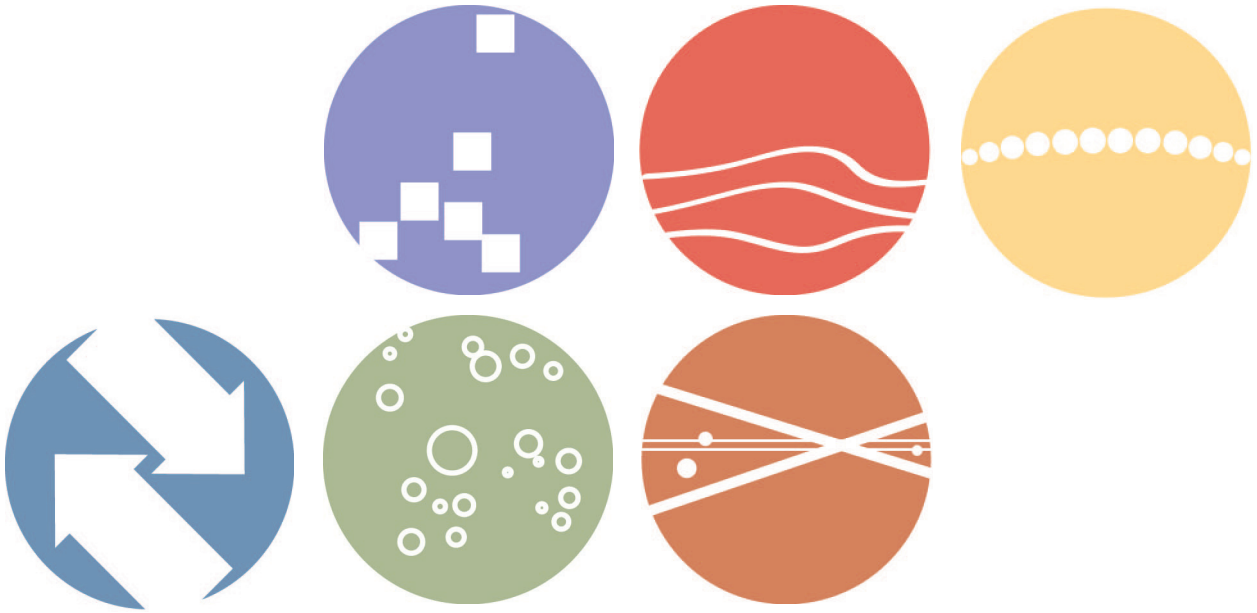


CIRES

COOPERATIVE INSTITUTE FOR RESEARCH IN ENVIRONMENTAL SCIENCES

FISCAL YEAR 2009 & 2010 SCIENTIFIC WORKPLAN

For collaborative work with NOAA's Boulder research laboratory by the University of Colorado

Based on Cooperative Aggreement
NA17RJ1229 dated 1 July 2001

PROJECT DIRECTOR: Konrad Steffen, Director of CIRES
INCLUSIVE DATES: 1 July 2008 - 30 June 2010

Colorado
University of Colorado at Boulder

CONTENTS

INDEX OF PROJECTS

I. INTRODUCTION

This document represents CIRES' proposed biannual scientific workplan (Workplan) for the eighth and ninth year (July 1, 2008 – June 30, 2010) of its current cooperative agreement between NOAA and the University of Colorado. It describes collaborative research that integrates scientific projects conducted by CIRES under the research themes discussed in that cooperative agreement. For each of the proposed research projects, the goal, approach, and milestones are described.

II. SCOPE

This workplan covers the research activities funded by NOAA through its cooperative agreement with the University of Colorado. Support currently includes funding through NOAA's Office of Oceanic and Atmospheric Research (OAR), Climate Program Office (CPO), National Environmental Satellite Data and Information Service (NESDIS), and the National Weather Service (NWS). Task I within the cooperative agreement provides base funding for CIRES administration, research support, a visiting scientists program, and start-up funds for emerging research activities. Task II provides funding for the NOAA/NESDIS research conducted at the National Snow and Ice Data Center (NSIDC), and is included within the Workplan. The majority of the research efforts and funding is allocated within Task III, which constitutes the collaborative research conducted between CIRES and NOAA research centers and laboratories.

CIRES administration is currently comprised of approximately 30 staff members who support scientific planning and reporting, financial functions, human resources, facilities management, communication and information systems, scientific computing, and outreach.

The matrices in sections VII and VIII identify the expected full-time equivalent level of effort, relating CIRES research themes to NOAA division projects. These projects are sequentially labeled by division and are grouped by theme. Some divisions have activities in most themes, while others are focused on only one. The matrix is further subdivided by Research Scientists (typically including principal investigators and Ph.D. scientists), Associate Scientists (primarily support scientists and engineers), and Graduate Research Assistants and Student Assistants. This Workplan is a projection of the research that will be conducted over the next two years. Any substantial revisions would be identified and a supplemental request would be submitted to NOAA via http://grants.gov.

III. FIT WITH NOAA'S STRATEGIC GOALS

CIRES is contributing to over half of the 28 scientific mission goals within *NOAA's Strategic Vision*. The following are examples where CIRES research will be supporting NOAA's cross-cutting priorities.

1. Protect, restore and manage use of coastal and ocean resources through ecosystem management approaches. CIRES is improving the integration of coastal data and developing new products that will enable enhanced assessment of coastal hazards, vulnerability, and risk. These efforts will contribute to more accurate modeling of coastal inundation and tsunami-threatened coastal regions. Coastal precipitation is being studied by linking terrain slopes and wind-vector profiles to spatial patterns of precipitation accumulations. In addition, the processes that deliver atmospheric gases and fine particles from the atmosphere to the biosphere are being evaluated for their potentially harmful consequences for ecosystems.
2. Understand climate variability and change to enhance society's ability to plan and respond. Understanding the production and fate of ozone, and the compounds that deplete it, is a focal point of collaborative NOAA and CIRES research. Ongoing efforts include measurements of stratospheric

ozone, aerosols, and water vapor, as well as research on ozone-depleting gases in the troposphere, stratosphere, oceans, polar snowpack, and terrestrial ecosystems. Climate dynamics research seeks to improve the understanding of tropical Pacific Ocean dynamical processes associated with the El Niño phenomenon and the North American Monsoon. Climate trend analyses and evaluation of the requisite observational datasets for spatial and temporal coverage, time-variability quantification, and consistency are helping to improve the understanding of recent and unexpected changes in polar regions. The Global Monitoring Division-Radiation (G-RAD) group operates the first U.S. climate radiation budget network consisting of sites in seven distinct climate regimes. All sites collect and maintain long- term ultraviolet and infrared, cloud cover, and column aerosol and cloud optical depth measurements for assessing the primary causes of surface radiation variability. State-of-the-art high-performance computing efforts are achieved collaboratively with NOAA, CIRES, and industry partners, and disseminated to the user community. NSIDC's analog collection of glacier photographs is being inventoried, scanned, and made available online to preserve this valuable dataset and to make the information more easily obtained by users. A monthly summary of climate information is compiled and made available to water-resource decision makers and other climate-sensitive sectors. Other resources provided to enable more informed decision making include reports, datasets, workshops and conferences, presentations, technical support, and educational services. CIRES and NOAA researchers are also lead authors of a *Citizen's Guide to Climate Change*.

3. Serve society's needs for weather and water information. The performance of numerical weather and climate models is being improved through model process evaluation using data streams from focused observational campaigns and spaceborne measurements. A version of the Hurricane-WRF modeling system is being developed and, when completed, will be supplied to the weather research modeling community and maintained through the Data Testbed Center. Rainfall estimates based on ground, airborne, and space measurements will be improved through increased understanding of the number and size of raindrops in precipitating cloud systems. A monthly summary of water information, including precipitation and precipitation outlooks, snow-water equivalent, reservoir levels, and streamflow forecasts, as well as web-based seasonal guidance important during periods of drought, are provided to water managers and the public.
4. Support the Nation's commerce with information for safe and efficient transportation. Reference models of the geomagnetic field are being produced for land, sea, air, and spaceborne magnetic navigation and altitude/heading systems. Ionospheric parameters, derived from magnetic field observations, can be used to monitor and predict disturbances affecting GPS and radio communication.

ECOSYSTEMS
Habitat
Ecosystem Observations
Ecosystem Research

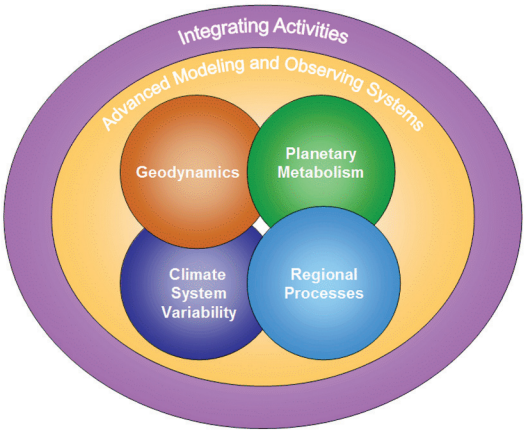
CLIMATE
Climate Observations & Analysis
Climate Forcing
Climate Predictions & Projections
Climate & Ecosystems
Regional Decision Support

WEATHER & WATER
Local Forecasts & Warnings
Space Weather
Hydrology - Rivers, Lakes & Floods
Air Quality
Environmental Modeling
Weather Water Science, Technology & Infusion

COMMERCE & TRANSPORTATION
Aviation Weather
Geodesy

IV. CIRES SCIENTIFIC THEMES

The CIRES Cooperative Agreement with NOAA identifies the scientific themes at the right, which organize and align its collaborative research with NOAA and affiliated university entities. These themes were identified and selected through strategic planning retreats and represent the current scientific emphases within CIRES. They also provide the mechanism for identifying parallel and complementary activities that span a broad range of organizational entities within NOAA, CIRES, and the University of Colorado. Future workplans will anticipate and build upon this integration to achieve greater synergy among groups within these organizations. Projects within these themes will evolve over the cooperative agreement period as the science evolves. The scientific themes currently identified are briefly discussed below.



Advanced Modeling and Observing Systems: The development of new measurement techniques, instrumentation, and analysis methods throughout CIRES makes this one of the largest and overarching themes, including activities in every unit. The space domain links most research fields ranging from local and regional to global scales. It includes the optimization of observing and modeling systems for the various science disciplines, such as atmospheric chemistry processes, atmosphere and ocean physical processes, cryospheric processes, remote sensing of terrestrial applications, non-linear systems applications, and data centers and data management. Modeling efforts deal with data assimilation applied to space weather forecasting, forecasts of the geomagnetic environment, and turbulent processes, among others. Instrumentation for more rapid and accurate real-time sampling of the atmosphere has been developed to better study the environment, and understand the complex processes affecting it. Because of its emphasis on technology rather than subject, this theme frequently brings together CIRES scientists of disparate backgrounds to cooperatively conduct interdisciplinary research that the Institute was created to promote. Since all themes utilize measurement and modeling techniques, activities listed within this theme are those where the tools were primarily developed through NOAA-CIRES-University of Colorado partnerships or where the tools themselves are the focus of the research.

Climate System Variability: Climate variability affects virtually all natural systems and human activities. Climate directly impacts vital areas, including agriculture, water quantity and quality, ecosystems, and human health. Understanding and potentially predicting climate changes is, therefore, critical to the public, as well as to a broad array of decision makers within federal and state government, industry, resources management and hazard mitigation. Indeed, basic issues include determining whether observed changes may be attributable to either natural or anthropogenic forcing, and the extent to which natural and human-induced changes may be linked. Fundamental problems include: (1) detection and description of climate changes, (2) identification of causes (attribution), and (3) prediction, which is intrinsically stochastic in nature. Prediction problems of vital importance include estimating changes in the likelihood of extreme events and identifying risks for abrupt climate change, recognizing that the potential for major societal and ecosystem impacts is likely to be particularly significant in such cases. The major research partners in this theme include the Physical Sciences Division (PSD), the Chemical Sciences Division (CSD), the Global Monitoring Division (GMD), the National Snow and Ice Data Center (NSIDC), and the University of Colorado's Department of Atmospheric and Oceanic Sciences (ATOC). Research conducted under this theme is

especially useful to CIRES' Center for Science and Technology Policy Research, as results are often relevant to risk forecasting, management, and mitigation.

Geodynamics: The goal of geodynamics is to better understand the internal processes of the planet, including the properties of the core-mantle boundary, convection within Earth's mantle, and how that convection affects the surface of the planet. The slow changes of flow processes in Earth's deep liquid interior, which drive the magnetic field, are frequently described using spherical harmonic analysis of the nearly 300 years of surface magnetic observations. The convective motion within the mantle, which is on the order of a few centimeters per year, causes oceans to open and close, continental plates to drift across Earth's surface, and Earth's crust to buckle and deform creating mountain ranges and other structural features. These convective displacements are the underlying source of earthquakes and volcanic activity. This convective process plays a fundamental role in determining Earth's climate, through its influence on surface topography. The overriding goals of the CIRES effort in geodynamics are to (1) increase our knowledge of the fundamental processes that drive the mantle and core-mantle boundary, (2) use spherical harmonic analysis to model Earth's magnetic field,(3) use new experimental methods to detect and monitor internal motions of the mantle, the presence of layering, the movements of continents, and the transfer of mass between atmosphere, continent and ocean, (4) examine the chemistry and physics of near-surface rock processes, and (5) investigate links between geophysical processes and human responses. Partners in geodynamics include NOAA's National Geophysical Data Center (NGDC) and National Ocean Service and the University of Colorado's Physics and Geological Sciences departments.

Integrating Activities: CIRES engages in a wide range of integrating activities in research, education, and outreach that encompass each of the Institute's research themes and contribute to the overall mission of the Institute, NOAA, and the University of Colorado. The primary focus is on five overlapping categories that include: (1) education and outreach, (2) graduate and post-graduate education, (3) scientific assessments, (4) interdisciplinary research, and (5) science and technology policy research. For example, one team is focused on the decision-making processes of the individuals, groups, and organizations that have responsibility for managing, using, treating, and protecting water resources. By understanding decision-making processes and the stresses and the constraints of this community, researchers seek to assess vulnerability to climate variability and develop hydro-climate products that enable better-informed decisions. Such scientific assessments bring together CIRES expertise across a range of fields, including policy research and technology transfer, in collaboration with experts and end users who partner from outside of CIRES. Collaborations with colleagues in the local NOAA laboratories have resulted in the transformation of basic research into applied science.

Planetary Metabolism: The sustainability of the biosphere during the current period of rapid changes in the earth system is an issue of prime importance for the environmental sciences. The physical and chemical features of Earth are intimately tied to organisms and the activities required for their sustenance. The health of the biosphere can usefully be considered using the concept of "planetary metabolism," which refers to the complex web of biochemical and ecological processes that occur within the biosphere, and the interaction of these processes with the lithosphere, atmosphere and hydrosphere. Both natural and anthropogenic disturbances drive the structure and dynamics of natural systems, and a thorough understanding of these complex processes is essential to efforts to protect the biosphere from adverse effects due to pollution, destruction of natural landscapes, and alteration of climate. This theme's overriding goals are to (1) increase our knowledge of the fundamental processes that drive the biosphere, (2) use experimental tools to accurately measure indicators of change, (3) enhance the sophistication of prognostic models capable of forecasting the response of ecosystems and the global biosphere to future environmental changes, and (4) carry out research that will develop the science and technology needed to help restore and protect the health of the biosphere. The predominant collaborations and parallel activities include the Chemical Sciences Division

(CSD), the National Geophysical Data Center (NGDC), and the University of Colorado's Molecular, Cellular and Developmental Biology (MCDB) department and the Ecology and Evolutionary Biology (EBIO) department.

Regional Processes: Many of the research endeavors within CIRES and NOAA have a regional focus or regional scientific focus. They address issues involving geography, demographics, weather and climatic regimes. This confluence of factors has produced a range of research within CIRES and NOAA that is not only rich in its diversity, but provides an essential connection between science and its constituents. These constituents include human populations ranging from coastal megalopolises to communities of indigenous populations on the margin of the Arctic Ocean, all of which must coexist with sensitive aquatic and terrestrial ecosystems in a highly variable and evolving climate. Indeed, the impact of short-term climate variability and extremes is often regionally focused, influencing very specific populations, economies, and ecosystems. CIRES scientists in the Chemical Sciences Division (CSD), the Global Monitoring Division (GMD), and the Physical Sciences Division (PSD) work on such projects as the mechanisms of atmospheric transport on climate and air quality, chemical transformation of products of biomass burning, air/sea gas transfer, and ozone pollution. This research contributes substantially to CIRES' Center for Science and Technology Policy Research and the Western Water Assessment. The latter is of particular value because of its broad focus, which includes social scientists in the areas of economics, geography and behavioral sciences, in addition to CIRES physical science experts.

V. FISCAL YEAR 2009 AND 2010 SCIENTIFIC WORKPLAN

The following is the proposed CIRES-NOAA research workplan for two fiscal years (FY09, FY10), beginning July 1, 2008, and ending June 30, 2010. CIRES workplans have been approved by NOAA and the Department of Commerce as scientific "roadmaps" with necessary clarity and accountability. The explicit definition of research objectives provides a broad perspective of the overall research program.

While this plan accounts for Task III research of the NOAA-CIRES-University of Colorado cooperative agreement, it also seeks to weave scientific objectives into an integrated fabric of earth systems science. The Workplan is organized along CIRES' six research themes, then CIRES projects within those themes. This effort was initiated to integrate scientific initiatives conducted by CIRES employees. The actual distribution of work efforts and budget among the units is shown in the following matrices that are organized first by CIRES scientific research theme, then CIRES project, and finally by NOAA division/center project number.

Scientific Theme: ADVANCED MODELING AND OBSERVING SYSTEMS

AMOS-01 INSTRUMENTATION DESIGN, PROTOTYPING AND ANALYSIS

CSD-01	Instrumentation for Atmospheric Observation and Analysis
PSD-08	Sensor and Technique Development
CET-01	Remote Hydrologic Sensing

CSD-01 Instrumentation for Atmospheric Observation and Analysis

GOAL: Design and evaluate new approaches and instrumentation to make atmospheric observations of hard-to-measure species and parameters that are important players in the chemistry of the troposphere and stratosphere.

APPROACH: Identify key atmospheric species and parameters that are not adequately measured by current methods; research potentially effective new ways to enhance the quantitative measurement of the species at their anticipated atmospheric abundance levels; and design and evaluate prototype instrumentation in the laboratory for eventual deployment in field missions.

JULY 2008-JUNE 2009 MILESTONES:

- Develop a scanning aerosol lidar system to measure plume dispersion, rise, and particle mass emission rates of aircraft jet engines. Impact: Results of these analyses will improve our understanding of local air quality impacts of aircraft operations at airports, and will help improve air quality models.
- Develop, test, and deploy an aircraft-based Doppler lidar to measure wind and turbulence profiles. Impact: Measurement of wind and turbulence profiles from an aircraft platform will allow for the study of the creation, transport and mixing of pollutants over a much larger area than is currently possible, and will provide mixing height information for such an area. Measurements will also provide validation for models, such as WRF-Chem.
- Develop an improved version of the single-particle albedo instrument. Impact: This research will enable the single scattering albedo of individual aerosol particles to be obtained and will improve the understanding of scattering on chemical composition. The optical properties of dust are of special

interest.

- Evaluate fast response, state-of-the-art instrumentation suitable for airborne measurements of nitrate (NO3)/dinitrogen pentoxide (N2O5). Impact: The results of this intercomparison will document the proficiency of the newly developed CIRES cavity ring-down system (CaRDS) to reliably carryout the fast-response measurement of NO3 and N2O5. This technology will greatly enhance the ability of CIRES and NOAA to determine the role that these reactive nitrogen species play in ozone and aerosol formation.

JULY 2009-JUNE 2010 MILESTONES:

- Assess the capability of the single-particle albedo instrument by acquiring ambient data. Impact: This research will enable the single scattering albedo of individual aerosol particles to be obtained. When achieved, this information will improve the understanding of the dependence of scattering on chemical composition, and will facilitate obtaining the molecular speciation of the organic content of marine aerosols. The optical properties of dust are of special interest.
- Assess the capability of a new space-based Doppler wind lidar to measure wind profiles in the lower troposphere. Impact: Accurate estimates of global tropospheric wind fields will have a major effect on weather prediction and will improve understanding of atmospheric processes important for both weather and climate applications.
- Develop and test a new, fully-automated instrument to measure ozone on board a high-altitude, long-duration unmanned aerial vehicle. Impact: The new instrument will obtain ozone data of high precision and accuracy in remote regions of the globe over flight trajectories of unprecedented duration.

PSD-08 Sensor and Technique Development

GOAL: Design, develop, enhance and evaluate remote and *in-situ* sensing systems for use from surface and other platforms of opportunity in order to measure critical atmospheric, surface, and oceanic parameters.

APPROACH: Deploy sensors in focused field programs designed to evaluate and refine sensor performance. Deploy sensors for new applications that extend the ability to observe and understand the earth system.

JULY 2008-JUNE 2009 MILESTONES:

- Deploy roving calibration standard on two ships.
- Complete construction of PSD W-band radar for ship and airborne deployment.
- Complete installation and develop operations plan for flux tower at the Canadian Arctic station in Nunavut (Eureka).

JULY 2009-JUNE 2010 MILESTONES:

- Deploy roving calibration standard on two ships.
- Test new ruggedized fast carbon dioxide sensor for permanent installation on NOAA Ship Ronald H. Brown.
- Complete designs for installation of PSD W-band radar on NOAA P-3.
- Submit for publication a paper describing special problems of Arctic flux measurements.

CET-01 Remote Hydrologic Sensing

GOAL: Develop microwave remote sensing capabilities to facilitate NOAA measurements of key hydrological variables.

APPROACH: Utilize advanced microwave radiometric techniques, including ground-based, shipborne, airborne, and satellite techniques using frequencies up to ~1 THz to quantitatively measure hydrological variables for NOAA research and forecasting applications. Variables of interest include atmospheric moisture, soil moisture, snow water equivalent, ocean salinity, clouds and precipitation, and sea ice. The project will incorporate advances in microwave sensing and data assimilation technology along with integration of microwave sensors on new platforms, such as unmanned aerial vehicles.

JULY 2008-JUNE 2009 MILESTONES:

- Develop a ground-based microwave profiling system for long-term Arctic cloud and water vapor measurements.
- Develop submillimeter microwave radiometers for ground-based and airborne cloud sensing.
- Develop all-weather radiance assimilation of satellite passive microwave observations.

JULY 2009-JUNE 2010 MILESTONES:

- Develop a ground-based microwave profiling system for long-term Arctic cloud and water vapor measurements.
- Develop submillimeter microwave radiometers for ground-based and airborne cloud sensing.
- Develop all-weather radiance assimilation of satellite passive microwave observations.

AMOS-02 DATA MANAGEMENT, PRODUCTS AND INFRASTRUCTURE SYSTEMS

NGDC-01	Geospatial Technology for Global Integrated Observing and Data Management Systems
NGDC-02	Marine Geophysics Data Stewardship
NGDC-08	Improve Integration of Coastal Data to Support Community Resiliency
SWPC-03	Information Technology and Data Systems
SWPC-04	Space Environment Data Algorithm and Product Development
GSD-07	High Performance Computing Systems (HPCS)

NGDC-01 Geospatial Technology for Global Integrated Observing and Data Management Systems

GOAL: Develop methods and processes for integrating multiple types of observations (gridded satellite products, *in-situ* measurements) using new Geographic Information System (GIS) data management and access tools; develop methods and processes for partnering with scientists to facilitate interoperability by producing metadata for scientific observations that are compliant with national Federal Geographic Data Committee (FGDC) and International Standards Organization (ISO) standards, and; create tools that allow

the mining of vast environmental archives for the purpose of knowledge extraction, data quality control and trend detection.

APPROACH: During the last several years the World Wide Web, Relational Database Management Systems, and Geographic Information Systems have converged to form a powerful foundation for environmental data management, integration and access. Taking advantage of this foundation in the arena of scientific research requires building technologies for transitioning legacy systems into the new framework and understanding the sociology of such transitions. This will require developing, implementing, and testing web-based tools for creating and managing metadata for scientific datasets, while ensuring scientists and other data creators can use those tools effectively. Data mining technology will create (1) a system for connecting distributed data archives, (2) a set of data models for representing those data in a common format, and (3) tools based on advanced mathematics for extracting the required information in an automated fashion. Data mining technology will help address the continually increasing data volumes.

JULY 2008-JUNE 2009 MILESTONES:

- Design, develop, and demonstrate systems that provide integrated access to data quality information using international standards.
- Design, develop, and demonstrate systems that provide integrated access to *in-situ* environmental observations using Open Geospatial Consortium standards as well as emerging international approaches.

JULY 2009-JUNE 2010 MILESTONES:

- Design, develop, and demonstrate systems that provide integrated access to data quality information using international standards.
- Design, develop, and demonstrate systems that provide integrated access to *in-situ* environmental observations using Open Geospatial Consortium standards as well as emerging international approaches.

NGDC-02 Marine Geophysics Data Stewardship

GOAL: Contribute to a streamlined, more fully automated, accessible, and web-based management and stewardship process for marine geophysical data in support of seafloor research at CIRES and throughout the environmental science community.

APPROACH: Acquire, archive, quality-assess, store, and make available the fullest extent possible, UNCLASSIFIED, marine geophysical data collected by national, international, and academic marine institutions. Data stewardship includes assuring the quality of the data, documenting the quality and pedigree in generated metadata, and developing and adapting new data delivery systems to meet the needs and requests of the user community for rapid, web-based access to data for analysis and research.

JULY 2008-JUNE 2009 MILESTONE:

- Search, target, acquire, and provide access to new marine geophysical data from the worldwide oceanographic community. Impact: Marine geophysical data are the basis for many regional and global geophysical compilations (e.g., bathymetry, gravity, and magnetics) that contribute to modeling of Earth's surface, gravity and magnetic fields, ocean circulation, and environmental hazards, such as tsunamis.

Acquiring new marine geophysical data permits more accurate, refined modeling, which contributes to better understanding and forecasting of global processes.

JULY 2009-JUNE 2010 MILESTONE:

- Search, target, acquire, and provide access to new marine geophysical data from the worldwide oceanographic community. Impact: Marine geophysical data are the basis for many regional and global geophysical compilations (e.g., bathymetry, gravity, and magnetics) that contribute to modeling of Earth's surface, gravity and magnetic fields, ocean circulation, and environmental hazards, such as tsunamis. Acquiring new marine geophysical data permits more accurate, refined modeling, which contributes to better understanding and forecasting of global processes

NGDC-08 Improve Integration of Coastal Data to Support Community Resiliency

GOAL: Improve integration of coastal data and develop new products that enable improved assessment of hazards, coastal vulnerability, and risk for improved community resiliency. Research goals include the development of seamless, accurate, high-resolution digital elevation models (DEMs), which will improve the accuracy of coastal inundation modeling, and the development and expansion of historic events databases, tsunami deposits databases, and hazard assessments.

APPROACH: Apply new techniques and methods to improve the integration of coastal bathymetric and topographic data into seamless, accurate representations of Earth's surface suitable for coastal inundation modeling, and seek to minimize the uncertainty associated with DEMs in hazard modeling. Also, develop new databases and hazard assessment techniques that will improve assessment of coastal hazards for at-risk U.S. communities.

JULY 2008-JUNE 2009 MILESTONES:

- Produce six to nine seamless, integrated bathymetric–topographic DEMs of select U.S. coastal communities sufficient for tsunami forecast and warning and coastal inundation mapping. IMPACT: Accurate and effective tsunami forecast and warning and coastal inundation mapping requires accurate, high-resolution, integrated bathymetric–topographic coastal DEMs as input to the hazard modeling software. These DEMs will provide the necessary foundation for effective assessment of the threat from tsunami and other hazards for the selected regions.
- Produce an online database of global tsunami deposits that will support improved assessment of tsunami hazard for at-risk coastal communities.

JULY 2009-JUNE 2010 MILESTONES:

- Produce six to nine seamless, integrated bathymetric–topographic DEMs of select U.S. coastal communities sufficient for tsunami forecast and warning, and coastal inundation mapping. Impact: Accurate and effective tsunami forecast and warning, and coastal inundation mapping requires accurate, high-resolution, integrated bathymetric–topographic coastal DEMs as input to the hazard modeling software. These DEMs will provide the necessary foundation for effective assessment of the threat from tsunami and other hazards for the selected regions.
- Produce a pilot study on the effects of different gridding algorithms on integrated bathymetric–topographic DEMs, and their impacts on coastal inundation that result from hazard modeling for a

specific at-risk community.

SWPC-03 Information Technology and Data Systems

GOAL: Determine the necessary research data systems and infrastructure required to successfully implement the empirical and physical scientific models of the space environment, such as those envisioned in SWPC-01 and SWPC-02 with fast and efficient access to appropriate data sources.

APPROACH: Scientific specification and forecasting of the space environment requires fast and efficient access to appropriate data sources in order to understand and predict complex events, such as the response of the thermosphere and ionosphere to solar activity. It requires powerful computing resources to manipulate, display, and process data and model output. The current era of information technology is rapidly evolving and it is imperative to keep abreast of new approaches to handling disparate data sources in order to evaluate the use of data assimilation techniques for specification and forecast of the space environment, and to model output.

JULY 2008-JUNE 2009 MILESTONES:

- Support ongoing development of the Geostationary Operational Environmental Satellite (GOES) NOP series ground data system (GDS). Enhance the current GOES-N GDS and deploy it to operations. Provide project management for GDS deployment to operations. Begin transitioning this system to support GOES-O telemetry streams and product development. Continue to provide analysis and technical support to algorithm development, instrument checkout and data verification.
- Assist Space Weather Prediction Center (SPWC) efforts to modernize data processing and distribution systems that are currently hosted on legacy systems. Provide development, transition and mentoring support for contracts to outsource modernization efforts. Implement specific portions of the modernization that will not be outsourced. Develop and deploy the next generation decoder/processor for weather station observation messages received from the Air Force Weather Agency network.
- Aid in new model development and transition to operational products. Develop ionospheric analysis products to improve Global Positioning System (GPS) location determination. Implement extensions to the D-Region Absorption Prediction (D-RAP) product to improve its utility in forecasting High Frequency (HF) communication availability. Continue to support the identification of new models and products, as well as assisting in refining the organizational work flow processes by which those new models and products are developed and deployed.
- Provide support for SWPC endeavors to improve data storage systems. Help optimize the operational data store, for example by implementing views and stored procedures. Deploy externally the available product data store to operations. Improve data archiving processes that move product data to National Geophysical Data Center, and deploy these processes to operations. Develop documentation that better describes SWPC's data storage system and its operation.
- Continue to maintain the reliable operation of existing operational product generation infrastructure, generation and display systems that are used by SWPC to specify and forecast the space environment. Perform ongoing data quality validation, as well as provide timely problem analysis and resolution services as requested.
- Investigate current GPU technologies and GSD applications suitable for acceleration with GPU co-processors.

JULY 2009-JUNE 2010 MILESTONES:

- Support ongoing development of the Geostationary Operational Environmental Satellite (GOES) NOP series ground data system (GDS). Enhance the GOES-O data processing systems and deploy to operations. Provide project management assistance when necessary. Begin transition of this system to support GOES-P telemetry streams and product development. Continue to provide analysis and technical support to algorithm development, instrument checkout and data verification.
- Assist Space Weather Prediction Center (SPWC) efforts to modernize data processing and distribution systems that are currently hosted on legacy systems. Provide development, transition and mentoring support for contracts to outsource modernization efforts. Implement specific portions of the modernization that will not be outsourced. Improve legacy replacement systems that now exist and support new modernization projects as they are identified.
- Aid in new model development and transition to operational products. Enhance newly developed product software as requested. Continue to support the identification of new models and products, as well as assist in refining the organizational work flow processes by which those new models and products are developed and deployed.
- Provide support for SWPC endeavors to improve data storage systems. Help optimize the operational data store, for example by implementing views and stored procedures. Improve data archiving processes that move product data to National Geophysical Data Center, and deploy these processes to operations. Develop documentation that better describes SWPC's data storage system and its operation.
- Continue to maintain the reliable operation of existing operational product generation infrastructure, generation and display systems that are used by SWPC to specify and forecast the space environment. Perform ongoing data quality validation, as well as provide timely problem analysis and resolution services as requested.

SWPC-04 Space Environment Data Algorithm and Product Development

GOAL: Explore new techniques for analyzing and modeling Geostationary Operational Environmental Satellite (GOES) space environment data, and develop and validate new algorithms and products.

APPROACH: The GOES-N series and the GOES-R series satellites will include instruments with new capabilities that will enable improved space weather products. Also, new scientific understanding will continue to enable new data processing and new modeling capabilities. Using data from current GOES satellites and other complementary instruments, new concepts for data processing and modeling will be tested. New algorithms and products will be developed and validated using available data. These activities will ensure that GOES space environment data will be fully utilized in support of space weather needs.

JULY 2008-JUNE 2009 MILESTONES:

- Develop, validate, document and implement new algorithms and products to be generated with the GOES-13 and the GOES-R series satellites. Impact: The availability of new validated products will ensure that the maximum value is obtained from the space environment data on the GOES satellites.
- Research and develop new models and analysis techniques to improve the accuracy and to expand the scope of operational products derived from the GOES data. Impact: By developing new scientific understanding and utilizing this understanding in the processing and modeling of GOES data, en-

hanced products and services will be enabled that will increase the value of GOES data to the users of space environment services.

JULY 2009-JUNE 2010 MILESTONES:

- Develop, validate, document and implement new algorithms and products to be generated with the GOES-13 and the GOES-R series satellites. Impact: The availability of new validated products will ensure that the maximum value is obtained from the space environment data on the GOES satellites.
- Research and develop new models and analysis techniques to improve the accuracy and to expand the scope of operational products derived from the GOES data. Impact: By developing new scientific understanding and utilizing this understanding in the processing and modeling of GOES data, enhanced products and services will be enabled that will increase the value of GOES data to the users of space environment services.

GSD-07 High Performance Computing Systems (HPCS)

GOAL: Provide systems research support for high-performance computing (HPC) efforts and assistance to the user community; provide HPCS communications equipment and software research; and provide research support for high-performance file systems.

APPROACH: Perform research in each of the following key areas: (1) issues related to operating system efficiency in HPC environments, (2) architectural advances in HPC, (3) the effective use of high-performance interconnects, (4) high-performance file systems and their extension outside of the HPC environment throughout the enterprise, and (5) creation and application of new technologies, which improve system reliability and user productivity. Successes from research will be incorporated into existing production systems and disseminated to the user community. This research will be conducted as a group among NOAA, CIRES, and the on-site HPC integrator (currently Raytheon), as well as through collaboration with other NOAA HPC sites.

JULY 2008-JUNE 2009 MILESTONES:

- Complete feasibility study of implementing Cluster Resource's Moab on Boulder HPCS and estimates of improved system efficiency through use of advanced scheduling features, such as advanced reservations and user-definable node sets.
- Continue development of HPC Workflow Manager, further extending its use outside of NOAA-Boulder and publish system as Open Source (OS).
- Implement single OS image and tools across multiple generations of HPC hardware platforms.
- Begin coordinating with HPCS users of dominate codes used (WRF variants, FIM) to implement a parallel I/O paradigm to improve code efficiency.
- Support investigations of large, core-count model scalability in heterogeneous computing environments.
- Investigate current GPU technologies and GSD applications suitable for acceleration with GPU co-processors.

JULY 2009-JUNE 2010 MILESTONES:

- Conduct technical study of latest hardware architectures to support future NOAA procurements.
- Complete technical investigation on alternative HSM technologies.
- Evaluate (and implement if robust) available technologies to support true system-level checkpoint restart for user applications.
- Complete feasibility study of extending existing Parallel HPC file systems in use on HPCS throughout the GSD laboratory.
- Research methods and approaches to implementing affected distributed HPC file systems in high-latency environments.
- Investigate tools to automate the use of GPU co-processors within existing GSD codes.

AMOS-03 PREDICTION, MODEL DEVELOPMENT AND EVALUATION

CSD-02	Chemical Transport Model Research
PSD-16	Raindrop Size Distributions
PSD-17	Environmental Monitoring and Prediction
GSD-01	Numerical Weather Prediction
GSD-03	Verification Techniques for the Evaluation of Aviation Weather Forecasts
GSD-05	Numerical Prediction Developmental Testbed Center
NGDC-03	Space Weather
SWPC-01	Solar Disturbances in the Geospace Environment
SWPC-02	Modeling the Upper Atmosphere

CSD-02 Chemical Transport Model Research

GOAL: Undertake research that contributes to the ability to forecast regional air quality and improves the understanding of the budget of ozone in the upper troposphere.

APPROACH: Design and evaluate state-of-the-art model capabilities to describe the transport and chemical evolution of pollutants in the atmosphere. The focus will be on regional air quality with an emphasis on ozone and particulates. The regional chemical transport model will integrate the emission, the vertical and horizontal transport, and the chemical conversions of pollutants. Comparison of the model results with integrated field studies will lead to an improved model system and its components. Detailed tracer transport studies and meteorological analysis, including satellite observations and coordinated measurements with a network of ozone sondes, will lead to an improved understanding of the ozone budget over the United States during the summer.

JULY 2008-JUNE 2009 MILESTONES:

- Evaluate the emissions of carbon monoxide (CO), nitrogen oxides (NOx), and carbon dioxide (CO2) from the Houston and Dallas/Fort Worth urban areas by comparison of aircraft observations, tunnel

measurements, and emission inventories. Impact: This research will provide a further observational constraint on mobile source emission inventories in these urban areas, which is key to understanding the factors that influence air quality in the region.

- Use measurements of ozone, aerosols, and their precursors made during the 2006 Texas Air Quality Study/Gulf of Mexico Atmospheric Composition and Climate Study to evaluate the capabilities of chemical forecast models. Impact: This research will contribute to improved forecasts of ozone and aerosols within air quality models. The evaluated models will enable measurements obtained during intensive field experiments to be set into a broader context. Detailed comparisons of observations and model results can identify inconsistencies in the parameterizations of key chemical and physical processes within individual models. Comparing performance of several models identifies the most successful or appropriate approach, and biases common to all models identifies problems in collective scientific understanding needing further research.

JULY 2009-JUNE 2010 MILESTONES:

- Use the WRF-Chem regional chemical transport model to conduct a detailed study of the California ozone budget throughout the troposphere for March through September 2006. This research will study: (1) the impact of stratospheric intrusions on the mixing ratios of ozone in the mid- and lower troposphere over California during spring and summer, (2) the contribution of lightning nitrogen oxides (NOx) emissions to free tropospheric ozone production above the southern United States with episodic impact above California during summer, and (3) the photochemical formation of ozone in the lower troposphere due to the photochemical processing of local anthropogenic and biogenic emissions over California. Impact: This research will assist scientists and policy makers in understanding the influence of California emissions on ozone, as well as guide the California air quality study that is currently planned for the summer of 2010.
- Examine the feasibility of using satellite-retrieved tropospheric nitrogen dioxide (NO2) vertical columns in combination with predictions from a regional chemical transport model to evaluate the emission strength of nitrogen oxides (NOx) from a variety of Texas sources. These comparisons can constrain inventories of important NOx sources and indicate how their emissions are changing with time. A particular focus will be on NO2 columns near isolated point sources in East Texas and the urban areas of Dallas and Houston. Impact: This research will assist scientists and policy makers in understanding the use of satellite-based NO2 column measurements to determine the response of ambient NO2 concentrations to emission controls applied to power plants and mobile NOx sources. It will also provide insights into the ozone changes that can be anticipated as power plant and urban NOx emission reductions continue to be implemented throughout the United States.
- Use measurements of ozone, aerosols, and their precursors made during the 2006 Texas Air Quality Study (TexAQS) and 2004 New England Air Quality Study (NEAQS) field missions in conjunction with a state-of-the-art air quality forecast model to relate uncertainties in PM2.5 aerosol forecasts to uncertainties in the parameterizations of key chemical and physical processes. Impact: This research will contribute to improved forecasts of PM2.5 aerosols within air quality models, and directly supports NOAA's mission of having an operational national PM2.5 aerosol forecasting system by 2011. The WRF/Chem community model maintained at NOAA/ESRL offers flexibility and a wide choice of options for the numerical treatment of chemical and physical processes important to PM2.5 aerosol forecasts. Data collected during two intensive field missions will be used to quantify the impact various processes and their numerical treatments have on PM2.5 forecast errors. This work involves close collaboration with other NOAA researchers developing the national forecast system with the National Weather Service.

PSD-16 Raindrop Size Distributions

GOAL: Improve ground-based, airborne, and spaceborne radar rainfall estimates through increased understanding of the number and size of raindrops in precipitating cloud systems.

APPROACH: Deploy multi-frequency, vertically pointing Doppler radar profilers and surface instruments to observe the vertical structure and evolution of the raindrop size distribution and the vertical air motion in precipitating cloud systems.

JULY 2008-JUNE 2009 MILESTONE:

- Polarimetric scanning radars provide more accurate rainfall estimates than non-polarimetric radars by also estimating the mean raindrop diameter of the raindrop size distribution (DSD) in the radar resolution volume. The relative errors of polarimetric scanning radar rainfall and mean raindrop diameter will be quantified by comparing polarimetric retrievals with surface and vertically pointing profiler DSD estimates. Data from Darwin, Australia, will be used in this study.

JULY 2009-JUNE 2010 MILESTONE:

- Attenuation-based rainfall algorithms used by high-frequency radars, including the W-band radar on the CloudSat satellite, assume the rainfall is uniform in height. Deviations from this assumed uniform structure will be quantified using rain rate and median raindrop diameter estimates from an X-band polarimetric scanning radar and S-band vertical pointing profilers deployed in support of NOAA-Hydrometeorological Testbed-West.

PSD-17 Environmental Monitoring and Prediction

GOAL: Improve the performance of numerical weather and climate models through model process evaluation using data streams from focused observational campaigns and spaceborne measurements.

APPROACH: Research will be conducted in each of the following key areas associated with improving weather forecasts and climate simulations/prediction: (1) assessment of the model-simulated dynamical interaction between the convective cloud and the atmospheric boundary layer processes, which is critical to the forecasting of tropical storm development and the enhancement of the wintertime precipitation in the U.S. West Coast, (2) evaluation of the model-simulated connection between the large-scale interannual oscillation and local precipitation processes, which is essential to regional climate simulation and prediction, (3) verification of model physics (such as land-surface, atmospheric boundary layer transport, and cloud microphysics/subgrid convection parameterizations) that are critical to the prediction of hazardous weather events, (4) quantification and stochastic modeling of the uncertainties of numerical models for the purpose of ensemble prediction and data assimilation, both of which are vital to the improvement of weather forecast, and (5) diagnosis of the impact of observations from field campaigns and spaceborne measurements on the initialization of numerical models for extratropical and tropical storm prediction. This research will be conducted primarily with the Advanced Weather Research and Forecast model, the NCEP operational models, and the newly developed ESRL weather and climate modeling system.

JULY 2008-JUNE 2009 MILESTONES:

- Assess operational NWP model forecasts of water vapor and/or surface wind with SSM/I and QuikSCAT satellite observations for wintertime precipitation events along the U.S. West Coast.
- Verify and evaluate the operational prediction models' capability of reproducing the dynamical interaction between the convective cloud and the atmospheric boundary layer processes in the U.S. West Coast using special observations from the Hydrometeorological Testbed field campaigns.

JULY 2009-JUNE 2010 MILESTONES:

- Provide data and assess uncertainties of satellite water vapor and/or surface wind products assimilated into ensemble prediction models for wintertime precipitation events along the U.S. West Coast.
- Implement stochastic modeling of the uncertainties in the convective parameterization scheme of the NCEP operational global weather prediction model for ensemble prediction applications.

GSD-01 Numerical Weather Prediction

GOAL: Design and evaluate new approaches for improving regional-scale numerical weather forecasts, including forecasts of severe weather events.

APPROACH: Perform research in each of these key areas associated with improved regional weather forecasts: (1) data assimilation, including use of new observation types and improved use of existing observations, (2) numerical forecast models, including dynamical solvers and parameterizations of subgrid scale and complex processes, (3) development of new numerical techniques for global models, including use of icosahedral coordinates, finite volume, and hybrid isentropic-sigma coordinates, (4) diagnosis of key weather parameters from numerical-model output applicable to different problems, including aviation and severe storm forecasting, and (5) display and visualization techniques, data acquisition, and computer processing. This research will be conducted primarily with the Weather Research and Forecast (WRF) model and the Flow-following Finite-volume Icosahedral Model (FIM).

JULY 2008-JUNE 2009 MILESTONES:

- Continue ESRL/GSD testing of North American Rapid Refresh 1-h intermittent assimilation cycling. Emphases will be on the performance of GSD enhancements in the use of surface observations and cloud and radar data in the Gridpoint Statistical Interpolation analysis and initialization of hydrometeors, and to the performance of physics suites in the WRF forecast component.
- Port well-tested ESRL/GSD code for North American Rapid Refresh to NCEP and begin pre-implementation testing at NCEP/EMC in preparation for Rapid Refresh implementation into NCEP operations in the year 2008.
- Implement a subset of WRF physics options into FIM and compare performance with FIM using the GFS physics suite.

JULY 2009-JUNE 2010 MILESTONES:

- Pending evaluation by NCEP on the readiness of the Rapid Refresh for real-time operational status, initiate operational implementation of the Rapid Refresh.

- Conduct and evaluate a summer 2009 convection forecast exercise with other Aviation Weather Research Program Research Teams (Convective Weather, in particular), in which the High Resolution Rapid Refresh (HRRR) plays a dominant role. The goal of this exercise is to evaluate the potential effectiveness of the HRRR in correctly predicting high-impact aviation weather, particularly convection, 3-10h in advance.
- Port FIM code, embedded within the Earth System Modeling Framework, to NCEP, and begin pre-implementation testing of FIM as a member of the Global Ensemble Forecast System.

GSD-03 Verification Techniques for the Evaluation of Aviation Weather Forecasts

GOAL: Design and evaluate new verification approaches and tools that will provide information about the quality of aviation forecasts and their value to aviation decision makers.

APPROACH: Research key verification approaches that can apply to aviation verification problems, such as icing, turbulence, convection, and oceanic weather; design and test the verification approaches using the Real-Time Verification System (RTVS); analyze the statistical results using the new approaches and summarize information in written reports. Contribute to the ongoing development of the RTVS by enhancing system design and functionality.

JULY 2008-JUNE 2009 MILESTONES:

- Provide quality assessment reports summarizing the Graphical Turbulence Guidance product and the National Ceiling and Visibility Analysis product. The reports are provided to the Aviation Weather Technology Transfer Technical Review Panel. The Panel members use the information as evidence to determine whether the forecast product should transition from research to NWS operations.
- Demonstrate the Network-Enabled Verification Service (NEVS) prototype for evaluating convective forecast quality. NEVS is a service that will replace the Real-Time Verification System (RTVS).
- Provide a real-time verification capability for assessing the forecast lead time from ceiling and visibility forecasts.

JULY 2009-JUNE 2010 MILESTONES:

- Provide quality assessment reports summarizing version 4 of the Graphical Turbulence Guidance, the Consolidated Storm Prediction for Aviation (CoSpa, the National Ceiling and Visibility Forecast), and the Volcanic Ash Plume forecast products.
- Demonstrate a NEVS prototype for evaluating convective and turbulence forecast quality utilizing Open Geospatial Consortium standards for accessing and distributing quality assessment information in real time. Demonstrate NEVS capabilities for the Developmental Testbed Center.

GSD-05 Numerical Prediction Developmental Testbed Center

GOAL: Develop and maintain a version of the Hurricane Weather Research and Forecasting (HWRF) modeling system that is to be supplied to the weather research modeling community through the Developmental Testbed Center (DTC).

APPROACH: Perform the following activities in each of these key areas associated with improved hurricane forecasts: (1) port the HWRF system from NOAA/NCEP to the computer facilities at ESRL and NCAR, (2)

raise the HWRF system software to Weather Research and Forecast (WRF) model repository (version 3.0) standards, (3) include an adaptive movable grid-nesting algorithm capability in the HWRF system, (4) perform tests on the ported modeling system to verify acceptably similar results to those obtained at NCEP, (5) begin work to incorporate an ocean and wave model component to the HWRF system under the direction of Dr. Naomi Surgi at NCEP, and (6) write scientific and technical direction documentation describing the HWRF system for future use in community support function.

JULY 2008-JUNE 2009 MILESTONES:

- Define an approach to the problem and assign tasks in conjunction with NCEP and DTC staff. Develop a schedule for completion of tasks 1-4 as described in the project approach.
- Meet with the HWRF development team at NCEP to identify what needs to be understood about the software to enable porting of the system to Boulder computers.
- Develop the atmospheric Nonhydrostatic Mesoscale Model component of HWRF with static grid nesting to the DTC systems running at NCAR and ESRL to meet WRF repository standards.
- Verify that hurricane analyses and forecasts performed with the HWRF system completed under task #3 are acceptably similar to results produced at NCEP.
- Complete the first draft of the documentation describing the atmospheric-only component to the HWRF system.

JULY 2009-JUNE 2010 MILESTONES:

- Work collaboratively with NOAA/AOML in Miami, FL to include an adaptive movable grid-nesting algorithm capability in the HWRF system.
- Complete the documentation describing the atmospheric-only component to the HWRF system.
- Port the ocean and wave modeling components to the HWRF system and verify that results are satisfactory relative to those obtained on the NCEP computer system.
- Deliver the first HWRF tutorial to the community as part of the biannual DTC/NCAR WRF model tutorials.
- Develop first draft of the documentation describing the atmospheric, ocean , and wave coupled model components of the HWRF system.

NGDC-03 Space Weather

GOAL: Assess the current state of the space environment from the surface of the sun to the upper atmosphere, use data-driven physical models to construct a realistic and authoritative gridded database of the space environment, and place that description into its long-term climatological perspective.

APPROACH: NOAA's National Geophysical Data Center is responsible for the long-term archive of and access to space environmental monitoring data and the assessment of the near Earth space environment. These data provide the foundation, and physical models provide the technique, required to assess the state of the space environment. This project will: (1) assist in the archive of data from the Department of Defense (DoD) and NOAA's observing systems; (2) evaluate the different physical models of the space environment developed by academia, i.e. the coupled ionosphere and thermosphere, the radiation belts, the inner and outer magnetosphere, interplanetary space, and solar source; (3) construct the data assimilation required to drive the best models; (4) generate gridded databases of the space environment over the long-term; (5) use

the data-driven models to support virtual observatories, which can be placed anywhere in the space environment; and (6) construct the first climatology of the space environment. This is a joint project with DoD's Air Force Weather Agency, NASA's Living With a Star Program, and NOAA's Space Weather Program.

JULY 2008-JUNE 2009 MILESTONES:

- Integrate ionospheric data flows with real-time systems in support of global modeling. This includes support for the Global Assimilation of Ionospheric Measurements (GAIM) model at the Air Force Weather Agency and/or Space Weather Prediction Center.
- Create a GPS data system to manage, collect, and distribute the African GPS network data in support of the International Geophysical Year (IHY). These data are key to the success of the IHY because it will allow scientists to have coverage previously not available. This system will be freely distributed via the World Data Center network.
- Run the Assimilative Mapping of Ionospheric Electrodynamics (AMIE) model using a common code base for 1990-2004. This will create a long-term climate record for the high-latitude ionosphere.

JULY 2009-JUNE 2010 MILESTONES:

- Run 10 years of physically-driven modeling using the Simulation of the Inner Magnetosphere (SIMM) inner-magnetosphere model and new data-assimilative version of the code. These efforts will produce the first long-term archive of this domain.
- Using data generated by southwest Australia (SWA) climate modeling, generate a state of the space environment report. This will detail changes in Earth's magnetosphere over the solar cycle.
- Generate physical parameters from ionospheric satellites (DMSP, POES) to be made available to the community through a standard interface. This will allow for much better utilization of a long-term climate archive.

SWPC-01 Solar Disturbances in the Geospace Environment

GOAL: Improve the prediction of traveling solar disturbances that impact the geospace environment. Such disturbances, which are associated with both coronal holes and coronal mass ejections from the sun, can cause substantial geomagnetic effects leading to the crippling of satellites, disruption of radio communications, and damage to electric power grids.

APPROACH: Solar Sources: Acquire, analyze, and interpret relevant solar data providing information on the launch and properties of traveling interplanetary disturbances that affect the geospace environment. Propagation: Develop empirical and numerical simulation tools that provide improved forecasts of traveling solar disturbances in the inner heliosphere.

JULY 2008-JUNE 2009 MILESTONES:

- GOES X-Ray instrument: Implement algorithms to optimize parametric fits to observed data from a sounding rocket solar X-ray spectrometer for new flights, and apply the results to operational products and calibration routines.
- Global Solar Wind Predictions: Continue sophistication of an operational prediction tool based on the Wang-Sheeley-Arge source surface model, and include evolving solar wind and tracing of magnetic field lines down to the solar photosphere.

- Coronal Mass Ejection Locator: Finalize development and initiate verification and validation studies of the operational tool based on white-light corona observations from NASA STEREO spacecraft.
- Extreme Ultraviolet Imaging Telescope (EIT) waves and dimmings: Investigate possible relationships between coronal mass ejection properties and dimmings observed by EIT instrument and validate using NASA STEREO spacecraft observations.

JULY 2009-JUNE 2010 MILESTONES:

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SWPC-02 Modeling the Upper Atmosphere

GOAL: Understand responses of the upper atmosphere to solar, magnetospheric, and lower atmosphere forcing, and the coupling between the neighboring regions. Since many of the space weather effects occur in the ionosphere and neutral upper atmosphere, it is important to develop an understanding of the system to the point where accurate specification and forecasts can be achieved.

APPROACH: Develop empirical and physical models of Earth's upper atmosphere in order to understand and predict the response of the thermosphere and ionosphere to solar events such as flares and geomagnetic storms resulting from solar coronal mass ejections and co-rotating streams. Evaluate the use of data assimilation techniques for specification and forecast of the space environment and determine the essential and most beneficial data sources required for a robust assimilative system. Investigate coupling between the upper atmosphere and the geophysical regions above, the magnetosphere, and below, the lower atmosphere.

JULY 2008-JUNE 2009 MILESTONE:

- Couple the Global Ionosphere Plasmasphere code, including an electrodynamics module, with the Whole Atmosphere Model. Clear signatures have emerged of the impact of terrestrial weather on the spatial structure and temporal variability of the upper atmosphere. The coupling will begin to elucidate the physical processes responsible for the ionospheric variability and the impact on space weather.

JULY 2009-JUNE 2010 MILESTONE:

- Develop the algorithms to provide the ionospheric correctors for GPS dual frequency receivers over CONUS. Provide rapid centimeter or decimeter accuracy positioning from a GPS data file (RINEX) requires estimates of the line of sight total electron content between the receiver and all GPS satel-

lites in view. These ionospheric correctors will be obtained from the US-TEC operation product, or a higher accuracy post-processing application, and will be provided to the National Geodetic Survey.

AMOS-04 OBSERVING FACILITIES, CAMPAIGNS AND NETWORKS

GMD-02	Surface Radiation Network
PSD-10	Cloud and Aerosol Processes
GSD-04	Unmanned Aircraft Systems

GMD-02 Surface Radiation Network

GOAL: Collect long-term, research-quality, up-welling and down-welling broadband solar and infrared radiation data at seven U.S. sites. Collect long-term, broadband ultraviolet radiation data to evaluate variations in the erythemal doses. Collect long-term, spectral filter data to measure column aerosol optical depth and cloud optical depth. Collect cloud cover data to assess the effect of clouds on the surface radiation budget.

APPROACH: The Global Monitoring Division-Radiation (G-RAD) group operates the first climate radiation budget network ever established in the United States. It currently consists of sites in seven distinct climate regimes of the country. Measurements are made of broadband solar and terrestrial infrared radiation following the guidelines of the WMO/WCRP Baseline Surface Radiation Network (BSRN). All sites also maintain ultraviolet, cloud cover, column aerosol, and cloud optical depth measurement capabilities for assessing the primary causes of surface radiation variability.

JULY 2008-JUNE 2009 MILESTONES:

- Publish results of an objective comparison of automated total-sky imager cloud fraction retrievals and sky cover determinations from trained observers at Eglin Air Force Base and the Desert Rock rawinsonde station.
- Complete the reconstruction of the multi-filter rotating shadow-band radiometer (MFRSR) angular response measurement database for the Atmospheric Radiation Measurement (ARM) program, and use the results to determine the sensitivity of changing angular responses on the retrieval of aerosol optical depths from MFRSR measurements. Publish the results.

JULY 2009-JUNE 2010 MILESTONE:

- Using the SURFRAD irradiance database, look for long-term changes in the total horizontal irradiance (referred to as global dimming or brightening) and relate this, if applicable, to the concomitant aerosol changes from the MFRSR aerosol optical depth measurements. Publish the results.

PSD-10 Cloud and Aerosol Processes

GOAL: Make observations of clouds, aerosols, and water vapor over a variety of ice, land, and sea surfaces using a multi-sensor, multi-platform approach to improve retrieval techniques useful for satellite validation studies.

APPROACH: Employ research radars (cloud, clear-air, and precipitation), lidars, and radiometers on land, ships and aircraft. Deployment periods can last for weeks or years, and marine observations may revisit critical regions during a particular season over many years in order to build up the climatological record.

JULY 2008-JUNE 2009 MILESTONES:

- Participate in VOCALS-REX research cruises in October/November 2008, deploy cloud radar, radiometer, and flux systems to measure key surface marine boundary layer parameters, low cloud macrophysical, microphysical, and radiative properties.
- Submit synthesis paper of Stratocumulus cruises.
- Participate in AMMA research cruises in May 2009; deploy cloud radar, radiometer, and flux systems to measure key surface marine boundary layer parameters, low cloud macrophysical, microphysical, and radiative properties.
- Deploy suite of cloud and boundary-layer remote sensing instrumentation at the North Pole during the Arctic Summer Cloud Ocean Study (ASCOS) in August-September 2008 through extensive international collaboration. Begin processing and analysis of ASCOS data.
- In collaboration with the NOAA/University of Colorado Center for Environmental Technology and the University of Leeds, obtain airborne spatial measurements near the ASCOS site at the North Pole of synoptic/mesoscale atmospheric structure, cloud distribution, cloud microphysics, and aerosols. This is the Arctic Mechanisms of Interaction between the Surface and the Atmosphere (AMISA) project in August 2008. Begin processing and analysis of data.
- Produce cloud macrophysical and microphysical datasets for Arctic Atmospheric Observatories.
- Develop a climatology of back trajectories for Arctic stations to provide context for cloud and aerosol analysis.

JULY 2009-JUNE 2010 MILESTONES:

- Begin analysis of data from VOCALS-REX research cruises in October/November 2008, key surface marine boundary layer parameters, low cloud macrophysical, microphysical, and radiative properties.
- Submit paper on flux/cloud comparisons of AMMA cruise data and NOAA model.
- Participate in AMMA research cruises in May 2010; deploy cloud radar, radiometer, and flux systems to measure key surface marine boundary layer parameters, low cloud macrophysical, microphysical, and radiative properties.
- In an international collaboration, continue analyzing and modeling the ASCOS data set over the Arctic pack ice, focusing on links between low-level clouds, boundary layer structure/processes, surface energy budget, and cloud aerosols.
- Using data from AMISA, continue the analysis of the spatial thermodynamic, kinematic, and cloud structure over the pack ice in the vicinity of the R/V Oden deployed during ASCOS.
- Produce cloud macrophysical and microphysical datasets for Arctic Atmospheric Observatories.
- Submit paper discussing seasonal variation of back trajectories.

GSD-04 Unmanned Aircraft Systems

GOAL: Test and evaluate a variety of unmanned aircraft systems to collect scientifically valuable environ-

mental data. The tests will be carried out in a variety of situations in support of multiple scientific goals. Results of funded unmanned aircraft projects will be provided in written reports that can be shared within NOAA and the general scientific community.

APPROACH: Three geographic areas will be the initial focus: the hurricane region, the Pacific region, and the Arctic region. In the first two years, each of these three regions will be explored using small unmanned aircraft with payload capacity of less than 20 kg. Tests with larger unmanned aircraft in the same three regions will be carried out in collaboration with NASA. Results of these initial efforts will be evaluated with respect to how well they support NOAA's missions.

JULY 2008-JUNE 2009 MILESTONE:

- Test the capabilities of Low Altitude Long Endurance Unmanned Aircraft for taking measurements over ice and open water.

JULY 2009-JUNE 2010 MILESTONE:

- Evaluate measurements from Unmanned Aircraft Systems for their ability to measure sea ice characteristics and marine mammals.

Scientific Theme: CLIMATE SYSTEM VARIABILITY

CSV-01 DETECTION OF CLIMATE MODES, TRENDS AND VARIABILITY

GMD-03	Climate Trend Analysis
PSD-04	Decadal Climate and Global Change Research
NGDC-04	Paleoclimatology: Understanding Decadal- to Millennial-Scale Climate Variability

GMD-03 Climate Trend Analysis

GOAL: Interpret operational data (ozone column, ozone profile, aerosol extinction, broadband spectral radiation, and other environmental parameters) collected by NOAA ground-based and NCAR aircraft-based instruments. Assess data for long-term quality. Evaluate stability and interannual variability in the ground-based and aircraft-based datasets. Provide scientific community with information relevant to climate research and evaluate usefulness of data for validation of other independent measurements, including satellite observations.

APPROACH: Exercise statistical and analytical methods to assess the quality of the data. Develop new approaches to improve the quality of the product derived from ground-based and aircraft-based measurements. Evaluate data for trends using state-of-the art radiative transfer models and statistical analysis. Provide support for validation of climate related products.

JULY 2008-JUNE 2009 MILESTONES:

- Investigate the impact of stray light in Dobson and Brewer instruments on the consistency of ozone retrievals from Umkehr measurements to improve these observations for trend analysis and satellite validation.
- Develop ozone profile retrieval algorithm for use with automated Dobson and Brewer radiometric measurements. Implement operational ozone profile processing and retrieval system that will provide

expanded capability for detection and tracking of projected stratospheric ozone recovery and validation of satellite profile observations.

- Develop new products for Brewer NOAA network, such as tropospheric ozone and nitrogen dioxide (NO2) column. Evaluate and characterize new products against well-established and co-located measurements. Provide data to OMI/AURA satellite validation campaigns. Impact: This new dataset will provide expanded resources for climate change and tropospheric pollution studies.

JULY 2009-JUNE 2010 MILESTONES:

- Investigate the impact of stray light in Dobson and Brewer instruments on the consistency of ozone retrievals from Umkehr measurements to improve these observations for trend analysis and satellite validation.
- Develop an ozone profile retrieval algorithm for use with automated Dobson and Brewer radiometric measurements. Implement operational ozone profile processing and retrieval system that will provide expanded capability for detection and tracking of projected stratospheric ozone recovery, and validation of satellite profile observations.
- Develop new products for Brewer NOAA network, such as tropospheric ozone and NO2 column. Evaluate and characterize new products against well-established and co-located measurements. Provide data to OMI/AURA satellite validation campaigns. Impact: This new dataset will provide expanded resources for climate change and tropospheric pollution studies.

PSD-04 Decadal Climate and Global Change Research

GOAL: Improve understanding of long-term climate variations through analysis of observations and hierarchies of General Circulation Model (GCM) experiments. Seek dynamical explanations of oceanic variability and changes through observational analyses and GCM experiments. Provide attribution for long-term regional climate changes.

APPROACH: CIRES is assessing the significance of and diagnosing the relationships between observed recent multi-decadal changes in tropical ocean temperatures and the global atmospheric circulation. Techniques include the use of atmospheric models forced by sea surface temperatures (SSTs), ocean models forced by wind stresses and heat fluxes, and hierarchies of coupled ocean-atmosphere GCMs, including runs forced by greenhouse gases. Similar techniques are being used to understand the markedly different climate during the mid-Holocene (ca 6000 years BP) in terms of the generally colder tropical Pacific ocean and reduced greenhouse gas concentrations existing during that period. Researchers will study the origin and climatic impact of decadal mid-latitude ocean variability, particularly over the North Pacific. It is believed that progress can be made by improving the understanding of regional responses around the globe to slow changes in the tropical Pacific, Indian, and Atlantic oceans. Understanding these decadal-scale oceanic changes will require careful observational and climate model diagnosis.

JULY 2008-JUNE 2009 MILESTONES:

- Investigate the relative contributions of ENSO-related and ENSO-unrelated tropical SST variations on global climate changes over the last 130 years.
- Continue assessing importance of coupled air-sea interactions, decadal ocean dynamics, land-surface feedbacks, and land-use changes on decadal and longer-term atmospheric variability.
- Diagnose impacts of subseasonal tropical and stratospheric variability on longer-term global climate

variability and the mean climate.

JULY 2009-JUNE 2010 MILESTONES:

- Investigate the relative contributions of ENSO-related and ENSO-unrelated tropical SST variations on global climate changes over the last 130 years.
- Continue assessing importance of coupled air-sea interactions, decadal ocean dynamics, land-surface feedbacks, and land-use changes on decadal and longer-term atmospheric variability.
- Diagnose impacts of subseasonal tropical and stratospheric variability on longer-term global climate variability and the mean climate.

NGDC-04 Paleoclimatology: Understanding Decadal to Millennial-Scale Climate Variability

GOAL: Improve the understanding of observed long-term climate variations through compilation and analysis of data from the pre-instrumental record and provide access to both data and information from the paleoclimatic record.

APPROACH: Because instrumental records of climate are rarely over a century long, paleoclimatic data provide an unique way to understand the full range of climate variability. In collaboration with paleoclimatic researchers from around the world, new paleoclimatic data and research results will be compiled and made available, and systems for data archive, access, visualization, and analysis will be developed. This work will also draw upon collaborations with educators and communications professionals to develop new approaches for presenting information to students, policy makers, and the public.

JULY 2008-JUNE 2009 MILESTONES:

- Respond to increased community interest in abrupt climate change by revising the Paleo Perspective on Abrupt Climate Change web pages, soliciting new abrupt climate change datasets, and cataloging significant datasets currently in the archive.
- Enhance discovery of records at the NOAA Paleoclimatology website by adding the capability to search XML records by age and geographic coordinates, as well as through an ArcIMS interface.
- Contribute to the goals of National Integrated Drought Information System for new portal content and for establishing partnerships with U.S. and international agencies.

JULY 2009-JUNE 2010 MILESTONES:

- Create the first version of a database of raw data used in paleoclimate reconstructions of the last thousand years.
- Continue to expand and enhance data search at NOAA Paleoclimatology website by harvesting XML records from other data centers and by adding advanced search capabilities.

CSV-02 MECHANISM AND FORCINGS OF CLIMATE VARIABILITY

CSD-03	Chemistry, Radiative Forcing, and Climate
PSD-01	Modeling of Seasonal to Interannual Variability
PSD-02	Understanding and Predicting Subseasonal Variations and their Implications for Longer Term Climate Variability
GMD-04	Climate Forcing

CSD-03 Chemistry, Radiative Forcing, and Climate

GOAL: Observe and model the radiative forcing due to stratospheric ozone changes and tropospheric radiatively active gases. Carry out upper-troposphere airborne experiments and diagnostic analyses that characterize the dynamical and chemical processes that influence the radiative balance in the global atmosphere. Quantify the chemical and optical properties that determine the lifetimes, abundances, and trends of greenhouse gases. Use passive cloud observations to develop techniques that can be used to estimate cloud properties.

APPROACH: Use line-by-line radiative models to calculate the profile of radiative forcing. Evaluate the tropospheric cooling/warming due to ozone layer losses/increases. From airborne and surface observations in convective areas, estimate the radiative forcing from biomass burning, lightning, and pollution. Design, carry out, and analyze results from airborne and ship-based field missions to study climate-relevant atmospheric chemistry. The analytical foci include water vapor, methane (which is radiatively active and a dynamical tracer), ozone, and fine particles. Use laboratory analytical methods to establish chemical reaction rates, their temperature and isotopic sensitivities, and the optical band strengths. The current emphasis is on precursors of tropospheric ozone, many of the non-carbon dioxide greenhouse gases (methane, hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride), and other potential greenhouse gases. Measure near-infrared spectra in the presence of clouds and analyze using the differential optical absorption spectroscopy (DOAS) technique with a focus on estimating liquid and ice abundances in the cloud. Use modeling and analytical approaches to define emissions inventories and evaluate the chemical composition of the atmosphere, especially with regard to radiatively important trace species.

JULY 2008-JUNE 2009 MILESTONES:

- Evaluate the global and regional surface emission inventories used to simulate the evolution of the composition of the atmosphere over the past 100 years. Participate in the organization of the work of an international group that will compare existing inventories at global and regional scales. Impact: These efforts will contribute to the definition of the emission inventories that will be used in simulations performed for the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) report currently under definition.
- Use measurements to evaluate the climate impact of ship emissions. Impact: Ships emit climate-relevant pollutants, including black carbon and other particles, into remote regions of the atmosphere where they can have relatively more impact than emissions in continental areas.
- Examine the impact of tropical cyclones on the distribution of water vapor and other radiatively important trace gases in the upper troposphere and lower stratosphere. Impact: Improve understanding of how regional perturbations caused by tropical cyclones affect the tropical budgets of upper troposphere and lower stratosphere humidity and trace gases.

- Archive and begin analysis of the data from the International Chemistry Experiment in the Arctic Lower Troposphere (ICEALOT) field mission. ICEALOT was carried out in spring of 2008 as part of the International Polar Year to examine the aerosol properties and atmospheric chemistry over an ice-free region of the Arctic. The study investigated: (1) springtime sources and transport of pollutants to the Arctic, (2) evolution of aerosols and gases into and within the Arctic, (3) aerosol – radiation interactions, and (4) ozone budget and climate effects.
- Archive and begin analysis of data from the Aerosol, Radiation, and Cloud Processes affecting Arctic Climate (ARCPAC) field mission. Impact: ARCPAC was carried out in spring of 2008 as part of the International Polar Year to examine the aerosol properties and atmospheric chemistry over an ice-free region of the Arctic. The study investigated: (1) direct warming of the lower troposphere by the absorption of solar radiation and infrared emission by aerosol particles from anthropogenic and biomass burning, (2) changes in snow melt due to deposition of soot (light-absorbing carbon) to the surface in springtime, (3) increases in infrared emissivity of wintertime and springtime clouds in the Arctic due to the effects of anthropogenic aerosol particles on cloud properties, and (4) direct radiative effects of tropospheric ozone in the Arctic.

JULY 2009-JUNE 2010 MILESTONES:

- Evaluate the evolution of the chemical composition of the lower atmosphere over the past 30-40 years, using both chemistry-transport and chemistry-climate models. Compare the results of the simulations with observations, perform sensitivity studies, and quantify the impact of anthropogenic processes on the evolution of the troposphere over the past few decades. Impact: This research will enable quantification of the respective role of anthropogenic and natural processes on the evolution of the chemical composition of the lower atmosphere.
- Evaluate the effect of aqueous organic chemistry on aerosols in the troposphere. Impact: Organic compounds are a large fraction of the aerosol mass in the free troposphere. These particles interact with clouds in a reciprocal manner: the particles can affect cloud formation, and the aqueous chemistry in clouds can change the particles.
- Use satellite measurements, radiosondes and global chemistry climate models to examine changes in the width of the tropical upper troposphere and the height and temperature of the tropical tropopause in response to sea surface temperature changes. Impact: Widening of the tropical upper troposphere as well as changes in the characteristics of the tropical tropopause can impact the transport of water vapor and other radiatively important trace gases into the stratosphere.
- Analyze, interpret and publish the climate-related results from the International Chemistry Experiment in the Arctic Lower Troposphere (ICEALOT) field mission. Impact: ICEALOT was carried out in spring of 2008 as part of the International Polar Year to examine the aerosol properties and atmospheric Chemistry over an ice-free region of the Arctic. The study investigated: (1) springtime sources and transport of pollutants to the Arctic, (2) evolution of aerosols and gases into and within the Arctic, (3) aerosol – radiation interactions, and (4) ozone budget and climate effects.
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on cloud properties, and (4) direct radiative effects of tropospheric ozone in the Arctic.

PSD-01 Modeling of Seasonal to Interannual Variability

GOAL: Understand how much predictability, especially outside the tropics, exists on seasonal-to-interannual timescales beyond that associated with linear ENSO signals, and what additional useful predictive information can be extracted by making large ensembles of nonlinear General Circulation Model (GCM) integrations.

APPROACH: Explore the nonlinearity and sensitivity of the global response to the details of anomalous tropical sea surface temperature (SST) fields. Focus on the distributional aspects of the response, especially changes of variance and altered risks of extreme values, and not just shifts of the mean. Since the utility of deterministic predictions of the chaotic climate system is limited, the intent is to shift the emphasis from deterministic to probabilistic seasonal predictions. The utility of probabilistic predictions is unbounded in principle, in the important sense that it is ultimately determined by the needs of particular users.

JULY 2008-JUNE 2009 MILESTONES:

- Assess the legitimacy of atmospheric GCM simulations with prescribed SST boundary conditions to estimate atmospheric predictability associated with SST changes, through clean comparisons with corresponding coupled GCM integrations.
- Continue 20th century reanalysis efforts in collaboration with NCEP, NCAR, NCDC, ECMWF, U. of East Anglia, Environment Canada, ETH-Zurich, and the UK Hadley Centre.
- Assess the importance of the global nonlinear impacts of central equatorial Pacific SST changes.
- Assess the predictability of Northern American precipitation, associated with the ENSO-related and ENSO-unrelated components of anomalous SST fields, using a number of atmospheric general circulation models.

JULY 2009-JUNE 2010 MILESTONES:

- Assess the legitimacy of atmospheric GCM simulations with prescribed SST boundary conditions to estimate atmospheric predictability associated with SST changes, through clean comparisons with corresponding coupled GCM integrations.
- Continue 20th century reanalysis efforts in collaboration with NCEP, NCAR, NCDC, ECMWF, U. of East Anglia, Environment Canada, ETH-Zurich, and the UK Hadley Centre.
- Assess the importance of the global nonlinear impacts of central equatorial Pacific SST changes.
- Assess the predictability of Northern American precipitation, associated with the ENSO-related and ENSO-unrelated components of anomalous SST fields, using a number of atmospheric general circulation models.

PSD-02 Understanding and Predicting Subseasonal Variations and their Implications for Longer Term Climate Variability

GOAL: Investigate the variability and predictability of weekly averages of the atmospheric circulation through modeling and diagnosis of the observed statistics, and also through detailed analysis of numerical weather forecast ensembles for Week Two.

APPROACH: Extracting useful information about which aspects of the circulation remain predictable beyond a week presents interesting challenges given that the details of daily weather become unpredictable beyond that time. Forecast information on these time scales is in great demand from users. CIRES scientists are addressing these issues by developing low-dimensional, empirical-dynamical models that not only successfully represent the statistics of weekly anomalies, but also demonstrate comparable forecast skill in Week Two to that of state-of-the-art comprehensive numerical weather prediction (NWP) models. They are also making extensive use of large ensembles of retrospective two-week forecasts generated in-house using the NCEP NWP model for the period 1979-2004 to develop methods for optimally extracting useful predictive information from such ensembles. An intelligent combination of the empirical and numerical model forecasts may yield Week Two forecasts that are superior to either in isolation.

JULY 2008-JUNE 2009 MILESTONES:

- Use an empirical-dynamical coupled atmosphere-ocean model of tropical subseasonal variations to assess the impact of air-sea coupling on the Madden-Julian Oscillation.
- Continue investigating the variability and predictability of extratropical subseasonal variations in all seasons of the year using a linear empirical-dynamical model that includes air-sea coupled tropical and stratospheric influences. Assess the predictability from deterministic and probabilistic perspectives, particularly in regard to the case-by-case and regime-dependent variations of predictability.

JULY 2009-JUNE 2010 MILESTONES:

- Use an empirical-dynamical coupled atmosphere-ocean model of tropical subseasonal variations to assess the impact of air-sea coupling on the Madden-Julian Oscillation.
- Continue investigating the variability and predictability of extratropical subseasonal variations in all seasons of the year using a linear empirical-dynamical model that includes air-sea coupled tropical and stratospheric influences. Assess the predictability from deterministic and probabilistic perspectives, particularly in regard to the case-by-case and regime-dependent variations of predictability.

GMD-04 Climate Forcing

GOAL: Greenhouse gases: Conduct research to better understand the interactions of the atmosphere with the land and ocean. Aerosols: Characterize the means, variabilities, and trends of climate-forcing properties for different types of aerosols, and understand the factors that control these properties. Radiation: Research broadband irradiance to improve benchmarks for climatic processes.

APPROACH: Understanding climate forcing is a long-term experiment of global proportions that can only be addressed through sustained high-quality observations around the world. This sampling strategy will help link chemical and physical measurements, provide ground-truth data for satellite remote sensing, and provide inputs to global models. Data records of sufficient duration are expected to reveal the extent of irradiance variations over time that reflect a combination of cause and effect of climate change.

JULY 2008-JUNE 2009 MILESTONES:

- Complete the development of an instrument to measure the aerosol absorption coefficient.
- Complete merging of mesoscale model B-RAMS with global transport model TM5 (completion of

ongoing project initiated in FY07).

- Initiate project to use 14CO2 (radio-carbon) to calibrate promising candidate atmospheric gas species for use as fossil fuel tracers.
- Establish two new, temporary tall-tower sites (in conjunction with the NOAA/ESRL North American Carbon Observing System - Carbon America) in the San Francisco and Sacramento, CA area to characterize and understand urban influences on the tall-tower network measurements.
- Establish one new tall-tower site in the NOAA/ESRL Carbon America tall-tower network to aid in reducing the uncertainty of carbon uptake by the North American continent and to better characterize regional terrestrial carbon flux estimates.
- Initiate project using a Lagrangian source-receptor approach to diagnose the impact of long-range transport on atmospheric carbon dioxide concentrations (at local scale for the NOAA/ESRL Carbon America tall-tower measurements; at global scale for the surface seasonal cycle at different latitudes as measured by the NOAA/ESRL Cooperative Global Atmospheric Sampling Network).

JULY 2009-JUNE 2010 MILESTONES:

- Conduct an intensive field campaign to compare three instruments that measure aerosol hygroscopic growth.
- Complete development of a field-operational temperature/humidity/GPS system to augment current trace gas vertical profile measurements in the NOAA/ESRL Carbon America aircraft network (a prototype system exists and is in use currently at five network sites; the system allows for automated measurements of the ambient temperature and humidity and the position and altitude associated with each sample in a vertical profile).
- Establish one new tall-tower site in the NOAA/ESRL Carbon America tall-tower network to aid in reducing the uncertainty of carbon uptake by the North American continent and to better characterize regional terrestrial carbon flux estimates.
- Implement assimilation of eddy covariance carbon flux measurements in the NOAA/ESRL ensemble Kalman filter carbon data assimilation system, CarbonTracker.

CSV-03 STRATOSPHERIC OZONE DEPLETION

CSD-04	Photochemical and Dynamical Processes that Influence Upper Troposphere/ Lower Stratosphere Ozone
GMD-05	Ozone Depletion

CSD-04 Photochemical and Dynamical Processes that Influence Upper Troposphere/ Lower Stratosphere Ozone

GOAL: Improve theoretical capabilities to predict the natural and human influences on the stratospheric ozone layer. Characterize the photochemical reactions relating to the anthropogenie loss of ozone in the stratosphere. Carry out *in-situ* studies of the photochemical and dynamical processes that influence the stratospheric ozone layer.

APPROACH: Design and evaluate multidimensional models of the chemistry and transport of the global stratosphere. The current focus is on simulating the integrated response of the ozone layer to volcanoes

and chlorofluorocarbons, halons, and other halogens with the effects of changing temperatures. The scope includes both polar and global processes. Ozone Depletion Potentials (ODP) will be calculated for gases of policy relevance. Use fast-flow reactors and laser photolytic cells to measure the rate of chlorine- and bromine-induced chemical reactions associated with ozone loss. Determine the pressure and temperature sensitivities associated with stratospheric conditions. The current emphasis is on reactions associated with substitutes of the banned ozone-depleting substances, such as n-propyl bromide. Extend these studies to the reactions that occur on the surfaces of particles, both sulfate and ice, to resemble volcanic and other types of particles. Use high-altitude research aircraft to conduct a suite of chemical measurements in a variety of global locations and seasons. Collaborate with numerous institutions to assemble a broad chemical spectrum of measurements. Emphases include investigations of the impact of stratospheric aircraft on the ozone layer, particle formation processes and their role in the depletion of stratospheric ozone, and the connections between ozone depletion and climate-related factors.

JULY 2008-JUNE 2009 MILESTONE:

- Further study the transport processes associated with the subtropical jet stream using airborne and high-resolution model output. Impact: The distribution of trace gases such as water vapor, ozone and methane in the upper troposphere and lower stratosphere are important for climate and stratospheric ozone calculations.

JULY 2009-JUNE 2010 MILESTONE:

- Use ozone data from flights of the NCAR HAIPER GV aircraft to examine transport and photochemical processes in the upper troposphere and lower stratosphere. Impact: The data and intercomparisons with high-resolution models will offer new insights into how ozone can be used to constrain transport and photochemical processes in global models.

GMD-05 Ozone Depletion

GOAL: Stratospheric Ozone Measurements: Measure ozone declines during the past two decades at northern hemispheric midlatitudes and the tropics, and characterize dramatic ozone depletions over Antarctica. Ozone-Depleting Gases: Conduct research in the troposphere, stratosphere, oceans, polar snowpack, and terrestrial ecosystems in an effort to understand and predict the atmospheric behavior of these gases. Stratospheric Aerosols: Conduct experiments and measurements on aerosols to determine their impacts on solar insolation. Stratospheric Water Vapor: Conduct measurements to determine the change in water vapor and its coupling with aerosols.

APPROACH: Understanding the production and fate of ozone and the compounds that deplete it is a focal point of collaborative CIRES research with GMD and CSD. Stratospheric Ozone Measurements: Six Dobson instruments have been automated to provide ozone vertical profiles using the Umkehr technique and eight balloon-borne ozonesonde stations provide ozone profiles to an altitude of ~32 km. These ozone-measuring techniques are being used to monitor spectral UV and quantify the expected anticorrelation between ozone and UV.

Ozone-Depleting Gases: Gases that make a significant contribution to stratospheric ozone depletion (CFC-11, CFC-12, N2O, HCFCs, and other halogenated compounds) have been incorporated into the measurement program as the number of monitoring sites has increased. Most of the gases that are responsible for depleting stratospheric ozone are anthropogenic, but some, such as CH3Br and CH3Cl, also have natural sources. CIRES scientists will monitor the distributions and trends of these gases as well as investigate their

sources and sinks.

Stratospheric Aerosols: Ozone depletion, through halogen-related chemistry, is facilitated by increased stratospheric particles as provided by stratospheric clouds in the polar regions and globally by volcanic eruptions. CIRES modeling suggests that with present halogen levels, a major eruption such as that of Pinatubo in 1991 could decrease total column ozone by as much as 10% at mid-latitudes. Stratospheric Water Vapor: Utilizing balloon-borne frost-point hygrometers, an approximately 1% per-year increase in stratospheric water vapor has been detected since 1980. Besides implications for climate change, increased water vapor can affect the rate of chemical ozone loss, for example, by increasing the incidence of polar stratospheric clouds.

JULY 2008-JUNE 2009 MILESTONES:

- The Ozone Depleting Gas Index will be updated and refined, as needed, with continued measurements of ozone depleting gases.
- Utilize medium- and high-altitude aircraft and stratospheric balloon platforms to validate tropospheric and stratospheric measurements of ozone depleting gases (N2O, CFC-11, CFC-12) by spaceborne instrumentation aboard the Aura satellite. These measurements, made as part of NASA- and NSF-sponsored campaigns, also increase the knowledge about upper atmospheric transport and chemistry, which in turn improve the understanding of stratospheric ozone and its projected recovery.
- Utilize the NCAR/NSF Gulfstream-V aircraft to measure the latitudinal, longitudinal, and vertical distributions of ozone depleting gases above a large region of the Pacific Ocean during different seasons. The data will provide needed tests of atmospheric transport models, help to quantify large-scale ozone depleting gas sources and sinks, and examine inter-hemispheric exchanges of tropospheric air.
- Continue a study of cross-tropopause transport in the northern mid-latitudes using the NCAR/NSF Gulfstream-V aircraft and *in-situ* measurements of ozone depleting and other gases, including ozone and water vapor. The results will increase the understanding of stratosphere-troposphere exchange, which is influential in determining the lifetimes of ozone depleting substances, and may lead to improved predictions of stratosphere-troposphere exchange rates and how they might be affected by climate change.
- Several statistical techniques will be applied to the total column ozone observations from the Dobson network to evaluate indicators for stratospheric ozone change for their sensitivity and capability to detect projected recovery.
- The longer-term ozonesonde record (more than 20 years) at South Pole will be used to look for signs of springtime stratospheric ozone recovery by testing various indicators of ozone profile changes in regions that are most sensitive to chemical ozone loss.

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CSV-04 CLIMATE DYNAMICS

PSD-06	Climate Dynamics
PSD-03	Empirical and Process Studies
PSD-15	Surface Processes

PSD-06 Climate Dynamics

GOAL: Conduct research to improve the understanding of tropical Pacific Ocean dynamical processes related to the subseasonal atmospheric variability, and atmospheric circulation, convection, and moisture and heat budgets associated with the El Niño phenomenon and the North American Monsoon (NAM).

APPROACH: Analyze wind profiler, tropical atmosphere ocean buoy, and satellite data, combined with reanalysis products, to examine circulation, convection, marine boundary layer winds, and moisture/heat budgets. Current emphases are on the processes associated with precipitation and on the interactions between and interannual variability of various atmospheric and surface daily cycles.

JULY 2008-JUNE 2009 MILESTONE:

- Quantify the spatial variability of the daily cycles of precipitation observed during the NAM along the Gulf of California. This will be done by comparing daily cycles of precipitation observed by satellite and during multi-year NAM experiment (NAME) instrument deployments. This will provide high-resolution, observationally-based ground truth to be used towards solving one of the key problems driving NAME: the inability of models to correctly predict the timing and amount of warm-season precipitation.

JULY 2009-JUNE 2010 MILESTONE:

- Evaluate the ability of NCEP regional reanalyses to capture the daily cycles observed during the NAM along the Gulf of California. This will be done by comparing daily cycles of 915-MHz profiler winds and virtual temperatures and precipitation observed during multi-year NAME deployments with NCEP regional reanalysis products. The results contribute to improvements in analysis and prediction of the NAM system by identifying which aspects of many atmospheric and hydrologic parameters are and are not captured by special NAME analysis products and simulations.

PSD-03 Empirical and Process Studies

GOAL: Improve understanding of basic physical processes that contribute to climate variability across a broad spectrum of scales, with emphases on moist atmospheric convection, radiative transfer in cloudy areas, and air-sea interaction.

APPROACH: Observations and hierarchical modeling will be used to better understand moist atmospheric convection and investigate its behavior in various environments. A key objective is to evaluate the assumptions at the center of cumulus parameterization schemes used in current weather and climate models. Research into the climatic importance of clouds will be conducted to understand the impact of east Pacific stratocumulus decks on the seasonal cycle of sea surface temperature (SST), and to develop statistically-based prescriptions of subgrid scale cloud variability for improving the representation of radiative transfer in cloudy regions. Air-sea interactions in the tropical western Pacific will be studied during different phases of the Madden-Julian Oscillation (MJO) cycle in order to improve its representation in weather and climate models. The MJO influence on ENSO, particularly in its onset and decay phases, and on the extratropical circulation are other topics of interest.

JULY 2008-JUNE 2009 MILESTONES:

- Develop empirical models of daily SST and near-surface air temperature variations at all oceanic grid points from observations and climate model simulations. Such models are critical for improving the understanding parameterization of sea surface fluxes that are at the heart of coupled climate system dynamics.
- Continue assessing stochastic influences on climate variability and predictability through (1) linear and nonlinear inverse modeling and (2) development and implementation of stochastic parameterizations in weather and climate models.

JULY 2009-JUNE 2010 MILESTONES:

- Develop empirical models of daily SST and near-surface air temperature variations at all oceanic grid points from observations and climate model simulations. Such models are critical for improving the understanding parameterization of sea surface fluxes that are at the heart of coupled climate system dynamics.
- Continue assessing stochastic influences on climate variability and predictability through (1) linear and nonlinear inverse modeling and (2) development and implementation of stochastic parameterizations in weather and climate models.

PSD-15 Surface Processes

GOAL: Develop and/or improve physical representations of atmosphere-surface interactions.

APPROACH: Combine state-of-the-art observations of surface fluxes, boundary-layer structure, and mesoscale features with high-resolution numerical modeling. Current work focuses on boundary layers over ice/snow surfaces and the effects of terrain on coastal precipitation. High quality observations of surface turbulent, radiative, and precipitation fluxes are combined with radar measurements and mesoscale model simulations. Parameterizations are being developed for stable surface-layer flux-profile relationships and linking terrain slopes and wind-vector profiles to spatial patterns of precipitation accumulations.

JULY 2008-JUNE 2009 MILESTONES:

- Determine accuracy of ERA-40 surface turbulent fluxes over the Arctic pack ice and devise methods of improvement through a combination of satellite measurements and modeling.
- Determine the turbulent flux characteristics and associated processes at the Study of Environmental Arctic Change (SEARCH) sites at Alert and Eureka. Determine the extent to which Monin-Obukhov Similarity (MOS) applies at these locations. Consider if a non-MOS (non-local) flux scheme is necessary and, if so, suggest a process-based algorithm.
- Incorporate the Surface Heat Budget of the Arctic Ocean (SHEBA) flux scheme and the double-moment microphysics scheme into the WRF model and evaluate their effect on simulated surface energy and boundary-layer processes.
- Using remote sensors deployed during AMISA in collaboration with NOAA's Center for Environmental Technology, obtain airborne measurements of the spatial distribution of surface characteristics of the Arctic pack ice in the vicinity of the icebreaker Oden during ASCOS.

JULY 2009-JUNE 2010 MILESTONES:

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- Determine the turbulent flux characteristics and associated processes at the Study of Environmental Arctic Change (SEARCH) sites at Alert and Eureka. Determine the extent to which Monin-Obukhov Similarity (MOS) applies at these locations. Consider if a non-MOS (non-local) flux scheme is necessary and, if so, suggest a process-based algorithm.
- Analyze the ASCOS and AMISA data to better understand the physical processes producing the end of the summer melt season.

CSV-05 CLIMATE RESEARCH DATABASE DEVELOPMENT

NSIDC-01	Digitization of Analog Cryospheric Data under the Climate Database Modernization Program
NSIDC-03	World Data Center for Glaciology, Boulder - Current Programs

NSIDC-01 Digitization of Analog Cryospheric Data under the Climate Database Modernization Program

GOAL: Scan and make available online data from NSIDC's analog collections so that it is more easily located, browsed, and obtained by users.

APPROACH: Working with the NOAA Climate Database Modernization Program (CDMP), have glacier photographs from NSIDC's collection inventoried, scanned, and made available through an online search tool. In their analog form, the photos are difficult to use and are at risk of deterioration. Many of these photographs exist only as mounted prints. Also through CDMP, continue scanning a collection of sea ice charts from Alaska, covering the years 1953-1986. This collection was compiled by William H. Dehn and his organization Sea Ice Consultants, Inc., and donated to NSIDC by his estate for use by the climate and global

change research community.

JULY 2008-JUNE 2009 MILESTONE:

- Add the Austin Post collection of thousands of glacier photographs to the Online Glacier Photograph Data Base, in collaboration with the University of Alaska, NOAA NGDC, and the NOAA CDMP program.

JULY 2009-JUNE 2010 MILESTONE:

- Add additional glacier photograph collections to the Online Glacier Photograph Data Base, in collaboration with NOAA NGDC, and the NOAA CDMP program.

NSIDC-03 World Data Center for Glaciology, Boulder - Current Programs

GOAL: Improve the understanding of recent and unexpected changes in polar regions including lower sea-level atmospheric pressure, increased air temperature over most of the Arctic, lower temperatures over eastern North America, reduced sea ice cover, thawing permafrost, and changes in precipitation patterns.

APPROACH: Investigate hypotheses that relate changes to the Arctic Oscillation, to feedbacks among ocean, land, ice and atmosphere, and to global climate change. Central to these investigations are long-term and pan-Arctic observations. The preparation of the requisite observational datasets involves quantifying time variability of the measured parameter, assessing consistency in observational method, flagging erroneous data, and examining issues of spatial and temporal coverage.

JULY 2008-JUNE 2009 MILESTONES:

- Maintain and update existing research datasets (e.g., the Sea Ice Index). Publish new datasets and improve data visualization tools, including Google Earth.
- Make research information available through the NSIDC Information Center, acquire and catalog cryospheric materials in the NSIDC library, and maintain NSIDC's analog datasets.

JULY 2009-JUNE 2010 MILESTONES:

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CSV-07 CLIMATE SERVICES

PSD-05	Experimental Regional Climate Services
PSD-07	Experimental Climate Data and Web Services

PSD-05 Experimental Regional Climate Services

GOAL: Couple enhanced observations and research in regions of strong climate variability and societal impact with analysis of past data and improved modeling. Determine factors influencing the occurrence of extreme events. Improve the diagnosis, modeling, and prediction of the regional consequences of climate change and variability on timescales of days to decades on hydrological variables of relevance to society.

APPROACH: The impact of climate variability is regionally specific and is often strongly influenced by local topography, watersheds, and other geographical features. CIRES is seeking to better understand the impacts of ENSO, and of anomalous sea surface temperatures (SSTs) in general, on climate variability over the United States, especially hydroclimatic variability associated with droughts and floods. Current emphasis is on (1) evaluating the ability of the current suite of ENSO forecast models to correctly "predict" the evolution of past El Niño events in terms of their timing, duration, intensity, and spatial extent and (2) examining how past droughts in the southwestern United States have persisted, been interrupted, or terminated through the evolution of an El Niño, employing both analyses of the instrumental record and ensemble climate model simulations for this purpose. This work is being done in conjunction with CIRES' Western Water Assessment and the Climate Assessment Project for the Southwest (CLIMAS), which is concerned with assessing the impacts of climate variability and longer-term climate change on human and natural systems.

JULY 2008-JUNE 2009 MILESTONES:

- Continue monitoring daily, seasonal, and longer-term precipitation variability over the western United States. Continue downscaling NCEP Week Two ensemble forecasts for Colorado water-resource managers. Continue developing seasonal forecast guidance tools for the United States based on the predictability of tropical SSTs several seasons in advance.
- Continue programmatic development and impact assessments of climate, weather, and water services, especially in conjunction with the National Integrated Drought Information Service.

JULY 2009-JUNE 2010 MILESTONES:

- Continue monitoring daily, seasonal, and longer-term precipitation variability over the western United States. Continue downscaling NCEP Week Two ensemble forecasts for Colorado water-resource managers. Continue developing seasonal forecast guidance tools for the United States based on the predictability of tropical SSTs several seasons in advance.
- Continue programmatic development and impact assessments of climate, weather, and water services, especially in conjunction with the National Integrated Drought Information Service.

PSD-07 Experimental Climate Data and Web Services

GOAL: Improve public access to climate information and forecast products to facilitate research, to inform public planning and policy decisions, and to assist any interested parties impacted by climate.

APPROACH: Climate services require sustained and systematic communication of climate information to a broad spectrum of users, and interactions with users to determine their priorities and needs. Research at CIRES and elsewhere indicates that there remain substantial barriers to the effective use of climate information (e.g., better and timelier access to data, improved visualization, user-specific needs, and organizational obstacles to using climate information in decisions). CIRES is developing several approaches to overcome

such barriers, such as (1) enhanced weather and climate monitoring products and experimental climate forecasts, (2) enhanced online access, analysis, and visualization tools for climate data, (3) studies of specific user groups and societal interactions, (4) Western Water Assessment activities (covered elsewhere in this Workplan), and (5) studies of the links between climate and public health. All of these are long-term ongoing efforts, with adjustments made every year in response to new opportunities and needs.

JULY 2008-JUNE 2009 MILESTONES:

- Continue updating the extensive, publicly-accessible climate data holdings on the Climate Diagnostic Center/PSD website. Continue acquisition of new precipitation and soil moisture datasets.
- Continue with acquisition and major updating of South and North American historical daily precipitation datasets.

JULY 2009-JUNE 2010 MILESTONES:

- Continue updating the extensive, publicly-accessible climate data holdings on the Climate Diagnostic Center/PSD website. Continue acquisition of new precipitation and soil moisture datasets.
- Continue with acquisition and major updating of South and North American historical daily precipitation datasets.
- Continue programmatic development and impact assessments of climate, weather, and water services, especially in conjunction with the newly established National Integrated Drought Information Service (NIDIS).

Scientific Theme: GEODYNAMICS

GEO-01 GEOPHYSICAL DATA SYSTEMS

NGDC-05	Improved Integration and Modeling of Geomagnetic Data

NGDC-05 Improved Integration and Modeling of Geomagnetic Data

GOAL: Produce reference models of the geomagnetic field for land, sea, air and spaceborne magnetic navigation and altitude/heading systems. Develop real-time models of the magnetic field for advanced magnetic accuracy requirements and space weather applications. Derive ionospheric parameters from magnetic field observations to monitor and predict ionospheric disturbances affecting GPS and radio communication.

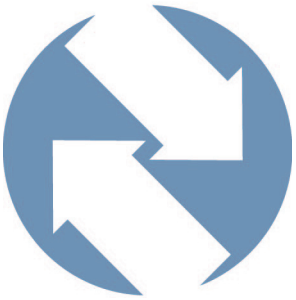
APPROACH: Apply new techniques and methods to improve acquisition, analysis, and integration of geophysical data collected from ship, plane, satellite, and surface platforms, creating long-term, research-quality global databases. Assist in the planning of new satellite magnetic missions. Produce models representing magnetic fields from sources in Earth's core, mantel, crust, oceans, ionosphere and magnetosphere. Derive secondary parameters such as core flow, crustal magnetization and electric fields. Develop external magnetic field models that can be driven by real-time data flows from ground observatories and satellites.

JULY 2008-JUNE 2009 MILESTONES:

- Produce and distribute a new model of the day-side eastward electric field in the equatorial ionosphere.
- Produce and distribute updated global magnetic anomaly map at 3 arc minute resolution, compiled from marine, airborne, and satellite magnetic measurements.

JULY 2009-JUNE 2010 MILESTONES:

- Produce and distribute the World Magnetic Model 2010.
- Produce and distribute beta version of a new Advanced Geomagnetic Model.



Scientific Theme: INTEGRATING ACTIVITIES

IA-01 SCIENCE AND SOCIETY

IA-02 WESTERN WATER ASSESSMENT

IA-03 RESOURCE DEVELOPMENT FOR EDUCATORS AND DECISION MAKERS

IA-01 SCIENCE AND SOCIETY

CSD-10	Scientific Assessments for Decision Makers
Policy-01	Science Policy Lecture Series

CSD-10 Scientific Assessments for Decision Makers

GOAL: Plan, lead, prepare, and disseminate assessments for the decision-making communities associated with ozone-layer depletion, greenhouse warming, and regional air quality.

APPROACH: Current emphases are on (1) the UNEP/WMO Ozone Science Panel of the Montreal Protocol, (2) the Intergovernmental Panel on Climate Change, (3) the synthesis and assessment products of the U.S. Climate Change Science Program, and (4) the surface-level ozone and fine particles assessments of the North American Research Strategy for Tropospheric Ozone (NARSTO). These assessments form a link to CIRES, ESRL, other NOAA, national, and international research groups and results. CIRES researchers serve in roles such as lead authors, coauthors, contributors, reviewers, and coordinating editors. The assessments interact with governments, industry, and the public to describe scientific findings in user-friendly terms.

JULY 2008-JUNE 2009 MILESTONE:

- Contribute to the coordination and completion of the Synthesis and Assessment Product of the U.S. Climate Change Science Program (SAP 2.4, on chemistry related to the stratospheric ozone layer). Impact: This research contributes to information needed by U.S. decision makers on topics related to climate.

JULY 2009-JUNE 2010 MILESTONES:

- Carry out the early planning, organizational, and drafting stages of the UNEP/WHO 2010 scientific state-of-understanding assessment of the ozone layer for the U.N. Montreal Protocol. Impact: This research contributes to the international scientific community's periodic updates of scientific understanding, which support the decision making of the over 180 nations that are Parties to the United Nations Montreal Protocol on Substances that Deplete the Ozone Layer.

Policy-01 Science Policy Lecture Series

GOAL: Provide useful information that will help improve the relationship between societal needs and science and technology policies.

APPROACH: Develop a regular lecture series focused each year on a different topic of interest to the science and technology policy (and larger) community.

JULY 2008-JUNE 2009 MILESTONE:

- Continue the highly successful noontime seminar series held at the Center for Science and Technology Policy Research that brings in students, faculty, and researchers to discuss their science policy research and conduct additional outreach to departments that have not previously been involved to broaden the audience. Prepare for publication, a book developed on the Presidential Science Advisor lecture series. Plan a follow-up lecture series.

JULY 2009-JUNE 2010 MILESTONES:

- Continue the highly successful noontime seminar series held at the Center for Science and Technology Policy Research that brings in students, faculty, and researchers to discuss their science policy research and conduct additional outreach to departments that have not previously been involved to broaden the audience. Launch lecture series focusing on a current topic of interest to the science policy community.

IA-02 WESTERN WATER ASSESSMENT

WWA-01	Scientific Assessments
WWA-02	Climate Products
WWA-03	Climate and Water Affairs
WWA-04	Management

WWA-01 Scientific Assessments

GOAL: Identify and characterize regional vulnerabilities to climate variability and change for use by Intermountain water-resource decision makers.

APPROACH: Using models, analyses, surveys, written reports, and presentations, acquire and disseminate information about the relationship between Rocky Mountain climate and water resources.

JULY 2008-JUNE 2009 MILESTONES:

- *Colorado Meteorological Station Data long-term trends*. In conjunction with the Colorado State Climatologist's office, evaluate all suitable stations in Colorado for long-term precipitation and temperature trends.
- *Colorado River Climate Change Analysis*. Utilize USBR's Colorado River Seasonal Forecasting (CRSS)

model to investigate the vulnerability of the Upper Colorado River basin to changes in inflows based on stochastically-generated streamflows that preserve spectral characteristics identified in historic and paleo records. The CRSS operations model will be used to analyze how current operating policies perform under differing streamflow regimes. In addition, the operations model will be run in optimization mode to identify how different operating policies would perform under modified streamflows.

- *Colorado River Seasonal Forecasting*. Investigate and identify historical relationships between seasonal streamflows in the basin and large scale climate variables such as PDO, ENSO, and AMO in order to develop a set of predictors for the Upper Colorado River basin streamflow. Predictors will be used to project upcoming year streamflows and the streamflows will be used in an operations model for the next 24 months. The operations model will be run in two modes: one using current reservoir rules and one using modified rules to identify beneficial policy changes.
- *Colorado Snowcourse Analysis*. In conjunction with the local U.S. Department of Agriculture's Natural Resources Conservation Service (USDA NRCS) office, the full data record of snowcourses, dating back to 1936, and SNOTEL, dating back to 1978, will be surveyed in order to develop basin-wide normals based on the longest and most reliable records. The existing 'normals' utilize all records, despite known problems with certain sites that can lead to erroneous analysis of runoff by water managers.
- *Dust on Snow Studies*. Investigate variability and impacts of dust storms on Southwest Colorado snowpack. Preliminary analyses indicates that runoff can occur up to one month earlier with significant impacts on water management.
- *Lead Authors on the U.S. Climate Change Science Program (CCSP) Unified Synthesis Product*. Provide input into water chapter of new CCSP "National Assessment" through lead authorship.

JULY 2009-JUNE 2010 MILESTONES:

- *Colorado River Climate Change Analysis*. Utilize USBR's Colorado River Seasonal Forecasting (CRSS) model to investigate the vulnerability of the Upper Colorado River basin to changes in inflows based on stochastically-generated streamflows that preserve spectral characteristics identified in historic and paleo records. The CRSS operations model will be used to analyze how current operating policies perform under differing streamflow regimes. In addition, the operations model will be run in optimization mode to identify how different operating policies would perform under modified streamflows.
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WWA-02 Climate Products

GOAL: Develop information, products and processes to assist water-resource decision makers throughout

the Intermountain West.

APPROACH: Provide decision makers with datasets, documents, websites and other products to enable more informed decision making.

JULY 2008-JUNE 2009 MILESTONES:

- *Monthly Intermountain Climate Summary*. Climate information is widely scattered on the web and other locations. Water managers and other climate-sensitive sectors have requested a single-monthly summary of climate information including precipitation, temperature, snow water equivalent, long-lead temperature and precipitation outlooks, reservoir levels, and streamflow forecasts.
- *Web-based Seasonal Guidance for Water Managers, Climate Prediction Center (CPC)*. Improve ability of federal, state, and local water managers to plan water operations during drought. Provide input to CPC seasonal outlooks.
- *National Integrated Drought Information System (NIDIS)*. As necessary, the Western Water Assesment (WWA) will provide support activities for NIDIS implementation efforts. This may include providing support for conferences, performing research, and providing input to NIDIS pilot projects, including the anticipated Colorado River pilot.
- *Lead authors on "Citizen's Guide to Climate Change"*. Provide overall guidance and author several chapters for a citizen's guide currently being developed by a local foundation.
- *WWA Website*. Provide a portal into all Western Water activities for researchers, water providers and the public. Website provides extensive documentation on Colorado River climate, various forecasts, and results of past research.

JULY 2009-JUNE 2010 MILESTONES:

- *Monthly Intermountain Climate Summary*. Climate information is widely scattered on the web and other locations. Water managers and other climate-sensitive sectors have requested a single-monthly summary of climate information including precipitation, temperature, snow water equivalent, long-lead temperature and precipitation outlooks, reservoir levels, and streamflow forecasts.
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WWA-03 Climate and Water Affairs

GOAL: Increase decision makers' level of knowledge about climate science so they can become better consumers and demanders of climate products and assessments, which will assist WWA in setting its research agenda.

APPROACH: Using workshops, personal interactions, websites and written documents, communicate climate and hydrology information to key water-resource decision makers.

JULY 2008-JUNE 2009 MILESTONES:

- *Dendrohydrological Workshops*. Increasing interest by water managers in tree-ring reconstructions of streamflow has led to a demand for a hands-on workshop on how the reconstructions are generated and assessed. The goal is to provide water managers with the necessary tools to better interpret the reconstructions and apply them to water planning.
- *Water Availability Task Force*. Provide technical support for the Governor's drought task force, as needed, including issuing experimental regional seasonal forecasts.
- *Speakers for Interested Organizations and Public Events*. WWA is often invited to speak on the interaction of climate and water at public events and to various organizations, and will continue to perform this service.
- *Provide Technical Analysis and Education for Front Range Water Providers*. A consortium of Front Range Water providers has been awarded an Awwa Research Foundation grant to investigate the changes in runoff that may occur in response to climate change. WWA will provide technical support and educational services for this effort.

JULY 2009-JUNE 2010 MILESTONES:

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WWA-04 Management

GOAL: Provide overall guidance to project as well as day-to-day management.

APPROACH: Using regular meetings, web sites and written documents.

JULY 2008-JUNE 2009 MILESTONE:

- *General Management Activities*. Hold biweekly team meetings. Prepare annual budget. Interact with Regional Integrated Sciences and Assessments (RISA) Program managers. Interact with CIRES and

NOAA administrative staff. Establish strategic activities.

JULY 2009-JUNE 2010 MILESTONE:

- *General Management Activities*. Hold biweekly team meetings. Prepare annual budget. Interact with Regional Integrated Sciences and Assessments (RISA) Program managers. Interact with CIRES and NOAA administrative staff. Establish strategic activities.

IA-03 RESOURCE DEVELOPMENT FOR EDUCATORS AND DECISION MAKERS

Policy-02	Outreach to Decision Makers through the Internet
Policy-03	Outreach to Decision Makers through Newsletters

Policy-02 Outreach to Decision Makers through the Internet

GOAL: Provide useful information that will help improve the relationship between societal needs and science and technology policies.

APPROACH: The Center for Science and Technology Policy Research maintains an extensive website to disseminate research results and other information of interest to science and technology policy decision makers.

JULY 2008-JUNE 2009 MILESTONE:

- Continue to maintain and upgrade the Center for Science and Technology Policy's website and increase its usefulness to users. Increase its reliability and stability through hardware and software upgrades as necessary.

JULY 2009-JUNE 2010 MILESTONE:

- Seek ways to determine preferences of website users and incorporate those preferences into the site design and content.

Policy-03 Outreach to Decision Makers through Newsletters

GOAL: Provide useful information that will help improve the relationship between societal needs and science and technology policies.

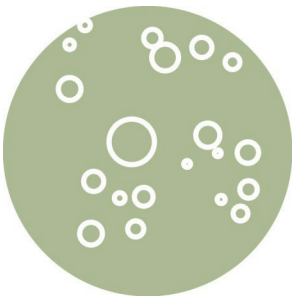
APPROACH: The Center for Science and Technology Policy Research currently publishes a newsletter, *Ogmius*, three times a year. Each issue includes at least one opinion piece and news of interest to the science and technology policy community. *Ogmius* is available online and in pdf format. Subscriptions are free and subscribers receive email notification when a new *Ogmius* is available. The Center plans to resume publication of the *Weatherzine* newsletter, which temporarily suspended publication in 2002 because of a shortage in funding. This newsletter, which addresses the societal aspects of weather, follows a format similar to *Ogmius*.

JULY 2008-JUNE 2009 MILESTONE:

- Add new section to newsletter: "Ask a Science Policy Expert." Continue to seek ways to expand readership.

JULY 2009-JUNE 2010 MILESTONE:

- Continue to upgrade newsletter and expand readership.



Scientific Theme: PLANETARY METABOLISM

PM-01 BIOSPHERE-ATMOSPHERE INTERACTIONS

PM-02 RESPONSE OF NATURAL SYSTEMS TO PERTURBATIONS

PM-01 BIOSPHERE-ATMOSPHERE INTERACTIONS

CSD-07	Biosphere-Atmosphere Exchange

CSD-07 Biosphere-Atmosphere Exchange

GOAL: Gain an improved understanding of the role that the exchange of gases between the surface and the atmosphere plays in shaping regional climate and air quality.

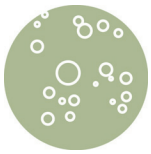
APPROACH: Perform measurements and modeling analyses to make frequent, ultra-sensitive measurements of gases that are emitted by vegetation (e.g., oxygenated organic compounds) or that are the result of biomass burning (natural or anthropogenic) that subsequently influence regional climate and air quality. Design laboratory, field, and diagnostic studies to gain a better understanding of the compounds that are emitted, the sources and extent of those compounds, and the impact on the atmospheric environment. Focus particularly on those compounds likely to play an important role in the chemistry related to air quality in the lowermost troposphere, as well as climate-related gases. In addition, study the processes that deliver atmospheric gases and fine particles from the atmosphere to the biosphere, with potentially harmful consequences for ecosystems.

JULY 2008-JUNE 2009 MILESTONES:

- Measure particle nucleation and growth rates in laboratory experiments following the gas-phase oxidation of biogenic sesquiterpene (C15H24) compounds by ozone (O3) and the hydroxyl (OH) radical. Impact: This research will provide information currently needed to quantitatively evaluate the role of biogenic compounds in new particle formation as well as secondary organic aerosol formation.
- Measure the emissions of acidic and other trace gases from biomass burning at the Fire Sciences Laboratory in Missoula, Montana, using a new chemical ionization mass spectrometry (CIMS) method. Impact: Determine emissions factors for organic acids from forest fires, which are suspected to be a large fraction of the total emissions.

JULY 2009-JUNE 2010 MILESTONES:

- Measure reaction rate coefficients and evaluate the atmospheric degradation mechanisms of key bio-



genic species. Impact: This research will provide information needed to quantitatively evaluate the role of biogenic compounds in regional ozone production and secondary organic aerosol formation, and has implications for regional air quality.

- Analyze the atmospheric chemistry implications of trace gases emitted from biomass burning. Impact: The emissions from biomass burning have implications for regional air quality and climate.

PM-02 RESPONSE OF NATURAL SYSTEMS TO PERTURBATIONS

NGDC-07	Anthropogenic Remote Sensing

NGDC-07 Anthropogenic Remote Sensing

GOAL: Provide spatial and temporal depictions of human activities based on satellite detection and mapping of population centers, fires, gas flares, and heavily-lit fishing boats.

APPROACH: The technique will use nocturnal observations of anthropogenic lighting associated with human settlements, biomass burning, gas flares and heavily-lit fishing boats. Time series analysis through individual years makes it possible to separate these four sources of lighting. The resulting products will be used in mapping urban growth and modeling the density of impervious surface areas, gross domestic product, poverty levels, national level gas flaring volumes, and trends in fishing activity.

JULY 2008-JUNE 2009 MILESTONES:

- Develop intercomparable radiance calibrated nighttime lights set for 1996-97, 2000-01, and 2005-06.
- Complete a geospatial depiction of global economic activity based on satellite-observed nighttime lights.
- Develop an earth observation mission concept for moderate resolution nighttime lights.

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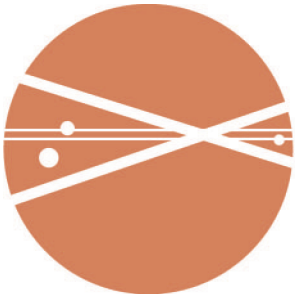


Scientific Theme: REGIONAL PROCESSES

RP-01 REGIONAL HYDROLOGICAL CYCLES IN WEATHER AND CLIMATE

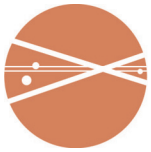
PSD-11 Water Cycle

GOAL: Improve weather and climate predictions through an increased knowledge of regional and global water cycle processes.

APPROACH: Design innovative measurement systems for improved water cycle observations. Deploy ground-, ship-, and aircraft-based systems as part of focused field program designed to increase the understanding of regional water-cycle processes. Use available satellite data to better understand global water cycle processes. Use knowledge gained from observational studies to improve forecast model performance.

JULY 2008-JUNE 2009 MILESTONES:

- Plan and execute the 2009 Hydrometeorology Testbed (HMT)-West field campaign, conducted in the northern California American River basin, located in the Sierra Nevada mountains west of Lake Tahoe and east of Sacramento. CIRES investigators will be key participants and contributors to these activities.
- Using a suite of wind-profiling radar, GPS, and meteorological *in-situ* instrumentation deployed during the 2008 NOAA HMT, a prototype of a graphical decision-making support tool will be designed and developed to aid in the forecasting of extreme orographic precipitation events. Model forecast data will also be integrated into the tool to provide verification of quantitative precipitation forecasts, and to aid in identifying and isolating deficiencies in modeled precipitation-forcing processes. Feedback from weather forecasters and water-resource and emergency managers will be gathered to determine the most applicable way to represent the tool for efficient use in near-real-time decision making.
- Develop and test a remote sensing method to retrieve precipitation parameters from CloudSat. Model the hydrometeor and gaseous attenuation at W-band and estimate the multiple scattering effects for



the CloudSat configuration. Modeled results will be used to develop a method that will relate rainfall rate to the gradients of the observed CloudSat measurements in the rain layer. The cloud absorption will be estimated and statistically analyzed. The developed method will be tested on a number of case studies of rainfalls of different intensity. The results of CloudSat rainfall retrievals will be quantitatively compared with available surface measurements (e.g., from the ground-based precipitation radars). The retrieval errors of the CloudSat retrievals will be assessed. The proposed method is expected to be immune to the errors in the absolute radar calibrations and will be applicable to CloudSat measurements above water and land surfaces.

- The height of the freezing level of precipitation is important for predicting the amount of runoff that will occur in hydrologic catchments during wintertime storms. A feasibility study will evaluate if X-band polarimetric scanning radar observations can be used to identify the precipitation freezing level. Observations from the NOAA-HMT-2006 field campaign will be used in this feasibility study.

JULY 2009-JUNE 2010 MILESTONES:

- Plan and execute the 2010 HMT-West field campaign, likely the last in a series of field efforts conducted in the northern California American River basin, located in the Sierra Nevada mountains west of Lake Tahoe and east of Sacramento. Also, plan the first HMT-East field campaign, likely to be conducted in the mid to southern Atlantic region of the eastern United States. CIRES investigators will be key participants and contributors to these activities.
- A real-time, quasi-operational version of the orographic–precipitation support tool will be developed and implemented with web interface access. Evaluation and fine tuning of the product will occur based on continued feedback from weather forecasters and water-resource and emergency managers using the tool to assess real-time flooding risks.
- Develop and test a dual-wavelength mm-wavelength method to simultaneously retrieve cloud and rainfall parameters using ground-based Ka- and W-band radars. The proposed method will take advantage of different rates of radar signal attenuation in clouds and rain at Ka and W-bands. Modeling with available drop size distributions will lead to the two-dimensional matrix describing Ka- and W-band attenuation in rainfall layer containing both rain and liquid clouds. A combined polarimetric-Doppler approach will be developed to identify the boundaries of this layer as seen by the ground-based vertically pointing Ka- and W-band radars. The retrieval method will use the observed Ka- and W-band attenuated reflectivity measurements and convert them to estimated mean rain rate and liquid cloud water path using the attenuation matrix. The Ka-band radar measurements will be corrected for attenuation in rain and melting layers to estimate ice water path above the freezing level. The proposed method will be applied to the measurements from Climate Research Facilities maintained by the Atmospheric Radiation Measurement Program. The retrieval results will provide a more comprehensive characterization of the components of the water cycle in the vertical atmospheric column in presence of precipitation.
- If X-band polarimetric scanning radar observations can be used to identify the precipitation freezing level, NOAA weather forecasters in the field will need a simple display of the freezing level to help support their forecasts. Dependent on the outcome of the 2008-2009 precipitation freezing level feasibility study, a Decision Support Tool prototype will be developed that estimates the precipitation freezing level height using X-band polarimetric scanning radar observations.

RP-02 SURFACE/ATMOSPHERE EXCHANGE

PSD-12	Air-Sea Interaction

PSD-12 Air-Sea Interaction

GOAL: Perform cutting-edge micrometeorological and climatological research over the open ocean aboard research vessels, sea-based towers, and buoys.

APPROACH: Design and deploy innovative measurement systems for open-ocean observations within the marine boundary layer. Examples of measurement systems include: cloud, precipitation, wind profiling, and clear-air radars; a variety of lidar systems; air-sea turbulence systems for measurement of the fluxes of gas, momentum, and heat; and sea-spray droplet spectral observations. Deployments may last a few weeks or many months, or may reoccur every year at a particular cruise location in order to develop a climatological record. Resulting datasets will be processed and analyzed for interpretation of surface, boundary-layer, and cloud processes over the ocean for use in improving the physics in small-scale parameterizations, which can be applied to larger-scale predictive models.

JULY 2008-JUNE 2009 MILESTONES:

- Complete a synthesis data set for EPIC extended monitoring cruises.
- Continue parameterization of sea spray as part of the NOAA hurricane studies.
- Analyze flux and gas transfer observations from NOAA GASEX-III field program in the Southern Ocean.
- Parameterization of stable boundary-layers as part of the NOAA/NSF Polar Programs.

JULY 2009-JUNE 2010 MILESTONES:

- Begin construction of a synthesis data set for VOCALS-REX data.
- Continue parameterization of sea spray as part of the NOAA hurricane studies.
- Analyze flux and gas transfer observations from NOAA GASEX-III field program in the Southern Ocean. Submit results for publication.
- Parameterization of stable boundary-layers as part of the NOAA/NSF Polar Programs.

RP-03 REGIONAL AIR QUALITY

GMD-06	Baseline Air Quality
PSD-13	Air Quality
CSD-08	Regional Air Quality
GSD-02	Regional Air Quality Prediction

GMD-06 Baseline Air Quality

GOAL: Study intercontinental transport events to improve the understanding of their importance in affect-

ing overall air quality and impacts on public health.

APPROACH: Although much effort has been focused on obtaining long-term measurements of the remote atmosphere, it has been necessary to make observations at sites that are influenced regionally in order to understand the distribution and nature of the sources of climatically important gases. Large-scale pollution and dust from Asia, for example, is transported at mid-latitude across the Pacific Ocean in a matter of days and affects sites in the United States. Fires in Central America send smoke plumes across Mexico and the South-Central United States, and dust from Africa regularly reaches the eastern United States.

JULY 2008-JUNE 2009 MILESTONES:

- As part of the Department of Energy's Atmospheric Radiation Measurement Program, aerosol optical and cloud forming properties from the Anhui Province in China will be measured.
- Analyze the surface ozone and ozone vertical profile measurements at Trinidad Head, California, and at Mauna Loa, Hawaii, for longer-term changes that could be related to changing Asian emissions.

JULY 2009-JUNE 2010 MILESTONES:

- As part of the Department of Energy's Atmospheric Radiation Measurement Program, aerosol optical and cloud forming properties from the Azores Island in the Atlantic will be measured.
- Analyze ozone profile measurements along with other constituent measurements obtained from small aircraft to identify ozone sources that are associated with long-range transport.

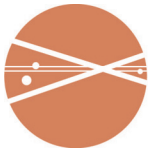
PSD-13 Air Quality

GOAL: Gather and analyze atmospheric observations to characterize meteorological processes that contribute to high-pollution episodes. Compare these measurements with air-quality forecasting model predictions to assess and improve research model performance.

APPROACH: Develop and deploy state-of-the-art lidar and wind profiler remote-sensing and supporting instruments in various regions of the United States that have difficulty meeting the national air-quality standards. The remote-sensing observations will also be used to evaluate the performance of air-quality forecasting models in terms of the meteorological processes crucial for air quality.

JULY 2008-JUNE 2009 MILESTONES:

- Submit two publications on wind profiler, air/sea fluxes, ozone fluxes, and rawinsonde data onboard the NOAA Research Ship Ronald H. Brown during the Texas Air Quality Study 2006.
- Analyze meteorological data collected during the 2008 Front Range Air Quality Study. Advise air chemistry experts on the results. During the summer of 2008, ESRL conducted a Front Range air quality study, partly in response to the region's failure to meet EPA's national ambient air-quality standard for ozone. Because of the complex terrain and urbanization, there are complex meteorological processes that affect the transport of pollutants. Using wind profilers and a surface station on the continental divide, the meteorological processes that contribute to ozone exceedances will be investigated.
- Contribute to planning for the 2010 California Air Quality Study. In 2010, ESRL will use surface and airborne chemical and meteorological measurements to characterize the pollution events in Califor-



nia. CIRES investigators will help design the surface networks.

JULY 2009-JUNE 2010 MILESTONES:

- Analyze data from the International Polar Year (IPY)/International Chemistry Experiment in the Arctic Lower Troposphere (ICEALOT) cruise on R/V Knorr for planetary boundary layer flux aspects of winter pollution off the U.S. East Coast (contrast with the New England Air Quality Study).
- Participate in the 2010 California Study by deploying a network of wind profilers and related meteorological equipment to provide the meteorological context for air pollution events in California. Monitor the data collection and provide real-time access to the data, as well as derived products, including mixing depth and wind-profiler-based trajectories.

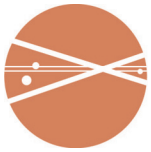
CSD-08 Regional Air Quality

GOAL: Conduct laboratory measurements, atmospheric observations, and diagnostic analyses that characterize the chemical and meteorological processes involved in the formation of pollutant ozone and fine particles. Undertake research that contributes to the enhancement of air quality prediction and forecasting capabilities.

APPROACH: Design, evaluate, and apply state-of-the-art measurement methods from airborne and shipborne platforms and ground-based sites to the study of natural and anthropogenic ozone and fine-particle precursors and diagnostic species in key regions of the United States. Current special foci include the examination of the roles of natural sources; the effect of anthropogenic emission sources, such as power plants and refineries; coastal meteorological influences on ozone production over adjacent land areas; the regionality of ozone production, and; the chemical makeup of fine particles. A hallmark of this research is the collaborative involvement of CIRES researchers affiliated with several NOAA laboratories, as well as partners in numerous other organizations and agencies. Apply laboratory analytical methods to quantify the rates of reactions and their temperature and other dependencies, and the chemical products that are produced. The current emphasis is on using the newly-developed optical cavity approaches to study the photochemistry of highly-reactive, short-lived chemical species that evoke much of the ozone formation, nighttime species, and particle-forming species, such as ammonia. Design and evaluate the detailed chemistry and height resolution in air quality models using the detailed, simultaneous multi-species measurements carried out in the state-of-the-art measurement methods described above. A current emphasis is on diagnostic modeling that can guide the planning of regional field studies. A further emphasis is on the advancement and evaluation of models used to forecast air quality.

JULY 2008-JUNE 2009 MILESTONES:

- Continue to interpret, present and publish results from the 2006 Texas Air Quality Study (TexAQS) field study. Impact: TexAQS 2000 and 2006 data and analyses will be used to help the State of Texas develop a plan to bring several areas into compliance with the federally mandated National Ambient Air Quality Standards for ozone and particulate matter.
- Contribute to an air quality study in the Colorado Front Range area in summer 2008 by deploying an ozone and Doppler wind lidar on a research aircraft. Impact: This research will provide important information on the distribution and transport of ozone and aerosols in the Front Range urban corridor. This study is very timely as the greater Denver area violated the national ozone standard last year and, with a new, lowered ozone standard recently approved by the EPA, is likely to face continued air quality problems.



- Analyze High-Resolution Doppler Lidar measurements data to study nocturnal boundary layer structure and develop techniques to estimate boundary layer height. Impact: Accurate estimation of the height of the stable boundary layer (SBL) and its evolution through the night are very important for better understanding of nighttime mixing processes, scaling laws, parameterization development, and evaluation of the representation of these processes in numerical weather prediction and air quality models. Consideration of nocturnal mixing and transport processes is important for proper interpretation of nighttime chemistry observations. Aspects of the nocturnal SBL and the accompanying low-level jet have a key role in wind-energy development.
- Measure the quantum yields for the formyl radical (HCO) in the UV photolysis of glyoxal, HC(O)C(O)H, over a range of wavelengths and pressures relevant to the atmosphere. Impact: This research will provide data required for atmospheric model calculations of the wavelength and pressure dependence for aldehyde photolysis channels that lead to odd hydrogen (HOx) production in the atmosphere. This research has implications for regional air quality and climate-chemistry coupling.
- Measure the rate coefficient for the reaction of hydroxyl radical with methyl glyoxal, CH3C(O)C(O)H, over the range of temperatures and pressures common to the troposphere and lower stratosphere to better elucidate the role of oxygenated hydrocarbons in radical (HOx) and ozone production. Impact: This research will provide rate coefficient data for the accurate determination of the atmospheric loss of methyl glyoxal by reaction with the hydroxyl (OH) radical. Knowledge of atmospheric lifetimes and chemical destruction pathways for methyl glyoxal (an oxygenated hydrocarbon) is important for understanding of air quality.

JULY 2009-JUNE 2010 MILESTONES:

- Prepare for the 2010 CalNex Air Quality Study in California and continue to study processes that affect air quality in the Colorado Front Range area. Impact: In the summer of 2009 additional research flights will be carried out to continue studying processes that play an important role in determining air quality in the Front Range Urban Corridor, and to test and upgrade airborne ozone and Doppler lidar systems for the 2010 CalNex Air Quality Study in California. A major focus of the instrumentation upgrade will be to co-deploy ozone and Doppler wind lidars on a NOAA Twin Otter aircraft. This combination of airborne lidars will enable measurements of horizontal and vertical transport processes and ozone and aerosol distribution simultaneously at high resolution.
- Apply new techniques to analyze observations from lidar studies of jet plume characteristics to improve estimates of emission rates. Impact: A field study employing a new scanning aerosol lidar for characterizing backscatter and extinction in plumes from jet engines is planned for late 2008. Aircraft engine emissions are a potential source of degradation around high-traffic airports in urban areas. New analysis methods, including development of a physically-based model for plume behavior and investigation of new mixing rules, offer the potential to significantly improve estimates of plume emissions from aircraft taxiing or on takeoff.
- Carryout detailed planning for the 2010 CALNEX combined air-quality and climate field study. Impact: CALNEX data and analyses will be used to help the State of California develop plans to bring several areas of the state into compliance with the federally mandated National Ambient Air Quality Standards for ozone and particulate matter, and to help guide the state on the best options to combine air quality improvement with the mitigation of climate forcing.
- Measure the UV absorption spectrum of the ClO dimer (Cl2O2) in laboratory experiments over the range of wavelengths and temperatures most relevant to polar stratospheric photochemistry. Impact: This research will provide data needed to reduce uncertainties in atmospheric model calculations of polar ozone loss. This research has implications for stratospheric ozone chemistry and climate-

chemistry coupling.

- Continue laboratory measurements to evaluate radical and molecular production formation in the UV/visible photolysis of key atmospheric oxygenated compounds, such as acetone (CH3C(O)CH3) and formaldehyde (H2CO). Impact: Research under this theme will reduce uncertainties in model calculations of odd hydrogen (HOx) production in the atmosphere. This research has implications for regional air quality and climate-chemistry coupling.
- Measure chlorine activation in laboratory experiments of the heterogeneous reaction of dinitrogen pentoxide (N2O5) with hydrogen chloride (HCl)-doped sulfate aerosol and bulk surfaces. Impact: This research will evaluate the possible significance of this chemistry as an atmospheric source of chlorine activation. This research has implications for air quality, stratospheric ozone, and climate-chemistry coupling.

GSD-02 Regional Air Quality Prediction

GOAL: Design and evaluate new approaches for improving air quality prediction.

APPROACH: Perform research to develop and evaluate new techniques for improved transport and chemical evolution in fully coupled atmospheric/chemistry models capable of real-time forecasts. Engage in real-time air quality forecasts for ozone and PM2.5 and PM10. Evaluate forecasts using observations from special observing periods.

JULY 2008-JUNE 2009 MILESTONES:

- Develop and test the capability to assimilate, using the Gridpoint Statistical Interpolation analysis and observations of ozone and chemical species important in reactions involving ozone, into the WRF-chem prediction model.
- Prepare documentation and tutorials to support WRF/Chem as a community model.

JULY 2009-JUNE 2010 MILESTONES:

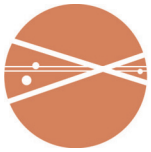
- Introduce aerosol prediction capability into the flow-following, icosahedral global weather prediction model, using the GOCART (Goddard Chemistry Aerosol Radiation and Transport) module, together with global wildfire definition and global aerosol emissions data. Make aerosol predictions on test cases.
- Continue to coordinate worldwide development of WRF-chem as an air-quality prediction tool.

RP-04 INTERCONTINENTAL TRANSPORT AND CHEMICAL TRANSFORMATION

CSD-05	Tropospheric and Stratospheric Transport and Chemical Transformation

CSD-05 Tropospheric and Stratospheric Transport and Chemical Transformation

GOAL: Carry out modeling studies and airborne and surface measurements of chemical species in order to elucidate the processes involved in the intercontinental transport of photochemical pollution.



APPROACH: Design, evaluate, and apply state-of-the-art measurement methods from airborne and ship-borne platforms and ground-based sites. Use these data and correlations among species to establish natural and anthropogenic influences on global "greenhouse" tropospheric ozone and related species, with an emphasis on analysis of the data collected over the North Atlantic and Eastern Pacific regions. The research has an initial focus on the long-lived pollutants, carbon monoxide, ozone, and fine particles.

JULY 2008-JUNE 2009 MILESTONES:

- Archive and begin analysis of the data from the International Chemistry Experiment in the Arctic Lower Troposphere (ICEALOT) field mission. ICEALOT was carried out in spring 2008 as part of the International Polar Year to examine the aerosol properties and atmospheric chemistry over an ice-free region of the Arctic. The study investigated: (1) springtime sources and transport of pollutants to the Arctic, (2) evolution of aerosols and gases into and within the Arctic, (3) aerosol – radiation interactions, and (4) ozone budget and climate effects.
- Archive and begin analysis of data from the Aerosol, Radiation, and Cloud Processes affecting Arctic Climate (ARCPAC) field mission. Impact: ARCPAC was carried out in spring 2008 as part of the International Polar Year to examine the aerosol properties and atmospheric chemistry over an ice-free region of the Arctic. The study investigated: (1) direct warming of the lower troposphere by the absorption of solar radiation and infrared emission by aerosol particles from anthropogenic and biomass burning, (2) changes in snow melt due to deposition of soot (light-absorbing carbon) to the surface in springtime, (3) increases in infrared emissivity of wintertime and springtime clouds in the Arctic due to the effects of anthropogenic aerosol particles on cloud properties, and (4) direct radiative effects of tropospheric ozone in the Arctic.

JULY 2009-JUNE 2010 MILESTONES:

- Analyze, interpret and publish the climate-related results from the International Chemistry Experiment in the Arctic Lower Troposphere (ICEALOT) field mission. Impact: ICEALOT was carried out in spring 2008 as part of the International Polar Year to examine the aerosol properties and atmospheric Chemistry over an ice-free region of the Arctic. The study investigated: (1) springtime sources and transport of pollutants to the Arctic, (2) evolution of aerosols and gases into and within the Arctic, (3) aerosol – radiation interactions, and (4) ozone budget and climate effects.
- Analyze, interpret and publish the climate-related results from the Aerosol, Radiation, and Cloud Processes affecting Arctic Climate (ARCPAC) field mission. Impact: The ARCPAC field mission was carried out in spring 2008 as part of the International Polar Year to examine the aerosol properties and atmospheric chemistry over an ice-free region of the Arctic. The study investigated: (1) direct warming of the lower troposphere by the absorption of solar radiation and infrared emission by aerosol particles from anthropogenic and biomass burning, (2) changes in snow melt due to deposition of soot (light-absorbing carbon) to the surface in springtime, (3) increases in infrared emissivity of wintertime and springtime clouds in the Arctic due to the effects of anthropogenic aerosol particles on cloud properties, and (4) direct radiative effects of tropospheric ozone in the Arctic.

RP-05 AEROSOL CHEMISTRY AND CLIMATE IMPLICATIONS

CSD-09	Aerosol Formation, Chemical Composition, and Radiative Properties

CSD-09 Aerosol Formation, Chemical Composition, and Radiative Properties

GOAL: Carry out airborne, shipborne, and ground-based experiments that characterize the chemical composition of radiatively important aerosols in the upper troposphere and at Earth's surface.

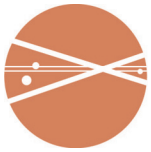
APPROACH: Conduct experiments aboard aircraft and ship platforms to characterize the chemical composition of individual particles, which is a key to establishing their radiative role and air quality implications. Emphases include the chemistry of rocket plumes, the chemical makeup of Northern Hemisphere tropical aerosols, and particle-cloud interactions. Conduct laboratory experiments to elucidate formation mechanisms of atmospheric aerosols.

JULY 2008-JUNE 2009 MILESTONES:

- Deploy a ship-based Doppler lidar to measure clear-air, sub-cloud updraft velocities and horizontal winds over the ocean to study aerosol-cloud-precipitation dynamical interactions. Impact: Low-level horizontal winds, vertical winds, and turbulence strength impact the relationship between aerosols (at the surface or aloft) and the formation of closed and/or open cell stratocumulus decks that, in turn, affect Earth's albedo.
- Analyze field data from the R/V Knorr during the International Chemistry Experiment in the Arctic Lower Troposphere (ICEALOT) experiment. Impact: This experiment, done in cooperation with the Pacific Marine Environmental Laboratory and others, will examine the role of pollution and other factors on climate in the northern Atlantic and Arctic oceans.
- Analyze field data from the NOAA WP-3D research aircraft during the Aerosol Radiation, and Cloud Processes affecting Arctic Climate (ARCPAC) experiment. Impact: These data will improve the knowledge of aerosols and climate in the Arctic.
- Use data acquired during the Gulf of Mexico Atmospheric Composition and Climate (GoMACCS) field study and models to publish findings that evaluate the radiative forcing of clouds in the Houston area and the influence of aerosols on this forcing. Impact: The radiative forcing of clouds, and the modification of this forcing due to aerosols, is one of the largest unknown variables in climate change. The combination of measurements and models will enable the evauation of the magnitude of this forcing.
- Use data from the 2006 Texas Air Quality Study (TexAQS) to examine the relationship between black carbon aerosol and carbon monoxide in a highly polluted urban area. Impact: Black carbon aerosol, emitted from fossil fuel and biomass burning, is a principal component of anthropogenic climate change. Establishing the relationship between black carbon and carbon monoxide emissions will help improve the representation of black carbon emissions in global aerosol models and policy discussions of climate change.
- Use data from the 2006 TexAQS to examine the mass, mixing state, and optical size of individual black-carbon particles in fresh emissions from urban and biomass burning sources. Impact: These measurements will bound the likely variability in the microphysical state of black carbon emissions from typical continental processes, and provide direct measurements of the size distribution and coating state of fine-mode black carbon for use in constraining climate and aerosol models.

JULY 2009-JUNE 2010 MILESTONES:

- Analyze ship-based Doppler lidar measurements of clear-air vertical velocities and vertical wind



shear over the ocean to understand aerosol-cloud-precipitation dynamical interactions and perform satellite validation. Impact: Vertical winds and turbulence strength impact the relationship between aerosols and cloud decks that, in turn, affect surface albedo. Low-level mixing heights and wind and turbulence profiles acquired during cloud-free periods demonstrate utility for current and future wind satellite validation and performance prediction, as well as for validation of satellite-based studies of boundary layer structure.

- Analyze field data from the R/V Knorr during the International Chemistry Experiment in the Arctic Lower Troposphere (ICEALOT) experiment for the impact of European pollution. Impact: Pollution will have different effects on the climate of the Arctic than on other regions, and these differences are vital to understanding climate change in the Arctic.
- Publish and present field data from the NOAA WP-3D research aircraft during the Aerosol Radiation, and Cloud Processes affecting Arctic Climate (ARCPAC) experiment. Impact: These data will improve knowledge of aerosols and climate in the Arctic.
- Model case studies of the interaction of aerosols with clouds and compare to Arctic field data. Impact: Model studies are essential to understand the indirect effects of aerosols on climate in this region.
- Use data from the 2008 ARCPAC study to examine the mass, mixing state, and optical size of individual black-carbon particles in remote high-latitude regions. Impact: Black carbon is an important component of anthropogenic climate forcing in the Arctic region. These measurements will provide a basis to evaluate the transport of black carbon to the Arctic region and to characterize changes in radiative forcing.

VI. ACRONYMS

AFWA	Air Force Weather Agency
AMISA	Arctic Mechanisms of Interaction between the Surface and the Atmosphere
AMMA	African Monsoon Multidisciplinary Analyses
AMO	Atlantic Multidecadal Oscillation
AMOS	Advanced Modeling and Observing Systems (CIRES scientific theme)
ARCPAC	Aerosol, Radiation, and Cloud Processes affecting Arctic Climate
ARM	Atmospheric Radiation Measurement
ASCOS	Arctic Summary Cloud Ocean Study
ASR	Arctic System Reanalysis
ATOC	Atmospheric and Oceanic Sciences Department
BP	Before Present
BSRN	Baseline Surface Radiation Network
CaRDS	Cavity ring-down system
CDMP	Climate Database Modernization Program
CET	Center for Environmental Technology
CFC	Chlorofluorocarbon
CH3Br	Methyl Bromide
CH3Cl	Methyl Chloride
CIMS	Chemical Ionization Mass Spectrometry
CLASS	Comprehensive Large Array Stewardship System
CLIMAS	Climate Assessment Project for the Southwest
CM	Core-Mantle
CME	Coronal Mass Ejection
CO	Carbon Monoxide
CO2	Carbon Dioxide
CPC	Climate Prediction Center
CPO	Climate Program Office
CSD	Chemical Sciences Division
CSV	Climate System Variability (CIRES scientific theme)
CTIPe	Coupled Thermosphere-Ionosphere-Plasmasphere-electrodynamic
CU	University of Colorado
CUCF	Central UV Calibration Center
CVI	Counterflow Virtual Impactor
DEM	Digital Elevation Model
DOAS	Differential Optical Absorption Spectroscopy
DOC	Department of Commerce
DoD	Department of Defense
D-RAP	D-Region Absorption Prediction
DSD	Drop Size Distribution
DTC	Developmental Testbed Center
ECMWF	European Center for Medium-Range Weather Forecasting
ECUV	European reference Center for Ultraviolet radiation measurements
EEB	Ecology and Evolutionary Biology
eGY	Electronic Geophysical Year
EIT	Extreme Ultraviolet Imaging Telescope
ENSO	El Niño/Southern Oscillation
EPIC	Eastern Pacific Investigations of Climate

ERL	Environmental Research Laboratories (now ESRL)
ESRL	Earth System Research Laboratory
ESS	Earth Systems Science
EUV	Extreme Ultraviolet
FAA	Federal Aviation Administration
FGDC	Federal Geographic Data Committee
FIM	Flow-following Finite-volume Icosahedral Model
FRAMES	Fire Research and Management System
FTE	Full Time Equivalent
GAIM	Global Assimilation of Ionospheric Measurements
GasEx	Gas Exchange Experiment
GCM	General Circulation Model
GDS	Ground data system
GEO	Geodynamics (CIRES scientific theme)
GFDL	Geophysical Fluid Dynamics Laboratory
GFS	Global Forecast System (NCEP model)
GIP	Global Ionosphere Plasmasphere
GIS	Geographic Information System
GMD	Global Monitoring Division
GOES	Geostationary Operational Environmental Satellite
GoMACCS	Gulf of Mexico Atmospheric Chemistry and Climate Study
GPS	Global Positioning System
G-RAD	Global Monitoring Division-Radiation (G-RAD) group
GSD	Global Systems Division
GSI	Gridpoint Statistical Interpolation
HCFC	Halogenated Chlorofluorocarbon
HF	High Frequency
HFC	Hydrofluorocarbons
HIRS	High-Resolution Radiation Sounder
HMT	Hydrometeorological Testbed
HNO3	Nitric Acid
HPC	High-performance computing
HPCS	High Performance Computing Systems
HRRR	High Resolution Rapid Refresh
HWRF	Hurricane Weather Research and Forecasting
IA	Integrating Activities (CIRES scientific theme)
ICARTT	International Consortium for Research on Transport and Transformation
ICEALOT	International Chemistry Experiment in the Arctic Lower Troposphere
IDEA	Integrated Dynamics through Earth's Atmosphere
IPCC	Intergovernmental Panel on Climate Change
IPY	International Polar Year
ISO	International Standards Organization
ITCT	Intercontinental Transport and Chemical Transformation
ITCZ	Intertropical Convergence Zone
KPP	Kinetic PreProcessor
LPAS	Laser Photo-Acoustic Spectroscopy
MBDDB	Multibeam Bathymetric Data Base
MCDB	Molecular Cellular and Developmental Biology
MFRS	Multi-filter rotating shadow-band radiometer

MHD	Magnetohydrodynamic
MJO	Madden-Julian Oscillation
MM5	Mesoscale Model 5
MOS	Monin-Obukhov Similarity
N2O5	Dinitrogen Pentoxide
NAM	North American Monsoon
NAME	North American Monsoon Experiment
NARR	North American Regional Reanalysis
NARSTO	North American Research Strategy for Tropospheric Ozone
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NCDC	National Climatic Data Center
NCEP	National Centers for Environmental Prediction
NCS	National Critical Systems
NEAQS	New England Air Quality Study
NESDIS	National Environmental Satellite Data and Information Center
NetCDF	Network Common Data Form
NEVS	Network-Enabled Verification Service
NGDC	National Geophysical Data Center
NIDIS	National Integrated Drought Information Service
NIST	National Institute of Standards and Technology
NMM	Nonhydrostatic Mesoscale Model
NO2	Nitrogen Dioxide
NO3	Nitrate
NOx	Nitrogen oxides
NPOES	NOAA Polar-orbiting Operational Environmental Satellite
NSF	National Science Foundation
NSIDC	National Snow and Ice Data Center
NWP	Numerical Weather Prediction
NWS	National Weather Service
O3	Ozone
OAR	Oceanic and Atmospheric Research
ODP	Ozone Depletion Potential
OMI/AURA	ESS spacecraft
PACS	Pan-American Climate Study
PBL	Planetary Boundary Layer
PDO	Pacific Decadal Oscillation
PM	Planetary Metabolism (CIRES scientific theme)
PM2.5	Fine particulate matter less than 2.5 micrometers in diameter
PM10	Coarse particulate matter between 2.5 - 10 micrometers in diameter
PSD	Physical Sciences Division
QPE	Quantitative Precipitation Estimates
R/V	Research Vessel
RISA	Regional Integrated Sciences and Assessments
RP	Regional Processes (CIRES scientific theme)
RTVS	Real-Time Verification System
RUC	Rapid Update Cycle
SBL	Stable Boundary Layer
SEARCH	Study of Environmental Arctic Change

SHARE	Sierra Hydrometeorology and Atmospheric River Experiment
SHEBA	Surface Heat Budget of the Arctic Ocean
SST	Sea Surface Temperature
SURFRAD	Surface Radiation
SWE	Snow Water Equivalent
SWPC	Space Weather Prediction Center
TEC	Total Electron Count
TexAQS	Texas Air Quality Study I (2000), II (2006)
TWP-ICE	Tropical Western Pacific – International Cloud Experiment
UAS	Unmanned Aircraft Systems
UV	Ultraviolet
VOC	Volatile Organic Carbon
WAM	Whole Atmosphere Model
WCRP	World Climate Research Programme
WMO	World Meteorological Organization
WRF	Weather Research and Forecasting
WSR-88D	Weather Surveillance Radar 88 Doppler
WWA	Western Water Assessment