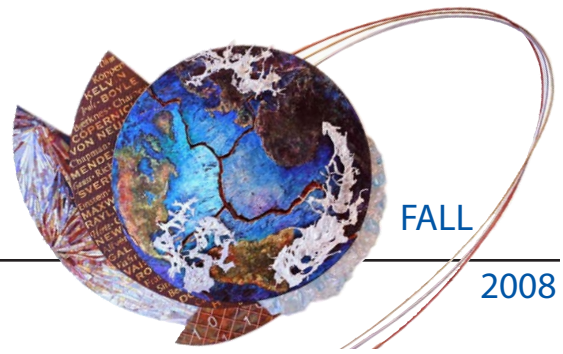


ESRL Quarterly

News from NOAA's Earth System Research Laboratory



FALL

2008

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FIM Shapes Up

ESRL tests new global model

It may look like a cool new type of soccer ball, but FIM is more likely to generate excitement among weather modelers than young athletes.

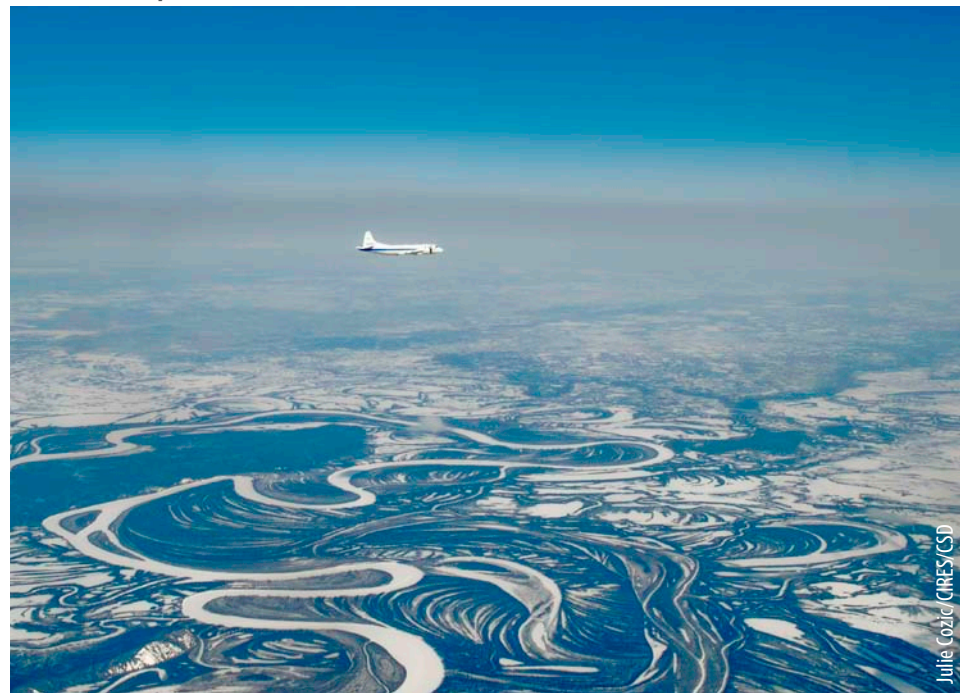
FIM (with the tongue-twisting title of Flow-following, finite-volume Icosahedral Model) is a global weather model under development at ESRL. The model's unusual grid system makes it look like a soccer ball crafted from thousands of polygons, but researchers here hope it will soon improve the accuracy of operational forecasts.

In testing at ESRL, FIM is holding its own against the Global Forecast System (GFS) model—the global model used today by National Weather Service forecasters. By midsummer, FIM was skillfully predicting temperatures, rainfall, hurricane tracks and other weather features around the globe.

“FIM has proved to be quite robust. It doesn't crash, it produces credible forecasts and it appears to be competitive with the GFS,” John Brown, a model developer in ESRL's GSD,

see FIM p4

Arctic Haze, see p6



NASA's P-3, captured from NOAA's P-3 during an instrument comparison flight above Alaska, with visible haze.

Julie Cozic/CIRES/CSD



At NOAA's Earth System Research Laboratory in

Boulder, Colorado, 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 Boulder, and the Cooperative Institute for Research in the Atmosphere at

Colorado State University.



Clamoring for Climate Help

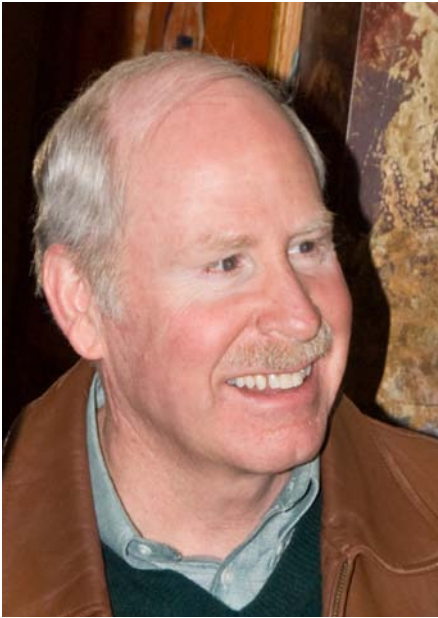
Reviewers: NCS could help public access, understand climate change information

The nation needs a National Climate Service, similar to the National Weather Service, but focused on long-term changes in temperature, precipitation, sea level, and other factors, according to a group of climate experts that gathered in Vail this summer.

Government insiders and outsiders spent three days in June reviewing NOAA's developing plans for a National Climate Service, said Randall Dole, acting Deputy Director for Research at ESRL and one of several ESRL scientists involved. The reviewers urged NOAA to push forth with plans for an NCS, given growing demand for climate information from citizens, companies, natural resource managers, and others.

“Clearly, the sense from the meeting was it should be transformational, that we should be taking a major step forward,” Dole said. “We talked about Arctic changes, sea level rise,

see NCS p3



Director's Corner

Rome wasn't built in a day, and neither will ESRL be built in a day. But with the first issue of *ESRL Quarterly* we pass another important milestone in building the pre-eminent organization needed to address some of the world's most important problems. As you will see in this first issue, ESRL scientists are working in many areas: in the Arctic trying to understand aerosols and the causes of rapid Arctic change, on improving global weather prediction, in interagency committees working on assessments of climate change, and on "Climate Scene Investigation" teams that investigate killer climate patterns. A common theme is that these efforts benefit from the multi-disciplinary breadth of ESRL.

The promise of ESRL is that the whole will be more than the sum of the parts. Our job, all of us in ESRL and our partners who receive this, is to try to make that promise a reality. This happens at all levels. When a scientist can approach a scientific problem in a more general and effective way by working with another division, that draws on the strength of having comprehensive Earth system's disciplines all encompassed in the same building. At the senior level, scientific leadership of ESRL is embodied in a group called the Science and Technology Council (STC). Since the inception of ESRL, the STC has met periodically to discuss the scientific direction of the lab. During our first year, Randy Dole led discussions of the importance of Integrated Earth System Analysis, in which the atmosphere, ocean, chemistry, biology, ice, and other parts of the Earth system are analyzed through time based on state-of-the-art global observing and modeling. The premise is that to understand and predict the earth system, we

must understand all components and how they work together. This is the kind of job that really demands efforts across ESRL, and indeed with other research institutions, such as GFDL.

An example of the "across ESRL" approach is the development of the FIM, the new ESRL global model described in the cover article. Much thought was given to making the model useful for Earth system modeling, driven in part by the preceding STC discussion of Earth system analysis. We designed FIM to be extremely conservative—to neither spuriously create nor destroy the mass of model substances. If we are to track carbon dioxide, or get global budgets of aerosols, this is a property that is extraordinarily valuable. In the past, such a model designed for weather prediction was typically non-conservative, because it wasn't designed for Earth system modeling. In the weather arena, FIM was done in close collaboration with our colleagues in NWS's National Centers for Environmental Prediction. If ESRL is to meet its potential, we must all continually work to take advantage of the formidable collection of experience and talent that is literally "down the hall" from all of us, and with our partners elsewhere in NOAA and beyond.

In closing, I want to thank the ESRL Division Directors for agreeing to support the *ESRL Quarterly*. We can't meet our potential without much better communication among us and with our collaborators. I think you will agree that our editor, Katy Human, has us off to an excellent start with Issue 1 of *ESRL Quarterly*.

—Alexander MacDonald

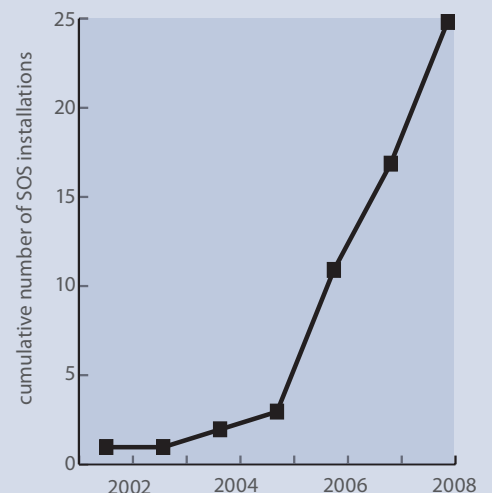
By the Numbers

Science on a Sphere



"SOS is a triumph. The folks in the lobby can't get enough of it. People are constantly using their cell phone cameras to take pictures of the sphere, and are then talking excitedly to their friends about what they're looking at."

—Seth Jarvis, director of the Clark Planetarium in Salt Lake City, where SOS was installed in spring 2008.





More than half the nation's citizens live within a coastal zone. A National Climate Service would provide planners and decision makers information on how a changing climate may affect local environments.

...NCS, from p1

and coastal inundation, western water... These are issues of emerging national and international significance."

People now understand that climate change may affect them personally, and they are asking for information that is simply not available today, said Chet Koblinsky, Director of NOAA OAR's Climate Program Office. Government reports and academic papers provide some information, Koblinsky said, "but it's broadly distributed and not readily available in a form that would enable any kind of decision making. "Just google a climate change issue and you will quickly learn how hard it is to find regular, authoritative, user-friendly information."

A priority of an NCS should be to help users figure out how to manage risk in a world of changing climate, said Amy Luers. Luers, the former Director of the Union of Concerned Scientists' California Climate Program, and now Program Manager of Google.org's Predict and Prevent Initiative, attended the Vail conference as an external reviewer and potential user of an NCS, as did Jeanine Jones from the California Department of Water Resources.

"The issue is helping people understand what it means to adapt, and what it means to manage risk under these dynamic uncertainties," Luers said.

"The focus should be less on data and more on information," Jones said. "The most important message is that they need to provide the information in a way that's useful to practitioners. It shouldn't be just another web portal."

"Just google a climate change issue and you will quickly learn how hard it is to find regular, authoritative, user-friendly information."

—Chet Koblinsky, Climate Program Office Director

Truly useful information might include regional probability statements, Jones said. "If someone can tell us that at a 90-percent confidence level, precipitation in the Sierra Nevada in December, January and February will be 120 to 150 percent of normal, well, that would help a lot," Jones said. "It would affect how we move water around the system."

In an update this summer, OAR Assistant Administrator Richard Spinrad noted the importance of organizing an NCS from the bottom up. "Rather than begin by designing an organizational chart, the first stage of this formative process has focused on the user-driven aspects of organizational principles, products and services that should constitute a National Climate Service," Spinrad wrote.

The National Research Council first outlined a vision of an NCS in 2001. This summer, NOAA staff and external advisors identified four general approaches to creating the service, Koblinsky said. Options range from simply expanding and improving climate information already provided by NOAA, to the more "transformative" creation of an NCS federation—including NOAA, other agencies, and non-governmental organizations—that would figure out how to deliver climate services to the nation.

Teams are now evaluating the pros and cons of each strategy, Koblinsky said. "The idea is to come up with a suite of alternatives, to be considered as early as next year."

Climate Program Reports Out

ESRL researchers contribute to state-of-the-science assessments

This fall, the U.S. Climate Change Science Program will complete a set of 21 reports on the causes and consequences of climate change in North America—a significant undertaking that relied on the commitment and expertise of ESRL scientists, said CCSP acting director William Brennan.

The assessments explain the most up-to-date science, on a range of climate issues, to policy makers and resource managers. Topics include the state of stratospheric ozone to the effects of climate change on agriculture and water supply, Brennan said.

"The basic rationale was to provide, in a timely fashion, information to the public in a field where our understanding is advancing rapidly," Brennan said. "These reports certainly have helped my job in convincing folks that climate change is real and is going to have real impacts on real people." The authors present the finalized assessment products to Congress, and the reports have already generated dozens of media reports.

"Of the 21 products, NOAA is doing eight of them, the lion's share," Brennan said. "And ESRL is doing the lion's share of that lion's share, with five products."

Among the findings of final and draft assessments now available online:

- North America accounts for more than one-fourth of the world's carbon-laden fossil fuel emissions. The United States is responsible for 85 percent of North American emissions.
- Growing plants on this continent absorb about 30 percent as much carbon as is emitted by fossil fuel use, and that contrast is likely to increase if fossil fuel emissions continue to grow.
- Droughts, heavy downpours, and excessive heat are likely to become more commonplace in North America in the future.
- The United States contributed significantly to the depletion of the ozone layer (the ozone hole), and then to the healing of the layer, through participation in the Montreal Protocol and its amendments.

NOAA's authors of the assessment products won the 2008 Administrator's Award this summer. ESRL recipients include: John Daniel, Randall Dole, David Fahey, Graham Feingold, Martin Hoerling, Stephen Montzka, Roger Pulwarty, A. R. Ravishankara, and Robert S. Webb.

concluded during a July technical review of FIM.

FIM development began in 2002, based on the assumption that an icosahedral grid—one comprised of evenly sized pentagons and hexagons—should represent the planet better than grids based on latitude and longitude. Latitude-longitude grids become compressed into tiny spaces near the poles, which can make forecasts unreliable.

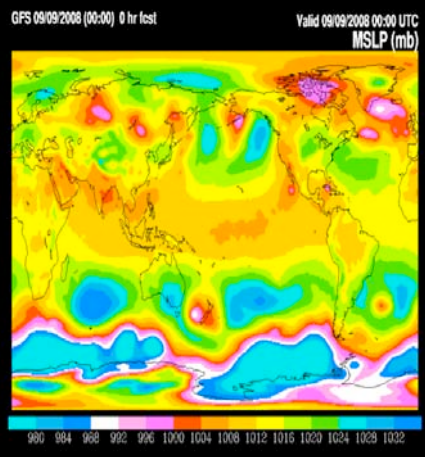
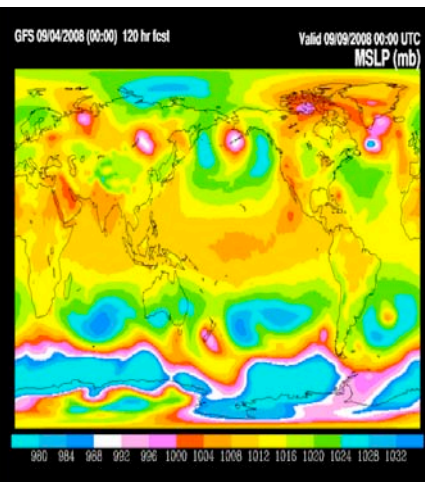
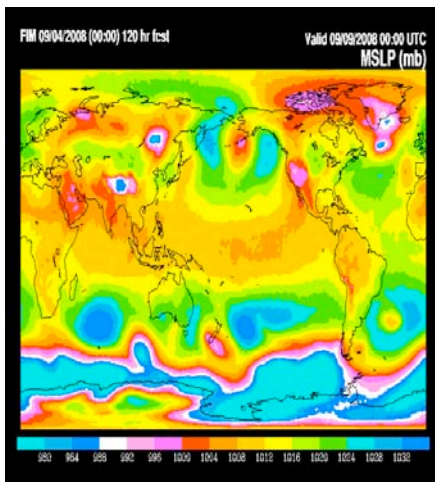
Although a handful of researchers around the globe have begun developing models based on icosahedral grids, FIM represents NOAA's first application of the technique said Stan Benjamin, Chief of the Modeling and Assimilation branch of ESRL's GSD. "It's not yet proven better, but we know it's a very reasonable idea," Benjamin said.

Up to 655,000 hexagons and 12 pentagons comprise FIM's icosahedral grid, and the model is also "flow following," focusing calculations around weather fronts, changing the grid system as needed to best capture the detailed physics and chemistry that occur when air masses meet.

"Essentially, there is closer spacing of computation in spots where things are happening," Benjamin said.

The FIM also incorporates an advanced numerical method to properly conserve certain species—such as atmospheric pollutants, trace gases, and mass—as they are transported around the globe, using the "finite volume" principle. This property is important for predicting the transportation of water vapor in thin "atmospheric rivers" and frontal systems.

Alexander MacDonald, now Director of ESRL, and Jin Lee, another GSD scientist, started building the model after German researchers and Colorado State University professor Dave Randall, began working with icosahedral grids in 2002. Louis Uccellini, Director of the National Centers for Environmental Prediction, challenged MacDonald to include the flow-following concept in FIM—the idea had already been applied in the Rapid Update Cycle, an operational prediction model largely designed and maintained by GSD. Letting the atmosphere's vertical layers float could make FIM particularly good at tracking water vapor, trace gases and pollutants, modelers figured. MacDonald took up Uccellini's challenge, and enlisted the help of some of GSD's Rapid Update Cycle developers to transform FIM into a three-dimensional weather model.



FIM vs. GFS. Five-day forecasts produced September 4 (by FIM, top left and GFS, top right) compared with observations September 9 (below right).

Stephen Lord, Director of the Environmental Modeling Center at NCEP, said he's been watching FIM development closely during the last few years, with an eye to incorporating FIM in "ensemble" weather predictions by 2010. Today, forecasters generate ensembles—a variety of possible weather futures—by initializing weather models with slightly different initial conditions or by tweaking parameterizations. A second global model to complement the GFS could produce a wider range of ensemble solutions, Lord said.

"I'm optimistic this will come along and become a useful part of our forecast system," he said in June. "So far, it looks like FIM is about the same (as GFS) in the Southern Hemisphere and a little worse in the Northern Hemisphere, but it's too early to tell. The people in Boulder are pretty good at tracking down problems."

By July, ESRL researchers corrected two key problems in the model: bright "freckles" of ocean that suddenly appeared in the middle of continents, and a tendency to produce air masses that were too dry. The drying problem is still there, Brown said, but far less severe than before the sources of the freckles was discovered and fixed.

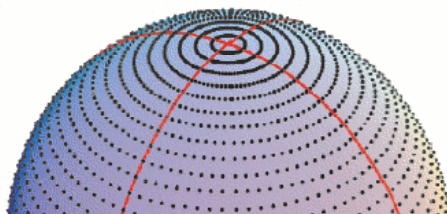
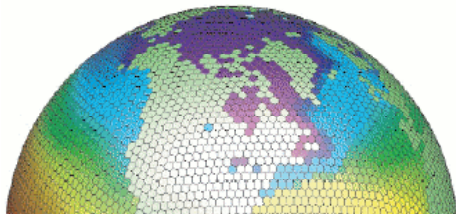
A problem with defining the model's initial conditions over high terrain was found in August, Brown and Benjamin said, making FIM competitive with GFS.

"No doubt other, more subtle, issues will emerge," Brown said, "but our results are very encouraging."

<http://fim.noaa.gov>

In Partnership: FIM relies on the physics of the Global Forecast System model used by the National Weather Service. The Environmental Modeling Center of NCEP supplied ESRL with verification software, so FIM results can be compared with those from other forecast models. Ranier Bleck, an ocean modeler with the NASA Goddard Institute for Space Studies at Columbia University, is also actively involved in FIM's development. FIM's dispersed contributors discuss and critique the model regularly.

ESRL is hosting the 4th Workshop on the Use of Isentropic and other Quasi-Lagrangian Vertical Coordinates in Atmosphere and Ocean Modeling, October 7 to 9.



CSI:

Climate Scene Investigation

On television's CSI, Gil Grissom leads a team of forensic scientists who investigate brutal crimes. In NOAA's version, Marty Hoerling leads a group of researchers who investigate killer climate patterns such as heat waves, tornadoes, and the floods that struck the Mississippi this summer.

Hoerling and colleagues across NOAA created Climate Scene Investigators, CSI, early last year following chaotic media coverage of the record hot year of 2006. "Even within NOAA, we presented opposite opinions. It was because of global warming, and it was not global warming," said Hoerling, of ESRL's PSD. "There was no organized attribution effort that was timely enough. The questions pop up all the time and you want to respond with the best information."

The CSI team set out to perform fast-response "attribution" work, using models, historic data and recent observations to try to understand the sources of unusual climate and weather patterns.

This is the kind of information increasingly sought by decision-makers and the media, Hoerling said. "They all want to know how well we understand the causes of regional and seasonal climate variation and trends." If an attribution study suggests, for example, that La Niña winters are often associated with extreme snowfall events, communities can use that information to get ready.

In February, a public figure suggested that global warming could be responsible for a series of deadly tornadoes in Florida, and CSI quickly responded with an attribution study. "We found no evidence warming enhances tornadic activity," Hoerling said. "The tornadoes were consistent with La Niña. There was research out there

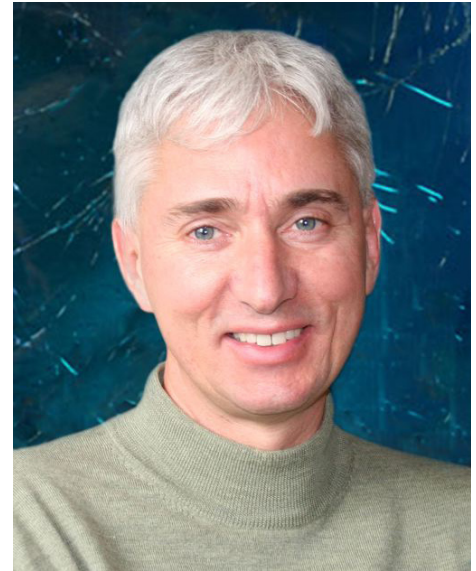
showing higher activity in those places at that time during La Niñas."

In climate attribution work, researchers start by identifying possible underlying causes for weather and climate trends—an increase in greenhouse gases, perhaps, natural changes in ocean temperatures, or land-use changes.

They then use climate models and historic records to ask if such "antecedent conditions" can produce climate patterns consistent with observations. In the case of the February tornadoes, for example, records did not show an increase in the number of tornadoes coincident with rising greenhouse gas levels in the atmosphere. Instead, records and published research revealed an increased risk of tornadoes along a band from Louisiana to Michigan during La Niña years.

This summer's devastating Midwest floods, however, did carry a signature of global warming. The CSI team looked for evidence of a La Niña influence—and found none. However, the severe Midwest drought of 1988 coincided with a recent strong La Niña event. CSI found that global sea surface conditions could have contributed to heavy winter precipitation in the Upper Midwest, which saturated soils and contributed to later floods. Ocean conditions in January through March slightly increase the risk of extra moisture in the upper Midwest in those months.

But the extreme rain events best fit into an emerging pattern of water cycle changes occurring because of greenhouse gas forcing in the atmosphere, CSI concluded.



Marty Hoerling

Although climate models do not predict an increase in mean precipitation falling over the Midwest, models and observations suggest that the character of precipitation is changing in many places. The United Nations' Intergovernmental Panel on Climate Change and the U.S. Climate Change Science Program both note an increase in heavy precipitation events over North America during the last 50 years, which is consistent with more water vapor in the atmosphere. This, in turn, is consistent with a rise in greenhouse gases.

"I think of NOAA climate services to the nation as currently having two branches—monitoring and prediction. Sitting between them is the service of explaining climate conditions—*attribution*," Hoerling said. "Our fledgling NOAA-CSI effort at real-time climate attribution is seeking to fill this gap. It's what explains the observations, and that informs predictions."

<http://www.cdc.noaa.gov/CSI/>

NOAA CSI Cast:

Mike Alexander (ESRL)	Michelle L'Heureux (NWS)
Antionietta Capotondi (ESRL)	Mike McPhaden (PMEL)
Randall Dole (ESRL)	Jim O'Brien (COAPS)
David Easterling (NCDC)	Judith Perlwitz (ESRL)
Jon Eischeid (ESRL)	Xiaowei Quan (ESRL)
Dave Enfield (AOML)	Andrea Ray (ESRL)
Marty Hoerling (ESRL)	Cathy Smith (ESRL)
Tom Karl (NCDC)	De-zheng Sun (ESRL)
Arun Kumar (CPC)	Robert Webb (ESRL)
Tom Knutson (GFDL)	Klaus Weickmann (ESRL)
Chris Landsea (NHC)	Klaus Wolter (ESRL)
Doug LeComte (CPC)	Taiyi Xu (ESRL)



Flooding in Cedar Rapids, Iowa

Arctic Haze, by Plane and by Ship

For many people, “the Arctic” still conjures up images of pristine coldness, with ice and snow and crystalline skies. Researchers have long known otherwise—Arctic marine mammals, for example, carry surprising levels of toxins in their bodies.

Nor is Arctic air clear. In the last few decades, a heavy haze has hung over the region in winter and spring. This spring, in part because of the International Polar Year, ESRL scientists joined colleagues from around the world in a major initiative to better understand the Arctic’s polluted springtime atmosphere. The haze particles, which come from around the world and contain black carbon (soot) and other pollutants, may help explain why the North is warming more quickly than many expected. In the last few years, summer sea ice extent in the Arctic has declined by about 40 percent, relative to the 1979–2000 average, and the ice is also thinning.

“The Arctic is changing before our eyes,” said A.R. Ravishankara, Director of ESRL’s CSD. “Capturing in detail the processes behind this large and surprisingly rapid transformation is a unique opportunity for understanding climate changes occurring elsewhere.”

ESRL’s Arctic work this year relied on NOAA’s P-3 research airplane and the Woods Hole Oceanographic Institution research vessel *Knorr*, both packed with instruments. ARCPAC flights soared out of Fairbanks, Alaska, and the ship-based ICEALOT cruised out from Massachusetts,

focusing data-gathering in the area between Norway, Iceland, and Greenland.

Back in Boulder, researchers are churning through data, said ESRL’s Dan Murphy, who coordinated the ARCPAC effort with Chuck Brock and Tom Ryerson. Although it’s not yet clear what the results will be, it is clear that the data will help scientists better describe the Arctic atmosphere and warming.

“The instruments worked very well and the aircraft flew into very interesting air—three types of air we wanted,” Murphy said. Pilots and scientists on the WP-3 encountered aged Arctic air, which contained signatures of the unique Arctic dynamics that dominate in winter and early spring. They sampled soot-laden air that swept in from Asia and included evidence of the fires near Lake Baikal and elsewhere, and they collected data from very low air, just 300 feet over the ice, Murphy said.

NOAA’s P-3 carried two types of chemistry instruments—gas phase chemistry and aerosol instruments (aerosols are atmospheric fine particles). The aerosol instruments focused on light-absorbing black carbon. Many other

types of aerosols reflect light, but dark sooty particles absorb it, and have the potential to affect climate in different and significant ways.

Forest and agricultural fires in Asia were the most significant source of aerosols arriving in Alaska, Murphy said, but it is not yet clear if that pattern is a representative one.

“The Arctic is changing before our eyes.”

—A.R. Ravishankara,
CSD Director

ARCPAC: Aerosol, Radiation, and Cloud Processes Affecting Arctic Climate

ICEALOT: International Chemistry Experiment in the Arctic Lower Troposphere

PMEL researchers led the ship-based ICEALOT mission, in which CSD and PSD scientists played key roles, taking trace gas and meteorology measurements, and operating a cloud radar. From the *Knorr*, scientists collected data closer to sources of pollution, to complement the aircraft measurements. Both missions also aimed to gather “baseline” atmospheric measurements, since declining seasonal ice cover may lead to an increase in ship traffic along the Northern Sea Route and the Northwest Passage.

During the Alaska missions, there were about 18 hours of light a day, Murphy said, and every day felt longer than the previous one. That was by design—the Arctic missions took advantage of rapidly changing atmospheric dynamics in the region. “We wanted to get a precise description of the chemistry as dark winter gives up to light spring, when sunlight sparks a chain of chemical reactions,” Murphy said.

The episodes of polluted air blowing through the region were less planned, but dramatic, he said. “On one flight, when the plane flew over Barrow, the air looked brown, truly brown.”

ESRL researchers will present most of their results at the December 2009 AGU meeting, although some results may be ready by this year’s San Francisco meeting.



To test the instruments onboard NOAA’s P-3, ESRL and other researchers flew the airplane around Denver and the Front Range in the spring of 2008, collecting data on the chemistry and physics that affect air quality in the region. At right, aurora borealis captured during ARCPAC, and an Arctic Ocean lead.



Daniel Ladd/CIRES/CSD

Dan Ladd/CSD

ESRL Cultivates Young Scientists



Vanessa Malone tests out the pilot's seat in NOAA's P-3, during a tour of Rocky Mountain Airport with GMD's Jim Elkins. Researchers with NOAA, NCAR, and Harvard University were preparing the airplane for a test flight.

Gray hair may be increasingly common at NOAA and other federal science agencies, but this summer brought a flood of diverse young researchers to ESRL through several educational programs. High school, undergraduate, and graduate students wrote code to analyze weather data, collected air samples, and tested new chemical detection techniques.

"I'm a nerd for life. That's my niche, so my goals were met," said Vanessa Malone, a senior at the University of the Virgin Islands. Malone spent the summer studying pollutants in air samples, mentored by GMD's Jim Elkins.

Although the numbers of women, blacks, and Hispanics in science and engineering jobs are rising, those groups remain underrepresented, according to National Science Foundation (NSF) figures released this year. NSF also found that 26 percent of all science and engineering degree holders in the U.S. labor force are age 50 or older.

"We need to bring new, talented young people into the workforce," said Steve Koch, Director of ESRL's GSD and technical monitor for a new NOAA educational program called the Interdisciplinary Scientific Environmental Technology Cooperative Science Center (ISET). "Science is well served by the energy and fresh ideas provided by a diverse workforce that includes a significant number of young people," Koch said.

ESRL is committed to improving the figures, Director Alexander MacDonald said. This summer, MacDonald announced the reestablishment of a student internship

program called PHASE (Practical Hands-On Application to Science Education), and he promoted Ann Thorne to coordinate the diverse programs that bring young people to ESRL. One of those is NOAA's Educational Partnership Program (EPP), which aims to increase the number of students graduating with degrees in sciences related to NOAA's work by awarding competitive grants to minority-serving universities. EPP supported Malone's paid summer of research.

During the school year, Malone said, she works in an organic chemistry laboratory, searching for antibiotic properties in the extracts of ocean sponges.

"Getting out of the water and into the air has been really different," Malone said. "Oh, and I got to work with a GC ECD system! It was fun." That system, a gas chromatograph with an electron capture detector, is the "magic" behind air chemical analysis, Malone explained in her end-of-summer presentation.

EPP, established in 2001, not only supports individual students seeking research experience. The program also directly helps minority-serving institutions, by providing money for new faculty, new programs, and new computing facilities, said Solomon Bililign, a physics professor at North Carolina A&T State University.

EPP's most recent program is ISET, established in the fall of 2006, with Bililign as director. ISET includes six other universities from Alaska to Tennessee. ESRL scientists are mentoring ISET students, serving as thesis and dissertation committee members, and visiting ISET

campuses to lecture and provide technical assistance, Bililign said.

"One of the problems we are trying to solve is the nature of the workforce at NOAA. It doesn't reflect the demography of the country," Bililign said.

This summer for the first time, ISET sent 12 graduate and undergraduate students to Boulder, to work with ESRL scientists.

"These are students who are already interested in the field, in science, but some of them might not have had an opportunity to pursue education or research without the financial and administrative assistance of ISET," Bililign said.

Sukhdip Singh, a senior chemistry major at California State University, Fresno, said that's the case with him. He spent about three weeks in Boulder, splitting his time between the National Center for Atmospheric Research and ESRL's Chemical Sciences Division, hosted by Jim Burkholder.

"This is great. At Fresno State I get to use just a few types of instruments. Here, everything is customized and I don't understand any of it right off," Singh said. "But I'm learning, and I can begin to see these different ways to approach problems."

Singh will be the first in his family to graduate from college, and his passion for science is already inspiring his father, who is taking a chemistry class at Fresno. "He still doesn't say 'molecule,' he says 'muscle,'" Singh said, "but he's getting there."

<http://epp.noaa.gov/>

Bleach Alert!

New tool gives advance warning of coral-stressing heat

Warm water can kill coral, and ESRL researchers are hoping a new tool to forecast warm water episodes can help reef managers and conservationists protect vulnerable reef ecosystems. Increases in ocean temperature due to global warming have brought renewed attention to the issue of coral bleaching.



Coral reefs are important and productive ocean ecosystems, providing shelter and protection for diverse sea life. Large coral structures are formed from colonies of hundreds or thousands of tiny coral polyps, which use carbon dioxide to build limestone shells. Microscopic algae called zooxanthellae inhabit coral polyps and give the coral its vibrant color, but unusually warm water temperatures can damage that symbiosis. In some areas, a prolonged temperature increase as small as 1°C can trigger coral to expel zooxanthellae, resulting in bleaching and eventual death.

With NOAA's Coral Reef Watch program, ESRL scientists have developed the new Experimental Seasonal Coral Bleaching Outlook Tool, to provide advance warning of warm-water events. Corals can recover from mild bleaching, especially if the reef ecosystem is generally healthy. With advance warning of potential temperature stress, decision makers can reduce other stressors, by limiting diving and fishing, removing coral predators, treating coral disease, or reducing coastal runoff.

NOAA Coral Reef Watch was already using sea surface temperature data from environmental satellites to alert managers and scientists around the world of the *current risk* for coral bleaching. Robin Webb, ESRL/PSD, decided to combine the satellite data with sea surface temperature forecasts. "NOAA scientists have developed and improved experimental sea surface temperature forecasting products for climate outlooks," said Webb. "The bleaching outlook translates that enormous effort into a management product that can help protect living marine ecosystems." The experimental forecasts predict the likelihood of seasonal bleaching up to three months in advance, and forecasts are generated by an experimental sea surface temperature model developed by PSD's Cecile Penland and Ludmilla Matrosova. The first outlook was issued in July for August through October, and it noted a risk of widespread bleaching in the Northwestern Hawaiian Islands, with less severe bleaching in the Caribbean.

As part of the Global Earth Observation System of Systems (GEOSS), ESRL is also partnering across NOAA, with other federal agencies, and with international researchers to develop a worldwide monitoring network that will issue outlooks for coral reefs.

—contributed by Barb DeLuisi



Honors and Awards

Nine ESRL researchers received NOAA Administrator's Awards for work on the CCSP's Synthesis and Assessment Products—**John Daniel** (CSD), **Randall Dole** (ESRL/PSD), **David Fahey** (CSD), **Graham Feingold** (CSD), **Martin Hoerling** (PSD), **Stephen Montzka** (GMD), **Roger Pulwarty** (PSD), **A.R. Ravishankara** (CSD), and **Robin Webb** (PSD). CIRES/CSD scientist **Christine Ennis** was a key member of the team and will also be honored for her contributions. **Eric Hackathorne** (GSD) won a Virtual Learning Prize from the New Media Consortium, to create a virtual learning experience based on the Climate Time Line. **Marty Hoerling, Gary Bates** (PSD) and colleagues who co-authored a paper on the Indian monsoon and El Niño, were awarded the World Meteorological Organization's 2009 Norbert Gerbier-MUMM International Award. **Alexander MacDonald** (ESRL Director) was a finalist for the 2008 Service to America Medal, for his invention of Science on a Sphere. **John McGinley, John Smart, Linda Wharton,** and **Daniel Birkenheuer** (GSD) won NOAA's Technology Transfer Award, for work developing and transferring to industry the Local Analysis and Prediction System—a wind assimilation scheme that helps in the planning of military and civilian aerial resupply missions. **Stephen Montzka** (GMD) was lauded by the American Geophysical Union editors for excellence in refereeing. **Dan Murphy** (CSD) shared the Benjamin Y.H. Liu Award of the American Association for Aerosol Research (AAAR), for significantly advancing aerosol instrumentation and experimental techniques. **Susan Solomon** (CSD) received the 2008 John Scott Award for discoveries related to the Antarctic ozone hole. Dr. Solomon also received the American Geological Institute's 2008 Award for outstanding contribution to public understanding of the geosciences, and the "Grande Medaille," the French Academy of Sciences' highest honor.

In Brief

Sooty Ships

In a comprehensive study of soot emission by oceanic vessels, Daniel Lack and colleagues at CSD found that tugboats put out more soot per fuel used than other commercial vehicles, and large cargo ships emit twice as much soot as previously estimated. Soot is both a health hazard and a climate-warming agent. Commercial shipping is responsible for about 130,000 metric tons of soot per year, 1.7 percent of the global total. Using a photoacoustic spectrometer—an instrument developed at CSD—Lack and his colleagues captured detailed emissions data from tankers, cargo and container ships, large fishing boats, tugboats, and ferries, during the 2006 Texas Air Quality Study. The new paper came out in July, in *Geophysical Research Letters*.

Helping California

PSD signed a 5-year agreement with the California Department of Water Resources to help state officials improve precipitation forecasts, especially during extreme events. California's aging water infrastructure (for supply and flood protection) is struggling to meet strict standards, and will likely be further challenged by climate change. To help officials address those challenges, ESRL researchers plan to test and implement new climate and weather observing and forecasting techniques in California. The deployment will build on NOAA's Hydrometeorological Testbed project in the North Fork of the American River.

New CIRA Director

Graeme Stephens, a Distinguished Professor at Colorado State University, has been named Director of CIRA, the Cooperative Institute for Research in the Atmosphere. Stephens replaces Tom Vonder Haar, who is returning to CSU's Department of Atmospheric Science. In 2006, Stephens helped NASA launch the world's first cloud-profiling radar, CloudSat, part of NASA's A-Train of Earth



Graeme Stephens, CIRA Director

observation satellites. CloudSat measures the amount and type of precipitation in clouds, giving scientists information about fresh water on the planet and its effect on weather and climate. CIRA, established in 1980, is a joint research institute of CSU and NOAA.

Meeting Broadcasters

ESRL scientists, including Alexander MacDonald discussed climate change with broadcast meteorologists this summer, when participants in the American Meteorological Society's 36th Conference on Broadcast Meteorology toured ESRL. ESRL scientists also spoke during climate change panel at the Denver conference—Randall Dole (PSD Deputy Director and ESRL Acting Deputy Director for Research) and Pieter Tans (GMD), joined Kevin Trenberth and Warren Washington from NCAR, and James O'Brien from COAPS at Florida State University.

Dozens of meteorologists participated, asking panelists to explain climate change issues simply, so meteorologists could better pass the information along to the public. Meteorologists asked panel members about ice core climate records, the lack of apparent warming in Antarctica, and scientific controversy.

Dole explained climate attribution research to the meteorologists, describing how computer models can help scientists understand *why* the climate is changing. "If you exclude greenhouse gases, you cannot simulate what has occurred in the 20th century," Dole said.

Tans said that when he began his career, he found it difficult to imagine that people could cause climate change. "It seemed impossible. How can we little human beings change the Earth? Well, we do."

Bruce Sussman, News Chief Meteorologist with



Gene Norman of KHOU-TV in Houston, Texas, asks a question during the AMS Broadcasters Annual Meeting panel on climate change. Pieter Tans (GMD) responds.

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UAS Greenland

Unmanned Aircraft Systems Let NOAA Collect Data From Remote Regions

Two lightweight airplanes zigzagged over the surface of Greenland's Jakobshavn glacier this summer—unpiloted—collecting data for researchers at CIRES and ESRL. Instruments onboard snapped photographs of glacial lakes and gathered altitude and depth information from areas otherwise inaccessible to scientists.

The Greenland mission proved to the aircraft's maker (Advanced Ceramics Research, Inc.) and to researchers that unmanned aircraft systems (UAS) have an important future as remote scientific eyes.

“UAS have the potential to revolutionize how we measure the Earth system, a revolution as significant as that created by radar in the 1950s or satellites in the 60s, 70s and 80s,” said Marty Ralph, who has been managing ESRL's UAS projects. Robbie Hood is taking over that work this fall.

Unmanned aircraft systems range from the 6-foot-wide Mantas to massive Global Hawks, with wingspans of 115 feet. NOAA is planning to focus near-term UAS work on three regions: the rapidly changing Arctic, Pacific air masses carrying moisture and aerosols into the western United States, and Atlantic hurricanes.

John Adler, NOAA Corps CDR and a graduate student at CIRES, managed the Greenland Manta work this summer, gathering data for his Ph.D. Adler and his mentors are trying to better understand the dynamics of glaciers, especially the lakes of water that form on the surface of glaciers and can suddenly drain away to great depth.

“That water on the surface drops through and, in theory, lubricates the contact between glacier and the substrate,” Adler said, “but no one has used a UAS to look into this theory.”

The changing dynamics of glacial lakes may contribute to loss of ice in Greenland—Greenland's ice sheet is disappearing by 40–50 cubic miles each year, according to NASA satellite measurements, and that rate of loss is accelerating as the region warms.

Mark Angier, president of Advanced Ceramics., who worked closely with Adler in Greenland for two weeks, said the mission was both exhilarating and challenging. One of the company's Manta's experienced a propeller failure and was forced to land on the ice pack in the fiord, where it was subsequently lost. Still, Angier called the mission a huge success for ACR. In 17 flights, the airplanes flew for 33 hours, gathering scientific data that would have been difficult or impractical to collect with manned aircraft.

“Our company is seeking to become the leader in providing unmanned aerial systems for Earth science,” Angier said, “and this mission really showed what we can do.”

ESRL's Betsty Weatherhead (GSD and CIRES) said the loss of the Manta actually confirmed the value of UAS missions, since flights invariably carry some risk, especially in remote areas. “We're glad all we lost was instrumentation, not people,” Weatherhead said.

A Manta on the airfield in Greenland



Published, by ESRL researchers, more than 50 papers this summer. Highlights are below. For a full list, <http://www.esrl.noaa.gov/quarterly>.

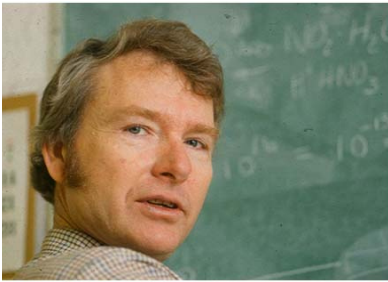
- Anderson, P. S. and W. D. Neff, Boundary layer physics over snow and ice, *Atm. Chem. Phys.*, 8.
- Augustine, J.A., G.B. Hodges, E.G. Dutton, J.J. Michalsky, and C.R. Cornwall, An aerosol optical depth climatology for NOAA's national surface radiation budget network (SURFRAD), *J. Geophys. Res.*, 113.
- Bernardet, L., L. Nance, M. Demirtas, S. Koch, E. Szoke, T. Fowler, A. Loughe, J.L. Mahoney, H. Chuang, M. Pyle, and R. Gall, The developmental testbed center and its winter forecasting experiment, *Bull. AMS*, 89 (5).
- Gensch, I.V., H. Bunz, D.G. Baumgardner, L.E. Christensen, D.W. Fahey, R.L. Herman, P.J. Popp, J.B. Smith, R.F. Troy, C.R. Webster, E.M. Weinstock, J.C. Wilson, T. Peter, and M. Krämer, Supersaturations, microphysics and nitric acid partitioning in a cold cirrus cloud observed during CR-AVE 2006: An observation–modeling intercomparison study, *Environ. Res. Lett.*, 3.
- Koch, S.E., W. Feltz, F. Fabry, M. Pagowski, B. Geerts, K.M. Bedka, D.O. Miller, and J.W. Wilson, Turbulent mixing processes in atmospheric bores and solitary waves deduced from profiling systems and numerical simulation, *Mon. Wea. Rev.*, 136 (4).
- Lack, D., B. Lerner, C. Granier, T. Baynard, E.R. Lovejoy, P. Massoli, A.R. Ravishankara, and E.J. Williams, Light-absorbing carbon emissions from commercial shipping, *Geophys. Res. Lett.*, 35.
- Lu, C. and S. Koch, Spectral and structure function analyses of gravity waves and turbulence in the upper troposphere, *J. Atmos. Sci.*, 65 (8).
- Oltmans, S.J., A.S. Lefohn, J.M. Harris, and D.S. Shadwick, Background ozone levels of air entering the west coast of the U.S. and assessment of longer-term changes, *Atmos. Environ.*, 42.
- Parrish, D.D., D.B. Millet, and A.H. Goldstein, Increasing ozone concentrations in marine boundary layer air inflow at the west coasts of North America and Europe, *Atmos. Chem. Phys. Discuss.*, 8.
- Patra, P. K., Takigawa, M., Dutton, G. S., Uhse, K., Ishijima, K., Lintner, B. R., Miyazaki, K., and Elkins, J. W., Transport mechanisms for synoptic, seasonal and interannual SF₆ variations in troposphere, *Atmos. Chem. Phys. Discuss.*, 8.
- Penland, C., and B.D. Ewald, On modeling physical systems with stochastic models: diffusion vs. Levy processes, *Phil. Trans. Royal Society A*, 366 (1875).
- Pincus, R., C. Batstone, R. J. Hofmann, K. E. Taylor, and P. J. Glecker, Evaluating the present-day simulation of clouds, precipitation, and radiation in climate models, *J. Geophys. Res.*, 113.
- Roberts, J.M., H.D. Osthoff, S.S. Brown, and A.R. Ravishankara, N₂O₅ oxidizes chloride to Cl₂ in acidic atmospheric aerosol, *Science*, 321.
- Schlatter, P.T., T.W. Schlatter, and C.A. Knight, An unusual hailstorm on 24 June 2006 in Boulder, Colorado. Part I: Mesoscale setting and radar features, *Mon. Wea. Rev.* 136.
- Schwarz, J.P., R.S. Gao, J.R. Spackman, L.A. Watts, D.S. Thomson, D.W. Fahey, T.B. Ryerson, J. Peischl, J.S. Holloway, M. Trainer, G.J. Frost, T. Baynard, D.A. Lack, J.A. de Gouw, C. Warneke, and L.A. Del Negro, Measurement of the mixing state, mass, and optical size of individual black carbon particles in urban and biomass burning emissions, *Geophys. Res. Lett.*, 35.
- Wang, W., S. Liang, and J.A. Augustine, Estimating high-spatial resolution clear-sky land surface upwelling longwave radiation from MODIS data, *Trans. Geosci. Rem. Sens.*, in press.
- Zuidema, P., H. Xue, and G. Feingold, Shortwave radiative impacts from aerosol effects on marine shallow cumuli, *J. Atmos. Sci.*, 65.

Fred Fehsenfeld Symposium

Scientists from around the world gathered at ESRL for two days in late September, to celebrate Fred Fehsenfeld's 46 years of scientific achievement and leadership at NOAA. Fehsenfeld, who turns 74 in October, agreed to the celebration, he said, on one condition: "This is a celebration for us, not me."

To his colleagues, Fehsenfeld's insistence on sharing credit is legendary. "Collaboration is the hallmark of Fred's science," said A.R. Ravishankara, CSD Director.

In 46 years with NOAA and CIRES, Fehsenfeld published more than 300 papers, ranking among the most-cited geoscientists in the world (paper and book citations are a measure of scientific accomplishment and leadership). Fehsenfeld has also won dozens of scientific awards and honors, including the Department of Commerce Gold Medal, several Silver Medals, the NOAA Administrator's Award, and outstanding paper awards.



His early work was in ionospheric chemistry, studying ion-molecule reactions that affected the propagation of radio waves in the atmosphere. Fehsenfeld and his colleagues studied scores of reactions that underpin the understanding of ionospheric chemistry to this day, said Dan Albritton, a longtime colleague, retired Acting Director of the Earth System Research Laboratory, and Director of the former Aeronomy Laboratory. In the 1980s, Fehsenfeld shifted down in altitude, to study the more complicated chemistry of the troposphere, especially as it relates to pollution. He and several colleagues won a Group Silver Medal in 2004, for discovering a previously unrecognized factor contributing to ozone pollution in the Houston region.

"He changed his research thrust as the societal needs for scientific information changed. In this way he epitomizes the best of NOAA research," wrote Richard Spinrad, Assistant Administrator of NOAA for OAR. Spinrad could not attend the symposium but sent a letter praising Fehsenfeld's "extraordinary accomplishments." Ravishankara read the letter during the symposium, before a crowd of more than 100 people, from as far as France and Japan.

Fehsenfeld described his career shift more humbly. "When I came here forty-six years ago, we were interested in the upper atmosphere around 100 km altitude.



Fred Fehsenfeld and Daniel Albritton

However, the focus of my research has been declining at the rate of about two kilometers a year," he said. "I guess if I stay in science much longer I'll go into solid earth physics."

A week before the symposium in his honor, Fehsenfeld was compiling a PowerPoint presentation for Eldon Ferguson. Ferguson, who didn't have easy access to presentation software, was Fehsenfeld's graduate advisor at the University of Texas, and recruited Fehsenfeld to Boulder more than 40 years ago.

"I just had a little theory—Fred and Art (Schmeltekopf) did all the experiments," Ferguson said during his talk, clicking through slides that his former graduate student had prepared.

"As much as things change, they stay the same," Fehsenfeld said, smiling.

Sun-Powered Victory

In any normal cross-country car race, teams need to figure out when their vehicles are likely to run low on fuel, so they can set up pit stops. In a 2,400-mile solar race, the question is where the sun will shine brightly enough to power up solar cells. A University of Michigan team racing in the ninth annual North American Solar Challenge in July relied on data from GMD's surface radiation (SURFRAD) network—and the team won.

Michigan has won the race five times in the nine years since it began. "We've been around a long time, with years to build on what we started with," said Brad Charboneau, team meteorologist. But Charboneau was also bold enough to contact GMD several weeks before the race, to see if researchers could provide real-time solar data from SURFRAD, which includes seven stations measuring solar radiation at Earth's surface, for climate and weather forecasting. One station is in Sioux Falls, S.D., about midway through the solar car racecourse.

John Augustine of GMD said it took staff about a week to get SURFRAD data refreshing every 15 minutes instead of once daily. "We'd always talked about doing this," Augustine said. "It took some work to finally figure it out."

Scientists use SURFRAD data to validate satellite estimates of surface radiation, to build maps of solar energy resources, and to validate algorithms used in weather and climate models. In a solar race, the information helps drivers figure out how to balance speed with battery conservation,

Charboneau said. "If it's really sunny, we know we can run about 50 miles an hour and break even on the battery charge," he said. "If it's cloudy, we're running solely on the battery pack, so knowing real-time solar radiation helps us make decisions about how fast to go."



University of Michigan solar car race team members run with their vehicle across the finish line in Alberta, Canada. The team relied on solar data from GMD's surface radiation network to plan the race.

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KOIN in Portland, OR, said he appreciated the time Tans and others spent with the meteorologists over the weekend. "I got to speak in person and on tape with some of the biggest experts in the business," he said.

Alaska Observatory Chief Returning

ESRL's longtime Barrow Observatory station chief Dan Endres plans to return to Boulder in November, after 24 years of collecting atmospheric data on the tundra. Endres will move into a position in GMD's observatory operations group. Last winter, Endres recorded exceptionally warm temperatures at Barrow, with November's average 15 degrees Fahrenheit (8°C) warmer than the long-term average, and December 22°F (12°C) warmer than the norm. In the 1980s, Endres said, the Arctic Ocean 3 km away would generally freeze by mid-October. Last December, it was still not frozen, and the warmer ocean likely kept the land warmer.

ASCOS/AMISA

The Arctic climate is changing fast, with temperatures warming nearly twice as quickly as the global average. To try to understand why, ESRL and University of Colorado researchers joined international colleagues in the high Arctic this summer. The ASCOS and AMISA missions (Arctic Summer Cloud Ocean Study and Arctic Mechanisms of Interaction between Surface and Atmosphere) focused on Arctic clouds, which are dominated in the summer by low-level stratocumulus and fog. Today's climate models do a poor job handling those types of clouds in the Arctic, in part because model cloud physics have generally been built from observations made in the mid-latitudes and tropics. From the Swedish icebreaker *Oden*, stationed near the North Pole, and a NASA DC-8 research airplane, scientists collected data from the sea-ice interface through the cloud-topped atmospheric boundary layer, and into the free troposphere above. ESRL contributed a suite of remote sensors to measurement arrays on and near the *Oden*, while the University of Colorado deployed instruments on both the *Oden* and the DC-8.



University of Colorado graduate student Ankita Chaturvedi (at window) and Ellen Sukovich (PSD/CIRES) in the NASA DC-8 research airplane, during AMISA.



Dan Wolfe (PSD) and Rob Albee (GMD) by a ceilometer they tested on the roof of the David Skaggs Research Center this summer. The ceilometer, which measures distance to the base of clouds, was shipped to Poland, loaded on a Russian ice-breaker, and carried to a Russian drifting ice station in August. The ceilometer will remain deployed for a year in the Arctic Ocean. Alexander Makshtas of the Arctic and Antarctic Research Institute in St. Petersburg, Russia, was a crucial collaborator in this effort, which is part of the International Polar Year.

Acronyms

AMS: American Meteorological Society
ESRL: Earth System Research Laboratory
CIRA: Cooperative Institute for Research in the Atmosphere
CIRES: Cooperative Institute for Research in Environmental Sciences
COAPS: Center for Ocean-Atmospheric Prediction Studies
CSD: ESRL Chemical Sciences Division
GFDL: Geophysical Fluid Dynamics Laboratory
GMD: ESRL Global Monitoring Division
GSD: ESRL Global Systems Division

NCAR: National Center for Atmospheric Research
NCS: National Climate Service
NWS: National Weather Service
OAR: Office of Oceanic and Atmospheric Research
PMEL: Pacific Marine Environmental Laboratory
PSD: ESRL Physical Sciences Division
UAS: Unmanned Aircraft Systems

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