Strategic and Implementation Plan:  
*Center for Multi-Scale Modeling of Atmospheric Processes (CMMAP)*  
Years 6-10

**Lead Institution:** Colorado State University

**Partner Institutions:**  
- Colorado College  
- National Center for Atmospheric Research  
- State University of New York at Stony Brook  
- University of California at Berkeley  
- University of California at San Diego  
- University of Colorado  
- University of Utah  
- University of Washington

**Collaborating Institutions:**  
- Atlantic Oceanographic & Meteorological Laboratory (NOAA)  
- Earth System Research Laboratory (NOAA)  
- European Centre for Medium Range Weather Forecasting  
- Geophysical Fluid Dynamics Laboratory (NOAA)  
- Goddard Space Flight Center (NASA)  
- Institute for the Global Environment and Society/Center for Ocean-Land-Atmosphere Studies  
- Langley Research Center (NASA)  
- Lawrence Livermore National Laboratory  
- Max Planck Institute for Meteorology  
- National Centers for Environmental Prediction (NOAA)  
- Pacific Northwest National Laboratory  
- Poudre School District  
- Scripps Institution of Oceanography  
- Thompson School District  
- University of California at Los Angeles  
- University Corporation for Atmospheric Research
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Executive Summary

The Center for Multiscale Modeling of Atmospheric Processes (CMMAP) is a Science and Technology Center that is supported by the National Science Foundation. CMMAP funding commenced on July 1, 2006.

CMMAP’s research vision is to dramatically improve our ability to understand and predict the role of cloud processes in the climate system. Such predictions are made using climate models, which include physically based representations of the atmosphere, the ocean, the land-surface, and the cryosphere. The models run on the most powerful computers available. They are being used to forecast the climatic effects of anthropogenic changes in the composition of the Earth’s atmosphere. These forecasts serve as input to policy decisions that have enormous economic implications for the U.S. and the world. Cloud feedbacks are the largest sources of uncertainty in climate-change predictions. A broad international community of researchers is working to improve the representation of clouds in climate models. CMMAP’s unique role, within this larger community, is to take advantage of its academic setting, sustained funding, and talented research team to attack important research problems that are too risky to undertake in a mission-oriented center or laboratory. CMMAP’s research goals are to create a flexible new family of global atmospheric models based in part on explicit simulation of individual large clouds, with state-of-the art parameterizations of cloud particle formation, turbulence, and radiation. CMMAP models are used in “academic applications” focused on multiscale interactions of the atmosphere with the ocean (including sea ice) and the land-surface. We perform and analyze extended simulations of present and future climates, and critically evaluate the results using a wide range of observations. CMMAP’s research is important because our models, especially the Multiscale Modeling Framework, uniquely avoid the questionable closure approximations used to represent deep cumulus clouds in conventional models, while still running fast enough to be used in simulations of climate change.

CMMAP’s work benefits both climate modeling centers and numerical weather prediction centers. Our main Knowledge-Transfer partnership in the climate modeling arena is with the Community Climate System Model (CCSM) project, which is led by the National Center for Atmospheric Research. CMMAP will collaborate with CCSM in connection with the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC), which will be completed in 2013. CMMAP and CCSM scientists will perform simulations of direct relevance to AR5, using CMMAP computing resources, and a unique model created by CMMAP using some components from the CCSM. Analysis of the simulation results will provide a basis for evaluation of the cloud-related feedbacks on climate change, in comparison with results from a conventional version of the CCSM. Our results will be provided as input to the IPCC’s Assessment. On the weather prediction side, CMMAP will continue its partnership with the National Centers for Environmental Prediction (NCEP), and will also begin a new partnership with the Earth System Research Laboratory (ESRL). CMMAP will organize an international intercomparison of very high-resolution global dynamical cores.

In addition, CMMAP will organize both graduate university classes and summer schools aimed at training future global modelers. The content will deal with both the conceptual basis and the practical implementation of global models. Our goal is to create a national training resource for global modelers.

CMMAP will create a non-technical online publication, tentatively called ClimateSense, whose mission is to provide a venue for a multidisciplinary conversation surrounding the Earth’s climate and climate change, and to promote Earth-Science literacy.

According to Ralph Cicerone, the President of the National Academy of Sciences, “scientists are necessary but not sufficient to solve the climate problem.” CMMAP’s educational initiatives will both train necessary scientists and contribute to a sufficiently-educated larger culture. We will continue to support 25 graduate students at seven universities who are up to their eyeballs in the details of inventing the new multiscale models of the climate system. These students will be among
the leaders of an emerging generation of climate scientists. Besides their outstanding scientific education, they are being trained as professionals in teaching, writing, and research skills. They participate in summer workshops on proposal writing, supercomputing, classroom teaching, and in undergraduate teaching fellowships. They learn about the role of science in the larger culture through intensive workshops in climate policy and in focus groups with school teachers and other community leaders. At the undergraduate level, we will offer three new courses in global change at CSU and Colorado College. CMMAP will support ChangingClimates @ CSU, a curriculum infusion program designed to enhance undergraduate climate content across all academic disciplines. We sponsor climate lectures attended by thousands of undergraduates each year, and have engaged over 80 faculty members from 37 departments, and are working to disseminate this approach to colleges and universities nationwide. CMMAP supports K-12 science and Earth Science education through the Little Shop of Physics (LSOP), which develops curricular materials and engages more than 20,000 students in public schools each year with its unique brand of hands-on inquiry-based investigations. Each year, we conduct classes for middle school science teachers, a summer camp for middle school students from underrepresented groups, and a statewide conference on climate change for high school students. Our educational materials are disseminated worldwide to teachers and students in both Spanish and English through the Windows to the Universe website, reaching over 20 million unique users each year. We will study, document, and disseminate experimental research on all these activities through structured partnerships with sociologists and educational psychologists.

Understanding the climate system and addressing the concerns of our society requires engagement with the full suite of cultural perspectives and the human capital of the larger US population. During Years 6 - 10, we will enhance connections between LSOP, SOARS and other diversity and education efforts. Our annual summer course on Teaching Climate will focus on schools with populations of students that are underrepresented in science fields. We will continue to work with Native American populations, building on the relationships we have already established with schools on Pine Ridge, Navajo, and Mountain Ute lands. We will continue to offer a one-week summer workshop on weather and climate as part of CSU’s participation in the NSF-supported Math-Science Partnership. CMMAP is participating in an NSF-sponsored initiative to develop a unique course on climate and global change to be taught at Tribal Colleges across the USA. Scott Denning and Raj Pandya attended the planning workshop for this activity in 2009, and will continue to participate in years one and two of the renewal.

We will conduct a transdisciplinary and multicultural conversation about climate change with leaders from diverse schools across our region, on native lands and in tribal colleges, in inner-city and rural farm communities, and with stakeholders and policymakers at various levels of government. We have designed and implemented a mostly qualitative study to track the experiences of women and men across ethnicities and nationalities from the undergraduate to the early post-doctoral years in Climate Science and related STEM fields. We will study how the atmospheric/climate science “leaky pipeline” can be made less porous using existing institutional data sets.

CMMAP is managed by a six-member Executive Committee, which meets regularly via telecon and in person. Once per year we are reviewed by a visiting committee organized by the National Science Foundation. We also support an External Advisory Panel that reports to the Executive Committee, and an Internal Advisory Panel composed of Colorado State University administrators and faculty. We participate in the annual meetings of the STC Directors.

The legacy of CMMAP will include important new modeling tools that are used to provide substantially more reliable predictions of climate change, as well as more accurate weather forecasts. Our most important legacy will be the cadre of diverse young scientists we have trained, who will share a sense of the context of their work in the larger culture, and the many thousands of K-12 students who we have influenced through the Little Shop of Physics and our Teacher Training course.
Preface

The purpose of this Strategic and Implementation Plan is to document the vision, mission, goals and objectives of the Center for Multiscale Modeling of Atmospheric Processes (CMMAP), the strategies by which the Center accomplishes its mission, and the organizational structure of the Center. The Plan is deliberately concise. It evolves over time.

This version of the plan has been created to formalize CMMAP’s mission for year’s 6-10 of the project. It therefore reflects CMMAP’s Objectives, Partnerships, etc., as planned for 2011 and later, and as described in the renewal proposal.

What Is CMMAP?

1. The germ of an idea

CMMAP was created to achieve a critical and long-standing goal: Understanding and predicting the role of clouds in the global climate system. Cloud processes are central to the Earth Sciences. For example:

- Changes in cloudiness can either amplify or damp climate change.
- Cloudiness is a key element of any weather forecast.
- Quite obviously, 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 areas is being held back by our limited ability to understand and predict global cloudiness.

Why has this been so difficult? The core of the problem is the wide range of spatial scales that matter for cloud systems.

Individual clouds have horizontal and vertical scales that range from a few hundred meters to a few kilometers. The “footprint” of an individual cloud, i.e., the horizontal area that it covers, ranges from a fraction of a square kilometer to about 10 or 20 square kilometers. The processes that govern the growth and decay of individual clouds are relatively well understood, because they have been observed for decades using aircraft and radar, and because they have been simulated in considerable detail using high-resolution numerical models.

In principle, we can start from our understanding of how individual clouds work, and just “scale up” by including as many clouds as it takes to represent cloud processes in the whole global atmosphere. There are two big problems with this, however.

The first problem, which can be called the Problem of Scales, is that the surface area of the Earth is very large: about 500 million square kilometers, which is about 100 million times larger than the footprint of a medium-size cloud. For this reason, it takes an extremely powerful computer to simulate the distribution of individual clouds throughout the entire atmosphere. The computing requirements are especially daunting if long simulations are required, as in climate-change studies.

The second problem, which can be called the Problem of Understanding, is that even if a sufficiently powerful computer were available, the simulation produced would just be a huge collection of numbers. We would still want to ask why the numbers came out as they did. Only after answering that question could we claim to understand our results.

To achieve such understanding, we need to devise a theory that explains how large collections of clouds interact with each other and with larger-scale weather systems to form “cloud systems.” Such theories exist, but despite the efforts of many scientists over a period of about forty years,
our understanding of cloud systems is still rudimentary. The theories are crude, but good enough to be useful.

The conventional approach to solving the Problem of Scales has been to insert a “middle man” between the cloud-scale and the global scale. The middle-man is “cloud parameterization,” which is intended to represent the combined effects of a collection of clouds covering a middle-sized area of perhaps 50,000 square kilometers -- about ten thousand times larger than the footprint of a middle-sized cloud. Roughly 10,000 such middle-sized areas, each with a copy of the cloud parameterization, are sufficient to cover the surface area of the Earth. This approach cuts a model’s computing requirements by about a factor of a million!

Unfortunately, the approach has been less than fully satisfactory because of the limitations of current cloud parameterizations. For example, the recently released Fourth Assessment of the Intergovernmental Panel on Climate Change (IPCC) states that “Cloud feedbacks remain the largest source of uncertainty” (IPCC, 2007). The Problem of Understanding thus stands in the way of the conventional approach to solving the Problem of Scales.

The good news is that, within the last five years or so, advances in computer power have finally made it possible to run models that simulate the distribution of individual clouds over the entire Earth (e.g., Tomita et al., 2005). These are called “Global Cloud-Resolving Models,” or GCRMs. As discussed later, CMMAP has created a GCRM. Even with the most powerful computers in the world today, however, a GCRM cannot be run for more than a few simulated weeks. We are still decades away from being able to use GCRMs in climate change simulations.

CMMAP is therefore pursuing what might be called a compromise approach, which was pioneered by CMMAP scientist Wojciech Grabowski (e.g., Grabowski and Smolarkiewicz, 1999). The idea is to keep the “middle-man,” as discussed above, but to replace the cloud parameterization by a simplified cloud-resolving model (CRM). A CRM that is used in this way is sometimes called a “super-parameterization,” and a global atmospheric model that uses a super-parameterization is called a Multiscale Modeling Framework, or MMF. In an MMF, the CRM does not cover the entire middle-sized area of 10,000 square kilometers or so. Instead, it represents only a sample of the middle-sized area. Cloud statistics computed from the sample are assumed to apply to the entire middle-sized area, much as an opinion pollster computes statistics from a small sample of a population, and attributes them to the entire population.

An MMF is several hundred times slower than a conventional global model that uses cloud parameterizations, but it is several thousand times faster than a GCRM. Using today’s fastest computers, it is possible (though expensive) to do a century-long climate-change simulation with an MMF. Within a decade, such simulations will be routine.

Tests have shown that an MMF can produce simulations of the present climate that are considerably more realistic than those obtained with conventional global models. (e.g., Khairoutdinov et al., 2005). The increasing power of computers is thus making it possible to solve the Problem of Scales, first through MMFs, and later through GCRMs.

During CMMAP’s first five years, its primary research goal was to create, evaluate, and apply an improved, second-generation MMF, and later through GCRMs.
proved cloud parameterizations, which will always be needed to interpret and explain model results, even if they are not actually used inside a model. During CMMAP’s second five years, we will exploit the MMF and GCRM that we have created to make major progress towards solving the Problem of Understanding.

2. Learning new things

Much of CMMAP’s research is performed by professors and graduate students, i.e., it occurs in the context of graduate education. Research is itself a form of education. A professor is essentially a very senior graduate student.

The graduate students matriculate from the undergraduate population, which in turn emerges from the K-12 education system. As the years pass, new classes of students move through the pipe, from K-12, to undergraduate, to graduate school, to professor. And so it goes.

As discussed in the Education and Diversity Plans below, CMMAP aims to feed this academic pipeline with young people who are excited about science, and who represent the full diversity of the U.S. population.

3. Changing the world around us

The fruits of CMMAP’s research have applications in climate-change studies, and in weather prediction. To ensure that these benefits are fully realized, CMMAP is partnering with national centers both inside and outside the United States. Through a partnership with the National Center for Atmospheric Research, these efforts will include simulations of twenty-first-century climate change.

Because global atmospheric models are being used in more ways, and becoming increasingly important to society, there is a need for a larger workforce of model builders. CMMAP is launching an initiative to create training courses for modelers, both within universities and through summer schools.

During its first five years, CMMAP partnered with IGES (the Institute for the Global Environment and Society) to launch a new scientific journal called the Journal of Advances in Modeling the Earth Sciences (JAMES). CMMAP is now stepping back to allow IGES to fully manage JAMES in a financially self-sufficient mode.

Research Plan

1. Vision Statement for Research

Major advances in our ability to understand and predict the effects of clouds on weather and climate, achieved by taking advantage of recent increases in computing power.

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 and ever-continuing increases in computer performance are enabling new research approaches.
3. CMMAP started 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, cloud-scale observationalists, and scientists who study physical processes to collaborate over an extended period of time within a highly focused research framework with centralized management. CMMAP fosters scientifically productive interactions among these diverse and historically disjoint communities.

Challenges

1. The CMMAP team is dealing with an extremely difficult, long-standing, many-faceted problem: The role of clouds in climate.
2. The CMMAP team is geographically far-flung.
3. CMMAP’s central scientific focus is highly interdisciplinary within the atmospheric sciences.
4. CMMAP’s modeling work requires very large amounts of computer time.
5. Members of the CMMAP team need to share and analyze 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 data sets, 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. In Years 6-10, this third goal will receive increased emphasis.

Objectives

1. Further development of global models with diverse representations of cloud processes. Relates to Goal A.

2. Further development and testing of improved parameterizations of microphysics, turbulence, and radiation. Relates to Goal A.

3. Application of CMMAP models to study multiscale interactions of the atmosphere and land-surface. Relates to Goal C.

4. Application of CMMAP models to study the coupled climate system. Relates to Goal C.

5. Analysis of cloud-related feedbacks on climate change. Relates to Goals B and C.

6. Provision and management of hardware and software resources; and management, analysis and visualization of very large model output datasets. Relates to all Goals.

5. Strategies

A. Work to create a physically based unified parameterization that can be used in models with a wide range of horizontal grid spacings, from a few kilometers to a few hundred kilometers.

B. Aggressively develop the Quasi-3D MMF and the global cloud-resolving model, with a unified parameterization of physical processes, while simultaneously continuing research with the prototype MMF. Relates to Goal A.

C. Couple the prototype MMF, and the Q3D MMF when ready, to land-surface, ocean, and sea-ice models, to permit simulation of the climate system. Relates to all Goals.

D. Pursue “Research Themes” on the MJO, low-cloud feedbacks on climate change, development of the Quasi-3D MMF and global cloud-resolving model, parameterized physical processes, and cyberinfrastructure. Use these Themes to foster collaboration among scientists at various CMMAP partner institutions. Relates to all Goals.

E. Acquire and manage supercomputer resources. Relates to all Goals.
6. Implementation Plan for Research

Table 1: For each Research Objective, we list “Actions Required,” with a time-frame, and identify two Team Leaders who assume responsibility for the Objective as a whole. Appendix A lists the Objectives associated with each CMMAP participant.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Actions Required</th>
<th>Time-frame</th>
<th>Team Leader(s)</th>
<th>Supports Goal(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Further development of global models with diverse representations of cloud processes</td>
<td>Continue work with the prototype MMF</td>
<td>Ongoing</td>
<td>Randall &amp; Konor</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Complete development of the Q3D MMF, and perform climate simulations with it</td>
<td>Global version by Year 6</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Complete development of the GCRM, and perform short climate simulations with it</td>
<td>First version by Year 6</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Development of a unified parameterization</td>
<td>Ongoing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Further development and testing of improved parameterizations of microphysics, turbulence and radiation</td>
<td>Develop and test improved microphysics parameterizations</td>
<td>Ongoing</td>
<td>Moeng &amp; Morrison</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Develop and test improved turbulence parameterizations</td>
<td>Ongoing</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Develop and test improved radiation parameterizations</td>
<td>Ongoing</td>
<td></td>
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<tr>
<td>3. Application of CMMAP models to study multi-scale interactions of the atmosphere and land-surface</td>
<td>Land-atmosphere interactions in the current climate</td>
<td>Ongoing</td>
<td>Denning &amp; Bonan</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>Changing roles of biogeochemistry and land-use change in future climates</td>
<td></td>
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<tr>
<td>4. Application of CMMAP models to study the coupled climate system</td>
<td>Studies of cloud feedback</td>
<td>Ongoing</td>
<td>Stan &amp; C. DeMott</td>
<td>C</td>
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<td></td>
<td>Studies of the MJO</td>
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<tr>
<td></td>
<td>Climate simulations using the MMF in a coupled model</td>
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<tr>
<td>5. Clouds and Climate</td>
<td>Analysis of climate change simulations</td>
<td>Ongoing</td>
<td>Bretherton &amp; P. Blossey</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>Participation in intercomparisons</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>6. Provision and management of hardware and software resources; and management, analysis and visualization of very large model output datasets</td>
<td>Resource procurement and distribution</td>
<td>Ongoing</td>
<td>Helly &amp; Schuchardt</td>
<td>A, B, C</td>
</tr>
<tr>
<td></td>
<td>Data management</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Analysis and visualization of model results</td>
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</tbody>
</table>
7. Metrics for Research

- Number of refereed journal articles published.  
  *Addresses all Objectives.*

- Number of conference and workshop presentations made.  
  *Addresses all Objectives.*

- Number of graduate student journal articles published in collaboration with CMMAP scientists.  
  *Addresses all Objectives.*

- Number of awards and other significant recognition of CMMAP sponsored research.  
  *Addresses All Objectives.*

- Computational resources acquired.  
  *Addresses Objective 6.*

8. Management Plan for Research

The research agenda of CMMAP is managed by the Center Director, who relies on advice from the other members of the Executive Committee, as well as the External Advisory Panel. The Deputy Director shares oversight of CMMAP’s research activities. A key goal is to maintain an extremely tight focus on CMMAP’s research objectives.

The Center Director appoints lead scientists for each of the Research Objectives. These Objective Leaders are responsible for collecting and writing up progress summaries for use in the CMMAP Annual Reports to NSF.

CMMAP also has Research Working Groups, which we have now brought into one-to-one correspondence with the Research Objectives. The Working Groups convene the bi-annual CMMAP Team Meetings. The Working Group leaders are the same as the corresponding Objective Leaders.
**Education Plan**

1. **Vision Statement for Education**

   It is the vision of CMMAP to enhance climate and earth-science literacy and awareness for students, teachers, policy makers, and the general public.

2. **Mission Statement for Education**

   The mission statement for education focuses on educating and training a diverse population in climate and earth system science. CMMAP will provide high quality educational experiences at all levels, disseminating science content through multiple media. We will engage stakeholders, policy makers and the general public thus improving science pedagogy and infusing the next generation of climate scientists with a sense of the role of science in the larger culture.

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], and the University Corporation for Atmospheric Research, [UCAR]).
   4. Strong partnerships with programs for recruiting and retaining students from underrepresented groups, (e.g. Significant Opportunities in Atmospheric Research and Science [SOARS]).

   **Challenges**
   1. Distributed nature of CMMAP 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 science 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 climate science to the public and to climate stakeholders.

   **Objectives**
   1. Enhance K-12 science education.
   2. Improve undergraduate climate education
   3. Train the next generation of climate scientists.
   4. Engage the larger culture regarding climate.

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 acquire enhanced teaching skills, both formally (through pedagogical instruction) and informally (through mentoring).

G. Engage in rigorous educational research studies to examine links between curriculum enhancement, teacher professional development, and teacher implementation on the one hand, and changes in student achievement and attitudes towards science on the other.

H. Maintain active communication across the Center’s infrastructure 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 2: For each Education Objective, we list “Actions Required,” identify an Action Leader who is responsible for the Action, 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-frame” column in the table.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Actions Required</th>
<th>Action Leader</th>
<th>Team Leader</th>
<th>Location</th>
<th>Supports Goal(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Enhance K-12 science education.</td>
<td>1. Develop, document, distribute and test curriculum enhancement kits for classroom teaching in local schools and make information available via web.</td>
<td>Jones</td>
<td>CSU/UCAR</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Develop climate content for LSOP and TV show to be distributed through school programs, mini programs, workshops, Channel 10, Rocky Mountain PBS, and the web.</td>
<td>Jones</td>
<td>CSU/UCAR</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Provide, document, and disseminate K-12 teacher training course to teachers every year.</td>
<td>Jones/Burt</td>
<td>CSU/UCAR</td>
<td>B</td>
<td></td>
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<tr>
<td></td>
<td>4. Develop levelized climate and atmospheric science content for K-12 students and teachers via Windows to the Universe.</td>
<td>R. Johnson</td>
<td>CSU/UCAR</td>
<td>B</td>
<td></td>
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<tr>
<td></td>
<td>5. Develop, promote and disseminate web-based seminars and virtual labs designed for high school climate science teachers and students.</td>
<td>Pandya</td>
<td>CSU/UCAR</td>
<td>B</td>
<td></td>
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<tr>
<td></td>
<td>6. Host a state-wide global climate conference for high school students every year.</td>
<td>Jones/Fleming</td>
<td>CSU/UCAR</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Examine effects of education activities including LSOP delivery systems, student gains in science content, use of exhibits, and Everyday Science Show.</td>
<td>Lacy/Albright</td>
<td>CSU/UCAR</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Spin-off a nonprofit enterprise to distribute materials developed.</td>
<td>Jones</td>
<td>CSU/UCAR</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>2. Improve undergraduate climate education</td>
<td>1. Host summer undergraduate research interns.</td>
<td>Burt</td>
<td>CC/CSU</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Develop, pilot and package for distribution new undergraduate climate courses at Colorado State University and Colorado College.</td>
<td>Denning/Drossman</td>
<td>CC/CSU</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Sponsor undergraduate research opportunities at Colorado College.</td>
<td>Drossman</td>
<td>CC/CSU</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Collaborate with CSU faculty to infuse climate content across undergraduate curriculum.</td>
<td>Calderazzo/Campbell</td>
<td>CC/CSU</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Objective</td>
<td>Actions Required</td>
<td>Action Leader</td>
<td>Team Leader</td>
<td>Location</td>
<td>Supports Goal(s)</td>
</tr>
<tr>
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</tr>
<tr>
<td>3. Train the next generation of climate scientists</td>
<td>1. Support graduate students across institutions who have direct involvement in the center’s research.</td>
<td>Denning</td>
<td>Burt</td>
<td>CC/CSU</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>2. Host CMMAP graduate student summer colloquium</td>
<td>Burt</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>3. Provide formal and informal opportunities for graduate students to develop skills in pedagogy.</td>
<td>Burt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Host CMMAP graduate student teaching fellowships at Colorado College</td>
<td>Drossman</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Support social science graduate student research on climate policy and politics and/or the use of scientific information in environmental decision making.</td>
<td>Betsill</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Engage the larger culture regarding climate</td>
<td>1. Outreach to climate stakeholders and policymakers through science policy dialogues</td>
<td>Betsill</td>
<td>Burt</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>2. Improve citizen literacy on climate issues through formal and informal outreach activities</td>
<td>Calderazzo/Campbell</td>
<td></td>
<td>CSU</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>3. Create and disseminate short video productions on climate</td>
<td>Calderazzo/Campbell</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7. Metrics for Education

- *Evaluation of curriculum materials, teacher training, and outreach*
  
  *Addresses Objective 1. Enhance K-12 science education.*

**Metric for Action 1:**
- Number of new Atmospheric Science experiments developed, type of distribution and number of teachers/students/public trained

**Metric for Action 2:**
- Number of school programs, mini-programs, Channel 10, Rocky Mountain PBS, and amount of web content developed

**Metric for Action 3:**
- Number of teachers trained, hours trained, content, and breakdown of elementary, junior high, and high school focus

**Metric for Action 4:**
- Number of cloud, climate and weather pages added to Windows to the Universe, and number of visits to these pages

**Metric for Action 5:**
- Number of web-based virtual labs designed and available on the web, and number of visits

**Metric for Action 6:**
- Number of student and sponsor attendees, student and sponsor evaluations, and subsequent conference refinements

**Metric for Action 7:**
- Strategic research plan examining the link between each educational action and their hypothesized effects

**Metric for Action 8:**
Progress of nonprofit enterprise

Evaluation of undergraduate climate education
Addresses Objective 2. Improve undergraduate climate education.

Metric for Action 1:
- Number and accomplishments of summer interns

Metrics for Action 2:
- Development, pilot results, refinement, packaging and distribution of new undergraduate climate courses
- Number of undergraduate students completing the course

Metric for Action 3:
- Number and type of research scholarship opportunities at Colorado College

Metric for Action 4:
- Number and type of events, number of participants, number and types of changes in undergraduate curriculum to incorporate climate content

Evaluation of CMMAP graduate research and education.
Addresses Objective 3. Train the next generation of climate scientists

Metric for Action 1:
- Number of CMMAP supported graduate students and types of research

Metric for Action 2:
- Number of attendees, colloquium content, attendee feedback and subsequent refinement

Metric for Action 3:
- Number and types of formal and informal opportunities for graduate students and number of students participating

Metric for Action 4:
- Number of students applying, number of students participating in co-teaching, student evaluations of course and instructor

Metric for Action 5:
- Type of research conducted

Evaluation of outreach to the stakeholder, policy makers and the public
Addresses Objective 4. Engage the larger culture regarding climate

Metrics for Action 1:
- Number of government officials and CMMAP participants attending dialogue sessions and attendee feedback

Metric for Action 2:
- Number and type of activities developed, number or participants, and feedback from participants

Metric for Action 3:
- Number of videos created, video content, number of video views/uses

8. Management Plan for Education

The 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 for CMMAP is facilitated by a full-time Education and Diversity Manager, and is advised by the ED Committee, whose members are CMMAP scientists and education professionals. The ED Committee serves in part to ensure that CMMAP scientists are actively engaged in CMMAP’s ED activities.
Education and Diversity Manager:

CMMAP’s Education and Diversity work is managed by Melissa Burt, an Atmospheric Scientist who is a SOARS alumna. CMMAP’s K-12 Education and Diversity work is being led by the Little Shop of Physics, which has been a key CMMAP partner from the beginning of the Center. Duties include:

- Working with the STC’s Managing Director and ED partners to track performance of component activities
- Managing communications among ED partners and between CMMAP scientists and ED resources, to facilitate dissemination of science content to students, educators, stakeholders, policy makers, and the public
- Organizing monthly teleconferences with ED partners and management
- Organizing and scheduling ED component of twice-annual CMMAP meetings
- Promoting CMMAP graduate programs and our summer undergraduate internship program, and recruiting students for these programs.

ED Committee

A committee of CMMAP scientists and education professionals oversees planning and implementation of ED activities. The committee is chaired by the Director for ED, Prof. Denning, with membership changing through regular rotation, plus representatives from LSOP, UCAR, and public schools. The committee co-hosts two full-day meetings per year for all CMMAP scientists and students to review ED activities. The 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

CMMAP’s vision for diversity is to assist in developing a climate science workforce that taps the human potential of the whole U.S. population.

2. Mission Statement for Diversity

CMMAP seeks to broaden participation in climate science by aggressively recruiting members from underrepresented groups*. We will work to increase graduate student diversity, place these students in leadership positions and aid them in becoming excellent scientists and educators. CMMAP will enhance the science and engineering pipeline by mentoring and recruiting at earlier academic levels. We will study diversity issues, problems and solutions, and disseminate results.

*According to the National Science Foundation’s diversity mission statement, underrepresented groups include members who are Black or African American, American Indian or Alaska Native, Hispanic or Latino, Native Pacific Islander, female, and persons with disabilities.

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).
3. Center faculty include experts in gender issues and in academic assessment studies.

**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 ethnic minorities in region of CMMAP home institution.
5. Women, ethnic minorities, and individuals with disabilities are underrepresented on CMMAP faculty in relation to the US population.

4. Goals and Objectives

**Goals**

A. Increase the number of underrepresented groups who are pursuing graduate degrees in atmospheric science.

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

C. Improve participation in science and engineering by women and minorities at all academic levels.

**Objectives**

1. Recruit and support undergraduate and graduate students from underrepresented groups.
2. Implement programs that encourage retention of women, minorities and the underrepresented in the science pipeline.
3. Study diversity problems and solutions, and disseminate results.
4. Engage diverse communities in conversations about climate.

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, in order to 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.
### Implementation Plan for Diversity

Table 3: For each Diversity Objective, we list “Actions Required,” identify an Action Leader who is responsible for the Action, 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 Diversity activities are ongoing continuously during the life of the project. For this reason, we do not include a “Time-frame” column in the table below.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Actions Required</th>
<th>Action Leader</th>
<th>Team Leader</th>
<th>Location</th>
<th>Supports Goal(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Recruit and support undergraduate and graduate students from underrepresented groups.</td>
<td>1. Support graduate fellows and summer interns per year through SOARS.</td>
<td>Pandya</td>
<td>Burt</td>
<td>UCAR/CSU</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>2. Develop relationships with Minority Serving Institutions</td>
<td>Burt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Host summer undergraduate interns from underrepresented groups.</td>
<td>Burt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Support minority scholarships in Atmospheric Science at CMMAP institutions.</td>
<td>Burt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Promote atmospheric science graduate programs to underrepresented, undergraduate populations.</td>
<td>Burt</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>6. Actively recruit and promote summer internships and graduate programs at national conferences and host informal sessions at universities/colleges.</td>
<td>Burt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Implement programs that encourage retention of women, minorities and the underrepresented in the science pipeline.</td>
<td>1. Support undergraduate women in Little Shop of Physics internships.</td>
<td>Jones</td>
<td></td>
<td>CSU</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>2. Support K-12 programs that encourage and engage students in science.</td>
<td>Jones</td>
<td></td>
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<tr>
<td></td>
<td>3. Develop, package and port a one week course in weather and climate for middle school students (MSP Program).</td>
<td>Jones</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>4. Support LSOP to provide programs, teacher workshops and instructional activities to diverse communities and schools in the region.</td>
<td>Jones</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Understand historical ethnic underrepresentation in climate science</td>
<td>1. Survey study of Atmospheric Science graduate students at CSU and nationally to assess education and career pathways</td>
<td>Canetto/ MacPhee</td>
<td>Canetto</td>
<td>CSU</td>
<td>B</td>
</tr>
<tr>
<td>4. Engage diverse communities in conversations about climate</td>
<td>1. Create focus groups in school districts with diverse populations to assess community attitudes, concerns and questions about climate change.</td>
<td>Jones/Pandya</td>
<td></td>
<td>CSU</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>2. Meet with community leaders to discuss and learn how climate change affects their communities.</td>
<td>Denning/Pandya</td>
<td></td>
<td>CSU</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Document and disseminate results.</td>
<td>Denning/Pandya</td>
<td></td>
<td>CSU</td>
<td></td>
</tr>
</tbody>
</table>
7. Metrics for Diversity

- Degree to which CMMAP graduate students represent US demographics.

Addresses Objective 1. Recruit and support undergraduate and graduate students from underrepresented groups.

**Metrics for Actions 1-4:**

- Number of students supported, underrepresented group breakdown, accomplishments and areas of study
- Number of CMMAP-supported students from above, placed in Ph.D. programs

**Metrics for Actions 5-6:**

- Number and type of promotions and results
- Evaluation of mentoring programs targeting students from underrepresented groups.

Addresses Objective 2. Implement programs that encourage retention of women, minorities and the under-served in the science pipeline.

**Metric for Action 1:**

- Number of CMMAP-supported women in LSOP internships; hours, accomplishments, student reflections and graduate program chosen

**Metric for Action 2:**

- Number served, ages, under-served breakdown, types of activities and pre- and post-test results

**Metric for Action 3:**

- Development and implementation of course, package and distribution of results

**Metric for Action 4:**

- Number, type and duration of programs; under-served breakdown, and results

- Evaluation of academic studies of diversity in science.

Addresses Objective 3. Understand historical ethnic underrepresentation in climate science

**Metric for Action 1:**

- Number of students interviewed and underrepresented group breakdown, results

- Evaluation of engaging diverse communities about climate.

Addresses Objective 4. Engage diverse communities in conversation about climate.

**Metric for Actions 1 and 2:**

- Number and type of focus groups, topics discussed, number of participants

**Metric for Actions 3:**

- Results found, number of publications

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.

Strategic Plan, Center for Multiscale Modeling of Atmospheric Processes
May, 2012
Knowledge Transfer Plan

1. Vision Statement for Knowledge Transfer

Partnerships for a new generation of operational models for climate simulation and weather forecasting, and new scientific publications devoted to global environmental modeling

2. Mission Statement for Knowledge Transfer

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

3. Opportunities and Challenges

Strengths and Opportunities

1. Capabilities of the prototype MMF.
2. Migrate MMF concepts into collaborations with CCSM in direct relevance to AR5.
3. Capitalize on education and publication projects through the spin-off nonprofit.

Challenges and Weaknesses

1. Inertia of established modeling centers.
2. Develop and implement a successful business model to sustain KT and Education activities beyond the funding cycle of the SCT.

4. Goals and Objectives

Goals

A. Enable improved climate and weather prediction models.
B. Enlarge and enhance the global modeling workforce.
C. Create publications that communicate climate science to a wide range of audiences.

Objectives

1. Collaborate with CCSM on climate change simulations. Relates to Goal A.
2. Collaborate on global atmospheric model development. Relates to Goal A.
3. Create a national training resource for global modelers. Relates to Goal B.
4. Formalize REACH - our nonprofit corporation - Goal

5. Strategies

CMMAP’s work benefits both climate modeling centers and numerical weather prediction centers.

Our main Knowledge-Transfer partnership in the climate modeling arena is with the Community Climate System Model (CCSM) project, which is led by the National Center for Atmospheric Research (NCAR). CMMAP will collaborate with CCSM in connection with the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC), which will be completed in 2013. CMMAP and CCSM scientists will perform simulations of direct relevance to AR5, using CMMAP computing resources, and a unique model created by CMMAP using some components from the CCSM. Analysis of the simulation results will provide a basis for evaluation of the cloud-related feedbacks on climate change, in comparison with results from a conventional version of the CCSM. Our results will be provided as input to the IPCC’s Assessment.

On the weather prediction side, CMMAP will continue its partnership with the National Centers for Environmental Prediction (NCEP), and will also begin a new partnership with the Earth System Research Laboratory (ESRL). CMMAP will organize an international intercomparison of very high-resolution global dynamical cores.

In addition, CMMAP will organize both graduate university classes and summer schools aimed at training future global modelers. The content will deal with both the conceptual basis and the practical implementation of global models. Our goal is to create a national training resource.
for global modelers.

CMMAP will create a non-technical online publication, tentatively called ClimateSense, whose mission is to provide a venue for a multi-disciplinary conversation surrounding the Earth's climate and climate change, and to promote Earth-Science literacy.
6. Implementation Plan for Knowledge Transfer

Table 4: 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.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Actions Required</th>
<th>Time-frame</th>
<th>Team Leader</th>
<th>Supports Goal(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Collaborate with CCSM on climate change simulations.</td>
<td>Perform simulations</td>
<td>Ongoing</td>
<td>Randall</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Analyze results</td>
<td>Ongoing</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Communicate results to AR5</td>
<td></td>
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</tr>
<tr>
<td>2. Collaborations on global atmospheric model development.</td>
<td>Continue interactions with NCEP, NCAR and GFDL</td>
<td>Ongoing</td>
<td>Krueger/Collins</td>
<td>A</td>
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<tr>
<td></td>
<td>Create new interactions with ESRL</td>
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<tr>
<td></td>
<td>Organize intercomparison of GCRMs</td>
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<tr>
<td>3. Create a national training resource for global modelers.</td>
<td>Create materials for both university classes and summer school</td>
<td>Start Year 6, ongoing thereafter</td>
<td>Randall</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>Create summer school</td>
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<td></td>
<td>Make class materials available nationally</td>
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<tr>
<td>4. Complete the launch of REACH - our nonprofit corporation</td>
<td>Create business model/ByLaws/Strategic Plan</td>
<td>6, 7, 8</td>
<td>Ames</td>
<td>C</td>
</tr>
<tr>
<td></td>
<td>Create REACH web site and online magazine for public outreach</td>
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<tr>
<td></td>
<td>Develop and act on goals and objectives to advance REACH into a stand-alone entity.</td>
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</tbody>
</table>

7. Metrics for Knowledge Transfer

- Number of collaborative research papers on global modeling. 
  *Addresses Objectives 1 & 2.*
- Adoption of CMMAP methods or tools by external organizations 
  *Addresses Objective 1 & 2*
- Organize summer school to train global modelers. 
  *Addresses Objective 3*
- Create and maintain the REACH website and online magazine, *Climate Sense.*
  *Addresses Objective 4*
- Transfer of CMMAP and creation of new activities to REACH 
  *Addresses Objective 4*
8. Management Plan for Knowledge Transfer

The Director for Knowledge Transfer, for years 6-10 is Prof. Steve Krueger of the University of Utah. Professor Krueger reports to the Center Director, and provides direction and oversight to these components of the Center. Figure 3 shows the management structure for the KT division 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: Management of the Knowledge Transfer Committee.

KT Manager

The Director for KT is assisted by a full-time KT Manager, Rodger Ames, who is responsible for managing the interactions of CMMAP with the KT Partners. The KT Manager’s duties include:

- Working with the CMMAP EC to track performance of component activities
- Managing communications among KT partners, and between CMMAP scientists and KT resources, to facilitate dissemination of science results to students, educators, stakeholders, policy makers, and the public
- Organizing and scheduling KT component of twice-annual CMMAP meetings

KT Committee

A committee of CMMAP scientists oversees planning and implementation of KT activities. The 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 CMMAP has set up a formal management process to organize and prioritize this effort.

The plan outlined here forms the basis of a System Description Document (SDD) which will evolve 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 are overseen by a Cyberinfrastructure Working Group (CIWG) of interested researchers in coordination with the Director for Cyberinfrastructure. The CIWG has 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.

One of the key responsibilities of the CIWG is to manage the future of our computational resources, as well. This includes integration with the emerging new generation of petascale computing resources that are beginning to be defined by recent awards of the NSF Teragrid Track 1 and Track 2 computational programs, as well as our ongoing collaboration with existing Teragrid and Earth System Grid resources.

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 Director for Cyberinfrastructure. 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 computing 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. Other resources are 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 develops and submits 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 is under the care of the CIWG. In the future, it will
be accessible via the CMMAP web site. Further discussion is given in Appendix B.

6. Coding standards

CMMAP models and post-processing software comprise millions of lines of code. As a guideline, all CMMAP code should follow the coding standards of the Community Climate System Model, as documented at http://www.ccsm.ucar.edu/models/ccsm3.0/csim/RefGuide/ice_refdoc/node15.html.

CMMAP will not enforce this guideline in a rigid way; we don’t want to have “code police.” We will invoke the standards on a case-by-case basis, however, to deal with problems as they arise.

7. CyberInfrastructure

The cyberinfrastructure for CMMAP evolves, but the current 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 is a key management function.

Backup and recovery are 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, is accomplished using CMMAP facilities at CSU on an appropriate medium. Backups are run regularly on a schedule that evolves. The schedule is documented in the SDD.

Supported products include codes, documentation and data that are maintained by CMMAP for the benefit of the community. Access to supported products is through the Internet, using appropriate methods for the task. We plan to create a central web-portal to provide “one-stop-shopping” through the resources of CMMAP. This site will integrate and redirect users to appropriate secondary servers for access to supported products.

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

Interoperability

As indicated in Fig. 3, interoperability is a key feature of the CMMAP cyberinfrastructure. We support efforts to interoperate with the Earth System Grid, as well as existing community resources such as those provided and supported by NCAR. We develop and maintain the interface descriptions needed 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 carries out a wide range of research and educational activities. Within CSU, CMMAP is a project within the Department of Atmospheric Science, which, in turn, is part of the College of Engineering. The Head of the Department of Atmospheric Science has lead responsibility for personnel actions, account management, and space allocations. CMMAP management relies on Department of Atmospheric Science staff to approve purchases. CMMAP is comfortably housed in a building that was created for it. The building was completed in April 2009. It is managed by the Department of Atmospheric Science.

In addition to CSU, CMMAP has 9 partner institutions and 16 collaborating institutions; here the distinction is that partners cost-share, while collaborators do not. CMMAP has 12 subcontractors, who are funded through CSU; of these, 8 are partners and 4 are collaborators. A summary is given in Table 5.

CMMAP is governed by an Executive Committee (EC), which consists of the Center Director, a Deputy Director, three Directors, and a Managing Director.

Figure 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. All of the doors of the Center are open, including especially the Center Director’s door.

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 are led by the Center Director. They are 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 includes a Deputy Director, Dr. Chin-Hoh Moeng of NCAR, who assists the Director in management of the Center, in part through special assignments. The Deputy Director represents the Director as necessary in various meetings and official functions.

The EC includes a Director for Education and Diversity (ED), Prof. A. Scott Denning of CSU, who is responsible for the overall leadership of the Center’s ED activities. The Director for ED is assisted by a full-time Education and Diversity Manager, who is responsible for managing the interactions of CMMAP with the ED Partners. The Education and Diversity Manager is in residence at CSU, but makes frequent visits to CMMAP’s ED Partners. Each ED partner institution has a designated single point of contact for CMMAP activities. An ED Committee, consisting of CMMAP scientists, works with the Director for ED.
of financial independence from CMMAP. The KT Manager will also 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 Director for KT.

The EC includes a Director for Cyberinfrastructure, Dr. John Helly of the San Diego Supercomputer Center, who is responsible for planning and managing CMMAP’s computational resources, both in-house and at supercomputer centers, as well as management of CMMAP data.

CMMAP employs a Managing Director (MD), Marcia Donnelson of CSU who along with Connie Hale, the Operations Manager (OM) are both part of the EC Committee. The MD has a broad range of key responsibilities. She serves as the Center’s “Chief of Staff.” She oversees all financial matters, including subcontracts and cost sharing. She coordinates CMMAP’s daily activities, and facilitates interactions among center personnel and with external entities. The MD tracks ongoing CMMAP activities against this Strategic Plan, makes sure that CMMAP meets the NSF reporting requirements in a timely fashion, and ensures the Center’s compliance with university and Federal policies. In addition, the MD participates in multiple Education, Diversity and KT projects. The OD maintains all financial records, assists in preparing financial and grant reports, supervises the Events Coordinator, Claire Fleming, reviews and approves subcontracts and provides guidance in financial areas as required.

The Directors, Deputy Director, and Managing Director report to the Center Director.

The EC members orchestrate CMMAP’s overall scientific direction, manage the budget, initiate or discontinue partnerships and collaborations, monitor progress relative to established milestones, develop diversity, enforce the highest standards of ethics and research quality, and promote broad dissemination of results.

The EC teleconferences frequently in order to conduct business without excessive travel. Other CMMAP personnel participate in the teleconferences as appropriate. The EC meets face-to-face in conjunction with each of the CMMAP Team Meetings, NSF Site Visits and External Advisory Panel (EAP) meetings, for a minimum of four times per year.

The EC teleconferences frequently in order to conduct business without excessive travel. Other CMMAP personnel participate in the teleconferences as appropriate. The EC meets face-to-face in conjunction with each of the CMMAP Team Meetings, NSF Site Visits and External Advisory Panel (EAP) meetings, for a minimum of four times per year.

CMMAP’s graduate education activities are by their nature highly integrated with the research work. Undergraduate and K-12 educational activities are 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.
As discussed earlier 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 5: A summary of CMMAP’s participating institutions. “Partners” cost-share. “Collaborators” do not.

<table>
<thead>
<tr>
<th>Institution/Organization</th>
<th>Subaward</th>
<th>Partner</th>
<th>Collaborator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colorado State University (Lead)</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Colorado College</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>European Centre for Medium Range Weather Forecasting</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Institute for the Global Environment and Society/Center for Ocean-Land-Atmosphere Studies</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Lawrence Livermore National Laboratory</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Max Planck Institute for Meteorology</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>NASA Goddard Space Flight Center</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>NASA Langley Research Center</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>National Center for Atmospheric Research</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>NOAA Earth System Research Laboratory</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>NOAA Geophysical Fluid Dynamics Laboratory</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>NOAA National Centers for Environmental Prediction</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>NOAA Atlantic Oceanographic and Meteorological Laboratory</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Pacific Northwest National Laboratory</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Poudre School District</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Research Institute for Global Change, Japan</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Scripps Institution of Oceanography</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>State University of New York at Stony Brook</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Thompson School District</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>University Corporation for Atmospheric Research</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>University of California, Los Angeles</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>University of California, Berkeley</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>University of California, San Diego</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>University of Colorado</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>University of Washington</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>University of Utah</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

2. Cohesion of the Center

The research activities of CMMAP are 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 activities are 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 is a key to CMMAP’s success. We hold two CMMAP Team Meetings per year, each lasting three days. The meetings are conducted as “Workshops,” with presentations focusing on recent results and near-term plans, and a lot of discussion time. Each Team Meeting also includes several longer, invited talks, including some by scientists who are not part of CMMAP. Half of the Team Meetings are held in Fort Collins, and half elsewhere. We also use teleconferences and video conferences as appropriate.

CMMAP has created Research Working Groups that undertake projects aimed at making progress towards CMMAP’s Research Objectives. The Working Groups have breakout sessions at CMMAP Team Meetings. The number and makeup of the Working Groups evolve as appropriate over the life of the Center.

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

3. Succession Plan

NSF requires that this proposal include a plan for succession of the Center leadership. If Prof. Randall is unable to continue as the CMMAP P.I./Center Director, he will be replaced by Prof. A. Scott Denning of CSU, who has agreed to be designated as “next in line” for the CMMAP directorship.

If the Deputy Director or one of the Directors steps down, a successor will be chosen by the EC, in consultation with the EAP and NSF.

4. Resource Allocation

Resources are 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 activities, and 1/6 to support Knowledge Transfer activities. These percentages may evolve as the Center matures and external circumstances change.

5. External Advisory Panel

CMMAP recruits an External Advisory Panel that meets at least once per year. The EAP consists of six members, including a Chair. The members include representatives of academia, atmospheric science research centers, a computing center or company, and the education sector. The EAP monitors CMMAP’s progress, and makes recommendations to the EC.

The members of the EAP will serve three-year terms, and the Chair rotates every two years.

Beginning in Year 5, CMMAP established an “Internal Advisory Panel” composed of CSU Administrators and faculty, and Chaired by CSU’s Vice President for Research and Engagement, currently William Farland. The Internal Advisory Panel provides advice to CMMAP’s Executive Committee.

6. Reporting

There are three categories of Reports within the Center’s management process.

First, sub-award institutions are contractually required to report their progress to the EC, every six months. These formal reports, minus any budget information, are made available to the Ob-
jective Leaders (see below).

Second, CSU participants funded by CMMAP are required to report annually to the EC. These reports, minus any budget information, are also made available to the Objective Leaders.

Third, CMMAP provides annual progress reports to NSF, as well as additional progress updates as requested. The annual report to NSF is prepared by the EC, with help from the Science Education and Diversity and KT Managers, based on input from the full team. Reporting is organized by Objective, as required by NSF.

The Objective Leaders (listed in the tables of Objectives for Research, Education, Diversity, and Knowledge Transfer) are responsible for organizing the input from the team, drafting the sections they are responsible for, and then funneling the input to the EC. The Objective Leaders have access to the sub-award reports and CSU participant reports (minus budget information) for this purpose.

7. **Refinement of this Strategic Plan**

This Strategic Plan is 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 is emailed to the CMMAP participants, and posted on the CMMAP web site.

8. **Management Goals and Objectives**

**Goals**

A. Create, nurture, and promote 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. Coordinate Team Meetings, Advisory Panel Meetings, internships, intern-recruiting activities, Teacher Training Workshops, lectures, colloquia, and other CMMAP activities.

D. 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 sepa-
## 10. Implementation Plan for Management

Table 6: For each Management Objective, we list “Actions Required.” The Executive Committee has responsibility for achieving these objectives, so “Team Leaders” are not listed.

<table>
<thead>
<tr>
<th>Objective</th>
<th>Actions Required</th>
<th>Supports Goal #</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td>Hold “all hands” meetings twice per year, with half of the meetings hosted away from CSU.</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Define “Research Themes” that foster collaboration leading to progress on CMMAP’s research Objectives.</td>
<td></td>
</tr>
<tr>
<td>2. Create productive interactions among the researchers and educators involved in CMMAP so that the researchers and educators function together as a team.</td>
<td>Create ED and KT Committees, with participation by CMMAP scientists.</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Engage CMMAP scientists as content providers for the ED “translators.”</td>
<td></td>
</tr>
<tr>
<td>3. Communicate CMMAP’s activities and accomplishments to the outside world.</td>
<td>Maintain CMMAP web page.</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>Publish review articles that provide overviews on topics highly relevant to CMMAP.</td>
<td></td>
</tr>
<tr>
<td>4. Manage the CMMAP budget from year to year to maximize productivity across the whole range of the Center’s activities.</td>
<td>Adjust funding levels as appropriate to achieve objectives.</td>
<td>A and C</td>
</tr>
<tr>
<td></td>
<td>Add or delete funded program elements to optimize progress towards the Center’s goals.</td>
<td></td>
</tr>
<tr>
<td>5. Attract funding, including cost-share.</td>
<td>Submit proposals for CMMAP-related research as opportunities arise.</td>
<td>B and C</td>
</tr>
<tr>
<td></td>
<td>Monitor and adjust cost-share agreements as required.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Seek private donations.</td>
<td></td>
</tr>
</tbody>
</table>
11. Management Metrics

- Number of “all hands” CMMAP Team Meetings held
  *Addresses Objectives 1 - 2.*

- Number of people participating in CMMAP Team Meetings.
*Addresses Objectives 1 - 2.*

- Number of publications co-authored by CMMAP participants from more than one institution
*Addresses Objectives 1 - 2.*

- Number of EC tele-cons conducted
*Addresses Objectives 1 - 5.*

- Number of hits on CMMAP web page.
*Addresses Objective 3.*

- STC funding attracted, including cost-share.
*Addresses Objective 5.*

- Participation in annual STC Directors’ meeting.
*Addresses Objective 3.*

- Professional development of CMMAP staff.
*Addresses Objectives 2.*

- Annual reviews of progress and plans by the External Advisory Panel.
*Addresses all Objectives.*
### Appendix A: Center Personnel

Table 7: Primary CMMAP personnel and their roles. Under “Objectives,” the prefixes R, E, D, and KT denote Research, Education, Diversity, and Knowledge Transfer, respectively.

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
<th>Role(s) in CMMAP</th>
<th>Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tom Ackerman</td>
<td>UW</td>
<td>Comparison of Model Results with Observations</td>
<td>R5</td>
</tr>
<tr>
<td>Akio Arakawa</td>
<td>UCLA</td>
<td>Development of improved MMF, GCRM, and conventional parameterizations</td>
<td>R1, 2</td>
</tr>
<tr>
<td>Len Albright</td>
<td>CSU</td>
<td>Evaluator - Education and Diversity</td>
<td>E1</td>
</tr>
<tr>
<td>Rodger Ames</td>
<td>CSU</td>
<td>Knowledge Transfer Manager</td>
<td>KT 4</td>
</tr>
<tr>
<td>Michele Bettsill</td>
<td>CSU</td>
<td>Climate change policy</td>
<td>E3, 4</td>
</tr>
<tr>
<td>Peter Blossey</td>
<td>UW</td>
<td>Community-based evaluation of results produced by CMMAP models</td>
<td>R5</td>
</tr>
<tr>
<td>Gordon Bonan</td>
<td>NCAR</td>
<td>Application of CMMAP models to study multiscale interactions of the atmosphere and land surface</td>
<td>R3</td>
</tr>
<tr>
<td>Chris Bretherton</td>
<td>UW</td>
<td>Development of improved cloud parameterizations</td>
<td>R2, 4, 5</td>
</tr>
<tr>
<td>Melissa Burt</td>
<td>CSU</td>
<td>Education and Diversity Manager</td>
<td>E2, 3, 4 &amp; D1,2,3</td>
</tr>
<tr>
<td>John Calderazzo</td>
<td>CSU, English</td>
<td>Engage the larger culture regarding climate</td>
<td>E2, 4</td>
</tr>
<tr>
<td>SueEllen Campbell</td>
<td>CSU, English</td>
<td>Engage the larger culture regarding climate</td>
<td>E2, 4</td>
</tr>
<tr>
<td>Silvia Canetto</td>
<td>CSU, Psychology</td>
<td>Understanding historical ethnic underrepresentation in climate science</td>
<td>D3</td>
</tr>
<tr>
<td>William Collins</td>
<td>UCB</td>
<td>Developer of radiative transfer parameterizations; Liaison to CCSM</td>
<td>R2, 4, &amp; KT2</td>
</tr>
<tr>
<td>Charlotte DeMott</td>
<td>CSU/ATS</td>
<td>Application of CMMAP models to study the coupled climate system</td>
<td>R4</td>
</tr>
<tr>
<td>Allan Scott Denning</td>
<td>CSU/ATS</td>
<td>Director for ED; Application of CMMAP models to study multiscale interactions of the atmosphere and land surface</td>
<td>E &amp; D All, &amp; R 3</td>
</tr>
<tr>
<td>Marcia Donnelson</td>
<td>CSU/ATS</td>
<td>Managing Director</td>
<td>KT 4</td>
</tr>
<tr>
<td>Howard Drossman</td>
<td>CC</td>
<td>Liaison to the CC Environmental Studies Program</td>
<td>E 2, 3</td>
</tr>
<tr>
<td>Claire Fleming</td>
<td>CSU</td>
<td>Enhance K-12 science education</td>
<td>E1</td>
</tr>
<tr>
<td>Steven Ghan</td>
<td>PNNL</td>
<td>Research on aerosols and cloud microphysics in climate change</td>
<td>R2</td>
</tr>
<tr>
<td>Wojciech Grabowski</td>
<td>NCAR</td>
<td>Development of improved CSRM and MMFs</td>
<td>R2</td>
</tr>
<tr>
<td>John Helly</td>
<td>UCSD/SDSC</td>
<td>Director for Computation, and liaison to SDSC</td>
<td>R6</td>
</tr>
<tr>
<td>Andrew Heymsfield</td>
<td>NCAR</td>
<td>Parameterization of ice microphysics</td>
<td>R2</td>
</tr>
<tr>
<td>Roberta Johnson</td>
<td>NESTA</td>
<td>Windows too the Universe Website</td>
<td>E1</td>
</tr>
<tr>
<td>Brian Jones</td>
<td>CSU, Physics</td>
<td>Director of Little Shop of Physics; K-12 education</td>
<td>E1, D2, 4</td>
</tr>
<tr>
<td>Joon-Hee Jung</td>
<td>CSU/ATS</td>
<td>Development of the next-generation MMF</td>
<td>R1</td>
</tr>
<tr>
<td>Marat Khairoutdinov</td>
<td>SUNY/SB</td>
<td>Development of CSRM and MMFs</td>
<td>R1, 2</td>
</tr>
<tr>
<td>Masahide Kimoto</td>
<td>RIGC, Japan</td>
<td>Development and application of Global Models</td>
<td>R1 &amp; KT 1</td>
</tr>
<tr>
<td>James Kinter</td>
<td>IGES/COLA</td>
<td>Application of CMMAP models to study the coupled climate system</td>
<td>R4</td>
</tr>
<tr>
<td>Celal Konor</td>
<td>CSU</td>
<td>Development of dynamical cores</td>
<td>R1</td>
</tr>
<tr>
<td>Sonia Kreidenweis</td>
<td>CSU/ATS</td>
<td>Development of aerosol and microphysics parameterizations for MMFs and GCRMs</td>
<td>R2</td>
</tr>
<tr>
<td>Steven Krueger</td>
<td>UU</td>
<td>Community-based evaluation of results produced by CMMAP models</td>
<td>R 5 &amp; KT All</td>
</tr>
<tr>
<td>Christian Kummerow</td>
<td>CSU/ATS</td>
<td>Liaison to TRMM and GPM; model evaluation</td>
<td>R5</td>
</tr>
<tr>
<td>Name</td>
<td>Institution</td>
<td>Role(s) in CMMAP</td>
<td>Objectives</td>
</tr>
<tr>
<td>--------------------</td>
<td>-------------------</td>
<td>---------------------------------------------------------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>Michael Lacy</td>
<td>CSU, Sociology</td>
<td>Assessment of Little Shop of Physics</td>
<td>E1</td>
</tr>
<tr>
<td>Jin-Luen Lee</td>
<td>ESRL</td>
<td>Knowledge Transfer re model development for NWP</td>
<td>KT2</td>
</tr>
<tr>
<td>Stephen Lord</td>
<td>NCEP</td>
<td>Knowledge Transfer re model development for NWP</td>
<td>KT2</td>
</tr>
<tr>
<td>Jan Lanting</td>
<td>TSD</td>
<td>Liaison to TSD; development and evaluation of SEE-ME</td>
<td>E1</td>
</tr>
<tr>
<td>David MacPhee</td>
<td>CSU/HDFS</td>
<td>Understanding historical ethnic underrepresentation in climate science</td>
<td>E3</td>
</tr>
<tr>
<td>Eric Maloney</td>
<td>CSU/ATS</td>
<td>Tropical climate</td>
<td>R2, 4, 5</td>
</tr>
<tr>
<td>Chin-Hoh Moeng</td>
<td>NCAR</td>
<td>Deputy Director; development of boundary-layer parameterizations for use in the MMF</td>
<td>All, but especially R2</td>
</tr>
<tr>
<td>Mitchell Moncrieff</td>
<td>NCAR</td>
<td>Analysis of MMF Results</td>
<td>KT2</td>
</tr>
<tr>
<td>Hugh Morrison</td>
<td>NCAR</td>
<td>Development of microphysics parameterizations</td>
<td>R2</td>
</tr>
<tr>
<td>Teriyuki Nakajima</td>
<td>RIGC, Japan</td>
<td>Development of improved MMFs, and climate simulation</td>
<td>KT2</td>
</tr>
<tr>
<td>Rajul Pandya</td>
<td>UCAR</td>
<td>Director of SOARS</td>
<td>E1, D1,4</td>
</tr>
<tr>
<td>Robert Pincus</td>
<td>CU</td>
<td>Development of conventional cloud parameterizations</td>
<td>R2, KT1, 2</td>
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<tr>
<td>David Randall</td>
<td>CSU/ATS</td>
<td>Director; Development of improved MMF, GCRM, and conventional parameterizations</td>
<td>All</td>
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<tr>
<td>Masaki Satoh</td>
<td>RIGC, Japan</td>
<td>Development of improved CSRM</td>
<td>KT1</td>
</tr>
<tr>
<td>Wayne Schubert</td>
<td>CSU/ATS</td>
<td>Further development of the MMF with an emphasis on the choice of governing equations</td>
<td>R1</td>
</tr>
<tr>
<td>Karen Schuchardt</td>
<td>PNNL</td>
<td>Data management and visualization</td>
<td>R6</td>
</tr>
<tr>
<td>Richard Somerville</td>
<td>SIO</td>
<td>Analysis of MMF Results</td>
<td>R2, 3, 4</td>
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<tr>
<td>Cristiana Stan</td>
<td>IGES/COLA</td>
<td>Application of CMMAP models to study the coupled climate system</td>
<td>R4</td>
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<tr>
<td>Bjorn Stevens</td>
<td>Max Planck</td>
<td>Development of conventional parameterizations</td>
<td>R1, 2, 4</td>
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<tr>
<td>David Swartz</td>
<td>PSD</td>
<td>Liaison to PSD; development and evaluation of SEE-ME</td>
<td>E1</td>
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<tr>
<td>Wei-Kuo Tao</td>
<td>GSFC</td>
<td>Development of improved MMFs, and application to data assimilation</td>
<td>R1, 2 &amp; KT2</td>
</tr>
<tr>
<td>Kuan-Man Xu</td>
<td>LaRC</td>
<td>Development of turbulence parameterizations for use in the MMF</td>
<td>R2</td>
</tr>
</tbody>
</table>
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 are promptly published in the peer-reviewed literature. CMMAP’s modeling techniques, including source codes, are 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.

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 have jointly signed an Intellectual Property Agreement, which can be found at [http://www.cmmap.org/members/](http://www.cmmap.org/members/). 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.

Non-subaward 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 requires all Center and subawardee staff and students to participate in ethics trainings during our “all-hands” Team Meetings.
ing covers 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 we base our ethics training.

CMMAP’s Education and Diversity activities include research involving human subjects. The Research Integrity and Compliance Review 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 monitors ongoing and proposed CMMAP activities to detect any emerging issues in connection with unethical behavior, and takes action to deal with such issues as they arise.

Appendix D: Postdoctoral Researcher Mentoring Plan

This Postdoctoral Researcher Mentoring Plan has been prepared by Colorado State University. The Plan establishes guidelines for work to be performed by a Postdoctoral Researcher in support of the NSF Science and Technology Center awarded to Colorado State University, entitled “The Center for Multiscale Modeling of Atmospheric Processes” (CMMAP). The Postdoctoral Researcher assigned to the project may be conducting research at CSU or for one of our many partner institutions. This research may involve cloud modeling, the carbon cycle, or other topics relevant to CMMAP’s research, education, diversity, or knowledge transfer objectives.

To accomplish this goal, the mentoring plan follows the guidance of the National Academies of Science and Engineering on how to enhance the postdoctoral experience, by providing career planning assistance, and opportunities to learn a number of career skills such as writing grant proposals, teaching students, writing articles for publication and communication skills [1]. Specific elements of the mentoring plan are as follows:

1. Orientation includes in-depth conversations between the Senior Research Scientist and the Postdoctoral Researcher. Mutual expectations are discussed and agreed upon in advance. Orientation topics include (a) the amount of independence the Postdoctoral Researcher requires, (b) interaction with coworkers, (c) productivity including the importance of scientific publications, (d) work habits, and (e) documentation of research methodologies and experimental details so that the work can be continued by other researchers in the future.

2. Career Counseling is directed at providing the Postdoctoral Researcher with the skills, knowledge, and experience needed to excel in his/her chosen career path. In addition to guidance provided by the Senior Research Scientists, the Postdoctoral Researcher is encouraged to discuss career options with researchers and managers involved in the CMMAP project and with former
students and colleagues of the Senior Research Scientist.

3. **Experience with Preparation of Grant Proposals** is gained by direct involvement of the Postdoctoral Researcher in proposals prepared by CMMAP researchers. The Postdoctoral Researcher has an opportunity to learn best practices in proposal preparation including identification of key research questions, definition of objectives, description of approach and rationale, and construction of a work plan, timeline, and budget.

4. **Publications and Presentations** are expected to result from the work supported by the grant. These are prepared under the direction of the Senior Research Scientist and in collaboration with researchers at CMMAP, CSU and/or other collaborating institutions as appropriate. The Postdoctoral Researcher receives guidance and training in the preparation of manuscripts for scientific journals and presentations at conferences.

5. **Teaching and Mentoring Skills** are developed in the context of regular meetings within the CMMAP research group, during which graduate students and postdoctoral researchers describe their work to colleagues within the group and assist each other with solutions to challenging research problems, often resulting in cross fertilization of ideas.

6. **CMMAP Team Meetings** are held semi-annually. The Postdoctoral Researcher is expected to attend these meetings and to make presentations as requested. The team meetings also provide a forum for the Postdoctoral Researcher to network with Senior Researchers, speakers and colleagues.

7. **Instruction in Professional Practice** is provided on a regular basis in the context of the research work and includes fundamentals of scientific research and standards of professional practice. In addition, the Postdoctoral Researcher is encouraged to affiliate with one or more professional societies in his/her chosen field.

8. **Knowledge Transfer** activities include regular contact with researchers within CMMAP. The Postdoctoral Researcher is given an opportunity to become familiar with the university-industry relationship including applicable confidentiality requirements and the importance of intellectual property.

9. **Success of the Mentoring Plan** is assessed by monitoring the personal progress of the Postdoctoral Researcher through a tracking of the Postdoctoral Researcher’s progress toward his/her career goals after finishing the postdoctoral program. The Senior Research Scientist follows the progress of the Postdoctoral Researcher as they move into the next phase of their professional development.


Strategic Plan, Center for Multiscale Modeling of Atmospheric Processes
May, 2012

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## Appendix E: List of Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Meaning</th>
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<tbody>
<tr>
<td>AGEP</td>
<td>Alliance for Graduate Education and the Professoriate</td>
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<tr>
<td>AMIP</td>
<td>Atmospheric Model Intercomparison Project</td>
</tr>
<tr>
<td>AOML</td>
<td>Atlantic Oceanographic and Meteorological Laboratory, NOAA</td>
</tr>
<tr>
<td>CAM</td>
<td>Community Atmosphere Model</td>
</tr>
<tr>
<td>CC</td>
<td>Colorado College</td>
</tr>
<tr>
<td>CCNY</td>
<td>City College of New York</td>
</tr>
<tr>
<td>CCSM</td>
<td>Community Climate System Model</td>
</tr>
<tr>
<td>CCSR</td>
<td>Center for Climate Systems Research, University of Tokyo</td>
</tr>
<tr>
<td>CI</td>
<td>The Catamount Institute</td>
</tr>
<tr>
<td>CIPP</td>
<td>Colorado Institute of Public Policy</td>
</tr>
<tr>
<td>CMMAP</td>
<td>Center for Multi-Scale Modeling of Atmospheric Processes</td>
</tr>
<tr>
<td>CSRM</td>
<td>Cloud-System-Resolving Model</td>
</tr>
<tr>
<td>CSU</td>
<td>Colorado State University</td>
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<tr>
<td>CSU/ATS</td>
<td>CSU Atmospheric Science</td>
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<tr>
<td>CSU/HDFS</td>
<td>CSU Human Development and Family Studies</td>
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<tr>
<td>CU</td>
<td>University of Colorado</td>
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<tr>
<td>DOE</td>
<td>U. S. Department of Energy</td>
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<tr>
<td>EC</td>
<td>CMMAP Executive Committee</td>
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<tr>
<td>ED</td>
<td>Education and Diversity</td>
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<tr>
<td>FRCGC</td>
<td>Frontier Research Center for Global Change, Japan</td>
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<tr>
<td>GCM</td>
<td>General Circulation Model</td>
</tr>
<tr>
<td>GCRM</td>
<td>Global Cloud-Resolving Model</td>
</tr>
<tr>
<td>GCSS</td>
<td>GEWEX Cloud Systems Study</td>
</tr>
<tr>
<td>GEWEX</td>
<td>Global Energy and Water Experiment</td>
</tr>
<tr>
<td>GFDL</td>
<td>Geophysical Fluid Dynamics Laboratory, NOAA</td>
</tr>
<tr>
<td>GSFC</td>
<td>Goddard Space Flight Center, NASA</td>
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<tr>
<td>HU</td>
<td>Hampton University</td>
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<tr>
<td>IBM</td>
<td>International Business Machines</td>
</tr>
<tr>
<td>KT</td>
<td>Knowledge Transfer</td>
</tr>
<tr>
<td>LaRC</td>
<td>Langley Research Center, NASA</td>
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<tr>
<td>LEES</td>
<td>Laboratory for Earth and Environmental Science at SDSC</td>
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<tr>
<td>LLNL</td>
<td>Lawrence Livermore National Laboratory, DOE</td>
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<tr>
<td>LSOP</td>
<td>Little Shop of Physics</td>
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<tr>
<td>MMF</td>
<td>Multi-Scale Modeling Framework</td>
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<tr>
<td>MSC</td>
<td>Meteorological Service of Canada</td>
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<tr>
<td>NCAR</td>
<td>National Center for Atmospheric Research</td>
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<tr>
<td>NCEP</td>
<td>National Centers for Environmental Prediction, NOAA</td>
</tr>
<tr>
<td>NOAA</td>
<td>National Oceanographic and Atmospheric Administration</td>
</tr>
<tr>
<td>NSF</td>
<td>National Science Foundation</td>
</tr>
<tr>
<td>PNNL</td>
<td>Pacific Northwest National Laboratory, DOE</td>
</tr>
<tr>
<td>PSD</td>
<td>Poudre School District, Fort Collins, Colorado</td>
</tr>
<tr>
<td>SDSC</td>
<td>San Diego Supercomputer Center</td>
</tr>
<tr>
<td>SIO</td>
<td>Scripps Institution of Oceanography</td>
</tr>
<tr>
<td>SUNY/SB</td>
<td>State University of New York at Stony Brook</td>
</tr>
<tr>
<td>TSD</td>
<td>Thompson School District, Loveland, Colorado</td>
</tr>
<tr>
<td>UCAR</td>
<td>University Corporation for Atmospheric Research</td>
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<td>UCLA</td>
<td>University of California at Los Angeles</td>
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<td>UCSD</td>
<td>University of California at San Diego</td>
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References


