



SCIENTIFIC WORKPLAN 1 July 2010 - 30 September 2012



COOPERATIVE INSTITUTE FOR RESEARCH IN ENVIRONMENTAL SCIENCES

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

Based on Cooperative Agreement NA10OAR4320142

1 July 2010 - 30 September 2012

PROJECT DIRECTOR: Konrad Steffen, Director of CIRES

Colorado
University of Colorado at Boulder™

CONTENTS

I.	INTRODUCTION	1
II.	SCOPE	1
III.	FIT WITH NOAA'S STRATEGIC GOALS	3
IV.	CIRES SCIENTIFIC THEMES	3
V.	SCIENTIFIC WORKPLAN PROJECTS	3
	SCIENTIFIC THEME: ADVANCED MODELING AND OBSERVING SYSTEMS	4
	SCIENTIFIC THEME: CLIMATE SYSTEM VARIABILITY	16
	SCIENTIFIC THEME: GEODYNAMICS	27
	SCIENTIFIC THEME: INTEGRATING ACTIVITIES	28
	SCIENTIFIC THEME: PLANETARY METABOLISM	33
	SCIENTIFIC THEME: REGIONAL PROCESSES	35
VI.	ACRONYMS	41
VII.	EFFORT MATRICES	44
VIII.	PROJECT LEADS AND CONTACT INFORMATION	74

INDEX OF PROJECTS

CET-01.....	5	NGDC-04.....	17
CSD-01.....	4	NGDC-05.....	27
CSD-02.....	9	NGDC-07.....	34
CSD-03.....	18	NGDC-08.....	6
CSD-04.....	21	NSIDC-01.....	24
CSD-05.....	39	NSIDC-03.....	24
CSD-07.....	33	POLICY-01.....	28
CSD-08.....	38	POLICY-02.....	31
CSD-09.....	39	POLICY-03.....	31
CSD-10.....	28	PSD-01.....	19
CSD-11.....	9	PSD-02.....	19
CSD-12.....	17	PSD-03.....	23
CSD-13.....	20	PSD-04.....	16
CSD-14.....	34	PSD-05.....	25
DIR-01.....	29	PSD-06.....	22
GMD-02.....	14	PSD-07.....	25
GMD-03.....	16	PSD-08.....	4
GMD-04.....	20	PSD-10.....	14
GMD-05.....	22	PSD-11.....	35
GMD-06.....	37	PSD-12.....	36
GSD-01.....	10	PSD-13.....	37
GSD-02.....	39	PSD-15.....	23
GSD-03.....	11	PSD-16.....	10
GSD-04.....	15	PSD-17.....	10
GSD-05.....	11	SWPC-01.....	13
GSD-06.....	12	SWPC-02.....	13
GSD-07.....	8	SWPC-03.....	7
GSD-08.....	31	SWPC-04.....	8
NGDC-01.....	5	WWA-01.....	29
NGDC-02.....	6	WWA-02.....	30
NGDC-03.....	12	WWA-03.....	30
		WWA-04.....	30

I. INTRODUCTION

This document represents the proposed scientific workplan (Workplan) for the 27-month period from 1 July 2010 – 30 September 2012, under the current Cooperative Agreement between NOAA and the Cooperative Institute for Research in Environmental Science (CIRES), University of Colorado at Boulder. 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, Climate Program Office, National Environmental Satellite Data and Information Service, and the National Weather Service. 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, 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 section VII 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 27 months. Any substantial revisions would be identified and a supplemental request would be submitted to NOAA via <http://grants.gov>.

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III. FIT WITH NOAA'S STRATEGIC GOALS

CIRES is contributing to more than half of the 28 scientific mission goals in NOAA's *Strategic Vision*. The following are examples of planned CIRES research in support of NOAA's cross-cutting priorities.

1. Protect, restore, and manage use of coastal and ocean resources through ecosystem management approaches.

CIRES contributes to NOAA's ecosystem mission goal by developing new datasets and other information products that can help assess coastal hazards, vulnerability, and risk. High-resolution digital elevation models of U.S. coastal communities continue to be developed to support tsunami modeling and coastal inundation mapping. The Hurricane Weather Forecasting model is improving forecasts for tropical cyclone intensity, wave and storm surge, and hurricane-related inland flooding. Prediction of coastal flood and debris flow risk is being improved by new instrumentation and forecasting research. CIRES is providing spatial and temporal depictions of anthropogenic lighting associated with human settlements, biomass burning, gas flares, and brightly lit fishing boats. These products are helpful for assessing sensitive ecosystems at risk from human disturbances and direct impacts of light. 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.

CIRES is a world leader in climate science research relevant to NOAA's climate

mission goal, contributing significantly to all three categories of NOAA's climate-related programs: 1) climate observations and monitoring, 2) climate research and modeling, and 3) climate service development. In the observation and monitoring arena, long-term work will continue to measure trends in atmospheric constituents that contribute to greenhouse warming and stratospheric ozone depletion, and to understand the atmospheric dynamics that affect those trends. The National Snow and Ice Data Center will continue to inventory, scan, and make available online dozens of climate databases, including its analog collection of glacier photographs and the Sea Ice Index. In climate research and modeling, innovative research continues on the effects of oceanic dynamics on atmospheric variability; interactions between clouds, the boundary layer and heat budgets; and the dynamics of ozone layer recovery and its effects on climate. In support of NOAA's goal to serve society with climate products, 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.

3. Serve society's needs for weather and water information. A version of the Hurricane Weather Forecasting model and the experimental Flow-following finite-volume Icosahedral Model are being developed and, as completed, will be maintained and supplied to the weather research modeling community.

Numerical weather model forecasting is being advanced through model improvements and evaluation, and assimilation of data collected in focused observational campaigns, ongoing monitoring, and from satellite missions. Water information is provided to water-resource managers and the public by the Western Water Assessment's research on paleohydrologic and tree-ring data for use in streamflow projection and on the impacts of dust deposition on snow on Colorado River runoff, and by its Web-based seasonal guidance, of particular importance during periods of drought. Related efforts by other CIRES water researchers include the design of innovative measurement systems, such as ground-, ship-, and aircraft-based instruments to increase our understanding of water-cycle processes; and analysis of satellite data to better understand the global water cycle.

4. Support the Nation's commerce with information for safe and efficient transportation. Aviation transportation safety is being enhanced with improved regional-scale numerical weather forecasts and verification approaches for aviation parameters, including: icing, turbulence, convection, and oceanic weather. Marine geophysical data that are critical for hazard mapping and for understanding ocean circulation patterns are being archived at and delivered by NGDC to improve marine transportation safety. CIRES contributes to NOAA's goal of environmentally sound transportation through its continuing research on particulate emissions from ships and design of new sensitive instrumentation. GPS navigational precision

Climate	Commerce & Transportation	Ecosystems	Weather & Water
Climate Observations & Analysis	Aviation Weather	Habitat	Local Forecasts & Warnings
Climate Forcing	Geodesy	Ecosystem Observations	Space Weather
Climate Predictions & Projections		Ecosystem Research	Hydrology - Rivers, Lakes & Floods
Climate & Ecosystems			Air Quality
Regional Decision Support			Environmental Modeling
			Weather Water Science, Technology & Infusion

and radio wave communication are aided by the improved analysis of Earth's geomagnetic field, which is a natural reference frame for orientation on Earth's surface, underground, and in the oceans and the atmosphere.

IV. CIRES SCIENTIFIC THEMES

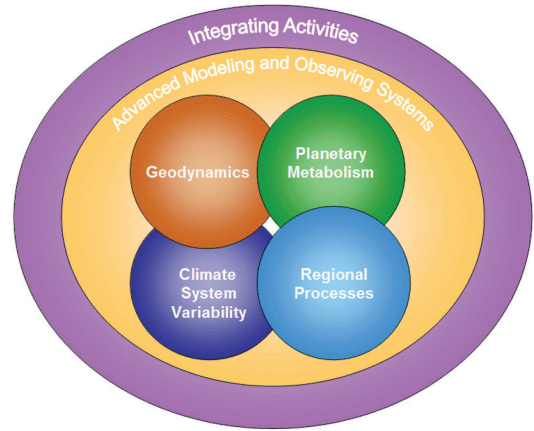
The CIRES Cooperative Agreement with NOAA identifies the scientific themes, at right, which organize and align its collaborative research with NOAA and affiliated university entities. These themes were identified and selected through strategic planning retreats and represent the current scientific emphases 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: CIRES researchers characterize and predict the state of the Earth system on a variety of scales using direct observations and mathematical techniques for projecting outcomes.

Climate System Variability: Climate directly influences agriculture, water quantity and quality, ecosystems, and human health. CIRES research on this theme addresses climate change that occurs on time scales from seasons and decades to millennia.

Geodynamics: CIRES geodynamics research focuses on the internal processes of the planet, including the properties of the core-mantle boundary, convection within the Earth's mantle, and the effects of convection on the surface of the planet.

Integrating Activities: CIRES is committed to working across conventional disciplinary boundaries to produce rigorous, cutting-edge science and technology and to share that knowledge with a broad audience.



Planetary Metabolism: Planetary metabolism encompasses the complex web of biochemical and ecological processes that occur within the biosphere and their interaction with the lithosphere, atmosphere, and hydrosphere.

Regional Processes: Climate variability and extreme weather events are influenced by topography, watersheds, vegetation, and other geographical features that often impact very specific populations, economic systems, and ecosystems.

V. 2010-2012 SCIENTIFIC WORKPLAN

The following is the proposed CIRES-NOAA research Workplan for the Cooperative Agreement extension beginning July 1, 2010 and ending September 30, 2012. 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

AMOS-02 Data Management, Products, and Infrastructure Systems

AMOS-03 Prediction, Model Development, and Evaluation

AMOS-04 Observing Facilities, Campaigns, and Networks

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.

1: Develop and test a new, fully automated instrument to measure water vapor on board a high-altitude research aircraft. Impact: The new instrument will include in-flight calibration to ensure that water vapor measurements made over a wide dynamic range (1-200 parts per million) have known, high accuracy. CIRES Lead: Troy Thornberry. Federal Lead: Ru-Shan Gao.

2: Construct and deploy a three-wavelength, photoacoustic/cavity ring-down combination to measure single scattering albedo. Impact: Single scattering albedo controls whether the direct radiative effect of aerosols is a warming or cooling. This instrumentation will make measurements of single scattering albedo with better sensitivity, higher accuracy, and fewer artifacts than previous instrumentation. CIRES Leads: Justin Langridge, Daniel Lack. Federal Lead: Dan Murphy.

3: Develop and test cavity enhanced spectroscopy (CEAS) instruments for glyoxal (C₂H₂O₂), nitrous acid (HONO), and nitrogen dioxide (NO₂). Impact: Both glyoxal and nitrous acid are reactive intermediates in atmospheric chemistry that serve as photochemical radical sources and, in the case of glyoxal, may participate in secondary organic aerosol formation. Understanding their abundances is important to both regional air quality and climate. CIRES Lead: Rebecca Washenfelder. Federal Lead: Steven Brown.

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 our ability to observe and understand the Earth system.

- 1: Report on the use of roving calibration standard for ship flux measurements on two University-National Oceanographic Laboratory System (UNOLS), ships. CIRES Lead: Jeffrey Hare. Federal Lead: Jim Jordan.
- 2: Perform laboratory study on crosstalk and sensitivity of new fast carbon dioxide (CO₂) sensor. CIRES Lead: Ludovic Bariteau. Federal Lead: Christopher Fairall.
- 3: Install and make test flights of PSD W-band radar on NOAA P-3. CIRES Leads: Andrey Grachev, Christopher Williams. Federal Lead: Jim Jordan.

CET-01 Remote Hydrologic Sensing

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

Approach: Use 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 aircraft systems.

- 1: Develop sensors and perform observations to understand Arctic processes. CIRES Lead: Albin Gasiewski. Federal Lead: Tim Schneider.
- 2: Improve radiative transfer and assimilation techniques for remote sensing and numerical forecasting. CIRES Lead: Albin Gasiewski. Federal Lead: Alexander Voronovich.
- 3: Develop sensors and perform observations to understand Arctic processes. CIRES Lead: Albin Gasiewski. Federal Lead: Taneil Uttal.

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

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

Goal: Develop methods and processes for integrating multiple types of observations (e.g., gridded satellite products and 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 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 understand-

ing 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 that 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.

1: Design, develop, and demonstrate systems to support dataset discovery, documentation, lineage, and usage (metadata) using international standards. CIRES Lead: Richard Fozzard. Federal Lead: Ray Habermann.

2: Design, develop, and demonstrate systems that provide integrated access to and visualization of in situ and satellite environmental observations. Employ Open Geospatial Consortium (OGC) standards as well as emerging international approaches to ensure interoperability across systems. CIRES Lead: Richard Fozzard. Federal Lead: Ray Habermann.

3: Design, develop, and demonstrate systems to support in situ and satellite dataset ingest, archival, and data quality monitoring. CIRES Lead: Richard Fozzard. Federal Lead: Ray Habermann.

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 to 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.

1: Search, target, acquire, and provide access to new and historical marine geophysical data (e.g., bathymetry, gravity, seismic, and magnetics) from the global oceanographic community. CIRES Lead: Jennifer Henderson. Federal Lead: Susan McLean.

2: Improve metadata content and data discovery capability for marine geophysical data in support of the U.S. Extended Continental Shelf and Integrated Ocean and Coastal Modeling projects, including a “Data Inventory” that enables comment and access to a variety of marine geophysical data in a geographically distributed environment. CIRES Lead: Jennifer Henderson. Federal Lead: Susan McLean.

3: Improve access to a variety of regional and global coastlines through development of an interactive map service and updating of other online services to provide the most direct and up-to-date links to various vector shoreline data, including a new high-resolution community coastline dataset developed at NGDC. CIRES Lead: Jennifer Henderson. Federal Lead: Susan McLean.

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

Goal: Improve integration of coastal data and develop new products that promote community resiliency through better assessments of hazards, coastal vulnerability, and risk. Research goals include the development of seamless, accurate, high-resolution digital elevation models (DEMs) to improve the accuracy of coastal inundation modeling; the development and expansion of historic events databases and 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.

- 1: Produce nine to 14 seamless, integrated, bathymetric–topographic digital elevation models of select U.S. coastal communities to support tsunami forecast and warning, hurricane storm-surge modeling, and coastal inundation mapping. CIRES Lead: Kelly Carignan. Federal Lead: Susan McLean.
- 2: Investigate the effects of different gridding algorithms and near-shore morphologic features on integrated bathymetric–topographic digital elevation models, and their impacts on coastal inundation that result from tsunami modeling. CIRES Lead: Barry Eakins. Federal Lead: Susan McLean.
- 3: Develop techniques and software to process raw Deep-ocean Assessment and Reporting of Tsunamis (DART) data with various time discretization and record lengths to produce high-quality datasets for climate and tsunami research. CIRES Lead: George Mungov. Federal Lead: Susan McLean.
- 4: Enhance online and offline access and delivery of hazards data. CIRES Lead: Jesse Varner. Federal Lead: Susan McLean.

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 to evaluate the use of data assimilation techniques for specification and forecast of the space environment, and to model output.

- 1: Support ongoing development of the Geostationary Operational Environmental Satellite (GOES) NOP series ground data system (GDS). Continue to enhance the GOES-NOP data processing systems and support GOES-N and GOES-O operationally used products. Provide analysis and technical support to algorithm development, instrument checkout and data verification for GOES-P as it completes post-launch testing. Facilitate planning for the transition of GOES-NOP GDS operations to the National Environmental Satellite, Data, and Information Service (NESDIS). CIRES Lead: David Stone. Federal Lead: Steven Hill.
- 2: 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. CIRES Lead: David Stone. Federal Lead: Steven Hill.

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.

1: Development of the algorithm and software tool for specifying satellite anomaly hazards from Geostationary Operational Environmental Satellite (GOES) energetic particle data shall be completed and put into operational test mode. Research and development of five algorithms for phase two of the GOES-R project shall be completed. Research and development of the six phase three algorithms will be started and shall progress through preliminary design and into critical design. CIRES Lead: Mary Shouldis. Federal Lead: Steven Hill.

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 HPC 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 to 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 collaboratively with NOAA, CIRES, and the on-site HPC integrator (currently Raytheon) as well as with other NOAA HPC sites.

1: Conduct technical study of latest hardware architectures to support future NOAA procurements.

CIRES Lead: Craig Tierney. Federal Lead: Pam Weber.

2: Investigate tools to automate the use of Graphical Processor Units (GPU) co-processors within existing GSD codes. CIRES Lead: Craig Tierney. Federal Lead: Pam Weber.

3: Support investigations of large, core-count model scalability in heterogeneous computing environments. CIRES Lead: Craig Tierney. Federal Lead: Pam Weber.

AMOS-03 PREDICTION, MODEL DEVELOPMENT, AND EVALUATION

- CSD-02 Chemical Transport Model Research
- CSD-11 Processes in the Marine Boundary Layer
- PSD-16 Raindrop Size Distributions
- PSD-17 Environmental Modeling 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
- GSD-06 Environmental Information Systems
- 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 ozonesondes, will lead to an improved understanding of the ozone budget over the United States during the summertime.

1: Conduct a detailed study of the California ozone budget during the CalNex field study in the spring of 2010. Impact: This CIRES research will result in the first measurement-based tropospheric ozone budget for California. The findings will enable scientists and air quality managers to quantify the contribution of baseline ozone to the exceedances of ozone air quality standards in California. CIRES lead: Owen Cooper. Federal lead: Michael Trainer.

2: Use existing inventories, available field and satellite measurements, and models to improve the emission inventories for chemical transport models; and initiate a multiagency effort to coordinate U.S. research on emissions and enhance access to emission datasets and tools for their evaluation. Impact: These comparisons will provide an evaluation of the status of the most recent inventories and the temporal trends in emissions that have been seen over the last decade. The multiagency initiative will strengthen the research relationships between the inventory development, observations, and modeling communities. CIRES leads: Gregory Frost, Si-Wan Kim, Stuart McKeen. Federal lead: Michael Trainer.

3: Use measurements of aerosols and their precursors made during the 2006 Texas Air Quality Study field mission in conjunction with a state-of-the-art air quality forecast model to assess recent developments in the treatment of secondary organic aerosol formation and their impact on particulate matter (PM_{2.5}) aerosol forecasts. Impact: This CIRES research contributes to improved forecasts of aerosol within air quality models and directly supports NOAA's mission of having an operational national PM_{2.5} aerosol forecasting system by 2015. CIRES leads: Stuart McKeen, Ravan Ahmadov. Federal lead: Michael Trainer.

CSD-11 Processes in the Marine Boundary Layer

Goal: Understand dynamic processes in the marine boundary layer, such as the distribution of wind flow characteristics, including development of nocturnal low-level jets, the primary source of wind resources for offshore wind farms.

Approach: The expected input of the wind generated electricity to the total U.S. energy budget (up to 20 percent during the next two decades), will require, along with improved turbine engineering, better knowledge of wind regimes at the wind farm sites and accurate estimates of wind-flow characteristics at the heights of modern turbine rotors. To address the expanded wind energy requirements for accurate wind-resource assessment and to improve knowledge of wind-flow characteristics over water surfaces, this work will reanalyze measurements obtained by the ship-based NOAA research lidar during the New England Air Quality Study of 2004, to obtain distributions of wind speed, wind directions, and low-level jet parameters along the shore line and as a function of distance from the coast.

1: Develop a detailed analysis of spatial and temporal variability of the offshore boundary layer wind flow characteristics using past experiment Doppler lidar measurements in the Atlantic off the coast of the northeastern United States. Impact: This research will advance the understanding of the spatial and temporal variability of windflow characteristics responsible for mixing and transport processes in the offshore boundary layer, ultimately providing accurate estimates of wind resources at the heights where multi-megawatt wind turbines operate. The results can also be used for validation of satellite estimates of wind-flow characteristics and in numerical models. CIRES Lead: Yelena Pichugina. Federal Lead: Robert Banta.

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.

1: A vertical air motion estimation technique will be developed using collocated 50- and 920-MHz radar observations to isolate the vertical air motion resolved in the 50-MHz radar observations. These columnar dual-frequency vertical air motion estimates will provide reference measurements for simultaneous dual-Doppler scanning radar estimates. CIRES Lead: Christopher Williams. Federal Lead: Tim Schneider.

PSD-17 Environmental Modeling 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 focus on one region and season to understand and eventually improve understanding and modeling of atmospheric water vapor and transport.

1: Assess the representation of water vapor content and transport in the new Flow-following finite-volume Icosahedral Model during wintertime precipitation events along the U.S. West Coast using satellite observations, and compare with that of other operational models. Federal lead: Gary Wick. CIRES Lead: Darren Jackson.

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 as well as improved use of existing observations, 2) numerical forecast models, including dynamical solvers as well as parameterizations of sub-grid-scale and complex processes, 3) 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 and applicable to various 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 following models: Weather Research and Forecast (WRF) model; Hurricane WRF; Rapid Update Cycle (RUC); High-Resolution Rapid Refresh (HRRR); Flow-following finite-volume Icosahedral Model (FIM); Local Analysis and Prediction System (LAPS); and Space-Time Mesoscale Analysis Systems (STMAS).

1: Conduct and evaluate a summer 2010 and 2011 convection forecast exercise with other Aviation Weather Research Product Development Teams (convective weather, in particular), in which the High-Resolution Rapid Refresh (HRRR) run at convection-resolving resolution over the conterminous United States plays a dominant role. The goal of this exercise is to evaluate the potential effectiveness of HRRR in predicting high-impact aviation weather, particularly convection, 3-12 h in advance. CIRES Lead: Curtis Alexander. Federal Lead: Stephen Weygandt.

2: Progress toward construction of an ESRL Earth system model by coupling an icosahedral formulation of the global Hybrid Coordinate Ocean Model (currently under development within ESRL) with the global Flow-following finite-volume Icosahedral atmospheric Model (FIM) on an identical horizontal grid. Test this coupled model on individual cases and in real time if adequate computing resources and initial data are available. CIRES Lead: Rainer Bleck. Federal Lead: John Brown.

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 and its successor, the Network Enabled Verification Service (NEVS), by enhancing system design and functionality.

1: Develop a verification plan for assessing the quality of the Graphical Turbulence Guidance Product version 3, and the Graphical Turbulence Guidance Product Nowcast. CIRES Lead: Matthew Wandishin. Federal Lead: Jennifer Mahoney.

2: Provide assessment report summarizing the findings from an evaluation of the Current Icing Potential and the Forecast Icing Potential. CIRES Lead: Michael Kay. Federal Lead: Jennifer Mahoney.

3: Provide a comprehensive assessment of the Consolidated Storm Prediction for Aviation forecast algorithm in support of the Federal Aviation Administration FY10 demonstration. CIRES Lead: Steven Lack. Federal Lead: Jennifer Mahoney.

GSD-05 Numerical Prediction Developmental Testbed Center

Goal: Transition new developments from research to operations in the Gridpoint Statistical Interpolator (GSI) data assimilation system and the Hurricane Weather Research and Forecasting (HWRF) modeling system through the Developmental Testbed Center (DTC).

Approach: Perform the following activities in each of these key areas associated with improved data as-

simulation and hurricane forecasts: 1) include operational code for GSI and the HWRf system from NOAA's National Centers for Environmental Prediction (NCEP) in the general community repositories and port the codes to computer facilities at ESRL and the National Center for Atmospheric Research, 2) maintain the codes by creating and running regression tests, 3) include new developments in the GSI and HWRf software packages, 4) perform tests of ported code and new developments to verify quality of results, and 5) provide HWRf and GSI user support by writing scientific and technical documentation, maintaining a website, and providing tutorials.

1: Upgrade the community HWRf code to contain new developments used by NCEP for the 2010 operational hurricane season and run extensive tests to assure that the community HWRf is performing as well as operational HWRf, enabling a transition of the community code to NCEP for the 2011 hurricane season. CIRES Lead: Ligia Bernardet. Federal Lead: Steven Koch.

2: Maintain the code repositories for GSI and HWRf and provide user support for both codes (helpdesk, website, code distribution, and documentation). CIRES Lead: Shaowu Bao. Federal Lead: Steven Koch.

GSD-06 Environmental Information Systems

Goal: Develop information systems that deliver atmospheric observation data and environmental products to users of weather, water, and climate information.

Approach: The Advanced Weather Interactive Processing System (AWIPS) is the backbone forecasting system of the National Weather Service (NWS). AWIPS II is under development by a contractor but requires the development of added capabilities and enhancements by OAR/ESRL/GSD. The Meteorological Assimilation Data Ingest System (MADIS) continues by adding meteorological datasets from both public and private sources, improving decision support services for information users, and adding enhancements to Web-based observation products used by emergency managers. An operational MADIS is being developed at the NWS to ensure availability of real-time observations data for both the NWS forecasters and to assimilate into the operational prediction models.

1: Complete final operating capability of MADIS at the National Weather Service. CIRES Lead: Leon Benjamin. Federal Lead: Patricia Miller.

2. Port FX-Collaborate software to AWIPS II. CIRES Lead: Chris Golden. Federal Lead: Joe Wakefield.

3. Develop an AWIPS II collaboration prototype as part of the AWIPS II. CIRES Lead: Chris Golden. Federal Lead: Joe Wakefield.

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 and physical models provide the foundation and 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 (e.g., 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 the DOD's Air Force Weather Agency, NASA's Living With a Star Program, and NOAA's Space Weather Program.

1: Add new features to the Space Physics Interactive Data Resource (SPIDR), including the workflow system, data dashboard, and collaboration on new Web service interface development with colleagues at the Russian Academy of Sciences Geophysical Center. CIRES Lead: Justin Mabie. Federal Lead: Eric Kihn.

2: Develop an operational version of the D-Region Absorption Prediction (DRAP) modeling system on the NGDC website, which will generate model outputs that are available from, and archived at, NGDC. CIRES Lead: Justin Mabie. Federal Lead: Eric Kihn.

3: Develop a "Geomag Tracking Database" to track geomagnetic data holdings at NGDC to modernize the geomagnetic data stewardship program and provide a tool that will help correct past difficulties in data stewardship and dissemination. CIRES Lead: Justin Mabie. Federal Lead: Eric Kihn.

4: Develop a "MIRror of online MAGnetic data" (MIRRMAG) data ingest system that will ingest available, online geomagnetic data into NGDC databases. Once ingested, the system will perform any needed format processing, load the data into the SPIDR database, port the data to the NGDC FTP site, and port the data to the tape library ingest staging area. CIRES Lead: Justin Mabie. Federal Lead: Eric Kihn.

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.

1: SWPC will modify and test the empirical relationship linking helicity and future flaring potential of a given active region, and will evaluate its potential as a forecasting tool for solar flares. CIRES Lead: Alysha Reinard. Federal Lead: Rodney Viereck.

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 the 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 both above and below in the magnetosphere and the lower atmosphere.

1: Quantify the impact of sudden stratospheric warmings (SSW) on the upper atmosphere. Recent ob-

servations suggest that SSW impact the dynamics and electrodynamics of the lower thermosphere, and change the diurnal variation of total electron, which is an important component of space weather. The recently developed Whole Atmosphere Model (WAM) simulates SSW naturally so will be used to quantify their impact on the thermosphere and ionosphere. CIRES Lead: Timothy Fuller-Rowell. Federal Lead: Rodney Viereck.

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 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 World Meteorological Organization/World Climate Research Programme 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.

1: Using surface radiation (SURFRAD) databases, complete and publish an analysis of spectral albedo at the Table Mountain, Colorado, SURFRAD station, and present the results in conferences. CIRES Lead: Gary Hodges. Federal Lead: Joseph Michalsky.

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), light detection and ranging (lidar), 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 during many years in order to build up the climatological record.

1: Produce cloud macrophysical and microphysical datasets describing the clouds at Arctic atmospheric observatories. These datasets will include information on cloud occurrence, vertical distribution, boundaries, phase, and microphysical properties. CIRES Leads: Matthew Shupe, Ludovic Bariteau. Federal Lead: Taneil Uttal.

2: Utilize ground-based, multi-instrument, remote-sensor measurements, aircraft in situ observations, and high-resolution mesoscale models to study the role of cloud dynamical-microphysical processes in the Arctic cloud life cycle. Specific observations will come from various sites, including NOAA's Study of Arctic Environmental Change (SEARCH); the Department of Energy's Atmospheric Radiation Measurement (ARM) sites; the international Surface Heat Budget of the Arctic (SHEBA) mission; Arctic Summer

Cloud Ocean Study (ASCOS); and Arctic Mechanisms of Interaction between the Surface and Atmosphere (AMISA) field campaign. CIRES Lead: Matthew Shupe. Federal Lead: Taneil Uttal.

3: Participate in the Northwest Tropical Atlantic Station (NTAS) project; Prediction and Research Moored Array in the Atlantic (PIRATA Northeast Extension, PNE); and CalNex research cruises in 2010. Deploy cloud radar, radiometer, and flux systems to measure key surface marine boundary layer parameters, low cloud macrophysical, microphysical, and radiative properties. Conduct initial analysis focused on the associations between low clouds and the boundary layer structure. CIRES Lead: Ludovic Bariteau. Federal Lead: Christopher Fairall.

GSD-04 Unmanned Aircraft Systems

Goal: Test and evaluate a variety of unmanned aircraft systems to collect scientifically valuable environmental 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.

1: Analyze sea ice images collected from satellite to automatically identify ice seals and derive fractal ice characteristics. CIRES Lead: Elizabeth Weatherhead. Federal Lead: Sara Summers.

Scientific Theme:

CLIMATE SYSTEM VARIABILITY

CSV-01 Detection of Climate Modes, Trends, and Variability

CSV-02 Mechanism and Forcings of Climate Variability

CSV-03 Stratospheric Ozone Depletion

CSV-04 Climate Dynamics

CSV-05 Climate Research Database Development

CSV-07 Climate Services

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
- CSD-12 Emissions and Atmospheric Composition

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 National Center for Atmospheric Research aircraft-based instruments. Assess data for long-term quality. Evaluate stability and interannual variability in the ground-based and aircraft-based datasets. Provide the 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 quality of the data. Develop new approaches to improve 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.

1: Analyze ground-based, balloon, and aircraft in situ ozone measurements for long-term trends in the troposphere and at the surface. CIRES Lead: Irina Petropaclovskikh. Federal Lead: Samuel Oltmans.

2: Continue to assess and improve quality of column and profile ozone measurements for climate trend analysis and satellite validation. CIRES Lead: Irina Petropaclovskikh. Federal Lead: Samuel Oltmans.

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 analysis and GCM experiments. Provide attribution for long-term regional climate changes.

Approach: CIRES is assessing the significance of and diagnosing the relationships between observed re-

cent 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.

1: Investigate the relative contributions of El Niño-Southern Oscillation (ENSO)-related and ENSO-unrelated tropical SST variations on global climate changes over the last 130 years. CIRES Lead: Prashant Sardeshmukh. Federal Lead: Randall Dole.

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 data and information from the paleoclimatic record.

Approach: Because instrumental records of climate are rarely more than a century long, paleoclimatic data provide a 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.

1: Expand the database of transient climate change during the last 21,000 years to include terrestrial temperature reconstructions and stable isotope records from speleothems and ice cores. Also, add raw age model data to the database to allow users to generate new age models as dating and calibration methods are refined. CIRES Lead: Carrie Morrill. Federal Lead: Dave Anderson.

2: Expand the last millennium temperature database to include gridded climate reconstructions. These gridded reconstructions will complement the point reconstructions already included in the database and will provide a template for the eventual addition of climate model simulations. CIRES Lead: Michael Hartman. Federal Lead: Dave Anderson.

CSD-12 Emissions and Atmospheric Composition

Goal: Improve understanding of past and projected future anthropogenic and natural emissions of atmospheric trace gases that influence climate and climate variability.

Approach: Gather, analyze, and evaluate available inventories of emissions of atmospheric chemical compounds. Use chemistry-transport and chemistry-climate models to evaluate the impact on the composition of the atmosphere. Use models to examine the past and projected future evolution of the chemical composition of the atmosphere. In retrospective analyses, 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. In projections, explore the impact of different anthropogenic emission scenarios on atmospheric chemical composition.

1: Evaluate anthropogenic and natural surface emissions of atmospheric chemical compounds during the past two decades by making detailed comparisons of available emissions inventories, and evaluate the consistency between global and regional emissions, and the impact on the composition of the atmosphere. Impact: This study will provide information used as inputs in climate models, focusing on the chemical compounds detected from space (CO, NO₂, ozone) and on hydrocarbons from natural and anthropogenic origins. CIRES Lead: Claire Granier. Federal Lead: Susan Solomon.

2: Evaluate the evolution of the chemical composition of the atmosphere during the next two to three decades, using the different emissions scenarios developed in support of the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) to assess different Representative Concentrations Pathways (RCPs). Impact: This research will support the IPCC AR5 report by determining the effects of different RCPs on the distribution of chemical species and on their deposition at the surface, which will enable improved understanding and modeling of the effect of atmospheric chemical composition on climate. CIRES Lead: Claire Granier. Federal Lead: Susan Solomon.

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 Implications for Longer-Term Climate Variability
- GMD-04 Climate Forcing
- CSD-13 Kinetics and Photochemical Studies

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 influencing 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 them 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.

1: Add ice habit information to cloud parcel modeling. Impact: Ice formation and growth is a critical and highly uncertain process for both precipitation and the radiative properties of clouds. A better description of ice habits will allow better calculations of both ice crystal growth and sedimentation. CIRES Lead: Barbara Ervens. Federal Lead: Graham Feingold.

2: In the CalNex 2010 field campaign, survey a wide variety of different sources of directly emitted gas and aerosol species (e.g., carbon dioxide, methane, nitrous oxide, halocarbons, and particle-phase soot)

that affect atmospheric radiative forcing. Impact: The planned suite of measurements includes both short-lived and long-lived forcing agents, and will provide survey data for anthropogenic, agricultural, biogenic, and geologic sources of these radiatively important trace species. These data will provide additional independent evaluation of newly developed greenhouse gas inventories in California and better define source sector emissions strengths for directly emitted greenhouse gases. CIRES Lead: Eric Williams. Federal Lead: Thomas Ryerson.

3: Investigate the climate impact of changes in stratospheric ozone and water vapor concentrations using the National Center for Atmospheric Research Community Atmosphere Model with the slab ocean component, using time-slice simulations and sensitivity studies and making use of new and improved ozone and water vapor datasets. Impact: The experiments aim to quantify the importance of these gases to both the modeled stratospheric and tropospheric climates. Also, the results will show the effect of using improved ozone data as a model boundary condition, which will be of great use and interest to the global modeling community. CIRES Lead: Paul Young. Federal Lead: Robert Portmann.

PSD-01 Modeling of Seasonal to Interannual Variability

Goal: Understand how much predictability, especially outside the tropics, exists on seasonal to inter-annual timescales beyond that associated with linear El Niño-Southern Oscillation signals, and what additional useful predictive information can be extracted by making large ensembles of nonlinear general circulation model integrations.

Approach: Explore the non-linearity 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.

1: Determine the sensitivity of North American drought to tropical SST changes at different locations, and identify the optimal anomalous tropical SST pattern for maximizing drought. CIRES Lead: Prashant Sardeshmukh. Federal Leads: Randall Dole, Martin Hoerling.

PSD-02 Understanding and Predicting Subseasonal Variations and 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 timescales 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 National Centers for Environmental Prediction (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.

1: Compare the week two and week three atmospheric circulation forecast skill of state-of-the-art global atmosphere-ocean coupled models with that of simple Linear Inverse Models (LIMs) based on lag-correlations of the northern hemispheric circulation and tropical convection fields. Assess the prospects for further skill improvement by performing a predictability analysis based on the relative magnitudes of the forecast signal and forecast noise. CIRES Lead: Prashant Sardeshmukh. Federal Lead: Randall Dole, Jeffrey Whitaker.

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 into 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.

- 1: Use data from 12 high-altitude observatories to develop a climatology of free tropospheric aerosol radiative properties. CIRES Lead: Anne Jefferson. Federal Lead: John Ogren.
- 2: Establish one new tall tower site in the NOAA/ESRL Carbon America tall tower network to help reduce the uncertainty of carbon uptake by the North American continent and to better characterize regional terrestrial carbon flux estimates. CIRES Lead: Anne Jefferson. Federal Lead: John Ogren.
- 3: 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). CIRES Lead: Anne Jefferson. Federal Lead: John Ogren.

CSD-13 Kinetics and Photochemical Studies

Goal: Determine the rates of climate-relevant processes and evaluate the lifetimes and radiative properties of atmospheric species (gases and particles) that influence climate.

Approach: Use laboratory approaches such as flow-discharge or flash photolysis to determine the rates, product pathways, and temperature/pressure dependence of homogeneous and heterogeneous processes important in climate and/or stratospheric ozone depletion. Use laboratory methods to determine the radiative properties and atmospheric lifetimes of gases important in climate.

- 1: Measure rate coefficients for the chlorine monoxide self reaction ($\text{ClO} + \text{ClO} + \text{M}$) over a range of temperatures and pressures 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. CIRES Lead: Dimitrios Papanastasiou. Federal Lead: Jim Burkholder.
- 2: Measure ultraviolet (UV) absorption cross sections of the long-lived ozone-depleting and greenhouse gases nitrous oxide (N_2O) and carbon tetrachloride (CCl_4) as a function of temperature. Impact: UV photolysis is the key atmospheric loss process for these compounds. The laboratory data will be used as input for atmospheric models to better define the impact of these trace gases on stratospheric ozone and climate change. CIRES Lead: Nabilah Rontu Carlon. Federal Lead: Jim Burkholder.

3: Develop and use a new laboratory apparatus to measure the Henry's Law solubility of key atmospheric trace species in aqueous solutions, and measure hydrolysis rate constants and product yields for reactive species. Impact: This research will evaluate the partitioning of trace species between the gas- and aqueous-phase and the possible significance of aqueous chemistry as an atmospheric loss process. This research has implications for both stratospheric ozone and climate-chemistry coupling. CIRES Lead: Ranajit Talukdar. Federal Lead: Jim Burkholder.

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 anthropogenic 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 included. 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 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.

1: Use ozone data from flights of the National Center for Atmospheric Research HIAPER Gulfstream-V aircraft and the Global Hawk unmanned aircraft system 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. CIRES Lead: Troy Thornberry. Federal Lead: David Fahey.

2: Using diagnosed proxies for tropical in-mixing based on meteorological analyses and satellite measured chemical species, examine changes in the width and isolation of the tropical pipe on seasonal, inter-annual, and decadal time scales. Impact: Changes in the characteristics of mixing between the tropics and mid-latitudes in the lowermost stratosphere can affect residence time and possibly species distribution throughout the stratosphere. CIRES Lead: Sean Davis. Federal Lead: Karen Rosenlof.

3: Examine stratospheric mean meridional circulation and mixing changes during recent decades with observations, reanalysis data, chemistry-climate model output, and a simple stratospheric model. Impact: Understanding how the stratospheric circulation has recently changed will likely help improve understanding of how changes in the troposphere affect the stratosphere. CIRES Lead: Eric Ray. Federal Lead: Karen Rosenlof.

GMD-05 Ozone Depletion

Goal: Understanding the production and fate of ozone and the compounds that deplete it is a focal point of collaborative CIRES research with ESRL's Global Monitoring and Chemical Sciences divisions. **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 characterize, understand and predict the atmospheric behavior of gases that cause ozone depletion. **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: **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 about 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:** Atmospheric measurements of chemicals that cause ozone depletion will be continued with instrumentation located at remote sites across to globe. Measurements of these chemicals and others will also be obtained from flasks collected at a broader number of remote sites. One focus will be to distinguish atmospheric composition changes related to human activity and policy decisions from those arising as a result of natural processes. The total atmospheric burden of ozone-depleting gases will be updated as the Ozone Depleting Gas Index for mid-latitudes and the Antarctic on a yearly basis. **STRATOSPHERIC AEROSOLS:** Ozone depletion, through halogen-related chemistry, is facilitated by increased stratospheric particles as provided in polar regions by stratospheric clouds 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 percent at mid-latitudes. **STRATOSPHERIC WATER VAPOR:** Using balloon-borne frost-point hygrometers, an approximately 1-percent-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.

- 1: From flask and in situ measurements of ozone-depleting substances around the globe, update the Ozone Depleting Gas Index. CIRES Lead: Geoffrey Dutton. Federal Lead: Stephen Montzka.
- 2: Report on the vertical profiles of ozone-depleting substances from the first three campaigns of the HIPPO Pole-to-Pole Observations of Greenhouse Gases mission (HIPPO). Submit data to the HIPPO archive and report on the results at a scientific meeting. CIRES Lead: Fred Moore. Federal Lead: James Elkins.

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 understanding of tropical Pacific Ocean dynamical processes related to the sub-seasonal 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 inter-annual variability of various atmospheric and surface daily cycles.

1: Explore relationship between sea breezes along the West Coast of Mexico during the NAM and precipitation along the western Sierra Madres Occidental. Publish results. CIRES Lead: Leslie Hartten. Federal Lead: Christopher Fairall.

2: Publish papers documenting the daily cycle of winds during the NAM and their longitudinal and year-to-year variability. CIRES Lead: Leslie Hartten. Federal Lead: Christopher Fairall.

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 emphasis 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 to 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 sub-grid 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 El Niño-Southern Oscillation (ENSO), particularly in its onset and decay phases, and on the extratropical circulation are other topics of interest.

1: Conduct a local and non-local feedback analysis of tropical SST variations in observations and the IPCC climate models through Linear Inverse Modeling. CIRES Lead: Prashant Sardeshmukh. Federal Leads: Randall Dole, Klaus Weickmann.

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 meso-scale 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.

1: Analyze data from Surface Heat Budget of the Arctic (SHEBA); Arctic Summer Cloud Ocean Study, (ASCOS); Arctic Mechanisms of Interaction between Surface and Atmosphere (AMISA), and other field programs to understand the links between the clouds, atmospheric boundary layer, and surface processes over sea ice. Evaluate their respective contributions to the net surface energy fluxes. CIRES Lead: Ola Perrson. Federal Lead: Christopher Fairall.

2: Using a Weather Research and Forecasting (WRF) or one-dimensional model, simulate select cases from SHEBA, ASCOS, AMISA and other field programs to a) evaluate the model representation of the observed physical processes, and b) suggest improvements to related parameterizations when possible. Improve-

ments to the parameterization of turbulent fluxes and surface albedo will be tried. CIRES Lead: Ola Persson. Federal Lead: Jian-Wen Bao.

3: Use the Surface Flux Analysis project's global Numerical Weather Prediction (NWP) surface flux archive to examine the Arctic surface energy budget and its sensitivity to surface flux parameterizations. CIRES Lead: Ola Persson. Federal Lead: Christopher Fairall.

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), glacier photographs from NSIDC's collection will be inventoried, scanned, and made available through an online search tool. In their analog form, the photos are difficult to use and in danger of loss through deterioration. Many of these photographs exist only as mounted prints. Also through CDMP, a collection of sea ice charts from Alaska, covering the years 1953-1986, is being scanned. 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. This scanning work is in partnership with a NOAA contractor.

1: Add additional glacier photographs or other analog material to the collections in collaboration with NGDC and CDMP. CIRES Lead: Jane Beitler. Federal Lead: Carl Groeneveld.

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

Goal: Improve 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.

1: 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, acquire and catalog cryospheric materials in the NSIDC library, and maintain NSIDC's analog datasets. CIRES Lead: Jane Beitler. Federal Lead: Carl Groeneveld.

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 El Niño-Southern Oscillation (ENSO), of anomalous sea-surface temperatures (SSTs) in general, and on climate variability over the United States, especially hydroclimatic variability associated with droughts and floods. Our 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 U.S. have persisted, been interrupted, or terminated through the evolution of an El Niño, employing both analysis of the instrumental record and ensemble climate model simulations for this purpose. This is being done in conjunction with CIRES's Western Water Assessment (WWA) and the Climate Assessment Project for the Southwest, concerned with assessing the impacts of climate variability and longer-term climate change on human and natural systems.

- 1: Examine the transitional probability of drought/pluvial conditions over the United States at different phases of SST evolution in the tropical Pacific Ocean based on observational data and multi-model ensemble simulations. CIRES Lead: Xiaowei Quan. Federal Leads: Robert Webb, Roger Pulwarty.
- 2: Evaluation of statistical and dynamical down-scaled climate projections for the Colorado River Basin, including data from North American Regional Climate Change Assessment Program, particularly as it relates to hydroclimatic processes and variability. Work with stakeholders through WWA in evaluating needs and approaches for applying regional climate change information to water and land resource management. CIRES Lead: Joseph Barsugli. Federal Leads: Robert Webb, Roger Pulwarty.
- 3: Continue programmatic development and impact assessments of climate, weather, and water services in conjunction with the National Integrated Drought Information Service (NIDIS) and other programs. CIRES Leads: Joseph Barsugli, Klaus Wolter, Xiaowei Quan. Federal Leads: Robert Webb, Roger Pulwarty.

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, including 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.

1: Improve PSD's visualization and analysis of climate data to support experimental monitoring and explanation of current and evolving climate conditions, and to advance understanding of the climate system through imaging and animation. CIRES Lead: Catherine Smith. Federal Lead: Martin Hoerling.

Scientific Theme:
GEODYNAMICS

GEO-01 Geophysical Data Systems

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 attitude/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 global positioning systems 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, mantle, 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.

1: Satellite-derived crustal magnetic field model: Using the latest measurements from the Challenging Minisatellite Payload satellite, develop a global crustal magnetic field model to spherical harmonic degree and order 150, and integrate it into NGDC/CIRES magnetic reference products for navigation and heading. CIRES lead: Stefan Maus. Federal Lead: Susan McLean.

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
- DIR-01 Science Communications for Diverse Audiences

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 United Nations Environment Programme/World Meteorological Organization (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. These assessments describe scientific findings in user-friendly terms. They link governments, industry, and the public to CIRES, NOAA, and other national and international research groups and results. CIRES researchers serve in roles such as lead authors, coauthors, contributors, reviewers, and coordinating editors.

1: Organize and oversee the international peer review of the UNEP/WMO 2010 scientific state-of-understanding assessment of the ozone layer for the U.N. Montreal Protocol; complete the editing and publishing of the final report; and deliver the report to the Montreal Protocol decision makers and the worldwide scientific community. Impact: This CIRES research supports the decision making of the more than 190 nations that are Parties to the United Nations Montreal Protocol on Substances that Deplete the Ozone Layer. CIRES Lead: Christine Ennis. Federal Lead: A.R. Ravishankara.

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: Organize a seminar series each semester focused on a different topic of interest to the science and technology policy community and others. Maintain an extensive website to disseminate research results and other information of interest to science and technology policy decision makers. Publish a newsletter three times a year with an opinion piece and news of interest to the science and technology policy community. Distribute a briefing to science policy decision makers in Washington, D.C. and elsewhere, highlighting the Center's work.

- 1: Organize a fall noontime seminar series focused on decision making under uncertainty, in conjunction with other units of CIRES. CIRES Lead: Roberta Klein. Federal Lead: Randall Dole.
- 2: Revise and update website. CIRES Lead: Roberta Klein. Federal Lead: Randall Dole.
- 3: Continue to upgrade newsletter and briefing, and expand readership. CIRES Lead: Roberta Klein. Federal Lead: Randall Dole.

DIR-01 Science Communications for Diverse Audiences

Goal: Convey the importance of NOAA and CIRES research to diverse audiences, from the general public and Congressional staffers to real and potential scientific collaborators.

Approach: Research, develop, write, and edit compelling stories about NOAA and CIRES research, with topics ranging from ecosystems and climate to weather, water, and transportation. Work with colleagues across NOAA and the cooperative institutes to develop print and Web-based information products.

- 1: Publish a quarterly science news magazine for NOAA’s Earth System Research Laboratory, and re-purpose articles for other outlets, especially ClimateWatch, NOAA World, NOAA.gov, CIRES web, ESRL web, CIRES Annual Report, and CIRES Spheres magazines. CIRES Lead: Katy Human. Federal Lead: Donald Mock.
- 2: Collaborate on other communication projects with colleagues across NOAA and its Cooperative Institute system, primarily the CIRES Annual Report, but also informational “two-pagers,” annual accomplishment writeups for NOAA Congressional Analysis and Relations Division, and various other programmatic and scientific documents. CIRES Lead: Katy Human. Federal Lead: Donald Mock.
- 3: Maintain a constituent database for the Earth System Research Laboratory, to be used for distributing newsletters, print publications, invitations to events and seminars, and for other purposes. CIRES Lead: Katy Human. Federal Lead: Donald Mock.

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 Inter-mountain 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.

- 1: The WWA education goal for coming years is to develop a suite of process-oriented frameworks for improving the climate literacy of different users with distinct informational needs. CIRES Lead: Kristen Averyt. Federal Lead: Robert Webb.
- 2: WWA will continue to partner with the Center for Snow and Avalanche Studies in Silverton, CO, to investigate the impacts of dust deposition on snow on Colorado River runoff. CIRES Lead: Bradley Udall. Federal Lead: Robert Webb.
- 3: WWA proposes to increase availability and use of paleohydrologic data in Utah during the next three

to five years by coordinating methods proven successful elsewhere, beginning with scoping of Utah stakeholder needs for new paleohydrologies (gauge reconstructions) with one or two workshops in 2010, followed by an assessment of existing tree-ring data network for reconstructing those gauges, and in developing new gauge reconstructions. CIRES Lead: Jeffrey Lukas. Federal Lead: Robert Webb.

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.

1: WWA will continue to publish the *Intermountain West Climate Summary*, a compact Web-based package that includes the latest climate observations and forecasts for Colorado, Wyoming, and Utah. This package will be produced seven to eight times each year. CIRES Lead: Jeffrey Lukas. Federal Lead: Robert Webb.

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

1: WWA research is positioned to inform decision making. WWA will continue facilitating conversations, discussions, and interactions within the WWA stakeholder network of 100 organizations and 250 individuals, while assessing the impacts of such outreach activities. CIRES Lead: Bradley Udall. Federal Lead: Robert Webb.

2: WWA researchers will, over the next two years, identify, engage, and support research scientists and stakeholders affected by decisions made at the interface of the water-energy nexus. In collaboration with energy-focused university and governmental researchers (including those from the National Renewable Energy Laboratory and the National Energy Technology Laboratory) and WWA's existing network of water professionals, WWA plans to identify salient issues and researchers approaching the energy-water nexus from either sector. CIRES Lead: Kristen Averyt. Federal Lead: Robert Webb.

WWA-04 Management

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

Approach: Using regular meetings, websites, and written documents.

1: WWA will co-locate a research liaison with respective state climatologists in Colorado, Utah, and Wyoming to build stakeholder relationships, identify climate science critical to the state, and integrate locally-needed and locally-occurring research with other WWA activities. These partnerships will also strengthen the relationship between WWA and National Integrated Drought Information System (NIDIS) as the state climatologists are involved in the NIDIS Upper Colorado River Basin Pilot study. Partners will meet on at least a quarterly basis. CIRES Lead: Kristen Averyt. Federal Lead: Robert Webb.

2: WWA will begin a structured review process for all activities, which will require WWA to obtain feedback from its local stakeholders and regularly reconsider its role within NOAA and NOAA-administered programs (e.g., NIDIS) and other line offices, including the emerging NOAA Climate Service. This will be implemented over the next five years. CIRES Lead: Kristen Averyt. Federal Lead: Robert Webb.

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
- GSD-08 Science Education and Outreach

Policy-02 Outreach to Decision Makers through the Internet

Goal: Explain the mixture of findings of an earlier WWA-funded project (Drought Impact Indicators); determine how farmers, ranchers, and the federal grazing system respond to climate variability and what role climate information plays in decision making.

Approach: Face-to-face interviews with or written questionnaires to individual farmers, ranchers, and state and federal officials.

1: Design field project, conduct interviews, and write up findings for peer review. CIRES Lead: Roberta Klein. Federal Lead: Roger Pulwarty.

Policy-03 Outreach to Decision Makers through Newsletters

Goal: This project will determine whether agricultural water-rights holders in the U.S. West have experienced impacts from, and made adaptations to, earlier snowmelt.

Approach: Face-to-face interviews with or written questionnaires to individual farmers and ranchers.

1: Design field project, conduct interviews, and write up and present findings. CIRES Lead: Roberta Klein. Federal Lead: Robert Webb.

GSD-08 Science Education and Outreach

Goal: Enhance scientific environmental literacy and improve understanding, value, and use of weather and water information and services to the public, including the K-12 education community.

Approach: Develop visual displays of NOAA's Earth science data in a way that engages audiences of all ages and builds public understanding of the scientific, technological, and environmental topics: 1) continue to develop and install Science On a Sphere® (SOS) exhibits in science museums and other venues, 2) continue to collaborate and partner with educational institutions and others through a SOS Users Collaborative Network, 3) continue to develop virtual worlds modules on the Web to provide an interactive discovery process about environmental phenomena and NOAA's environmental science mission.

1: Communicate and coordinate NOAA educational activities with respect to SOS with the SOS user community and the public. Specific activities include the creation of thematic narratives for the user community, the annual SOS Users Group meeting, numerous traveling exhibits, and field trips from local schools and universities. CIRES Lead: Brandon Lynge. Federal Lead: William Bendel.

2: Develop new and enhance existing features of the SOS system through software improvements. CIRES

Lead: Elizabeth Russell. Federal Lead: Wiliam Bendel.

3: Explore the expanding frontiers of virtual worlds, including the Second Life client 2.0, OpenSim, Blue Mars; and related software, including Unreal Engine. CIRES Lead: Elizabeth Russell. Federal Lead: Wiliam Bendel.

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: Improved understanding of how the exchange of gases between the surface and the atmosphere shapes regional climate and air quality.

Approach: Perform measurements and modeling analyses to make frequent, ultra-sensitive measurements of gases emitted by vegetation (e.g., oxygenated organic compounds) or by 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 emitted, their sources and extent, and the impact on the atmosphere. Focus particularly on compounds likely to play an important role in the chemistry related to air quality in the lowermost troposphere, and on 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.

1: Continue studies to measure reaction rate coefficients and evaluate the atmospheric degradation mechanisms of key biogenic 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. This research has implications for regional air quality. CIRES Lead: Munkhbayar Baasandorj. Federal Lead: Jim Burkholder.

2: Initiate laboratory investigation of switch grass emissions to quantify volatile organic compounds emitted by different switch grass species, and to prepare for a summer 2011 field study of agricultural switch grass emissions. Impact: This CIRES research will provide information needed to assess the environmental impact of a large-scale production and use of alternative fuels produced from biofuel crops. Emissions of volatile organic compounds from vegetation can play a significant role in the formation of ozone and aerosol in polluted atmospheres. CIRES Lead: Jozef (Joost) de Gouw. Federal Lead: William Kuster.

3: Develop and test the acid chemical ionization mass spectrometry (CIMS) system for measuring organic and inorganic acids in the atmosphere. Impact: The acid CIMS will enable measurement of a large number of organic and inorganic acids, rapidly and with high sensitivity. This capability can be applied to research as diverse as ecosystem fluxes, emissions from combustion sources, and the participation of organic acids in secondary organic aerosol formation. CIRES Lead: Patrick Veres. Federal Lead: Jim Roberts.

PM-02 RESPONSE OF NATURAL SYSTEMS TO PERTURBATIONS

- NGDC-07 Anthropogenic Remote Sensing
- CSD-14 Tropical Ocean Productivity

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.

- 1: Complete a radiance calibrated Defense Meteorological Satellite Program Operational Linescan System (DMSP OLS) nighttime lights product for the year 2010 using satellite F16. CIRES Lead: Benjamin Tuttle. Federal Lead: Chris Elvidge.
- 2: Develop a methodology for determining gain settings on DMSP OLS operational data for satellites F16 and F18. CIRES Lead: Kimberly Baugh. Federal Lead: Chris Elvidge.
- 3: Development of a robust and effective calibration method for the DMSP OLS time series based on reflected moonlight from desert surfaces for satellites F16 and F18. CIRES Lead: Daniel Ziskin. Federal Lead: Chris Elvidge.

CSD-14 Tropical Ocean Productivity

Goal: Understand the effects of changes in temperature, vertical mixing, and aerosol fertilization on primary productivity in the tropical ocean.

Approach: Use satellite observations of the ocean from the Sea-viewing Wide Field-of-view Sensor mission, which provides estimates of surface chlorophyll concentration, aerosol optical depth, cloud cover, and sea-surface temperature to study the interconnections of climate and tropical ocean productivity. Use satellite-derived surface chlorophyll concentration to derive the temporal changes in surface area of oligotrophic habitat in the tropical gyres in the Pacific Ocean. Using co-spectral analysis, identify the temporal and spatial scales of the processes that link chlorophyll concentration to aerosols and temperature. Research could involve the use of other data sources to separate the effects of continental aerosols, which would be expected to deposit iron into the ocean, from aerosols produced over the ocean, which would not be expected to fertilize the ocean.

- 1: Identify the temporal and spatial scales of the processes that link chlorophyll concentration in tropical ocean waters to aerosols and temperature. Impact: This research will help identify the processes leading to the recently observed expansion of the tropical ocean. These processes are important to predicting the rate of CO₂ uptake by the ocean of the future. CIRES Lead: Brandi McCarty. Federal Lead: James Churnside.

Scientific Theme: REGIONAL PROCESSES

RP-01 Regional Hydrological Cycles in Weather and Climate

RP-02 Surface/Atmosphere Exchange

RP-03 Regional Air Quality

RP-04 Intercontinental Transport and Chemical Transformation

RP-05 Aerosol Chemistry and Climate Implications

RP-01 REGIONAL HYDROLOGICAL CYCLES IN WEATHER AND CLIMATE

■ PSD-11 Water Cycle

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 our 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.

- 1: Plan and execute the 2011 Hydrometeorology Testbed West (HMT-West) field campaign, an annual 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. CIRES investigators will be key participants and contributors to these activities. CIRES Lead: David Kingmill. Federal Lead: Tim Schneider.
- 2: Develop and test an approach for a synergetic use of C-band scanning polarimetric radar and vertically pointing 8-mm wavelength radar for simultaneous retrievals of parameters in stratiform precipitating systems at the Tropical Western Pacific Darwin Atmospheric Radiation Measurement (ARM) Climate Research Facility (ACRF). This remote-sensing approach will aim to estimate liquid cloud water path and rain water path in the liquid hydrometer layer and simultaneously retrieve an ice water content profile and ice water path in the same vertical atmospheric column. In addition to measurements from radars that are currently available at the Darwin ACRF, the ground-based rain gauge and disdrometer data will be used to constrain retrievals. The suggested remote-sensing approach will be tested using data from a number of experimental events. The retrieval uncertainties will be evaluated. CIRES Lead: Sergey Matrosov. Federal Lead: Tim Schneider.
- 3: Apply a CloudSat method for simultaneous retrievals of mean rain rate and ice water path in stratiform precipitating systems to multi-year datasets collected during the CloudSat overpasses in the vicinity of the ACRF. The CloudSat retrievals will be analyzed for possible correlations between parameters of the ice parts of precipitating systems (e.g., ice water path) and the resultant rainfall. The satellite retrievals will be also compared to the ARM retrievals, so a consistency between spaceborne and ground-based esti-

mates of hydrometeor parameters in precipitating cloud systems will be investigated. CIRES Lead: Sergey Matrosov. Federal Lead: Tim Schneider.

4: Maintain configurations and Web access to the real-time water vapor flux tool for use by researchers and weather forecasters to assess and monitor extreme precipitation events along the U.S. West Coast. CIRES Lead: David Kingsmill. Federal Lead: Daniel Gottas.

5: The CalWater experiment is a multi-year effort supported by NOAA and the California Energy Commission to study the impact of anthropogenic aerosols and climate change on precipitation and associated water supply in California. Aerosol and meteorological observing instruments will be deployed in key locations in California. Part of this effort will be to diagnose the vertical structure of the precipitating cloud systems in the context of collocated aerosol observations. Another part of this effort will entail analysis of meteorological observations to characterize the Sierra barrier jet, its modulation by atmospheric rivers and the resultant spatio-temporal distribution of precipitation. CIRES Lead: Christopher Williams. Federal Lead: Gary Wick.

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 light detection and ranging (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.

1: Complete construction of synthesis dataset for the VAMOS Ocean-Cloud-Atmosphere-Land Study Regional Experiment data. CIRES Lead: Leslie Hartten. Federal Lead: Christopher Fairall.

2: Submit papers on parameterization of sea spray as part of the NOAA hurricane studies. CIRES Lead: Laura Bianco. Federal Lead: Jian-Wen Bao.

3: Analyze flux and gas transfer observations from NOAA's Southern Ocean Gas Exchange Experiment (GasEx III) field program. Submit publication on results. CIRES Lead: Jeffrey Hare. Federal Lead: Christopher Fairall.

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 better understand their effects on 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 to understand the distribution and nature of the sources of climatically important gases. GMD studies boundary layer pollutants and emissions in both source and receptor regions. GMD supports a monitoring network of aerosol, organic, and ozone constituents throughout the world. The measurements are strategically located in either source regions or receptor coastal sites. Models are used to identify the transport pathways and predict the impact of pollutants on a local region.

1: An aerosol measurement system will be deployed to India's Ganges Valley to study the effect of aerosol on radiation, convection, and cloud formation. The study will span the pre- to post-monsoon seasons. CIRES Lead: Anne Jefferson. Federal Lead: Samuel Oltmans.

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 light detection and ranging (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.

1: PSD engineers will deploy three wind profiling radars with radio acoustic sounding systems and surface meteorology towers at three key locations in southern California for the CalNex field campaign in the spring and summer of 2010. Meteorological observations collected at these sites will be accessed, displayed, and archived and quality controlled. CIRES Lead: Timothy Coleman. Federal Lead: Allen White.

2: Execute the surface flux, boundary layer, and cloud observations for the CalNex cruise. Process and analyze the CalNex dataset from the NOAA ship *Ronald H. Brown* cruise, including turbulent fluxes of momentum, sensible heat and latent heat, down-welling radiative fluxes, cloud radar statistics, ceilometer observations, radio-soundings for boundary layer structure, microwave radiometer observations of cloud liquid water and column integrated water vapor, etc. Lead: Ludovic Bariteau. Federal Lead: Christopher Fairall.

3: Deploy systems on the Gulf of Mexico oil platform for the Minerals Management Service observational program. Data include fluxes of sensible heat, latent heat, momentum, and sea-surface temperature. CIRES Lead: Ludovic Bariteau. Federal Lead: Christopher Fairall.

4: Develop, operate, and maintain a wind profiler trajectory tool for the CalNex field campaign. The tool

is used by scientists to document transport pathways for air pollution and to help plan aircraft missions. Starting this year, the trajectory tool will be maintained by the PSD Water Cycle Branch, the same group responsible for operating and maintaining the wind profilers. CIRES Lead: Jeffrey Hare. Federal Lead: Christopher Fairall.

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 enhances air quality prediction and forecasting.

Approach: Design, evaluate, and apply state-of-the-art measurement methods from airborne and ship-based platforms and ground-based sites to the study of natural and anthropogenic ozone, fine-particle precursors, and diagnostic species in key regions of the United States. Current special foci include the roles of natural sources, the effects of anthropogenic emission sources such as power plants and refineries, coastal meteorological influences on ozone production over adjacent land, the regionality of ozone production, and the chemical makeup of fine particles. This research is highly collaborative, involving CIRES researchers affiliated with several NOAA laboratories and partners in numerous other organizations and agencies. Apply laboratory analytical methods to quantify the rates of reactions, their temperature and other dependencies, and the chemical products that are produced. The current emphasis is on using 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. Emphases include diagnostic modeling to guide the planning of regional field studies, and the advancement and evaluation of models used to forecast air quality.

1: Measure the reactivity and optical properties of compounds that are replacements for ozone-depleting substances, and evaluate their global warming potentials. Impact: The determination of the atmospheric loss processes and atmospheric lifetimes of replacement compounds is critical decision-support information. This research has implications for regional air quality, stratospheric ozone, and climate change. CIRES Lead: Munkhbayar Baasandorj. Federal Lead: Jim Burkholder.

2: In the CalNex 2010 field campaign, use surface, airplane-, ship-, and satellite-borne sensors to survey a wide variety of sources of directly emitted gas and aerosol species that impact atmospheric air quality via ozone and secondary organic aerosol formation. Impact: This CIRES research will investigate the distribution and source strengths of precursors to pollution, leading to an improved understanding of anthropogenic, agricultural, biogenic, and geologic sources of pollutant species. The study will also investigate the daytime and nighttime chemical transformations and pollutant transport in the atmosphere. These data and analyses will provide the State of California with the scientific foundation for their efforts to develop plans to bring several areas of the state into compliance with federally mandated National Ambient Air Quality Standards for ozone and particulate matter. CIRES Lead: Eric Williams. Federal Lead: Thomas Ryerson.

3: Co-deploy airborne ozone and Doppler wind lidars during the 2010 CalNex air quality study to investigate transport processes of air pollutants. Impact: The combination of airborne ozone and Doppler lidars will allow the simultaneous measurement of ozone concentration and wind speed and direction at high resolution, and thus enable the characterization and quantification of transport processes of air pollutants in California on local and regional scales. The information will be scientific input for air quality decision makers in the state of California. CIRES Lead: Christoph Senff. Federal Lead: Michael Hardesty.

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, PM_{2.5}, and PM₁₀. Evaluate forecasts using observations from special observing periods.

1: Test and evaluate the global Flow-following finite-volume Icosahedral Model Chemistry (FIM-Chem) currently under development in ESRL and containing chemistry modules from the Goddard Chemistry Aerosol Radiation and Transport (GOCART) model, together with global wildfire definition and global anthropogenic emissions data. Run FIM-Chem in real time at the highest affordable resolution to predict multi-day global transport of aerosol and impact on weather forecasts. CIRES Lead: Georg Grell. Federal Lead: John Brown.

2: Continue to coordinate worldwide development of the Chemistry Weather Research and Forecasting Model (WRF-Chem) as an air-quality prediction tool and support the growing user community. CIRES Lead: Georg Grell. Federal Lead: John Brown.

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 to elucidate processes involved in the intercontinental transport of photochemical pollution.

Approach: Design, evaluate, and apply state-of-the-art measurement methods including airplane-, ship-, and ground-based platforms. 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 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.

1: Analyze the long-range transport of aerosols in the Arctic by using data from aircraft flights and other sources to provide chemical characterization of the aerosols. Impact: Aerosol particles, especially black carbon, have large climate effects in the Arctic. This CIRES research will analyze aerosols in the Arctic free troposphere, polluted Arctic regions, biomass burning plumes in the Arctic, and the air just above the pack ice, all of which are potentially subject to long-range transport. CIRES Lead: Roya Bahreini, Karl Froyd, Daniel Lack. Federal Lead: Charles Brock.

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, ship-based, 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 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.

1: Use data from the Hiaper Pole-to-Pole Observations (HIPPO) mission deployments to examine the mixing state and optical size of individual black-carbon particles as well as black-carbon mass loadings in remote 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 treatment of black carbon in global aerosol models and to characterize the contribution of black carbon to global radiative forcing. CIRES Leads: Joshua Schwartz, Ryan Spackman, Anne Perring. Federal Lead: David Fahey.

2: Examine organosulfate molecules in atmospheric aerosols. Impact: Organosulfate molecules can be formed when reaction products of isoprene and other biogenic organic products encounter acidic sulfate particles. Laboratory calibrations and a review of more than 10 years of field data will allow an assessment of the importance of these compounds in many atmospheric situations, including the Amazon boundary layer and the free troposphere over the United States. CIRES Lead: Karl Froyd. Federal Lead: Dan Murphy.

3: Use data from the 2010 CalNex field campaign to investigate secondary organic aerosol (SOA) formation in the urban Los Angeles area. Impact: This CIRES research will enable the quantification of the anthropogenic source of SOA to the atmosphere, which is currently not well understood. By combining the results from multiple measurements, an investigation into how the budget of organic carbon in the gas and aerosol phases changes as a function of the degree of photochemical processing can be conducted. The results will be used to estimate the global source of SOA derived from anthropogenic volatile organic compounds and other urban precursors. CIRES Lead: Jozef (Joost) de Gouw. Federal Lead: David Parrish.

VI. ACRONYMS

ACRF	ARM Climate Research Facility
AMISA	Arctic Mechanisms of Interaction between the Surface and Atmosphere
AMOS	Advanced Modeling and Observing Systems
AR5	Fifth Assessment Report
ARM	Atmospheric Radiation Measurement
ASCOS	Arctic Summer Cloud Ocean Study
AWIPS	Advanced Weather Interactive Processing System
BSRN	Baseline Surface Radiation Network
C-POL	C-band scanning polarimetric radar
CAM	Community Atmospheric Model
CDMP	Climate Database Modernization Program
CEAS	Cavity enhanced spectroscopy
CET	Center for Environmental Technology
CIMS	Chemical ionization mass spectrometry
CIRES	Cooperative Institute for Research in Environmental Sciences
CLIMAS	Climate Assessment Project for the Southwest
CPO	Climate Program Office
CSD	Chemical Sciences Division of NOAA's Earth System Research Laboratory
CSV	Climate System Variability
DART	Deep-ocean Assessment and Reporting of Tsunamis
DEM	Digital elevation models
DMPS OLS	Defense Meteorological Satellite Program Operational Linescan System
DOAS	Differential optical absorption spectroscopy
DOD	Department of Defense
DRAP	D-Region absorption prediction
DTC	Developmental Testbed Center
ENSO	El Niño-Southern Oscillation
ESRL	Earth System Research Laboratory
FGDC	Federal Geographic Data Committee
FIM	Flow-following finite-volume Icosahedral Model
FTP	File transfer protocol
G-RAD	Global Monitoring Division-Radiation
GCM	General circulation model
GDS	Ground data system
GEO	Geodynamics
GIS	Geographic information system
GMD	Global Monitoring Division of NOAA's Earth System Research Laboratory
GOCART	Goddard Chemistry Aerosol Radiation and Transport
GOES	Geostationary Operational Environmental Satellite
GPS	Global positioning system
GPU	Graphical processor units
GSD	Global Systems Division of NOAA's Earth System Research Laboratory
GSI	Gridpoint Statistical Interpolator
HIAPER	High-performance Instrumented Airborne Platform for Environmental Research
HIPPO	HIAPER Pole-to-Pole Observations
HPC	High-performance computing
HPCS	High-performance computing systems
HRRR	High-Resolution Rapid Refresh
HWRF	Hurricane Weather Research and Forecasting
IA	Integrating Activities

IPCC	Intergovernmental Panel on Climate Change
ISO	International Standards Organization
IWCS	Intermountain West Climate Summary
LIM	Linear inverse model
MADIS	Meteorological Assimilation Data Ingest System
MIRRMAG	MIRror of online MAGnetic data
MJO	Madden-Julian Oscillation
NAM	North American Monsoon
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction
NESDIS	National Environmental Satellite Data and Information Service
NIDIS	National Integrated Drought Information Service
NOAA	National Oceanic and Atmospheric Administration
NSIDC	National Snow and Ice Data Center, CIRES
NTAS	Northwest Tropical Atlantic Station
NWP	Numerical weather prediction
NWS	National Weather Service
OAR	NOAA Office of Oceanic and Atmospheric Research
ODP	Ozone depletion potential
OGC	Open Geospatial Consortium
PIRATA	Pilot Research Moored Array in the Tropical Atlantic
PM	Particulate matter
PM	Planetary Metabolism
PNE	PIRATA Northern Extension
Policy	Center for Science and Technology Policy Research, CIRES
PSD	Physical Sciences Division of NOAA's Earth System Research Laboratory
RCP	Representative Concentrations on Pathways
RP	Regional Processes
RTVS	Real-Time Verification System
RUC	Rapid Update Cycle
SEARCH	Study of Environmental and Arctic Change
SHEBA	Surface Heat Budget of the Arctic
SOA	Secondary organic aerosol
SOM	Slab ocean component
SOS	Science on a Sphere®
SPIDR	Space Physics Interactive Data Resource
SST	Sea-surface temperatures
SSW	Sudden stratospheric warmings
SURFRAD	Surface Radiation
SWPC	Space Weather Prediction Center
TWP	Tropical Western Pacific
UNOLS	University-National Oceanic Laboratory System
UV	Ultraviolet
WAM	Whole atmospheric model
WRF	Weather Research and Forecasting
WWA	Western Water Assessment, NOAA/CIRES

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