Cooperative Institute for Research in Environmental Sciences

FY 2003 Annual Report

NOAA Cooperative Agreement NA17RJ1229

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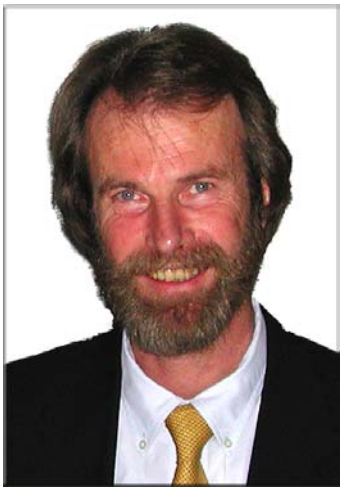
Interim Director's Welcome



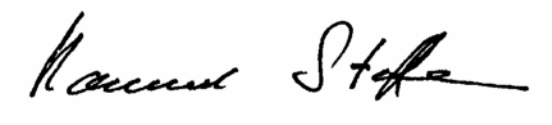
My year as Interim Director of CIRES, while Susan Avery was on sabbatical in Washington D.C., has been an interesting and challenging time. We all have good memories of CIRES' 35th anniversary celebration, particularly because it brought the reunion of our former directors Chris Harrison (1969-1972), Carl Kisslinger (1972-1979) and Bob Sievers (1980-1993). This event also marked the departure of Lynn Walloch, CIRES administrator from 1973-2002. The Institute was only 40 or so people at the time she began, and today we have over 500.

In 2002, the NOAA Science Advisory Board appointed a panel of seven scientists to review CIRES' ongoing and planned research. The panel judged CIRES' research to be of the highest quality, but they also identified some areas in the CIRES/NOAA relationship which requires some degree of attention. The panel concluded that CIRES' current structure is diverse and flexible, well suited to maintain a strong interaction with the NOAA laboratories and to respond to NOAA's implementation and operational needs. During the past twelve months, we continued to strive for excellence in science, but we also addressed some of our shortcomings by implementing recommendations from our internal inequities committee.

We all felt the economic downturn of the recent past; the State of Colorado in particular was under enormous pressure to reduce budget spending which ultimately affected the budget of the University of Colorado at Boulder. I am proud to say that even under these difficult times, we were able to increase our research funding by 22 percent due to successful competitive proposal submissions to a number of federal agencies. We were further able to replace a number of departing faculty members with new junior faculty members. The federal budget in support of NOAA was also worrisome during part of this year, but the situation has improved and we are all anxious to move on and do what we do best – the research and application in environmental sciences.

The research summaries highlighted in this year's annual report are all posted on CIRES research theme homepage: http://cires.colorado.edu/themes/. Given the size of this Institute, only some of the projects underway have been featured and discussed in this report. Again, several projects have been reported in the popular press and updates are listed on http://cires.colorado.edu/news.html

This annual report is a collaborative effort of a number of people in CIRES, researchers as well as administrative staff, and they all deserve credit for what you will find on the following pages. Enjoy your reading!



Executive Summary and Research Highlights

The Cooperative Institute for Research in Environmental Sciences (CIRES) is a joint institute established in 1967 between the University of Colorado and the National Oceanic and Atmospheric Administration (NOAA) to create a synergy between studies of the geosphere, biosphere, atmosphere, hydrosphere and cryosphere. The institute is comprised of more than 500 researchers, faculty, students, and staff housed on the University of Colorado campus and in the David Skaggs Research Center. Approximately half of last year's $40 million budget derives from its cooperative agreement with NOAA.

The previous year was very productive with CIRES scientists and faculty publishing over 500 scholarly papers, including 282 in reviewed journals. Major activities focused on the Arctic climate system as well as climate variability impacts in the Interior Western United States. Atmospheric measurements of trace gases and their implications for air quality were also a high priority last year. CIRES also celebrated its 35th anniversary and completed a major NOAA external review with outstanding results. CIRES and the NOAA laboratories also developed a new process for annual research planning that resulted in a far more integrated picture and plan for the subsequent year.

Adequately summarizing the vast array of research activities across the breadth of CIRES is a challenging task. The following bullets highlight some of the research accomplishments during this last year. They are grouped by CIRES' six scientific research themes that were identified as the foci for integrated studies.

Advanced Modeling and Observing Systems

- A new method was developed to estimate the optical thickness and extinction coefficient of ice clouds using radar returns.
- A research effort incorporating fast response sensors suspended beneath a kite on a CIRES-developed tethered lifting system revealed temperature differences in the nighttime boundary layer in excess of 3.5K over a vertical distance of a few meters.
- A NOAA/CIRES research effort used chemical ionization mass spectrometry techniques to study the uptake of HNO_3 by cirrus clouds and to develop a diagnostic for stratospheric-to-tropospheric exchange of ozone.
- CIRES scientists developed an asymptotic theory that describes tsunami-induced perturbations to the mean wind velocity, which, in the lowest tens of cm of the atmosphere can be comparable to the unperturbed wind velocity.
- CIRES' scientists played a key role in development of the Global Assimilation of Ionospheric Measurements (GAIM) model, which provides assimilation of ionospheric data as part of a multi-organizational attempt to develop a space weather global ionospheric model similar to numerical weather models.

Climate System Variability

- A CIRES study concluded that a Northern Hemisphere reanalysis of the lower and middle tropospheric circulation in the first half of the 20th century is feasible even using only surface pressure observations.
- Pronounced changes of Arctic climate over the past several decades include rises in surface air temperature, reductions in sea ice, warming and thawing of permafrost, and increased river discharge. The Arctic Rapid Integrated Monitoring System, or RIMS, developed by the CIRES'

research team to monitor key components of the Arctic terrestrial hydrologic system has now attained operational status.

- CIRES researchs developed a theory of ENSO as a planetary scale “heat pump". According to this theory, La Niña is a mechanism by which the subsurface equatorial Pacific Ocean stores excess solar heat, and El Niño acts a “ventilator” to transport that excess poleward. ENSO is thus a regulator of the tropical Pacific climate.
- Recent studies at CIRES indicate that runoff from the Siberian Arctic drainage basin has increased substantially in the past several decades. Model calculation show that with the thickening of the active layer, together with its estimated impact on ground ice melting, an increased runoff equivalent of 0.9 to 2.4 mm in the Ob, 7.8 to 11.3 mm in the Yenisey, and 15.3 to 19.4 mm in the Lena. There is also evidence of a longer thawing season associated with both earlier onset and later termination dates.

Geodynamics

- Researchers developed techniques to extract vertically integrated atmospheric water storage from GRACE satellite data to determine changes in the amounts of water stored within continental regions. Combining these with radar altimeter data enabled determination of changes in heat storage distribution throughout the world’s oceans.
- CIRES researchers deployed a Nepal/Tibet earthquake seismic array that yielded the data necessary for a full geodynamic model of Himalayan crustal deformation, slab subduction, and the mountain building processes that are important for hazard analysis.
- CIRES’ researchers developed a new method to monitor the extent and treatment of underground fluid waste, based on the changes in seismic attenuation and elastic properties of the storage material modified by influent remediation, flooding or contaminant leakages. Laboratory work was field-tested in Colorado and Arizona during the past year.

Integrating Activities

- CIRES’ researchers partnered with hydrologists from the Colorado Basin River Forecast Center (CBRFC) to improve operational streamflow forecasts. The experimental method is now being applied by the CBRFC alongside the traditional forecasting method for comparison.
- Researchers with CIRES’ Western Water Assessment program created a new model to assess the stresses on the South Platte basin in Colorado and benefits and pitfalls of coping strategies and resource management decisions. The model developed was based on interviews with regional stakeholders, resource managers and water users aimed at identifying issues, improving hydro climate monitoring and improving the relevance, use, and value of climate information.
- CIRES' Center for Science and Technology Policy Research was officially approved by the University of Colorado in fall, 2002. Comprised of six full-time staff members, 10 graduate and undergraduate students and several affiliated faculty members, the center is working on issues such as drought, global climate change, flood damage, technology transfer and national security.
- CIRES Outreach has been identified as a leader in the emerging Digital Library for Earth Systems Education (DLESE) program. K-12 educators, college faculty, researchers, NSF, NASA, earth science data providers, technologists, and librarians are collaborating in this program to develop and provide Earth system data and tools for educational practice, evaluation and assessment.

Planetary Metabolism

- Bacteria in some contaminated sites have been found evolving new enzymes and metabolic pathways that allow biodegradation of anthropogenic pollutants.

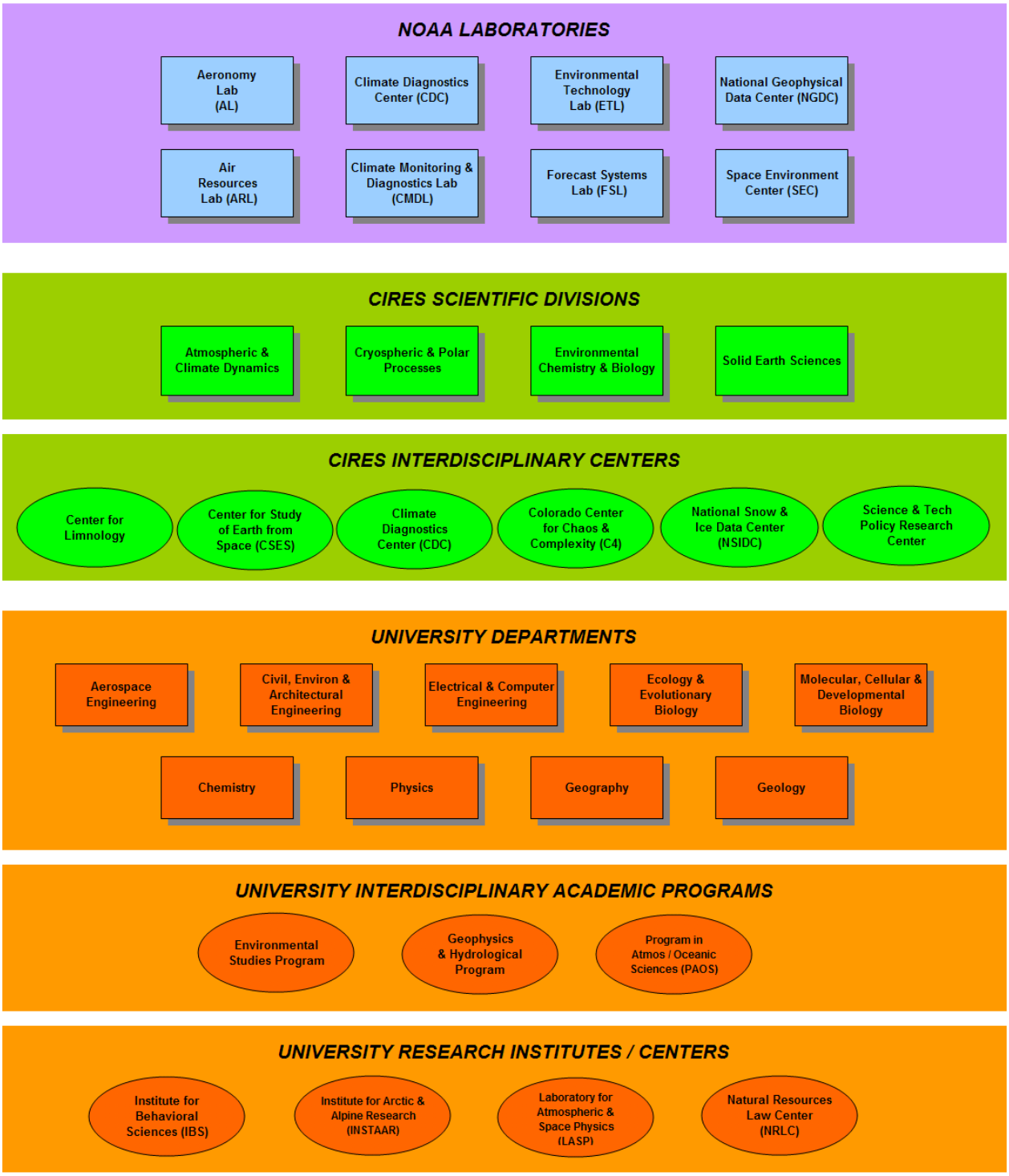
- Studies of the significant fraction of organic compounds in atmospheric aerosols have shown that while O_3 will be a powerful oxidant, OH will still be the dominant atmospheric oxider due to its fast rate of hydrogen abstraction in these organic compounds.
- Salvage logging and subsequent soil erosion of a subalpine ecosystem that experienced a freak blow down appeared to delay ecosystem recovery more than the initial wind disturbance itself.
- Studies of climate variability on low flows in the South Platte River showed that failure to use extended gage records for estimating characteristic low flows leads to potential overestimates of the dilution potential of waters in the drainage and is an additional risk must be factored into regulations affecting the discharge of pollutants.

Regional Processes

- Regional studies of climate variability revealed very different degrees of winter flooding in adjacent watersheds due to El Niño events, documented the transport of atmospheric rivers of elevated water vapor flux, and found that satellite-derived surface wind directions may be inaccurate near frontal zones. This information is very important to short range coastal weather forecasts and longer term climate outlooks.
- Airborne measurements during the Texas Air Quality Study revealed that net ozone formation rates and yields per NO_x molecule oxidized in petrochemical industrial source plumes were substantially higher than rates and yields observed in urban or rural power plant plumes.
- Findings during the New England Air Quality Study revealed that high ozone episodes were due to advected pollutants from other regions. Ozone values aloft were significantly higher indicating that the surface and the marine boundary layer aloft were decoupled due to strongly suppressed vertical mixing in the stable atmosphere over the Gulf of Maine.
- A more accurate algorithm was developed from measurements during GASEX 2001 for estimating CO_2 fluxes over the ocean that has been characterized as a breakthrough by NOAA's Carbon Cycle Program. The improved algorithm provides a significant reduction in the uncertainty of oceanic CO_2 uptake on a basin scale.
- Regional field studies in the Arctic (LEADEX, SHEBA, and AOE) significantly improved understanding of how the components of the Arctic atmosphere (synoptic disturbances, clouds, boundary and surface layers) interact with each other and with the underlying open and ice covered ocean and improved the hierarchy of forcasting, climate and regional models with new observation-based parameterizations.

CIRES is a unique bridge that provides the mission-oriented NOAA laboratories access to an academic diversity that it does not itself possess. It provides and strengthens the scientific basis upon which NOAA's many services depend. CIRES' connections with NOAA's office of Oceanic and Atmospheric Research (OAR) and sister joint institutes also provide an avenue for coordinated studies on a scale that could not be addressed by academic departments on their own. Our joint research is defined with NOAA's strategic goals in mind to further develop and maintain the foundation supporting NOAA's operational mission.

SCIENTIFIC CONNECTIONS FACILITATED THROUGH CIRES

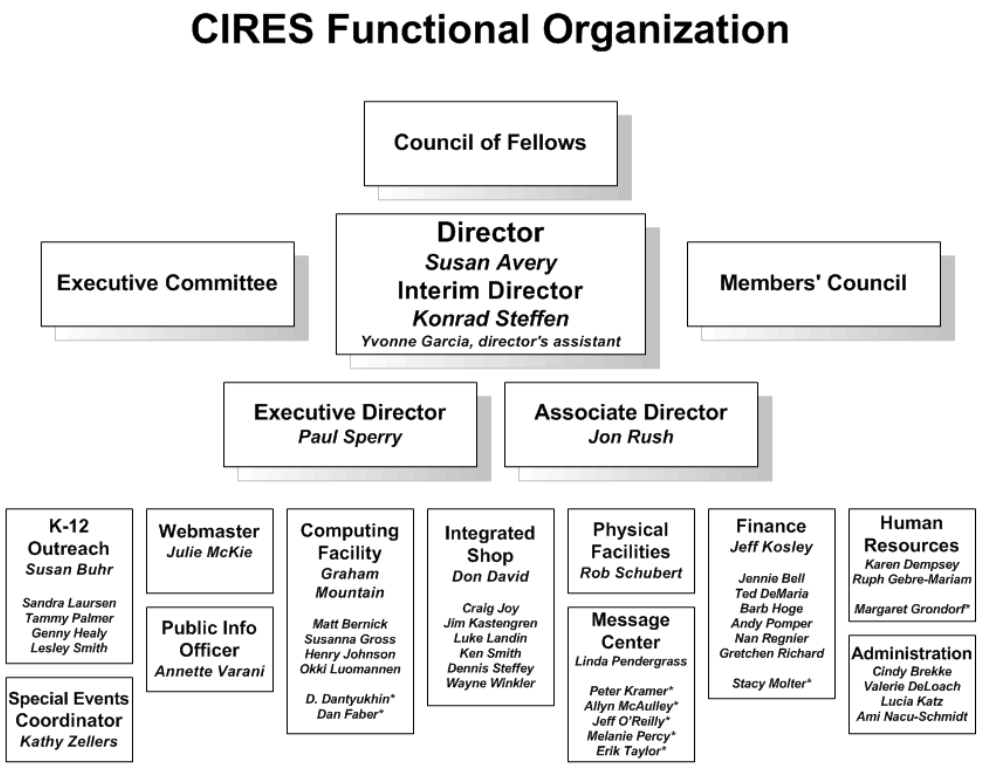


CIRES in 2002-2003

Overview

The Cooperative Institute for Research in Environmental Sciences (CIRES) is a joint institute established in 1967 between the University of Colorado and the National Oceanic and Atmospheric Administration (NOAA) to create a synergy between studies of the geosphere, biosphere, atmosphere, hydrosphere and cryosphere. CIRES is a unique bridge that provides the mission-oriented NOAA laboratories access to an academic diversity that it does not itself possess. It provides and strengthens the scientific foundation upon which NOAA's many services depend. CIRES' connections with NOAA's office of Oceanic and Atmospheric Research (OAR) and sister joint institutes also provide an avenue for coordinated studies on a scale that could not be addressed by academic departments on their own.

Traditional disciplinary research is conducted through a broad range of academic departments and the eight local NOAA laboratories shown in the table at left. Interdisciplinary science is fostered through centers that cross traditional boundaries and include the *Center for the Study of Earth from Space*, the *Center for Limnology*, the *Colorado Center for Chaos and Complexity*, the *National Snow and Ice Data Center*, the *Climate Diagnostic Center*, and the new *Science & Technology Policy Research Center*. CIRES' campus affiliation provides NOAA a breadth of connections such as the Natural Resources Law Center that forms a unique component of the Western Water Assessment.

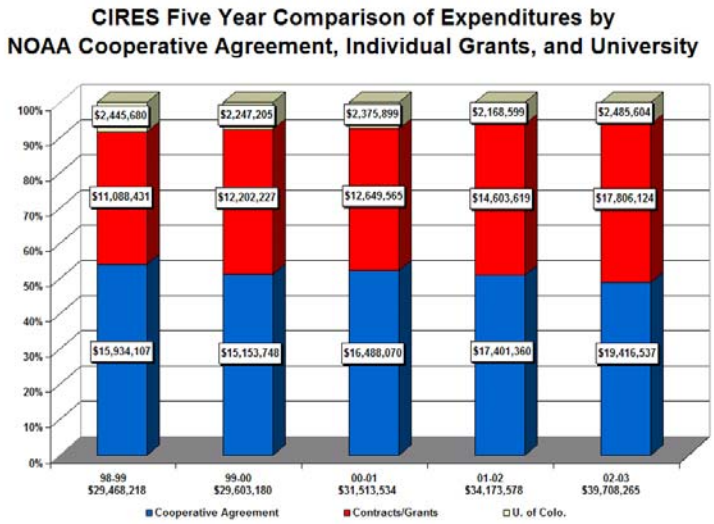


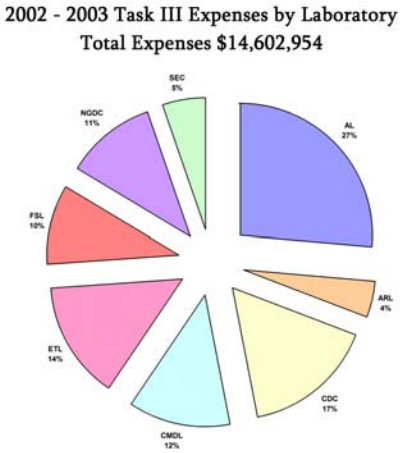
CIRES' *direction* is provided through its Council of Fellows, an active executive committee, and committees working on focused objectives (such as maintaining computing facility excellence). *Communication* is facilitated through a members' council, scientific retreats, regular town meetings, and an active outreach effort. *Career progression and excellence* are promoted through a career track and outstanding employee recognition program. A vibrant *academic and research environment* is fostered

through a graduate research fellowship program, a visiting faculty and postdoctoral program, CIRES Innovative Research Program, an interdisciplinary lecture series, and research initiative seed funding. *Advanced research tools* are provided through an instrument design group, machine shop, glassblowing, numerical climate models, and access to various tools such as remote sensing instrumentation. Other *support* includes a computing facility, specialized software tools (such as Geographic Information System, or GIS, and statistics), auditorium, and classrooms fitted with audio-visual tools.

CIRES is comprised of more than 500 researchers, faculty, students, and staff housed on the University of Colorado campus and in the David Skaggs Research Center. At the end of the year, this included 24 professors, 147 research scientists, 218 research associates, 21 post doctoral fellows, 12 visiting fellows/scientists, 54 graduate students, 11 other staff and nearly a hundred undergraduate employees.

The charts below provide a summary of CIRES expenditure trends by source and NOAA laboratory. The NOAA cooperative agreement includes research and base funds, the contracts and grants bars derive from supplemental federal agency sources, and university support includes faculty salaries, indirect cost recovery, and non-research general funds.





CIRES is increasingly providing vision and leadership in conducting interdisciplinary research that presents results in a context that can be utilized by decision makers. The Western Water Initiative is just such an effort that is addressing the potential impact of climate variability on the availability, quality, and allocation of scarce water in the rapidly populating areas of the arid Interior West (covered under Integrating Activities in the pages ahead). CIRES has also been an active partner with the four other Regional Integrated Sciences and Assessments (RISA) supported by NOAA's Office of Global Programs.

Visiting Fellows Program

One of the key programs that CIRES supports to invigorate research and provide research collaboration opportunities is its visiting fellows program. We typically offer six to eight one-year visiting fellowships to scientists with research interests in the areas of:

- physics, chemistry, and dynamics of the Earth system (atmosphere, biosphere, hydrosphere, lithosphere)
- global and regional environmental change

- climate system monitoring, diagnostics, and modeling
- remote sensing and *in-situ* measurement techniques for the Earth system
- interdisciplinary research themes

A tabulation of last year's seven visiting fellows, research topics, mentors and affiliations can be found in the appendices. Research undertaken last year addressed climate systems variability and regional processes research themes through a diversity of projects. These included snow and ice surface studies; mathematical analyses of glacier crevasse patterns undertaken to discriminate between climatically and dynamically induced ice deformation and movement; studies of the relationship between glacial erosion and tectonic activity in the evolution of mountain ranges; and characterizations of Arctic Ocean surface energy flux. Research by visiting fellows resulted in more than 20 publications presented at science meetings, or now submitted or already in press in peer reviewed journals.

One visiting fellow developed a research program on "Volatile Organic Compounds from Plants" created for export to Cal Poly University, Pomona. A science education project, a major component of the program is the involvement of pre-service teachers from liberal studies majors in the performance of science, working with science majors to collect samples and generate questions and organize and analyze data. As a result of this fellowship, two senior chemistry majors from Cal Poly spent time at CIRES doing research. These students will serve as the core of the Biogenic Volatile Organic Compounds (BVOCs) work at Cal Poly in coming years.

Distinguished Lecture Series

CIRES is seeking to promote connections with University departments and NOAA laboratories thorugh its distinguished lecture series. We invite scholars with global perspectives in the hope of establishing enduring connections after their departures. The following is a list of scientists and academicians invited during the previous year.

Tim Palmer, director of the European Center for Medium Range Weather Forecasting (ECMWF), spoke on "Weather and Climate - A Risky Business."

Andrew C. Revkin, New York Times science reporter, spoke on "The Daily Planet: Why the Media Stumble over the Environment."

Claude Jaupart, Chairman of the Institut de Physique du Globe de Paris, spoke on "Physical Controls on Volcanic Eruptions."

Philip England, Oxford University Department of Earth Sciences, spoke on "The Viscosity of Continents."

V. Ramanathan, the Victor P. Alderson Professor of Ocean Sciences and director for the Center for Atmospheric Sciences and Scripps Institute of Oceanography, UCSD, spoke on "The Asian Brown Cloud."

Thure E. Cerling, distinguished professor of geology and geophysics from the University of Utah, spoke on "Welcome to the C-4-World: Ecological Change and Evolution in the Neogene."

New Annual Scientific Workplan

CIRES initiated and completed a major improvement to its definition of research planned for the subsequent year. An annual scientific workplan was assembled by CIRES, NOAA and campus colleagues that integrates scientific projects under the research themes specified in our cooperative agreement. Driven by scientific objectives, the workplan identifies goals and approaches for each of these objectives

and incorporates milestones and impacts for the proposed research projects. This will shift our process from basing activities upon funding to basing it upon the science that is expected during the coming year. It will be a practical demonstration of research conducted within NOAA's recently developed matrixed approach and has already provided improved collaboration on complementary efforts.

Scholarly Publications

CIRES scientists and faculty published over 500 scholarly papers during the preceding year. The following tables tabulate these by affiliation of first author, by whether or not they were peer reviewed, and compares these with the previous year total number of publications (sum of peer-reviewed and non-peer reviewed)..

2002 Peer Reviewed Publications

CIRES Lead Author	NOAA Lead Author	Co-Author	Total Publications
112	60	110	282

2002 Non-Peer Reviewed Publications

CIRES Lead Author	NOAA Lead Author	Co- Author	Total Publications
			250 (extrapolated)

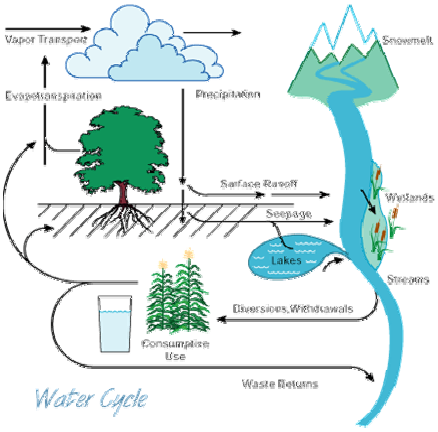
2001 Peer Reviewed and Non-Peer Reviewed Publications

CIRES Lead Author	NOAA Lead Author	Co -Author	Total Publications
164	43	127	334

CIRES' Research Centers

Interdisciplinary research at CIRES is promoted through centers that provide a forum for more specialized interactions that cross traditional boundaries and seek insights at the interfaces between them.

Center for Limnology



The mission of this center is to promote research and teaching related to inland aquatic ecosystems, including lakes, streams, and wetlands. Limnology is the scientific study of the life and phenomena of inland water, including lakes, rivers, streams and wetlands. Research at the Center for Limnology has shown over the last two years that organic nitrogen has a surprisingly high availability to microbes, i.e., it can be a significant biotic nitrogen source even when inorganic nitrogen is depleted. This new information runs contrary to the common supposition that organic nitrogen is highly refractory and thus unusable in the food chain. This finding has implications for analysis of the nitrogen cycle and interpretation of the consequences of anthropogenic nitrogen

Center for Science and Technology Policy Research

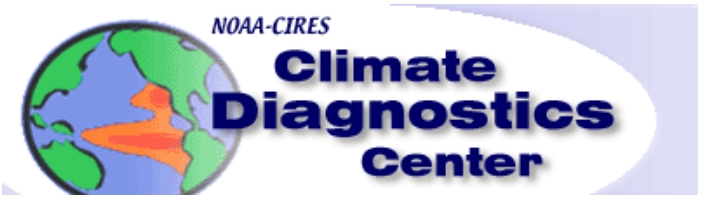
Center for Science and Technology Policy Research

This center's mission is research and education at the interface of science and decision-making. Linking science with the needs of decision makers, the center's researchers play a valuable role in focusing the science community's efforts on societal issues, and helping decision makers to incorporate scientific and technological advances into their decision processes. The recent decade has seen growing interest among scientists in investigating research problems that require the input of more than just a single traditional discipline. At the same time, decision makers in both public and private settings have asked the science and technology communities to provide knowledge that is more directly usable. Science and technology policy research provides a mechanism to reconcile these two closely related - but not identical - trends.

Center for the Study of Earth from Space

CSES was founded in 1985 to provide a focus for the development and application of modern remote sensing techniques used in the research of all aspects of Earth sciences at the University of Colorado. Although measurements from space are emphasized, aircraft and field measurements are integral to any remote sensing project. Within CSES the aim is to work on all scales of problems extending from technique development in small test sites to understanding pattern and process on a regional and global scale. Data from the available electromagnetic spectrum, extending from the UV to the microwave region are used. CSES facilities were developed with generous support from the W.M. Keck Foundation and matching funds from the University. The laboratories are dedicated to both research and teaching.

Climate Diagnostics Center



CDC incorporates a joint activity between NOAA and CIRES/CU that is housed in the David Skaggs Research Center. It develops and applies climate diagnostic techniques to increase understanding of the causes of observed climate variations and improve models used for climate analyses, predictions, and assessments. The mission of CDC is to identify the nature and causes for climate variations on time scales ranging from a month to centuries. The goal is to develop the ability to predict important climate variations on these time scales. Short-term climate variations of interest include major droughts and floods over the continental U.S., and the global anomalies associated with El Niño-Southern Oscillation (ENSO). These events often have enormous social and economic consequences and attract great public interest. On longer time scales, basic research goals include identifying the causes for decadal to centennial climate variations, and separating natural variability from anthropogenically induced climate changes in order to provide an improved scientific basis for public planning and policy decisions. CDC has made considerable progress toward these goals through a coordinated program of diagnostic and modeling studies.

Colorado Center for Chaos and Complexity

CIRES' Colorado Center for Chaos and Complexity, or "C4," supports interdisciplinary education and research, focusing on nonlinear problems that demonstrate complex behavior from simple systems and simple behavior from complex systems. Within the last two decades, new ways of thinking about complex interacting systems have emerged from fields as diverse as physics, population dynamics, mathematics, Earth sciences, economics, biology, and computer science. These new paradigms are characterized by the growing conviction that many of the important properties of natural systems cannot be understood from studying individual systems in isolation or from a top-down, reductionist approach. Rather, these new approaches are distinguished from more traditional ones by the notion that these important properties are "emergent" attributes of systems as a whole.

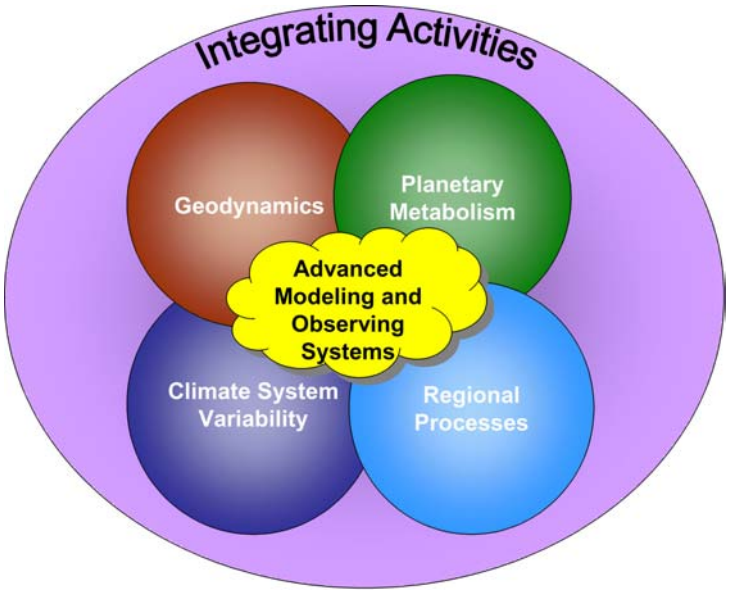
National Snow and Ice Data Center/World Data Center for Glaciology

NSIDC's, goal is to make fundamental contributions to cryospheric science and excel in managing data and disseminating information to advance understanding of the Earth System. NSIDC serves as one of eight Distributed Active Archive Centers (DAAC's) funded by the National Aeronautics and Space Administration to archive and distribute data from NASA's past and current satellites and field measurement programs. NSIDC also supports the National Science Foundation through the Arctic System Science Data Coordination Center and the Antarctic Glaciological Data Center. Established by NOAA as a national information and referral center in support of polar and cryospheric research, NSIDC archives and distributes digital and analog snow and ice data. They also maintain information about snow cover, avalanches, glaciers, ice sheets, freshwater ice, sea ice, ground ice, permafrost, atmospheric ice, paleoglaciology, and ice cores.

CIRES' Scientific Themes

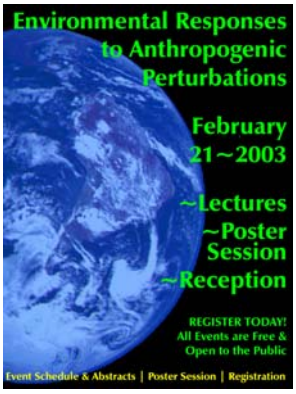
As connections among Earth systems, and the integrated dynamics at boundary layers of Earth, ocean, and atmosphere have become better understood, science disciplines have increasingly overlapped. Now more than ever, specialists need to partner with one another in flexible and changing research teams.

CIRES coordinates its research efforts toward specific scientific objectives through scientific themes. We address questions of scientific and societal relevance to present useful results in a meaningful context. This matrixed approach is decidedly more difficult than traditional organizational structures, but it represents a change in thinking that will translate into improved integration between disciplines and groups. It also allows CIRES to be more adaptive in how it responds to changing scientific priorities and national imperatives.



The current themes include *Integrating Activities, Geodynamics, Climate System Variability, Planetary Metabolism, Regional Processes,* and *Advanced Modeling and Observing Systems*. The last theme encompasses areas where CIRES has particular expertise in the development and design of techniques that can be applied to many different disciplines. These themes are intended to integrate with and complement our existing scientific divisions that include *Atmospheric & Climate Dynamics* (ACD), *Cryospheric & Polar Processes* (CPP), *Environmental Chemistry & Biology* (ECB) and *Solid Earth Sciences* (SES).

In 2002, three interdisciplinary symposia were sponsored as part of our theme emphasis. These symposia were designed to encourage exchange between CIRES' scientists and invited colleagues. Attendance ranged from 50 to 150 participants. Subsequent feedback noted that CIRES is providing a unique service by sponsoring the stimulating and highly interdisciplinary seminars.



This annual report reflects CIRES' theme-based approach to research, differing from previous year's. Previous reports can be found on CIRES website (http://cires.colorado.edu/publications/)

Research Theme Accomplishments: *Climate System Variability*

General Objectives

Climate variability affects virtually all natural systems and human activities. Understanding and predicting climate changes are therefore critical to the public, and also to decision-makers within government and industry for resource management and hazard mitigation. Predictions of the likelihood of extreme events and abrupt climate changes are especially important because of their potentially major societal and ecosystem impacts.

Climate changes may have natural or human-induced causes. Large-scale and long-term climate variations may be linked to variations in local weather quantities such as temperature, precipitation, cloud cover and storminess, as well as in atmospheric carbon dioxide, ozone, and water vapor. A systematic approach to climate variability studies involves 1) detecting and describing climate variations on all scales; 2) diagnosing and attributing their causes; and 3) prediction.

To address these fundamental questions, four sub-topics in established areas of CIRES' expertise were pursued in research on climate system variability. They are:

- detection of climate variability and trends
- mechanisms and forcings of climate variability
- Climate and Cryosphere Interactions
- prediction of climate variability

CIRES' research on these topics is consistent with NOAA's mission to understand and predict changes in the Earth's environment, consistent with NOAA's Strategic Plan, mission goal # 2. to understand climate variability and change to enhance society's ability to plan and respond.

Examples of recent CIRES research activities in these areas are provided below.

Detection of Climate Variability and Trends

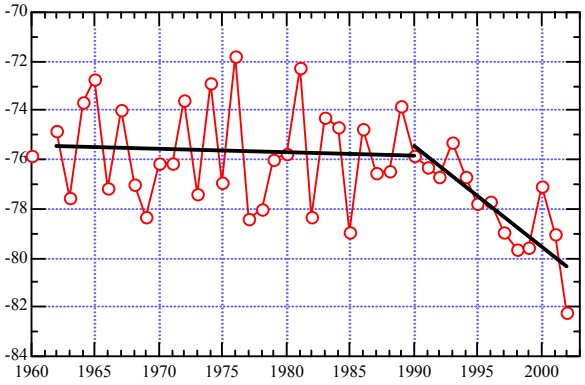
Feasibility of Atmospheric Circulation "Reanalyses" before the Radiosonde Era
In this study, undertaken for a reconstruction of weather maps of the past 100 years (a "reanalysis"), when no upper-level radiosonde wind observations are available pre-1948, the feasibility of reanalyzing the early record using an ensemble square-root filter (EnSRF) was examined. Real surface pressure observations for 2001 were used, sub-sampled to resemble the density of observations estimated to be available in 1915. Analysis errors were defined relative to a three-dimensional variational (3DVar) analysis performed using current observation densities. The study concluded that a Northern Hemisphere reanalysis of the lower and middle tropospheric circulation in the first half of the 20th century is feasible even using only surface pressure observations. The expected analysis errors of 40 m for 500 hPa heights for the 1915 observation network would be similar to the errors of current 2.5 day forecasts.

Monitoring and Analysis of Arctic Climate Variability and Change
Pronounced changes of Arctic climate over the past several decades include rises in surface air temperature, reductions in sea ice, warming and thawing of permafrost, and increased river discharge. A synthesis of surface observations, models and remote sensing is a prerequisite for understanding these changes.. The Arctic Rapid Integrated Monitoring System, or RIMS, developed by the CIRES' research team to monitor key components of the Arctic terrestrial hydrologic system has now attained operational status. Gridded fields of precipitation, surface air temperature, moisture flux convergence, active layer

thickness, snow extent and near-surface freeze-thaw status are updated in near-real time, and are used to diagnose, using a water balance model, poorly observed fields such as evaporation, soil moisture, shallow groundwater storage and runoff. River discharge data are also either acquired or diagnosed in near real time. We are using these data to investigate recent Arctic climate variability. For example, the downward trend of Arctic sea ice extent since 1979 was sharply reinforced in September 2002. Using our datasets, we were able to link this sharp downturn to anomalous winds and temperatures in the preceding winter and spring, and show that they preconditioned the ice cover to rapid decay in the very warm and stormy summer of 2002.

Temperature Trends in the Tropical Lower Stratosphere

This study examined the long-term trends in geopotential height and temperature near the tropopause and lower stratosphere over the warm pool region of the tropical western Pacific, a critical region for monitoring climate changes. The region has several well maintained and continuously operated radiosonde stations with daily reports of winds and temperatures as far back as the late 1950s, with the data usually extending at least up to the 10 hPa (~30 km) level. The stratosphere has been expected to show cooling as a result of both increases in greenhouse gases and decreases in ozone. Results so far are surprising. The long-term trend in stratospheric temperatures was small and not even of consistent sign from 1960 until about 1990, but thereafter a strong cooling set in at all the stations examined. The seasonal dependence of this strong cooling trend, however, suggests that it is not radiative in origin, but instead results from intensified upwelling in the tropical stratosphere caused by wave-mean flow interactions in midlatitudes.



January mean 70 hPa temperatures over Yap (9.5 N, 138 E)

Mechanisms and Forcings of Climate Variability

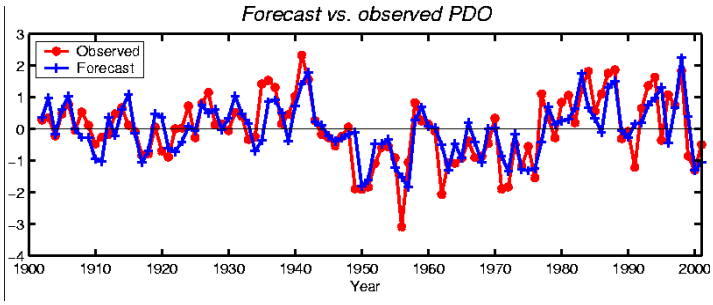
ENSO as a "Heat Pump" Regulator of the Mean Climate

This research developed a theory of ENSO as a planetary scale “heat pump" has been developed. According to this theory, La Niña is a mechanism by which the subsurface equatorial Pacific Ocean stores excess solar heat, and El Niño acts a “ventilator” to transport that excess poleward. ENSO is thus a regulator of the tropical Pacific climate. We have shown that the observed variations of the tropical Pacific heat balance over the last 20 years are consistent with this view. Numerical experiments with a coupled atmosphere-ocean model consisting of an empirical atmospheric model coupled to an NCAR Pacific basin ocean model also support this view. The anomalous ENSO activity observed over the last two decades could thus be a response to enhanced radiative heating over the tropical Pacific, consistent with the anomalously high warm-pool SSTs observed in this period. By underscoring the importance of ENSO in regulating the mean climate, the heat pump view suggests caution in accepting predictions of mean climate changes by models that misrepresent ENSO variability.

ENSO-Forced Variability of the Pacific Decadal Oscillation

North Pacific SST anomalies forced by ENSO via the "atmospheric bridge" peak a few months after the ENSO maximum in tropical Pacific SSTs. Furthermore, North Pacific SSTs "remember" the previous winter's SSTs: deep oceanic mixed layer temperature anomalies from one winter become decoupled from the surface in summer and then “re-emerge” through entrainment into the mixed layer the following winter. Thus, over the course of years the North Pacific integrates the effects of ENSO. Based on these

considerations, we have constructed the simplest possible model of the "Pacific Decadal Oscillation" (PDO) using the annual-averaged SST anomalies in the central North Pacific. Model forecasts of the PDO index have a correlation of 0.74 with observations. This shows that to first order the PDO may be considered as a red response to atmospheric noise as well as ENSO, resulting in more decadal variability than both. This null hypothesis should be kept in mind when diagnosing and modeling "intrinsic" decadal variability in the North Pacific. For example, much has been made of the fact that the dominant spatial pattern of observed decadal Pacific SST variability is different from that of interannual SST variability, with relatively higher amplitudes in the extratropics than the tropics. The researchers' simple model suggests, however, that this could simply be a consequence of the relative amplification of the extratropical impact of decadal ENSO variations through the reddening mechanisms discussed above. The figure above describes the Null hypothesis" model of annual mean PDO, contrasting a time series of "forecast" and observed PDO.



Local and Remote Influences on Rainfall Variations and Extreme Events in the La Plata Basin

The research attempts to understand the large-scale conditions leading to the clustering of heavy rainfall events in the Rio de la Plata basin of South America. The basin includes parts of five countries and is the center of South American economic and agricultural activity. Two particularly interesting features affecting it are the South American low-level jet (LLJ) which transports large amounts of moisture from the Amazon region, and the Madden-Julian oscillation (MJO) which seems to be related to a downstream intensification of the LLJ concurrent with decreased convective activity in the South Atlantic convergence zone. The CIRES' scientists examined the spatial and temporal variations of rainfall extremes in the basin and quantified their contribution to the seasonal totals. The research team also investigated the relationships between the LLJ and daily rainfall extremes, with emphasis on how the LLJ and extreme rainfall events are modified by the underlying surface conditions and modulated by synoptic-scale waves.

Understanding the Effects of Atmospheric Boundary Layer Clouds on Air-Sea Interaction in the Tropical Eastern Pacific

In this project a modest ship-based cloud and flux measurement program was implemented to obtain statistics on key surface, marine boundary layer (MBL), low-cloud macrophysical, microphysical, and radiative properties. The measurements were made as part of the PACS/EPIC monitoring program for the 95 W and 110 W TAO buoy lines in the tropical eastern Pacific. The goal was to acquire a good sample of most of the relevant bulk variables that are commonly used in GCM parameterizations of these processes. These data are being compared to known relationships in other well-studied regimes. While not comprehensive, these data are useful for MBL/cloud modeling and for improving satellite retrieval methods for deducing MBL/cloud properties on larger space-time scales. We completed seven missions beginning in fall of 1999 and ending in fall of 2002. Each mission included transects of the 95 and 110 buoy lines between 8 S and 12 N. A description of the project and preliminary analysis of the fall 99 cruise is available on the ETL website at http://www.etl.noaa.gov/programs/pacs/.

Atmospheric Boundary Layer in the Limit of Very Strong Stability

Understanding atmospheric boundary-layer regimes and proper parameterization of surface fluxes are of obvious relevance for climate modeling and weather forecasting in the Arctic region. This study focused on the behavior of near-surface turbulence in the limit of very strong stable stratification. Results were derived from data collected at five levels on a 20-m tower over the Arctic pack ice during the Surface Heat Budget of the Arctic Ocean experiment (SHEBA). The characteristics of strongly stable boundary

layers are determined mainly by the reduction of surface friction. From this one expects the stability functions φ_m and φ_h to scale as $\varphi_m \propto (z/L)^{1/3}$ and $\varphi_h \propto (z/L)^{-1/3}$, where L is the Obukhov length. Our SHEBA profile data were more consistent with this scaling than with the classical "z-less" behavior (φ_m , $\varphi_h \propto z/L$) originally predicted by Monin and Obukhov (1954) to occur in strongly stratified layers.

Air-Sea Interaction Processes in Warm and Cold Sectors of Extratropical Cyclonic Storms in the North Atlantic and along the California Coast
Swell-influenced systematic differences between surface stress and wind directions suggest that satellite-derived surface wind directions may be inaccurate near frontal zones. Studies in coastal California show that near shore, warm-sector, surface heat fluxes enhance the convective available potential energy of coastal convection during an El Niño winter, and thus represent an additional mechanism by which ENSO-modulated changes may affect California precipitation. These conclusions are based on unique measurements of surface stress and surface sensible and latent heat fluxes in high-wind regions of maritime extratropical cyclones. Composites of 10 storms showed clear modulation of surface fluxes by passing cyclones, with the heat fluxes being a minimum in the low-level jet region just prior to cold frontal passage. Offshore and nearshore measurements in the warm-sector of a major California landfalling cyclone during the El Niño winter of 1997-1998 show that coastal surface fluxes can contribute about 25 percent to the convective available potential energy (CAPE) of air that subsequently produces strong coastal convection and heavy precipitation. Surface flux parameterizations show that such a convective destabilization may only occur in El Niño years, with no effect or a stabilizing effect in non-El Niño years. This ENSO-modulation of a mesoscale process has not been recognized before.

Climate and Cryosphere Interactions

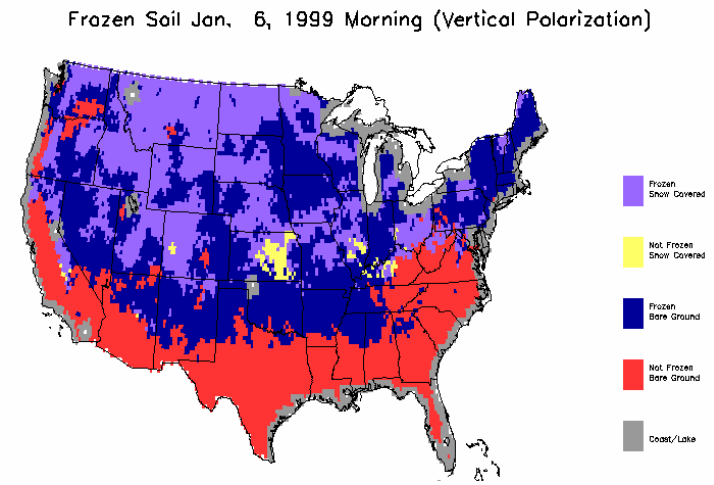
Hydrologic Response to Permafrost Thawing Over the Russian Arctic Drainage Basin
Recent studies indicate that runoff from the Siberian Arctic drainage basin has increased substantially in the past several decades. The cause of this increase is currently unknown. The researchers hypothesized that changes in the active layer and permafrost dynamics have played a key role. The team documented (i) the permafrost and ground ice distribution; (ii) the changes in permafrost temperature, active layer thickness, and length of thaw season over the past few decades, and (iii) their impact on the hydrological cycle in the Ob, Yenisey, and Lena river basins of the Siberian Arctic. The permafrost underlying substantial portions of these basins is responsible for the excess ground ice over them. The annual-mean soil temperature at 40 cm depth has increased by 0.8 degrees C to 1.6 degrees C in these basins from 1930 to 1990, leading to a thawing of the permafrost and thickening of the active layer. Over the Lena basin, the thickening was about 15 cm from the mid 1960s to the mid 1980s. Consistent increases of a thawing index have been documented in all three river basins, suggesting that the active layer thickening is widespread. A 15 cm thickening, together with its estimated impact on ground ice melting, imply an increased runoff equivalent of 0.9 to 2.4 mm in the Ob, 7.8 to 11.3 mm in the Yenisey, and 15.3 to 19.4 mm in the Lena. There is also evidence of a longer thawing season associated with both earlier onset and later termination dates. A thicker active layer and longer thawing season delay the next freeze-up of the active layer. This later freeze-up has also contributed to the increased runoff in the winter months.

Frozen-Ground Data and Information -Advances in the Global Geocryological Data (GGD) System
Permafrost regions occupy about 23.9 percent and seasonally frozen ground regions underlie about 57.1 percent of the exposed land area of the Northern Hemisphere. Consolidation of widely dispersed past data holdings and continued updating of current frozen-ground datasets are critical for fundamental process understanding, environmental change protection, and engineering applications in these regions. Researchers at the World Data Center (WDC) for Glaciology in Boulder have established, in collaboration with the International Arctic Research Center (IARC), a new Frozen Ground Data Center (FGDC) as a key node in the GGD system. The FGDC has recently released the Circumpolar Active-

Layer Permafrost System (CAPS) Version 2 CD set. It includes over 100 data and information products and many more metadata descriptions of data available elsewhere. The FGDC is developing additional products to help improve Arctic climate assessments and models. For more information on CAPS2, see http://nsidc.org/data/g01175.html. and also the FGDC Web site at http://nsidc.org/fgdc/index.html.

Detecting the Near-surface Soil Freeze-thaw Cycle using Frozen Soil Algorithm

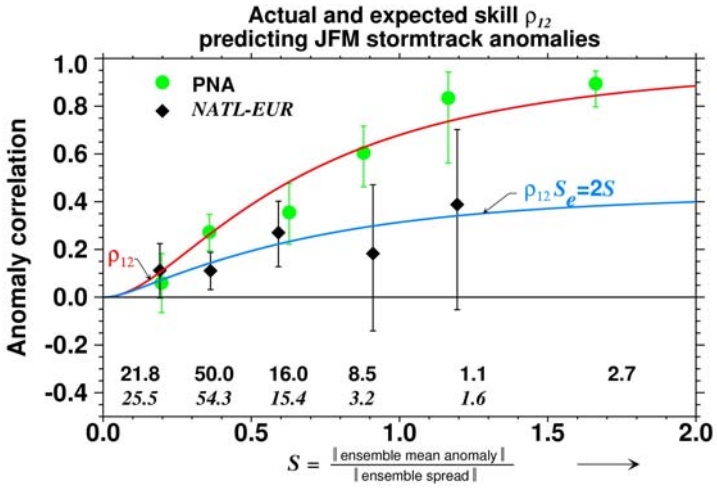
Improved knowledge of the near-surface freeze/thaw cycle of soils is essential for evaluating the impact of cold season/cold region processes on surface and subsurface hydrology, regional and global climate, carbon exchange between the atmosphere and land, and the terrestrial ecosystem as a whole. The challenge is to develop reliable techniques to obtain information of this freeze/thaw cycle. CIRES' researchers have developed a combined frozen soil algorithm to detect the cycle over both snow-free and snow-covered land areas. It uses a passive microwave satellite remote sensing algorithm over snow-free areas, and a one-dimensional numerical heat transfer model over snow-covered areas. The remote sensing algorithm was calibrated using observed 5 cm soil temperatures at 26 U.S. stations during July 1997 - June 1998. When tested against soil temperature measurements taken at the same stations during July 1998 - June 1999, the combined algorithm correctly detected frozen soil with 76 percent accuracy and classified frozen and unfrozen soils with 83 percent accuracy. We then used the combined algorithm to investigate the timing, duration, and areal extent of near-surface frozen soils from July 1997 through June 1999 over the entire U.S. The maximum areal extent of frozen ground was shown to reach 63 percent of the total land area in the winter of 1997/98 and 74 percent in the winter of 1998/99. The duration of frozen ground was also shown to range from less than one month in the southern U.S. to over eight months in the Rocky Mountains.



Prediction of Climate Variability

Predictability of Anomalous Extratropical Storm Tracks

The statistics of extratropical daily weather (usually referred to as "stormtracks") averaged over individual winter seasons, decades, and even longer intervals are not constant but vary susbtantially from one interval to next. These variations have a random part associated with sampling fluctuations and a potentially predictable part associated with slow changes of the underlying SSTs and atmospheric composition. In this study, researchers used very large sets of atmospheric GCM runs made at NCAR and NCEP with prescribed



observed evolving SSTs during the past 50 years to isolate the SST-forced part of the extratropical stormtrack variations. The team found that a significant SST-forced stormtrack signal exists in many winters, but whose strength and pattern can vary substantially from winter to winter. The correlation of the SST-forced and observed stormtrack variations over the 50 winters was found to be high enough in the Pacific-North American sector to suggest useful predictability. The researchers also showed that most of the predictable stormtrack signal is associated with tropical Pacific SST forcing. Variations from winter to winter of the pattern correlation of the observed and SST-forced stormtrack anomaly fields were generally consistent with variations of the signal strength, and to that extent should be identifiable *a priori* from tropical SST variations. The long-term trend of the Pacific storm track in the 50-yr record was also consistent with the stronger ENSO SST forcing in the second half of the record. In the figure Anomaly correlation skill of stormtrack forecasts made using GCM-diagnosed stormtracks for winter (JFM). Red curve shows the expected skill of 12-member ensemble mean forecasts as of function of the signal to noise ratio $\boldsymbol{S}$. Blue curve shows the expected skill when a systematic error equal $\boldsymbol{S}_e=2\boldsymbol{S}$ is present in the forecast. Symbols show the actual skill of stormtrack forecasts for the PNA (green circles) and North Atlantic-European (diamonds) binned over similar $\boldsymbol{S}$ values. Percentage of cases in each bin is indicated.

A Study of Subseasonal Predictability

CIRES' researchers have estimated the predictability of subseasonal atmospheric variations using a 37-component "linear inverse model" (LIM) of weekly extratropical circulation and tropical diabatic heating anomalies derived from their observed simultaneous and time-lag correlation statistics. In both winter and summer, the LIM's forecast skill at Week 2 (Days 8 to 14) and Week 3 (Days 15 to 21) is comparable to that of NCEP's global medium range forecast model. Its skill at Week 3 is actually somewhat higher on average, partly due to its better ability to forecast tropical heating variations and their influence on the extratropical circulation. This makes the much simpler LIM an attractive tool for assessing predictability at these forecast ranges. Defined as the expected forecast skill of a "perfect" model, predictability is closely related to the forecast signal to noise ratio, whose average values at Weeks 2 and 3 at each geographical location are easily obtained for the LIM. At most locations this average expected skill is modest. The expected skill in individual forecast cases can, however, differ substantially from the average skill due to variations of the forecast signal strength and pattern from case to case. We have determined that these predictable skill variations are associated primarily with three amplifying and evolving signal structures with large initial amplitude in the tropics. When the initial atmospheric state projects strongly on these structures, the extratropical circulation is not only potentially but is also actually more predictable at Weeks 2 and 3 than on average. One can therefore identify such high-skill cases *a priori*. Each LIM forecast also takes only a few seconds of CPU time, so extremely cheap and potentially useful Week 3 forecasts are possible now.

Research Theme Accomplishments: *Regional Processes*

General Objectives

The regional processes theme in CIRES is organized into several topic areas that address important region-specific aspects of University and NOAA research. The scientific understanding necessary to deliver improved environmental prediction and management must cover many scales of forcing and response in both space and time. Because the world is composed of many regions that differ widely in geography, demographics, weather, climatic and natural and anthropogenic influences, studies that provide scientific understanding of the atmospheric must be addressed at the regional scale. The processes that control local air-quality and meteorology must be evaluated, if not determined, at the regional scale. Understanding processes that shape regional and global climate as well as validating the satellite that can do global monitoring must be undertaken on the regional scale. For the first time, scientific capabilities are available to undertake systematic, integrated studies of these atmospheric environmental problems on a regional scale.

The organizing foci of the Regional Processes Theme are the integrated regional field studies undertaken by CIRES scientists supported by CIRES laboratory studies and model development. These investigations provide scientific information concerning regional air quality, climate variability, and interactions at the interface between the surface and the atmosphere. The understanding of processes expedites the development of reliable tools to provide badly needed warnings, forecasts and predictions. These regional science applications are organized following several region-specific topics. The scientific objectives addressed last year in this theme included:

- region-specific impacts of climate variability: The aim of this topic is to couple enhanced observations and research within regions characterized by a strong climate variability signal with analysis of past data and improved modeling. Areas of particular interest include complex coastal regions where a better understanding is required of ocean-atmosphere interactions offshore as well as the on-shore responses to short-term changes in climate regimes.
- regional atmospheric composition and climate: This research seeks to identify the natural and anthropogenic emissions that influences the formation of ozone and fine particles in atmosphere over various regions of North America and determines the chemical and meteorological processes that control their transformation and redistribution.
- surface exchange processes: The goal here is to better characterize the physical and chemical exchange mechanisms and to determine how these processes mediate the physical and chemical properties of the atmosphere on regional scales.
- high latitude processes: This research focuses on studies of high latitude regions of the Earth where atmosphere, water, ice, and land meet and are expected to allow complex responses and feedbacks to climate variability and change on local scales.

The following are short descriptions of last year's major scientific accomplishments within CIRES' regional processes theme.

Region-Specific Impacts of Climate Variability

The Weather-Climate Connection
The Weather-Climate Connection effort began in FY2002, expanding NOAA's research on the causes and predictability of extreme weather and climate events. The overall goal was to develop improved capabilities to predict risks of extreme events, such as major floods, droughts, and cold waves, at lead

times from several days to a season. More specifically, this research aimed to: 1) improve early guidance on threats of high impact weather and climate events, such as major floods or cold waves, and 2) better localize the areas of most likely impacts. This research addresses a major gap in scientists' ability to predict in the time scales between weather and climate. Recent accomplishments have included a better understanding of watershed scale responses to the ENSO on the U.S. West Coast, the role of "Atmospheric Rivers," highly concentrated bands of moisture over the ocean extending from the tropics to mid-latitudes and the importance of changes in the near shore ocean heat content on the behaviour of land-falling winter storms. Specifically, NOAA and CIRES researchers

- examined watershed-scale sensitivity to large-scale flow patterns influenced by tropical forcing. Watersheds that are adjacent experienced very different degrees of winter flooding during the strong El Niño of 1997/98. Analyses reveal both the causes of this difference (characteristics of the low-level jet within intense extratropical cyclones), and its linkage to ENSO. These results are of great interest to emergency managers and water resource managers due to the potential of refining decision making to account for more local variations in rainfall, runoff and flooding.

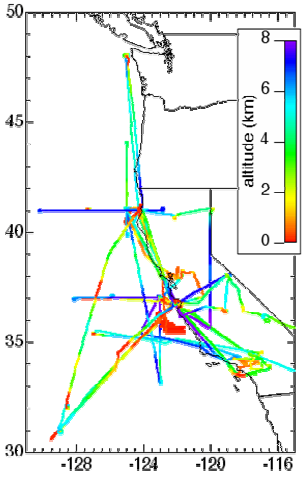
- documented the structure of a modest atmospheric river using aircraft and satellite data from CALJET, and analyzed satellite data for the entire 1997/98 winter season. Seventy-five percent of the meridional water vapor flux was found in narrow plumes roughly 400 km wide, playing a critical role in extreme rainfall events in coastal areas. Documenting the structure and role of highly concentrated moisture transport from the tropics to the mid-latitudes is critical to improving modeling approaches as well as improving guidance for longer-range forecasts or extreme events.

- found swell-influenced systematic differences between stress direction and wind direction over the ocean, suggesting that satellite-derived surface wind directions may be inaccurate near frontal zones. Studies in coastal California show that near-shore, warm-sector, surface heat fluxes enhance the convective available potential energy of coastal convection during an El Niño winter, therefore suggesting an additional mechanism by which ENSO-modulated changes may affect California precipitation. Such studies, quantifying surface fluxes of heat, moisture, and momentum in coastal areas from satellite data and in numerical models, is essential to improving both short range forecasts as well as predicting the effects of climate variability on coastal weather.

Results from Regional Atmospheric Composition and Climate Studies

The International Transport and Chemical Transformation (ITCT) Study
Ozone, fine particles, and their precursors, even compounds with reasonably short lifetimes, can be detected at great distances from their sources—with consequences for both climate and air quality. The Intercontinental Transport and Chemical Transformation (ITCT) project is a major research activity that directly addresses the tropospheric chemistry and long-range transport of ozone, fine particles and other chemically active greenhouse-compounds, and the impact that this intercontinental transport has on regional climate and air quality.

The inaugural ITCT field campaign (dubbed "ITCT 2k2") was carried out in April and May of 2002. The campaign specifically focused on east Asia-to-east Pacific "inflow" into the West Coast region of North America, with the



Flight track of NOAA WP3 during the 2002 ITCT study color coded according to the altitude of aircraft above sea level.

aim of understanding how the Pacific basin affects the chemical processing and removal of compounds of anthropogenic origin that influence the regional budgets of ozone and fine particles downwind over the continental U.S. CIRES' scientists deployed instruments on the WP-3D research aircraft to measure the amount of the pollutants and to determine the sources of these pollutants and the chemical production and loss that occurs as they move from one continent to another.

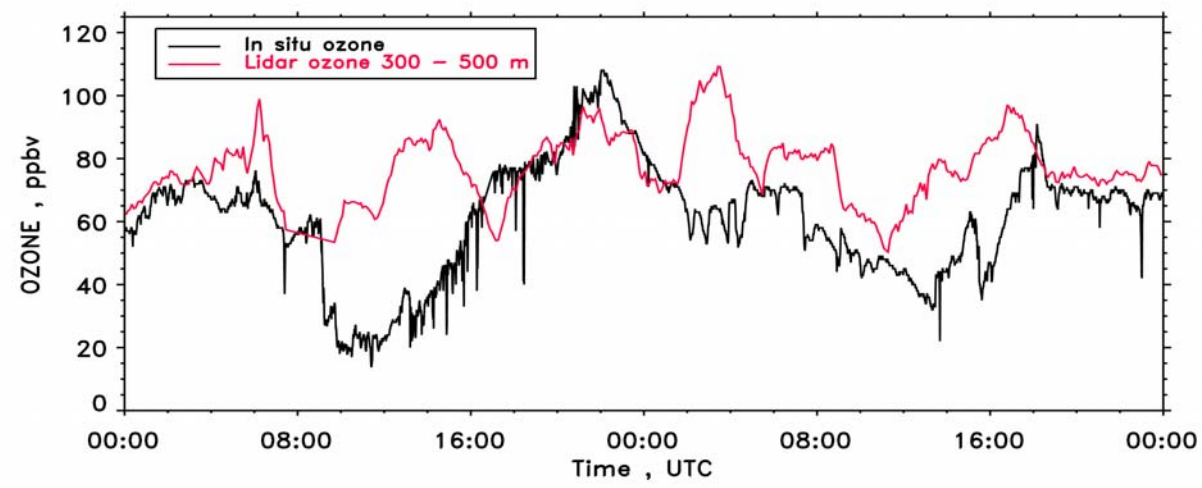
The NOAA WP-3 conducted 13 research flights over the eastern Pacific Ocean and the western continental United States at altitudes up to 8 km (see figure). The initial focus of the study is on the long-lived pollutants, CO, ozone and fine particles. The chemical composition of the plumes allowed the origin of the plumes to be established. Asian transport plumes with CO mixing ratios greater than 150 ppbv were observed on six flights. The reactive nitrogen observations along with the back trajectory analysis suggest that the NO_y partitioning was largely controlled by the meteorological conditions during transport. Additional gas phase species enhanced in these plumes include sulfuric acid, methanol, acetone, propane, and ethane. Chemical composition measurements combined with detailed long-range transport simulation have allowed the origins of the sampled air to be established. The VOCs in the background marine free troposphere appear to be associated with aged Asian pollution. In addition to Asian pollution, plumes associated with lightning and stratospheric intrusions were also observed. The identification of the gas phase chemical characteristics of these plumes provides crucial understanding concerning the influence of the transport of Asian emissions on air quality in the Western United States and on global climate change through perturbations to the tropospheric ozone budget. The current results suggest that the photochemical environment of the temperate North Pacific marine boundary layer and lower free troposphere is now not so dominated by O_3 destruction as it was in the mid-1980s.

The Texas Air Quality Study

Petrochemical industrial facilities can emit large amounts of highly reactive hydrocarbons and NO_x to the atmosphere; in the summertime, such co-located emissions are shown to consistently result in rapid and efficient ozone formation downwind. Airborne measurements made by CIRES' scientists aboard the NCAR Electra have been shown that the initial hydrocarbon reactivity in petrochemical source plumes in the Houston, TX metropolitan area is primarily due to routine emissions of the alkenes propene (C_3H_6) and ethene (C_2H_4). Reported emissions of these highly reactive compounds are substantially lower than emissions inferred from measurements in the plumes from these sources. Net ozone formation rates and yields per NO_x molecule oxidized in these petrochemical industrial source plumes are substantially higher than rates and yields observed in urban or rural power plant plumes.

The New England Air Quality Study

Northern New England, in particular coastal areas of New Hampshire and Maine, experience several



high-ozone episodes every summer despite lacking any significant pollution sources. Air pollution events in northern New England are primarily caused by transport of pollutants from distant sources rather than being locally produced. The extent and severity of these high-pollution episodes depend critically on the transport pathways of the pollutants, the chemical transformation of the pollution plumes, and the meteorological conditions they encounter during transport. A key objective of the 2002 New England Air Quality Study (NEAQS) was to characterize and understand the role these processes play during high-pollution events in northern New England. The primary measurement platform of this study was the NOAA research ship *Ronald H. Brown*, which spent about three weeks in July and August of 2002 in the Gulf of Maine and was equipped with an extensive set of chemical and meteorological sensors. A vertically pointed lidar was deployed to characterize the vertical structure of ozone and aerosols and to assess whether the surface chemical and aerosol measurements were representative of the entire marine boundary layer. The above figure shows a time series of ozone mixing ratio measured onboard the ship, and at 300 – 500 m MSL measured with the lidar for a 48-hour period. A similar pattern was observed on many other days of the study. Most of the time, ozone values aloft were significantly higher than at the surface, indicating that the surface and the marine boundary layer aloft were decoupled due to strongly suppressed vertical mixing in the stable atmosphere over the Gulf of Maine. Similar ozone values at the surface and aloft were observed near the shore under offshore flow conditions, when convectively mixed air was transported from the land over the Gulf of Maine.

Findings Regarding Surface Exchange Processes

Accurately characterizing the exchange of heat, momentum, moisture, gases, and aerosols at the surface of the Earth provides one of the major challenges for the diagnoses and prediction at regional scales. The initial emphasis of this topic has been is on the processes and sources that are most important in the determination of air-quality, meteorology and climate to the United States. Using an aircraft platform with fast response measurements of trace gases, particle size distributions, and particle composition, spatial variations in trace gas mixing ratios and particle mass have been measured. The studies have allowed the determination of important biosphere atmosphere exchange processes.

Intercontinental and Chemical Transformation Study: Deposition during Long-Range Transport Over Oceans

The oceans cover some 70 percent of the globe, yet they constitute one of the major data voids of the Earth. During Intercontinental and Chemical Transformation study that was undertaken in March and April of 2002 (ITCT 2k2), measurements made aboard the NOAA WP3 detected compounds that were transported from Asia. Acetonitrile (CH_3CN) was shown to be an excellent tracer for biomass burning. During the 2002 ITCT study CH_3CN from biomass burning was measured in air sampled over the eastern Pacific off the coast of California. This compound was uniquely identified as emission from biomass burning in Asia. No significant acetonitrile release was observed from sources on the West Coast (power plants or ships). Increased loss of acetonitrile was observed close to or the coast. Analysis of the results indicated that acetonitrile was efficiently lost by dissolving in the upwelling ocean water or by biological processes in the surface water. The ocean uptake of acetonitrile appears to be the principal loss mechanism for acetonitrile from the atmosphere.

Over land, the exchange is complicated by spatially and temporally varying land use, often in topographically complex regions. The formation and loss of ammonia nitrate aerosols are associated with a major air-quality problem in Southern California. During ITCT 2k2, the spatial variations in the conversion of gas phase nitric acid (HNO_3) to particulate ammonium nitrate were observed using airborne measurements of trace gas mixing ratios, particle size distributions, and particle composition. Gas-to-particle conversion processes that resulted in HNO_3 depletion and ammonium nitrate formation were

observed downwind from regions characterized by large agricultural NH_3 emissions in the Los Angeles Basin and San Joaquin Valley.

Ship-based Air-Sea Interaction Studies
ETL and CIRES' staff collaborated with scientists at the Woods Hole Oceanographic Institution to develop instruments and processing technologies to permit the first direct covariance measurements of exchange of CO_2 over the ocean. The measurements were performed in the GASEX-1998 program from the NOAA ship *Ronald H. Brown* and repeated in the tropics in GASEX-2001. These measurements have fostered the development of a CO_2 version of the NOAA/COARE bulk flux algorithm which has become the standard for estimating CO_2 fluxes over the ocean. This work has been characterized as an important breakthrough by NOAA's Carbon Cycle Program. The more accurate algorithm provides a significant reduction in the uncertainty of oceanic CO_2 uptake on the basin scale. NOAA and CIRES' staff are presently working to extend the methods to other important gases (ozone and DMS) that are important for air quality, biological productivity, and cloud-aerosol interactions. Improved parameterization of air-sea gas transfer will result and be incorporated into larger scale models for more accurate forecasting of carbon dioxide sequestration and future climate.

NOAA and CIRES' scientists collaborated with colleagues at the Woods Hole Oceanographic Institution and Australia's Commonwealth Scientific and Industrial Research (CSIRO) to develop and maintain an algorithm to compute air-sea fluxes from bulk meteorological variables. The present version of the algorithm (3.0) was published and released to the public in 2003. COARE is the most accurate algorithm available and its wide use for weather, climate, and research applications has established it as the global standard (it has been referenced in more than 400 scientific publications). A streamlined version is used by NCEP for their operational forecast models. It has been extended to polar conditions and applied to heat, moisture, and momentum exchange over sea ice. A recent experimental breakthrough has allowed the algorithm to be extended to trace gas (CO_2, ozone, DMS, etc) exchange over the ocean. Work is underway to extend the verified wind speed range past 25 m/s and to incorporate the effects of sea spray for hurricane applications

High Latitude Processes Findings

Regional Field Studies in the Arctic
This activity has had a long history beginning in 1992 with the Arctic Leads Experiment (LEADEX), and continuing with major contributions to the year-long Surface Heat and Energy Budget of the Arctic (SHEBA) Experiment (1997-1998) and to the international Arctic Ocean Expedition (AOE) in 2001. Arctic studies are presently continuing with extensive analysis and production of high level data sets from these field programs and from Barrow, Alaska. The most recent effort is the development of a network of NOAA Arctic Atmospheric Research Observatories focused on the objectives of the multi-agency Studies of Environmental Arctic Change (SEARCH) program. Deployment of the first of these facilities will begin in FY2004 in northeastern Canada.

Specific accomplishments of the joint NOAA/CIRES Arctic Program include:

- in-house development of state-of-the-art radars, radiometers and flux systems that are Arctic hardened and capable of operational monitoring as well as portable field operations
- development of theoretical retrieval techniques to blend data streams from multiple sensors to determine atmospheric properties that can not be determined from one system alone.
- generation of multi-year, archived data sets of cloud macro and microphysical properties, boundary and surface-layer structure and turbulent exchanges, and surface energy budgets for

coastal Arctic and Arctic Ocean locations.

- prototyping of procedures to validate satellite retrievals of Arctic cloud properties as well as assessment of the impact of Arctic clouds on satellite retrievals of the properties of snow and ice covered land and ocean surfaces.
- improvements to a hierarchy of forecasting (e.g. ECMWF), climate (e.g. CCCMa, CCSM and regional (e.g. ARCSYM, MM5) models with new observation-based parameterizations as well as providing unique data sets for model validation.
- significantly improved understanding of how the components of the Arctic atmosphere (e.g., synoptic disturbances, clouds, boundary and surface layers) interact with each other and with the underlying open and ice covered ocean.

This work has been motivated by the knowledge that the Arctic is a key region controlling global climate processes, it is the region with the largest predicted changes in climate-change scenarios, it is the region of greatest uncertainty in climate and weather models, and it is a region with historically very sparse data. In addition, the Arctic appears to be in a state of precipitous climate change with repercussions on U. S. fisheries, northern transportation routes, and the livelihood of indigenous peoples.

Research Theme Accomplishments: *Geodynamics*

General Objectives

The processes that form and modify the surface of the Earth are governed by the geodynamics of the Earth's mantle (driven by internal heat) and erosion of surface materials (a function of climate). The geodynamics theme is focused on both the internal and external factors affecting the evolution of the Earth's surface. Research activities within Geodynamics at CIRES include mantle convection and earthquake seismology, plate motions and plate boundary deformation, geochemistry of continental evolution, geochemistry of water resources and climate change, mechanics and hydrology of surface fractures, links between erosion, mountains, and climate, and monitoring mass transfers through satellite geodesy. These research topics range from laboratory scale to global scale and from applied environmental research to global potential field measurements and modeling. Observational data are a critical component of this CIRES theme. The observational data include field measurements in seismology and geodesy made in remote orogenic regions, new satellite measurements from the Gravity Recovery and Climate Experiment (GRACE), seismic measurements to monitor groundwater pollution, groundwater geochemistry, and geochemical sampling of basalts to determine continental evolution and mantle reservoirs. These observational data are used to constrain theoretical models and forward predictions of these processes.

The scientific objectives for this theme for 2002-2003 were:

- geodynamics and topography: Explore and develop methodologies and numerical approaches to geodynamic modeling of continental deformation.
- quantifying the global hydrologic budget: The Gravity Recovery and Climate Experiment (GRACE) is poised to provide vertically integrated water mass change over large river basins. Analysis of data from the TOPEX/Poseidon satellite mission is used to determine variations in sea level.
- continental deformation: Operate field campaigns in orogenic regions and combine field, theoretical, and numerical analyses for modeling surface deformation in terms of causative Earth processes throughout the lithosphere. Investigate links between geophysical processes and human demographics.
- near surface rock processes: Design and evaluate new approaches to make observations of chemistry and physics of near-surface fluid flow.
- geochemistry of the lithosphere and hydrosphere: Use remote sensing and geochemical means to monitor current and past ice sheet movements, and the plumbing of volcanic systems and the continents.

Geodynamics and Topography

The static view of topography is that surficial processes are invariant over time scales of importance to humans, but a review of these processes throughout the past few thousands of years reveals substantial perturbations to climate that have in turn resulted in massive changes in erosion, with an attendant topographic response, that in turn may affect climate, the recurrence intervals and locations of mid-continent earthquakes, and global sea level.

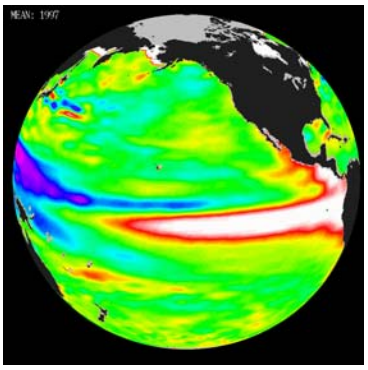
The volume of surface rocks removed in the past several million years is unusually high compared to previous periods in Earth's history because of disequilibrium between surface topography and glacial/interglacial climate conditions. Climate is to a certain degree driven by the Earth's surface relief.

Thus the topography of the Earth, and hence its instantaneous climate, presumably continues to evolve toward a state of equilibrium. Similar disequilibrium exists in the oceans. In the past 10,000 years global sea levels have asymptotically slowed to low rates of rise that may recently have been perturbed. The most sensitive indicators of the effects of shoreline disequilibrium are the world's deltas. Climate, relative sea level, topographic change and erosional interactions are perceived as an exciting area for geodynamics research because of their relevance to the urban and rural environment.

Towards this objective, CIRES sponsored a workshop "The Superficial Earth" to bring together a distinguished panel of scientists to discuss and debate the evolution and deformation of the Earth's lithosphere. The workshop was held at CIRES in Fall of 2002. Problems discussed included earthquakes in intra-plate settings. Earthquakes in mid-plate settings rarely occur below 40 km depth, indicating that the physical and chemical conditions prevailing in deeper rocks cannot sustain brittle failure. In support of this observation, the equivalent elastic thickness of the continents inferred from free-air gravity data is typically less than 40 km. In contrast, estimates of flexural loading of the lithosphere require elastic conditions to prevail to depths of 40 to 100 km over periods of many thousands of years. Hence the paradox – how is it possible for the Earth to support loads elastically at great depth and over long periods when the crust fails seismically at shallow depth and at short periods? Work that CIRES researchers have performed this year in the Himalaya and in the Eastern United States provide critical data to resolve this paradox.

For many years, laboratory measurements of high-temperature creep of rock-forming minerals have been used to infer that crustal minerals should deform more readily than olivine at the same temperature. This has led to the "jam sandwich" image of a brittle upper crust and weak ductile lower crust, and a stronger, if also ductile, upper mantle. Topography and the distribution of deformation near the earth's surface concur with this image, at least for regions like the Basin and Range Province and Tibet. At the same time, space geodetic measurements suggest that viscous deformation within or adjacent to the lithosphere is fast, and a weak lower crust does not participate. So, to what extent does a jam sandwich emulate the rheology of continental lithosphere? CIRES researchers have studied this problem with recent experiments across zones of continental deformation in New Zealand and Tibet.

Quantifying the Land-based Hydrologic Cycle



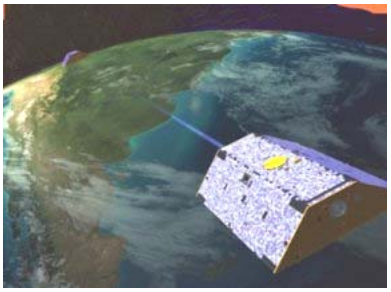
Sea surface height from Topex/Poseidon mission showing El Niño effect.

The launches of Earth remote sensing satellites Jason, GRACE, and ICESat, during the past year were important milestones for satellite geodesy. CIRES' geodynamics researchers play key roles in analysis of data from such satellites. The Jason 1 and the Topex/Poseidon satellites continue observations of the global climate interaction occurring between the sea and the atmosphere as a result of stored solar energy. Instruments on the satellites map variations in ocean surface topography to monitor world ocean circulation, study interactions of the oceans and atmosphere, improve climate predictions and observe events like El Nino. The joint NASA/CNES (France) TOPEX/Poseidon satellite, originally scheduled to map ocean surface topography for an initial period of 3 years, has now reached its astonishing 10-year anniversary this year. CIRES researchers monitoring the 10-years of data from TOPEX/Poseidon have observed a rise in mean sea level of 2.6 mm/year over the past ten years. The cause of this sea level

change is in part thermal expansion of the oceans, with a contribution from the melting of temperate glaciers in Patagonia, Asia and Alaska offset by an increase in the construction of water-storage reservoirs on the world's continents. These mass re-distributions have been invoked as a possible explanation for a large change in the Earth's oblateness (J2) during 1998-2002 detected using satellite laser ranging data (SLR).

Possibly the most important of these new satellites to studies of geology is the NASA/DLR gravity satellite GRACE (the Gravity Recovery and Climate Experiment), launched in March, 2002. This mission will map out the Earth's gravity field to unprecedented accuracy at monthly intervals, permitting the study of a wide range of processes involving the redistribution of mass within the Earth and at or near its surface.

The mission is presently nearing the end of its commissioning phase, and data are on the verge of being released for public consumption. Among projects completed during the last year by CIRES scientists were the development of analysis techniques to (1) use GRACE data to determine changes in the amount of water stored within continental regions of arbitrary shape and size, such as river basins; (2) combine GRACE and radar altimeter data to determine changes in the distribution of heat storage throughout the world's oceans; and (3) use GRACE data to better understand the viscosity of the Earth's mantle, through observations of the time-variable gravity signal over northern Canada caused by post-glacial rebound.



ORBITING TWINS. A microwave relay between the GRACE satellites measures their separation, which varies as the craft pass over gravitational anomalies on Earth's surface. NASA

Unlike conventional point or gridded hydrologic measurements, such as those from rain gauges, stream gauges, rain radars, and radiometric satellite images, GRACE data are sets of coefficients in a spherical harmonic expansion of the geoid. CIRES scientists have developed techniques to extract vertically integrated water storage within a given region from these coefficients. By comparing water storage estimates from synthetic GRACE data with water storage estimates by the same hydrologic model, CIRES researchers assess the accuracy of GRACE estimates, with a focus specifically on water storage variations within North American river basins. These results indicate that GRACE will provide a direct measure of seasonal water storage for river-basin water balance analyses; such data are without precedent in hydrologic analysis.

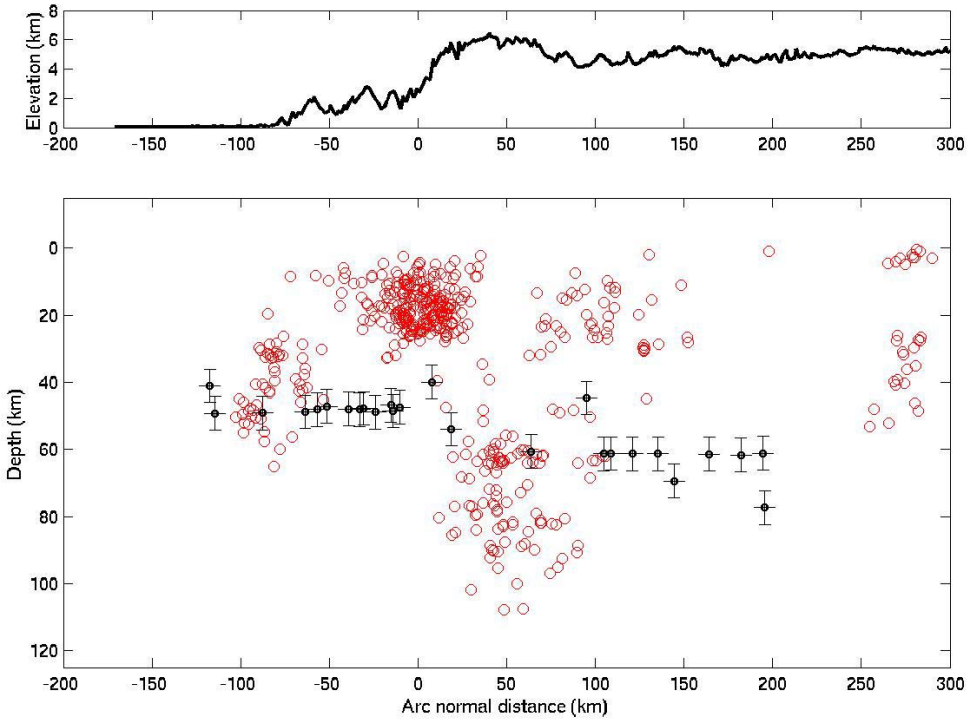
Continental Deformation and Mountain Building

A newly identified process of mantle/crust interaction is under investigation by CIRES researchers. This process may explain the behavior of parts of the western United States. Because of thermal contraction, the mantle portion of the lithosphere (through which heat is conducted, not convected) must be denser than deeper, hotter material brought adiabatically to the same depth (same pressure). Hence, the potential for a convective instability exists.

Previous work has shown that such instability, if initial perturbations are sufficiently large, can grow in geologically short times (1-10 millions of years). Rapid growth means that mantle lithosphere should be drawn into sinking sheets or plumes, and lithosphere remaining near the surface should thin, making volcanism likely, and perhaps also, upward movement of the Earth's surface. Two aspects of this process

are being investigated: (1) the effect of a low density overlying layer, simulating the Earth's crust, and (2) the application of scaling laws that we have derived to place bounds on the average viscosity of the mantle lithosphere. The investigations have resulted in the identification of a mechanism that can lead to thinning of the crust and mantle lithosphere, in a region separated geographically from where thickening occurs. The mechanism may explain why in the past 10 million years, mantle lithosphere was removed from beneath the Sierra Nevada in southern California, and that cold material now underlies the crust southwest of the southern Sierra. The investigation involves seismic and gravity data analysis, numerical modeling, and geochemical analysis.

CIRES' geodynamics researchers re-measured numerous geodetic arrays in Asia and North America in an attempt to more precisely define the rates of deformation in mid-continent areas. A new GPS campaign was initiated in the Colorado Rocky Mountain Front Range region to measure a first set of baseline



South (left) to north (right) cross section of topography (black solid line), seismicity (red circles) and crustal thickness (black bars) across the Himalaya of Nepal and Tibet. Earthquakes cluster in the midcrust beneath the region of maximum relief along the Himalayan front, a zone also identified as a locked zone from GPS measurements.

geodetic measurements across the region. Such initial measurements are essential as a starting point to determine crustal deformation, and can be remeasured after several years or after any major earthquakes. The strain rates in the Rocky Mountain region are assumed by many to be small, but no accurate measurements exist. This work is coupled with a seismic hazard analysis being carried out in the Colorado Front Range by CIRES researchers. The seismic hazard analysis involves the development of an earthquake catalog and measurements of earthquake faulting geometry throughout the southern Rocky Mountains.

Experiments are underway to monitor slow changes in the Indian sub-continent, and to monitor the past

and future effects of large earthquakes in the Himalaya. First results from a seismic array in the Nepal Himalaya deployed by CIRES' researchers track the complex geometry of the descending Indian plate. The flexure of the Indian continent by the stress system imposed by its plate-tectonic collision with Asia has been invoked to explain mid-continent earthquakes there. Years of geodetic measurements in the Himalaya by CIRES' researchers have clearly determined how the surface is moving in response to plate tectonic forces. However, such surface deformations have been explained by using models with subsurface slip that were not constrained by observational data. The Nepal/Tibet earthquake seismic array deployed by CIRES' researchers provides the subsurface images and 3D earthquake faulting patterns needed for a full geodynamic model of crustal deformation, slab subduction, and the mountain building process. The new information on subsurface faults and site velocity and amplification is important for earthquake hazard analysis.

CIRES' mountain research efforts were highlighted in a public outreach conference on the year of the mountain sponsored by CIRES. The conference, entitled "International Year of the Mountain Conference: From Ecosystems to Earthquake" featured a broad cross section of mountain researchers, anthropologists, and adventurers. The conference was open to the general public and was received with enthusiasm.

Near surface rock processes

A novel method to monitor the extent and/or treatment of underground fluid waste has been developed by CIRES' geodynamics researchers. The new method depends on the seismic attenuation and elastic properties of the storage material being modified by changes in interfacial tension between subsurface grains and contaminants. Remediation, flooding or contaminant leakage changes these interfacial tensions sufficiently to modify the amplitude and phase of transient seismic waves and the Earth's body tides. Initial work for the project was laboratory based, and in the past year the methods have been field tested at sites in Colorado and Arizona.

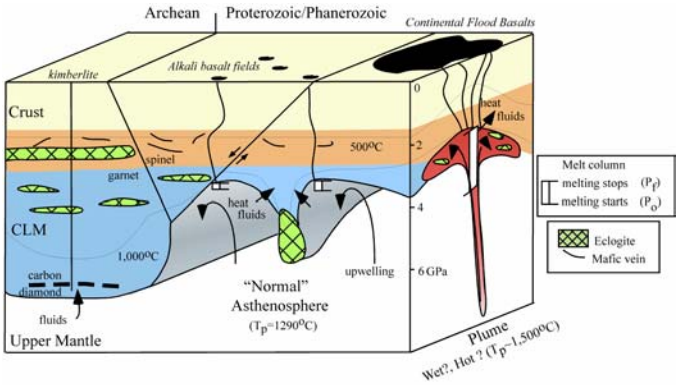
Geochemical studies of the lithosphere and hydrosphere

Highlights from the past year for CIRES' geodynamics in geochemical studies include

- The discovery that large iceberg "armadas" dispersed into the north Atlantic during periodic collapses of Late Quaternary Northern Hemisphere ice sheets (Heinrich events) were largely derived from North America and were likely not triggered by ice sheet instabilities in European ice sheets, as previously thought

- The publication of the first global compilation of continental alkali basalt chemical and isotopic compositions, along with a general review of relationship of basaltic magma formation and the deep evolution of the Earth's continental lithosphere (the diagram outlines how decompression melting of the sublithospheric mantle leads to continental basalt formation)

The creation of a North American Volcanic and Intrusive Igneous Rock Database (NAVDAT), in conjunction with the University of Kansas, the University of North Carolina, the U.S. Geological Survey, and the Carnegie Institute of Washington. This project is an integral part of the National Science Foundation's Geoinformatic Initiative.



Research Theme Accomplishments: *Planetary Metabolism*

General Objectives

The sustainability of the biosphere during the current period of rapid changes in the Earth system is an issue of prime importance for the environmental sciences. The physical and chemical features of the Earth are intimately tied to organisms and the activities required for their sustenance. The health of the biosphere can usefully be considered using the concept of "planetary metabolism," which refers to the complex web of biochemical and ecological processes that occur within the biosphere, and the interaction of these processes with the lithosphere, atmosphere and hydrosphere. Both natural and anthropogenic disturbances drive the structure and dynamics of natural systems, and a thorough understanding of these complex processes is essential to efforts to protect the biosphere from adverse effects due to pollution, destruction of natural landscapes, and alteration of climate.

The goals addressed last year within the Planetary Metabolism theme were to:

- increase our knowledge of the fundamental processes that drive the biosphere;
- use experimental tools to accurately measure indicators of change;
- enhance the sophistication of prognostic models capable of forecasting the response of ecosystems and the global biosphere to future environmental changes;
- carry out research that will develop science and technology to help restore and protect the health of the biosphere.

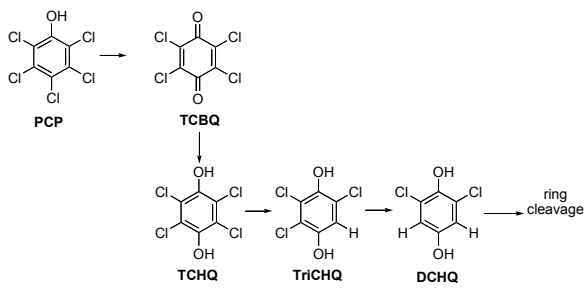
The participants in this endeavor include researchers from both the NOAA labs (the Aeronomy Laboratory and the National Geophysical Data Center), and the University (the Departments of Molecular, Cellular and Developmental Biology, Chemistry and Biochemistry, and Ecology and Evolutionary Biology). Seven CIRES Fellows whose work falls under the Planetary Metabolism theme have research supported by a broad cross-section of agencies, including NSF, NASA, ARO, EPA, USGS and NIH.

The Planetary Metabolism theme recognizes the integrated nature of the Earth System and, in its emphasis on biology, underscores the need for a system perspective. It addresses important components of the biosphere which contribute to and often drive human and natural system vulnerability and response to global environmental change. Studies within this theme bridge the temporal and spatial scales of climatic, environmental and societal interactions, and thereby serve to deepen our understanding of the mechanisms and dynamics underlying system adaptation or failure under changing conditions. Consequently, this theme contributes to and strengthens NOAA's research efforts to improve our ability to observe, understand, predict and respond to change in the global environment.

Research activities in Planetary Metabolism are diverse in nature and range in scale from microbes to regions. The broad nature of research under this theme is highlighted by these five projects:

Studies of enzymes that have been recruited to serve new functions in the degradation of an anthropogenic compound

This study was undertakin to discover how microorganisms evolve pathways for degradation of anthropogenic compounds. Pentachlorophenol is one of a number of anthropogenic pollutants that has been introduced into the environment during the last century. Such compounds often pose environmental problems because they are recalcitrant to



biodegradation. However, bacteria in some contaminated sites appear to be evolving new metabolic pathways that allow biodegradation of anthropogenic compounds, although these processes are often inefficient. During the past year, a new enzyme was indentified that involved biodegradation of the anthropogenic pollutant pentachlorophenol. This enzyme catalyzes reduction of tetrachlorobenzoquinone to tetrachlorohydroquinone. It is especially intriguing that this enzyme does not appear to be related to any of the many types of quinone reductases found in bacteria, but rather to proteins that normally transfer electrons to iron-sulfur clusters in proteins. Thus, this protein has apparently been recruited to perform a novel function during degradation of pentachlorophenol. In a separate project, genome shuffling methods have been used to generate mutant strains of *Sphingobium chlorophenolicum* that are significantly more effective at degrading pentachlorophenol and may be useful in bioremediation efforts.

Processing of organic film models of atmospheric aerosols by ozone and OH

This study was undertaken to understand the extent and effects of oxidative processing of organic atmospheric aerosols Recent field measurements have shown that a significant fraction of the mass of atmospheric aerosols is organic. Organic compounds preferentially partition to the surface of the aerosols and thus will be extremely susceptible to oxidation by OH, O_3, halogen atoms, and NO_3. Oxidation reactions with hydrocarbons can lead to fission of carbon-carbon bonds or formation of oxygenated compounds. Either pathway results in changes to the molecules at the aerosols' interface that will affect the ability of the aerosols to act as cloud condensation nuclei. This has direct implications for modeling and predicting climate change. In this work, thin films and pure organic aerosols were investigated as proxies for surface alkane and alkene organic compounds. Our results show that ozone will be a powerful oxidant for unsaturated compounds on atmospheric surfaces due to the consistently higher concentration. Ozonolysis reactions are important in the atmosphere because the mechanism involves the shredding of the initial compound, releasing volatile organics, which can be further oxidized to produce HO_x. However, OH will still be the dominant atmospheric oxidizer due to its reactivity towards any organic compound and the fast rate of hydrogen abstraction.

Impact of wind and salvage-logging on ecosystem dynamics in a subalpine forest ecosystem

Understanding the mechanisms that enable an ecosystem to regenerate following disturbance is critical to sustaining ecosystem function. To understand the effects of natural and anthropogenic disturbances on ecosystem function, this study examined the response of a subalpine forest ecosystem to both a natural and anthropogenic disturbance. The forest sustained a catastrophic blowdown in 1997; portions of the blowndown forest were salvage-logged in 1999. Results from this four-year study indicate that salvage-logging significantly reduced the ecosystem's ability to regenerate into subalpine forest. Soil erosion was significant following salvage-logging activities, but not following the 1997 windstorm. Consequently soils in salvage-logged areas contain less organic and inorganic nitrogen than unlogged blowdown areas. These results highlight the importance of organic matter in maintaining biotic control over ecosystem recovery of nutrient cycling in a wind-disturbed forest. Furthermore, this study shows that subalpine forests are relatively resilient to wind disturbance. Finally, salvage-logging appears to have the unintended consequence of delaying ecosystem recovery of this wind-disturbed forest by removing tree seedlings and soil organic matter, and by altering microclimate conditions.

Influence of climate variability on low flows in the South Platte River, Colorado

This study undertook to establish a quantitative basis for predicting the effect of intermediate-term climatic variability in regional watersheds. The maximum concentration of a pollutant that is allowed in wastewater effluent usually is determined in large part from the amount of dilution provided by the receiving water (stream segment or lake). Dilution is estimated from historical data by use of statistical criteria that define the expected extreme conditions (i.e., low-flow conditions) for any given month. The basis for statistical analysis is either a gage record or short-term field measurements of flow. However, gage records often are too short to reflect the whole range of irregularities in climate variation, including particularly synoptic variations with multiyear periodicities (e.g., ENSO). By use of selected gage records for watersheds that have a very long period of record, it was possible to show the effect of record length on estimates of available dilution in several sub-watersheds of the South Platte drainage. Time blocks of three to five years, which are commonly used for estimating low flows, produce estimates of low flow that are highly variable and are consistently greater than estimates derived from a longer record periods. Estimates of low flow from 10-year blocks, although more stable, differ from the long-term estimates by as much as a factor of two because of climate variability.

The study shows that failure to use extended gage records in estimating characteristic low flows leads to potential overestimates of the dilution potential of waters in the South Platte drainage, and probably elsewhere as well. This additional risk must be factored into regulations affecting the discharge of pollutants.

Creation of a new research project on biogenic volatile organic compounds for the California State University

A research program on "Volatile Organic Compounds from Plants" is being developed to take to Cal Poly University, Pomona. This project will involve measurements of emissions of volatile organic compounds from plants at several locations in southern California. This project will not only extend the total number of emission observations, but will also contribute to improved estimates of the response of biogenic emissions to climate and land management change. This project will involve pre-service teachers in the "doing of science". This research offers experiences to a broad range of students from liberal studies majors who can make measurements and organize emission data, to biology and chemistry majors who can investigate the origin and regulation of the VOC. Future teachers from the SCI211 course (Chemical Sciences), along with science majors in chemistry courses and the new environmental biology program will be able to take CHM 200 (independent study) to participate in this long-term project.

Research Theme Accomplishments: *Advanced Modeling and Observing Systems*

General Objectives

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

The scientific objectives for this theme are diverse and last year included:

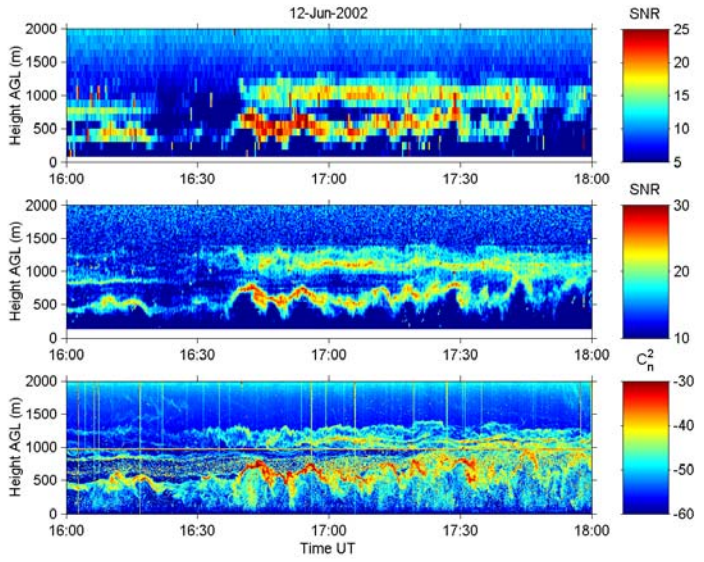
- instrumentation for atmospheric observation and analysis: Design and evaluate new approaches and instrumentation to make atmospheric observations of hard-to-measure species that are important players in the chemistry of the troposphere and stratosphere.
- sensor and technique development: Design and develop prototypical remote sensing systems for use from surface, airborne, and satellite platforms to measure critical atmospheric, surface, and oceanic parameters and address emerging observational priorities.
- end-to-end data management for field experiments and models: Develop prototype methods and processes for partnering with scientists to integrate modern data management and access tools into the planning and execution of field experiments as well as into the analysis and modeling of the results of those experiments.
- space weather reanalysis: Generate a complete eleven-year space weather representation using physically consistent data-driven space weather models. The project will create a consistent, integrated historical record of the near Earth space environment

Atmospheric Observing System Research

Atmospheric Observing Systems research in CIRES during 2003 included improvements and developments of new techniques and understanding associated with radar wind profilers, meteorological radar observations of ice cloud microphysical parameters, lidar profiling of atmospheric water vapor, studies of performance of a space based lidar for observing atmospheric winds, and deployment of multiple remote sensors to study aerosols' indirect effect on climate. In addition to these remote sensing techniques, CIRES researchers applied innovative, kite-based instruments to observe extreme gradients in the nighttime boundary layer, developed and deployed aircraft-based sensors to address HNO_3 uptake by cirrus clouds, and developed a diagnostic for stratospheric-to-tropospheric exchange of ozone.

Wind profilers provide an effective technique for continuously measuring winds under all weather conditions. New research has improved understanding of scattering mechanisms and the effects on the first three moments of the radar wind profiler Doppler spectra. In particular, the effects of radar scattering volume interactions with thin turbulent layers have been studied and new first principle

equations developed. Also, CIRES researchers have applied multiple-frequency techniques and range-imaging signal processing techniques to improve the range resolution of radar wind profilers. By applying these techniques, small-scale atmospheric phenomena such as entrainment zone structure, internal gravity waves, and Kelvin-Helmholz instabilities can be more effectively studied and characterized.



The range resolution of the data shown in the upper panel of the figure is 105-m. The same data have been RIM processed and are shown in the middle panel. It is clear that much more atmospheric structure has been revealed using the RIM technique. The FMCW radar data shown in the lower panel confirms this. Although not shown here, RIM can also be used to obtain wind estimates at high vertical resolution.

Microwave radars, used for observing cloud and precipitation structure, can be applied to measure the microphysical and radiative parameters of clouds. Within CIRES, a new method was developed to estimate the optical thickness and extinction coefficient of ice clouds using radar returns. The technique incorporates vertical profiles of reflectivity and Doppler velocity to retrieve profiles of ice cloud mass and particle characteristic size, which are then used to estimate cloud extinction from empirical relations that relate particle mass, size, and cross-sectional area. The extinction measurements derived using this method will be helpful for validating satellite-based optical retrievals of cloud characteristics, and can also be applied to measurements from space-borne radars.

In 2002, development and application of lidar techniques was a primary focus of CIRES' observing systems research, such that in 2003, a new compact, continuously operating differential absorption lidar designed to measure water vapor profiles in the lower troposphere was demonstrated. In comparisons with surface based sensors and radiosondes, the lidar-measured water vapor concentrations agreed with the in situ sensors to within about 0.2 g kg^{-1}. Future work will focus on increasing the range by increasing the laser transmitter. Eventually the lidar technology demonstrated in this research effort has the potential to provide one-half hour profiles and be deployed in mesoscale arrays.

CIRES scientists have extensively researched Doppler lidar techniques over several years. A current focus of Doppler lidar research is the eventual deployment of a Doppler lidar on a satellite platform to measure wind fields over all regions of the earth. Over the past year, CIRES' scientists developed performance models for a spacebased Doppler lidar that can be used for engineering studies aimed at optimizing proposed satellite designs.

CIRES' and NOAA scientists are collaborating to develop new methodologies to characterize the first aerosol indirect effect on climate, i.e., the effect of aerosol particles on cloud drop size and reflectance. The technique uses a suite of ground-based remote sensors, including a cloud radar, microwave radiometer, and Raman lidar, to quantify the response of clouds to a change in aerosol loading. Specifically, the remote measurements are analyzed to show the relative change in cloud drop effective

radius for a relative change in aerosol extinction under conditions of equivalent cloud liquid water path. The method was demonstrated for non-precipitating, ice-free clouds at the Southern Great Plains Atmospheric Radiation Measurement site.

In addition to the remote sensing research cited above, CIRES' scientists also developed and incorporated state of the art in situ sensors for atmospheric studies. A research effort incorporating fast response sensors suspended beneath a kite on a CIRES-developed tethered lifting system revealed temperature differences in the nighttime boundary layer in excess of 3.5 K over a vertical distance of a few meters. Maximum gradients as high as 20 K m^{-1} were observed at the top of the layer, with these intense gradients often observed to last for a reasonable fraction of an hour. Such results are important for understanding and modeling transport and diffusion of gases, as well as electromagnetic scattering, in the lower atmosphere.

State of the art in situ sensors deployed on high altitude aircraft are applied to measure atmospheric chemical parameters. A NOAA/CIRES research effort used chemical ionization mass spectrometry techniques to study the uptake of HNO_3 by cirrus clouds and to develop a diagnostic for stratospheric-to-tropospheric exchange of ozone. Results based on measurements of condensed-phase HNO_3 indicated that some cirrus clouds have significant potential to redistribute HNO_3 in the upper troposphere. For diagnosing tropospheric-stratospheric exchange, measurements of hydrochloric acid and ozone and application of the compact linear correlation of HCl with ozone in the lower stratosphere enabled differentiation of stratospheric ozone in the upper troposphere from ozone that originated in troposphere. The approach should processes affecting stropshere to troposphere transport to be diagnosed in the atmosphere with greatly increased precision and accuracy.

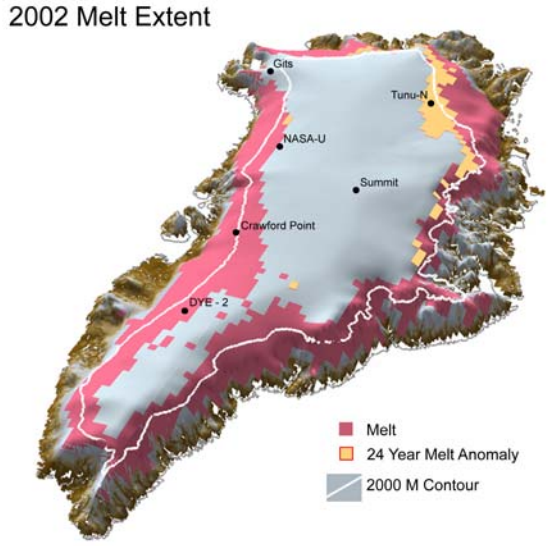
CIRES' scientists also apply advanced observing systems to investigate space weather phenomena. In one investigation, the relationship between equatorial magnetometer observations and the daytime vertical ExB drift velocities, which is related to the electrojet current was observed on a day-to-day basis. Previously such a relationship had been observed qualitatively but not quantitatively. A unique way of determining the strength of the electrojet, a narrow band of enhanced eastward current flowing in the 100 to 120 km altitude region within +/- 2 degrees latitude of the dip equator, is to observe the difference in magnitudes of the H component between a magnetometer placed directly on the magnetic equator and one displaced 6 to 9 degrees away.

Surface and Geophysical Observations and Modeling

During 2002 CIRES' research associated with surface observation techniques included improvement of surface heat flux over the ocean through improved retrievals of near-surface air temperature and specific humidity, as well as characterization of glacial and ice sheet melt in Greenland, observation of seasonal trends in horizontal angle of acoustic signals propagating over long ranges in the ocean, and investigation of new remote sensing techniques for early detection of tsunamis. CIRES Research was also aimed at improving global snow cover products from satellite remote sensing and at exploring possible applications of time-variable gravity measurements from the Gravity Recovery and Climate Experiment (GRACE).

Observations in Polar Regions represent a major center of expertise within CIRES. Institute scientists have been making expeditions to Greenland for measurements associated with changes and variability of the Greenland ice cap for several years. During 2002/2003, a variety of observations, including sensible and latent heat flux, GPS-derived strain rates, and ground penetrating radar, were combined to assess basal and surface melt rates at the Petermann glacier. Results showed that the ratio of the surface height change to ice thickness change is roughly six, indicating that the bottom topography of the glacier's floating ice tongue is reflected in the surface topography. The Greenland studies also showed that the

total area of surface melt on the entire Greenland ice sheet broke all known records for the island, and show a very dramatic warming trend since 1979. The 2002 melt extent seems to be a new record.



Maximum melt extent on the Greenland ice sheet observed in 2002 based on passive microwave satellite data (SSM/I). Note that in the northeast of Greenland a large region showed for the first time surface melt based on the 24-years long time series.

CIRES studies of snow cover were not limited solely to Polar Regions. An investigation of satellite estimates of snow cover, which compared data from visible and microwave sensors, was carried out. The visible data showed slightly higher annual maxima and minima and greater departures from the monthly mean within the time series, and defined the respective advantages and disadvantages of the two types of satellite data for snow cover mapping. The study concluded that a blended product would represent an optimal approach; such a product is currently under development.

New ocean observing techniques also received attention at CIRES during 2002. Techniques aimed at detecting tsunamis based changes in ocean surface roughness were explored. As part of this work, CIRES scientists developed an asymptotic theory that describes tsunami-induced perturbations to the mean wind velocity, which, in the lowest tens of cm of the atmosphere can be comparable to the unperturbed wind velocity. By observing changes in surface roughness with satellite or aircraft based microwave radars and radiometers, "tsunami shadows" associated with destructive tsunamis should be observable. Also, information on ocean inhomogeneities associated with mesoscale eddies can potentially be gleaned from seasonal changes in horizontal refraction angle. CIRES scientists gathered experimental data to study changes in horizontal refraction angle along a 4000 km propagation path from Kauai to the coast of California, and are analyzing these measurements to investigate changes in ocean structure.

CIRES' research efforts use satellites to study ways to improve estimates of the sensible and latent heat transfer to the atmosphere. Because a significant portion of the errors associated with the use of bulk formulae in satellite retrievals of heat flux is attributed to uncertainties in retrieved near-surface temperature and humidity, CIRES scientists have investigated ways to improve accuracy of these retrievals. Use of co-located AMSU-A and SSM/I observations improved estimates of temperature by 0.16 K, and near surface humidity estimates by 0.19 g/kg, based on comparison with ship observations. Energy dynamics at the Earth's surface were also investigated by applying fractal models to derive relations for hydraulic conductivity, which should lead to improvements in models of energy and moisture fluxes at the land/air interface.

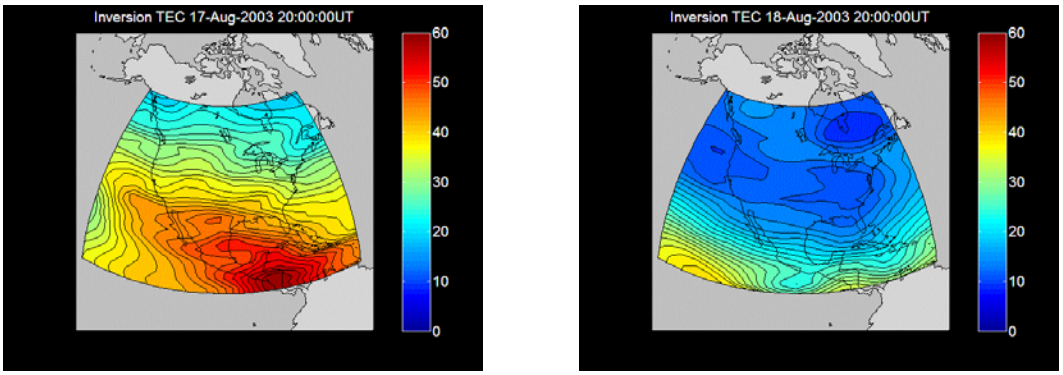
CIRES plays a major role in the five-year GRACE mission, which will map out the Earth's gravity field to unprecedented accuracy at monthly intervals. Temporal variations in gravity inferred from GRACE data will allow study of a wide range of processes, such as changes in continental water storage, changes in the distribution of snow and ice on the polar ice sheets, changes in sea floor pressure over scale of a few hundred km, that involve redistribution of mass within the Earth and at or near its surface. CIRES is developing new methods for converting the GRACE gravity fields into useful measurement of mass distribution, and looking at ways to combine GRACE measurements with measurements from other techniques such as laser altimeter observations of ice sheet elevations and GPS crustal motion observations.

Modeling the Space Environment

During 2002, CIRES research associated with modeling the space environment represented significant activity. Models were developed and examined within CIRES or as part of collaborative efforts to develop assimilation techniques for incorporating ionospheric measurements into models, improve prediction of solar wind interplanetary magnetic field, predict geomagnetic storms, better understand transient disturbances, and simulate response of the low latitude upper atmosphere to geomagnetic storms.

CIRES' scientists played a key role in development of the Global Assimilation of Ionospheric Measurements (GAIM) model, which provides assimilation of ionospheric data as part of a multi-organizational attempt to develop a space weather global ionospheric model similar to numerical weather models. CIRES scientists are developing low latitude ionospheric inputs and global neutral composition specifications. In addition, CIRES scientists are validating the GAIM model through the use of a network of GPS receivers to provide an estimate of line-of-sight total electrons between a receiver and a satellite. Initial validation results showed that the GAIM model consistently showed accuracies two to three times that of current empirical models.

Validation of an empirical storm-time ionospheric correction model, which provides a useful tool for estimating the changes to the ionosphere in response to geomagnetic activity, has also been pursued at CIRES. Results showed significant improvement in the current version of the International Reference Ionosphere which includes the empirical model, relative to an earlier version.



The example shows the response of the ionosphere over the CONUS in response to a geomagnetic storm in August 2003. The top figure shows the normal development of the peak total electron content during the day reaching values over 50 TEC units on August 17 (1 TEC = 10^{16} electrons m^{-2}). On the storm day on August 18th, in the right-side figure, the geomagnetic storm wiped out the normal development of the dayside peak, leaving a trough in electron density.

Research Theme Accomplishments: *Integrating Activities*

General Objectives

Boundaries between scientific disciplines have traditionally served as obstacles to collaboration. However, over the past decade or more, policy makers and the general public have demanded that publicly-funded science show greater relevance to the material issues facing nations today. The result is that research has become increasingly interdisciplinary and focused on the needs of decision makers.

Scientists also recognize that scientific advances are accelerated at the intersection of traditional disciplines, boosting their desire to work across disciplinary boundaries. Consequently scientists specializing in the physical and biological sciences today work together more than in the past, and interdisciplinary research now occurs across the physical, biological and social sciences as well as between the sciences and humanities, and between scientists and educators.

As society grapples with environmental concerns of the 21st century, it has come to value scientific analyses for help in understanding and resolving concerns. But society has also come to realize that scientific information is insufficient by itself for decision making. And as scholars have recognized for many years, the connections linking science and decision making are complex and challenging.

Thus, for science to be truly useful, it has become apparent that research on the connections of science and decision making must be undertaken and the links understood before science can contribute effective responses to modern environmental challenges.

CIRES sought last year:

- to respond to these trends toward collaboration within the scientific enterprise,
- to serve as a leader in the conduct of interdisciplinary science
- to forge new ways to connect science with society's needs, and
- to promote science literacy.

Interdisciplinary Research

The Center for Science and Technology Policy Research was initiated within CIRES in the summer of 2001 to deliberately support and subminister CIRES' Integrating Activities research projects. The center's mission is research, education and outreach at the interface of science and decision making. In 2002, to meet these goals the center has engaged in a wide range of integrating activities in interdisciplinary research, education, and outreach that encompass the Institute's other research themes and contribute to the overall mission of the Institute, NOAA, and the University of Colorado. These areas are described below.

- ***Science policy.*** The traditional scholarly interest in science policy has for years been captured by the phrases "science for policy" and "policy for science." The Center will explore how scientific information is linked to decision making and will also examine governance of the scientific enterprise with topics that range from broad federal government resource allocation issues to the practice of peer review.
- ***Technology policy.*** Technology policy refers to the interrelationship of government, academia, and the private sector, and their shared goal of enhancing economic vitality through the transfer of knowledge to useful products and processes. Technology policy research seeks to understand these relationships and to develop, evaluate, and critique them.

- ***Technology assessment.*** Technology assessment seeks to integrate knowledge of technological systems with their broader social and policy context as a contribution to the governance of science and technology. Decisions about how to allocate finite (and frequently scarce) resources can be made more effectively when decision makers consider integrated understandings of technology in society.

CIRES' Western Water Assessment (WWA), a core project within the CIRES Center for Science and Technology Policy Research, typifies the Center's direction in fostering interdisciplinary research and connections between science and decision making.

The mission of the WWA is to improve water-related decision-making and management in the Interior West by increasing the scope, quality, availability and relevance of climate products and knowledge.

Research focuses on the decision-making processes of the individuals, groups, and organizations in the Interior West that have responsibility for managing water resources, as well as those who use the water, and those responsible for its treatment and the protection of the aquatic environment. Collectively, this diverse set of individuals, groups and organizations represent the WWA "user community." By understanding the decision making processes, the stresses, and the constraints of this community, WWA researchers can develop hydro-climate products that meet user needs, allowing the user community to make more informed decisions.

The project has established an interdisciplinary team to study contemporary problems of water availability, water allocation, and water use. Moreover, and central to the goal of linking academic research with societal needs, the WWA project has developed strong partnerships with a suite of different climate-sensitive organizations and information brokers.

The interdisciplinary nature of the WWA project differs from most of the CIRES projects in other themes. Like other projects, the approach is problem oriented. However, the problem selected is one that is of high societal significance, and one that requires input from multiple disciplines to provide useful insights. The problem addressed by WWA researchers revolves around the availability of adequate water supplies: Will we have enough water of adequate quality to meet the competing demands from municipal and industrial and agricultural water users, while still maintaining enough water in lakes and streams to protect endangered species and limit the environmental effects of pollutant discharges?

These research questions are assessed using an integrated model of the South Platte water supply and distribution system. The model unites climate-related river flow scenarios and forecasts, quantified water demands, institutional arrangements for water allocation, and the effects of the resultant flows on water shortages and water quality within a quantitative framework designed for evaluation of policy options. Integration is made possible because the model itself provides a common language which researchers from different disciplines can use and understand. The model provides a virtual hub that allows researchers to share data and ideas. The model structure and assumptions are transparent, so model findings can be easily shared with decision-makers.

Placing academic research at the service of societal needs is another explicit objective of the WWA project. The partnership between WWA researchers and operational hydrologists at the Colorado Basin River Forecast Center—an organization that sits at a key interface between scientists and users of science—models this new paradigm.

The goal of the partnership is to improve operational streamflow forecasts. CBRFC has implemented WWA experimental methods for streamflow prediction in their operational forecast system, and CBRFC

hydrologists are running these experimental procedures side-by-side with their traditional forecasting procedures. This partnership is successful because (1) WWA researchers work within CBRFC's operational framework—they do not strive to re-invent the operational hydrologic forecasting system; (2) The Hydrologist in Charge at the CBRFC has given one of his employees responsibility to incorporate WWA experimental products in the CBRFC operational systems, and (3) all parties receive professional benefits for a successful research-operational partnership.

Within its Integrating Activities Theme, CIRES also is home to a diverse range of research, education and outreach activities. 2002 saw the initiation of the following projects:

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

Experimental Climate Services (including Web and Data Services): Couple enhanced observations and research within regions characterized by strong climate variability with analysis of past data and improved modeling. A special emphasis is on determining factors influencing the occurrence of extreme events. The need to better observe, model, and predict the regional consequences of climate change and variability on hydrological variables, on time scales ranging from days to decades, also falls within this goal.

Educational Standards and Web Access to Scientific Information: Facilitate integration of data collected by CIRES and NOAA scientists into the National Science Digital Library (NSDL) system for their research activities by creating compliant metadata for those datasets.

Regional Ecosystems Assessment Data: Evaluate data and informatics needs to support integrated regional ecosystem assessments and improve the empirical basis for ecosystem assessment and communication to policy and decision makers.

Support Local Educational Change Efforts: Advance local school district efforts in science education by providing in depth content and understanding of the scientific enterprise, and by providing K-12 schools with access to university researchers, new scientific knowledge and educational opportunities.

Evaluation Service Center for the Digital Library for Earth Systems Education (DLESE): Examine the impact of digital library use within science education and promote the use of social science methodologies in evaluating geoscience education.

GIS and Environmental Modeling: Advance collaborative research and development of environmental modeling and mapping by improving integration of geographic information systems (GIS), prototyping second-generation informatics tools and technologies, and refining integrated assessment frameworks and protocols for application in sound decision making.

Data Mining of Environmental Archives: Create tools that allow the mining of vast environmental archives for the purpose of knowledge extraction, data quality control and trend detection.

Research Support

Innovative Research Program (IRP)

CIRES created an Innovative Research Program to stimulate a creative research environment and encourage synergy between disciplines. The intent was to provide an uncomplicated mechanism for supporting small research efforts that can quickly provide concept viability or rule out further consideration. This program encourages novel, unconventional and/or fundamental research that might otherwise be difficult to fund. The principal investigators and research topics selected during last year's competition include:

Chris Aiken, Andy Moore and John Hart (PAOS)
The Search for Optimal Perturbations

Shelley Copley (MCDB) and Ryan Gill (CEAE)
A Post-Genomics Approach to Evolution of Microbial Fitness in Complex Mixed-Waste Environments

Bruce Kindel and Carol Wessman (CSES)
Direct Measurements of Evapotranspiration: A Novel Approach

Balaji Rajagopalan (CDC), Martyn Clark (NSIDC) and Edie Zagona (CADSWES)
An Integrative Framework for Water Quantity and Quality Decision Making in the Face of Climate Variability

Anton Seimon and Todd Albert (Geography)
Mapping Ecological and Environmental Responses to 20th Century Warming in a Tropical Andean Cordillera

Veronica Vaida (Chemistry), Erik Richard, Adrian Tuck, John Daniel and Susan Solomon (NOAA/AL)
Water Complexes as Unconventional Absorbers of Solar and Terrestrial Radiation

Carol Wessman (CSES) and Nancy Golubiewski (INSTAAR)
Urban Ecology in the Colorado Front Range: Assessing Interdisciplinary Components and Functional Structure

Integrated Instrument Design Facility (IIDF)

The CIRES/Chemistry Integrated Instrument Development Facility is multi-faceted, consisting of machine, glass, and electronics shops dedicated to the design and fabrication of scientific instrumentation for physical, chemical and biomedical research. Our primary areas of expertise are opto-mechanical assemblies, high-vacuum instrumentation, charged particle optics, systems for laboratory-based and flight-based atmospheric research, and data acquisition and control electronics and software. The IIDF is the only facility at the University of Colorado that specializes in complete instrument fabrication -- from theory to testing. It also works with the university Technology Transfer Office to assist in sharing technology with the scientific community and provide an avenue for patenting developments where appropriate.

Education and Outreach

CIRES contributes to the public's understanding of environmental science through many different avenues, including K-12 and undergraduate education, articles in local and national news media, and through public events such as conferences and symposia. CIRES also contributes to the development of the future environmental science workforce through graduate student education and support of programs that engage under-represented groups in the environmental sciences.

The CIRES Education Outreach program has a number of projects and new initiatives, some of which are listed in the following:

- The Sombrero Marsh project is a partnership between a research institute (CIRES), a non–profit organization, a local government agency, and a school district (Boulder Valley SD). The project is supported by a new NSF grant awarded to a consortium of university science departments.
- CIRES Outreach has strong ties with the Digital Library for Earth Systems Education (DLESE), devoted to improving science education at all levels, and to increasing the use of Earth science data and research in education.
- CIRES Outreach hosted the 2003 DLESE Annual Meeting. The event attracted 215 attendees and provided visibility for CIRES and the University. Meeting participants ranged from K-12 educators, college faculty, researchers, NSF and NASA program officers, governmental agency leaders, earth science data providers, technologists, and librarians.

CIRES Outreach continues to support researcher's requests for education outreach components on research grant proposals. These components are encouraged or requested by funding agencies as a means of transferring new science knowledge to the public. A new research and education project (directed by Russ Monson, Ph.D.) has been funded through the NSF biocomplexity program; several new proposals are currently under review.

CIRES promotes a scientifically-literate society and the development of the scientific workforce through its support of collegiate and graduate education. CIRES' funding agencies particularly recognize the importance of engaging under-represented groups (minorities and females) within the environmental sciences workforce. CIRES responds to these concerns through several mechanisms:

- CIRES' faculty is diverse and associates with a number of departments, including chemistry and biochemistry, civil-environmental and architectural engineering, electrical and computer engineering, physics, geography, geological sciences, ecology and evolutionary biology, molecular-cellular and developmental biology; and programs such as the Program in Atmospheric and Oceanic Sciences, Environmental Program, Environmental Studies Program, Geophysics Program, and Hydrology Program.
- Of the 487 CIRES members, a total of 54 graduate students are associated with and supported by CIRES. Of these, several (seven in 2002/2003) receive CIRES graduate fellowships. In addition, CIRES supports a total of 98 undergraduate students on an hourly basis.
- CIRES and NOAA support two students to participate in the Significant Opportunities in Atmospheric Research and Science (SOARS) program at UCAR. The SOARS program is dedicated to increasing the number of African American, American Indian, and Hispanic/Latino students enrolled in master's and doctoral degree programs in the atmospheric and related sciences with the goal of increasing ethnic diversity within the scientific community of the future.

Partnership with CIRES allows protégés to access research opportunities beyond those available at UCAR.

- Every year, undergraduate students who are part of the Summer Multicultural Access to Research Training (SMART) program receive mentoring from CIRES members. SMART funds undergraduate research activities during a 10-week summer session aimed at minority students. Participants conduct individually-designed research projects, and attend workshops and seminars on technical writing, oral communication, and application to graduate school.
- CIRES researchers contribute to the undergraduate teaching mission of the University in several ways. CIRES members teach undergraduate courses within departments and programs at the university and provide research opportunities for undergraduates within CIRES laboratories. In addition, the CIRES Outreach staff established a unique science course designed specifically for prospective teachers. This course is offered through the Geological Sciences department and is a sister to a similar course taught within the Molecular, Cellular and Developmental Biology department.

CIRES, in collaboration with various departments on the Boulder campus, organize graduate student seminars, colloquia, and workshops in the environmental sciences. These gatherings are well attended and provide unique opportunities for students to interact with researchers in various fields and disciplines. A number of students are involved in ongoing field research activities through CIRES faculty members and researchers all over the globe, providing valuable experience and mentoring during their graduate education.

APPENDICES

Visiting Fellows Program

CIRES typically budgets $450,000 to maintain an active visiting fellows program. Selections for this program are based in part on the likelihood of interactions between the Visiting Fellow and the scientists at CIRES and the degree to which both parties will benefit from the exchange of new ideas. To further this goal, priority is given to candidates with research experience at institutions outside the Boulder scientific community. Visiting Fellows selected last year from a highly competitive pool are shown in the following table. Further information can be found at http://cires.colorado.edu/visfell/vf.html.

Name	Affiliation	Research Mentor(s)	Project Title
Alargov, Dimitar	Aeronomy	Fehsenfeld, Frederick & Sievers, Robert	Behaviors of Organic Substances in Supercritical Fluids at High Pressure
Brocklehurst, Simon	Geology	Steffen, Konrad & Bilham, Roger	Study periglacial hillslopes in glaciated environments and tectonically active setting.
Burgos, William	Geology	Bilham, Roger	Effect of Biological Ferric Oxide Dissolution, Uraninite Precipitation and Bacterial Growth on Electrical Resistivity, Seismic Absorption, and Permeability of Soil
Denys, Paul	Geology	Bilham, Roger	Measure the verticle velocity of tide gauge structures AND measure the uplift of a mountain belt.
Fortin, Tara	ETL, Policy Center	Hardesty, Michael & Pielke, Roger ,	Evaluating Uncertainty in Atmospheric Models: Implications for Science and Science Policy
Herzfeld, Ute	Geology	Steffen, Konrad & Barry, Roger	Study of ice-surface features as indicators of glaciologic and climatic processes, based on analysis of ground and satellite data
Walton, Edward	Outreach	Buhr, Susan	Workshops for teachers that communicate both science content & scientific approach

Graduate Research Fellowship Program

This program is open to CIRES-affiliated Ph.D. candidates (typically in their last year) to enable a greater focus upon their research project. They receive 12 month, nonrenewable awards that include half-time stipends, tuition and partial student health insurance. The summer-month stipend may be augmented by funds from contracts and grants under Graduate School and departmental policy as available.

Name	Affiliation	Research Mentor(s)	Project Title
Cullather, Richard	PAOS	Lynch	Atmospheric Moisture Transport and Freshwater Budget of the Arctic
Fortin, Tara	CHEM	Tolbert	Laboratory Studies of Atmospheric Aerosols
Golubiewski, Nancy	EPOB	Wessman	Urban Sprawl in Colorado's Front Range: Net Primary Productivity and Carbon Storage
Hintze, Paul	CHEM	Vaida	The Spectroscopic Properties of Gas Phase Sulfuric Acid
Koch, Linda	CHEM	Ravishankara	A Missing Link in the CLAW Hypothesis: DMS Oxidation
McGrath, Claire	EPOB	Lewis	Mechanisms for the Displacement of Greenback Cutthroat Trout by Brook Trout
Rosenstiel, Todd	EPOB	Monson	Metabolic Regulation of Ionosphere Emission

Significant Opportunities in Atmospheric Research and Science (SOARS) Program

SOARS is a model learning community and mentoring program for promoting racial and gender equity in the atmospheric and related sciences. Created by and administered through the National Center for Atmospheric Research, CIRES has formed a partnership with this program to participate in this highly regarded program while providing NCAR with a wider range of disciplines to place students. It is a multi-summer, four year undergraduate and graduate program for students majoring in an atmospheric science or a related field such as biology, chemistry, computer science, earth science, engineering, environmental science, mathematics, meteorology, oceanography, physics, or social science. Program information can be found at http://www.ucar.edu/soars/.

Name	Affiliation	Research Mentor	Project Title
Navarro, Fabiola	CIRES	Avery, Susan & Cindy Schmidt	Development of a New Meteor Radar for Measuring Upper Atmosphere Winds
Thornbrugh, Casey	CIRES	Lynch, Amanda, Elizabeth Cassano & Nancy Dawson	Forecasting Extreme Wind Events Impacting Barrow, AK through Analysis of Regional Sea-Level-Pressure Patterns

Undergraduate Research Opportunities Program (UROP)

The Undergraduate Research Opportunities Program (UROP) was designed to create research partnerships between faculty and undergraduate students. Research in this context is interpreted as any scholarly or creative activity ranging from traditional scientific experimentation to the creation of new artistic works. UROP awards stipends and/or expense allowances to students who undertake an investigative or creative project in collaboration with a faculty member. Although projects are normally designed around some aspect of the faculty sponsor's research, they may also develop from original ideas of the student, which are endorsed by a faculty sponsor. Whether the context is scholarly or artistic, UROP projects call for significant input on the part of the faculty sponsor. Program information can be found at http://www.colorado.edu/Research/UROP/ .

Name	Affiliation	Research Mentor	Project Title
Brown, Ian	NSIDC	Scambos, Theodore	Blue Ice Areas in Antarctica
Azman, Andrew	Engineering	Gupta, Vijay	Investigating Heat Transport in a Simple Climate Model
Noble, Andrea	Limnology	Lewis, William	Gucontent Analysis of Greenback Cutthroat Trout and Brook Trout in Montane Streams in Colorado
Klass, Jeremy	EPOB	Wessman, Carol	Effects of Grazing and Land Use on Soil Chemistry
McConnell, Megan	CSES	Chase, Thomas	Investigating Simulated Climate Trends

CIRES Staffing by Title and Degree

Current as of 30 June 2003

JOB TITLE	TERMINAL DEGREE	TOTAL
PROFESSOR	DOCTORATE	11
ASSOCIATE PROFESSOR	DOCTORATE	8
ASSISTANT PROFESSOR	DOCTORATE	4
RESEARCH PROFESSOR	DOCTORATE	1
	Sub total	24
RESEARCH SCIENTIST	POST-DOCTORATE	4
" " " "	DOCTORATE	133
" " " "	MASTER'S LEVEL	5
" " " "	BACHELOR'S LEVEL	3
" " " "	NOT INDICATED	2
	Sub total	147
RESEARCH ASSOCIATE	DOCTORATE	2
" " " "	MASTER'S LEVEL	83
" " " "	SOME GRADUATE SCHOOL	2
" " " "	BACHELOR'S LEVEL	106
" " " "	2-YEAR COLLEGE DEGREE	2
" " " "	SOME COLLEGE	10
" " " "	HIGH SCHOOL GRADUATE	1
" " " "	NOT INDICATED	12
	Sub total	218
DIRECTOR	DOCTORATE	1
EXECUTIVE DIRECTOR	MASTER'S LEVEL	1
ASSISTANT TO THE DIRECTOR	MASTER'S LEVEL	1
MACHINING TRADES III	2-YEAR COLLEGE DEGREE	1
GROUNDS & NURSERY I	SOME COLLEGE	1
ADMIN ASSISTANT INT	SOME COLLEGE	1
ADMIN ASSISTANT II	BACHELOR'S LEVEL	2
ADMIN ASSISTANT III	SOME COLLEGE	1
OFFICE MANAGER I	NOT INDICATED	1
IT TECHNICIAN II	NOT INDICATED	1
	Sub total	11
POST DOCTORAL FELLOWS	DOCTORATE	21
VISITING PROFESSOR	DOCTORATE	1
VISITING FELLOWS	VARIOUS	7
VISITING SCIENTISTS	VARIOUS	4
	Sub total	33
GRADUATE STUDENTS	VARIOUS	54
UNDERGRADUATE STUDENTS	HIGH SCHOOL GRADUATE	98
	Sub total	152
	Grand total	585

CIRES Committees for 2002-2003

Council of Fellows

Susan Avery	Tim Fuller-Rowell	Bill Neff	John Wahr
Balaji Rajagopalan	Alex Goetz	Steve Nerem	Carol Wessman
Ben Balsley	Vijay Gupta	Roger Pielke Jr.	
Roger Barry	Ted Habermann	George Reid	*43 total CIRES Fellows*
John Birks, *Emeritus*	Mike Hardesty	Doug Robertson	*41 voting*
Roger Bilham	Jose Jimenez	Thomas Schlatter	*2 Emeritus*
Thomas Chase	Craig Jones	Anne Sheehan	*2 Affiliates*
Shelley Copley	*Carl Kisslinger*, *Emeritus*	Robert Sievers	*1 Ex-officio*
Randy Dole	Bill Lewis	Susan Solomon	*2 Member's Representatives*
David Fahey	Amanda Lynch	Hartmut Spetzler	*Staff Representatives, as needed*
Chris Fairall	Peter Molnar	Konrad Steffen	
Lang Farmer	Russ Monson	Pieter Tans	
Graham Feingold	Andy Moore	Maggie Tolbert	
Fred Fehsenfeld		Veronica Vaida	

CIRES Affiliates

Henry Diaz, effective 2003
Ray Fall, effective 2002

Executive Committee	**Member's Council Representatives**
Director	Wayne Angevine
Executive Director	Cathy Burgdorf
Associate Directors	Mihail Codrescu
Shelley Copley (exp. Sept. 03 – 2nd term)	Julia Collins
Tim Fuller-Rowell (exp. Sept. 04 – 1st term)	Dave Costa
William Neff (exp. Sept. 03 – 2nd term)	Rod Frehlich
Carol Wessman (exp. Sept. 04– 2nd term)	Jeff Hare, Member's Rep to Fellows/Exec
Rob Schubert, Members' Representative	Ruth Hobson
Jeff Hare, Members' Representative	Michelle Holm
CIRES Staff (Ex-officio)	Anne Jefferson
	Ted Scambos
	Robert Schubert, Member's Rep to Fellows/Exec

Associate Directors	**Acting Directors**	
Fred Fehsenfeld (Environmental Chem. and Biology)	Paul Sperry	Maggie Tolbert
Roger Bilham (Solid Earth Sciences)	Konrad Steffen	Alex Goetz
Roger Barry (Cryospheric and Polar Processes, Acting)	Ben Balsley	
Mike Hardesty (Atmospheric and Climate Dynamics)	Bill Lewis	

Career Track Committee	**Visiting Fellows**
Chris Fairall	Ben Balsley, Chair
Doug Robertson, Chair	Roger Pielke Jr.
Vijay Gupta	Balaji Rajagopalan
Tom Schlatter (need to replace)	
Veronica Vaida	

Computing Advisory Committee	**Distinguished Lectureship Series**
Ted Habermann, Chair Tom Chase Julia Collins Ted DeMaria Rod Frehlich Ken Knowles Leanne Lestak Mark Lohaus Robert Schafer Ex officio: Paul Sperry, Graham Mountain	Peter Molnar, Chair Maggie Tolbert

Director's Reappointment Committee (02-03)
John Wahr, Chair Fred Fehsenfeld Anne Sheehan

Fellows Appointment/Reappointment	**Space Committee**
Craig Jones, Chair Alex Goetz Maggie Tolbert Russ Monson	Bill Lewis, Chair Lang Farmer John Wahr Ex-officio: Rob Schubert

Innovative Research Proposal Reviewers	**Awards Committee**
To be determined pending receipt of proposals	Bill Lewis, Chair Carl Kisslinger George Reid

Faculty Search Committee (Geomorphology)	**Faculty Search Committee Mesoscale Regional Integrated Climate , PAOS**
Peter Molnar, Chair Anne Sheehan Karl Mueller John Pitlick Nel Caine	Amanda Lynch, Chair Andy Moore Roger Barry Weiqing Han

Graduate Fellowship	**Theme Leaders**
Paul Sperry, Chair CIRES Director Jose Jimenez	Koni Steffen, Mike Hardesty - Adv. Modeling and Observing Systems Andy Moore, Roger Barry - Climate Systems Variability Roger Bilham - Geodynamics Shelley Copley, Carol Wessman - Planetary Metabolism William Neff, Fred Fehsenfeld - Regional Processes Roger Pielke Jr. – Integrating Activities

Honors and Awards

July 2002 –June 2003

President of the American Meteorological Society
Susan Avery

Elected Fellow of the American Geophysical Union
Roger Bilham

Appointed Lifetime National Associate, National Academy of Sciences
William M. Lewis, Jr

American Registry of Outstanding Professionals
Rudolph Dichtl

American Men and Women of Science
Rudolph Dichtl

NOAA Outstanding Scientific Paper Award. 2002. "Observations of Ozone Formation in Power Plant Plumes and Implications for Ozone Control Strategies," Science, Vol 292, pp. 719-723, 2001. Ryerson, T.B., M. Trainer, J.S. Holloway, D.D. Parrish, L.G. Huey, D.T. Sueper, G.J. Frost, S.G. Donnelly, S. Schauffler, E.L. Atlas, W.C. Kuster, P.D. Goldan, G. Hübler, J.F. Meagher, and F.C. Fehsenfeld. 2001
John Holloway
Donna Sueper
Greg Frost
Gerhardt Hübler
Fred Fehsenfeld

National Science Teachers Association, SciLinks Award for All About Snow (http://nsidc.org/snow/)
Michael Meshek

Meritorious Presidential Rank Award winner
Steven Clifford

Group Achievement Award from NASA for the Fourth Convection and Moisture Experiment (CAMEX-4) Science Team
Kenneth Aikin
Erik Richard

2002 Editor's Award, Monthly Weather Review
Thomas Hamill

Sixth Annual Webby Awards People's Voice Award Winner for Science, http://earthobservatory.nasa.gov
Michon Scott
Laurie Schmidt

Scientific American Sci-Tech Web Award, ***http://www.sciam.com/article.cfm?articleID=000A2802-95C1-1CFB-93F6809EC5880000***
Michon Scott
Laurie Schmidt

Certificate of Appreciation from ETL
Lee Church

Outstanding scientific paper award from NOAA Office of Oceanic and Atmospheric Research for research paper: Sardeshmukh, P. D., G. P. Compo, and C. Penland, 2000: Changes of probability associated with El Nino, J. Climate, 13, 4268-4286.
Prashant Sardeshmukh
Gilbert Compo

Best Poster at the 2002 CMDL Annual Meeting
Robert Stone

Honorable Mention, 2002 Universities Council on Water Resources (UCOWR) PhD Dissertation Award Competition
Shaleen Jain

NOAA Outstanding Paper Award: "Characteristics of the Tropical Tropopause as Revealed by Radiosondes" (Journal of Geophysical Research 106, 7857-7878, 2001, by Dian Seidel, Rebecca Ross, James Angell, and George Reid)
George Reid

Elected as a Fellow of the Institute of Electrical and Electronic Engineers
Ed Westwater

Dupont Fellowship, University of Virginia
Oliver Frauenfeld

2002 Harold D. Lasswell Prize for chapter in Finding Common Ground: Governance and Natural Resources in the American West
Roberta Klein

ETL Outstanding Seminar Award
Oleg Godin

NOAA Outstanding Scientific Paper award for Oltmans, S. J., H. Vömel, D. J. Hofmann, K. H. Rosenlof, and D. Kley, The increase in stratospheric water vapor from balloonborne frost-point hygrometer measurements at Washington D.C., and Boulder, Colorado, Geophys. Res. Lett., 21, 3453-3456, 2000
Holger Voemel

2002 CIRES Outstanding Performance Award
Mihail Codrescu
Geoff Dutton

University of Colorado's Engineering Distinguished Alumnus Award
Ben Balsley

Finalist in the 2002 Pirelli International Award for Environmental Education
Mark McCaffrey

Climate TimeLine awarded NSTA SciLinks Certification for excellence in Science Education
Mark McCaffrey

Adjunct recipient of a Department of Commerce Silver Medal award for "development of the first highly accurate and accessible estimates of threats from tornadoes, windstorms, and large hail anywhere in the U.S."
Michael Kay

Outstanding Performance Award from NOAA/ETL for extensive service to NOAA in the development and testing of new airborne hydrological imaging capabilities
Marian Klein

Award of special recognition for contributions to AWIPS Build 5 1999 - 2002 By FSL/NOAA, U.S Department of Commerce
Xingbao Jing

FSL Web Award for Best Product (for the RTVS web site)
Beth Sigren

National Science Foundation (NSF) Doctoral Fellowship
James Miller

Career Track Promotions
Heidi Schumacher, Associate Scientist I to AS II
John Maurer, Associate Scientist I to AS II
Ross Swick, Associate Scientist II to AS III
Fiona Lo, Associate Scientist II to AS III
Chris McNeave, Associate Scientist II to III
Michael Meshek, Associate Scientist II to AS III
Stevermer, Amy, Associate Scientist II to AS III
Jason Wolfe, Associate Scientist II to AS III
Rudolph Dichtl, Associate Scientist II to AS III
Florence Fetterer, Research Scientist II to Associate Scientist III
John Cassano, Research Scientist I to RS II
Feng Ling, Research Scientist I to RS II
Eduardo Araujo, Research Scientist I to RS II
Brant Liebmann, Eduardo Araujo, Research Scientist II to RS III
Matthew Newman, Research Scientist II to RS III
Roger Pulwarty, Research Scientist II to RS III
E.C. Richard, Research Scientist II to RS III
Oleg Godin, Research Scientist III to Senior RS

Professional Service

July 2002 –June 2003

Accatino, Gabrielle
CIRES Members Council

Aikin, Kenneth
Consulted for the World Meteorological Organization (WMO)

Allured, David
Contributed South American climate data to Global Daily Climatology Network (GDCN) (National Climatic Data Center, NCDC)
Provided climate data, software support, and/or data quality control to the science community

Angevine, Wayne
CIRES Members' Council Representative
Member of AMS Committee on Boundary Layers and Turbulence

Araujo, Eduardo
Spanish translation and revision of the NOAA's posters: - The Ozone Hole... solving a scientific mystery - What is a tsunami? Answering all the Spanish inquiries directed to SEC.

Arge, Charles
CCMC's Scientific Working Group.
Scientific group leader/organizer for the SHINE 2002 and 2003 workshops.

Armstrong, Richard
Liaison to NASA EOS Program IDS and Instrument/Science Teams and provide science support to NSIDC DAAC User Services Office (USO).
Member, WCRP-ACSYS-CliC Data Management and Information
Panel Member, Remote Sensing Working Group, GEWEX Asian Monsoon Experiment (GAME), International Commission on Snow and Ice (ICSI), representative to International Association of Hydrological Sciences (IAHS).
Chairman, ICSI Snow and Climate Working Group

Avery, Susan
International URSI Representative to SCOSTEP
NRC, Committee for the NOAA/NESDIS Transition from Research to Operations (CONNTRO
Digital Library for Earth System Education (DLESE), Steering Committee, 2001 – present.]
NASULGC, Board on Oceans and Atmosphere, Executive Committee
AMS, Commissioner, Education and Human Resources
AGU, Committee on Education and Human Resources
AGU, Nominations Committee
USNC/URSI, Secretary, 1994-1996; Chair, 1997 – 1999; Past Chair.
Delegate to the 27th General Assembly of URSI
Science Policy Board, University of Arizona Science and Technology Center, Tucson, Arizona
American Meteorological Society, Atmospheric Policy Program (APP), Washington, DC.
Commission on Food, Environment and Renewable Resources (CFERR) Voting Delegate
NOAA, Joint Institute Executive Committee

Science Policy Board, University of Arizona Science and Technology Center, Tucson, Arizona
Space Science Institute, Board of Directors
Scripps Howard Institute on the Environment, Science Director and Presenter, University of Colorado, Boulder, CO
Aerospace Engineering Sciences Department: External Advisory Board
Ted Scripps Fellowship Advisory Committee, Environmental Journalism Program
Center for the American West Faculty Advisory Committee
Institute of Behavioral Science Program Review Panel

Balaji, Rajagopalan

Organized and chaired an oral and poster session "Incorporating climate variability information in water resources decision making", at the Fall American Geophysical Union Meeting, Dec 6 - 10, 2002.
Served on the "Curriculum Committee" during 2002. The functions involve review of new course proposals, help devise strategies to implement ABET recommendations.
Served as Departmental Secretary in Spring 2002. This service entails recording and compiling the minutes of the faculty meetings and its subsequent distribution to the faculty.
Serving on the CIRES Visiting Fellows Search Committee.

Balsley, Ben

Chair of CIRES Visiting Fellows Selection Committee

Barry, Roger

World Data Center for Glaciology/National Snow and Ice Data Center, 25th Anniversary of operation at University of Colorado, Boulder, under my direction.
World Meteorological Organization, Joint IOC/WMO Technical Commission for Oceanography and Marine Meteorology. Co-Chair,
Steering Group for the Global Digital Sea Ice Data Bank (GDSIDB).
Development of a US CliC Committee.
Director of World Data Center for Glaciology/National Snow and Ice Data Center.
World Climate Research Programme. Co-Vice Chair, Scientific Steering Group(SSG) for the Arctic Climate System/Cryosphere and Climate(CliC) project.
Co-Chair Standing Committee for Data, Information and Communications (SCDIC), International Permafrost Association.
Terrestrial Observation Panel for Climate (TOPC)member.
Chair, Ad-hoc Task Force of the International Commission for Snow and Ice (ICSI) and the International Permafrost Association (IPA) on a proposal that the Commission attain Association status within the IUGG structure.
CIRES Executive Committee
Co-organizer of CIRES Conference on the Year of the Mountain, Nov 15-16, 2002, at the University of Colorado under the Climate System Variability theme.

Barsugli, Joseph

CDC Computer Users Advisory Committee
National Science Foundation

Bergman, John

Performed reviews for NSF, Journal of Climate, Journal of the Atmospheric Sciences
Served on the CDC Science Council

Bilham, Roger

Scientific advisor and actor in the IMAX movie Kilimanjaro.
Reviewed 235 NSF proposals as member of NSF Geophysics Review Panel.
Organized two day CIRES Mountain conference and film festival (100-200 delegates).
Associate Director CIRES.
NSF Geophysics panel to review 230 proposals.
Organized Geodynamic conference discussing the elastic thickness of the Earth's crust.

Buhr, Susan
Chair, AGU Atmospheric Section Education Committee

Burgdorf, Catherine
NOAA Environmental Research Laboratories Technical Committee on Computing Resources Aeronomy Lab representative
NOAA Boulder IT Council Aeronomy Lab representative

Cassano, John
Member of Ross Island Meteorology Experiment (RIME) science plan committee

Chase, Thomas
CIRES Visiting Fellow Committee
CIRES Computer Committee
Geography Undergraduate Committee
Geography Colloquium Committee

Chilson, Phillip
Co-chairman of the Permanent Working Group for Mesosphere Stratosphere Troposphere radars: System Calibrations and Definitions Serving on the Mesosphere Stratosphere Troposphere Radar Steering Committee
Lecturer: International School of Atmospheric Radar, Abdus Salam International Centre for Theoretical Physics in Trieste, Italy.

Codrescu, Mihail
Chair, Science Working Group (SWG) for the Community Coordinated Modeling Center (CCMC); Member on the GPS Meteorology Interagency Working Group (GMIWG).
Members Council representative
Seminar Chair for the 2002 SEC seminar series.

Collins, Julia
CIRES Members' Council
Chaired the CDC Workplace Advisory Committee (WAC)

Compo, Gilbert
CDC Computer Users Advisory Committee member
Lecturer on global impact of El Nino to undergraduate students in the CU Center for Science Technology and Policy/NCAR Global Climate Change and Society program
CDC/CPC SOOS course: helped with lab and lecture design.
Member, Working Group on surface pressure, Atmosphere Observation Panel for Climate, WCRP/Global Climate Observing System

Copley, Shelley
Councilor, Biological Division, American Chemical Society

CIRES Theme Team-Leader for Environmental Chemistry and Biology (with Russ Monson)
CIRES Executive Committee
Boulder Faculty Assembly Faculty Affairs Committee
Organizer, Microbial Biology Supergroup
Member, NSF Molecular Biochemistry Panel

Cornwall, Christopher
Served on Boulder IT Council, representing the Air Resources Lab (ARL)
Represent ARL on the Technical Committee for Computer Resources.

Costa, Dave
CIRES Members' Council

Devenyi, Dezso
Head of Subcommision for Meteorological Observations of the Meteorological Scientific Commission of the Hungarian Academy of Sciences

Ennis, Christine
Served as the Aeronomy Lab's NOAA/OAR "Outreach Coordinator," exchanging ideas with others in the group about educational and general-public outreach events.

Farmer, Ray
Member-IMAGES (International Marine Past Global Changes) working group on Ice Sheet/Ocean interactions
Organized first annual Workshop for North American Volcanic Rock database (NAVDAT), Boulder, CO.

Fetterer, Florence
Rapporteur at U.S. National Climate and Cryosphere (CliC) workshop
NSIDC Director Transition Review Panel, 6-8 March 2002.

Fifarek, Richard
Active member of Boulder Linux Users Group

Frauenfeld, Oliver
Development Foundation's Cooperative Grants Program

Frehlich, Rod
Member of CIRES Council
Member of NASA's Coherent Lidar Technology Advisory Team
Member of NASA's Advisory Team for Data Requirements for Global Measurements of Winds

Frost, Gregory
Editor of review paper on organic aerosols
Seminar coordinator for the NOAA Aeronomy Laboratory

Fuller-Rowell, Tim
Member of JASTP Editorial Board
Member of COSPAR Panel for Space Weather, assist in the organizing of the Space Weather Symposium and chair session in COSPAR 2002, Houston
Advances in Space Research, quest editor for Space Weather edition

Member of IRI Working Group
Member of Program Committee of the Ionospheric Effect Symposium, chair session
Member of Decadal Survey Panel for Magnetosphere-Ionosphere-Atmosphere
Serve on NASA LWS Geospace Mission Definition Team
Co-organizer of CEDAR GIFT
Serve on AGU Student Awards Committee

Gilles, Mary

Representative, NOAA Safety Office
Representative for the Atmospheric Chemical Kinetics Laboratory to the Computing Communications Committee
Referee for the following journals: J. Chem. Phys. A., Chem. Phys. Lett. Referee for proposals from the following agencies: NASA, National Environmental Research Council

Godin, Oleg

Served as Vice-Chairman of Organizing Committee of the 9th L. M. Brekhovskikh's Conference on Ocean Acoustics (Moscow, Russia, May 2002)
Member of Scientific Committees of the Sixth International Conference on Theoretical and Computational Acoustics (Honolulu, Hawaii, 2003)
Member of the Technical Committee on Acoustical Oceanography of the Acoustical Society of America.
Served on a regular basis as an internal ETL reviewer for journal articles, conference papers, and technical reports

Goetz, Alexander

Coordinated CIRES, CU-Boulder, the National Academies Space Studies Board Steering Committee on Space Applications and Commercialization Workshop III: Facilitating Public Sector Uses of Remote Sensing Data.
Member, NRC Steering Committee on Space Applications and Commercialization.
Member of the NASA Technology Subcommittee of the Earth System Science and Applications Advisory Committee (ESSAAC).
Hosted and served as consultant to the Director of Central Intelligence's Advanced Technology Panel. Hyperspectral Intelligence Task Force, CU-Boulder.

Granier, Claire

Member of the organizing committee of the SPARC-IGAC workshop on climate-chemistry interactions, to be held in Giens, France, April 2003
Convenor of the AS13 session (Variability of the tropospheric chemical composition) of the EGS-AGU-EGU Joint Assembly, to be held in Nice, France, April 2003
Member of the organizing committee of the CCSM workshop on emission
Co-chair of the GEIA (Global Exchanges and Interactions Activity) of IGBP (International Geosphere-Biosphere Program)
Member of the SPARC (Stratospheric Processes and their Role in Climate) Program Scientific Steering Group

Gupta, Vijay

Nonlinear Geophysics Committee of AGU, 2000-2002.
CIRES fellows reappointment committee.
Co-PI in-charge of research on a NSF grant to hold a workshop for a new initiative on Earth Systems Engineering (ESE) through CEAE department.

Member: board of directors to represent CU in a new university consortium for advancement of hydrologic sciences incorporated Stochastic Environmental Research and Risk Assessment (SERRA) Spriger-Verlag.
Distinguished seminar speaker: IIHR-Hydroscience and Engineering, University of Iowa, 2002.
Science advisor: Peter Wall Institute International workshop on Issues of scale and non-linearity in hydrology, U British Columbia, Vancouver, Canada, June 2-5, 2002.
Member: Scientific Advisory Council of Mississippi Riverside Environmental Research Station (MRERS), IIHR-Hydroscience and Engineering, College of Engineering, University of Iowa.

Hamill, Thomas
Associate Editor, Monthly Weather Review
Member of ensemble forecast working group for WRF, the "Weather Research and Forecast model."

Hare, Jeff
Representative to the CIRES Members' Council
CIRES Members' Council Research Associate Representative to both the CIRES Fellows Council and the CIRES Executive Committee
Clouds, Radiation, and Surface Processes Division representative to the ETL Planetary Boundary Layers Working Group
Member of the Air-Sea Exchange Committee within the American Geophysical Union Atmospheric Science Section
Science advisor to the Wyoming-2002 Expedition

Hartten, Leslie
Member of the AMS Board on Women and Minorities' Ad Hoc Volunteer Committee
Science Research Mentor for an aspiring scientist under the auspices of UCAR's Significant Opportunities in Atmospheric Research and Science (SOARS) program.

Hobson, Vinita
Representative to CIRES Members' Council on behalf of PRA's in NGDC and CMDL

Hooper, Don
NOMADS (NOAA Operational Model Archive and Distribution System) meeting host
CDC's Computer Users Advisory Committee (CUAC)

Hübler, Gerhard
HIAPER community
CIRES Members Council representative for NOAA AL

Jain, Shaleen
Worked with the USDA-Natural Resources and Conservation Service Colorado Office Chief Mike Gillespie to develop better tools for snowpack outlooks
Participation in: (a) Colorado Drought Task force Meeting (b) US Bureau of Reclamation (Climate Information for Water Resources, Ongoing Project 2002-present) (c) Snowpack Outlooks and monitoring tools for Water Manager meetings and media briefings

Jefferson, Anne
Member of CIRES Member Council

Jimenez, Jose

Invited Tutorial Lecture "Aerosol Mass Spectrometry: Instrumentation and Applications" at the 2002 Annual Conference of the American Association for Aerosol Research.
Participation in Pittsburgh Supersite Field Campaign with an Aerosol Mass Spectrometer.
Participation in the NASA CRYSTAL-FACE Aircraft Field Mission. Deployed an Aerosol Mass Spectrometer in an Aircraft.
Co-Chair of the Aerosol Chemistry Working Group of the American Association for Aerosol Research (AAAR).
Organizer of the Third Aerodyne Aerosol Mass Spectrometer (AMS) Users' Meeting.
Chair of two (2) oral presentation sessions at the 2002 Annual Meeting of the American Association for Aerosol Research (AAAR).
Created the "Front Range Aerosol Email List" which has proven to be an effective tool for rapid dissemination of information on Aerosol Research.
Member of the Aerosol Instrumentation Committee for the High Performance Research Aircraft (HIAPER) of the National Center for Atmospheric Research (NCAR).
Interested Party of the Inlet Committee for the High Performance Research Aircraft (HIAPER) of the National Center for Atmospheric Research (NCAR).

Jones, Craig
Chair, Fellows Reappointment Committee, 2002-3, CIRES.
Associate Editor, Tectonics.
Continued maintenance of web pages indexing earthquake maps around the globe.

Knowles, Ken
CIRES Computing Facility Advisory Committee

Kosley, Jeffrey
Co-leader of the Colorado Adopt-A-Highway program for CIRES employees

Kowal, Daniel
GLOBE presentation to 5th graders at the Jarrow Montesorri School

Laursen, Sandra
Co-PI and executive committee member for the ChemLinks Coalition (1993-present)
Member of the National Visiting Committee for the Texas Collaborative for Excellence in Teacher Preparation (TxCETP)
External evaluator for an ongoing NSF-DUE CCLI grant, "Enhancement of the Undergraduate Physical Chemistry Laboratory

Lestak, Leanne
Member of the CIRES Computer Action Committee (CAC)
Developed a CU Geospatial user group with Bill Manley and Barbara Buttenfield

Lewis, William
Council of Aquatic Scientists. Board member.
Review team for the International Institute for Tropical Forestry, Puerto Rico (member).
State of Colorado Department of Public Health Advisor.
State of Colorado Department of Public Health and Environment Mixing Zone Technical Working Group.
Rocky Mountain Hydrologic Research Center, Ft. Collins, CO (President).
Advisory Panel, Max Planck Institute for Limnology (1999-present).
Past President, American Society of Limnology and Oceanography (2002-2004).

Chair, National Academy/National Research Council, Committee on Endangered and Threatened Fishes in the Klamath River Basin (2001-present).
Editorial Board, Limnology and Oceanography Methods Journal.
President, American Society of Limnology and Oceanography (2000-2002).
Chair, Awards Committee, CIRES.
Management Committee, CIRES Western Water Initiative (Member).
Acting Director, CIRES (occasional).
CU Boulder Center of the American West (Board Member).
Review Committee Member, Mountain Research Station.

Lin, Jialin

Max A. Eaton student prize committee, AMS 25th Conference on Hurricane and Tropical Meteorology

Lohaus, Mark

CIRES CAC (Computer Advisory Committee)

Lynch, Amanda

Member, Panel on Climate Change Feedbacks, National Research Council
Member, Climate Research Committee, National Research Council
Member, Polar Research Board, National Academies of Science and Engineering
Member, NSF Arctic System Science Program (ARCSS) Committee
Member, DOE ARM Archive User Group
Member, NSF ARCSS Land Atmosphere Ice Interactions (LAII) Science Steering Committee
Member, NSF ARCSS LAII Arctic Transitions in the Land-Atmosphere System (ATLAS) Science Steering Committee
Chair, Advisory Committee, Office of Polar Programs (OPP), National Science Foundation
Public lecture on “big storms”, Barrow (August 2002)
Member, CIRES Computing Advisory Committee
Member, PAOS Curriculum Committee
External Review Committee, Mountain Research Station
Review of book proposal “Winds of Change: An Introduction to Climate Change and Weather” for Brooks/Cole publisher.

Maslanik, James

Member of science advisory group for the Barrow Arctic Science Consortium
Member of international working group on sea surface temperature and ice temperature data sets
Member of "Friends of Cooper Island" (migratory bird habitat) Science Advisory Council
Consultant to Ball Aerospace Corp. for remote sensing algorithms
Community outreach presentations (various) at Barrow, AK
Seminar presentations in Engineering dept. remote sensing classes.

Matrosov, Sergey

Reviewed journal articles and research proposals

McCaffrey, Mark

Moderator for the National Science Ocean Bowl
Vice Chair of Education/Outreach Committee, Consortium of Universities for the Advancement of Hydrologic Sciences, Inc. (CUAHSI)

Mefford, Thomas

Observatory Operations representative to the CMDL Computer Advisory Team

Molnar, Peter
Member of the American Geophysical Union's Waldo Smith Medal committee
Member of Department Search Committee for Terrestrial Quaternary Geology
CIRES search committee for a Geomorphologist
Chairman of CIRES Distinguished Lecture CIRES Committee
Boulder Faculty Assembly
BFA Library Committee

Moore, Andrew
Consultant for Foresight Weather, FSWX, Boulder, CO.
CIRES Theme Leader (Climate System Variability).
Co-Organiser of the CIRES Distinguished Lecturer Series.
Member of the PAOS Curriculum Committee.
Member of the PAOS Director's Executive and Advisory Committee.
Associate Director, PAOS.

Moore, Fred
NOAA/CMDL representative on the NIST shops committee

Morrison, Glenn
Worked with NOAA scientist Carl Howard and Fairview High School teachers to develop and perform experiments for students in the International Baccalaureate Program

Muschinski, Andreas
Served as NOAA/ETL-internal reviewer for numerous papers
Coordinated profiler development activities within NOAA/ET2

Nance, Louisa
Co-Program Chairperson for the AMS Tenth Conference on Mountain Meteorology and MAP Meeting 2002 (17-21 June 2002)
Reviewer for NOAA/ETL internal review process

Naugolnykh, Konstantin
Member of Editorial Board for "Acoustical Physics"
Member of Editorial Board for "Journal of Computational Acoustics" Member of Committee on International Research and education of the Acoustical Society of America

Newman, Matthew
Board member, CCCA (Dept. of Commerce Day Care Center)
CDC seminar coordinator
CDC science council

Nolin, Anne
Science consultant for the Science Discovery program on Glaciers module

Ostashev, Vladimir
Chair of the session "Atmospheric and Seismic Propagation" at the 145 Meeting of Acoustical Society of America, Nashville, TN

Painter, Thomas

Organization of 'Front Range Cryosphere Seminar' with Dr. Stephen Fassnacht, Colorado State University.

Intensive Study Area Leader and Team Leader, NASA/NWS Cold Land Processes Experiment, Rocky Mountains, Colorado

Parks, Bradley

Completed programmatic tasks (as director) for the 4th International Conference on Integrating GIS and Environmental Modeling (GIS/EM4),

Persson, Ola

On the Ph.D. Committees of Nicolas, Sandy Starkweather, and Jeff Mirocha

Member of scientific steering committee for Coastal Oceans

Petropavlovskikh, Irina

Member of the US science team on AURA satellite for OMI instrument

Science advisory board for the National Polar-orbiting Operational Environmental Satellite System (NPOESS), Ozone Mapping and Profiler Suit (OMPS)

Pielke, Jr., Roger

Member, Science Steering Committee, World Weather Research Programme.

Member, National Academy of Sciences, Board on Ocean Sciences Committee on Abrupt Climate Change.

Member, Expert Social Science Review Panel, National Oceanic and Atmospheric Administration Science Advisory Board.

Adjunct Scientist, University of Illinois, Illinois State Water Survey.

Academic Advisory Board, Columbia University, Center for Science, Policy and Outcomes.

Faculty Associate, Columbia University, Center for Science, Policy and Outcomes.

Member, Expert Social Science Review Panel, National Oceanic and Atmospheric Administration Science Advisory Board.

Consultant, National Academy of Sciences, Board on Environment and Natural Resources, Committee on Public-Private Partnerships in Weather and Climate Services.

Associate Director, Environmental Studies Program Graduate Curriculum Committee.

Member, Environmental Studies Program Executive Committee.

CIRES Innovative Research Program Review Committee.

Member, Beverly Sears Graduate Student Grant Committee.

Participant, Science and Media Round-Table Discussion, Carbon, Climate and Society NSF REU, University of Colorado, Boulder.

Oversaw initial development of the CIRES Center for Science and Technology Policy Research.

Associate Editor, Natural Hazards Review, American Society of Civil Engineers.

Member, Editorial Board, Policy Sciences.

Member, Editorial Board, Bulletin of the America Meteorological Society.

Congressional Testimony - Statement of Dr. Roger A. Pielke, Jr. to the Committee on Environment and Public Works of the United States Senate, Hearing on Economic and Environmental Risks Associated with Increasing Greenhouse Gas Emissions.

Invited Expert Lecturer, WMO CAS XIII, Oslo, Norway, 13 February.

Pincus, Robert

Member, AMS Committee on Radiation

Organizing the program and chairing sessions at the 2002 Conference on Radiation.

Member, Computer Users' Advisory Committee, CDC Member, Workplace Advisory Committee, CDC

Pulwarty, Roger
NOAA Science Advisory Board Social Sciences Committee
NOAA Regional Reanalysis Advisory Committee
NOAA Climate and Global Change Postdoctoral Program
CCSP/USGCRP Decision Support

Reid, George
Member of CIRES Executive Committee

Reid, Stephen
Ozone E-mentor for CIRES community outreach program. Talks in several local schools on ozone loss and climate change

Rye, Barry
Topical Editor, Applied Optics (Optical Society of America)

Scambos, Ted
Numerous radio, TV, newspaper interviews on Antarctica and Global Change.
Member of the CIRES Member's Council
Served on NSIDC's Task Force for Re-Organization
Scientific Editor for Journal of Glaciology Scientific Editor for Annals of Glaciology
Chairman of the McMurdo Area User's Committee

Schafer, Robert
Member of the computer advisory committee (CAC)

Scharfen, Gregory
Serves on the SCAR/COMNAP Joint Committee on Antarctic Data Management
Serves on the MODIS Snow and Ice Products Ad Hoc Advisory Group

Schubert, Rob
CIRES Adopt-A-Highway Program Coordinator
Members Council-Campus PRA representative

Scott, James
Member of the Computer User's Advisory Committee at NOAA/CDC
Member of the Workplace Advisory Committee at NOAA/CDC

Serreze, Mark
Media contact to: New York Times, LA Press, Denver Post, Boulder Daily Camera, BBC.
Conducted an in-depth radio interview with National Public Radio
Science Steering Committee, NSF SEARCH Program
Chair, WCRP/ACSYS Working Group on Polar Products from Reanalysis
Board of Directors, ARCUS
Science Steering Committee, NSF ARCSS program

Sheehan, Anne
Chair, Career Track Committee

Member, State of Colorado Earthquake Hazard Subcommittee
Committee Member, Incorporated Institutions for Seismology (IRIS) Program for Array Seismic Studies of the Continental Lithosphere (PASSCAL) Standing Committee.
Advanced National Seismic System (ANSS), Intermountain West Regional Working Group member, State of Colorado representative for proposal to Intermountain West ANNS regional group to improve seismic monitoring in Colorado.
CIRES, Chair, CIRES Reappointment Committee.
Geological Sciences, Chair, Spring 2002 colloquium series.
CIRES, Member, Geomorphology Faculty Search Committee.
Geological Sciences Chair, Fall 2002 colloquium series.
CIRES, Member, Director reappointment committee
Chair, Geophysics PhD Program committee.
Wrote Proposal for Geophysics Graduate Certificate.
Member, Beverly Sears Graduate Student Grant Committee
Gave invited lecture to Evergreen Chapter of American Association of University Women (AAUW), 2002.

Sievers, Robert
Center of the American West - Advisory Board
Member, Foundation Fundraising Committee. Norlin Society Contributor
Chairman and Member, Board of Directors of AKTIV-DRY.
Community Member, Board of Directors, Wells Fargo Bank

Smith, Catherine
Assisted the Smithsonian Institution in their creation of an El Nino exhibit at the Natural Science Museum
Member of CDC's workplace advisory committee

Smith, Lesley
Member of the Education Committee, American Society for Limnology and Oceanography Offered a workshop entitled "Strategies to Develop a Successful Outreach Program"

Sperry, Paul
Moderator at the National Ocean Science Bowl Science
Science Committee member for CU's Conference on World Affairs
Moderator at a Conference on World Affairs session

Steffen Konrad
Member, Publication committee, International Glaciological Society.
Member, NASA Algorithm Theoretical Review Panel for sea ice and oceans.
Member, RADARSAT Geophysical Processor System Team (NASA/RGPS).
NSF-OPP Panel review committee for Antarctic research.
NASA ICESat Science System Operation Readiness Review committee member.
NSF-OPP Steering committee for long-term monitoring site – Summit Greenland.
WMO/WCRP Arctic Climate Systems Scientific Steering committee member.
WMO/WCRP ACSYS Observations Products Panel committee Chair.
WMO/WCRP Remote Sensing Committee member.
CIRES Interim Director CIRES.
CIRES Executive Committee Member.
CIRES Associate Director for Cryospheric and Polar Processes.
CIRES Observation and Modeling Theme Leader.

CIRES NSIDC Center Review committee for (chair).
GEOG Personal Committee, member.
GEOG Distinguished Prof. Nomination Committee (chair).
Faculty position in paleoclimatology, INSTAAR.
Member, Remote sensing certificate committee.
INSTAAR Mountain Research Review Committee.
Geophysics Program Committee.
UCAR - GPS user committee.

Stevermer, Amy

ARL representative on NOAA's Boulder Outreach Coordinating Committee
Writing and communication mentor, Significant Opportunities in Atmospheric Research and Science (SOARS) program, University Corporation for Atmospheric Research.

Stroeve, Julienne

Radio Interview in California during Fall AGU Meeting on the Record Sea Ice Minimum during 2002
AMSR-E Sea Ice Team Member
Member of the AATSR LST Validation

Thomson, David

RMS Information Technology Committee
Organized and helped host a tour of the NOAA DSRC facility for the middle school class of RMS
Aeronomy Lab and CIRES representative to the Transportation Alternatives Committee of the Department of Commerce Labs

Tiampo, Kristy

Program Coordinator, Nonlinear Geophysics Committee, AGU Spring Meeting
Appointed to AGU Committee for Nonlinear Geophysics

Tolbert, Margaret

CIRES Fellow
General Chemistry Coordination
Atmospheric chemistry committee
CIRES/Chem Faculty Search Committee (chair)
Executive Committee, Chemistry and Biochemistry
BFA Awards Committee, Research and Scholarly Work
Co-editor or Editoral Board Member of Journal (does not include advisory boards)
Associate Editor, Atmospheric Environment

Tyus, Harold

Invited speaker in a Biodiversity Forum on the Boulder Creek Watershed.
Committees of the Western Division of the American Fisheries Society (Native Fishes, Environmental Concerns)

Vaida, Veronica

Served on an NSF review panel for CAREER awards.
NSF Research Instrumentation Panel.
Committee on Women in Science.
Atmospheric Program Committee.
Chair, department of Chemistry and biochemistry.
Taskforce for Retention and Recruitment.

CIRES Fellow.

Velicogna, Isabella

Member of the science team for the JPL Mars Scout proposal to map the magnetic and gravitational field of Mars in the period from 2007-2009

Member of the AGU Hydrology Remote Sensing Committee

Member of IGeS Working Group: `Preparation of Standard Procedures for Global Gravity Field Validation'.

Convener: European Geophysical Society, (EGS 2002, EGS 2003)

American Geophysical Union (AGU, 2002, 2003)

Wahr, John

Participated in Press Conference on GRACE, at the 2002 Fall Meeting of the American Geophysical Union San Francisco.

Advisory Editor for the journal: Physics of the Earth and Planetary Interiors.

Member of the IERS Special Bureau for Loading.

Member of NASA's Earth Visions Committee for the Solid Earth, Ice Sheets, and Sea Level.

US Representative to the lAG Earth Tides Commission.

Member of IAG/IAPSO working group on "The geodetic effects of non-tidal ocean processes".

Member of GRACE Science Team.

Member of IAG Special Study Group on "Gravity field missions calibration and validation".

Chair of the AGU Fellows Selection Committee for the Geodesy Section of the American Geophysical Union.

Co-Convener of session: "New Results From the GRACE Mission" at the Fall Meeting of the American Geophysical Society, San Francisco, December 6-10.

Chair of Director's Reappointment Committee (CIRES).

Evaluation Panel (Physics Department).

Advising Committee; Chair in the Fall Semester (Physics Department).

Member of Beverly Sears Graduate Student Grant Selection Committee (CU Graduate School).

Chair of ad hoc Curriculum Revision Committee for the Geophysics PhD Program (Graduate School).

Member of ad hoc Comprehensive Examination Restructuring Committee for the Geophysics PhD Program (Graduate School).

Wang, I-Pin

Vice President, Rocky Mountain Chinese Society of Science and Engineering

Weil, Jeffrey

Chairman, AMS/EPA Regulatory Model Improvement Committee;

Board of Reviewers, Boundary-Layer Meteorology; Reviewer for: Atmospheric Environment, Boundary-Layer Meteorology, Journal of the Atmospheric Sciences, Journal of Applied Meteorology;

Welsh, Robin

Judge, Publications competition for the Society of Technical Communicators

Alternate Judge for the Online Publications competition for the Society of Technical Communicators

Wessman, Carol

CIRES Executive Committee

EPOB Teaching Evaluation Committee

CIRES, co-Theme Leader for Planetary Metabolism Research Theme

EPOB Teaching Evaluation Committee Chair

Editorial Board of Ecological Applications

Westwater, Edgeworth
Served as Associate Editor Radio Science
Organized and conducted two sessions on Passive Remote Sensing for the 2002 General Assembly of URSI

White, Allen
Member of NOAA/NWS Science and Technology Infusion Planning (STIP) team for Winter Weather Services
Member of ETL Strategic Planning Committee
Member of ETL Publications Committee

Wolter, Klaus
Lecturer: Water Availability Task Force

Zhang, Jincai
CIRES exhibition at 2002 AGU Fall meeting

Zhang, Tingjun
Member of the Editoral Board of the Journal of Glaciology and Geocryology
Member of the Editoral Board of the Cold Regions Science and Technology
Member of NASA Cold Land Surface Processes Working Group
Scientific Director of the Institute of Plateau Meteorology (IPM), China Meteorological Administration (CMA), Chengdu, China

Journal Publications

January – December 2002

Aiken, C. M., A. M. Moore, J. H. Middleton. 2002. The non-normal nature of recirculating flows in the coastal zone, *J Phys Oceanogr,* **32***,* 2955-2974.

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