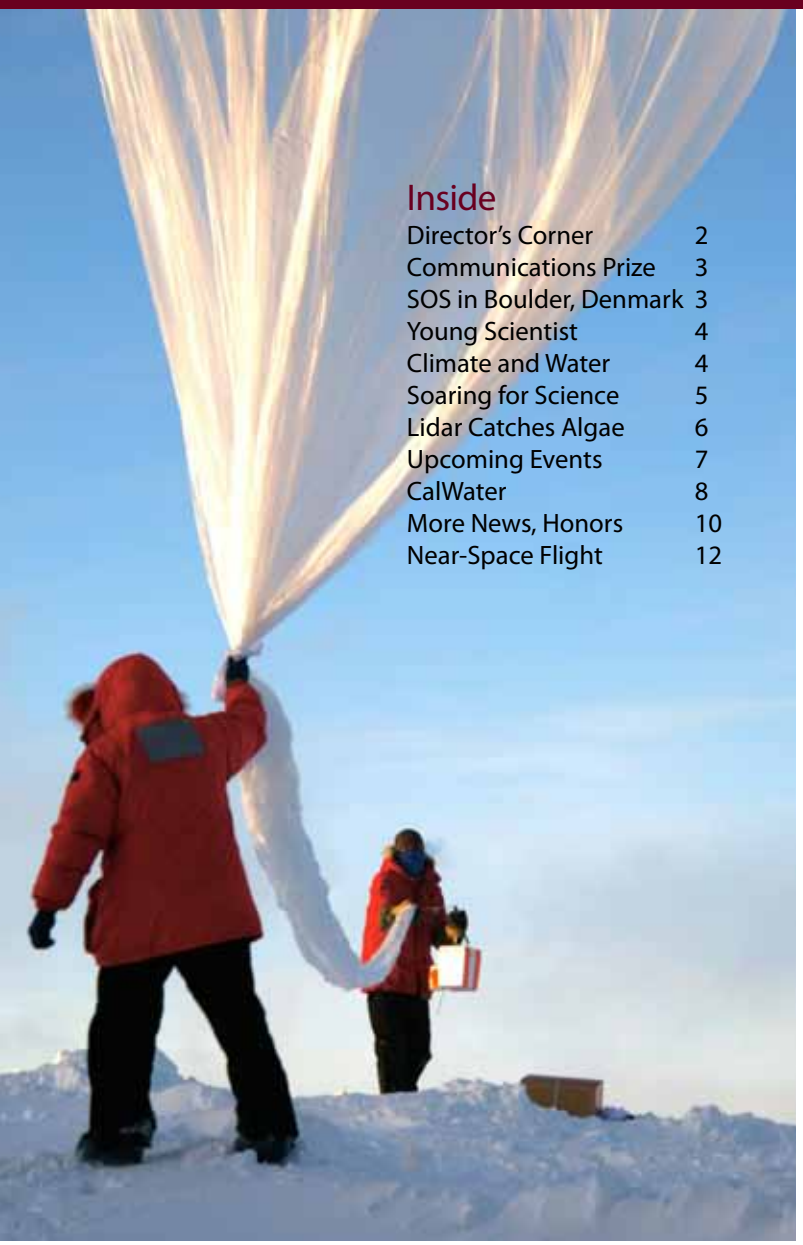
ESRL Quarterly

News from NOAA's Earth System Research Laboratory

Winter 2009/10



Inside

What Science Takes

Methane data are rolling in from the Russian Arctic, after bug battles and an overturned research lab

In a remote part of the Russian Arctic, a land studded with thousands of lakes and a few towns, a thin electric cable connects a tiny research station and instrument tower with a power generator more than a mile away. The cable—made for indoor use—travels outdoors along jury-rigged tripods made of branches. Moose will knock down anything, eventually, and the tripods are cheaper and easier to repair than more permanent structures, according to local Russian scientist Sergei Zimov.

Here, near the town of Cherskii, ESRL researchers, Zimov, and other collaborators have managed to collect more than a year's worth of nearly-continuous data on the atmospheric concentration of methane, a powerful greenhouse gas. Zimov travels to the research site at least a couple times a month, repairs the power line as needed, downloads data onto a thumb drive, and sends it back to ESRL through the web.

"The data are very good," said ESRL's Ed Dlugokencky (Global Monitoring Division). "This is going to be a great site for understanding the Arctic processes that affect atmospheric methane."

Methane is a potent greenhouse gas that's emitted directly by some human activity, by microbes in wetlands and permafrost, and through

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Building Connections

New ESRL computing specialists advance federal efforts to link, improve Earth system models

A coupled air-ocean-wave model lets scientists at the Naval Research Laboratory better predict the impact of hurricanes on the Gulf Coast. Researchers working with a NASA atmospheric general circulation model can swap in different chemistry packages, depending on the problem they are studying. People downloading data generated for the next Intergovernmental Panel on Climate Change, IPCC, assessment will get consistent, thorough descriptions of the many models and experiments involved.

NESII software infrastructure makes these systems work. The new NOAA Environmental Software Infrastructure and Interoperability group, led by Cecelia DeLuca, moved in November from the National Center for Atmospheric Research to ESRL, bringing along a suite of projects focused on building, coupling, and using Earth system models. The need for interoperability between such models is growing, DeLuca said.

"For example, as computing power increases and global models can be run at higher resolution, climate modelers are interacting with weather modelers to understand and improve representation of smaller-scale processes," DeLuca said. But often, weather and climate models cannot "speak" to one another because they were built so differently. So DeLuca's team writes code that allows models from very different origins to interact. And that code is not just for linking components of weather and climate models— NESII helps modelers working in space weather, hydrology, and coastal processes build models that interact well with others.

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Drought Origins Differ

Understanding events of the 1930s, 1950s may help in forecasting future drought

During the iconic Dust Bowl, great clouds of dust swirled east out of the U.S. Northern Plains, blackening skies as far away as New York. Drought conditions set up in 1932 and didn't ease for seven years. Just a decade later, another severe drought hit, this one scorching the Southern Plains and Southwest.

ESRL scientists seeking to improve today's drought warning systems recently turned their investigative skills on better understanding the origins of those two events. In an analysis of historical records and climate model experiments, they discovered two very different setups. Their conclusions may improve scientists' ability to give accurate early warning of drought, to help communities take precautions and prepare.

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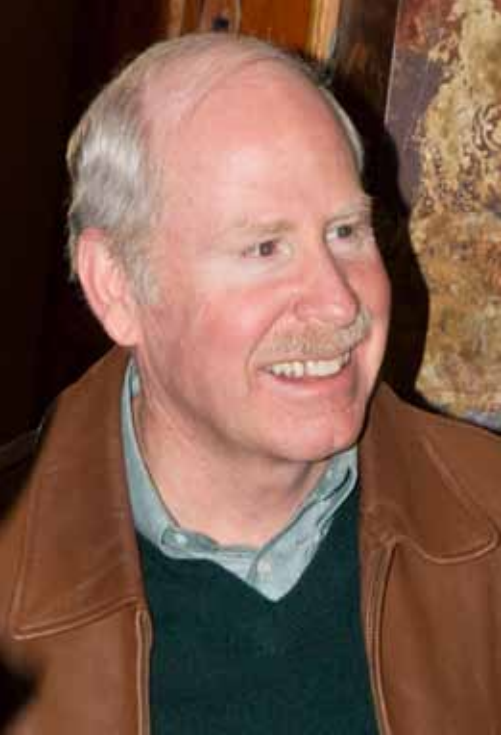


Director's Corner

In December, I was honored to be a member of the NOAA delegation attending the international climate talks in Copenhagen. It was fascinating to see the whole international community grappling with the very difficult problems being driven by anthropogenic changes to our Earth system.

I was pleased to be given two key communication challenges during the conference. The first day, I gave a presentation on how the United States monitors and understands the dynamics of carbon dioxide and other greenhouse gases. ESRL's Janet Intrieri and others here (Pieter Tans, for example) and at NASA and the National Science Foundation were instrumental in helping me pull together the presentation.

I also gave several presentations at the U.S. exhibit, where ESRL's Science On a Sphere® was a centerpiece. I'd like to thank my ESRL colleagues, especially William Bendel, Beth Russell, and other members of the SOS team in the Global Systems Division for their extraordinary work during the conference and organizing behind the scenes.

In a live "SphereCast," I used SOS to discuss and illustrate climate change for audiences at museums around the world and many others who chose to watch online. Beth gave a well-attended presentation to a delegation from the U.S. House of Representatives, just before President Obama's speech. SOS was also "on" nearly constantly at the two-week conference, sometimes displaying climate data quietly in the background, often driven by scientists discussing Arctic sea ice changes, climate change impacts on wildlife and wild lands, and other topics.

After the Copenhagen conference, Dr. Lubchenco sent a very kind thank you to ESRL's SOS team: "The Bella Center was abuzz with kudos for you and the US Center… You have made all of us very proud."

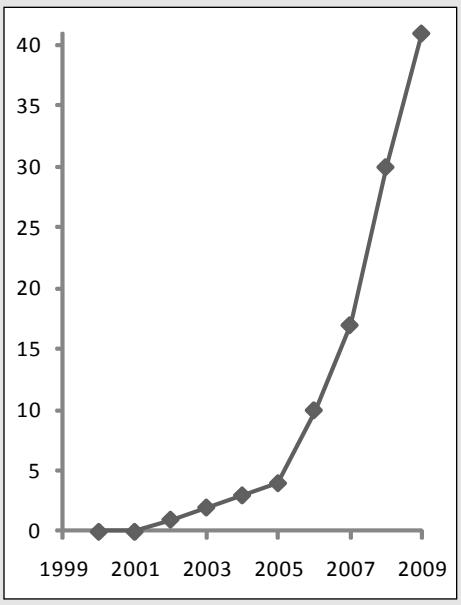
NOAA had a very strong presence at Copenhagen, and representatives throughout the agency played important roles. Among them: James Overland of the Pacific Marine Environmental Laboratory (PMEL) spoke about the rapidly warming Arctic; PMEL's Richard Feely focused on ocean acidification; Tom Karl, Director of the National Climate Data Center, presented research on extreme weather in a changing climate and climate change impacts in the United States; and Frank Niepold from our Climate Program Office discussed the importance of climate literacy. NOAA administrator Jane Lubchecno gave a critical talk on the impact of climate change on oceans and other ecosystems.

U.S. negotiators played a positive, progressive role in this conference, articulating the need for strong action to mitigate some future warming, and to deal with the changes already inevitable. At the end of Copenhagen, however, international negotiators did not come to agreement on legally binding action. Countries agreed to emissions-control objectives and to develop international monitoring systems, and richer countries pledged to help poorer ones in dealing with climate change impacts.

—Alexander MacDonald

By the Numbers

SOS installations



"The future's really in our hands. This is the critical time. We can't wait for the end of this century to respond. The Earth is changing fast."

Alexander MacDonald, NOAA Earth System Laboratory Director, during a live "SphereCast" December 8, at the United Nations Climate Change Conference in Copenhagen, Denmark. Hundreds of people watched the Science on a Sphere® presentation from 11 museums and other institutions around the world.

http://sos.noaa.gov/

Communication Prize

ESRL's David Fahey wins Daniel L. Albritton honor

David Fahey (Chemical Sciences Division) was honored with the 2009 Daniel L. Albritton Outstanding Science Communication Award, for his extraordinary work communicating scientific information about the ozone layer to decision makers, educators, and the public.

In presenting the award, ESRL Director Alexander MacDonald said Fahey's efforts, particularly on the depletion of Earth's protective ozone layer, exemplify those of Albritton, who was Fahey's first NOAA supervisor 30 years ago.

"Dr. Fahey clearly lays out the science, from the big picture down to the details, in a way that reminds me of Dan's ability to convey importance," MacDonald said. "This award is so important, because communication is so important."

Fahey has worked on many scientific problems during his decades at NOAA, from ozone depletion to climate change, and has won many awards for his contributions. In 2007, he shared the Nobel Peace Prize with other authors of the Intergovernmental Panel on Climate Change climate science assessment.

Fahey received the Albritton prize for his ongoing work to communicate the importance of ozone layer depletion. Nearly a decade ago, Albritton himself asked Fahey to help with the 2002 Ozone Assessment (a quadrennial state-of-the-science assessment in support of the Montreal Protocol on Substances that Deplete the Ozone Layer). Albritton asked Fahey to write the "Questions and Answers" section, a feature of the assessments pioneered in 1994 and 1998 by ESRL's Susan Solomon (also Chemical Sciences) and the late French scientist Gérard Mégie. Fahey greatly expanded the text and graphics to produce a stand-alone booklet called *Twenty Questions and Answers about the Ozone Layer*, published in 2002 (and updated in 2006) and distributed around the world. Fahey is working with Canadian scientist Michaela Hegglin on the *Twenty Questions* update for the 2010 assessment, currently in preparation.

The document's accessibility to those without scientific expertise, and its impeccable accuracy propelled its global reach, said A.R. Ravishankara, Director of the ESRL's Chemical Sciences Division.

Fahey said he was humbled to receive the award, having witnessed the communications acumen of Albritton himself. He said he also felt like his role was as a "transcriber, not the one source," given the contributions of many colleagues.

When accepting the award, Fahey said that in his research and communications work, he often reminds himself of a quote by Victor Hugo, conveyed to him by Albritton. "'Science has the first word on everything and the last word on nothing,'" Fahey said. "So let's make the first word as clear and complete and accessible as possible, so the people who make the decisions can make the most reasonable ones."

SOS Users

International science educators gather to discuss innovative use, impact of ESRL's Science On a Sphere®

Science On a Sphere®, an educational tool developed at ESRL, now wows audiences at 41 science museums and other institutions around the world. In November, nearly 100 people from those institutions visited ESRL for the third annual SOS Users Collaborative Network Workshop. Participants traveled from as far away as Mexico, Finland, and South Korea. They shared stories about how to best engage visitors with the giant animated globe, and presented evidence that watching climate data swirl across the sphere (or hurricanes, or clouds, or ocean currents) can measurably improve people's understanding of the planet.

John Schneider, ESRL's Deputy Director for Science, welcomed the workshop participants. "Our mission, at heart, is to develop scientific and technical knowledge and share it with the world," Schneider said. "So where we are concerned, SOS is a big success."

Christos Michalopoulos, Assistant Director of NOAA's Office of Education, also spoke to the group. "These are really opportune times for science education, because the new administration views STEM (science, technology, engineering and mathematics) as a necessity for the competitiveness of this country," Michalopoulos said. "We feel that SOS, and all of you, have a key role to play."

Manjit Goldberg, from the Maryland Science Center, explained how her team has built hands-on kiosks near the SOS, with interactive programming that helps visitors understand what they're seeing on the sphere. "We found an increase in curiosity…and better understanding of color keys and geographical references," Goldberg said.

Elizabeth Ban from the Smithsonian Natural History Museum said a recent evaluation of the museum's Sant Ocean Hall showed that visitors enjoy, and are learning from, SOS. Many visitors leave the Ocean Hall with the museum's intended primary message, that the ocean is one, interconnected system, Ban said. "When we ask them where they got that message, one place they point to is our Global Ocean Systems section, which has our SOS."

Left: *Sanna Reponen from Heureka, the Finnish Science Center.* ***Right:*** *Maurice Henderson from NASA Goddard Space Flight Center (left) and ESRL's William Bendell (Global Systems Division). Photos by Will von Dauster, NOAA.*

NOAA's Ryan Neely watches young scientist Hunter Solheim put together his instrument, an infrared thermometer that can monitor cloud-bottom conditions. Photo by Will von Dauster, NOAA.

ESRL Tests Young Scientist's Invention

Like "Doogie Howser, M.D.," TV's teen prodigy from the 1980s, 14-year-old Hunter Solheim is ahead of most of the other kids in his Boulder middle school. But Hunter is not only a real teenager, the young inventor also won a U.S. patent early in 2009, for an instrument he devised to measure cloud-bottom temperature.

Hunter and his dad, Fredrick Solheim, visited ESRL in October to have Hunter's infrared thermometer—the "IRT"—tested by NOAA scientists who hope to use it to support field operations.

Hunter's instrument is designed to monitor the conditions of the bottom of clouds. Combined with radar data, the IRT would let researchers and forecasters monitor more accurately the tropospheric environment where weather occurs. For example, operating remotely, the IRT can observe the base of clouds, which tend to be very low (and cold) when they are about to snow. Instruments on NOAA's GOES satellites measure cloud-top temperature, but cannot "see" through clouds to weather below.

In addition, scientists who use lidar instruments to measure small particles in the stratosphere could use an instrument that can remotely and continuously monitor cloud cover, because the lidar needs cloud-free conditions to measure upper atmospheric aerosols. "We can use Hunter's instrument to see if it's cloudy, and to turn our lidars on or off automatically," said Ryan Neely, a CIRES graduate student in ESRL's Global Monitoring Division.

In remote places like Summit Station in Greenland, Neely said, automation is particularly useful: "This detection device will help us get more data without wasting laser lifetime or operator time."

If it tests as well as NOAA scientists expect, Hunter's instrument will travel to Greenland for the ICECAP project (Integrated Characterization of Energy, Clouds, Atmospheric state, and Precipitation) to take measurements of the atmosphere, clouds, and precipitation for four years as part of the Arctic Observing Network (AON). NOAA is a long-time partner of AON.

Hunter's father, president of the instrumentation firm Radiometrics, said Hunter was a kid "who always fiddled with things." Hunter loved spinning the wheels of his sister's baby carriage and was frustrated when he tried to spin the wheels on a parked SUV. He played with wires, including once dismantling an electric outlet.

Radiometrics has an instrument to measure temperatures of "really cold things," Hunter said. But it was his "aha!" moment to point it up at the clouds. When he mentioned the idea to his dad, the elder Solheim said, "Brilliant!" They went to work on the IRT, which includes a rain and snow sensor and gauge.

NOAA scientists and Hunter's family know about his scientific accomplishments, but Hunter keeps a low profile elsewhere. "I don't talk about this stuff at school," he said. "I don't like to brag."

—Carol Knight, NOAA

Western Climate and Water

It's hard enough to figure out, in a too-short, two-year fellowship, how precipitation in the Colorado River Basin has varied historically, and how that variability may change with future warming. But ESRL postdoctoral researcher Galina Guentchev wants to push her research work even further.

"I want to do a better job relating my results to the needs of the people who are sponsoring my research, the Southern Nevada Water Authority (SNWA) and the U.S. Bureau of Reclamation (USBR)," Guentchev said. "I would like to be able to tell them what this variability means in terms of streamflow, and put it into a hydrological model."

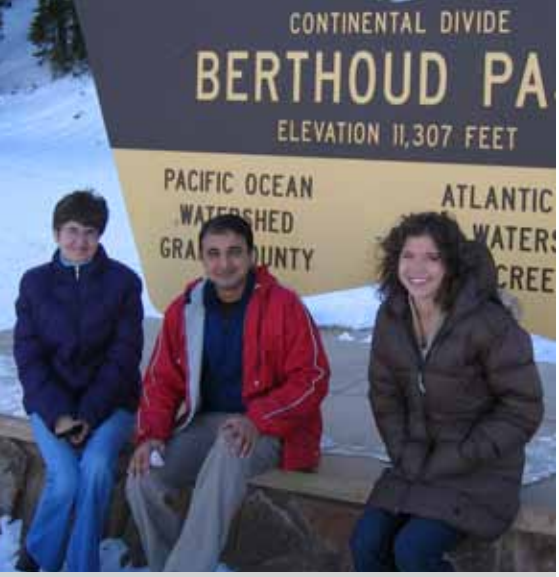
Guentchev is one of four ESRL postdocs working on western water and climate issues this year, with support from NOAA's Climate Program Office, USBR, SNWA, and the National Research Council.

Joe Barsugli (Physical Sciences Division) organized a mid-November "mini-workshop" for the four postdocs, and he invited water management professionals with the Bureau of Reclamation and other agencies to attend and help the young researchers refine their research plans.

After Guentchev presented her project, Imtiaz Rangwala discussed his proposal to dissect elevation-dependent warming in the Upper Basin of the Colorado River. "I'd like to improve our understanding of what's happening—in terms of past and future climate change—at elevations above 9,000 feet," Rangawala said.

Kelly Mahoney described her goal to better understand how climate change will affect extreme precipitation events and therefore dam operations in the West. And Stephanie McAfee discussed how she plans to use tree-ring data and physiological plant models to investigate what appears to be accelerating tree mortality across the West. "We will be asking if today's events really are unique or unprecedented, or if they are widescale and jarring, but also standard," McAfee said.

Kristen Averyt, Deputy Director of NOAA/University of Colorado Western Water Assessment, praised the young scientists for tackling soci-



Galina Guentchev, Imtiaz Rangwala, and Kelly Mahoney on their way to Colorado's Fraser Experimental Forest. Photo by Robin Webb, NOAA.

etal challenges in their research. "It's all about making science useful and getting it into the hands of people who are making decisions."

"This is a great lesson for NOAA, as it struggles to define the role of research in a national climate service," added ESRL's Robin Webb (Physical Sciences Division).

Other ESRL postdocs (and advisors):

Mimi Hughes (Marty Ralph) is working on connections between atmospheric rivers, orographic precipitation, and climate variability

Sara Lance (Graham Feingold) is making airborne measurements of cloud microphysical properties and the aerosol Indirect effect in the springtime lower Arctic troposphere.

Stephanie Leroux (George Kiladis) is working on interseasonal variability of tropical convection.

Scott Mackaro (Yuan Suxie and Nikki Privé) is developing a regional observing system simulation experiment (OSSE) for Atlantic storms.

Shane Murphy (Daniel Murphy) is working on understanding the aerosol direct effect with novel measurements of the single scattering albedo of individual aerosol particles

Jocelyn Turnbull (Pieter Tans) is quantifying fossil fuel and biofuel emissions from East Asia.

Soaring the Pacific for Science

An unmanned aircraft with wings stretching 116 feet soared into the air over NASA's Dryden Flight Research Center in October, in preparation for its first science mission in February. The Global Hawk Unmanned Aircraft System (UAS), built by Northrop Grumman Corp. and operated jointly by NASA and NOAA, will take at least six long-duration flights (as long as 30 hours) above the Pacific Ocean this spring, in a mission dubbed GloPac, for Global Hawk Pacific. A ground-based crew will guide the aircraft from the equator to the Arctic Circle, as remotely controlled scientific payloads on board collect data on key regions of the atmosphere important in climate change and ozone layer research.

Researchers on the ground will be able to watch their data arrive in near real-time via satellite link, and can redirect the aircraft to certain phenomena or regions of interest along the flight track.

"This first Earth science mission of the Global Hawk will demonstrate the value of this unique and powerful resource to atmospheric science, to our national agencies, and to the world," said ESRL's David Fahey (Chemical Sciences Division), one of two GloPac mission scientists (with Paul Newman from NASA's Goddard Space Flight Center).

In October, the Global Hawk completed several successful test flights in controlled airspace above Edwards Air Force Base, spiraling up to about 61,000 feet in altitude. The aircraft is one of two that NASA and Northrop Grumman have partnered on to convert from military test aircraft to scientific and aeronautical research platforms. Before October's flights, neither had been in the air for more than six years.

"That's a big story from our perspective," said Global Hawk pilot and NOAA Corps officer CDR Philip Hall. "In 18 months, we've taken an airplane that sat on the ground for six years and we made it flyable with a completely new communications system and ground control station optimized for scientific payloads. These programs normally would take years, and a lot more money."

In February, scientists will travel to Dryden to install sophisticated instruments on the airplane, including two from ESRL—one to measure ozone and the other to measure a variety of gases in the atmosphere. Jim Elkins (Global Monitoring Division) is principal investigator on UCATS, the Unmanned aircraft systems Chromatograph for Atmospheric Trace Species, which measures water vapor, ozone, nitrous oxide, sulfur hexafluoride, hydrogen, methane, and carbon monoxide. Ru-Shan Gao (Chemical Sciences Division) is in charge of the dedicated ozone instrument on board.

"As with David Fahey, these guys are all world-class leaders in atmospheric science.," Hall said. "They have vast backgrounds in flying their instruments on a variety of airplanes, so they bring a lot of experience and knowledge to the program."

One of the science goals this spring, Fahey said, will be to investigate what happens to the Arctic polar vortex as it breaks up. In winter, high-altitude winds tend to sweep around the pole, isolating high northern latitudes chemically and dynamically. When the vortex breaks up every spring, it can spin fragments of Arctic air to lower latitudes and altitudes, providing opportunities to sample the chemical nature of Arctic stratospheric air and to test models that simulate atmospheric air motions.

The Global Hawk will also "underfly" a suite of NASA satellites, specifically, the Aura satellite, to provide "ground-truth" data for comparison with atmospheric measurements taken from space, Hall said.

Hall described the GloPac mission as a "hybrid" of satellite and aircraft capabilities, with a field of view somewhere in between the two. The extreme range, duration, and altitude of the Global Hawk's flight envelope give it remarkable capabilities for the scientific community, not previously obtainable, he said.

More: http://www.espo.nasa.gov/glopac/

... from page 1: Drought

"In the case of the severe 1950s drought of the Southern Plains states, it appears global sea surface temperatures were the principal cause. However, the 1930s Dust Bowl drought … was not caused by ocean conditions, but rather the evidence points to random changes in the atmosphere as the instigator," said lead author Martin Hoerling.

Hoerling, Xiao-Wei Quan, and Jon Eischeid (all Physical Sciences Division) published their work, "Distinct Causes for Two Principal U.S. Droughts of the 20th Century," in *Geophysical Research Letters* this fall.

Drought variability over the Southern Plains was strongly forced by variability in sea surface temperatures, the researchers found, and the primary driver was the El Niño-Southern Oscillation, a pattern of ocean temperatures in the tropical Pacific Ocean that includes El Niño and La Niña. During La Niña years, characterized by unusually cold water in the equatorial Pacific Ocean, droughts in the Southern Plains were common—both in observations and in models.

But northern lands hit hardest during the Dust Bowl were farther away from weather patterns influenced by the tropical Pacific Ocean. Instead, random atmospheric variation was likely responsible.

The authors note that while an ocean observing system—a network of instruments including stationary and free-floating buoys as well as satellites—is vital to any drought early warning system, it may not adequately warn of a drought caused by other factors, and may not provide early warning for a drought over the northern Plains states, such as what occurred in the 1930s.

...from page 1: Methane

other processes that can be amplified by warming. Many researchers are concerned that someday, a dangerous feedback cycle will occur as warming triggers the release of methane that's tied up today in wetlands and frozen soils. "The methane feedback is a big, open question for science right now," Dlugokencky said.

In a paper published last fall, he and colleagues reported that global methane data do not yet show evidence of feedback. Dlugokencky's team analyzed air samples collected in flasks and from towers around the world. Methane levels did increase in 2007 and 2008, following nearly a decade of near-zero growth. But the spatial pattern of those increases was most likely related to unusual weather patterns—first, anomalous warmth in the Arctic in 2007, and then very high precipitation in the tropics in 2008. In 2007, forest fires also contributed to the growth in methane, the researchers reported.

Despite ESRL's extensive air sampling network and ability to study global trends, researchers still don't understand the details of the methane cycle, Dlugokencky said. "We need better data on the ground, to figure out the processes that are going on that relate to what is going on in the atmosphere."

Such data would help global climate modelers refine models to better depict the reality of the methane cycle, and would help scientists and others understand what to expect in the future.

The Cherskii site seems ideal for studying such land-air processes, Dlugokencky said. Last year, his colleague Andrew Crotwell (ESRL's Global Monitoring Division) traveled with a University of Alaska researcher to the remote site, and installed the instrument that continuously measures methane, wind speed, and direction.

It was not an easy install, Crotwell admitted. His group first had to retrofit an old shack once used to warm the tundra enough to punch in fence posts and to smoke fish. Then, after the equipment was carefully installed, the scientists hooked the "laboratory" to an old tank to pull it more than a mile away to a new site. The shack caught on a tree stump and flipped.

Crotwell un-installed the equipment, pulled it out of the shack, and reinstalled it after the team managed to right the structure. It took hours, Crotwell said, and the mosquitoes were nearly unbearable.

The data, however, already make the effort seem worthwhile. The tower site data contains an anthropogenic signal only rarely, when winds sweep down from Cherskii, which lies 40 km to the northeast. "When the wind comes from the lowland sector to the northwest, we see methane enhancement from local wetlands," Dlugokencky said.

***Top**: The Cherskii methane measurement site. **Left**: Investigating the damage after the instrument "lab" flipped over (insects are visible). **Right**: Righting the lab. Photos by Andrew Crotwell, NOAA.*

Airborne lidar catches algae

ESRL's Jim Churnside (Chemical Sciences Division) has used lidar instruments on airplanes to find schools of fish and squid. He's used lidar—which bounces laser light off distant objects and captures the information-rich return signals—to find abandoned "ghost nets," which can ensnare and kill ocean animals. Now, Churnside is using airborne lidar to find layers of phytoplankton—tiny plant-like creatures that are the foundation of most oceanic food chains.

This spring, Churnside and his colleagues took an unprecedented look at the progression of a phytoplankton bloom in Washington's East Sound, by flying a remotely-controlled lidar on a small Cessna airplane over the water. Backed by ship and underwater glider data from Percy Donaghay, Jan Rines, and Jim Sullivan of the University of Rhode Island, and Alan Weidemann of the Naval Research Laboratory, the study provided the first on-the-ground validation that airborne lidar can detect thin layers of phytoplankton in water.

The technique could help fisheries biologists seeking to better understand fish population dynamics, Churnside said, as well as scientists trying to understand how climate change is affecting the oceans. The U.S. Navy, which funded part of Churnside's research, is also interested in thin layers of plankton, which affect can acoustics and optics.

In May, Churnside's team "watched" with lidar as a bloom of algal phytoplankton formed and then dissipated in East Sound. Measurements from a nearby channel captured the inflow of turbid water, as the bloom dissipated, and the lidar data captured the vertical movement of the bloom, as well. The phytoplankton dynamics were apparently related to the temperature stratification of the water, the tide, and possibly to biological factors as well, Churnside said. He reported his team's results at the annual December meeting of the American Geophysical Union.

Photomicrograph of diatoms in East Sound, courtesy of Jan Rines, University of Rhode Island.

... from page 1: Interoperability group

"We grew up at NCAR, but as our group evolved, we got more and more involved with the federal modeling centers," DeLuca said, explaining her team's move to ESRL. "NOAA offers closer proximity to the modeling groups we are working with, and NOAA has a service philosophy that's closer to our values and the goals of our work."

"NOAA has a service philosophy that's close to our values..."

One of NESII's main projects is the Earth System Modeling Framework, ESMF, which the team began working on in 2002 with many community partners. ESMF lets modelers wrap their whole model (or individual components) in standard interfaces. It also offers toolkits for grid remapping, time management, and other common functions. The project's sponsors include NOAA, the National Science Foundation, the Department of Defense, and the National Aeronautics and Space Administration, NASA. ESMF has been incorporated into models funded by each of these agencies and is managed by a multiagency consortium.

DeLuca's group includes 10 people, from software engineers and computational scientists to metadata and database experts. Six work remotely from locations across the country; four work from ESRL: DeLuca, NESII manager; Sylvia Murphy, a technical project manager; Silverio Vasquez, ESMF tester and release manager; and Robert Oehmke, a computer scientist.

Mark Govett, from ESRL's Global Systems Division, said NESII's move demonstrates NOAA's growing recognition that collaboration is critical in Earth system modeling. Increasingly, agencies are using pieces of one another's code, often informally, he said. That means when ESRL, for example, makes a change to an atmospheric model, it might be critical for the U.S. Environmental Protection Agency to understand how the change could affect their air pollution models.

"As models become increasingly complex, we can no longer afford to develop every part of Earth system models ourselves. We must collaborate with other laboratories and agencies, and use tools such as ESMF to link the science needed," Govett said. " NESII is helping us do that in a formal way."

Some of NESII's current projects (more: http://gip.noaa.gov/)

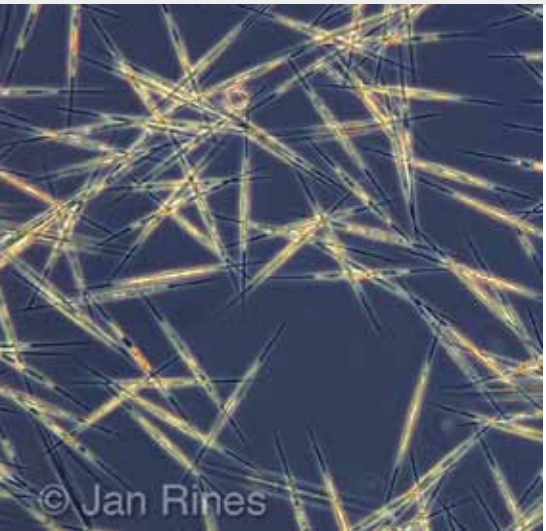
Global Interoperability Program (GIP): The new GIP program includes projects involving weather prediction, climate research, and teaching graduate students how to build and use models. What connects these efforts is a base of software infrastructure—some shared, and some specialized—built by NESII and other groups around the country and the world. GIP, which is funded by the NOAA Climate Program Office, is working to improve the software that underlies high-priority efforts such as the fifth IPCC assessment, due in 2014. The goal is to help ensure that the United States can respond to increasing demands for weather and climate information.

Earth System Curator: The Curator project builds software to support running, documenting, and using climate models. The current focus is on delivering a system for displaying the model metadata collected for the fifth IPCC assessment. It's a broad effort: Curator is supported by the NSF and NASA, and works closely with the DOE's Earth System Grid data portal, and other partners from federal, academic, and international institutions. The metadata available for the upcoming assessment will be a big improvement over what was available for the IPCC's fourth assessment report, DeLuca said. "When you're downloading the older data, it's hard to tell the difference between two model versions ," she said. "You might want to ask, 'Did that run include the indirect effects of aerosols?'"

Earth System Modeling Framework (ESMF): ESMF continues to grow and evolve, taking on new grids, new remapping approaches, new computing platforms, new communities who are interested in it, and different ways of linking components. Much of the NESII group's time is spent on ongoing development and support of the framework, as more and more modelers around the world seek to use it.

National Unified Operational Prediction Capability (NUOPC): The Air Force, Navy, and NOAA are coordinating to improve their operational forecasting systems, and collaborating on a new multi-model ensemble for numerical weather prediction that's based on ESMF. A central element of the ensemble is the National Environmental Modeling System (NEMS), a next-generation weather model being developed by the National Weather Service. NEMS uses ESMF to connect to other models and model components for research and operations, including ESRL's Flow-following finite-volume Icosahedral Model. NESII staff have been working with NUOPC partners to understand operational requirements and lay out a plan for technical development.

NESII is also involved the **Battlespace Environments Institute**, an effort within the Department of Defense to create an ESMF-based "whole Earth modeling environment," and the **Modeling Analysis and Prediction Program** at NASA, which used ESMF extensively to develop the GEOS-5 atmospheric general circulation model.



Upcoming Events at ESRL

Physical Science Research Review >> March 9-12

Global Monitoring Annual Conference >> May 19-20

CalWater

ESRL scientists study California's water future in a changing climate

Water security is never far from the mind of any decision maker in the U.S. West—but it's not a terrorist attack on a dam or canal that triggers the most anxiety, it's climate change. This fall, California Gov. Arnold Schwarzenegger called his state's water troubles a "holy water war" pitting "north versus south, California versus the feds, rural versus urban...." And well-known challenges—the vicissitudes of weather, periodic drought, and a growing demand for water from a growing population—could be exacerbated by climate change, the governor told a state water committee this fall.

In that fraught setting, ESRL scientists helped launch CalWater this fall, a major mission to better understand how climate change could affect California's water resources, through changes in rain and snowfall patterns. The project involves researchers from a wide variety of institutions, including the University of California, the California Department of Natural Resources, the state's Air Resource Board, the Scripps Institution of Oceanography, and others; and it is funded by NOAA, Scripps, and the California Energy Commission.

"There's evidence from modeling studies that climate change could affect the pattern and intensity of precipitation in North America," said Marty Ralph (Physical Sciences Division). "We want to understand exactly how that could play out across the state of California, but our results could be applicable to other parts of the country as well."

ESRL's involvement in CalWater is two-fold, Ralph said: ESRL scientists will study how tiny particles of air pollution called aerosols affect the amount and location of rainfall in California; and how changes in the frequency and intensity of atmospheric rivers affect extreme rainfall, water supply, and flood risk in the state. Both will help assess the performance of regional climate models, which decision makers rely upon to understand the future of water resources in the state.

Christopher Williams (Physical Sciences Division and CIRES) is helping to lead the aerosol research. Scientists understand, generally, that aerosols from air pollution can affect climate, cloud formation and behavior, Williams said. High levels of aerosol can make some clouds less likely to drop rain or snow, for example, and can lead to clouds that reflect more or less sunlight back into space, cooling or warming the surface. But how those behaviors modify precipitation processes within clouds is not yet well understood, creating uncertainty in global and regional climate models.

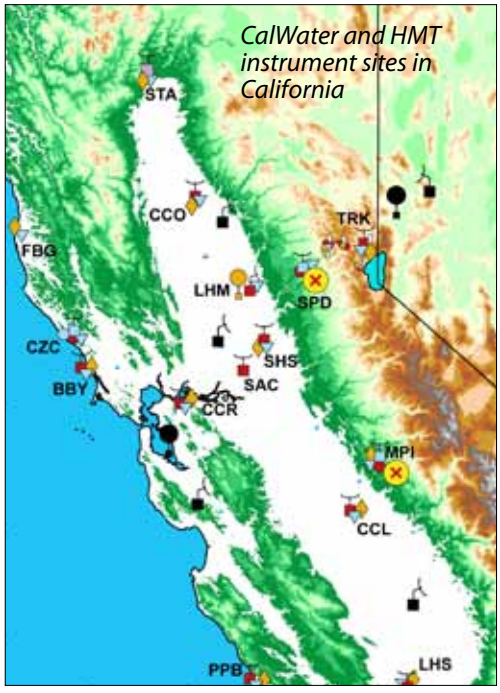
Some researchers have proposed that air pollution has already changed the pattern of rainfall in the state, letting water-rich clouds travel over the Sierra Nevada mountains into Nevada before dropping their rain, leaving California with less. Williams and his colleagues suspect other factors, distinct from aerosol effects, may be at play, too, such as the "Sierra barrier jet" that can form along the Sierra Nevada. The scientists will use sophisticated instruments and techniques—from ground-based radars and airborne instruments to chemical "fingerprinting" of particles found in falling rain and snow—to gather data across California for the next several years, to build a more accurate picture of the relationship between air quality, water resources, and climate.

Since climate models try to represent the physical processes that occur in clouds, better understanding from ESRL research will create more accurate projections as California experiences a changing climate, Williams said.

Atmospheric rivers also play a major role in California's water resources. These moisture-rich "rivers" of air can sweep up from the Pacific, dumping rain on California's coast and snow in the mountains. In earlier work in the state, scientists have estimated that atmospheric rivers deliver as much as 50 percent of the state's precipitation every year, and are responsible for most of the major flood events.

ESRL researchers suspect that some of the uncertainty in climate model projections of California's future is the fault of poor representation of atmospheric rivers in the models. CalWater's measurement-intensive campaign—involving atmospheric river and climate observatories on the coast of California and inland—should help, said Gary Wick (Physical Sciences Division). Those observatories include sophisticated radars, raindrop disdrometers, GPS-meteorology instruments, and others that will let Wick and his colleagues record the structure and variability of atmospheric river systems at sea and as they move onto land, where they are transformed by regional topography and weather systems.

Because atmospheric rivers events in California can end droughts, fill reservoirs, and trigger dangerous flooding, Wick said, it's critical to better understand how climate change could affect the systems. The findings will be relevant for policy makers considering decisions about public investments in flood control and water storage projects, including new reservoirs.



CalWater and HMT instrument sites in California

Emerging science: Snow-level radar and HMT's legacy project

ESRL scientists have developed an inexpensive radar system that can detect and monitor snow level during winter storms. Because snow level can determine how much of a particular mountain basin will experience rain versus snow, it is an important predictor of snowpack levels and streamflow amount and timing—key data for water supply managers and for flood control.

ESRL's new snow-level radars have been installed at two sites in California, with seven more to follow in the next few years. With 18 other snow-level detecting radars deployed across the state this winter, these new systems will serve climate missions in the CalWater project and a legacy of the HMT-West project, the California Department of Water Resources EFREP (Enhanced Flood Response and Emergency Preparedness) program.

HMT's legacy project, which also involves other state-of-the-art monitoring equipment, modeling efforts and decision support tools, is intended to help California deal with the challenges of an aging water infrastructure, increased standards for urban flood protection, and the impacts of climate change.

The snow-level radars record cloud and precipitation information every 35 seconds, and report snow level every 10 minutes. These radars will help determine if there are long-term trends in snow level, and will assist forecasters in providing more accurate and timely forecasts of winter storms. Data from the radars, combined with CalWater measurements, will also provide critical data scientists need to improve regional climate models. Better modeling can help water managers prepare for California's future under climate change.

SkyWater radar, NOAA photo.

Snow-level radar, NOAA photo.

Measuring water in the air

Another key tool for CalWater is the Physical Sciences Division's scanning "SkyWater" radar, which is being set up north of Sacramento, to monitor the interaction between landfalling atmospheric rivers and the Sacramento barrier jet for two winters. The jet is not included in climate models, and detailed observations from the Sacramento instruments will help scientists assess how its absence from models affects projections of California precipitation.

HMT-West

CalWater draws from another major ESRL effort focused on California—HMT-West—taking advantage of some of the custom instruments, sites, and knowledge developed earlier by HMT (NOAA's Hydrometeorology Testbed Program).

Weather forecasters know that conventional instrument suites aren't always enough to accurately predict hazardous weather. Deadly storms can sneak in literally below radar, and runoff models sometimes don't capture an imminent flood. HMT, which involves ESRL scientists and research products, is developing, prototyping, and infusing new science and technology into the daily operations of the National Weather Service and its River Forecast Centers. ESRL researchers have helped design and place custom instrument packages (from disdrometers and radars to weather instruments launched on balloons) and run experimental models in regions of California that are prone to winter floods.

The knowledge and tools generated through HMT are aiding in the design of climate-focused field studies, such as CalWater, and are providing new methods for regional climate monitoring, such as soil moisture measurement methods and systems that are useful for NIDIS pilot studies.

Isidora Jankov, Steve Albers, and colleagues in the Global Systems Division are doing the modeling. The team gathers all available observations—from HMT-West's custom instrument suites to conventional meteorological data gathered in both California and Washington regions—and uses it to fire up forecast models.

"See that blue? That's enhanced moisture flux moving toward the coast," Jankov said, pointing to her computer screen in November. "That's going to hit Seattle tomorrow, but today, it's hitting Vancouver. They're going to get some heavy rain."

The modelers are producing some of the longest-lead-time, high-resolution forecasts ever for the California and Pacific Northwest regions, Jankov and Albers explain, and they are mixing-and-matching different physics, dynamics, and initialization schemes to create ensembles. (Model ensembles are widely recognized as being able to produce more skillful forecasts than single, or "deterministic" model runs).

Jankov and Albers say they are still working closely with the HMT and CalWater teams, including the River Forecast Centers, and the National Weather Service, to figure out what combinations of model components and ensemble methods will produce the best precipitation forecasts. The researchers are especially interested in accurately forecasting when and where rain turns to snow, or vice versa. "This is very helpful information for the water managers who need accurate runoff predictions," Albers said.

2008 Cooling

It was strangely cool in 2008 in North America. ESRL scientists and colleagues evaluated temperature trends and patterns from that year and concluded that the cooling was likely from natural variation—North American temperatures would have been considerably colder in 2008 without human-induced climate warming, they found.

Lead author Judith Perlwitz (ESRL Physical Sciences Division and the Cooperative Institute for Research Environmental Sciences) and her colleagues used observations and computer climate models to investigate the sources of observed climate and weather patterns in 2008—a technique called "attribution." Cold North American temperatures were primarily due to the fact that the region is sensitive to natural variation in the tropical and northeastern Pacific sea surface, which was unusually cold that year.

"The implication is that the pace of North American warming is likely to resume in coming years, and that climate is unlikely embarking upon a prolonged cooling," the scientists concluded in a paper published Dec. 8 in *Geophysical Research Letters*. More: doi:10.1029/2009GL041188.

Air Quality Workshop

More than 100 researchers from around the world gathered in Boulder in December, for the first International Workshop on Air Quality Forecasting Research, sponsored by NOAA and Environment Canada. Participants described ongoing efforts to develop and improve operational air quality forecast models and discussed the challenges faced by researchers and by agencies, including the need for more and better observations.

"Our focus is on research that is specifically related to operational air quality forecasting, and I don't have to tell this group about the growing need," said Jim Meagher, Deputy Director of ESRL's Chemical Sciences Division, during an introductory plenary session.

Paula Davidson, NOAA's Project Manager for Air Quality Forecasting, described the impact of air pollution in the United States: "There are more than 60,000 premature deaths in the U.S. from poor air quality, with huge associated health costs, more than $100 billion per year."

Davidson and Veronique Bouchet (Environment Canada) discussed the models and data used today by each country to forecast levels of air pollutants—from smoke to surface ozone—and described forecasting successes and challenges. Both researchers focused on the difficulty of accurately predicting particulate matter, fine particles and droplets from a variety of sources that can affect human health and are regulated in both countries.

Meagher said that he hopes that the workshop will be the first of an annual series. More: http://www.esrl.noaa.gov/csd/events/iwaqfr/.

AGU Town Hall

Instead of the usual NOAA-Research "All Hands" meeting at the American Geophysical Union, AGU, meeting in San Francisco, NOAA and Exploratorium leaders hosted a Town Hall meeting to talk about the educational collaboration between the agency and the museum.

The Exploratorium in San Francisco, "a museum of science, art, and human perception," is an international leader in informal science education, said Rick Spinrad, NOAA's Assistant Administrator for Research. Earlier this year, NOAA and the museum signed an agreement to codevelop interactive exhibits, online learning experiences, professional development workshops, and more.

Spinrad invited researchers and staff across NOAA to have fun with the new collaboration, and build connections with the Exploratorium's exhibit designers and program managers. "You have carte blanche," Spinrad said. "Literally: a NOAA badge will get you into the Exploratorium free."

Rob Semper, Exploratorium Executive Associate Director, described the museum's plans to move to an expansive new location on a pier near downtown San Francisco, a site that will include outdoors and dock space. "It would be daunting to move into this opportunity, this environment, without someone who really knows about it, and that's you," Semper said.

Mary Miller, the Exploratorium's director of the new partnership, said it has already resulted in tangible results: Exploratorium visitors online and in person can learn about– and communicate with–NOAA's *Okeanos Explorer*. And Exploratorium staff are working with ESRL's Physical Sciences Division, to develop an exhibit based on innovative weather and climate instruments researchers here developed for field work in California. Miller described ESRL's raindrop disdrometers, which help researchers understand the physics of precipitating clouds, as "poetic and artistic, as well as scientific. "We know this is going to result in some really cool exhibits on the floor," she said.

AGU Science

Hundreds of ESRL researchers and affiliates from CIRES and CIRA attended the AGU meeting. ESRL scientists and affiliates chaired more than a dozen sessions, gave talks and posters, spoke as invited presenters and during press conferences, and led additional smaller meetings during the larger conference (which included more than 15,500 presentations). ESRL outreach staff maintained a strong presence at the NOAA booth in the AGU Exhibition Hall. More: http://www.agu.org/meetings/fm09/.

Climate "Roadshows"

One-day workshops can significantly improve the "climate literacy" of resource managers, according to ESRL data presented at the American Geophysical Union annual meeting in San Francisco.

Kristen Averyt (Physical Sciences Division and CIRES) discussed a series of workshops held across Colorado in 2009, to disseminate information about how climate variability and change affect the state's water resources. The workshop involved short presentations, extensive interactions between participants and climate scientists, and breakout discussions. The information presented was based on *Climate Change in Colorado*, a report written last year by the Western Water Assessment (a joint project of NOAA and CIRES) in support of Colorado Governor Bill Ritter's Climate Action Plan.

The 80 workshop participants were quizzed about climate facts both before and after the

International air quality forecasting experts gathered at ESRL for a research conference. Photo by Will von Dauster, NOAA.

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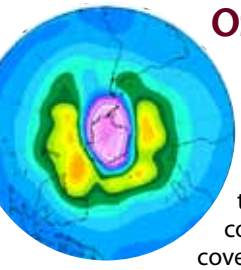
workshop, Averyt said, and made significant gains in understanding. Before the workshop, participants tended to accurately identify global climate change impacts, but did not understand some basic climate science concepts. Only 23 percent of those who completed surveys understood basic climate trends in Colorado (increased temperature and variable precipitation, for example); after the workshop, that number jumped to 74 percent.

"Some misconceptions remained," Averyt said. "People still confuse climate change and climate variability, and the influence of ENSO in Colorado…so we need to work on better communicating those messages."

She and her colleagues also asked participants prior to the workshop whether they use climate information to inform decisions, and where they obtained that information. People tended to use just a couple federal sources of climate data, and were unaware of many regional and other federal sources, Averyt said. During the workshop, the team discussed many sources of information, and participants said they were eager to begin using some of the climate tools they'd just learned about—especially from the National Integrated Drought Information System, NIDIS.



Ozone Hole

The Antarctic ozone hole reached its 2009 peak circumference in late September, according to ESRL measurements. Slightly smaller than the North American continent, the ozone hole covered 9.2 million square miles, according to satellite observations. This ranks as the 10th largest since satellite measurements began in 1979.

Ozone over South Pole Station, Antarctica, also reached its thinnest point of the year on Sept. 26. Measured in Dobson Units (DU), which indicate the amount of ozone in a vertical column of air, the 2009 low level of 98 DU is the seventh smallest since 1986 (the record low of 89 DU was recorded on Oct. 6, 1993).

The atmospheric ozone layer protects the Earth from harmful ultraviolet radiation. It has been damaged by human-produced compounds known as chlorofluorocarbons, or CFCs, which release ozone-destroying bromine and chlorine into the atmosphere. International agreements have strictly limited the use of CFCs since the early 1990s.

"The Montreal Protocol has been effective in reducing emissions of long-lived CFC gases, but high enough concentrations remain in the atmosphere to lead to significant ozone destruction in polar regions," said Bryan Johnson, project leader of ESRL's Ozonesonde Group. "Monitoring ozone over Antarctica provides the essential yardstick to see whether we are on the predicted track for recovery based on the current rate of declining CFCs." Although CFCs are slowly decreasing in the atmosphere, scientists project that the ozone hole will not fully recover before 2060.

Aerosol Effects on Climate

Cloud systems are complicated, characterized by feedbacks and buffering mechanisms, many of them involving tiny atmospheric particles (aerosol). Overall, aerosol particles are estimated to cool the climate system—partly offsetting warming by greenhouse gases—but their effects vary from place to place, and uncertainty about aerosol-cloud-climate interactions still plagues global climate models.

A study by Graham Feingold (Chemical Sciences Division) and Max Planck Institute scientist Bjorn Stevens reviewed research to date on the aerosol-cloud-climate system, to assess why the uncertainties remain so large on this topic. They identified problems in the ways researchers attempt to investigate aerosol-cloud-climate systems—including a failure to take into account the ways that the aerosol, clouds, and precipitation can each affect the other, with one effect sometimes compensating or canceling out another. Moreover, those interactions differ in different regions of the world in ways that are still not well understood or represented in climate models.

Feingold and Stevens proposed a new research strategy—a coordinated effort to study cloud system behaviors on timescales of days to seasons. Arrays of sophisticated equipment at the surface and aboard airplanes could be placed to make long-term measurements and to take advantage of "natural" experiments, such as episodes of biomass burning in regions where the meteorological variability is small. Their study was published Oct. 1 in *Nature* (doi:10.1038/nature08281).

Published

ESRL's peer-reviewed publications:

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

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Electric Annie

Outreach expert Annie Reiser helped scientist Tom Lefebvre (both Global Systems Division) develop a hands-on student exercise with a Van de Graaff generator, which accumulates electrical charge on a metal globe. The exercise demonstrates several effects of static electricity charge and its relationship to atmospheric lightning. It will be unveiled at the 9th annual WeatherFest in Atlanta, Ga. in January. The WeatherFest is a science fair focused on weather, climate, and related fields, held by the American Meteorological Society.

Honored

Three researchers in ESRL's Global Systems Division won Research and Service Initiative Awards from CIRA, the Cooperative Institute for Research in the Atmosphere at Colorado State University. **Jacques Middlecoff** and **Ning Wang** were lauded for outstanding performance in helping develop the state-of-the-art global weather and climate prediction model FIM. CIRA gave **Sher Schranz** the award "for outstanding leadership in the design, development, testing, deployment, and operational support for FX-Net, Gridded FX-Net and Fire Weather Projects."

Robert (Robin) Webb and **Mary Cécile Penland De Garcia** (Physical Sciences) were part of a team awarded a Department of Commerce Silver Medal for Scientific/Engineering Achievement, for their development of the Coral Reef Bleaching Outlook tool. The team was recognized "for providing timely ocean information and capacity for improved global monitoring and management of coral reef ecosystems relative to climate change."

Scott Woodruff (Physical Sciences) was reselected to serve as the Chair of the Expert Team on Marine Climatology, for the Joint World Meteorological Organization-IOC Technical Committee for Oceanography and Marine Meteorology. The expert team collaborates with international programs to determine procedures and principles for the development and management of global and regional oceanographic and marine meteorological climatological datasets. http://icoads.noaa.gov/etmc/.

Valery Zavorotny (Physical Sciences) was elevated to a Fellow of the Institute of Electrical and Electronics Engineers (IEEE), for contributions to ocean remote sensing and wave propagation in random media.

Annie Reiser and the Van de Graaff generator. Photo by Will von Dauster, NOAA.

Near-Space Flight

Every week, ESRL sends balloons 100,000 feet into the atmosphere bearing ozone and water vapor instruments. The balloon-borne instruments, released from several sites around the world, create long-term records of the concentrations and distributions of the two gases, which are important in terms of climate and Earth's protective ozone layer.

On one flight from Boulder, CO this fall, engineers Allen Jordan and Emrys Hall (Global Monitoring Division) added a lightweight digital camera to the package. The stunning photographs captured the curvature of the Earth and the blackness of space.

"We weren't sure what we would learn," Hall admitted, "but in some of the images, you can see smoke from a controlled burn." The smoke might help researchers better understand the ozone and water data, likely affected by the fire.

The experience of adding the camera to the flight package may also help ESRL engineers better integrate a new instrument they're hoping to begin flying regularly, soon: an Aethalometer, which measures the amount of black carbon in the atmosphere. Black carbon particles are air pollutants and also contribute to atmospheric warming.

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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.

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