ESRL Quarterly

News from NOAA's Earth System Research Laboratory

2009
Summer

Inside

Emergency Planning

ESRL helps develop a response system for airborne threats

ESRL's Rich Jesuroga pulled up a map of Fort Worth, Texas on his computer, and clicked the mouse once in a suburb. "Suppose there's a toxic release here," he said.

Within one minute, Jesuroga, a researcher in ESRL's Global Systems Division, learned that prevailing conditions would swirl the imaginary airborne toxin west. Within two minutes, he traced a polygon over the "hottest" part of the dispersing plume—the people there would need to be evacuated first—and he pointed to an icon that, when clicked, would send out a warning through a variety of systems, including the Federal Emergency Management Agency's (FEMA) Integrated Public Alert and Warning System.

This is Draft One of a collaborative NOAA project called the Geo-Targeted Alerting System, or GTAS, newly funded by FEMA for up to five years. ESRL researchers and colleagues at NOAA's Air Resources Laboratory and the National Weather Service hope to learn how scientists can best support the emergency managers who must plan for and react to airborne threats, from tornadoes and flash floods to chemical releases.

"There are a lot of questions that we need answered," Jesuroga said. How quickly can an advanced dispersion model be run at National Weather Service Forecast Offices? Is it enough to model a toxin's spread at 15-minute intervals, or would 5-minute intervals be more helpful? What if the threat is a severe storm? Precisely what kind of information do emergency managers need before making warning or evacuation decisions?

"We don't know the answers yet, and that's why we're doing this," Jesuroga said.

GTAS starts with HySPLIT—the Hybrid Single Particle Lagrangian Integrated Trajectory Model—a plume dispersion model developed at the Air Resources Laboratory, ARL.

"We take the meteorological fields output from forecast models, and use those to move around particles in the airfield," said ARL's Roland Draxler. HySPLIT accounts for the facts

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ESRL's Robin Webb, left, speaks with participants in a climate workshop for weather forecasters.

Barb DeLuisi, NOAA

Climate for Forecasters

ESRL researchers discuss climate with Weather Service

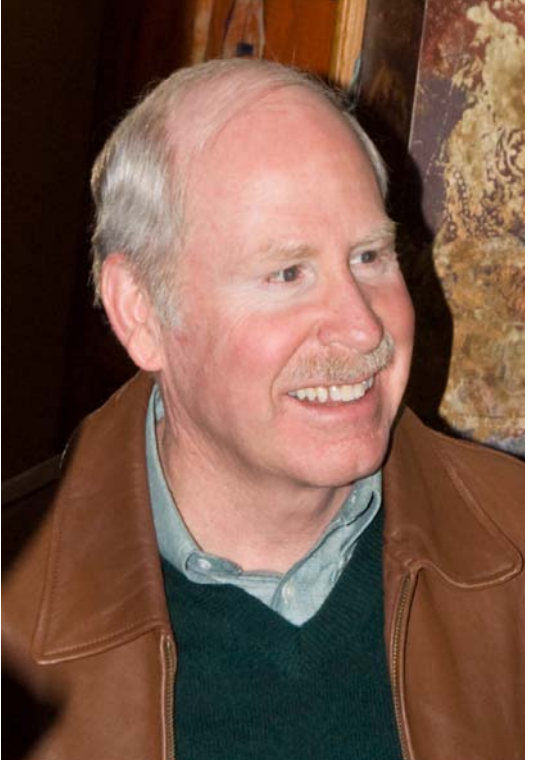
ESRL researchers spent three days with National Weather Service forecasters in April, during a workshop designed to share scientific information about climate change, its impacts, and communicating with the public about the issues. About 50 people attended the climate seminar, drawn from Weather Forecast Offices across the West.

"I look at you as the first responders, the front-line people getting bombarded on a daily basis with requests for information," said Robin Webb, from ESRL's Physical Sciences Division, who participated in the conference. "We are trying to support you, to produce data and information you can use and you can distribute."

Andrea Ray, Brad Udall, Joe Barsugli, and Klaus Wolter from Physical Sciences also

see p 7

See p 9. ESRL digital pioneer Eric Hackathorne, with a weather balloon in the virtual world Second Life.



Director's Corner

Get ready! Things are changing in NOAA, and these changes are clearly going to be affecting us in ESRL. Collectively, the laboratories in Boulder have had 15 to 20 years of flat or shrinking budgets (adjusted for inflation). The reasons are complex, and in part, involved changes in NOAA's funding process. The repercussions have been relatively straightforward, however: NOAA's weather programs, for example, have not grown for 20 years, and the National Weather Service modernization reached its completion with the installation of AWIPS around the year 2000, followed by years of decreasing emphasis on new capabilities. Although the climate program grew significantly in the 1990s, it has been very diversified by design, investing higher percentages of NOAA's climate research dollars in competitive research grants outside of NOAA. It can be argued that if the emphasis is purely on a search for knowledge, such short-term (e.g., three year) principal investigator grants are a good way to invest research funds. However, NOAA also needs infrastructure and deep expertise to support its core mission of understanding and prediction.

Given increasing demand for NOAA's core mission capabilities in weather (e.g., improved hurricane prediction) and climate (e.g., better understanding global change), there is a new emphasis on supporting the necessary people and equipment. We in ESRL bring a lot to this endeavor, and recent planning and funding activities demonstrate that the administration and Congress see us in a bigger and more important role.

Congress makes the ultimate funding decision. Every fiscal year, the House and Senate each develop a proposed budget (the "mark"), and then meet to negotiate a final budget. The House has done its mark for the coming fiscal year (FY 2010), and it includes a number of efforts that would involve ESRL. In climate, the House mark includes significant increases for the National Integrated Drought Information Service, Regional Integrated Science Assessments (the Western Water Assessment is one), and Chemical Climate Research. In weather, it supports an increase for the Developmental Testbed Center and Severe Weather Forecast Improvements.

Prospects for FY 2011 look even brighter. The creation of a National Climate Service is a strong priority for the administration, and ESRL will have many connections to this program. For example, there is a greatly increased need to monitor greenhouse gases as we move to a national and global mitigation effort. Similarly, the need for big increases in computing power —to make the next generation of Earth system models interoperable—are being met with funding.

During my 27 years as a director I have concluded that the easiest programs to manage are those that stay at the same funding level. Growing programs are difficult, and shrinking programs are even worse. We are coming into an era of growth: we will need more people, more space, more equipment, etc. The exciting new roles that we will be taking on will more than compensate for any difficulties.

In reading this issue of the *ESRL Quarterly*, you can see the harbingers of this new era. The ESRL Global Monitoring Conference was a huge success, in the number of attendees and in the quality of the presentations and discussions. ESRL covers the whole spectrum of things that are required for environmental services, from new instruments (ASTER), to new understanding (the use of satellite data to understand NO_2 emissions), and new ways to educate people about NOAA's mission (Second Life).

So, **get ready!** We have big, exciting, important work to do!

—Alexander MacDonald

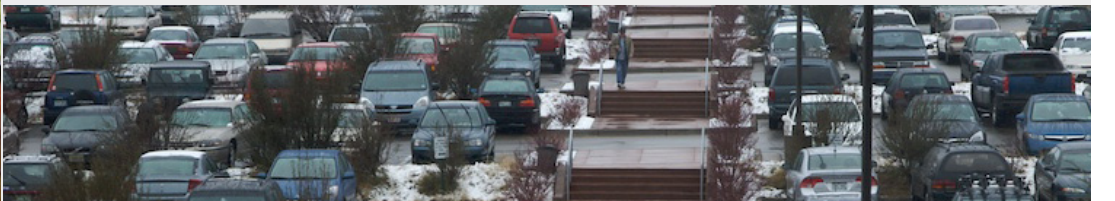
By the Numbers

Composting

110 tons

of CO_2-equivalent greenhouse gas emissions avoided in seven months, thanks to an expanded recycling program at the David Skaggs Research Center in Boulder.

That's equivalent to taking **20 cars** off the road for a year. From October 2008 to April 2009, employees diverted more than 40 percent of the building's waste from the landfill, by composting and recycling (see p 5). Compost photo is courtesy of Janet Wood; cars courtesy of Will von Dauster, NOAA.



Annual Greenhouse Gas Index 2008

New data show unrelenting rise in carbon dioxide and other greenhouse gases

The climate-warming gases carbon dioxide and methane continued to increase in the atmosphere last year, despite the global economic slump and a decrease in activities that consume fossil fuels.

ESRL researchers released the annual greenhouse gas index in April, based on atmospheric data collected from 60 sites around the world. Researchers here measured an additional 16.2 billion tons of carbon dioxide (CO_2)—a byproduct of fossil fuel burning—at the end of 2008, compared with 2007's year-end-figures. There were also an additional 12.2 million tons of the potent greenhouse gas methane, according to the new report.

386 ppm, today's CO_2 concentration. Pre-industrial revolution, it was 280 ppm.

"Only by reducing our dependence on fossil fuels and increasing energy production from renewable resources will we start to see improvements and begin to lessen the effects of climate change," said ESRL scientist Pieter Tans, of the Global Monitoring Division. The Global Monitoring Division has monitored carbon dioxide emissions and other greenhouses gases for decades and will continue to do so to help assess the climate situation and advise decision makers, Tans said.

The increases in CO_2 and methane during 2008 are slightly less than those measured in 2007, but fall well within the range of yearly fluctuations from natural changes, according to NOAA experts. CO_2 levels vary from year to year along with plant growth and decay, wildfire activity, and soil conditions. But people's burning of coal, oil, and gas for transportation, power, and industry create the insistent increase underlying those fluctuations.

At the end of 2008, global average CO_2 concentration was 386 parts per million (ppm); before the Industrial Revolution began in the 1880s, CO_2 concentration was 280 ppm.

Methane levels rose in 2008 for the second consecutive year after a 10-year lull, for a 2008 global average concentration of 1,788 parts per billion (ppb). Pound for pound, methane is 25 times more powerful as a greenhouse gas than carbon dioxide, but because there is far less of it in the atmosphere, methane's overall climate impact is half that of carbon dioxide.

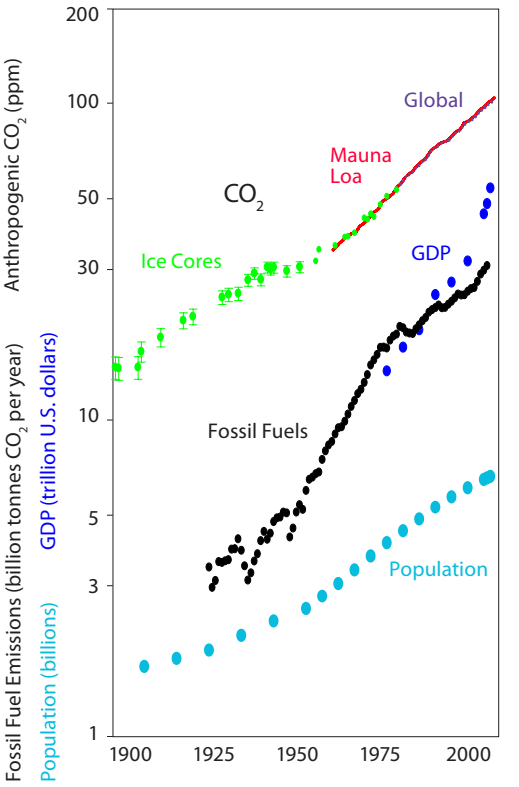
Carbon dioxide growth rates have increased by more than two percent each year since preindustrial times, doubling every 31 years, according to a study published in *Atmospheric Environment* in December by ESRL's David Hofmann, James Butler, and Tans.

The carbon dioxide record does have dips: A slowdown occurred in 1930–1936 after the Great Depression, and another during the 1940s, possibly related to World War II. The large volcanic eruptions of Indonesia's Mount Agung in 1963 and the Phillippines' Mount Pinatubo in 1991 each slowed CO_2 buildup for several years. Volcanic emissions cool the lower atmosphere and scatter sunlight. Those changes can reduce plant respiration, a process that releases CO_2, and boost photosynthesis, which removes CO_2 from the air.

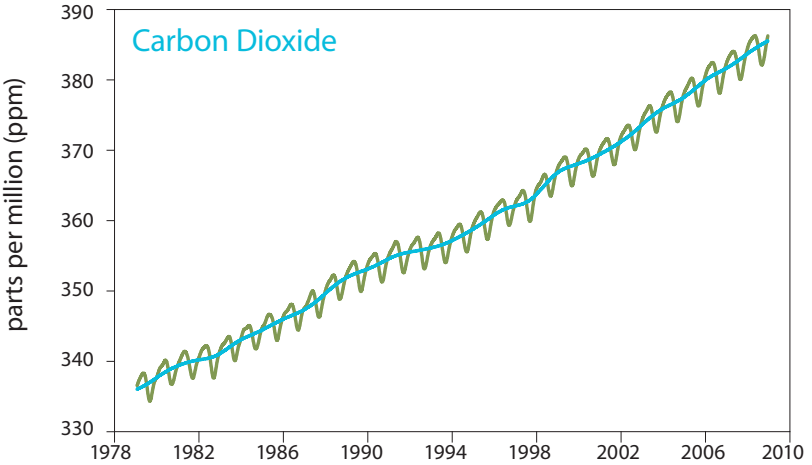
"Atmospheric CO_2 growth is best reflected by the world population trend," said Hofmann. "The two have tracked each other extremely well over the past century."

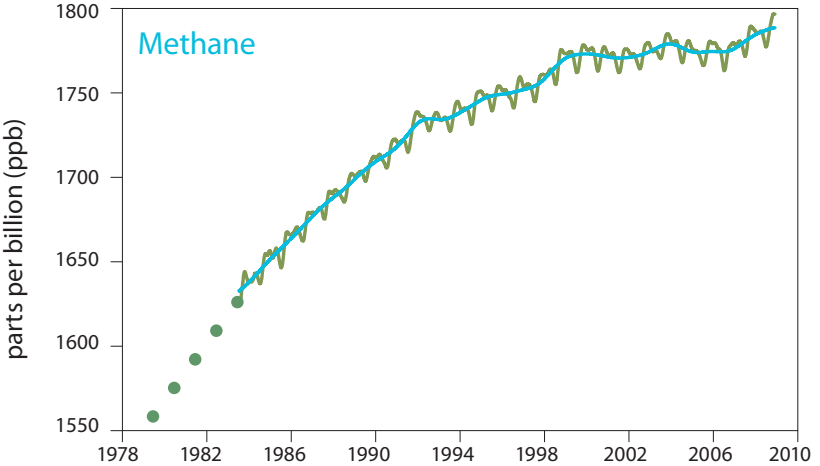
A break in the close relationship between population growth and CO_2 growth would be a clear sign of progress in efforts to limit atmospheric CO_2, Hofmann said.

—contributed by Anatta



Several factors associated with CO_2 emissions, presented on a logarithmic scale. Anthropogenic CO_2 refers to CO_2 levels above pre-industrial. Adapted from Hofmann et al. 2008.



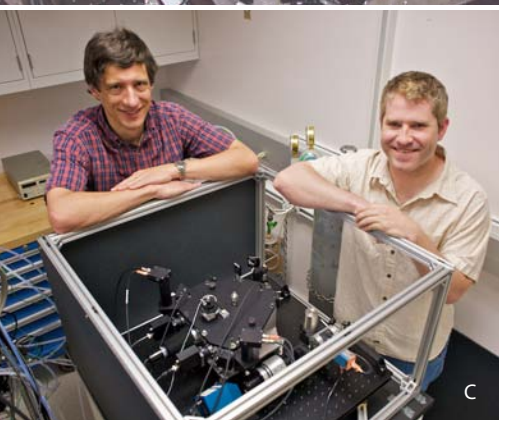


ASTER Inventing an Instrument

ESRL scientists need extremely precise instruments to answer critical questions about the atmosphere. Much of the time, there is no catalogue to order from, so ESRL researchers and engineers do the instrument design and construction themselves. Below, we describe one pilot instrument in ESRL's Chemical Sciences Division: Aerosol Scattering To Extinction Ratio (ASTER). Aerosol comprises tiny particles in the atmosphere with both natural and anthropogenic sources and are known to have climate impacts. Overall, atmospheric aerosol cools the atmosphere, partially offsetting warming by greenhouse gases. However, certain classes of aerosol—such as black carbon or soot—can warm the surrounding atmosphere and are of growing interest to climate scientists. A particle's "radiative effect" depends, in part, on how it scatters (a cooling effect) and absorbs (warming) sunlight.


A


B


C


D


E

The Need

Better understanding the behavior of atmospheric aerosol is critical for improving our predictions of how climate change will affect the Earth system. "In climate models, the uncertainty around aerosol effects is usually very large," said Todd Sanford, who, with Daniel Murphy, is leading ASTER's development. "The idea of this instrument is to help reduce that uncertainty."

Multiple Errors

Today, scientists use a variety of instruments to measure how aerosol scatters and absorbs light. Each instrument has its own set of potential small errors, and there may also be differences between aerosol samples measured in each. That means multiple sets of errors are possible in measurements.

Simultaneous Measurement

ASTER measures a single aerosol particle's light scattering and extinction (extinction = scattering + absorption) simultaneously. From this, a scientist can calculate the climatically-important metric of single-scattering albedo. A diode laser sends light into a three-mirror, high reflectivity cavity. Single aerosol particles are introduced into the cavity laser beam, from which they scatter and absorb light. A scattering cell captures and measures scattered light, and extinction is measured from the "leakage" of light through a cavity mirror. The instrument can also provide a measure of a particle's size.

Serendipity

Waiting for a flight after a field mission in Costa Rica three years ago, ESRL's Dan Murphy asked Sanford about an instrument Sanford was using to measure single-scattering albedos of single particles. Murphy asked if Sanford ever observed "dips" in the light transmitted through the cavity mirrors. "Actually, we do," Sanford remembers saying. "And that was it. Until then, we didn't appreciate that this cavity could measure extinction in a more direct, simpler way." This development simplified the operation of ASTER, and will make field-deployment more feasible.

Stability

ASTER's diode laser may be rugged, but it's signal is noisy. Sanford stabilizes the laser by using the cavity as a stable, frequency reference, in a technique called Pound-Drever-Hall frequency stabilization.

Initial Results

In a test of air pulled from outside ESRL, where a nearby construction project produces dust and engine exhaust, Sanford found that most of the sampled particles were purely scattering (cooling), but a small fraction were dark and more absorbing. A more traditional "bulk" measurement could have concluded only that the aerosols were primarily scattering and therefore cooling. "The bulk measurements are very useful, but important information is lost in the averaging process," Sanford said. "We would have missed these highly absorbing particles, which are very important for climate."

Future Tests

Sanford hopes to test ASTER in the field sometime this year, in the foothills behind the David Skaggs Research Center in Boulder, Colo. He also wants to compare the instrument's measurements with existing aerosol optical and composition instruments. With luck, the instrument could be deployed in a ground-based setting during CalNex, a 2009-2010 mission to study climate change and air quality in California. Ultimately, ASTER could fly on research aircraft.

A. Earth, courtesy of NASA. **B**. An early ASTER prototype, NOAA photograph. **C.** ESRL's Dan Murphy (left) and Todd Sanford (right), of the Chemical Sciences Division, next to the current ASTER instrument. Photo courtesy of Will von Dauster, NOAA. **D.** Construction next to the David Skaggs Research Center, ESRL's home in Boulder, Colo. Photo courtesy of Will von Dauster, NOAA. **E.** Foothills behind the David Skaggs Research Center, where ASTER may be initially field-deployed. Photo courtesy of Will von Dauster, NOAA.

Molly Heller helped direct traffic during an electronics recycling event she helped organize for David Skaggs Research Center workers and the community. Photos courtesy of Will von Dauster, NOAA.

Making a Difference

One researcher's push to cut human climate impact

ESRL researcher Molly Heller coordinates NOAA's cooperative air sampling and aircraft networks of more than 80 atmospheric sampling sites around the world. She makes sure each has what it needs to collect air samples for the precise measurement of greenhouse gases and other constituents. During the last year, Heller also made time to create a building-wide composting program for the David Skaggs Research Center, DSRC, which includes ESRL.

Heller, a NOAA affiliate with the Cooperative Institute for Research in Environmental Studies (CIRES), was honored with a CIRES Outstanding Performance in Service Award this year, for her "exceptional" work in both categories.

In ESRL's Global Monitoring Division, Heller so effectively streamlined the processes involved in the logistics of sampling networks and preparing sample containers that she handles the workload once meant for two people.

She also composts. Dedicated to minimizing her climate impact on the planet, Heller used to walk several blocks from her home to carry her own compostables to a public drop-off site. At work, Heller was frustrated to see compostable material in trash bins. She also tired of carrying her own lunch scraps home in the evening. "It was getting messy," Heller said.

In the spring of 2008, Heller began investigating the science and economics of composting. She soon learned that the DSRC could save both greenhouse gas emissions and money by adding composting to the recycling mix.

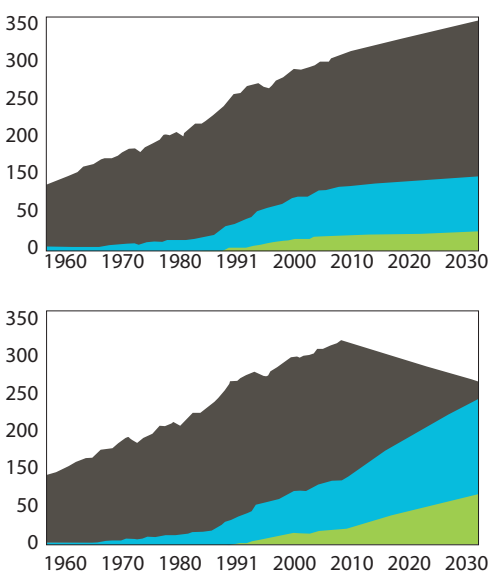
Composting—an aerobic process—generates the greenhouse gas carbon dioxide. But in landfills, decomposition is anaerobic—without oxygen—and that process releases the more potent greenhouse gas methane, Heller said. Reducing methane emissions would have 72 times the impact of reducing equivalent emissions of carbon dioxide (measured as "global warming potential" during a 20-year time horizon).

So Heller and a few colleagues with NOAA and the U.S. General Services Administration, began crafting a plan to bring composting to the David Skaggs Research Center.

It wasn't easy, Heller said. She had to scramble to find the few hundred dollars it would take, up front, to purchase new composting bins and create signs. She and a colleague spent a weekend in the building, setting up bins and posters to explain the new system. She is still frustrated to find people putting compostable paper towels in trash bins and trash in the compost, but recognizes that employees have come a long way. DSRC workers now compost and recycle about 40 percent of our waste. "I would like that number to be closer to 70 percent," Heller said.

Still, she said she is pleased with the response. "To me, this is about the whole environmental package," said Heller, who also rides the bus to work. "We didn't have all this stuff 100 years ago, and we need to figure out what we're going to do with it all. One small thing is putting waste in the right place."

Waste, in millions of tons per year
Business As Usual (**top**) and Zero Waste Approach (**bottom**) to disposing of waste in the United States. By 2030, 90 percent of domestic waste could be diverted from landfills to recycling and composting. This would achieve seven percent of the cuts in equivalent CO_2 emissions needed to reduce total U.S. emissions 80 percent below 1990 levels by 2050.



Monitoring Meeting

"21st Century Challenges for Long-Term Monitoring" draws atmospheric scientists from around the world

More than 250 people attended ESRL's Global Monitoring Annual Conference in May, presenting dozens of talks and posters on atmospheric trends and analyses, many of them derived from ESRL-collected data. For three days, researchers from 19 countries discussed regional emissions of greenhouse gases, how best to interpret data showing a rise in global methane levels, and the dynamics and speed of the ozone layer's recovery.

"First: *thanks*," said **Barry Huebert**, a professor of oceanography at the University of Hawaii at Manoa, who gave a research talk. Huebert used data from NOAA's Mauna Loa Observatory (MLO) to analyze patterns in atmospheric particles called aerosols, which can influence both air quality and climate. "The staff at MLO is fantastic," Huebert said. "It's hard to imagine how much they do there, and how much we all rely on them." ESRL's Global Monitoring Division operates Mauna Loa as one of five baseline atmospheric observatories that stretch from northern Alaska to the Antarctic. The others are in Barrow, Alaska; Trinidad Head, Calif.; American Samoa; and the South Pole.

Jim Butler, director of ESRL's Global Monitoring Division, opened the 36th annual monitoring conference with a commitment to continue and improve upon the division's atmospheric monitoring, data collection, and analysis. Below are summaries from a few talks. Abstracts from all talks and posters are available at: http://www.esrl.noaa.gov/gmd/annualconference/.

Air Quality Problem

David Parrish, from ESRL's Chemical Sciences Division, analyzed weekly measurements taken by ESRL colleagues in Trinidad Head, Calif., to look at the effect of background ozone levels on air quality in inland Northern California. The U.S. Environmental Protection Agency regulates levels of surface ozone, which, at high levels, can damage people's lungs. Normally, ozone violations occur when sunlight "cooks" local chemical pollutants—from cars, oil and gas operations, manufacturing, and other sources—into ozone smog. Parrish found that air from over the Eastern Pacific was transported ashore at high altitude and mixed down to Northern California surface sites. Ozone levels in this air made substantial contributions to ozone-level violations. "Background ozone alone can exceed the national standard," Parrish said. "That means achieving the standard may not be possible in this region with only local and regional control efforts."

Constraining the Amazon

John Miller, from ESRL's Global Monitoring Division, presented data collected above Brazil's Amazon Basin, during nearly a decade of close collaboration with Brazil's Atmospheric Chemistry Laboratory (part of IPEN, the Instituto de Pesquisas Energeticas e Nucleares) in Sao Paulo. The Amazon Basin is one of the most poorly sampled regions of the globe in terms of atmospheric chemistry, Miller said. During an ongoing air-based measurement program Miller and his colleagues discovered methane fluxes that were significantly larger than previous estimates (including those made by GMD's background sites in the Atlantic Ocean, 2,000 miles away). Data from the ongoing international collaboration suggest aircraft and other measurements are needed to support ground-based measurements, to detect important details in the global carbon cycle.

Ozone Layer Recovery Slow

ESRL's **Dave Hofmann** presented data on the recovery of Earth's Antarctic ozone hole in the stratosphere. High-altitude ozone protects the Earth surface from damaging ultraviolet radiation. Man-made chemicals that are now regulated can destroy stratospheric ozone, triggering higher skin cancer rates and damaging crops. A little more than a decade ago, when the emissions of ozone-depleting chemicals began dropping, researchers calculated that the Antarctic ozone hole would show early signs of recovery by 2010, with complete recovery by 2050. "I can tell you that ozone is not showing any sign of recovery," Hofmann said, flashing a slide of data from 2006. "We're still seeing fantastic loss." Hofmann and his colleagues now calculate that the ozone hole in Antarctica may begin to recover by 2030, with complete recovery closer to 2065.

Invited Talks

Michael B. McElroy, Gilbert Butler Professor of Environmental Studies at Harvard University, gave a keynote speech entitled "Prospects for a Low-Carbon Energy Future." McElroy outlined the climate problem—the need to dramatically reduce carbon dioxide emissions around the world—and laid out a plan for the United States and other countries to obtain power from wind.

Chet Koblinsky, Director of NOAA's Climate Program Office, updated the group on NOAA's growing commitment to provide the nation with climate products and services. Decision makers are "knocking on NOAA's door" for more information about heat waves, droughts, Atlantic hurricanes, wave heights, heavy rain events, and other environmental events, Koblinsky said. "They're aware we're going into a different world in which these statistics are changing, and they're all looking for ways to interact with us to gain better access to information."

NOAA's global monitoring community knows how to provide such services and data, Koblinsky said. He lauded conference attendees for already helping to build the foundation for NOAA's future climate services.

Left: Bernie Zak from Sandia National Laboratory speaks with Russ Schnell, Deputy Director of ESRL's Global Monitoring Division, during the annual Global Monitoring Conference. **Right:** Jim Butler, director of ESRL's Global Monitoring Division, speaks with Paul Fraser of CSIRO in Australia. Photos courtesy of Will von Dauster, NOAA.

...EMERGENCY Technology from p 1

that some toxins—radiological ones, for example—are heavier than others, and that toxic gases will behave differently than dusts or liquids.

Jesuroga, Draxler, and their colleagues are selecting five weather forecast offices around the country as test sites—Dallas-Fort-Worth in Texas and Seattle, Wash. are the first two—and are installing HySPLIT locally, so the same people keeping an eye on local weather can turn around and quickly run a plume dispersion model.

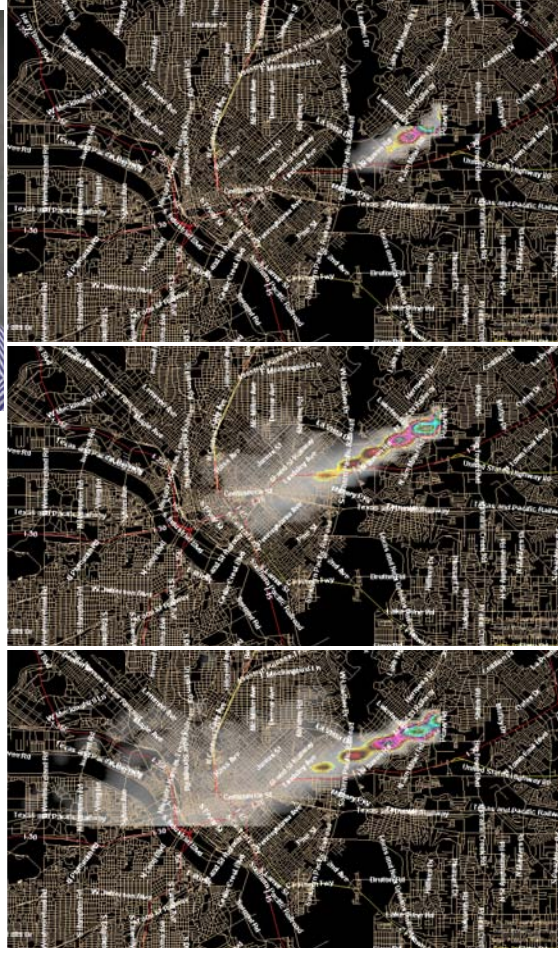
The HySPLIT dispersion model will be run on a platform that enables real-time collaboration—emergency managers across town can watch forecasters run the dispersion model, and forecasters can watch as emergency managers draw polygonal warning areas. That kind of collaboration could strengthen helpful relationships between forecast offices and state and local emergency managers, Jesuroga said.

Draxler said that for his team, the project represents a valuable opportunity to develop a complete warning system, from front-end forecasts to final decision-making. "We are used to running models and coming up with outputs, maybe ending up with a radiation dose. But is that important? Often, I don't know," Draxler said. "Here, we'll be involved from the front to the back, and that's useful to us."

Rich Jesuroga

Jesuroga led a similar pilot warning project in Boulder a few years ago, to warn about dangerous storm conditions. His team tested a system that would send out warnings to people within high-risk polygons, and that project, too, relied on a vendor to distribute the reverse-911-type warning calls.

"Homeland Security learned about what we were doing, and their idea was, could we use this kind of system in the case of a toxic plume?" Jesuroga said.



In a simulation, an airborne toxin in Fort Worth, Texas moves west 15, 30, and 45 minutes after release.

...CLIMATE for Forecasters from p 1

spoke during the workshop, as did Pieter Tans from ESRL's Global Monitoring Division, and Susan Solomon from the Chemical Sciences Division.

Climate research and communication have become major priorities for NOAA, Ahsha Tribble, the National Weather Service's (NWS) Climate Services Division chief, told the seminar participants. The National Weather Service has developed a plan to overhaul national and local climate web pages, Tribble said, and people across NOAA are designing other climate web portals and discussing how best to connect weather products with longer-term climate services, from seasonal outlooks to decades-out temperature projections.

"I look at you as the first responders, the front-line people getting bombarded on a daily basis with requests for information."

Such weather-climate and operations-research connections are already being forged, said Ray, a researcher with ESRL's Physical Sciences Division who works closely with the Western Water Assessment. "Climate outlooks are used operationally every summer in national wildfire planning," Ray said. "And ENSO (El Niño-Southern Oscillation) forecasts are consulted routinely by decision makers in the Pacific Northwest, California, the Southwest, the Southeast…"

Andrea Bair with the NWS Western Region Headquarters presented results of a recent survey assessing the climate perceptions and knowledge of Western Region field office staff. The survey was conducted after other studies suggested that meteorologists are, in general, more skeptical about human-caused climate change than scientists.

More than 10 percent of Western Region forecasters surveyed said they had never heard of the United Nations' Intergovernmental Panel on Climate Change, Bair said. Of those that had, only one-third believed the document represented the consensus of the scientific community.

Most of those attending the NWS climate change workshop believed humans were the main cause of climate change, according to a quick raise-your-hands survey. But some attendees said Bair's results made sense. "There are folks in my office who are passionate in denying there is climate change," one forecaster said. "I just kind of cringe when the phone goes to them."

Susan Solomon spoke with workshop participants about the role of science in the 1987 Montreal Protocol, an international agreement to protect Earth's ozone layer, and launched a discussion about the appropriate role of science in current discussions about climate change policy.

In the case of ozone depletion, it wasn't just that the science was good, it was critical that the scientists were good communicators, Solomon said. "We were able to present clear, consistent information… that anyone could understand." In the case of climate change, she continued, "there really is a huge role in communications, and nobody's better than you, the National Weather Service, at that."

On the last day of the workshop, Susan Buhr from the Cooperative Institute for Research in Environmental Sciences at the University of Colorado at Boulder, led participants in a two-hour, research-based exercise to hone climate communication skills.

The threat of a wet spring snowstorm sent some participants to Denver International Airport half a day early. The storm ultimately took shape almost exactly as the NWS predicted, dropping more than four inches of moisture on Boulder.

ESRL's Chad McNutt, Lisa Darby, and Andrea Ray (all from the Physical Sciences Division) at a forecasters conference on climate change. Photo courtesy of Barb DeLuisi, NOAA.

Science to Ops

First NOAA Testbed Workshop draws innovators, operators

Nearly 70 weather and climate experts from around the country gathered at ESRL in April, for the First NOAA Testbed USWRP Workshop. In NOAA testbeds, researchers tackle serious, practical forecast challenges—improving flood forecasts in California, for example, or getting more lead-time on landfalling hurricanes. Testbed research involves innovative strategies that are not guaranteed to work, but serve society in powerful ways if they do, said Marty Ralph, chair of the U.S. Weather Research Program (USWRP) executive committee that organized and sponsored the Testbed Workshop, and part of ESRL's Physical Sciences Division.

"I'm excited to see this group here," ESRL Director Alexander ("Sandy") MacDonald said in a talk welcoming testbed workshop participants to Boulder. "We at the Earth System Research Laboratory are hell-bent to make all of our operational weather services the best," MacDonald said. "Testbeds are a way to take what we have learned and get it into operations. Our job is to apply the science, so we provide the people of the United States with the best possible weather services."

"Our job is to apply the science, so we provide the people of the United States with the best possible weather services."

NOAA has been experimenting with testbeds for about a decade now, said Janet Intrieri from the Earth System Research Laboratory, who coordinated Testbed Workshop. Intrieri, Ralph, and John Gaynor (NOAA's Office of Atmospheric and Oceanic Research) organized the workshop so as to ensure that a wide variety of projects were represented, so participants could share best practices and potential pitfalls. Testbeds represented at the workshop included:

- Joint Hurricane Testbed
- Hydrometeorology Testbed
- Developmental Testbed Center
- Societal Impacts Program of the National Center for Atmospheric Research
- Collaborative Science, Technology, and Applied Research
- Joint Center for Satellite Data Assimilation
- Short-Term Prediction Research and Transition Center
- Hazardous Weather Testbed
- GOES-R Proving Ground
- Climate Testbed

Researchers involved in each testbed discussed recent and long-term achievements, and shared ideas for future work, especially collaborations. Diversity is part of what makes NOAA's testbed program so strong, Ralph said. "It's similar to ensemble forecasting. We all know that a diversity of models makes forecasts better," he said. "A diversity of approaches in testbeds also leads to improvements."

Among the attendees was Don Berchoff, the new Director of the Office of Science and Technology in the National Weather Service. "I found this extremely valuable," Berchoff said after the workshop. "The testbed community needs to think about interoperability between the testbeds," and the forum represented a start. Berchoff said that since the National Weather Service is laying plans to better incorporate uncertainty into forecasting, the social science presentations at the workshop were important for him to hear. "The briefings helped me to formulate a strategy and framework that I believe will help us focus our limited resources on what promises to deliver the biggest payback."

Virtual NOAA

Many visitors to NOAA in Second Life had never heard of the agency, but hope NOAA's new media efforts will expand

A powerful tsunami kills no one in the online virtual world Second Life, and the house blown apart by waves reassembles itself within seconds. Glaciers that melt and flow into the ocean are quickly sculpted back into cold, hard ice. But visitors to NOAA's Second Life exhibits still get the point: Climate change is reshaping the planet. Tsunamis are deadly strong.

"You can read about a tsunami in a textbook or you can *experience* one in a virtual world," ERSL's Eric Hackathorn, told Linden Lab (the creator of Second Life) this spring. "I believe that experience has a greater impact."

Hackathorn, part of ESRL's Global Systems Division, serves as NOAA's Virtual Worlds Program Manager and has directed the creation of NOAA islands. Avatars (people's virtual representations online) who visit NOAA's islands can ride into a hurricane on a research airplane, or walk across a weather map of the United States, experiencing current conditions—rain in eastern Oregon, scattered clouds over Maryland's beaches.

Linden Lab featured NOAA's Second Life presence in a case study this spring, concluding "NOAA has found ways to reach new audiences in profound and meaningful ways." Forty percent of visitors to NOAA's Second Life islands had never heard of the agency before, Linden Lab reported.

NOAA's activities in virtual worlds address a particular challenge in communicating climate change—those changes happen too slowly for many people to perceive them as threatening. When a virtual glacier crumbles before visitors' eyes, or a coral reef's brilliant, digital colors fade to gray in seconds, the effects of climate change can become strangely more real, Hackathorn said.

NOAA began incorporating Second Life into communication and educational programs in 2006 to reach new audiences and raise general brand awareness at home and abroad. NOAA's vision for the virtual world is the same as in reality: To create an informed society that understands the role of the ocean, coasts, and atmosphere in the global ecosystem to make the best social and economic decisions.

The Linden Lab report also found that NOAA's efforts in Second Life are considered "pioneering," so much so that Hackathorn and his supervisor William Bendel, also in the Global Systems Division, are

see p 8

Powering Science

Coal-fired power plants help ESRL scientists and colleagues verify satellite pollution measurements

In a strange twist, polluting power plants in the West are actually helping advance air quality research. A new study by ESRL scientists and colleagues used the large pollution plumes from rural Western power plants to understand satellite measurements of nitrogen dioxide (NO_2) pollution over urban areas including Los Angeles, Las Vegas, Denver, and Phoenix. There's good news in the data: urban NO_2 emissions appear to be much lower than estimated using the latest vetted conventional, bottom-up approaches.

By fine-tuning space-based measurements with such an approach, scientists believe satellites could offer a new view on emissions to improve air quality policy-making. NO_2 and other nitrogen oxide gases are emitted by industry and motor vehicles and are key ingredients in ground-level ozone—smog—a lung-damaging pollutant.

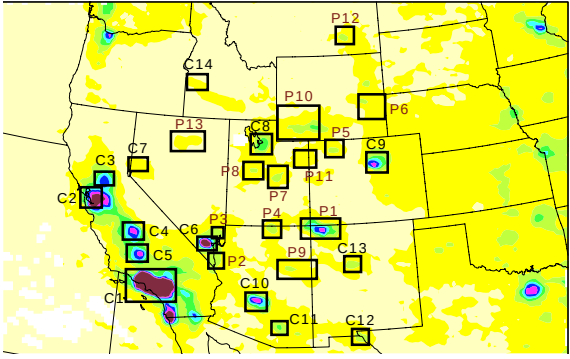
"Because there are very few other large sources of NO_2 in areas like the Four Corners, pollution plumes from coal-fired power plants in this region are easily visible from space," said atmospheric chemist Greg Frost, a researcher in ESRL's Chemical Sciences Division and the University of Colorado's Cooperative Institute for Research in Environmental Sciences (CIRES). Frost is a coauthor of the new study, published in the *Journal of Geophysical Research—Atmospheres*. "These plumes provide a unique reference point against which we can test the accuracy of satellite measurements of NO_2, because power plants measure the emissions coming from their smokestacks," Frost said.

In urban areas, emissions from cars and trucks are often the dominant source of NO_2, which complicates pollution monitoring, said Frost. While power plants are required to keep close tabs on smokestack emissions, regulators have no reliable way to track all tailpipe emissions. Instead, most urban emission inventories are modeled off estimates of miles traveled per vehicle type, and checked with spot roadside measurements, said Frost. Such bottom-up estimates are updated only every few years.

"...pollution plumes from coal-fired power plants in this region are easily visible from space."

"Satellites are one of the few tools available to us on a daily basis that can help us evaluate emissions of dangerous air pollutants from the top down," said study lead author Si-Wan Kim, with ESRL's Chemical Sciences Division and CIRES, who has also used satellites to study changes in power plant emissions in the eastern United States.

Other studies have investigated large-scale changes in global air pollution patterns with satellites, but the new study is the first to test whether satellites can accurately measure urban emissions by comparison with power plant emissions. The authors hope their work will inform air quality policy making at a local scale.



Summer 2005 NO_2 column measurements by satellite, with greens, blues, and reds indicating increasing concentration. Boxes highlight plumes from power plants (P) and cities (C).

Using the NO_2 emissions records from Western power plants, Kim and Frost evaluated three satellite datasets that captured NO_2 pollution plumes from space. They also ran a weather and air quality model incorporating emission data from a regional inventory and power plant records.

The satellite data and models agreed on NO_2 emissions from power plants, the study reported. However, Kim and Frost found large discrepancies in NO_2 measured over cities, with satellites consistently documenting less NO_2 than the inventory-based models predicted.

The satellite measurements also show that NO_2 over cities has declined in recent years. Ongoing work should help the researchers come up with a more quantitative understanding of the causes of the model-measurement differences and satellite changes.

—Contributed by Adriana Bailey, CIRES

Second Life visitor Melanie O. watched NOAA's glacial melt, and posted her images on Flikr. "The start of the NOAA glacier simulation. So beautiful," she wrote in her post. " ... and after global warming, no more glacier." Images courtesy of Melanie O.

...VIRTUAL NOAA

regularly approached by other government agencies seeking to develop a presence in the virtual world.

More: http://secondlifegrid.net/casestudies (then see Corporate/Government Case Studies)

Things to Do

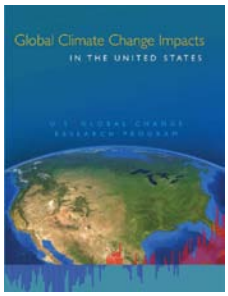
on NOAA's Second Life Islands:

- **Float** on a weather balloon
- **Fish** for Alaska king crab
- **Soar** through a hurricane
- **Explore** underwater caves
- **Clean** up an oil spill
- **Walk** through real-time weather
- **Trigger** a tsunami
- **Watch** Science On a Sphere
- **Traverse** a glacier
- **Map** the ocean floor

Achievements, in Brief **The following sections—News, Honored, and Published—highlight a few measures of ESRL's impact.**

News

Climate Report Contributions



ESRL's Roger Pulwarty and Brad Udall were among the many NOAA co-authors of *Global Climate Change Impacts in the United States*, a multi-agency report released in June and extensively covered by the media. The 190-page report, a synthesis of findings by the U.S. Global Change Research program, was released during a White House briefing. "This report provides the concrete scientific information that says unequivocally that climate change is happening now, and it's happening in our own backyards, and it affects the kind of things people care about," NOAA Administrator Jane Lubchenco said during the briefing. More: http://globalchange.gov/

CalWater Begins Early

ESRL scientists and colleagues installed an aerosol-meteorological observatory package in California's Sierra Nevada early this spring, to observe the aerosol content within individual raindrops and snowflakes. The deployment represents an early start to the CalWater experiment, scheduled to begin in November. CalWater, funded by NOAA and the California Energy Commission, will address the controversial concept that aerosol pollution is affecting the timing and location of rainfall in the Sierra Nevada region, leaving the state with fewer water resources.

Unmanned Aircraft

NOAA's Climate Program Office (CPO) received $1 million in the 2009 budget to fund data analysis from the agency's budding Unmanned Aircraft Systems (UAS) work in the Arctic. Because there are not many data yet from Arctic UAS projects, said CPO Director John Calder, the money will fund work to analyze regional data from other sources, which will give context to UAS data as they come in, and to fund planning meetings. ESRL's Robbie Hood directs NOAA's UAS program. "This gives us an opportunity for UAS and CPO to plan a robust research venture," Hood said.

Also: In April, ministers from each of the eight countries with territory in the Arctic unanimously agreed to create a team of scientists and aviation authorities who will coordinate and facilitate "the safe use of unmanned aircraft systems for research and monitoring in the Arctic." ESRL's Betsy Weatherhead, with the Global Systems Division, worked in scientific and political circles to bring the issue to the attention of the Arctic Council. "This is a major step forward that will allow us to take measurements we've never been able to take before," said Weatherhead, who is the co-lead of NOAA's UAS Arctic Testbed. More: http://arctic-council.org/

Fire Weather Conference

Several dozen fire, weather and climate specialists convened at ESRL in April for the seventh annual National Seasonal Assessment Workshop. The interagency group spent three days generating a "seasonal assessment" for the Western States and Alaska, and the assessment process included evaluation of many NOAA and ESRL research products.

"I look at everything—I'm a geek," said Rich Naden, a National Park Service meteorologist in Albuquerque, N.M. and prediction coordinator for regional interagency fire group. Naden said he is especially interested in several of the Physical Sciences Division's experimental outlooks. "Basically, the stuff coming out of this building is all good," Naden said during the workshop. "We need more of this kind of interaction between academia and the people doing the science."

Volcanic Ash Tool Delivers

When Alaska's Mount Redoubt erupted this spring, the National Weather Service and the Federal Aviation Administration used the Volcanic Ash Coordination Tool (VACT)—developed by ESRL's Global Systems Division—in real time. VACT helped the National Weather Service report the location, aerial extent, and movements of ash. The volcano spewed plumes of ash and gas to heights of 65,000 feet, disrupting flights and closing the Anchorage airport. VACT integrates high-resolution weather, aircraft location, FAA routing, enhanced satellite imagery, and ash dispersion modeling data sets to help users graphically display and predict the path of the volcano's plume.

Visitors

Secretary of Commerce Gary Locke visited ESRL in early May, as part of a visit to all Commerce facilities in Boulder, Colo. ESRL Director Sandy MacDonald gave Locke a briefing with ESRL's unique visualization tool, Science On a Sphere®, and Secretary Locke took a short tour of ESRL's laboratories before answering questions during a town hall meeting for Commerce employees.

In late May, NOAA Administrator Jane Lubchenco toured ESRL's research laboratories, and spoke with employees. "It's clear that there's so much going on here that is not only scientifically interesting, but important for the world," Lubchenco said. She also gave a brief update on the multi-agency effort to create a National Climate Service—NOAA's climate services

Left: Mt. Redoubt's eruption, courtesy of the U.S. Geological Survey. **Middle:** ESRL Director Sandy MacDonald and NOAA Administrator Jane Lubchenco, photo courtesy of Steve Peckham, NOAA. **Right:** ESRL Deputy Director for Administration Don Mock with U.S. Commerce Secretary Gary Locke, photo courtesy of Will von Dauster, NOAA.



Left: David Welsh with ESRL's Physical Sciences Division and Tammy Morrison, a North Carolina Agricultural and Technical State University student. Photo courtesy of Will von Dauster, NOAA. **Middle:** Air traffic, http://radar.zhaw.ch. **Right:** 2008 Wildfire in Australia, courtesy of Mark Maupin.

are now directed by Tom Karl. "My hope and expectation is that there will be an interagency mechanism," Lubchenco said of the national effort, "and NOAA will be the lead agency."

Summer Students Arrive

More than 50 interns arrived at ESRL May 26 to begin a summer of research. ESRL Director Sandy MacDonald welcomed the students, noted that they had an opportunity to deal with some of the world's most pressing problems, and urged them to contribute their talents to future solutions. ESRL researchers from all divisions chatted with the students over refreshments.

Climate-Changing Planes

Airplane emissions affect climate in many ways—oxides of nitrogen indirectly warm the atmosphere, some types of aerosols cool it, and carbon dioxide, water, and aviation-induced clouds all warm it. ESRL's David Fahey and colleagues updated an assessment of the "radiative forcing" of aviation—its overall warming and cooling effect—and published findings in *Atmospheric Environment* this spring. Aviation represented about 3.5 percent of all anthoropogenic radiative forcing effects in 2005, the team concluded, and that number is likely to increase to 4-4.7 percent by 2050.

Fahey is also engaged in discussions with the International Civil Aviation Organization about how to quantify the non-CO_2 effects of aviation. These effects are often quantified simply as a multiple of the CO_2 climate effect. However, such a multiplier is not a scientifically defensible way to calculate aviation's full climate effect, Fahey said. A more suitable metric is required to explicitly include the radiative forcing of all aviation emissions and cloudiness changes. Some 'carbon calculators' used to offset an aircraft passenger's contribution to climate forcing use multipliers incorrectly.

Monitoring in Congress

ESRL Director Sandy MacDonald detailed NOAA's greenhouse gas and aerosol monitoring activities in a hearing of the House Committee on Science and Technology this spring. Representatives from two universities, the U.S. Forest Service, NASA, the Environmental Protection Agency, and the National Institute of Standards and Technology also testified. More: http://science.house.gov/Publications/hearings_markups_details.aspx?NewsID=2424

Honored

Wayne Angevine (ESRL's Chemical Sciences Division) was appointed as the Chair of the American Meteorological Society Committee on Boundary Layers and Turbulence.

Susan Solomon (ESRL's Chemical Sciences Division) became a Chevalier ("knight") in the French Legion of Honor. "This award testifies to the President's high esteem for your merits and accomplishments," French Ambassador to the United States Pierre Vimont wrote in a letter informing Solomon of the award.

Brad Udall, director of the Western Water Assessment (WWA) and several colleagues were honored with the U.S. Department of the Interior's "Partners in Conservation Award" for their role in creating guidelines for managing the Colorado River during droughts. WWA, a joint effort of ESRL's Physical Sciences Division and the University of Colorado at Boulder, shared the award with the University of Colorado at Boulder's Center for Advanced Decision Support for Water and Environmental Systems, CADWES. "In the midst of the worst drought in more than a century they formed an agreement that promises a future of cooperation in the Colorado River Basin," said Interior Secretary Ken Salazar, who presented the award.

Twelve ESRL scientists received significant awards at the fourth annual Rendezvous Science Symposium of the Cooperative Institute for Research in Environmental Sciences (CIRES):

- **Andrew Crotwell**, **Geoff Dutton**, **Molly Heller**, **Debra Mondeel**, **Carolina Siso**, and **Kelly Sours** of ESRL's Global Monitoring Division received the CIRES Silver Medal for their contributions to the Annual Greenhouse Gas Index (AGGI). Their NOAA colleagues won a Department of Commerce Silver Medal.
- **Christine Ennis** (in ESRL's Chemical Sciences Division) received a CIRES Director's Award for her excellent work on the Climate Change Science Program's "Synthesis and Assessment Product 2.4," on ozone-depleting substances and the stratospheric ozone layer. Ennis' NOAA colleagues were awarded the NOAA Administrator's Award.
- **Molly Heller** also received a CIRES Outstanding Service Award for her contributions in logistics for the carbon cycle and greenhouse gases flask program, and for creating the David Skaggs Research Center's new recycling program.
- **John Holloway** (in ESRL's Chemical Sciences Division) received an Outstanding Performance Award in Science and Engineering for work on a state-of-the-art instrument to measure carbon monoxide from aircraft.
- **Sergey Matrosov** (in ESRL's Physical Sciences Division) also received an Outstanding Performance in Science and Engineering Award for his use of millimeter wavelength radar to study the properties of clouds and precipitation.
- **Sonja Wolter**, **Doug Guenther**, and **Fred Moore** (in ESRL's Global Monitoring Division) received an Outstanding Performance in Science and Engineering Award for their work on a programmable flask package air sampler.

Published

ESRL's peer-reviewed publications are now available digitally:

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

Division publication sites remain:

GMD: www.esrl.noaa.gov/gmd/publications/

PSD: www.cdc.noaa.gov/pubs

CSD: www.esrl.noaa.gov/csd/pubs/

GSD: www.fsl.noaa.gov/publications/

Hundreds Attend NOAA Green Fair

"Bring Your Child Down to Earth Day" focused on science, fun

Victoria Loughe, 10, led her team to victory in a recycling relay at NOAA's Boulder laboratories April 23, and she said she spent the day learning not only about compost, but about Earth's atmosphere and oceans.

"It was lots of fun," Victoria said after NOAA's "Bring Your Child Down to Earth Day," a day of activities for employees, children, and the public. NOAA held its own version of "Bring Your Child to Work Day" the day after Earth Day, in tandem with a Green Fair.

More than 300 people wandered through an outdoors tent featuring products and information from local green vendors, moved inside to watch presentations on ESRL's unique visualization tool, Science On a Sphere®, and created flip-books to illustrate Arctic Sea ice loss. Kids also watched presentations of "Big Green Rabbit," a television program about conservation.

"I liked that Science On a Sphere®," Victoria said, "especially how it showed hurricanes."

Richard Roth, president of Cool Solar, Inc. in Boulder, said he was grateful for the invitation to spend a day at NOAA, displaying products and chatting with employees. Cool Solar installs photovoltaic panels on homes and businesses. "Our company did get some interest," Roth said, "but it was also interesting and informative for me to just meet some of the people from NOAA. I had extensive discussions about issues relevant to the solar industry."

Dozens of NOAA employees helped staff children's activities, inflate balloons, present Science On a Sphere®, and discuss CarbonTracker, a NOAA system that tracks the global release and uptake of carbon dioxide, a critical greenhouse gas.

Beth Powell, outreach coordinator for the city of Boulder's ClimateSmart Program, set up a table of materials at the fair, including information on a new county-wide loan program to help homeowners purchase solar panels, energy efficient windows, tankless water heaters, etc.

"By the end of the day, all my materials had been taken," Powell said. Although many NOAA employees study climate change or factors that influence climate and the weather, Powell said, she did not feel like she was "preaching to the choir" when discussing the climate impacts of energy use, transportation choices, and purchasing decisions. "Many of us in our daily, busy lives may not be thinking about how what we do each day affects our atmosphere for decades."

Victoria said the recycling relay was her favorite part of the day. She and two teammates accurately tossed a plastic fork into the trash bin, a slip of paper into recycling, and a dandelion into the compost bin.

"I didn't know what compost was before that," Victoria said.

Top: Checking out bins set up for a recycling relay. Photo courtesy of Annie Reiser, NOAA. **Bottom:** Visitors work with ESRL meteorologist Sara Summers (Global Systems Division) on a soil and water experiment. Photo courtesy of Will von Dauster, NOAA.

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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.

CIRA CIRES NOAA