ESRL Quarterly

News from NOAA's Earth System Research Laboratory

Winter 2011

Weekly flask samples taken at remote sites, such as Mauna Loa, Hawaii, shown, enabled a new analysis of the key atmospheric cleanser hydroxyl. Pictured is Aidan Colton, NOAA. Photo by James Elkins, ESRL.

Inside

Air Cleanser

ESRL-led team measures the variability of the atmosphere's self-cleaning capacity

An international, ESRL-led research team took a significant step forward in understanding the atmosphere's ability to cleanse itself of many air pollutants and some other gases. The issue has been controversial for many years, with some studies suggesting the self-cleaning power of the atmosphere is fragile and sensitive to environmental changes, while others suggest greater stability. And what researchers are finding is that the atmosphere's self-cleaning capacity is rather stable.

A new analysis published in *Science* in January shows that global levels of the hydroxyl radical, a critical player in atmospheric chemistry, do not vary much from year to year. Levels of hydroxyl, which help clear the atmosphere of many hazardous air pollutants and some important greenhouse gases – but not carbon dioxide – dip and rise by only a few percent every year; not by up to 25 percent, as was once estimated.

"The new hydroxyl measurements give researchers a broad view of the 'oxidizing' or self-cleaning capacity of the atmosphere," said ESRL chemist Stephen Montzka (Global Monitoring Division), the study's lead author.

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Night Lights

ESRL researchers find small but significant effect of nighttime city lighting on air pollution

Every night, the cities of the Los Angeles Basin throw a dome of light into the dark sky, cast by millions of street lamps and other outdoor lights. That glow is 10,000 times dimmer than sunlight, but still powerful enough to influence chemistry affecting air pollution, ESRL scientists discovered.

In a press conference and poster session at the American Geophysical Union annual fall meeting, Harald Stark (Chemical Sciences Division, CSD) and colleagues presented measurements

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Snow and Warming

Northern Hemisphere could warm further in response to lost snow

Racing down a ski slope or snowshoeing across a ridge, it is not obvious that the snow covering the ground isn't just a product of the weather – it also influences the weather. A white blanket of snow can simultaneously trap heat in the ground and reflect solar radiation back into the atmosphere or out to space, much like a mirror reflects visible light.

"When you change the amount of snow, you change how much heat flows between the atmosphere and ground," said Mike Alexander

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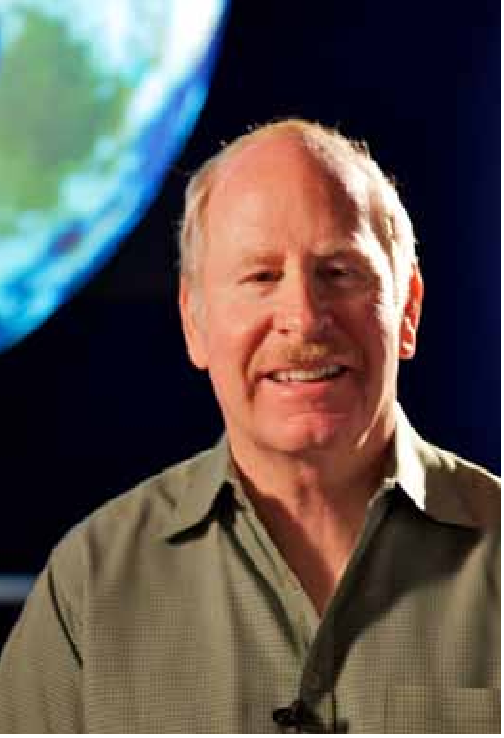
Los Angeles at night. Flikr creative commons.



Director's Corner

What is the Role of NOAA's Research Laboratories? Last week I attended the Annual Meeting of the American Meteorological Society. In the last 30 years I have only missed one of these meetings, so it is a chance to renew longtime friendships and to catch up on the progress of our profession. The Seattle meeting did not disappoint and the contributions of ESRL were much in evidence. Our work included interesting papers on understanding the climate system, the exciting results we are getting in model assimilation, and the leading edge of global and regional models. I went to a talk by Stan Benjamin on the High Resolution Rapid Refresh, and the excitement about this new model slated for operations was palpable.

The dinner for the retiring Director of the Pacific Marine Environment Laboratory (PMEL), Dr. Eddie N. Bernard, was a particularly enjoyable celebration. The speakers, each with their own interesting stories, recounted the amazing accomplishments of PMEL during Eddie's tenure. The equatorial array of moored buoys, starting with the TAO array in the Pacific, and now fully extending into the Atlantic and Indian Oceans, have been the foundation of improvements in our understanding of the ocean's role in the global climate system. This array was made possible by the buoy-building prowess of PMEL, and by the ability of the lab to implement and sustain major infrastructure. A similar story was told of the leadership of Dr. Bernard in the fielding of revolutionary new technology to detect tsunamis. Other accomplishments of PMEL cover the gamut from discovery of undersea volcanoes and thermal vents to the rapidly changing Arctic. Every story told during dinner reinforced the reasons-to-be for NOAA's research labs – which foster a combination of professionals and unique infrastructure related to NOAA's core mission.

As I attended the AMS sessions, I thought about the equivalent infrastructure and people that ESRL brings to NOAA's mission. The Chemical Sciences Division has shown how a combination of scientists and other technical people can use assets such as NOAA's P3 airplanes to understand the immensely complex chemistry of the atmosphere. The latest demonstration of these capabilities was the role that this group played in understanding the air chemistry over the Deepwater Horizon oil spill. The Global Monitoring Division's global network of people and infrastructure was rightly recognized at the Mauna Loa 50th celebration as a global treasure.

This year's Revelle Medal given to Pieter Tans by the American Geophysical Union is a testimony to the important science that he has done, but I'm sure Pieter would agree that it was due to the far flung observational assets as well as the advanced laboratories that a NOAA lab can command. The Global Systems Division's leadership in computing has made possible a 20 percent improvement in tropical cyclone track accuracy, a result that was expected to take five years. Furthermore, the next generation of computing, use of Graphic Processor Units for geophysical models, has GSD at the forefront.

The Physical Sciences Division has ESRL's most diverse set of infrastructure, including its boundary layers and aircraft observing tools, its role in the network of Arctic observatories, and its important role in the operational test beds. PSD has played a leading role in the use of data to better understand weather and climate, and in the new role that NOAA will be playing in providing climate services.

The above examples illustrate the role that NOAA's research laboratories fill. NOAA's mission is significantly different from any other U.S. organization, public or private. If NOAA needs to understand the chemistry of some remote area, e.g., the stratosphere over the Antarctic, it must have the infrastructure to observe it, and the scientific and engineering talent to analyze and understand the story the data tell. In another of many possible examples, advancements in the complexities of a full spectrum of real-time atmospheric and oceanic data handling are unique to our discipline. NOAA's research laboratories, each with a critical mass of scientists, engineers, and technical people who spend decades working with the unique infrastructure associated with a particular component of its mission, are the foundation of NOAA's recognized leadership in oceanic and atmospheric science. At the AMS meeting, I was reminded of this often as I watched our science on display.

—Alexander MacDonald

By the Numbers
The Day vs. LA

10,000

Nighttime lights in the Los Angeles Basin shine 10,000 times less intensely than the Sun, but 25 times more than the full moon. That's bright enough to trigger some unexpected chemistry. See "Night Lights" on page 1.

Young Students Film Scientists

February gala to feature NOAA-funded Earth Explorers videos

What do you wear in Antarctica?

Does taking a tree core hurt the tree?

What is a laser, anyway?

Several dozen middle school students from Longmont's Trail Ridge Middle School peppered ESRL and other Boulder-area scientists with questions during hours of interviews last fall.

From those interviews and time in the field with scientists, student film companies stitched together short films, a few minutes long, which will be shown in a gala premier February 12, at the University of Colorado's ATLAS Institute (Alliance for Technology, Learning and Society).

"This project was first and foremost about connecting diverse kids with science and scientists in a fun way," said ESRL outreach specialist Carol Knight (Director's Office), who was awarded a NOAA Preserve America grant last spring for the video program. "We did that."

Earth Explorers was funded by NOAA, and implemented in collaboration with the Boulder History Museum, Trail Ridge Middle School, the National Center for Atmospheric Research, the National Ecological Observatory Network, and ATLAS.

The questions the students asked and the angles they chose for their movies reflect diverse and sometimes quirky interests.

Students were fascinated with Mongolian chemist Munhk Baasandorj, for example, who works in ESRL's Chemical Sciences Division. Her descriptions of family members living halfway across the world in Ulaanbaatar made the cut. So did a clip of the students playing with vapor from liquid nitrogen Baasandorj uses to cool her equipment. (An explanation about how she uses lasers to study atmospheric chemistry didn't make it in.)

Some student teams injected themselves into their films, even mugging for the camera; others focused exclusively on their subject. Most teams spent a lot of time figuring out how to identify themselves: Fluffy Space Monkeys and Superview Productions, for example, and UFF (Unidentified Flying Films).

"We knew to anticipate the unanticipated stuff," Knight said, laughing at some of the names. "The point was for them to have fun while learning something."

The students themselves – from economically and culturally diverse backgrounds – were effusive about the program.

"We worked with Bruce Bauer. He studies ancient climates," said Emily, an 8th grade student at Trail Ridge, whose team interviewed the NOAA paleoclimate expert.

"He told us about how he gets climate information, from tree cores, ice cores…" her team member, LaJessie, added.

"And coral cores. The coral cores were cool!" Emily said.

LaJessie, also in 8th grade, said she's been interested in science for ages, but always imagined pursuing medical science. "This changed my perception," she said of the Earth Explorers program. "I'm more open to other science fields."

The students, their mentors and teachers spent dozens of hours on the project. October through December, the students met every school day for 30 minutes before classes started with Trail Ridge science teacher and MESA coordinator Liz Sims.

MESA, Math Engineering Science Achievement, is a program of the St. Vrain Valley School District, and it focuses on encouraging student interest and continued education in science. Earth Explorers staff, complemented by Sims' and other Trail Ridge teachers' expertise, met for an hour every Tuesday afternoon, and spent five fall Saturdays on video editing.

Jenn Glaser, who created and directed the Earth Explorers program, and Carolyn Wiley, director of video education, and other Trail Ridge teachers also worked with the students on interviewing, telling stories through video, and the architecture of a good story.

"We learned about plot, rising action, conclusions…" said 7th grader Cade, who worked with a team featuring retired NOAA satellite engineer Lorne Matheson.

"We had a little trouble with our conclusion… so we ended up asking people what the world would be like if there were no satellites," Cade said.

"We wouldn't know what Earth looks like," said teammate Justin, an 8th grader. "We wouldn't be able to predict the weather without them."

"Or have TV, or phones," Cade added.

One of the program's strengths, Sims and Glaser said, was that it drew on the students' unique strengths and interests.

"Some kids were interested in the interviewing, animation, making their own music with Garage Band (a computer program)…" Sims said.

"One kid kind of checked out during the scientist interviews, but he became obsessed with Garage Band, and very good at it," Glaser said. "The most important thing was that they all felt empowered and proud, They took real ownership in their films."

There will be no red carpet or Oscar-style designer gowns at the upcoming gala, said one student, with just a touch of disappointment. "It's business casual," she said. "That means professional, I guess."

More: http://www.colorado.edu/atlas/earthexplorers/

Caught on film

"The work I get to do benefits everybody, the whole country," marveled ESRL's **Tom LeFebrve** (Global Systems Division). "I write computer software that helps forecasters do a better job of forecasting and helps them warn the public."

"I love the work I do for NOAA," said ESRL's **Brian Vasel** (Global Monitoring Division). "I think it's very important and relevant to society… I couldn't imagine doing anything else."

Trail Ridge Earth Explorers test filming techniques. Photo by Jenn Glaser.

ESRL in Cancun

Ravishankara, Schnell give key state-of-the science presentations

ESRL's Russ Schnell and A.R. Ravishankara were among a few dozen U.S. scientists chosen to speak publically during international climate negotiations in Cancun, Mexico this fall. The two gave independent talks at the U.S. State Department-sponsored "U.S. Center" during negotiations of the 16th Conference of Parties (COP) of the United Nations Framework Convention on Climate Change, in December.

Ravishankara, Director of ESRL's Chemical Sciences Division, discussed the intersection of air quality and climate change and win-win strategies to address both. Schnell, Deputy Director of ESRL's Global Monitoring Division, spoke about the changing atmosphere and the importance of tracking greenhouse gases.

David Herring, Communications Director for NOAA's Climate Program Office, said the two ESRL scientists did an excellent job describing how science can guide and inform international decision making.

"Anytime you can get someone talking directly with a scientist who is good at communicating, well, that's the best you can hope for," said Herring, who helped organize programs at the U.S. Center. "The whole world doesn't usually have access to world-class scientists like Russ and Ravi – but in this case they did. There they were on stage, speaking to the world about very important science, and they couldn't have done any better."

The audience at the U.S. Center included members of the press, policy makers, staff from negotiating countries, non-government organization representatives, other researchers, and thousands more people who watched events online.

Ravishankara, Director of ESRL's Chemical Sciences Division, spoke on a panel with NASA colleague Hanwant Singh; the two scientists highlighted knowledge gained during air quality field campaigns conducted over megacities in the last 20 years, including Mexico City and Los Angeles. Those and other studies have revealed how human activities can sometimes contribute to both air quality problems and climate change—and therefore how policies to deal with one can also help with the other.

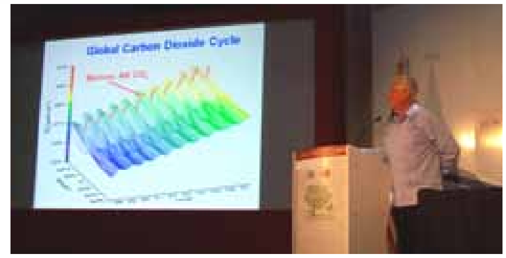
Although Ravishankara has served since 2007 as co-chair of the scientific assessment panel of the Montreal Protocol, an international agreement to protect the ozone layer, this was his first participation in COP, he said. "I felt it was important to help show how science can identify win-win opportunities," in which policies to deal with air quality also help mitigate climate change, and vice versa. Reducing emissions of soot (from inefficient fuel combustion) to protect human health, for example, may also mitigate the climate warming effects of the dark particles.

Schnell, Deputy Director of ESRL's Global Monitoring Division, spoke about steadily increasing amounts of carbon dioxide and other greenhouse gases in Earth's atmosphere, and the importance of international, cooperative programs to track and understand those gases.

"Even if the negotiators weren't going to come to any major agreement, the information exchange at the centers was terrific," Schnell said. "There was so much good data flowing around … It's important for the politicians to realize how many people are involved and concerned about climate."

Herring agreed. "The U.S. Center represents the way in which the State Department communicates and projects an image and voice about the United States to the international community," he said. With scientist panels and an interactive touch table computer on which visitors could explore U.S. climate-related activities, the U.S. delegation showed that "we're at the table, contributing," Herring said. "The story we told was that we're committed to helping with international negotiations, to playing an active role in knowledge gathering, sharing data, tools, techniques…all to help guide and inform adaptation and mitigation decision making. Our story was heavily laced with science but in a way non-scientists could easily understand."

More: http://www.connectsolutions.com/cop16/



Russ Schnell in Cancun. Photo by David Herring, NOAA .

Steven Koch to Lead NSSL

Director of ESRL's Global Systems Division will move to National Severe Storms Laboratory

From Craig Mclean, Acting Assistant Administrator for Oceanic and Atmospheric Research:

"I'm pleased to announce that we have selected Dr. Steven Koch as Director of the National Severe Storms Laboratory in Norman, OK. Steve will begin his NSSL duties on April 24.

Steve will lead a world-renowned laboratory with a research focus in weather radar, severe weather, hydrological models for water forecasting and management, and improving the way forecasters use weather models.

Steve began his career at NOAA in 2000 as Chief of the Forecast Research Division at the then-Forecast Systems Laboratory. The lab was merged into the Earth System Research Laboratory in 2006, and Steve became the acting director of the Global Systems Division the same year; the following year, he was named director.

Steve's early work history includes teaching meteorology at North Carolina State University in Raleigh, and conducting research as a meteorologist at NASA Goddard Space Flight Center in Greenbelt, MD.

He earned his PhD from the University of Oklahoma in 1979, and earned his Master's and bachelor's degrees in meteorology from the University of Wisconsin, Madison, Wis., in 1974 and 1972 respectively.

Please join me in congratulating Steve.

I also want to thank NSSL Deputy Director Kevin Kelleher for his work as acting NSSL Director since Jeff Kimpel retired last year, and Kurt Hondl, for his work as acting NSSL Deputy Director for Kevin."

Understanding Atmospheric Boundaries

International "DynVar" workshop focuses on the climate-relevant connections between the troposphere and stratosphere

Atmospheric researchers haven't always crossed boundaries fluidly. There were those who focused on the troposphere, the layer of air down near Earth's surface, where most of our weather phenomena occur and which has been warming. And those whose sights were set higher, in the stratosphere, where ozone depletion has been among the main events in recent decades.

Increasingly, however, scientists understand that the connections between the troposphere and stratosphere are critical for understanding past climate changes, for forecasting seasonal climate and for projecting the future.

About 70 researchers from around the world gathered at NOAA's Earth System Research Laboratory in Boulder, CO in early November, for the second Dynamics and Variability (DynVar) of the Stratosphere-Troposphere System. The workshop, which concentrated on modeling, was organized by ESRL's Judith Perlwitz (also with the Cooperative Institute for Research in Environmental Sciences) and colleagues from the United States, Germany, and the UK.

Researchers presented initial results or described experiments planned to clarify the relationship of the stratosphere to storm tracks, sea ice extent and circulation patterns such as El Niño-Southern Oscillation and North Atlantic Oscillation.

"We want to focus on the impact of the two-way stratosphere-troposphere coupling on mean climate, variability, and change," Elisa Manzini (Max Planck Institute for Meteorology, Hamburg) said during an introduction to the workshop, which lasted three days.

ESRL's Susan Solomon gave a keynote address suggesting that the audience members should look into the stratosphere. "I recommend investing yourself in stratospheric processes and their roles in climate," Solomon said. "This is an amazing time to be working on the stratosphere."

Solomon drew upon some of her own recent research, which demonstrated that stratospheric changes in water vapor can help explain recent temperature changes at Earth's surface.

Several speakers discussed now well-known work showing that the seasonal loss of stratospheric ozone in the Antarctic has amplified certain wind patterns, keeping the interior of the continent cold. In the future, ozone recovery, models show, will likely amplify Antarctic warming caused by the increase of greenhouse gases.

And many speakers looked to the future, describing planned modeling experiments to extract the roles of the stratosphere on climate. Seasonal Forecast Models and Earth System Models are beginning to go "high-top," meaning they stretch high enough in altitude to account for stratospheric dynamics.

DynVar participants agreed that careful comparisons of "high-top" and comparable "low-top" models will be essential for determining whether including stratospheric processes will improve climate forecasts, from seasonal to decadal time scales.

"If you want to predict regional rainfall changes you need extended models" said Makoto Deushi, who discussed "The role of stratospheric ozone on the medium-range weather forecast." Deuishi suggested that the DynVar group gathered in Boulder should lay plans for a careful, multi-model comparison of high-top vs. low-top model results available through the Coupled Model Intercomparison Project (CMIP5). CMIP5 data include the results of climate models run in support of the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report, expected in 2013-2014.

The DynVAR 2 workshop was sponsored by NOAA's Modeling, Analysis, Prediction and Projection (MAPP) Program, Stratospheric Processes and their Role in Climate (a core program of the World Climate Research Program), and the European integrating project COMBINE (Comprehensive Modelling of the Earth System for Better Climate Prediction and Projection).

More: http://www.sparcdynvar.org/

ESRL@ SC10

ESRL innovations, job fair at Supercomputing conference

NOAA researchers were involved in several technical presentations at SC10 this year, hosted a booth, and also participated in the job fair.

Researchers discussed Graphics Processing Units and how to use the processors – designed to improve video games – in weather and climate modeling. They highlighted the NOAA Global Interoperability Project, and unveiled N-NEW, a next-generation, secure network to serve the weather and climate research community.

This year's conference drew more than 12,000 attendees from across the country and internationally. Among the conference-goers were many students who swarmed the exhibit hall, handing out their resumes in search of internships and employment opportunities.

ESRl's Rhonda Lange (right) during the SC10 job fair. Photo by Will von Dauster, ESRL .

...from page 1: self-cleaning atmosphere

"Now we know that the atmosphere's ability to rid itself of many pollutants is generally well buffered or stable," said Montzka. "This fundamental property of the atmosphere was one we hadn't been able to confirm before."

His co-authors include Maarten Krol (University of Utrecht and Wageningen University in the Netherlands); Ed Dlugokencky and Bradley Hall (ESRL GMD); Patrick Jöckel (Max-Planck-Institute for Chemistry in Mainz, Germany, and the Institut für Physik der Atmosphäre, Oberpfaffenhofen, Germany); and Jos Lelieveld (Max-Planck and the Cyprus Institute in Nicosia, Cyprus).

The new finding adds confidence to projections of future air pollutant loads. The hydroxyl radical, comprised of one oxygen atom and one hydrogen atom, is formed and broken down so quickly in the atmosphere that it has been extremely difficult to measure on global scales.

"In the daytime, hydroxyl's lifetime is about one second and it is present at exceedingly low concentrations," said Montzka. "Once created, it doesn't take long to find something to react with."

The radical is central to the chemistry of the atmosphere. It is involved in the formation and breakdown of surface-level ozone, a lung- and crop-damaging pollutant. It also reacts with and destroys the powerful greenhouse gas methane and air pollutants including hydrocarbons, carbon monoxide and sulfur dioxide. However, hydroxyl radicals do not remove carbon dioxide, nitrous oxide or chlorofluorocarbons.

To estimate variability in global hydroxyl levels – and thus the cleansing capacity of the atmosphere – researchers turned to studying longer-lived chemicals that react with hydroxyl.

The industrial chemical methyl chloroform, for example, is destroyed in the atmosphere primarily by hydroxyl radicals. By comparing levels of methyl chloroform emitted into the atmosphere with levels measured in the atmosphere, researchers can estimate the concentration of hydroxyl and how it varies from year to year.

This technique produced estimates of hydroxyl that swung wildly in the 1980s and 1990s. Researchers struggled to understand whether the ups and downs were due to errors in emissions estimates for methyl chloroform, for example, or to real swings in hydroxyl levels. The swings would be of concern: Large fluctuations in hydroxyl radicals would mean the atmosphere's self-cleaning ability was very sensitive to human-caused or natural changes in the atmosphere.

To complicate matters, when scientists tried to measure the concentration of hydroxyl radical levels compared to other gases, such as methane, they were seeing only small variations from year to year. The same small fluctuation was occurring when scientists ran the standard global chemistry models.

An international agreement helped resolve the issue. In response to the Montreal Protocol – the international agreement to phase out chemicals that are destroying the Earth's protective stratospheric ozone layer – production of methyl chloroform all but stopped in the mid-1990s. As a result, emissions of this potent ozone-depleting gas dropped precipitously.

Without the confounding effect of any appreciable methyl chloroform emissions, a more precise picture of hydroxyl variability emerged based on the observed decay of remaining methyl chloroform. The scientists studied hydroxyl radicals both by making measurements of methyl chloroform from NOAA's international cooperative air sampling program and also by modeling results with state-of-the-art models.

The group's findings improve confidence in projecting the future of Earth's atmosphere.

"Say we wanted to know how much we'd need to reduce human-derived emissions of methane to cut its climate influence by half," Montzka said. "That would require an understanding of hydroxyl and its variability. Since the new results suggest that large hydroxyl radical changes are unlikely, such projections become more reliable."

Montzka and Lelieveld participated in a NOAA teleconference with journalists, the day the paper came out online. Stories appeared in many outlets, from AOL News and Discovery News to the *New York Times* and *Dow Jones*.

... from page 1: Night lights and pollution

made during several nighttime flights in California last summer, part of the CalNex field campaign in California, to study the nexus of air quality and climate change.

"We showed that city lights diminish the nighttime cleansing of the atmosphere," Stark said, "and that could have an influence on what happens the next day," in terms of air pollution.

Stark's coauthors are Steve Brown, William Dubé, Nicholas Wagner, Thomas Ryerson, Illana Pollack, and David Parrish, all of CSD.

In a typical air quality field campaign, scientists make masses of measurements during the day, when sunlight triggers interesting chemistry. Several of CSD's recent field experiments have looked at new dimensions of the air quality issue by studying nighttime chemistry. CalNex involved several nighttime flights, although Stark wasn't originally planning to participate.

At Brown's urging, Stark decided to pull a few all-nighters, re-calibrating a key instrument – designed to measure sunlight during the day – to pick up the faint intensity of city lights at night.

He and his colleagues also used controlled ground-based measurements and chemical models to further understand the chemistry taking place in the Los Angeles (LA) Basin.

"We measured light intensities 10,000 times dimmer than the Sun…but 25 times brighter than the full moon," Stark said. His team also found evidence of the breakdown of nitrate radicals (NO_3). Nitrate typically helps cleanse the nighttime atmosphere by breaking down certain air pollutants.

Sunlight quickly destroys NO_3, which is consequently at extremely low concentrations during the day. Stark and his colleagues determined that the nighttime glow of the LA Basin was intense enough to do some damage, reducing the nighttime cleansing activity of NO_3 by as much as 7 percent.

That, in turn, could leave more pollutants in the air overnight, the team calculated – as much as 5 percent more nitrogen dioxide, NO_2, in particular. NO_2 is a key ingredient in the daytime formation of ozone, a regulated pollutant that can harm people's lungs as well as crops and ecosystems.

"Many cities are really close to their regulatory limits for ozone… so even a small effect like this could be important for those regulations," Stark said.

Many media outlets covered the story following the AGU press conference, from the BBC to *Nature* and the *Economist*.

AMS WeatherFest. AMS photo.

AMS Experiment

ESRL researcher, colleagues set up equipment to measure human impact on meeting environment

Peggy LeMone, president of the American Meteorological Society (AMS), had an inspiration for this year's annual conference. Since the theme was about communicating climate, she wanted an informal, real-time experiment run during the conference, to demonstrate how people affect the environment.

At the most basic level, people modify immediate surroundings simply by body heat and breathing. At another level, our buildings have great impact: to keep conditions comfortable indoors, most buildings must get rid of excess heat through HVAC (Heating, Ventilating, and Air Conditioning) systems. Collectively, buildings help make cities warmer than rural areas.

LeMone asked meteorologists Dan Wolfe of ESRL's Physical Sciences Division and Collin Daly of Campbell Scientific, both of them experts in creating and deploying meteorological instruments, to develop a monitoring system to measure room conditions and changes during AMS.

"We've used similar monitoring systems for research experiments on land, ships and aircraft to study boundary layer and climate processes," said Wolfe. Components for the indoor analysis system were provided by Vaisala and LICOR, integrated by Campbell Scientific, and tested by Wolfe and Daly.

LeMone also wanted to engage students attending the conference by involving them in the study. About 10 students volunteered, learning from Wolfe and Daly how to assemble equipment and monitor data.

Two identical systems measured temperature, relative humidity, and CO_2 data at different locations throughout the convention center. Data were transmitted by cell phone in real-time to Campbell Scientific, and made available on the company's website and via smart phone; all conference attendees had access.

The system was first tested at the AMS exhibit during WeatherFest, an interactive science fair open to the public. "Students working in the booth enthusiastically explained to visitors how our system operated and our objective," said Wolfe.

The primary monitoring location was at the Presidential Forum, with about 1,400 participants. Calculations before the event showed the potential for significant increases in temperature and CO_2 readings, not factoring in the HVAC. To make things more interesting, the HVAC system was discreetly turned off for 25 minutes during the Forum. This was long enough to see a change in the data signal, without a major impact on people's comfort.

At the request of LeMone, Professor David Sailor of Portland State University gave a talk the next day at a Town Hall meeting on the "Impact of Human Occupancy at the 2011 AMS Annual Convention." Sailor didn't have much time to analyze the data before his talk, but as expected, CO_2 and temperature levels fluctuated as occupancy changed. When the HVAC was shut off, the temperature and CO_2 level rose more rapidly – with CO_2 reaching nearly 1100 ppm (ambient atmospheric levels average about 390 ppm).

"Neither CO_2 nor water vapor nor temperature rose as much as we thought it would," said Sailor, "because the room was still in 'communication' with other parts of the building and created suction." The room wasn't completely sealed off, allowing air to rush in through open doors and adjacent spaces, decreasing the expected impact.

At the end of the Presidential Forum, session surveys were handed out that included questions about room acoustics and temperature. More than 500 surveys were returned and are in the process of being collated and reviewed. Sailor said that thus far, there is a trend suggesting that the conference rooms tend to be too cool, which could mean wasted energy and money.

Sailor will attend a different conference at the same venue in the near future, and may revisit the experiment. In the coming months, he hopes to do a detailed analysis of the data and perhaps publish the results in the *Bulletin of the American Meteorological Society*.

Many conference attendees who Wolfe spoke with thought the experiment was a great idea. "We were able to accomplish more than initially anticipated, because of the efforts of all those involved," said Wolfe.

—*Barb DeLuisi*

Now Boarding...Weather!

ESRL scientists seek to improve aviation efficiency by developing highly accurate and timely weather information for integration into air traffic management operations

Managing commercial air traffic is difficult enough without having to worry about weather. To keep increasing numbers of airplanes away from one another and on track, most air traffic controllers and managers rely on technologies, some of which are significantly less powerful than their own smart phones, said ESRL's Lynn Sherretz (Global Systems Division, GSD).

Add weather to the system, and air traffic management becomes an even greater challenge. If a thunderstorm threatens, for example, air traffic managers usually stop using computerized tools that normally help them efficiently line airplanes up for landing.

"That system would produce solutions that could put planes right into storms," Sherretz said. "This is an example of why weather needs to be integrated into these tools."

> Domestic air traffic delays cost the U.S. economy about $41 billion per year, according to the Congressional Joint Economic Committee... Two-thirds of commercial aviation delays could be prevented with better weather information, the FAA estimates.

So Sherretz and colleagues throughout GSD are helping to develop and test weather-related concepts for the Next Generation Air Transportation System (NextGen). NextGen is an executive and Congressionally mandated effort to significantly improve efficiency and safety in the skies by 2025, when air traffic is expected to at least double . ESRL's work is in collaboration with many other organizations and federal agencies, from NASA and the National Center for Atmospheric Research to NOAA's National Weather Service, the U.S. Department of Transportation, and the Massachusetts Institute of Technology's Lincoln Laboratory.

GSD's role

GSD's responsibilities within NextGen revolve around weather information research and development, said Sherretz, the division's NextGen program manager. This includes developing and testing concepts for producing, displaying, and verifying meteorological observations and forecasts, and tools for standardizing and quickly sharing such data through Internet technologies.

The overall goal, he said, is to deliver timely and accurate weather information, whenever and wherever needed, to those managing the U.S. airspace, to improve efficiency and absorb predicted increases in traffic. More reliable or consistent forecasts, for example, might prevent an airline from unnecessarily loading airplanes with enough extra fuel to get to an alternative destination—a costly precaution that's mandated if visibility at the destination terminal is predicted to be poor.

Right now, weather information is widely distributed, not standardized for accessibility, often not detailed enough to be useful, and sometimes even contradictory. In part, that's because various weather products were developed for different users (e.g., public and aviation operations), or because regulations have led to diverse weather products that are not always consistent.

"At any given time, several different organizations may be all putting out information on the same weather event," said GSD's Darien Davis, NOAA's Research and Development Coordinator for NexGen. "There are warning products, meteorological impact statements, the collaborative convective forecast… " Davis said. "And guess what: What comes out of one office isn't always the same as what comes out of another. So that leaves folks in aviation wondering what to believe."

That lack of consistency is a major problem for air traffic managers, who must often act upon the most conservative forecasts—the ones most likely to cause delays.

A single, authoritative source

A major part of the NextGen weather effort, therefore, is to produce what has been termed the "Single Authoritative Source," or SAS, Davis and Sherretz said. The SAS is envisioned as the single best forecast at any given place and time for any given aviation operation. A policy has already been established that the Federal Aviation Administration must use the SAS; other aviation operators may use it if they choose.

This could mean, for example, the best forecast for enroute airspace, complete with statistical information about the likelihood of certain events, say icing or hail formation. Or it might be real-time information about turbulence, relayed by aircraft in the sky.

Either way, observations and forecasts must be conveyed along networks in accessible formats, so they can be quickly ingested by many different systems, including decision support tools used in air traffic management. Those data will also find a home in a virtual repository that includes access tools—the so-called "4-D Weather Cube" (three dimensions of space plus time).

The NWS plans to release a request for proposals, for companies interested in building the Cube (also known as the Weather Information Database), Sherretz said. The contractor will be responsible for the hardware and software involved in data services and management, and with the NWS, GSD will work closely with the contractor, testing architecture, speed, accuracy, and other components.

Early testing and data

Weather data and predictions are so critical to aviation operations that some of NextGen's first tasks deal with weather data exchange. A key initial goal is for NOAA and FAA to exchange meteorological observations and forecasts using standard data services and standard product formats.

Last fall, an experiment run from the FAA's William J. Hughes Technical Center (WJHTC) in Atlantic City, NJ, showed early success. NOAA and the FAA ran a "capability evaluation," demonstrating they could share meteorological data in standard formats along secured networks.

GSD researchers are also working on verification systems, to understand the skill of various types of forecasts and tools, including the value added by human forecasters. Understanding skill and accuracy will be critical for helping NextGen managers decide what forecast models, data, and data assimilation systems should be part of the future aviation weather system.

"GSD researchers are excited about contributing advanced weather-related capabilities to enhance the efficiency of tomorrow's national airspace system," Sherretz said.

Last year, a series of severe winter storms walloped the Eastern Seaboard, paralyzing air travel in the region, Davis said.

"Those storms were very well predicted, and many airports even closed down ahead of time," she said "That's because we were all spot on and we were all consistent… That's how it should work, but it's not always the case." NextGen, she and her colleagues said, should make such successes increasingly common.

Building the NextGen 4-D Data Cube

The second annual Interagency Weather Research Review and Coordination Meeting

There was a chill in the air the last day of November; a reminder that severe winter weather and all of its perils are just around the corner. But it's a comfort to know that some of the brightest minds in weather forecasting research and technology gathered in Boulder, CO with the goal of making better forecasts to make air traffic run more smoothly, even in the face of increasing numbers of flights. More than 100 participants from government agencies, the private sector, and academia spent two and a half days discussing the research necessary to reach that goal, targeting the area of 2-6-hr convection.

The meeting—coordinated and hosted by organizers from NASA, NOAA, NCAR, and the FAA—addressed critical issues in numerical weather prediction, from observational needs, testbeds, and demonstrations to forecasting of convection, ceiling and visibility, turbulence, in-flight icing, volcanic ash, and other factors.

Darien Davis of ESRL's Global Systems Division, GSD, worked with her colleagues to put together a comprehensive agenda that included several presentations from GSD. John Murray, NASA's lead coordinator for the conference, said meeting participants were focused on the 4-D Weather Cube, a virtual database of weather observations and forecasts that will serve the reinvented U.S. air traffic management system envisioned by NextGen. "This meeting, he said, should help us from a science standpoint to address the path forward for aviation weather in the NextGen 4-D data cube with a strong appreciation for the end user in mind."

Workshop participants from government, business, and academia talked about what research is needed to fill gaps in understanding and bridge research and operations. Dan Hartung, for example, from CIMSS/SSEC (a NOAA/University of Madison cooperative institute) develops satellite algorithms with a convection focus. "It's in my interest to see which pieces are still unaddressed that operational forecasters would like to see developed and implemented," Hartung said. "Through meetings like this we can assure that there isn't too much overlapping of redundant research conducted." He will personally apply the knowledge gained from this meeting by adding and or shifting focus as he refines and optimizes algorithms.

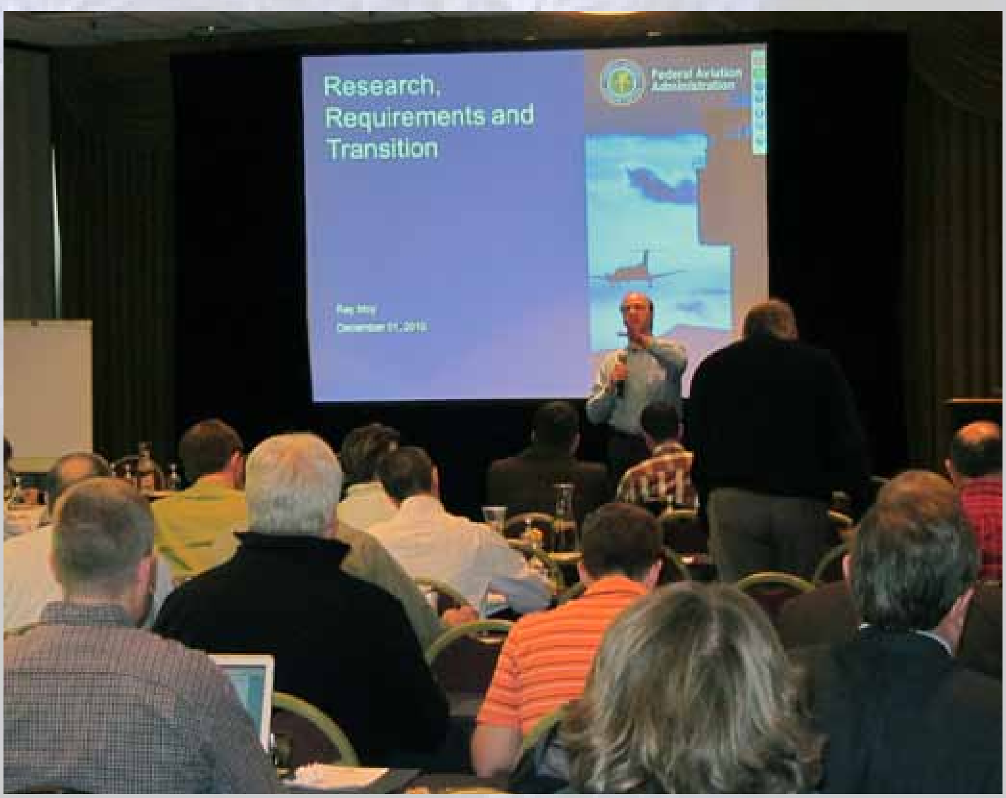
Companies such as Northrup Grumman and Vaisala, Inc. sent representatives because their research and systems support the aviation community or serve various weather models. They came to investigate the scientific community's longer-term plans and how those will integrate into NextGen.

Murray and other organizers anticipate that the next meeting, planned for the week of November 14, 2011, will be driven by user needs and the science related to those needs. Next year's meeting could include demonstrations of "tabletop scenarios". Operational forecasters might, for example, present a realistic scenario; a severe weather event that could disrupt air traffic. From there, researchers could move it into the science that would support the forecasters' needs and inform developers how best to use their science.

More: http://esrl.noaa.gov/gsd/research/events/nov2010/

—Annie Reiser

Interagency Weather Research Review and Coordination Meeting. Photo by Annie Reiser.



...from page 1: snow affects climate

of ESRL's Physical Sciences Division.

With a warming climate threatening to reduce snow cover, Alexander and colleagues from the National Center for Atmospheric Research wanted to find out how the various effects of snow cover might affect Earth's atmosphere.

The researchers started by extracting snow cover information from a fully coupled climate model (the Community Climate System Model CCSM3) that included changes in greenhouse gases. They pulled data from two periods: one at the end of the 20th century (1980-1999 "control"), and the other at the end of the 21st century (2080-2099 "perturbation.")

Then, the team ran a land-atmosphere model using the two very different snow cover patterns that emerged (there was more snow in all seasons in the "control" than the "perturbation").

"We used our computer as a lab," said Alexander, "so that we could isolate what happens to the land and the atmosphere when only the snow changes."

He and his colleagues found that Eurasia and North America warmed by 1-3°C in the 21st century due to less snow cover, which increased the amount of solar radiation absorbed by the Earth's surface. The largest changes occurred in the fall and spring when there is more direct sunlight and the ground heats more rapidly where the snow cover decreases.

In a complementary study that focused on the effects of shrinking sea ice, surface temperature changed by as much as 10°C, but only in a narrow band ringing the Arctic Circle. This study showed that snow cover may have a wider impact, extending over most of the Northern Hemisphere continents.

The warming due to the loss of snow was not confined to the surface, either. The temperature structure, or stability of the atmosphere, influences how much heat reaches up into the atmosphere. The temperature structure is more stable in the fall than in the spring, so warming extends further into the atmosphere during May than in November.

Snow cover can also influence atmospheric circulation, including the strength and position of highs and lows, said Alexander. The circulation changes due to snow cover were fairly modest, but tended to involve lower pressure above areas of lost snow cover.

Findings were published in the *Journal of Climate* on December 2, 2010, and highlighted by *Nature* in October 2010.

—Barb DeLuisi

Achievement

More news, publications, and honors from NOAA's Earth System Research Laboratory

News in Brief

Atmospheric Rivers by UAS

ESRL researchers and colleagues at NASA and other institutions are using unmanned aircraft to study "rivers in the sky" during the Winter Storms and Pacific Atmospheric Rivers, or WISPAR, field campaign that began February 11. The focus of the research is to improve our understanding of how atmospheric rivers form and behave, and to evaluate the operational use of unmanned aircraft for investigating these phenomena. Atmospheric rivers are narrow regions in the atmosphere that transport large amounts of water vapor across the Pacific and other regions.

More: http://www.noaanews.noaa.gov/stories2011/20110210_atmosphericrivers.html

Ozone Assessment Out

The ozone layer – the thin atmospheric band that protects living things on Earth from the Sun's harmful ultraviolet rays – faces potential new challenges even as it continues to repair from earlier damage, according to a new *Ozone Assessment* released in January. The WMO and the UN produce the international science assessment every four years; A.R. Ravishankara, (CSD Director) serves as co-chair, and many other ESRL staff are deeply involved. More: http://www.unep.ch/ozone/Assessment_Panels/SAP/Scientific_Assessment_2010/index.shtml

Science Games Summit

ESRL's Erick Hackathorn (Global Systems Division) co-organized NOAA's "Games and Simulation Summit" in Silver Spring, Md. in January. Representatives from 10 federal agencies, universities and science centers met to discuss the value and future of using games and simulations to foster understanding. A full story, from the NOAA Ocean Service, is here: http://oceanservice.noaa.gov/news/weeklynews/jan11/games-summit.html

A simulated oil rig. In one game designed to teach about NOAA, players try to prevent an oil spill. NOAA image.

Melting permafrost, crumbling ground. CIRES photo.

Permafrost's Warm Future

One- to two-thirds of Earth's permafrost will disappear by 2200, unleashing vast quantities of carbon into the atmosphere, says a *Tellus* study by researchers at the CIRES National Snow and Ice Data Center (NSIDC), with ESRL co-author Lori Bruhwiler (Global Monitoring Division).

"The amount of carbon released is equivalent to half the amount of carbon that has been released into the atmosphere since the dawn of the industrial age," said NSIDC scientist Kevin Schaefer. "That is a lot of carbon."

More: http://cires.colorado.edu/

NACHTT at Night

ESRL scientists and colleagues from Boulder and across the country are gathering at NOAA's tall tower in Erie, CO for a month-long study of the chemistry of the wintertime atmosphere, which they hope will shed light on some scientific mysteries.

The central question they will tackle: Exactly why and how does a compound usually associated with the atmosphere near oceans – nitryl chloride – also form during the winter nighttime in land-locked regions such as the foothills of the Rocky Mountains?

The questions are important to answer because of the implications for both climate and air quality. Nitryl chloride breaks apart quickly as the Sun rises to release chlorine atoms, which can affect greenhouse gases and contribute to smog formation.

"Nighttime formation of nitryl chloride is a gateway to forming more highly reactive chlorine atoms," says Steve Brown, the scientist at ESRL who is leading the study in Erie. "It changes the atmosphere's starting point for the next day."

Brown and colleagues first observed the phenomenon three years ago while testing instruments in Boulder in preparation for an experiment in the Arctic. More on NACHTT (Nitrogen, Aerosol Composition, and Halogens on a Tall Tower): http://esrl.noaa.gov/csd/tropchem/2011NACHTT/

New Tool

The NOAA machine shop, open for use by all staff associated with the Boulder Department of Commerce campus, has a new computer-controlled milling machine. The machine is a multi-axis, 30"x16" Fadal CNC milling center. More information: Kevin Knott, 303-497-6268, kevin.d.knott@noaa.gov.

Upcoming in Boulder:

- **April 22**: CIRES Rendezvous science symposium, Millennium Harvest House Hotel
- **May 17-18**: Global Monitoring Annual Conference, David Skaggs Research Center

Reanalysis Published

From the hurricane that smashed into New York in 1938 to the impact of the Krakatoa eruption of 1883, the late 19th and 20th centuries are rich with examples of extreme weather. Now an international team of climatologists have created a comprehensive reanalysis of all global weather events from 1871 to the present day, and from Earth's surface to the jet stream level.

The 20th Century Reanalysis Project, outlined in the *Quarterly Journal of the Royal Meteorological Society*, not only allows researchers to understand the long-term impact of extreme weather, but provides key historical comparisons for our own changing climate.

"Producing this huge data set required an international effort to collate historical observations and recordings from sources as diverse as 19th century sea captains, turn of the century explorers and medical doctors, all pieced together using some of the world's most powerful supercomputers at the US Department Energy's National Energy Research Scientific Computing Center in California and the Oak Ridge Leadership Computing Facility in Tennessee," said lead author Gil Compo, from ESRL's Physical Sciences Division.

More from the publisher: http://www.wiley.com/WileyCDA/PressRelease/pressRelease-Id-90037.html

Renewable Support

ESRL's Betsy Weatherhead (Global Systems Division) and Melinda Marquis (Director's Office) are helping NOAA provide the data, knowledge and technology for accelerating renewable energy development.

Weatherhead co-chaired a panel at the December American Geophysical Union meeting. Marquis led a town hall meeting at the January American Meteorological Society Meeting.

Feature: http://www.research.noaa.gov/

Reaching Teachers

ESRL's Debra Daily-Fisher (Chemical Sciences Division) led NOAA's outreach effort during the 2010 Colorado Science Conference, an annual professional development event of the Colorado Association of Science Teachers (CAST). About 800 teachers attended the conference, and that included educators from every level—kindergarten through university, said Theresa Hemming, the Exhibits Chair of the Colorado Science Conference. Daily-Fisher and other ESRL outreach specialists handed out classroom materials for teachers, referred them to NOAA education websites, and answered questions. More NOAA educational resources: http://esrl.noaa.gov/outreach/education.html and http://www.education.noaa.gov/

Honors

Jim Churnside (CSD) won the 2011 George W. Goddard award from SPIE, the international society for optics and photonics. Churnside was lauded for "creativity and leadership in developing and advancing the airborne fish lidar technique, and for wide-ranging contributions to optical propagation in the atmosphere and ocean."

Bill Cushman (GMD) was named the NOAA Research Employee of the Year, for personal and professional excellence. The award is granted to an individual or team who has demonstrated the preeminence of NOAA Research with "initiative, commitment, effort, and competence."

Bill Cushman

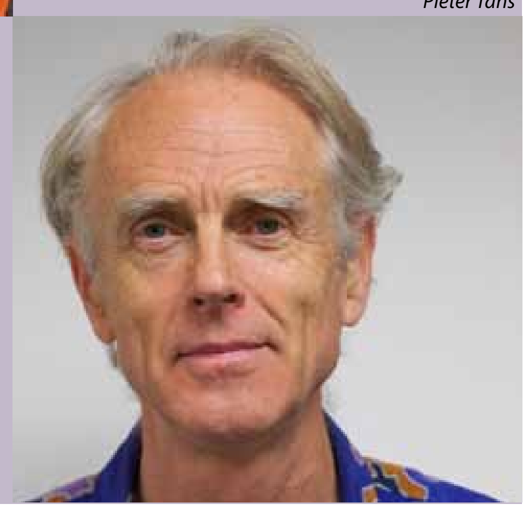
Sean Davis (CSD) co-authored a paper that won a 2010 Alan Berman Research Publication Award from the Naval Research Laboratories. The paper, "Directly Measured Heating Rates of a Tropical Subvisible Cirrus Cloud," was published in the *Journal of Geophysical Research* last year.

Russell Schnell (GMD) was awarded a NOAA Distinguished Career Award, one of the highest honors that can be granted by the NOAA Administrator. Schnell was recognized "for exemplary vision and leadership of the laboratory and baseline observatory network throughout nineteen years of service to NOAA."

Susan Solomon (CSD) was selected to give one of two inaugural Kavli Foundation lectures, part of the foundation's new "Innovations in Chemistry" program. Solomon will deliver her lecture in August, at the ACS meeting in Denver.

Pieter Tans (GMD) was awarded the Roger Revelle Medal at the 2010 fall meeting of the American Geophysical Union (AGU) in San Francisco. AGU recognized Tans for his work "expanding our understanding of the global carbon cycle and raising awareness for climate change."

Pieter Tans



Published

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

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

Division 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/

Photo by Jenn Glaser

Students from Trail Ridge Middle School in Longmont visit the National Center for Atmospheric Research as part of a NOAA-funded "Earth Explorers" program. Student "film companies" created short features about Boulder scientists, including a few from ESRL. More on page 3.

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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.