The Cooperative Institute for Research in Environmental Sciences (CIRES)

Annual Report on NOAA Cooperative Agreement NA67RJ0153

October, 1999

Susan K. Avery, Director
Paul D. Sperry, Executive Director

University of Colorado at Boulder
National Oceanic and Atmospheric Administration
Boulder, CO

CIRES Annual Report
on NOAA Cooperative Agreement NA67RJ0153

October, 1999

CIRES as a joint institute between the University of Colorado and NOAA by definition establishes links between many different units in both organizations. It is the largest of seven institutes within the University of Colorado system and maintains eight departmental plus three programmatic affiliations on campus. The various departments can be thought of as providing the academic foundation for the *disciplinary* research we conduct within CIRES. The university programs tend to be academic activities that focus along *interdisciplinary* themes. As the largest of the eleven NOAA Cooperative or Joint Institutes, CIRES maintains a close affiliation with nine NOAA laboratories, most within the Boulder community.

CIRES is internally structured into both divisions and centers. The four divisions tend to group themselves along *disciplinary* lines and include:

Atmospheric and Climate Dynamics
Cryospheric and Polar Processes
Environmental Chemistry and Biology
Solid Earth Sciences

The five centers are intended to cross traditional boundaries to facilitate *interdisciplinary* research and include:

Center for Limnology
Center for the Study of Earth from Space
Climate Diagnostics Center
Colorado Center for Chaos and Complexity
National Snow and Ice Data Center (World Data Center)

CIRES currently has over five hundred employees distributed between Fellows, graduate students, undergraduate students, research scientists, associate scientists, and administrative staff. This distribution when broken down by affiliation reveals that approximately half of the organization is associated or affiliated with NOAA laboratories, while the remaining half is associated with university laboratories.

CIRES is continuing to develop its *K-12 Outreach Program* that has already been recognized as an exemplary model by a scientific research institute. Its projects are of high quality and combine rigorous science with innovative learning practices. Ongoing projects include professional development for K-12 teachers, classroom presentations for students, mentoring and partnership programs with teachers and students, and undergraduate course development for pre-service teachers at the University. CIRES

hosted this year's Colorado regional competition of the National Ocean Sciences Bowl and is closely interacting with NOAA and CU public affairs and outreach staff.

Rather than individually list all research activities, we have chosen to highlight some of our major research initiatives and the more interesting developments of the previous year. NOAA's recent review of CIRES provides a more detailed summary of scientific accomplishments over the past few years. A list of recent CIRES publications and presentations is also attached.

WESTERN WATER ASSESSMENT

The Western Water Assessment is a highly interdisciplinary program being facilitated by CIRES that will closely integrate with NOAA's existing assessment programs. Formal collaborations have expanded during the year and now include NOAA's Climate Diagnostics Center (CDC) and National Geophysical Data Center (NGDC), the University of Colorado departments of Geography and Economics, the Institute of Behavioral Sciences (IBS), the Institute for Arctic and Alpine Research (INSTAAR), the Natural Resources Law Center (NRLC), the National Snow and Ice Data Center (NSIDC), and various groups within CIRES. The primary scientific areas of focus include 1) Environmental Quality, 2) Social Science and User Needs Assessment, and 3) Climate Variability, Snowpack and Applied Hydrology.

During its first year, the program conducted a seminar series that brought together scientists from multiple disciplines, water managers, and other stakeholders. In addition, a climate variability and water resources conference was held to review the current status of hydroclimatic science and technology, water management and water policy as they relate to the Interior West. It also sought to project future developments in these fields, especially as related to improved capability for prediction of climate variation. CDC also held several workshops to present NOAA forecasts, experimental products, and an overview of ENSO-related climate variability in the West to water managers. Ongoing work is focusing on South Platte basin user identification, involvement, and outreach with collaborative research across a wide spectrum of natural and social sciences. Assessment components are addressing user needs, climate, hydrology, water quality, environment, and social vulnerabilities.

PREDICTION OF CLIMATE VARIABILITY

CIRES scientists contributed substantially to understanding and predicting seasonal-to-interannual climate variability through a wide range of diagnostic and modeling studies. Published studies examined fundamental topics such as: 1) the effects of the seasonal cycle on the response to tropical forcing, 2) asymmetries and non-linearities in the extratropical response to forcing from El Niño and La Niña, 3) the effects of the 1997-98 El Niño on individual storms, 4) effects of mid-latitude sea surface temperatures on extratropical predictability, and 5) the relationships between tropical heating and U.S.

precipitation. This research has contributed substantially to improvements in existing climate forecast products and to the development of new forecast products within NOAA.

SPACE WEATHER MODELING

"Variability" is the unifying theme for recent advances in ionospheric modeling by CIRES Scientists at NOAA's Space Environment Center (SEC). Maps of the electric field variability have been assembled representing one of the key drivers of the Earth's upper atmosphere. The use of these maps has shown the fundamental importance of electric field variability in shaping the global temperature and composition structure of the thermosphere. In a similar vein, a Coupled Thermosphere Ionosphere Model (CTIM) is being run in a near real-time operational mode to track the hour-by-hour changes in the ionosphere in response to geomagnetic activity. Capturing this aspect of variability is one of the fundamental challenges of the National Space Weather Program. Metrics have been developed and are being used to quantify the accuracy of these models.

The Department of Defense recently awarded one of their Multi-Disciplinary University Research Initiatives (MURI) to CIRES/NOAA. This is a multi-million dollar, five-year effort to develop a Global Assimilation of Ionospheric Measurements (GAIM) model. The universities involved in this work are the University of Colorado, Utah State University, University of Texas at Dallas and the University of Washington. The objective is to develop a global ionospheric model that would specify and forecast the space weather environment very much as numerical weather models assimilate data to forecast global meteorological weather.

CROP RELEASE OF REACTIVE ORGANIC COMPOUNDS

During the past year, CIRES and NOAA scientists collaborated on new measurements of volatile organic compounds (VOCs) that are released from crop plants as a result of wounding. They developed an analysis technique using proton-transfer chemical ionization mass spectrometry (CIMS) that allows online, simultaneous measurement of numerous VOCs without preconcentration or chromatography. They observed that the harvest or cutting of major crop species (clover, alfalfa) and urban grasses leads to a large release of VOCs. Much larger releases of VOCs were found when the cut vegetation dried. The reactive aldehydes released are the precursors of organic nitrates and ketones that become HO_x sources in the middle atmosphere. It is thus predicted that cutting and drying of crops and lawns will contribute to long-range transport of reactive nitrogen species, impact regional ozone formation during the summer months, and also contribute to oxidant formation in the upper troposphere.

A METHOD TO DETECT SPACE-TIME PATTERNS IN HIGH DIMENSIONAL COMPLEX SYSTEMS

CIRES scientists discovered a series of methods that allows space-time patterns in nonlinear complex systems to be characterized and revealed. Based upon Karhunen-Loeve techniques, these methods allow sets of patterns, corresponding to eigenstates, to be defined under various conditions. For example, one can detect the eigenstates corresponding to probabilities in a data set, or one can define eigenstates corresponding to frequencies of recurrence in the given data. A variety of forecast algorithms can then be constructed. One of them shows considerable promise when applied to real earthquake data from southern California.

ANTARCTIC ICE SHELVES BREAKING UP DUE TO DECADES OF HIGHER TEMPERATURES

Two ice shelves on the Antarctic Peninsula known as the Larsen B and Wilkins are in "full retreat" and have lost nearly 3,000 square kilometers of their total area in the last year. Researchers at CIRES' *National Snow and Ice Data Center* (NSIDC) and the *British Antarctic Survey* attribute the retreats to a regional warming trend. The trend has caused the annual melt season to increase by 12 days to a total of 20 days over the last 20 years. Satellite photos monitored by NSIDC show that the Larsen B ice shelf has continued to crumble after an initial small retreat in spring 1998. In a series of events that began in November 1998, an additional 1,714 square kilometers of shelf area caved away. On the opposite side of the peninsula, the Wilkins Ice Shelf retreated nearly 1,100 square kilometers during early March of last year. The recent warming trend has led to greater amounts of ponding melt on the shelf further weakening it. Melt water at the surface acts to increase the extent of fracturing in the ice. The weight of the water essentially forces the cracks open, so a relatively small amount of climate warming can destroy a large, centuries-old ice shelf.

NEWTONIAN GRAVITY CONSTANT EXPERIMENT

Recent determinations of the Newtonian gravity constant have produced values that differ by nearly 40 times their individual error estimates (>0.5%). CIRES and NOAA scientists conducted an experiment to resolve this situation by using laser interferometry to track the trajectory perturbation of a falling object in the presence of a one-half metric ton source mass. This experiment is the only laboratory determination of gravity that does not suspend the test mass from a support system, therefore it is free of many systematic errors associated with supports. The measured value of G was (6.6873 +/- 0.0094) X 10^{-11} m^3 kg^{-1} sec^{-2}.

THE JOINT AIR-SEA MONSOON INTERACTION EXPERIMENT (JASMINE)

The University of Colorado (CU) and the NOAA's Environmental Technology Laboratory (ETL) collaborated on a joint NOAA/NSF-sponsored study of monsoon interactions in the Indian Ocean and Bay of Bengal. The JASMINE study is part of NOAA's *Global Ocean, Atmosphere, Land System* (GOALS) program, which also has a North American monsoon component. It was conducted aboard the NOAA *R/V Ronald H. Brown* and is the most comprehensive investigation of air-sea interactions ever done in this region. Groups from the University of Hawaii, the University of Washington, and CSIRO joined scientists from CU and ETL in Canberra, Australia to conduct the 40-day study. El Niño is the major source of interannual variability of the monsoons and it is hypothesized that air-sea interactions (particularly in the Indian Ocean) are one source of break and active periods within a given monsoon season. While information is sketchy, initial evidence suggests that the balance of physical processes driving both atmospheric deep convection and the upper-oceanic heat budget in the Indian Ocean are much different from those in the Pacific Ocean warm pool. There is thus considerable concern that numerical models optimized for the Pacific warm pool may not be effective when applied in the Indian Ocean. Data collected included direct measurements of air-sea fluxes, Doppler radar studies of monsoon convection with the ship's C-band radar, plus upper ocean budgets of heat, momentum, and salt and their response to the monsoon. The weather cooperated with the cruise plan and a complete set of measurements were obtained in both active and break monsoon periods.

PUBLICATIONS

(July 1998 - June 1999)

C.H. Jones, L.J. Sonder, J.R. Unruh, Lithospheric gravitational potential energy and past orogenesis: implications for conditions of initial basin and range and Laramide deformation, **Geol., 26(7)**: 639-642, July 1998.

A.O. Langford, T.J. O'Leary, C.D. Masters, K.C. Aikin, M.H. Proffitt, Modulation of middle and upper tropospheric ozone at northern midlatitudes by the El Niño oscillation, **Geophys. Res. Lett., 25(14)**: 2667-2670, July 1998.

W.M. Angevine, A.W. Grimsdell, S.A. McKeen, J.M. Warnock, Entrainment results from the flatland boundary layer experiments, **J. Geophys. Res., 103(D12)**: 13,689-13,701, June 1998.

J.H. McCutchan, Jr., W.M. Lewis, Jr., J.E. Saunders III, Uncertainty in the estimation of stream metabolism from open-channel oxygen concentrations, **J.M. Am. Benthol Soc., 17(2)**: 155-164, 1998.

E.C. Shang, A.G. Voronovich, Y.Y. Wang, L.A. Ostrovsky, Applications of modal-horizontal-refraction tomography and modal-phase tomography for ocean remote sensing, **Proceedings of 4th Pacific Ocean Rem. Sens. Conf.**, Qingdao CHINA, 28-31 July 1998: 698-702, 1998.

E.C. Weatherhead, G.P. Reinsel, G.C. Tiao, X-L. Meng, D. Choi, W-K. Cheang, T. Keller, J. DeLuisi, D.J. Wuebbles, J.B. Kerr, A.J. Miller, S.J. Oltmans, J.E. Frederick, Factors affecting the detection of trends: statistical considerations and applications to environmental data, **J. Geophys. Res., 103(D14)**: 17,149-17,161, July 1998.

D. Robertson, The New Renaissance: Computers and the Next Level of Civilization, Oxford Press: 1-198, 1998.

G.P. Asner, Biophysical and biochemical sources of variability in canopy reflectance, **Rem. Sens. Environ., 64**: 234-253, 1998.

T.P. Stanton, L.A. Ostrovsky, Observations of highly nonlinear internal solitons over the continental shelf, **Geophys. Res. Lett., 25(14)**: 2695-2698, July 1998.

N.Y. Nikitina, L.A. Ostrovsky, An ultrasonic method for measuring stresses in engineering materials, **Ultrasonics, 35**: 605-610, 1998.

J.L. Chau, B.B. Balsley, Interpretation of angle-of-arrival measurements in the lower atmosphere using spaced antenna radar systems, **Rad. Sci., 33(3)**: 517-533, May-June 1998.

T. Shinoda, H.H. Hendon, J. Glick, Intraseasonal variability of surface fluxes and sea surface temperature in the tropical western Pacific and Indian oceans, **J. Clim., 11(7)**:

1685-1702, July 1998.

F. Fetterer, D. Gineris, C.C. Wackerman, Validating a scatterometer wind algorithm for ERS-1 SAR, **IEEE Trans. on Geosci. and Rem. Sens., 36(2)**: 479-492, Mar 1998.

M.M. Van Dyne, C. Tsatsoulis, F. Fetterer, Analyzing lead information from SAR images, **IEEE Trans. on Geosci. and Rem. Sens., 36(2)**: 647-660, Mar 1998.

C. Bertoia, J. Falkingham, F. Fetterer, Chap. 10: Polar SAR data for operational sea ice mapping, **Analysis of SAR Data of the Polar Oceans**, (eds.) Tsatsoulis and Kwok, Springer; 200-234, 1998.

J. Gozani, Propagation of waves through non-Gaussian longitudinally correlated random media, **J. Mathem. Phys., 39(9)**: 4664-4674, Sep 1998.

R.M. Gether, Climate change and the daily temperature cycle, **UMAP Module 770**, 19(1): 34-86, 1998.

D.M. Murphy, D.S. Thomson, A.M. Middlebrook, Bromine, iodine, and chlorine in single aerosol particles at Cape Grim, **Geophys. Res. Lett., 24(24)**: 3197-3200, Dec 1997.

D.M. Murphy, D.S. Thomson, A.M. Middlebrook, M.E. Schein, In situ single-particle characterization at Cape Grim, **J. Geophys. Res., 103(D13)**: 16,485-16,491, July 1998.

A.M. Middlebrook, D.M. Murphy, D.S. Thomson, Observations of organic material in individual marine particles at Cape Grim during the First Aerosol Characterization Experiment (ACE 1), **J. Geophys. Res., 103(D13)**: 16,475-16,483, July 1998.

R.H.J. Grimshaw, J.-M. He, L.A. Ostrovsky, Terminal damping of a solitary wave due to radiation in rotational systems, **Studies in Appl. Math., 101**: 197-210, 1998.

R.L. Herman, D.C. Scott, C.R. Webster, R.D. May, E.J. Moyer, R.J. Salawitch, Y.L. Yung, G.C, Toon, B. Sen, J.J. Margitan, K.H. Rosenlof, H.A. Michelsen, J.W. Elkins, Tropical entrainment time scales inferred from stratospheric N_2O and CH_4 observations, **Geophys. Res. Lett., 25(15)**: 2781-2784, Aug 1998.

M.W. Miles, R.G. Barry, A 5-year satellite climatology of winter sea ice leads in the western Arctic, **J. Geophys. Res., 103(C10)**: 21,723-21,734, Sep 1998.

J.F. Meagher, E.B. Cowling, F.C. Fehsenfeld, W.J. Parkhurst, Ozone formation and transport in southeastern United States: overview of the SOS Nashville/Middle Tennessee ozone study, **J. Geophys. Res., 103(D17)**: 22,213-22,223, Sep 1998.

D. Helmig, J. Greenberg, A. Guenther, P. Zimmerman, C. Geron, Volatile organic compounds and isoprene oxidation products at a temperate deciduous forest site, **J.**

Geophys. Res., 103(D17): 22,397-22,414, Sep 1998.

D. Serca, A. Guenther, L. Klinger, D. Helmig, D. Hereid, P. Zimmerman, Methyl bromide deposition to soils, **Atmos. Environ., 32(9)**: 1581-1586, 1998.

B.T. Jobson, D.D. Parrish, P. Goldan, W. Kuster, F.C. Fehsenfeld, D.R. Blake, N.J. Blake, H. Niki, Spatial and temporal variability of nonmethane hydrocarbon mixing ratios and their relation to photochemical lifetime, **J. Geophys. Res., 103(D11)**: 13,557-13,567, June 1998.

T.B. Ryerson, M.P. Buhr, G.J. Frost, P.D. Goldan, J.S. Holloway, G. Hübler, B.T. Jobson, W,C, Kuster, S.A. McKeen, D.D. Parrish, J.M. Roberts, D.T. Sueper, M. Trainer, J. Williams, F.C. Fehsenfeld, Emissions lifetimes and ozone formation in power plant plumes, **J. Geophys. Res., 103(D17)**: 22,569-22,583, Sep 1998.

B.T. Jobson, G.J. Frost, S.A. McKeen, T.B. Ryerson, M.P. Buhr, D.D. Parrish, M. Trainer, F.C. Fehsenfeld, Hydrogen peroxide dry deposition lifetime determined from observed loss rates in a power plant plume, **J. Geophys. Res., 103(D17)**: 22,617-22,628, Sep 1998.

R.E. Sievers, P.D. Milewski, S.P. Sellers, K.D. Kusek, P.G. Kleutz, B.A. Miles, Supercritical CO_2-assisted methods for the production and pulmonary administration of pharmaceutical aerosols, **J. Aeros. Sci., 29(1)**: S1271-S1272, 1998.

D-Z. Sun, K.E. Trenberth, Coordinated heat removal from the equatorial Pacific during the 1986-87 El Niño, **Geophys. Res. Lett., 25(14)**: 2659-2662, July 1998.

L.M. Hartten, D.S. Gutzler, Estimates of large-scale divergence in the lower troposphere over the western equatorial Pacific, **J. Geophys. Res., 103(D20)**: 25,895-25,904, Oct 1998.

D.F. Hurst, P.S. Bakwin, J.W. Elkins, Recent trends in the variability of halogenated trace gases over the United States, **J. Geophys. Res., 103(D19)**: 25,299-25,306, Oct 1998.

B.J. Sandor, W.G. Read, J.W. Waters, K.H. Rosenlof, Seasonal behavior of tropical to midlatitude upper tropospheric water vapor from UARS MLS, **J. Geophys. Res., 103(D20)**: 25,935-25,947, Oct 1998.

B. Liebmann, J.A. Marengo, J.D. Glick, V.E. Kousky, I.C. Wainer, O. Massambani, A comparison of rainfall, outgoing longwave radiation, and divergence over the Amazon Basin, **J. Clim., 11**: 2898-2909, Nov 1998.

G. Sharman, D. Metzger, J. Campagnoli, T. Butler, T. Berggren, D. Davins, M. Steele, GEODAS: a hydro/bathy data management system, **Survey. and Land Inform. Sys., 58(3)**: 141-146, 1998.

S.Y. Matrosov, A dual-wavelength radar method to measure snowfall rate, **J. Appl. Meteor., 37**: 1510-1521, Nov 1998.

S.Y. Matrosov, A.J. Heymsfield, R.A. Kropfli, B.E. Martner, R.E. Reinking, J.B. Snider, P. Piironen, E.W. Eloranta, Comparisons of ice cloud parameters obtained by combined remote sensor retrievals and direct methods, **J. Atmos. and Ocean. Tech., 15(1-1)**: 184-196, Feb 1998.

D.K. Rajopadhyaya, P.T. May, R.C. Cifelli, S.K. Avery, C.R. Williams, W.L. Ecklund, The effect of vertical air motions on rain rates and median volume diameter determined from combined UHF and VHF wind profiler measurements and comparisons with rain gauge measurements, **J. Atmos. and Ocean. Tech., 15(6)**: 1306-1319, Dec 1998.

U. Radok, T. Brown, In search of polar warming, **Meteor. Atmos. Phys., 67**: 249-252, 1998.

A.J. Farrington, S. Lubker, U. Radok, S. Woodruff, South Atlantic winds and weather during and following the little ice age - a pilot study of English East India Company (EEIC) ship logs, **Meteor. Atmos. Phys., 67**: 253-257, 1998.

J.P. Schwarz, D.S. Robertson, T.M. Niebauer, J.E. Faller, A free-fall determination of the Newtonian constant of gravity, **Science, 282**: 2230-2234, Dec 1998.

M.J. Clark, R.G. Barry, Permafrost data and information: advances since the Fifth International Conference on Permafrost, **Proceedings, 7th International Conference on Permafrost**, (eds.) Lewcowitz and Allard, Univ. of Laval, Quebec: 181-188, 1998.

A.W. Grimsdell, W.M. Angevine, Convective boundary layer height measurement with wind profilers and comparison to cloud base, **J. Atmos. and Ocean. Tech., 15**: 1331-1338, Dec 1998.

A. Lester, G.L. Farmer, Lower crustal and upper mantle xenoliths along the Cheyenne belt and vicinity, **Rocky Mountain Geol., 33(2)**: 294-303, Oct 1998.

D. Helmig, B. Balsley, K. Davis, L.R. Kuck, M. Jensen, J. Bognar, T.Smith, Jr., R.V. Arrieta, R. Rodriquez, J.W. Birks, Vertical profiling and determination of landscapes fluxes of biogenic nonmethane hydrocarbons within the planetary boundary layer in the Peruvian Amazon, **J. Geophys. Res., 103(D19)**: 25,519-25,532, Oct 1998.

P. Pilewskie, A.F.H. Goetz, D.A. Beal, R.W. Bergstrom, P. Mariani, Observations of the spectral distribution of solar irradiance at the ground during SUCCESS, **Geophys. Res. Lett., 25(8)**: 1141-1144, Apr 1998.

J.L. Chau, B.B. Balsley, A statistical comparison of VHF techniques to study clear-air vertical velocities in the lower atmosphere using the Jicamarca radar, **Radio Sci., 33(6)**: 1565-1583, Nov-Dec 1998.

J.L. Chau, B.B. Balsley, A statistical comparison of horizontal winds obtained by a variety of spaced antenna techniques using the Jicamarca VHF radar, **Radio Sci., 33(6)**: 1669-1683, Nov-Dec 1998.

M.P. Clark, M.C. Serreze, D.A. Robinson, Atmospheric controls on Eurasian snow extent, **Int'l J. Clim., 19**: 27-40, 1999.

D.K. Rajopadhyaya, S.K. Avery, P.T. May, R.C. Cifelli, Comparison of precipitation estimation using single- and dual-frequency wind profilers: simulations and experimental results, **J. Atmos. & Ocean. Tech., 16**: 165-173, Jan 1999.

D.A. Gilichinsky, R.G. Barry, S.S. Bykhovets, V.A. Sorokovikov, T. Zhang, S.L. Zudin, D.G. Fedorov-Davydov, A century of temperature observations of soil climate: methods of analysis and long-term trends, **Permafrost, 7th Int'l Conf. Proceedings**, (eds.) Lewcowitz and Allard, Yellowknife, Canada: 313-317, June 1998.

R.G. Barry, M.J. Clark, Data and information working group report, **Permafrost, 7th Int'l Conf. Proceedings**, (eds.) Lewcowitz and Allard, Yellowknife, Canada: 221-225, June 1998.

R.E. Sievers, U. Karst, P.D. Milewski, S.P. Sellers, B.A. Miles, J.D. Schafer, C.R. Stoldt, C.Y. Xu, Formation of aqueous small droplet aerosols asisted by supercritical carbon dioxide, **Aeros. Sci. and Tech., 30**: 3-15, 1999.

D. Odstrcil, V.J. Pizzo, Three-dimensional propagation of coronal mass ejections (CMEs) in a structured solar wind flow 1. CME launched within the streamer belt, **J. Geophys. Res., 104(A1)**: 483-492, Jan 1999.

T. Zhang, K. Stamnes, Impact of climatic factors on the active layer and permafrost at Barrow, Alaska, **Permafrost Periglac. Process., 9**: 229-242, 1998.

B.T. Lottman, R.G. Frehlich, Extracting vertical winds from simulated clouds with ground-based coherent Dopplar lidar, **Appl. Opt., 37(36)**: 8297-8305, Dec 1998.

J.L. Chang, S.K. Avery, R.A. Vincent, New narrow-beam meteor radar results at Christmas Island: implications for diurnal wind estimation, **Radio Sci., 34(1)**: 179-197, Jan-Feb 1999.

D. Helmig, A review of "Perspectives in Environmental Chemistry", (ed.) D.L. Macalady, Oxford Univ. Press., **Bull. Amer. Meteor. Soc., 79(12)**: 2801-2803, Dec 1998.

M. Wheeler, G.N. Kiladis, Convectively coupled equatorial waves: analysis of clouds and temperature in the wavenumber-frequency domain, **J. Atmos. Sci., 56**: 374-399, Feb 1999.

R.S. Pulwarty, R.G. Barry, C.M. Hurst, K. Sellinger, L.F. Mogollon, Precipitation in the Venezuelan Andes in the context of regional climate, **Meteor. Atmos. Phys., 67**: 217-237, 1998.

T. Shinoda, H.H. Hendon, Mixed layer modeling of intraseasonal variability in the tropical western Pacific and Indian oceans, **J. Clim., II**: 2668-2685, Oct 1998.

D.M. Murphy, D.S. Thomson, M.J. Mahoney, In situ measurements of organics, meteoritic material, mercury, and other elements in aerosols at 5 to 19 kilometers, **Science, 282**: 1664-1669, Nov 1998.

D.S. Robertson, Algorithmic information theory, free will, and the Turing test, **Complexity, 4(3)**: 25-34, 1999.

W.L. Ecklund, C.R. Williams, P.E. Johnston, K.S. Gage, A 3-GHz profiler for precipitating cloud studies, **J. Atmos. & Ocean. Tech., 16**: 309-322, Mar 1999.

C. Karbiwnyk, J. Birks, D. Helmig, Measurement of atmospheric non-methane volatile organic compounds using ambient CFC reference compounds, **Pittcon '99 Book of Abstracts, #1338**, 7-12 March, Orlando FL: 1999.

D. Helmig, Eddy correlation measurements of atmospheric volatile organic compound emissions (fluxes), **Pittcon '99 Book of Abstracts, #1354**, 7-12 March, Orlando FL: 1999.

D. Helmig, L.F. Klinger, A. Guenther, L. Vierling, C. Geron, P. Zimmerman, Biogenic volatile organic compound emissions (BVOCs) I. identifications from three continental sites in the U.S., **Chemosphere, 38(8)**: 2163-2187, 1999.

D. Helmig, L.F. Klinger, A. Guenther, L. Vierling, C. Geron, P. Zimmerman, Biogenic volatile organic compound emissions (BVOCs) II. landscape flux potentials from three continental sites in the U.S., **Chemosphere, 38(8)**: 2189-2204, 1999.

J.P. Greenberg, A. Guenther, P. Zimmerman, W. Baugh, C. Geron, K. Davis, D. Helmig, L.F. Klinger, Tethered balloon measurements of biogenic VOCs in the atmospheric boundary layer, **Atmos. Environ., 33**: 855-867, 1999.

R.G. Barry, R.L. Armstrong, J.A. Maslanik, T.A. Scambos, Cryospheric research and data products from the National Snow and Ice Data Center, **Arctic Research of the United States, Fall-Winter 1998, 12**: 64-69, 1998.

R.G. Barry, Microclimate, **Encyclopedia of Environmental Science**, (eds.) Alexander and Fairbridge, Kluwer Acad, Publ.: 408, 1999.

W. Abdalati, K. Steffen, Accumulation and hoar effects on microwave emission in the Greenland ice-sheet dry-snow zones, **J. Glaciol., 44(148)**: 523-531, 1998.

E.R. Westwater, Y. Han, J.B. Snider, J.H. Churnside, J.A. Shaw, M.J. Falls, C.N. Long, T.P. Ackerman, K.S. Gage, W. Ecklund, A. Riddle, Ground-based remote sensor observations during PROBE in the tropical western Pacific, **Bull. Amer. Meteor. Soc., 80(2)**: 257-270, Feb 1999.

P.L. Verplanck, G.L. Farmer, M. McCurry, S.A. Mertzman, The chemical and isotopic differentiation of an epizonal magma body: Organ Needle Pluton, New Mexico, **J. Petrol., 40(4)**: 653-678, 1999.

D.F. Hurst, G.S. Dutton, P.A. Romashkin, P.R. Wamsley, F.L. Moore, J.W. Elkins, E.J. Hintsa, E.M. Weinstock, R.L. Herman, E.J. Moyer, D.C. Scott, R.D. May, C.R. Webster, Closure of the total hydrogen budget of the northern extratropical lower stratosphere, **J. Geophys. Res., 104(D7)**: 8191-8200, Apr 1999.

A.M. Moore, R. Kleeman, Stochastic forcing of ENSO by the intraseasonal oscillation, **J. Clim., 12**: 1199-1220, May 1999.

A.F.H. Goetz, P.J. McIntosh, L.R. Lestak, Multi-year calibration of LANDSAT TM for studies of land-use and land-use change in the High Plains, **Proceedings of the 30th Int'l Conf. of Appl. Geol. Rem. Sens., II**: 183-190, Mar 1999.

S.E. Martinez-Alonso, A.F.H. Goetz, W.W. Atkinson, F.A. Kruse, D.D. Eberl, Multiscale study of infrared spectra of clay minerals: from *AB Initio* quantum calculations to hyperspectral remote sensing, **Proceedings of the 30th Int'l Conf. of Appl. Geol. Rem. Sens., II**: 174-181, Mar 1999.

S. Chabrillat, A.F.H. Goetz, H.W. Olsen, L. Krosley, D.C. Noe, Use of AVIRIS hyperspectral data to identify and map expansive clay soils in the Front Range urban corridor in Colorado, **Proceedings of the 30th Int'l Conf. of Appl. Geol. Rem. Sens., II**: 390-397, Mar 1999.

E.C. Shang, Y.Y. Wang, Subarctic frontal effects on long-range acoustic propagation in the North Pacific Ocean, **J. Acoust. Soc. Am., 105(3)**: 1592-1595, Mar 1999.

V.V. Vavilova, W.M. Lewis, Jr., Temporal and altitudinal variations in the attached algae of mountain streams in Colorado, **Hydrobiol., 390**: 99-106, 1999.

T. Zhang, Review of "General Geocryology" by E.D. Yershov, **J. Hydrology, 219**: 97-99, 1999.

J.P. Schwarz, D.S. Robertson, T.M. Niebauer, J.E. Faller, A new determination of the Newtonian constant of gravity using the free fall method, **Meas. Sci. Technol., 10**: 478-486, 1999.

R. Fall, Biogenic emissions of volatile organic compounds from higher plants, **Chap. 2, Reactive Hydrocarbons in the Atmosphere**, 41-96, 1999.

R. Fall, M.C. Wildermuth, Isoprene synthase: from biochemical mechanism to emission algorithm, **J. Geophys. Res., 103(D19)**: 25,599-25,609, Oct 1998.

V.F. Malone, A.J. Chastain, J.T. Ohlsson, L.S. Poneleit, M. Nemecek-Marshall, R. Fall, Characterization of a *Pseudomonas putida* allylic alcohol dehydrogenase induced by growth on 2-methyl-3-buten-2-ol, **Appl. and Environ. Microbiol., 65(6)**: 2622-2630, June 1999.

J.A. de Gouw, C.J. Howard, T.G. Custer, R. Fall, Emissions of volatile organic compounds from cut grass and clover are enhanced during the drying process, **Geophys. Res. Lett., 26(7)**: 811-814, Apr 1999.

D. Helmig, Review: Air analysis by gas chromatography, **J. Chromatogr. A, 843**: 129-146, 1999.

I.B. Esipov, O.M. Johannessen, K.A. Naugolnykh, E.C. Shang, Y.Y. Wang, On the application of a parametric radiator to monitoring the Fram Strait, **Acoustical Phys., 45(4)**: 448-454, 1999.

J.G. Isebrands, A.B. Guenther, P. Harley, D. Helmig, L. Klinger, L. Vierling, P. Zimmerman, C. Geron, Volatile organic compound emission rates from mixed deciduous and coniferous forests in northern Wisconsin, USA, **Atmos. Environ., 33**: 2527-2536, 1999.

M.C. Serreze, M.P. Clark, R.L. Armstrong, D.A. McGinnis, R.S. Pulwarty, Characteristics of the western United States snowpack from snowpack telemetry (SNOTEL) data, **Water Resour. Res., 35(7)**: 2145-2160, July 1999.

K. Naugolnykh, E.C. Shang, Y.Y. Wang, Numerical simulation of the parametric array application for ocean monitoring in the Fram Strait environment, **Theoret. and Comput. Acous. '97**, (eds.) Teng, Shang, Pao, Schultz, Pierce, World Scientific Publ.: 487-498, 1999.

E.C. Shang, Y.Y. Wang, The frontal effects on long-range acoustic propagation in the north Pacific ocean, **Theoret. and Comput. Acous. '97**, (eds.) Teng, Shang, Pao, Schultz, Pierce, World Scientific Publ.: 475-486, 1999.

A. Guenther, S. Archer, J. Greenberg, P. Harley, D. Helmig, L. Klinger, L. Vierling, M. Wildermuth, P. Zimmerman, S. Zitzer, Biogenic hydrocarbon emissions and landcover/climate change in a subtropical savanna, **Phys. Chem. Earth (B), 24(6)**: 659-667, 1999.

D. Thomson, R. Winkler, Software for the PALMS mass spectrometer, **Scient. Comput. & Instrum.**: 54-57, July 1999.

K. Steffen, W. Abdalati, I. Sherjal, Faceted crystal formation in the northeast Greenland low-accumulation region, **J. Glaciol., 45**: 63-68, 1999.

E.R. Westwater, Y. Han, V.G. Irisov, V. Leuskiy, E.N. Kadygrov, S.A. Viazankin, Remote sensing of boundary layer temperature profiles by a scanning 5-MM microwave radiometer and RASS: comparison experiments, **J. Atmos. and Ocean. Tech., 16(7)**: 805-818, July 1999.

Y. Zhao, Signal-induced fluorescence in photomultipliers in differential absorption lidar systems, **Appl. Opt., 38(21)**: 4639-4648, July 1999.

J. Heinrichs, K. Steffen, The winter C-bank backscatter of land ice and fast sea ice near Lady Anne Strait, N.W.T., **Appl. Develop. and Res., RADARSAT Int'l, Canadian Space Agency**: 1999.

G. Reid, Solar variability and its implications for the human environment, **J. Atmos. Solar-Terres. Phys., 61**: 3-14, 1999.

S.Y. Matrosov, Retrievals of vertical profiles of ice cloud microphysics from radar and IR measurements using tuned regressions between reflectivity and cloud parameters, **J. Geophys. Res., 104(D14)**: 16,741-16,753, July 1999.

S.Y. Matrosov, R.A. Kropfli, R.F. Reinking, B.E. Martner, Prospects for measuring rainfall using propagation differential phase in X- and K_a- radar bands, **J. Appl. Meteor., 38(6)**: 766-776, June 1999.

A.J. Matthews, G.N. Kiladis, The tropical-extratropical interaction between high-frequency transients and the Madden-Julian oscillation, **Mon. Wea. Rev.** : 661-677, May 1999.

M.E. Waite, S. Ge, H. Spetzler, A new conceptual model for fluid flow in discrete fractures: an experimental and numerical study, **J. Geophys. Res., 104(B6)**: 13,049-13,059, June 1999.

HONORS, AWARDS AND RECOGNITION

AKIN, Kenneth
Received the Group Achievement Award for POLARIS Project Team

AVERY, Susan
Awarded *Elizabeth Gee Memorial Lectureship Award*
Appointed Fellow, Institute of Electrical and Electronics Engineers

BENDICK, Rebecca
Recognized for Outstanding Student Paper at the Fall AGU Meeting in San Francisco

BILHAM, Roger
Elected to Fellowship in the American Geophysical Union at the Fall Meeting in San Francisco

BURGDORF, Catherine
Received Scientific Assessment of Ozone Depletion "stellar support recognition

COPLEY, Shelley
Received Mortar Board Honor Society Outstanding Professor Award

COSTA, David
Received a NOAA Outstanding Performance Award

DUTTON, Geoffrey
Received NOAA Outstanding Science Papers of the Year award
Received NASA Group Achievement Award for POLARIS campaign

FREI, Allan
Selected as a finalist for the Association of American Geographers 1998 Nystrom Award

GAO, Ru-shan
Received NOAA/ERL Outstanding Scientific Paper award (co-author)

GOTTAS, Daniel
NOAA/ETL Certificate of Recognition for outstanding contributions meeting the data management and analysis needs
Received NOAA/ETL/ET7 Team Achievement for CALJET

HOLLOWAY, John
Presented an invited talk to an undergraduate colloquium at Fort Lewis College in Durango

HAN, Yong
NOAA/ETL Certificate of Recognition for contributions to the DOE Atmospheric Radiation Measurements Program

HAYES, Patrick
Part of team that received a bronze medal for NOAA/NASA Pathfinder work

HAYS, William
Keynote Speaker, 6th ECOD Workshop, Sundvolden, Norway
Keynote Speaker, 2nd European Paleontological Congress, Vienna, Austria

HOLCOMBE, Troy
Received Chandler-Misener Award for scientific paper on research on Lake Erie

HURST, Dale
Received NASA Group Achievement Award for POLARIS

LANDER, James
Recognized for outstanding and long term research contribution by the 7th International Conference on Natural and Man-made Hazards, Crete

LEWIS, William
Elected President, American Society of Limnology and Oceanography
Received the Naumann-Thiemann Medal, Int'l Society for Pure and Applied Limnology, Dublin, Ireland

MAPES, Brian
Received Editor's Award from the *Journal of the Atmospheric Sciences*

MARCHBANKS, Richard
NOAA recognition for critical contributions to ETL

MILLER, Leroy
Received an NSF International Research Fellow Award

MILLER, Tim
Served as CIRES representative for the Colorado Combined Campaign

MOORE, Fred
Received NASA Group Achievement Award as a POLARIS Project Team member

OSTROVSKY, Lev
Received an Orson Andersen Fellowship for 6 months research at Los Alamos National Laboratory
Included in the 1998-99 edition of Strathmore's Who's Who
Included in the new editions of Marcius' Who's Who in the World; Who's Who in America; and Who's Who in Science and Engineering
Included in the reference book "Renowned Russians"

PERSSON, Ola
Received NOAA Silver Medal Award as lead scientist for CALJET research team

RAVISHANKARA, A.R.
Awarded the 1998 Polanyi Medal from the Faraday Division of the Royal Society of Chemistry, United Kingdom

RAY, Eric
Received NASA Group Achievement Award for POLARIS Project Team

ROMASHKIN, Pavel
Received NASA Group Achievement Award for POLARIS

ROSENLOF, Karen
Received the 1998 NOAA/ERL Outstanding Paper Award
Presented an ozone research lecture at Bear Creek Elementary

SENFF, Christoph
Received NOAA/ETL recognition for outstanding performance

SHERIDAN, Patrick
Received Letter of Appreciation from editors of Geophysical Research Letters and Journal of Geophysical Research for quality of manuscript reviews

SMIRNOVA, Tatiana
Received FAA Aviation Weather Research Program award (RUC/MAPS Implementation group)

SPEISER, Theodore
Served as a Judge for Best Student Posters, Fall AGU Meeting in San Francisco

SPERRY, Paul
Listed in Who's Who in Science and Engineering

SPETZLER, Hartmut
Awarded 3-month fellowship from Alexander von Humboldt foundation in Germany

One of CU faculty honored during Spring Academic Recognition

THOMPSON, Sarah
Received "Stellar" support recognition

THOMSON, David
Award for one of top three posters, Research and Development category, National Instruments Worldwide Conference on Measurement and Automation

VARANI, Annette
Awarded Editor Seat of the AM-1 outreach web site, study section, Earth Observer, NASA Goddard Space Flight Center

VÖMEL, Holger
Received NASA Group Achievement Award for OMS/POLARIS

WAHR, John
Awarded *Vening Meinesz* medal from the Universities of Utrecht and Delft, The Netherlands

WEIL, Jeffrey
Chosen to serve as Chairman, AMS Committee on the Meteorological Aspects of Air Pollution

WHITE, Allan
Received Department of Commerce Silver Medal, ET7 Division Achievement for CALJET

ZHANG, Lingling
Recognized by NOAA for work in the Cloud Radar Project

ZAVOROTNY, Valery
Listed in Marquis "Who's Who in Science and Engineering", 1998-99

COMMUNITY SERVICE AND OUTREACH

ANGEVINE, Wayne
Gave a presentation to the Colorado Soaring Association, Ft. Collins

ARGE, Charles
Served as a judge at the Nederland Junior High School Science Fair

ASNER, Gregory
Served as consultant to Tropical Forest Foundation, Belem, Brazil

BATES, Gary
Volunteer at Boulder Energy Conservation Center

BILHAM, Roger
Presentation to CU Boulder Fine Arts on Seismology and Music

CHESIRE, Laura
Volunteer at Denver Art Museum
Volunteer for American Institute for Graphic Arts Halloween Fundraising event

CHURCH, Lee
Active member, Mile Hile United Way Charity Golf Tournament

CORNWALL, Christopher
Volunteer facilitator, Boulder County Health Department

COSTA, David
Serves as a volunteer firefighter and medic, Boulder Rural Fire Department
Presented a talk to a 5th grade class on the Arctic
Serves as a volunteer at Boulder City Channel 8

CRONIN, Gregory
Assisted with the Earth Systems Science Teachers Workshop

DeCLERK, Karen
Served as CIRES Colorado Combined Campaign Coordinator
Food bank volunteer for Boulder County AIDS Project
Served on Boulder Area Human Resources Association

ERICSON, Renea
Volunteer work with *United Parents of Denver*, a support group for premature and critically ill children
Received the Baby Steps Award from the *American Association for Premature Infants* for creation of the "Preemie Purple Heart"

EUBANK, Charles
Served as a Science Fair judge at the Eisenhower Elementary School

EVANS, Robert
Provided instruction, data analysis, and information to the Total Ozone Measurement Programs of Australia, South Africa, Argentina, and Norway

FARLEY, Paul
Boulder County Poultry Coordinator for 4-H and Extension Programs
Project Leader for 1998 Colorado Poultry Camp

Made presentations at the Rocky Mountain Philatelic Library and the Boulder Stamp Club

FOZZARD, Richard
Meritorious Typing award from the Western Stenographic Society

FREHLICH, Rod
Served on Board of the Village Arts Coalition in Boulder

FRITZ, Richard
Worked with the Colorado Department of Health and Environment during the 1997-1998, 1998-1999 high pollution season
Represented NOAA/ETL on the Boulder County Clean Air Consortium
Served as a Consortium judge at the Boulder Valley Science Fair

GEORGE, Joanne
Serving as treasurer of *Calico and Boots*, a non-profit group which performs traditional American dance for a wide variety of audiences

GILLES, Mary
Served as a judge for the Eisenhower Elementary School Science Fair
Service as lead judge of the Junior Physical Sciences Division, Colorado Science and Engineering Fair
Served as a member of the All Science Team for judging of the entire Junior Sciences Division, Colorado Science and Engineering Fair

GUENTHER, Douglas
Served as an elementary school science fair judge

HARTTEN, Leslie
Served as science fair judge at both Eisenhower Elementary School and Horizons Elementary School in Boulder
Participated in a nature walk for CIRES "Take our children to work day"
Produced a display for the Limon CO Heritage Museum on climate of the eastern plains

HAUSER, Rachel
Presented information at a Science Career Day for middle school girls

HAYES, Patrick
Helped put the 1998 Teacher Guide online for the Globe Program

HEINRICHS, John
Served as a Participating Scientist in the NCAR LEARN program
Participant in planning sessions for Earthworks Workshop

HELMIG, Detlev
Continuing member of CIRES Bolder Boulder team

HOLLOWAY, John
Presented an invited talk to an undergraduate colloquium at Fort Lewis College in Durango

JOBSON, Bertram
Active coach for the Boulder Little League baseball

KNOWLES, Ken
Received Boulder County Commissioners Volunteer Grant Award

KUCERA, Patrice
Presented a weather demonstration to chilidren on "Bring Your Child to Work Day"

LONGFELLOW, Cheryl
Developed Earth Systems high school science teachers Workshop
Served as science fair judge, Burlington Elementary School

LOUGHE, Andrew
Taught "The Science of Weather" to third graders in the Adams County schools

LUSK, Cynthia
Served as science fair judge

LYNCH, Amanda
Assisted implementation of Earthworks Workshop for teachers of earth science, August 1998.

MAPES, Brian
Judged student contributions for the Max Eaton prize at the AMS Hurricanes and Tropical Meteorology conference
Active participant in K-12 Outreach

MARCHBANKS, Richard
NOAA recognition for critical contributions to ETL
Served as judge at Martin Park Elementary K-5 Science Fair
Created a web page for an educational outreach program

MASARIE, Ken
Routinely sing and play guitar in the St. Vrain and Boulder Valley elementary schools
Serve as coach of U11 Interleague boys soccer, St. Vrain Youth Soccer Association

MASLANIK, James
Provided exhibit materials and text for CU Museum presentation on space-related research
Provided interviews to network news reporters and appeared in network news footage of Arctic field work activities at the SHEBA ice camp
Acted as a presenter at Geography Department Career Days

MILLER, Tim
Served as CIRES representative for the Colorado Combined Campaign

MOORE, Andrew
Authored 25 questions for use by the National Ocean Sciences Bowl, a national competition for American high school students

NEUMAN, Andrew
Serve as tour guide of the NOAA Aeronomy Lab and the NIST buildings for children from the Commerce Childcare Center

NISHIYAMA, Randall

Received 5 year service certificate
Assist summer interns and high schools with scientific projects

NOLIN, Anne

Presented an Earth Systems Science Workshop to the science teachers of the St. Vrain school district (co-organizer)

O'NEILL, Michael

Made three presentations at local schools concerning research being done at CMDL's South Pole research station

PENLAND, Cecile

Served as Career Day speaker at Louisville Middle School

SAUNDERS, James

Assisted the Colorado Department of Public Health and Environment, Water Quality Control Division, in support of TMDL model calibration
Assisted Metro Wastewater Reclamation District in the planning and implementation of several studies of reaeration in the South Platte River
Served as Science Fair judge at Foothill Elementary

SERREZE, Mark

Served as judge for Martin Park Elementary School science fair

SIEVERS, Robert

Exhibited in Loveland's annual "Sculpture in the Park", August 1998
Exhibited sculpture at ARS NOVA concerts, 2 Boulder churches, December 1998

SIGREN, Beth

Serve as an instructor in CU's Continuing Education Program

SJODIN, Arne

Assisted the Colorado Department of Public Health and Environment, Water Quality Control Division, in support of TMDL model calibration

SMIRNOVA, Tatiana

Received FAA Aviation Weather Research Program award (RUC/MAPS Implementation group)

SMITH, Catherine

Contributed to Boulder School District Watershed Project

SPERRY, Paul

Judge for the regional Science Fair.

STEVERMER, Amy

Participant in plenary sessions for the Women and Girls in Science Roundtable program, Boulder County YWCA

SUEPER, Donna

Served as an elementary and middle school Science Fair Judge

VÖMEL, Holger

Made Antarctic presentation for Hodgkins Middle School
Participated in Science Discovery Program at Flatirons Elementary school

WEAVER, Alexandra

Made 26 presentations for classrooms and public audiences outside the CU system
Made 4 presentations specifically for teachers outside the CU system
Chosen as Keynote speaker at the Girls and Women in Science Conference, Beloit College, Wisconsin
Served as Science Fair judge at Burlington Elementary school
Taught two courses in the adult education program, Boulder Valley School District

WILLIAMS, Susan

Elected to the Board of Directors of the Wild Bear Science School, Nederland CO; providing scientific guidance and helping to establish a Nature Center for Nederland