

Atmospheric Circulation

Newsletter of the University of Washington Atmospheric Sciences Department

End of an Era: UW's state-of-the-art airborne research facility grounded after 30 years

By Vince Stricherz, *UW News and Events*



Husky One, the Convair 580 research aircraft operated by the University of Washington's Cloud and Aerosol Research Group, retired this year. (NASA photo)

After three aircraft and more than 30 years of airborne studies, UW atmospheric sciences professor Peter Hobbs has decided to ground his research facility.

During that time, the Cloud and Aerosol Research Group led by Hobbs did some of the first studies of the effects of industrial pollution on the atmosphere and some of the earliest research on acid rain. The team flew through the acrid smoke from burning oil wells in Kuwait after the Gulf War, burning jungle vegetation in the Amazon River basin and Africa, and through ash spewing from volcanoes such as Mount St. Helens in Washington and Redoubt in Alaska.

"We've built up one of the best facilities in the world for this type of study," Hobbs said. "It's a big facility for a university group to run. It takes several million dollars a year, and that has gotten increasingly hard to find."

Started by Hobbs in 1963, CARG developed into one of the world's largest groups studying clouds, precipitation and atmospheric pollution, all of which are important in understanding climate change. (Please see CARG back page)

Inventing the 180° Backscatter Nephelometer

By Matt Carr, *Atmospheric Sciences Ph.D. 2001*

From climbing Mount Fuji to ascending the altar, Sarah Masonis has plenty to reflect on after five years in pursuit of a better tool to examine atmospheric aerosols. Now this UW Atmospheric Sciences post-doctoral Research Associate can add a place in the U.S. Patent Office to her impressive list of scientific accomplishments.

Earlier this year, Masonis and UW collaborators Tad Anderson and Bob Charlson were awarded a patent by the United States Patent and Trademark Office for their invention of a 180° backscatter nephelometer (pictured below with Masonis). The instrument could help paint the clearest picture yet of the tiny particles that befuddle forecasts of global climate change.

Masonis (better known by her maiden name, Doherty) came to the department via the ozone hole. In 1992, she landed a post at McMurdo Research Station on the Antarctic coast, where she spent two years running, among other scientific instruments, a lidar, which uses laser light to measure scatter by atmospheric particles. In the process, she developed a curiosity for the atmospheric phenomena it was designed to study, and in 1995, came to UW for a Master's degree, working with Steve Warren to analyze satellite data over the Antarctic.

"I hadn't intended to do a Ph.D.," Masonis recalled over a bowl of steaming soup at one of the Ave's finer establishments. "I just wanted to understand the science behind the instruments." But just as she completed her (Please see Invention page 5)



Sarah Masonis makes adjustments to the nephelometer, a new invention that measures scatter by atmospheric particles

Chairman's Column



On July 1, 2002, I became the 8th chairman of the Department of Atmospheric Sciences, since its beginning in 1947. It is an honor to chair this department, with its continuing record of excellence in teaching, research and service. I want to congratulate Prof. Jim Holton on the completion of a successful five-year term as chair. Jim's term saw some significant transitions, with retirements of Professors Robert Charlson (atmospheric chemistry), Halstead

Harrison (atmospheric chemistry), Conway Leovy (planetary atmospheres), and Norbert Untersteiner (polar climate). Jim supervised the recruitment of four new assistant professors to the teaching faculty, namely Greg Hakim (synoptic dynamics), Lyatt Jaeglé (atmospheric chemistry), Qiang Fu (atmospheric radiation), and David Catling (astrobiology/planetary atmospheres); and three new assistant professors to the research faculty: Igor Kamenkovich (climate and the oceans), Mark Stoelinga (mesoscale processes), and Sandra Yuter (physical meteorology). All of our retirees remain with us as emeritus faculty, and it is wonderful to have a new generation of faculty with enthusiasm and fresh ideas to lead us into the 21st Century.

The future for Atmospheric Sciences looks bright. Our core subjects of weather, climate and air quality are intellectually vibrant and important to people, and the quality of our teaching and research effort at UW is world famous. We have the only comprehensive undergraduate program in Atmospheric Sciences west of Wisconsin and north of California. We now have four tracks in our undergraduate major: meteorology, atmosphere and the environment, atmosphere and the ocean, and teacher education. Grant and contract support for Department research efforts has grown, and we continue to be successful in the wars to recruit the very best graduate students.

One cloud darkens the horizon. Because of anti-tax sentiment and competition with other state programs for resources, higher education is being squeezed financially to the point where it is impossible to maintain a high quality research and teaching effort without private support. We have therefore begun an effort to explain our needs to friends and alumni who may have a desire to make a difference in the field of Atmospheric Sciences. Some information about this will appear on the departmental web page soon. In the meantime, I encourage you to send a tax-deductible donation to the Atmospheric Sciences Discretionary Fund by using the form near the back of this newsletter. Best wishes for a happy and productive year ahead.

Dennis L. Hartmann
Professor and Chair of Atmospheric Sciences

3-Tier Inc: A New Environmental Prediction Firm Founded by Atmospheric Sciences Alumnus

By Clifford F. Mass, Professor of Atmospheric Sciences

Recently, a group of UW staff members and ex-students started a firm that specializes in hydrological and environmental prediction services: 3-Tier, Inc. CEO Ken Westrick (BS 1995, MS 1998), came to the department after serving 14 years in the Army. Ken spent 3 years in the 82nd Airborne Division, 3 years in the 2nd Ranger Battalion, and 5 years in the elite Delta Force—which takes on the most difficult and dangerous missions. His years in the service included combat experience in Grenada and Panama and a large number of parachute descents. Starting with nighttime college courses at age 30, Ken spent three years as an ROTC instructor at the UW while earning his B.S. degree in atmospheric sciences.

Entering the graduate program under adviser Cliff Mass, his thesis research investigated the value of coupling the MM5 atmospheric prediction model and DHSVM, a distributed hydrological model developed in Civil Engineering. The initial coupled model predictions of streamflow were so promising that after securing his M.S. degree in 1998, he remained in the department for several years, expanding the system to include most rivers in western Washington. During the latter few years he was assisted by Pascal Storck, who received his Ph.D. in Civil Engineering in 2000, and also served as a staff member in the department. Ken and Pascal formed 3-Tier in 2000 to offer environmental prediction and energy diagnostic services. Although cognizant of the difficulties of starting a new high-tech business in the current environment, Ken quotes an old Delta Force Sergeant Major SGM Country Grimes, “the greatest failure is the failure to try.”

As in the military, for Ken and Pascal “failure in not an option,” and they have already garnered a number of contracts and built a large computational facility in their offices. For example, they now have contracts to provide wind predictions for wind energy firms and will be giving Seattle City Light detailed streamflow and weather prediction services for their Skagit and Boundary River projects. With extraordinary determination and excellent technical skills, we expect that 3-Tier will be able to provide a new generation of technical services to the energy and public resource agencies as well as private sector firms.

For more information about 3-Tier, check their web site at <http://www.3tierrgroup.com>.



AMS University of Washington Student Chapter

By Tim Whitcomb, Undergraduate and AMSUW President

The American Meteorological Society—UW Chapter (AMSUW) is a registered Local Chapter of the national AMS, as well as a University of Washington Registered Student Organization. Founded in 2001, the AMSUW exists to “...promote fellowship among members, to stimulate awareness and interest in Atmospheric Science and the activities of the chapter within the community.” Chapter social activities have included an intramural softball team, Sonics Night, and a Mariners game. At meetings, the AMSUW discussed topics like the Northwest Avalanche Center, the MM5 and the rise of mesoscale modeling, as well as the history and heritage of the national AMS with visits from KING5 weathercaster Rich Marriott, NWS forecaster Ted Buehner, and UW professor Cliff Mass.

While members are primarily undergraduate students in the department, membership is open to any UW student with an interest in the atmospheric sciences. The AMSUW is more than just an academic organization—it provides a forum for students to meet with reasons beyond upcoming exams, and to foster a sense of community within the department.

The AMSUW also sponsors an annual Photo Contest for students, staff, and the general public to exhibit their favorite weather photos, and to compete for prizes. This past year, we received photos including impressive supercell thunderstorms, rainbows, mountains, and the classic lightning shots. Contest winner Jeremy Smith’s photo and the other entries can be viewed at <http://students.washington.edu/amsuw>.

Officers for the 2002-2003 academic year are Candace Berg, Brian Garcia, Madhu Narayanan and Tim Whitcomb. For more information, email amsuw@u.washington.edu.

Outreach Activities

By Justin J. Wettstein, Graduate Student and Outreach Volunteer

What a great year! Many students, faculty and staff from the UW Department of Atmospheric Sciences volunteered last year to make outreach activities a great success. The individuals and groups we responded to were as varied as the requests we received, but each resulted in the volunteers getting as much out of the interaction as those seeking assistance (and maybe even more).

During the past year, the department was asked to share our expertise in relation to a variety of requests. We’ve been asked to answer specific atmospheric science questions from students and professionals around the world, to proctor competitive science competitions for primary and secondary school students, to receive groups interested in a description of our field and to visit schools and give hands-on demonstrations. Responses to the nearly 70 requests ranged from simple e-mail or phone correspondence, to coordinating an on-site visit with groups contacting us for the first time.

As an example of a “typical” visit, we had five Girl Scout and Boy Scout troops visit the department. Our student volunteers led the scouts in experiments related to weather phenomena, described the various tools we have for assessing weather and climate, showed real-time model and satellite images and described what it is like to be a young scientist. The kids and volunteers appreciated each of these components, though I guess it’s still true that we all liked “blowing things up” the best (i.e. when the experiments go as planned).

As our department continues to excel in advancing atmospheric science knowledge through research and courses, it is fulfilling to share our expertise and experiences with children and other groups in the broader community. Volunteers found the time well spent in thinking about how scientific knowledge is perceived, pondering the intersection of different sub-disciplines and just plain having fun with our work.

Atmospheric Science Students PRIME K-12 Kids for Science Careers

By Kathryn Stout, Academic Advisor

This past year two of our students took part in the National Science Foundation’s second annual Partnerships for Research in Inquiry-based Math, Science and Engineering Education Program (PRIME), culminating in a Showcase at Mary Gates Hall.



Ph.D. Student Kevin Rennert, pictured at left, supported this past year as a PRIME Fellow, worked with an undergraduate student from Physics at the Albert Einstein Middle School in Shoreline. His showcase project was “Exploring the Mysteries: Augmenting inquiry based learning in 8th grade science,” in

which the focus was on developing inquiry-based units for Atmospheric Science, Geology, and Waves. The strategy was to bring everyday experiences of the students into class discussion, add to them in class, helping to build a solid foundation for understanding. In the Atmospheric Sciences unit the students explored the mysterious effects of atmospheric pressure and how it impacts weather. They then applied these principles to our own locale to understand why Seattle area weather is so unique.

B.S. Student Madhu Narayanan, pictured at right, worked on his PRIME project with a Ph.D. student from Mechanical Engineering, at Seattle’s Nathan Hale High School. Their showcase project was “9th grade Sciences and Senior Level Physics,” exploring more challenges of inquiry-based learning. For example, they used a target-shooting contest to learn about work and energy, and water rockets (equipped with eggs as passengers) to learn about Newton’s Laws and momentum.



Recent Graduates in Atmospheric Sciences

Doctor of Philosophy Degree Recipients

Jadwiga Beres, “Gravity Wave Generation by Tropical Convection—What Really Goes on in There?” (J.R. Holton)

Ulrike Dusek, “Aerosol Physical Properties Measured in South-East Portugal and Their Importance for the Direct and Indirect Aerosol Forcing of Climate,” (D.S. Covert)

Sasa Gabersek, “The Dynamics of Gap Flow over Idealized Topography,” (D. Durran)

Kristin Larson, “Tropical Climate Sensitivities: Cloud, Water, Vapor, Radiation and Large-Scale Circulation,” (D.L. Hartmann)

James McCaa, “A New Parameterization of Marine Stratocumulus and Shallow Cumulus Clouds for Climate Models,” (C. Bretherton)

Daniel Vimont, “The Seasonal Footprinting Mechanism: Implications for Pacific Climate Variability,” (D.S. Battisti)

Jeffrey Yin, “The Peculiar Behavior of Baroclinic Waves During the Midwinter Suppression of the Pacific Storm Track,” (D. Battisti/E. Sarachik)

Master of Science Degree Recipients

Robert Contreras, “Effects of Rain on Ku-band Backscatter from the Ocean Surface, Implications for the TRMM PR and the QuikSCAT Scatterometer,” (R.A. Brown)

Ioana Dima, “Annular Structures in Low Latitude Wind and Temperature Variability,” (J.M. Wallace)

David Erickson, “The Optical Properties of Sea Ice: Temperature, Salinity and Wavelength Dependence,” (J.M. Wallace)

Eric Grimit, “Implementation and Evaluation of a Mesoscale Short-range Ensemble Forecasting System over the Pacific Northwest,” (C.F. Mass)

Socorro Medina, “Air Motions and Precipitation Growth in Alpine Storms,” (R.A. Houze)

Brian Polansky, “Reconstructing 500-hPa Height Fields over the Northern Hemisphere,” (J.M. Wallace)

Ignatius Rigor, “On the Response of Sea-Ice to the Arctic Oscillation,” (J.M. Wallace)

Bachelor of Science Degree Recipients

Robert Gallup	Brian Rice
Scott Guhin	Michael Ronayne
Amy Haase	Benjamin Schott
James Kerley	Jason Sechrist
Jerrold McAlpine	Victor Stegemiller
Charles Parks	Jeremy Wolf

Scholarships

The Department of Atmospheric Sciences offers two prestigious named scholarships. The Bruce Caldwell Memorial Scholarship, named for an atmospheric sciences alumnus, was established through the generous contributions of Bruce Caldwell’s parents and friends. This scholarship supports both graduate recruitment and undergraduate scholarships. The Atmospheric Sciences Anonymous Endowed Fund exclusively supports undergraduate scholarships. Together these funds awarded scholarships to the following undergraduate students during the past year: **Sean Casey, Brian Garcia, Scott Guhin, James Kerley, Madhu Narayanan, Liam Nyman, Charles Parks, Benjamin Schott, and Timothy Whitcomb.**

Martha Stevens, an atmospheric sciences graduate student working with Prof. Greg Hakim, was awarded a three-year National Science Foundation Graduate Fellowship.

American Meteorological Society Fellowships, of one academic year each, were awarded to **Jasmine Cetrone** and **Ryan Torn**, who are both incoming graduate students this fall.

The UW’s new interdisciplinary Program on Climate Change (PCC) awarded first year fellowships to incoming graduate students **Ken Takahashi** and **Sarah Strode**.

Incoming graduate student **Sarah Strode** has been awarded the Seattle Chapter of the ARCS Foundation (Achievement Reward for College Scientists) award.

The American Meteorological Society 75th Anniversary Scholarship has been awarded to **Timothy Whitcomb**, who will be a senior in our program this year and is working with Prof. Sandra Yuter.

Weather Forecast Contest Winners

From among the thirty-plus contestants, the overall winner of the annual spring Forecast Competition was “Luke Oudawinda,” also known as Affiliate Associate Professor Nick Bond. Bond also won the temperature portion, and undergraduate Jeremy Wolf won the precipitation contest.

Wolf also won the annual Snow Depth Competition with a prediction of only 0.5 inches of snow at any point during the past winter on the north lawn in front of the Atmospheric Sciences–Geophysics building. Twenty-eight snowcasters participated in the contest this year. There was even a prediction for twenty-two inches of snow!

New Graduate Students

The department welcomes fifteen incoming graduate students this fall. We will also host Christopher Ruckstuhl, who will spend autumn quarter here as an exchange student from Switzerland. New graduate students are:

Marie Ammerman	UC Santa Barbara
Larissa Back	Cornell
Peter Caldwell	Western Washington
Joseph Casola	Duke
Jasmine Cetrone	UC Los Angeles
Celeste Cory	Michigan State
Louise Leahy	Reading, United Kingdom
David Reidmiller	Colgate
Alex Reinecke	Utah
Sarah Strode	Washington U. St. Louis
Ellen Sukovich	Carleton College
Ken Takahashi	Pontifica U. Catolica, Peru
Ryan Torn	U. Wisconsin-Madison
Patrick Zahn	Princeton

Richard Reed Symposium

On January 15, 2002, the American Meteorological Society sponsored, "A Half Century of Progress in Meteorology: The Richard Reed Symposium." The one-day symposium held in Orlando, Florida, celebrated the extraordinary scientific career and achievements of Professor Emeritus Richard Reed, who retired in 1991.

The symposium highlighted the broad scope and significant impact of a half century of Richard Reed's research, spanning virtually the entire field of meteorology from the Tropics to the Arctic, from the boundary layer to the mesosphere, from turbulence to planetary-scale motions, and from fog to explosive cyclogenesis. With seemingly boundless and contagious energy and enthusiasm, Reed has tackled many problems across this broad spectrum, and his unique insight in the interpretation of observations has led to fundamental discoveries that have shaped the course of the science in many of these areas.

Conway Leovy Symposium

In May, the Department hosted a symposium in honor of Professor Emeritus Conway Leovy who retired in 1999. Leovy joined the department in 1968 as an Associate Professor. During his tenure, he built a distinguished record in research on the upper atmosphere and planetary atmospheres. In the 1970s he was a key partici-

pant in NASA planetary programs, including service as the primary meteorologist on the Mars Viking mission. His early work on the circulation of the middle atmosphere remains one of the most frequently cited papers among scientists working on dynamics of the stratosphere and mesosphere. Although retired, he remains a key participant in the UW Astrobiology Program.



Several of Leovy's former graduate students came to campus for the symposium. Pictured from left to right are Jeff Barnes, Joel Norris, Matthew Hitchman, Conway Leovy, Thomas Ackerman, Robert Haberle, Jordan Sutton, Richard Zurek and Sungsu Park.

Invention continued from Page 1

Master's, Masonis discovered that Charlson and Anderson were looking for someone to help tackle a problem that she had encountered herself back in the Antarctic: how to use the signal information retrieved by lidar to make quantitative conclusions about the aerosols themselves. It was a challenge she couldn't resist.

The three modified an existing instrument, the integrating nephelometer (the original design of which earned Charlson and UW colleague Norm Ahlquist a patent of their own back in 1972) to measure 180° backscatter. The quantity is one of a pair needed to convert the lidar signal to a meaningful description of particles. By measuring the backscatter, the team aimed to calculate the lidar ratio (the ratio of the particle optical extinction to the 180° backscatter) under a range of conditions—something that lidar experts had sought for years.

After toiling for months, the three arrived at a design, and began calibration. "We were shocked how on it was," Masonis recalled, referring to the instrument's agreement with Mie scattering theory. Subsequent field experiments over the Indian Ocean (where she got engaged on camelback), in an Illinois cornfield (to which she drove wedding dress in hand, and to which she returned days after marrying husband Rob), and Japan (summitted Mt. Fuji) have been equally pleasing. Despite her success, Sarah has not stopped thinking about the ozone hole—in particular, what lies beyond. NASA is currently considering her application for the astronaut training program.

Faculty Notes

Prof. **David Battisti** was named the Distinguished Visiting Scholar by the Woods Hole Oceanographic Institute for Summer 2002.

Prof. **Dennis L. Hartmann** was elected Fellow of the American Geophysical Union in January 2002. Hartmann was cited "for fundamental contributions to understanding of planetary-scale climate fluctuations." Fellows are elected from the membership of the AGU by a committee appointed by the President.

Prof. Emeritus **Robert Fleagle** recently authored, "Eyewitness: Evolution of the Atmospheric Sciences." This book, published by the AMS, describes how the atmospheric sciences were transformed in the span of the author's professional career at the UW from its origins in primitive weather forecasting to its current focus on numerical modeling of environmental change. It describes the author's observations of the role that the science of the atmosphere now plays in climate change and other issues of social and political policy.

Research Associate Prof. **Bradley Smull** was given the NOAA Award for Sustained Superior Performance in December 2001.

In January 2002, the AMS awarded Professor **Christopher Bretherton** the Editor's Award for reviews for the *Journal of the Atmospheric Sciences*.

The U.S. Board on Geographic Names recently designated a ridge in Antarctica on Ross Island "Warren Ridge," named after Prof. **Stephen G. Warren** who investigated climate processes on the Antarctic plateau in four deployments to South Pole Station, including the full year of 1992 as station science leader.

Alumni News

Professor **Michael Biggerstaff** (PhD 1991) is moving from Texas A & M to the University of Oklahoma.

Jin-Yi Yu (PhD 1993) resigned his position as a Research Assistant Professor at UCLA Department of Atmospheric Sciences and accepted a teaching faculty position in the Department of Earth System Science at UC Irvine that began in July 2002.

Professor **Ming-Jen Yang** (PhD 1995) is moving from the Chinese Culture University to the National Central University. Both universities are in Taiwan.

James Renwick (PhD 1995) writes, "These days, I'm working in the climate dynamics research group at NIWA (National Institute of Water & Atmospheric Research). I visited JISAO in early June of this year, on my way back from a sabbatical at the UKMO Hadley Centre. It was great to see people again, though the three days we had there was clearly nowhere near long enough!"

Robert Kotchenruther (MS 1997), received a Ph.D. in Chemistry from the UW in 2000. He writes, "Now I'm employed at the US EPA as an environmental scientist doing air quality work, Region-10 office in downtown Seattle."

Andrew Gettelman (PhD 1999), a postdoctoral researcher at NCAR, leads a study that will assess the information divide between the west and developing countries along the Indian Rim. Earlier this year, he surveyed researchers' experiences with publishing and distribution of their work domestically and internationally, and how they access and use computers. Then Gettelman toured locations across the Indian Rim to learn firsthand how access to information, or lack of it, affects climate research. In August, he visited the department and presented a travelogue of his tour. The results of the assessment may improve weather forecasting, and responses to climate changes such as monsoons and tropical storms in countries along the Indian Rim. For more information, see <http://www.asp.ucar.edu/infoex>.

Research by **David Thompson** (PhD 2000), Assistant Professor at Colorado State University, was featured in the "news scan" section of Scientific American, August 2002. Dr. Thompson, working with Dr. Susan Solomon of the NOAA Aeronomy Laboratory, has found evidence that recent surface climate changes over the Antarctic in summer are linked to the ozone hole that develops in the Antarctic stratosphere during the spring. In the same article, Scientific American noted that a year earlier **Mark Baldwin** (PhD 1987) and **Timothy Dunkerton** (PhD 1980) of Northwest Research Associates had shown that disturbances in the Northern Hemisphere winter stratosphere typically precede weather anomalies in the troposphere, thus providing evidence for a downward propagating influence of stratospheric disturbances.

Scott Guhin (BS 2002) will begin studies at the Rosenstiel School of Marine and Atmospheric Science of the University of Miami this fall.

The National Weather Service hired more of our undergraduates! **Jeremy Wolf** (BS 2002) joined the Pendleton, Oregon, office this summer, while **Amy Haase** (BS 2002) continues on at the Seattle office.



Donor Recognition



The Department of Atmospheric Sciences gratefully acknowledges the donors who have generously supported us during the past fiscal year July 1, 2001 through June 30, 2002.

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Giving to the Department of Atmospheric Sciences

Please consider supporting the activities of the Department of Atmospheric Sciences. Your gift strengthens the core of the UW through recruitment and retention of world-class faculty. Your support of undergraduate and graduate students helps to create the next generation of scientific leaders. Help us to ensure that the department continues to be a leader in weather and climate research.

Contributions to the **Atmospheric Sciences Discretionary Fund** are unrestricted and can be used to provide support

where the need is greatest. In recent years this fund has helped defer travel costs for graduate student recruitment, refurbished the undergraduate instrument laboratory, and funded student orientation activities.

If you wish to provide direct financial support for students, the **Atmospheric Sciences Fund** provides a mechanism to support undergraduate scholarships and financial aid for graduate students.

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Dennis L. Hartmann, Chair
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Please send alumni news, comments, questions, and address updates to laurie@atmos.washington.edu, or call (206) 543-4250.

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After a \$2 million retrofit in the late 1990s, the airplane, dubbed Husky One, was one of the world's best-equipped planes for measuring trace gases, aerosols, clouds and precipitation. The 40-year-old aircraft, kept in a hangar at Paine Field in Everett, was acquired as surplus property from the federal government.

The Convair 580 replaced a Convair C-131A, which the group used from 1984 through 1997 for extensive research on the structure of clouds, the effects of clouds on solar radiation, pollution in the Arctic and the properties of smoke and its effects on climate and atmospheric chemistry. With that aircraft, the group monitored the smoke pouring from oil wells in Kuwait set ablaze by Iraqi forces during the Gulf War of 1991, and later analyzed smoke from burning jungle forests in the Amazon region.

The group's first plane, used from 1970 to 1984, was a World War II-vintage Douglas B-23 previously owned by Howard Hughes. Its first mission was to gather measurements in Pacific Northwest storms, studies that provided the first details on the organization of precipitation in cyclones that occur outside the tropics. The B-23 is now displayed in the McChord Air Museum at McChord Air Force Base near Tacoma.

Through the years, the research group has published more than 300 scientific papers. A flight of just a few hours can yield enough data for a student's degree thesis,

Hobbs said. He noted that since 1970, the group's airborne measurements have been the basis for 55 master's and doctoral degree dissertations. "Although we have been very productive, we have always collected far more data than we've been able to analyze," he said. "There is enough unanalyzed data to keep CARG scientists and students busy for many years."

Among its recent missions, Husky One flew over the Arctic, the tropical Pacific and southern Africa. But its last assignment, in November and December, was to fly over the Cascade Mountains in Oregon, obtaining measurements aimed at improving the models used for weather forecasts.

"We sort of came full circle by returning to what we started out doing in the 1970s, but with much better equipment," Hobbs said.

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