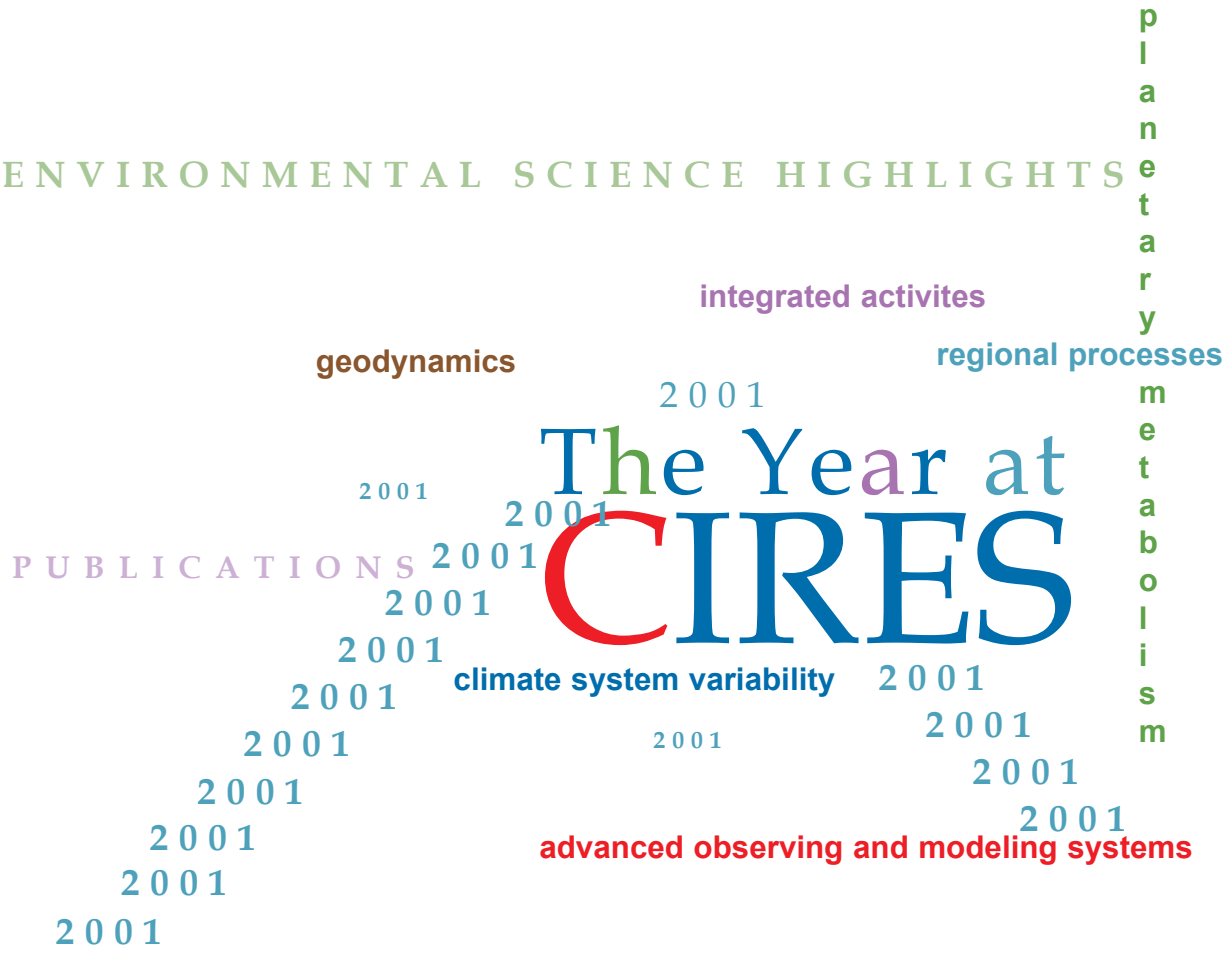

CIRES

1967-2002

THE COOPERATIVE INSTITUTE FOR RESEARCH IN ENVIRONMENTAL SCIENCES

CIRES

2001

Annual Report

The Cooperative Institute for Research in Environmental Sciences

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Director's Welcome

*H*appy Anniversary!

This year, the Cooperative Institute for Research in Environmental Sciences celebrates 35 years of research and education in the environmental sciences. While CIRES always looks to the future, this has been a year of reflection too.

Thanks to a team led by Carl Kisslinger, we now have a new book on CIRES' history. This book should be required reading for all newcomers to the Institute, and for those not so new, because it gives an excellent perspective on the evolution of the Institute and its science during these exciting 35 years.

The research summaries highlighted in this year's annual report represent only some of the projects underway in the Institute. Several of our projects have been reported in the popular press – a reflection of CIRES' attempts to enhance public awareness of the science that impacts our planet.

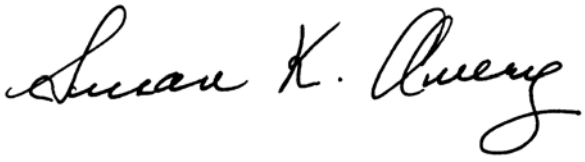
Theoretical work on the role of landforms in paleoclimates has yielded interesting new insights on past ENSO events. Earthquake hazards continue to play a major role in the research agenda with new information being conveyed to those countries that are highly vulnerable.

The sun and its impacts on "space weather" is an area seeing increased emphasis as part of the Space Weather Program. New forecast models of the ionosphere are leading to a better predictive capability for warnings of events that can impact the civilian infrastructure in space. New techniques for observing the planet, from space, from parachutes, and from the ground, are yielding insights into physical, chemical, and biological processes.

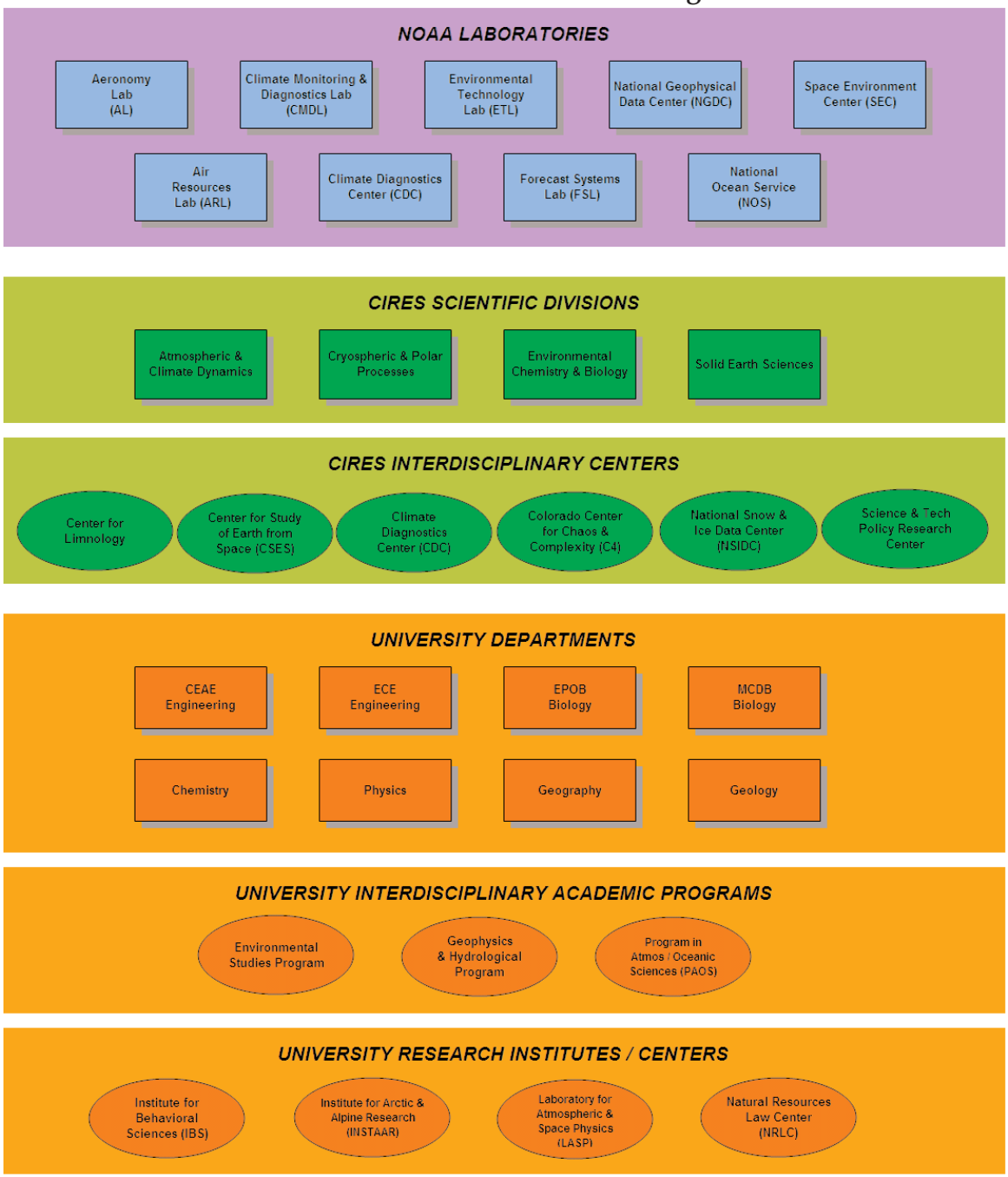
Field campaigns continue to be an important mechanism for obtaining coordinated measurements of the earth system. Such observations have conclusively shown the impacts of global warming in the polar regions. Other observations are providing invaluable information for new modeling efforts in air-quality forecasting.

The development of the new Science and Technology Policy Research Center represents a major success for CIRES. Integrating the natural environmental sciences with social sciences, economics, policy, and philosophy, Center activities address many elements of the Institute's research agenda. The Center's challenge is to make science useful to operational and policy decision-makers.

This annual report is the result of the efforts of many people in CIRES. I hope you will read it, and trust you will find the reading enjoyable and informative.



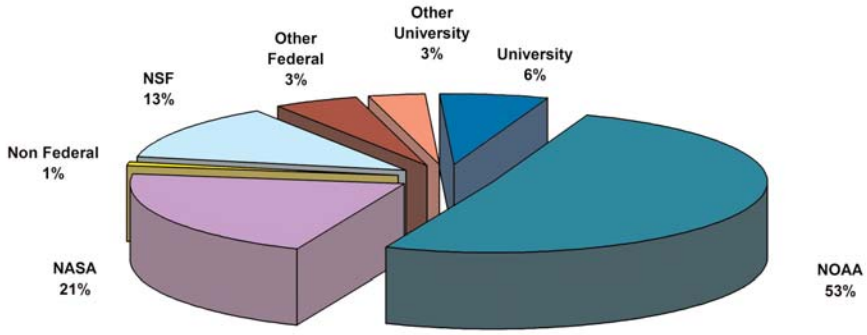
Scientific Connections Facilitated through CIRES



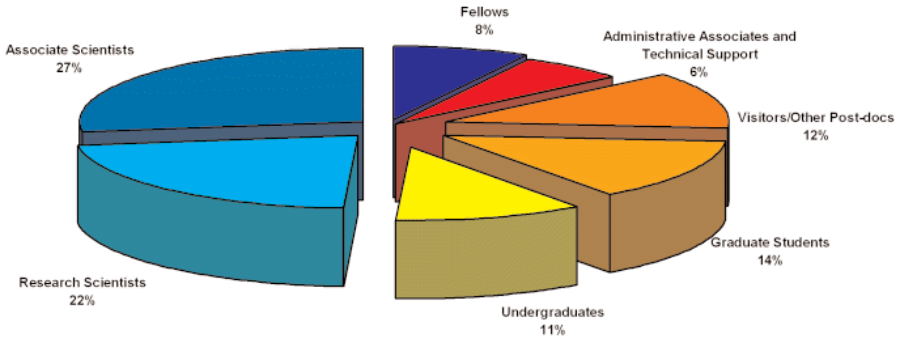
Overview of CIRES

The Cooperative Institute for Research in Environmental Sciences (CIRES) is a joint institute established 35 years ago between the University of Colorado (CU) 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.

2001 - 2002 Total Expenditures by Funding Source
Total Expenses - $34,173,577



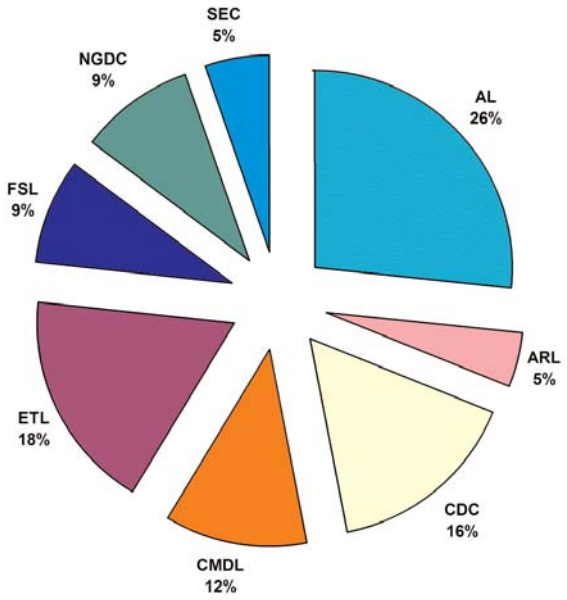
CIRES is comprised of over 500 researchers, faculty, students, and staff housed in the David Skaggs Research Center (DSRC) and on campus. About half of our personnel fill scientist positions and more than a quarter consist of undergraduate and graduate student positions. Traditional disciplinary research is conducted through eight University departments on campus while mission-oriented research supporting NOAA objectives is conducted less than a mile away at the nine federal laboratories in the DSRC. Interdisciplinary science is fostered through CIRES and its Centers that cross traditional boundaries to provide an integrated perspective. CIRES' support of campus entities such as the *Natural Resources Law Center* and the *Institute for Behavioral Sciences* provide water law, economic and user survey information to the NOAA/CDC-CIRES Western Water Assessment (WWA).



CIRES direction and counsel is provided to its Director through the 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, annual town meetings, and an active outreach effort. *Career progression and excellence* are promoted through our Career Track and Outstanding Employee Recognition Program. A vibrant *academic and research environment* is fostered through an active Visiting Faculty and Postdoctoral Fellowship program, a Research and Education

Fellowship, a Graduate Research Fellowship program, an Innovative Research Program, a Distinguished Lecture Series, and research initiative seed funding. *Advanced research tools* are provided through an instrument design group, machine shop, glassblowing facility, 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 [GIS] and statistics), auditorium, and classrooms fitted with audio visual tools. NOAA *funding* is allocated among three Tasks including administrative support (Task I), National Snow and Ice Data Center (Task II) and scientific research (Task III).

2001 - 2002 Task III Expenses by Laboratory
Total Expenses $13,056,340

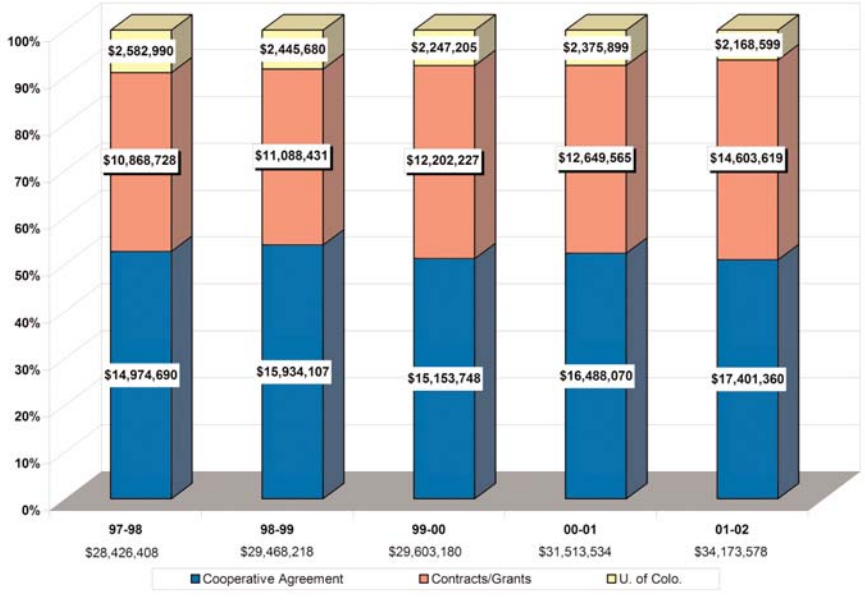


The charts on these pages provide a summary of funding trends, sources by agency, and a breakdown by NOAA Tasks. The latter remains our largest funding source and includes research and base funds. CU funding includes faculty salaries, indirect cost recovery, and non-research general fund support. CIRES is fortunate also to be able to support two types of funding programs, one for scientific visitors, and one for graduate students.

CIRES research programs have recently involved field investigations in the Arctic and Antarctic regions, the Himalayas, South America, various Pacific islands as well as research sites throughout the United States. Results of this research bear upon societal problems such as the potential impacts of climate change upon watersheds, pollutant destruction of Earth's ozone, the thinning of polar ice, the degradation of air and water quality, and earthquake prediction.

CIRES is increasingly providing vision and leadership in conducting highly interdisciplinary research where results are presented 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. It is building mutually beneficial partnerships between public and private sector users of information to determine what tools are available, can be adapted, or should be developed to assist in the utilization of a growing body of climate information. CIRES has also been an active partner with the four other Regional Integrated Science Assessments (RISA) supported by NOAA's Office of Global Programs (OGP).

CIRES 5 Year Comparison of Expenditures by NOAA Cooperative Agreement, Individual Grants, and University Funding



CIRES Research Themes

Earth science research is changing: *in today's scientific environment, the need is for collaboration among specialists and rapid exchange between theorists and practitioners.*

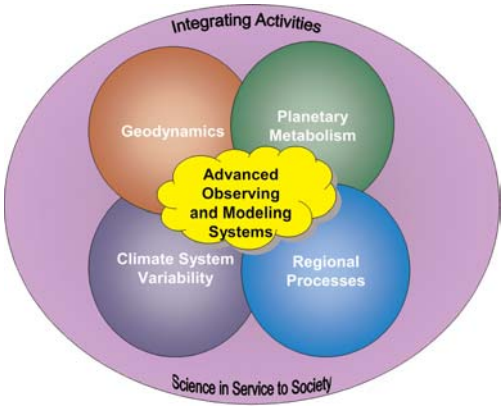
As connections among Earth systems, and the integrated dynamics at boundary layers of Earth, ocean, and atmosphere have become better understood, science disciplines have increasingly overlapped. Now more than ever, specialists need to partner with one another in flexible and changing research teams, depending on the questions under the microscope or within the sensor's field of view.

For instance, questions concerning the radiation budget and Earth's climate may involve any combination of glaciologists, climatologists, atmospheric scientists, biologists, chemists, and oceanographers, all of whom can blend their collective experience and knowledge of remote sensing to enrich our understanding.

Moreover, decision makers and communities need scientific knowledge faster than ever before in history to inform policy and practice. Results concerning emissions that affect air and water quality can't be pondered in the isolation of the ivory tower, but shared as soon as possible with the people whose lives they affect. Now more than ever before, natural resource managers need to partake of science research on an on-going basis, even as results evolve.

Theme-based science best supports interdisciplinary research..

CIRES' Science Executive Committee defined areas of study to which CIRES research naturally adhered. By adopting a theme-based research policy, CIRES remains poised to evolve with a dynamic research environment.



CIRES provides a crucible for interdisciplinary science by:

1) supporting researchers and students in a multitude of science divisions, centers and labs

2) fostering connections among them

3) and promoting **theme-based** scientific research

CIRES Research Themes:

Advanced Observing and Modeling Systems: effectively characterizing and predicting the state of the Earth system on all scales using direct observations and techniques for projecting outcomes mathematically.

Geodynmics: gaining a better understanding of convection within the Earth's mantle, and of how convection affects the surface of our planet, primarily involving geophysicists and geologists.

Regional Processes: understanding the role of climate information used in regional decisions concerning natural resources.

Climate System Variability: climate changes that occur both in the short term - seasons to decades - and those that occur across millennia

Planetary Metabolism: 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.

Integrating Activities: boundary-crossing pursuits that convey CIRES' science mission to society.

Summary of Research Highlights

The following bullets encapsulate some of the research accomplishments of 2001. In the Research Theme sections following, projects are given in greater detail.

Advanced Observing and Modeling Systems:

- -Application of sophisticated data assimilation techniques to space weather forecasting
- -Transition ionosphere research model to operational forecasts of geomagnetic storms
- -Improved characterization of global snow cover for validation of climate and hydrology models and for monitoring climate change
- -Discovery of role of up-gully surges in enhancement of diffusion and transport of ground-level atmospheric quantities into lower atmosphere
- -Improved atmospheric analysis and short term prediction system for aviation and severe weather forecasting
- -New ultra-sensitive spectrometer for measuring atmospheric trace gases
- -New remote sensing technique for evaluating surface currents in the ocean
- -Improved parameterization of turbulent processes in forecast models using airborne Doppler lidar
- -Feasibility demonstration of using a power parachute for sampling chemical constituents
- -Development of long-term data set on arctic cloud microphysical properties for use in climate and radiation models
- -Use of passive microwave emission and radar backscatter to monitor climate change on Antarctic ice sheet
- -Globally distributed glacier measurements for analysis of climate change and related hydrologic changes
- -Improved understanding through field measurements of the melt-induced acceleration of the Greenland ice-sheet flow
- -Development and field-test of a snow-level algorithm for use with vertically-pointing Doppler radar to improve real-time snow level information to forecasters and decision-makers

Climate System Variability

- -Monitoring of stratocumulus cloud properties for understanding effects of atmospheric boundary-layer clouds on air-sea interaction in the tropical Pacific
- -Detailed ENSO analysis to quantify influence on extreme events
- -Verification and diagnostics of regional climate changes for national assessment activities
- -Ensemble weather forecasting for improving probabilistic weather and climate information
- -Development of 23-year global data set of radiance and clouds for interannual climate variability studies
- -Development of data set using pollen to describe regional distribution of past vegetation for studying changes in vegetation, sea level, and standing surface water in Beringia
- -Improved understanding and prediction of processes that control interannual variability of sea ice conditions along the Alaskan North Slope
- -Impacts of northern hemisphere snow on predictability of climate, snow cover, and monsoon precipitation for the western U.S.
- -Documentation of the role of equatorial atmospheric disturbance in forcing the ocean toward enhancing predictability of climate variability and climate shifts
- -Exploration of environmental variables that can robustly determine climate trend detectability

Regional Processes

- -Field measurements to improve understanding of long-range, intercontinental transport and chemical transformation in the troposphere and its influence on climate and air quality
- -Airborne measurements of biomass burning to determine sources and sinks of emissions

-Field study in New England to determine processes that control the production and distribution of air pollutants in the region
-Intensive measurement campaign of ozone-depleting substances in the trans-Siberian railway corridor
-Improved understanding of effect of distant forest fires on ozone pollution in the U.S.
-Timely analysis and communication of findings from air-quality study in Texas has led to scientific basis for actions to improve the region's air quality
-Design of a moveable observing system testbed for weather, air quality, and homeland security applications
-Documented shallow rainfall process that contributed to flooding rains which were undetected by conventional operational radar network

Integrating Activities
-Development of global chemistry-transport models to assess impact of road traffic emissions on composition of lower atmosphere
-Examination of responses to 2002 drought along the Colorado Front Range
-Understanding of the vulnerability of the interior west to climate-related stresses on water
-Improved streamflow forecasts that meet needs of water managers in different parts of the country
-Determination of how to build an effective working relationship between research and operational communities via the development of a web-based form for collecting feedback on real-time, experimental meteorological products
-Reanalysis of National Weather Service estimates of flood damage in the U.S. between 1926-2000
-Development of a model for best practice in geoscience education for K-12 students using the Sombrero Marsh
-Establishment of local partnerships for systemic reform of geoscience K-12 education
-Development of an evaluation toolkit for the Digital Library in Earth Science Education (DLESE) for promoting better practices in geoscience education
-Development of creative projects within undergraduate education for non-science majors

Geodynamics
-Demonstration of importance of tropical sources on climatic differences at high latitudes over geologic time
-Development of novel technique for converting GRACE gravity fields to useful measurements of mass redistribution
-Geodetic measurements combined with historical archives to provide new insights into future earthquake hazards in India
-Monitoring of plate boundary deformation in various countries to determine physics of earthquake process
-Improved understanding of the evolution of the deep continental lithosphere through fieldwork in Colorado and Wyoming
-Studies showing that convective motion of dense material at the top of the mantle can drive deformation of the Earth's surface and influence plate boundary geometries

Planetary Metabolism
-Use of aerosols in delivery of drugs for lung ailments
-Analysis of nitrogen dynamics in agriculturally impacted streams
-Identification of regional biogeochemical impacts of urbanization in semi-arid environments
-Further insight into the capacity of soil bacteria to evolve new pathways for degradation of anthropogenic pollutants
-Determination that sub-alpine forests in the western U.S. are the only significant carbon sink in the region during decadal-scale droughts on the west coast
-Development of rigorous estimates for the yield of total nitrogen and nitrogen fraction from continents
-Development of new method for a whole-system capability for measuring denitrification rates in streams and rivers

Advanced Observing and Modeling Systems

Effectively characterizing and predicting the state of the Earth system on all scales using direct observations and techniques for projecting outcomes mathematically.

No model exists that can faithfully mimic the real world or adequately represent all important processes in modeled systems. Our ability to represent the environment and accurately forecast climate depends on our ability to measure Earth systems. Observations serve to both validate models and provide the data necessary to parameterize modeled processes.

CIRES researchers collaborate with national and international teams to assist in innovating remote sensing and *in situ* instrumentation and measurement techniques. Advanced observing and modeling serves a broad spectrum of science applications. Space observing techniques and technologies are a common element among most, and the remote-sensing expertise within our centers and departments forms a special strength among the disciplines at CIRES.

At CIRES, modeling and observations research activities are dedicated to extending current capabilities of characterizing Earth and space environments. Projects focus on: Atmospheric chemistry, the physical parameters of atmosphere and oceans, the cryosphere, data centers and data managment, ecosystem and environmental modeling, remote sensing of terrestrial properties, non-linear systems, and space weather.

Example: A CIRES scientist developed a technique and an instrument to measure concentrations of elusive atmospheric species such as nitrate radicals (NO_3), which influence the stratospheric ozone layer and the production of ozone pollution in the lower atmosphere. Historically the measurement of NO_3 has been a difficult problem because the gas is present in the atmosphere only in trace amounts— often less than 1 molecule of NO_3 per trillion molecules of air —and only in the dark. Highly unstable and reactive, nitrate radicals are produced by burning fossil fuels but also occur naturally in the atmosphere. The scientist received the Presidential Early Career Award for Scientists and Engineers for his valuable innovation.

RESEARCH GOALS

1) To develop new measurement techniques
2) To develop new instrumentation,
3) To advance theoretical understanding, and
4) To refine data management and analysis methods.

Contributors:

CU-Boulder's Department of Chemistry and Biochemistry
NOAA's Aeronomy Laboratory
NOAA's Environmental Technology Laboratory (ETL)
NOAA's Forecast Systems Laboratory
NOAA's Space Environment Center
CIRES Center for the Study of Earth from Space (CSES)
CIRES National Snow and Ice Data Center (NSIDC)
Program in Atmospheric and Oceanic Sciences (PAOS)
NOAA-CIRES Climate Diagnostics Center (CDC)
CU-Boulder's Department of Geography
CU-Boulder's Department of Geological Sciences
CU-Boulder's College of Engineering and Applied Sciences

Effect of Collisional Excitation by Atomic Oxygen on the Upper-Atmospheric Response to Anthropogenic Forcing by CO_2

***Scientific Impact:** A new and somewhat unexpected result demonstrating weak sensitivity to an important but still relatively poorly known rate of collisional excitation by O in the mesosphere and thermosphere to possible anthropogenic forcing.*

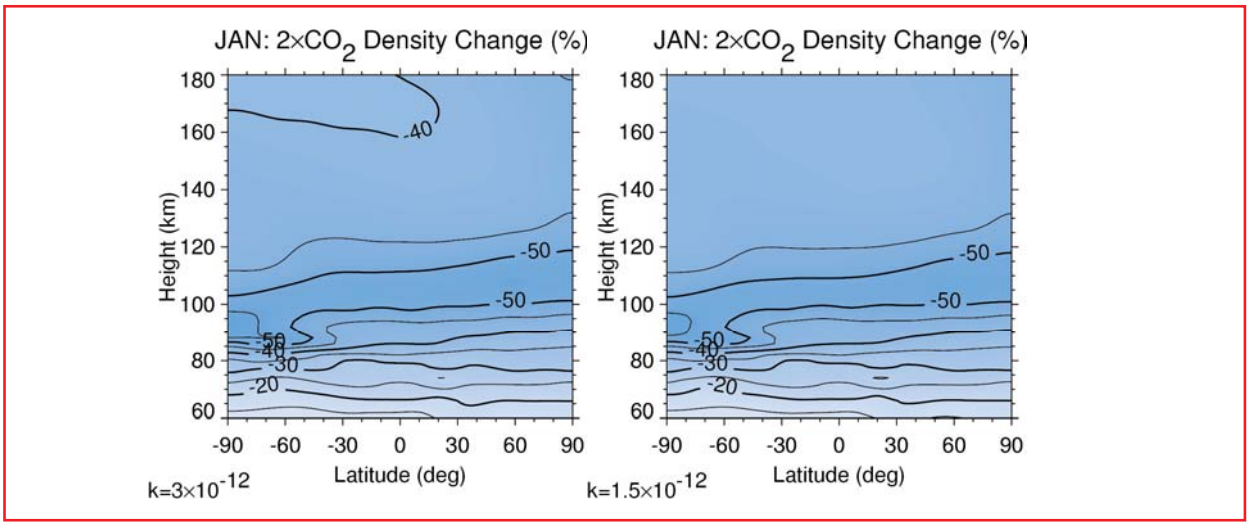
Response of the upper-atmospheric structure to the increase of CO_2 over the last four decades and to the standard $2XCO_2$ scenario has been investigated with the Spectral Mesosphere/Lower Thermosphere Model. The overall response is negative (cooling and density reduction) and substantially stronger compared to what is expected in the lower atmosphere.

Collisional excitation of CO_2 by atomic oxygen with a subsequent emission of radiation in the 15-mm band is the major cooling mechanism in the upper atmosphere. Unfortunately the rate constant, k, of this important process is still poorly known, with estimates from upper-atmospheric observations and laboratory measurements differing by about a factor of 4. It has been suggested that the temperature and density response to CO_2 increases should strongly depend on k. Presumably, estimates of temperature and density trends observed during the recent decades might then shed light on the real rate of excitation. Our modeling experiments with two values of k differing by a factor of 2, as recommended based on recent laboratory measurements, indicate, quite counterintuitively, that the atmospheric response is insensitive to the exact value of k. Figures below compare the percentage density change due doubling of CO_2 for the two values of k (cm^3s^{-1}).

Project Personnel:
R. A. Akmaev

Funding Sources: NSF, NASA

References:
Modeling the cooling due to CO_2 increases in the mesosphere and lower thermosphere, *Phys. Chem. Earth* 27:521-528, 2002.



Global Assimilation of Ionospheric Measurements (GAIM) Model

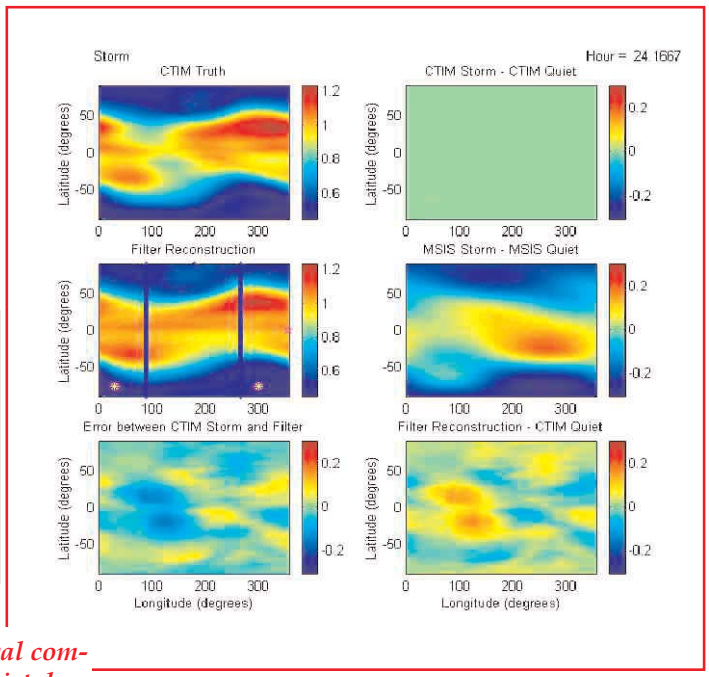
Scientific Impact: Development of the GAIM model is the first time sophisticated data assimilation techniques have been applied to space weather forecasting. Real-time specification and forecasts of ionospheric parameters are valuable for improved navigation and communication.

The Department of Defense (DoD) has recently funded a Multi-Disciplinary University Research Initiative (MURI) to develop a global, ionospheric data assimilation model. This funding represents the first time a concerted effort has been made to develop a Space Weather global ionospheric model similar to the numerical weather models that were initiated more than forty years ago. The Global Assimilation of Ionospheric Measurements (GAIM) model is being developed by a consortium of universities that include Utah State University (USU), the University of Colorado (CU), the University of Texas at Dallas (UTD), and the University of Washington (UW).

The University of Colorado group is responsible for developing 1) The low latitude ionospheric inputs to GAIM - ExB drift velocities and the neutral wind fields and 2) The global neutral composition specifications (see Figure) that are required GAIM inputs. Data assimilation techniques using Kalman Filters have been applied to obtain these important inputs in near real-time. GAIM development is in its fourth year of a five-year effort. When completed, GAIM will become an operational ionospheric model at Air Force Weather Agency (AFWA), Offutt AFB, Omaha and at the Space Environment Center in Boulder, providing real-time ionospheric specification and forecasts for DoD and civilian customers.

Project Personnel: David N. Anderson, Tim Fuller-Rowell, Mihail Codrescu, Cliff Minter and Adela Anghel

Funding Sources: DoD



Kalman filter results for neutral composition after 24 hours of a quiet day.

Forecasting Ionospheric Scintillation Activity, Night-to-Night

Scientific Impact: The validation indicates more than half of the increase in variance during a geomagnetic storm can be captured by this simple empirical model.

Project Personnel: David N. Anderson

Funding Sources: DoD

Currently, no operational techniques exist to realistically forecast ionospheric scintillation activity at low latitudes, night-to-night. The objective of this study is to develop the ability to forecast UHF scintillation activity on a night-to-night basis. To succeed it is first necessary to establish the relationship between the vertical ExB drift velocity right after sunset (1800-2000 LT) and the subsequent occurrence or non-occurrence of scintillation activity. The approach for determining the vertical E x B drift enhancement is to observe the increase in the "true" height of a given electron density value in the bottom side ionosphere as measured by a ground-based digital ionospheric sweep-frequency sounder The observations of scintillation activity have been obtained from a network of UHF and L-band receivers established by the Air Force in the South American sector. We have analyzed more than 130 days in 1998 and 1999 when both the Jicamarca Digisonde was used to infer vertical ExB drifts after sunset and the SCINDA network of scintillation receivers measured the subsequent S4 values at UHF and L band frequencies. Figure 1 presents a summary of the 130 plus nights at Antofagasta West and Ancon West. Because there is an apparent threshold effect, the nights are "binned" into two ExB drift categories, >20 m/sec and <20 m/sec. For each of these ExB drift bins, the S4 observations are placed into 2 bins where S4 is greater than 0.5 and when S4 is less than 0.5. For Antofagasta west observations, when ExB drift is greater than 20 m/sec, a "forecast" that the subsequent S4 value would be >0.5, would be correct 92% of the time. Similarly, when ExB drift was less than 20 m/sec, a forecast that S4 would be <0.5, would be correct 85% of the time. Near the magnetic equator at Ancon, Peru the two corresponding percentages are 64% and 85%, respectively. These are impressive results and hold out the promise that, on a night-to-night basis, with the appropriate sensors at the appropriate locations, one can forecast scintillation activity with a one to two hour lead-time.

Number of Days Associated with Different Values of ExB Drift and S4 Index at Antofagasta and Ancon

Antofagasta West

	S4<0.5	S4>0.5
ExB<20	53	9
ExB>20	6	66

Ancon West

	S4<0.5	S4>0.5
ExB<20	45	8
ExB>20	17	30

Comprehensive Validation of the Empirical Storm-time Ionospheric Correction Model (STORM)

Scientific Impact: Using appropriate ground-based sensors it has been shown that it is possible to forecast ionospheric irregularities at low latitudes, and the occurrence of scintillations in ground-to-satellite radio signals.

The empirical storm-time ionospheric correction model has been developed and has been tested at Space Environment Center for about a year. It has also been implemented in the new International Reference Ionosphere (IRI2000). The empirical model is driven by the previous time-history of the geomagnetic index, ap, and is designed to scale the quiet-time F-layer critical frequency (foF2) to account for storm-time changes in the ionosphere. The model provides a useful, yet simple tool for estimating the changes to ionosphere in response to geomagnetic activity. To evaluate its usefulness for HF propagation users, a comprehensive validation has been performed by comparing the model prediction with all available observations taken during the 14 storms in 2000 and 2001. To quantify the skill, the root-mean-square-error (RMSE) has been evaluated and compared with the previous version of the reference ionosphere, IRI95, which did not include the geomagnetic activity dependence. The results of this study illustrate that IRI2000 has a 30% improvement over IRI95 during the storm days, and is able to capture half of the increase in variance as a result of the storm.

Project Personnel: Eduardo Araujo, Tim Fuller-Rowell, Mihail Codrescu

Funding Source: NSF, NOAA

References: Fuller-Rowell, T.J., M.V. Codrescu, and E. Araujo-Pradere, Capturing the storm-time F-region ionospheric response in an empirical model. AGU Geophysical Monograph 125, 393-402, 2001.

Araujo-Pradere, E.A., T.J. Fuller-Rowell, M.V. Codrescu, STORM: An empirical storm-time ionospheric correction model, I. Model Description. *Radio Science*, in press, 2002.

Araujo-Pradere, E.A., T.J. Fuller-Rowell, M.V. Codrescu, STORM: An empirical storm-time ionospheric correction model, II. Validation. *Radio Science*, in press, 2002.

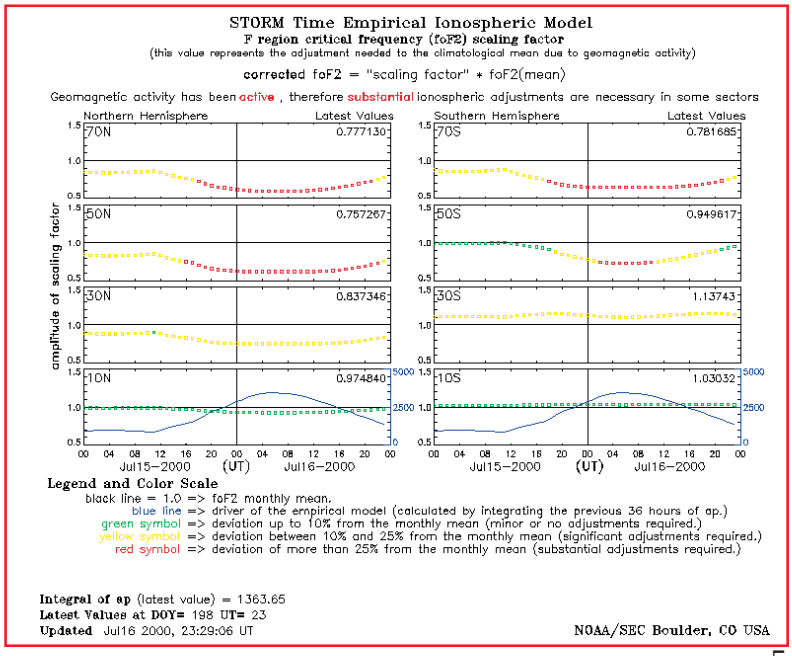


Illustration of the STORM prediction during the Bastille Day storm in July 2000.

Operational Space Weather Models

Scientific Impact: The improvement and transitioning of the research models (described below) to operations permit more reliable forecasts of the geomagnetic environment.

Wang-Sheeley Model:

The Wang & Sheeley (WS) model is a physics-based representation of the quasi-steady global solar wind flow that is used to predict the background solar wind speed and the inter-planetary magnetic field (IMF) polarity at Earth. It uses photospheric magnetic field data from three ONR-supported solar observatories (i.e., Wilcox, Mount Wilson, and Kitt Peak) as input to a magnetostatic model of the coronal expansion. Real-time solar wind predictions are routinely made available and current to NOAA/SEC forecasters and the broader research community via a SEC web page. Work is underway to further improve the WS model though the incorporation of additional and more realistic physics-based models into the prediction scheme.

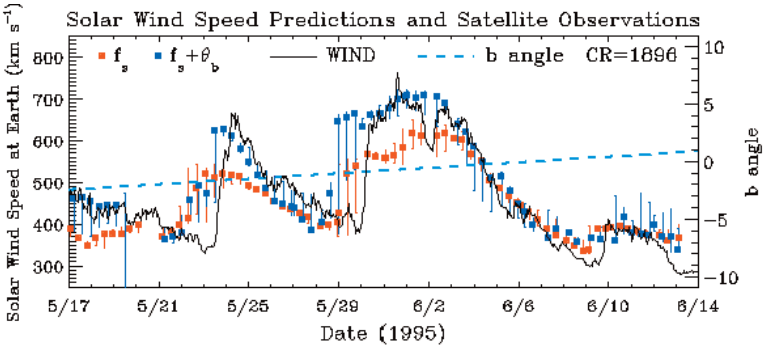


Fig. 1 - Comparison of solar wind speed observations (thin solid line) with predictions generated by two different versions of the Wang-Sheeley model. The predictions produced by a recently improved version of the model (blue dots) agree better with observations than those from an older version (red dots). The vertical bars are uncertainty estimates determined by calculating the solar wind speeds for values located 2.5° above and below the sub-Earth points.

Project Personnel: Charles N. Arge, Victor J. Pizzo, Dusan Odstrcil, Leslie R. Mayer, and Susan Wahl.

Funding Sources: Office of Naval Research (ONR) and the National Science Foundation (NSF).

References:

Arge, C. N., D. Odstrcil, V. J. Pizzo, and L. R. Mayer, Improved Method for Specifying Solar Wind Speed Near the Sun, submitted to the Proc. of the Tenth Internat. Solar Wind Confer. 2002.

Arge, C. N., K. L. Harvey, H. S. Hudson, and S. W. Kahler, Narrow Coronal Holes in Yohkoh Soft X-ray and the Slow Solar Wind, submitted to the Proc. of the Tenth Internat. Solar Wind Confer. 2002.

Luhmann, J. G., Y. Li, C. N. Arge, J. T. Hoeksema, and X-P. Zhao, A Solar Wind Source Tracking Concept for Inner Heliospheric Constellations of Spacecraft, submitted to the Proc. of the Tenth Internat. Solar Wind Confer., 2002.

Arge, C. N., S. Wahl, J. Chen, S. Slinker, and V. J. Pizzo, Implementation and Verification of the Chen Prediction Technique for Forecasting Large Nonrecurrent Storms, accepted in *Adv. in Space Res,* Proceedings of the COSPAR Colloquium in Beijing China, 2002.

Arge, C. N., E. Hildner, V. J. Pizzo, and J. W. Harvey, Two solar cycles of non-increasing magnetic flux, accepted *J. Geophys. Res.*, 2002.

Luhmann, J. G., Y. Li, C. N. Arge, P. R. Gazis, and R Ulrich, Solar Cycle Changes in Coronal Holes and Space Weather Cycles, accepted *J. Geophys. Res.*, 2002.

Wang & Sheeley Model:
http://www.sec.noaa.gov/ws/
Chen Model:
http://solar.sec.noaa.gov/chen/index.html

Chen Model:

The Chen IMF prediction model is a feature-based pattern recognition technique designed to predict the occurrence, duration, and strength of moderately large to large geomagnetic storms using real-time solar wind data available from a spacecraft upstream from Earth, such as the Advanced Composition Explorer (ACE) satellite. The Chen technique identifies prospective interplanetary magnetic field (IMF) events in the solar wind, estimates their duration and amplitude, and then calculates the probability that a geomagnetic storm will be generated (e.g., Figure 2). An IMF event is defined as any Bz excursion (northward or southward) from zero back to zero. A real-time prediction web page is on line at SEC.

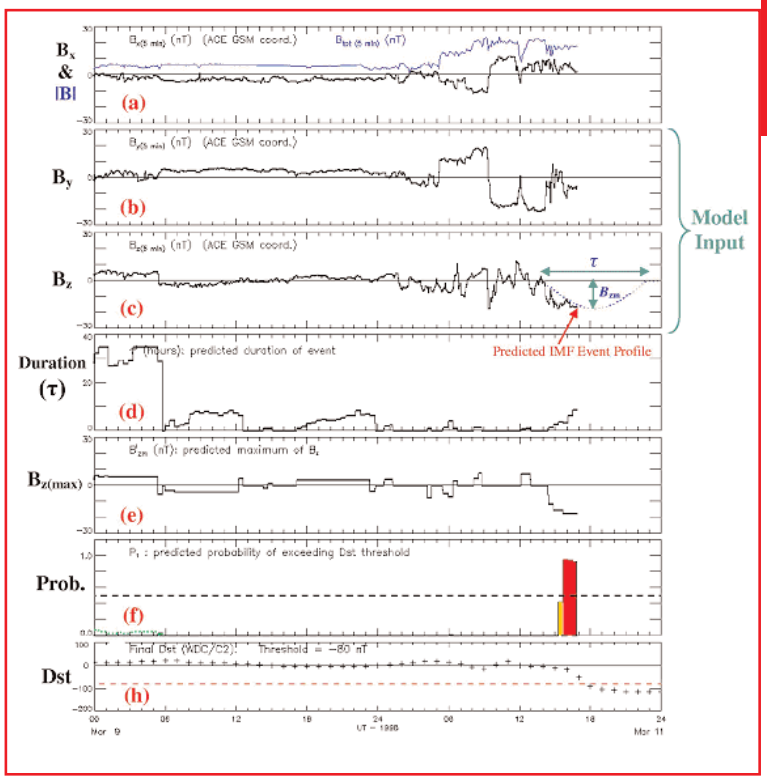


Fig. 2 - Example Chen model prediction: (a-c) IMF field values measured at ACE. (c) predicted IMF event profile (dotted blue sinusoidal curve) (d) predicted IMF event duration (t). (e) predicted IMF event extremum Bz. (f) Probability of IMF event exceeding Dst threshold. (g) observed Dst. The model successfully predicts, ~1 hour in advance, that Dst threshold will be exceeded.

Operational Sun-to-Earth model:

We are developing a simplified modular Sun-to-Earth space weather model. Because quantitative solar inputs are currently quite limited, the components of this prototype model consist of simple physics-based and semi-empirical models as well as numerical MHD models that can run on workstations. An advantage of this architecture is that it allows for extensive experimentation and permits easy replacement of individual models by improved ones as they (and any required data streams) become available. The model will complement large first-principle models now under development by working out the architecture and techniques needed to link them into an operational global Sun-Earth structure. It is controlled by a generalized Java-based routine (see Figure 3) originally developed by Lance William at TRW and recently modified by us.

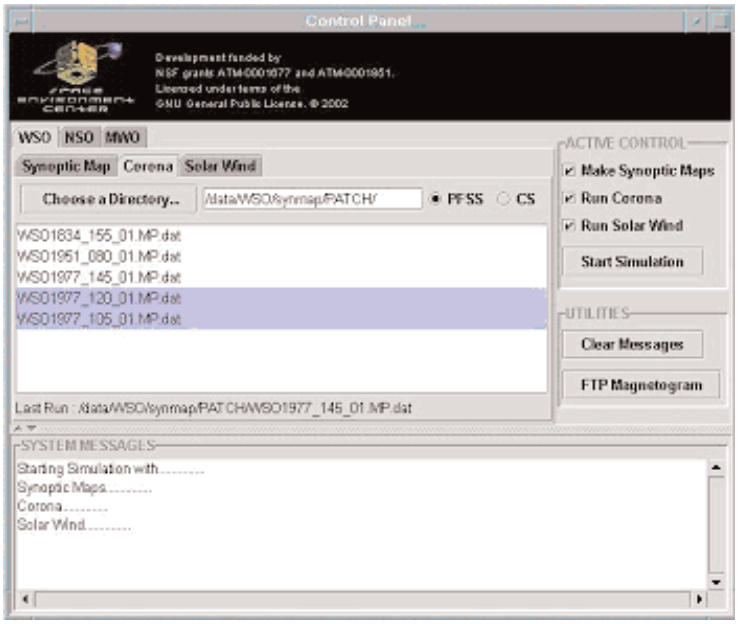


Fig. 3 - Java-based control panel for the modular Sun-to-Earth model.

Global Snow Cover Products Derived from Satellite Remote Sensing: Analysis of Long-Term Climatologies and Development of Near Real-Time Products from Current Satellite Sensors

Scientific Impact: Improved characterization of global snow cover to provide input data for, and support calibration and validation of, climate and hydrologic models and to monitor climate change.

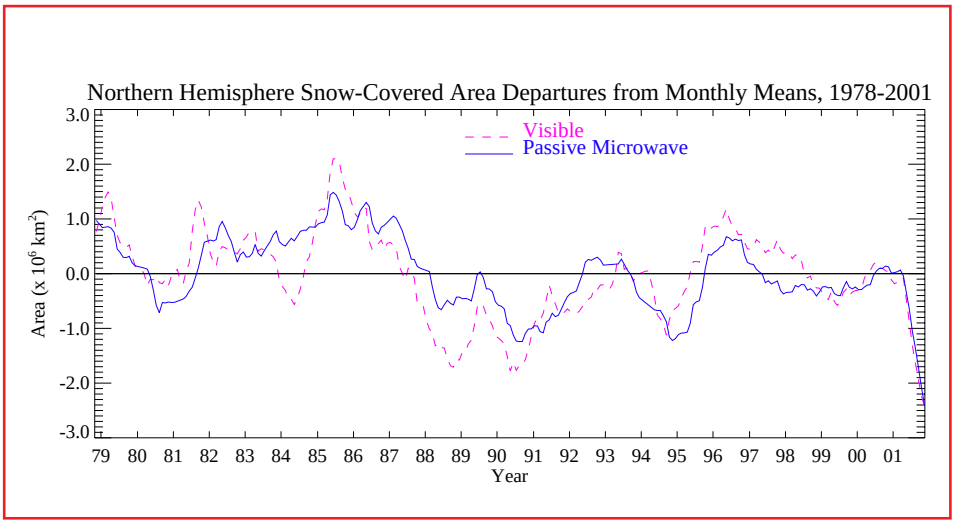
Project Personnel: R. L. Armstrong and M. J. Brodzik

Funding Sources: NASA

References: Armstrong, R.L. and M.J. Brodzik. 2001. Recent Northern Hemisphere snow extent: a comparison of data derived from visible and microwave sensors. *Geophysical Research Letters* 28:(19):3673-3676.

Armstrong, R.L. and M.J. Brodzik. 2002. Hemispheric-scale comparison and evaluation of passive microwave snow algorithms. *Annals of Glaciology* 34:38-44.

Snow, which can cover as much as 50 percent of the Northern Hemisphere land surface, has the highest albedo of any natural surface and can reflect significant amounts of solar radiation that would otherwise be absorbed at the Earth's surface, heating the ground and atmosphere above. Snow cover also has a higher emissivity than snow-free ground resulting in the further reduction of temperature due to enhanced infrared cooling. Snow has extremely low thermal conductivity, preventing heat stored in the ground from being released to the overlying atmosphere. Snow cover represents a significant heat sink during the melt period of the seasonal cycle due to a relatively high latent heat of fusion. As a result, snow cover exerts a dominating influence on the energy budget of the lower atmosphere and the surface. Therefore, realistic simulation of snow cover in climate and hydrologic models is essential for correct representation of the surface energy balance, as well as for understanding winter water storage and predicting year-round runoff. The lack of spatially integrated snow cover data to calibrate, execute and validate these models can be a major obstacle to improved simulations. Satellite remote sensing provides the source for these spatially integrated data sets. Passive microwave remote sensing can enhance snow measurements based on optical data alone, because of the ability to penetrate most clouds, provide data during darkness and to provide a measure of snow depth or water equivalent. This study compares data derived from two satellite products that involve completely different sensor systems and analysis techniques. The visible data show slightly higher annual maxima and greater departures from the monthly means within the time series. Both data sets indicate a decrease in snow extent of approximately 3 percent per decade. This study has defined the respective advantages and disadvantages of the two types of satellite data for snow cover mapping and it is clear that a blended product would represent the optimal approach. We are currently developing a product that combines snow cover data from two NASA EOS satellites, the visible-spectrum MODIS sensor on the Terra platform and the AMSR-E passive microwave sensor on Aqua.



Visible-derived (NOAA) and passive microwave-derived (SMMR and SSM/I) snow covered area departures from the monthly means (dashed lines) and 12-month smoothed (solid lines). Armstrong and Brodzik, 2001.

Up-Gully Surges: A New Mechanism for Perturbing the Nighttime Lower Atmosphere

Scientific Impact: Discovery of a possible means of enhancing diffusion and transport of ground-level atmospheric quantities into the lower atmosphere

Studies using data gathered during the nighttime stable boundary layer campaign (CASES-99) east of Wichita, Kansas in October 1999, showed a surprising phenomenon: when the near-surface nighttime wind direction shifted through the "up-gully" direction of a significant gully near the CASES 55m tower, the flow produced a pronounced but localized upward surge of vertical velocity up to at lease tower-top level. This surge, in turn, generated a packet of atmospheric gravity waves that propagated outward from the source. Observations using the CIRES TLS (kite in this case) located more-or-less upwind of the tower and somewhat above tower level, detected these waves, which had vertical and horizontal wavelengths of a few hundred meters.

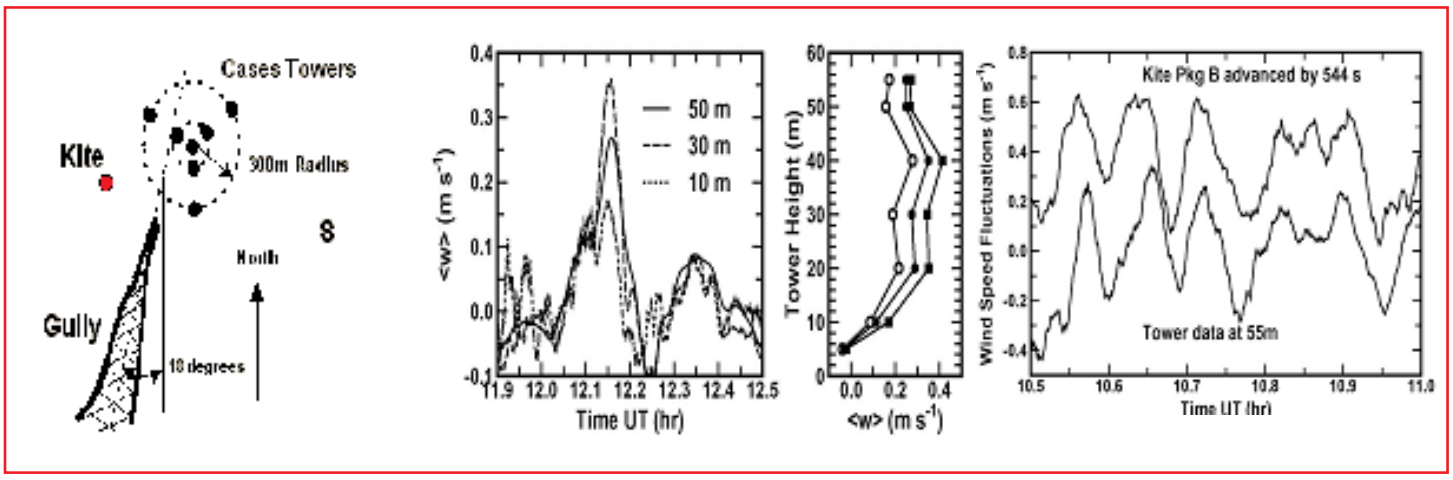
As a working hypothesis, we posit that the up-gully flow is constricted and strengthened as it progresses up the narrowing gully. Upon exiting the gully, this flow will have an upward velocity component that will in turn produce the wave packet observed by the TLS.

Project Personnel: B. Balsley, R. Frehlich, Y. Meillier, M. Jones, D. Fritts (CoRA), S. Vadas (CoRA), and R. Coulter (ANL)

Funding Source: NSF, ARO

References: Up-Gully Flow in the Great Plains Region: A Mechanism for Perturbing the Nighttime Lower Atmosphere (to appear in GRL)

The left-hand figure below shows the relative location of the tower, the gully, and the TLS kite (red dot). The central two figures show the time history and the profile of a surge at different tower heights. The right-hand figure shows the wave packet observed by the tower (lower curve) and the TLS (upper curve). Note that the TLS "saw" the packet 544 seconds later than when it was observed at the tower.



Observations of Trapped Waves in the Nighttime Stable Boundary Layer: TLS Observations

Scientific Impact: Demonstration of the utility of using the CIRES TLS (Tethered Lifting System) as a valuable tool for in situ measurements in the lower atmosphere

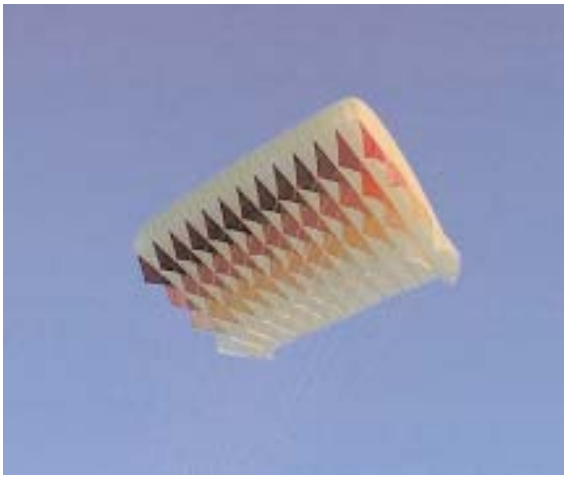
The fundamental characteristics of wave motions that occur in the stable nocturnal boundary layer over the mid-western plains were studied during CASES-99 from a location east of Wichita, Kansas in October 1999. The CASES-99 Campaign employed a large number of sensors including both ground-based instruments (VHF/UHF radars, lidars, sodars, microbarographs, etc.), tower-mounted instruments on a series of towers, and in situ instruments mounted on or below aircraft, balloons, radiosondes, and the CIRES TLS. The TLS, or Tethered Lifting System, comprises either an aerodynamic balloon (low winds) or a high-tech kite (higher winds) as a lifting device from which are suspended a series of delicate instruments. For CASES-99 the instrument cluster included sensors for wind speed and direction, temperature, humidity, and in-house designed hot and cold-wire sensors to measure high-frequency turbulence quantities (Ct2 and Epsilon).

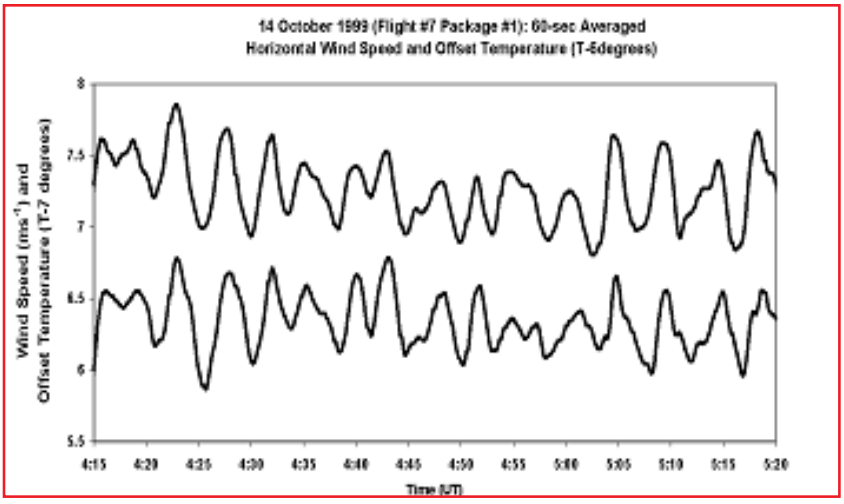
Project Personnel: B. Balsley, M. Jensen, R. Frehlich, Y. Meillier D. Fritts (CoRA), C. Nappo (NOAA), D. Riggin (CoRA), W. Eichinger (NOAA), and R. Newsom (NOAA)

Funding Source: NSF, ARO

References: Analysis of Ducted Motions in the Stable Nocturnal Boundary Layer During CASES-99 (submitted to Spec. Issue of J. Atm. Phys.)

Observations during the night reported here (14 October 1999), showed very coherent vertical motions and attendant horizontal wind and temperature fluctuations (see below) in the vicinity of a pronounced stratification around 500m altitude. Analysis of these and other features are consistent with the presence of a ducted wave propagating along maxima in stratification and mean wind.





A New Version of the Rapid Update Cycle for Aviation and Severe Weather Forecasting

Scientific Impact: An improved atmospheric analysis and short-term prediction system running in real time at the National Centers for Environmental Prediction (NCEP) and used nationwide.

Project Personnel: Stanley G. Benjamin, John M. Brown, Kevin J. Brundage, Dezs` Devenyi*, Georg A. Grell*, Dongsoo Kim*, Barry E. Schwartz, Tatiana G. Smirnova*, Tracy Lorraine Smith, and Stephen A. Weygandt.

Funding Sources: FAA, NOAA

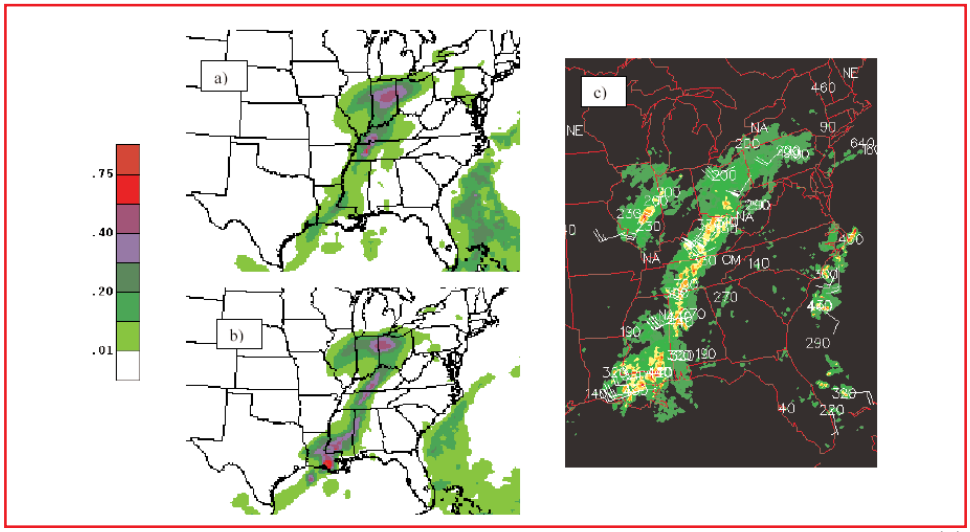
Reference: RUC20 *Technical Procedures Bulletin* (30 pp.) available at http://ruc.fsl.noaa.gov/

* CIRES employee

The Rapid Update Cycle (RUC) has been running operationally in real time at NOAA's National Centers for Environmental Prediction since September 1994. Developed by a team including CIRES employees at NOAA's Forecast Systems Laboratory, the RUC uses the latest observations from commercial aircraft, wind profilers, satellites, radars, weather balloons, and surface stations on land and offshore to generate detailed analyses of surface and atmospheric conditions over the U.S. every hour. These analyses are the basis for a 12-h forecast every third hour and a 3-h forecast at the intervening hours. RUC output is used widely for aviation, severe-storm forecasting, and general weather forecasting. The newest version, called the RUC20 because of its 20-km resolution, became operational on 17 April 2002. It has 50 computational levels in the vertical.

The smaller grid spacing used by the RUC20, in comparison with its predecessor, provides better resolution of variations in land elevation, land-water boundaries, and other land-surface features. This detail leads to improved forecasts of regional and local precipitation and surface wind phenomena. The RUC20 incorporates satellite cloud data to improve its cloud, icing and precipitation forecasts. It also handles convective and non-convective clouds more effectively.

For aviation operations, the RUC20 enhancements result in better forecasts in the vicinity of warm and cold fronts, where bad weather tends to concentrate, including areas of potentially hazardous turbulence and icing, and more accurate forecasts of surface winds, temperature, and precipitation (see figure). RUC forecasts of jet-level winds and temperature, critical for U.S. flight routing and air traffic management, are also improved.



Precipitation (inches) predicted between 0900 and 1200 UTC by RUC forecasts started at 0000 UTC 26 March 2002: a) from the old version of the RUC, b) from the RUC20. c) a composite radar image showing precipitation intensity at 1115 UTC.

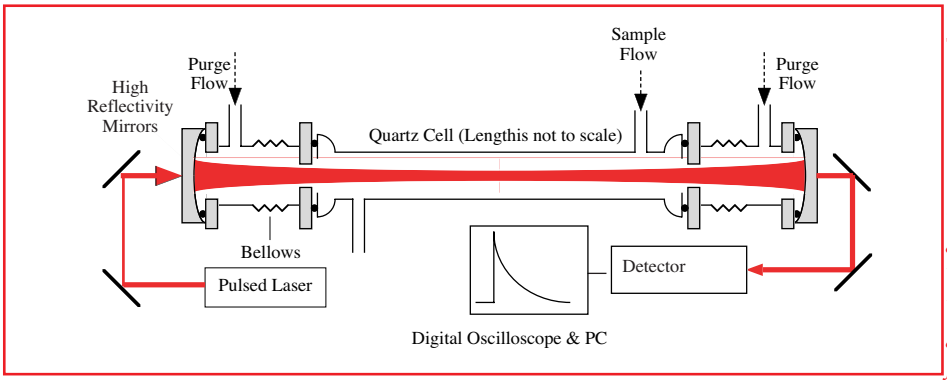
Cavity Ring-Down Spectroscopy: A New Approach for Difficult-to-Measure Atmospheric Trace Gases

Scientific Impact: Development of a new, ultra-sensitive capability for measuring trace gases in the atmosphere has opened new frontiers of inquiry, discovery, and assessment in atmospheric chemistry.

The chemistry of the atmosphere is dominated by the rarest of its constituents-highly reactive species present as a few molecules in a billion (or even per trillion) molecules of air. Precisely because they are so reactive, these trace species "live" in the atmosphere only for short periods of time, making their measurement a particularly challenging scientific endeavor. But, because these ephemeral species lie at the heart of the atmosphere's chemical workings, the ability to quantify their abundance is often a key to understanding fundamental processes. In this research, CIRES scientists and their colleagues in NOAA have pioneered a new technique, cavity ring-down spectroscopy (CRDS), to quantify some particularly elusive atmospheric constituents that play important roles in the real atmosphere. A particular focus in 2001/2002 was the development of a field-ready CRDS instrument for deployment in the summer 2002 New England Air Quality Study.

The approach, described in more detail in the figure (below), is a novel application of the "tried and true" technique of absorption spectroscopy. It is based on measuring the time decay of a laser-generated light pulse in a cell containing the absorbing molecule, rather than the magnitude of the decrease in its intensity due to absorption. Work in 2001/2002 focused on developing the field CRDS to measure nitrate radical (NO_3) and dinitrogen pentoxide (N_2O_5), key players in the nighttime chemistry of the atmosphere that have not been measurable using other techniques. The nighttime chemistry of NO_3 and N_2O_5 is a major uncertainty at present in model predictions of air pollution. A first major field deployment will occur in July/August 2002. The new capability will contribute to a more complete scientific understanding of the chemistry that influences air quality, and it will thereby enhance the effectiveness of future government/industry efforts to improve air quality.

Project Personnel: S. Brown, H. Stark, M. Aldener, S. Ciciora, A.R. Ravishankara (NOAA/AL)
Funding Sources: NOAA
References: Brown et al. 2001. *Geophysical Research Letters* 28:3227-3230.



Cavity Ring-Down Spectroscopy: High-Tech "Photon Ping-Pong" at Work

This technique puts some new twists on more traditional approaches in absorption spectroscopy. "Cavity ringdown spectroscopy" begins in a familiar way, with a pulse of laser light entering a cell that contains an absorbing gas of interest. The light pulse reflects off of mirrors at opposing ends of the cell, yielding multiple passes through the absorber and a gradual decay in the intensity of the light (see figure). What's new is that instead of measuring the magnitude of the reduction in light intensity due to absorption, the technique measures the time it takes for the light intensity to decay as it bounces back and forth between the mirrors. This decay time is not sensitive to variations that occur from one laser pulse to the next, so a major source of noise in traditional absorption spectroscopy is averted. The result: sensitivity skyrockets.

Response of the Low Latitude Ionosphere and Thermosphere to Geomagnetic Storms

Scientific Impact: Improved physical understanding of the response of the low latitude upper atmosphere to storms will aid in specification and forecasting.

Numerical simulations of the response of the low latitude upper atmosphere to geomagnetic storms have been simulated using a model of the thermosphere, ionosphere, and plasmasphere, with coupled electrodynamics. It has been recognized for many years that the redistribution of plasma by electric fields is critical in the low latitude ionosphere. The formation of the equatorial ionization anomaly (EIA) is a direct result of this process. A large post-sunset enhancement of the zonal electric field leads to a particularly strong EIA. The accepted understanding is that zonal neutral winds flowing eastward across the terminator give rise to the polarization electric field. It is reasonable, therefore, to expect changes in the low latitudes zonal wind to be the primary driver of the equatorial storm-time changes. The simulations, however, revealed that mid-latitude meridional winds may play an even more important role. During geomagnetic storms, the high latitude geomagnetic energy sources drive neutral wind surges from the high to low latitudes and produce changes in the global circulation. The immediate response is for predominantly meridional winds to flow, and the zonal component builds up gradually at mid-latitudes from the action of the Coriolis force. In the simulation, the electric field response at low latitude, from the dynamo action of the neutral winds, occurred well before the zonal winds had a chance to develop. The results indicate that the mid-latitude meridional winds play a leading role in the electrodynamic response and the subsequent redistribution of plasma at low latitudes during a storm.

Project Personnel: Tim Fuller-Rowell, Mihail Codrescu

Funding Source: NSF, NOAA

References: Millward, G. H., A. D. Aylward, I. C. F. Mueller-Wodarg, T. J. Fuller-Rowell, R. J. Moffett, and A. D. Richmond, An investigation into the influence of tidal forcing on F region equatorial vertical ion drift using a global ionosphere-thermosphere model with coupled electrodynamics, *J. Geophys. Res.*, 106, 24733-24744, 2001.

Fuller-Rowell, T.J., M.C. Codrescu, A.D. Richmond, and G.H. Millward, Storm-Time Changes in Thermospheric Dynamics at Low Latitudes. *J. Atmos. and Solar Terr. Phys*, in press, 2002.

Maruyama, N., S. Watanabe, and T.J. Fuller-Rowell, Dynamics and Energetic Coupling in the Equatorial Ionosphere and Thermosphere, *J. Geophys. Res.*, in press, 2002.

Radiometric Manifestations of Oceanic Currents

Scientific Impact: A new remote sensing technique for observing and quantitatively evaluating surface currents in the ocean

Project Personnel: O. A. Godin (CIRES and NOAA/ETL) and V. G. Irisov (Zel Technologies, LLC and NOAA/ETL)

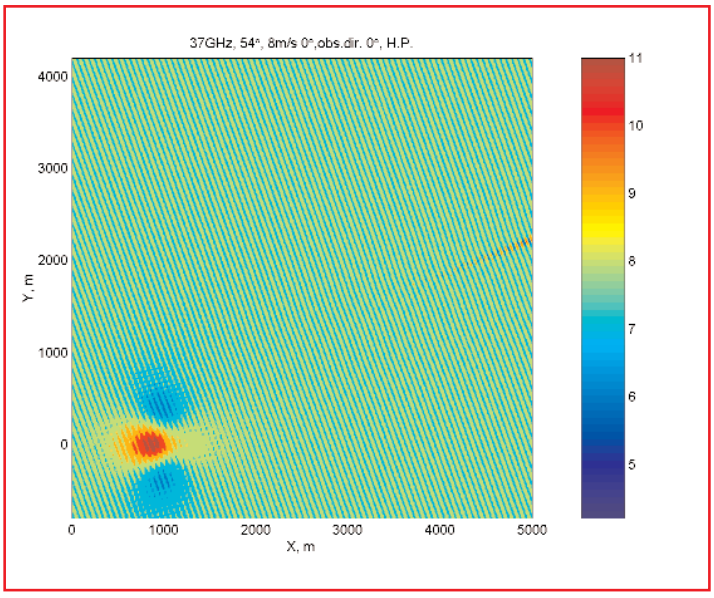
Funding Sources: DoD

References: A Perturbation Model of Radiometric Manifestations of Oceanic Currents (accepted for publication in *Radio Science* (2002)

Extracting quantitative oceanographic information from microwave images of the ocean surface requires a physical understanding and an efficient mathematical model of surface wave interaction with currents. We have developed a practical model for simulating brightness temperature variations due to horizontally inhomogeneous, time-dependent currents with velocities up to a few tens of cm/s on the ocean surface. The currents change the brightness temperature by refracting surface waves and thus modulating ocean surface roughness. Wave-atmosphere and wave-wave interactions are taken into account within the relaxation approximation. Computational efficiency of the model is achieved by using the ray theory and analytically solving equations governing surface gravity waves to calculate the surface roughness. The hydrodynamic theory is combined with an electromagnetic model based on the small-slope approximation to simulate microwave emission from the ocean surface. Analysis of the theoretical results demonstrates that the physics of surface wave interaction with time-dependent currents, which are inhomogeneous in two spatial dimensions, is more rich and complex than is suggested by the one-dimensional models considered theoretically in the past.

As an example, the figure to the right shows a 5×5 km^2 fragment of a simulated map of brightness temperature contrast (in K) at horizontal polarization. Inhomogeneous current is due to perturbation of barotropic tide with velocity 0.35 m/s by a 100 meter high seamount in 300 meter deep ocean. The seamount is axially symmetric with respect to the line x=0, y=0 and has half-width of about 1 km. Background wave field is generated by 8 m/s wind in the presence of swell. Note strong brightness temperature contrasts up to ±3.5 K in a vicinity of the seamount and 4 km away from it.

Our model predicts that emissivity variations are a sensitive measure of surface currents, with brightness temperature contrasts up to 6 K resulting from currents with velocities less than 25 cm/s in the examples considered. The relation between temperature variation and current velocity is generally not local. This is because perturbations in surface wave amplitude and wave vector by horizontally inhomogeneous currents, unlike currents inhomogeneous in one dimension, can accumulate along the trajectory of the wave. Another manifestation of the perturbation accumulation along the surface wave trajectory is the appearance of large-scale temperature features that extend well beyond the region of inhomogeneous currents. These features may be helpful in detecting smaller-scale changes in bathymetry, especially with satellite-based radiometers.



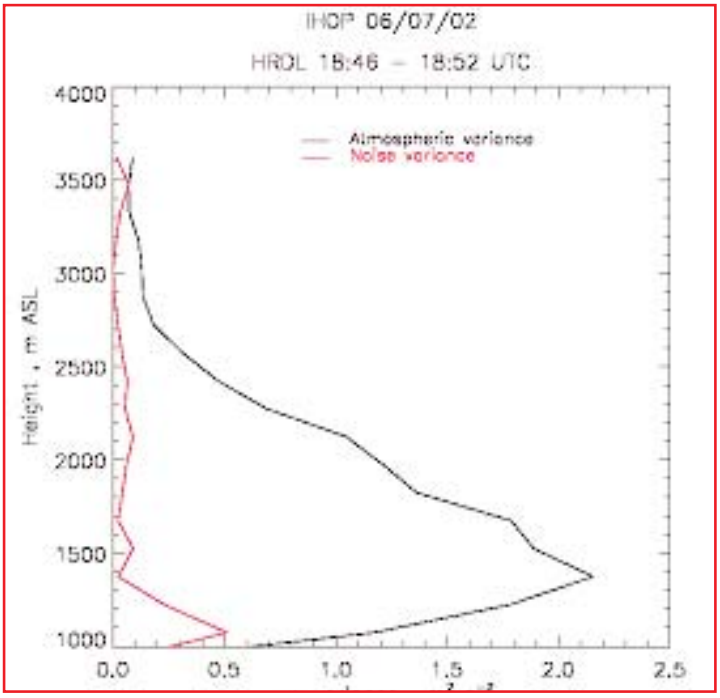
Characterization of Boundary Layer Turbulent Eddy Structure Using Airborne Doppler Lidar

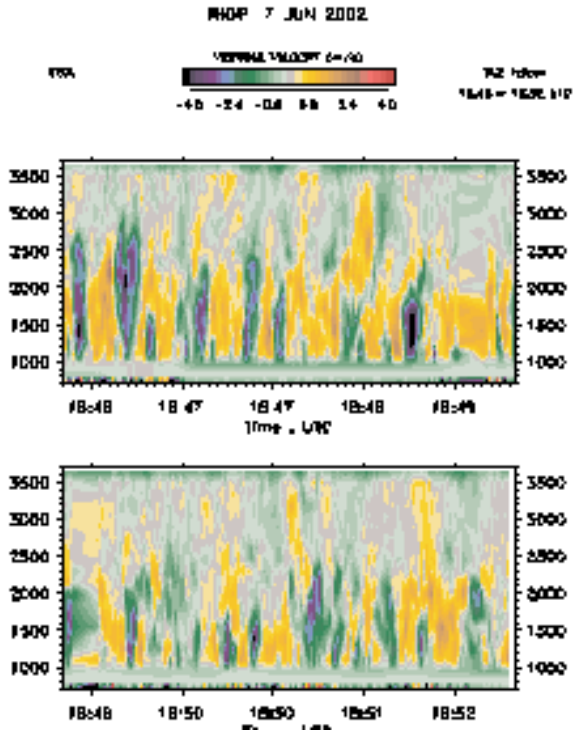
Scientific Impact: Improved parameterization of turbulent processes in forecast models.

Project Personnel: M. Hardesty, A. Brewer, S. Cooley, A. Weickmann, S. Sandberg, C. Senff
Funding Source: NOAA USWRP, NOAA IPO

A key requirement for both weather prediction models and global circulation models is proper characterization of turbulence in the planetary boundary layer and lower troposphere. Turbulent processes directly affect the exchange of heat, moisture, and momentum between the surface and the free atmosphere. Although generally well characterized over flat terrain under uniform conditions, representation of turbulent processes becomes more difficult in complex terrain or under varying conditions of surface moisture, land use, or land type. Airborne remote sensing offers the opportunity to characterize the two and three dimensional turbulent eddy structure over large areas, and to investigate the correlation between differing surface features and the observed turbulent eddy structure. To provide these needed measurements, a NOAA/CIRES team modified a surface-based Doppler lidar and deployed it, alongside a DIAL water vapor lidar, on a Falcon F-20 research airplane during the recent International H_2O Experiment (IHOP). The measurements marked the first attempt to measure two-dimensional velocity turbulence structure using lidar, and offer the potential of estimating moisture flux profiles by combining measurements from the DIAL and Doppler lidars.

To obtain the measurements, the NOAA/ETL High Resolution Doppler Lidar (HRDL) was mounted in the aircraft such that a turning mirror directed the beam downward. The surface returns provided an indication that the beam was actually vertical such that aircraft motion was not contributing to the measured Doppler shift. Vertical winds were measured with a vertical and horizontal resolution of approximately 150 m during several aircraft flight legs. The left figure shows the measured vertical motion as a function of time. The total period shown corresponds to roughly 60 km in space. The data are consistent with expected velocity structure in a convective boundary layer: narrow intense updrafts interspersed with broader, less intense downdrafts. The left figure shows the profile of velocity variance as a function of height averaged over the 60-km interval. Turbulence intensity peaks at a height corresponding to 1/3 the height of the mixed layer, as might be expected. Eventually, we hope to combine the wind and water vapor observations to estimate flux profiles, which are important for characterizing the vertical structure and transport of low level moisture for forecasting precipitation.





Progress Towards Correcting Wind-Profiler Range Errors Induced by Strong Atmospheric Reflectivity Gradients

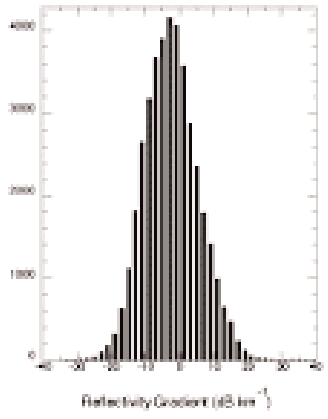
Scientific Impact: Explained discrepancies between collocated wind profiles obtained with different pulse lengths, and proposed both complex and simple solutions to help resolve the differences.

Long-term averages of wind-profiler data show differences between the 915-MHz and the 50-MHz wind profiles, as well as differences between the data collected with 100-m and the 500-m pulses by the 915-MHz systems. Comparisons of mean winds determined using a 100-m pulse length, a 500-m pulse length, and a 1000-m pulse length show that the profiles obtained with the longer pulses are displaced in height from contemporaneous profiles measured with the 100-m pulse. These discrepancies are disturbing in and of themselves; they also hinder efforts to merge collocated profiler measurements into a common dataset.

The standard radar equation, which assumes constant reflectivity within the scanned volume and range much greater than pulse length, does not adequately account for the conditions under which wind profiler observations are made. For example, measured reflectivity gradients are rarely near zero (Figure 1). A more complex radar equation has been derived and used to simulate the radar response to the atmosphere. Results show that the range location of the observations could be corrected by incorporating the effects of a suitable profile of atmospheric reflectivity.

Examples of these errors and the application of the correction, using unaveraged radial profiles and the associated measured atmospheric reflectivity gradients, indicate that the main cause of the pervasive differences observed between the different radar observations involves the reflectivity gradients. Applying this technique on a scan-by-scan basis to historical as well as real-time data will be a logistical and computational challenge. However, recent work with half-hourly profiles of horizontal winds has shown that even assuming a simple, exponentially decaying reflectivity profile (based on global measurements made by the National Bureau of Standards in the 1940's and 1950's) can improve the height assignments of the winds collected by 500-m pulse lengths. Results from eight 10-day case studies in which heights were so adjusted show up to 18% reductions in differences between 100-m and 500-m profiles. Efforts to find a way to improve height assignments without having to go back to the original scanned data are continuing.

Project Personnel: L.M. Hartten, P.E. Johnston, D.M. Coleman (U. Virginia and SOARS)
Funding Sources: NOAA, SOARS® (Significant Opportunities in Research in Atmospheric Sciences)
References: Johnston, P.E., L.M. Hartten, C.H. Love, D.A. Carter, and K.S. Gage, 2002: Range errors in wind profiling caused by strong reflectivity gradients. *J. Atmos. Oceanic Technol.* 19:934-953.



Reflectivity gradients measured on 20 and 21 Oct 1999 with the Christmas Island (2.0°N,157.3°W) 50-MHz wind profiler using a 1000-m pulse length. Data from one vertical and four oblique antenna beams are combined; bin size is 2 dB km^{-1}.

The Powered Parachute: Quasi-Continuous Sampling of Atmospheric Quantities Near Park Falls, Wisconsin

Scientific Impact: Demonstration of the feasibility of employing a powered parachute as a method of sampling chemical constituents in the daytime lower atmosphere

Project Personnel: M. Jensen, B. Balsley, J. Birks, and K. Schulz

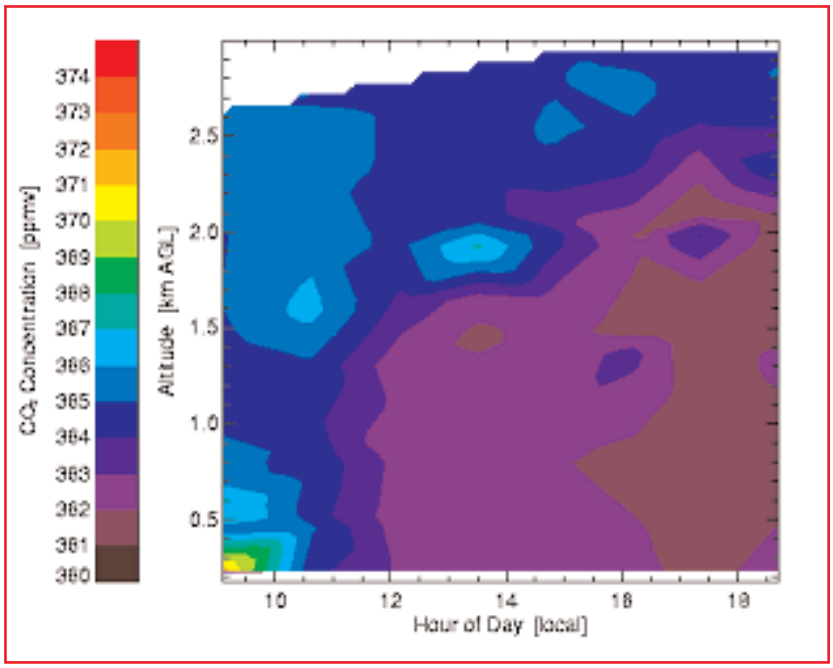
Funding Source: DOE (NIGEC)

References: In preparation as a PhD thesis

In situ sampling in the lower atmosphere by a manned powered parachute (PPC) promises to provide a unique new technology for rapidly profiling atmospheric quantities from literally ground level up to over 3 km AGL. The PPC can carry a relatively heavy (40-50 kg) suite of instruments to study the spatial and temporal variability of various quantities over distances of a few km and periods of hours to days. At this point, we have profiled temperature, wind speed and direction, as well as humidity, O_3 and CO_2 concentration.

The photo shown below depicts the PPC landing in a small clearing by the WLEF radio tower near Park Falls, Wisconsin. The figure to the right shows contours of CO_2 obtained from ten-hour period of quasi-continuous PPC ascents and descent. The CO_2 samples in this example were obtained using a series of Tedlar bags inflated at pre-selected height during these flights. Analysis of the bag contents was accomplished immediately upon landing using a LICOR analyzer.

Note the enhanced CO_2 levels that can be seen near the surface in the early morning and the gradual depletion that can be seen beginning in mid-afternoon. These results can be compared with concurrent profiles of temperature, wind, and water vapor (none of which is shown here) to better understand the dynamical and biological processes involved in CO_2 distribution.



Inferring Ice Cloud Microphysical Properties from Doppler Radar Measurements

Scientific impact: A long-term data set on arctic cloud microphysical properties to be used in climate and radiation models

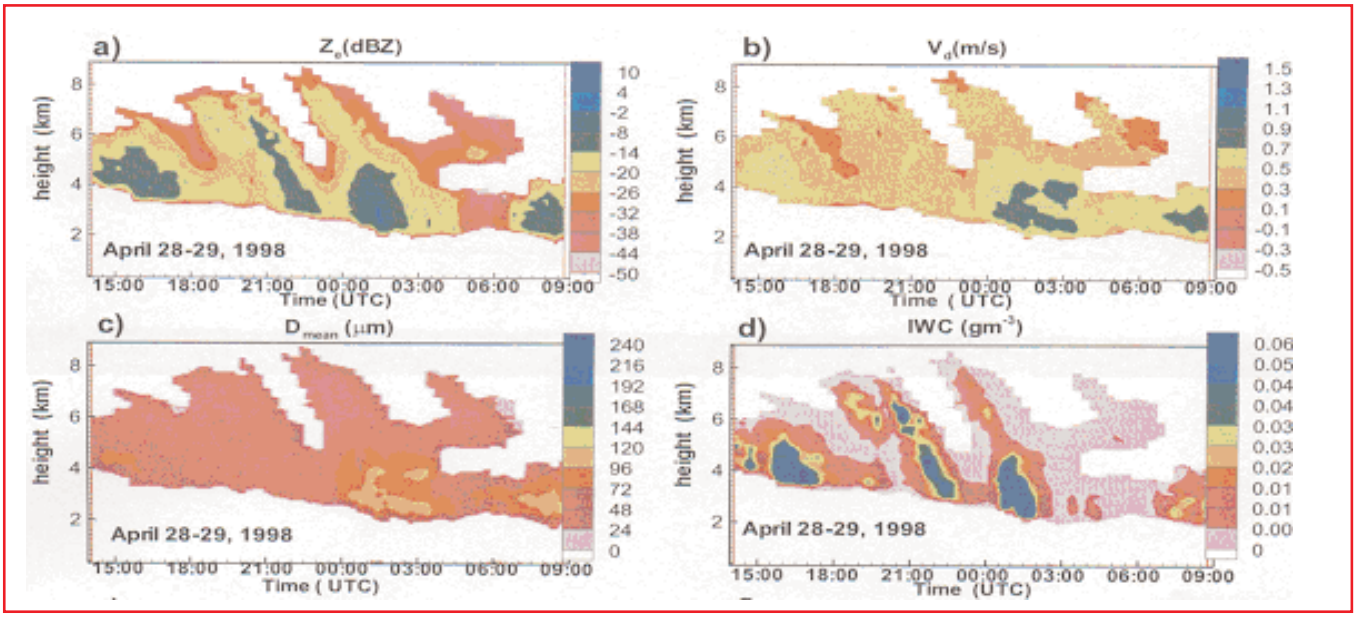
Project Personnel: S.Y. Matrosov, M.D. Shupe

Funding Sources: NCF

References: Profiling Cloud Ice Mass and Particle Characteristic Size from Doppler radar measurements, *J. Appl. Meteor.*, 19:1003-1018, 2002.

Many modeling studies indicate that clouds play a very important role in the earth's radiation budget and hydrological cycle. Cloud radiative properties are determined by their microphysical properties such as water content and cloud particle characteristic size. Satellite measurements can provide layer-mean values of the cloud microphysical parameters of interest. However, vertical profiles of cloud microphysics are of a greater interest since they determine where in the atmosphere actual heating/cooling occurs. Ground-based instruments such as 8 mm wavelength vertically-pointed radar are capable of measuring vertical profiles of reflectivity and Doppler velocity in non-precipitating clouds. These measurements can be then used to retrieve vertical profiles of cloud microphysical parameters of interest.

The NOAA Environmental Technology Laboratory deployed its 8 mm cloud Doppler radar on board of a Canadian icebreaker during a year-long Surface Heat Budget of the Arctic (SHEBA) experiment. A unique data set on arctic clouds was collected from October 1997 to October 1998. A new remote sensing method was recently developed in the same laboratory to retrieve cloud microphysical parameters from radar measurements. A figure below shows an example of reflectivity (a) and Doppler velocity (b) measurements and corresponding cloud particle mean size (c) and ice water content (d). The retrievals for the whole SHEBA year have been recently performed and the measurements and the retrieved data have been posted on the web for the users in the modeling community. http://www.etl.noaa.gov/et6/arctic/sheba



An Evaluation of Real-Time Forecasts from a Weather-Chemistry Forecasting Model Using Observations from the Texas AQS 2000 Field Experiment

Scientific Impact: Test and evaluate the meteorological performance of NOAA's coupled weather-chemistry model in the Houston area.

In this study, meteorological observations taken during the Texas Air Quality Study 2000 are used to evaluate the forecasts of NOAA's coupled weather-chemistry forecasting model. This study focuses on a meteorological evaluation of the performance of the coupled model by comparing the real-time forecasts using the model with data sets from wind profilers, rawinsondes, and NCAR's Electra aircraft for the high surface ozone episode during the time period of 25-30 Aug 2000.

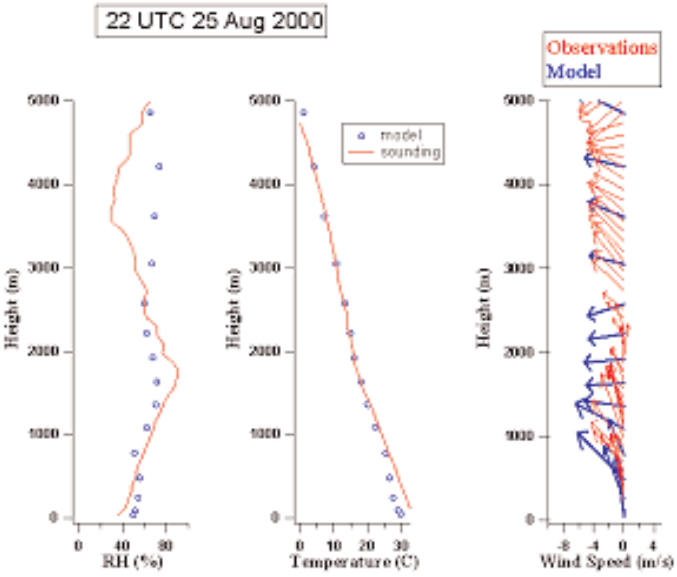
NOAA's coupled weather-chemistry forecasting model combines a modified version of the fifth generation Penn State/NCAR Mesoscale Model (MM5) and the chemical mechanism of the Regional Acid Deposition Model Version 2. The transport of chemical species (grid-scale and sub-grid scale) is treated simultaneously with meteorology. Photolysis, biogenic emissions, and deposition are also calculated "online". The chemical fields are initialized with the previous forecast to take into account the effect of accumulation. The emission inventory was compiled with databases from EPA and TNRCC.

The figures shown are examples of the type of comparisons that were made. It is clear from this comparison that the model possesses a cold bias at low-levels and an easterly wind bias in the lower troposphere. Model-observation comparisons reveal that the PBL is colder than observed when the prevailing low level winds are from the Gulf of Mexico than when the low-level winds are from inland. Other comparisons also indicate that the forecasted land-sea breeze cycle is in good agreement with the wind-profiler observations, but differences do exist in the wind direction and speed. The forecasted strength of the nocturnal low-level jet agrees fairly well with observations. However, the forecasted direction of the nocturnal low-level jet is more easterly than observed. The forecasted PBL mixing layer generally grows faster and deeper compared with observations, although the on-set of the PBL growth does compare well with observations. There is also a sensitivity to the initial conditions.

Project Personnel: S. A. Michelson, J-W. Bao (ETL), S. A. McKeen, A. B. White, and G. A. Grell

Funding Sources: Texas Natural Resource Conservation Commission (TNRCC)

Reference:
http://www.mmm.ucar.edu/mm5/workshop/ws02/Michelson.pdf



Comparison of the observed and forecasted soundings at 95.54°W 29.9°5 N.

Numerical Simulations of Transient Interplanetary Disturbances

Scientific Impact: Better physical understanding of how transient disturbances of solar origin propagate through interplanetary space.

Numerical simulations play an important role in space weather research and forecasting. However, significant effort is needed to develop more realistic models and meet challenges presented by the: (a) different physical phenomena, effects, and mechanisms; (b) non-linearly coupled complex systems; and (c) enormous range of spatial and temporal scales. Recent advances in parallel computer systems are promising to enable realization of new space-weather simulation tools, which will link closely sophisticated observations and theoretical models.

The CU/CIRES-NOAA/SEC research team is involved in large, multi-institutional projects, with the aim being to develop comprehensive physics-based numerical simulation models that describe the space environment from the Sun to the Earth. These models will serve three complementary goals: (a) we will do fundamentally new science, increasing our understanding of the complex, closely coupled Sun-Earth system; (b) in partnership with NOAA's Space Environment Center we will convert the results of our research into robust and operationally useful forecasting tools for space weather forecasters; and (c) in our education programs we will make the geospace environment accessible to understanding through models and visualization tools.

Our specific responsibility is to provide the link between the solar corona and Earth magnetosphere models. We have modified our 3-D magnetohydrodynamic numerical code to run on parallel supercomputers and incorporated the adaptive mesh refinement technique (in planar geometry so far).

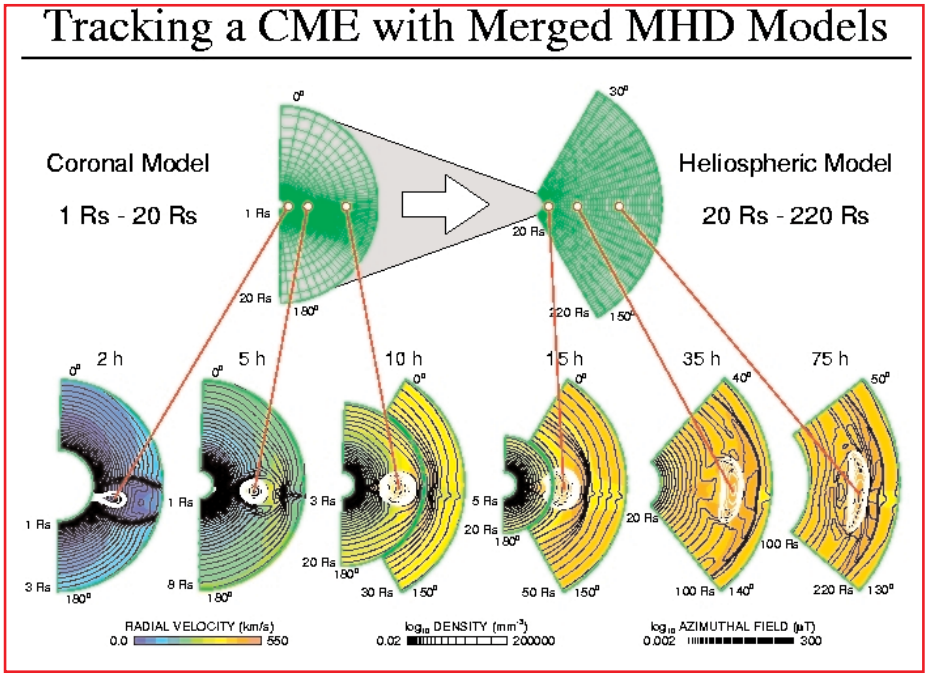
The figure illustrates our recent achievements in tracking of a coronal mass ejection from its origin in the solar corona to its impact at Earth. Computations were performed by merging the coronal model (SAIC, San Diego) with the CU/CIRES-NOAA/SEC heliospheric model as indicated at the top. Distributions of the radial velocity (color scale), number density (black contours), and azimuthal magnetic field (white contours) are shown at six different times after CME launch. Note that different sub-domains of the computational regions are shown in the each panel to better illustrate the evolution of transient disturbances.

We are currently working on the development of model coupling procedures for 3-D problems, incorporation of adaptive mesh refinement technique in spherical geometry, and evaluation of various procedures for driving numerical simulations with plasma parameters derived from the observed solar magnetic field.

Project Personnel: Dusan Odstrcil and Victor J. Pizzo.

Funding Sources: NSF, DoD/AFOSR, NASA

References: Numerical simulation of interplanetary disturbances. *Solar Cycle and Space Weather.* ESA SP-477, 24-27, 2002).
Merging of coronal and heliospheric numerical 2-D MHD models. *J. Geophys. Res.* in press 2002.



Experimental Studies of Horizontal Refraction of Acoustic Signals Propagating over a Long Range in the Ocean

Scientific Impact: Measurements of horizontal refraction angles of acoustic signals propagating in the ocean can provide a new technique for remote sensing of structures in the ocean, e.g. mesoscale eddies.

In 1998, the North Pacific Acoustic Laboratory (NPAL) carried out a comprehensive long-range sound propagation experiment using a billboard acoustic array installed near the cost of California. The billboard acoustic array recorded signals due to the source located near Hawaii for about a year. Our goal in processing the data recorded during the NPAL experiment is evaluation of the horizontal refraction angles (HRA) of acoustic signals as a function of time. The dependence of the HRA on time should contain important information about internal gravity waves and meso-to-global scale structures in the ocean. Short-period (hours-to-days) variations of HRA are caused by sound scattering by internal gravity waves. Long-period (weeks-to-months) variations of HRA can be caused by meso-to-global scale structures in the ocean such as mesoscale eddies. Revealing long-period trends in the dependence of HRA on time will be an important finding. If such trends do exist, they will give a unique opportunity for acoustic monitoring of large-scale structures in the ocean.

Review of the method and scientific results:
A numerical code for signal processing of the NPAL data was developed. Using this code, the dependence of HRA on time was calculated. The results obtained are shown in the figure. It follows from the figure that there are fluctuations in HRA due to sound scattering by internal gravity waves. A model theory of sound propagation through internal gravity waves is been developing which gives the variance of HRA of the same order as that in figure.

The solid line in the figure is a long-term trend of HRA. This trend shows that a structure of the ocean perpendicular to the propagation path changes during a year.

The dependence of the horizontal refraction angle on time. The vertical axis corresponds to the horizontal refraction angle (HRA). The solid line represents polynomial fitting of the HRA shown by "x". 211 day corresponds to August 1, 1998.

Project Personnel: Vladimir E. Ostashev (CIRES) and Alexander Voronovich (NOAA/ETL).

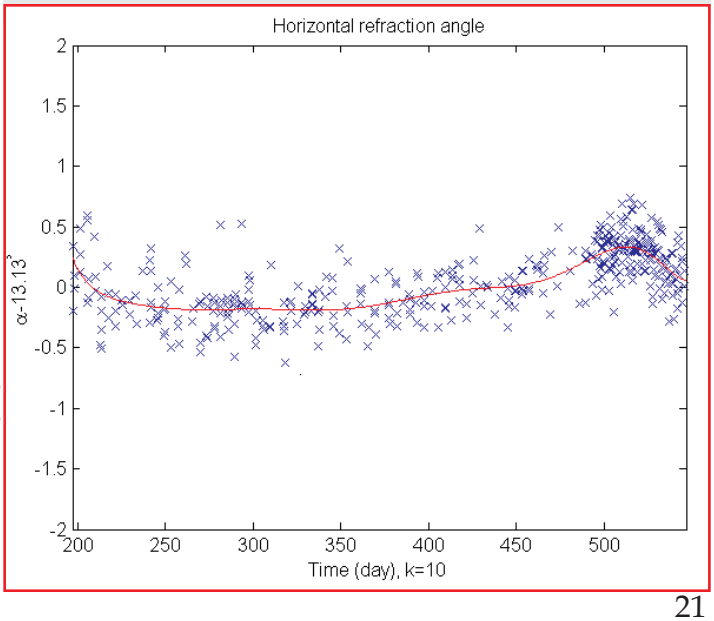
Funding Sources: Supported by the Office of Naval Research.

References:

A.G. Voronovich, V.E. Ostashev, and the NPAL group (J.A. Colosi, B.D. Cornuelle, B.D. Dushaw, M.A. Dzieciuch, B.M. Howe, J.A. Mercer, R.C. Spindel, and P.F. Worcester), "Experimental studies of horizontal refraction of acoustic signals in the ocean", to be published in: *Izv. Acad. Scienc., Atmos. Ocean.Phys.*, No 6 (2002).

A.G. Voronovich, V.E. Ostashev, and NPAL Group, "Studies of horizontal refraction of acoustic signals recorded by NPAL", Proceedings of the 9th L.M. Brekhovskikh's conference "Ocean Acoustics", 88-91, Moscow (2002).

A. G. Voronovich, V. E. Ostashev, J. A. Colosi, B. D. Cornuelle, B. D. Dushaw, M. A. Dzieciuch, B. M. Howe, J. A. Mercer, R. C. Spindel, and P.F. Worcester, "Horizontal refraction of acoustic signals retrieved from NPAL billboard array data," *J. Acoust. Soc. Am.* V. 109, No 5, Pt.2, 2385 (2001).



Remote Sensing of the Late-Summer Boundary Layer Near the North Pole

Scientific Impact: Demonstrate the performance of a suite of remote sensors designed to sample the shallow Arctic boundary layer at high temporal resolution. Deduce the transient mixing processes transporting heat, momentum, and aerosols in the generally stable Arctic PBL.

To facilitate linking changes in atmospheric properties and aerosol concentrations to Arctic boundary layer (ABL) structures and processes, a suite of remote sensors was deployed on the Swedish icebreaker Oden and on the pack ice near the North Pole during the Arctic Ocean Expedition-2001 (AOE-2001) in July and August, 2001. This suite consisted of two Doppler sodars, a 915 MHz wind profiler, a scanning 5 mm radiometer, and an S-band Doppler radar. These sensors were chosen to obtain observations of the thermal, kinematic and turbulent structure in the lowest 400-1000 m of the ABL with temporal resolution of an hour or less. They complement each other well, but also have a degree of redundancy. The data from the remote sensors are validated and checked for consistency with the episodic measurements provided by a tethered balloon and kites, six hourly GPS rawinsondes, and the hourly surface data.

The preliminary results (e.g., Figs. 1 & 2) demonstrate the synergistic potential of this suite of instruments for providing the thermodynamic and kinematic profiles with the high temporal and spatial resolution necessary to study transitory mixing events in the Arctic boundary layer. Future work will utilize this data to study the link between the quasi-persistent, thermal and kinematic features of the ABL (e.g., surface-based mixed layers, low-level jets within the stable air above, and low-level stratus clouds and fog), and more transitory features and processes often related to the quasi-persistent features. These transitory features and processes may facilitate vertical exchange. Some of the structures and processes possibly related to vertical exchange include breaking gravity waves, cloud-top cooling, surface mixed layers, and horizontal roll vortices. Many of these transitory features and processes occur on time scales of an hour or less.

Project Personnel: P. O. G. Persson , S. Abbott (NOAA/ETL), M. Jensen, B. Larsson (SMHI), V. Leuski, A. Targino (U. Stockholm), B. Templeman, M. Tjernström (U. Stockholm), and A. White

Funding Sources: University of Stockholm

References: Persson, P. O. G., S. Abbott, M. Jensen, B. Larsson, V. Leuski, A. Targino, B. Templeman, M. Tjernstrom, and A. White, 2002: Remote sensing of the late-summer boundary layer near the North Pole. Preprints, 15th Symposium on Boundary Layers and Turbulence, 15-19 July, Wageningen, The Netherlands, 133-136.

Tjernström, M., M. Jensen, S. Oncley, O. Persson, and A. Targino, 2002: The boundary-layer program during the Arctic Ocean 2001 Experiment. Preprints, 15th Symposium on Boundary Layers and Turbulence, 15-19 July, Wageningen, The Netherlands, 366-369.

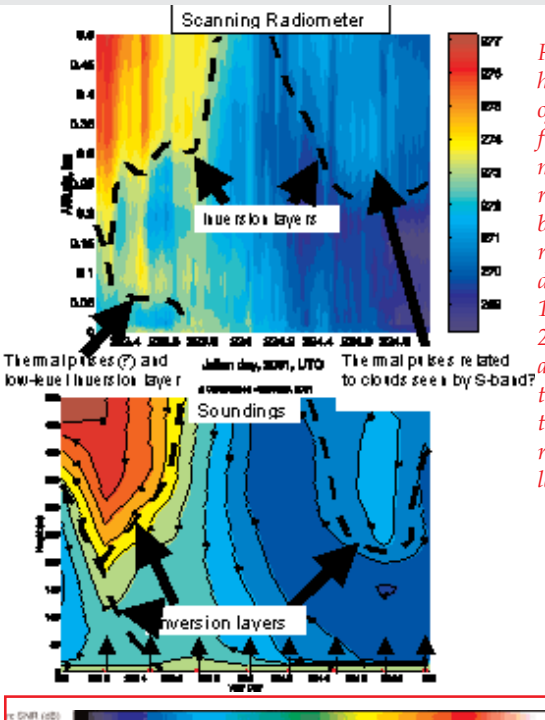


Fig. 1: Time-height sections of temperature from a) the 5-mm scanning radiometer and b) the 6-hourly rawinsondes during Aug. 11-12 (JD 223-224). The arrows along the x axis show the times of the rawinsonde launches.

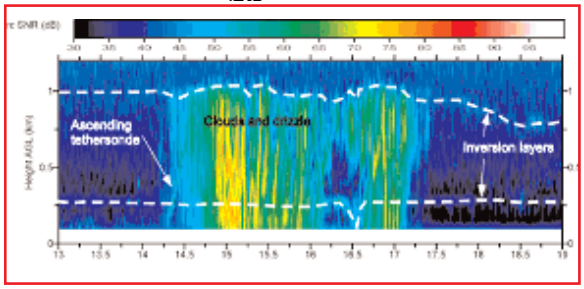


Fig.2: Time-height section of reflectivity from the low mode of the S-band radar for 13-19 UTC on JD224. Also shown are inversion layers as determined from the rawinsondes and the scanning radiometer and the enhanced backscatter from a tethersonde.

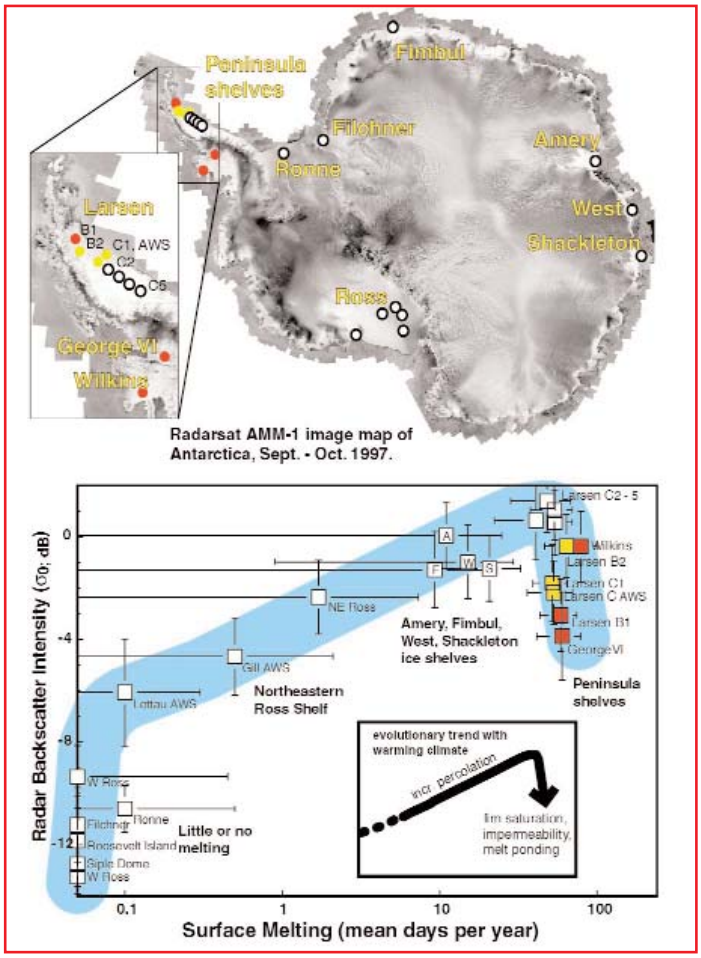
Assessment of Antarctic Ice Shelf Stability Via Passive Microwave Emission and Radar Backscatter

Scientific Impact: A means of monitoring climate change on the Antarctic ice sheet

Five decades of rapid warming have caused the loss of 13,500 km^2 of ice shelf in the Antarctic Peninsula. The mechanism of loss appears to be closely linked with mean air temperature rise and a resulting increase in surface melting. Areas of breakup are closely associated with areas of ponded surface meltwater. This observation has led to a model in which breakup occurs through the action of water flowing into surface crevasses on the shelves. Previous studies have hypothesized that if crevasses can be kept nearly brim-full of water, the crevasse will continue to fracture through the ice sheet. With hundreds of breaks in the formerly solid ice mass, the stability of the shelf is compromised, and subsequent storms or ocean currents can disaggregate it.

To support ponded water on its surface, an ice shelf requires a dense, ice-saturated upper layer of firn. This occurs by repeated long summer melt seasons, during which meltwater seeps into porous firn and refreezes. Initially, this creates ice lenses within the firn. As extensive melting continues, the firn gradually saturates with ice and becomes impermeable. This process has a profound effect on the wintertime radar backscatter of the near-surface snow. Backscatter increases rapidly, as ice layers add highly scattering surfaces within the upper few meters of the snowpack. However, as seasonal melting proceeds to the point of saturation, the winter backscatter levels off, and then drops, as the upper surface becomes ice-filled and smooth. At this point the surface can support melt ponds, and the process of enhanced fracturing and rapid breakup can begin.

Project Personnel: T. Scambos, J. Bohlander
Funding Sources: NASA
References: Climate-induced ice shelf disintegration in Antarctica (submitted to Antarctic Research Series volume *Antarctic Peninsula Climate Variability*, E. Domack, A. Burneet, A. Leventer, P. Conley, M. Kirby, and B. Bindschadler, editors)



The graph shows the relationship for melt season length (determined from passive microwave data by a well-known technique) and backscatter (from the October, 1997 Radarsat AMM-1 data set) for 14 ice shelves in Antarctica. Colored in yellow and red are the ice shelves most at risk for further breakup, and ice shelves that have already begun to disintegrate.

Global Land Ice Measurements from Space (GLIMS)

Scientific Impact: Development of a database of globally distributed glacier measurements suited to the analysis of climate change and related hydrologic changes. This is in direct support of the Global Climate Observing System (GCOS), in which glaciers were recently identified as a priority parameter for monitoring the terrestrial system.

GLIMS (Global Land Ice Measurements from Space) is an international project to survey a majority of the world's 160,000 glaciers with data collected by the ASTER (Advanced Spaceborne Thermal Emission and reflection Radiometer) instrument aboard the EOS Terra spacecraft, and Landsat ETM+ (Enhanced Thematic Mapper Plus). Approximately 1,500 ASTER images suitable for GLIMS analyses have been acquired as of mid-2002. A group of internationally distributed glaciologists at Regional Centers of expertise have begun to analyze the satellite data, derive glacier measurements (glacier geometry, surface velocity, and snowline elevation), and provide them in a standard format for archival and use by the research community via the World Wide Web. The National Aeronautics Space Administration (NASA) and the United States Geological Survey (USGS) are supporting the GLIMS coordination and data management effort and providing the satellite data. With NASA funding, the National Snow and Ice Data Center (NSIDC) is developing the information management system for GLIMS. The database design, data transfer specification, and ingest module were completed this year. User interfaces are being tested. The database is being populated with the initial results from Regional Centers. Contents include measurements (over time) of glacier length, area, boundaries, topography, surface velocity vectors, and snowline elevation. We are also adding historic glacier data from Central Asia. As contributions from the network of Regional Centers increase, the GLIMS information management system will provide an easy to use and widely accessible service for the glaciological community and other users needing information about the world's glaciers.

Project Personnel: Roger Barry, Vince Troisi, Bruce Raup, Siri Jodha Singh Khalsa, Ross Swick, I-Pin Wang

Funding Sources: NASA Pathfinder Program, USGS

References: URL: http://www.glims.org/ and http://nsidc.org/data/glims/

The Hydro-Climatology of the Arctic Terrestrial Drainage System: Monitoring and Variability

Scientific Impact: This work has led to: (a) improved ability to monitor the hydrology of the Arctic terrestrial drainage system; (b) improved understanding of variability and recent change in this system.

This work aims to: (1) develop a system for monitoring the Arctic terrestrial hydrologic system through blending in-situ observations, satellite data streams and output from atmospheric, hydrologic and thermal models; (b) provide insight into the causes of hydrologic variability and recent change over northern high-latitude lands.

At time lags of about one month, updated gridded fields are assembled of precipitation, surface air temperature, moisture flux convergence, active layer thickness, snow extent and water equivalent and near surface freeze-thaw status. Precipitation and temperature represent inputs into a water balance model, which outputs gridded fields of evaporation, soil moisture, shallow groundwater storage and runoff. These are variables for which direct observations are scanty. River discharge data are acquired in near real time at over 50 sites. The water balance model and routing schemes provide discharge estimates from the ungauged portions of the Arctic drainage. All spatial fields are assembled over a domain covering the entire terrestrial Arctic drainage. A suite of budget variables is also compiled back to 1960 to provide a historical baseline.

Studies of variability and change have focused on the large individual watersheds (the Ob, Yenisey, Lena and Mackenzie). All basins exhibit summer maxima in precipitation and minima in net precipitation (precipitation less evaporation). The relative frequency of four 500 hPa synoptic types captures the basic time series structure of basin-averaged precipitation. Net precipitation in the Ob is negative during summer because of high evaporation rates. On the scale of these watersheds, about 25% of July precipitation is associated with recycling of water vapor evaporated within each domain. This points to a significant effect of the land surface on the hydrologic regime. Cold-season river discharge has increased sharply in the Yenisey. While this fundamentally relates to higher air temperatures, increased winter precipitation, and strong summer drying, changes in active layer thickness and thawing of permafrost are likely also involved.

Project Personnel: CIRES (M.C. Serreze, T. Zhang, R.L. Armstrong, M.P. Clark, R.G. Barry, A.J. Etringer, F. Lo, M.J. Brodzik), University of New Hampshire, Durham (C. Vorosmarty, R. Lammers), The Ohio State University (D.H. Bromwich).

Funding Sources: NSF, NASA

References:

Serreze, M.C., D.H Bromwich, M.P. Clark, A. Etringer, T Zhang and R. Lammers, 2002: The large-scale hydro-climatology of the terrestrial Arctic Drainage System, *Journal of Geophysical Research* (in press).

Serreze, M.C., M.P. Clark and D.H. Bromwich, 2002: Monitoring precipitation over the Arctic terrestrial drainage system: Data requirements, shortcomings and applications of atmospheric reanalysis, submitted to *Journal of Hydrometeorology.*

Oelke, C. T. Zhang, M.C. Serreze and R.L. Armstrong, 2002: Regional-scale modeling of soil freeze/thaw over the Arctic drainage basins, submitted to *Journal of Geophysical Research.*

Physical and Chemical Effects of Fluids: Seismic Absorption and Modulus Measurements in Cracks and Porous Rocks

***Scientific Impact:** The greatest scientific impact of our research is the development of theory that explains the mechanism of low frequency attenuation in cracks and porous rocks. The result of our work will most profoundly impact the environmental and engineering industry's ability to monitor bioremediation progress and the onset of contaminant leaking at buried waste sites.*

Research Personnel: Hartmut Spetzler, Wendy Wempe and Jincai Zhang

Funding Source: Department of Energy

Our primary objective is to understand and characterize the physicochemical effects of small amounts of organic compounds on the mechanical properties of partially saturated sediments and rocks. Our ultimate goal is to develop monitoring systems to determine bioremediation progress and contaminant leaking at buried waste sites.

Small amounts of organic compounds (i.e. contaminants and contaminant reducing bacteria) adsorbed to granular surfaces change the rock's surfaces properties (i.e. surface tension), which significantly change the rock's transport properties (i.e. permeability and effective porosity) and bulk mechanical properties (i.e. compressibility and ability to attenuate energy). We found that fluid redistribution in a periodically stressed, partially-saturated rock occurs via meniscus deformation or contact line motion, both of which require energy that is lost from a passing seismic wave (seismic absorption). We built an apparatus that harmonically stresses a rock core plug at low frequencies and measures subsequent deformations in the rock. The lag between the applied stress and the rock's deformation response to the stress is related to the energy attenuation due to fluid redistribution.

We are currently studying the effects of different fluid saturations and of contaminant-reducing bacteria on attenuation at low frequencies in the laboratory and are preparing to develop a system to measure attenuation in the field during different saturation and contamination conditions. We will also extend our work to include potential effects in unconsolidated sediments. By the end of this year, we expect to have developed a better understanding of the combined effects of saturation and contamination on low-frequency seismic attenuation.

Surface Melt-Induced Acceleration of Greenland Ice-Sheet Flow

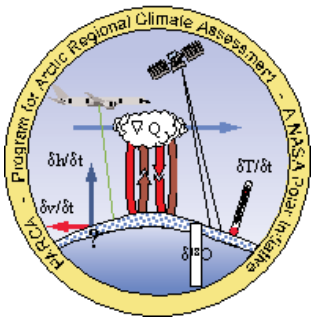
Scientific Impact: Improved understanding of Arctic climate variability.

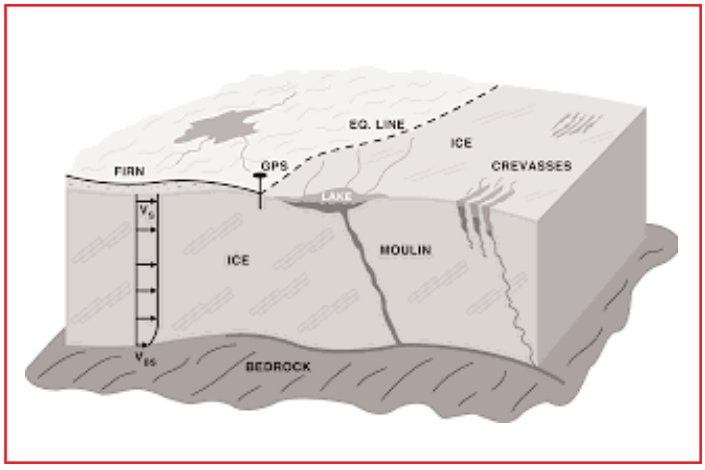
The Greenland ice sheet plays a pivotal role in global climate, not only because of its high reflectivity, high elevation (i.e., as a topographic barrier), and large area but also because of the substantial volume of fresh water stored in the ice mass. The ice volume is estimated to be 2.6 x 106 km^3, which is an equivalent of 6.7-m sea level rise. Ice flow at a location in the equilibrium zone of the west-central Greenland ice sheet accelerates above the mid-winter average rate of 31.3 cm/day during periods of summer melting. The near coincidence of the ice acceleration with the duration of surface melting, followed by deceleration after the melting ceases, indicates that glacial sliding is enhanced by rapid migration of surface melt water to the ice-bedrock interface (see figure on the right). Interannual variations in the ice acceleration are correlated with variations in the intensity of the surface melting, from a 1.5 cm/day velocity increase during the low-melt summer of 1996, to 3.8 cm/day in the average-melt summer of 1997, and to 8.8 cm/day and 7.3 cm/day increases during the high-melt summers of 1998 and 1999. The indicated coupling between surface melting and ice-sheet flow provides a mechanism for rapid large-scale dynamic response of ice sheets to climate warming.

Project Personnel: K. Steffen, J. Box, N. Cullen, S. Starkweather
Funding Sources: NASA, NSF
Reference: Zwally, J., W. Abdalati, T. Herring, K. Larson, J. Saba, and K. Steffen. Surface melt-induced acceleration of Greenland ice-sheet flow, *Science*, 297, 218-222, 2002.

Based on a network of 20 automatic weather stations deployed on the ice sheet starting in 1990, the annual mean air temperature was found to be 2°C warmer for the central part of Greenland for the time period 1995-1999, as compared to the standard decade 1951-1960. This recent warming has a strong impact on the surface energy balance which is in delicate equilibrium with the present climatic conditions; small changes in radiation or surface reflectivity can result in large changes in the mass balance.

The interaction among warmer summer temperatures, increased surface meltwater production, water flow to the base, and increased basal sliding provides a mechanism for rapid response of the ice sheets to climate change. These projects are a contribution to the Program for Arctic Regional Climate Assessment (PARCA).





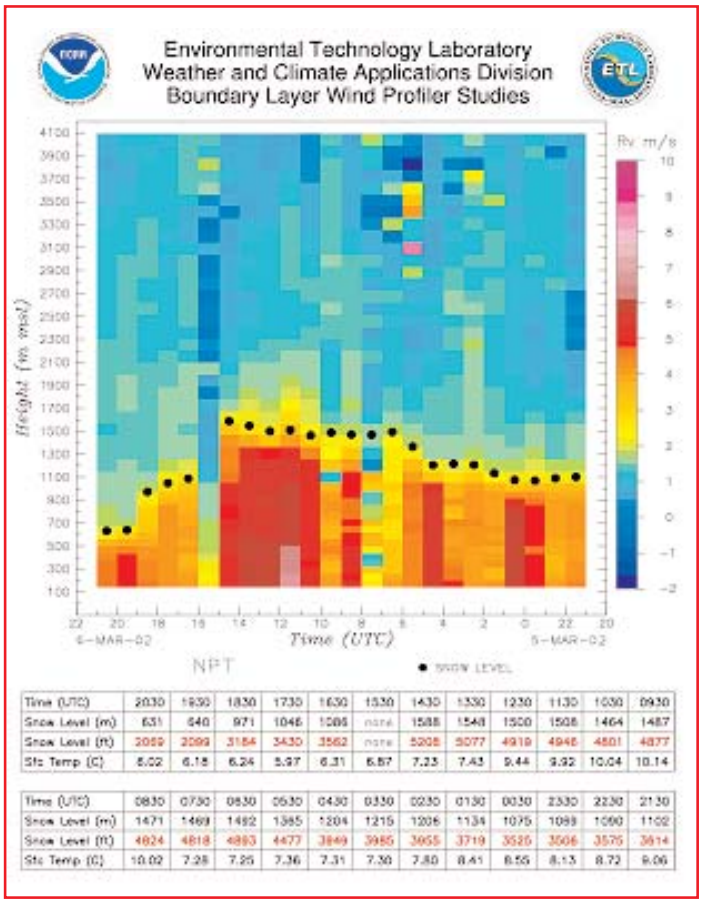
Snow-level Detection Using Vertically-pointing Doppler Radar

Scientific Impact: Developed and field-tested a snow-level algorithm for use with vertically-pointing Doppler radar. Provided real-time snow level data to Western Region NWS Weather Forecast Offices and River Forecast Centers during the Pacific Land-falling Jets Experiment.

Project Personnel: A. B. White, D. J. Gottas F. M. Ralph (ETL), P. J. Neiman (ETL), L. Nance, E. T. Strem (NWS/CNRFC)
Funding Sources: NOAA
References: An Automated Brightband Height Detection Algorithm for use with Doppler Radar Spectral Moments (*J. Atmos. Oceanic Technol.*, 19, 687-697), http://www.etl.noaa.gov/programs/2002/pacjet/

Because knowledge of the snow level is critical to river forecasters and other users, CIRES and the NOAA Environmental Technology Laboratory have developed an objective algorithm to detect the bright-band height from profiles of radar reflectivity and Doppler vertical velocity collected with commercially available Doppler wind profiling radar. The bright-band height is a better estimate of the snow level than the melting level because of the time required for ice particles to melt as they descend. The ability to monitor the bright-band height in real time is likely, therefore, to aid in snow-level forecasting and verification that would prove invaluable to a wide array of user groups, including weather forecasters and hydrologists, emergency managers, and the transportation and ski industries.

The algorithm (patent pending) uses vertical profiles to detect the bottom portion of the bright band, where vertical gradients of radar reflectivity and Doppler vertical velocity are negatively correlated. A search is then performed to find the peak radar reflectivity above this feature, and the bright-band height is assigned to the altitude of the peak. Reflectivity profiles from the off-vertical beams produced when the radar is in a Doppler beam swinging mode provide additional bright-band measurements. A consensus test is applied to sub-hourly values to produce a quality-controlled, hourly-averaged bright-band height. This algorithm was applied quasi-operationally in the West during the winter of 2001-2002, with favorable reaction from both NWS weather forecast offices (WFOs) and river forecast centers. During the winter of 2002-2003, we will engage several WFOs in the Northeast to provide feedback on the snow-level product derived from a modest network of boundary-layer wind profilers deployed there. An example of the graphical display used to relay algorithm results to the public via the internet is shown below.



Time (UTC)	2030	1930	1830	1730	1630	1530	1430	1330	1230	1130	1030	0930
Snow Level (m)	631	640	971	1046	1086	none	1588	1548	1500	1508	1464	1487
Snow Level (ft)	2069	2099	3184	3430	3562	none	5208	5077	4919	4946	4801	4877
Sfc Temp (C)	5.02	6.18	6.24	5.97	6.31	6.87	7.23	7.43	9.44	9.92	10.04	10.14

Time (UTC)	0830	0730	0630	0530	0430	0330	0230	0130	0030	2330	2230	2130
Snow Level (m)	1471	1469	1492	1385	1204	1215	1206	1134	1075	1099	1090	1102
Snow Level (ft)	4824	4818	4893	4477	3949	3985	3955	3719	3525	3606	3575	3614
Sfc Temp (C)	10.02	7.28	7.25	7.36	7.31	7.30	7.80	8.41	8.55	8.13	8.72	9.06

Example of the snow level web display produced from profiler data recorded at Newport, Oregon on 5 March, 2002. The colored rectangles indicate values of Doppler vertical velocity (Rv; positive downward). The snow level algorithm output is indicated by the black dots.

Vertical Profiling of Precipitation

Scientific Impact: Vertical profiling of precipitating systems can provide improvements in the measurements of rainfall and the hydrological cycle.

Project Personnel: C. R. Williams, P. E. Johnston, K. S. Gage (NOAA/AL)

Funding sources: NOAA, NASA

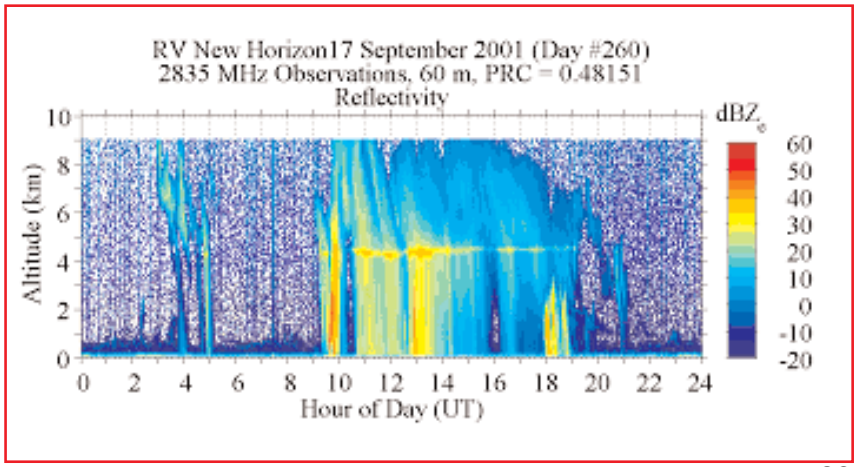
References: (1) Combined Wind Profiler/Polarimetric Radar Studies of the Vertical Motion and Microphysical Characteristics of Tropical Sea-Breeze Thunderstorms, May, P. T., et al., *Monthly Weather Review*, 130: 2228-2238, September 2002. (2) Profiler Contributions to Tropical Rainfall Measuring Mission (TRMM) Ground Validation Field Campaigns, K. S. Gage, et al., *J. Atmos. Oceanic Technol.*, 19: 843-863, June 2002.

Paramaterization of the hydrological cycle is a major source of uncertainty in weather and climate forecasting. There is large-scale coverage of the land areas with scanning radars, and over the oceans instruments such as the Tropical Rainfall Measuring Mission (TRMM) satellite provide large areal coverage of precipitating systems. These instruments miss some of the vertical structures and have calibration issues that reduce their effectiveness. Adding a vertical profiler under these instruments helps resolve calibration and sampling issues. In addition, profilers can provide information about drop size distributions that is not available from scanning instruments.

CIRES scientists and their colleagues at the NOAA Aeronomy Laboratory have been using the vertical beams of wind-profiling radars to examine precipitating systems for many years. Recently, we have started to use radars with only a vertical beam to examine precipitation. These instruments provide detailed time and height information about rain events. The plot at right shows one day's data from a vertical profiler mounted on the ship R/V New Horizon, as it sailed in the tropical eastern Pacific during EPIC 2001 (Eastern Pacific Investigation of Climate Processes in the Coupled Ocean-Atmosphere System). This detailed view of the raining system is being used in conjunction with a scanning radar located on the R/V Ronald H. Brown to help characterize and calibrate the rain cloud systems observed during this study.

Profiler measurements can be combined with other instruments. May et al. (2002), used a profiler with a scanning radar to provide details of the processes in the cloud systems that are not feasible with just one instrument.

Profilers will not replace scanning radars, due to their small areal coverage. However, they are proving very useful, when used in conjunction with other radars and instruments, to reduce calibration error and to analyze the physical processes that occur inside clouds. In addition, current work with the spectra from the radars is starting to provide drop size distributions with the same height and time resolutions shown in the figure. This is very useful in relating the processes that occur in the cloud and are observed by scanning radars with the observations of drop sizes and precipitation made on the surface.

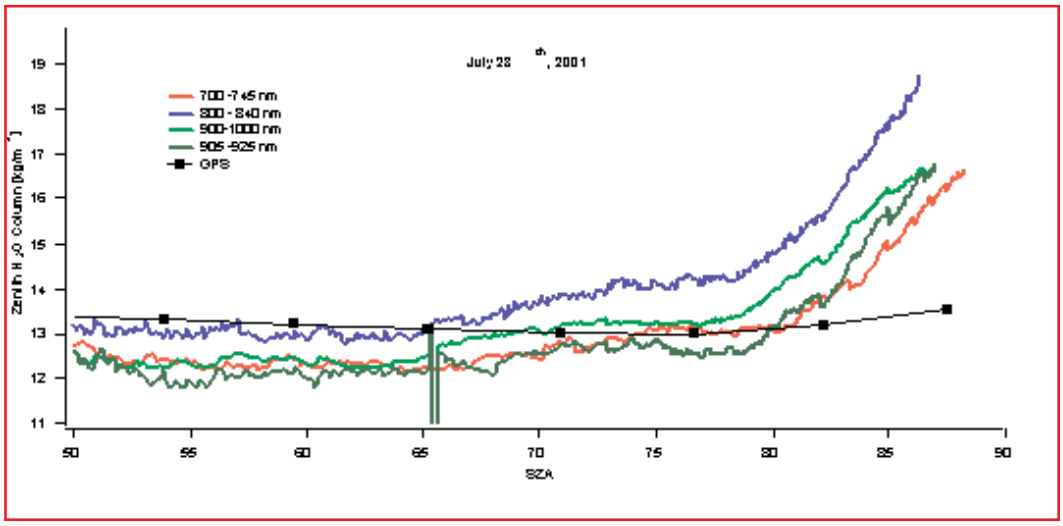


DOAS Field Measurements for Quantification of Spectroscopic Database Errors and Water Vapor

Scientific Impact: Improved characterization of water vapor absorption for use in radiative transfer and climate models.

Project Personnel: B. Sierk; from NOAA/AL: S. Solomon, J. Daniel, R. Portmann, A. Langford
Funding Sources: NOAA, CIRES
References: Field test of optical absorption spectroscopy databases for tropospheric water vapor, (in preparation)

This project aims at improving our understanding of absorption of solar radiation by tropospheric water vapor. It addresses various problems, which limit our ability to accurately model the atmospheric radiative transfer (RT) of sunlight in the short wave spectral region, where H_2O is the dominant molecular absorber. One problem is that of spectral line parameters, which characterize thousands of individual rotation-vibration transitions of the highly complex water spectrum. Calculations of atmospheric transmission rely on spectral parameters such as line strengths, which are provided by molecular databases such as HITRAN. In a field experiment deploying independent techniques for remote sensing of tropospheric water vapor we investigated the accuracy and consistency of these widely used databases. For this purpose we carried out spectroscopic absorption measurements of direct sunlight in clear-sky conditions at 1 nm resolution. The data were analyzed using the Differential Optical Absorption Spectroscopy (DOAS) technique in different absorption bands of water vapor between 440 and 1000 nm. Retrievals of column abundance of H_2O from these data were compared to independent estimates from Global Positioning System (GPS) data and simultaneous radiosonde soundings. Fig. 1 shows time series of DOAS-retrieved zenith mapped integrated water vapor using various H_2O bands as a function of solar zenith angle (SZA), along with GPS estimates. The differences between the DOAS results reveal the inconsistencies between the line parameters for different bands. The availability of independent measurements by GPS and radiosondes allows determination of correction factors for the line strengths in each band. Another problem addressed in the experiment is the water vapor continuum, a broad-band absorption feature which has not yet been measured in the visible and near infrared spectral regions. Taking advantage of extremely long absorption paths during sunrise, the magnitude and spectral shape of this weak but important absorption component could be quantified for the observed spectral range. The results of this study are expected to improve RT codes, which underlie climate models.



Climate System Variability

Climate changes that occur both in the short term — seasons to decades — and those that occur across millennia.

Short-term climate changes occur with weather events: floods, droughts, storms, temperature extremes and vacillations, and volcanic eruptions. Because they affect air quality and water availability and quality, such events impact agricultural practices, recreation, and the health of ecosystems and populations. In the short term, climate change often creates a need for natural resource management strategies, or natural hazards mitigation.

By comparison, long-term climate change has more to do with environmental sustainability, conservation, and species survival than with weather events. Therefore, scientists, planners and legislators are most concerned with understanding the underlying causes and eventual repercussions of climate change in order to craft effective responses.

CIRES research in climate system variability aims at gaining a breadth of understanding in science fields that specialize in detection of climate trends, understanding the mechanisms and forcings of climate variability, understanding climate and cryosphere interactions, prediction of climate variability, study of extreme events and rapid climate change, and atmospheric ozone.

RESEARCH GOALS

1) Data collection and analysis
2) Observation and modeling
3) Forecasting

Example: A meteorologist with the NOAA-CIRES Climate Diagnostics Center recently innovated research focused on new ways of making parallel forecasts and ways to assimilate the forecast information to make more accurate weather probabilities. Used in ensemble weather forecasting, a technique practiced since about 1992 in the United States and Europe, this new method uses computers to generate multiple weather forecasts. The forecast research merited the Presidential Early Career Award for Scientists and Engineers.

Contributors:

CU-Boulder and NOAA's Climate Diagnostics Center (CDC)
NOAA's Climate Monitoring and Diagnostics Laboratory
NOAA's Aeronomy Laboratory
Program in Atmospheric and Oceanic Sciences (PAOS)
CIRES Western Water Assessment
CIRES National Snow and Ice Data Center (NSIDC)
NOAA's National Centers for Environmental Prediction (NCEP)
NOAA's Geophysical Fluid Dynamics Laboratory (GFDL)

The CRYSTAL-FACE Field Experiment

Scientific Impact: Improved understanding of the physical formation processes of tropical cirrus clouds gained during CRYSTAL-FACE will enable more accurate estimates of the Earth's radiation budget and will ultimately contribute to greater success in modeling of Earth's climate.

The 2001/2002 time period was one of planning and instrument preparation for the Cirrus Regional Study of Tropical Anvils and Cirrus Layers - Florida Area Cirrus Experiment mission. CRYSTAL-FACE is an interagency mission designed to investigate the physical properties and formation processes of tropical cirrus clouds. Clouds can reflect the sun rays away from the surface, cooling the climate, but they also act as "blankets," trapping sun's radiative heat. These various interactions are complex and not fully understood. Understanding the production of upper tropospheric cirrus clouds is essential for the successful modeling of Earth's climate.

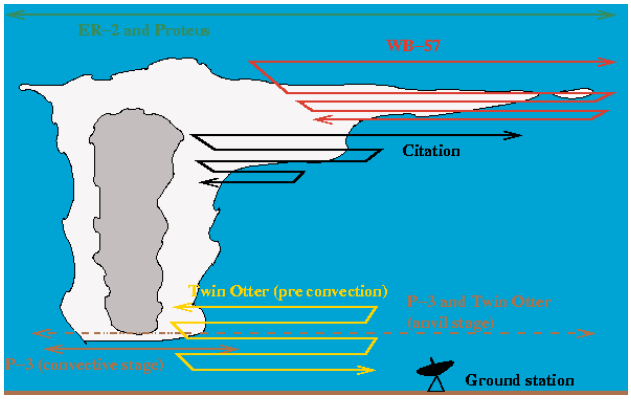
Six aircraft will sample subtropical convection and cloud systems over southern Florida during July 2002 from a base in Key West, FL, providing a full "top-to-bottom" look at the physical and chemical processes involved (Figure 1). The CIRES/NOAA effort is concentrated on the use of NASA's WB-57 aircraft, which is unique it its ability to access the critical outflow region of convective cloud systems at altitudes between 40,000-60,000 feet. The Aeronomy Lab will measure nitric acid, ozone, methane, aerosol composition, water vapor, air pressure, temperature, and winds (Figure 2). CMDL scientists will also be participating, measuring long-lived gases, and ETL will contribute ground-site measurements.

These measurements will be compared with data from ground-based radars and satellites, and the results of advanced atmospheric models, with the aim of improving our ability to forecast future climate change.

Project Personnel: CIRES scientists from the Aeronomy Lab are: K. Aikin, D. Cziczo, S. Hovde, P. Hudson, T. Marcy, P. Popp, E. Ray, E. Richard, M. Schein, D. Thomson. CIRES scientists from other NOAA Laboratories participated, and there were dozens of scientists from NOAA, NASA, NCAR, and academia involved in the multi-organization effort.

Funding Sources: NOAA, NASA

References: The CRYSTAL-FACE website is: http://cloud1.arc.nasa.gov/crystalface/



Schematic showing how a tropical cirrus cloud will be sampled with a suite of six aircraft and ground measurements planned for the CRYSTAL-FACE mission.

Parameterizing Vertically Coherent Cloud Distributions

Scientific impact: Potentially it will improve the specification of cloud structures for large-scale atmospheric models, which will help improve radiative transfer and microphysical calculations in those models.

Project personnel: John W. Bergman and Philip J. Rasch (NCAR)

Funding source: National Science Foundation

Reference: Bergman, J. W. and P. J. Rasch, 2002: Parameterizing vertically coherent cloud distributions. *J. Atmos. Sci.*, Vol. 59, 2165-2182

The specification of spatial structures for unresolved cloud fields is important for satellite data retrieval and for numerical models of the large-scale atmospheric flow. In particular, the resolved-scale cloud fraction in an atmospheric model can be very sensitive to how unresolved cloud fields are specified. This has implications for radiative transfer and microphysical calculations. However, to date, cloud fields are specified from highly-idealized overlap assumptions that can lead to large changes of resolved-scale cloud fraction and radiative fluxes from changes of vertical resolution or minor changes to parameterizations that determine cloud fraction in individual vertical levels.

Here, a method for specifying cloud distributions for atmospheric models is developed. The fractional area of a grid-scale column in which clouds from two levels overlap (i.e., the cloud overlap probability) is described in terms of the correlation between horizontal cloudiness functions in the two levels. Cloud distributions that are useful for radiative transfer and cloud microphysical calculations are then determined from cloud fraction at individual model levels and a decorrelation depth. All pair-wise overlap probabilities among cloudy levels are obtained from the cloudiness correlations. However, those probabilities can over-constrain the determination of the cloud distribution. It is found that, using a method analogous to constructing a coherent time series with a Markov process, cloud fraction in each level along with the overlap probabilities among nearest neighbor cloudy levels is sufficient to specify the full cloud distribution.

The parameterization has both practical and interpretative advantages over existing parameterizations. The parameterized cloud fields are consistent with physically meaningful distributions at arbitrary vertical resolution. In particular, bulk properties of the distribution, such as total cloud fraction and radiative fluxes calculated from it, approach asymptotic values as the vertical resolution increases. Those values are nearly obtained once the cloud distribution is resolved; that is, if the thickness of cloudy levels is less than one half of the decorrelation depth. Furthermore, the decorrelation depth can, in principle, be specified as a function of space and time, which allows one to construct a wide range of cloud distributions from any given vertical profile of cloud fraction.

Stable Boundary-Layer Scaling Regimes: the SHEBA Data

Scientific Impact: Understanding of the atmospheric boundary-layer regimes and proper parameterization of the surface fluxes are of obvious relevance for climate modeling, weather forecasting, and other important applications in the Arctic region.

Project Personnel: A. A. Grachev (CIRES), C. W. Fairall (NOAA/ETL), P. O. G. Persson (CIRES), E. L. Andreas (CRREL, Hanover NH), P. S. Guest (NPS, Monterey CA)

Funding Sources: NSF, NOAA, US Department of Army

References: Stable Boundary-Layer Regimes Observed During the SHEBA Experiment. 15th Symposium on Boundary Layers and Turbulence. Wageningen, The Netherlands, Amer. Meteorol. Soc., July 2002, Proceedings.

In this study a new classification of the scaling regimes for the atmospheric stable boundary layer (SBL) is proposed based on the SHEBA data. Although research has been done on the SBL for at least 50 years, a unified picture or theory does not exist. Classifying the SBL into few prototype cases is a useful way for future studies including parameterization of the very stable state.

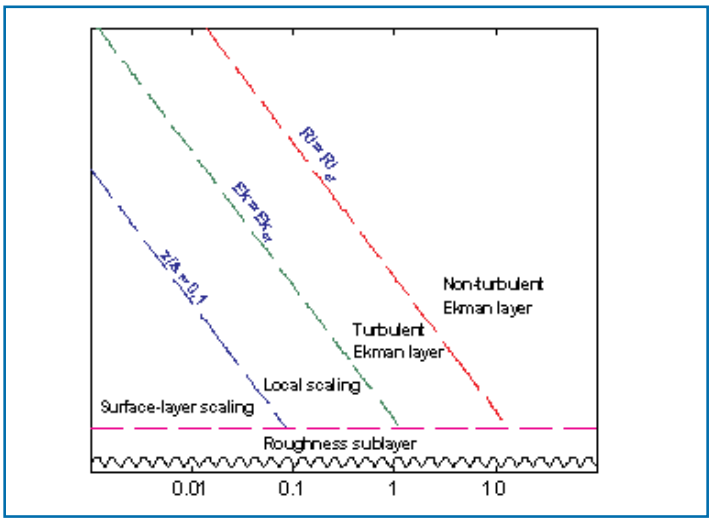
Different SBL regimes are described in terms of the Monin-Obukhov similarity theory (MOST) stability parameter, z/L, associated with the stratification, with Ekman number (Ek) that qualifies the influence of the Earth's rotation, and with the Richardson number (Ri) that determines the intensity of the turbulence. These three non-dimensional parameters govern four major regimes (see figure):

I. Surface-layer scaling regime, $0 < z/L < 0.1$, is associated with shear stress and the heat flux that are approximately constant with height. This regime is governed by traditional MOST predictions ($Ek >> 1$ and $Ri << 0.2$).

II. Local-scaling regime, $z/L > 0.1$ and $Ek > 1$. In this regime, the approximation of height-independent fluxes becomes invalid. However, the flow is insensitive to the Earth's rotation, and turbulence is more or less continuous. In this regime, MOST seems adequate, but similarity theory should be redefined in terms of local similarity, where L is based on the local fluxes at height z.

III. Turbulent Ekman Layer, $Ek < 1$ and $Ri < 0.2$. In this regime, turbulent fluxes are small and vary with height. A surface layer with continuous turbulence may be very shallow, and the wind structure is influenced by the Coriolis force. MOST appears to break down in this regime.

IV. Non-turbulent Ekman layer, $Ri > 0.2$. The supercritical stable regime is associated with collapsed turbulence and the strong influence of the Earth's rotation ($Ek << 1$). Observed wind speeds show features of the Ekman spiral even near the surface. However, even in this regime, some sporadic and intermittent turbulence persists.



Shipboard Monitoring of Stratocumulus Cloud Properties in the PACS Region

Scientific Impact: Understanding of the effects of atmospheric boundary-layer clouds on air-sea interaction in the tropical Eastern Pacific.

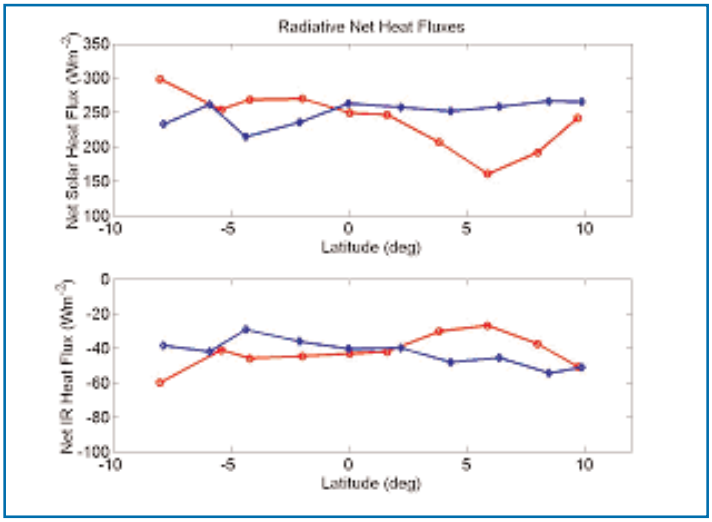
Project Personnel: C. W. Fairall (NOAA/ETL CIRES Fellow), J. E. Hare (CIRES), A. A. Grachev (CIRES), Taneil Uttal (NOAA/ETL)
Funding Sources: NOAA CLIVAR Pan American Climate Studies
References: Cronin, M. F., N. Bond, C. W. Fairall, J. E. Hare, M. J. McPhaden, and R. A. Weller, 2002: Enhanced oceanic and atmospheric monitoring for the Eastern Pacific Investigation of Climate Processes (EPIC) experiment. EOS, Transactions of AGU. 83: 205-211.

In this project we implemented a modest ship-based cloud and flux measurement program to obtain statistics on key surface, MBL, and 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 (Cronin et al., 2002). Our goal is 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 modelers (both statistically and for specific simulations) and to improve satellite retrieval methods for deducing MBL and cloud properties on larger spatial and temporal scales.

The primary objectives were to
• Obtain new measurements of near-surface, MBL, and cloud statistics (cloud droplet and drizzle properties and probability of occurrence of drizzle)
• Characterize surface cloud forcing and ocean-atmosphere coupling.
• Provide periodic high quality near-surface data for intercomparison with ship-based IMET and buoy-based meteorological measurements.
• Provide high quality measurements of basic surface, MBL and cloud parameters for 'calibration' of satellite retrieval techniques.

We completed six missions beginning in fall of 1999 and ending in spring of 2002. Each mission has 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 http://www.etl.noaa.gov/programs/pacs/. Our major effort so far has been in executing the cruises twice a year and processing the data from the array of sensors to produce integrated products. We have been collaborating with Nick Bond at PMEL on the atmospheric boundary layer aspects and Meghan Cronin at PMEL on the fluxes and cloud forcing aspects. We are working to create a web-accessible database for our collaborators and other EPIC investigators. Data are archived for public use at ftp://ftp.etl.noaa.gov/et7/anonymous/cfairall/EPIC/epicmonitor/.

A data sample for net solar and IR flux climatologies is shown in Fig. 1.



Average measurements of net solar (upper panel) and IR (lower panel) radiative fluxes vs latitude at 95/110 W longitude: redline=fall; blue line=spring. A positive value implies warming of the ocean.

Changes of Subseasonal Variability Associated with El Niño

Scientific Impact: ENSO influence on weather statistics depends on timescale in the midlatitudes but not in the Tropics. This influence, particularly in the North Atlantic, may depend on the details of the ENSO event.

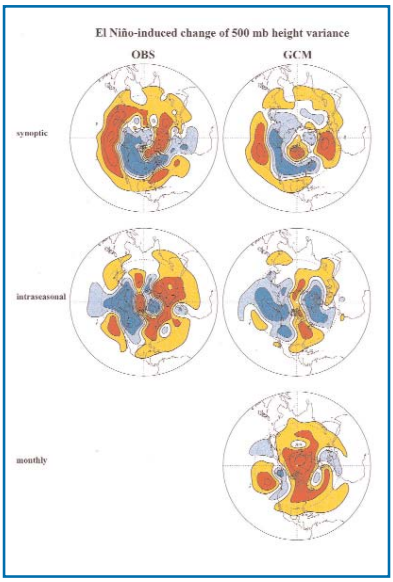
The effect of El Niño/Southern Oscillation on the risk of extreme events such as floods, and heat waves depends on both the ENSO-altered seasonal mean and any ENSO effect on the statistics of weather within a season. One may imagine a situation in which El Niño alters the occurrence of both cold waves and warm spells in a winter. The effect is a meaningful change in the risk of extreme weather, even though little seasonal mean signal is evident. The few published studies on ENSO effects on variability, constrained either by sampling requirements or data availability, have formed composites over several ENSO events to diagnose the effect in limited regions.

We have estimated the effect globally from a large ensemble of atmospheric GCM integrations (a total of 540 members) for El Niño 1987 and La Niña 1989, and compared them with observational composites based on 11 El Niño and 11 La Niña events in the recent record. The purpose of this comparison was to gauge the robustness of the changes of variability, their predictability, and their variation from event to event.

The most important result from this analysis, depicted in the Figure, is that the patterns of SST-forced anomalous height variability are markedly different for the synoptic (2 to 7 days), intraseasonal (8 to 45 days), and monthly (30-day average). In contrast, the patterns of the anomalous tropical rainfall variability are nearly identical across these time scales (not shown). The results for La Niña are similar and generally of opposite sign.

The main ENSO effect on the synoptic scale is a southward shift of the storm tracks over the Pacific ocean and North America. On the intraseasonal scale, it is a decrease of height variance over the north Pacific, consistent with a decrease of blocking activity. On monthly (and seasonal) scales, there is an overall increase of variance. These differing ENSO impacts on extratropical noise have very different implications for the risk of extreme anomalies on these scales. We believe that three distinct dynamical mechanisms are responsible for these sharp differences, and are currently investigating them in a hierarchy of dynamical models. The predictability of these changes is also under investigation.

Project Personnel: G.P. Compo, P. D. Sardeshmukh, and C. Penland (NOAA).
Funding Sources: NOAA OGP, CLIVAR-Pacific
References: 2001: Changes of subseasonal variability associated with El Niño. *J. Climate*, 14, 3356-3374.



El Niño-induced changes of variance on three different subseasonal timescales. The quantity plotted is the square root of the anomalous variance, with red shading for positive and blue for negative anomalous variance. The left panels are based on statistics averaged over 11 observed El Niño and 17 observed "neutral" January-March winters in the NCEP reanalysis dataset. The right panels are derived from a large AGCM ensemble with observed SST forcing for the El Niño winter of JFM 1987. Top panels: Synoptic scale (2 to 7 day periods). Middle panels: Intraseasonal scale (8 to 45 day periods). Bottom panel: Monthly scale (30-day averages). Contours are drawn at 8 m intervals starting at 4 m in the top panels, and at 16 m intervals starting at 8 m in the middle and lower panels.

Climate-Based Boundary Definitions for Regions for Water Resources Management

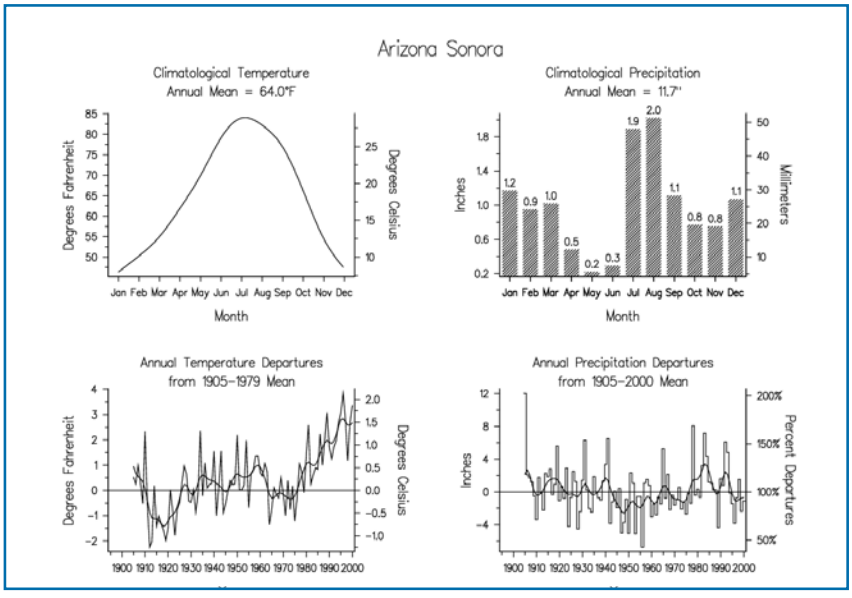
Scientific Impact: Verification and diagnostics of regional climate changes and National assessment activities.

Project Personnel: Henry F. Diaz and Jon K. Eischeid
Funding Source: Office of Global Programs, NOAA.
Reference: Biomes, River Basins, and Climate Regions: Rational Tools for Water Resources Management. In Diaz, H.F. and B.J. Morehouse (eds.), *Climate and Water: Transboundary Challenges in the Americas*. Kluwer Academic Publishers, (2003).

The modern climate record exhibits substantial decadal-scale variability, as is illustrated in the figure below. In the post-World War II period, increased temperatures, a severe drought in the 1950s, and unprecedented population growth have left their mark on the western landscape. Considering a longer temporal context, ecological studies have established that significant changes also have occurred in vegetation structure over the past 200 years, due in part to human-induced factors, and paleoclimate records indicate there may have been even more pronounced episodes of drought in the past 1,000 years, as compared with the last hundred years. One inescapable fact illustrated in this figure is the strong warming trend in Desert Southwest, and a drying trend that sets up after years of above average precipitation.

Extreme climatic anomalies, whether periods of severe and sustained drought or periods of heavy precipitation that lead to severe flooding, produce large and measurable responses on the landscape through changes in erosion processes. Human actions often exacerbate these natural shocks; they are often taken because an analysis of the potential impacts of such actions either is lacking or is ignored. Furthermore, in cases where natural biomes cut across national boundaries, managing the impacts of climate and humans on nature tends to be complicated by political divisions. A change in outlook and of perspective by decision makers to more fundamentally take into account the interconnectedness of natural systems is a crucial step toward more effective stewardship of our natural resources.

It is recognized that change and variability are natural attributes of the earth's climate as they are of its biosphere. Therefore, in a longer-term perspective, natural biome boundaries are subject to modification, linked to variations in climate and other natural processes. What should be clearly understood is that the natural rates of change of climate and ecosystems are much slower than the corresponding rates of change forced by human activity. Hence, in a rapidly changing climate, such as is expected in the next century in response to human-induced alterations in atmospheric greenhouse gases (carbon dioxide, methane, nitrous oxides, and other gases), ecosystems will be unable to adapt fast enough to the projected changes in climate, with potentially disastrous consequences. Likewise, when humans modify their environment directly through actions such as deforestation, introduction of non-native species, and dam construction, the abruptness with which those changes occur precludes nature from developing balanced responses to those changes.



Climatological annual cycle of the regions encompassed by the Arizona side of the Sonoran Desert. Bottom panels: Time series of annual departures from the long-term mean for the same region.

A Surface Energy Balance Approach Based Model for Near-surface Heat Fluxes and Permafrost Thermal Regime

Scientific Impact: A surface energy balance approach based model for near-surface heat and thermal regime of permafrost containing unfrozen water was developed.

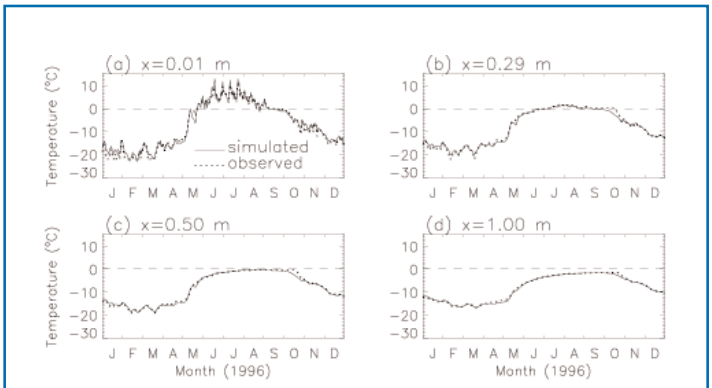
Project Personnel: Feng Ling, Tingjun Zhang

Funding Sources: NOAA, NSF

References: A surface energy balance approach based model for near-surface heat fluxes and thermal regime of permafrost containing unfrozen water (submitted to *Cold Regions Sciences and Technology*)

Ground surface energy balance in cold regions is a complex function of seasonal snow cover, vegetation, atmospheric radiation, surface moisture content, and atmosphere temperature. Thus, the accurate approach for describing ground surface temperature should be through the physically-based models which account for the relevant processes occurring within, and at the boundaries of permafrost, snow, and atmospheric components of the natural system. Due to the presence of unfrozen water in permafrost, transition between water and ice in soil occurs by gradual phase change over a temperature range below the freezing temperature. The efficient model of heat transfer with phase change for permafrost study must consider the effect of unfrozen water. A numerical model for near-surface heat fluxes and permafrost thermal regime was developed. Surface energy balance approach was used to estimate the upper boundary temperature condition. The influence of unfrozen water on permafrost thermal parameters was included in the model.

Model was validated against observed data collected at the National Weather Service (NWS) station, Barrow, Alaska. Simulated ground temperatures were in good agreement with field measured values. It is concluded that the numerical model described in this report can be used to simulate the near-surface heat fluxes, snow surface and ground surface temperatures, and permafrost thermal regime with confidence. Density and thickness of seasonal snow cover can affect the surface temperature and permafrost thermal regime significantly.



Comparison of simulated and measured ground temperatures at different depths at Barrow, Alaska during 1996.

Ensemble Weather Forecasting and Atmospheric Data Assimilation

Scientific Impact: This research is undertaken to improve probabilistic weather and climate forecasts.

Even the smallest error in describing the current weather will inevitably grow in numerical weather forecast models, making them more and more inaccurate as forecast lead time increases. Given this, rather than trying to tell the public exactly what the weather will be (which would be intellectually dishonest!), we are performing basic research in the field of "ensemble forecasting," whereby we attempt to describe the weather forecasts probabilistically. We seek to be able to forecast the likelihood of any weather scenario and to know how this likelihood changes from one day to the next.

Specifically, in the last year we have been working on advanced techniques for feeding back the probabilistic information from our ensemble forecasts into the "data assimilation" process for defining the current weather. The current state of the weather (and the uncertainty in the estimate of this state) are needed for making subsequent probabilistic weather forecasts.

We have been developing new methods for this "ensemble data assimilation" and testing them in simplified numerical models of the atmosphere as a proof of concept (see Figure). Over the coming years, we will continue to try these techniques in increasingly complex forecast models, and if the technique continues to show benefit compared to existing operational techniques, then we will work with the National Centers for Environmental Prediction in Washington, D.C., to try to have these techniques used in their daily operations.

Project Personnel: Thomas M. Hamill (CIRES), Jeff Whitaker (NOAA-CIRES Climate Diagnostics Center), and Chris Snyder (National Center for Atmospheric Research)

Funding Sources: NOAA ("Weather/Climate Connection")

Selected References:

Hamill, T. M., Whitaker, J. S., and C. Snyder, 2001: Distance-dependent filtering of background error covariance estimates in an ensemble Kalman filter. *Monthly Weather Review*, v. 129, 2776-2790.

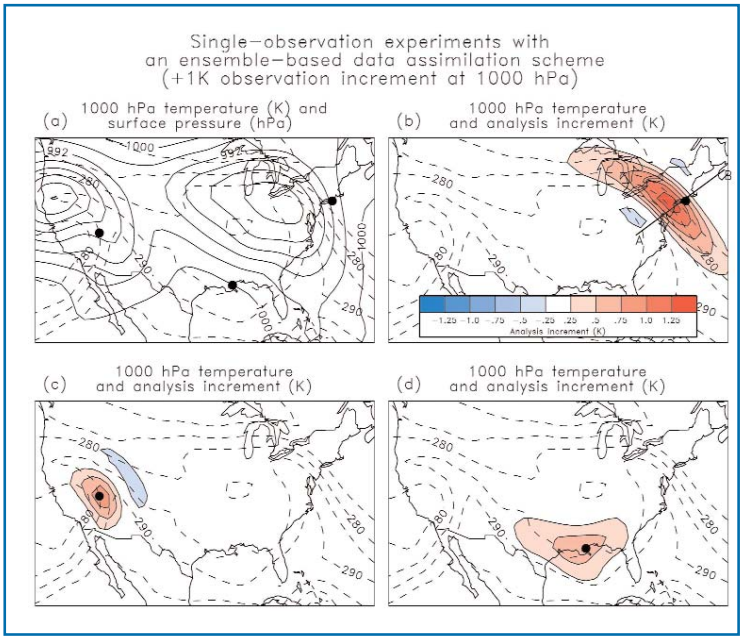
Hamill, T. M., and C. Snyder, 2002: Using improved background error covariances from an ensemble Kalman filter for adaptive observations. *Monthly Weather Review*, v. 130, 1552-1572.

Whitaker, J. S., and T. M. Hamill, 2002: Ensemble data assimilation without perturbed observations. *Monthly Weather Review*, v. 130, 1913-1924.

Hamill, T. M., C. Snyder, and R. E. Morss, 2002: Analysis-error statistics of a quasigeostrophic model using 3-dimensional variational assimilation. *Monthly Weather Review*, accepted.

Snyder, C., T. M. Hamill, and S. J. Trier, 2002: Linear evolution of error covariances in a quasigeostrophic model. *Monthly Weather Review*, accepted.

Hamill, T. M., C. Snyder, and J. S. Whitaker, 2002: Ensemble forecasts and the properties of flow-dependent analysis-error covariance singular vectors. *Monthly Weather Review*, submitted.



"Atmospheric Data Assimilation" is the process of combining information from prior weather forecasts and the latest weather observations in order to define the current state of the weather as accurately as possible. A crucial part of data assimilation is deciding how much influence an observation is to have in adjusting the prior weather forecast. By estimating the error statistics of the weather forecast using information from our ensemble of weather simulations, we can determine how to optimally combine observations and prior forecasts. In the figure above, we examine the corrections made in the region of three different synthetic observations which were set to have temperatures 1 K larger than the prior forecast temperature. The upper-left panel shows the surface pressure pattern (solid lines) and the surface temperature (dashed). The other three panels show the corrective effects of three different observations. The corrective effects vary from one location to the next, depending on the local weather scenario at each observation location. For instance, in the upper-right panel, the corrective effects are stretched out along a nearby warm front. This sort of correction makes intuitive sense to weather forecasters; if the front is misplaced in New York, it is most likely misplaced in similar fashion in Ontario as well. By tailoring the corrections to vary with the weather scenario through the use of ensembles, dramatic reductions in the errors of the analyzed state of the weather may be possible. Hopefully this will reduce the error in subsequent numerical weather forecasts.

A 23-year Global Data Set of HIRS Radiance and Cloud Data for Climate Studies

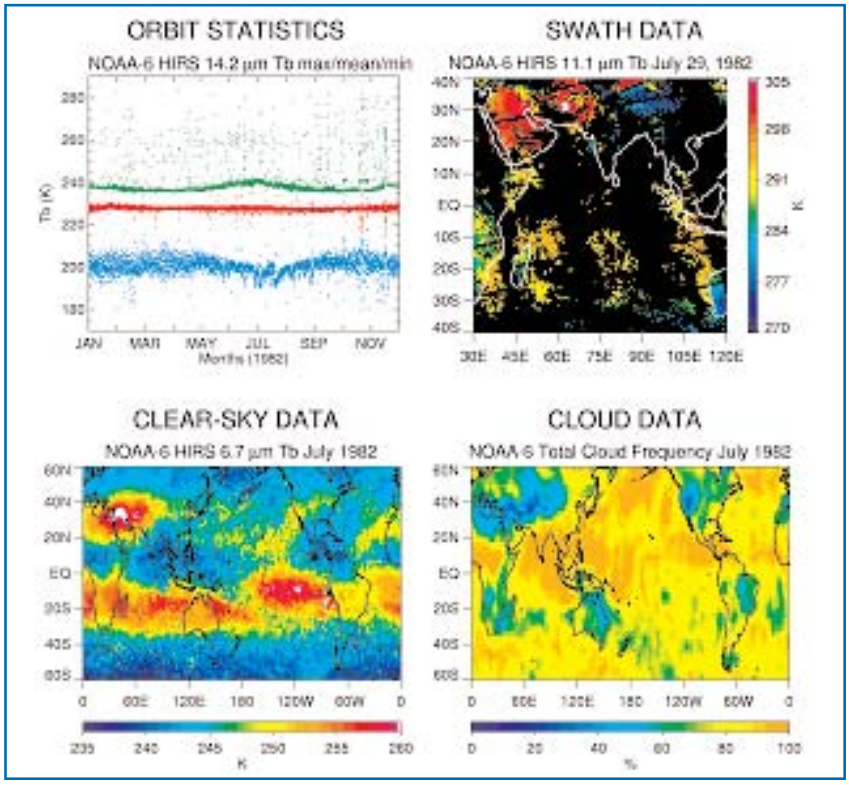
Scientific Impact: Provide global observations of HIRS radiance, temperature, water vapor and clouds for study of interannual climate variability

Project Personnel: Darren L. Jackson (CIRES), John J. Bates (NOAA/NCDC), and Donald P. Wylie (SSEC/Univ. Wisconsin-Madison)
Funding Source: NOAA
References: Jackson, D.L. and J.J. Bates, 2001: Climate analysis with the 21-yr HIRS Pathfinder radiance clear-sky data set. Proceedings 11th Conference on Satellite Meteorology & Oceanography, Madison, Wisconsin, October 15-18, 2001, pp 138-140.

HIRS observations provide a unique set of continuous global observations over the past 23 years that can ultimately help us better understand long-term fluctuations in temperature, water vapor, and clouds. The mission of this study is to provide a consistent, accurate and well-documented set of HIRS radiance and retrieval data that can be used for studies of interannual climate variability.

The HIRS has flown aboard all NOAA polar orbiting satellites since 1978 and has collected approximately 1.5 million observations each day during that period. This instrument passively measures infrared radiation in 19 narrow-band channels strategically chosen to provide tropospheric profiles of temperature and water vapor. Radiance is computed directly from the level 1b data using NESDIS calibration coefficients and raw instrument counts. The 11.1 m window channel finds clouds by identifying relatively cold (cloudy) observation through comparison with neighboring observations and climatology. Cloudy observations utilize radiance from the 14 m temperature channels to identify cloud top height, temperature, and emissivity. Final data products include clear-sky radiance and cloud retrieved data for all 11 NOAA satellites and 19 infrared channels.

The HIRS data products have many different applications in climate research. We have shared our orbit statistics data to assist with quality control for the assimilation system for the ECMWF 40 re-analysis project (ERA-40). We have contributed upper tropospheric humidity analysis, derived from the 6.7 m channel, to the WCRP SPARC water vapor assessment for the assessment of upper tropospheric/lower stratospheric humidity. Cloud retrievals will assist research at the University of Wisconsin/SSEC in diagnosing the interannual variation in total and high cloud cover. The figure presents various forms of the HIRS data that are being used for these studies. Orbit statistics provide basic statistical information on the radiance data from each orbit. Swath data shows clear-sky 11.1 m observations for three ascending orbits over the Indian Ocean. Missing data along each swath indicates cloudy observations. Monthly grid data of the 6.7 m water vapor observations illustrates low upper tropospheric humidity in the dry subtropical high regions, and cloud frequency data indicates low and high frequency cloudiness during the same period.

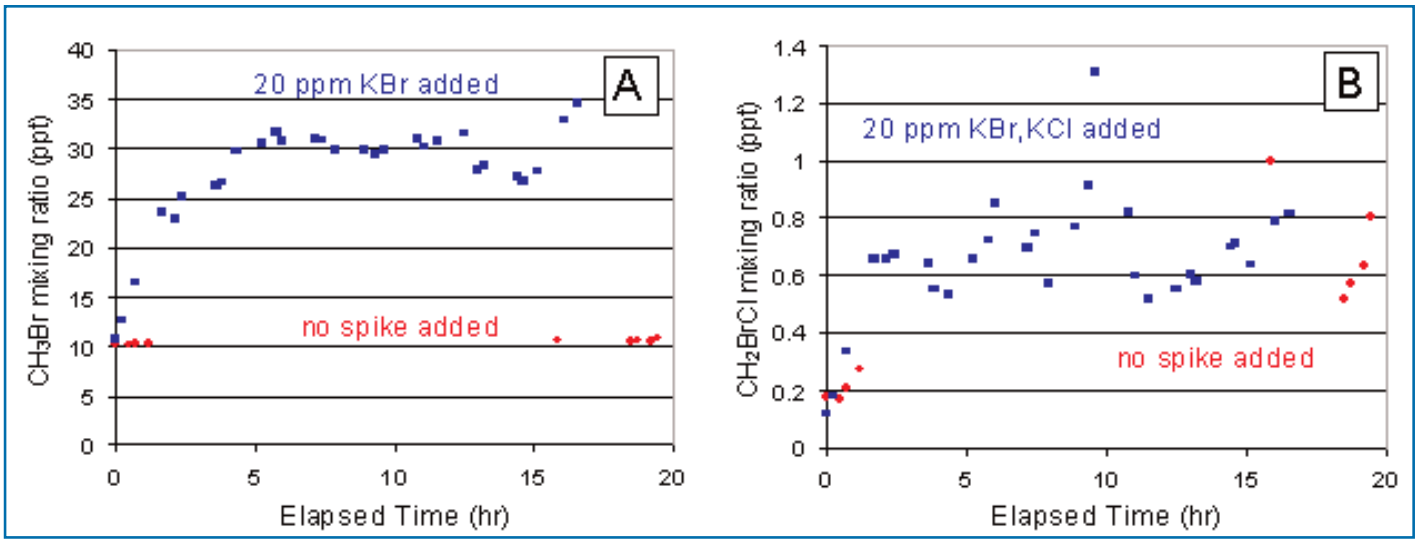


Natural Halocarbon Production by Tomato Plants

Scientific Impact: Demonstrated that natural halocarbon production by tomato plants occurs and can be measured in a hydroponic greenhouse.

Project Personnel: Daniel King, Debra Mondeel, James Butler (NOAA/CMDL)
Funding Sources: CIRES Innovative Research Program

Natural halocarbons contribute significantly to the destruction of stratospheric ozone. Methyl bromide and methyl chloride, both of which come primarily from natural sources, supply about one-quarter of the equivalent chlorine to the atmosphere. Other halogenated compounds, such as dibromomethane, bromoform, and methyl iodide, might be significant halogen sources to the stratosphere as well. The budgets of these compounds, and the mechanisms responsible for their production and destruction, generally are poorly understood. For example, known sinks of both methyl bromide and methyl chloride outweigh their known sources by 50-100%, making it difficult to predict future atmospheric concentrations of these compounds. As the global climate changes, atmospheric halocarbon concentrations are likely to respond to changes in sea surface temperature, biological productivity on land and in water, and global wind patterns. Terrestrial plants are a potentially significant source of many light halocarbons. As a first cut to assess this potential, the production of about 20 halocarbons by tomato plants in a hydroponic greenhouse in Northern California was measured. This enabled the investigation of production directly from the plants, without the interference of soils, which have been shown to remove some of these compounds from the atmosphere. Results differed for the methyl halides and the polyhalogenated compounds. Methyl halide production was small or zero during initial experiments. However, the addition of a halide ion solution (KBr, KCl, and KI) to the plants' nutrient mixture increased production of methyl bromide by a factor of three (Fig. A) and methyl iodide by a factor of seven. In contrast, several polyhalogenated compounds (e.g., bromoform and bromochloromethane) were produced during all experiments, with concentration increases on the order of 50% to 600% (Fig. B). The halide ion addition did not affect the production of these compounds. The results from these experiments underscore the potential of the biosphere to contribute to global atmospheric fluxes of light halocarbons and suggest the need for investigation of other species or ecosystems.



Methyl bromide (A) and bromochloromethane (B) concentrations during two experiments: no halide ion addition and 20 ppm KBr, KCl, and KI spike.

Halocarbon Measurements in the Southern Ocean

Scientific Impact: Methyl bromide undersaturations in the Southern Ocean are a result of both in situ degradation (chemical and biological) and mixing with older waters that are depleted in methyl bromide.

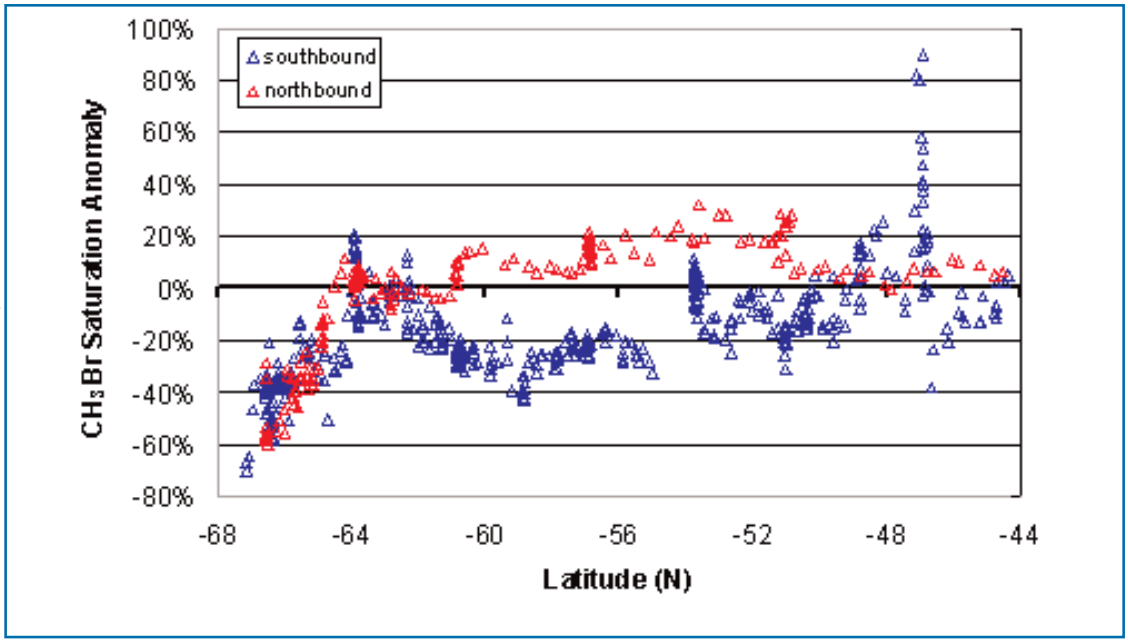
Project Personnel: Daniel King, James Butler (NOAA/CMDL)
Funding Sources: NASA, NOAA

During fall 2001 we participated on a research cruise in the Southern Ocean (CLIVAR SR3 2001). The Aurora Australis (an Australian ship) departed Hobart, Tasmania, on October 29, and returned to Hobart on December 13. The cruise headed south towards the Antarctic coast before returning to Australia, retracing a previous CLIVAR (Climate Variability and Predictability Programme) cruise track. Over 20 halogenated compounds were measured in situ in surface seawater and the overlying atmosphere with an automated gas chromatograph-mass spectrometer. In total, over 2200 samples were analyzed during the cruise. The measurements of CH3Br and CH3Cl will be coordinated with research groups from NOAA/AOML (halocarbon depth profiles) and the University of California at Irvine (CH_3Br and CH_3Cl degradation rates) with the eventual goal to model the cycling of these compounds in the surface ocean.

Preliminary results show that CH_3Br and CH_3Cl were generally supersaturated north of 50°S and undersaturated south of that latitude.

Undersaturations peaked at the southernmost latitudes, in ice-covered waters, and saturations approached equilibrium as the ship returned to Tasmania. The behavior of conservative tracers (e.g., CFC-12, CFC-113, and halon-1211) was similar, suggesting that physical processes contributed to the undersaturations of the methyl halides. In contrast, CH_2Br_2 and $CHBr_3$ were generally supersaturated throughout the cruise, with highest values in the ice pack.

CH_3Br undersaturations at the higher latitudes reproduced previous observations in that region. Using measured chemical and biological degradation rates and depth profiles, we were able to determine that the large undersaturations were a function of both degradation (primarily biological) and mixing with upwelled waters that were depleted in methyl bromide.



Methyl bromide saturation anomaly during the CLIVAR SR3 2001 cruise.

Land-atmosphere Interactions in Beringia over the Last 21 ka

Scientific Impact: The goal of this research is to improve our understanding of the characteristics, mechanisms, and feedback processes associated with changes in vegetation, sea level, and standing surface water in Beringia during the last 21,000 years, and to use this understanding to aid in the development of predictive tools for future pan-Arctic climate change.

The geographical distribution of different vegetation types, lakes, and coastal zones represent significant controls of energy, water, and CO_2 exchanges between land surfaces and the atmosphere. These exchanges affect local, regional, and global climates, which, in turn, influence the biogeography and physiology of vegetation. The boreal forests and tundra of the far north are of particular importance; consequently, changes in these biomes and their associated landscapes have the potential for significant impact on the seasonal and annual climatology within arctic regions and through much of the Northern Hemisphere.

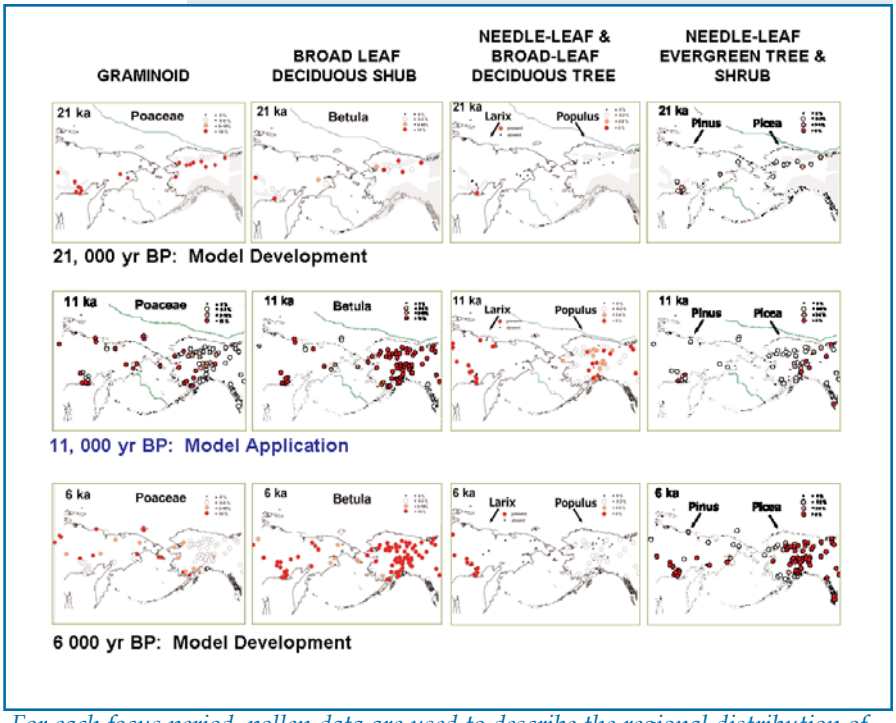
Our specific research objectives and tasks are to:
- Refine a modeling strategy for simulating regional paleoclimatic variations utilizing global and regional climate models and an equilibrium vegetation simulation model.
- Compile detailed data including the location of former shorelines, the distribution and density of lakes, and the spatial pattern of vegetation and its biophysical characteristics.
- Test and improve this modeling strategy by applying it to the present and to key times in the past (i.e 21,000 and 6000 calibrated (cal) years before present).
- Apply the improved model strategy to a set of sensitivity-test experiments focused on elucidating the response of the regional climate to the dramatic changes in climatic controls during the early Holocene (i.e. around 11,000 (cal) years before present).

For each focus period, pollen data are used to describe the regional distribution of past vegetation through the use of plant functional types with different land-surface characteristics. The assemblage of plant functional types forms the basis for reconstructing past biomes for each period. These empirically reconstructed biomes are compared with biomes simulated by the vegetation model BIOME4, which is driven by data from paleoclimate simulations for each time period. Pollen data have been compiled from over 150 sites, spanning 21-0 yr. BP. These data were contributed to the PARCS ATLAS by the PARCS Beringian working group.

Project Personnel: Amanda H. Lynch
Thomas N. Chase
Aaron R. Rivers
University of Colorado Boulder
Patricia M. Anderson
Linda B. Brubaker
University of Washington
Patrick J. Bartlein
University of Oregon Eugene
Mary E. Edwards
Norwegian University of Science and Technology/University of Alaska Fairbanks

Funding Source: National Science Foundation

References: An assessment of the influence of land cover uncertainties on the simulation of global climate in the early Holocene. Amanda H. Lynch, Aaron R. Rivers and Patrick J. Bartlein *Climate Dynamics* (in review)



For each focus period, pollen data are used to describe the regional distribution of past vegetation through the use of plant functional types with different land-surface characteristics.

Sea Ice Variability in the Beaufort and Chukchi Seas: Processes and Prediction

Scientific Impact: Improved understanding and prediction of the processes that control the interannual variability of sea ice conditions along the Alaskan North Slope

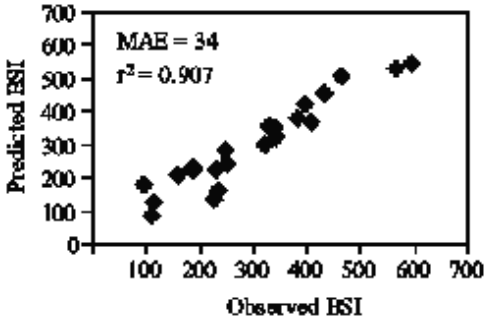
Variability in Arctic sea ice conditions is a significant factor in climate-change assessment and prediction, and has profound effects on Arctic coastal communities and habitat. Our project seeks to improve our understanding of regional sea ice changes off the Alaskan coast, and to improve predictions of ice severity ("heavy" vs. "light" ice pack).

Our initial approach has been to characterize ice conditions and determine similarities/differences in atmospheric and ice conditions during light and heavy ice summers. In our work to date, ice conditions in the Beaufort and Chukchi Seas have been assessed according to the Barnett Severity Index (BSI), from 1953 - 2000. The BSI is a measure of a variety of sea ice-related factors affecting conditions along the northern Alaska near-shore region, and has been used since the 1970's for ice severity studies.

We have developed a new statistical model to predict the BSI based on atmospheric circulation and remotely-sensed ice conditions. The model performs quite well (Figure 1), and provides a considerably longer lead time for predictions compared to previous methods.

Project Personnel: James Maslanik, Sheldon Drobot, Charles Fowler
Funding Sources: NSF
References: A Practical Method for Long-range Forecasting of Ice Severity in the Beaufort Sea. *Geophys. Res. Lett.*, (in press)
Interannual Variability in Summer Beaufort Sea Ice Conditions: Relationship to Winter and Summer Surface and Atmospheric Variability. *J. Geophys. Res.*, (submitted).

In addition to the obvious benefits of the development and improvement in long-range prediction for North Slope residents and operations, the methodology provides an extended time series of a climate record that integrates a number of factors. Further, this approach helps to identify key physical mechanisms regulating the interannual variability in ice conditions as a function of atmospheric circulation modes and other large-scale forcings that may evolve due to climatic change.



Predicted vs. observed Beaufort Ice Severity Index.

Local, Regional, and Remote Effects of Northern Hemisphere Snow on Western U. S. Climate and Water Resources

Scientific Impact: Improved predictability of climate, snow cover , and monsoon precipitation for the Western U.S.

Project Personnel: A. Nolin, M. Clark, M. Serreze, S. Marshall, F. Lo
Funding Sources: NSF
References: Marshall, S., R. J Oglesby and A. W. Nolin, The predictability of winter snow cover over the western United States, (accepted pending revisions, *J. Climate*)
Lo, F. and Clark, M., 2002: Relationships between spring snow mass and summer precipitation in the southwestern USA associated with the North American Monsoon System, *J.Climate*, 15, 1378-

Most previous studies have taken the view of snow cover as a passive responder to climate. This investigation examines the role of snow cover as an active climate driver and examines, on multiple scales, the effects of snow cover on climate and water resources in the western U.S. Modeling experiments using a 42-year run of the NCAR CCM3 were designed to assess the relative roles of snow cover anomalies and initial atmospheric states on the subsequent snow accumulation and ablation seasons. Results indicate that there is some inherent predictability with snow cover climate, particularly in modifying the atmospheric circulation. Snow cover anomalies in the early spring lead to subsequent snow cover and air temperature anomalies in the ablation season. Differences in predictive skill between winter (low predictive skill) and spring (higher predictive skill) and an examination of energy balance conditions for those two periods indicate that it is the surface albedo that is primarily responsible for modifying air temperatures and atmospheric circulation patterns.

In other work, we examine the role of snow cover in modulating the North American Monsoon System (NAMS). Lo and Clark (2002) identified an apparent inverse relationship between spring snow mass in the western United States mountains and NAMS precipitation in New Mexico and Arizona. The snow-monsoon associations are thought to occur because of land-surface memory: an anomalously high winter snowpack acts as an energy sink. In high snow years more energy is required to melt the snowpack and evaporate the subsequently high levels of soil moisture. The higher spring albedo of the surface plays a complementary reinforcing role. These factors can lead to delayed and decreased warming of the North American landmass and a reduction of the large-scale land-ocean heating contrasts that may be necessary for strong monsoonal circulations. However, we have found that the statistical relationship between winter snow mass and summertime precipitation is variable through time. Correlations between western U.S. snow mass and Arizona monsoon precipitation are strongest from 1955 to 1970, while correlations between western U.S. snow mass and New Mexico monsoon precipitation are strongest from 1970 to 1990. Initial results from a regional scale model with assimilated observations show that NAMS precipitation is correlated not with soil moisture but with sea surface temperature in the north Pacific Ocean.

In related work, we are comparing surface energy balance components from 1-D, regional and hemispheric-scale models. Initial results appear to indicate that albedo is important at all scales but that the turbulent fluxes are not in good agreement between model scales.

The Role of an Equatorial Kelvin Wave in the Termination of the 1997-98 El Niño

Scientific Impact: Documentation of the role of equatorial atmospheric disturbances in forcing the ocean, leading to enhanced predictability of climate variability and climate shifts.

Atmospheric Kelvin waves are large scale disturbances which propagate eastward at roughly 15 m/s parallel to the equator. They are associated with significant wind and convective precipitation signals, and are important components of the climate of the equatorial zone. Our interest in these disturbances is also motivated by their ability to force changes in sea surface temperature (SST) over the Pacific, and their potential role in the El Niño phenomenon.

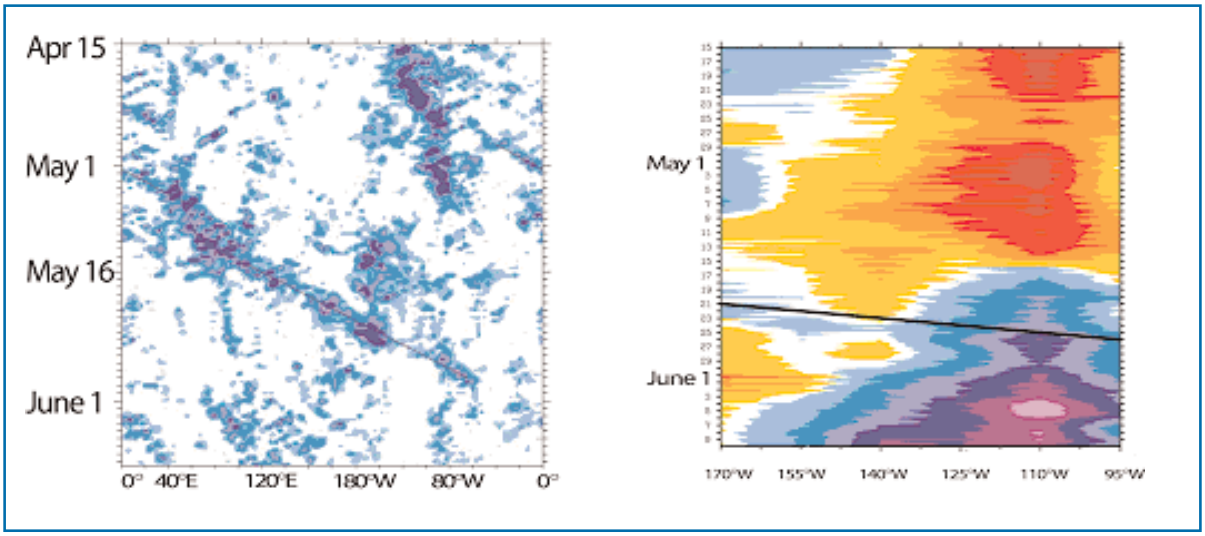
We analyzed multiple data sources to examine a Kelvin wave event during 1998. An example of a Kelvin wave (tracked by the diagonal black line) can be seen in a time-longitude diagram of cloudiness measured from satellite in the bottom left panel, where deeper clouds are shown by darker blue. This disturbance propagates rapidly eastward from the Atlantic and reaches the Indian Ocean at around 60°E in early May. At this stage the scale of the cloudiness signal increases and its propagation speed slows to around 5 m/s, which is indicative of a different type of equatorial disturbance, the Madden-Julian Oscillation (MJO). Once the MJO reaches 100°E, a Kelvin wave resumes propagating from there across the Pacific. One interesting aspect of this evolution concerns the apparent "triggering" of the MJO by the Kelvin wave. Another involves the fact that the easterly trade winds are known to be significantly modulated by the MJO, which in turn determine the SST over the equatorial Pacific. The bottom right panel shows that warm SST (redder shading) rapidly gave way to cooling (blue) as the MJO/Kelvin complex evolved, resulting in an abrupt end to the strong 1997-98 El Niño. This was a consequence of the rapid increase in equatorial trade winds, in turn forced by the MJO over the Indian Ocean. Once Pacific SST cooled, convection there disappeared and was relocated over the more normal position of Indonesia, terminating El Niño. Also notable is the short-term cooling of SST following the Kelvin wave (bottom right).

Monitoring of rapidly evolving atmospheric disturbances such as Kelvin waves and the MJO will ultimately enable the prediction of such abrupt and perhaps more slowly evolving shifts in the state of the ocean-atmosphere system within the tropics.

Project Personnel: K. H. Straub, G. N. Kiladis (NOAA/AL)

Funding source: NOAA Office of Global Programs

References: Observations of a Convectively coupled Kelvin wave in the eastern Pacific ITCZ. 2002 *Journal of the Atmospheric Sciences*.



New Methods to Infer Snow Albedo from the MISR Instrument

Scientific Impact: Accurate knowledge of snow albedo is essential for monitoring the state of the cryosphere. This study investigated the usefulness of angular and spectral data from the Terra MISR instrument for improved albedo calculations from space.

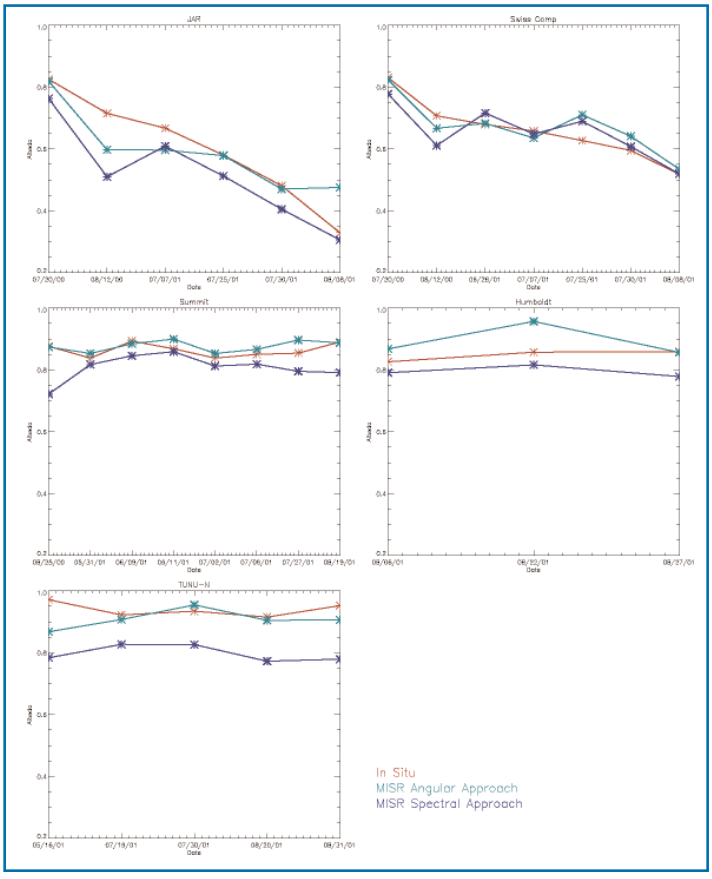
Snow-covered surfaces have a very high surface albedo, thereby allowing little energy to be absorbed by the snowpack. As the snowpack ages and/or begins to melt, the snow albedo lowers and allows more energy to be absorbed by the snowpack. Therefore, accurate estimation of snow albedo is essential for monitoring the state of the cryosphere. This study examined the retrieval of snow albedo using data from the Multiangle Imaging SpectroRadiometer (MISR) instrument over the Greenland ice sheet. Two different methods were developed and examined to derive the snow albedo; one based on the spectral information from MISR, and one utilizing the angular information from the MISR instrument. The latter method is based on a statistical relationship between in situ albedo measurements and the MISR red channel reflectance at all MISR viewing angles and is found to give good agreement with the ground-based measurements. Good agreement is also found using the spectral information, although the method is more sensitive to instrument calibration, snow Bidirectional Reflectance Distribution Function (BRDF) models and narrow-to-broadband relationships. In general, using either method results in snow surface albedo values that are within about 6% of that measured at automatic weather stations in Greenland. At this point it is not possible to say which approach gives better overall results. Further validation with more MISR imagery is needed to make any conclusive statements about the performance of either method. The angular information of the MISR data does however appear capable of capturing the general variability and magnitude of the surface albedo. The advantage of developing such statistical models is the relative ease with which such a model can be implemented.

Project Personnel: Julienne Stroeve and Anne Nolin

Funding Source: NASA

References: Stroeve, J. and A. Nolin, New Methods to Infer Snow Albedo from the MISR Instrument with Applications to the Greenland Ice Sheet, *Transactions on Geoscience and Remote Sensing,* in press.

Stroeve, J. and A. Nolin, Comparison of MODIS and MISR-derived surface albedo with in situ measurements in Greenland, Workshop Remote Sensing of Land Ice and Snow - Bern, March 2002, Proceedings.



MISR-derived and in situ measured surface albedo at (a) JAR, (b) ETH/CU, (c) Summit, (d) Humboldt and (e) TUNU-N. MISR-derived albedos using both the spectral method (blue) and the angular method (green) are shown.

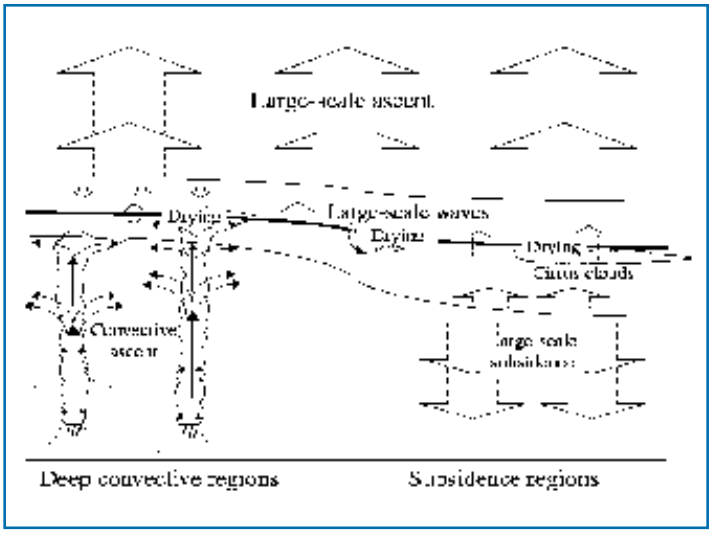
Observations of Tropical Upper Tropospheric and Lower Stratospheric Water Vapor and Ozone

Scientific Impact: Improved understanding of the tropical tropopause layer and the increase in stratospheric water vapor

The tropical tropopause region controls the transport of water substance into the stratosphere and therefore impacts the global distribution of stratospheric water vapor. However, the dynamical and chemical processes occurring in this region are poorly understood. Recently the tropical tropopause has attracted significant attention, in particular because the increase in stratospheric water vapor seems to be in contradiction with an apparent cooling of the tropical tropopause temperature. The radiative impacts of this water vapor increase are significant for the global atmosphere and a better understanding of the processes around the tropical tropopause is needed.

Dedicated soundings of water vapor and ozone using small balloons have produced high resolution and high quality vertical profiles of these species at San Cristóbal, Galapagos; Wautkosek, Indonesia; Juazeiro do Norte, Brazil; and a ship cruise along the equator in the Western Pacific. These data are used to study the longitudinal and seasonal variation of the processes at the tropical tropopause that control the amount of water substance in this region. Clearly, dehydration processes are not only linked to convective events in the western Pacific, as previously believed, but are also linked to large scale planetary waves and slow ascent driven by the global stratospheric dynamics. Thus, for example, air can get dehydrated in the eastern Pacific through slow ascent and wave processes almost to the same extent as in deep convective events in the Western Pacific. The tropical tropopause is no longer viewed as a boundary between troposphere and stratosphere, but is replaced by a transition layer, in which tropospheric characteristics fade into those typical for the stratosphere.

Project Personnel: H. Vömel, S. Oltmans, D. Sherman
Funding Sources: NOAA, Hokkaido University, Kyoto University, NASA
References: Vömel, H., S. J. Oltmans, F. Hasebe, M. Shiotani, M. Fujiwara, N. Nishi, M. Agama, J. Cornejo, F. Paredes, and H. Enriquez, Balloon-borne observations of water vapor and ozone in the tropical upper troposphere and lower stratosphere, *J. Geophys. Res.*, 10.1029/2001JD000707, 2002.



Longitudinal variations of the processes occurring around the tropical tropopause region. Typical deep convective regions are the Western Pacific or the northern part of South America, whereas typical subsidence regions are the Eastern Pacific or the equatorial Atlantic.

Exploring Trend Detectability in Environmental Data

Scientific Impact: Developing reasonable expectations for when, where, and in which variables environmental changes can most readily be detected can greatly benefit both scientists and policymakers.

Project Personnel: Elizabeth Weatherhead, Amy Stevermer
Funding Sources: NSF, NOAA FSL, NASA GSFC, NASA LaRC
References: Detecting Environmental Changes and Trends, *Phys. Chem. of Earth*, 2002.

Our understanding of human impacts on the environment, particularly those associated with greenhouse warming, suggests that a number of environmental parameters are likely to be changing. Increases in surface temperatures and changes in upper-air temperatures have already been reported. Changes in other parameters, for instance cloudiness or precipitation, may also be detectable if climate changes proceed as projected by models. Decreases in stratospheric ozone amounts have been well documented over the past 30 years, and attention is now focused on detecting the recovery expected to result from the regulation of ozone-depleting substances.

In each of the cases above, detecting the change in question requires being able to distinguish a clear signal above the noise inherent in the data. This noise includes natural variability, which can be large for certain parameters or in certain regions of the globe, as well as instrument noise. These factors can confound our ability to detect environmental change, often adding decades to the monitoring time required to clearly detect a trend. The techniques developed to explore trend detectability have been extended to several datasets to evaluate whether certain locations, altitudes, or even parameters may be more conducive than others for identifying environmental change. For instance, analysis of temperature profiles from 40 years of radiosonde data suggests that the changes in free troposphere may be detected almost two decades earlier than changes near the surface. Preliminary analysis of ozone profile measurements suggests that the 40-kilometer altitude region may be a critical area to monitor.

Determining the locations and timeframes most conducive to detecting expected changes can provide useful guidance to scientists involved in environmental monitoring efforts. At the present time, many proposed and continuing monitoring efforts identify detecting change as a primary objective. Knowing where to monitor, as well as the types of measurements that may best for detecting trends, can help science managers develop networks that are optimal for studying prospective changes. Likewise, developing reasonable expectations for monitoring can help policymakers evaluate the success of current legislation and restrictions in meeting the goals for which they were designed.

Regional Processes

Understanding the role of climate information used in regional decisions concerning natural resources.

Short-term climate variability and extremes are felt within natural boundaries associated with topography, watersheds, and other geographical features that, in turn, influence and determine climate. Therefore, climate variability and extreme weather events impact very specific regional populations, economies and ecosystems.

Increasingly, the research community is being called to develop the scientific understanding necessary to deliver better tools and improved forecasting to help manage impacts of weather extremes and assist in directing natural resource use. Such prediction must cover many scales of forcing and response.

Regional process studies require intensive field campaigns to learn the conditions, influences, and interactions of specific topography, vegetation, latitude and cultures.

Example:
CIRES investigators interested in surface/atmosphere exchange will evaluate the net primary production and carbon stocks of Southwestern rangelands that are undergoing woody plant encroachment due to land-use practices. This shift in plant functional types, from grassland to shrubland, could cause significant shifts in carbon and nitrogen pools, and possibly fluxes.

RESEARCH GOALS

To better understand
1) Region-specific impacts of climate variability and extreme events
2) Regional hydrological cycles in weather and climate
3) Surface atmosphere exchange
4) Regional air quality
5) Intercontinental transport and chemical transformation
6) Atmospheric chemical forecasting
7) High latitude/high altitude regional processes

Contributors:
CIRES Center for Science and Technology Policy Research
CIRES Western Water Assessment
NOAA Aeronomy Laboratory
NOAA Air Resources Laboratory (ARL)
NOAA Forecast Systems Laboratory (FSL)
NOAA-CIRES Climate Diagnostics Center (CDC)

The Intercontinental Transport and Chemical Transformation (ITCT) "2k2" Field Mission

Scientific Impact: Improved understanding of long-range, intercontinental transport and chemical transformation in the troposphere and its influence on climate and air quality.

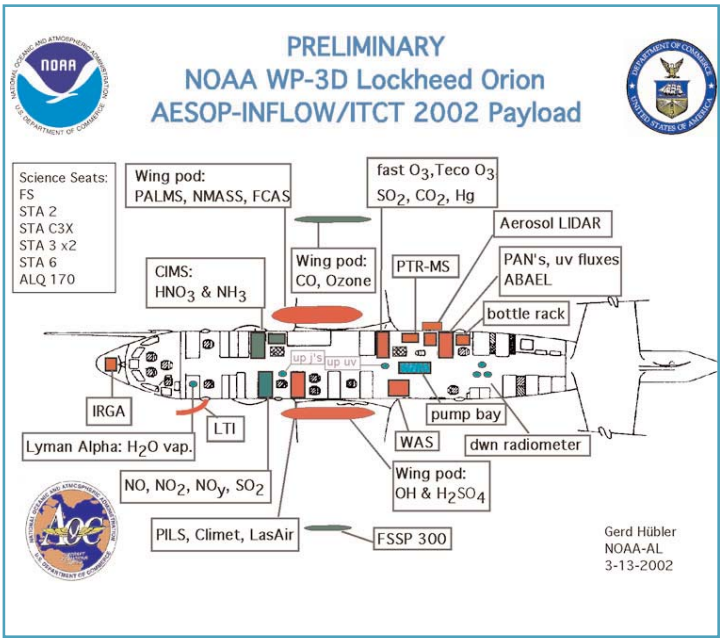
There is increasing evidence that ozone and fine particles and their precursors, even compounds with reasonably short lifetimes, can be detected at great distances from their sources — with consequences for both climate and air quality. The Intercontinental Transport and Chemical Transformation (ITCT) project is a major new research activity of the International Global Atmospheric Chemistry (IGAC) Program 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 month-long inaugural ITCT field campaign (dubbed "ITCT 2k2") started April 21 in Monterey, CA and involved CIRES and NOAA researchers in several NOAA Research labs, as well as colleagues in other agencies and academia. The campaign specifically focused on east Asia-to-east Pacific "inflow" into the West Coast region of North America, with the 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 from the Aeronomy Laboratory deployed instruments on the WP-3D research aircraft to measure the amount of the pollutants and to determine the chemical transformation that occurs as they move from one continent to another (see figure). Eleven science flights of the P-3 were flown in the Pacific coastal region extending from California to the Canadian border during the month-long mission. ETL deployed wind-profiling radars along the coast from San Francisco to northern Washington to diagnose whether the wind measured was local air or had been transported from across the Pacific. CMDL established a monitoring site at Trinidad Head, CA, where ITCT scientists made ground measurements of surface ozone and other gases, aerosol particles, and solar radiation.

Project Personnel: Dozens of international researchers from many organizations are involved in the ITCT planning and field research. CIRES scientists from the Aeronomy Lab are: C. Brock, C. Burgdorf, J. deGouw, E. Dunlea, J. Holloway, G. Hübler, S. McCaffery, S. McKeen, P. Murphy, A. Neuman, D. Nicks, K. Perkins, C. Simons, D. Sueper, D. Thomson, C. Warneke, E. Williams. CIRES scientists from other NOAA Laboratories also participated.
Funding Sources: NOAA
References: Data are undergoing analysis. ITCT website: www.al.noaa.gov/WWWHD/Pubdocs/ITCT/2k2/

ITCT research will benefit decisionmakers in government and industry in two areas: climate/climate change; and air quality. Results will become available as the analysis proceeds in the coming months.

A special session on ITCT will take place at the AGU Fall Meeting in December 2002.



Airborne Measurements of Acetonitrile: Biomass Burning Source, Ocean Sink?

Scientific Impact: Improved understanding of the sources, long-range intercontinental transport, and chemical transformation of acetonitrile (an emission from biomass burning) in the troposphere.

Project Personnel: J. de Gouw, C. Warneke
Funding Sources: NOAA
References: Emission Sources and Ocean Uptake of Acetonitrile (CH_3CN) in the Atmosphere (in preparation for *J. Geophys. Res.*)

Acetonitrile (CH_3CN) is an inert organic trace gas in the atmosphere. Although there is relatively little known about its atmospheric sources and sinks, the consensus is that acetonitrile is predominantly emitted from biomass burning and is lost in reaction with OH and by ocean uptake. Airborne measurements of acetonitrile were performed during the Intercontinental Transport and Chemical Transformation experiment in 2002 (ITCT2k2), which was aimed at quantifying the transport of polluted air from Asia across the Pacific to the U.S. The measurements of acetonitrile were done onboard a NOAA WP-3D aircraft using proton-transfer-reaction mass spectrometry (PTR-MS), a novel technique that allows acetonitrile and other compounds to be monitored with a fast response time. Figure 1 shows the results of our measurements in a forest fire plume observed over Utah. The mixing ratios of acetonitrile and CO (carbon monoxide) are strongly enhanced in the plume. The DCH_3CN/DCO ratio derived from the data is 2.9±0.5 pptv $ppbv^{-1}$. This ratio is higher than previously reported emission factors, which may have important consequences for the global budget of acetonitrile. No significant enhancements of acetonitrile were found in the outflow from other potential sources (urban pollution, power plant, ocean vessels), confirming that biomass burning is the dominant source of acetonitrile to the atmosphere.

We found acetonitrile to be significantly reduced in the marine boundary layer (MBL) over the Pacific. Figure 2 shows the result of CO and acetonitrile measurements during a descent off the coast of Washington. CO is relatively independent of altitude, whereas acetonitrile drops to nearly zero in the MBL. These are the lowest acetonitrile mixing ratios reported in the literature so far and indicate the significance of ocean uptake as a loss mechanism. The ITCT2k2 data indicate that ocean uptake of acetonitrile is particularly strong off the west coast of the U.S., possibly explained by the enhanced biological activity in the seawater.

Significant enhancements of acetonitrile were observed in many Asian air masses transported across the Pacific, indicating the importance of biomass burning emissions to the pollution. Work is in progress to analyze these data in detail.

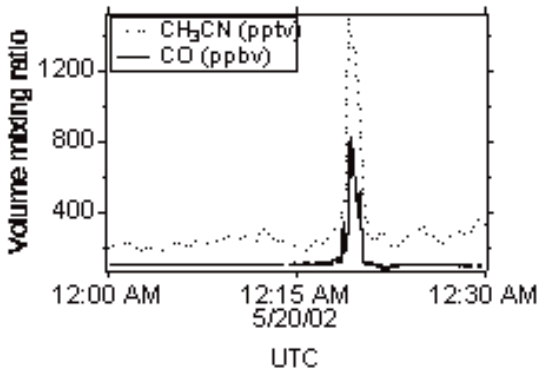


Figure 1: Acetonitrile and CO enhancement in a forest fire plume over Utah.

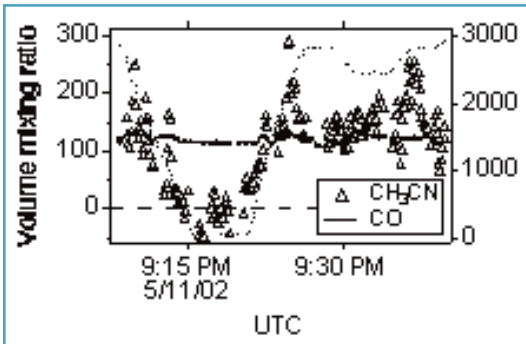


Figure 2: Acetonitrile and CO observations in the MBL west of Washington.

The New England Air Quality Study (NEAQS): Advance Field Work and Planning Efforts

Scientific Impact: Improved understanding of the atmospheric processes that control the production and distribution of air pollutants in the New England region.

During July and August of 2002, CIRES scientists and their colleagues in NOAA and other organizations will embark on a multi-institutional research project focusing on air quality prediction & monitoring, weather, and climate-related issues in the 2002 New England Air Quality Study (NEAQS). The intensive research study program is designed to provide scientific information for environmental decisionmakers in the region to aid in the development of effective strategies for air quality management.

In recent years, it has become increasingly evident that the most persistent air pollutants (e.g., ground-level ozone and fine particles) are inherently a regional problem requiring a regional approach. Finding effective solutions is particularly difficult in the case of ozone and fine particles since both of these pollutants are formed by a complex series of chemical reactions that occur in the atmosphere and involve pollutants emitted from a variety of sources, often far away and hence involving transport from long distances.

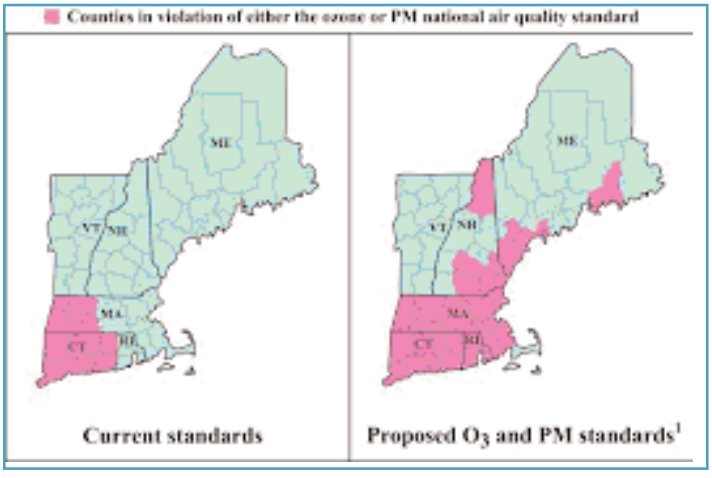
Nowhere is the regional nature of this problem more evident than in New England. There are currently several counties in southern New England where ozone and/or particulate matter (PM) levels exceed the standard established by EPA to protect public health and welfare. The number of counties in the region that are expected to violate EPA's proposed new standards is considerably greater (see the accompanying figure). The poor air quality responsible for these violations can adversely impact the health of the region's citizens and the environment with serious consequences for the local economy.

The summer 2002 mission is using the NOAA Research Vessel Ronald H. Brown deployed in the Gulf of Maine, with CIRES scientists and their colleagues operating a complete complement of sensors and instruments for measuring gases and aerosol particles. The use of a ship in such an air quality study will afford scientists a powerful vantage point to study the role of coastal meteorology in transporting polluted air from the Gulf of Maine to the populated areas in the region. Measurements from ground stations and from instrumented aircraft, as well as modeling forecasts and analyses, will provide a powerful suite of information that will enable researchers to develop an understanding of the key processes that affect air quality in New England.

Project Personnel: Dozens of international researchers from many organizations are involved in the NEAQS planning and field research. CIRES scientists from the Aeronomy Lab are: W. Angevine, C. Burgdorf, J. deGouw, S. McCaffery, S. McKeen, P. Murphy, C. Simons, D. Sueper, C. Warneke, E. Williams. CIRES scientists from other NOAA Laboratories also participated.

Funding Sources: NOAA

References: 2001/2002 activities were in preparation for the July/August 2002 mission. The NEAQS website is:
http://www.al.noaa.gov/NEAQS/

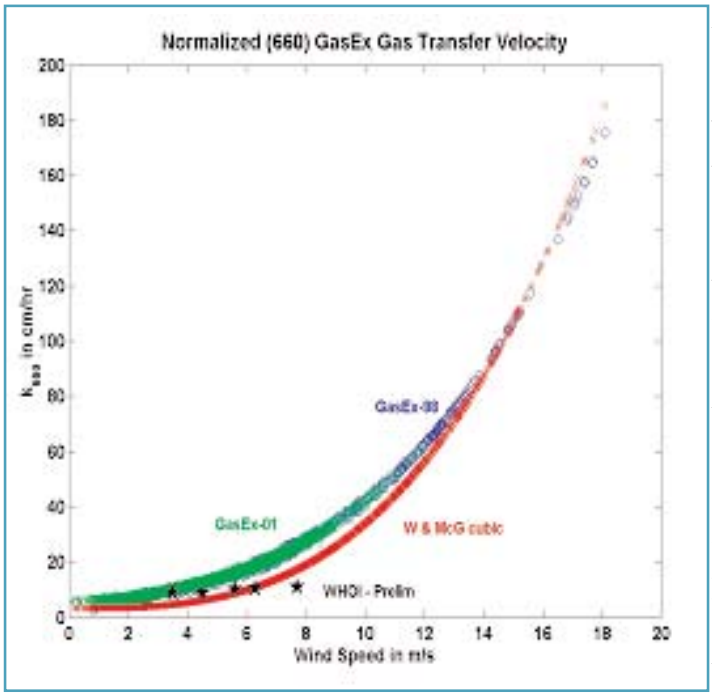


Improvement to a Micrometeorologically-Based Air-Sea Gas Transfer Parameterization

Scientific Impact: Improved parameterization of air-sea gas transfer which can be incorporated into larger scale models for more accurate forecasting of carbon dioxide

Project Personnel: Jeffrey Hare, Christopher Fairall (CIRES Fellow)
Funding Source: NOAA Office of Global Programs
Reference: Fairall, Hare, Edson, and McGillis, 2000: Parameterization and Micrometeorological Measurement of Air-Sea Gas Transfer, Boundary-Layer Meteorology, v96, pp 63-105.

Large uncertainties in the extent of carbon dioxide transfer between the atmosphere and ocean have prevented us from accurately quantifying how the increasing atmospheric CO_2 burden is partitioned between the ocean and terrestrial biosphere, which limits our ability to accurately predict future atmospheric CO_2 levels. The need for accurate predictive models of air-sea gas flux has prompted a number of field experiments in recent years, including the NOAA-sponsored GasEx-1998 and GasEx-2001 cruises, where the experimental emphasis was placed on making accurate direct covariance measurements of gas fluxes within the context of an accurately measured environment. Air-sea gas transfer is driven by complex physical processes within the lower marine atmosphere, in the upper oceanic boundary layer, and at the sea surface, and improvements to small-scale gas transfer parameterizations can only be realized through comprehensive measurement strategies such as those accomplished in the GasEx cruises.



The CO_2 gas flux (F) can be expressed quite simply: $F = k\,(\,aw\,fCO_2w + as\,fCO_2a\,)$, where k is the gas transfer velocity, a is the gas solubility in the water (w) or at the surface (s), and fCO_2 is the fugacity of carbon dioxide in the water (w) and air (a). The transfer velocity is conceptually similar to a dimensional "transfer coefficient" in the traditional bulk model context.

The Fairall et al (2000) gas transfer parameterization has a basis in the Toga Coare bulk flux parameterization for heat and momentum fluxes and expresses the gas flux (or transfer velocity) in terms of the matching of turbulent and molecular dissipative properties at both sides of the interface. Additional considerations have been applied for the effects of higher wind regimes (modulation by wave effects, breaking waves, and bubble enhancement of gas transfer). Currently, we are working toward refining these high wind adjustments in order to reproduce the gas flux observations from the cruise data sets. Additional work is underway to investigate the effect of the thermal structure of the near surface water (cool-skin and warm-layer effects) on the modeled transfer velocity.

The figure shows the gas transfer velocity (k) estimated from the Fairall parameterization (normalized to an arbitrary Schmidt number) from the two GasEx cruise datasets along with the simple Wanninkhof and McGillis cubic wind-speed dependent relationship and preliminary direct CO_2 flux measurements from GasEx-2001.

Emissions of Ozone-Depleting Substances in the Trans-Siberian Railway Corridor during Summer 2001

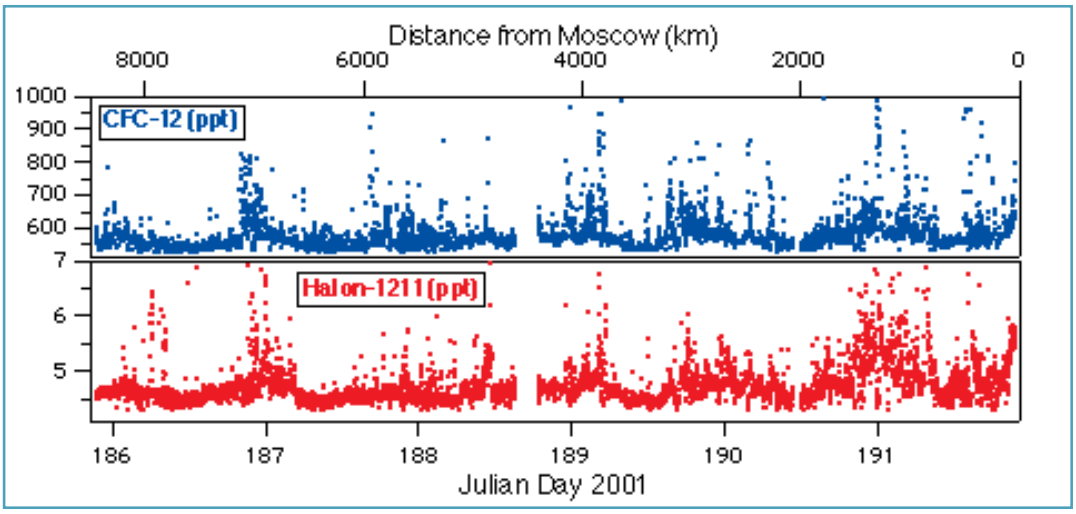
Scientific Impact: First intensive measurement campaign of ozone-depleting substances (ODS) in a previously under-investigated region. Our estimates of ODS emissions in Russia can help improve predictions of future stratospheric halogen loads and ozone abundance.

Project Personnel: Dale Hurst, Pavel Romashkin, James Elkins (NOAA/CMDL)
Funding Sources: CIRES, NASA, NOAA

The former Soviet Union and post-1991 Russian Federation pledged to cease production of the principal ODS by the January 1996 deadline for developed countries (Montreal Protocol on Substances that Deplete the Ozone Layer). In 1994, Russia was granted a four year deadline extension because of its difficult transition to a market economy. Russian production reportedly ceased in December 2000, but banks of ODS still exist in equipment and stockpiles held within the country. Russian ODS emissions will undoubtedly continue into the future, but their magnitude and persistence are highly uncertain because (1) the amounts of materials banked in Russia and their emission rates to the atmosphere are not well known and (2) patterns of ODS usage may change dramatically now that production has ceased. These uncertainties may hinder stratospheric ozone trend predictions, especially if Russian ODS emissions are globally significant far into the future.

In summer 2001, we made >5000 measurements each of 6 ODS (CFC-11, CFC-12, CFC-113, halon-1211, CCl_4, and CH_3CCl_3) during a two-week, 17,000 km journey on the trans-Siberian railway between Moscow and Khabarovsk, Russia, as part of the seventh Trans-Siberian Observations into the Chemistry of the Atmosphere (TROICA-7) expedition. TROICA-7 was a collaboration between American, Russian, and German scientists. Our data show elevated concentrations of five of these six ODS, indicating the presence of sources within the railway corridor. CFC-12 and halon-1211 were both extremely variable, as shown in the Figure below for the westbound (return) trip from Khabarovsk to Moscow.

We developed a method to estimate ODS emissions in the trans-Siberian railway corridor using our measurements, coincident data for radon-222 (emitted by soils), and 12-hour back-trajectories of air masses reaching the train. For 2001, railway corridor emissions estimates of CFC-12, CFC-113, and halon-1211 represent 1 to 4% of 2001 global emissions estimates, while CFC-11, CCl_4, and CH_3CCl_3 emissions are <0.1%. We plan to return to Russia in 2003, repeat our measurements of ODS from the train, and update our emissions estimates for the trans-Siberian railway corridor.



CFC-12 and halon-1211 data for the July 4-10, 2001, return trip from Khabarovsk to Moscow. Not shown are 83 CFC-12 measurements >1000 ppt and 41 halon-1211 measurements >7 ppt.

The Effect of Distant Forest Fires on Ozone Pollution in the U.S.

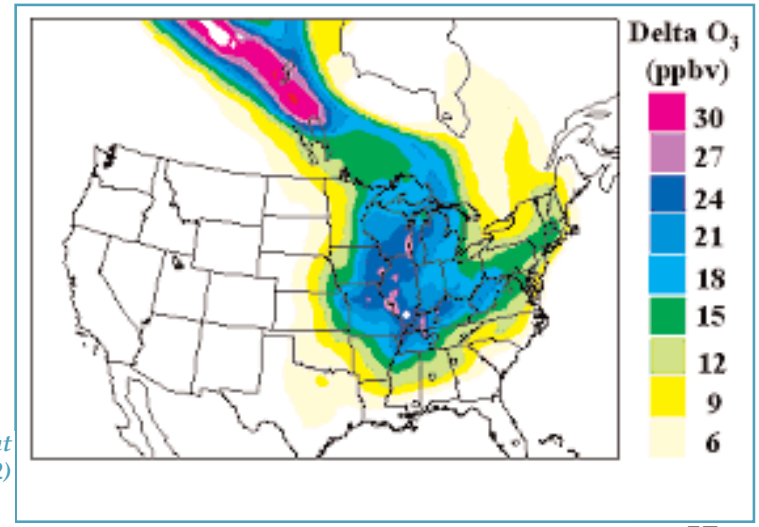
Scientific Impact: Improved understanding of long-distance factors that influence air quality, accompanied by an improved ability to understand and forecast air quality exceedances in the U.S.

Project Personnel: S. McKeen, J.S. Holloway, G. Hübler, F. Fehsenfeld (NOAA/AL), & others
Funding Sources: NOAA
References: S. McKeen et al., Ozone Production from Canadian Wildfires during June and July of 1995, *J. Geophys. Res.*, in press, 2002.

The purpose of this research is to characterize the importance of large, yet remote Canadian and Alaskan forest fires on the air quality within the continental U.S. The work is a case study of June and July of 1995, when CIRES and NOAA scientists and their colleagues deployed a wide array of instrumentation aboard the NOAA WP-3D aircraft during the multi-agency Southern Oxidants Study (SOS)-95 conducted out of Nashville, TN. Carbon monoxide (CO) measurements collected from ground sites and the NOAA WP-3D aircraft during the study showed high "spikes" of CO, which were subsequently shown to have originated from extensive wildfires in the Northwest Territories of Canada during June and July of 1995 (Wotawa and Trainer, *Science*, 2000). In 2001/2002 research, photochemical model studies were performed to assess the impact that CO, nitrogen oxides, and non-methane hydrocarbons (NMHC) from these fires had on ozone concentrations throughout the eastern half of the U.S.

Ozone concentrations during the summer of 1995 in the Eastern U.S., as far south as Alabama, were significantly influenced by the Canadian wildfires burning in the northern reaches of western Canada (see figure). The ozone increases consisted of roughly 12 to 15 parts per billion (ppb) to the background air originating from Canada. However, the carbon monoxide emitted from the fires enhances local ozone production over cities and isolated nitrogen oxide (NO_x) sources (e.g., coal-fired power generation facilities) disproportionately more than cleaner, more rural areas. The net effect is that urban regions like Nashville, TN experienced ozone 25 to 30 ppb higher than non-fire conditions. Several nearby ozone monitors were out of compliance with the proposed 80 ppb, eight-hour average ozone limit during two episodes having a clear fire influence. The results of this study show the significance of long-range, natural sources to local or regional ozone compliance issues, and the need to consider these sources in air quality forecasts and state implementation models.

The results of this research are useful to scientists and decision makers that are directly involved with ozone compliance issues, particularly in the eastern U.S. where federal ozone limits are often exceeded and ozone episodes present a significant health risk. Future research may extend to studies of other regions of the country and other time periods when remote forest fires may have influenced ozone formation.



Model Simulation of Ozone Increases from Distant Canadian/Alaskan Forest Fires, summer 1995 (McKeen et al., 2002)

The 2000 Texas Air Quality Study: Conveying Decision-Relevant Findings to Stakeholders

Scientific Impact: The timely analysis and communication of findings from the 2000 Texas Air Quality Study has benefited Houston-area air quality managers and decisionmakers in industry, by providing a firm scientific basis for their actions to improve the region's air quality.

In 2001/2002, CIRES and NOAA researchers and their colleagues led an extraordinary exchange of scientific information and understanding on the topic of air quality in the Houston region, engaging multiple communities that included air quality managers, scientists from the major petrochemical facilities and other industries that are concentrated in the region, and the broader scientific community.

Forming the basis for the exchange were the findings of the summer-2000 Texas Air Quality Study (TexAQS-2000), the largest air quality field study ever done in the State of Texas. Up to 250 researchers studied ozone, ozone precursors, and fine particles in a broad region of eastern Texas. Six different research aircraft and over 20 ground stations were used in the multi-organization effort.

Scientific understanding gained from TexAQS is of keen interest to many stakeholders in Texas; the region experiences some of the most severe episodes of poor air quality in the Nation. TexAQS-2000 researchers have been responsive to the pressing need for sound scientific understanding of the underlying factors, and 2001/2002 efforts have focused on the analysis and communication of the results in several venues.

The first of these was a September 2001 face-to-face "roundtable" held in Boulder and involving the TexAQS scientists, air quality managers for the State of Texas, and scientists from the major petrochemical industries in the Houston area. The roundtable was prompted by new insights that have emerged from the field study that relate to hydrocarbon emissions from the petrochemical facilities. Escaped emissions of the hydrocarbons are estimated by industry using modeling approaches, and the TexAQS data are of particular interest because they provide the opportunity to cross-check those emissions' inventory estimates. The roundtable initiated a productive and ongoing dialogue between the groups that now underlies current efforts of the region to meet its air quality goals.

In December 2001 the venue for the dialogue was Houston, at a meeting hosted by the Texas Natural Resource Conservation Commission (the group charged with managing air quality for the State of Texas). The meeting attracted about 200 constituents from trade groups, clean air groups, regulatory agencies, and industry. TexAQS scientists presented their findings, which focused on the role of various and relatively unique sources of ozone precursor pollution in the region (such as transportation, the petrochemical industries, and other industrial sources), as well as the specific coastal meteorological feathers of the region (in which departing air is "recirculated" over the Gulf and returned back to the land area).

At the AMS Annual Meeting in January 2002, the findings were described to the broader scientific community.

Project Personnel: Dozens of international researchers from many organizations are involved in the TexAQS-2000 research. CIRES scientists from the Aeronomy Lab are: C. Brock, J. Holloway, G. Hübler, S. McCaffery, S. McKeen, P. Murphy, A. Neuman, D. Nicks, K. Perkins, C. Simons, D. Sueper, D. Thomson, E. Williams. CIRES scientists from other NOAA Laboratories also participated.

Funding Sources: NOAA

References: The TexAQS website is: www.utexas.edu/research/ceer/texaqs/

Mesoscale Modeling of the Wintertime Boundary Layer Structure Over the Arctic Pack Ice

Scientific Impact: Successful modeling of the Arctic boundary layer will facilitate the extension of SHEBA flux observations from the local scale to the scale of GCM grids. Understanding and properly modeling processes in the Arctic PBL are crucial for linking the atmospheric and cryospheric changes associated with climate changes.

Accurate modeling of the Arctic boundary layer structure and its interaction with the surface is crucial for understanding and simulating processes important for the Arctic climate and climate change. The uncertainties in the modeled terms in the surface energy budget are larger or similar to the variations that differentiate years of annual net ice mass loss or balance (Persson, et al 2002a). Three-dimensional MM5 simulations of one-week periods during the Surface Heat Budget of the Arctic Ocean (SHEBA) Experiment are carefully compared to observations. We examine the various individual fluxes and boundary layer structures important for the surface energy budget terms, and not just the net fluxes or net effects of the fluxes. This helps isolate discrepancies. At least one case will be chosen from each season, so the processes important at different times of the year are represented.

The first case chosen was the week of Jan. 14-20, a relatively "simple" period with no solar radiation, predominantly clear skies, and strong low-level stability. More complex cases from other seasons will be studied during the coming year. The results from this first case lead us to conclude that:

1) the presence or absence of clouds have a major impact on the near-surface Arctic wintertime environment (see observations at JD380 and JD385 in Fig. 1).

2) a surface model with multiple ice and snow levels is necessary to insulate the Arctic PBL from the warm ocean and provide proper timescales for PBL responses to changes in forcing. Most GCMs use only one snow level and are therefore inadequate. (Fig.1b)

3) the RRTM longwave radiative scheme performs best (Fig. 1a), but still underestimates the incoming radiation (LWd), probably because specific aerosol concentration profiles are not used.

4) the choice of PBL scheme is much less important than the sophistication of the surface model as described in 2) (Fig. 1c).

5) the PBL height and temporal fluctuations are in good agreement with observations (not shown)

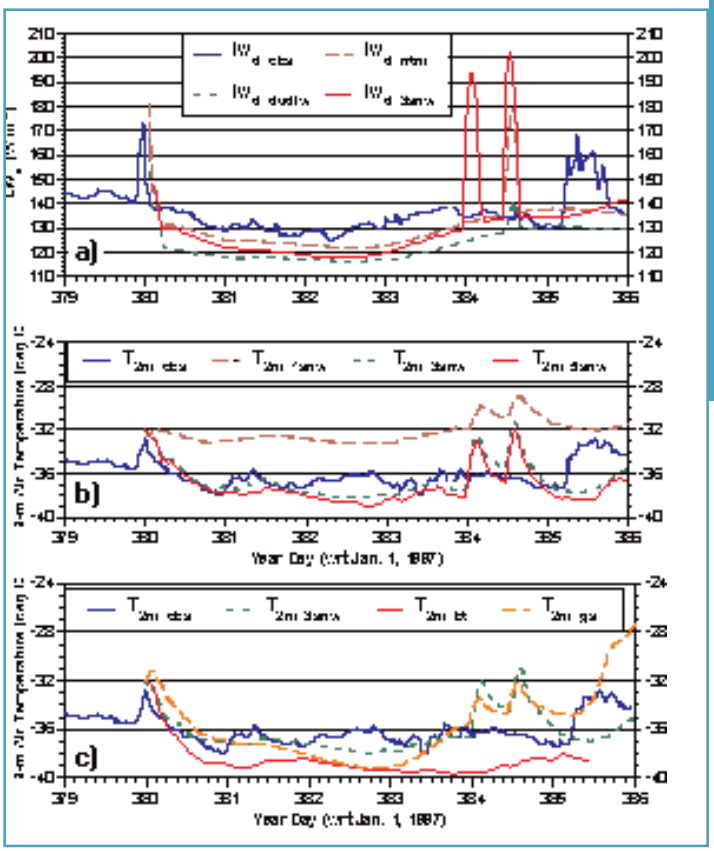
6) Momentum and sensible heat fluxes (Hs) are too large in magnitude (not shown), but this is due to an excessive large scale pressure gradient and wind in the model rather than significant problems with the flux parameterization schemes. The excessive downward Hs compensates for the reduced LWd, producing a modeled near-surface temperature that is in good agreement with observations.

Project Personnel: P. Ola G. Persson (CIRES), J.-W. Bao (NOAA/ETL), and Sara Michelson (CIRES)

Funding Sources: National Science Foundation

References: Persson, P. Ola G., C. W. Fairall, E. L. Andreas, P. S. Guest, and D. K. Perovich, 2002a: Measurements near the Atmospheric Surface Flux Group tower at SHEBA: Near-surface conditions and surface energy budget. *J. Geophys. Res.* In press.

Persson, P. Ola G., J.-W. Bao, and Sara Michelson, 2002b: Mesoscale modeling of the wintertime boundary layer structure over the Arctic pack Ice. Preprints, 15th Symposium on Boundary Layers and Turbulence, 15-19 July, Wageningen, The Netherlands, 335-338.



Time series of a) incoming longwave radiation for the radiation tests (DUDLW, RRTM, 3SNW), b) 2-m air temperature for the snow/ice model tests (1SNW, 3SNW, 5SNW), and c) 2-m air temperature for the PBL tests (3SNW, BTPBL, GSPBL) for January 14-20, 1998. The heavy solid curves are observed values in all panels

A Proposed Moveable Observing System Testbed (MOST)

Scientific Impact: To establish a national network of boundary-layer wind profilers for monitoring characteristics of the lower troposphere including vertical mixing and horizontal transport for weather, air quality, and homeland security applications.

Project Personnel: F. M. Ralph (ETL), A. B. White, W. D. Neff (ETL)
Funding Sources: NOAA
References:
http://www.etl.noaa.gov/programs/2002/taq/

Feedback collected by the NOAA Forecast Systems Laboratory from weather forecasters and other users of the NOAA National Profiler Network indicated overwhelmingly that these users would like to see more observations of the lower troposphere and, in particular, the boundary layer. The 915-MHz wind profiler with radio acoustic sounding system developed by NOAA was designed specifically to provide wind and temperature profile measurements in the boundary layer and lower free troposphere.

NOAA and CIRES researchers in the Weather and Climate Applications Division of NOAA/ETL have developed a Moveable Observing System Testbed (MOST) concept that could eventually lead to a national boundary-layer profiler (BLP) network. This network is intended to capture diverse meteorological conditions associated with differing geographic regions, document inter-annual variations in key meteorological factors influencing weather and air quality, monitor weather patterns in major pollution source regions and transport corridors, and establish a climatological baseline to optimize future regional network enhancements.

Figure 1 shows the first step in MOST, which would add 30 to the existing number of BLP sites to establish a backbone national network of approximately 50 BLPs. In outlying years, enhancements to the backbone network would be implemented in each region based upon research and impact assessments over a 2-year period using the MOST approach. This approach oversamples in a particular region and engages scientists, forecasters, and observing system users to evaluate final siting priorities within that region. The progression of MOST from East to West is demonstrated in Figure 2.

NOAA/ETL has successfully applied this concept to regional studies in the West and, more recently, in the Northeast.

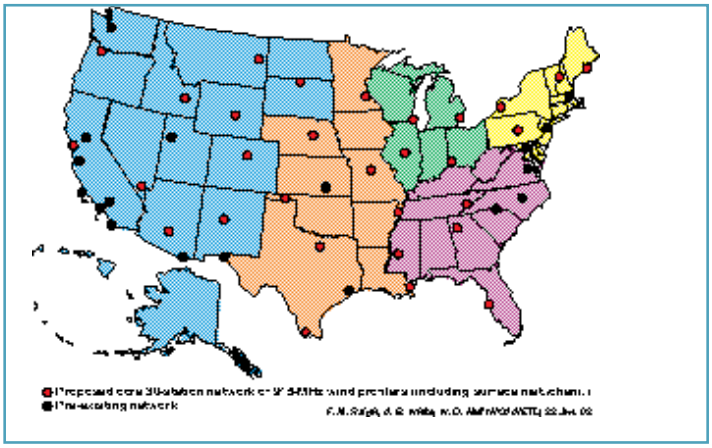


Figure 1. Proposed initial deployments in MOST.

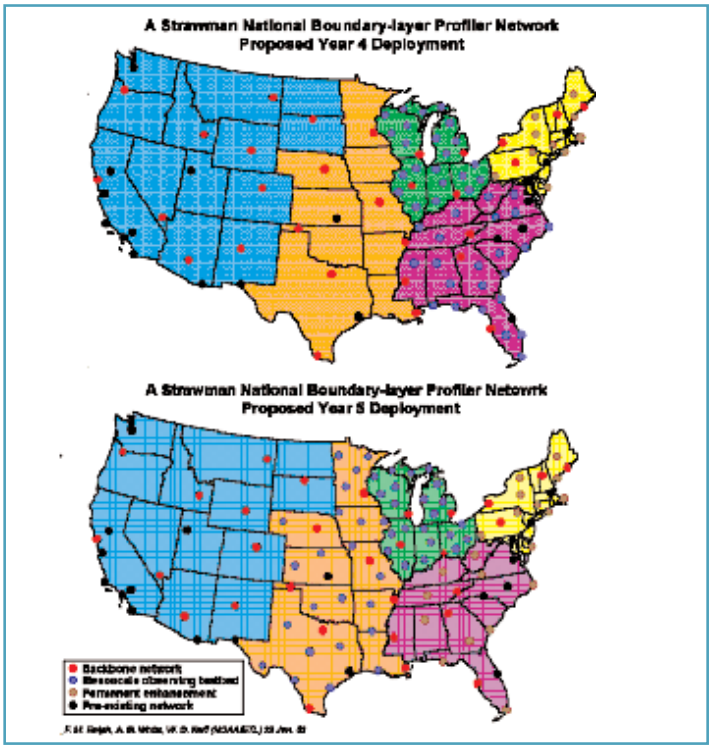


Figure 2. A demonstration of how MOST deployments would proceed in successive years.

Bulk Microphysical Characteristics of Rainfall Observed in the Coastal Mountains of California during CALJET

Scientific Impact: Documented a shallow rainfall process that contributed to flooding rains yet was largely undetected by the operational radar network.

The overarching goal of the California Land-falling Jets Experiment, conducted in 1997-1998 was to help improve the 0-24 h forecasts of damaging weather impacting the Western United States, with a particular emphasis on the coast of California. During CALJET, we identified a quasi-steady, orographically-forced, shallow rain process observed primarily beneath the melting level in California's coastal mountains using the NOAA Environmental Technology Lab.'s vertically-pointing S-band radar with extended dynamic range. This shallow rain, which did not possess a bright-band signature that normally occurs with midlatitude stratiform precipitation systems, contributed substantially to the record-setting rainfall during CALJET and, yet, occurred mostly beneath the coverage of the operational network of National Weather Service (NWS) Doppler precipitation surveillance radars (WSR-88D). In addition, this shallow rain process created sustained rain rates capable of producing regional flooding (i.e., >12 mm h^{-1} rule-of-thumb rain-rate threshold used by local forecasters for guidance in issuing flood statements).

The schematic figure highlights the differing bulk microphysical characteristics of the shallow rain and its bright-band counterpart, and it also demonstrates problems of adequately observing this shallow rain with the operational WSR-88D radars. The shallow non-bright-band rain consistently occurred with weaker radar reflectivity and smaller Doppler vertical velocity than its bright-band rain counterpart possessing equivalent rain rates, implying that the shallow rain consists of smaller drops. These results suggest that this shallow rainfall process would be under-represented in rainfall estimates derived from WSR-88D radars, as well as from satellite. Microwave satellite techniques would assume microphysical attributes that are not applicable to non-bright-band rain and would yield deficient rainfall estimates. Infrared techniques would underestimate the intensity of this rain because of the relatively warm cloud-top temperatures. In short, existing radar-derived and satellite-derived quantitative precipitation estimation (QPE) techniques may indicate little or no rain is falling when, in fact, heavy non-bright-band rain is occurring.

Knowledge gleaned from these new observations can ultimately be applied operationally by improving forecasting of shallow rain events in the coastal zone, by revising reflectivity-based QPE algorithms that take into account small drop size distributions associated with this class of rain, and by improving satellite-derived QPE products based on microphysical attributes and cloud-top temperatures.

Project Personnel: A. B. White, P. J. Neiman (ETL), F. M. Ralph (ETL), P. O. G. Persson, D. E. Kingsmill (DRI)
Funding Sources: NOAA
References: Bulk Microphysical Characteristics of Rainfall Observed at a California Coastal Mountain Site during CALJET (submitted to *J. Hydromet.*), Extending the Dynamic Range of and S-band Radar for Cloud and Precipitation Studies *(J. Atmos. Oceanic Technol.* 17:1226-1234).

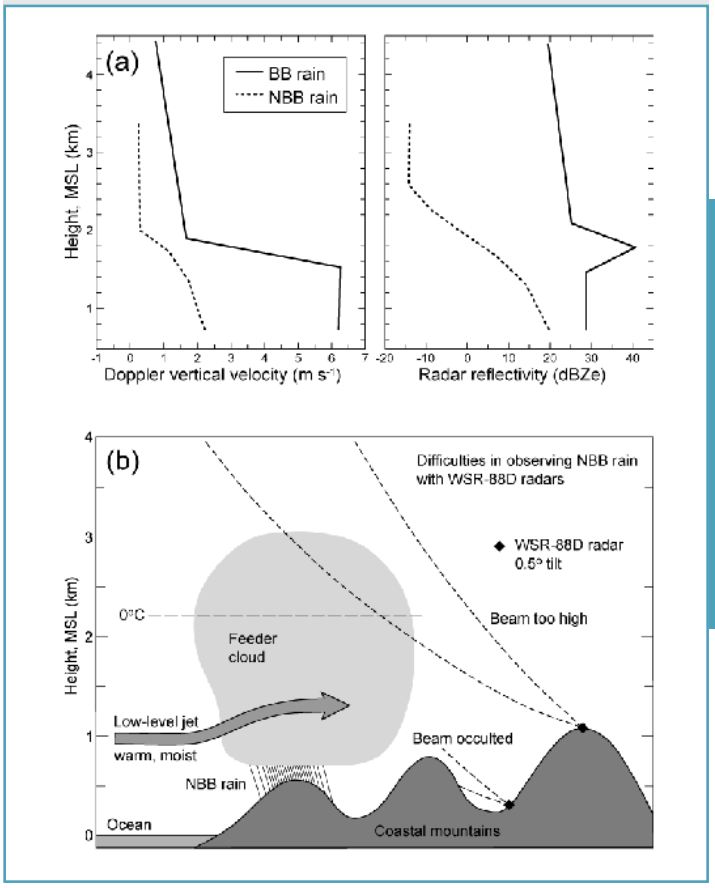


Figure. (a) Composite winter-season profiles of Doppler vertical velocity (m s^{-1}; positive downward) and equivalent radar reflectivity factor (dBZe) measured by the S-band profiler during bright-band rain (BB; solid) and non-bright-band rain (NBB; dashed). The altitude scale of individual bright-band profiles was normalized with respect to the bright-band height prior to the compositing, and the composite bright-band profiles were then plotted relative to the average bright-band height. The average rain rate for each rain type is approximately the same (3.95 mm h^{-1}). (b) Conceptual representation of shallow NBB rain in California's coastal mountains, and the inability of the operational WSR-88D radars to adequately observe it. NBB rain is portrayed falling from a shallow feeder cloud forced by warm and moist onshore flow associated with a land-falling low-level jet (bold arrow).

Integrating Activities

Boundary-crossing pursuits that convey CIRES' science mission to society.

CIRES engages in a wide range of integrating activities in research, education, and outreach that encompass each of the Institute's research themes and contribute to the Institute's mission and those of our partners, NOAA and the University of Colorado. CIRES is committed to science and environmental education, whether that occurs in the classroom, at science conferences, in town meetings, or in congressional hearings.

At CIRES, we believe sharing our knowledge will result in better natural resource and land management, better environmental quality, and a better quality of life for people and other living species.

CIRES provides environmental information to a variety of communities via programs in:
- K-12 Interdisciplinary education and outreach
- graduate and post-graduate education,
- scientific assessments,
- interdisciplinary research, and
- science and technology policy research.

Example: a team of CIRES researchers is partnering with local decision-makers on the North Slope of Alaska.

RESEARCH GOALS

1) To foster interdisciplinary cooperation
2) To share knowledge
3) To forge mutually-beneficial partnerships
4) To open strong lines of communication between CIRES and communities that can use environmental science.

As glaciers melt and permafrost warms and destabilizes, indigenous communities that depended on conditions specific to cold are losing their way of life.

Informed by CIRES environmental research in the area, stakeholders are better able to clarify new requirements for managing their natural resources.

Contributors:
CIRES' K-12 & Public Outreach Program
CIRES' Center for Science and Technology Policy Research
CIRES' National Snow and Ice Data Center Distributed Active Archive Center
CIRES' Western Water Assessment

Global Climate Change and Society

Scientific Impact: Global Climate Change and Society is a REU (Research Experience for Undergraduates) that focuses on the integration of scientific knowledge with social scientific and humanistic perspectives.

Global Climate Change and Society consists of three program leaders (a philosopher, atmospheric scientist, and a policy scientist) and twelve students, the latter drawn from the physical sciences, the social sciences, and the humanities. Students explore the nature of scientific knowledge — its epistemological character, and its social and philosophic implications —and the contribution that social scientific and humanistic perspectives can make in public policy debates. These themes are developed through an examination of the issues surrounding global climate change.

Issues include:
How is climate modeled? What are the predictive abilities of these models, and what are their assumptions, boundary conditions, and initial conditions? Which limits of global climate models are inherently fixable (with more data and more efficient algorithms), and which are fundamentally unaddressable by the scientific method?

What is the nature of scientific knowledge? Does scientific knowledge offer a single, objective methodology that provides an unequivocal knowledge base for the fashioning of public policy? Or are we instead asking science and technology to address questions or problems that are also fundamentally political and/or philosophical in nature? How certain must the science be before the scientist comes before the public? What contribution can the humanities make to our public life? Is it possible that our environmental problems require that we learn how to blend the insights of the humanities with those of the social and physical sciences?

Students receive free housing and a $2000 stipend for the eight weeks. For the 2002 program, 120 applications were received for the 12 spots. The program will run again in the summer of 2003.
Participating Mentors:
Patricia Limerick, CU
James Saunders, CU
Al Cooper, NCAR
Robert Harriss, NCAR
Jill Litt, CU
Clark Chapman, SWRI

Project Personnel: R. Frodeman, R. Pielke, Jr., at the Center for Science and Technology Policy Research; M. Bullock, A. Shaw
Funding Sources: National Science Foundation
References: "Global Climate Change: the State of the Debate," Science and Technology Newsletter, 130 (Winter, 2001); "Undergraduates Study Climate Change Science, Philosophy, Policy," *EOS*, Vol. 83, Number 3, 15 January 2002.

The Impact of Road Traffic on Global Tropospheric Ozone

Scientific Impact: Development of global chemistry-transport models to assess the impact of emissions related to human activities on the composition of the lower atmosphere.

High ozone levels are recorded in urban areas, particularly during summertime, which result from the release of ozone precursors by automobiles, power plants and other industrial facilities. In spite of the measures taken to reduce traffic and industrial emissions, ozone pollution events are still often observed in North America, Europe and Asia. The purpose of this study is to assess the importance of emissions related to traffic on background ozone, and to compare this specific contribution to the effect of other sources, such as non-road traffic, ships or aircraft emissions.

A first step of the study has been completed using the IMAGES global chemistry-transport model, which simulates the distribution of about 70 chemical species in the troposphere. The model accounts for natural as well as human-induced emissions of the species. In the case of CO, the estimated emissions from traffic represent 67% of the anthropogenic emissions and 14% of the total emissions. Estimated traffic emissions represent 40% of the fuel-related emissions of nitrogen oxides and 24% of its total source.

Project Personnel: C. Granier

Funding Sources: NOAA

References: The impact of road traffic on global tropospheric ozone (submitted to *Geophys. Res. Lett.)*

The model simulations show that the perturbations to the distributions of these ozone precursors are significant not only in the vicinity of the emissions areas, but also at the global scale. For example, typical increases resulting from traffic emissions of the CO surface concentration in January are 35% in the US and Western Europe, and 25% in the North Atlantic. The photochemical production of ozone is important during the summer months, and as shown in the figure (left side), emissions related to road traffic increase surface ozone concentrations by 10-15% in Northern America, Western Europe and Eastern Asia. At 300 hPa (right side), where the perturbations are more uniformly distributed in space, the ozone increase in the northern hemisphere is typically 5-8%, which is of similar magnitude as the ozone change produced by current commercial aircraft operations.

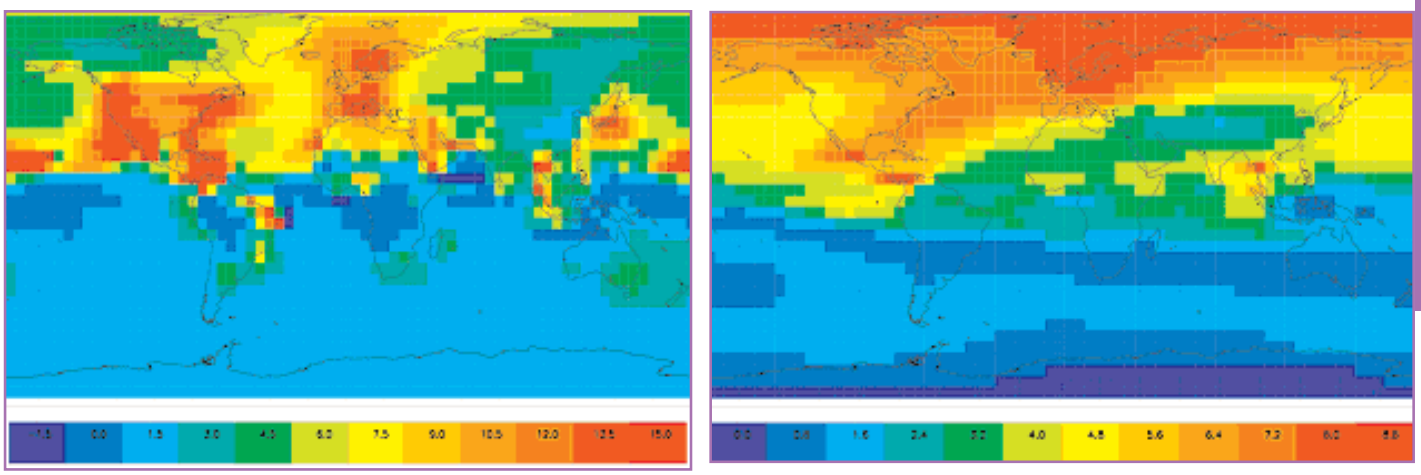


Figure: Percentage difference in the concentration of ozone at the surface (left) and at 300 hPa (right) due to road traffic in July.

2002 Municipal Response to Drought in the Colorado Front Range

Scientific Impact: As part of the larger ongoing Western Water Assessment, this project will identify regional vulnerabilities, as well as regional adaptation strategies and their effectiveness, in the context of the 2002 drought.

In 2002, Colorado experienced one of the lowest snowpack accumulations in decades, as well as one of the driest springs. This came on the heels of several previous dry years. By the end of May the statewide snowpack was only 2% of average, and from October 1, 2001 - May 31, 2002, precipitation was only 56% of average. Statewide reservoir storage was 73% of average on June 1.

By the late spring of 2002, the severity of the drought finally captured the attention of municipal water managers in the Denver metropolitan area along Colorado's Front Range. The result was a variety of policy responses aimed primarily at reducing summer outdoor water consumption through time and type of use restrictions, and secondarily at reducing long-term vulnerability to water shortages.

Project Personnel: D. Kenney, R. Klein, B. Gravell, A. Morrison
Funding Sources: NOAA

In an effort to determine the effectiveness of various adaptation strategies, during the summer of 2002 the Western Water Assessment examined the responses to drought in twelve municipalities along the Front Range. The project tracked the policy response of each municipality to the drought, including the date on which the policy was enacted, the provisions of the policy, the policy's goal, and any enforcement mechanisms. The project also compiled daily water usage and climate data for 2002, as well as for previous years. The project is in the process of analyzing daily water usage, evapotranspiration, and precipitation data, as well as population and economic factors, to identify the effectiveness of particular types and combinations of municipal policy responses to drought.

The CIRES-NOAA Western Water Assessment

Scientific Impact: Understanding the vulnerability of society to climate-related and other stresses, and development of hydro-climate prediction products that meet user needs.

The National Oceanic and Atmospheric Administration (NOAA) under its Office of Global Programs (OGP) developed the Regional Integrated Sciences and Assessments (RISA) program for research and development to improve climate information and its use in the Interior West and in other regions (the Northwest, Southwest, California and Florida). The NOAA-CIRES Western Water Assessment (WWA) began in 1999 and involves a team of over 30 scientists and students at the University of Colorado and NOAA's Climate Diagnostics Center. The mission of the WWA project is to increase the relevance and value of scientific information so as to improve decision-making strategies.

Research is stakeholder-driven. Research focuses on the decision-making processes of the individuals, groups, and organizations 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.

Research Highlights

- Leaders of the Colorado water management community are concerned about their ability to satisfy the new and competing demands for water, particularly in light of increased difficulties in obtaining water from neighboring basins, constraints imposed by interstate obligations, the increasing value placed on environmental protection, and the impacts of regional growth on water quality. These concerns are exacerbated by climate variability. For example, in-stream water rights for environmental protection are comparatively junior, and cannot be relied upon to maintain water levels during times of drought. In response, WWA scientists are currently developing a comprehensive model-based methodology for regional planning. The intent is to understand the benefits and pitfalls (and third-party effects) of various strategies that may be used to cope with water shortages under different climate regimes, and identify innovative management practices that will both sustain economic prosperity and protect the environment.
- Reservoir managers in the Interior West are currently faced with the challenge of providing water for new uses (e.g., in-stream flows, recreation), while still meeting the needs of traditional rights holders and uses (e.g., irrigation, hydropower). Better use of climate information is one tool that may enable reservoir managers to meet these new uses while minimizing conflicts. WWA researchers have focused on specific problems of current concern to reservoir managers (e.g., the increasing need for environmental protection), and organized climate information needs in terms of an annual calendar of decisions. This decision calendar delineates the times of the year that specific types of climate information are most relevant and most useful. The decision calendar has provided a springboard that has encouraged WWA scientists to develop partnerships with reservoir managers to improve the quality, relevance, use, and value of climate information. These partnerships resulted in improved methods for climate monitoring, development of procedures to use seasonal climate outlooks in reservoir operating plans, and improved short-term streamflow forecasts to optimize the management of water and increase in-stream flows for environmental protection. More uses of climate information are emerging which (if implemented) will lead to both higher efficiencies and improvements in environmental protection.

Project Personnel: S. Avery, R. Dole, M. Clark, M. Hoerling, C. Howe, D. Kenney, W. Lewis, D. Mock, R. Pielke, Jr., J. Saunders, P. Sperry, A. Barrett, G. Bates, G. Cronin, J. Eischeid, C. Goemans, S. Jain, R. Klein, M. Lohaus, A. Nacu-Schmidt, C. Nierenberg, J. Pitlick, R. Pulwarty, A. Ray, B. Rajagopalan, L. Rozaklis, R. Webb, J. Wiener, K. Wolter, C. Woodhouse

Funding Sources: NOAA

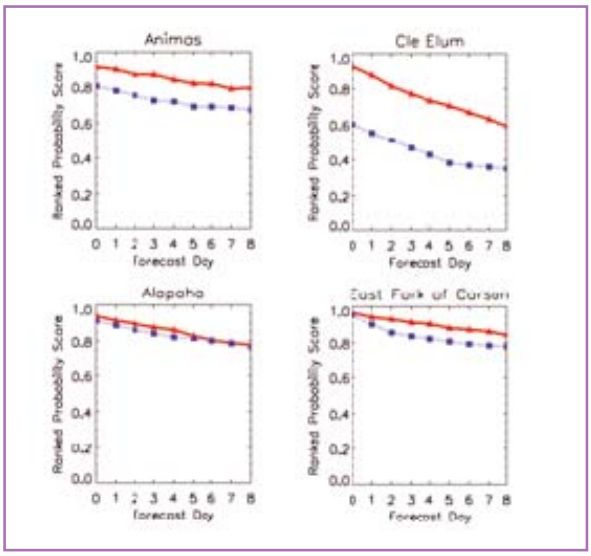
References: For more information and a complete set of references, see http://sciencepolicy.colorado.edu/wwa/.

Hydro-Climate Research and Decision Making

Scientific Impact: Improved streamflow forecasts that meet the decision-making needs of water managers in different parts of the country.

Project Personnel: M. Clark, S. Gangopadhyay, A. Barrett, L. Hay, G. McCabe, R. Viger, S. Markstrom, G. Leavesley, B. Rajagopalan, Y. Hwang, S. Regonda, K. Grantz, E. Zagona, S. Jain, A. Ray, J. Whittaker, D. Boyle, G. Grell, W. Gutowski, R. Arritt, E. Takle, R. Wilby, D. Brandon, S. Shumate, J. Schaake, Q. Duan
Funding Sources: NOAA

Several grants at the Center for Science and Technology Policy Research revolve around the central theme of advancing hydro-climate research to meet the decision-making needs of water managers in different parts of the country. Work elements include a) comparison and development of methods for statistical downscaling of global-scale forecast model output to provide forecasts of precipitation and temperature at local scales in individual river basins, and b) assessment of the use of multi-model superensemble techniques in hydrology to provide probabilistic forecasts of streamflow, and c) assessment of the issues involved in fully integrating hydrologic forecasting capabilities within atmospheric modeling systems. Results demonstrate that our experimental streamflow forecasting system has considerable skill in the snowmelt-dominated basins in the western United States (see Figure). We are currently working with the Colorado Basin River Forecast Center to compare our experimental streamflow forecasting procedures with the current operational procedures during the 2003 snow melt season, and are also working with the NWS Office of Hydrologic Development to infuse our experimental forecasting techniques in the NWS Advanced Hydrologic Prediction System.



This figure summarizes the skill of our experimental streamflow forecasting system (red triangles, solid line) versus the traditional ESP approach (blue squares dotted line) in terms of the ranked probability skill score. Results are shown for four river basins nationwide: the Animas River in southwestern Colorado, the Cle Elum in central Washington, Alapaha River in southern Georgia, and the east fork of the Carson on the California/Nevada line.

Experimental Meteorological Products in the Operational Environment: Real-Time Access, Training, and Feedback

Scientific Impact: Determined how to build an effective working relationship between the research and operational communities. Developed a web-based form for collecting feedback on real-time, experimental meteorological products.

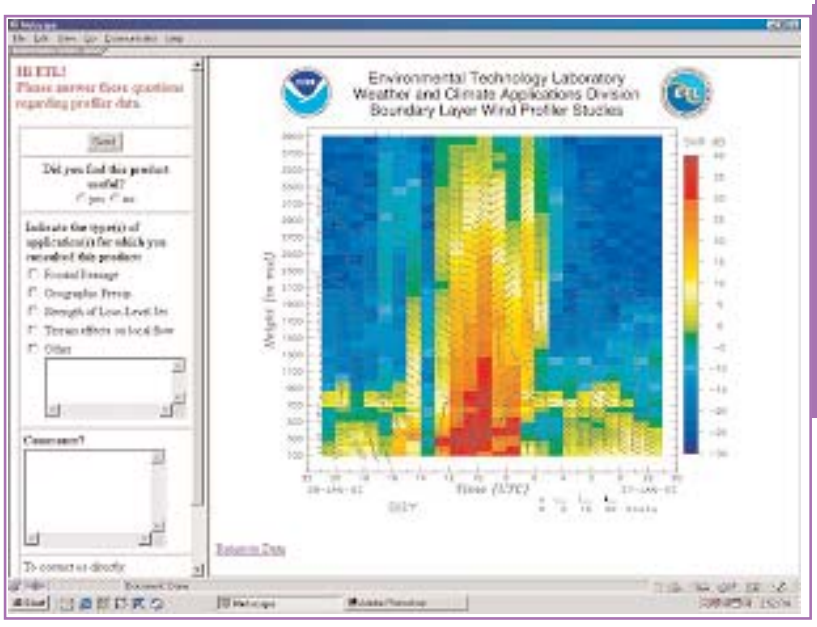
Project Personnel: L. B. Nance, A. N. Keane (ETL), D. J. Gottas, W. R. Schneider (NWS/Portland, OR), and F. M. Ralph (ETL)
Funding Sources: NOAA
References:
http://www.etl.noaa.gov/programs/2002/pacjet/eval/tally.pl?list=1

Interactions between a research team and the National Weather Service (NWS) forecast offices in California as part of the California Land-falling Jets Experiment (Jan-Mar 1998) suggested that real-time availability of experimental data could be of substantial benefit to local forecasting in coastal regions, particularly the NWS Watch-Warning program. Based on this experience, the Regional Weather and Climate Applications Division of NOAA/ETL has actively pursued opportunities to provide NWS forecasters on both the West and East Coasts of the United States with real-time access to experimental products during subsequent field experiments.

Through our experiences, we have discovered that simply providing real-time access to experimental products is not sufficient. For the operational community to make effective use of experimental products, training on how to access the data and potential forecast applications needs to be provided. Two types of training have been utilized: teletraining and office visits. While teletraining provides an inexpensive means of reaching a number of forecast offices, visiting the office and interacting with the forecasters face-to-face appears to be the most effective means of motivating forecasters to incorporate experimental products into their forecast process.

In addition to training, NOAA/ETL put into place mechanisms to collect feedback from the forecasters in order to assess the impact of the experimental products on the forecast process. Given the constraints of the operational environment, these mechanisms were designed to collect feedback in real-time while having a minimal impact on a forecaster's workload. Three strategies for collecting feedback were tested during recent field experiments: web-based forms, feedback via Area Forecast Discussions, and a special email address. A web-based form that appears with the experimental product proved to be the most effective means of gathering feedback from operational forecasters (example shown below). This form used a simple point and click methodology with an option to provide additional comments. The point and click portion of the form gathered information on whether the forecaster found the product useful and the forecast applications for which they consulted the product. Forecasters used the comments box to indicate how the product impacted their forecast (e.g., issuance of a Winter Storm Warning), problems with a particular product, or aspects of a product they especially liked. Information on which office submitted the comments, which product the comments are related to, and the date and time of the entry are automatically logged when the feedback is submitted.

The response from the NWS forecast offices to this important interaction between research and operations has been very positive.



Flood Damage in the United States, 1926-2000
A Reanalysis of National Weather Service Estimates

***Scientific Impact:** We need flood damage data to assess the reasons for increasing flood damage and their implications for policy, decision makers need to distinguish the influences of climate, population growth and development, and policy on damage trends. For example, increased damage due to changing climate may require different policy actions than would increases that result from implementation of particular policies. Scientists, too, need historical flood damage data at a variety of spatial scales to analyze variations in flood damage and what contributes to them.*

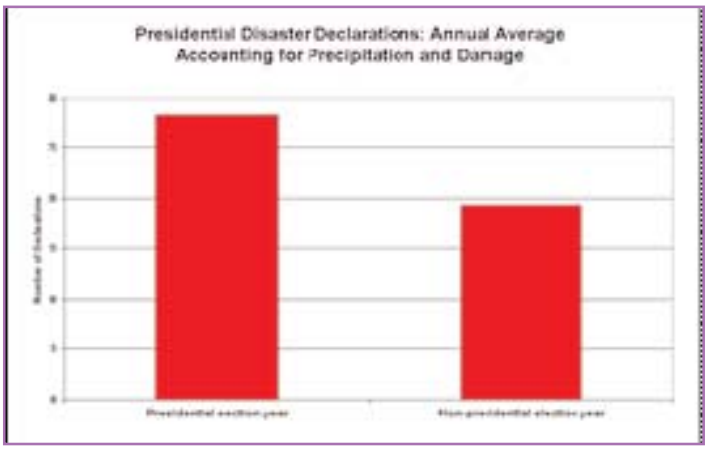
Flood damage has increased in the United States, despite local efforts and federal encouragement to mitigate flood hazards and regulate development in flood-prone areas. To help researchers and policy makers assess national progress in reducing vulnerability to flood hazards, reasonably accurate assessments of flood damage are needed. Yet, accurate accounting for losses has historically received little attention, except in the case of insured property.

The National Weather Service (NWS) is the only organization that has maintained a reasonably consistent long-term record of flood damage throughout the U.S. The NWS damage estimates do not represent an accurate accounting of actual costs, nor do they include all of the losses that might be attributable to flooding. Rather, they are rough estimates of direct physical damage to property, crops, and public infrastructure.

The flood damage estimates presented in this project are compiled from NWS records and publications, supplemented by reports of other federal and state agencies. The report includes an evaluation of the accuracy of the estimates and recommendations for users of the data. Users should be aware that estimates for individual flood events are often quite inaccurate. However, when estimates from many events are added together the errors become proportionately smaller. When properly used, the reanalyzed NWS damage estimates can be a valuable tool to aid researchers and decision makers in understanding the changing character of damaging floods in the U.S.

Project Personnel: R. Pielke, Jr., M. Downton (NCAR), Z. Miller (CU-PSCI)
Funding Source: NOAA OGP Climate Change Data and Detection
References: Downton, M. and R. Pielke, Jr., 2001: Discretion Without Accountability: Climate, Flood Damage and Presidential Politics, *Natural Hazards Review*, 2(4):157-166. http://sciencepolicy.colorado.edu/pielke/hp_roger/pdf/downtonpielke2001.pdf

Pielke, Jr., R.A., M.W. Downton, and J.Z. Barnard Miller, 2002. Flood Damage in the United States, 1926-2000: A Reanalysis of National Weather Service Estimates. Boulder, CO: UCAR. http://www.flooddamagedata.org/



Sombrero Marsh: A Model for Best Practice in Geoscience Education

Scientific Impact: The Sombrero Marsh Environmental Education Program integrates sound educational pedagogy and scientific research by providing students of the Boulder Valley School District an opportunity to conduct studies at the marsh and input their data into a database, which will be used by the city of Boulder's Open Space and Mountain Parks for monitoring the restoration of the marsh. Through this process, students become models of the scientific process.

Personnel: Lesley K. Smith (CIRES), Mark Sparn and John Delmonico (Boulder Valley School District), Pat Comeaux (Thorne Ecological Institute), Dave Sutherland and Joe Mantione (city of Boulder Open Space and Mountain Parks)

Funding Sources: Boulder Open Space and Mountain Parks, GOCO, CIRES, EPA.

The Sombrero Marsh Environmental Education Program was established by a unique group of partners; the Boulder Valley School District (BVSD), the Thorne Ecological Institute and the city of Boulder Open Space and Mountain Parks (OSMP). CIRES Outreach (L. Smith) is collaborating with these organizations at their request to develop curriculum that uses "student-scientists" to monitor the restoration of the marsh and the impact of classroom groups on the health of the marsh. When fully implemented, the Education Program will accommodate every 1st and 4th grade, and middle school BVSD student, as well as high school students partaking in supervised research projects.

The involvement of CIRES Outreach was requested because of Dr. Smith's expertise in wetland ecology and our strengths in field- and inquiry-based pedagogy. One interesting and innovative aspect of the project is that student-generated data will be used by OSMP for their marsh restoration and monitoring program. The curriculum includes general student field observations (sights, sounds, smell), along with weather, groundwater depth and temperature, human impacts on the marsh, and ecosystem activities. The curriculum Dr. Smith helped to develop is integrated with the district-wide science education infrastructure, is suitable to transfer to other schools and is designed to include all special needs (physical and learning disabilities), English as a second language (ESL), and under-represented students in outdoor learning experiences. The educational value of the visit is increased by pre- and post-visit classroom activities. Teachers must attend professional development classes before being allowed to bring their students to the marsh, wherein they learn more about the important scientific processes of the marsh and become accomplished with the pre- and post-visit activities.

Post-visit activities include contribution to a database to be accessed by subsequent student groups and by OSMP, writing an environmental impact statement based upon their observations, and growing marsh plants under different watering regimes. The curriculum and teacher professional development has been pilot-tested with ten teachers and 125 BVSD students in preparation for wider implementation in the upcoming academic year. As the project matures, BVSD desires scientific input from CU for the monitoring study and to engage scientists as high school student mentors.

This project has high visibility due to the nature of the partnership, the support of EPA and Colorado Lottery funds, and the role of students in the restoration of the marsh. The CIRES contribution to the effort is being acknowledged when the project is discussed, and is establishing stronger relations within the partner organizations.

St. Vrain Valley School District (SVVSD) Systemic Reform

Scientific Impact: CIRES contributions to local geoscience education, established local partnerships

CIRES Outreach has contributed to systemic reform in science education at the SVVSD since 1996, but our efforts have expanded over the past year to influence more of the district curriculum. We have expanded from professional development and integration of geoscience into physical science courses at the high school level to providing scientific expertise for district-wide science standards and associated assessment. The SVVSD science standards are being established and aligned with standards throughout the curriculum (e.g. social science, math, literacy). This new science framework, articulated throughout the grades, will provide the basis of new professional development for SVVSD teachers in the upcoming year. An example of how CIRES contributes to district science education is the new "Geology at our Doorsteps" project (S. Laursen and A. Lester). This program features the development of rock collections comprised of samples from Front Range geological formations and related educational materials. Building the kits is a professional development opportunity for science teachers, and the kits will be used with other school districts and in a CIRES CU-Boulder Earth Science course for prospective teacher education.

Project Personnel: S. M. Buhr, , S. Laursen, A. Boehm, Karen Hunter (St. Vrain Valley School District)

Funding Source: St. Vrain Valley School District, Eisenhower Education Funds, CIRES, University Outreach.

The CIRES/DLESE Evaluation Toolkit and Community

Scientific Impact: Promotes better practices in geoscience education through bridging of geoscience and social science communities.

Project Personnel: S.M. Buhr, T. Palmer, CIRES; Lecia Barker, ATLAS, CU-Boulder, Marianne Weingroff, Jennifer Mangan, UCAR.
Funding: National Science Foundation

As more and more research institutions and science departments initiate education and outreach activities, funding agencies and stakeholders demand a greater understanding of our successes and failures. A key to meeting our accountability needs and informing our practices is the use of robust project evaluation, a social science endeavor in which few natural and physical scientists have experience. To enable more and better use of project evaluation, CIRES Outreach is developing a digital resource and community within the Digital Library for Earth System Education (DLESE) to make project evaluation more readily implemented and more visible within the field.

The goals of the Evaluation Toolkit and community project are to:

- Establish a forum and community for evaluation dialogue within DLESE.
- Provide a robust collection of evaluation resources useful for Earth science educators.
- Disseminate the resource through the DLESE infrastructure and through professional society workshops and proceedings.

To these ends, we have built and populated a beta web site for geoscience evaluation, garnered initial community feedback from the DLESE and broader geoscience education community, and begun to increase the visibility of project evaluation within the geoscience education field.

Our target audiences for the Evaluation Toolkit site are:

- Principal investigators and project managers with geoscience education projects to administer,
- K-12 teachers with project such as outdoor center or service learning projects,
- Professional evaluators searching for geoscience education evaluation tools, and
- Out of field evaluators-those who conduct evaluation but have not been formally trained.

The site contains features that allow users to access professional development about evaluation, search and find evaluation resources, submit resources, find or offer evaluation services, and sign up for upcoming workshops The resources within the collection have met initial screening criteria, but will also be subjected to rigorous peer review by evaluators, educators, scientists and users. The web site has been refined and revamped once in response to feedback from the advisory board, which is composed of members of the target audiences. The site has progressed enough that it will be made public this fall, prior to a CIRES project evaluation workshop to be held at the 2002 Fall AGU meeting.

This workshop and others are being held because the success of the project is intrinsically tied to community input and awareness. The web site and project were presented to the DLESE community for the first time during a talk and evaluation workshop during the DLESE Annual Meeting. In response, many community members voiced support, volunteered resources or involvement and solicited advice or contacts to help them meet their evaluation needs. A most welcome response was "I always saw evaluation as a chore, but you really make me think it is worthwhile and doable." Two more workshops are in the planning stages, one for the Fall 2002 AGU meeting and one during the National Science Teachers Association annual meeting. Project evaluation in geoscience education is also the topic of a special session at the Fall AGU meeting.

Creative Projects within Undergraduate Education

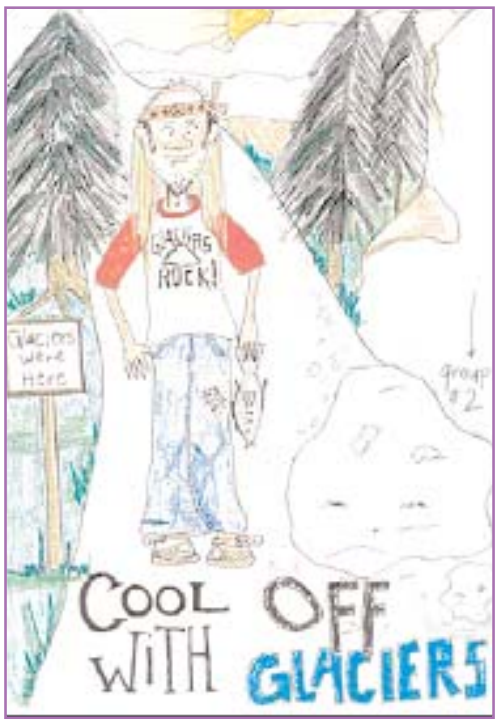
Scientific Impact: Promotes better understanding and teaching practices with non-science undergraduates.

The 2002 Research and Education Fellow, Dr. Ray Beiersdorfer, has concentrated on understanding teaching strategies based on engaging a student's creativity while they learn science. Such strategies avoid reinforcing non-major science students' perceptions that science is hard and done by "other people". In order to help the students make connections, Dr. Beiersdorfer creates a class environment where students can combine the science subject matter with their creative talents. This is accomplished by a series of group projects related to various geology topics (such as rocks, minerals, earthquakes, volcanoes, etc.). The projects are designed to enable students to learn the course content while they are synthesizing and applying the subject matter in creative ways. These projects enhance learning for students whose dominant learning style is not consistent with a traditional lecture-based approach. They engage several of the students' Multiple Intelligences not typically associated with a science class (Musical/Rhythmic, Visual/Spatial, Bodily/Kinesthetic, Interpersonal) and require the students to use higher order thinking skills of application and synthesis.

While at CIRES, Dr. Beiersdorfer defined a study of student outcomes resulting from such projects, to be conducted in a quasi-experimental mode within his and other courses at Youngstown University; adapted tools from other studies to this application; contributed to CIRES Outreach projects; and developed a DVD about using this kind of creative project that has been very well received. He has made numerous presentations and contacts about this work while here, and also spent much of his time conducting soils research, which will also influence his courses at Youngstown University.

Project Personnel: Ray Beiersdorfer

Funding: CIRES Visiting Fellowship, Youngstown University



The CIRES Outreach Program: Outreach Components for Research Grant Proposals

Scientific Impact: High quality outreach components enhance competitiveness of research proposals.

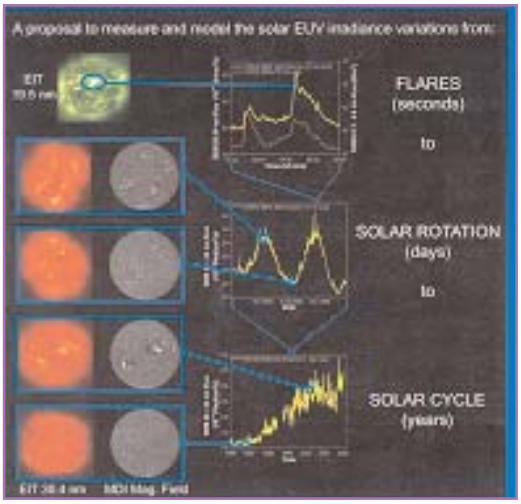
Project Personnel: S. M. Buhr, S. Laursen

Funding: CIRES, NASA

"*NSF* has many outstanding science proposals. It is beginning to be the case that the difference between an excellent proposal and an excellent proposal that will be funded is the quality of the response to Criterion 2 - the broader impacts of the research." (Margaret Leinen, NSF Assistant Director, Geosciences Directorate, quoting a Program Officer in the Division of Environmental Biology, Fall Meeting AGU 2001.

CIRES Outreach collaborates with principal investigators to meet funding agency requirements for outreach components on research grant proposals. For many NASA programs, such requirements are specifically tied to education and public outreach (EPO), while NSF Criterion 2, Broader Social Impacts, encompasses a wider range of activities. For some programs, the education component can account for twenty percent of the proposal review weight, a percentage too substantive to treat lightly when research dollars are tight. The CIRES Outreach Program has existing projects and contacts that are leveraged within research-related projects, such as our Earthworks summer teacher workshop, our Department of Geological Sciences Earth Systems course for prospective teachers, and our systemic reform work with the St. Vrain Valley School District. Such existing projects provide a stable home for mission-related education, while the funding received through successful proposals allows the outreach program to expand into new areas. In the past several years the CIRES Outreach program has provided outreach components for research proposals in astrobiology, hurricane research, global atmospheric dynamics, arctic climate systems data archival, and interactions between climate change and cholera. The research teams we have worked with have been led by CIRES or NOAA investigators, or include CIRES research collaborators.

In example, a major proposal to the NASA Solar Dynamics Observatory program has been funded recently, along with the associated education outreach. This LASP research project will measure the output of the Sun's extreme ultraviolet radiation, in collaboration with the SEC and others. The education project contributes to the developing Denver Museum of Nature and Science Space Odyssey exhibit, funds new work with a nationwide after school program for educationally disadvantaged youth, and provides new funding for some of our existing projects.



Cover page from a recently funded NASA project.

integrating activities

Geodynamics

Gaining a better understanding of convection within the Earth's mantle, and of how convection affects the surface of our planet.

The mantle extends from the top of the Earth's liquid core at a spherical radius of about 3500 kilometers up to the Earth's surface at a radius of about 6400 kilometers. It behaves as a solid at time scales over which we live, but convects as though it were fluid over geological time scales. As yet, neither mantle structures nor convection processes are well understood.

Its convective motion, on the order of a few centimeters per year, causes oceans to open and close, continental plates to drift across the Earth's surface, and the Earth's crust to buckle and deform creating mountain ranges and other structural features. Convective displacements underlie earthquake and volcanic activity. The convective process plays an indirect but fundamental role in determining the Earth's climate through its impact on surface topography.

CIRES' studies of geodynamics focus on mantle convection and deep-earth seismology, plate motions and plate boundary deformation, geochemistry of continental evolution, mechanics and hydrology of surface fractures, erosion, mountain building and climate, and monitoring mass movements.

RESEARCH GOALS

1) To increase our knowledge of the fundamental processes that drive the mantle.
2) To use new experimental methods to detect and monitor internal motions of the mantle, the presence of layering, the movements of continents and the transfer of mass between atmosphere, continent and ocean.
3) To examine the chemistry and physics of near-surface rock processes
4) To investigate links between geophysical processes and human demographics.

Example:

CIRES researchers have conducted geodetic measurement programs in China, Tibet, Nepal, India, Mexico, Ethiopia, Venezuela, New Zealand, and the eastern Caribbean, mostly aimed at resolving the details of plate motions. Particular interest centers on velocity fields across plate boundaries because these hold clues about the generation and distribution of future earthquakes. Experiments use GPS and absolute-gravity measurements to determine strain and vertical motions, occasionally supplemented by leveling, tiltmeters, and strainmeters.

Contributors:

CU-Boulder's Geological Sciences Department
CU-Boulder's Geophysics Program
CIRES Colorado Center for Chaos and Complexity (C4)
NOAA's National Geophysical Data Center

El Niño as a Blueprint for Pre-Ice Age Climate

Scientific Impact: Demonstration of the importance of a tropical sources on climatic differences at high latitudes over geologic time.

We challenge the common notion that the change from warm equable climate to an Ice-Age Earth resulted from forcing at high latitudes; this is commonly manifested in emphasis on changes in North Atlantic Deep Water production in the Atlantic.

A year ago, we showed that the closing of the Indonesian Seaway by New Guinea's northward movement toward the equator should have transformed Indonesian Throughflow from transport of warm water in the Pacific south of the equator to flow of cooler water from north of the equator into the Indian Ocean. We inferred that the New Guinea's blockage of warm water could have created the warm pool in the western Pacific, with its related ENSO processes. A test of such an idea can be made by comparing differences between Pre-Ice Age climates from those at present with El Niño's teleconnections and tropical anomalies.

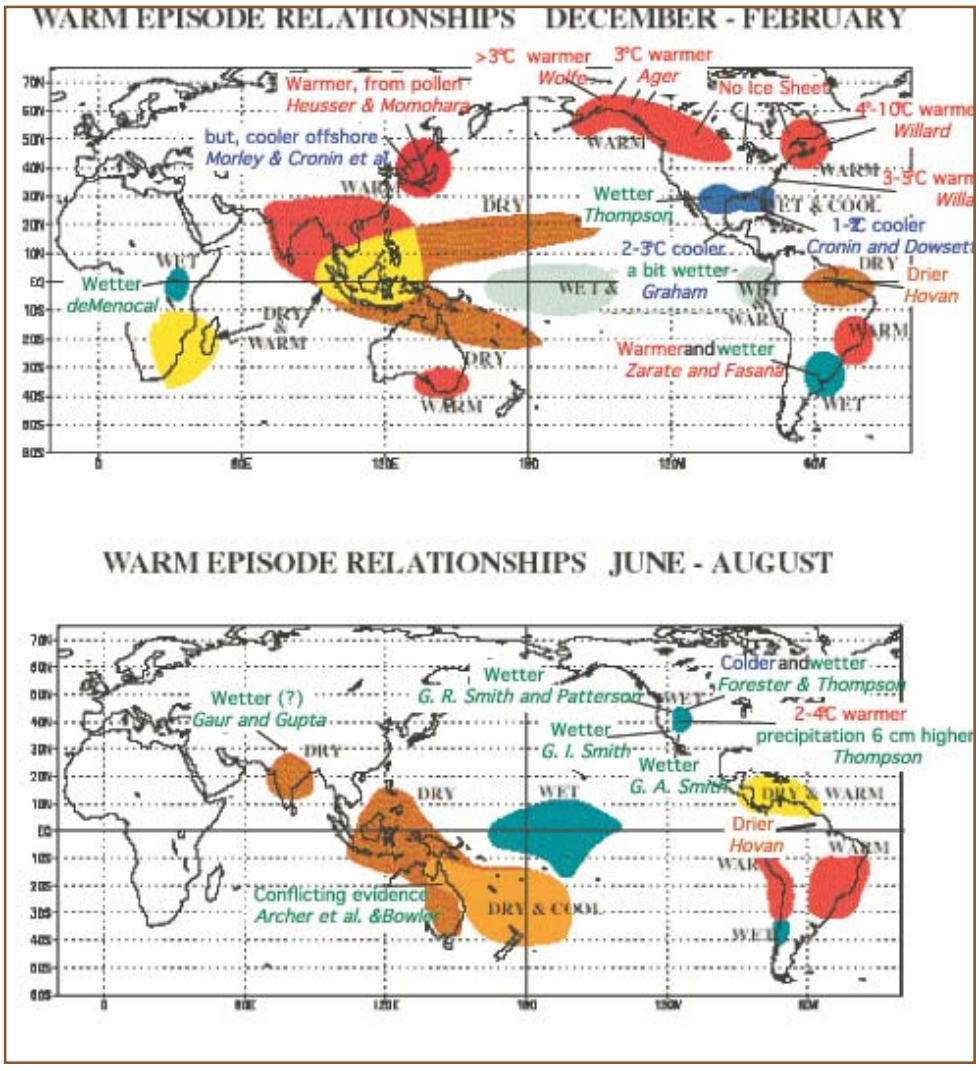
Indeed, paleoceanographic inferences of sea-surface temperatures and depths of the thermocline in the tropical Pacific imply that before ~3 million years ago, the sea surface in the eastern Pacific was warmer than today and the thermocline was deeper. Moreover, the thermocline in the western Pacific was shallower. All of these are consistent with a pattern similar to that during El Niño events. Moreover, differences between Pre-Ice Age climates and those today bear resemblance in many, but not all, El Niño teleconnections (see figure). Specifically, Canada, where ice sheets formed, was warmer, but the Gulf of Mexico was cooler than today. The Amazon basin seems to have been dry.

These observations suggest that we may view, to a first approximation, differences in Pre-Ice Age climates and those today as perturbations to the present-day basic state, with the main difference being the forcing in the tropics.

Project Personnel:
P. Molnar, M. A. Cane (Columbia University)

Funding Sources:
CIRES (Molnar), NSF (Cane)

References: El Niño's tropical climate and teleconnections as a blueprint for pre-Ice Age climates, Paleoceanography, 17 (2), 10.1029/2001PA000663, 2002.



Preparing for Time-Variable Gravity Measurements from the GRACE Satellite

NASA, in partnership with the German Space Agency DLR, launched the dedicated gravity satellite GRACE in March, 2002. This five-year mission will map out the Earth's gravity field to unprecedented accuracy at monthly intervals. The temporal variations in gravity inferred from these data will allow people to study a wide range of processes, cutting across a variety of Earth science disciplines, that involve redistribution of mass within the Earth and at or near its surface. It will be possible, for example, to produce monthly estimates of changes in continental water storage anywhere in the world, averaged over scales of a few hundred km and greater, to accuracies of better than 1 cm water thickness. Changes in the distribution of snow and ice on the polar ice sheets will be determined to this same level of accuracy. Monthly estimates of changes in sea floor pressure over scales of a few hundred km and greater will be determined to a few tenths of a mbar or better, everywhere over the globe. The effects of the solid Earth's viscoelastic response to the removal of the enormous late Pleistocene ice sheets and to the Holocene fluctuations of the Antarctic and Greenland ice sheets can be determined.

CIRES is taking a leading role in exploring the possible applications of this novel technique, developing methods for converting the GRACE gravity fields into useful measurements of mass redistribution, and looking at ways of combining GRACE measurements with measurements from other techniques (i.e. the satellite radar altimeter measurements of sea surface height; GLAS laser altimeter measurements of ice sheet elevations; GPS crustal motion measurements) to optimize the scientific return.

Project Personnel: J. Wahr, I. Velicogna, S. Jayne, S. Swenson
Funding sources: NASA, JPL, University of Texas, NSF
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Earthquakes in India

Scientific Impact: Geodetic measurements throughout the Indo-Asian collision, combined with historical archives provide new insights into future earthquake hazards in India.

Geodetic and historical archive data for damaging earthquakes in India have been systematically re-processed to revise magnitudes and rupture parameters. Special studies have been undertaken for M>7.5 earthquakes in 1505, 1819, 1803, 1833, 1842, 1881, 1892, 1897, 1905, 1914, 1931, 1935, and 2002 which have claimed more than 100,000 lives. In the past several centuries earthquakes have ruptured less than 35% of the Himalayan plate boundary, and a similar pattern is emerging for the western and eastern transfoms in Baluchistan and Burma. Geodetic measurements reveal an absence of significant strain within the subcontinent (<3 mm/yr in the past decade) but suggest significant convergence across the ancient rift zone of Kachchh (1 cm/yr in the past century). We are entertaining the possibility that flexure of the subcontinent may underly local deformation, and most of India's mid-plate seismicity

Continuous GPS tracking sites in Pakistan, Bhutan, Nepal and India are planned to form part of a monsoon-monitoring network in the subcontinent.

Project Personnel: Roger Bilham, Peter Molnar, Becky Bendick, Kali Wallace, Freddy Blume and Nicole Feldl.

Funding Source: NSF

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Crustal Deformation in California, Africa, Venezuela and Mexico

Scientific Impact: Plate boundary deformation processes are monitored in several countries with a view to determining the physics of the earthquake process.

GPS monitoring programs in Venezuela and Mexico provide details of the plate boundary velocity fields in these areas. In Venezuela we report an estimate for the rotation pole of the Caribbean plate relative to south America. In Mexico we report episodic changes in aseismic slip on the subduction zone. In California we operate an array of five creepmeters on the Hayward fault in the Bay Area, and a pair of long baseline tiltmeters monitoring volcanic activity in Long Valley. A slow earthquake was detected on a normal fault in the Long Valley caldera with a coherent strain field detected on the 11 independent sensors of the 850-m-long biaxial tiltmeter. An analysis of tidal strain amplitude (20-minute kinematic GPS solutions over five months) across the African rift produced the null result, that strains within and contiguous to the Ethiopian rift show no evidence for rheologic weakness of the rift zone.

The new 500-m-long tiltmeter that was installed near Acapulco, Mexico used float sensors. In 1999 and 2002 we installed similar sensors in the Long Valley tiltmeters. The new sensors have the advantage that they require no maintenance and operate at low power (<0.1 watt). They monitor tilt signals between deep reference points and the equipotential water surface directly, halving the number of signals required to measure each axis of tilt. The new biaxial tiltmeter costs roughly $40k to construct and install, has a tilt resolution of 1 nanoradian, and a long term stability better than 0.1 µrad/yr.

Project Personnel: Roger Bilham, Becky Bendick, Omar Perez, Modesto Ortiz, Tony Lowry, Kristne Larson and Vladimir Kostoglodov

Funding Source: NSF, USGS, Conacyt, and V.S.F.

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Chemical and Physical Evolution of the Earth's Lower Continental Crust

Scientific Impact: Fundamental insights into the evolution of the deep continental lithosphere

The Earth's lower continental crust is generally inaccessible to direct study, but its chemical composition and thermochemical evolution are critical aspects of the overall evolution of the Earth's continents. To gain insights into how the lower crust is formed and then modified by subsequent geologic events, a major investigation was undertaken of the lower crust beneath northern Colorado and southern Wyoming. This work is part of the Rocky Mountain Continental Dynamics projects funded by the National Science Foundation (EAR), and involved workers at the University of Wisconsin, MIT, the University of Massachussetts and CU.

In detail, the study demonstrated that north of the Cheyenne Belt, within the southern portion of the Archean Wyoming craton, lower crustal xenoliths entrained in ~ 1Ma ultrapotassic volcanic rocks at Leucite Hills are dominantly mafic (3.5 to 13.5 wt % MgO), one or two-pyroxene (garnet absent) hornblende granulites. Estimates of peak metamorphic conditions are on order of 1.1 to 1.3 GPa and 800-1000^{o}C that, along with their high densities (2.7 to 3.1 g/cm^{3}), suggest that the mafic rocks are lower crustal in origin. U-Pb zircon dates (~2.6 Ga) and Late Archean Nd (TDM) dates all indicate that the mafic lower crust is Late Archean, equivalent in age to exposed felsic crust in southern Wyoming. Physical property measurements from mafic granulites yield V_p=6.2 to 6.9 km/s and V_s=3.5 to 3.9 km/s, at 1 GPa.

South of the Cheyenne Belt, in Paleoproterozoic crust, mafic granulite xenoliths entrained in Devonian kimberlites of the State Line district in northern Colorado have similar major element compositions to Leucite Hills xenoliths. These xenoliths are dominantly one or two pyroxene, garnet granulites that lack hornblende or other hydrous phases. Peak metamorphic temperatures are between 625 - 831°C and pressures are generally 1.1 - 1.2 GPa, similar to the values determined for Leucite Hills xenoliths. The State Line xenoliths yield a complex spectrum of Paleoproterozoic U-Pb zircon dates, and some Archean grains as old as 3.1 Ga. Whole rock Nd isotopic compositions lie within the range of values expected for Paleoproterozoic crust. The xenoliths also generally lack the prominent relative depletions in high field strength element abundances relative to large ion lithophile elements characteristic of the Leucite Hills xenoliths, but can be divided into high La/YbN and low La/YbN groups (La/YbN =3.0 to 14.6 vs. 0.4 to 0.9). The latter xenoliths likely represent restite remaining after partial melting of lower crust at ~1.4 Ga. Due to the presence of garnet, seismic velocities for the State Line mafic granulites (V_p=6.6 to 7.2 km/s, V_s=3.7 to 3.9 km/s, at 1 GPa) are generally higher than for their Leucite Hills counterparts. The existence of a high-velocity lower crustal layer beneath northern Colorado suggests that garnet bearing mafic lower crust persists beneath the region today. The new data reveal that mafic lower crust north of the Cheyenne Belt has remained hydrous and largely unperturbed thermally since Late Archean while Paleoproterozoic lower crust in northern Colorado is anhydrous, garnet-rich, and shows evidence for heating and partial melting after the crust originally formed. We speculate that deep continental crust beneath Leucite Hills was shielded mantle from the thermal events that extensively affected Paleoproterozoic crust immediately to the south by thick, buoyant Archean lithospheric mantle.

Project Personnel: G. Lang Farmer
Funding Source: NSF (EAR-Continental Dynamics)
References: "Contrasting Lower Crustal Evolution Across an Archean-Proterozoic Suture: Physical, Chemical and Geochronologic Studies of Lower Crustal Xenoliths in Southern Wyoming and Northern Colorado", Farmer et al., submitted to AGU Monograph, July, 2002.

Implications of Pliocene Removal of Mantle Lithosphere of the Sierra Nevada, California

Scientific Impact: Convective motion of dense material at the top of the mantle can drive substantial deformation of the Earth's surface and influence plate boundary geometries.

Pliocene (~3.5 Ma) removal of dense eclogitic material under the Sierra Nevada has been proposed on the basis of xenolith and volcanic rock petrology, geochemistry, and seismological and magnetotelluric observations. A necessary consequence of replacing eclogite with peridotite is that elevations and gravitational potential energy both increase, which in turn should increase extensional strain rates in the area. If it is assumed that Pacific-North America plate motion is constant, then increased extensional strain rates in the vicinity of the Sierra must be accompanied by changes in the rate and style of deformation elsewhere. Changes in deformation in California and westernmost Nevada are consistent with these predictions. Uplift along the Sierran crest of >~1 km is dated to 3-8 Ma, and probably was accompanied by an increase in gravitational potential energy of 1.2 x 1012 N/m or more. Extensional deformation within ~50 km of the eastern side of the modern Sierra initiated about 3 Ma, and shortening that produced the California Coast Ranges is estimated to have begun about 3-5 Ma. The Pliocene uplift, and initiation of extension and contraction along the margins of the Sierra, all suggest that this delamination event extended the entire length of the range. The uplifted area lies between two large, upper-mantle, high-P-wave-velocity bodies at each end of the Great Valley that plausibly represent the material removed from the base of the crust.

Project Personnel: Craig H. Jones, G. Lang Farmer

Funding Source: NSF

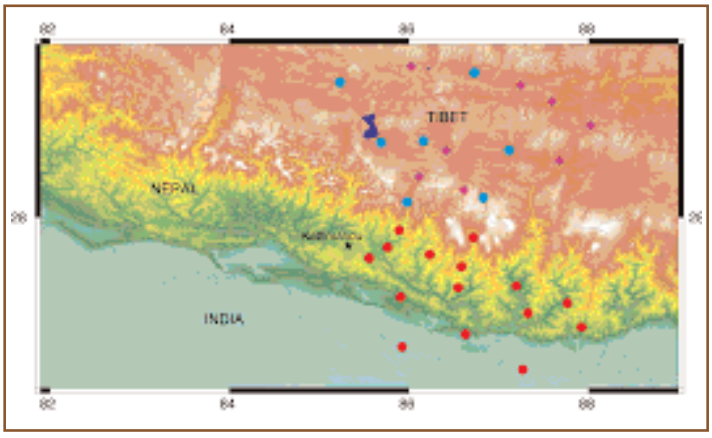
Reference: Jones, C. H., G. L. Farmer, and J. R. Unruh, Tectonics of Pliocene Delamination of Lithosphere of the Sierra Nevada, California, submitted to *Geology,* August 2002.

HIMNT: Himalayan Nepal Tibet Seismic Experiment

Scientific Impact: Improved understanding of nature of India/Eurasia continental collision, earthquake hazards along the Himalayan Frontal Thrust fault, and the mountain building associated with Mt. Everest.

Project Personnel: A. Sheehan, R. Bilham, F. Blume, R. Bendick
Funding Sources: NSF
References:
Continuous data archived at IRIS data management center at www.iris.edu.

The most impressive continental collision today is in the Himalaya. Recent GPS surveys in this area have identified a zone less than 100 km wide where some 18 mm/yr of the overall collision are being absorbed. In order to better understand how this deformation is accommodated at depth, and to better understand both the earthquake hazards and mountain building processes in the region, we deployed 15 broadband seismometers in eastern Nepal. Colleagues at SUNY Binghamton deployed 13 seismometers in southern Tibet as part of this same project. The seismic array is sensitive to faint seismicity associated with subsurface faults. The seismometers were deployed in October 2001. The stations were serviced in February and May, with accompanying data downloads. The data have been archived with the IRIS Data Management Center in Seattle. Analysis of the data is ongoing, and includes
(1) teleseismic P and S arrival times and waveforms will be used to decipher the general crustal and upper mantle structures under the Himalaya to determine the presence of subduction zone and other structures under the Himalaya, (2) the arrival times of hundreds of earthquakes under the orogen will be used to image the 3-D crustal structures underneath the Himalaya and relocate earthquakes to determine the internal structure and rheology of the orogen, (3) SKS anisotropy under the Himalaya to map upper mantle flow, (4) focal mechanisms from regional moment tensor inversion to determine kinematics of orogenic deformation. We seek to determine the geometry of fault ramps, where seismic events with characteristic focal mechanism concentrate, and whether the decollement can be detected through seismicity or material differences. Using teleseismic data we expect also to map features in the upper mantle underneath the orogen, such as the subducted Indian lithosphere and products of delamination. The geometry of the source zones, the nature of the seismic slip and kinematics derived from this experiment will also help constrain the interpretation of ongoing expanded geodetic surveying in the area.



Planetary Metabolism

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.

The sustainability of the biosphere in the face of rapid changes in the Earth system is an issue of critical importance. The physical and chemical features of the Earth are intimately tied to organisms and the activities required for their sustenance.

Both natural and anthropogenic disturbances drive the structure and dynamics of natural systems. A thorough understanding of these complex processes is essential for efforts to protect the biosphere from adverse effects due to pollution, destruction of natural landscapes, and climate change.

Research activities in planetary metabolism aim to quantify and locate the major biogeochemical cycles on global scales, investigate biosphere-atmosphere interactions at the biochemical level, identify the response of natural systems to perturbations (such as applications of pesticides), and study the influence of pollution on soil, air, and water.

Example: CIRES scientists are using two tower-flux systems in the Colorado subalpine forest to quantify carbon fluxes between the forest and atmosphere to get a better understanding of the ecological controls over the rate and seasonal pattern of carbon sequestration, and elucidate the manner by which volatile organic emissions from the forest interact with deposits carried from the Denver metropolitan corridor.

RESEARCH GOALS

1) To increase knowledge of the fundamental processes that drive the biosphere
2) To use experimental tools to accurately measure indicators of change
3) To enhance the sophistication of prognostic models capable of forecasting ecosystem and the global biosphere response to future environmental changes
4) To carry out research that will develop science and technology to help us restore and protect the health of the biosphere.

Contributors:

CIRES Center for the Study of Earth from Space (CSES)
CU-Boulder's Environmental, Population and Organismic Biology Department (EPOB)
CU-Boulder's Molecular, Cellular and Developmental Biology Department (MCDB)
CIRES' Center for Limnology
CU-Boulder's Enviornmental Program

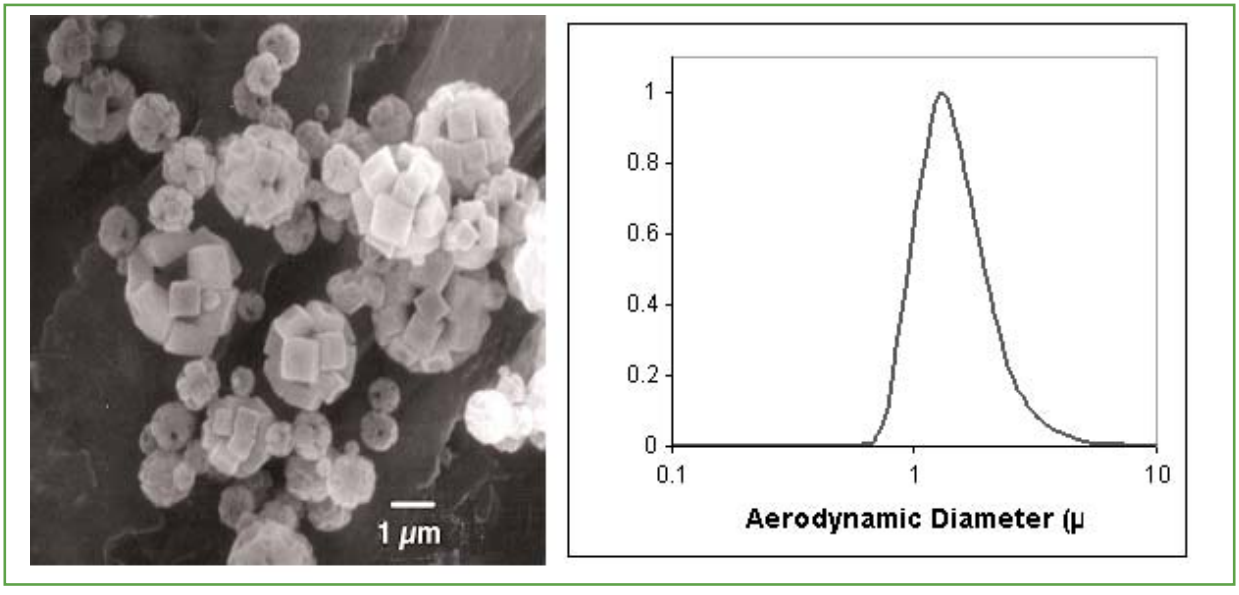
CO_2 Assisted Aerosolization of Drugs for Lung Ailments

***Scientific Impact:** Microparticle and nanoparticle aerosol powders of compounds are ideal vehicles for delivery of therapeutic or preventative agents into the lungs. The Sievers group within the University of Colorado has developed and patented a novel method (Carbon Dioxide Assisted Nebulization with a Bubble Dryer®, i.e., CAN-BD process) to make fine dried powders of therapeutic and chemopreventive agents. In the figure below, clusters of sodium chloride crystals with aerodynamic diameters mostly between 1 and 3 microns were dried in only three seconds as bubbles of cubic crystals and serve as models for both pharmaceutical applications and atmospheric aerosols.*

Our goals in the current research project are to investigate this method for making aerosols of the protein therapeutic alpha-1-antitrypsin for emphysema and anti-inflammatory chemopreventive compounds for lung cancer, as well as others for the treatment of pollution-exacerbated asthma.

During the last year, we have completed our study of the aerosolization of trypsinogen, a model enzyme, and have begun studies of alpha-1-anti-trypsin. In collaboration with IDEC Pharmaceuticals, we have investigated the stabilization of a humanized monoclonal antibody. These interdisciplinary studies have been a collaboration of atmospheric chemists, chemical engineers and pharmaceutical scientists.

Project Personnel: R.E. Sievers, E.T.S. Huang, S.P. Cape, C.D. Liang, J.A. Villa, T.R. Walsh, H. Meresman, H.Y. Chang
Funding Sources: Colorado Tobacco Research Fund, Grant No. 1R-031 and MedImmune Pharmaceuticals
References: We have summarized some of our research in the manuscript entitled "Micronization of water-soluble or alcohol-soluble pharmaceuticals with a low-temperature Bubble-Dryer®", which has been accepted for publication and is in press at the Journal of Supercritical Fluids.



SEM image and aerodynamic size distribution of microparticles produced by CAN-BD

Nitrogen Dynamics in Two Agriculturally Impacted Streams of the Midwest

Scientific Impact: Statistical models, such as the SPARROW model, indicate that as stream order increases the quantity of nitrogen lost via denitrification decreases. However, a paucity of denitrification data are available to verify these types of models, especially in agriculturally impacted streams that form the drainage of the Gulf of Mexico. Our study shows that nitrate loading and stream discharge have a robust positive correlation, but denitrification and discharge are only weakly correlated. Other physical and biological factors, such as hyporheic exchange, carbon quality, and microbial populations, which are difficult to incorporate into simple models may be important drivers of denitrification.

Project Personnel: Lesley K. Smith (CIRES), John Karl Bohlke, Mary Voytek, Judson Harvey (USGS, Reston, VA), Richard Smith (USGS, Boulder, CO), Andrew Laursen (Rutgers University)

Funding Sources: U.S. Department of Agriculture, U.S. Geological Survey

In recent years, a zone of low oxygen (hypoxic zone) roughly 100 square miles in size has persistently developed in the Gulf of Mexico, which is seriously impacting a vital fishery. Although not 100% conclusive, the likely candidate creating the hypoxic zone ("Dead Zone") is the high nitrogen (N) loads of the Mississippi River, which are derived from the heavily fertilized drainage area of the Midwest. Very little information is available that details N cycling in streams and rivers draining into the Mississippi River. Statistical models, such as the SPARROW model, indicate that as stream order increases the quantity of nitrogen lost via denitrification decreases, yet few denitrification measurements are available to verify these types of models.

Our study is using a variety of techniques to measure denitrification rates, an inherently difficult measurement to make, in two sub-tributaries of the Mississippi River. The techniques, all of which are novel, include: membrane inlet mass spectrometry (L.K. Smith), natural abundance 15N additions to sediment cores (Bohlke) and streams (Harvey), open channel method (Laursen), and delineation of denitrifying bacteria (Voytek).

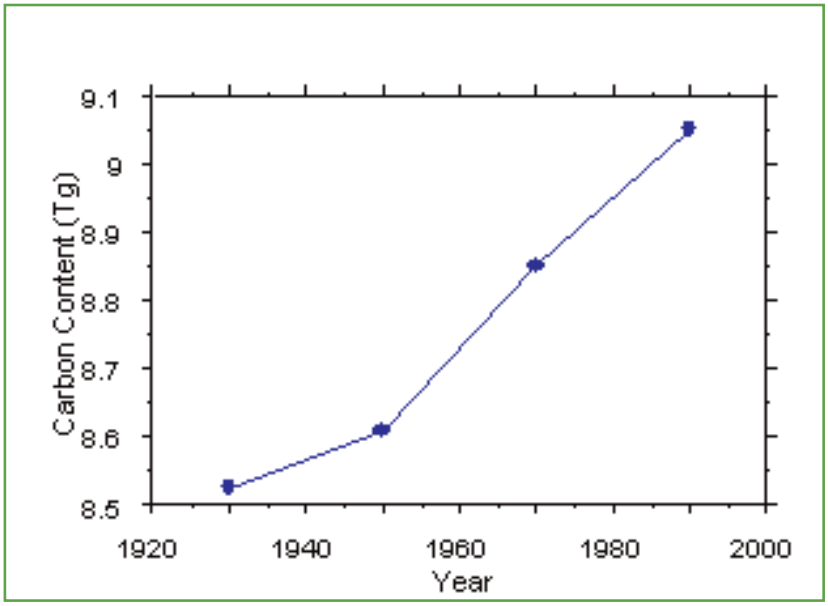
Each technique has its advantages and disadvantages. However, we are finding that our data are yielding a similar trend. Our study shows that nitrate loading and stream discharge have a robust positive correlation, but denitrification and discharge are only weakly correlated. Other physical and biological factors, such as hyporheic exchange, carbon quality, and microbial populations, which are difficult to incorporate into simple statistical models may be important drivers of denitrification. Future studies will focus on quantifying the relationship between these other factors we have identified and denitrification rates. This should help further refine statistical models of N loading.

Urban Sprawl in Colorado's Front Range: Implications for Regional Aboveground NPP and Carbon Storage

Scientific Impact: Identify regional biogeochemical impacts of urbanization in semi-arid environments

Project Personnel: N. Golubiewski, C. Wessman
Funding Sources: NSF, CIRES, EPOB
References: Regional shifts in ecosystem processes as a result of urban sprawl in Colorado's Front Range (to be submitted to Ecosystems)

Urbanization — as it spreads over pastures, croplands, and grasslands — constitutes an unplanned experiment on biota and the physical environment. This study examined the consequences of urban sprawl for carbon storage and aboveground net primary productivity (ANPP) in the Denver metropolitan area. The Front Range of Colorado offers a unique setting for such a study due to its unique geophysical location against the Rocky Mountains and its current status as a "boomtown". In addition, dryland and irrigated farming have transformed much of the region's natural grasslands. Fifty-four suburban and urban area sites throughout the Denver-Boulder area were inventoried for soil C storage, vegetative C storage, ANPP, leaf area, phenology, and management. Land-cover data were analyzed for temporal and spatial relationships through a change-detection study and then combined with biogeochemical data from prairie, agricultural, and urban sites in order to assess the alterations in ecosystem processes that accompany land-cover change. Regional increases occurred in grass production and C storage and in tree aboveground storage. Soil C storage was variable with equal to lower values than those pre-development. A preliminary analysis of the land-cover data estimates a net gain of approximately 0.5 teragrams (Tg) of carbon over the past 60 years, accounting for an increase in suburban woody vegetation and loss of land in transportation networks. The regional landscape of C storage and ANPP varied markedly throughout the twentieth century as development increased. Thus, regional analyses could benefit from inclusion of data from urban areas rather than assume ecosystem properties in urban areas mimic those of natural or agricultural ones.



Change in Carbon Stocks in the Colorado Front Range: Early Estimates

A Previously Unrecognized Step in Pentachlorophenol Degradation in *Sphingobium chlorophenolicum* is Catalyzed by Tetrachlorobenzo-quinone Reductase (pcpD)

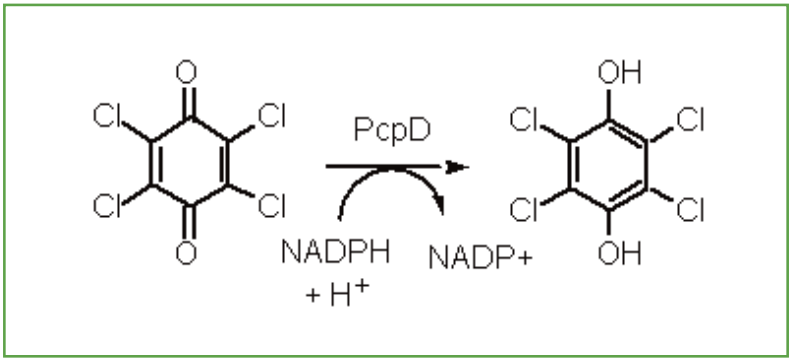
Scientific Impact: This work provides further insight into the capacity of soil bacteria to evolve new metabolic pathways for degradation of anthropogenic pollutants.

Sphingobium chlorophenolicum is a soil bacterium that was originally isolated from soil that was heavily contaminated with pentachlorophenol (PCP), a widely used wood preservative. This bacterium can completely mineralize PCP, which is remarkable because PCP is highly toxic and furthermore is of anthropogenic origin. Thus, it appears that S. chlorophenolicum has evolved a new metabolic pathway to convert PCP into a recognizable metabolite since the introduction of PCP into the environment in 1936. We are studying the origins and quality of function of each of the enzymes in the initial part of this newly evolving metabolic pathway. The first step in the pathway has been believed to be conversion of PCP to tetrachlorohydroquinone for over a decade. We have shown that PCP is actually converted to tetrachlorobenzoquinone, which is subsequently reduced to tetrachlorohydroquinone by PcpD, a protein that had previously (and incorrectly) been assigned a different role. A mutant strain lacking functional PcpD has an impaired ability to remove PCP from the medium. In contrast, the mutant strain removes tetrachlorophenol from the medium at the same rate as does the wild type strain. These data suggest that PcpD catalyzes a step necessary for degradation of PCP, but not for degradation of tetrachlorophenol. Based upon the known mechanisms of flavin monooxygenases such as PCP hydroxylase, hydroxylation of PCP should produce tetrachlorobenzoquinone, while hydroxylation of tetrachlorophenol should produce tetrachlorohydroquinone. Thus, we proposed and verified experimentally that PcpD is a tetrachlorobenzoquinone reductase that catalyzes the NADPH-dependent reduction of tetrachlorobenzoquinone to tetrachlorohydroquinone.

Project Personnel: MingHua Dai, Julie Bull Rogers, Joseph Warner, and Shelley D. Copley

Funding Source: ARO

References: Dai, M.-H., Rogers, J. B., Warner, J. R., and Copley, S.D. "A Previously Unrecognized Step in Pentachlorophenol Degradation in *Sphingobium chlorophenolicum* is Catalyzed by Tetrachlorobenzo-quinone Reductase (pcpD)", *J. Bacteriol.*, in press.



Forest/Atmosphere Carbon Fluxes in a Colorado Subalpine Forest

***Scientific Impact:** Our combined measurement and modeling analyses indicate that subalpine forests in the western U.S. are (1) among the most important carbon sinks of the region during years with normal climate, and (2) become the only significant carbon sinks of the region during decadal-scale droughts on the west coast.*

We have studied the magnitude and pattern of net ecosystem CO_2 exchange (NEE) over a three-year period. Annual carbon sequestration rates ranged between 57.6 - 80.5 g C m^{-2} (Fig. 1). The cold winters at the Niwot Ridge site force the ecosystem into a respiratory mode with significant consequences to the annual carbon balance; between 50-65% of the C sequestered during the growing season is lost during respiration the following winter. In order to place these annual rates of C sequestration into the context of the regional carbon budget, we worked with a version of the Century model parameterized for Ameriflux sites (including Niwot Ridge) in the Western U.S. During a thirteen-year period between 1980-1993 when drought along the western coast reduced annual C gain for normally productive coastal Pacific and Northwestern forests, areas of high C sequestration are predicted to be found within the montane and subalpine forests of the Intermountain West and South Central U.S. (Fig. 2). Thus, despite modest C sequestration rates in subalpine forests compared to more temperate forests in the Southeastern and Northeastern U.S., future climate shifts toward a drier West could mean that these forests represent the most significant C sinks in the region.

Project Personnel: Russell Monson, Laura Scott-Denton, Andrew Turnipseed

Funding Source: DOE, NSF

References: Monson, R.K., Turnipseed, A.A., Sparks, J.P., Harley, P.C., Scott-Denton, L.E., Sparks, K., Huxman, T.E. (2002) Carbon sequestration in a high-elevation, subalpine forest. *Global Change Biology* 8: 459-478.
Turnipseed, A.A., Blanken, P.D., Anderson, D.E., Monson, R.K. (2002) Energy budget above a high-elevation subalpine forest in complex topography. *Agricultural and Forest Meteorology* 110: 177-201.

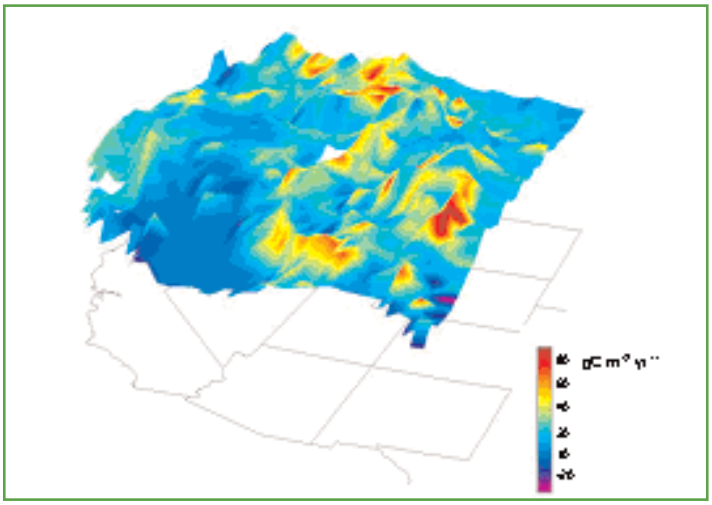


Fig. 2. Model overlay of the south-central and western U.S. color coded for predicted rates of C sequestration during the period 1980-1993. Predictions were made using the Century model parameterized for the period 1885-1993, with validation during the period 1998-2002 using flux data from western Ameriflux sites. (From Schimel et al. 2002).

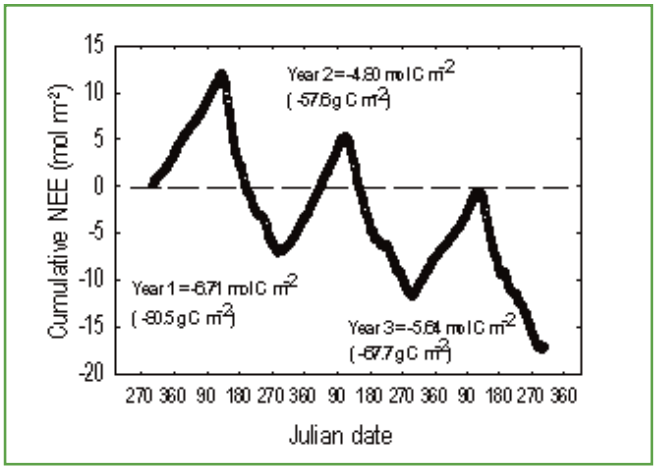


Fig. 1. Cumulative NEE for the first three years of the Niwot Ridge Ameriflux study. Measurements were initiated on Nov. 1, 1998 and are reported through October 31, 2001.

Background Yields of Nitrogen and Nitrogen Fractions from Continents via River Flow

Scientific Impact: Establish global and regional baselines for evaluation of the magnitude of anthropogenic effects on the nitrogen cycle

No rigorous estimate has been available for the yield of total nitrogen and nitrogen fractions from continental land masses via runoff. Estimates of this type are very difficult for nitrogen because of extensive alteration of nitrogen fluxes by human activity. The purpose of this project was to develop an estimate of background yields for total nitrogen and nitrogen fractions through a test of the hypothesis that nitrogen yields from selected pristine areas could be generalized to the continental scale on the basis of relationships between nitrogen yields and easily measured variables such as amount of runoff or vegetative cover.

In the first phase of the study, it was demonstrated for tropical watersheds, where data on pristine conditions are most readily available, that annual runoff is an excellent predictor of both total nitrogen and nitrogen fractions. The prediction is either completely insensitive or minimally sensitive to all other easily measured physical or biotic attributes of watersheds. Thus, the prediction of nitrogen yields proved for the tropics to be much simpler than anticipated.

In a second phase of the study, an extension was made to temperate latitudes through validation of the hypothesis that atmospheric deposition of nitrogen does not affect nitrogen output from watersheds until a specific threshold of deposition is reached. Thus, analysis of nitrogen yield from watersheds beneath this threshold is a valid estimator of yield under pristine conditions. Such an analysis produced excellent estimation of yield for total nitrogen and nitrogen fractions based on runoff alone, in a manner similar to the results obtained for tropical watersheds. Furthermore, and quite surprisingly, the yields per unit of runoff are essentially the same for tropical and temperate watersheds. The work is now being extended to produce global estimates from the equations.

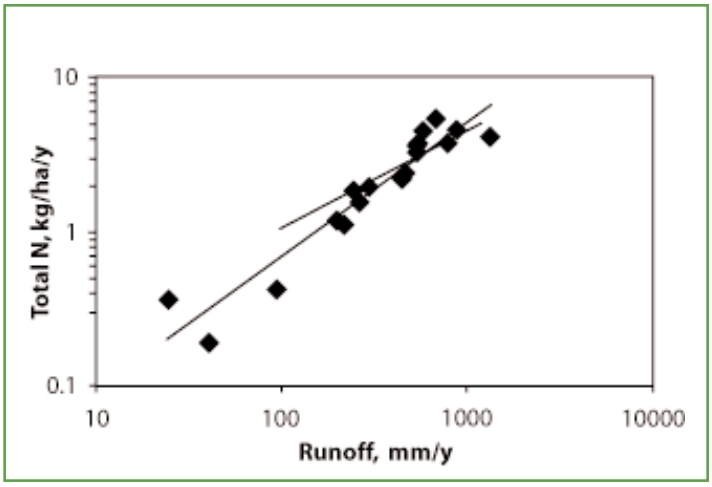
Project Personnel: William M. Lewis, Jr.

Funding Source: NSF

References:

Lewis, W.M. Jr., J.M. Melack, W.H. McDowell, M. McClain, and J.E. Richey. 1999. Nitrogen yields from undisturbed watersheds in the Americas. *Biogeochemistry* 46: 149-162.

Lewis, W.M. Jr. 2002. Yield of nitrogen from minimally disturbed watersheds of the United States. *Biogeochemistry* 57/58: 375-385.



Relationship of runoff and N yield from temperate benchmark watersheds (long line) and tropical watersheds (short line).

A New Method of Measuring Denitrification Rates in Rivers and Streams

Scientific Impact: Provides for the first time a whole-system capability for measuring denitrification rates in streams and rivers

Project Personnel: William M. Lewis, Jr., Alena Pribyl, James F. Saunders, III, and James McCutchan, Jr.
Funding Source: NOAA
References:
McCutchan, J.H. Jr., J.F. Saunders, III, A. Pribyl, and W. M. Lewis, Jr. 2002. Open channel estimation of denitrification. *Limnology and Oceanography Methods* (submitted).

Denitrification is a process by which nitrate, which is active biologically, is converted to dinitrogen, which is inactive biologically. Thus, denitrification is a natural process by which the nitrogen content of soil or water can be reduced. This process can be highly beneficial in offsetting nitrogen enrichment of waters by human activity. It is difficult to measure under natural conditions, however, because it occurs primarily within the substrate of an aquatic environment (e.g., within the sediments beneath a river or stream). Measurements under laboratory conditions are quite feasible, but are likely to be misleading because laboratory conditions differ very much from those in the field.

This project involves development of a method to estimate the flux of nitrogen gas from water surfaces. Where denitrification is occurring, the water is supersaturated with dinitrogen, which is produced during the process of denitrification. Thus, there is a net flux of nitrogen gas from the water surface to the overlying atmosphere. If this flux can be measured, the rate of denitrification can be estimated quantitatively. Our method involves estimation of the rate of gas exchange at the water surface by use of a tracer gas (propane) and 24-hour monitoring of the concentration of dinitrogen dissolved in the water. The latter has recently become possible because of the development of the membrane inlet mass spectrometer, which provides an unprecedented means for making precise measurements of N_2 concentrations in water.

We have applied the method to the South Platte River, which shows a high rate of denitrification. We have validated the method by use of a mass-balance analysis, i.e., estimation of denitrification by the method of differences based on concentrations and rates of processes affecting nitrate in transit. The agreement between the more cumbersome and indirect mass-balance method and the simpler and more direct whole-system method based on N_2 flux is very good, indicating that the N_2 flux method works as expected.

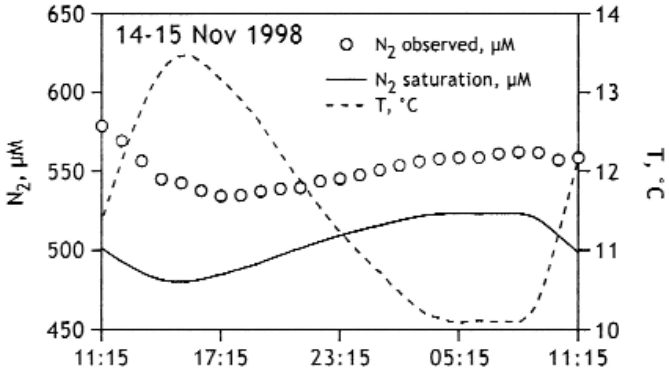


Illustration of nitrogen supersaturation in a river where denitrification is occurring (South Platte River below Denver).

CIRES Committees

The Director makes all Committee assignments at the beginning of the academic year unless otherwise noted.

Executive Committee (2002/2003)

The Executive Committee assists and advises the director in matters regarding day-to-day management of the institute and makes important decisions and policies affecting CIRES. Members of the Executive Committee include the Associate Directors of the four administrative units for CIRES, two fellows elected at-large for a two-year term, renewable for one term, and two voting members that are the Members' Council representatives. Staff representatives are ex-officio members of the committee.

Executive Committee (2002/2003)

Director:
Executive Director:
Associate Directors:
Shelley D Copley (exp. Sept. 03 - second term)
William D. Neff (exp. Sept. 03 - second term)
Timothy Fuller-Rowell (exp. Sept. 04 - first term),
Carol A. Wessman (exp. Sept. 04 - second term)
Jeffrey Hare, Members' Representative
Rob Schubert, Members' Representative
CIRES Staff (Ex-officio)

Theme Leaders

Theme Leaders are fellows or senior scientists who take the leadership role to develop science activities in each of the CIRES Research Theme areas. These science activities help to define new projects, encourage interdisciplinary dialog, and further refine strategic planning. Theme leaders are also responsible for helping to coordinate the science within their themes for reviews and annual reports.

Theme Leaders
Advanced Observing and Modeling Systems:
Konrad Steffen, R. Michael Hardesty
Climate Systems Variability:
Andrew M. Moore, Roger G. Barry
Geodynamics - Roger Bilham
Planetary Metabolism:
Shelley D. Copley, Carol A. Wessman
Regional Processes:
William D. Neff, Fred C. Fehsenfeld
Integrating Activities:
Roger Pielke, Jr.

Associate Directors (02/03)

The Associate Directors are the leaders of CIRES four administrative divisional units, in which every scientist is represented. These units are aligned with disciplinary expertise. Their responsibilities include dealing with personnel and supervisory issues, financial oversight and spending policies for indirect cost recovery return within their units, and representing the scientific interest of their units to the Executive Committee and Council of Fellows. The director appoints the associate directors for an indefinite term.

Associate Directors
Environmental Chemistry and Biology
Fred C. Fehsenfeld
Solid Earth Sciences
Roger Bilham
Cryospheric and Polar Processes
Roger G. Barry (acting)
Atmospheric and Climate Dynamics
R. Michael Hardesty

Acting Deputy Directors (02/03)

serve as Director in her absence.

Acting Deputy Directors

Paul Sperry.
Thereafter:
Konrad Steffen
Ben B. Balsley
William M. Lewis, Jr.
Margaret A. Tolbert
Alexander F. H. Goetz

Career Track Committee (02/03)

This committee is charged with consideration of all nominations for promotion within the CIRES career tracks of Research Scientist, Associate Scientist and Administrative Associate. Nominations are made once yearly, and the committee's recommendations are forwarded to the director for consideration and action.

Career Track Committee

Veronica Vaida, Chair
Christopher W. Fairall
Vijay Gupta
Douglas S. Robertson
Thomas W. Schlatter

Visiting Fellows Committee (02/03)

This committee is responsible for the review of all applications for CIRES Visiting Fellowships. In the process of this review, the committee makes the decision regarding those best qualified for a fellowship in any given year, and submits that slate to the Fellows Council for final discussion and selection.

Visiting Fellows Committee

Ben B. Balsley, Chair
Roger Pielke, Jr.
Anne F. Sheehan
Balaji Rajagopalan

Computing Advisory Committee (02/03)

The purpose of the CIRES Computing Advisory Committee (CAC) is to provide expert counsel and recommendations on technical issues, user support, resource allocations and the establishment of computing policies. That advice is available to anyone in CIRES; however, the primary CAC advisees are the Director and Council of Fellows and the CIRES Computing Facility (CCF) Manager. CIRES staff or the CCF manager, through CAC members, or via a Web suggestion page to the CAC chairperson for committee consideration, submits questions, issues and recom-

Computing Advisory Committee

R. Edward Habermann, Chair
Julia Collins
Rod Frehlich
Leanne Lestak
Rob Schaefer
Thomas Chase
Ted DeMaria
Ken Knowles
Mark Lohaus

ex officio:
Graham Mountain
Paul Sperry

mendations. CAC also serves as the last resort mediator of disputes between users and the CCF. The CAC membership includes people with diverse expertise that is required to understand and contribute to the CIRES computing decision-making process as well as representing the user groups that are supported by the CIRES Computing Facility. The director of CIRES appoints the chair of the committee as well as one other fellow. Additional members are nominated and selected by the CAC. All members serve a three-year term.

Distinguished Lecture Series (02/03)

This lecture series is designed to bring outstanding scientists and innovative thinkers who have given serious consideration to environmental and earth system science issues. Two coordinators are given the task of putting together this program and hosting the scientists' visit.

Distinguished Lecture Series Coordinators
Peter H. Molnar, Chair
Margaret A. Tolbert

assisted by:
Jeff Kosley
Kathy Zellers

Fellows Appointment (02/03)

All CIRES Fellows are subject to periodic review. First term fellows are reviewed after two years, and continuing term fellows generally every five years thereafter. This committee considers the package of reappointment submitted by the Fellow, which includes a cover letter outlining reasons for continuing as a Fellow and a curriculum vita. The committee prepares its recommendations that are submitted to the full Council of Fellows for consideration and final vote. This committee is also charged with considering the identification and nomination packages of possible new fellows within the community of scientists at the University of Colorado and NOAA. Nominations for new Fellows are considered once yearly.

Fellows Appointment
Craig Jones, Chair
Alexander F.H. Goetz
Russell K. Monson
Margaret Tolbert

Space Committee (02/03)

A continuing problem for CIRES is the limited office and laboratory space for employees. This committee provides advice on the best use and distribution of existing space, provides ideas on improvement of space through renovation, and develops options for the planning of future space.

Space Committee
William M. Lewis, Jr., Chair
G. Lang Farmer
John M. Wahr

ex-officio:
Rob Schubert

Graduate Research Fellowship Committee (02/03)

This committee selects those graduate students awarded graduate research fellowships designed to help them complete their research in their last year.

Graduate Research Fellowship Committee
Paul Sperry, Chair
Susan Avery
José Jimenez

Faculty Search Committee (02/03)

When new faculty hiring is approved, an appropriate search committee is established that actively recruits candidates for the position, reviews applications, and develops final slates for interviews. They are also responsible for helping to coordinate the interview, deliberating the candidates after the interview, and preparing final recommendations to the Council of Fellows and associated academic department who will provide the tenure home.

Geomorphology Position:
Peter H. Molnar, Chair
Anne F. Sheehan
Karl Mueller
John Pitlick
Nel Caine

Mesoscale Regional Integrated Climate Position *(pending)*:
Amanda H. Lynch, Chair
Andrew M. Moore
Peter Molnar

Innovative Research Proposal Review Committee (02/03)

This committee selects those applications awarded innovative research funds.

Innovative Research Proposal Committee
TBD following receipt of applications

Awards Committee (02/03)

A newly formed committee in 2002, this group will identify and prepare nominations of CIRES employees for awards offered by the university, the professional societies, the federal agencies, the national academies, and other organizations.

Awards Committee
William M. Lewis, Jr., Chair
Carl Kisslinger,
George C. Reid

CIRES Visiting Fellows

CIRES offers up to six one-year Visiting Fellowships at the University of Colorado in Boulder. Fellowships are open to scientists with research interests in the areas of CIRES Research Themes.

Awards may be made to Ph.D. scientists at all levels and faculty planning sabbatical leave. Recent Ph.D. recipients and those affiliated with minority institutions are especially encouraged to apply. Selections for the Visiting Fellows Program are based in part on the likelihood of interactions between the Visiting Fellows 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.

The program is open to scientists of all countries, and appointments can begin at any time during the year. Salary is commensurate with qualifications, current salary and cost of living considerations. The Fellow will be eligible for benefits, office space, telephone and computer facilities, and a small moving and start-up allowance.

Visiting Fellowships are potentially renewable for a second year, provided supplemental funding is available.

2001-2002

Christopher Aiken, working with Andy Moore
"Stochastically Forced Variability of Antarctic Circumpolar Current"

Eyal Ben-Dor, working with Alex Goetz
"Monitoring and Management of Soil Degradation Problems Derived from Soil Structural Crust Processes"

James Donaldson, working with Maggie Tolbert and Veronica Vaida
"Surface Thermodynamics as well as Rainwater Composition and Sea Surface Coatings"

Henrik Kjaergaard, working with Susan Solomon and Veronica Vaida
"Spectroscopy and Atmospheric Relevance of Water Clusters"

Thomas Painter, working with Koni Steffen
"Spatio-temporal Distribution of Snow Albedo and Snow Covered Area"

German Poveda, working with Vijay Gupta
"Spacetime Variability of Soil Moisture and Precipitation in Tropical South America At ENSO Timescales"

Bernhard Steinberger, working with Peter Molnar and John Wahr
"Lithospheric Stresses"

Vera Schulte-Pelkum, working with Craig Jones, Peter Molnar and Anne Sheehan
"Imaging Continental Deformation and Crust-Mantle Interaction through Array Analysis of Seismic Wavefields"

Carsten Warneke, working with Ray Fall and Fred Fehsenfeld
"Oxygenated Biogenic Hydrocarbons in the Atmosphere"

Research and Education Visiting Fellows

CIRES' six- to twelve-month Research and Education Fellowship provides a unique opportunity for a science faculty member to simultaneously enhance his or her research and to develop educational expertise. Of special interest to CIRES is the impact this Fellowship may have in enhancing science education and research opportunities among a broad and diverse group of students, and in building new partnerships with other U.S. educational institutions.

Applicants' proposed research and educational interests should complement CIRES' Research Theme activities, in particular Science education research and outreach: K-12 science education reform, K-12 teacher preparation, undergraduate course development and design, communication of research results to the public.

The fellowship may begin at any time after 7/1/02. Salary is commensurate with qualifications, current salary and cost of living considerations. The Fellow will be eligible for benefits, office space, telephone and computer facilities, and a small moving and start-up allowance.

2001-2002

Ray Beiersdorfer, working with the CIRES Outreach Team
"The Use of Creative Projects in Undergraduate Geoscience Courses"

Graduate Research Fellows

CIRES Graduate Research Fellows receive 12 month, nonrenewable awards that include half-time stipends (at rates set by the degree-granting department) and 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. Eligibility requirements include: enrollment in good standing in a Ph.D. program at the University of Colorado at Boulder that is connected with CIRES research programs, and admission within that program to Ph.D. candidacy. Awards are based on academic credentials (including grades, publications, other awards, and relevant academic experience), and on the quality of the proposed research as judged within the context of CIRES research missions.

2001-2002

Richard Cullather, working with Amanda Lynch
"Atmospheric Moisture Transport and Freshwater Budget of the Arctic"

Tara Fortin, working with Maggie Tolbert
"Laboratory Studies of Atmospheric Aerosols"

Nancy Golubiewski, working with Carol Wessman
"Urban Sprawl in Colorado's Front Range: Net Primary Productivity and Carbon Storage"

Paul Hintze, working with Veronica Vaida
"The Spectroscopic Properties of Gas Phase Sulfuric Acid"

Linda Koch, working with A.R. Ravishankara
"A Missing Link in the CLAW Hypothesis: DMS Oxidation"

Claire McGrath, working with Bill Lewis
"Mechanisms for the Displacement of Greenback Cutthroat Trout by Brook Trout"

Todd Rosenstiel, working with Russell Monson
"Metabolic Regulation of Ionosphere Emission"

Undergraduate Research Opportunities Program (UROP)

2001 UROP Participants
Jeremy King working with Sujay Kaushal, Limnology: The Effects of Urbanization on Dynamics of Organic and Inorganic Nitrogen in a Montane River.

Blake Audsley working with Sujay Kaushal, Limnology: Ecological Significance of Organic Nitrogen in Minimally Distrubed Streams

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.

Summer Minority Access to Research Training (SMART) Program

The University of Colorado at Boulder offers 10-week summer research internships through the Summer Multicultural Access to Research Training (SMART) program. The SMART program, intended for undergraduate students who are interested in preparing for graduate degrees in science, math, and engineering, offers 25 outstanding students the opportunity to conduct research under the guidance of a faculty mentor. SMART interns also participate in workshops designed to enhance their research experience and strengthen their preparation for graduate school.

2001 SMART Participant
Melinda Koslow working with Amanda Lynch, Climatology: The Climatology of Cyclonic Behavior near Barrow, AK

Significant Opportunities in Atmospheric Research and Science (SOARS) Program

2001 SOARS Participants
-Ernesto Muñoz-Acevedo working with Leslie Hartten, Aeronomy: The Daily Cycle of Low Level Winds over the Island of Nauru in the Equatorial Western Pacific.
-Shanna Pitter working with Anne Nolin, NSIDC: Improving Western United States' Snow Water Equivalent (SWE) Estimates from Passive Microwave Sensors.
-Yasmin Rodriguez working with Ray Fall, chemistry: Isoprene-producing Bacteria in the Rhizosphere.

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 in which 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.

Practical Hands-on Application to Science Education (PHASE)

PHASE was developed as a cooperative effort among NOAA/OAR agency representatives, the University of Colorado, the Colorado Alliance for Science (CAS), and community organizations such as Colorado Mathematics, Engineering Science Achievement (MESA). The primary purpose is to have NOAA/OAR and NIST laboratories identify summer education opportunities for high school and college students. These students are highly motivated junior and senior high school students (PHASE I) with grade point averages of 3.0 and above, college students (PHASE II) who are pursuing college majors of interest to NOAA. Teachers (PHASE III) have been added to the program. These are high school teachers with high academic performance and interest in atmospheric science and related disciplines.

The objectives of the program are (1) for laboratories to identify summer education opportunities, (2) to provide laboratories with student profiles that can be easily reproduced and distributed to selecting officials, and to include under-represented students in referrals for summer and other vacation-time opportunities.

Students participating in PHASE have an important role and responsibility within their community to utilize the programs provided for them. They need to represent themselves in a professional manner to ensure that the next generation of students is given the same considerations. This is an opportunity for a student to be exposed during the summer months and vacation periods to a government laboratory, experience new challenges, and be motivated to higher levels of achievement.

Career focuses of students have included meteorology, oceanography, computer science, physical science, engineering, and chemistry.

2001 PHASE Participants
Richard Schwarz working with Bill Neff, Environmental Technology Laboratory (ETL)

Rebecca Washenfelder, working with Fred Fehsenfeld, Aeronomy Laboratory (AL)

Distinguished Lecture Series

CIRES promotes global perspectives by jointly sponsoring distinguished speakers that cross disciplinary boundaries. This lecture series is designed to bring outstanding scientists and systems thinkers who take imaginative positions on environmental issues and can establish enduring new connections after their departure. Participants involve joint sponsorship between CIRES' eight University departments, five University programs, and nine NOAA lab affiliates.

2001 Distinguished Lecturers

September 4, 2001: Roger Kennedy, Former US National Park Service Director, on "The Abrasion of Human and Natural Systems: Fire, Flood, Risk and Responsibility."
October 12, 2001: Kerry Emanuel, Program in Atmospheres, Ocean and Climate, Massachusetts Institute of Technology, on "A Simple Model of Multiple Climate Regimes."
January 25, 2002 Dennis Lettenmaier, University of Washington, on "Implications of Hydrologic Variability and Change for Western Water Management."
February 22, 2002 Michael Bender, Princeton University, on "An Absolute Age Scale for the Vostok Ice Core: Implications for the Role of Milankovitch Forcing of Glacial-Interglacial Climate Change."
March 22, 2002 James R. Holton, University of Washington, on "The Tropical Tropopause Layer, the Quasibiennial Oscillation, and Stratospheric Dehydration."
April 19, 2002 Carl Wunsch, Massachusetts Institute of Technology, on "A Revisionist View of the Milankovitch Hypothesis for Climate Change."

Innovative Research Program Awards

This program is designed to stimulate a creative research environment and encourage synergy between disciplines within CIRES. The intent is to provide an uncomplicated mechanism for supporting small research efforts that can quickly provide concept viability or rule out further consideration. The program encourages novel, unconventional and/or fundamental research that might otherwise be difficult to fund, supports pilot or exploratory studies where results can be quickly acquired, and sponsors activities that are not tightly restricted and can range from instrument development, lab testing, and field observations to model advancement. Awards of up to $250,000 each year can be applied to equipment, materials, travel or salary contingent upon Federal and University fiscal guidelines. One submission per researcher is considered, and all research should be completed within one year. Researchers are asked to give a presentation or poster highlighting the results, impact, and suggested avenues for further studies. Selections are made by a review committee.

Innovative Research Program Awards made June 2001

John Bergman and Prashant Sardeshmukh (CDC)
CLIMATE MODELING WITH SIMPLIFIED DYNAMICS AND DETAILED PHYSICS
John and Prashant will be testing viability of an intermediate complexity model that will be easier to interpret, have a better statistical footing, and be useful in detecting/predicting long term climate change.

Tom Chase, Vijay Gupta and Keith Nordstrom (CSES)
DEVELOPING AN INTERFACE BETWEEN SIMPLE AND COMPLEX CLIMATE SYSTEM MODELS FOR INVESTIGATING GEOPHYSIOLOGY
They are coupling a simple biospheric/hydrologic model with GCMs as a means for identifying negative feedbacks that are not yet included in current parameterizations.

Martyn Clark (NSIDC) with Lauren Hay and George Leavesley (USGS)
THE USE OF MULTI-MODEL SUPER-ENSEMBLE TECHNIQUES IN HYDROLOGY
They are adapting proven meteorological ensemble techniques to a hydrology model to assess improvement of runoff, understand variations, apply regression improvement, and combine with atmospheric ensemble model output.

Gil Compo, Jeff Whitaker and Prashant Sardeshmukh (CDC)
FEASIBILITY OF REANALYSIS BEFORE THE RADIOSONDE ERA
They are testing the validity of surface and lower tropospheric circulation reanalyses simulated from previous surface synoptic data as a means of extending climate studies back to the early 1900's.

Dale Hurst and Jim Elkins (CMDL)
INAUGURAL SURVEY OF RUSSIAN AND CHINESE EMISSIONS OF OZONE-DEPLETING SUBSTANCES FROM IN-SITU MEASUREMENTS ABOARD THE TRANS-SIBERIAN RAILWAY
Dale and Jim will be participating in a rare opportunity to measure CFCs in a remote part of Siberia and test progress toward meeting Montreal Protocol standards.

Innovative Research Program Awards ***continued***

Dan Kowal and Mark McCaffrey (NGDC)
THE CLIMATE TIME LINE INFORMATION TOOL
Dan and Mark are developing a Web tool to provide user-friendly access to interdisciplinary data that includes a map locator, temporal and spatial displays, statistical assessment tools, and tutorial.

Russ Monson (EPOB) and James Roberts (AL)
THE UPTAKE OF NITROGEN OXIDES BY PLANTS - PROBING THE BIOLOGICAL AND CHEMICAL MECHANISMS
Russ and Jim are linking biological and atmospheric processes by studying peroxyacetyl nitrate radical equilibria and uptake by vegetation.

Louisa Nance (ETL) and Eric Thaler (NWS)
A STUDY OF ANOMALOUS PROPAGATION SIGNATURES IN WSR-88D DATA DURING DOWNSLOPE WINDSTORMS
Louisa and Eric are testing the hypothesis that unexplained Nexrad Doppler echoes reveal terrain-induced gravity waves and may help in predicting destructive downslope winds.

Anne Sheehan and Fred Blume (Geology)
QUANTIFYING SEISMIC HAZARD IN THE SOUTHERN ROCKY MOUNTAINS THROUGH GPS MEASUREMENTS OF CRUSTAL DEFORMATION
Anne and Fred will investigate the seismic stability of the Front Range, take benchmark measurements, and begin recording crustal strain for the first time.

Veronica Vaida (Chemistry) with Shelley Copley (MCDB), Dan Cziczo, Dan Murphy and Adrien Tuck (AL)
ROLE OF METEORITIC TRANSITION METALS IN DETERMINING THE CHEMICAL AND OPTICAL PROPERTIES OF ATMOSPHERIC AEROSOLS
They are investigating aerosol coagulation and meteoric metal catalysis of organic materials that could have an impact on origin of life theories.

Wanli Wu and Amanda Lynch (PAOS)
AN INTERDISCIPLINARY INVESTIGATION OF UNCERTAINTIES IN THE VARIABILITY OF THE CLIMATE AND TERRESTRIAL ECOLOGY
Wanli and Amanda are conducting ensemble model simulations to evaluate variability of regional climate and terrestrial ecology uncertainties arising from boundary forcing plus testing if future surface energy partitioning could be expected to change.

Honors and Awards: 2001

The following list details recognitions received by CIRES employees for career track promotions, elections to fellowships or chairmanships, who's who listings, invitations to speak, scientific medal awards, editor's award for journal reviews, and similar career achievements.

Aikin, Kenneth
NASA Group Achievement Award for the SAGE III Ozone Loss and Validation Experiment Science Team.

Bohlander, Jennifer
NASA Group Achievement Award 2001, presented to the Earth Observatory Web Page Team: "For Observatory web page."
NASA Goddard Space Flight Center Group Award for Public Service, 2001.

Brown, Steven
Presidential Early Career Award for Scientists and Engineers (PECASE) 2001.

Chilson, Phillip
AGU Editor's Citation for Excellence in Refereeing.
Recipient of the ETL Outstanding Seminar Award

Clifford, Steven
Meritorious Presidential Rank Award.

Cohen, Lee
HPCS web page was awarded "Best New Web Page" in the Forecast Systems Laboratory.

Daniels, Katherine
AGU Fall 2001 Meeting Outstanding Student Paper Award.

Dichtl, Rudy
"Who's Who in Science and Engineering", published by Marquis Who's Who 2001.

Frehlich, Rod
Recipient of the Editors award from the Journal of Applied Meteorology at the 2001 AMS annual meeting.

Hamill, Thomas
Presidential Early Career Award for Scientists and Engineers (PECASE) 2001

Haran, Terence
Co-recipient NSIDC Outstanding Employee Award, April 9, 2001.

Hobson, Vinita
CIRES 5 year Service Award.

Hodges, Gary
Certificate of Excellence from Air Resources Lab, Surface Radiation Research Branch.

Hurst, Dale
NASA Group Achievement Award 2001 for SOLVE program.

Jefferson, Anne
CIRES Members' Council Award of Excellence.

Longenecker, David
Certificate of accomplishment from the US Department of Commerce/CMDL for sustained superior perform ance and initiative in the area of CMDL radiation field activities and data archival.

Loughe, Andrew
Recognition from AWC for efforts made during the successful deployment of the new RTVS web-based/database application that was delivered to the AWC in 2001.

Matrosov, Sergey
Department of Commerce 2001 Gold Medal for new remote sensing system to identify hazardous in-flight icing conditions in cloud.

McKie, Julie
CIRES 20-Year Service Award.

McLean, Bradley
NSIDC outstanding employee award.

Meshek, Michael
Westword 2001 "Best of Denver" award for "All About Glaciers" (Best Web Site for Slow Modems).
Award of Merit, Society of Technical Communication (Rocky Mountain Chapter) 2000-2001 for Reference Material for NSIDC's Arctic Climatology Project: Arctic Meteorology and Climate Atlas on CD-ROM.

Mondeel, Debra
CMDL Director's Award, 2001.
STRATAFORM Research Program (ONR) award, 2001.
Muschinski, Andreas
NOAA/ETL Outstanding Seminar Award.
Naranjo, Laura
Award of Merit for contributions to the "Arctic Climatology Project: Arctic Meteorology and Climate Atlas" in the Society of Technical Communication (Rocky Mountain Chapter) 2000-2001 Publication and Online Competition, Online Reference Materials category.
NASA Group Achievement Award for contributions to the "Earth Observatory" Web site.
Westword 2001 "Best of Denver" award for "All About Glaciers" (Best Web Site for Slow Modems).
Nolin, Anne
NASA Group Achievement Award 2001 for participation on the MISR Science Team.
Selected as convener of the Third International Workshop on Multiangular Measurements and Models.
Ohrenschall, Mark
2001 NGDC Staff Excellence Award.
Parks, Bradley
Re-elected GIS/EM Secretariat.
Perkins, Katherine
NRC Post-Doctoral Fellowship Award.
2001 NASA Group Achievement Award for the SAGE III Ozone Loss and Validation Experiment Science Team
Reid, George
Selected for the Nicolet Lecture, one of the Bowie Lectures of AGU.
Richard, Erik
NASA Group Achievement Award 2001as part of the SAGEIII Ozone Loss and Validation Experiment (SOLVE) Science Team.
Scott, Michon
NASA Group Achievement Award, 2001 contributions to NASA's Earth Observatory.
NASA Goddard Space Flight Center Group Award for Public Service, 2001.
Schmidt, Laurie
NASA Group Achievement Award 2001, presented to the Earth Observatory Web Page Team: "For Observatory web page."
NASA Goddard Space Flight Center Group Award for Public Service, August 8, 2001.
Smith, Catherine
CIRES Members' Council Award of Excellence.
Stone, Robert
CMDL Director's Award for Scientific achievement.
Straub, Katherine
Student Paper Award, 13th Conference on Atmospheric and Oceanic Fluid Dynamics, Breckenridge, CO, June 2001.
Tiampo, Kristy
Program Coordinator, Nonlinear Geophysics Committee, AGU Spring Meeting.
Tyus, Harold
"Who's Who in Science and Engineering", published by Marquis Who's Who 2001.
Varani, Annette
NASA Group Achievement Award 2001 for contributions to the Earth Observatory web site.
NASA Goddard Space Flight Center Group Award for Public Service, 2001.
Vickroy, James
Certificate of Recognition for contributions to the SXI project.
Virden, William
Excellence in Cartography" at the 20th International Cartographic Congress, the map poster "Bathymetry of Lake Ontario" 2001, Beijing, China.
Welsh, Robin
Award of Merit, From the Society of Technical Communicators (STC - http://stcrmc.org/) for the "Arctic Climatology Project - EWG Arctic Meteorology and Climate Atlas".
Westwater, Edgeworth
Elected as a Fellow of the Institute of Electrical and Electronic Engineers, January, 2001

Community Service and Outreach: 2001

The following list details the wide involvement of CIRES employees in nonpaid activities that give service to CIRES, NOAA or CU communities, and to regional communities and schools through teaching and instruction, mentoring and advising, services to the broader scientific community, through local volunteer services, and through professional organizations.

Aikin, Kenneth
Consulted for the World Meteorological Organization (WMO) the findings from this analysis were published in the highly publicized WMO Antarctic Ozone Bulletins

Akmaev, Rashid
Presented a seminar on upper-atmospheric dynamics and climatology for graduate students and faculty of the upper-atmospheric group Physics Dept., Colorado State University, Fort Collins, Co
Proposal and manuscript reviews:
NASA, NSF, US Civilian Research and Development Foundation (CRDF), Annales Geophysicae, Geophysical Research Letters, Journal of Atmospheric and Solar-Terrestrial Physics, Journal of Geophysical Research, Physics and Chemistry of the Earth

Allured, David
Advocacy: Bolder Bicycle Commuters Association, Boulder, Co

Andrews, Elisabeth
Mentoring 2 graduate students from the School of Education, CU-Boulder
Science fair project mentor for student from Centennial High School, Lafayette, Co
Email mentor to student at Fairview High School, Boulder, Co
Review of papers for:
Atmospheric Environment, Journal of Geophysical Research, Journal of Atmospheric Science
Reviewed applications for NASA postdoc fellowships

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

Araujo-Pradere, Eduardo
Boulder County "I have a Dream" Foundation: Speaker at the Career Day at NOAA-SEC
The oral presentation "Clima Espacial: ¿Qué es?, ¿Cuándo y cómo nos afecta?" (Space Weather: What it is? When and how it affect us?), given to the local Latin community
Teaching Front Range Community College, Westminster, Co- Physics Calculus Based PHY-211 (5 credits): Spring semester: 22 students, Fall semester: 12 students
Spanish translation and revision of the NOAA's posters: Aquatic Nuisances Species, Our Changing Atmosphere, Ocean Observations
Spanish translation and revision of the SEC comic SPACE WEATHER
Inclusion of the model STORM as the perturbed conditions correction for the global model IRI Adopted as an operational product by SEC of the STORM model

Arbetter, Todd
Volunteer MaxFund Animal Shelter, Denver, Colorado

Arge, Charles
Served as a judge at the Nederland Junior High School science fair, Nederland, Colorado
Served as the CIRES/NOAA/SEC seminar chair for the year
Organized a special session entitled "Sources of Long-Term Trends in Space Weather" at the 2001 Spring AGU

Armstrong, Richard
Press interviews during the winter months regarding avalanche hazards, avalanche characteristics and snow properties;
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
Science Policy Board Member, University of Arizona Science and Technology Center
Space Science Institute, Board of Directors
American Meteorological Society, Commissioner, Education and Human Resources,
National Resource Council, Board Member, on Atmospheric Science and Climate
Digital Library for Earth System Education (DLESE), Steering Committee Member
NASULGC, Commission of Food, Environment and Renewable Resources (CFERR), Voting Delegate
Elizabeth Gee Award Committee
UCAR Scientific Programs Evaluation Committee (SPEC)
Federal Relations Advisory Committee (FRAC)

Barry, Roger
Co-Chair, World Meteorological Organization, Joint IOC/WMO Technical Commission of Oceanography and Marine Meteorology, Steering Group for the Global Digital Sea Ice Data Bank (GDSIDB)
Co-Chair, Standing Committee for Data, Information and Communications, Int'l Permafrost Assoc
Two book proposal reviews for NOAA-OGP and the U.S. Civilian Research Defense Foundation
World Climate Research Programme, Co-Vice Chair, Scientific Steering Group (SSG), for the Arctic Climate System/Cryosphere and Climate (CliC) project

Barsugli, Joseph
Produced responses to internal and external inquiries regarding the Reanalysis model
Refereed two articles for the *Journal of Climate* and four proposals for NOAA's CLIVAR-related programs

Bergman, John
Science fair judge: Jarrow Montessori Elementary School, Eisenhower Elementary School, and Summit Middle School, Boulder, Co
Gave a 30 minute talk for children on 'Bring your kids to work day'
Served on the CIRES/CDC Science Council
Performed the following reviews:

- CLIVAR-PACS proposal (M. Patterson, Progam Manager)
- National Science Foundation proposal (A. Bamzai, Program Manager)
- *Journal of Climate* (N. Nicholls, Ed.)
- *Journal of Climate* (L. Donner, Ed.)
- *Journal of the Atmospheric Sciences* (G. Kiladis, Ed.)
- *Quarterly Journal of the RMS* (J. Haigh, Ed.)
- *Monthly Weather Review* (revision; P. Smith, Ed.)
- *International Journal of Climatology* (G. McGregor, Ed.)

Bilham, Roger
Wrote two sections and contributed photographs to the National Geographic Book on Kilimanjaro
Participation in the production of the Kilimanjaro IMAX movie
Contributed voice-over sound recording and acted as scientific advisor
Organizer NSF International Bhuj Conference in Delhi, along with the Meteorology Dept. of India
Presented lecture on "Earthquakes in India" at the Indian Institute of Science, Ahmadabad, India

Boehm, Anita
Earthworks Teacher
Provided educational opportunities for teachers i.e., lead for Ocean Journey field trip, substitute for River Watch program, CU Museum Teacher's Night, Ocean Bowl Assistant

Brock, Charles
Science/mathematics tutor and classroom assistant, Crest View Elementary School, Boulder, Co

Buhr, Susan
Reviewer *Journal of Geoscience Education*

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

Capotondi, Maria-Antonietta
Reviewed oceanographic papers submitted to major oceanographic and climate-related journals
Review proposals submitted to the National Science Foundation

Cartwright, John
Boy Scouts of America - teaching rock climbing

Cassano, Elizabeth
Referee for the *International Journal of Climatology*

Cassano, John
Referee for *Monthly Weather Review, Tellus, Atmosphere-Ocean,* and *International Journal of Climatology*
Session chair at 6th AMS Polar Meteorology and Oceanography Conference
Session chair at 8th Scientific Assembly of the International Association of Meteorology and Atmospheric Sciences
Member of Ross Island Meteorology Experiment (RIME) science plan committee

Chilson, Phillip
Two one-hour presentations at Louisville Elementary School, Louisville, Co
Student Advisor Fairview High School student as part of a BVSD Science Research Project
Member Operations Council for the Platteville Atmospheric Observatory, Platteville, Co
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
Member of the ETL Publications Committee
Reviewer for *Nature, Radio Science, Geophysical Research Letters, Annales Geophysicae, Journal of Atmospheric* and *Solar-Terrestrial Physics,* NOAA/ETL

Clifford, Steven
Typescripts reviewed: one paper for the Optical Society of America on Atmospheric MTF by Tofstad BASC "Report on Climate Services"; Internal review for NOAA book: "Electromagnetic Scintillation II. Weak Scattering", by A.D. Wheelon. Cambridge Press "The complex Doppler shift measured with a spaced-antenna radar wind profiler," by A. Muschinski. To be published in Journal of Atmospheric and Oceanic Technology "Retrieval of ocean surface wind speed and wind direction using reflected GPS signals," by A. Komjathy, M. Armatys, D. Masters, P. Axelrad, V.U. Zavorotny, and S.J. Katzberg. To be published in *Journal of Atmospheric and Oceanic Technology* Belmonte, A., and B.J. Rye. Response to comment on "Heterodyne lidar returns in the turbulent atmosphere: Performance evaluation of simulated systems," by Frehlich and Kavaya. To be published in *Applied Optics.*

Codrescu, Mihail
Serving member on the GPS Meteorology Interagency Working Group (GMIWG)
CIRES Members' Council representative
CIRES awards committee member
Reviewed papers for *JGR, GRL,* and *Annales Geophysicae*
Reviewed proposals for NSF and NASA

Cohen, Lee
Judge Science Fair- Eisenhower Elementary School, Boulder, Co

Compo, Gilbert
Provided wavelet analysis support to: California State University-Los Angeles, Dept. of Computer Science & Electrical Engineering, West Virginia Univ. Univ. of Wales, NOAA/National Geophysical Data Center
CDC Computer Users Advisory Committee member
CDC NOAA Review document - designed figures and performed new calculations
Peer Reviews for *Dynamics of Atmos. Oceans, J. Climate, J. Geo.Res.,* and *Tellus*
Member, Working Group on surface pressure, Atmosphere Observation Panel for Climate, WCRP/Global Climate Observing System

Copley, Shelley
Nominating Committee Member, American Chemical Society, Division of Biological Chemistry
Organized Trick-or-Treat for UNICEF Drive at Bixby School

Cornwall, Christopher
Volunteer facilitator for Boulder County Health Department OASOS (Out And Supporting Our Selves) youth group
Served on Boulder IT Council, representing the Air Resources Lab (ARL)
Deputy CIRES Supervisor for NOAA/ARL/SRRB
Represent Air Resources Laboratory on the Technical Committee for Computer Resources

Costa, David
Volunteer Support Member on the Boulder Rural Fire Department
Volunteer at Boulder City Channel 8 as a camera operator
CIRES Members' Council representative

deGouw, Joost
Review of proposals for NOAA's Climate and Global Change Program
Review of manuscripts for the *Journal of Atmospheric Chemistry, Environmental Science and Technology,* and the *Journal of Physics B*

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

Dutton, Geoffrey
Presented an overview on tropospheric and stratospheric trace gas measurements made by the HATS group for the Wofsy Group at Harvard University

Ennis, Christine
Niwot Youth Sports Head Coach of a girls "8 and under" softball team
Writing contribution to narratives on several ozone-layer topics for the forthcoming Macmillan Guide to Pollution
Writer and editor of the Aeronomy Laboratory's newsletter, which is distributed to colleagues in NOAA, CIRES, and other agencies, and is also posted on the Internet
Poster author for OAR educational outreach
CIRES Representative on the Aeronomy Lab's NOAA/OAR Outreach Team

Farmer, G. Lang
Member, Geochemistry and Petrology Program Panel, NSF

Fetterer, Florence
Volunteer in Colorado's Big Brothers Big Sisters program
With the NOAA at NSIDC team, released the Arctic Climatology and Meteorology Primer (an educational product for the general public)
Presentation to Nature Conservancy and Science regarding NSIDC products and research

(Fetterer, continued)
Gave an invited lecture on "Remote Sensing of Sea Ice and Oceans with Synthetic Aperture Radar" for CU PAOS Remote Sensing Seminar course
Developed NSIDC promotional and presentation materials for the NSIDC 25th Anniversary activities in Boulder and the Fall AGU meeting
Reviewed two papers for the *Canadian Journal of Remote Sensing* and one for *Annals of Glaciology*
Contributed to The United States Detailed National Report on Systematic Observations for Climate: United States Global Climate Observing System (US-GCOS) Program

Fifarek, Richard
Active member of Boulder Linux Users Group

Fischer, Christopher
I helped demonstrate RTVS to meeting attendees in the FSL booth at the AMS 81st Annual Meeting in Albuquerque NM

Frehlich, Rod
Board member of the Village Arts Coalition, a non-profit corporation to support music and dance in Boulder
Local co-organizer of the 2001 URSI meeting
CIRES Members' Council representative
CIRES Computing Advisory Committee member
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
Board member for the Commerce Children's Center, a child care facility on the Department of Commerce Boulder campus
Reviewed manuscripts for the *Journal of Geophysical Research*

Fuller-Rowell, Timothy
Chair of CIRES Career Track Committee
Serve on SEC "User Support" Strategic Themes committee
Participate in Satellite Drag and Orbit Prediction Meeting
Contribution to *Space Weather Week*
Organize and contribution of various meetings at SEC
Review papers for scientific journals
Review proposals for various agencies
Member of JASTP Editorial Board
Member of COSPAR Panel for Space Weather, assist in the organizing of the Space Weather Symposium 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 2001 Asia Pacific Radio Science Conference, Tokyo
Co-organizer of Spring AGU 2001 special session
Serve on Decadal Survey Panel on Magnetosphere-Ionosphere-Atmosphere
Serve on NASA LWS Geospace Mission Definition Team
Co-convenor of EGS, Nice, session on Space Weather
Co-convenor and Chair of AP-RASC session
Co-organizer of CEDAR GIFT and Decadal survey workshops

Getting, Ivan
Vice-president of the Holland Ditch Co

Gilles, Mary
Student advisor Fairview High School, Boulder, Co
CIRES lab safety representative a liaison between the University, NOAA Aeronomy
Laboratory and the 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
Participated in the development of the document "The NOAA Role in the Study of Environmental Arctic Change (SEARCH)"
Serve on a regular basis as an internal ETL reviewer for journal articles, conference papers, and technical reports
Reviewed papers for *Journal of Fluid Mechanics, Journal of the Acoustical Society of America, Journal of Computational Acoustics, IEEE Journal of Oceanic Engineering,* and *Waves in Random Media*
Served as a Member of Scientific Committees of the Fifth International Conference on Theoretical and Computational Acoustics (Beijing, China, May 2001)
Member of the Technical Committee on Acoustical Oceanography of the Acoustical Society of America

Goetz, Alexander
Member, NRC Steering Committee on Space Applications and Commercialization
Board Member, Colorado Space Grant Consortium
Presented talk on the "Future of Studying the Earth from Space " at the Denver Museum of Science and Technology

Granier, Claire
Chair of the program committee of the workshop "Emissions of Chemical Species and Aerosols into the troposphere"
Member of the scientific program committee of the 8th European Symposium on the physico-chemical behavior of atmospheric Pollutants
Member of the TROPOSAT/EUROTRAC-2 steering committee
Member of the Editorial Board of the Atmospheric Environment revue
Lead author of chapter 8 (Modeling activities) of the Integration and Synthesis report of the IGAC project
Member of the SPARC (Stratospheric Processes and their Role in Climate) Program Scientific Steering Group
Member of the IGAC/GIM (Global Intercomparison and Modeling) Project coordination committee

Gross, Susanna
Reviewed four papers and four proposals this year.

Gupta, Vijay
Member, Scientific Advisory Council of Mississippi Riverside Environmental Research Station (MRERS), Iowa Institute of Hydraulic Research, College of Engineering, University of Iowa

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

Hare, Jeffrey
Science advisor to the Montana-2002 Expedition, students from State College PA and Scotland will travel to the Hidden Lake - Ramshorn Peak area for a science camp
Student instruction in meteorological instruments and measurement techniques, demonstrating and assisting in the deployment of a micro-meteorological tower in the surrounding area, and subsequent advice to help the students develop a poster for presentation at the AMS Education Conference at the January 2003 Annual Meeting
CIRES Members' Council representative
Appointed as a Member of the Air-Sea Exchange Committee within the American Geophysical Union Atmospheric Science Section

Hartman, Mike
Worked the NSIDC booth at the fall American Geophysical Union meeting

Hartten, Leslie
Member of the AMS Board on Women and Minorities' Ad Hoc Volunteer Committee
Member of the American Geophysical Union, the American Meteorological Society, and the European Geophysical Society

Huang, Huei-Ping
Served as referee for Monthly Weather Review, Climate Dynamics, and Naturwissenschaften (Germany)

Hobson, Vinita
Volunteer with Koke'e Resource Conservation Program, Kaua'i
Science Fair judge for Burlington Elementary School, Longmont
CIRES Members' Council representative

Hodges, Gary
Judge for science fair at the Boulder Country Day School located in Gunbarrel, Colorado

Holecek, John
Volunteer for the NOAA Open House celebrating 30 years of NOAA by leading tours of our research laboratories

Hooper, Don
Member of the CIRES/CDC Computer Users Advisory Committee (CUAC)

Hurst, Dale
served as a reviewer of the Stratospheric Processes and their Role in Climate (SPARC) Assessment of Upper Tropospheric and Stratospheric Water Vapour, eds. D. Kley, J.M. Russell III, and C. Phillips, SPARC Report No. 2, 312 pp., 2000 (distributed in 2001)
reviewed two manuscripts for J. Geophys. Res. - Atmospheres, one manuscript for Environ. Sci. Tech., and one Ph.D. thesis (University of Wollongong, Australia)

Hübler, Gerhard
Reviewed paper for JGR

Jackson, Darren
Provided review for a Journal of Geophysical Research Atmospheres journal article

Jain, Shaleen
Scientist Participant, EARTHWORKS 2001 (Earth System Science for Secondary Teachers -- CIRES Outreach Program)
Contribution to NOAA Climate Services by participation in:
    CDC Task Force for Afghanistan Humanitarian Efforts
    Colorado Drought Task force Meeting
US Bureau of Reclamation (Climate Information for Water Resources, Ongoing Project)
Contribution to the CDC External Review Document
WWA External Review
Water Resources Research (reviewer)
Journal of Hydrology (reviewer)
University of Arizona Press (Book Chapter reviewer)

Jayne, Steven
Participated as a science judge in the Ocean Science Bowl
Reviewer for 3 NSF proposals
Referee for 4 journal articles
Panel member for the reviewing of this year's National Defense Science and Engineering Graduate Fellowships from the Department of Defense
Jefferson, Anne
CIRES Members' Council representative

Johnston, Paul
Judge at Burlington Elementary School Science Fair

Johnson, Eric
Judge for the National Ocean Science Bowl
Invited speaker/presenter with CU President Elizabeth Hoffman on a university outreach trip to Lamar, Colorado

Joy, Craig
Charter representative for Boy Scout Troop 548 in Longmont, Colorado
Trustee for Moose Lodge 1548 in Longmont, Colorado a family community service organization that supports Community Food Share, Our Center community center, and Make a Wish Foundation for Kids

Kastengren, Jim
Volunteer at Heatherwood Elementary School, Gunbarrel, Co

King, Daniel
Science judge for 2001 National Ocean Science Bowl (Colorado regional competition)
Science judge for 2001 Boulder Valley School District Science Fair
Science judge for 2001 Denver Metropolitan Regional Science Fair
Served on CIRES/CMDL Diversity Focus Group Sub-Committee
Edited CMDL Summary Report No. 26, 2000-2001
Reviewed manuscripts for JGR-Atmospheres and Geobiology
Reviewed a proposal for the Natural Environment Research Council

Kitzis, Duane
Rocky Mountain National Park technical rescue volunteer
Career presentation at a local high school

Klein, Marian
Volunteer ice hockey coach for the Boulder Valley YMCA, Arapahoe Branch, in Spring and Summer sessions of 2001

Klein, Roberta
Humane Society of Boulder Valley

Kowal, Daniel
Facilitated some hydrology learning activities for kindergarten students at the Bixby School
Assisted with the Earthworks Workshop (CIRES Outreach Program) at Cal-Wood, Jamestown, Co

Laursen, Sandra
Boulder Public Library: book group discussion leader
Annual Book Discussion Day 2001 and 2002; as planning committee member for the Book Discussion Day's Western film series
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), a large NSF-sponsored initiative for science and math teacher preparation in Texas (P.I. Mauro Castro, Texas A&M-Kingsville)
External evaluator for an ongoing NSF-DUE CCLI grant, "Enhancement of the Undergraduate Physical Chemistry Laboratory" (P.I. Rama Viswanathan, Beloit College, WI)
Member of the workshop planning group and workshop leader for a three-year collaborative effort to disseminate the results of several major NSF chemistry initiatives,
"Multi-Initiative Dissemination: Strategies to Promote Active Learning in Chemistry Courses," under an NSF-DUE grant (P.I. Eileen Lewis, U. California, Berkeley)

Lestak, Leanne
Data sharing with Northslope researchers and residents
CIRES Computing Advisory Committee member

Lewis, William
Member, State of Colorado Department of Public Health and Environment Water Quality Monitoring Advisory Committee
Member, State of Colorado Department of Public Health and Environment Mixing Zone Technical Working Group
Member, Council of Aquatic Scientists
President, Rocky Mountain Hydrologic Research Center

Ling, Feng
Volunteer at the 2001 Colorado Regional Ocean Sciences Bowl

Lohaus, Mark
CIRES Computing Advisory Committee member

Loughe, Andrew
Committee member to improve the Boy Scout program in the north Denver area and also merit badge counselor for three different merit badge classes
Executive secretary to The Church of Jesus Christ of Latter-day Saints in the north Denver area
Volunteer service at a religious temple located on the south side of Denver

Lynch, Amanda
Member, Polar Research Committee, National Research Council
Met with junior and senior high school students to discuss careers in science for women
Presented public lection on "Big Storms" in Barrow AK
Was interviewed on National Public Radio program, "Living on Earth", about climate change in Alaska
Mentored an Inupiat Eskimo student from Barrow High School on the development and completion of her science fair project

Machol, Janet
Summit Middle School science fair judge
Member of the CIRES/ETL Millennium Team
ETL internal reviews reviewed papers
Reviewed paper for Applied Optic

Mapes, Brian
Judge for science fair at local elementary school
Contributed Spotlight article to CDC web page
Steering committee, international workshop on the dynamics and forecasting of tropical weather systems

Martins, Jorge
Volunteer YMCA soccer coach for 4th grade kids
Judge for the National Ocean Sciences Bowl

Matrosov, Sergey
Numerous reviews of journal articles

McCaffrey, Mark
President of the Boulder Creek Watershed Initiative
Serve as Science Fair Judge for local elementary schools
Gave presentations on hydro-climatic science for Children's Water Festival
Moderator for the National Ocean Sciences Bowl
Vice Chair of Education/Outreach Committee, Consortium of Universities for the Advancement of Hydrologic Sciences, Inc. (CUAHSI)
McCarty, Brandi
CIRES Members' Council representative

McKeen, Stuart
Science Fair
Mentoring state Science Fair project

McLean, Bradley
Volunteer at Colorado's Ocean Journey-serve as a Journey guide
Serve as a Coach for local high school cross country and track & field teams

Mefford, Thomas
Observatory Operations representative to the CIRES/CMDL Computer Advisory Team

Meshek, Michael
Volunteer with the following groups:
Backcountry Skiers Alliance
Center for Native Ecosystems
Singletrack Mountain Bike Adventures
Boulder Business Series

Molnar, Peter
Member, American Geophysical Union's Waldo Smith Medal Committee

Monson, Russell
Member, Steering Committee for Terrestrial Ecology Research Facilities, Department of Energy
Member, Research Advisory Committee, Columbia University Biosphere 2 Center
Serve as Director, Baker Residential Academic Program

Moore, Fred
CIRES/CMDL representative on the NIST shops committee
Arranged a safety class and am in the process of arranging a hands on shop class for CIRES/CMDL employees
Reviewed several manuscripts in both the atmospheric sciences and in the atomic and elementary particle sciences

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
Serve as Secretary for the Indoor Air committee of the Air and Waste Management Association
Co-Chair of AWMA 2000 Panel Session entitled, "Monitoring and Instrumentation for Indoor Air Quality"
Peer-reviewer for the journal, "Environmental Science and Technology"

Mullins, Teresa
Served as Outreach Coordinator for CIRES/NSIDC
Participated in the INSTAAR Open House for regional students

Muschinski, Andreas
Served as CIRES/ETL-internal reviewer for numerous papers
Led CIRES/ETL's Profiler Development Group
Review for Boundary-Layer Meteorology
Review for Geophysical Research Letters
Review for IEEE Sensors Journal
Review for Journal of Atmospheric and Oceanic Technology
Review for Journal of the Atmospheric Sciences
Review for Radio Science
Review for Theoretical and Applied Climatology
Review for the U.S. Army Research Office
Nance, Louisa
Reviewer for CIRES/ETL internal review process
Contributed to a NWS forecaster from Great Falls with feedback on a presentation he was preparing for the Great Divide Weather Workshop
Briefed Portland NWS forecast office on potential forecast applications for real-time data CIRES/NOAA/ETL was providing in support of the IMPROVE project
Co-Program Chairperson for the AMS Tenth Conference on Mountain Meteorology and MAP Meeting 2002

(Muschinski, continued)
Reviewer for National Science Foundation proposal
Reviewer for articles submitted to the following journals:
- Weather and Forecasting
- Journal of Applied Meteorology
- Monthly Weather Review

Naranjo, Laura
Volunteered for the American Institute of Graphic Arts, Denver Chapter
Volunteered for the MaxFund Animal Adoption Center, Denver
Coordinated an in-house panel discussion with NSIDC's Outreach group during NSIDC's 25th Anniversary

Nelson, Ingrid
Served as elementary school science fair judge

Newman, Matthew
CDC seminar coordinator; served on CDC science council
One journal article review; three proposal reviews

Nishiyama, Randall
On the Board of Directors (1993-Present) and one of the officers (2000-Present) of the Mamertion Foundation, a non-profit organization which sponsors the archaeological excavations at Oppido Mamertina in southern Italy
Member of the following organizations:
The Archaeological Institute of America (located at the University of Colorado at Boulder)
The Colorado Arts and Crafts Society (located at the Boettcher Mansion in Golden, Colorado)
The Colorado Textile Group (based in Denver, Colorado)
The Egyptian Study Society (located in Denver, Colorado)
The Leonardo da Vinci Society (based at the University of London)
Volunteer to the University of Colorado Museum of Natural History

Nolin, Anne
Science consultant for the Science Discovery program on Glaciers module
CIRES Members' Council representative
Journal reviewer for:
- Journal of Climate
- Journal of Hydrometeorolgy
- Journal of Geophysical Research
- Remote Sensing of Environment
- Proposal reviewer for: NASA, NSF, NOAA

Odstrcil, Dusan
Preparation of materials for the Space Weather Modeling Summer School, Boston MA

Oelke, Christoph
Maintenance of the ACSYS Data and Information Service (ADIS), a web-based data service of the ACSYS/CliC Data Management and Information Panel (DMIP) of WCRP ACSYS/CliC

O'Neill, Michael
Presentations to local schools, youth organizations and community open houses about the research being done in Antarctica by CIRES/CMDL

Ostashev, Vladimir
Chairman of the session "Acoustics" at the International Workshop: "Tomography and Acoustics" (Leipzig, Germany, March 2001)
Contributed two chapters to Lecture Notes in Physics "Sound-Flow Interactions" to be published by Springer Verlag.

Palmer, Tamara

Rules Judge for the National Ocean Sciences Bowl
Staffed CIRES and CIRES Outreach informational booths

Parks, Bradley
Contribution of time and leadership to improve school governance, administration, and educational performance in the Nederland Middle and High Schools, Nederland, Co
Leadership of a Boy Scout troop in the Indian Peaks area Colorado
Coordinate a student internship program with CIRES-NOAA projects
Served as participating/advising scientist with Colorado Coalition, an alliance of research and development interests working to build capacity in support of the National Biological Information Infrastructure within Colorado's front range
Completed programmatic tasks (as director) for the 4th International Conference on Integrating GIS and Environmental Modeling (GIS/EM4)
Edited papers of participating scientists for inclusion in the Proceedings of the 4th International Conference on Integrating GIS and Environmental Modeling (GIS/EM4)

Peng, Shiling
Article reviews for: Climate Dynamics Tellus Section Chair for: 11th Conference on Interaction of the Sea and Atmosphere

Perkins, Katherine
Tutoring for Sojourner Middle School, Boulder, Co

Persson, Ola
Ph.D. Committee member:
- Nicolas Cullen (Dept. of Geography, K. Steffen main advisor)
- Sandy Starkweather (Dept. of Geography, K. Steffen main advisor)
- Jeff Mirocha (PAOS, J. Curry main advisor)

Reviewed 2 manuscripts submitted for publication
Session chair at 6th Conference on Polar Meteorology and Oceanography

Petropavlovskikh, Irina
Member of the US science team on AURA satellite for OMI instrument involving validation of satellite ozone profile measurements
Serves on the science advisory board for the National Polar-orbiting Operational Environmental Satellite System (NPOESS), Ozone Mapping and Profiler Suit (OMPS)

Pielke, Jr., Roger
Member, Expert Social Science Review Panel, NOAA, Science Advisory Board
Member, Science Steering Committee, World Weather Research Programme
Presented public lecture, "Societal Impacts of Extreme Weather: What are the Facts?", at the Denver-Boulder Chapter of the American Meteorological Society
Presented public lecture, "Breaking the Global Warming Gridlock", at the Institute for Behavioral Science, Univ. of Colorado, and at the NOAA Coastal Services Center in Charleston SC
Presented a public lecture, "Weather Extremes and Their Societal Impacts: What are the Facts?", at the Univ. of Puerto Rico-Mayaguez
Presented a public lecture, "Evaluation of Weather Catastrophe Models", to ICAT Managers

Pincus, Robert
Member, AMS Committee on Radiation
Organizer for the program for the 2002 Conference on Radiation

Regnier, Nancy
Volunteer time and knowledge with partially disabled neighbor
Visits elderly neighbor who now resides in local retirement facility and provides assistance when needed

Reid, George
Member of CIRES Executive Committee
Reid, Stephen

Ozone E-mentor for CIRES community outreach program and gave lectures in several local schools on ozone loss and climate change
Publication of book: "Ozone & Climate Change: A Beginner's Guide"

Richard, Gretchen
Member Parent Teacher Organization Prairie Ridge Elementary School, Fredrick, Co

Rundle, John
Chair, American Geophysical Union, Technical Committee on Nonlinear Geophysics

Rundle, Marie
Leader of the National Ocean Sciences Bowl program (NOSB) both nationally and in our local and statewide communities
Provides materials and information for scientists to use when working with K-12 audiences, and provides outreach volunteer opportunities for scientists

Rye, Barry
Topical Editor, Applied Optics (Optical Society of America)
Reviewed journal papers (Applied Optics, Journal of Atmospheric and Oceanic Technology) and SBIR proposals (Dept. of Energy)

Sardeshmukh, Prashant
CIRES Co-coordinator in the production of CDC's Science Program Review document for the 4-year CDC Review
Compiled Book of Abstracts of CDC publications for distribution to the CDC reviewers
Wrote Chapter 2 ("Modeling Research on Seasonal to Interannual Variability") and most of Chapter 3 ("Understanding and Predicting Subseasonal Variations") in the CDC Science Program Review document with input from other CDC scientists
Reviewed journal articles for the Journal of Climate, Monthly Weather Review, Climate Dynamics, Science, Tellus and the International Journal of Climatology
Reviewed proposals submitted to NSF and NOAA/OGP

Saunders, James
Science Fair judge at Foothill Elementary School, Boulder, Co
Manuscript reviewing: Water Research proposal reviewing: EPA STAR program, National Sea Grant program

Scambos, Ted
Presentations at local Elementary School: "The Chemical Elements"
Presentations for numerous radio, TV, and newspaper interviews on Antarctica and Global Change

Schafer, Robert
Field day guide for high school students from Steamboat Springs, Co, showing them the radars/meteorological instruments at Platteville Atmospheric Observatory, Platteville, Co
CIRES Computing Advisory Committee member
Review of 2 journal articles for Journal of Atmospheric and Oceanic Technology
Review of 1 journal article for Geophysical Research Letters

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
Member, Architectural Review Committee - Waneka Pointe Homeowners Association
CIRES Members Council representative
Adopt-A-Highway Program Coordinator representing CIRES

Schweitzer, Roland
Host OAR "Web Tea" bimonthly technical discussion of Web technology

Scott, Donna
CIRES' Members, Council representative

Scott, James
Member of the Computer User's Advisory Committee CIRES/CDC
Member of the Web Developers' Advisory Committee at CIRES/CDC/CCD

Scott, Michon
Maintained Strange Science: The Rocky Road to Modern Paleontology and Biology
Developed Golden Brain site about amateur paleontology
Produced a Web feature for Rocky Mountain PBS's New Frontier site
Volunteer to the Denver Museum of Nature and Science, Denver, Co
Developed the museum's Ancient Denver Web site

Senff, Christoph
Internal reviewer for several CIRES/NOAA/ETL papers or conference contributions

Serke, David
Volunteer NOAA Science Fair

Serreze, Mark
Science Steering Committee, NSF SEARCH Program
Peer Review, climate research under the Meteorological Service of Canada
Chair, WCRP/ACSYS Working Group on Polar Products from Reanalysis
Board of Directors, ARCUS
Media contact for issues related to Arctic climate change

Sheehan, Anne
Member, State of Colorado Earthquake Hazard Subcommittee
Member, Incorporated Institutions foe Seismology (IRIS) Program for Array Seismic Studies of the Continental Lithosphere (PASSCAL)
Interviewed for an article in the Boulder Daily Camera, "Quarry Quandry"
Interviewed for article in the Colorado Woman News, "Women in Science"
Chair, CIRES Career Track Committee

Sheffield, Elizabeth
Work part-time at WOW! - World of Wonder Children's Museum, which focuses on children aged 15 months to 11 years
Volunteer scorekeeper for the Colorado and Wyoming Regional National Ocean Science Bowl (NOSB)
Volunteer for NSIDC involvement with INSTAAR Open House
Attended American Society for Photogrammetry and Remote Sensing (ASPRS) meeting, where I supported the NASA-EOSDIS DAAC Alliance booth by answering questions about DAAC Alliance data and services, handed out information on our products, and directed people to appropriate datasets or booths at the meeting

Shinoda, Toshiaki
Reviewers of 3 papers,
- Journal of Climate
- Journal of Geophysical Research-Ocean
- Journal of the Atmospheric Science

Sievers, Robert
Member, Foundation Fundraising Committee, Norlin Society Contributor
Member, Board of Directors, Norwest Bank
Organized and hosted the IUPAC CHEMRAWN XIV Conference on Green Chemistry: Toward Environmentally Benign Processes and Products" (attended by scientists from over 30 countries)
Served as teacher/advisor for the Baker Hall Residential Academic Program in Environmental Sciences

Sigren, Beth
Invited member of W4G (World Wide Web Working Group) at CIRES/FSL/NOAA

Smirnova, Tatiana
Reviews of papers for refereed Journals:
Monthly Weather Review
Journal of Applied Meteorology
Journal of Hydrometeorology
Reviews of proposals for GAPP

Smith, Catherine
Point of Contact for a variety of questions by the general public, especially with regards to data availability outside of CDC and general climate questions
Authored a CDC "spotlight" webpage that highlights work of CIRES/CDC scientists
Preparing science articles and media releases for energy company employees, and scientists about ENSO, climate and data availability

Smith, Lesley
Judge for the National Ocean Science Bowl
Participant in the Colorado Water Education Provider Meetings (provided input for formation of Colorado Water Education Foundation)
Scientific advisor for Integrated Earth exhibit designed by the Space Science Institute
Volunteer with the Boulder Valley School District, the city of Boulder Open Space and Mountain Parks, and the Thorne Ecological Institute on a field-based curriculum at Sombrero Marsh
Reviewed course outline for the Tribal Watershed Training Program
Workshops leader/collaborator at the following venues:
Teaching Outside the Box (Colorado Alliance for Environmental Education), Winter Park, Co
Colorado Science Convention, Denver, Co
CIRES Earthworks, Jamestown, Co
CU Science Explorers reviewed Wetlands and Stream Biology Curriculum and taught in Alamosa, Bayfield, Boulder, Longmont all Colorado cities
Lead field trips for local schools on Boulder Watershed:
3rd grade classes of Flatirons Elementary School, Boulder, Co
1-6 grade classes Community Montessori School, Boulder, Co

Sperry, Paul
Helped with senior center field trips
Science fair judge
Moderator at the National Ocean Science Bowl
Helped Boulder Mayor on environmental initiative
Helped organize a women student tour with the NWS
Staffed the "Partners in Research" joint booth with NOAA at the AMS

Spetzler, Hartmut
Scientific Coordinator of CIRES Outreach Program, dealing with, e.g., new course development for future teachers; class visits to local schools; observations of teaching in rural Colorado schools

Steffen, Konrad
Chairman, World Climate Research Program ACSYS Observation Product Panel
Member, Publication committee, International Glaciloogy Society
Member, RADARSAT Geophysical Processor System Team (NASA/RGPS)
Member, NASA Polar Data Active Archive Center Advising Group (PODAG)

Stephens, Britton
Serving on a NOAA committee working to recommend future carbon cycle observations

Stevermer, Amy
Scientific writing mentor, Significant Opportunities in Atmospheric Research and Science (SOARS) program, University Corporation for Atmospheric Research
CIRES/ARL representative on NOAA's Boulder Outreach Coordinating Committee

Stowe, Mike
Volunteer for Avon Breast Cancer Walk - August 2001

Stroeve, Julienne
Expert witness for "mock Senate" hearing on climate change in Kansas, ATOC 4800, CU-Boulder
Journal Articles Reviewed:
The impact of Cloud Cover on the Net Radiation Budget of the Greenland Ice Sheet by Cawkwell and Bamber, submitted to Annals of Glaciology
Surface Albedo over the Arctic Ocean Derived from AVHRR and its Validation with SHEBA Data by Xiong, Stamnes and Lubin, submitted to Journal of Applied Meteorology
Proposals Reviewed:
Proposal by Oelermans et al regarding improving the BRDF for snow/ice using MISR/AATSR and in situ measurements
Multi-Sensor (Multi-Scale) Approach to Snowmelt Detection Using Active and Passive Microwave Remote Sensing, by Forster, submitted to NASA
Collaborative Research: High spectral resolution measurements of surface reflectivity in the Arctic by Minnett, et al., submitted to NSF

Talukdar, Ranajit
Science Fair Judge at Woodrow Wilson Academy
Reviewed three manuscripts for the J. Phys. Chem. and Chem. Phys. Lett

Tanaka, Ken
Volunteer for the BLEA (Boulder Labs Employee Association) gift shop

Templeman, Brian
State of Colorado and City of Boulder - Aided in the monitoring of bat populations in and around Boulder, Co

Thrasher Hybl, Tracy
Volunteer at the University Lutheran Chapel
Served as the NASA USWG outreach lead
Served on the NSIDC 25th Anniversary Planning group
Served as the primary point of contact for news@kryos
Submitted the "Into the Arctic" CD-ROM to the ESE Education Products Review Board
Provided input to the outreach section of NSIDC's DAAC report
User Services Representatives at NSIDC support the earth science and cryospheric community on a daily basis through actively engaging in data and information development, distribution, and support.

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

Timlin, Michael
Tuscom Little League, Tuscola, IL - Asst. Coach
Cub Scout Pack 80, Tuscola, IL - Pack planning committee member
Cub Scout Pack 80, Tuscola, IL - Den Leader for 2nd graders
GrADS functions and feature development

Tolbert, Margaret
Member, AGU Awards Committee

Tyus, Harold
Served as a science advisor to the Rocky Mountain Arsenal Wildlife Refuge and have been working on the development of a new science exhibit at the Refuge's Visitor Center
Served as Santa at the annual CIRES Christmas party
Contributed as an invited speaker in two American Fisheries Society symposia
Reviewed for five management documents produced by the U.S. Fish and Wildlife Service, and was a reviewer for a scientific journal

Vaida, Veronica
Serves on committee for Women in Science
Member of Baker Hall Director search

Velicogna, Isabella
Seminar at the University of Udine - Italy

Verplanck, Emily
Classroom Assistant, Crest View Elementary School, Boulder, Co
Girl Scout Leader, Troop #1609, Boulder, Co
Science Fair Judge, Crest View Elementary School, Boulder, Co

Voemel, Holger
Participated in atmospheric science workshop for kids in Galapagos

Walloch, Lynn
Marketing Committee, CU Federal Credit Union
Co-Coordinator of Broomfield Days 5K Mayor's Race
Member of the Research Administrators of Institutes on Campus
CIRES Executive Committee Member
Fellows Meeting, Ex-Officio Member
Chair, NOAA Joint Institute Administrators Group
Coordinator of CIRES Christmas Project

Wang, I-Pin
Treasurer, Rocky Mountain Chinese Society of Science and Engineering

Weil, Jeffrey
Assistant Scoutmaster, Troop 78, Boy Scouts of America
Church Ministry, Sacred Heart of Mary Church
Team Dad, GSBMCT Junior Cycling Racing Team
Member, American Meteorological Society (AMS) Committee on the Meteorological Aspects of Air Pollution
Planning Committee, AMS 12th Joint Conference on the Applications of Air Pollution Meteorology with the AWMA (Norfolk, VA)
Chairman, AMS/EPA Regulatory Model Improvement Committee
Board of Reviewers, Boundary-Layer Meteorology
Convenor of Atmospheric Dispersion Session, International Symposium on Environmental Hydraulics 2001
Organizing Committee, Transport and Air Pollution, 10th International Scientific Symposium
Reviewer for: Atmospheric Environment, Boundary-Layer Meteorology, Journal of the Atmospheric Sciences, Journal of Applied Meteorology

Welsh, Robin
Judge for the Publications competition for the Society of Technical Communicators

White, Allen
Volunteer, St. John's Episcopal Church
Youth Advisory Committee
Middle School Sunday School Teacher
Discernment Committee for ordination aspirant
Assistant to Director of Children's Ministries
Volunteer, Brown University Alumni Schools Committee
Presentation to the Monte Rio School in Monte Rio, CA with the eighth-grade science class about meteorology and the research that we were conducting during PACJET
Member of ETL Publications Committee
Organizing Committee, Radar Calibration Workshop prior to 2001 AMS annual meeting

White, Dave
Volunteer to tennis instructor at the Louisville Recreation Center through Downs Tennis Academy to beginner and intermediate tennis players

Williams, Christopher
Reviewed four journal manuscripts
Reviewed one manuscript from each of the following journals: Journal Geophysical Research - Atmospheres, Journal of Atmospheric and Oceanic Technology, Geophysical Research Letters, and the Journal of Applied Meteorology
Reviewed one NSF proposal

Wolfe, Jason
Created color flyer highlighting MODIS sea ice and snow cover products for user services staff to distribute at NSIDC booth (AGU 2001)

Wolter, Klaus
Presenter to Colorado Drought (and Flood) Task Force Meetings (monthly to quarterly)
Numerous interviews to public media, as tracked on the CIRES/CDC Outreach webpage
Monthly updates to MEI webpage
Monthly update climate forecast webpage for the interior southwest (CO/UT/NM/AZ) Analogous product for northern Utah alone for the Winter Olympics 2002
Journal reviews for J. Climate, Bull. AMS, Water Resources Research
Proposals reviews for NOAA/OGP

Young, Doug
Volunteer (Vice Chairman) on the Westminster Transportation Commission

Zellers, Kathy
Volunteer Pioneer Middle School, Denver, Co

Zhang, Tingjun
Board of Directors of the Rocky Mountain Chinese Association Council member of the Bohua Chinese School
Review papers for the following journals:
- Journal of Climate
- Geophysical research Letters
- Journal of Geophysical Research
- Climatic Change
- Journal of Hydrology
- Permafrost and Periglacial Processes
- Arctic, Antarctic, and Alpine Research
- Global and Planetary Change
- Polar Record
- Annals of Glaciology
- Journal of Glaciology and Geocryology
- Cold Regions Science and Technology

Proposal review for the following agencies: National Science Foundation
- NSF ARCSS Student Paper Competition Judge
- NASA Land Surface Hydrological Program and New Investigators Program
- NOAA Office of Global Change
- International Arctic Research Center

2001 Journal Publications by CIRES Scientists

Abdalati, W., and K. Steffen. 2001. Greenland ice sheet melt extent: 1979-1999. *J. Geophys. Res.,* 106(D24):33,983-33,989.

Abdrakhmatov, K.E., R. Weldon, S, Thompson, D, Burbank, Ch. Rubin, M. Miller**,** and P. Molnar**.** 2001. Origin, direction, and rate of modern compression in the central Tien Shan, Kyrgyzstan. *Russian Geol. & Geophys*., 42:1585-1609.

Akmaev, R. A. 2001. Simulation of large-scale dynamics in the mesosphere and lower thermosphere with the Doppler-spread parameterization of gravity waves: 1. Eddy mixing and the diurnal tide. *J. Geophys. Res.,* 106:1193-1204.

Akmaev, R. A. 2001. Simulation of large-scale dynamics in the mesosphere and lower thermosphere with the Doppler-spread parameterization of gravity waves: 2. Implementation and zonal mean climatologies. *J. Geophys. Res.,* 106:1205-1213.

Aloisio, S., P.E. Hintze, and V. Vaida. 2001. The hydration of formic acid. *J. Phys. Chem. A*, 106:363-370.

Anderson, W.C., R.E. Sievers, A.F. Lagalante, and T.J. Bruno. 2001. Solubilities of Cerium (IV), Terbium (III), and iron (III) B-diketonates in supercritical carbon dioxide. *J. Chem. & Engr. Data,* 46(5):1045-1049.

Andrews, A. E., K.A. Boering, B.C. Daube, S.C. Wofsy, M. Loewenstein, H. Jost, J.R. Podolske, R.L. Herman, R.D. May, D.C. Scott, E.J. Moyer, J.W. Elkins, G.S. Dutton, D.F. Hurst, F.L. Moore, E.A. Ray, P.A. Romashkin, P.R. Wamsley, and S.E. Strahan. 2001. Mean ages of stratospheric air derived from in situ observations of CO_2, CH_4, and N_2O. *J. Geophys. Res.-A.,* 106:32,295-32,314.

Andrews, E., P. Sheridan, and J. Ogren. 2001. In situ profiles over the Southern Great Plains CART site. *ARM- Science Team Meeting*.

Angevine, W. M. and K. Mitchell. 2001. Evaluation of the NCEP mesoscale Eta model convective boundary layer for air quality applications. *Monthly Weather Review,* 129:2761-2775.

Angevine, W. M., H. Klein Baltink, and F.C. Bosveld. 2001. Observations of the morning transition of the convective boundary layer. *Boundary-Layer Meteorology,* 101:209-227.

Araujo- Pradere, E. and T.J. Fuller Rowell. 2001. Evaluation of the Storm Time Empirical Model for the Bastille Day Event. *Solar Physics,* 204(1):317-324.

Armstrong, R. L. and M. J. Brodzik. 2001. Recent Northern Hemisphere snow extent: A comparison of data derived from visible and microwave satellite sensors. *Geophys. Research Lett.,* 23(19):3673-3676.

Armstrong, R. L. and M.J. Brodzik. 2001. Validation of passive microwave snow algorithms. *29th IAHS,* 267:87-92.

Baker, B., A. Guenther, J. Greenberg, and R. Fall. 2001. Canopy level fluxes of 2-methyl-3-buten-2-ol, acetone, and methanol by a portable relaxed eddy accumulation system. *Environ. Sci. & Tech.,* 35:1701-1708.

Barrett, A. P., R. Viger, G.H. Leavesley, A.W. Nolin, and M.P. Clark. 2001. A comparison of satellite and model derived snow covered area for a mountain watershed. *Remote Sensing and Hydrology 2000 IAHS Publ.*, 267:569-573.

Barry, R. G. and T. Zhang. 2001. Distribution of frozen ground in the Northern Hemisphere. *Proceedings of the 2nd Russian Conference on Geocryology,* 3:285-286.

Barry, R.G. 2001. Dynamic and synoptic climatology. *Ch. 5 in The Physical Geography of North America*, *A. Orme (ed.), Oxford Univ. Press*: 98-111.

Barry, R.G. 2001. *Snow cover, in Encycl. of Global Change, 2, A.S. Goudie (ed.), Oxford Univ. Press*: 380-382.

Barry, R.G. 2001. *The cryosphere. Mountain climates, in Encycl. of Global Environ. Change,* 1, The Earth system: Physical and chem-

ical dimensions of global environmental change, J. Wiley and Sons Publ.: 330-331; 540-541.

Bates, G., and M. Hoerling. 2001. Trends in upper tropospheric humidity. *Geophys. Research Lett.*, 28:1695-1698

Bates, G., M. Hoerling, and A. Kumar. 2001. Central U.S. Springtime Precipitation Extremes: Teleconnections and Relationships with Sea Surface Temperatures. *J. Clim.,* 14:3751-3766.

Bates, J. J., D.L. Jackson, F. M. Breon, and Z. Bergen. 2001. Variability of the upper tropospheric humidity (1979-1998). *J. Geophys. Res.-A.,* 106:32271-32282.

Belova, E., P. B. Chilson, M. Rapp, and S. Kirkwood. 2001. Electron temperature dependence of PMSE power: Experimental and modeling results. *Advances in Space Research,* 28(7):1077-1082.

Bendick, R., and R. Bilham. 2001. How perfect is the Himalayan Arc? *Geology*, 29:791-794.

Bendick, R., R. Bilham, E. Fielding, V.K. Gaur, S. Hough, G. Kier, M.N. Kulkarni, S, Martin, K. Mueller, and M. Mukul. 2001. The January 26, 2001 "Republic Day" earthquake. *India. Seism. Res. Lett*., 72(3): 328-335.

Benjamin, S.G., G.A. Grell, S.S. Weygandt, T.L. Smith, T.G. Smirnova, B.E. Schwartz, D. Kim, D. Devenyi, K.J. Brundage, J.M. Brown, and G.S. Manikin. 2001. The 20-km version of the RUC. *14th Conference on Numerical Weather Prediction,* J75-J79.

Berger, B., K. Davis, C. Yi, P. Bakwin, and C. Zhao. 2001. Long-term carbon dioxide fluxes from a very tall tower in a northern forest: Flux measurement methodology. *Journal of Applied Meteorology*, 18:529-542.

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