ESRL Quarterly

News from NOAA's Earth System Research Laboratory

Spring 2010

USFWS

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◄ *Climate change in pika habitat, page 4*

H_2O Matters

Stratospheric water helps explain temperature trends

Earth's surface temperatures have not risen as quickly in the last ten years as they did in the 1980s and 1990s. A team of researchers led by ESRL's Susan Solomon (Chemical Sciences Division, CSD) has now shown that a still-puzzling decline in water vapor 10 miles above Earth's surface may be part of the reason.

Water vapor is a powerful greenhouse gas, well understood to affect warming in Earth's atmosphere.

"Current climate models do a remarkable job on water vapor near the surface," Solomon said. "But this is different—it's a thin wedge of the upper atmosphere that packs a wallop from one decade to the next in a way we didn't expect."

Her team analyzed global satellite observations of stratospheric water, which began in the 1990s, and long-term balloon observations of water vapor from the only available site in the world, Boulder, CO. Sam Oltmans (Global Monitoring Division) and his colleagues have been taking measurements there for nearly 30 years.

Stratospheric water increased in the 1980s and 1990s, and dropped after 2000, globally. The authors used models and calculations to determine the effect of those stratospheric changes on Earth's surface temperatures. Results were published in *Science* January 28.

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GPS for Storms, Climate, More

ESRL sends innovative instrument packages offshore for first time

In preparation for this year's hurricane season, several ESRL researchers spent the winter working with Devon Energy, placing Frisbee-sized satellite antennas high atop two Devon oil platforms in the Gulf of Mexico. The instruments are based on Global Positioning System technology—most commonly known for its precise location measurements.

It's not as if storms are likely to push around the oil platforms. Rather, ESRL researchers are testing their ability to use a serendipitous power of GPS signals—information that can be gleaned about atmospheric water vapor—to improve regional weather forecasts, monitor climate, and help verify satellite and balloon measurements. The Gulf installations of "GPS-Meteorology" packages are the first deployed over open water far enough from land that satellite observations are not "contaminated" by land interference.

That could mean better hurricane intensity forecasts—since moisture-rich air can drive the intensification of a storm, and dry air can weaken it. But the GPS-Met packages may improve weather forecasting much farther away.

"If successful, the experiment could have far-reaching consequences, since most of the atmospheric moisture in the eastern two-thirds of the United States has its origins in the Gulf of Mexico," said ESRL's Seth Gutman (Global Systems Division).

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IceStories

Climate Service

ESRL research expected to fuel proposed NOAA office

NOAA proposes to create a Climate Service by bringing together climate science, products, and service delivery capabilities from around the agency, U.S. Commerce Secretary Gary Locke announced Feb. 8, in a press conference with NOAA Administrator Jane Lubchenco.

"By providing critical planning information that our businesses and our communities need, NOAA Climate Service will help tackle head-on the challenges of mitigating and adapting to climate change," Locke said.

Public and private entities involved in transportation, insurance, energy, water, fisheries, agriculture, and other industries increasingly seek climate information to help inform decisions, according to *A Vision for Climate Services in NOAA*.

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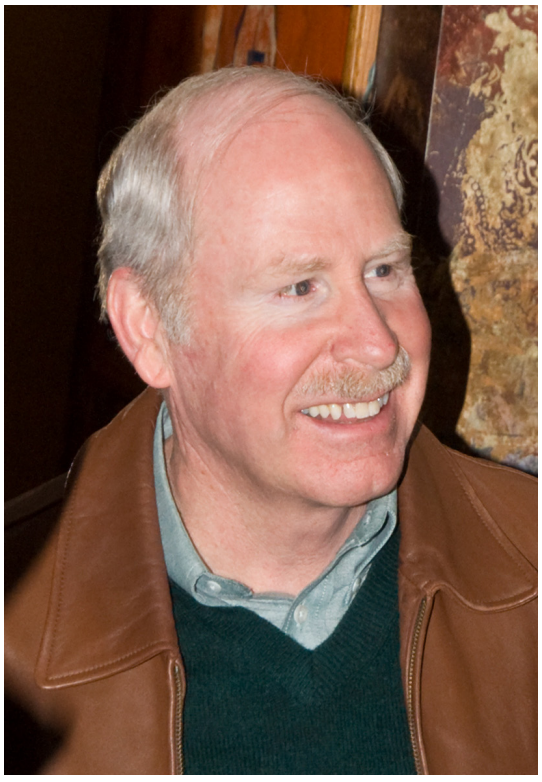


Director's Corner

A nice thing about my career in NOAA is that it has never been boring—it changes rapidly with the times, and today is no exception. As noted on page 1, Secretary of Commerce Gary Locke announced that NOAA would propose a "NOAA Climate Service" (NCS). The new line office would include three out of the four ESRL Divisions (CSD, GMD, PSD), with the remaining division (GSD) to continue in the research line office of NOAA. NOAA Administrator Jane Lubchenco emphasized that the planned reorganization would be accomplished with two goals in mind; first, to create a climate service, and second, to strengthen NOAA's science.

Rick Spinrad and the OAR (NOAA's Office of Oceanic and Atmospheric Research) leadership have been working on plans to assure that the "new" OAR will contribute to the strengthening of science. One idea being discussed is a Chief Scientist office, which would have an Innovation Office as part of its purview. The Innovation Office would be similar to the Defense Advanced Projects Agency (DARPA), which has been a highly innovative force for U.S. technology for many decades. Thus the very strong climate research that would be in the NCS would be complemented by a more innovative OAR—perhaps to be renamed the NOAA Research Service. Of course, NOAA must get approval of its plans from the administration and Congress, which will take time—perhaps six to 18 months before the final decision. In the meantime, I and the leadership of ESRL will be working to assure that this reorganization results in the continued high research productivity and important role that we play within NOAA and the nation. The role of the ESRL Director's Office in the reorganized NOAA is yet to be determined, but we are putting forward some ideas of how we can contribute in the new organization.

The other big change occurring is the retirement of Rick Spinrad, Assistant Administrator of OAR. I have had the privilege of working with all of the OAR AA's for the last 30 years, and it is with some perspective that I appreciate the great job he has done. He will be joining Oregon State University as the Vice President for Research.

Among the important things that Dr. Spinrad brought to OAR were his ideas on a re-vitalized laboratory review program. In the second week of March, ESRL conducted a review of its Physical Sciences program. It was truly outstanding—a source of pride for me and OAR management. My congratulations to Steve Koch, Bill Neff, John Schneider, Sara Summers, and everyone else who contributed to this excellent review. As of right now, ESRL has completed both of its Quadrennial Reviews, the Chemical Sciences review being the first of the new OAR review series, and Physical Sciences the last. The OAR lab reviews are a high standard for all of NOAA, including the new research service and the climate service—it's important that we keep the momentum on organizational reviews as the line structure changes.

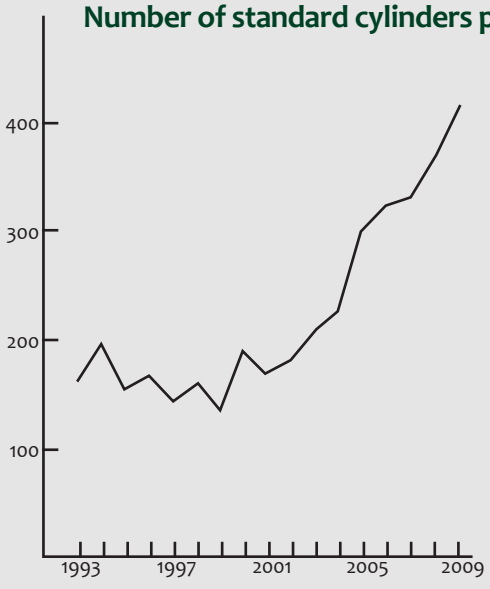
There is much to enjoy in this version of the *ESRL Quarterly*. The lovable pika on the front, or more correctly the important study about its fate in a changing climate, gives an indication of the wide ranging impacts that the NCS will have to confront. NOAA's mission of understanding and predicting climate change is also accentuated by the explanatory research from PSD that is evident in the article about the weird snowstorms in Washington D.C. Innovative ideas such as GSD's role in exploiting GPS and the use of UAS to track seals are other examples.

My closing thoughts for this column concerns the goals we set for ESRL, and the results from the last four and one-half years. One goal was to increase the integration of our research efforts; this was one of the strongest findings from the recent Physical Science review team. A second goal was to increase the financial support for our divisions. The results for this year, FY2010, and the exciting new initiatives that are in the President's budget for next year, FY2011, show that we have also been successful in this effort.

—Alexander MacDonald

By the Numbers
Standards

Number of standard cylinders prepared annually (carbon gases)



Since 1993, ESRL has nearly tripled the number of carbon gas standards made annually, and now maintains international standards for the World Meteorological Organization. Standards and calibration scales are an essential part of atmospheric science, allowing comparison of data captured by different instruments at different times and in different places.

Why is demand up? "The international community is committing funds for atmospheric research," said Duane Kitzis (Global Monitoring Division and Cooperative Institute for Research in Environmental Sciences). "Many more laboratories are making these measurements."

In the spring, Kitzis' group was preparing standard reference gas cylinders for use in NOAA laboratories, other laboratories around the country, on ocean buoys, and in laboratories in Switzerland, Norway, China, Japan, India, Canada, Singapore, Brazil, and Germany.

"Globally, the only way to compare data from different locations and programs is to have all instruments calibrated on a single, well-defined scale. We provide standard reference gases to all kinds of projects worldwide."

—Duane Kitzis

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Antarctic Tales

ESRL's Nick Morgan settles in for winter science, blogging

ESRL's man at the South Pole, NOAA Corps Officer Nick Morgan (lieutenant junior grade), is blogging regularly about his science and daily living experiences, through the Exploratorium's web site, Ice Stories (http://icestories.exploratorium.edu). In Morgan's dispatches, rich with videos and photographs, he shows how to sample pristine air at the South Pole, why solar radiation measurements are critical for understanding climate, and how a jog in Antarctica differs from one in Wisconsin.

"We are on our own now," Morgan wrote on March 8, after the last flight out before an eight-month "deep freeze."

Followers of Morgan's blog include a middle school class from Albuquerque, NM, NOAA colleagues, and a student from Prague who sent Morgan a "Flat Stanley" (a paper doll sent to distant places to learn new things).

Nick Morgan/NOAA

HFC-23 Emissions on the Rise

Policy experts take note of increase in the potent greenhouse gas

Three times in the last decade, ESRL scientists and colleagues traveled to Antarctica, drilled hundreds of feet into dense snow, and extracted air samples that they hoped would give them insight into atmospheric changes.

Air trapped in compressed snow ("firn") contains a record of atmospheric composition changes, and ESRL's Stephen Montzka (Global Monitoring Division) and David Fahey (Chemical Sciences) and their colleagues were especially interested in the powerful greenhouse gas, HFC-23. There have been international efforts to control emissions of the gas, which lasts 300 years in the atmosphere, and which is thousands of times more efficient (per molecule) at trapping heat than is carbon dioxide.

Still, HFC-23 emissions are up, the researchers reported Jan. 29 in *Geophysical Research Letters*.

"Without the international effort to reduce emissions of HFC-23, its emissions and atmospheric abundance would have been even larger," Montzka said. "As it was, emissions averaged over 2006-2008 were about 50 percent above the 1990-2000 average."

Although HFC-23, also known as trifluoromethane, is not itself an ozone-depleting gas, it is linked to the issue of stratospheric ozone depletion in another way. HFC-23 is released into the atmosphere primarily during the production of another chemical, HCFC-22, an ozone-depleting gas used in refrigeration, heat- and chemical-resistant products, and more. Today, HFC-23's overall contribution to warming is small, relative to other greenhouse gases, but since only a portion of the processes that generate HFC-23 are restricted, scientists are keeping tabs on it.

The United Nations Framework Convention on Climate Change is concerned enough about this greenhouse gas that it has facilitated the destruction of HFC-23 in developing countries since 2003. Developed countries have also reported significant drops in HFC-23 emissions after 2000. Montzka et al. concluded that increasing HFC-23 emissions and atmospheric concentrations in recent years can be attributed primarily to rapidly increasing production of the ozone-depleting gas HCFC-22 in developing countries.

Montzka presented the team's research to a Montreal Protocol "Stakeholder" meeting in late January, hosted by the Environmental Protection Agency (EPA) and the State Department. Parties to the Montreal Protocol, including the United States, set international policy on substances that deplete Earth's protective ozone layer.

The meeting drew about 100 people from diverse sectors, from industry groups to environmental organizations, said EPA's Cindy Newberg, Chief of the Alternatives & Emissions Reduction Branch (Stratospheric Protection Division). Discussion focused on possible policies to control HFCs under the Montreal Protocol, and policies regarding the destruction of ozone-depleting compounds.

NOAA

Collecting firn air in Antarctica.

"This was a great forum for Steve to present his findings. Many people have been thinking that HFC-23 is a problem, but his group actually went out and did the research," Newberg said. "Everyone was interested in connecting the science to potential policy options."

Last year, the United States and many other countries jointly declared a commitment to phase down the production and consumption of HFCs, in general. Without further regulation, HFC use is projected to grow, as countries phase out the use of ozone-depleting substances, and turn to HFCs as replacements.

There will be a Montreal Protocol working group meeting in Bangkok in June, and the 22nd meeting of the Parties is tentatively scheduled for October in Africa—where many anticipate additional discussions on potential HFC controls.

Science Pipeline

Paper examines diversity in atmospheric science

Soon after Leslie Hartten (Physical Sciences Division) began her career at NOAA and CIRES, the research meteorologist made a surprising realization. Just a few years past her Ph.D., she was the third eldest woman in her research group.

"I thought that was bizarre," Hartten said. "I wasn't that old or experienced. How could that be?"

Now, Hartten and colleague Peggy LeMone (National Center for Atmospheric Research, NCAR, and new President of the American Meteorological Society, AMS) have conducted a "cohort analysis" on several sets of diversity data collected over the years.

They conclude that although both gender and ethnic diversity have increased in the atmospheric sciences, those seeking to increase diversity in the field need to pay attention to the details. Among them:

- **The importance of community colleges**: 11 percent of students pursuing bachelor's degrees in atmospheric sciences held associates or similar degrees.
- **Reasons for trends**: In younger cohorts, the proportion of women in the field is higher, but primarily because the number of men in the field has dropped.
- **A single program can make a difference**: SOARS®, a research and mentoring program run by the University Corporation for Atmospheric Research (with sponsorship from NOAA and CIRES) had supported 84 non-white students by 2004. That's a high number relative to the total number (412) of non-white atmospheric scientists who responded to an AMS survey in 2005.

Hartten said she and LeMone have both had a longstanding interest not only in science, "but in how it gets done. Part of that is who scientists are," Hartten said.

For her, the most compelling reason to foster diversity in the field of atmospheric sciences is to improve the enterprise of science itself: "You get the most creative approaches when you draw from the largest pool. That's where I come from."

Hartten has served as chair of the American Meteorological Society's Board on Women and Minorities, and has been a mentor for undergraduates in SOARS® for nine years.

The cohort analysis paper will be published by the *Bulletin of the American Meteorological Society.*

ESRL's Leslie Hartten and student Melissa Burt in 2006.

A Climate for Pikas

ESRL analysis of habitat helps federal biologists make protection decision

American pikas, little rabbit-like mammals that live on cool and rocky high-altitude slopes, have become a symbol of climate change impacts for some environmental groups. They often cannot tolerate the relative warmth of valleys, and so if climate change forces their preferred habitat upslope, populations could be left isolated, on "sky islands" of good habitat.

In 2007, an environmental group requested that the U.S. Fish and Wildlife Service assess threats to the mammal—especially climate change—to see if pikas warranted protection under the Endangered Species Act. The FWS sought help from NOAA—the first time NOAA has been involved in a species status review.

"We were approached by Fish and Wildlife to conduct a rapid review of the area's climate that they could use to inform their decision on pika status," said ESRL's Andrea Ray (Physical Sciences Division, currently on assignment to NOAA's Office of Policy, Planning & Evaluation). "We brought different threads of scientific study together to bear on the particular problem and provided it in about six months so FWS could meet the deadline," she said.

Pikas generally live in alpine and subalpine rockfields, and their range includes mountainous regions from the U.S. and Canadian West.

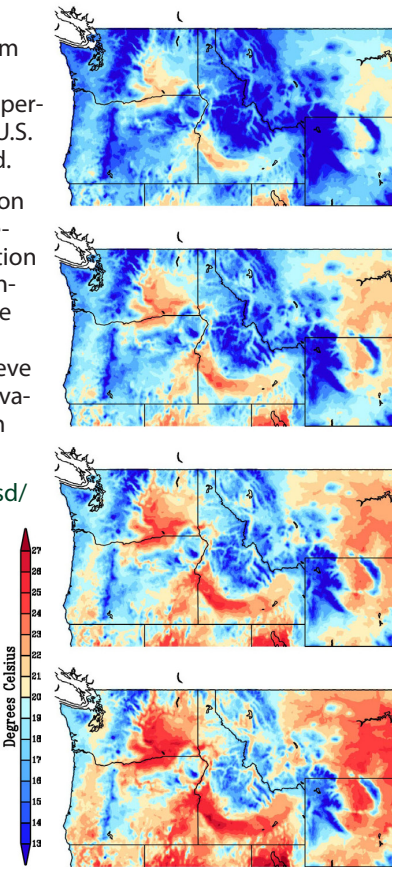
In February, ESRL's Ray and Joe Barsugli, Klaus Wolter, and Jon Eischeid (all Physical Sciences Division and CIRES) completed a 47-page analysis of observed and projected climate changes in pika habitat. The team assessed climate observations at and near pika locations; and projections from the Intergovernmental Panel on Climate Change Fourth Assessment report. They also "downscaled" the IPCC projections to project future climate patterns in 22 specific pika locations.

The research team found that for pika habitat, the average summers of the middle of this century will be warmer than the warmest summers of the past, by about 5°F. Observing stations in parts of Nevada and Oregon, for example, show summertime warming of 2-4°F during the past 30 years. These findings are consistent with the large-scale warming projected by the IPCC global models.

The trends identified in the NOAA report are probably enough to harm some pika populations, especially those in low-elevation, higher-temperature parts of the Great Basin, the U.S. Fish and Wildlife Service concluded.

"However, these losses will not be on the scale that would cause any species, subspecies or distinct population segments of pika to become endangered in the foreseeable future," the Service wrote, declining to confer protection to the species. "We believe the pika will have enough high elevation habitat to ensure its long-term survival."

More: http://www.esrl.noaa.gov/psd/



June, July, and August temperatures in the Pacific Northwest, including areas of pika habitat. a) Climatology (1950-1999 average); b) 2025 projection; c) 2050 projection; and d) 2090 projection. Images and downscaled modeling by Jonathan Eishcheid (Physical Sciences Division).

Playing with Fire

Striving for better fire predictions of fire weather and its effects on fire behavior

Spring in South Carolina is normally mild and moist, with weather that entices trumpet flowers to bloom—not burn. But in April last year, emergency managers had to evacuate thousands of people from their homes in the path of a Myrtle Beach wildfire. The fire, fueled in part by the weather, burned and jumped over highways and canals and caused $16 million in property damage.

ESRL's Sher Schranz (Global Systems Division, GSD) finds motivation in such unexpected fire behavior. As the Myrtle Beach fire demonstrated, protecting the public and firefighters requires a better understanding of how weather affects fire and fire affects weather.

"You need a model that couples weather physics and fire dynamics," Schranz said, and that's what her team is now working toward.

Such research is increasingly critical for public safety, according to a NOAA Science Advisory Board Report published last year, "Fire Weather Research: A Burning Agenda for NOAA." Fire seasons have recently become longer and the fires more severe, the authors noted, and they called for better fire data and fire weather information "to serve the American public."

Schranz has been helping NOAA and the National Weather Service (NWS) develop fire weather prediction tools for nine years. Her team developed the FX-Net workstation, which provides weather data to Incident Meteorologists (IMETs) during wildfires. IMETS use FX-net to brief fire behavior analysts and fire Incident Commanders onsite.

This summer for the first time, GSD will run an experimental, Western US weather model, the High Resolution Rapid Refresh (HRRR)/Chem/Smoke at 3-km resolution during wildfire season, in support of smoke and fire management operations.

"The HRRR has plume rise and fire emissions dispersion analysis and forecasts that are a big step forward for firefighting operations," Schranz said. "The 3-km winds over complex terrain, which, combined with the smoke forecast, provides critical situational awareness for the movement of fire fighters and emergency evacuation planning and execution." The U.S. Forest Service and NWS FX-Net users across the continental United States will have access to the 3-km HRRR model data.

Schranz anticipates NOAA and its partners will continue to make significant improvements to fire weather prediction. She's building collaborations with researchers who model fire behavior at 1-meter resolution. Linking those fire models to weather models will necessitate extremely fine resolution weather models, down to 100 m, Schranz said, which will require resources for dedicated downscaling research and increased access to high performance computers.

She's also seeking to use new technologies such as unmanned aircraft systems (UAS) to collect over-the-fire data essential for model verification. In 2006, a NOAA pilot study showed that a UAS could collect data over a southern California wildfire, but the plane carried only chemical sensors. To understand how well various fire models are behaving, researchers need atmospheric instruments to capture heat flux, relative humidity wind and pressure fields. These fields will also be used by forecasters in real time. "We really need relative humidity observations at night," for example," Schranz said. "If relative humidity drops at night, fires can flare substantially or suddenly."

Soarin' Over California

CalNex examines contributors to region's air quality, climate change challenges

The air over California will be scrutinized from every angle this spring, as ESRL scientists and colleagues make the most detailed analysis yet of factors influencing air quality and climate change in the state.

From airplane, ship, satellite, and tall tower, ESRL scientists and colleagues (led by ESRL's Chemical Sciences Division) will examine California's atmosphere with an arsenal of instruments. Their scientific goals include understanding the origins of pollutants and greenhouse gases, and the transport, reactions, and eventual fates of those particles and gases.

CalNex (for the "nexus" of climate change and air quality) should generate information that will help decision makers understand the complicated interactions of air quality and climate—because policies to address one are likely to influence the other, as well.

"The goal is to provide decision makers with the information they need for developing "win-win" strategies that help both climate and air quality," said A.R. Ravishankara, Director of the Chemical Sciences Division.

CalNex draws expertise from across NOAA—from all ESRL divisions, the Pacific Marine Environmental Laboratory, the Air Resources Laboratory, the National Centers for Environmental Prediction—and academic and international collaborators.

Tom Ryerson (Chemical Sciences Division) described CalNex during the American Geophysical Union meeting in December, with exhaustive lists of partners (foremost, the California Air Resources Board), instruments, and platforms.

"This is about understanding how ozone and secondary organic aerosols form from precursors, the spatial and temporal patterns of greenhouse gas emissions, methane emissions from rice paddies in the Northern Sacramento Valley, the sulfur budget of the LA Basin…," Ryerson said. "It's a kitchen sink approach, but an integrated kitchen sink."

Overall, CalNex scientists will quantify sources of diverse emissions, from the precursors of lung-damaging ozone and haze to the greenhouse gas carbon dioxide. The field campaign will track the chemical transformations of those emissions, including sunlight-driven and nighttime chemistry. And CalNex will follow the transport and mixing of emissions, to put those observations into context.

Mission scientists will also study the properties and heating effects of atmospheric particles and their interactions with clouds, and will develop and evaluate models used to understand regional climate and air quality.

In its comprehensive exploration of atmospheric chemistry, CalNex resembles two other regional, intensive campaigns led by the Chemical Sciences Division: The Texas Air Quality study of 2006, and the New England Air Quality study of 2002. Both field campaigns generated information that proved important for policy makers as well as scientists seeking to understand atmospheric processes.

In Texas, for example, ESRL scientists and colleagues found that reactive gases leaking from Houston's petrochemical refineries were an unexpectedly significant contributor to regional air quality problems. Regulators changed their approach in response to that discovery, at an estimated savings of 65,000 jobs in the state, and $10 billion between 2006 and 2010.

More: http://www.esrl.noaa.gov/csd/calnex/

...from page 1: Stratospheric water

Between 2000 and 2009, the drop in stratospheric water content acted to slow the rate at which surface temperatures rose by about 25 percent, compared with what would have occurred otherwise. The more limited balloon data suggest that earlier stratospheric water vapor increases could have enhanced surface warming in the 1990s by about 30 percent, compared with estimates that do not include stratospheric water vapor.

The research team noted that it is not yet clear why stratospheric water vapor levels have changed, and called for further observations of stratospheric water vapor, and careful examination of how climate models represent changes in stratospheric water content.

"The Boulder water data are a remarkable record, and the dedication of those who took those data over decades is one of the things that should be highlighted here—and the need for more!" Solomon said.

Solomon's co-authors were Karen Rosenlof, Robert Portmann, and John Daniel from CSD; Sean Davis and Todd Sanford from CSD and the Cooperative Institute for Research in Environmental Sciences; and Gian-Kasper Plattner from the University of Bern in Switzerland.

Texas A&M University atmospheric scientist Andrew Dessler told *ScienceNews* the new *Science* paper identified an important new source of short-term climate variability—but one that may well be temporary. People shouldn't rely on continually declining stratospheric water vapor to slow long-term global warming, Dessler told the magazine. "Water vapor is scarce in the lower stratosphere already, and you can't drop below zero," he said. "This is not going to save our bacon."

Balloon launch, including water vapor sensor

NOAA

... from page 1: GPS-Meteorology

Onshore weather forecasts will likely see immediate improvement, Gutman said, but the GPS-Met data may also help researchers assess satellite measurements of phenomena important to weather and climate—from the amount of water in the air to the measurement of sea level.

Gutman leads a team of ESRL researchers who have spent the last decade figuring out how to extract measurements of atmospheric water vapor from normal GPS signals, and how to assimilate those data into weather and other Earth system models.

By any measure, the team's success has been remarkable.

Gutman's team has documented how GPS water vapor measurements led to better severe weather forecasts in California, Canada, the U.S. Southeast, and other regions.

"In 10 years, our ability to measure the amount of water vapor in the atmosphere has improved by about 53 percent," Gutman said.

Water vapor is notoriously difficult to measure and understand, and observations using satellites, weather balloons, lidars, and microwave instruments are also often costly. Scientists seeking to understand weather and climate, however, need reliable measurements—atmospheric water vapor is the means by which moisture and latent heat are moved around the planet, causing weather. Water is also a greenhouse gas, affecting heat balance both directly and through its role in cloud formation.

In the early 1990s, scientists realized they could mathematically parse out total atmospheric water vapor from dual-frequency GPS satellite radio signals. In essence, water vapor bends and slows GPS radio signals traveling from satellites to ground-based GPS receivers. Researchers can measure the delay from several GPS satellites simultaneously and use math to extract the role—and amount—of water.

There are other sources of data on atmospheric water content, Gutman said, perhaps most importantly, NOAA satellite data. Those measurements, however, contain significant uncertainties, because some of the satellite instruments can "see" only over the oceans, other instruments can't see through clouds.

GPS satellites broadcast nearly continuously and in theory, water vapor information can be extracted from the hundreds of GPS ground receivers already serving other functions —earthquake detection and surveying, for example. Currently, NOAA is regularly importing data from about 300 GPS sites, Gutman said, and to transition GPS-Met into operations would require about 800 sites. The data are pulled into a system Gutman and his colleagues built to assimilate observations into operational weather models. When the system went live in 2005, the results were instant.

"You could see the system error drop instantly —Boom!—when we used these data," Gutman said. "The models were just starved for water vapor information."

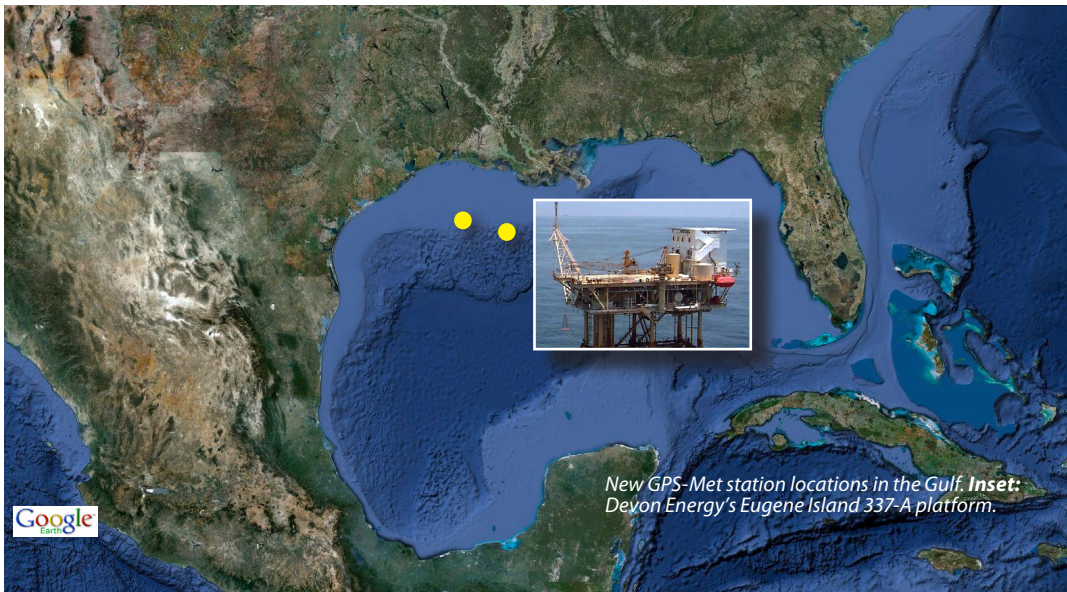
Today, he's working closely with the National Weather Service Lake Charles, LA Forecast Office, to assimilate data from the two new Gulf of Mexico platforms, and his team plans to document the subsequent change (likely significant improvement) in forecast skill.

They are also collaborating with Louisiana State University researchers, who want to use GPS-Met data to make more accurate measurements of water height changes associated with storm surges, subsidence, and climate change.

In collaborative work with NOAA's National Environmental Satellite, Data, and Information Service and the Cooperative Institute for Mesoscale Meteorological Studies, the team used GPS-Met data to identify an unexpected discrepancy between the GOES East and West satellite measurements, and figured out how to correct for it.

Finally, the ESRL team is working to install GPS-Met packages in other critical locations, including NOAA's climate observatories. When a station was installed in Barrow, AK recently, Gutman's team found disagreement between his instrument's measurements and observations made by balloon-borne instruments. It turned out that certain sensors on the balloon package were faulty.

"These problems were going unnoticed, because there was nothing to compare the data with," Gutman said. "Now we have a reliable point of comparison."



New GPS-Met station locations in the Gulf. ***Inset:*** *Devon Energy's Eugene Island 337-A platform.*

Washington's Weird Winter

NOAA assessment implicates NAO and El Niño

Explanations for the record-breaking snows that paralyzed the Mid-Atlantic this winter were as diverse as they were bizarre: An inauspicious alignment of the stars; global warming; global cooling.

But NOAA's Climate Scene Investigators (CSI), a team of "attribution" experts from around the agency, have identified the most usual of suspects: the ordinary ups and downs of weather.

The North Atlantic Oscillation and El Niño are normal climate cycles, both sources of natural weather variation. This winter, the two conspired to cripple the Mid-Atlantic with snow.

Dec. 19, a massive snowstorm hit the U.S. mid-Atlantic, laying down more than 20 inches of snow in some places. The storm set new records for December snowfall, and there was more to come. Another major snowstorm struck the region on Feb. 6, 2010, and then a third storm swept in with blizzard conditions just four days later.

CSI, led by ESRL's Marty Hoerling (Physical Sciences Division) assembled to analyze possible causes and quickly identified the two main suspects—North Atlantic Oscillation (NAO) and El Niño—already known to be at large.

The team's work is featured on http://www.climatewatch.noaa.gov/ ("Forensic Meteorology Solves the Mystery of Record Snows"), and a full scientific analysis of the storms will be posted at http://www.esrl.noaa.gov/psd/csi/.

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... from page 1: NOAA Climate Service

That document—produced by a select team of NOAA scientists led by ESRL's Susan Solomon (Chemical Sciences Division) and Randy Dole (Physical Sciences Division)—lays out goals and principles for a NOAA Climate Service.

As announced in February, the proposed NOAA Climate Service would include three of ESRL's four divisions—Global Monitoring, Chemical Sciences, and Physical Sciences—and the Director's Office. The Global Systems Division would remain in NOAA's Office of Oceanic and Atmospheric Research (OAR), all NOAA groups in Boulder would continue to collaborate, and no federal employee would be out of a job.

Also proposed for inclusion: NOAA's National Climatic Data Center, National Oceanographic Data Center, National Geophysical Data Center, Geophysical Fluid Dynamics Laboratory, Climate Program Office, and funding to manage several observing networks.

NOAA will continue to work with Congress, the Administration, NOAA employees, and external partners during upcoming months to gather feedback and refine the NOAA Climate Service proposal. In the end, NOAA and the Department of Commerce must submit a more refined proposal, known as a "reprogramming package," to the Office of Management and Budget and then to Congress for approval.

During a February webcast with NOAA employees, Lubchenco also highlighted the prototype NOAA Climate Services Portal, www.climate.gov. Once complete, the portal will be a central component of NOAA's climate data and services, the source of timely articles and information, education resources, and tools for engagement and decision-making, she said.

"The next time someone asks you what NOAA's climate work is all about, you can invite them to this site," she said. Climate.gov already includes data, articles, and images featuring ESRL science and scientists.

More for NOAA employees: https://inet.oar.noaa.gov/theExchange.

...from back page

Where's the Seal?

Field biologists tend to collect fascinating stories. The time a gorilla charged. The time someone stepped on a wasps' nest. That harrowing flight to the field station.

It can be difficult to keep tabs on living things, particularly when they inhabit remote areas, yet doing so is often critical for conservation decisions. So researchers across NOAA are collaborating to survey ice seals in the Arctic using unmanned aircraft systems (UAS) technology originally developed for military use.

The seals—ringed, ribbon, spotted, and bearded—all fall under NOAA's protection, and they each rely in some way on floating patches of sea ice—for breeding, foraging, or to escape predators. That makes the animals potentially vulnerable to climate change, which is whittling away at Arctic sea ice, said Robyn Angliss, Deputy Director of NOAA's National Marine Mammal Laboratory, in Seattle, WA.

It also makes the seals difficult to study, said ESRL's Betsy Weatherhead (Global Systems Division). "Seals occur over vast areas of the Arctic, and accessing these areas safely is challenging using current vessel-based and aerial survey technologies," Weatherhead said.

So Angliss, Weatherhead, and NMML researchers Peter Boveng, Michael Cameron, and Erin Moreland spearheaded a project to send UAS over sea ice, to see if the technique could be used to identify ice seals and monitor their populations. In May and June of 2009, the team launched a 10-foot-wingspan UAS called a Scan Eagle from the NOAA vessel *MacArthur II* in the Bering Sea west of Alaska. The UAS, owned by the University of Alaska-Fairbanks and operated by Greg Walker, carried a video camera and a digital still camera, which captured about 25,000 images during 10 flights.

Viewed from 300 feet above the surface, a ribbon seal can look like a shadow, or a puddle of dark water on a light-colored floe of ice, and the sheer number of images that require processing is daunting. Now, the research team is trying to figure out how to automatically retrieve data from the images they obtained. They're beginning to talk with image processing companies—groups that write face recognition software, for example—to help pick out seals from shadow. In March, the team received funding from NOAA's Arctic Research Office for this work.

The researchers have pored through enough of the images to know that they will be useful, Angliss said. "Based on preliminary review, we can determine ice seal species, relative age, and seal gender for some ice seal species," she said. There have been surprises in the photographs, too, Weatherhead said. "In some UAS images, you can see the footprints of polar bears."

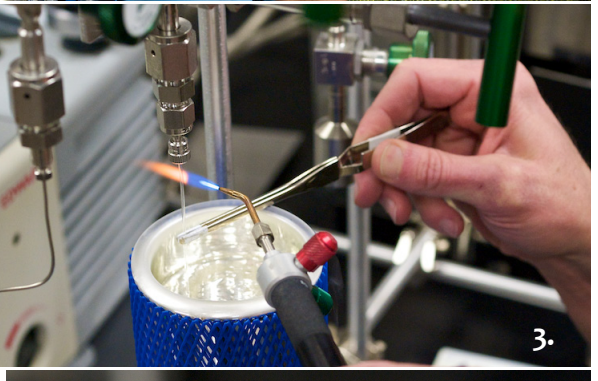
Setting the Standard

Global Monitoring Division standards laboratories key to global atmospheric science collaboration

Brad Hall's laboratory sits on special underground pillars, to better isolate the room from any activities taking place outdoors. Hall and his colleagues create meticulously calibrated standards of halocarbons and other trace gases found in the atmosphere. Some of their balances are precise enough to pick up the grease on an errant fingerprint.


1.


2.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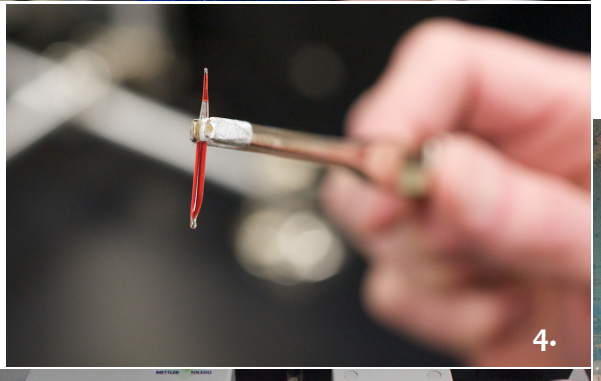
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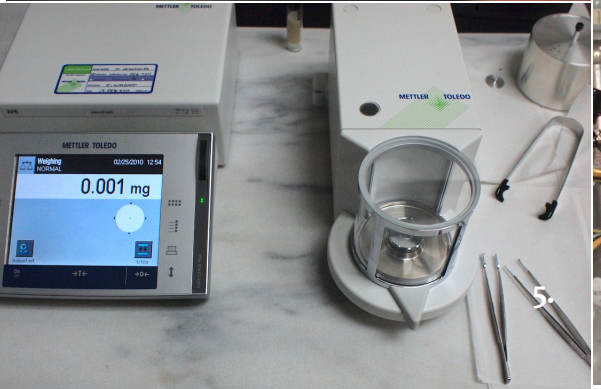


5.

"In our old lab, when a truck drove up to the loading dock, all my balances went off scale," Hall said. "I had to make standards at night."

Hall prepares standards of chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), hydrochlorofluorocarbons (HCFCs), and other gases. He and his colleagues create cylinders containing specific amounts of the materials, then send them around the world for scientists to use in calibrating their own measurement systems. That ensures that measurements made in China, on an airplane science mission, and on the ground in Antarctica are all comparable.

Many of the chemicals his team targets are ozone-depleting substances, released by human activity and now regulated by the Montreal Protocol because they damage Earth's protective ozone layer. Some are also greenhouse gases, of growing international interest.

"In the mid-1980s, there were huge differences among measurements and instruments," Hall said. "The idea of standards is to tie atmospheric measurements to a known, stable value. You have to be able to trust your measurements, especially if you're looking at a trend over, say, 20 years."

His colleague Duane Kitzis (Cooperative Institute for Research in Environmental Sciences) works with a standards team that focuses on carbon dioxide (CO_2), methane (CH_4), and carbon monoxide (CO). The NOAA carbon dioxide scale is based on the measurement of the pressure of CO_2 extracted from air ("manometric method") while other gases such as halocarbons and methane are based on standards prepared by weighing gases into cylinders ("gravimetric method").

Using these methods, Hall, Kitzis and their colleagues create in-house "scales" covering a range of concentrations needed to measure the range of atmospheric trace gas species. These so-called "primary" standards are used only to calibrate secondary and tertiary mixtures of gases. Secondaries also remain at ESRL; tertiary standards are sent and used worldwide.

Kitzis is currently coordinating a WMO "Round Robin intercomparison," an international contest of sorts, to see how accurately various laboratories around the world measure unknown samples of CO_2, CH_4, CO, and nitrous oxide, N_2O. Kitzis created three sets of cylinders containing amounts of carbon dioxide that only he knows. Every participating laboratory gets the cylinders for a few weeks, and reports results to "referee" Linxi Zhou at the Chinese Meteorological Administration, who does not know the actual concentrations. Results are tallied when all laboratories are finished. Laboratories use results to identify problems in instrument calibration or measurement methods, Kitzis said.

The images on this page show several steps in the process Hall uses to make standards gravimetrically, by measuring precise weights of tiny quantities of condensed gases. The posed pictures give a sense of how the work is done, but Hall can't let visitors in the lab when he's making actual samples. "It takes too much concentration," Hall said.

"Making the standards is not rocket science," Hall said. "Making them reproducible is tricky, and learning how to make them stable over long periods of time is the hardest."

ESRL's standards and standard-making processes are linked to NIST, the National Institute of Standards and Technology, its neighbor in Boulder's Department of Commerce campus.

Photographs *by Will von Dauster, NOAA ESRL*

1. *A canister of a pure HCFC.*
2. *Brad Hall attaches the canister to a vacuum apparatus, to pull the gas into a micropipette about 1 mm in diameter. Immersing the pipette in liquid nitrogen cools and liquifies the gas.*
3. *Hall seals the micropipette with a flame.*
4. *A sealed micropipette is ready to be weighed (this is Hall's "practice" version, filled with red water).*
5. *An extremely precise balance.*
6. *Tertiary standard cylinders containing various amounts of nitrous oxide.*


6.

Mentoring Undergraduate Innovators

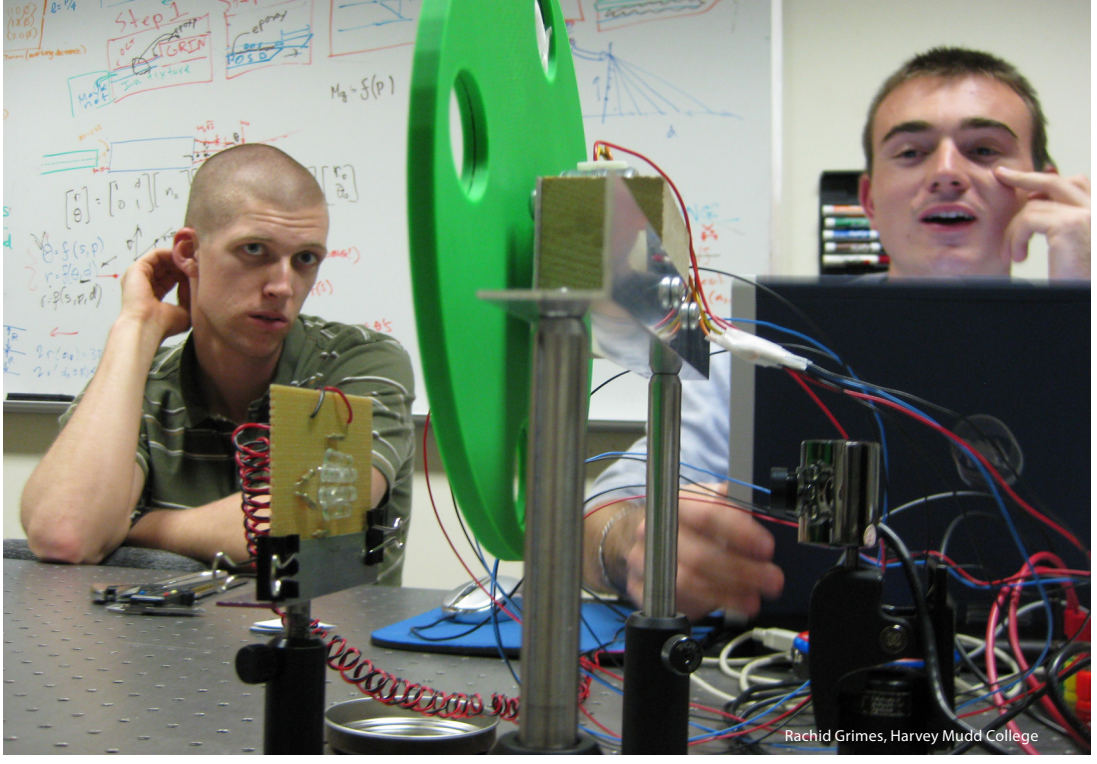
ESRL's John A. Ogren guides "clinic team" from alma mater

Some call it luck; others call it fate. For John A. Ogren (Global Monitoring Division), becoming a sponsor for one of this year's Harvey Mudd Clinic Program teams was merely a "remarkable set of coincidences."

Since Harvey Mudd College's inception in 1965, seniors the southern California school have been receiving practical, hands-on experience tackling real-world problems. Teams of three to five students take on open-ended problems identified by sponsors; there are no textbook answers, just the imaginative limits of the team. Those problems—from the need for a motion-sensitive prosthetic limb to the fast deciphering of text on a crumpled paper—come from software companies, the medical device industry, engineering companies, and even government laboratories. In January, the four directors of Harvey Mudd College's renowned Clinic Program visited ESRL, proposing a formal collaboration. Ann Thorne (ESRL education coordinator) and Tony Tafoya (NOAA EEO) hosted the visitors.

Ogren earned his undergraduate and master's degrees at Harvey Mudd, and his masters thesis focused on the role of the stratosphere in Los Angeles' ozone smog. He attended the January meeting thinking he could answer questions from scientists interested in sponsoring a team (from his alumnus perspective), but ended up getting more than he bargained for.

At the meeting, Engineering Clinic Director Patrick Little mentioned that he had a specific project in need of a technical advisor. One clinic team, working to create a cheaper instrument for the measurement of black carbon in developing countries, had lost its technical advisor mid-year. Coincidentally, Ogren's Ph.D. research was on atmospheric black carbon, and ESRL is actively involved in developing instruments to measure black carbon. Ogren sat down with Little for more details. After receiving the interim report and group proposal, Ogren agreed to act as the team's technical advisor.



Nathan Jones (left) and Laurent (Chris) Goudet (right) work on a low-cost black carbon instrument as part of a year-long Clinic Program at Harvey Mudd College. ESRL's John A. Ogren is mentoring the team.

More information: ann.thorne@noaa.gov

Ogren said he landed his first job at Meteorology Research, Inc. because of his own clinical project, so he understands the program's benefits. "It is a very good teaching technique...and good for sponsors because it gives them access to a lot of talent and enthusiasm on the part of the students."

Ogren said he believes it would be mutually beneficial for ESRL to look into sponsoring a Harvey Mudd Clinic project. "It would be a useful way to pursue projects that NOAA researchers do not have time to go after themselves."

Nathan Jones, the Harvey Mudd student team leader, said his team has quickly come to rely on and appreciate Ogren's understanding of black carbon monitoring. "The help that John Ogren has provided for our team has been outstanding. We are glad to have him as a resource," Jones said.

The team hopes that the prototype low-cost black carbon monitoring device could be "deployed anywhere and provide relative information about the air quality trends in a region, signifying to authorities when additional, more accurate measurements should be taken."

—by Miyuki Kei Kauffroath

Ozone Tied to Emissions Abroad

Springtime ozone above U.S. West is highest when winds sweep in from Asia

Springtime ozone levels above western North America are increasing primarily due to air flowing in from the west, an ESRL-led study concluded in January. The trend, which is strongest when air parcels originate in Asia, could challenge U.S. efforts to reduce ozone pollution, wrote the authors, headed by ESRL's Owen Cooper (Chemical Sciences Division and the Cooperative Institute for Research in Environmental Sciences, CIRES, at the University of Colorado).

The new study, published in *Nature*, focused on "background" tropospheric ozone, in a slice of the atmosphere from two to five miles above the surface of western North America. That's far below the protective ozone layer, but above the ozone-related, ground-level smog that is harmful to human health and crops.

There in the middle, ozone levels have been rising steadily since 1984, Cooper et al. found. The international team analyzed the nearly 100,000 tropospheric ozone observations gathered since 1984 in separate studies by instruments on aircraft, balloons, and other platforms. The researchers used meteorology records and sophisticated models to trace each measurement back to the broad region where the air originated.

When the dominant airflow came from south and east Asia, the scientists discovered the largest increases in ozone measurements.

"In springtime, pollution from across the hemisphere—not nearby sources—contributes to the ozone increases above western North America," Cooper said. "The big question is if this ozone is impacting the surface. We still don't know, but if it is, there's less margin for pollution in the United States."

The U.S. Environmental Protection Agency is currently considering a proposal to lower allowable ozone levels in the atmosphere. Current regulations in North America and Europe have already reduced the emissions of ozone's precursors—mostly byproducts of fossil fuel consumption—but a 2009 National Research Council study showed that emissions of those pollutants are up across much of Asia.

Kathy Law of the French Laboratoire Atmosphères, Milieux, Observation Spatiales commented on the new research in *Nature*, calling it "the most conclusive evidence so far of increasing ozone levels in the free troposphere over western North America."

The study's other ESRL authors included Sam Oltmans and Bryan Johnson (Global Monitoring), and David Parrish, Michael Trainer, Ken Aikin, Rushan Gao, and Tom Ryerson (Chemical Sciences).

News

Surprise Chemistry

In 2008, ESRL researchers and colleagues testing some equipment in Colorado discovered surprisingly high levels of a chlorine compound normally associated with marine air. Nitryl chloride gas forms at night, when manmade pollutants interact with airborne chloride-containing particles—often from sea spray. But the levels of nitryl chloride found in Boulder were comparable to those expected at oceanic sites, suggesting that chloride-containing particles were more ubiquitous inland than thought.

Now a follow-up study has confirmed that the chemical reactions involved can take place far inland, and that human activities—from coal burning and biomass burning to roadway de-icing—may influence chlorine chemistry in the air above the continental United States.

Chlorine chemistry may be involved in the generation of regional smog and other air quality problems, and may also help remove the greenhouse gas methane from the atmosphere.

The new paper, "A large atomic chlorine source inferred from mid-continental reactive nitrogen chemistry," appeared March 11 in *Nature*. ESRL and CIRES authors include Steve Brown, Ann Middlebrook, Nicholas Wagner, Julie Cozic, John Holloway, and William Dubé.

Physical Sciences Review

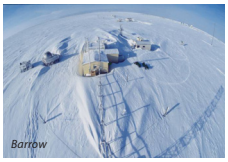
During four days in March, researchers from ESRL's Global Systems and Physical Sciences divisions (GSD and PSD) highlighted their accomplishments with talks, posters, and tours for a team of 10 reviewers. The Physical Sciences Review is a quadrennial assessment of the quality, relevance, and performance of research, required of all NOAA research laboratories.

Representatives from GSD and PSD related the importance of their group's research accomplishments, technology transfers, and future plans to NOAA's mission and strategic plan.

ESRL's Physical Sciences Reviewers are Michele Rienecker (NASA Goddard Space Flight Center), Gilbert Brunet (RPN Canada), Daniel Cayan (Scripps Institution of Oceanography), George Frederick Jr. (Falcon Consultants LLC), Tsengdar Lee (NASA Office of Earth Science), Margaret (Peggy) LeMone (National Center for Atmospheric Research), Ken Leonard (Federal Motor Carrier Safety Administration), Lars Peter Riishojgaard (NASA Goddard), John Walsh (University of Alaska), Robert Weller (Woods Hole Oceanographic Institution).

The team is expected to send an initial report to NOAA by the end of May.

Barrow Snowmelt


Barrow

Scientists are scrutinizing data collected at the NOAA/ESRL Barrow Observatory to understand how climate change is affecting the annual snow cycle there, in particular the date when snow melts each spring. Previous studies found that the melt date was occurring earlier than in the past and is influenced by urbanization effects near the village of Barrow, AK. Robert Stone (Global Monitoring Division) has concluded that snow is indeed melting earlier than in the past, but at a less dramatic rate than reported previously. An updated analysis using data collected at the Observatory, which is not prone to the effects of urbanization, suggests that synoptic-scale changes in atmospheric circulation are the primary causes of the observed trend. The changes (so far) cannot be linked directly to greenhouse warming. Rather they appear to be a manifestation of natural climate variations having decadal time scales, Stone said. More: http://esrl.noaa.gov/gmd/grad/snomelt.html

Achieven

More news, publications, and hono
Earth System Research Laboratory

Web Hits Soar

ESRL's web hits soared late in the day on February 27, from about 30,000 hits per hour (normal) to more than 180,000, according to ESRL webmaster Ann Keane.

Users were searching for web cams that might catch massive waves hitting Hawaii, after Chile's magnitude 8.8 quake. ESRL traffic returned to normal after the tsunami watch was lifted for Hawaii. ESRL hosts web cams watching the Mauna Loa Observatory and others at http://www.esrl.noaa.gov/gmd/obop/mlo/livecam/livecam.html.

A Force for Air

At 6:56 a.m. April 2, a massive unmanned aircraft once used by the U.S. military soared into the air over Southern California, bristling with devices designed to spy on the atmosphere. In the flight operations room at NASA Dryden Flight Research Center, scientists and flight planners—including several from NOAA—exploded into cheers.

The aircraft was a 116-foot-wingspan unmanned aircraft system, or UAS, called a Global Hawk, and it soared for more than six hours over southern California that day, in its first science test flight. Onboard were nearly a dozen instruments to collect precise information about the parcels of air the craft would

Ming Hu speaks with reviewer Ken Leonard during ESRL's Physical Sciences Review.

Will von Dauster/ESRL

Honors

Daniel Wolfe (Physical Sciences) and **Richard McLaughlin** (Chemical Sciences) received 2009 Distinguished Career Awards, announced in March by NOAA Administrator Jane Lubchenco. Wolfe, who has worked for NOAA in Boulder since 1975, won for his "long-term stewardship of the Boulder Atmospheric Observatory and its recent revitalization as a world-class climate observing facility." McLaughlin won "for sustained, outstanding, and diverse contributions to the success of airborne sampling instruments requiring creative design skills and mechanical craftsmanship." McLaughlin has worked for NOAA in Boulder since 1979.

Several ESRL scientists won 2009 Bronze Medals, also announced in March: **Klaus Weickmann** (Physical Sciences) was part of a Bronze team lauded for issuing skillful forecasts of weather and climate hazards based on an ensemble forecast system. **Bradley Hall** (Global Monitoring) won a Bronze medal "for his contributions to the

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rs from NOAA's

encounter—air enriched in chemicals that deplete Earth's protective ozone layer and with greenhouse gases.

The full science mission, dubbed GloPac for Global Hawk Pacific, should begin later this month, and will focus on measuring levels of atmospheric constituents important in climate change and stratospheric ozone depletion.

"Our planning and preparations paid off with good instrument performance on the first flight," said ESRL's David Fahey (Chemical Sciences Division), who is co-mission scientist on GloPac. Fahey said he had his colleagues think of UAS as "a hybrid" of satellites and aircraft, and in the future, they imagine, fleets of UAS could prowl the atmosphere, gathering data to help weather forecasters, climate and air quality researchers, and others.

NASA and NOAA engineers and colleagues from several academic and private research institutions have spent the last 20 months readying the Global Hawk for its first science campaign, which will eventually involve four or five flights over the Pacific Ocean from the tropics up to the Arctic. Those flights will be long—the aircraft can fly for up to 30 hours, reaching places and distances unobtainable with a more typical research airplane, Fahey said.

Mission scientists are blogging about the campaign at http://earthobservatory.nasa.gov/blogs/fromthefield/category/glopac/, and more information is available at: http://www.espo.nasa.gov/glopac.

Upcoming

- **April 21**: 30th Anniversary of Balloon Water Vapor Measurements, Marshall Mesa site south of Boulder, CO
- **May 18-19**: Global Monitoring Annual Conference, ESRL
- **May 3-5**: NOAA Testbed Workshop, ESRL
- **Mid-July**: Tiksi, Russia Observatory Grand Opening, Tiksi

Published

ESRL's peer-reviewed publications are available in a searchable database:

http://www.esrl.noaa.gov/search/pubs/

Divisions also have Publication pages:

GMD: www.esrl.noaa.gov/gmd/publications/
PSD: www.esrl.noaa.gov/psd/pubs/
CSD: www.esrl.noaa.gov/csd/pubs/
GSD: www.esrl.noaa.gov/gsd/publications/

Tom Tschida/NASA

ESRL's GloPac team at NASA Dreyden, left to right: Brad Hall (GMD), Geoff Dutton (GMD), Jim Elkins (GMD), Laurel Watts (CSD), Eric Hintsa (GMD), David Fahey (CSD), Phil Hall (NOAA Corps). Not pictured: RuShan Gao (CSD).

accurate calibration of greenhouse and other important atmospheric gases for NOAA, the nation, and the global community." **Charles Brock**, **Daniel Murphy** and **Thomas Ryerson** (Chemical Sciences) shared the medal with two colleagues from NOAA's Pacific Marine Environmental Laboratory, for their leadership of field missions during the International Polar Year, to study the fast-changing Arctic. **Stephen Weygandt**, **Stanley Benjamin**, and **John M. Brown** (Global Systems) shared a Bronze with colleagues from the National Weather Service, for developing an "operational radar reflectivity assimilation technique and improving convective storm forecasting." **Daniel Gottas**, **Paul Neiman**, **Allen White** (Physical Sciences), and **Seth Gutman** (Global Systems) shared a Bronze with a National Weather Service colleague "for innovative contributions to the development of the Coastal Atmospheric River Monitoring and Early Warning System."

Robert Banta (Chemical Sciences) and **Randy Dole** (Physical Sciences) were named Fellows of the American Meteorological Society.

Graham Feingold (Chemical Sciences) coauthored chapters in two books that received awards from the Atmospheric Science Librarians International, presented during the American Meteorological Society annual meeting. *Clouds in the perturbed climate system: their relationship to energy balance, atmospheric dynamics, and precipitation* won the ASLI Choice Award. *Aerosol pollution impact on precipitation: a scientific review* earned an honorable mention.

A proposal by **Carol Knight** (ESRL Director's Office) was one of 12 selected for a NOAA Preserve America Initiative grant, among more than 70 applicants. Knight will work with middle school students to produce YouTube-type oral history videos about NOAA-Boulder scientists and science.

David Parrish (Chemical Sciences) was invited to give the 19th annual Harold I. Schiff lecture in December last year, at York University in Toronto, Canada.

A paper authored by **A.R. Ravishankara**, **John Daniel**, and **Robert Portmann** (Chemical Sciences) was named one of *Nature's* top ten research highlights of 2009 (*Nature* editors select the best papers published in other journals). Ravishanakara, Daniel, and Portmann published "Nitrous Oxide (N_2O): The Dominant Ozone-Depleting Substance Emitted in the 21st Century" in *Science* in October.

A.R. Ravishankara (Chemical Sciences Division Director) was invited to be the 2010 Hinshelwood Lecturer at the Department of Chemistry of Oxford University. The lecturer—a distinguished chemist or physicist from overseas—spends about two weeks delivering lectures at several institutions in the United Kingdom.

Susan Solomon (Chemical Sciences) and colleagues in Switzerland and France co-authored a paper identified by Thomson Reuters Essential Science Indicators SM as a "New Hot Paper" in the field of geosciences, meaning it was one of the most-cited papers in geoscience published during the past two years. The article, "Irreversible climate change due to carbon dioxide emissions," was published in the *Proceedings of the National Academy of Sciences* in January 2009.

Find the Seals!

ESRL helps pilot new technology for monitoring ice seals, page 7.

Earth System Research Laboratory

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www.esrl.noaa.gov/news/quarterly

At NOAA's Earth System Research Laboratory, we observe, understand, and predict the Earth system through research that advances NOAA's environmental information and services, from minutes to millennia on global to local scales. ESRL's partners are the Cooperative Institute for Research in Environmental Sciences at the University of Colorado at Boulder, and the Cooperative Institute for Research in the Atmosphere at Colorado State University in Fort Collins.