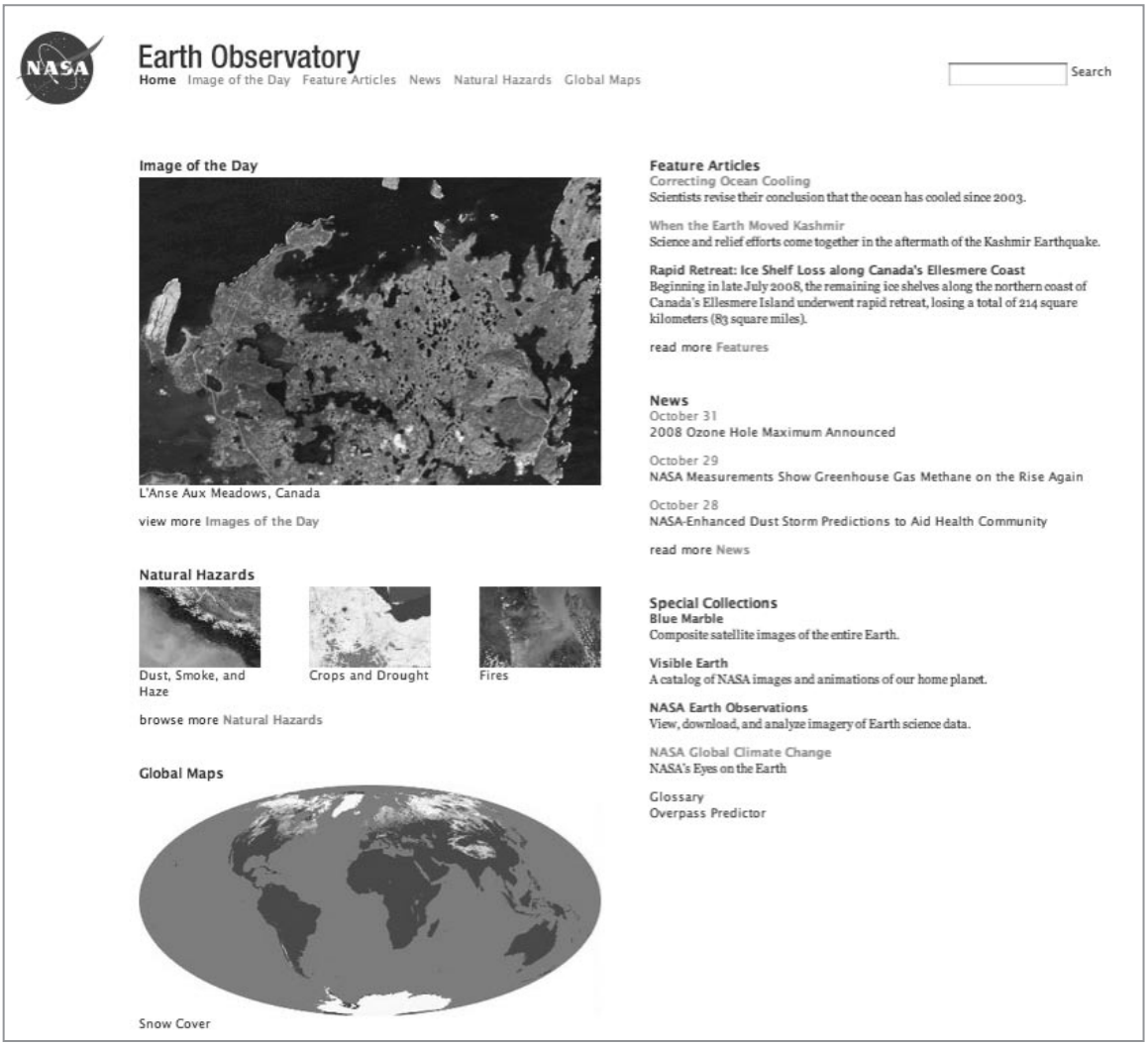
The Earth Observer. November - December 2008. Volume 20, Issue 6.

Editor's Corner

Steve Platnick
EOS Senior Project Scientist – Acting

I'm pleased to report that the Earth Observatory team has completed an extensive redesign of their site—*earthobservatory.nasa.gov.* Over the course of the past year, the team was hard at work implementing a new underlying core that included development of an improved information architecture, as well as administration and content management tools. Along with a redesigned user interface, these efforts have culminated in the launch of the *new* Earth Observatory (see screenshot below). This undertaking leaves the team better positioned to tackle additional components and content for the site as they look forward to their 10th anniversary in April 2009. Congratulations to the Earth Observatory team on their progress in maintaining and improving a wonderful resource for NASA Earth Science imagery, information, and news.

continued on page 2



the earth observer

eos.nasa.gov

In This Issue

Two new Earth observing missions are preparing for launch in early 2009. Final preparations are underway for a scheduled January launch of the Orbiting Carbon Observatory (OCO) from Vandenberg Air Force Base in California. OCO is an Earth System Science Pathfinder (ESSP) mission that will make column measurements of atmospheric carbon dioxide (CO_2). *The Earth Observer* featured a report on the OCO mission in its September–October issue [**Volume 20, Issue 5**, pp.8-11.]

Following shortly on the heels of OCO will be the latest satellite in the Advanced Television Infrared Observational Satellites -N series built by Lockheed Martin Space Systems Company. The NOAA-N Prime spacecraft is scheduled for launch from Vandenberg in February, and will complement NOAA-N (in orbit since 2005). As with previous members of the series, NASA Goddard Space Flight Center developed the spacecraft and will hand it over to NOAA to manage and operate after launch.

I can also share a progress update on the Landsat Data Continuity Mission (LDCM). The mission recently achieved an important programmatic milestone as it passed its Key Decision Point B (KDP-B) review. This means that project management has fully developed the baseline mission concept (*Phase A*) and is now prepared to complete the preliminary mission design and necessary technology development (*Phase B*). After nine years of mission formulation, re-formulation, multiple *pre-Phase A* attempts, and *Phase A*, reaching *Phase B* is a major accomplishment. Congratulations to LDCM Project Scientist **Jim Irons** and the rest of the team!

A significant consequence of the KDP-B review was a rescheduling of the LDCM launch readiness date from July 2011 to December 2012. The original date was considered excessively aggressive on the basis of historical mission development schedules and the later date was selected to reduce technical and programmatic risk. The current LDCM baseline mission includes a single Earth sensor, the Operational Land Imager (OLI) being built by Ball Aerospace Technology Corp. (BATC) of Boulder, CO. The baseline, however, does not preclude the addition of a Thermal Infrared Sensor (TIRS) at a later date. NASA is conducting efforts to reduce the risk to schedule of adding a second instrument to the LDCM payload in parallel to the development of the baseline design.

Meanwhile, the LDCM Project has already made significant progress towards the completion of *Phase B*. BATC completed a successful critical design review of the OLI on October 27-30. General Dynamics Advanced Information Systems is under contract to build the LDCM spacecraft and conducted a system requirements review in September. Also in September, NASA selected the Hammers Company of Greenbelt, MD to build the Mission Operations Element (the satellite command-and-control system). NASA and its partner in the LDCM, the U.S. Geological Survey, are working well towards the launch and operation of the LDCM.

On October 15, President Bush signed into law House Resolution 6063 known as the *NASA Reauthorization Act of 2008*. The law **authorizes** $20.21 B for NASA; of that amount, $4.93 B is for Science, including $1.52 B for Earth Science. Actual FY'09 funding is contingent on the passage of an appropriations bill that should happen early next year; NASA is so far only funded for FY'09 through a continuing resolution. That said, the resolution does provide guidance on several items relevant to Earth science including:

- Moving forward to develop and implement the new missions called for by the National Academies Decadal Survey: *Earth Science and Applications from Space*;
- developing a plan for the continuation of Landsat thermal infrared data or its equivalent, including an option for developing a thermal infrared sensor at minimum cost to be flown on the Landsat Data Continuity Mission with minimum delay to the schedule; and
- continuing funding for the Glory Mission.

To view the full text, visit: *www.govtrack.us/congress/billtext.xpd?bill=h110-6063.*

On a related note, I want to recognize the recent historic election of Barack Obama as President of the United States. During the campaign, then-Senator Obama had an opportunity to respond to questions concerning a diverse set of science issues, including some directly relevant to NASA Earth Science [1]. His answers expressed a desire to make science and technology—including climate change research—a high priority in his administration. I am hopeful that this will translate into policies that bode well for NASA, and in particular, for the future of Earth Sciences at NASA and elsewhere across the nation.

And finally, another year has somehow managed to draw to a close sooner than seems possible. On behalf of the entire staff of *The Earth Observer* I want to wish everyone a safe and enjoyable Holiday Season and all the best in the coming year.

[1] An organization called *ScienceDebate 2008* put before Obama and McCain a list of the *"top 14 science questions facing America,"* and solicited answers as to how each would respond to these issues if elected President. You can view responses at: *www.sciencedebate2008.com/www/index.php?id=42.*

On November 4, 2008, NOAA-N Prime—the latest polar-orbiting operational environmental weather satellite developed by NASA for the National Oceanic and Atmospheric Administration—arrived by C-5A military cargo aircraft at Vandenberg Air Force Base, CA, in preparation for a February launch.

feature articles

Using Remote Sensing for Improved Decision Making for Food Security

Molly E. Brown, SSAI / NASA Goddard Space Flight Center, molly.brown@nasa.gov

Earth observing satellites provide a wealth of information that is useful in assessing food security. FEWS NET's use of remote sensing has brought satellite-derived data and information to the attention of a wide variety of professionals across the world.

Early warning systems exist to warn the public and governments about impending climate- or weather-related hazards and other threats. The U.S. Agency for International Development's (USAID) Famine Early Warning Systems Network (FEWS NET) is a state-of-the-art warning system for the early detection of famine and food security crises in 25 countries around the world. Remote sensing data are critical tools for FEWS NET, as they provide early, reliable, and quantifiable estimates of large scale declines in agricultural production in regions at risk. In this article, the author describes FEWS NET, its structure, and its use of remote sensing data for detection of food security crises.

Introduction: The Famine Early Warning Systems Network

The Famine Early Warning Systems Network is a USAID-funded activity that collaborates with international, regional, and national partners to provide timely and rigorous early warning and vulnerability information on emerging and evolving food security issues. FEWS NET professionals in Africa, Central America, Haiti, Afghanistan, and the U.S. monitor and analyze relevant data and information in terms of its impacts on livelihoods and markets to identify potential threats to food security—see **Figure 1**. These threats are quantified into four categories: generally food secure, moderately food insecure, highly food insecure, and extremely food insecure. These categories are associated with nutritional outcomes as well as humanitarian responses required to alleviate these consequences.

Once the threats to food security are identified and quantified, FEWS NET uses a suite of communications and decision support products to help inform decision makers as they develop strategies to mitigate food insecurity. These products include monthly food security updates for 25 countries, regular food security outlooks and alerts, as well as briefings and support to contingency and response planning efforts. There are also more in-depth studies in some areas such as livelihoods and markets that provide additional information to support analysis as well as program and policy development.

One important source of information for FEWS NET is that of satellite remote sensing. Earth observing satellites provide a wealth of information that is useful in assessing food security. FEWS NET's use of remote sensing has brought satellite-derived data and information to the attention of a wide variety of professionals across the world. **Table 1** lists people at a variety of scales and organizational affiliations that have seen

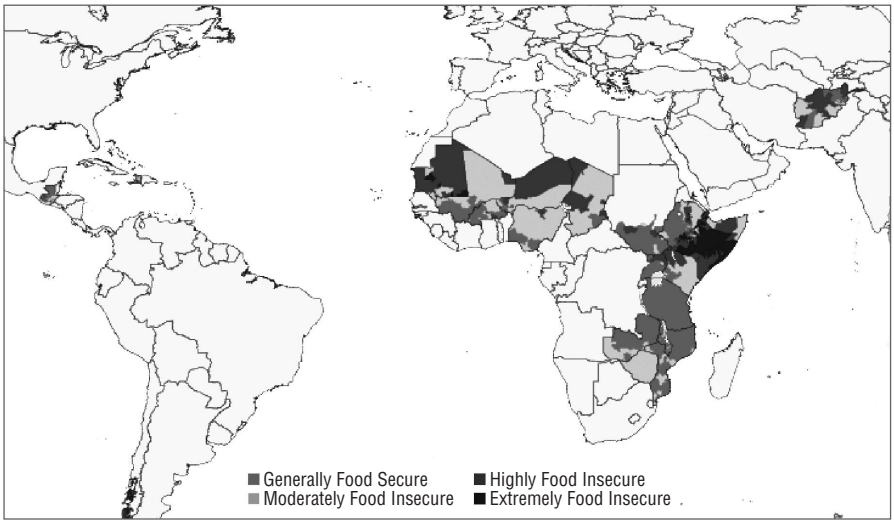


Figure 1. FEWS NET country locations and sub-national food security status, as of October 2008. To view this image in color please visit: *www.fews.net/Pages/imageryhome.aspx?map=0*

	Local	National	Regional	International
Community	Individuals with access			
Civil Society	Local NGOs	National NGOs	Regional NGOs	International NGOS (e.g., Save the Children, Oxfam)
Government or intra-governmental	Municipal or departmental government	Ministry of Agriculture, Health Parliament	ECOWAS SADC African Union	United Nations General Assembly
Private Sector	Local shop owner or trader	National Companies	Regional Companies	Transnational Corporations
International organizations			CILSS	FAO WFP
Donors		National Government Private sector	African Development Bank	USAID DFID EU

Table 1. A summary of the use of remote sensing-based data by people in different communities, at different scales (from R. Choularton, FEWS NET web site).

NGO = Non Governmental Organization
ECOWAS = Economic Community of West African States
SADC = Southern African Development Community
CILSS = Comite Permanent Inter.Etats de Lutte Contre la Secheresse au Sahel (CILSS)
FAO = Food and Agriculture Organization
WFP = World Food Program
USAID = U.S. Agency for International Development
DFID = Department for International Development (United Kingdom)
EU = European Union

and used remote sensing derived data for food security analysis in the context of FEWS NET's work. Broadening the audience for remote sensing derived information is a key part of improving decision support for weather and climate information globally [*Ingram and Stern*, 2007].

Broadening he audience for remote sensing derived information is a key part of improving decision support for weather and climate information globally.

In addition to increasing the use of remote sensing, FEWS NET also focuses its efforts on strengthening early warning and food security networks. Activities in this area include developing capacity, building and strengthening networks, developing policy-useful information, and building consensus around food-security problems and solutions.

FEWS NET's Structure

The most visible parts of FEWS NET are its field offices and field representatives in roughly 31 countries, and a contractor in Washington, DC (with an office located near USAID) that manages and technically directs them. The contractor is responsible for integrating FEWS NET's global early-warning information, resources, and training activities, in the field and in Washington, DC, and delivering finished products to information-gathering and decision-making processes of USAID both in Washington and the field, as well as to a broad range of international partners. At the time of this writing, these offices are in the following locations:

- *Africa*: Regional offices in Niger, Kenya, and South Africa. National offices in Senegal, Mauritania, Mali, Burkina Faso, Niger, Chad, Northern Sudan (located in Khartoum), Southern Sudan (located in Kenya), Eritrea, Ethiopia, Somalia (located in Nairobi), Kenya, Uganda, Angola, Tanzania, Rwanda, Malawi, Mozambique, Zambia, Zimbabwe, and South Africa (for coverage of Lesotho, Swaziland, and Botswana).
- *Central America*: Guatemala.
- *Caribbean:* Haiti.
- *Central Asia:* Afghanistan.

FEWS NET is composed primarily of local experts who work with specialists in the U.S. who coordinate their reporting. The field offices produce most of the reports, but the U.S. contractor manages and coordinates all reports so that a similar message is conveyed to decision makers. The organization estimates local food availability, access, and utilization with a wide variety of datasets, including remote sensing data, ground measurements of food production measuring *supply*—how much food is available in the region or country—and a wide range of other indicators meant to measure *demand*—the ability of a population to purchase food, including income and cost—in concert with political and economic pressures that may affect a region's food security [*Brown*, 2008]. Although FEWS NET's early and actionable information can motivate intervention to break the link between climate extremes and famine, it does not respond itself.

Table 2. Weather, climate, and crop information used by FEWS NET in its activities.

Parameter	Product	Source
Precipitation	NOAA Rainfall Estimate (RFE) TRMM 3B42 CMORPH	TRMM Meteosat AMSR-E NOAA GTS gauge
Derived products	Crop models Standardized Precipitation Index Start of season Number of dry days	TRMM AMSR-E AVHRR
Vegetation	NDVI	AVHRR SPOT VGT MODIS
Global Climate indicators	MJO Water vapor Temperature	MODIS AVHRR
Forecasts	Precipitation Wind Temperature	GFS, NAM, WRF models

NOAA = National Oceanic and Atmospheric Administration
TRMM = Tropical Rainfall Measuring Mission
CMORPH = Climate Prediction Center Mapping Technique
AMSR-E = Advanced Microwave Scanning Radiometer for EOS
GTS = Global Telecommunications System gauge dataset
AVHRR = Advanced Very High Resolution Radiometer
NDVI = Normalized Difference Vegetation Index
SPOT = System Pour l'Observation de la Terre (from SPOT)
VGT = Vegetation Index
MODIS = Moderate Resolution Imaging Spectroradiometer
MJO = Madden-Julian Oscillation
GFS = Global Forecast System
NAM = North American Mesoscale
WRF = Weather Research and Forecasting Model

Remote Sensing Datasets

Along with daily, weekly, 10-day, and monthly precipitation estimates for the Africa region, FEWS NET's staff and partners monitor meteorological and climatic phenomena for the continent including dryness, drought, flooding, temperature extremes, cyclones, and organized storm systems—see **Table 2**. A weekly weather hazards product is disseminated to give users early information that may help to make more accurate, relevant decisions—see **Figure 2**. The assessment of the weather in light of food security provides an opportunity to examine relevant remote sensing data products to determine if they show dryness in regions that are prone to food insecurity and if all the different products point to a similar level of dryness.

The major products that are viewed during the weekly weather assessment are the Rainfall Estimate (RFE), the water requirement satisfaction index (WRSI) and the Normalized Difference Vegetation Index (NDVI) from the Moderate Resolution Imaging Spectroradiometer (MODIS) and the Advanced Very High Resolution Radiometer (AVHRR). Below are general descriptions of each of these products.

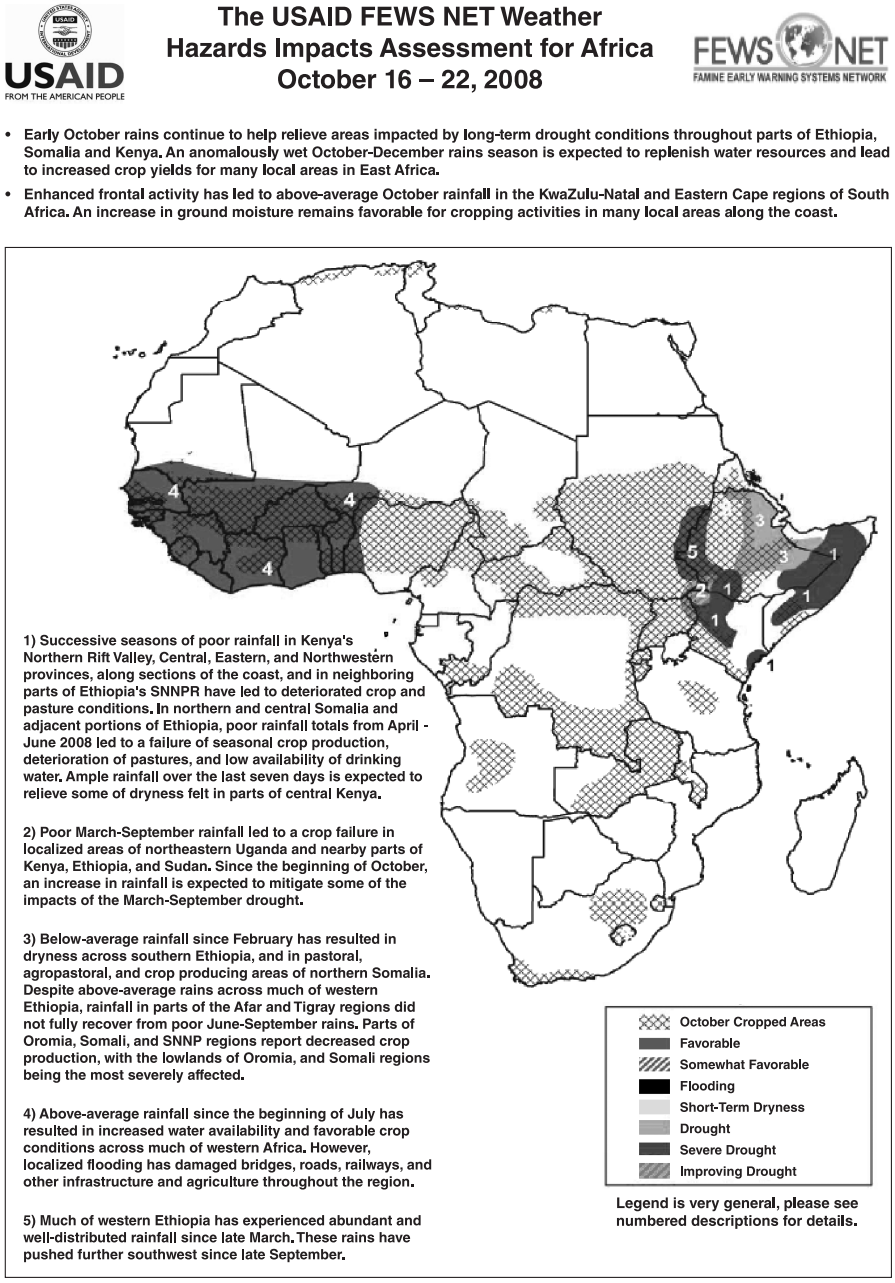


Figure 2. FEWS NET Weather Hazards Impact Assessment for October 16-22, 2008. To view this image in color please visit: *www.cpc.ncep.noaa.gov/products/fews/africa_hazard.pdf*

RFE

Rainfall Estimation (RFE) imagery is an automated (i.e., computer-generated) product which uses infrared data from the European Space Agency's Meteosat satellite, rain gauge reports from the global telecommunications system, and microwave satellite observations within an algorithm to provide RFE in millimeters (mm) at an approximate horizontal resolution of 10 km—see **Figure 3**. The main use of these data is to provide input for hydrological and agrometeorological models as well as to provide climate information—e.g., to compare the current state of rainfall with previous time periods [*Love et al., 2004*].

WRSI

The map in **Figure 4** portrays WRSI values for a particular crop from the start of the growing season until this time period. It is based on the actual estimates of meteorological data to-date. For example, if the cumulative crop water requirement up to this period was 200 mm and only 180 mm was supplied in the form of rainfall, the crop experienced a deficit of 20 mm during the period and thus the WRSI value will be ([180 / 200] * 100 = 90.0%). This approach is slightly different from the traditional

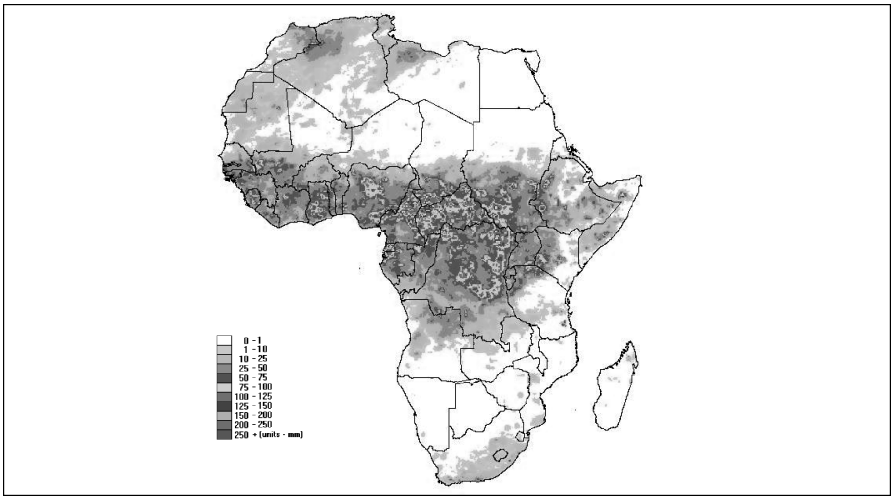


Figure 3. Rainfall estimate from the USGS early warning site. To view this image in color please visit: *www.cpc.ncep.noaa.gov/products/fews/monthly.gif*

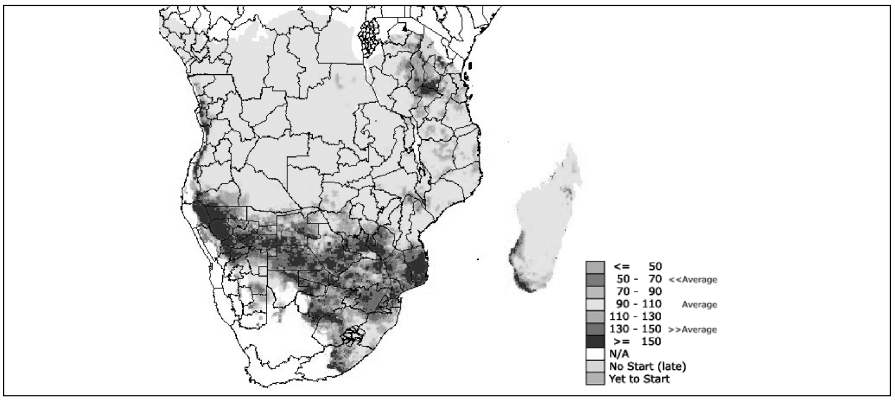


Figure 4. WRSI anomaly for maize in Southern Africa, February 2008. To view this image in color please visit: *igskmncnwb015.cr.usgs.gov/adds/imgbrowses2.php?adds=&image=cl&ext*

United Nations Food and Agricultural Organization (FAO) update. In the FAO report, the cumulative supply-to-date is compared to the total seasonal crop water requirement, instead of the requirement up to the current period. Unlike the FAO update, the current WRSI can increase in value in the later part of the growing season if the demand (crop water requirement) and supply (rainfall) relationship becomes favorable. However, both the FAO and this approach are mathematically equivalent at the end of the season (i.e., when the current ten-day period becomes the end-of-season ten-day period) [*Verdin et al., 2002*].

NDVI

NDVI imagery is calculated from the red and near infra-red reflectances observed by the AVHRR sensor on NOAA meteorological satellites—see **Figure 5**—as well as from the MODIS instrument on NASA's Aqua and Terra platforms. The NDVI image provides an indication of the vigor and density of vegetation at the surface. Images of NDVI are sometimes referred to as *greenness maps* since they represent the vegetative vigor of plants. The time series of NDVI data (from 1981–present for AVHRR) allows analysis of changes in vegetation vigor and density in response to biophysical conditions (including plant type, weather, and soil). The data are processed by NASA and represented as pixels (cells). NDVI values range between -1 and +1, with dense vegetation having higher values (e.g., 0.4–0.7) and lightly vegetated regions having lower values (e.g., 0.1–0.2). The primary use of these images is to compare the current state of vegetation with previous time periods; for example, the same time in an average year or a reference year (a particularly good or bad year) to detect anomalous conditions [*Tucker et al., 2005*].

Conclusion

Remote sensing is a critical part of FEWS NET's ability to identify and respond to weather-related food security crises. Because Africa produces 95% of the food that

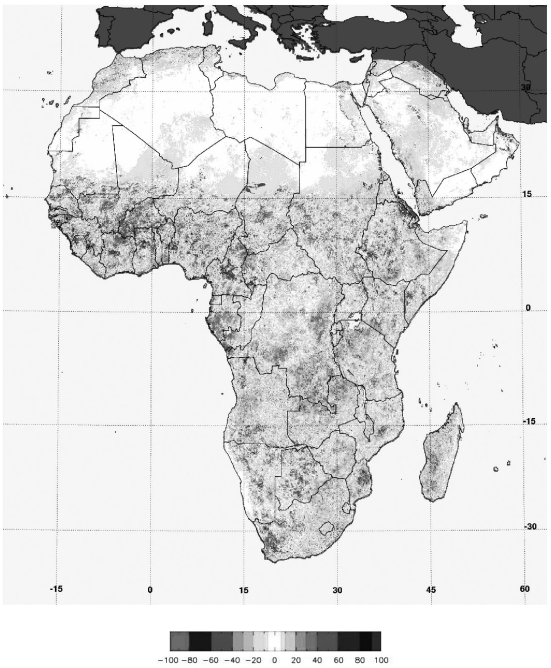


Figure 5. NDVI from the AVHRR series of satellites. To view this image in color please visit: *www.pecad.fas.usda.gov/cropexplorer/fews_briefing/*

it consumes every year, it is critical that production is closely monitored. In regions where production variability from one year to the next is high, multiple products are needed to ensure no mistakes are made. As we move into an era where climate and climate information become more and more important, it is critical that we learn how to transform biophysical data into information that can be used by decision makers. This complex task has been achieved in the context of famine early warning, and thus studying how the organization works can provide important lessons for future decision makers in their efforts to incorporate climate information into their decisions.

References

Brown, M.E. (2008) *Famine Early Warning Systems and Remote Sensing Data,* Heidelberg, Springer Verlag.

Ingram, H.M. and P.C. Stern, (Eds.) (2007) *Research and Networks for Decision Support in the NOAA Sectoral Applications Research Program,* Washington DC, National Research Council.

Love, T.B., V. Kumar, P. Xie, and W.M. Thiaw, (2004) *20-Year Daily Africa Precipitation Climatology using Satellite and Gauge Data.* The 84th American Meteorological Society Annual Meeting. Seattle, WA, AMS.

Tucker, C.J., J.E. Pinzon, M.E. Brown, D. Slayback, E.W. Pak, R. Mahoney, E.Vermote, and N. Saleous, (2005) *An Extended AVHRR 8-km NDVI Data Set Compatible with MODIS and SPOT Vegetation NDVI Data.* International Journal of Remote Sensing, 26, 4485-4498.

Verdin, J., and R. Klaver, (2002) *Grid cell based crop water accounting for the Famine Early Warning System.* Hydrological Processes, 16, 1617-1630.

Web Sites of Interest

www.fews.net—FEWS NET main web site, where all information on the system can be found.

earlywarning.usgs.gov—USGS web site where FEWS NET's remote sensing datasets can be viewed and downloaded.

www.cpc.ncep.noaa.gov/products/fews/briefing.html—Web site where NOAA has collected all its climate, weather and crop information for the weekly weather hazard analysis.

feature articles

Hanging Out in the Arctic: An Airborne Study of Arctic Atmosphere and Air Pollution, Part II

Introduction by Kathryn Hansen, NASA Goddard Space Flight Center, khansen@sesda2.com
Mike Obland, NASA's Langley Research Center, Michael.D.Obland@nasa.gov
Mike Fromm, Naval Research Laboratory (NRL), mike.fromm@nrl.navy.mil
Terry Lathem, Georgia Institute of Technology
Brian Stocks, Great Lakes Forestry Centre, Canada
Andreas Beyersdorf, NASA's Langley Research Center, Andreas.J.Beyersdorf@nasa.gov

Fly on the Wall: An Outsider's Take on the ARCTAS Mission

Sweat dripped down the co-pilot's brow as the flight crew flipped switches and checked gauges to prepare the DC-8 for takeoff. They were immersed in their work, but not too immersed to crack jokes through the headsets. I occupied the last seat in the cramped cockpit, trying to be a *fly on the wall* observing the take-off from Four-Wing Air Force Base in Cold Lake, Alberta, Canada. It was hard to be invisible with unwieldy video equipment in my lap.

Returning to the main cabin, I was awed by how many science experiments could be crammed into the small NASA plane. Nearly every other seat had been removed and replaced with an elaborate contraption to study the atmosphere outside, as part of the Arctic Research of the Composition of the Troposphere from Aircraft and Satellites (ARCTAS) mission. Instead of a book or an in-flight snack, the scientists occupied themselves with computer displays of instrument conditions and data.

After learning about how this gadget and that experiment worked, I found myself wanting to know more about the scientists themselves, many of whom leave their offices for field work almost every summer. Others, including myself, were journeying into the field for the first time.

For one scientist, who was also a father, the ARCTAS mission meant yet another missed family vacation. Another researcher, passionate about cycling with a team back in Colorado, was told to leave behind his bicycle in order to better focus on the work at hand—but managed to secure an old Peugeot bike during a short stopover flight in Greenland. He described an unforgettable ride among icebergs. Still another spoke of returning to Nepal, using what he learned in North America to expand and improve atmospheric science on the other side of the world.

For our eight-hour flight on July 1 [see corresponding blog entry on page 17] the focus was forest fires. I could hear over the headsets as pilots and crew compared notes with modelers, fire trackers, and weather forecasters on the ground to find the most productive flight path. They were hunting for smoke to fly though, over, and downwind. Their goal: unravel how the Arctic atmosphere is affected by forest fires in the region and by pollution from around the world.

A few hours into the flight, a yellow-brown haze clouded our view and filled the cabin with the smell of smoke. What seemed like a huge plume to me, I later learned, wasn't so big to the veterans of such flights and studies. But the turbulence and the view were enough to catapult me from my perch near the only window free of science equipment. I felt exhilarated, and it was enough to rouse even some of the more seasoned scientists from their naps.

In the weeks after my flight, researchers on the ground and in the air continued the well-choreographed field campaign, fueled by coffee and a determination to see years of planning pay off. A celebratory "grill-out" was a rare luxury, and the Fourth of July came and went like any other day of the week.

The trip and flight marked the first time in my career that I have joined the subjects of my stories in the field. Sure, I could learn a lot of science and other details remotely—by phone, paper, and e-mail—without ever leaving my office. But I never would have known that under the surface of ARCTAS was the untold story of intriguing, dedicated characters more engaging than anything on TV—even *Canadian Idol*.

And now *The Earth Observer* is pleased to continue to tell the *untold* story of ARCTAS and provide you, our readers, a behind-the-scenes look at a NASA field campaign from the perspective of the scientists involved …

ARCTAS is a NASA campaign with teams of scientists operating a variety of different instruments aboard three airplanes: the DC-8, P-3, and the King Air B-200. The first phase of the ARCTAS campaign took place in Barrow, Alaska in February of this year, and the primary objective was to make measurements of Arctic haze. The goal of the second phase is to measure forest fire smoke from the boreal forests, and the

Northwest Territories of Canada in July is an ideal place for these kinds of observations. In the July–August issue of *The Earth Observer* [**Volume 20, Issue 4**] we presented a summary of the first part of the mission and now we bring you the conclusion.

What follows is a series of blog entries that were compiled during the second part of ARCTAS from a number of the scientists who participated in the research and posted periodic updates as the campaign progressed. To view the complete blog please visit: *blogs.discovery.com/earth_live_arctas2/*. The condensed blog has been reprinted with the permission of *Discovery earthlive*™.

It's déjà vu all over again…

Mike Obland [NASA Langley Research Center (LaRC)]

Boulder, CO
June 23, 2008

Here we go again! The NASA *King Air* B-200 aircraft should be transiting to Yellowknife, Canada, in the Northwest Territories tomorrow to begin the second phase of the Arctic Research of the Composition of the Troposphere from Aircraft and Satellites (ARCTAS) campaign.

I am a research scientist with Science Systems and Applications Incorporated (SSAI) at NASA Langley Research Center on a team that operates the NASA airborne High Spectral Resolution Lidar (HSRL) instrument. Besides myself, the cast of characters for this latest adventure includes the principal investigators for the HSRL instrument, **Chris Hostetler**, **Rich Ferrare**, and **John Hair**, who are all involved with various planning aspects of the ARCTAS campaign. **Tony Cook** and **Dave Harper** are the brilliant engineers who built the instrument. **Ray Rogers** is another SSAI research scientist who shares the HSRL operation and data analysis duties with me. We will split the duties of the campaign such that one of us flies with the instrument while the other stays on the ground to analyze the data. Rounding out the ARCTAS 2 team is the airplane crew who make the flights possible. **Mike Wusk** is joining us again as co-pilot and logistics guru. The pilot duties are being handled by veteran pilot **Les Kagey**. The maintenance guys who keep the airplane running in top shape are **Dale Bowser**, **Mark Hinton**, and **Ed Kirby**. Everyone in this group is from NASA Langley Research Center (LaRC).

Field campaigns are always an adventure, and I'm sure this one will be no different. Yellowknife is out in the Canadian wilderness, at about the same latitude as Fairbanks, AK. Hopefully, we will be able to take some time to hike and see some local wildlife (besides mosquitoes), like the black bear that I saw on a hiking trail outside of Boulder tonight.

Before coming to Cold Lake, Alberta for ARCTAS, Mike Obland attended a meeting in Boulder, CO, and while he was there he spotted a black bear on a hiking trail outside the city.

All Systems Go

Mike Obland [NASA Langley Research Center (LaRC)]

Boulder, CO
June 24, 2008

The *King Air* is on its way to Canada. Les, Mike, Dale and Ray left Langley Research Center about noon today. Besides a minor problem with a single temperature sensor that Dave fixed before the airplane took off, the HSRL instrument operated perfectly. This was comforting because we had difficulties with our inertial measurement unit (IMU) in Alaska, and we were thankful that this problem is now fixed. The IMU provides airplane attitude data, including heading, pitch, and roll, which are necessary variables for analyzing our data. It is very sensitive to magnetic fields and was being adversely affected by magnetic metals in the plane and the rapidly changing magnetic field near the North Pole. We found a better position for the IMU so that we do not encounter these problems again. The only other major problem that we had while in Alaska was keeping the laser warm, but we should not have any problems with that in Canada in June and July—the article in the July–August issue chronicled the blog entries that discussed some of these technical challenges.

The HSRL took data today on a Cloud–Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) *overpass*—meaning that the *King Air* flew on the same track that the CALIPSO satellite was flying over. This is one of our instrument's primary purposes: to compare our data with the CALIPSO satellite for validation purposes. We will do these *CALIPSO runs* many times in the coming weeks, I'm sure. After a successful flight, the crew landed in Sault Ste. Marie, Canada, where they will spend the night. They should arrive in Yellowknife tomorrow night.

Christmas in June

Mike Fromm [Naval Research Laboratory (NRL)]

Cold Lake, Canada
June 25, 2008

Today is the science equivalent of Christmas Eve for me. I'll probably be dreaming of smoke plumes instead of sugar plumes—er, plums. Tomorrow, we descend on Cold Lake, Alberta and Yellowknife, Northwest Territories for 17 days of intense measurements from ground, air, and space. These measurements are focused on boreal wild fire, smoke, other emissions, and pollution in general.

The boreal forests of Canada and Alaska have been burning and impacting the atmosphere in the Arctic as well as in the mid-latitudes for eons, yet we still know very little about the true scope of their impact. For instance, in the area I study, it was not known until about 10 years ago that forest fire smoke (and other emissions) can enter the stratosphere. Indeed the discovery of stratospheric smoke violated one of meteorology's basic rules. These smokes enter violently in fire-generated thunderstorms, called pyrocumulonimbus (pyroCb), and share many qualities with volcanic eruptions. Unlike volcanoes however, the pyroCb eruption occurs where and when fire and weather conditions conspire to allow for a monstrous amount of heat energy release—and that occurs surprisingly often in Canada, Russia, the U.S., and even Australia.

I'm excited to be partnering with **Brian Stocks**, a forest science expert who will be on his home turf during the NASA ARCTAS campaign. Brian has seen thousands of fires

This photo shows a well-developed pyrocumulus cloud produced by a bushfire in the Gila River valley southwest of Phoenix, AZ, July 1, 2008. **Credit:** Wikipedia, T19380.

up close (and even set a few—strictly for science purposes, of course) and strongly believed the stratospheric potential of pyroCb before the world started paying attention. So you see why I'll be dreaming of smoke plumes. Between now and July 14, we hope to see one of these beasts "up close and personal" and learn a lot more about the causes, dynamics, and weather/climate impact.

NASA and other international collaborators have several other drivers and objectives for this International Polar Year (IPY) study, so I'm sure others are having their own dreams on the eve of this big, exciting event.

Relaxing Before the Push

Mike Obland [LaRC]

Boulder, CO
June 25, 2008

I should take this opportunity to introduce a new colleague on our Yellowknife crew: **Kirk Knobelspiesse**. Kirk is a graduate student at Columbia University and is responsible for maintaining a new instrument that was installed in the rear of the *King Air* for this campaign, the Research Scanning Polarimeter (RSP). The principal investigator for RSP is **Brian Cairns** at the NASA Goddard Institute for Space Studies (GISS). RSP is a *passive* instrument, meaning it only collects sunlight that is scattered back to it from the atmosphere and the surface. This is different than our HSRL, which as an *active* instrument sends out its own light (the laser) to scatter off the atmosphere. RSP actually measures a very special parameter of the scattered light known as *polarization*—the orientation of the electric field of the light. These polarization measurements provide the RSP scientists with information about the ground, atmosphere, and clouds that the RSP is viewing. RSP makes these measurements at a number of different wavelengths or "colors" of light, and at a number of different viewing angles—hence the "scanning" part of its name. Its detectors have to be VERY cold, so the instrument includes a *dewar*—a special insulated metal bottle filled with liquid nitrogen. Not only is RSP's data useful for atmospheric studies, RSP is also the airborne analog of an instrument that is scheduled to launch into orbit June 2009 onboard the Glory satellite. The joint data that we take on this mission will hopefully help us understand how to combine active and passive data to retrieve even more useful data about the atmosphere, both now and after the Glory satellite launches. We are glad to have Kirk and the RSP along on this trip.

Some Wild Rides

Terry Lathem [Georgia Institute of Technology (Georgia Tech)]

Palmdale and Ames, CA
June 26, 2008

California Air Resources Board (CARB) flights are now reaching their conclusion[1]. The CARB science flights (four for the DC-8 and one for the P-3) have been successful and exciting flights that have provided interesting case studies on particular sources of air pollution, how this pollution is transported, and how it may modify the climate. We measured everything from the reactive gases in the atmosphere that creates the smog and haze, to the particles floating around in the atmosphere and the radiation emitted by the clouds.

I have spent the CARB mission between Palmdale, CA (where the DC-8 is stationed) and Ames near San Francisco (where the P-3 is stationed). For both the ARCTAS and CARB missions, I have integrated a cloud condensation nuclei (CCN) instrument onto both aircraft and have been operating them simultaneously. CCN are those particles in the atmosphere that form cloud droplets, so my focus for both CARB and ARCTAS is to understand how various types of air pollution affect cloud properties.

The first DC-8 flight was about six hours and took us around the Los Angeles region, out over the coast to sample a smoke plume from the recent wildfires in the region, and then down to Santa Barbara and San Diego. We conducted two *missed approaches* at Los Angeles International Airport (LAX), where the plane approaches the runway

[1] NASA agreed to perform several additional ARCTAS flights in support of CARB interests prior to sending the aircraft to Cold Lake, Alberta. The data collected in California provide a greater dynamic range for measurement intercomparisons and valuable contrast and planning information for an upcoming NOAA field campaign in 2010.

fast and low, but does not land. Not only are these missed approach flights exciting to experience but they also allow us to get as close to the surface as possible, where the highest concentrations of local pollutants are usually located. Many instruments during the missed approach at LAX measured their highest readings for the ARCTAS mission thus far, and others their highest readings ever.

Tuesday, I was onboard the P-3 chasing ships out over the waters of San Francisco Bay and Los Angeles. The objective was to track the ship plumes and determine if there were any indications of particle-cloud interactions. We all had a lot of fun finding and chasing down ships over the open waters with the P-3. We would identify them on the navigation software, and then vector the plane in on their coordinates. Once we made visual contact, we descended to about 200 feet to get in line with the plume behind the ship. We followed the plume until just passing by the ship, where we then turned around to go back through the plume at a different angle or weaved in and out of it. After eight hours, we had tracked and chased down 19 cargo ships with great success.

This was also my first time flying on the P-3, and it is a completely different experience from the DC-8. The DC-8 is more like your traditional airliner, but the P-3 with its four humming propellers, can maneuver much faster and turn tighter. It also has a tendency to be a little more turbulent, especially when you are flying 200 feet above the ocean with 40-knot winds. I would say it is certainly not for those weak in the stomach, but if you can handle it, it is a fun ride and one you will not soon forget.

Now we prepare for the next mission ahead: Cold Lake, Alberta. I leave tomorrow morning and we will all have to wait and see what adventures unfold in Canada.

Getting Ready

Brian Stocks [Great Lakes Forestry Centre, Canada]

Palmdale and Ames, CA
June 26, 2008

Well, June 26th has finally arrived and, after many months of planning, the summer phase of ARCTAS begins today in Cold Lake, Alberta. The NASA aircraft and close to 140 people are arriving later today. Over the next 16–17 days, we are hoping to track and sample smoke from boreal forest fires in northern Canada.

Warm and dry burning conditions persist in northern Saskatchewan, with large fires occurring and exhibiting intense behavior. Fires in this region of Canada are monitored but not actively suppressed, as they are essential to the maintenance and health of boreal forest ecosystems. Defensive actions are taken if small communities are threatened, and a number of evacuations have already taken place, primarily to prevent smoke-related health problems. Although up-to-the-minute data are not available, it appears that close to 400,000 hectares (4000 sq km) have burned in this region in recent days, and the forecast indicates that burning will continue for the next week at least.

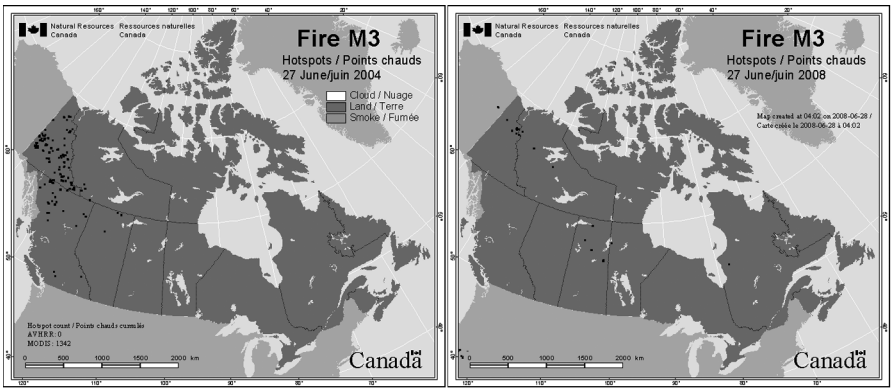
Mike Fromm, **Amber Soja**, and I have been working closely with provincial/territorial fire management agencies and various federal departments (Environment Canada, Natural Resources Canada) to forecast weather and fire danger conditions. We try to predict which fires are most likely to be most active at any given time, so that the three NASA aircraft deployed here can gather scientific fire and smoke composition/transport data in a coordinated manner.

Into Canada

Mike Fromm [NRL]

Cold Lake, Canada
June 27, 2008

Today, the business of ARCTAS got into full swing. We had an 8 a.m. all-hands meeting at *4 Wing* Cold Lake, a Canadian Air Force Base, where their elite fliers are trained. After greetings, logistics, maps, dos and don'ts, etc., we were off to find offices, plug into the Internet world, and start to work. We faced a noonish flight planning meeting so our little "Canada Fire" team (**Brian Stocks**, **Amber Soja**, and I) sniffed out where the wild fires of potential interest were burning in Canada, and even as far away as Asia.



[Left] Canadian Wildland Fire Information System (CWFIS) fire hotspot map for June 27, 2004.

[Right] The same hot spot map for June, 27, 2008. Notice the fires in Saskatchewan, Manitoba, Yukon, and the Northwest Territories, Canada, (and even one in Alaska.)

Notice that 2004 was a more active fire season than 2008, but 2008 still produced some good fires during ARCTAS.

It's Not So Cold at Cold Lake

Terry Lathem [Georgia Tech]

Cold Lake, Canada
June 30, 2008

Cold Lake is not quite what I was expecting for the eastern-central region of Alberta, Canada. It is as warm here as it is back home in northern Georgia (though certainly not as humid). These last few days have been mostly clear with lots of sunshine, pushing temperatures into the upper 70s Fahrenheit. I certainly would not have thought I would be wearing shorts, but thankfully, since we travel directly from one place to the other, I have the clothing from the deserts of Palmdale handy. The area is very flat, in fact, a local told me it was "*so flat you could see your dog run for three days out here.*" The countryside is very green and lakes are abundant.

The Cold Lake mission is off to a great start. The P-3 has finished its second back-to-back science flight and during both has gotten down and dirty into some forest fires near Lake Athabasca and the surrounding regions. We intercepted the fire plumes at various levels, and during some of the most developed fires, the plane darkened as we entered and the cabin filled with the faint scent of smoke. Instruments, of course, went crazy measuring all aspects of the chemistry and physical properties of the smoke particles. We all chimed in over our headsets, reporting record levels of species and concentrations.

Our interests extend beyond just the plume itself, as we are also interested in the transport and aging characteristics of these plumes. Therefore, we fly directly into the plumes, spiral in or around them, and fly constant altitude legs upwind and downwind to get a comprehensive sample. It has been an exciting couple of days.

A photo of Cold Lake in Alberta, Canada. **Credit:** Terry Lathem.

Yes Virginia, There is a Santa Claus!

Mike Fromm [NRL]

Cold Lake, Canada
June 30, 2008

Well, I got my Christmas, er ARCTAS, wish: a pyroCb!

I got in my room after dinner Saturday night (June 28th) hoping for an early bedtime. Checked my email, and sleep plans went out the window. **René Servranckx**—friend, and eager collaborator—had sent a late-evening satellite image of a classic pyroCb in Northwest Territories. (If you've ever played the board game *Risk* you know exactly where this is.) The cloud had just developed a couple of hours earlier.

The pyroCb was a surprise (albeit pleasant). However, it presented a challenge. We had a flight scheduled for 8 a.m. Sunday June 29, that would take on new relevance in light of this development. I scrambled together a slide presentation on the event, confirmed that this was a strong and classic pyroCb (including that the pyrocloud bubbled to the base of the stratosphere), and sent the document off to our ARCTAS team around 1 a.m. Sunday. The pre-flight briefing was 7 a.m., so I caught some sleep, hustled to the hangar early—bypassing shower and breakfast—and prepped for the flight. NASA put the B-200, P3-B and DC-8 in the air that day, so we were monitoring all three planes, plus the active fires, plus the pyroCb plume.

During the early hours of the mission, the DC-8 folks were frustrated; they were not seeing the mission's planned features of interest in Saskatchewan. (Unfortunately not on the *Risk* board; Saskatchewanians are rightly jealous of Albertans.) Flying northwest toward other remote target fires, they were stymied by cloud cover. At this point, they asked about the pyroCb's half-day old plume and whether it was reachable. We on the ground in the "Canada Fire" office (sounds impressive, if you ask me) sweated that one out, because much of the tenuous plume was at an uncertain altitude and was blowing away from the DC-8—toward Alaska.

The photo shows smoke and a capping cumulus cloud. Beautiful shot of the burning ground, dark and light plumes (indicate flaming vs. smoldering), smoke blowing off in the distance, and white cumulus clouds formed by the fires. **Credit:** Henry Fuelberg, Florida State University.

We in the "command center" are in real-time communication with the planes. The chatter was getting strained as they struggled to get their instruments to detect something interesting. We sent them to a small area based on a smidgen of evidence and heap of intuition, but soon found out that they were still detecting nothing but normal, clean air. The pressure mounted. We were pretty sure their only chance of sniffing pyroCb air was where we told them. Moreover, other parts of the plume would take them too far astray to accomplish the rest of their mission. Just after resigning ourselves to the idea that they'd come home empty-handed and frustrated, the words come over the chatter line from **David Knapp** (National Center for Atmospheric Research scientist onboard): *Bingo!* They had been flying low in the clouds. When they ascended closer to the stratosphere, all the instruments started spiking. My "Christmas" gift was delivered! The DC-8 *loitered* in that area, getting as much data as they had time for, and then went off for more objectives.

Later the pilots aborted one of the main objectives for the mission (a two-plane stacked formation), and the DC-8 folks went off to find bubbling fires. They found them and flew above a particularly turbulent fire, sending some crew, scientists, and any loose objects flying about. But they grabbed lots of good data. Several folks exclaimed at the sight of these big fires with convective clouds capping the plume ... having never seen anything like it.

I was on alert all day and never left the command center. Had three square meals of *M&Ms* (and three *Oreos* for a snack). But don't cry for me, Argentina; they were peanut *M&Ms*. When the aircraft landed, the ground contingent greeted the air contingent, and exchanged stories of the day.

At the end of the day, I brushed the *M&Ms* off my teeth and settled down for pleasant dreams.

Chasing Smoke Plumes

Mike Fromm [NRL]

Cold Lake, Canada
July 1, 2008

I was fortunate to have a chance for a ride on the NASA DC-8 today. On this venerable, former airliner now stuffed to the flaps with science instruments, we flew around fires and lots of smoke plumes at altitudes as low as 2000 feet. For a guy who is used to cruising at altitudes where the Grand Canyon looks, well, un-grand, cruising at seeming treetop level and watching birds fly by almost made me want to pull my legs up.

This novice was awestruck at the smooth operation between *science* (the experimenters) and *mission* (the aircraft crew). The communication between platform scientist **Jack Dibb** [University of New Hampshire] and crewmember **Frank Cutler** [NASA Dryden Flight Research Center] was a marvel of expert coordination. The result was a sinewy flight pattern that would have made a plate of spaghetti proud. We circled fires and weaved through plumes with a vengeance on the leg away from Cold Lake, and nearly flew back right on top of that curly pattern. Spaghetti-like as it was, it was all for a purpose. When Frank performed the post-flight roll call of the science teams, every one gave thumbs up to the completion of their objectives.

The objectives were to "sniff" smoke and other emissions from these fires. And sniff we did. In a few thick plumes, the remote sensing instrument we all have—our nose—caught the whiff of smoke in the cabin. We sliced through the plumes low and high.

No More Gnocchi

Mike Obland [LaRC]

Yellowknife, Canada
July 2, 2008

The *King Air* crew had a busy two-flight day today, somewhat making up for yesterday's unexpected no-fly day. As it was my turn to fly, I did both flights while **Ray** handled the data analysis. The first flight took us again southeast of Yellowknife to work some smoke plumes with the P-3. I had a number of minor, annoying hardware issues to deal with upon starting the instrument, but nothing that Ray or I had not seen before. Normally these minor issues rarely happen, but I think I had four of these issues all happen at the same time on takeoff. I guess it helps to keep me alert. This is primarily what the *operator* position entails: getting the instrument running and keeping it running in optimal condition, despite any problems that may show up. There is a large amount of money and support that goes into making our missions possible, and there is a lot riding on Ray and I to get high quality data, which can make the flights stressful when something major goes wrong with the instrument.

After our first flight, we landed in Thompson, Manitoba, to refuel. Our afternoon flight had limited coordination with the CALIPSO satellite. Also, there were high velocity head winds at 28,000 feet, so we transited back to Yellowknife at 20,000 feet and could not use the RSP instrument because we were in clouds the entire trip. We still took data with HSRL on the second flight and had a successful day overall. When we arrived in Yellowknife, I handed the data over to Ray and let him handle the analysis, uploads, and dissemination of the data and flight report. I was feeling a bit under the weather from some apparent food poisoning that I picked up, and I went straight to bed. I think it will be awhile before I eat gnocchi again!

This photo gives a aerial view of a forest fire plume. **Credit:** Les Kagey.

Getting Ready for Back-to-Back Flights

Andreas Beyersdorf
[LaRC]

Cold Lake, Canada
July 4, 2008

This morning the DC-8 took off for a nine-hour flight to study fires burning in Saskatchewan and Manitoba—today was my day to stay back at the "Canada Fire" office. Another flight is being planned for tomorrow afternoon (July 5th) and a possible flight to Thule, Greenland could happen late on the 6th. These back-to-back flights usually only happen a few times during these aircraft missions.

So why do the back-to-back flights? Well, the main reason (as always) is science. Often meteorological conditions make it preferable to do the back-to-back flights. A fire or pollution plume that we might be able to sample one day may be too far away by the next. In addition, by flying on two straight days it is possible to sample the same fire plume as it ages. Another factor making back-to-back flights necessary is scheduling. The ARCTAS mission has a little over one week remaining. This means we are trying to achieve as many of our scientific goals as possible. One of these is to fly the DC-8 to Thule. This will not only allow us to study fires and pollution plumes located over Eastern Canada and the Atlantic, but it also will allow our aircraft to intercompare with a British scientific aircraft participating in the Polar Study using Aircraft, Remote

Eddie Winstead of the Langley Aerosol Research Group Experiment (LARGE) filling an instrument with butanol between flights. **Credit:** Andreas Beyersdorf

Sensing, Surface Measurements and Models of Climate, Chemistry, Aerosols, and Transport (POLARCAT)— based out of Kangerlussuaq, Greenland. This aircraft has many instruments that are also on the DC-8 and is measuring pollution plumes over

the Atlantic Ocean. During these intercomparisons the two aircraft fly close to one another—very close! This means the instrument payload on both aircraft are sampling the same air. If the two instruments agree on the pollution levels during these intercomparisons, this gives us confidence that both sets of instruments are operating correctly. This also means that we can compare our measurements from fire pollution over Canada with their measurements of fire pollution over the Atlantic and we can have a much clearer picture of what happens to the fire plumes.

Fourth of July Fireworks … in Canada?!

Mike Fromm [NRL]

Cold Lake, Canada
July, 4, 2008

Fire here in Canada is making news. The number and size of the wild fires in Saskatchewan is threatening communities, which is unfortunate indeed. Interestingly enough, some ARCTAS scientists are in regular communication with Canadian Forest Service and Provincial agencies sharing knowledge of the fire behavior and weather for mutual benefit. We are hopeful that the open sharing of information reduces risk to the vulnerable communities. And we hope that we gain insights into boreal fires that will benefit science as well…

Today we took the DC-8 out in search of pyroCb. We knew where the candidate fires were. We predicted extreme fire weather conditions over the fires in Saskatchewan. We targeted late afternoon (which is when convection is likely). On the first leg of the flight in early afternoon, we flew east into Manitoba (also not on the *Risk* board, much to Manitobans' chagrin, I'm quite sure), sniffing for "older" fire emissions. Then we did a near 180, and headed back toward Saskatchewan and our rendezvous with pyroCb destiny. As we flew above the cloud deck into the sun, we could see several deep convection towers shooting up. Question: *Were they "regular" or "pyro?"* Only one way to find out… We had a marked point to hit, right over the biggest fire of the day—the Pelican Narrows fire. As the pilots took dead aim, I peered out and scanned intently for a sign that pyroCb were popping. The wise folks in the back said, "*Mike, it's in your hands. You tell the pilots where to go*." Gulp. Just as I picked one tower out, the pilots and I saw a nasty, bubbly convective tower close and to our left. It was even tinted tan to our eyes by smoke. In a few seconds, a peculiar cloud type called *pileus* formed above the growing thunderstorm. Pileus is usually an indicator of particularly vigorous uplift. Oh, how I was tempted to ask the pilots for a diversion! But we continued straight ahead toward an ominous storm one of the pilots called a "monster." We were already under its huge anvil top. But ahead under the anvil we could see the strong cauliflower texture of the thunderstorm cell. The pilots got us right up close to the turbulent storm, the instruments in back started chirping with all kinds of marvelous anomalies, and then … we smelled smoke! At 34,000 feet! We wanted to try and get above the cloud so we could see what energetic things were happening where this storm was banging against the *tropopause*—the atmosphere between the troposphere and the stratosphere. As hard as the pilots tried, we could not ascend beyond 39,000 feet—the icy outflow of this storm still spread above. Undeterred, we decided to fly downwind somewhat and spiral down, down, down to see the *profile* of fire emissions. After a few more pointed sampling spots, we headed home to Cold Lake. As I type, we still do not know exactly how to characterize the big storm we flew into. However, it is undeniable that we experimenters encountered something never before experienced. One way or the other, this close encounter will give us important new scientific insights.

To Thule to Search for a Plume

Mike Fromm [NRL]

Cold Lake, Canada
July 8, 2008

A riddle. *If July 1st is Canada Day and July 4th is Independence Day, what is July 8th?* Thule Day, of course! (OK, so I have to work on my riddle skills.) Nevertheless, today the NASA DC-8 headed off to Thule, Greenland, for a *suitcase flight*—meaning that participants bags are packed for what is now a two-day overnight stay. This adventure is the first true Arctic probe that the ARCTAS summer team is making. The DC-8 aimed north for the Arctic Ocean, then made a right turn for Thule, and en route probed from just above wave top to the stratosphere for signals of interesting atmospheric composition. Yours Thule, I mean truly, stayed put and held hands with

the science crew from the "Canada Fire" office. The 3 a.m. departure dictated an "all nighter," something I haven't done since my teen boys were colicky infants.

Like the crew and scientists aboard this exotic flight, I prepared by grabbing some food for the long haul and getting in a few early snores. I bought a microwavable double cheeseburger and supporting food last evening, got a couple of hours sleep, then entered the hangar at 12:30 a.m. (Walking to the hangar, I could see dusk/dawn light on the northern horizon.) At 1:30 a.m. we received the preflight briefing by pilot **Bill Brockett**. After giving a final preflight heads-up on projected plume locations to some science guys, a few of us crazies stood on the tarmac waving bye-bye to the flyers. Then I retired to the cozy "Canada Fire" office for the nightlong flight support. From 3–7 a.m., I was the only one in the place. When I got hungry, I pulled out my cheeseburger. Lazy slob that I am, I bit into it cold (no microwave to be found). Not a delightful taste sensation. Eureka! We have a coffee maker with two warming plates. On go the cold patties and a few minutes later I have a hot (although not quite delicious) cheeseburger. I'll call it the *mikeywave* approach.

The ARCTAS objectives for the Thule stay-over are not only to probe deeply into the Arctic, but to rendezvous with satellite overpasses and our European colleagues working for the larger POLARCAT campaign (*www.polarcat.no/*). In particular the DC-8 will attempt to make close formation measurements with the Deutsches Zentrum für Luft- und Raumfahrt (DLR) *Falcon* aircraft operating out of Greenland for POLARCAT. The Greenland operation, which includes a permanent experiment station in Summit (*www.summitcamp.org/*), is being used to monitor long-range transport of pollutants from North America and Asia. ARCTAS is catching (if we're fortunate) the emissions and pollutants close to the source, and the POLARCAT folks are picking them up farther downstream.

The Joys of Snow Photochemistry

Andreas Beyersdorf [LaRC]

Thule, Greenland July 8, 2008

Greetings from Thule. We arrived this afternoon at 5 p.m. The fog was thick when we landed and the pilots almost had to divert to Iqaluit, Canada. Thankfully, we didn't.

During tomorrow's flight, the DC-8 will fly over Summit in order to compare our DC-8 based measurements to the ground-based measurements. Summit is located at the top of the Greenland ice sheet and is vastly different than Thule. Typically the Summit base houses 4-6 researchers during the winter and 20-30 during the summer months. There are very few buildings at the site and most of the researchers sleep in unheated tents during the summer. Transport to the base is by Air National Guard C-130s that fly to the base approximately once a month during the summer.

While it is an enjoyable place (with great food!) and a great place to do research, being in such an isolated location can be tiring. Because of the small size of the base we may not be able to see it from the plane, but I will definitely be looking out the window for it.

Highly Successful ARCTAS Canada Mission Winding Down

Brian Stocks [Great Lakes Forestry Centre, Canada]

Cold Lake, Canada, July 9, 2008

We're now down to the final few days of ARCTAS Canada here in Cold Lake. While the days have been long and the nights very short, time has passed very quickly—it's been a blur of constant activity and enthusiasm.

Although the fire season started slowly across Canada, and has been largely non-existent over most of the country this year, many large fires developed in northern Saskatchewan just as ARCTAS Canada began. During the period of ARCTAS, these fires burned over between 350,000 and 400,000 hectares in this region, providing ample targets for the three NASA aircraft to sample smoke at various altitudes above fires, and downwind for significant distances.

In all, over 170 people (scientists, technicians, aircraft crews, support staff, etc.) have been involved in ARCTAS Canada. This has been a highly-integrated project, with

modelers, satellite specialists, and atmospheric chemistry experts all working in a closely coordinated fashion to make sure that data are gathered and analyzed in a cohesive manner. The three NASA aircraft have sampled smoke from both individual fires and clusters of fires, often tracking smoke downwind through Manitoba and Ontario. Smoke has been sampled at low to high altitudes depending on the energy of the fires measured and the height at which smoke was injected into the atmosphere. Aircraft frequently operated directly under satellite routes for data-comparison purposes.

Smoke from Siberian fires entered the Canadian Arctic during ARCTAS, and this aged smoke has been located and sampled by the NASA DC-8. It will also be monitored further downstream by European aircraft participating in International Polar Year (IPY) activities. Pyroconvection has also been observed on a few fires, lofting smoke to considerable altitudes, and this smoke has also been located and sampled.

After everyone returns home this weekend and decompresses a little, data analysis will begin, and results will be reported at science meetings beginning this coming winter. It is expected that the scientific discoveries from this highly integrated project will be substantial, and will lead to follow-on projects to determine and predict fire and climate change impacts across the boreal zone globally.

This project required the cooperation of many provincial/territorial fire management agencies across Canada who provided critical support and information upon request that ensured the success of ARCTAS Canada. In particular I would like to express sincere appreciation to the fire management staff of the Fire Management and Forest Protection Branch of Saskatchewan Environment, who have provided continuous support and encouragement throughout ARCTAS.

Heading Home

Mike Obland [LaRC]

Yellowknife, Canada
July 12, 2008

Everyone met for the usual continental breakfast in the lobby of our hotel just before 6 a.m. It felt like any other science flight day, except that we were starting much earlier than normal. We drove out to the airport to begin our preflight tasks and were surprised that most of the population of Yellowknife seemed to come out to see us off. By most of the population, I mean the mosquitoes, of course. The wind is very calm early in the morning so we were swarmed both inside and out of the airplane. I think that was one of the quicker preflights that we have ever done. We quickly packed up our gear, and checked the instruments while Ed and Mark unhooked the nitrogen tank from the RSP before running inside to avoid being eaten alive.

Les, Mike, Dale, and I got on board and closed up the airplane, along with the swarm of mosquitoes that were inside. I believe we killed off the last pair of stowaways about 2.5 hours later, shortly before landing in Thompson, Manitoba. That was the worst I had seen the mosquitoes during my entire stay in Yellowknife. It was as if they were trying to leave us with an impression of the place!

The weather was decent in Canada, although very cloudy, and we were able to measure more of what looked to be smoke from a smoldering fire around Lake Athabasca before landing in Thompson. We quickly refueled there and ate breakfast at the tiny snack bar inside the Thompson airport, since we knew we would not be stopping for lunch in Duluth, MN. The weather quickly degraded as we went further south and by the time we got to Duluth the winds at the airport were reported to be gusting to 25 knots, which makes for a very bumpy ride (definitely one of the bumpier descents I have experienced in the *King Air*) and a difficult landing. You really feel all the bumps and abrupt altitude changes in an airplane as small as the B-200. Les made the landing look easy, however, which is why he is our pilot.

The customs procedures went smoothly, even though the official was nearly blown off the tarmac by the strong winds. After refueling, we were on our way to Pontiac, MI. The winds at cruising altitude were with us and we arrived in Pontiac earlier than we had expected.

A Moment to Remember

Terry Lathem [Georgia Tech]

Cold Lake, Canada, July 12, 2008

Today was my last science flight for the ARCTAS mission and it was certainly one of my most memorable on the P-3. The objectives accomplished on this approximately 7-hour flight included an intercomparison with the NASA DC-8, a detailed study on the emissions generated from the refineries at Fort McMurray, and one last hurrah of sampling pyrocumulus plumes from fires north of Lake Athabasca.

I always enjoy the intercomparisons with the aircraft. Not only are they critical for validating our instrument data across multiple aircraft platforms, but the skill with which they are executed is a remarkable sight. In past missions, I've witnessed other intercomparisons, but always on the DC-8 looking out. I've seen both the NOAA and NASA P-3's from the DC-8, and I finally got the chance to be on the other side. It was truly amazing just to look out the window of the P-3 and see the DC-8 on the right side, nearly wingtip to wingtip, slowly moving up and down with the air currents.

While I would have loved to just look out the window and marvel at the DC-8, there was real science that needed to be accomplished during this intercomparison. Because I have instruments on both aircraft, it was critical that I got them both aligned perfectly and measuring at exactly the same conditions at exactly the same time. In order to do this, I had to communicate with the DC-8 through a messaging software we have on both planes (in theory I could have just held up a sign). It's kind of like instant messaging, but in mid-air flying on a plane. Chatting with investigators on the DC-8 while monitoring my instrument, we got them both synched up nicely.

Aside from work, Cold Lake is a quiet little town and since very few of us have rental cars, most of us have stayed on base. Many people purchased cheap bikes to ride into town or go to the lake. It is certainly different, but I think many have found this mission to be a lot more fun because we all get to interact and socialize together in the evenings.

But now it is time to say our goodbyes, off-load our instruments, pack up our things and head for home, sweet home. Many of us have been on the road since February, and the chance to settle back into normal life will be great indeed. We will all certainly meet again, whether it is the next mission or a conference down the road. Until then, we will just sit back on our smooth, commercial flights back home, reflect on the memories, and ponder the meaning of our exciting data sets.

Homecoming

Mike Obland [LaRC]

Hampton, VA July 13, 2008

We had to wait at the airport to take off because the Langley air field had a short field closure scheduled, so we did not want to arrive right in the middle of that and have to circle the airport. Soon enough, we were on our way from Pontiac, MI, to Hampton, VA. The clouds cleared out around the time we passed the Virginia state border, and we were on the ground shortly after 2 p.m. to a nice homecoming of loved ones and co-workers, who showed up even on a Sunday!

It feels good to be home, and most of us will be back at work tomorrow to start analyzing the data and trying to understand the science behind it, taking off our *instrument operator* caps to put on our *scientist's* caps. This job keeps us pretty busy, but I think most of us would not have it any other way. We should be at home for a while now, but it is only a matter of time before we are off to some new location to take data. Until then, thanks for reading along and joining me on this adventure!

Citizen Science as a Tool to Engage the Public in Earth System Science: The Citizens and Remote Sensing Observational Network (CARSON) Guide

Holli Riebeek, NASA Goddard Space Flight Center, holli.riebeek@nasa.gov

Citizen science programs, programs that involve non-scientists to collect or analyze large quantities of data, are valuable in both science and informal science education. In August 2008, a two-day workshop was held at NASA Goddard Space Flight Center to explore the feasibility of using citizen science to engage people in Earth system science. During the workshop, teams of scientists, education and outreach specialists, and data providers outlined a series of three citizen science activities involving both ground-based measurements and satellite data. The activities will become the first chapters in The Citizens And Remote Sensing Observational Network (CARSON) Guide.

Introduction: *Why Citizen Science?*

Citizen science—the involvement of non-scientists in scientific research—is becoming an increasingly popular tool both for scientific research and public education and outreach. Formal citizen science programs, which organize large groups of people to collect or analyze data for a pre-defined purpose, have grown throughout the past century. Both the Audubon Society and Cornell University's Laboratory of Ornithology use volunteers to collect bird observations. *Project BudBurst* tracks the phenology of both native and common ornamental plants across North America. The U.S. Geological Survey creates community shake maps depicting the impact of earthquakes based on reports sent in through their *"Did you feel it?"* web page. Other online citizen science programs ask participants to help scientists sort through pre-existing data. For example, in *Galaxy Zoo*, participants classify galaxies observed in the Sloan Digital Sky Survey, and in a program called *Clickworkers*, which is sponsored by NASA Ames and the Extraterrestrial Intelligence Institute (SETI) , participants identify craters on Mars using images from the Viking Orbiters, the Mars Global Surveyor, and the Mars Reconnaissance Orbiter [*Méndez*, 2008].

Citizen science can be valuable to the science community because it allows the collection of more data over larger areas and longer periods of time than would otherwise be possible. If properly trained, the citizen observer can return reliable observations. In a survey of invasive and native crab species within the intertidal zone between Maine and New Jersey, volunteers identified crab species with 80–95% accuracy [*Delaney et al.*, 2008]. *Clickworkers* also reported a tight match between volunteers' work and that of planetary scientists [*Méndez*, 2008].

The citizen science program has proven to be an effective outreach tool. Evaluations of existing citizen science programs have found that they improve *scientific literacy*—both knowledge of facts and understanding of the scientific process [*Brossard et al.*, 2005; *Thompson et al.*, 2007; *Trumbell et al.*, 1999]—and increase an individual's awareness of and connection to the local environment, which can influence conservation decisions [*Evans et al.*, 2005]. Highly engaged amateur scientists, such as amateur astronomers, can also become effective ambassadors for science in their local community through visits to schools and public programs, extending the reach of education and outreach programs [*Storksdieck et al.*, 2002].

In addition to enriching their local community through educational activities, citizen scientists may also make meaningful contributions to community development and land management. *Road Watch in the Pass*, a citizen science program in Alberta, Canada, collects wildlife observations along Highway 3 in the Crowsnest Pass. These observations helped identify zones where animals were crossing the road safely and will be used to plan future expansion of the road [*Lee et al.*, 2006]. Backyard wildlife monitoring may help property owners effectively partner with land managers to implement conservation strategies [*Cooper et al.*, 2007; *Evans et al.*, 2005].

With strengths in collecting data over a wide geographic region, increasing science literacy, and helping people connect with the natural world, could citizen science be an effective tool for engaging people in Earth System Science? A common thread in successful citizen science programs is that participants are making a meaningful contribution to science or their community. Further, people are most likely to participate in a citizen science program if the subject of study is one that captures their interest or impacts them directly, since the motivation for ongoing science learning is driven by personal interest and need [*Falk et al.*, 2007]. With these conditions for success, *citizen science has the best chance of being a successful tool in helping people take ownership of global issues such as climate change if it helps participants make local observations that can be connected to larger global systems*.

Evidence suggests that many Americans may not understand the relationship between local environmental issues like air or water quality and climate. In a 2007 survey of the public attitude towards science and

technology, the National Science Foundation found that 43% of Americans expressed a strong concern for the environment, up from 35% in 2005. Though global warming was an issue of concern, it only ranked eighth among ten environmental issues. Citizen science may help individuals connect local environmental issues that concern them directly with global environmental issues like climate change.

The CARSON Guide Workshop

On August 12-13, 2008, a workshop was held at NASA Goddard Space Flight Center to lay the foundation for a program in amateur satellite-based Earth observation, titled *The Citizens And Remote Sensing Observational Network (CARSON) Guide*. The CARSON Guide has two objectives:

1. to engage people in observations of their local environment; and
2. to help people connect their local observations to global systems using satellite data.

Sponsored by the education and outreach program for NASA's Terra mission, the workshop built on the success of the *AccessData* Workshop (sponsored by TERC), used to create the Earth Exploration Toolbook (a series of classroom activities centered around online Earth science data). Like the *AccessData* Workshop, the CARSON Project workshop brought together teams of scientists, educators, outreach specialists, and data providers to generate the basis for three citizen science activities. Attendees were divided into three teams, each of which was assigned a topic for a citizen science activity. The teams developed an outline for what will eventually become a chapter of the CARSON Guide.

The 2008 summer workshop focused on air quality, water quality, and precipitation. Each team identified local environmental measurements relevant to the satellite data set(s) appropriate for their topic. In two cases, precipitation and water quality, the teams found an existing citizen science project that had developed procedures for taking the ground-based measurements. The teams then outlined a procedure for comparing the measurements to the satellite data.

In discussions held throughout the course of the workshop, the group agreed that a citizen science program meant to engage people in Earth system science would be most effective when coupled with already existing community organizations. Such organizations are already collecting data that members of the community are likely to find personally relevant. Local citizen science efforts can be expanded to a global perspective by adding activities centered around global satellite data.

The group also agreed that it would be important to provide for different levels of involvement. Some individuals may only want to participate in the citizen science program for a single event, while others may want to be more immersed in the science.

CARSON Guide Activities

The air quality team developed an activity in which participants select a normally visible landmark and photograph it at the same time daily. The citizen scientist will note weather conditions, sky color, and the Environmental Protection Agency (EPA) air quality index for the time. Over time, participants will come to recognize what poor air quality typically "looks" like. The collected photos will serve as an archive of air quality to track trends over time. A comparison of photos from all participants could be used to determine regional trends in air quality. Those interested in taking quantitative measurements would be provided with information for buying and using a pyranometer or a sun photometer to measure solar irradiance.

For the second half of the activity, citizens will be asked to conduct a qualitative comparison of true color imagery from the Moderate Resolution Imaging Spectroradiometer (MODIS), available in near real time through direct broadcast or the MODIS Rapid Response System, with their photo observations. MODIS imagery may be used to identify large-scale transport of smoke, dust, or haze. The *Smog Blog* (see related News story on p. 36 of this issue) posts a daily discussion of air quality based at least partly on MODIS imagery. This may be an outlet for citizens wishing to report their results. Those who want to do a quantitative analysis will compare MODIS aerosol optical depth values, available through the *Giovanni* or NASA Earth Observations (NEO) web sites, to numerical air quality values over time.

The water quality team based its activity on the EPA's volunteer monitoring program. The United States' water quality is monitored by federal, state, and local agencies and by volunteers. The EPA has established guidelines for measuring and reporting water quality, including stream flow, dissolved oxygen, temperature, pH, turbidity, phosphorous, and nitrates. These measurements may be shared with scientists or other citizen scientists to help identify possible point sources of pollution.

Citizen scientists will connect their measurements of local water conditions to large-scale global patterns by monitoring ocean chlorophyll concentrations in waters closest to their water shed. Those monitoring water quality in the Washington, DC. region, for example,

would track chlorophyll concentrations in the Atlantic Ocean near the mouth of the Chesapeake Bay. MODIS chlorophyll images are available through NEO, while data and images are available through *Giovanni*. Citizens would identify unusual features, note interannual seasonal variations and look for anomalous events, hypothesize for possible causes, and relate ocean anomalies to local measurements to predict potential dead zones. Buoy and sea surface temperature data can provide supporting evidence.

The precipitation team encouraged citizen scientists to join an existing rain gauge network such as the Community Collaborative Rain, Hail, & Snow (CoCoRaHS) Network and collect rainfall measurements in their backyard. Citizens can compare their measurements to other local measurements to track regional variability and/or to historical records, available through the local weather office.

Citizen scientists will compare ground-based measurements with satellite estimates using Global Precipitation Climatology Project data, available through *Giovanni* to find out how many rain gauges are required to accurately observe one satellite grid cell, and to track regional and seasonal rainfall patterns. Those wanting to do further satellite-based comparisons could compare rainfall data and vegetation growth, stream flow, fire hazards, or soil moisture.

The activities outlined during the workshop will be developed into three chapters for the CARSON Guide in late 2008 and early 2009. The activities will be evaluated through a partnership with the Maryland Science Center beginning in April 2009. The Science Center will sponsor an Earth observation club for citizen scientists. Based on the response from participants in the club, the chapters will be revised before being released through the NASA Museum Alliance.

Participants in the workshop included: **Brooke Carter** [Science Systems and Applications Incorporated (SSAI)/NASA Goddard Space Flight Center (GSFC)), **Robert Simmon** [SSAI/GSFC], **George Huffman** [SSAI/GSFC], **Holli Riebeek** [SSAI/GSFC], **Ana Prados** [University of Maryland, Baltimore County (UMBC)], **Jim Acker** [Wyle Information Systems/GSFC], **Elizabeth Youngman** [TERC], **Katie Stofer** [Maryland Science Center], **Frank Niepold** [NOAA], **Kevin Ward** [SSAI], **Erin Bardar** [TERC], **Tamara Ledley** [TERC], **LuAnn Dahlman** [TERC], **Ed Laine** [Bowdoin College], **Emil Petruncio** [U.S. Naval Academy], **David Herring** [NOAA], and **Susan Blunck** [UMBC].

References

Brossard, D., B. Lewenstein, and R. Bonney, (2005, July 15). Scientific knowledge and attitude change: The impact of a citizen science project. *International Journal of Science Education,* 27(9), 1099-1121.

Cohn, J.P. (2008, March). Citizen Science: Can volunteers do real research? *BioScience*, 58(3), 192-197.

Cooper, C.B., J. Dickinson, T. Phillips, and R. Bonney, (2007). Citizen science as a tool for conservation in residential ecosystems. *Ecology and Society*, 12(2), 11. *www.ecologyandsociety.org*/vol12/iss2/art11/

Delaney, D.G., C.D. Sperling, C.S. Adams, and B. Leung, (2008). Marine invasive species: validation of citizen science and implications for national monitoring networks. *Biology Invasions*, 10, 117-128. DOI 10.1007/s10530-007-9114-0.

Evans, C., E. Abrams, R. Reitsma, K. Roux, L. Salmonsen, and P.P. Marra, (2005). The neighborhood nestwatch program: participant outcomes of a citizen-science ecological research project. *Conservation Biology,* 19(3), 589-594.

Falk, J.H., M. Storksdieck, and L.D. Dierking, (2007). Investigating public science interest and understanding: evidence for the importance of free-choice learning. *Public Understanding of Science,* 16, 455-469.

Lee, T., M.S. Quinn, and D. Duke, (2006). Citizen, science, highways, and wildlife: using a Web-based GIS to engage citizens in collecting wildlife information. *Ecology and Society*, 11(1), 11. *www.ecologyandsociety.org/vol11/iss1/art11/*

Méndez, B.J.H. (2008). SpaceScience@Home: Authentic research projects that use citizen scientists. In *EPO and a Changing World.* ASP Conference Series, Vol 389, 219-226.

National Science Board. (2008, January) Science and Engineering Indicators 2008. National Science Foundation. Accessed October 15, 2008. *www.nsf.gov/statistics/seind08/start.htm*

Storksdieck, M., L. Dierking, M. Wadman, M.C. Jones, (2002, May). Amateur astronomers as informal science ambassadors: results of an online survey. Astronomical Society of the Pacific. Accessed October 13, 2008. *www.astrosociety.org/education/resources/AAISA-SurveyResults.pdf*

feature articles

Thompson, S., and R. Bonney, (2007). Evaluating the impact of participation in an online citizen science project: a mixed methods approach. *Museums and the Web 2007*. *www.archimuse.com/mw2007/papers/Thompson/Thompson.html*

Trumbull, D.J., R. Bonney, D. Bascom, and A. Cabral, (1999). Thinking scientifically during participation in a citizen science project. *Science Education*, 84(2), 265-75.

Web Sites

Audubon, Citizen Science: *www.audubon.org/bird/citizen/index.html*

Community Collaborative Rain, Hail, & Snow Network: *cocorahs.org/*

Cornell Lab of Ornithology, Citizen Science: *www.birds.cornell.edu/LabPrograms/CitSci/*

Earth Exploration Toolbook: *serc.carleton.edu/eet/index.html*

Environmental Protection Agency, Air Quality Index: *airnow.gov/index.cfm?action=static.aqi*

Environmental Protection Agency, Volunteer Monitoring: *www.epa.gov/owow/monitoring/volunteer/*

Giovanni: daac.gsfc.nasa.gov/techlab/giovanni/

NASA Earth Observations: *neo.sci.gsfc.nasa.gov/Search.html*

Project BudBurst: *www.windows.ucar.edu/citizen_science/budburst/*

U.S. Geological Survey, "Did you feel it?": *earthquake.usgs.gov/eqcenter/dyfi/*

announcement

Experience NASA Science at the 2008 Fall AGU

Please join us at the NASA booth (#2321) during this year's Fall Meeting of the American Geophysical Union (AGU), where we will offer a wide variety of science presentations, interactive demonstrations, and tutorials for a variety of data tools and services. This year's program begins on **Tuesday, December 16** and will continue through **Thursday, December 18, 2008**.

Science presentations will focus on a diverse range of research topics, science disciplines, and programs within NASA's Science Mission Directorate. Interactive data-oriented demonstrations will include sessions on data accessibility and search-and-order capabilities, and will feature selected data visualization, data conversion, and other data manipulation tools.

A daily agenda will be posted on the Earth Observing System Project Science Office (EOSPSO) web site—*eos.nasa.gov*—in early December.

We look forward to seeing you in San Francisco!

Arctic Sea Ice Down to Second-Lowest Extent; Likely Record-Low Volume

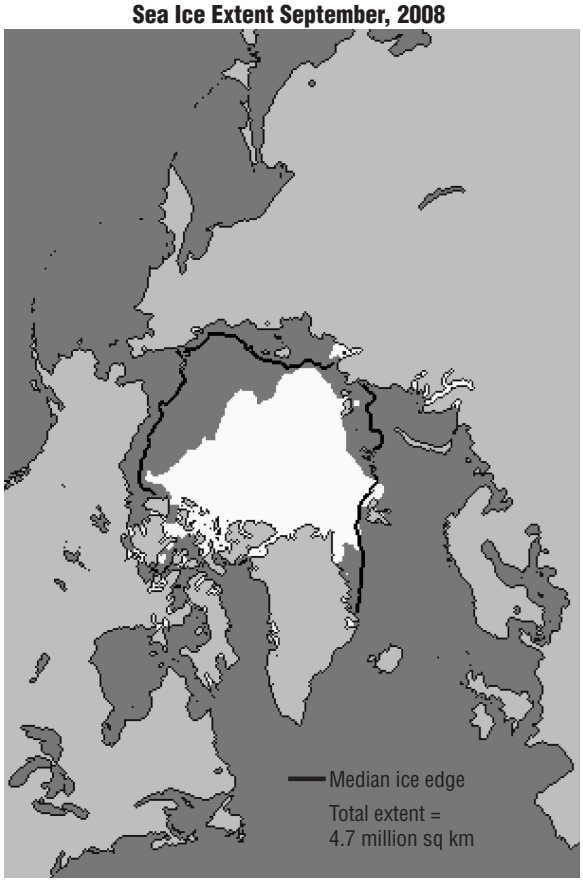
Stephanie Renfrow, National Snow and Ice Data Center, srenfrow@nsidc.org

Arctic sea ice extent during the 2008 melt season dropped to the second-lowest level since satellite measurements began in 1979, reaching the lowest point in its annual cycle of melt and growth on September 14, 2008. Average sea ice extent over the month of September, a standard measure in the scientific study of Arctic sea ice, was 1.80 million mi^2 (4.67 million km^2)—see **Figure 1**. The record monthly low, set in 2007, was 1.65 million mi^2 (4.28 million km^2); the now-third-lowest monthly value, set in 2005, was 2.15 million mi^2 (5.57 million km^2).

The 2008 season strongly reinforces the thirty-year downward trend in Arctic ice extent. The 2008 September low was 34% below the long-term average from 1979 to 2000 and only 9% greater than the 2007 record—see **Figure 2**. Because the 2008 low was so far below the September average, the negative trend in September extent has been pulled downward, from 10.7% per decade to 11.7% per decade—see **Figure 3**.

National Snow and Ice Data Center (NSIDC) Senior Scientist **Mark Serreze** said, "When you look at the sharp decline that we've seen over the past thirty years, a *recovery* from lowest to second lowest is no recovery at all. Both within and beyond the Arctic, the implications of the decline are enormous."

Conditions in spring, at the end of the growth season, played an important role in the outcome of this year's melt. In March 2008, thin first-year ice covered a record high 73% of the Arctic Basin. While this might seem like a recovery of the ice, the results are a bit deceptive, since the large extent masked an important aspect of sea ice health: **thin ice is more prone to melting out during summer**. So, the widespread thin ice of Spring 2008 set the stage for extensive ice loss over the melt season.



Through the 2008 melt season, a race developed between melting of the thin ice and gradually waning sunlight. Summer ice losses allowed a great deal of solar energy to enter the ocean and heat up the water, melting even more ice from the bottom and sides. Warm oceans store heat longer than the atmosphere does, contributing to melt long after sunlight has begun to wane. In August 2008, the Arctic Ocean lost more ice than any previous August in the satellite record.

NSIDC Research Scientist **Walt Meier** said, "Warm

*"When you look at the sharp decline that we've seen over the past thirty years, a 'recovery' from lowest to second lowest is no recovery at all. Both within and beyond the Arctic, the implications of the decline are enormous.— **Mark Sereze** [NSIDC Senior Scientist]"*

Figure 1. Arctic sea ice extent for September 2008 was 1.80 million mi^2 (4.67 million km^2), the second-lowest in the satellite record. The bold line shows the median ice extent for September from 1979 to 2000. Sea Ice Index data. **Credit:** National Snow and Ice Data Center.

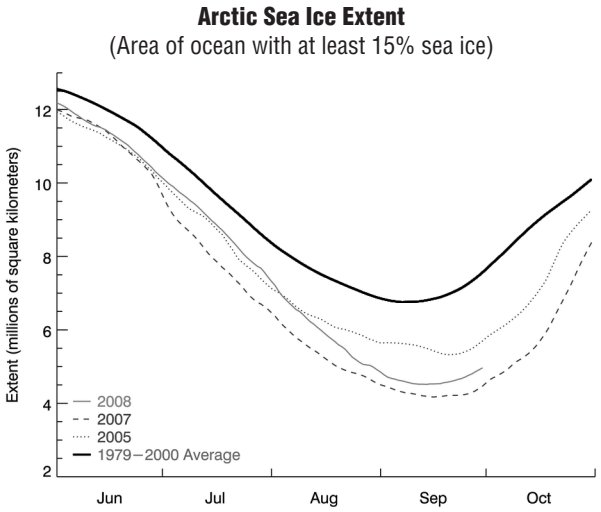


Figure 2. The updated time series plot puts this summer's sea ice extent in context with other years. The solid thin line indicates 2008; the dashed line shows 2007; the dotted line shows 2005; and the solid bold line indicates average extent from 1979 to 2000. Note the steep decline in August 2008, which depicts record ice losses for the month. Sea Ice Index Data. **Credit:** National Snow and Ice Data Center.

ocean waters helped contribute to ice losses this year, pushing the already thin ice pack over the edge. In fact, preliminary data indicate that 2008 probably represents the lowest volume of Arctic sea ice on record, partly because less multi-year ice is surviving now, and the remaining ice is so thin"—see **Figure 4**.

In the end, however, summer conditions worked together to save some first-year ice from melting and to cushion the thin pack from the effects of sunlight and warm ocean waters. This summer's weather did not provide the "perfect storm" for ice loss seen in 2007: temperatures were lower than 2007, although still higher than average; cloudier skies protected the ice from some melt; a different wind pattern spread the ice pack out, leading to higher extent numbers. Simply put, the natural variability of short-term weather patterns provided enough of a brake to prevent a new record-low ice extent from occurring.

NSIDC Research Scientist **Julienne Stroeve** said, "I find it incredible that we came so close to beating the 2007 record—without the especially warm and clear conditions we saw last summer. I hate to think what 2008 might have looked like if weather patterns had set up in a more extreme way."

The melt season of 2008 reinforces the decline of Arctic sea ice documented over the past thirty years. NSIDC Lead Scientist **Ted Scambos** said, "The trend of decline in the Arctic continues, despite this year's slightly greater extent of sea ice. The Arctic is more vulnerable than ever."

For a full listing of press resources concerning Arctic sea ice, including previous press releases and quick facts about why and how scientists study sea ice, please see *nsidc.org/arcticseaicenews/*. The original version of this article appears at [*nsidc.org/news/press/20081002_seaice_pressrelease.html*] and includes several additional animations.

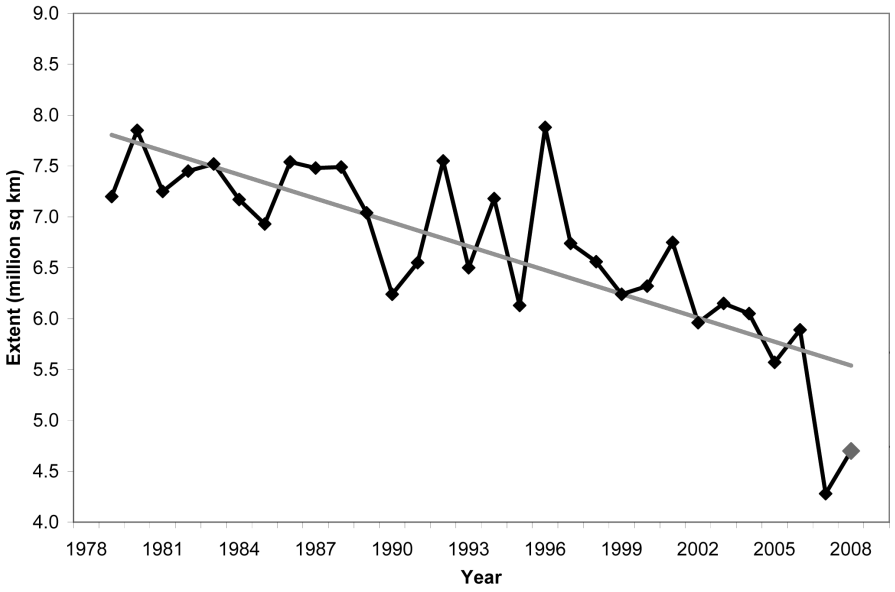


Figure 3. September ice extent from 1979 to 2008 shows a thirty-year decline. The September rate of sea ice decline since 1979 has now increased to -11.7% per decade from Sea Ice Index Data. **Credit:** National Snow and Ice Data Center.

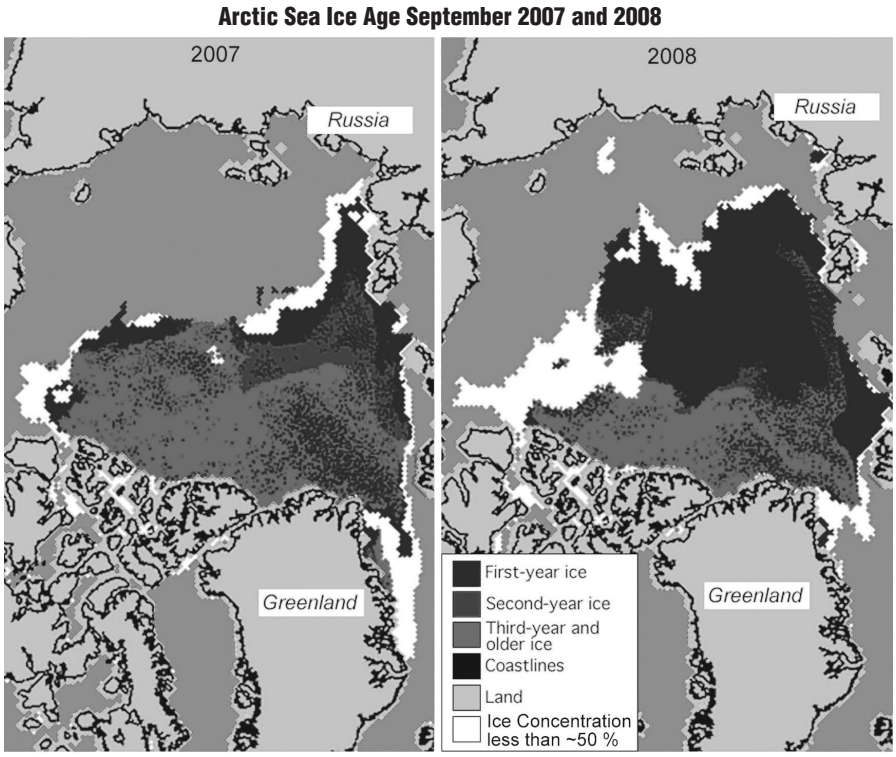


Figure 4. A comparison of ice age in September 2007 (left) and September 2008 (right) shows the increase in thin first-year ice (darkest gray) and the decline in thick multi-year ice (lighter grays). White indicates areas of ice below ~50%, for which ice age cannot be determined. Advanced Very High Resolution Radiometer (AVHRR), Scanning Multi-channel Microwave Radiometer (SMMR), Special Sensor Microwave Imager (SSM/I), and International Arctic Buoy Programme (IABP) buoy data. **Credit:** National Snow and Ice Data Center, courtesy C. Fowler, J. Maslanik, and S. Drobot, University of Colorado at Boulder. To see this image in color please visit: *nsidc.org/news/press/20081002_seaice_pressrelease.html.*

For Further Reading

Maslanik, J.A., C. Fowler, J. Stroeve, S. Drobot, J. Zwally, D. Yi, and W. Emery. 2007. A younger, thinner Arctic ice cover: Increased potential for rapid, extensive sea-ice loss, *Geophysical Research Letters*, **vol. 34**, L24501, doi:10.1029/2007GL032043.

Stroeve J., M.M. Holland, W. Meier, T. Scambos, and M. Serreze, 2007. Arctic sea ice decline: Faster than forecast, *Geophysical Research Letters*, **vol. 34**, L09501, doi:10.1029/2007GL029703.

Stroeve J., M. Serreze, S. Drobot, S. Gearheard, M. Holland, J. Maslanik, W. Meier, and T. Scambos. 2008. Arctic sea ice extent plummets in 2007, *EOS Transactions of the American Geophysical Union*, **vol. 89**, pp. 13–14.

HIRDLS U.K.-U.S. Science Team Meeting Summary

John Gille, University of Colorado and National Center for Atmospheric Research, gille@ucar.edu
Joanne Loh, U.S. HIRDLS Program Manager, University of Colorado, loh@ucar.edu

The High Resolution Dynamics Limb Sounder (HIRDLS) U.K.–U.S. Science Team Meeting was held in the Atmospheric, Oceanic and Planetary Physics (AOPP) building of the Department of Physics at Oxford University in Oxford June 24 -27, 2008. The meeting was conducted in two parts. The first two days were spent on technical details regarding the refinement of the HIRDLS algorithms and data processing, attended by the core HIRDLS team only. The last two days of the meeting were an open meeting for science discussions, to which many U.K. scientists interested in the HIRDLS data and U.K. users of the HIRDLS data were invited. These science presentations are available on the HIRDLS Project website at: *www.eos.ucar.edu/hirdls/*.

The core meeting opened with **John Gille** [University of Colorado, Boulder (UCB)/National Center for Atmospheric Research (NCAR)–*HIRDLS U.S. Principal Investigator*] giving a welcome and stating the objectives of the meeting, emphasizing the importance of making a decision regarding the release of version 004 (V4) of the HIRDLS data at this meeting.

Steve Massie [NCAR] spoke next, giving a summary of the algorithm currently used in the detection of cloud tops and cloud types. Massie presented and discussed changes made in our latest algorithm and possible future improvements.

Several improvements were implemented into the HIRDLS algorithm to produce the data for V4. **John Gille** summarized the changes in the *kapton* correction between the last released version of the data (V3) and the current one (V4). The team would evaluate the merits of the new data set and make a decision on its release. **Chris Halvorson** [NCAR] presented the current de-oscillation method used and discussed changes made in the noise filter for the eigenvectors. In a similar presentation, **Tom Eden** [NCAR] discussed the status of the correction for the fractional open area and the future improvements planned. **Rashid Khosravi** [NCAR] discussed the motivation for evaluating retrieval top (to address the temperature drop outs seen in previous versions of our data). **Cheryl Craig** [NCAR] then summarized the changes made in the Level 2 (L2) processor since January 2008.

After the presentations of the algorithm changes were complete, the remainder of the first day was devoted to presentations that discussed data validation, showed comparison results, and evaluated the data.

Temperature

Several team members, **John Barnett** [AOPP]—*HIRDLS U.K. PI*], **John Gille**, **Chris Hepplewhite** [AOPP], **Luis Millan-Valle** [AOPP] and **Alison Waterfall** [Rutherford Appleton Laboratory (RAL)], presented the results of their comparison of HIRDLS temperature data with correlative data. Agreement with sondes is generally within ~0.5K (100-10 hPa), but it appears that there are still some spikes associated with clouds. They compared the HIRDLS data with the European Centre for Medium-Range Weather Forecasts (ECMWF) data and the Goddard Earth Observing System Model, Version 5 (GEOS-5) data. The comparisons show differences between the two models, with HIRDLS generally comparing better to GEOS-5 than ECMWF. HIRDLS data compares well with the Constellation Observing System for Meteorology Ionosphere & Climate (COSMIC) data on Taiwan's Formosa Satellite Mission #3 as well as with The Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) on the European Space Agency's (ESA) Envisat satellite.

Ozone

Chris Hepplewhite, **Bruno Nardi** [NCAR] and **Alison Waterfall** made presentations on their validation work on HIRDLS ozone data. Overall the quality of V4 ozone is significantly improved over V3 in both vertical range and accuracy. The vertical range of useful measurements is extended earthward (i.e., lower in the atmosphere) at mid- and high-latitudes—previously data was good down to the 100 hPa level and now it is good down to 260 hPa. The low bias is also somewhat diminished, especially in the high latitude stratosphere. The improved cloud detection algorithm results in far fewer Upper Troposphere-Lower Stratosphere (UTLS) ozone spikes, especially in the tropics. However, the high bias in the tropical UTLS region persists in a diminished form. The vertical resolution remains about 1 km.

Nitric Acid

Chris Hepplewhite and **Doug Kinnison** [NCAR] discussed their evaluation of nitric acid (HNO_3). HIRDLS HNO_3 data are generally good between April 28, 2005 to the present over the latitude range of 64ºS to 80ºN and pressure range ~100 hPa to 10 hPa, with some profiles, depending on latitude, having useful information between 100 hPa to 161 hPa. HIRDLS observations before April 28, 2005 are marginal in quality and not recommended for science applications.

Water Vapor

John Gille, **Chris Hepplewhite**, **Alison Waterfall** and **Helen Worden** [NCAR] presented their findings on HIRDLS water vapor. There are improvements over previous data versions. HIRDLS vertical resolution provides more *structure* than data from the Microwave Limb Sounder (MLS) instrument. HIRDLS water vapor is getting close to being useful for studying the UTLS. However, there are still bias and scan-to-scan variability that need resolution. The team agreed that the water vapor product is not yet ready for release.

Clouds & Cloud Extinction

Steve Massie presented a quick status report on clouds and cloud extinction. There is still work to be done, but he feels that the cloud extinction data can be used in a qualitative manner, i.e. data can be used to indicate the geographical distributions of clouds. The team agreed that cloud extinction would be a new product to add to V4 for release.

Methane (CH_4), Nitrogen Dioxide (NO_2), Chlorine Nitrate ($ClONO_2$), Dinitrogen Pentoxide (N_2O_5), Nitrous Oxide (N_2O)

John Gille and **Doug Kinnison** presented charts from **Cora Randall** [Laboratory for Atmospheric and Space Physics (LASP)], and **Tom Eden** and **Chris Hepplewhite** presented their evaluations. These species are not yet ready for release. There are still lots of variability and noise in the data. Some results strongly indicate that there is a seasonal aspect of the *kapton* behavior that is not being accounted for in the current *kapton* correction. More work will be needed to remove this and improve these products.

Trichlorofluoromethane (F11), Dichlorodifluoromethane (F12)

Mike Coffey [NCAR] concluded the first day with a presentation of his results for the chlorofluorocarbons (CFCs). Both products are much better than in previous data versions. Evaluation of zonal mean and standard deviation of these products in this data version indicated that the 1% per year decrease seen in surface measurements can be seen in the HIRDLS data. These products are candidates for inclusion into the V4 release.

Discussions on the second day delved into the technical details of the current corrections used in the algorithm and the improvements needed. **John Gille** presented a summary of the problem encountered and the current approach. **Gene Francis** [NCAR] joined the discussion by phone, and gave a detailed overview of the current method. The team discussed some of the difficulties with the current method and the issues that needed to be addressed were discussed.

Craig Hartsough [NCAR] also joined the meeting by phone, and gave an overview of an alternate correction scheme—the *scaling method*. The motivation for working on an alternate method was to provide the ability to adjust to seasonal variations and variations with beta angle. It was also proposed to allow the use of physical instrument temperature measurements in the *kapton* correction and to provide the ability to adjust to seasonal variations. Similarly, **Tom Eden** has been doing some independent studies on the effects of different spatial, temporal, and thermal influences on the *kapton*, and his findings were presented and discussed.

Rashid Khosravi then presented his work on revision and updating of retrieval parameters. Khosravi discussed input random errors (e.g., radiometric noise, pointing jitter, forward model error, *a priori*) as well as retrieval accuracy.

Additional discussion followed on the role of the *a priori* errors in the retrievals in the UTLS region. Several actions and next steps were defined. Day two concluded with formulation of plans for future data versions.

The HIRDLS Open Science Team Meeting took place over the last two days of the week, June 26-27, 2008. The purpose of this part of the meeting was to introduce the HIRDLS data to the U.K. science community and provide an opportunity for scientific interaction with the HIRDLS team.

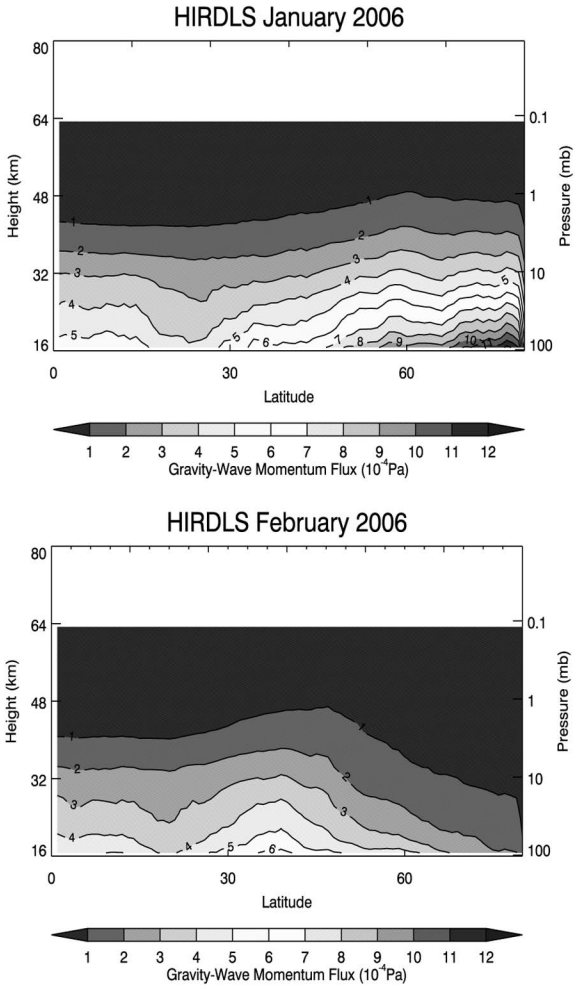
John Barnett opened the meeting with a welcome and gave a talk entitled *The HIRDLS Instrument*, which provided a brief introduction to HIRDLS for those in attendance. After the welcome came a series of talks from members of the HIRDLS team to describe the instrument and the current status of the HIRDLS products.

- *Correction algorithms applied to HIRDLS data*. **John Gille** gave a description of the effects of the kapton blockage on the HIRDLS data coverage and radiometery.
- *Cloud and aerosol detection and retrieval*. **Steve Massie** discussed the HIRDLS radiance profiles and cloud types (for the 12 μm channel), cloud detection algorithm and retrieval methodology.
- *HIRDLS retrieval algorithms*. **Rashid Khosravi** presented a description of the HIRDLS Level 2 algorithm and characterization of retrievals. The algorithm reproduces "truth" data very accurately, and the retrievals are mostly independent of the *a priori* data and have high vertical resolution. Errors, their sources and retrieval characterization were discussed.

- *Overview of HIRDLS validation*. **Bruno Nardi** presented a summary of the HIRDLS validation operations and efforts to date including some results for the released products.
- *Processing of HIRDLS data and a guide to the versions*. **Cheryl Craig** gave an overview of HIRDLS processing and an introduction to the data versions.
- *BADC holdings of HIRDLS data, and how to obtain them*. **Wendy Garland** [RAL, The Science and Technology Facilities Council (STFC)] gave an overview of the HIRDLS data held at the British Atmospheric Data Center (BADC) and how to access the data, including supporting documentation and links to other information.

Next came a series of science talks by both HIRDLS team members and U.K. scientists from outside the HIRDLS team.

- *HIRDLS ozone and HNO_3: assimilation and validation against ACE-FTS*. **Martin Juckes** [RAL, STFC] presented results of assimilation and validation against the Atmospheric Chemistry Experiment - Fourier Transform Spectrometer (ACE-FTS), as well as data from MLS and the Odin satellite. Preliminary analysis indicates that HIRDLS data compare fairly well against ACE-FTS, but detailed analysis still needs to be done. The annual cycle is markedly different from that obtained using data from the Odin Sub-Millimetre Radiometer (SMR) data, but consistent with MLS. Evolution of large scale structures are broadly consistent with potential vorticity evolution.
- *Assimilation of satellite data on atmospheric composition: effective collaboration between academic/research institutions and operational centres*. **Stefano Migliorini** [Department of Meteorology, University of Reading] provided an overview of the ESA-funded GlobModel project and a gave a summary of the results to date.
- *Resolution-dependent data analysis of stratospheric species: value and impact of HIRDLS and MLS data*. **Valery Yudin** [NCAR] discussed the resolution-dependent data analysis of stratospheric species. In the extra-tropical UTLS, resolution-consistent sampling of HIRDLS and MLS allow easy implementation of data analysis schemes. Lamination frequency is reproduced by Chemical Transport Model (CTM), analyses and HIRDLS retrievals.
- *HIRDLS analysis of gravity wave activity in the 2006 Arctic Stratosphere*. **Corwin Wright** [AOPP] presented results of his work on analysis of gravity wave activity using HIRDLS data.
- *Observations of gravity waves in HIRDLS data*. **Xiuping Yan** [Department of Physics and Astronomy University of Leicester] presented an overview of her gravity wave study.
- *A comparison between HIRDLS and the Hadley Centre Model: extratropical variability.* **Scott Osprey** [AOPP] showed results from the comparison between HIRDLS and model data. The accompanying figure shows gravity wave momentum flux data from January and February of 2006. The 2006 Northern Hemisphere winter was characterized by an unusually elevated stratopause over the pole. Linked with this was an anomalously strong vortex in the upper stratosphere overlying anomalously weak zonal winds in the lower stratosphere. HIRDLS observed reduced gravity wave activity entering the lower stratosphere during these times. Global Climate Model (GCM) studies have linked similar reductions in gravity wave activity during similar events.



Scott Osprey showed Gravity wave momentum flux data from HIRDLS duing his presentation.

- *MST radar measurements relating to vertical temperature structure*. **David Hooper** [RAL, STFC] described the Mesosphere-Stratosphere-Troposphere (MST) radar facility at Aberystwyth, U.K., its capability and observation/measurement results.
- *3D SLIMCAT modelling studies of Arctic Ozone loss*. **Wuhu Feng** [School of the Environment, **Univer-**

sity of Leeds] gave an overview of the 3D chemical transport model SLIMCAT and showed examples of CTM results.

- *The United Kingdom Chemistry and Aerosol Community Model (UKCA): validation and recent results*. **Peter Braesicke** [Centre for Atmospheric Science, University of Cambridge] presented a short overview of the UKCA and recent results.
- *Evaluation of the Whole Atmosphere Community Climate Model of HNO_3: A comparison with HIRDLS Observations*. **Doug Kinnison** showed model/observation comparisons of the evolution of HNO_3, and the usefulness of HIRDLS HNO_3 observation for the evaluation of chemical composition and transport processes in 3D chemistry climate models—specifically in the extra tropics, lower stratosphere.

The science discussions continued on the last day of the meeting concluding with the following talks.

- *Validation of HIRDLS fine vertical scale temperature structure using COSMIC radio occultation measurements*. **John Barnett** presented the results of comparison of HIRDLS data with COSMIC data, showing that HIRDLS data agree well with COSMIC data down to the order of 1-2 km resolution.
- *Validation of HIRDLS Temperature and Ozone profiles against sonde and ECMWF data*. **Alison Waterfall** presented recent results from comparison of HIRDLS data against sondes and ECMWF analyses.
- *HIRDLS observations of Ozone intrusions from the upper troposphere into the lower stratosphere (and vice versa)*. **John Gille** presented findings of HIRDLS observations of tropospheric intrusion events. HIRDLS' vertical and horizontal resolution allows observation of *laminae*—thin layers of trace gases in the UTLS. Orbital spacing and timing gives reasonable sampling of dynamical events. Maps of potential vorticity (PV) on *isentropic* (θ) surfaces show evidence of vigorous stirring and latitudinal transport, matching HIRDLS' observations of *laminae* with mixing ratios higher or lower than their surroundings. Regions of high/low ozone stay within PV contours for several days before PV relaxes to the surroundings, while the ozone concentration remains about the same. The frequency of these laminae increases through the winter, reaching a maximum in April, consistent with the frequency of baroclinic eddies. They are much less frequent in the summer and autumn.
- *MIPAS retrievals at Oxford*. **Anu Dudhia** [AOPP] presented an overview of the Oxford Level 2 processing and results of their processing of the MIPAS data. More information is available from the website: *www.atm.ox.ac.uk/group/mipas*.
- *Overview of Current Oxford MIPAS Cloud Products.* **Jane Hurley** [AOPP] presented a short overview of the status of her cloud modeling and her effort to use the MIPAS dataset to get a high cloud climatology.
- *HIRDLS Observations of Cirrus Near the Tropopause*. **Steve Massie** presented his work on HIRDLS observations of high cirrus.
- *Assessment of HIRDLS Capability to Detect Ozone Lamina in Mid-Latitudes Using Co-Located Ozonesonde Measurements*. **Bruno Nardi** presented an evaluation of HIRDLS measurements of fine ozone *lamina* in the northern hemisphere spring UTLS. Lamina features compared very well with individual coincident ozone sonde profiles. Additionally, comparison of a large sample of profiles over three years showed no appreciable degradation in mean of standard deviation in differences, when comparing only profiles containing lamina events, which provides a statistical confirmation of HIRDLS' stability as well as its ability to detect fine ozone layers.

Concluding Remarks

Subsequent to the Science Team Meeting, Version 4 (V4) of the Aura-HIRDLS Level 2 Atmospheric Product *HIRDLS2* was delivered and made publicly available from the NASA GSFC Earth Sciences (GES) Data and Information Services Center (DISC): *disc.gsfc.nasa.gov/Aura/HIRDLS/index.shtml*

The V4 Level 2 data products (geophysical parameters along the measurement track) include new products CFC11, CFC12, and the 12.1 μm cloud extinction. The HIRDLS team is in the process of refining the algorithm for other species, which will be made available in later versions. The Data Quality Document describing the characteristics of V4 was also delivered and available from the DISC web site, as well as the HIRDLS web site.

The open Science Team Meeting was the first of this kind to be held in the U.K. in the lifecycle of HIRDLS. In the past, the group's primary focus was on product generation and validation. And although there is still much work to do in that area to improve the HIRDLS data products and to obtain new products, the team is now shifting its focus to introducing the HIRDLS data to the science community, and starting science investigations and applications to establish validity and utility of this important data source. ■

HDF/HDF-EOS Workshop Summary

Daniel Marinelli, NASA Goddard Space Flight Center, daniel.j.marinelli@nasa.gov

The 12th Hierarchical Data Format (HDF) and HDF for the Earth Observing System (HDF-EOS) Workshop was held October 15-17, 2008 at the Doubletree Hotel in Aurora, CO. Forty-eight people attended with varied interests ranging from their perspectives as users, tool developers, and data producers. This year's theme was ***Moving Forward with HDF*: New Missions, New Opportunities, A New Generation of Users.**

The agenda with presentations and posters for all three days can be found at: *www.hdfeos.org/workshops/ws12/agenda.php*

Wednesday was dedicated to tutorials sessions. Members of the HDF Group (THG) [including **Elena Pourmal**, **Barbara Jones**, **Peter Cao**, and **Kent Yang**] provided in-depth information on all aspects of *version 5* of HDF (HDF5). THG gave tutorials on HDF5 data and programming models, advanced HDF5 features, HDF5 tools, migrating to *HDF5.1.8*, HDF View, and HDF Java products. **Ed Hartnett** [Unidata] provided an introduction to network common data form *version 4* (netCDF-4.0) that represents the fruits of an effort to build the netCDF application programming interface on top of the underlying HDF5 format.

Online help for HDF5 tools can be found at: *www.hdfgroup.org/hdf5tools.html.*

Information on the *netCDF4.0* release can be found at: *http://www.unidata.ucar.edu/software/netcdf/netcdf-4/*

Wednesday's lunch-time speaker was **Mohan Ramamurthy** [Unidata]. He presented Unidata's approach to broadening user communities over their history since 1983. Unidata has fostered enhancements in geoscience research and education through their products and services which consist of free, open-sourced, platform independent software applications. NetCDF has become a defacto standard for geoscience data representation, and the recent integration with HDF5 will allow a large community to take advantage of the power of both netCDF and HDF5.

Thursday morning was dedicated to talks relating to the status of projects and efforts which make use of HDF or HDF-EOS. Representatives from THG, the Earth Science Data and Information System (ESDIS) Project, and Raytheon gave information on the current state of their development and maintenance efforts. **Dan Marinelli** [ESDIS] provided an overview of the Earth Observing System Data and Information System (EOSDIS) Status and Developments followed by **Carol Boquist** [ESDIS] who provided a summary of the recently concluded 2008 EOSDIS User Survey.

Mike Folk [THG] then presented the status of HDF development followed by **Abe Taaheri** [Raytheon/Landover] who summarized the state of HDF-EOS development, maintenance, and tools. An overview of the HDF-EOS format was provided for users who are new to EOSDIS.

Thursday's lunch-time speaker was **Peter Fox** [National Center for Atmospheric Research (NCAR)]. He provided his perspective on informatics and building systems that can reach down to the details of data model representations while reaching up to meet the needs of users who are trying to access/amalgamate/synthesize data from any and all sources. This process must take into account budget realities while meeting the needs of user communities and there are substantial social aspects that must be considered at both individual and organizational levels.

In the afternoon, a panel discussion was held to take input from data users on what their needs are with respect to the data formats.

Mike Folk next discussed the culmination of an effort that began 2 years ago at the 10th workshop. The idea is to be able to support the long-term archivability of HDF data by preparing layout maps that can be used by software to interpret the data without using the HDF Application Programming Interface (API). The initial phase of this effort addresses data contained in EOS data which has been written using HDF4. The community is encouraged to read the wiki at: *www.hdfgroup.org/projects/hdf4mapping/* and comment heavily!

John Caron [University Corporation for Atmospheric Research/Unidata] gave a talk summarizing the status of reading the HDF family of formats through the open source NetCDF-Java library. Information on the library can be found at: *www.unidata.ucar.edu/software/netcdf-java/*

Peter Cao [THG] presented his work on HDF5 Rule Oriented Data Systems (IRODS). There are several links in his presentation for those interested. It is a data grid software system that enables a customizable architecture for sharing data distributed across heterogeneous resources. Finally, Thursday ended with three poster discussions and **Daniel Kahn** [Science Systems

Applications, Inc (SSAI)] led a discussion on bridging the gaps between HDF5 and high level programming languages. The posters were as follows:

- **Terry Haran** [National Snow and Ice Data Center, University of Colorado], *HDF-EOS and GeoTIFF: GIS Problems when Projection and Datum Spheroids are Different*;
- **Suresh K. Santhana Vannan** [Oak Ridge National Laboratory Distributed Active Archive Center (ORNL DAAC)] *ORNL DAAC MODIS Land Product Subsets*; and
- **Daniel Kahn**, *A Proposal for Array Dimension Names in HDF5.*

Friday's talks focused on applications and demonstrations. **Charles Nellis** [Raytheon/Aurora] discussed the structure of HDF5 files for the National Polar-orbiting Operational Environmental Satellite [NPOESS]. **Mike Folk** showed the work they would be performing in support of NPP/NPOESS in the form of user support, and tool enhancements to allow better viewing/manipulation of the NPP/NPOESS products.

John Evans [MathWorks] presented the status of MATLAB support for HDF5, and **Bill Okubo** [ITT Visual Information Solutions] presented the status of ENVI/IDL support for HDF and discussed their ENVI Plug-in MODIS Conversion Toolkit that can operate on all known MODIS products—143 at last count.

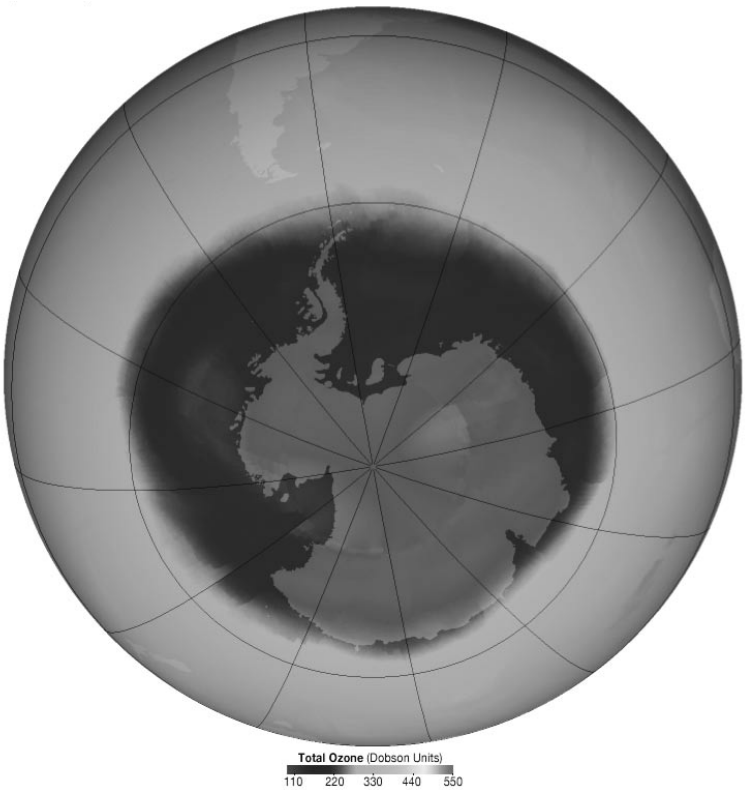
Thomas Hauser [Utah State University] gave a talk on his organization's conversion of their computational fluid dyamics General Notation System (CGNS) application to the use of HDF5 as the underlying storage format. The goal is to convert a suite of applications to the use of HDF5 while increasing performance and without impacting users doing their work.

Kent Yang wrapped up Friday, and the workshop, with an update on the OPeNDAP HDF5 data handler.

The location of next year's workshop was not decided at this time, but the program committee will make an announcement sometime in April, 2009.

Program Committee

Dan Marinelli, NASA Goddard Space Flight Center, *daniel.j.marinelli@nasa.gov*
Carol Boquist, NASA Goddard Space Flight Center, *Carol.L.Boquist@nasa.gov*
Michael Folk, The HDF Group, *mfolk@hdfgroup.org*
Elena Pourmal, The HDF Group, *epourmal@ncsa.uiuc.edu*
Kent Yang, The HDF Group, *ymuqun@ncsa.uiuc.edu*
Ebrahim Taaheri, Raytheon, *Abe_Taaheri@raytheon.com*



The Antarctic ozone hole reached its annual maximum on September 12, 2008, stretching over 10.5 million mi² (27.2 million km²). The area of the ozone hole is calculated as an average of the daily areas for September 21–30 from observations from the Ozone Monitoring Instrument (OMI) on NASA's Aura satellite.

This is considered a "moderately large" ozone hole, according to NASA atmospheric scientist, **Paul Newman**. And while this year's ozone hole is the fifth largest on record, the amount of ozone depleting substances has actually decreased about 3.8% from peak levels in 2000. The largest ozone hole ever recorded occurred in 2006, at a size of 10.6 million mi² (27.4 million km²). For more information and to view this image in color please visit *www.nasa.gov/topics/earth/features/ozonemax_2008.html* **Credit:** NASA.

in the news

"Smog Blog" for Central America and Caribbean Debuts

Stephen Cole, NASA Headquarters, stephen.e.cole@nasa.gov
Jennifer Morcone, Marshall Space Flight Center, Jennifer.J.Morcone@nasa.gov

NASA and its partners recently unveiled a new way to connect satellite air quality data with communities in Central America and the Caribbean. The MesoAmerican and Caribbean *Smog Blog*, a web site interpreting local and regional air quality, was introduced at a news conference in Panama City, Panama in conjunction with a Global Earth Observation System of Systems (GEOSS) in the Americas symposium.

The *Smog Blog* provides timely information about air pollution and its sources in the region, helping the public, governments, and health officials monitor air quality and mitigate negative health impacts. Faculty and students at the University of Panama and staff from the Water Center for the Humid Tropics of Latin America and the Caribbean (CATHALAC) contribute to the blog. It is the newest addition to SERVIR (Spanish word for *to serve*), a regional environmental monitoring system that leverages the satellite resources of the U.S. and other countries to put Earth observation data and other tools into action in Central America.

"CATHALAC has truly taken a leadership role in understanding how NASA atmospheric research information can benefit the citizens of Mesoamerica," said **Teresa Fryberger**, Associate Director of Applied Sciences in NASA's Earth Science Division and co-chair of the U.S. Group on Earth Observations. "With *Smog Blog*, Central American environmental and health officials will be able to better communicate warnings about hazardous air conditions so the public can take appropriate precautions."

Trained personnel make posts at least three times a week using information from satellites, air quality forecast models and soon-to-be-operational ground-based monitors. Satellites from NASA and the National Oceanic and Atmospheric Administration (NOAA) provide air quality information of use to the region. Data from NASA's Terra and Aqua satellites provide a variety of atmospheric measurements. The NASA–French Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) satellite mission provides bloggers with data about regional airborne particles. NOAA's Geostationary Operational Environmental Satellites (GOES) provides continuous monitoring of Earth necessary for timely, intensive data analysis. Another NOAA data asset providing material is a Hazard Mapping System that detects wildfires from space and tracks the smoke they produce.

Ruben Delgado and Hipolito Guerra work to update the *smog blog*.
Credit: SERVIR.

"The *Smog Blog* and other activities reflect the work of many partners in supporting the realization of GEOSS in the Western Hemisphere," said **Emilio Sempris**, Director of CATHALAC. "**In our region, this exciting initiative is going to improve the quality of life in vital sectors, including public health, energy, weather, climate, and agriculture**."

A team at the University of Maryland, Baltimore County has operated a U.S. *Smog Blog* for five years. The site draws 35,000 visits a month, mainly state and local air quality forecasters. It is a daily resource for "big picture" analyses of nationwide air quality and insights into how national trends may affect communities locally. Through a NASA cooperative agreement, the U.S. *Smog Blog* team is working with the SERVIR collaboration to bring this communications tool to Central America.

"The *Smog Blog* has been a powerful communications tool here in the United States," said **Erica Zell**, co-developer of the *Smog Blog* and research scientist for Battelle Memorial Institute. "We hope through sharing real-time air quality information in this region we will make an impact in preventing future harm. Pollution and acid rain have damaged ancient Mayan ruins and **air quality has immense public health impacts in this region**."

CATHALAC, the University of Panama, the University of Maryland, Baltimore County, Panama's national environmental authority, the World Bank, and Battelle Memorial Institute all provide support for the new *Smog Blog*. NASA, the U.S. Environmental Protection

continued on page 39

ASDC at NASA Langley Releases Several New CERES Products

The **Clouds and Radiative Swath (*CRS*)** product is designed for studies which require fields of clouds, humidity, and aerosols that are consistent with radiative fluxes from the surface to the Top-Of-the-Atmosphere (TOA)—e.g., studies of cloud and aerosol forcing at both TOA and surface, or investigations of possible errors in retrievals of TOA fluxes, cloud properties, surface skin temperature, etc. Each *CRS* is an hourly file containing instantaneous data (computed fluxes and observed fluxes) at the CERES field-of-view scale (20-km diameter at nadir) from a single CERES instrument mounted on one satellite. **Temporal Coverage**: May 2006–August 2007

The **Monthly Gridded Radiative Fluxes and Clouds (*FSW*)** archival data product contains hourly single satellite flux and cloud parameters averaged over 1.0º regions. Input to the FSW Subsystem is the CRS archival data product. The Aqua FSW *Edition2C* contains the gridded results from the newly released Aqua CRS *Edition2C* dataset and the Terra FSW *Edition2F* contains the gridded results from the newly released Terra CRS *Edition2F* dataset. Each FSW covers a single month of data from a single CERES instrument mounted on one satellite. Individual Aqua FSW *Edition2C* files and Terra FSW *Edition 2F* files contain information for three consecutive latitude bands. **Temporal Coverage**: May 2006–August 2007.

The **CERES International Satellite Cloud Climatology Project (ISCCP)-D2like** cloud product was designed to closely emulate the NASA-GISS ISCCP-D2like products, so that they meet the needs of the climate community and can easily be incorporated into Global Climate Model (GCMs), ISCCP simulators, and other climate modeling studies. The cloud retrievals have been stratified into 18 cloud types based on cloud-top pressure, optical thickness, and phase, similar to the ISCCP daytime 15 cloud types. The CERES Moderate Resolution Imaging Spectroradiometer (MODIS) cloud retrievals are separated into daytime (*Day*, solar zenith angle <82°) and nighttime (*Nit*) products. The A 5-satellite, daytime 3-hourly geostationary-only cloud retrieval (*GEO*, 60°N to 60°S) product is daytime only. **Temporal Coverage**: March 2000–October 2005. **This is a *Beta* product and is not regarded as publishable until an Edition is released, which should be in July 2009.**

The Atmospheric Sciences Data Center (ASDC) in collaboration with the Clouds and the Earth's Radiant Energy System (CERES) Science Team announces the release of the following data sets:

CER_CRS_Aqua-FM3-MODIS_Edition2C
CER_CRS_Aqua-FM4-MODIS_Edition2C
CER_CRS_Terra-FM1-MODIS_Edition2F
CER_CRS_Terra-FM2-MODIS_Edition2F

CER_FSW_Aqua-FM4-MODIS_Edition2C
CER_FSW_Terra-FM1-MODIS_Edition2F
CER_FSW_Terra-FM2-MODIS_Edition2F

CER_ISCCP-D2like-Day_Terra-FM1-MODIS_Beta1
CER_ISCCP-D2like-Nit_Terra-FM1-MODIS_Beta1
CER_ISCCP-D2like-Day_Terra-FM2-MODIS_Beta1
CER_ISCCP-D2like-Nit_Terra-FM2-MODIS_Beta1

CER_ISCCP-D2like-Day_Aqua-FM3-MODIS_Beta1
CER_ISCCP-D2like-Nit_Aqua-FM3-MODIS_Beta1
CER_ISCCP-D2like-Day_Aqua-FM4-MODIS_Beta1
CER_ISCCP-D2like-Nit_Aqua-FM4-MODIS_Beta1

CER_ISCCP-D2like _GEO _Beta1

Additional information about the CERES products, including data format, products available, documentation, relevant links, sample software, tools for working with the data, etc., can be found at the following URLs:

CRS and *FSW* Products: *eosweb.larc.nasa.gov/PRODOCS/ceres/table_ceres.html*
ISCCP-D2like Products: *eosweb.larc.nasa.gov/PRODOCS/ceres/level3_isccp_table.html*

For more information regarding our data holdings or for assistance in placing an order, please contact:

Atmospheric Science Data Center
NASA Langley Research Center
User and Data Services
Mail Stop 157D, 2 S. Wright Street
Hampton, VA 23681-2199
Phone: 757-864-8656
E-mail: *larc@eos.nasa.gov*
URL: *eosweb.larc.nasa.gov*

in the news

NASA Maps Shed Light on Carbon Dioxide's Global Nature

Alan Buis, NASA Jet Propulsion Laboratory, Alan.buis@jpl.nasa.gov

A NASA/university team has published the first global satellite maps of the key greenhouse gas, carbon dioxide, in Earth's mid-troposphere, an area about 5 mi (8 km), above Earth. The team's study reveals new information on how carbon dioxide, which directly contributes to climate change, is distributed in Earth's atmosphere and moves around our world.

Moustafa Chahine of NASA's Jet Propulsion Laboratory (JPL) leads a research team that found that the distribution of carbon dioxide in the mid-troposphere is strongly influenced by major surface sources of carbon dioxide, and by large-scale atmospheric circulation patterns such as the jet streams and weather systems in Earth's mid-latitudes. Patterns of carbon dioxide distribution were also found to differ significantly between the northern hemisphere, with its many land masses, and the southern hemisphere, which is largely covered by ocean.

The findings are based on data collected from the Atmospheric Infrared Sounder (AIRS) instrument on NASA's Aqua spacecraft between September 2002 and July 2008. Chahine, the instrument's science team leader, said the scientists will use the research products to refine models of the processes that transport carbon dioxide within Earth's atmosphere.

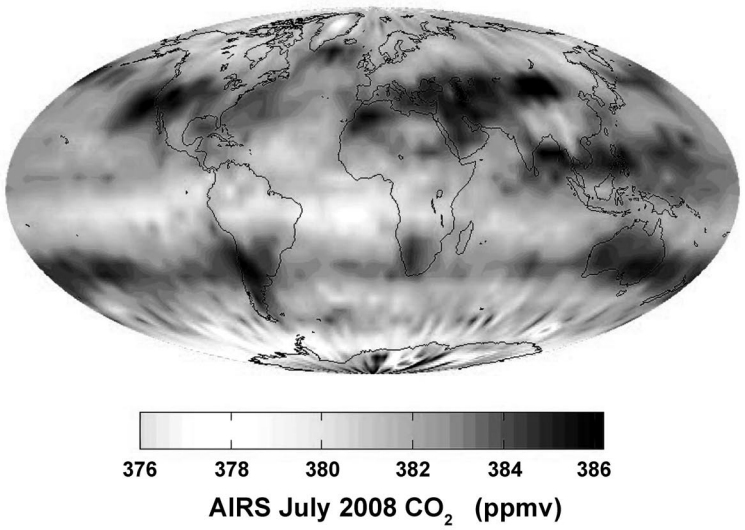
"These data capture global variations in the distribution of carbon dioxide over time," Chahine said. "These variations are not represented in the four chemistry-transport models used to determine where carbon dioxide is created and stored."

Chahine said the AIRS data will complement existing and planned ground and aircraft measurements of carbon dioxide, as well as upcoming satellite missions to study Earth's carbon cycle and climate. Included in the new satellite missions is NASA's Orbiting Carbon Observatory (OCO), planned for launch in January 2009. The combination of carbon dioxide data from AIRS and the OCO will allow scientists to determine the distribution of carbon dioxide in the lower atmosphere, above Earth's surface.

"Carbon dioxide is difficult to measure and track," he said. "No place on Earth is immune from its influence. It will take many independent measurements, including AIRS, to coax this culprit out of hiding and track its progress from creation to storage."

The new maps reveal enhanced concentrations of carbon dioxide south of the northern hemisphere jet stream, in a band between 30–40°N latitude. These enhanced concentrations correspond to a well-documented belt of pollution in the northern hemisphere mid-latitudes.

The team attributed the increased levels of carbon dioxide detected over the western North Atlantic to emissions transported from the Southeast U.S. on warm atmospheric conveyor belts. These belts lift carbon dioxide from Earth's surface into the middle and upper troposphere. The AIRS maps also showed enhanced carbon dioxide over the Mediterranean, resulting from North American and European sources. Carbon dioxide



This image was created with data acquired by the Atmospheric Infrared Sounder (AIRS), during July 2008. The image shows large scale patterns of carbon dioxide concentrations that are transported around the Earth by the general circulation of the atmosphere. To view this image in color visit *www.nasa.gov/topics/earth/features/airs-20081009.html* .

from South Asia ended up over the Middle East, while carbon dioxide from East Asia flowed out over the Pacific Ocean.

In the southern hemisphere, a belt of mid-tropospheric air containing enhanced concentrations of carbon dioxide emerged between 30–40°S. This belt had not previously been seen in the four chemistry-transport models used in this study. The researchers say the flow of air in this belt over South America's high Andes Mountains lifts carbon dioxide from major sources on Earth's surface, such as the respiration of plants, as well as forest fires and facilities used for synthetic fuel production and power generation. A portion of this lifted carbon dioxide is then carried into the mid-troposphere, where it becomes trapped in the mid-latitude jet stream and transported rapidly around the world. "The troposphere is like international waters," Chahine said. "What's produced in one place will travel elsewhere."

Study results were published recently in *Geophysical Research Letters*. Other participants included the California Institute of Technology, Pasadena, CA; and the University of California, Irvine.

More information on AIRS is online at *airs.jpl.nasa.gov/* .

NOTE: A video file accompanying this release is available on NASA Television. For more information, visit *www.nasa.gov/multimedia/nasatv/* . ■

"Smog Blog" for Central America and Caribbean Debuts

continued from page 36

Agency and the U.S. Agency for International Development fund this initiative.

The Group on Earth Observations is coordinating intergovernmental efforts to build GEOSS, a network designed to better understand, monitor, and forecast changes in the global environment. Driven by the 75-government Group on Earth Observations, GEOSS in the Americas is working as a catalyst for regional initiatives by advancing the use of Earth observations, encouraging shared use of data, and leveraging regional assets.

The SERVIR system, developed by researchers at NASA's Marshall Space Flight Center, Huntsville, AL, was introduced in 2005 in Panama at CATHALAC. SERVIR takes a global approach to environmental challenges by pooling Earth observation tools and data.

To read the MesoAmerican and Caribbean *Smog Blog*, visit: *www.nasa.gov/servir.* ■

EOS Scientists in the News

Kathryn Hansen, NASA Earth Science News Team, khansen@sesda2.com

Earth Satellite Observations Inform Energy Policy, August 27; *Environmentalresearchweb*. In July, **Richard Eckman** (NASA LaRC) and **Paul Stackhouse Jr**. (NASA LaRC) presented at the World Renewable Energy Congress in Glasgow, Scotland speaking to developments in how NASA's global Earth observations from satellites can be used to inform policy.

New Tsunami Warning System May Save Lives, August 28, 2008; *Earth & Sky*. **Tony Song** (NASA JPL) and colleagues are developing a new warning system—using GPS technology to detect the horizontal motion of the sea floor—that they say would quickly alert coastal dwellers that a tsunami might be coming.

Huge Ice Sheet Could Melt Much Faster Than Thought, Raise Sea Levels, August 31; *The Canadian Press*. Researchers including **Allegra LeGrande** (NASA GISS) challenge current predictions about the rate at which the Greenland ice sheet is predicted to melt over the next century, saying it could melt much faster than predicted.

A Planet on Thin Ice, September 3; *Boston.com (The Boston Globe)*. Climate change is affecting Earth's balance, particularly in the Arctic, and ice scientist **Jay Zwally** (NASA GSFC) estimates that the Arctic could have no summer ice at all within five to less than 10 years, while **Jim Hansen** (NASA GISS) says man-made emissions are creating: "a different planet."

Asian Soot, Smog May Boost Global Warming in U.S., September 4; *Associated Press*. Scientists from NASA, including **Drew Shindell** (GISS), and the National Oceanic and Atmospheric Administration contributed to a report that found short-term and often overlooked pollutants such as smog and soot are significant contributors to global warming, though carbon dioxide is still the leading cause.

University of California Building Massive Environmental Research Lab in Hills Above Silicon Valley, September 8; *Mercury News*. University of California researchers are assembling what could become the largest array of high-tech sensors to probe environmental mysteries as grand as climate shift or as subtle as sap flow, and **Christopher Potter** (NASA ARC) says that scientists at NASA Ames hope to use the site to study the environmental impact of air quality.

Josh Willis on Oceans and Earth's Energy Balance, September 9; *Earth & Sky*. Earth's oceans play a large role in maintaining the planet's energy balance, and humans are impacting that balance, explains **Josh Willis** (NASA JPL), who uses thousands of underwater sensors to study the ocean.

Bruce Wielicki on Clouds and Earth's Energy Balance, September 10, 2008; *Earth & Sky*. **Bruce Wielicki** (NASA LaRC), the principal investigator for NASA's Clouds and the Earth's Radiant Energy System (CERES) mission, describes how clouds affect the energy Earth receives by reflecting sunlight back to space to cool the planet and by heating Earth though the greenhouse effect.

Antarctic Winter Ice Gets Bigger; Arctic Shrinks, September 12, 2008; *Reuters*. The amount of sea ice around Antarctica has grown in recent Septembers in what could be an unusual side-effect of global warming—the wintertime ice extent increased at a rate of 0.6% per decade from 1979–2006, according to **Donald Cavalieri** (NASA GSFC)—while Arctic sea ice came close to matching a September 2007 record low.

Climate Change Could Devastate Philippines, September 12, 2008; *Agence France-Presse*. Climate change could have a devastating impact on the Philippines, leading to widespread destruction of the country's flora and fauna and flooding the capital Manila, warned **Joey Comiso** (NASA GSFC), who said he was working on a project (to be funded by the Manila government weather station) to monitor the effects of global warming in the Philippines.

Is it Going to Rain or is it Going to Pour?, September 18, 2008; *San Diego Union-Tribune*. William Patzert (NASA JPL) believes a multiyear pattern known as the Pacific Decadal Oscillation, which suppresses storms in Southern California during its negative phase, will be the dominant player this winter. Prediction: 6.26 in for San Diego.

Can Rubber Ducks Help Track a Melting Glacier?, September 21, 2008; *Reuters*. To help figure out what's happening inside Greenland's fast-moving Jakobshavn Glacier, researchers including **Alberto Behar** (NASA JPL) released a GPS probe and rubber ducks at a place where rivers of melt water flow into tunnels in the ice.

When recovered, the ducks could tell scientists about features along the water's path and where it flows.

Global Warming: Beyond the Tipping Point, October 2008; *Scientific American*. Researchers including **Jim Hansen** (NASA GISS) report that carbon dioxide could contribute to a temperature rise of 6°C by the end of the century or later, and the greenhouse gas will need to be reduced from its current 385 parts per million (ppm) to at most 350 ppm to preserve a planet similar to one on which civilization developed.

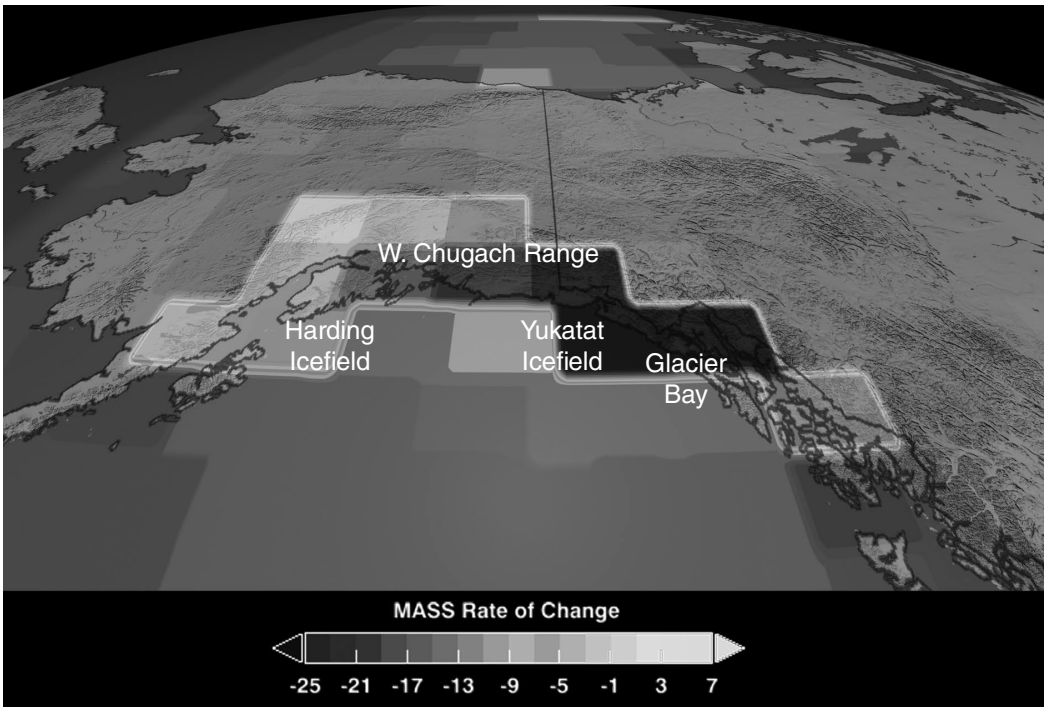
Still Time to Save the Planet … Just, October 2008; *New Scientist*. Researchers used policy scenarios and climate change models to show that it's technically and economically feasible to keep the Earth just 0.5°C warmer in 2100 than before the industrial revolution. **Gavin Schmidt** (GISS) believes the study's results are based on a more comprehensive set of scenarios than considered previously, but the conclusions are not entirely unexpected.

Robert Bindschadler on What Ice Sheets Reveal about Climate, October 1, 2008; *Earth & Sky*. Glaciologist **Robert Bindschadler** (NASA GSFC) uses images from satellites, along with core samples taken from ice sheets and glaciers, to study Earth's dynamic ice, and explains what these ice sheets can reveal about climate in the past…and in the future.

Newest Arctic Melt Record Leaves Scientists Scratching Their Heads, October 1, 2008; *Popular Mechanics*. While last winter was particularly cold, allowing the Arctic to recover slightly from last summer's shocking low, **Joey Comiso** (NASA GSFC) said that data show ice began to disappear much more quickly in August, leading to the fastest decline ever recorded for the month since satellites started collecting the measurements in 1979.

Arctic Grows Stormier, October 6, 2008; *Live Science*. The Arctic has become more stormy in the past 50 years due to the warming climate, which in turn has quickened the pace of drifting sea ice, according to a new study by **Sirpa Hakkinen** (NASA GSFC) and colleagues who analyzed data on the paths that storms took, as well as annual data on general storm activity, to confirm the accelerating trend.

U.S. Publishes First Global Carbon Dioxide Map, October 11, 2008; *Xinhua*. Researchers including **Moustafa Chahine** (NASA JPL) published the first global satellite maps of carbon dioxide in Earth's mid-troposphere, an area about 5 miles above Earth. ■



A NASA-led research team has used satellite data to make the most precise measurements to date of changes in the mass of mountain glaciers in the Gulf of Alaska, a region expected to be a significant contributor to global sea level rise over the next 50-100 years. This image shows mass changes of the Gulf of Alaska glaciers computed from the Gravity Recovery and Climate Experiment (GRACE) inter-satellite rate data, from April 2003 through September 2007. Using space-borne gravity measurements to assess glacier mass balance, NASA scientists determined mass variations along the Gulf of Alaska. The darkest shaded areas around Glacier Bay and the Yakutat Icefield represent significant mass loss and the lighter shaded inland areas represent slight mass gains. For information and to view this image in color please visit: *www.nasa.gov/topics/earth/features/glacier_tech.html.* **Credit:** NASA.

NASA Science Mission Directorate – Science Education Update

Ming-Ying Wei, NASA Headquarters, mwei@hq.nasa.gov
Liz Burck, NASA Headquarters, Liz.B.Burck@nasa.gov
Theresa Schwerin, Institute of Global Environment and Society (IGES), theresa_schwerin@strategies.org

NASA E-CLIPS: A NEW APPROACH TO LEARNING

NASA *eClips* are short (5-10 minute) video segments available on demand via the Internet. The video clips are designed to inspire students to learn more about science, technology, engineering and mathematics (STEM) and to understand the application of these subjects in the real world. The project is a NASA partnership with National Institute of Aerospace, Caption Max, Internet Archive, and *YouTube*.

Students, teachers, and the general public can look forward to new video and educational content highlighting current research and innovations each week throughout the school year. The video clips are available for streaming on NASA's Web site at *www.nasa.gov/education/nasaeclips* and on YouTube at *www.youtube.com/nasaeclips.* The NASA Web site permits users to download and save the video clips as well as stream them, and also provides lesson plans and instructions for educators on how to use the videos in the classroom.

Space Math Problems

In October, in order to better assist teachers in advanced planning of topics, *SpaceMath@NASA* transitioned from a weekly posting of problems to a quarterly posting. The first batch of 12 problems for the October–December period is now available on the Space Math Web site at *spacemath.gsfc.nasa.gov/.* The problems cover topics including probability, algebra, image scaling, and calculus for grades 4-12.

GLOBE Partner Expedition to Antarctica

October 2008 marked the start of a three-month International Polar Year expedition, called the Offshore New Harbor, to image sediments located below the sea floor. This project is part of the Antarctic Drilling (ANDRILL), a multinational initiative to recover stratigraphic core records for interpreting Antarctic's climatic, glacial, and tectonic history.

The expedition team includes scientists, students, and a schoolteacher who are living on the sea ice while collecting data that will seismically image the sediments that lie beneath the sea floor in the New Harbor area. The objective of this expedition is to locate the optimal site to drill for these sediments in the near future.

Educational activities are planned while on the ice, including the collection of meteorological data to be entered into the GLOBE Web site for use in student research. For more information about the educational efforts of the Offshore New Harbor Expedition, visit: *qcpages.qc.cuny.edu/offshore_new_harbor/offshore.htm.*

International GLOBE Gathering Kicks off New Student Research Approach

A workshop held August 3–9 brought together a diverse cross-section of the international GLOBE community. GLOBE partners and trainers received a hands-on introduction to GLOBE's Earth System Science Projects (ESSPs) and the GLOBE model of student research designed to support student scientific research around environmental topics.

This workshop was the first of several events designed to introduce the fundamentals of these projects and to glean feedback vital to the further development of ESSPs suitable for use in a wide variety of geographic regions, climate zones, and classroom environments around the world. The workshop was co-sponsored by GLOBE and the Digital Library for Earth System Education (DLESE).

As a major outcome, GLOBE partners are developing a professional staff development plan that they will be able to implement with partners and teachers in their countries and regions during the coming year—focusing on curriculum elements and inquiry and research strategies that are easily adaptable to local implementation.

The ultimate outcome will be the development of a new GLOBE Student Research collaboration and a global campaign that focuses on climate change. For more details, including links to the ESSPs, see *www.globe.gov/fsl/STARS/ART/Display.opl?lang=en&star=DLESE_Workshop.* ■

EOS Science Calendar

2008

December 8-12
ASTER Science Team Meeting, Pasadena, CA. Contact: Mike Abrams, *Michael.J.Abrams@jpl.nasa.gov*

December 12-13
GRACE Science Team Meeting, San Francisco, CA. URL: *www.csr.utexas.edu/grace/GSTM/*

2009

January 6-8
Landsat Science Team Meeting, Fort Collins, CO. Contact: Thomas Loveland *loveland@usgs.gov*

January 12-15
LCLUC Science Team Meeting, Khon Kaen, Thailand. URL: *lcluc.hq.nasa.gov*

Global Change Calendar

2008

December 2-6
Pan Oceanic Remote Sensing Conference, Guangzhou, China. URL: *http://ledweb.scsio.ac.cn/porsec2008*

December 5-13
The Fourth International Joint Conferences on Computer, Information, and Systems Sciences, and Engineering (CISSE 2008) URL: *www.cisse2008online.org*

December 15-19
2008 Fall AGU, San Francisco, CA. URL: *www.agu.org/meetings/fm08/*

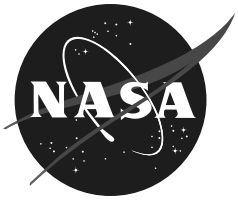
2009

January 11-15
89th Annual Meeting of the American Meteorological Society (AMS), Phoenix, AZ. URL: *www.ametsoc.org/MEET/annual/index.html*

April 26-30
7th International Science Conference on the Human Dimensions of Global Environmental Change (Open Meeting), Bonn, Germany. Contact: *openmeeting@ihdp.unu.edu*; URL: *www.ihdp.org/*

May 4-8
41st International Liege Colloquium on Ocean Dynamics, Liege, Belgium. URL: *modb.oce.ulg.ac.be/colloquium/*

May 4-8
33rd International Symposium on Remote Sensing of Environment, Stresa, Lake Maggiore, Italy. URL: *isrse-33.jrc.ec.europa.eu/index.php?page=home*



Code 610
National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, MD 20771

PRSRT STD
Postage and Fees Paid
National Aeronautics and Space Administration
Permit 396

Official Business
Penalty for Private Use: $300

(affix mailing label here)

eos.nasa.gov

The Earth Observer

The Earth Observer is published by the EOS Project Science Office, Code 610, NASA Goddard Space Flight Center, Greenbelt, Maryland 20771, telephone (301) 614-5561, FAX (301) 614-6530, and is available on the World Wide Web at *eospso.gsfc.nasa.gov/eos_homepage/for_scientists/earth_observer.php* or by writing to the above address. Articles, contributions to the meeting calendar, and suggestions are welcomed. Contributions to the calendars should contain location, person to contact, telephone number, and e-mail address.

To subscribe to *The Earth Observer*, or to change your mailing address, please call Steve Graham at (301) 614-5561, or send a message to *Steve.Graham@nasa.gov*, or write to the address above. If you would like to stop receiving a hard copy and be notified via email when future issues of The Earth Observer are available for download as a PDF, please send an email with the subject "Go Green" to *Steve.Graham@nasa.gov*. Your name and email address will then be added to an electronic distribution list and you will receive a bi-monthly email indicating that the next issue is available for download. If you change your mind, the email notification will provide an option for returning to the printed version.

The Earth Observer Staff

Executive Editor: Alan Ward (*award@sesda2.com*)

Technical Editors: Tim Suttles (*4suttles@bellsouth.net*)
Charlotte Griner (*clgriner@earthlink.net*)
Chris Chrissotimos (*cchrissotimos@sesda2.com*)
Nicole Miklus (*nmiklus@sesda2.com*)

Design, Production: Deborah McLean (*Deborah.F.McLean@nasa.gov*)

Printed on Recycled Paper