, biohazardous agents and rDNA, and controlled substances. The Human Research Committee (HRC) and its procedures have been fully approved by the federal office overseeing human subjects protections. The HRC strives to focus attention on basic ethical issues as expressed by the federal regulations, primarily 45 CFR Part 46. CSU holds a Federal-Wide Assurance allowing local review of CSU's human research. As part of this assurance, CSU agrees to formal training and continued training of researchers working with human subjects. The training consists of history, ethics, federal regulations, CSU procedures, and pertinent discussions. The relevant CMMAP personnel have already completed the training.

As part of its regular business, the CMMAP EC will monitor ongoing and proposed CMMAP activities to detect any emerging issues in connection with unethical behavior, and will take action to deal with such issues as they arise.

Appendix D: List of Acronyms

Acronym	Meaning
AGEP	Alliance for Graduate Education and the Professoriate
AMIP	Atmospheric Model Intercomparison Project
AOML	Atlantic Oeanographic and Meterological Laboratory, NOAA
CAM	Community Atmosphere Model
CC	Colorado College
CCNY	City College of New York
CCSM	Community Climate System Model
CCSR	Center for Climate Systems Research, University of Tokyo
CI	The Catamount Institute
CIPP	Colorado Institute of Public Policy
CMMAP	Center for Multi-Scale Modeling of Atmospheric Processes
Co-AMP	Colorado Alliance for Minority Participation
CSRM	Cloud-System-Resolving Model
CSU	Colorado State University
CSU/ATS	CSU Atmospheric Science
CSU/HDFS	CSU Human Development and Family Studies
CU	University of Colorado
DOE	U. S. Department of Energy
EC	CMMAP Executive Committee
ED	Education and Diversity
FRCGC	Frontier Research Center for Global Change, Japan
GCM	General Circulation Model
GCRM	Global Cloud-Resolving Model
GCSS	GEWEX Cloud Systems Study
GEWEX	Global Energy and Water Experiment
GFDL	Geophysical Fluid Dynamics Laboratory, NOAA
GSFC	Goddard Space Flight Center, NASA

Acronym	Meaning
HU	Hampton University
IBM	International Business Machines
KT	Knowledge Transfer
LaRC	Langley Research Center, NASA
LEES	Laboratory for Earth and Environmental Science at SDSC
LLNL	Lawrence Livermore National Laboratory, DOE
LSOP	Little Shop of Physics
MMF	Multi-Scale Modeling Framework
MSC	Meteorological Service of Canada
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction, NOAA
NOAA	National Oceanographic and Atmospheric Administration
NSF	National Science Foundation
PNNL	Pacific Northwest National Laboratory, DOE
PSD	Poudre School District, Fort Collins, Colorado
SDSC	San Diego Supercomputer Center
SIO	Scripps Institution of Oceanography
TSD	Thompson School District, Loveland, Colorado
UCAR	University Corporation for Atmospheric Research
UCLA	University of California at Los Angeles
UCSD	University of California at San Diego
UMd	University of Maryland
UU	University of Utah
UW	University of Washington