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Editor's Corner

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The Ocean Surface Topography Mission (OSTM)/Jason 2 satellite roared into space at 12:46 a.m. PDT on June 20 atop a Delta II rocket—see picture below. Fifty-five minutes later, it separated from the rocket's second stage and unfurled its twin solar arrays.

OSTM/Jason 2 is a joint NASA/Centre National d'Etudes Spatiales (CNES) [French Space Agency] collaboration that builds on the legacy of two previous missions—TOPEX/Poseidon and Jason 1—and continues the record of ocean surface topography (i.e., sea surface height) observations that dates back to 1992. In addition to monitoring changes in sea level, measurements of ocean surface topography provide information about the speed and direction of ocean currents as well as ocean heat storage. Combining ocean current and heat storage data is key to understanding the global climate.

In addition to NASA and CNES, other mission participants include the National Oceanic and Atmospheric Administration (NOAA) and the European Organisation for the Exploitation of Meteorological Satellites

continued on page 2

On June 20, 2008, the NASA-French Space Agency Ocean Surface Topography Mission/Jason 2 spacecraft launched from Vandenberg Air Force Base, CA, on a globe-circling voyage to continue charting sea level, a vital indicator of global climate change. The mission will return a vast amount of new data that will improve weather, climate, and ocean forecasts.

This photo shows the roll back of the mobile tower surrounding the Delta II launch vehicle supporting the satellite.

Credit: Carleton Bailie/United Launch Alliance.

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In This Issue

(EUMETSAT). CNES provided the spacecraft while NASA and CNES jointly provided instruments. CNES will hand off mission operations to NOAA after the checkout phase. Both NOAA and EUMETSAT will generate, archive and distribute data products.

OSTM/Jason 2's five primary instruments are improved versions of those flying on Jason 1. The technological advances will allow scientists to monitor conditions in ocean coastal regions—home to about half of Earth's population. Compared with Jason 1 measurements, OSTM/Jason 2 will have substantially increased accuracy and provide data to within 25 km of coastlines, nearly 50% closer to shore than in the past. NOAA will use the improved data operationally for ocean modeling, forecasting El Niño/La Niña events, and hurricane intensity prediction which is directly affected by the amount of heat stored in the upper ocean.

OSTM/Jason 2 entered orbit about 10 km below Jason 1. The new spacecraft will gradually use its thrusters to raise itself into the same 1336 km orbital altitude as Jason 1 and position itself to follow Jason 1's ground track, orbiting about 60 seconds behind Jason 1. The two spacecraft will fly in formation for about six months allowing for cross-calibration of the instruments. Once instrument intercomparisons are complete, Jason 1 will alter course, adjusting its orbit so that its ground tracks lie midway between those of OSTM/Jason 2. Together, the two spacecraft will double the existing global coverage.

Congratulations to OSTM/Jason 2 Project Scientists **Lee-Lueng Fu** [NASA/Jet Propulsion Laboratory] and **Yves Menard** [CNES], and the many others involved in the OSTM/Jason 2 mission who worked to bring about a successful launch. Best wishes for a successful mission!

This issue of *The Earth Observer* contains updates on two important upcoming NASA Earth science missions—Glory and Aquarius. Currently scheduled for launch in June 2009, Glory will gather important information on atmospheric aerosols and clouds using polarimeter measurements in visible to shortwave infrared bands, and continue the total solar irradiance measurements begun with the Solar Radiation and Climate Experiment (SORCE) mission [Total Irradiance Monitor (TIM) instrument]. Glory will join the existing Afternoon "A-Train" Constellation of Earth-orbiting satellites. The article on page 14 provides additional background on this exciting new NASA mission.

The Earth System Science Pathfinder (ESSP) Aquarius/Satellite de Aplicaciones Cientificas (SAC-D) satellite is designed to measure Sea Surface Salinity (SSS). The three-year baseline joint NASA and CONAE (Space Agency of Argentina) mission will reveal changing SSS patterns over the ice-free global oceans. SSS data from Aquarius, scheduled for launch in 2010, will complement existing satellite programs that monitor sea surface temperature. Together, salinity and temperature control density at the ocean surface. Sea-surface density

is extremely important since it influences the three-dimensional ocean circulation and is therefore key to understanding the ocean's capacity to store and transport heat. In addition, monthly maps of global SSS will improve understanding of the interaction between ocean circulation and the global water cycle. The article on page 17 provides more information on this upcoming mission.

Turning to Education and Public Outreach, for the eighth straight year the Earth Observing System Project Science Office (EOSPSO) sponsored an Odyssey of the Mind (OM) long-term problem related to Earth Science for team competitions during the past school year. EOSPSO staff members recently made the short trip to the University of Maryland in College Park to staff a large exhibit and give live electronic theatre presentations to the roughly 18,000 students, coaches, parents, officials, and spectators who gathered for the OM World Finals. There are two articles in this issue related to OM. **Steve Graham** has prepared an article [see page 22] called *NASA Gets "Eccentric" in Problem-solving Competition* that talks about NASA's presence at the World Finals this year and the problem that the EOSPSO sponsored—The Eccentrics.

In a unique opportunity to interact with the public, NASA recently participated in the Smithsonian Folklife Festival June 25–29 & July 2–6. The Folklife Festival is an international exposition of living cultural heritage annually produced outdoors on the National Mall of the United States in Washington, D.C., by the Smithsonian Institution's Center for Folklife and Cultural Heritage. Also highlighted in this year's festival were the nation of Bhutan and the state of Texas. For more details please visit *www.folklife.si.edu/center/festival.html*.

NASA's exhibit focused on *NASA: Fifty Years and Beyond* and showcased the role that the men and women of NASA have played in broadening the horizons of American science and culture, as well as the role that they will continue to play in helping to shape the future. The NASA Earth Science exhibits were organized and staffed by personnel representing NASA Centers as well as the EOSPSO. In addition, a number of NASA Earth scientists, Project Scientists, and university collaborators participated in panel discussions that reflected on both the personal and scientific side of a NASA Earth science career. In all, it was estimated that about 500 NASA personnel participated in the festival. This was a valuable and enjoyable experience (typical summer heat and humidity not withstanding), and a unique way in which to celebrate NASA's first 50-years.

Join Our Go Green Campaign

In an effort to cut back on the amount of paper used to produce this newsletter, we would like to announce our Go Green campaign. 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—so you have nothing to lose.

Issues dating back to January 1995 can be downloaded from this link:

eospso.gsfc.nasa.gov/eos_homepage/for_scientists/earth_observer.php

feature articles

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

Introduction by Kathryn Hansen, khansen@sesda2.com, Goddard Space Flight Center
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David Knapp, david@ucar.edu, National Center for Atmospheric Research
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To investigate the atmosphere's role in the climate-sensitive region of the Arctic, NASA and its partners undertook an extensive field campaign to study the chemistry of the Arctic's lower atmosphere. The spring deployment of the Arctic Research of the Composition of the Troposphere from Aircraft and Satellites (ARCTAS) mission aimed to help scientists identify how air pollution contributes to climate changes in the Arctic.

Three NASA research aircraft—the DC-8, P-3 and *King Air* B-200—served as airborne laboratories carrying instruments to measure air pollution gases, aerosols, and solar radiation. Of particular interest was the formation of the springtime *Arctic haze*, which is fueled by sunlight causing chemical reactions of pollutants accumulated over the winter. Long-range transport of lower-latitude pollutants results in this accumulation.

"It's important that we go to the Arctic to understand the atmospheric contribution to warming in a place that's rapidly changing," says **Jim Crawford** [NASA Headquarters—*Manager of the Tropospheric Chemistry Program*].

"The Arctic is a poster child of global change, and we don't understand the processes that are driving that rapid change," says **Daniel Jacob** [Harvard University—*ARCTAS Co-Project Scientist*] "We need to understand it better."

"We can see *Arctic haze* coming in, but we don't know its composition or how it got there. One goal of ARCTAS was to provide a comprehensive understanding of the aerosol composition, chemistry, and climate effects in the Arctic region," says **Hanwant Singh** [NASA Ames Research Center—*ARCTAS Co-Project Scientist*].

The new aircraft observations also helped researchers interpret data from NASA satellites orbiting over the Arctic, such as the Aura, Terra, and Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) missions. Interpreting satellite data can be difficult in the Arctic due to extensive cloud cover, bright reflective surfaces from snow and ice, and cold surface temperatures. For example, it's difficult for researchers to look at satellite data and distinguish between light reflected by clouds and light reflected from white ice cover.

"Satellites orbit over poles with good coverage and good opportunity, but you really need to have aircraft observations supporting those to make good interpretations of what satellites are telling you," Jacob says.

The new airborne view of the Arctic's atmosphere obtained during ARCTAS combined with satellite data provide scientists with a better understanding of the atmospheric side of the climate question.

A second phase of the ARCTAS campaign takes place this summer from Cold Lake in Alberta, Canada, where flights will focus on measurements of emissions from forest fires. Researchers want to know how the impact of naturally occurring fires in the region compares to the pollution associated with human activity at lower latitudes. Look for coverage of the second part of ARCTAS in a future issue of *The Earth Observer*.

Some of the spring ARCTAS field campaign participants reported on their experiences while on location in the Arctic. What follows are excerpts from a blog first published by *Discovery earthlive*$_{TM}$ titled *Flying Over the Arctic*. *The Earth Observer* has obtained permission to reprint portions of the blog, the full text of which can be found at *discovery.com/discoveryearthlive.*

To read more about Arctic haze studies, please see the news story, "NASA Scientists Hope to See the Data Through the Haze" on page 38 of this issue.

NASA's DC-8 flying laboratory lifts off the runway at Air Force Plant 42 in Palmdale, CA, on its first flight in the ARCTAS atmospheric science mission—*www.nasa.gov/mission_pages/arctas/arctas_update.html.* **Credit**: NASA.

A Long Way from Home

Mike Obland [NASA Langley Research Center (LaRC)]

Barrow, Alaska, April 1, 2008

Whew! Alaska (and Barrow in particular) is a long way from Virginia! My alarm unpleasantly woke me up at 4:30 a.m. By 5:30 a.m. I was at the airport, stuffing a last-minute supply of heater blankets for our laser into my already overstuffed bags. **Tony Cook** [LaRC], one of the engineers on the High Spectral Resolution Lidar (HSRL) instrument, made a special trip before sunrise to get them to me, rather than waiting for the one-week shipping time to Barrow....talk about dedication!

At this time of year, the only route in and out of Barrow is by air. There are no open roads, and sea routes are still frozen over out past the Point Barrow coastline. Everything comes and goes by air, which makes the passenger planes a little different. I flew into Barrow in a *Boeing 737-400 Combi*, whose forward half is a cargo plane loaded with huge crates of supplies, and the rear half is more or less a normal passenger airplane with about 12 rows of seats. The flight was maybe only half-full, probably filled with Barrow locals who were in Fairbanks on shopping trips. I can't imagine living in a place where the nearest shopping is a plane ride away....and this is still the U.S.!

Mike Obland and Ray Rogers inside the NASA *King Air* B-200 based at Langley Research Center.

Arctic Investigations 101

Mike Obland

Barrow, Alaska, April 2, 2008

The science flights for the ARCTAS campaign are not starting until tomorrow, so that gives us today off. We are taking today as a *hard-down* day so that we can be ready to fly the next six days, making our next day off next Wednesday. It is easy to work so much when you love what you do.

I'm a postdoctoral fellow at NASA Langley Research Center....just finished graduate school at Montana State University in May 2007, and started work at NASA in June 2007. My expertise is in laser radar (or lidar) systems. A *lidar* is a scientific instrument that sends out a laser beam, which interacts with whatever object you are trying to study, and measures the amount and properties of the light that is reflected back from that object. The primary advantage of a lidar is that it can map out where things are in the atmosphere without having to sample them directly. This is called *remote sensing* since you are making measurements remotely which is opposite of *in-situ* measurements—where you examine atmospheric particles directly to tell what is there. The HSRL we work with measures the location and properties of *aerosols*, which are things in the air that are not "air" (e.g., smoke, pollution, dust, and sea salt), looking down from our aircraft, the NASA *King Air* B-200. Using our data, we will be able to relay important information about the location of aerosol layers to these other researchers in real-time, helping them find the areas with the most interesting or characteristic samples to be taken. Our data are also used to validate and compare with satellite measurements, primarily from Moderate Resolution Imaging Spectroradiometer

(MODIS) and CALIPSO, to validate aerosol predictions from climate models, and to try and solve a variety of other research questions involving the atmosphere.

So you may be thinking, all well and good but: *Why are we here in Barrow, AK of all places?* We are here as part of a national campaign involved with the International Polar Year to study the Arctic region, specifically looking at changes in the region's atmosphere. There are over a hundred scientists involved with this study and several aircraft besides our own.

Back in the Air

Mike Obland

Barrow, Alaska, April 3, 2008

It's good to be back in the air again. Today was our first ARCTAS science flight. I packed my gear, which normally consists of a digital handheld camera that the pilots use to take pictures of sky conditions and a hard drive that we use to download the data for analysis as we land. In the Arctic, though, I also have to pack cold-weather gear.

Today was a beautiful day with clear blue skies, but the wind chill brought the temperature down around -10°F (-23°C). Our flight today took us northwest over the Arctic Ocean and the ice pack for an underflight of the CALIPSO satellite, to compare and validate its measurements. On flights like these, the flight crew has to wear exposure suits. Affectionately dubbed *poopy suits*, these are bright orange dry suits designed to help keep us alive if the worst were to happen and we were forced to make an unscheduled stop out on the ice pack or in the ocean! We like to joke that the suits will just make us more visible to polar bears.

Ray Rogers [LaRC] and I went to the hangar to do our preflight procedures and wrapped some heating blankets around the laser to warm it up before takeoff. The laser likes to operate at around room temperature; otherwise, its power output decreases.

The flight went beautifully. The scenery was amazingly desolate: white, pristine sheets of ice separated by long thin cracks of deep blue ocean water. With the Arctic haze, visibility was perhaps 30 to 40 mi and, of course, no towns or any indication of civilization were present. Beautiful and lonely scenery at the same time.

Ups and Downs of Fieldwork

Mike Obland

Barrow, Alaska, April 4, 2008

Today was a perfect example of what it is like to be an experimental scientist who does fieldwork. You have to be flexible and ready for plans to change. The plan was for Ray to take the flight, and I would stay on the ground. But as Ray, **Chris Hostetler** [NASA Langley Research Center—*HSRL Co-Principal Investigator*] and I were discussing the flight plan for the day, Chris suggested that we both fly so that we could troubleshoot the data downlink and Inertial Measurement Unit (IMU) problems that we encountered yesterday. I ran quickly back to the hotel, changed into my flight suit, and got back to the hangar to board the airplane.

The door was closed behind us, and we started our procedures. The instrument started up as normal except the IMU was still providing incorrect readings. It turns out that IMUs are highly sensitive to magnetic fields and to any metal in the vicinity that could carry magnetic fields. We thought about what had changed in the airplane and one thing stuck out: the heating pads that we had added to keep the laser warm during the flights! Sure enough, we removed the heating blankets, cycled the power to the IMU, and it came up with reasonable measurements once again. Unfortunately, we now needed a way to keep the instrument warm. I wrapped our jackets around the laser as a temporary solution. But the IMU started giving erroneous readings for no visible reason shortly before we started our descent for landing. The entire crew spent some time troubleshooting the problem and didn't come to any solutions, but I'm positive we will. Tomorrow is another day.

We had to cut short our low-level flight, so the pilots could establish radio contact with Thule Airbase, Greenland. There was some gnashing of teeth over this since one of our science objectives is to find ozone depletion events (ODE), presumably the

result of bromine oxide (BrO), which we stand a better chance of seeing at very low altitudes. It's a classic airborne science dilemma—how to satisfy air traffic control (ATC) as well as the science objectives.

Icebergs off the coast of Thule.
Credit: Andreas Beyersdorf.

Looking for Nitrogen

David Knapp [National Center for Atmospheric Research [NCAR]

Thule Airbase, Greenland, April 6, 2008

I'm an associate scientist with NCAR in the atmospheric chemistry division, in the Community Airborne Research Instrumentation (CARI) group. Our group operates a number of experiments studying a variety of gas compounds primarily on aircraft, but occasionally also on the ground. Our principal investigator, **Andy Weinheimer** [NCAR], and I will be measuring ozone, *active nitrogen*, and *reactive nitrogen*. Nitrogen naturally exists in our atmosphere as N_2—the most abundant gas which is about 80% of what we breathe. N_2 has a very strong and stable bond. Some natural processes, however, like lightning and bacterial metabolism, can break that bond and enable the combination of nitrogen with oxygen or other atoms to form still other nitrogen compounds which can then be used by plants and animals like humans. What we're measuring in ARCTAS are nitrogen compounds that mostly occur as a result of combustion, either from cars, industry, or fires.

We arrived at the airport for a 4:30 p.m. takeoff. Over Queen Maude Island in Northern Canada, we're seeing relatively high carbon monoxide (CO) and some sulfur dioxide (SO_2). It's surprising to see industrialized city levels of CO in such a remote place. Both of these compounds would be produced from coal burning, so this could be an aged coal burning plume. After descending to about 500 ft above the ground (I mean ice) we're seeing ozone drop to ~25 parts per billion by volume (ppbv). That sounds small, but [to give an idea,] ozone can be a health hazard at 100 ppbv.

A Brisk Morning Jog Before Flying in the Clouds

David Knapp

Thule Airbase, Greenland, April 5, 2008

[I am] up at 4:30 a.m. for a very brisk walk to the cafeteria at about 5°F. The snow crunches as I walk in my entirely inadequate running shoes. The nylon in my jacket makes cracking sounds. I was jogging with such a bounce in my step that I jogged right past the cafeteria building. A beautiful morning for such a mistake—the sun low on the horizon, ice fog gone, and just enough breeze to command a respect for the weather. Snowshoe hair tracks, and what I think are Arctic fox tracks, abound. We're back on the plane for pullout and fueling at about 7 a.m.

We just passed through what looks like some extremely wide *contrails*. NO_x and NO_y both went up, as did another group's condensation nuclei (CN) measurement—characteristic of a contrail. We're off the southwest shore of Greenland. The laptop

feels good and warm on my lap as there is cold air pouring from the wall. Outside the plane it's -22°F (-30°C) and we're flying about 375 mph at 20,000 ft. There is a layer of frost on the aluminum window blank next to me. Our instrument is working well, a reflection of how much time we spent designing and building it to be dependable.

Mike Puts on His Poopy Suit

Mike Obland

Barrow, Alaska, April 8, 2008

Rick Yasky [LaRC], **Mike Wusk** [LaRC], and I took off just before 1 p.m. and did a pass over the North Slope of Alaska site before heading northwest over the frozen ocean. It was consistently snowing in Barrow, and the conditions on the ground were completely overcast with low visibility. What that translates into at 28,000 ft is a solid sheet of fluffy clouds below us obscuring the ground. We were seeing some interesting data coming in showing some possible dust layers at high altitudes that have people excited. It is amazing, because this dust could be coming over from Asia or Europe and affecting the local air quality in Barrow, AK. **Air quality certainly does not follow international boundaries!**

We reached an important milestone today. Sometime during the morning flight, we logged the 500th hour of HSRL science operations aboard the NASA *King Air* B-200. The greatest virtue of the HSRL is that it can measure how aerosols scatter or absorb light. According to Mike, this may be the most flight hours for a single scientific project on any of the NASA Langley airplanes in the past 20 years, with over 160 flights across 2.5 years; something for our dedicated crew to be proud of! We will continue flying tomorrow.

The Children of Barrow

Mike Obland

Barrow, Alaska, April 9, 2008

Educating the public about NASA's research is a very important task, but something we rarely get to do in our daily jobs. Today was a pleasant exception. At last weekend's annual spring festival, we met a lady who is a second-grade school teacher here in town. Mike arranged for a few of us to go to their school this morning and give a short presentation about our work to the entire second-grade class, between 80 and 100 students.

The children, as usual, were incredibly smart and perceptive and asked great questions. Mike talked about what NASA does in general and how important education is to being successful in the science field. Ray talked about the specific atmospheric research that we are doing, and Chris explained how the Arctic haze they see comes from all parts of the world. I discussed the kinds of equipment that we need to be safe in this remote Arctic environment. Maybe I shouldn't be surprised, but these kids were able to come up with a list of all the safety equipment that we carry onboard in case of an emergency: tent, tools, life raft, dry suits, oxygen masks, food, etc. Very smart kids!

So Much to Do and Not Enough Time

Mike Cubison [University of Colorado]

Fairbanks, Alaska, April 9, 2008

The sheer scale of the logistical operations required of the NASA staff to pull off this mission in a successful manner cannot be underestimated. Not only do the majority of the science team have to execute various checks and calibrations on their instruments, but the crew is busy preparing the aircraft for the next flight, performing any number of tasks from refueling to navigation planning. The Alaskan weather does its utmost to upset the *status quo*. Need somebody to spend all day chipping ice from the exterior of the aircraft and sweeping the wings free of snow? Well, NASA has the man for the job.

The Best Laid Plans

Jennifer Olson [LaRC]

Fairbanks, Alaska, April 9, 2008

Earlier this week, we had planned for both the DC-8 and P-3B aircraft to do another suitcase flight to Thule, Greenland. A lot of the "places of interest," as forecast by the modelers here, are impossible to reach with the airplanes if they have to return to Fairbanks for landing. Doing the overnights in Thule gives us more stretch. One of those places of interest is Eureka on Ellesmere Island, Canada—latitude of about 80°N—and a population of 168, give or take a couple. Apparently there are plenty of musk ox, Arctic wolves, Arctic foxes, Arctic hares, and lemmings. (I did not know that lemmings were an Arctic animal. You learn something new every day). Eureka is an Arctic research station, and over the years, its measurements of ozone near the surface have shown very low ozone amounts during the springtime, leading us to believe that this chemistry involving bromine *[mentioned above]* is happening frequently in this area.

I was able to take in a marvelous dog-sled ride one evening earlier this week. It was one of the most peaceful things I've ever done. The Arctic light was soft, and the trail we were on was a gentle ride through the trees. I got to ride the runners for a while, too. Amazing! The Arctic is a lovely place.

Yikes! How Much for a Gallon of Milk?!

Mike Obland

Barrow, Alaska, April 11, 2008

Today was a *hard-down* day so that we could line up our flight plans with the other aircraft this weekend and next week. I, unfortunately, spent almost the entire day writing a scientific paper. I did get a chance to leave the hotel later in the afternoon, when Ray and I went out to the main local grocery store. The one thing that is very different is the price of the food. A gallon of milk will cost you about $9! The cost of groceries is crazy, due to the need to ship everything in by plane. A few items for meals for the week cost $55.

Cold, Smoke, and… Mexican Food??

Mike Obland

Barrow, Alaska, April 12, 2008

Wow! It's cold up here! At 3:30 p.m. on a nice, clear, sunny day, the temperature was -9°F (-23°C), and even though the wind is only blowing at 6 mph, factor in the wind chill, and it feels like -21° F (-29°C). I was working at the hangar, took a short lunch break, and walked back to the hotel which is about a quarter of a mile, without a face mask. I couldn't have been outside for more than 10 minutes, but my face felt like it had been exposed for hours.

We are back to business as usual, with Rick, Mike, and Ray doing a flight that includes a CALIPSO under-flight, coordinated with the NASA DC-8 aircraft and some measurements of Siberian forest fire smoke with the NOAA P-3. It is amazing to see the difference in the atmosphere from day-to-day. That is why predicting and modeling the atmosphere is so difficult … **how do you model something that changes minute-by-minute and mile-by-mile accurately enough to predict how it will respond 10 years from now?** Hopefully this campaign will help answer questions like that.

A Winter Break

Mike Obland

Fairbanks, Alaska, April 13, 2008

It looks like we're taking a little break from Barrow for a few days. We flew down to Fairbanks today so that we can participate in Media Day tomorrow, which is a chance for local reporters to come tour our airplanes, talk to the people involved in ARCTAS, and learn about what we do.

We were set to fly out around 11:30 a.m., depending on the morning fog, which gave a few of us time to attend a local church service. The walk back to the hangar from the church takes only about 10 minutes or so, but the wind was so brutal that I'm not sure I could have stayed outside much longer. The actual temperature was down around -20°F (-29°C) to start with…and adding a steady wind over 10 mph makes for an unpleasant morning. Any exposed skin just starts to hurt after a few minutes.

View of the Brooks mountain range outside Fairbanks from 28,000 ft **Credit**: Mike Obland.

This does not seem to bother the locals, though, **some of whom were outside playing basketball in this weather**. To them, I suppose this seems like a heat wave compared with the rest of the winter!

Back at the hangar, the plan was for Rick, Mike W, Ray, and I to do a CALIPSO under-flight in coordination with the NASA P-3 on our way to Fairbanks. We lifted off around noon, ascended to our cruise altitude of 28,000 ft, did a quick run over the Department of Energy (DOE) National Security Agency (NSA) site, and then headed southwest toward the CALIPSO track. There was quite a bit of coordination with the ground on this flight, as the P-3 scientists wanted periodic updates on the cloud situation that we were measuring below us. The weather was not cooperating and most of the CALIPSO track was covered with clouds. Our measurements in that case will be very different from CALIPSO's, even though we are measuring the same region at the same time.

After a long flight, we finally made it into Fairbanks and were thankful to see mountains, trees, and even people again! It has been a couple of weeks since we have seen stoplights or fast-food restaurants or driven on roads that were clear of snow.

Checking Out the King Air and HSRL

Mike Obland

Fairbanks, Alaska, April 14, 2008

Immediately after the media briefing, **John Hair** [LaRC], Ray, and I went back to the airport where the *King Air*, NOAA P-3, NASA P-3, and the NASA DC-8 were stationed and gave tours of our instrument. We had a number of different groups ranging from college English students, to graduate students in atmospheric studies, to congressional staffers, to scientists working on other instruments. It was fun to finally meet some of the other people involved with this campaign….the scientists that we will be analyzing data with and the pilots that we hear on the radio when we are in flight. The NOAA P-3 and NASA DC-8 might have a dozen or more instruments with dozens of researchers onboard—quite a bit different than our one instrument and one or two researchers!

One fun part about this job: a lot of the time you don't know what task you will be working on day to day…we just decided tonight that we are going to stay in Fairbanks for another night so that we can fly with the NASA and NOAA P-3 airplanes tomorrow.

A Clear Day for Aerosol Tracking

Mike Obland

Fairbanks, Alaska, April 15, 2008

Today was a long day. It officially started at about 6:20 a.m. We had to move our airplane out of the hangar to fuel it for today's flight, and then put it back in to keep the instrument warm. Hangar coordination has been complicated, because of the number of planes being kept in there. The NOAA P-3, our much smaller *King Air,* and the *Convair* aircraft that we have been flying frequently are all stored in this hanger.

The flight for today was coordinated with the NASA and NOAA P-3s early in the flight as we headed west from Fairbanks. Today had the best visibility that I have seen on any of our flights in Alaska so far. We were relaying our observations of the cloud and haze situation to the pilots on the other aircraft, and then down to scientists on the ground who were adjusting their flight plans moment-by-moment.

After working with the P-3s, we turned to intercept a CALIPSO track for the last part of a more than five-hour flight.

With the campaign coming to a close, there was some discussion about planning for the last few flights and for packing up and shipping everything back to the lower 48 states. The time up here has seemed to go by quickly. Actually, at this point, with all the days that we have been working in a row, it is hard to keep track of the days. I have to keep checking calendars to see what day of the week it is.

We are heading back to Barrow tomorrow and it will be another long, two-flight day. I need some sleep!

Refueling in Nome

Mike Obland

Barrow, Alaska, April 15, 2008

Back to the frigid north! We left Fairbanks at about 9:45 a.m. on the start of a long, roundabout trip back to Barrow. The plan was to take data along the NASA DC-8's flight path. They were doing a pentagon pattern counterclockwise around most of Alaska, and we would run over a few of their legs in the opposite direction on our way up to Barrow. We went west from Fairbanks, and stopped to refuel in Nome. The flight was longer than expected due to the 130 mph headwinds. Rick even commented at one point that if we had any more headwinds, we'd be flying backwards. The taxiways were solid ice, and we could feel the plane slipping and sliding around. With all the snow it was hard to tell the difference between taxiway and field! Our primary plan in Nome was to fuel the airplane as quickly as possible so that we would take off

Rick Yasky, Mike Wusk, Ray Rogers and Mike Obland (l-r) in the *King Air* heading back to Barrow from Fairbanks. **Credit:** Mike Obland.

in time for the CALIPSO run this afternoon, and if we could find some lunch that would be great, too. Fortunately, one guy fueled our plane while the other ran Mike and Ray into town to grab us some sandwiches without having to wait for a taxi. We thanked them and gave them some NASA calendars and stickers that Mike had on hand. After changing into our poopy suits for the afternoon over-water flight, we were on our way in only about an hour after landing.

We relayed the really interesting information we were seeing on dust and smoke layers below us to the pilots of the DC-8. We picked up the CALIPSO track and took some amazing data of what may have been Asian dust and smoke. We were all glad to arrive back in Barrow around 6:30 p.m. We were just beat after a long day.

We have another science flight with the NASA DC-8 and CALIPSO tomorrow, and we are starting to talk about when to head back to Virginia.

Winding Down

Jennifer Olson [LaRC]

Fairbanks, Alaska, April 16, 2008

Today is the last day for flight planning. When this was announced, you should have heard the chorus of cell phones being used to re-book tickets for home. Everyone here is exhausted, we're tired of eating out most of the time, and we miss our families and are ready to be home. But I don't think I'm alone in ultimately being very glad I was here.

The DC-8 is flying a sortie out of Fairbanks today. It's hitting a range of objectives, from flying low in the boundary layer up north at the land/sea ice boundary, to sampling some aging Asian pollution several km up in the troposphere, to flying low over some lakes on the Seward Peninsula to measure the methane (CH_4) flux out of them. Tomorrow, the DC-8 will head straight to Prudhoe Bay (near Barrow) and then to the North Pole (or as close as we can get, since the Russians claim the air space directly over the Pole). That flight will attempt to sample some European pollution that has entered the polar region, reminiscent of Arctic haze.

About 20 of us had dinner last night at a little Korean restaurant underneath a bowling alley (I think the location was the pull.) It's a close camaraderie within an interesting mix of people—a mix of people that are diverse enough that I can't find a single common thread between them all other than science. **For most people here, science is not so much their "work" as it is simply integrated into their lives.** It's exciting to be out here as a part of discovering new information. We're all in complete agreement that there's not much more important work to be done than learning about the impacts of climate change.

A Near-Miss of a Missed Approach

Mike Obland

Barrow, Alaska, April 17, 2008

Another typical day today. We had a flight planned for later in the morning, so I started the day by working on our data backups. Unfortunately, the Internet was down throughout town again. This seems to occur every week or so. Something happens, and the entire town loses its Internet connection. Back home I could at least go to a bookstore, coffee shop, or library to get the Internet, but not here… [remember, the nearest *Starbucks* is in Fairbanks].

I joined Rick and Mike on a flight east to Deadhorse, which is near Prudhoe Bay and the start of the Alaskan oil pipeline. We coordinated with the DC-8 by flying over it as the crew did a "missed approach" maneuver at the Deadhorse airport. For the *in-situ* measuring planes like the DC-8 and P-3s, this is standard procedure for coming down to a low altitude, sampling air along the way. It is interesting to see from the ground, because you have a huge DC-8 buzzing not very high overhead. It is also hard to take pictures of them unless you know exactly when they are coming. Chris and I both have been teased by the guys for missing these photo opportunities on this campaign!

After the DC-8 coordination, we turned west and did a CALIPSO satellite run northwest of Barrow, with the same desolate views of sea ice as far as we can see. We took fascinating data of smoke and a deck of cirrus clouds below the plane. Cirrus are wispy clouds that are usually higher than the plane, so it was rare to be able to measure their properties from above and will be very helpful in verifying CALIPSO results.

The mission is winding down. Tomorrow is a *hard-down* day, followed by perhaps our last research flight on Saturday, and possibly starting for home on Sunday or Monday.

Hanging Out in Barrow

Mike Obland

Barrow, Alaska, April 18, 2008

Today was our first day off since last Friday. It has been a long week, especially with the busy trip we had down to Fairbanks.

I wanted to do last-minute tourist tasks before leaving Barrow. Ray and I drove around the town taking pictures, and stopped in at the Laundromat and picked up a few Christmas gifts and souvenirs for friends and family. We also stopped by the AC grocery store, because for some reason they were having a crazy clearance sale on cologne, and the prices were too good to pass up. Of course, when I got back to the hotel, I opened up the container and the bottle had leaked about a quarter of the cologne. So, you get what you pay for, but it was still a good deal.

The people here seem very concerned about the changes to their environment, and several people have specifically mentioned all the haze and pollution that is coming their way. They have been appreciative of the work we are doing.

One thing we all wanted to do before leaving the frigid confines of Barrow was to take a few fun pictures of us decked out in our shorts and Hawaiian shirts. After a little coaxing, we all agreed and changed clothes. We were all pretty cold after taking those pictures, and were generously greeted back at the hangar with a home-cooked Philippine meal by one of the hangar employees, P. J., and his wife, Melva. P. J. has been very helpful with moving, servicing, and fueling our plane the entire time we have been in Barrow. The meal was delicious; we appreciated P. J. and Melva's hospitality.

What to do on a day off in Barrow? Mike Wusk goes Hawaiian in the snow. **Credit:** Mike Obland.

Stuffed from dinner, I went back to the hotel to start packing my suitcases for the trip home and to get some sleep. We have one more research flight tomorrow. Today may have been the most scenic flight I have had on the *King Air* since taking this job last June. We started our transit back to Virginia and flew from Barrow to Fairbanks and on to Juneau in two flights.

A Plane With a View

Mike Obland

Juneau, Alaska, April 20, 2008

Most of my gear was packed last night, so I just had to put a few last-minute items in my bag, upload some data, and check my email. Back at the hangar, Ray and I did the preflight for the instrument and made sure all the gear that we needed was onboard. After tightly packing luggage and gear for the four crew members who would be transiting back with the plane (Rick, Mike, **Dale Bowser** [LaRC] and myself), Rick, Mike and I went to church.

After church, we were expecting to basically just say our goodbyes, load onto the plane, and take off. Unfortunately, getting jet fuel in Barrow on a Sunday morning can sometimes be problematic, and we were forced to wait for a few hours as Dale and P. J. called everyone they could to try and find fuel. In the meantime, we played many rounds of really bad pool at the hangar. With all the thawing and freezing in the Arctic, building foundations tend to be very warped. A consequence of this is that the pool table is not exactly level, creating some interesting shots.

We finally lifted off at 1:15 p.m. and put Barrow behind us. We landed in Fairbanks to refuel and grabbed some quick snacks for lunch, and then we were on our way.

South of Fairbanks we finally had amazing views of southern Alaska: mountain peaks as far as you could see, being carved out by gigantic glaciers. Rick flew almost exactly over the peak of Canada's Mount Logan—the second-highest mountain in North America, at over 19,500 feet. Very impressive!

Our approach into Juneau was amazing, too. Juneau is situated between towering mountain peaks and right on an inlet from the ocean, and the airport is right in the middle of all that. We were lucky to fly in here on a clear-weather day. Dale had contacts with the local Army National Guard unit, and they graciously allowed us to park our airplane in their hangar overnight and use one of their vans to drive around town.

If you love to travel and see new places and things, this is a great job.

EDITORS NOTE: Roughly 150 scientists and support staff were involved, comprising 30 research teams. For a full list of ARCTAS participants, visit *www.espo.nasa.gov/arctas/participants.* ■

feature articles

An Update on the Glory Mission

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Scheduled for launch in June 2009, NASA's Glory mission will gather important information on total solar irradiance and aerosols that should help scientists reduce some of the uncertainty surrounding these two important climate regulators.

The Story Behind Glory

Total solar irradiance (TSI) is defined as the amount of radiant energy emitted by the Sun over all wavelengths that falls each second on 1 m^2 (11 ft^2) outside the Earth's atmosphere. TSI is the dominant external driver of global climate. A small change in the total amount of energy reaching the Earth from the Sun can have a large impact on climate. Tiny atmospheric particles called *aerosol*s are also essential constituents of the atmosphere that affect global temperature. These aerosols originate from natural processes as well as from *anthropogenic* processes—i.e., from the activities of humans.

Scientists think that the climate effects of solar (TSI) variability and aerosols are likely to be comparable to those of the greenhouse gases. But, unlike greenhouse gases, TSI and aerosols are not well represented in the models that scientists use to help them predict climate change. In fact, the inability to adequately incorporate these two important climate change agents may represent the largest uncertainty in current climate change studies—the errors are still so large that they preclude meaningful climate model evaluation by comparison with observed global temperature change. Scientists need to improve model representations of TSI and aerosols to adequately constrain the uncertainty in climate sensitivity.

Scheduled for launch in June 2009, NASA's Glory mission will gather important information on TSI and aerosols that should help scientists reduce some of the uncertainty surrounding these two important climate regulators. Glory is designed to support the U.S. Climate Change Science Program and will join the Afternoon "A-Train" Constellation of Earth-orbiting satellites[1]. This article provides some background on this exciting new NASA mission.

Science Objectives

The Glory Mission is intended to meet the following scientific objectives:

- Improve our understanding of the effect of solar variability on the Earth's climate by continuing the uninterrupted 30-year satellite measurement record of TSI.
- Provide the global distribution of the amount and microphysical properties of both natural and anthropogenic aerosols and clouds with much improved accuracy thus leading to improved understanding of both the direct and indirect effects of aerosols on climate.
- Provide improved aerosols model representations of aerosol microphysics for use in retrievals from other spaceborne instruments.
- Provide an improved framework for the formulation of comprehensive satellite missions for aerosols, cloud, and ocean color research.
- Link radiative energy inputs to atmospheric scatter and absorption, improving knowledge of energy balance.

[1] This constellation currently includes NASA's Aqua, Aura, CloudSat, and Cloud–Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) missions, as well as a Centre National d'Etudes Spatiales (French Space Agency) mission called Polarization and Anisotropy of Reflectances for Atmospheric Sciences Coupled with Observations from Lidar (PARASOL), and will also include NASA's Orbiting Carbon Observatory (OCO).

Instruments

The Glory science objectives will be achieved with two independent instruments. The Total Irradiance Monitor (TIM) will provide measurements of TSI with extremely high accuracy and precision. The Aerosol Polarimetry Sensor (APS) will collect accurate multi-angle photometric and polarimetric measurements of the Earth along the satellite ground track over a broad visible and near-infrared spectral range, thereby facilitating aerosol retrievals with unprecedented precision and accuracy.

TIM

The Laboratory for Atmospheric and Space Physics (LASP) at the University of Colorado/Boulder built the Glory TIM and it has already been integrated onto the Glory spacecraft. To identify long-term changes in solar irradiance, TSI instruments need long-term calibration stability as well as either very good absolute accuracy, allowing an operational instrument to be directly compared against previous and future ones on the same solar irradiance scale, or continuity of measurements, so that data from multiple instruments are compared via overlapping observations.

A photograph of the Total Irradiance Monitor.

Glory is expected to overlap with the ongoing Solar Radiation and Climate Experiment (SORCE) mission, which also carries a TIM instrument. (SORCE has been in its extended operations phase since January 2008 and should operate until at least 2012.) Furthermore, the Glory TIM instrument is intended to have an absolute accuracy of 100 parts per million [ppm] and a stability known to 10 ppm/yr. This absolute accuracy is better than that of any previous spaceborne TSI instrument and is achieved by meticulous ground calibrations at the component and system levels using a new dedicated calibration facility at LASP. Comparisons between this facility and flight spares of previous TSI instruments may also help diagnose existing instrument offsets.

APS

Although several satellite instruments are currently used to study aerosols and their climatic effects, the retrieval of accurate particle characteristics from space remains a very difficult task. The best ways to increase the information content of data provided by a passive spaceborne instrument measuring characteristics of the reflected sunlight are:

- to measure not only the intensity but also the other Stokes parameters describing the polarization state of the reflected radiation;
- to increase the number of spectral channels and the total spectral range covered;
- to increase the number and range of viewing directions from which a scene location is observed; and
- to improve the measurement accuracy, especially for polarization.

By combining all the above measurement capabilities, the Glory APS affords the development of optimal retrieval algorithms which take full advantage of the extreme

A photo of the Aerosol Polarimetry Sensor as it was being assembled at Raytheon.

sensitivity of high-accuracy polarization data to aerosol and cloud particle properties. Raytheon is building the APS and it is currently at the stage of final assembly and testing. The APS design is based on an aircraft instrument, the Research Scanning Polarimeter, which has proven the fundamental APS concept with better than 0.2% accuracy polarimetric data for a wide range of atmospheric and surface conditions.

Mission and Science Operations

The Glory spacecraft was built by Orbital Sciences Corporation (OSC). Glory will be launched from Vandenberg Air Force Base aboard a *Taurus XL* launch vehicle and will be flown in the A-Train orbit[2], facilitating synergistic measurements with other missions in the constellation. Glory will have an approximate 1:34 pm equatorial crossing time, placing it 11 minutes behind Aqua—the lead spacecraft in the formation. The Mission Operations Center at Orbital's campus in Dulles, VA will operate the spacecraft. LASP will provide the capability to command the TIM instrument, monitor its performance, and generate TSI science data products. The Goddard Institute for Space Studies will be responsible for scheduling the APS instrument activities, monitoring the instrument performance, and generating aerosol and cloud data products.

TIM will monitor the Sun during the daytime portion of each Glory orbit. Measurements of dark space during the eclipsed portion of each orbit will be used to correct for the instrument's internal thermal background. The Glory APS daytime aerosol and cloud products will be delivered with a ~6 km spatial resolution (at nadir) along the Glory ground track. The nominal A-Train orbit implies a repeat cycle of 233 revolutions/16 days. The APS and TSI data products will be archived and disseminated by the NASA Goddard Earth Sciences Data and Information Services Center.

Glory Science

Glory will be the first mission able to identify different aerosol types, which should help distinguish the relative influence of natural and anthropogenic aerosols.

TIM data acquired at 50-s intervals follow short-duration changes in the TSI due to solar convection and oscillations. They are subsequently averaged to provide reported daily and 6-hourly values for the TSI climate record. This quasi-continual monitoring helps diagnose short-term solar mechanisms causing irradiance changes and provides sufficient sampling of the variable Sun to compute an accurate average over each reporting period. The Sun has both direct and indirect effects on the terrestrial system, and Glory TIM measurements will provide the requisite understanding of the variability of this essential climate system parameter.

The Glory APS will yield a range of aerosol and cloud parameters such as particle size, amount, refractive index, and shape. Glory will be the first mission able to identify different aerosol types, which should help distinguish the relative influence of natural and anthropogenic aerosols. The scientific utility of the Glory APS will be enhanced by assimilating Glory results into advanced climate models as well as by exploiting the synergy with other A-Train instruments such as the Moderate-Resolution Imaging Spectroradiometer (MODIS) on Aqua, the Polarization and Directionality of the Earth's Reflectance (POLDER) instrument on PARASOL, and the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) on CALIPSO.

For additional information on the Glory Mission and its science, please visit the web sites *glory.gsfc.nasa.gov*, *glory.giss.nasa.gov*, and *svs.gsfc.nasa.gov/search/Instrument/Glory.html.*

[2] All A-Train missions fly at 705-km altitude, and have a 98.2° inclination with ascending sun-synchronous orbit.

Update on the Aquarius/SAC-D Mission

Annette deCharon, University of Maine—Education and Public Outreach Lead, annette.decharon@maine.edu
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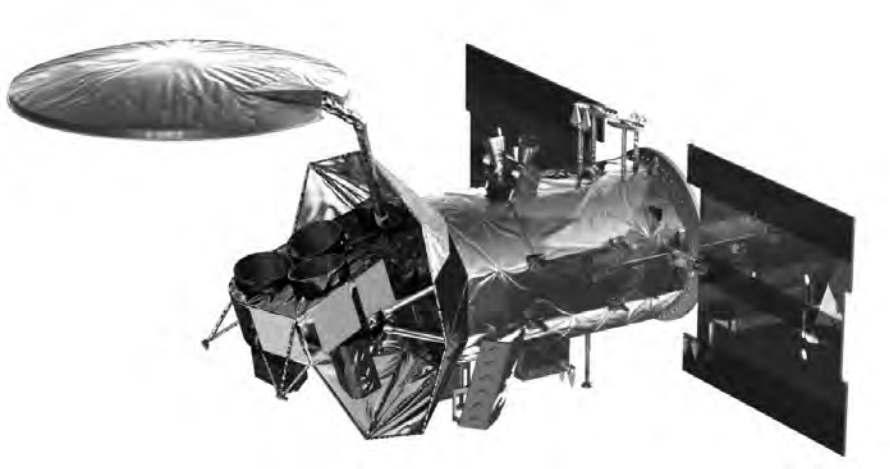
Over its three-year baseline mission, data from this pioneering mission will reveal changing sea-surface salinity (SSS) patterns over the ice-free global oceans. Two months after launch, the Aquarius instrument will collect more SSS data than has been amassed in the previous 100 years.

Background on Salinity Measurements and Aquarius / SAC-D

One of the most fundamental properties of seawater is its saltiness or *salinity*. Salinity has been measured directly for centuries, perhaps most notably by Benjamin Franklin as part of his efforts to map the Gulf Stream. Thus far, however, remote sensing of salinity of the ocean has been only through limited airborne measurements. But that is about to change…the decades of scientific and technical development have now made it possible to accurately measure sea-surface salinity (SSS) from a sun-synchronous orbit 408 mi (657 km) above Earth's surface, and in May 2010, a U.S.-Argentine satellite mission will be the first to measure SSS from space.

The Aquarius/Satellite de Aplicaciones Cientificas (SAC-D) satellite mission is designed with SSS as its primary measurement. Over its three-year baseline mission, data from this pioneering mission will reveal changing SSS patterns over the ice-free global oceans. Two months after launch, the Aquarius instrument will collect more SSS data than has been amassed in the previous 100 years. The SAC-D satellite, built by the Argentinian Space Agency—Comisión Nacional de Actividades Espaciales



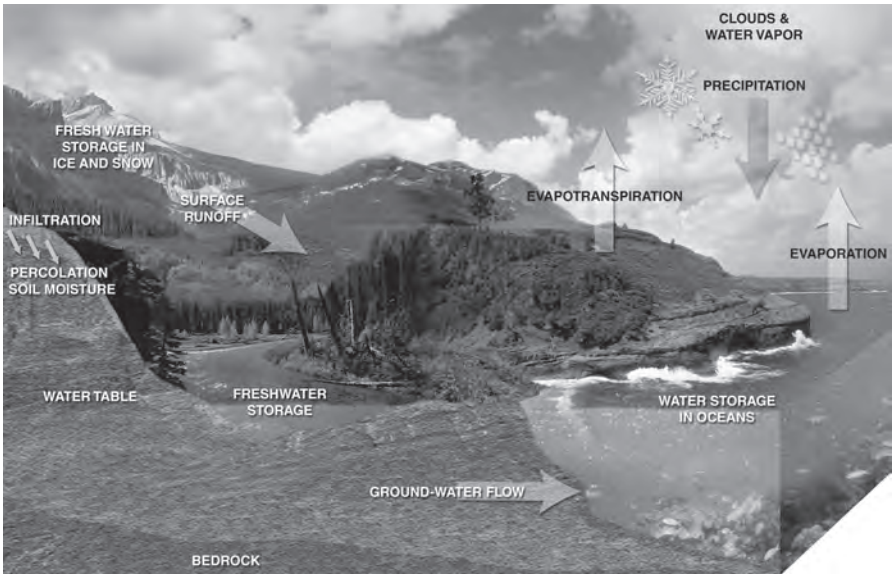
Artist rendering of the Satellite de Aplicaciones Cientificas.

(CONAE)—will accommodate the primary Aquarius SSS instrument plus several Argentinian SAC-D instruments and instruments from the French Space Agency—Centre National d'Etudes Spatiales—and Italian Space Agency—Agenzia Spaziale Italiana.

Importance of Salinity Measurements

SSS data from Aquarius will complement existing satellite programs that monitor sea-surface temperature. Together, salinity and temperature control density at the ocean surface. Sea-surface density is extremely important since it drives the formation of ocean water masses and thus influences the three-dimensional ocean circulation. Better understanding of SSS patterns will improve scientists' understanding of the ocean's capacity to store heat, transport heat, and regulate Earth's climate. In addition, monthly maps of global SSS will improve understanding of the interaction between ocean circulation and the global water cycle.

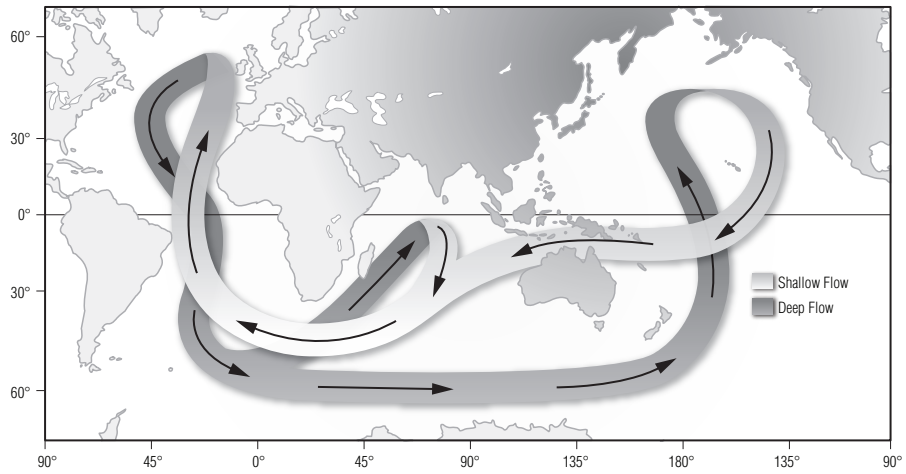
Ancient Greeks, including Homer and Plato, knew that water continually circulates from the ocean to the atmosphere to the land and back again to the ocean. Today's scientists know that Earth's *water cycle* is dominated by exchanges between the ocean and atmosphere. In fact, 86% of global evaporation and 78% of global precipitation occur



This diagram illustrates Earth's water cycle. Aquarius/SAC-D data will help scientists relate sea-surface salinity variations to global evaporation minus precipitation, and give them insight into how the ocean responds to changes in the water cycle from season-to-season and year-to-year.

over the ocean—see diagram above. SSS is a key tracer for understanding freshwater *fluxes*—i.e., movement of water into and out of the ocean system. This is because some parts of the water cycle decrease salinity (e.g., precipitation, groundwater flow to the ocean, river runoff), while other parts increase it (e.g., evaporation of seawater, freezing of seawater). To track changes in SSS patterns over time, scientists monitor the relationship between two primary processes in the oceans: *evaporation* and *precipitation*. With Aquarius data, scientists will be able to relate SSS variations to global evaporation minus precipitation, providing insight into how the ocean responds to variability in the water cycle, from season-to-season and year-to-year. Increases in SSS (i.e., evaporation exceeding precipitation) in high latitudes can increase seawater density and speed up the deep overturning circulation in the ocean. Conversely, decreases in SSS (i.e., precipitation exceeding evaporation or melting ice) may result in widespread decreases in seawater density, reducing its ability to sink. Oceanographers believe that maintaining density-controlled ocean circulation is key to keeping ocean heat transport in balance—and ocean heat transport plays a key role in regulating Earth's climate.

Well before widespread recognition of climate change, the scientific community understood the need for global SSS data to help diagnose shifts in the ocean-atmosphere system [*Lagerloef*, 1995]. The principal scientific objective of Aquarius is to make global SSS measurements over the open oceans with 150-km spatial resolution, and to achieve a measurement error less than 0.2 practical salinity scale of 1978 (PSS-78) on a 30-day time scale, taking into account all sensor and geophysical random errors and



This diagram illustrates the so-called ocean global conveyor belt that transports heat from the tropics to the poles and thus plays an important role in regulating global climate. Data from Aquarius should help scientists understand the impact that changes in sea surface salinity have on the efficiency of these ocean currents.

biases [*Lagerloef et al*, 2008]. Although Aquarius measurements will have relatively low spatial resolution, they will provide much greater detail than can be derived from historical data [World Ocean Atlas 2005].

In addition to Aquarius/SAC-D, the European Space Agency is developing an explorer-class mission—Soil Moisture Ocean Salinity (SMOS)—scheduled for launch in mid 2009, whose primary measurement will be soil moisture with about 45-km average spatial resolutions. However, SMOS will also measure SSS, though the final accuracy of these measurements is still being investigated. Between Aquarius/SAC-D and SMOS, satellite-based SSS observations, scientists hope to "fill in the blanks" that currently cover 25% of the ocean surface—vast areas where salinity has never been measured.

Recent drastic changes in Arctic sea ice cover—e.g., as documented in 2007 by the National Snow and Ice Data Center (*nsidc.org*)—have made the collection of SSS data more important than ever. A decrease in Arctic sea ice and associated increase in albedo are projected to result in a feedback loop that will exacerbate climate warming. In a very simple model, decreasing SSS in the North Atlantic (i.e., increasing "freshening") would reduce the formation of deep-water masses and, in turn, the efficiency of the ocean *global conveyer belt,* which helps to regulate global climate by moving heat from the tropics to higher latitudes—see diagram at bottom of page 18.

The Aquarius Salinity Measurement Mission and Design

To measure salinity from space, scientists must measure microwave emission from the sea surface, and they do this by observing a parameter called *brightness temperature*, in Kelvins (K), and correcting for other natural emission sources and sinks. Ocean brightness temperatures are related to the dielectric properties of seawater, and at lower microwave frequencies, these are dependent on salinity. Aquarius science instruments will include a set of three L-band (1.413 GHz) radiometers and a scatterometer that corrects for the ocean's surface roughness. Legally protected for scientific purposes (i.e., radio astronomy and Earth remote sensing) from radio interference, L-band is sufficiently sensitive to make viable measurements of salinity [*Klein and Swift*, 1977; *Swift and McIntosh*, 1983]. Two SAC-D instruments will complement Aquarius science measurements: the CONAE Microwave Radiometer for wind, rain, cloud water, sea-ice detection; and the CONAE New Infrared Scanner Technology for supplementary sea-surface temperature.

The Aquarius Ortho-Mode Transducer (OMT), around which the radiometer front-end components are mounted to achieve thermal stability. The Aquarius sunshade is also shown in the background. Photo was taken at JPL.

The Aquarius Radiometer in a Goddard Space Flight Center clean room.

"Salinity remote sensing signatures are quite small and present a difficult measurement challenge. Accordingly, the Aquarius microwave radiometer has very exacting require-

"Salinity remote sensing signatures are quite small and present a difficult measurement challenge. Accordingly, the Aquarius microwave radiometer has very exacting requirements for low noise and calibration stability, and will be the most accurate (by about an order of magnitude) ever developed for Earth remote sensing," says Gary Lagerloef [Earth & Space Research—Aquarius Principal Investigator].

ments for low noise and calibration stability, and will be the most accurate (by about an order of magnitude) ever developed for Earth remote sensing," says **Gary Lagerloef** [Earth & Space Research—*Aquarius Principal Investigator*]. To achieve the Aquarius goal for an accuracy of 0.2 practical salinity units (psu) on a monthly basis, the design requirement is that the radiometers be stable to within 0.13 K over seven days. A primary element in maintaining stability is adequate internal calibration and good thermal control. The design adopted for the Aquarius radiometers is based on research conducted under NASA's Instrument Incubator Program.

Initially approved as a NASA Earth System Science Pathfinder mission in 2001, Aquarius passed Mission Confirmation Review (MCR) in September 2005. At that point, the project had completed formulation activities during which the mission requirements, design, and costs were developed and reviewed. Since MCR, Aquarius/SAC-D has been in the implementation phase, during which the flight hardware is being built, tested, and readied for launch. In January 2008, the NASA Goddard Space Flight Center (GSFC) delivered the Aquarius radiometer to the Jet Propulsion Laboratory (JPL) in Pasadena, CA. Leading up to the Mission Critical Design Review (MCDR) in July 2008, the radiometer was integrated with the Aquarius instrument at JPL, including the JPL-built and tested scatterometer and antenna. Aquarius instrument integration and testing will continue through Spring 2009, followed by Aquarius/SAC-D observatory integration. The Aquarius/SAC-D Operations Readiness Review is scheduled for late Fall 2009, six months before the scheduled May 2010 launch.

Aquarius PI Gary Lagerloef poses with the SAC-D satellite at CONAE.

Data Distribution

SSS data are crucial for improving computer models of ocean circulation; data calibration, validation, and dissemination are key goals for the Aquarius/SAC-D mission. NASA and CONAE will share the data processing and distribution activity. CONAE will manage satellite telemetry and transmit raw Aquarius data to GSFC. The Aquarius data processing system will generate timely salinity products for ready access by the science community. Aquarius data will eventually be archived in NASA's Physical Oceanography Distributed Active Archive Center (PO-DAAC), located at JPL.

Like many other ocean-observing satellite missions, Aquarius will rely on *sea-truth* data from a variety of platforms including the global array of 3,000 free-drifting profiling Argo floats that measure the temperature and salinity of the upper 2000 meters of the ocean (*www.argo.ucsd.edu/*). They will also rely on volunteer observing ships,

research ships, and moored and drifting buoys. The system being developed will not only calibrate and validate Aquarius measurements; it will also accumulate and format *in situ* SSS and SST data, thus providing a valuable independent resource to the science community.

The Aquarius EPO objective is to demonstrate how better understanding of salinity-driven ocean circulation—and its influence on climate and the water cycle—can benefit student learning and society as a whole.

Education and Public Outreach

From the outset, education and public outreach (EPO) have been important, highly integrated, and complementary components of the Aquarius/SAC-D mission. The Aquarius EPO objective is to demonstrate how better understanding of salinity-driven ocean circulation—and its influence on climate and the water cycle—can benefit student learning and society as a whole. A key strategy is offering "hands on" activities and online data access tools, that can be directly integrated into classroom settings. Reviewed and approved by the NASA Science Mission Directorate Education Product Review, Aquarius offers nine "hands on" activities for elementary through high school audiences (*aquarius.nasa.gov/education.php*). Content focuses on essential concepts that are aligned with National Science Education Standards [National Research Council, 1996] and includes: properties of water, the hydrologic cycle, phases of water, and heat capacity.

In addition, the Aquarius education technology team has developed a set of interactive tools using historical salinity, temperature, and density data sets [World Ocean Atlas, 2005]. These data are available as three distinct, yet complementary, tools that highlight: (1) spatial patterns of long-term mean data; (2) annual cycle of monthly mean data; and (3) change over time of yearly mean data. In addition, Aquarius data tools are augmented by interactive tutorials and guiding questions and answers—for example: *Is salinity the same everywhere in the oceans? Were the oceans as salty a hundred years ago?* URL: *aquarius.jpl.nasa.gov*.

Another important component of Aquarius EPO is its "thematic partners" whose common vision is to better understand the ocean-atmosphere system and its potential impacts on society. Aquarius efforts are well-coordinated with the SAC-D Mission, whose specific EPO goal is to improve understanding of the water cycle and its impact on human life. Another key partner is the Centers for Ocean Sciences Education Excellence (COSEE), a nationwide network funded primarily by the National Science Foundation to promote ocean literacy through effective partnerships between research scientists and educators (*cosee.net*).

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feature articles

NASA Gets "Eccentric" in Problem-solving Competition

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The was the eighth year NASA's Earth Observing System Project Science Office (EOSPSO) has sponsored a long-term problem.

Students from around the world gathered to participate in the 29th Odyssey of the Mind (OM) World Finals, a creative problem-solving competition held at the University of Maryland in College Park, MD, May 31–June 3. These students had advanced from competitions held earlier in the year at the local, regional, state, or country levels and were in College Park to compete for the title of World Champion.

The 2008 World Finals marked the eighth year NASA's Earth Observing System Project Science Office (EOSPSO) sponsored a long-term problem. This year's problem, *The Eccentrics*, required teams to create and present a humorous performance about three Eccentric Characters that demonstrated odd behavior, peculiar mannerisms, and unconventional dress. The performance had to include a team-created "problem" within or involving an Earth system—the atmosphere, biosphere, cryosphere, geosphere, or hydrosphere. The eccentric characters then had to solve the problem. As a reward, a celebration is held in their honor and they end up launching a new fad.

NASA's EOSPSO also hosted activities at the OM World Finals Creativity Festival. The festival included exhibits featuring NASA's Earth Science programs and the Hubble Space Telescope. NASA and the University of North Dakota showcased NASA's aircraft program. In addition, a unique NASA classroom was set-up for the OM participants. Students and parents alike enjoyed participating in activities centered on NASA's aeronautics and *Living With a Star* programs.

Other NASA-featured activities included the Earth Science *E-Theatre*, a dynamic theater-style presentation that showcases Earth observations and visualizations in high-definition format. Staff from the Hubble Space Telescope and NASA Aircraft programs gave similar presentations.

Over the past year, NASA supported OM's preliminary competitions by posting Earth science information on a special web site hosted on NASA's Earth Observatory—*earthobservatory.nasa.gov.* The Earth Observatory serves as a host to many teacher and student learning modules. Web links were provided to assist students in developing solutions to problems facing the Earth.

There were 189 teams participating in *The Eccentrics* at World Finals. Following are those who won top honors in their division:

Division 1

1st Place: Anglo-Chinese School—Singapore
2nd Place: Afton Elementary School—Yardley, PA
3rd Place: Pisgah Elementary School—Candler, NC
4th Place: Marshpoint Elementary School—Savannah, GA
4th Place: Sarah Smith Elementary School—Atlanta, GA
5th Place: Lafayette Mills School—Manalapan, NJ
6th Place: River Oaks Elementary School—Houston, TX

Division 2

1st Place: North Rockford Middle School—Rockford, MI
1st Place: Stowe Playhouse—Stowe, VT
2nd Place: Countryside School—Champaign, IL
3rd Place: Warwick Middle School—Warwick, NY
3rd Place: Spring Forest Middle School—Houston, TX
3rd Place: Cooper Beech Elementary School—Glenside, PA
4th Place: Ludlow Elementary School—Ludlow, VT

5th Place: Newport Junior High School—Newport, AR
6th Place: Barker Road Middle School—Pittsford, NY

Division 3

1st Place: Anglo Chinese School—Singapore
2nd Place: Raffles Girls Secondary School—Singapore
3rd Place: Abington Heights High School—Clarks Summit, PA
4th Place: St. John Neumann High School—Williamsport, PA
4th Place: Myers Park High School—Charlotte, NC
5th Place: Cheshire High School—Cheshire, CT
6th Place: Savannah Arts Academy—Savannah, GA

Division 4

1st Place: University of Georgia—Athens, GA
2nd Place: Tufts University—New Canaan, MA
3rd Place: Georgia College and State University—Milledgeville, GA
4th Place: Stowarzyszenie Wiggor—Wroclaw, Poland
5th Place: Mt. Pleasant Lions Club—Midland, NC
6th Place: University of Wisconsin—Madison, WI

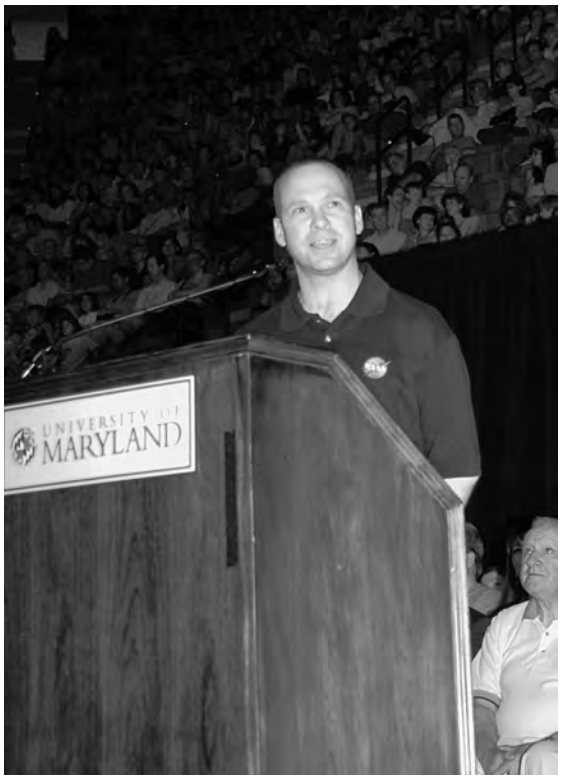
NASA reaches over two million students, teachers, parents, and coaches around the world through its sponsorship of an OM problem, stimulating interest in learning about Earth system science among all ages.

The OM program, founded in 1978, is an international educational program promoting team effort and creative problem solving for students from kindergarten through college. Over 800 teams from the U.S. and other countries including China, Japan, South Korea, Poland, Germany, and Mexico participated in World Finals. This includes teams from the Department of Defense Dependent Schools (DoDDS), many of which traveled from Europe.

NASA's Earth Science Division conducts and sponsors research, collects new observations from space, develops technologies and extends science and technology education to learners of all ages. Through a better understanding of our home planet, NASA hopes to improve prediction of climate, weather, and natural hazards using the unique vantage point of space. To access the OM official web site, visit: *www.odysseyofthemind.com.*

For the 2009 OM Competition, NASA's EOSPSO will sponsor Problem 1: *Earth Trek*.

To experience two firsthand accounts of teams that participated in the NASA-sponsored problem at the OM World Finals please visit NASA's EOS Project Science Office website at *eospso.gsfc.nasa.gov/OM/OM.pdf* and read "NASA Odyssey of the Mind Problem Showcases Adventures of The Eccentrics." ■



Steve Graham of NASA's EOS Project Science Office addresses the crowd gathered for the opening ceremonies, held at the Comcast Center on the campus of the University of Maryland. **Photo credit:** Carol Ann DeSimine, Big Eye Media.

NASA reaches over two million students, teachers, parents, and coaches around the world through its sponsorship of OM problems, stimulating interest in learning about Earth system science among all ages.

feature articles

NASA Satellite Images "Under Construction" at Folklife Festival

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During the weeks of June 25-29 and July 2-6, NASA joined with the Smithsonian Institution to support its annual Folk Life Festival. Thousands of visitors converged on the National Mall in Washington D.C. to experience NASA science and culture. NASA's EOS Project Science Office exhibit featured jigsaw puzzle activities to engage the public. The puzzles were both entertaining and educational as they focused on how binary code are the "building blocks" for satellite images. These popular tabletop puzzle activities featured a Landsat image of Washington D.C., NASA's Blue Marble, and the Helheim Glacier in Greenland, and brought hundreds of families to the NASA Earth science tents each day. Visiting families enjoyed the challenge of constructing the satellite images while learning how NASA Earth-observing satellites are making critical measurements in support of climate change research. Everyone seemed genuinely excited about the opportunity to interact with NASA scientists and learn about the exciting research activities within NASA's Earth Science programs.

NASA's exhibit at the Smithsonian Folklife Festival was both entertaining and educational. Hundreds of families visited the NASA tent during the festival and enjoyed the challenge of "constructing" satellite images while learning how satellite images are "constructed" from binary code and how Earth-observing satellites make critical measurements in support of climate change research.

Other popular activities at the Earth Science tents included a wall of NASA satellite imagery where Landsat team members challenged visitors to identify changes in land cover, the atmosphere, and the oceans. Representatives of the Aerosol Robotic Network (AERONET) described to visitors how their global network of instruments can take daily sun and sky measurements that are used to characterize the optical properties of particles from pollution, desert dust, and smoke and how this information is used in remote sensing applications and climate studies. A group from Goddard presented their exhibit titled *Honeybees, satellites, and climate change* and a team from Langley illustrated the concept of clouds and the Earth's radiation budget.

As a result of the efforts at the Folklife Festival, the George Bush Presidential Library and Museum in West College Station, TX has requested permission to reproduce our two-sided puzzle "using binary code to construct a satellite image" to be used for summer camps as one of their teaching tools for basic binary code. ■

Alexander Smirnov [GSFC] explains the AERONET project to visitors.

Teacher Inspires Students Through Her Own Science Expedition

Tiffany Reedy, JASON Project Media Officer, tiffany@tricomassociates.com

Fifth grade science teacher **Maria Natiello** believes her students learn best when they use real-life situations to understand science concepts. Last July, Natiello put that theory to the test when she embarked on an expedition to the Chesapeake Bay with renowned oceanographer **Sylvia Earle** as part of The JASON Project, a nonprofit subsidiary of the *National Geographic Society*.

Earle, a *National Geographic* Explorer-in-Resident, called a "Living Legend" by the Library of Congress, led Natiello and three other student *Argonauts*—named for the crew that sailed aboard *Argo* with Jason, the mythological Greek explorer—on a mission to assess the Bay's degraded ecosystem by gathering historical and current evidence. With production crew in tow, the group boarded a research vessel where they used cutting-edge technology to collect and analyze water and biotic samples in order to better understand the health of the Bay. The Chesapeake mission will be featured in JASON's recently released ecology curriculum, *Operation: Resilient Planet*.

To Natiello, the three-day expedition was somewhat grueling, but also incredibly rewarding.

"We were usually up by 5:30 am and our days consisted of gathering data on the water, attending meetings, and then follow-up work in a lab," said Natiello. "We were working until well after dinner and then spent the evenings working on our scientific and personal journals. It sounds exhausting, but every bit was worth it, and no matter how tired [we were], we always had fun and laughed a lot!"

Natiello was first introduced to the JASON Project ten years ago as a recent graduate from the State University of New York (SUNY) College of Environmental Science and Forestry. Inspired by her love of nature, she became an instructor at an outdoor education center in upstate New York where she taught environmental education to students in grades K-12. While there, she was able to teach JASON curriculum and create exhibits related to the expedition locations. The experience resonated with her several years later when, after receiving her master's degree, she became a 5th grade teacher at Fulmar Road Elementary School in Mahopac, New York.

"After getting the first year of classroom teaching under my belt, I helped convince my administration to participate in the JASON Project," said Natiello. "This is now my fourth year using JASON curriculum and I have enjoyed introducing my students to real-life science and seeing them discover the world around them!"

As a Teacher Argonaut, Natiello is in the process of fulfilling a two-year internship with the JASON Project in which she has worked with JASON staff to help develop, review, and launch *Operation: Resilient Planet.* The five-to-nine week core ecology unit takes students to Earth's critical ecosystems to investigate strategies for regeneration, learn ecosystem management by taking on the roles of researchers and policymakers, understand pressures from human-induced changes, and recognize their responsibility for defending biodiversity.

"This is now my fourth year using JASON curriculum and I have enjoyed introducing my students to real-life science and seeing them discover the world around them!"

Maria Natiello poses with a sponge from a submerged aquatic vegetation bed that she discovered while snorkeling in the Chesapeake Bay last July.

"Sylvia Earle uses her status in the scientific world to help bring about change and inspire others," said Natiello. "She makes it a point to be a life-long learner. I believe that is one of the most important ideas I have brought back to my classroom. I show my students that no one ever stops learning, not me as their teacher, or even Sylvia Earle!"

JASON's theory of science education is based on lighting the spark of inspiration through sustained connections with *great explorers* and *great events.* Embedding these connections in core science curriculum will, JASON believes, generate deeper student engagement, increased motivation, and higher achievement.

To accomplish this, JASON embeds the research of its partners—NASA, the National Oceanic and Atmospheric Administration (NOAA) and *National Geographic*—into core science curriculum units. Compelling scientists from those organizations serve as Host Researchers and *headline* each chapter. Taped on location working side-by-side with Argonauts, the researchers come to life in the classroom and in an online global community, challenging students to apply their knowledge to the same real-world scenarios the scientists face everyday.

After returning to the classroom, Natiello says that Earle and the Chesapeake Bay mission have inspired her to get her students even more excited about science. She shares pictures and stories from her adventure to help them understand that even "regular" people can become scientists.

Natiello believes that the most important outcome of her mission is the opportunity to become a role model for students across the country through JASON curriculum. She hopes to inspire them to not only pursue science, but to never stop learning.

"Sylvia Earle uses her status in the scientific world to help bring about change and inspire others," said Natiello. "She makes it a point to be a life-long learner. I believe that is one of the most important ideas I have brought back to my classroom. I show my students that no one ever stops learning, not me as their teacher, or even Sylvia Earle!"

And Sylvia Earle couldn't agree more. She told the Argonauts while on location that her passion for science and exploration started when she was their age and has never stopped.

Dr. Sylvia Earle (left) and Maria Natiello (right).

Sylvia Earle and her band of Teacher Argonauts during their research expedition in the Chesapeake Bay last July.

"I started out as a kid and did what kids do—ask questions! I had that sense of wonder that is born in kids, the curiosity that is just there. I never stopped [asking questions]. Scientists are kids who just never quite grew up," Earle said. "Your ideas, your words, your music, your actions can inspire those around you in ways that can have profound influence. Just believe in yourself."

Next school year, when Natiello's students flip the pages of their brand new curriculum, *Operation: Resilient Planet,* they will see a very familiar face on the page doing research with one of the world's most respected and inspirational explorers of the time.

JASON has collaborated with NASA for more than 15 years to inspire and motivate middle school students to become proficient in science. The agency's scientists, researchers, technologies, and mission themes have been prominently featured in JASON curricula and professional development, while NASA centers have served as hubs to distribute the curricula to local school districts and hosted workshops to train teachers in its use.

JASON's last curriculum, the award-winning *Operation: Monster Storms*, featured two NASA scientists: **Anthony Guilory**, Airborne Science Manager at the Goddard Space Flight Center/Wallops Flight Facility and **Robbie Hood**, atmospheric scientist also at the NASA Goddard Flight Center/Wallops Flight Facility.

meeting summaries

Workshop: NASA Earth Observations and Models Informing Decision Making in Support of Climate Change Mitigation and Adaptation

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Responding to global climate change has become an urgent priority for policymakers. In order to regulate potential threats to Earth's climate, Earth science researchers have the responsibility of providing decision-makers with better data that enhances their ability to make educated decisions. To assess this role that scientists play, Richard Eckman [NASA Langley Research Center—*Applied Sciences Program*] organized and led the *NASA Earth Observations and Models Informing Decision Making in Support of Climate Change Mitigation and Adaptation* Workshop at the *8th National Conference on Science, Policy, and the Environment*. The conference was held in Washington, D.C. from January 16–18, 2008, and the overall theme was "Climate Change: Science and Solutions."

With approximately 50 attendees and eight panelists, the workshop addressed the use of Earth observation measurements and model predictions to enhance management and policy decisions affecting climate change mitigation and adaptation issues. **Teresa Fryberger** [NASA Headquarters (HQ)—*Associate Director of Applied Sciences*] opened the workshop with a thorough review of the NASA Applied Sciences Program. After Fryberger, the other panelists gave brief remarks followed by discussion. Highlights of their presentations are included below.

Paul Higgins [American Meteorological Society (AMS)] spoke about the ways to deal with climate change and explored the concept of human responsibility. He said that policymakers could handle climate change by either taking no upfront action or the problem could be mitigated. Other options include building adaptive capacities or attempting geo-engineering. Regardless of which approach policymakers take, the creation of policy solutions would come at low or negative costs to humans simply because of the health benefits. Higgins stated that policy is not a question of science, but of values. He said the risks of climate change are already known, so now is the time to take action.

Molly Macauley [Resources for the Future (RFF)] discussed her organization, a premier independent institute dedicated exclusively to analyzing environmental, energy, and natural resource topics. RFF gathers, under one roof, a unique community of scholars conducting impartial research that enables policymakers to make sound choices. RFF specializes in fresh water resources, energy management, coastal and marine ecosystems, public health, agriculture, infrastructure, terrestrial ecosystems, and biodiversity.

Drew Shindell [NASA Goddard Institute for Space Studies] presented information on the importance of both models and satellite observations in climate change research. The only way to predict the future is with models; satellite observations help guide the predictions. Shindell stated that models could be used to develop, implement, and even modify strategies for mitigating and adapting to climate change.

Steve Smith [Joint Global Change Research Institute] discussed the importance of the presence of scientific data when trying to explain the state of the environment to decision-makers. Robust scientific research that is presented in a simple format (including data product visualizations) can aid decision-makers in forming more focused questions to experts so that they are better able to develop strategies for mitigating and adapting to climate change. However, he adds that there are still many policy areas where we need basic research to assist decision-makers.

Teresa Fryberger, Associate Director of Applied Sciences at NASA Headquarters, introduces one of the workshop panelists, **Drew Shindell** from NASA GISS. **Credit:** Richard Eckman.

Howard Diamond: [National Oceanic and Atmospheric Administration (NOAA)—*Global Climate Observing System (GCOS)*] provided an overview of the GCOS, which has been one of the leaders in the global effort to maintain systematic climate observations. The program provides support in a three-tiered approach of global, regional, and bi-lateral support. The organization focuses on monitoring the impacts of climate change, as well as responses to the risks of climate change. In addition, GCOS is dedicated to improving early detection of climate change due to human activity, and improving data for impact analysis in hopes of reducing the uncertainties.

Paul Stackhouse (NASA Langley) demonstrating the Surface Meteorology and Solar Energy (SSE) data set on the Magic Planet display at the NASA booth during the NCSE conference. **Steve Graham** (NASA GSFC) looks on. **Credit:** Richard Eckman.

Don Anderson [NASA HQ—*Modeling, Analysis and Prediction (MAP) Program*] spoke about the challenge of integrating and maintaining data sets. Anderson represented MAP, which studies the Earth's climate and weather, with particular emphasis on global change. The development of consistent, coupled Earth system models is a major goal of the MAP program. Validation of a wide range of Earth observations, specifically validation of NASA's satellite data program, is also a priority.

Linda Wennerberg [NASA HQ—*Environmental Management Division (EMD)*] closed out the workshop with a discussion of the policy issues facing climate change mitigation and adaptation, and how government agencies can respond. EMD also works closely with NASA centers to improve facility energy efficiency through the use of low carbon energy technologies. ■

Audience discussion during the workshop was energetic. Among those taking part are **Don Anderson** (NASA HQ), sitting at center, **Howard Diamond** (NOAA), sitting behind him, and **Lucien Cox** (NASA HQ) who can be seen behind Howard. **Credit:** Richard Eckman.

meeting summaries

CERES Science Team Meeting Summary

Shashi K. Gupta, Science Systems and Applications, Inc., Shashi.K.Gupta@nasa.gov

The Spring 2008 meeting of the Clouds and the Earth's Radiant Energy System (CERES) Science Team was held May 6-8, 2008, in Newport News, VA. **Norman Loeb** [NASA Langley Research Center (LaRC)—*CERES Co-Principal Investigator*] hosted the meeting. The Fall 2008 CERES meeting will be held jointly with the Geostationary Earth Radiation Budget (GERB) International Science Team (GIST) meeting, October 27-31, 2008, at the Goddard Institute for Space Studies (GISS) in New York, NY.

Major objectives of the meeting included science team review and approval of:

- Terra and Aqua shortwave (SW), longwave (LW), and total channel calibrations, and development and validation of cloud algorithm for *Edition-3*;
- evaluation of Global Modeling and Assimilation Office (GMAO) G5-CERES assimilated global datasets;
- production of top-of-atmosphere (TOA) and Surface Averages (SRBAVG) daily products and International Satellite Cloud Climatology Project (ISCCP)-like monthly products; and
- new adjusted SRBAVG dataset for climate modelers (also called Energy Balanced and Filled [EBAF]).

In addition to major objectives, the science team also reviewed plans for producing the Level-3 gridded version of the Surface and Atmospheric Radiation Budget (SARB) products, comparisons between CERES and GERB results, CERES participation in Global Energy and Water-cycle Experiment (GEWEX) Radiative Flux Assessment (RFA) activity, and efforts on the evolution of data processing and management systems at the Atmospheric Science Data Center (ASDC).

Norman Loeb [LaRC] presented an overview of a broad range of topics including the state of the U.S. Climate Change Science Program (CCSP), the Intergovernmental Panel on Climate Change (IPCC), NASA Earth Science, CERES, the National Polar-Orbiting Operational Environmental Satellite System (NPOESS), the NPOESS Preparatory Project (NPP), the Afternoon Satellite Constellation (or "A-Train"), and the National Research Council (NRC) Decadal Study. The CCSP Observations Working Group (OWG) is planning a second observation requirements workshop for Fall 2008. At this workshop, new tools for science community guidance will be evaluated and climate model Observing System Simulation Experiments (OSSEs) will be designed. NRC is currently reviewing the CCSP.

At NASA Headquarters, **Ed Weiler** has replaced **Alan Stern** as the new Associate Administrator for Space and Earth Science while **Mike Freilich** remains the Director of the Earth Science Division. **Don Anderson** and **Hal Maring** are the Modeling and Radiation Science leads, respectively. FY2008 and FY2009 budgets are now clearer and support for climate change science appears to be building in the U.S. Congress. There is some money available to support CERES Flight Model 5 (FM-5) now back on the NPP and FM-6 on or in formation with the first NPOESS. Senior Review of the CERES instruments on Terra and Aqua was completed during summer of 2007 and went very well. The next cycle of senior reviews is scheduled for early 2009.

The A-Train instruments are working well. The Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) satellite is not showing any signs of significant degradation and a 6-year lifetime appears likely. Efforts are underway at LaRC to develop a merged dataset of CERES, CALIPSO, CloudSat, and Moderate-resolution Imaging Spectroradiometer (MODIS) products (C3M) for the NASA Energy and Water-cycle Study (NEWS) program. Work toward putting FM-5 back on the NPP is proceeding well; however, the task has become much more complex due to additional interface requirements. The NPP launch is presently scheduled for (no earlier than) June 2010. This greatly reduces the radiation budget gap risk in the near term. FM-6 will be similar to the current CERES instruments with only modestly improved calibration since it will be constructed from leftover spare parts.

Terra/Aqua Instruments and Calibrations

Kory Priestley [LaRC] presented operational and calibration/validation status of all CERES instruments on Terra and Aqua, as well as work planned for CERES instruments on future missions. The FM-5 instrument is to be flown on the NPP mission and FM-6 is planned for the first NPOESS. The condition of the FM-5 instrument after eight years of storage was recognized as a major concern. He presented the status of current processing for *Edition-2* and the methodology used to characterize sensor radiometric stability for *Edition-3* processing. Priestley also discussed a method for correcting the trends observed in Terra and Aqua *Edition-2* data prior to the start of *Edition-3* processing.

CERES Cloud Properties

Patrick Minnis [LaRC] presented the status of the cloud algorithm for CERES *Edition-3* processing. Comparisons of cloud properties derived using God-

dard Earth Observing System Model 4 (GEOS-4) and GEOS-5 inputs showed that use of GEOS-5 slightly improved detection of clouds during polar night. The *Beta-1* version of the code shows significant improvements in dust, snow, thin cirrus, and low cloud detection. Minnis showed numerous comparisons with CALIPSO and CloudSat observations. He noted that, for cloud masking, the Terra 1.6 μm channel has been replaced by the 2.1 μm channel to provide consistency with Aqua. He also presented a summary of improvements planned for the *Edition-3 Beta 2* delivery.

Simple Surface Fluxes

David Kratz [LaRC] reported on the status and validation of the two SW and two LW models currently in use in the Surface-only Flux Algorithms (SOFA) processing. He spoke about the various improvements made to these models, based on lessons learned from their validation since the beginning of CERES. He outlined problems still outstanding and the solutions proposed and tested to remedy those problems in reprocessing for *Edition-3* and beyond. Kratz stated that if the window channel becomes unavailable on future CERES instruments, LW Model-A will become unusable. He also introduced another model (LW Model-C) to deal with that eventuality.

Terra and Aqua SARB Products

Thomas Charlock [LaRC] reported on the status of SARB products, especially the change of bias during 2005-2006 for TOA SW fluxes that include *Revision-1* corrections for both Terra and Aqua. All-sky ocean footprints from Aqua showed a larger increase in bias. This bias was traced back to an increase in aerosol optical depth (AOD) during the same period. Corresponding outgoing longwave radiation (OLR) values showed a trend that was attributed to the deterioration of the SW portion of the total channel. Charlock also presented assessment of the effects of input changes from MODIS *Collection-4* to *Collection-5* and GEOS-4 to G5-CERES.

CERES TISA Activities and Comparisons

David Doelling [LaRC] reported on the activities of the Time Interpolation and Spatial Averaging (TISA) Working Group and many TISA *Edition-2* products due for release in the near future. He compared Geostationary-enhanced (GEO) and non-GEO SRBAVG datasets and demonstrated that the diurnal variability is better captured using the GEO product. Doelling showed that differences between SRBAVG derived with G5-CERES and GEOS-4 inputs were small for TOA SW and LW fluxes but larger for surface LW fluxes and GEO-derived cloud properties. He also outlined the enhancements planned for processing.

Moguo Sun [Science Systems and Applications, Inc. (SSAI)] described special monthly average cloud products from CERES that are stratified by cloud-top pressure and optical depth (τ) like the ISCCP-D2 product. Two of these products are derived from MODIS data (MODIS-Day and MODIS-Night). The third, called Gridded GEO (GGEO) is from geostationary data. Comparisons with corresponding SRBAVG results showed good agreement, while the comparison of cloud statistics from actual ISCCP-D2 data showed significant differences.

Norman Loeb presented an adjusted SRBAVG-GEO dataset derived from the standard CERES SRBAVG-GEO product. The dataset contains five years of Terra data, and was developed for the climate modeling community based on their desire for a radiation budget dataset showing near balance at the TOA. An objective constrainment algorithm was applied to adjust SW and LW fluxes within their range of uncertainty. Doing so achieved a TOA balance that matched the best estimate of ocean heat storage. Corresponding clear-sky fluxes were estimated by making use of MODIS 1-km radiances for those regions where larger CERES footprints were never found to be clear.

GERB Status

Cedric Bertrand [Royal Meteorological Institute of Belgium (RMIB)] reported on the status of processing and validation activities for the GERB project. Validated *Edition-1* data from GERB-2 flying onboard Meteosat-8 are available for March 2004–May 2007. GERB-1 flying onboard Meteosat-9 is currently (starting in May 2007) the operational instrument and its products are undergoing validation prior to release. Comparisons of the latest GERB data with CERES *Edition-2* (rev.-1 corrected) data showed that scene dependent differences have now been corrected, though radiance differences of about 5% in SW and 1% in LW still remained.

CERES Outreach

Susan Moore [SSAI] reported on the status of the Students' Cloud Observations On-Line (S'COOL) project. The S'COOL database now has more than 69,000 observations from more than 2450 participants. Participants are from all 50 states of the U.S. and 74 other countries. More than 36,000 observations are matched with a Terra or Aqua overpass, and more than 600 of those are matched with both Terra and Aqua at the same time. Moore urged attendees to participate in S'COOL activities in their own communities.

Data Management Status

Lisa Coleman [SSAI] reported on the status of CERES data processing and presented lists of CERES products

released since the last science team meeting (November 2007). She also presented lists of those currently in production and those expected to be released by the end of 2008. Coleman reviewed the contents of the various documents available on-line, and provided contact information for users who have questions, and also discussed procedures for ordering CERES datasets.

John Kusterer [Atmospheric Science Data Center (ASDC)/LaRC] presented an overview of the support provided to CERES by the ASDC. The ASDC is responsible for processing, archiving, and distributing CERES data and providing data services to the user community. Kusterer provided metrics of ASDC activities and discussed the effort underway for phasing in the Archive-Next Generation (ANGe) to replace current archival systems. He stated that an ASDC User Working Group is being set up from among the representatives of data projects and the user community. User feedback from the group will guide future ASDC direction.

Invited Presentations

Michele Rienecker [Global Modeling and Assimilation Office (GMAO)] presented an overview of the GEOS-5 data assimilation product, also known as Modern Era Reanalysis for Research and Applications (MERRA). A special version of GEOS-5 that uses fixed analysis schemes and input streams, called G5-CERES, is also being produced. This climate quality product for CERES will be without the discontinuities related to abrupt changes in analysis and/or inputs. Comparisons of G5-CERES products with MERRA showed the differences between them to be small. Comparisons of many MERRA products with other reanalysis products, precipitation with the Global Precipitation Climatology Project (GPCP), and atmospheric water vapor with the Special Sensor Microwave Imager (SSM/I) showed good agreement. Most deficiencies identified in earlier versions of G5-CERES have now been remedied.

Brian Soden [University of Miami] presented an analysis of cloud feedback and aerosol radiative forcing (ARF) in global climate models (GCMs) represented in IPCC Assessment Report 4 (AR4). Data from the literature and from AR4 models showed that cloud feedback has neutral to positive values even though there is a large intermodel variability. Soden reported that SW feedback from low clouds primarily caused this variability and long-term, stable Earth radiation budget (ERB) measurements will be needed to reduce this uncertainty. He concluded further that inter-model differences in ARF are a significant source of uncertainty in 21st Century climate projections.

Robert Pincus [NOAA Earth System Research Laboratory (ESRL)] presented a framework for assessing the accuracy of cloud, radiation, and precipitation simulations in GCMs similar to the assessment of skill scores for numerical weather prediction (NWP) models. While skill scores for NWP models are well-defined and can be evaluated against present-day observations, there is no agreed upon framework for similarly assessing GCMs. Pincus suggested a set of metrics for assessing GCM simulations of clouds, radiation, and precipitation and evaluated results of AR4 models using several CERES and Earth Radiation Budget Experiment (ERBE) products. He also examined improvements achieved in GCM simulations during recent years.

Co-Investigator Presentations

Kuan-Man Xu [LaRC] presented an evaluation of the European Centre for Medium-Range Weather Forecasts (ECMWF) Operational Analysis (EOA) and 40-year Re-Analysis (ERA-40) cloud products using gridded cloud object datasets from Tropical Rainfall Measuring Mission (TRMM)/CERES retrievals for January–August 1998. Discrepancies for deep convective clouds in ERA-40 products were found to be slightly greater than those for EOA. Xu attributed this difference to recent improvement of the cloud parameterization scheme at the ECMWF.

Gerald Potter [Lawrence Livermore National Laboratory (LLNL)] presented an evaluation of GCMs from the IPCC and the Atmospheric Model Intercomparison Project (AMIP) by comparing their response to the 1997-98 El Niño episode with observations. Only the Hadley Centre model (HadAM3) successfully simulated the observed collapse of the Walker circulation. Most other models did not respond correctly to this strong forcing even when observed sea surface temperature (SST) and atmospheric state from NWP analysis were input into the models.

Norman Loeb presented *The Quest Is On* by Wielicki, Loeb, and Young; a response to recent papers published in Science, titled *Why is climate sensitivity so unpredictable?* by Roe and Baker and *Call off the quest* by Allen and Frame. Loeb stated that large uncertainties in climate sensitivity arising from ambiguities in various feedbacks are not inevitable as argued in the above papers. He presented a framework that can be used to define calibration/observation requirements for the Climate Absolute Radiance and Refractivity Observatory (CLARREO) mission to substantially narrow uncertainties in cloud and other feedbacks and climate sensitivity.

Marty Mlynczak [LaRC] presented an overview of the Far-Infrared Spectroscopy of the Troposphere (FIRST) instrument and some other development/demonstration projects underway at LaRC. These projects, aimed at improving understanding of Earth's climate and

climate change, were developed under the Instrument Incubator Program (IIP). The FIRST instrument has demonstrated the ability to measure Earth-emitted radiation in the far infrared (15-100 μm) on a balloon flight and is scheduled to participate in several field experiments in the near future.

Xianglei Huang [University of Michigan] presented a methodology for validating LW fluxes computed in GCMs using CERES and Atmospheric Infrared Sounder (AIRS) measurements. Both the CERES and AIRS instruments fly onboard Aqua. Fluxes in 10 cm^{-1} bands and broadband OLR were derived using AIRS observations with CERES scene classification and Angular Distribution Models (ADMs). AIRS OLR was validated with corresponding CERES measurements while band-by-band fluxes were used to validate results of the Geophysical Fluid Dynamics Laboratory (GFDL) atmospheric GCM.

Leslie Moy [University of Wisconsin-Madison] presented an assessment of clear-sky OLR computed with the rapid radiative transfer model (RRTM) using CERES observations and AIRS radiances and retrievals. RRTM results showed good agreement with CERES observations over the Atmospheric Radiation Measurement program's Southern Great Plains (ARM/SGP) site for the 2.5-year study period (September 2002–February 2005). Global comparisons over a four-day study period showed similar results. Good agreement was found over most CERES surface types except over deserts and snow/ice surfaces.

Istvan Laszlo [NOAA and University of Maryland] presented comparisons of MODIS-derived AODs with those from an algorithm developed for AOD retrievals using Visible/Infrared Imager/Radiometer Suite (VIIRS) data. VIIRS is an instrument that will replace MODIS on NPP and NPOESS satellites. Both sets of results were also compared with Aerosol Robotics Network (AERONET) observations. VIIRS results showed a small negative bias (-0.016) over mid- and high-latitude regions due to high wind speeds but a positive bias over regions with dust.

John Augustine [NOAA/ESRL] presented an 11-year (1997–2007) dataset of AODs derived from five channels of the Multi-Filter Rotating Shadowband Radiometer (MFRSR) at seven sites of the Surface Radiation (SURFRAD) network. He also presented monthly climatologies based on this dataset and noted that the entire dataset was free of any effects of volcanic eruptions. Highest AODs occurred over the Eastern U.S. but showed a slight decrease over this period. Increases observed over the two Western U.S. sites were consistent with an increased frequency of wildfires in that region. Comparisons with AERONET data showed good agreement.

Xiquan Dong [University of North Dakota] presented validation of CERES-MODIS retrieved cirrus cloud physical and microphysical properties against surface-based measurements made at the ARM/SGP site. As expected, retrieved daytime height and temperature were close to values from the cloud base; however, for nighttime, they were close to values from the cloud top. Daytime microphysical properties agreed well with ARM observations. During nighttime, ice-particle diameter values showed significant differences from observations.

Grant Matthews [Analytical Services and Materials, Inc. (AS&M)] presented a new technique for deriving absolute SW and LW irradiances of the lunar surface using CERES instruments. The measurements from different instruments seem to agree well with one another, which suggests that the moon can be used as a stable calibration target for CERES, especially for the LW channels. Success with this technique, where the celestial body does not completely fill the CERES telescope, may also lead to a new scheme for solar calibration of future CERES instruments.

Seiji Kato [LaRC] presented an analysis of TOA SW, LW, and net fluxes over the Arctic region (60–90°N) to assess the impact of decreased sea-ice extent on atmospheric state, cloud distribution, and Earth's radiation budget. Monthly averages for summer months of 2007 showed negative anomalies for SW. Relative to averages for March 2000–December 2004, Kato's analysis indicated positive anomalies for both LW and net fluxes. Cloud amounts showed positive anomalies from January to May. Kato stated the need to investigate regional patterns of these anomalies.

Wenbo Sun [Hampton University] compared the MODIS (*MOD04*) cloud mask with that from CALIPSO lidar and discussed the implication of differences between them for *MOD04* AOD retrievals. He showed that CALIPSO detected many more clouds than MODIS with ~25% of MODIS clear scenes found to be cloudy by CALIPSO and 8–22% of CALIPSO cloudy scenes identified by MODIS as clear. In a separate presentation, Sun showed that the ice water content (IWC) of ice clouds retrieved from millimeter radar cross sections suffers from large uncertainties due to the lack of explicit information on particle sizes, shapes, and orientation.

Sunny Sun-Mack [SSAI] presented an algorithm where CERES/MODIS thin cloud retrievals are enhanced using coincident CALIPSO and CloudSat measurements along the A-Train track. Comparisons of clouds retrieved before and after the use of this algorithm showed that almost all ice clouds that CERES retrievals miss were thin cirrus clouds with $\tau < 0.3$. The enhanced algorithm also improved cloud optical depth and phase

retrievals. Results of this algorithm showed much better agreement with CALIPSO retrievals.

Bing Lin [LaRC] presented an analysis of cloud properties and radiation fields derived from Aqua measurements to examine relationships between cloud types and associated atmospheric heating/cooling. Lin examined high-altitude cloud areas over mid-latitude storm tracks and examined tropical convergence zones and low-altitude cloud areas over subtropical subsidence regions. The same type of clouds had very similar seasonal and interannual variations. High-altitude cloud areas experienced a net radiative heating and low-altitude cloud areas experienced a net cooling.

Fu-Lung Chang [National Institute of Aerospace (NIA)] reported on recent enhancements to high-thin and multi-layer cloud retrievals. He stated that the use of a modified carbon dioxide (CO_2)-absorption technique improved high cloud retrievals in the presence of underlying low clouds. He also demonstrated improvements over the conventional technique using CALIPSO/CloudSat data for comparison. The modified technique will be used to enhance high-thin and multi-layer cloud retrievals in CERES *Edition-3* processing.

Takmeng Wong [LaRC] presented an update on recent GEWEX-RFA activities since the last CERES Science Team Meeting. He listed several new datasets added to the archive, such as the monthly/hourly satellite data over selected sites and the adjusted CERES SRBAVG-GEO dataset. Efforts in the near future will be focused on fine-tuning the archive, data analysis and intercomparisons, and error assessment. Also, a draft report will be assembled from participant contributions. A first draft of the report is expected by Summer 2008.

ADM/Inversion Working Group

Norman Loeb led the Working Group discussions. **Nitchie Manalo-Smith** [SSAI] presented an analysis of 33 months of clear-sky TOA window (WN) fluxes from Aqua to examine the consistency of day/night differences between Terra and Aqua measurements. Terra and Aqua data showed different trends since the periods examined for the two satellites were quite different. **Cedric Bertrand** reported on new ADMs being developed for clear land and desert regions over Africa. These will be used for GERB processing with the CERES TRMM, Terra, and Aqua rotating azimuth plane (RAP) data. The plan is to fit semi-empirical functions to CERES observations and develop monthly ADMs for 2° latitude intervals.

SARB/SOFA Working Group

Thomas Charlock led the Working Group discussions. **David Rutan** [SSAI] presented a study demonstrating that sampling atmospheric SW transmission at Terra and Aqua overpass times captured its interannual variability. He observed this variability in monthly mean time series with sufficient accuracy. **Fred Rose** [SSAI] outlined plans for Fu-Liou model-based radiative transfer computations using C3M cloud products for the NEWS program. **David Kratz** showed comparisons of line-by-line computations of broadband and spectral LW fluxes at the TOA, surface, and several atmospheric levels. He used editions of the High-Resolution Transmission Molecular Absorption (HITRAN) database from 1982–2004 to make his comparisons. Spectral fluxes in certain regions showed significant differences even though broadband flux differences were quite small. **Zhonghai Jin** [SSAI] presented an analysis of errors in snow-grain size retrievals arising from the algorithm itself and from MODIS calibration errors.

Cloud Working Group

Patrick Minnis led the Working Group discussion that focused on exploring solutions for outstanding problems. **Qing Trepte** [SSAI] discussed the discontinuity that occurs in the CERES cloud mask during the transition between day and night conditions. She stated methods which have progressively reduced the size of the discontinuity and invited suggestions for completely eliminating it. **Chris Yost** [SSAI] discussed a method for characterizing sub-pixel level cloudiness within a 1-km MODIS pixel using 250-m-pixels. He also talked about using the derivative of reflectance to determine a clear-cloudy threshold for the 250-m-pixels. ■

NASA Land-Cover/Land-Use Change Program Science Team Meeting Summary

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The NASA Land-Cover and Land-Use Change (LCLUC) Program Science Team Meeting was held May 1–2, 2008, at the University of Maryland Inn and Conference Center located in Adelphi, MD. The meeting was held in conjunction with the NASA Carbon Cycle and Ecosystems (CCE) Joint Science Workshop April 28–May 2, 2008. Over 630 participants joined the greater meeting, with over 60 participating in the LCLUC Science Team Meeting. The focus of the LCLUC Science Team Meeting was on research in the Arctic within the context of the International Polar Year (IPY). There were 18 science and programmatic presentations given at the LCLUC Science Team Meeting and 35 LCLUC-related posters presented at the CCE Joint Science Workshop. Information about the CCE Joint Science Workshop can be found at: *cce.nasa.gov/meeting_2008/.* The agenda for the LCLUC Science Team Meeting, as well as presentations and posters, can be found on the LCLUC website at: *lcluc.hq.nasa.gov.*

Science Issues

The focus of the LCLUC Science Team Meeting was on research in the Arctic, with emphasis on projects located in northern Eurasia having strong linkages to the Northern Eurasian Earth Science Partnership Initiative (NEESPI). The meeting agenda focused on human-ecosystems-climate interactions and placed particular importance on understanding human dimensions of land-use in the region. Science issues concerning climate change, hydrology, disturbance and changes in land cover and productivity, carbon cycling, resource management, and alteration of indigenous lifestyles were common themes to the research presentations. In addition, the discussion highlighted new data products being developed to support LCLUC research in the Arctic.

Opening Remarks

Garik Gutman [NASA Headquarters—*LCLUC Program Manager*] kicked off the meeting with a status update of the LCLUC program, including Science Team activities, projects, and data issues. He highlighted the role of LCLUC research in the framework of the NEESPI and Monsoon Asia Integrated Regional Study (MAIRS) regional initiatives. He also announced a new data sharing initiative within the LCLUC program. **Kelley O'Neal** [University of Maryland, College Park] presented the new data access capabilities on the LCLUC website. Gutman concluded with a list of near-term priorities for the program, including improved land-use models, an enhanced social science component, continued participation in the Global Observation of Forest and Land Cover Dynamics (GOFC-GOLD) program, coupling of LCLUC processes in climate and dynamic vegetation models, and development of land-cover and change products from the Global Land Survey (GLS) products.

Chris Justice [University of Maryland, College Park—*LCLUC Program Scientist*] presented some emerging themes relevant to LCLUC research that he noted from presentations and breakout sessions at the NASA CCE Joint Science Workshop:

- Increasing attention to human managed/modified ecosystems;
- modeling multiple stressors on managed systems and related challenges;
- examining "end-to-end" impacts of LCLUC; and
- projecting land-use adaptations to climate and socioeconomic changes.

Group photograph of the LCLUC meeting attendees.

Justice also discussed:

- Opportunities for tighter connection between Earth science and applications;
- importance of securing long-term observations; and
- opportunities from the decadal survey's proposed new systems for improved land-cover characterization and land-use science.

Scientific Presentations

A total of 11 scientific presentations were given during the Science Team Meeting.

Scott Goetz [Woods Hole Research Center] presented research on recent productivity and disturbance changes associated with high-latitude climate change. He focused on changes in fire regimes related to warming in high latitudes along with resultant changes in vegetation composition.

Matt Hansen [South Dakota State University] presented work toward mapping forest cover and forest-cover loss in the Boreal zone from 2000 to 2005. The process assesses change on an annual basis using MODIS data, mapping presence or absence of tree cover regardless of land use, and stratifying the Boreal biome into high, medium, and low areas of change.

Skip Walker [University of Alaska, Fairbanks] presented information regarding the cumulative effects of resource development, reindeer herding, and climate change on the Yamal Peninsula in Russia. He focused on current and future gas and oil production in the region, the effects on the nomadic herding society from loss of land, and the effects on land cover from overgrazing remaining land. He also noted only a modest warming trend in the region.

Nancy Maynard [NASA Goddard Space Flight Center] presented information on human dimensions in the Arctic tundra under changing climate conditions. She discussed the importance of understanding indigenous traditions in reindeer pastoralism and the utility of reindeer mapping in assessing the vulnerability of coupled human-ecological systems in the Arctic to global warming and climate change.

Svein Mathiesen [Saami University College, Norway] presented an overview of climate adaptation related to reindeer herding from the Ealat Network study. He noted the original high resilience of the Arctic tundra human-ecological system to climate variability and change. Mathiesen followed on to the previous presentation with emphasis on the importance of understanding indigenous knowledge and external pressures from development and industry in order to assess the future resilience of this system.

Richard Lammers [University of New Hampshire] presented research on hydrological change within the NEESPI region. He assessed the net impact of the combined effects of natural and anthropogenic sources of change in the patterns or hydrological variability and identified and ranked the sources of change.

Kyle McDonald [NASA/Jet Propulsion Laboratory] presented on LCLUC interactions between Arctic land cover and hydrology, and links to the carbon cycle. He focused on carbon sources from permafrost lakes and methane emissions, river discharge, frozen soils, and peatlands.

Olga Krankina [Oregon State University] presented an overview of land cover and carbon cycling at high latitudes. She highlighted results from her land-cover mapping project in northern Eurasia and emphasized the importance of input map selection in determining the accuracy of final results.

Vladimir Romanovsky [University of Alaska, Fairbanks] presented an overview of changes in permafrost in the northern hemisphere and linkages to the carbon cycle. He focused on permafrost dynamics during the last glacial cycle, the present state of permafrost and possible future changes, and consequences of these changes.

Irina Sokolik [Georgia Institute of Technology] presented an overview of radiation and Arctic aerosol interactions with LCLUC. She differentiated between natural and anthropogenic sources of aerosols, focused on long-term aerosols trends in the North American and Eurasian Arctic, and related aerosols to accelerated rates of warming.

Robert Chen [Center for International Earth Science Information Network (CIESIN)] presented an overview of social science data for high latitudes and highlighted the importance of including socioeconomic data in LCLUC research. He showcased socioeconomic data relevant to Arctic research available through CIESIN.

Programmatic Presentations

A total of five programmatic presentations were given during the Science Team Meeting.

Curtis Woodcock [Boston University] presented an overview of the Global Observations of Forest Cover-Global Observations of Land Cover Dynamics (GOFC-GOLD) program and discussed the new Reducing Emissions from Deforestation and Degradation (REDD) sourcebook. He also noted details and key activities for the Group on Earth Observations (GEO) task of land-cover characterization.

Thomas Loveland [U.S. Geological Survey (USGS)] presented a status update on the current Landsats and the Landsat Data Continuity Mission (LDCM). He reviewed LDCM instrument specifications and noted a planned launch date for July 2011. He also provided an overview of the current Landsat archive, a status update for Landsat 5 and Landsat 7, and noted the recent USGS policy changes for Landsat cost and availability.

Jeff Masek [NASA Goddard Space Flight Center] presented an overview of the GLS 2005 product, including processing and land-cover product development. He reviewed processing specifications, including scene selection criteria and sensor preference, and noted the current reprocessing of older Geocover datasets from 1975, 1990, and 2000 to GLS standards. Masek also noted the GLS 2005 effort is focusing on both data products and land-cover analysis through support from several LCLUC-funded projects. He introduced the planned GLS 2010 initiative.

Eric Vermote [University of Maryland, College Park] provided an overview of the Land Long-Term Data Record (LTDR) project providing a continuous data record from the Advanced Very High Resolution Radiometer (AVHRR) to MODIS. He presented details on AVHRR geolocation accuracy, calibration within the AVHRR series, and calibration between AVHRR and MODIS.

Tres Montano [University of Maryland, College Park] presented a demonstration of the new Land Measurements Portal designed to provide information on the land products from NASA and the international community, and the associated validation and coordination initiatives on land observations.

Arctic LCLUC Book for IPY

Garik Gutman discussed the plans and chapter content for *Arctic Land Cover and Land Use in a Changing Climate*, the LCLUC contribution to IPY. Topics covered include changes in vegetation cover and productivity, forest-cover loss, carbon balance, hydrology, reindeer pastoralism, resource development, aerosols, pollution, and an overview of scientific challenges for LCLUC research in the Arctic. The book is authored by LCLUC and NEESPI principal investigators and focuses on northern Eurasia. The book will be submitted by October 2008 and published at the conclusion of IPY.

Closing Remarks

Garik Gutman wrapped up the meeting with encouragement to the LCLUC community to organize topical science workshops in order to facilitate better coordination and collaboration. He emphasized the importance of data availability from the international assets and suggested a workshop on the GLS program. He encouraged LCLUC researchers to be involved with the emerging new NASA instruments planned for launch, and to give attention to the future national and international systems. He noted the need for increased research on the role of societal feedbacks, effects on ecosystems, and integration of LCLUC processes in climate models in order to assess vulnerability, resilience, and adaptation. He concluded the meeting with a reminder of the success of the LCLUC program in improving understanding of human-ecosystems-climate interactions.

Future Meetings

The next LCLUC Science Team Meeting is planned for January 2009 in Chiang Rai, Thailand to be held jointly with the MAIRS program. Its focus will be on tropical land-cover and land-use change. More information concerning this meeting, along with presentations from the Spring Science Team Meeting, can be found on the LCLUC website at: *lcluc.hq.nasa.gov.* ■

LASP Returns Nearly $3 M to NASA in Cost Savings on SORCE Mission

On June 17, the University of Colorado (CU) at Boulder's Laboratory for Atmospheric and Space Physics (LASP) took the rather unusual step of returning nearly $3 M in cost savings on the Solar Radiation and Climate Experiment (SORCE) to NASA. NASA launched SORCE as part of EOS in 2003 and the mission is controlled from the LASP Space Technology Building at the CU Research Park. During an event held at CU on June 17, LASP officials presented a $2,997,000 check for the cost savings from SORCE development and operations to Ed Chang, [NASA Goddard Space Flight Center—SORCE Manager]

This surplus is money that was not spent during the SORCE Prime Mission development and operations (first five years). The cost savings is a result of an efficient management team, effective pre-launch testing, an extraordinary science team, and the sharing of LASP Mission Operations Center personnel. In an era of tight budgets and ever rising costs this is quite an accomplishment. Congratulations to SORCE PI Tom Woods and everyone else involved in the mission on a job well done.

NASA Scientists Hope to See the Data Through the Haze

Denise M. Stefula, NASA Langley Research Center, Denise.M.Stefula@nasa.gov

Strange things are happening at the top of the world.

As early as the 1940s, weather reconnaissance pilots flying the Canadian high Arctic reported seeing smog bands of unknown origin, and the term *Arctic Haze* was soon born.

Since then, scientists have discovered that the atmospheric particles, or aerosols, found in *Arctic Haze* are composed of a variety of species associated with urban pollution: soot, sulfate, nitrate, ammonia, and organic acids. The thick layers of aerosols contribute to regional and global climate modifications.

Studying these aerosols may help researchers better understand what's going on inside the Arctic Circle—a "fragile" first alert system of global climate change.

How can such a seemingly pristine environment, relatively desolate and certainly remote as regions go, be so plagued by pollutants attributed to the far more populated, industrialized portions of the world?

The reason is found in the wind. Strong pressure gradients during winter months cause episodes that push the air northward. With this push, aerosols are transported into the Arctic from mid-latitude sources in North America and Eurasia.

Once reaching the Arctic, aerosols disperse into the atmosphere, and that's when things get strange.

Over the dark winter months, the Arctic atmosphere becomes stable. The lack of sunlight and low precipitation allow aerosols longer "residence" times, and the haze settles in the troposphere.

The awakening Arctic spring brings sunlight once again and photochemical processing first causes the formation of ozone, then essentially starts to clean aerosols from the troposphere in what scientists characterize as a fast, highly reactive process.

"During the spring when the sun reappears over the Arctic," says **Jennifer Olson**, a research scientist at NASA's Langley Research Center, "the sunlight interacts with the aerosols and photochemical reactions quickly begin to take place."

Through their participation in NASA's Arctic Research of the Composition of the Troposphere from Aircraft and Satellites (ARCTAS), Langley researchers are part of an international group of scientists brought together by the International Polar Year to collect data in the Arctic region. Their aim is to better understand human influences and changes in Arctic atmospheric conditions relating to pollution and climate. The first deployment took place in April to investigate the Arctic Haze phenomenon. Read firsthand accounts of the experience on page 4 of this issue.

ARCTAS scientists have used multiple approaches—lidar, *in situ* measurements, and satellite observations—to collect data. The Langley *King Air B-200* aircraft was used for lidar and *in situ* measurements. At no other time has this kind of extensive sampling of the Arctic been used on a scale as broad in such close proximity to the North Pole, and NASA Langley projects have played an important role.

"You don't have just one instrument measuring aerosols," says **Eddie Winstead**, a Langley Aerosol Research Group Experiment (LARGE) team scientist with Langley's Science Directorate. "Our rack (a frame for housing equipment) alone can sometimes have anywhere from 13 – 15 instruments and they all measure different parameters."

LARGE, headed up by Principal Investigator **Bruce Anderson**, measures aerosol particle sizes and concentrations and studies the impact of the amount of sunlight absorbed or reflected (radiative forcing) by Earth's system. Absorption warms, reflection cools.

"With Arctic Haze it's important to read the composition, size, and number of particles present, as well as the amount of light being scattered," Winstead explains. "This gives scientists insight into the energy balance and global climate effects."

The LARGE instruments include particle counters and sizers, photometers, spectrometers, cloud imaging probes, and nephelometers. These instruments not only provide data on the Arctic region's atmospheric conditions, they also benefit in validating operational success.

Operational success is measured in part through critical studies comparing results to ensure techniques and platforms are complementary. Flight planners also work to ensure that the aircraft collect observations in locations where Earth-observing satellites associated with NASA's A-Train are passing overhead. Putting instrumented aircraft in the path of a satellite allows scientists to gather comprehensive data for comparison and validation of satellite observations.

Eddie Winstead (far right) with some of the Langley Aerosol Research Group Experiment team members in Fairbanks, Alaska. From left: Andreas Beyersdorf, Gao Chen, Principal Investigator Bruce Anderson, and Terry Lathem. Credit: NASA.

"Aircraft in the field provide what scientists call *truth* data. One aircraft is sampling the air as another above takes *remote* measurements," says **Chris Hostetler**, one of Langley's platform scientists for the *B-200*. "The data are then integrated to provide a two dimensional vertical context to investigate new and existing remote techniques."

During the spring ARCTAS campaign, several aircraft underflights of the Langley-developed Cloud-Aerosol Lidar Pathfinder Satellite Observations (CALIPSO) satellite were performed. Data from campaigns like ARCTAS improve the utility of satellite measurements and aid in the formulation of future field activities.

"The data from different instruments overlap," explains Winstead. "This is state-of-the-art equipment, and we check the data carefully to see if the results agree."

Back in the lab, researchers like Winstead use the combined observational techniques to identify pollution sources and transport pathways, and study the radiative properties of aerosols in the Arctic. The results offer opportunities for a better understanding of the strange, rapid atmospheric changes occurring each spring at the top of our world, and how those changes apply to global climate concerns. ■

ESIP Federation Elects Four New Partners

The Federation of Earth Science Information Partners ("ESIP Federation") has elected four new partners for full membership. The following group illustrates the continuing strength of applicants for ESIP Federation partnership:

- The Comprehensive Large Array-data Stewardship System (CLASS), **Robert Rank**, NOAA/ NESDIS Office of Systems Development, Suitland, MD.
- CyberForSPACE: Cyberinfrastructure For Sustainable Programs And Community Empowerment, **James Wilson**, James Madison University Geographic Science Program, Harrisonburg, VA.
- Massachusetts Maritime Academy, **Tom Pham**, Buzzards Bay, MA.
- Marine Metadata Interoperability Initiative, **John Graybeal**, Monterey Bay Aquarium Research Institute, Moss Landing, CA.

"The ESIP Federation's growth continues to surpass all expectations," says **Charles Hutchinson**, ESIP Federation President. "We are drawing in new partners from a variety of sources, representing all the ESIP Types and the experts who innovate in the field of Earth science data and information technology management. The ESIP Federation's reputation as a collaborative community-driven forum for Earth science data and information technology experts is growing."

Celebrating its 10th anniversary, the ESIP Federation now comprises 110 partners representing a wide range of Earth science data interests. ESIP Federation partners include Earth science data centers, environmental research groups, practitioners in the application of environmental data, educators and technologists. Across these diverse interests, public, private and non-profit organizations are represented.

The ESIP Federation is a broad-based community drawn from agencies and individuals who collectively provide end-to-end handling for Earth science data and information. The ESIP Federation promotes increased accessibility, interoperability and usability for Earth science data and derivative products. Initiated by NASA in 1997, the ESIP Federation provides data, products and services to decision makers and researchers in public and private settings. The Foundation for Earth Science provides administrative and staff support to the Federation of Earth Science Information Partners.

in the news

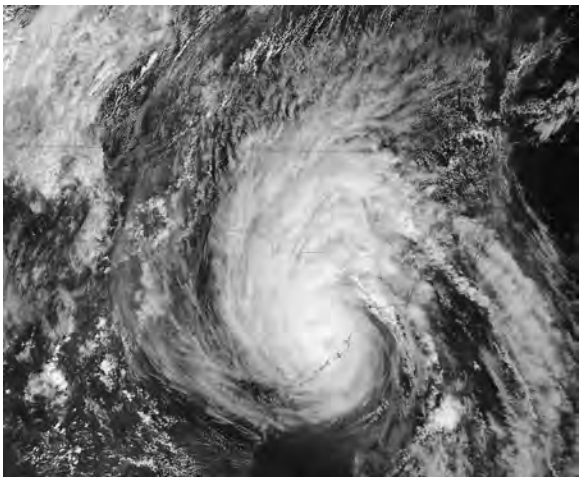
For Hurricanes, Storms, Raindrop Size Makes All the Difference

Gretchen Cook-Anderson, NASA Goddard Space Flight Center, Gretchen.R.Cook-Anderson@nasa.gov

When Tropical Storm Gaston hit Richmond, VA, in August 2004, its notable abundance of small and mid-sized raindrops created torrential rains that led to unexpected flash flooding throughout the city and its suburbs. **New research from NASA has concluded that tropical cyclones like Gaston produce rain differently than another class of storms called "extra-tropical" cyclones.** According to the study, making a proper distinction between these systems by looking at both raindrop size and abundance may be a key to assisting weather forecasters in estimating rainfall intensity. By doing so, forecasters can reduce the surprise factor of flash flooding and the unfortunate loss of property and life.

Ali Tokay, a research scientist from the Joint Center for Earth Systems Technology (JCET) at the University of Maryland, Baltimore County, Baltimore, and NASA's Goddard Space Flight Center, compared the rain measurements collected in tropical storms and hurricanes during the past three Atlantic hurricane seasons with measurements after these storms transitioned to being extra-tropical. Tokay's study appeared in the May issue of the American Meteorological Society's *Monthly Weather Review*.

When a *tropical cyclone*—the generic name for tropical depressions, tropical storms, and hurricanes—merges with a mid-latitude frontal storm system, measurable changes to the raindrop size and abundance occur as the system transitions to become extra-tropical. Extra-tropical cyclones also form outside the tropics without being part of a tropical system, and tend to form over land rather than over the open ocean. This category of storm can produce anything from a cloudy sky to a thunderstorm as it develops between *weather fronts*—the boundaries separating air masses of different densities.



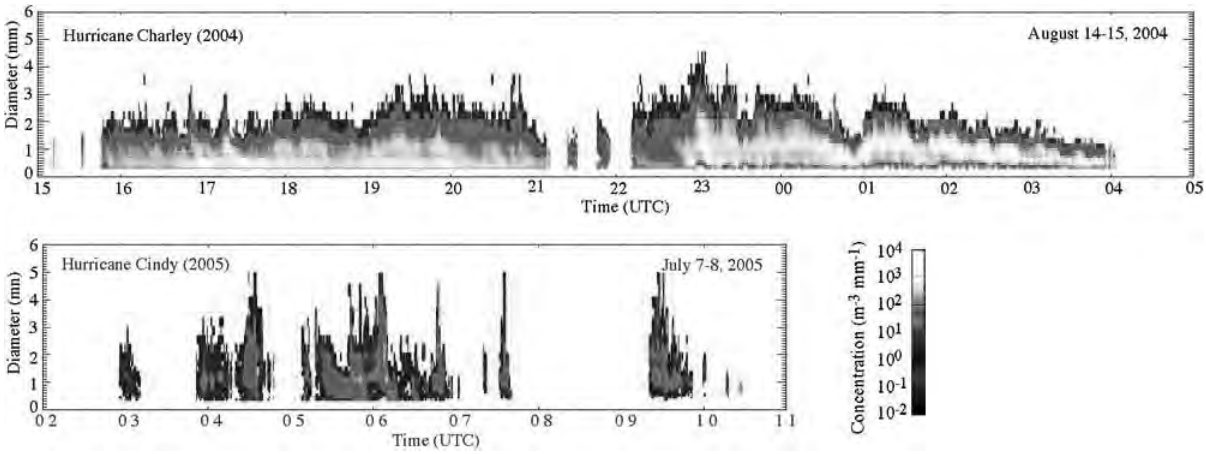
Tropical Storm Gaston moved ashore over the coast of McClellanville, South Carolina on August 29, 2004, as captured by the MODIS instrument aboard NASA's Terra satellite. At the time this image was taken, Gaston poured large amounts of small and mid-sized raindrops across several states, including the city of Richmond, VA. **Credit:** NASA.

Disdrometers like this one measure rainfall rates and size distribution. **Credit:** NASA.

Tokay looked at raindrop size, rain intensity, and the area in which rain falls in both tropical cyclones and extra-tropical cyclones using ground-based rain-measuring instruments called *disdrometers*. These instruments measure the range of raindrop sizes in a storm and the intensity of the rainfall. The disdrometer is an important part of the ground-based rain measuring instruments that are used to validate rainfall seen from satellites including the Tropical Rainfall Measuring Mission (TRMM), a joint mission with NASA and the Japanese Space Agency. He concluded that tropical cyclones that form over water tend to rain harder and have a greater amount of smaller drops before they transition to being extra-tropical with raindrops of larger size and mass.

"Torrents of rainfall from tropical storms are not surprising since the systems are large and move slowly. It is also true that slow-moving frontal systems associated with an extra-tropical cyclone can result in abundant rainfall at a site," said Tokay. "What is less known is that the distribution of raindrops within a volume of air between the two systems differs substantially even though weather radar may measure the same returned power which is known as *reflectivity*." This is why disdrometer measurements of raindrop size are needed.

"Both rain intensity and reflectivity are integral products of raindrop size distribution, but they are mathematically related to different powers of the drop size,"



Hurricane Cindy (2005) was observed after it became an extratropical cyclone indicated by larger raindrops that are decreasing in abundance of raindrops as the hours pass when compared to smaller raindrops in greater abundance during Hurricane Charley (2004). **Credit:** Ali Tokay/NASA.

said Tokay. Weather radars cannot measure the range of raindrop sizes. As a result, rainfall estimates from weather radars must employ the use of equations that make assumptions about raindrop size. These assumptions can result in underestimation of rain intensity, and the possibility of deadly flooding.

In the study, Tokay uses disdrometer data from various sites around the U.S. and abroad. Most of the data were collected at NASA's Wallops Flight Facility, Wallops Island, VA, where **Paul Bashor** of Computer Sciences Corporation, Wallops Island, VA maintains several types of disdrometers. The data from two tropical storms were collected at Orlando, FL, and Lafayette, LA through collaborative efforts with **Takis Kasparis** at the University of Central Florida's Orlando campus, and **Emad Habib** of the University of Louisiana at Lafayette. ■

CloudSat-TRMM Product Release to General Science Community

The CloudSat Data Processing Center (DPC) has released, to the general science community, the 2D-CloudSat-TRMM product. This product contains both CloudSat 2B Cloud mask and radar reflectivities (2B-GEOPROF) and TRMM Precipitation Radar (PR) data where the ground tracks of the two instruments cross within approximately 50 minutes of each other. A short segment of both the CloudSat and TRMM product data is included in the combined product. A Product Description Document can be found as a pdf download at: *www.cloudsat.cira.colostate.edu/ICD/2D-CLOUDSAT-TRMM/2D-CLOUDSAT-TRMM_PD_1.0.pdf.*

Details of the product format can also be found at: *www.cloudsat.cira.colostate.edu/dataSpecs.php?prodid=85.*

A browse image preview of the orbit crossings and data segments can be viewed on the 2D-CloudSat-TRMM "Intersects" page found at: *www.cloudsat.cira.colostate.edu/dpcstatusTRMM.php.*

To access the released data, use the DPC data ordering system interface found at: *cloudsat.cira.colostate.edu/data_dist/OrderData.php.* The 2D-CloudSat-TRMM products can be ordered in the same manner as other CloudSat products. These product files will have filenames as follows: *2006342013336_47T_25N_006E_01200_03257_CS_51638_TR.hdf.* A format description for the filename can be found in the Data Product Document listed above.

If you have any questions concerning the ordering process, contact the DPC at *cloudsat@cira.colostate.edu.*

in the news

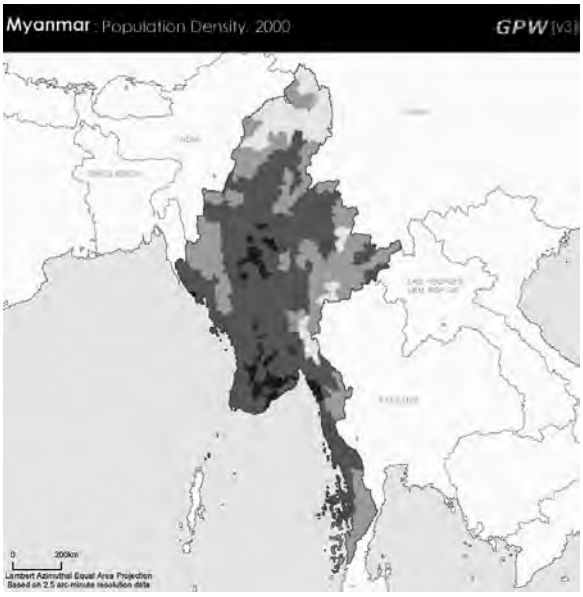
NASA Data Helps Pinpoint Impacted Populations in Disaster Aftermath

Gretchen Cook-Anderson, NASA Goddard Space Flight Center, Gretchen.R.Cook-Anderson@nasa.gov

When two catastrophic natural disasters struck within days of each other in May 2008, disaster relief, humanitarian aid, and health officials, as well as members of the news media, tapped into a unique set of NASA data products describing the location of the exposed populations. In the hours and days following the cyclone in Myanmar and the earthquake in China's Sichuan Province, workers had the data they needed to assess the numbers of people possibly affected in these deadly events. **What arose was a timely example of how NASA data comes to the aid of officials when such disasters occur.**

"The gridded population product we produce helps officials understand the density of the population in and around a disaster area," said **Robert Chen**, Manager of NASA's Socioeconomic Data and Applications Center (SEDAC) and Director of the Center for International Earth Science Information Network (CIESIN), part of the Earth Institute at Columbia University in New York. "The data set shows where people actually live in relationship to hazardous events."

Members of the news media use the data and associated maps to report on possible casualties and property destruction. "When a major disaster hits, people want to know how many people were exposed to the disaster, in addition to how many were killed," said Chen. "For example, CNN used our map of population density in Myanmar to help explain how the unusual path of Cyclone Nargis affected the low-lying, densely populated delta."



SEDAC/CIESIN's Gridded Population of the World map of Myanmar captures areas in shades of gray that become darker with increased population. Coastal areas hit hardest by the cyclone in May 2008 were highly populated. **Credit:** SEDAC/CIESIN.

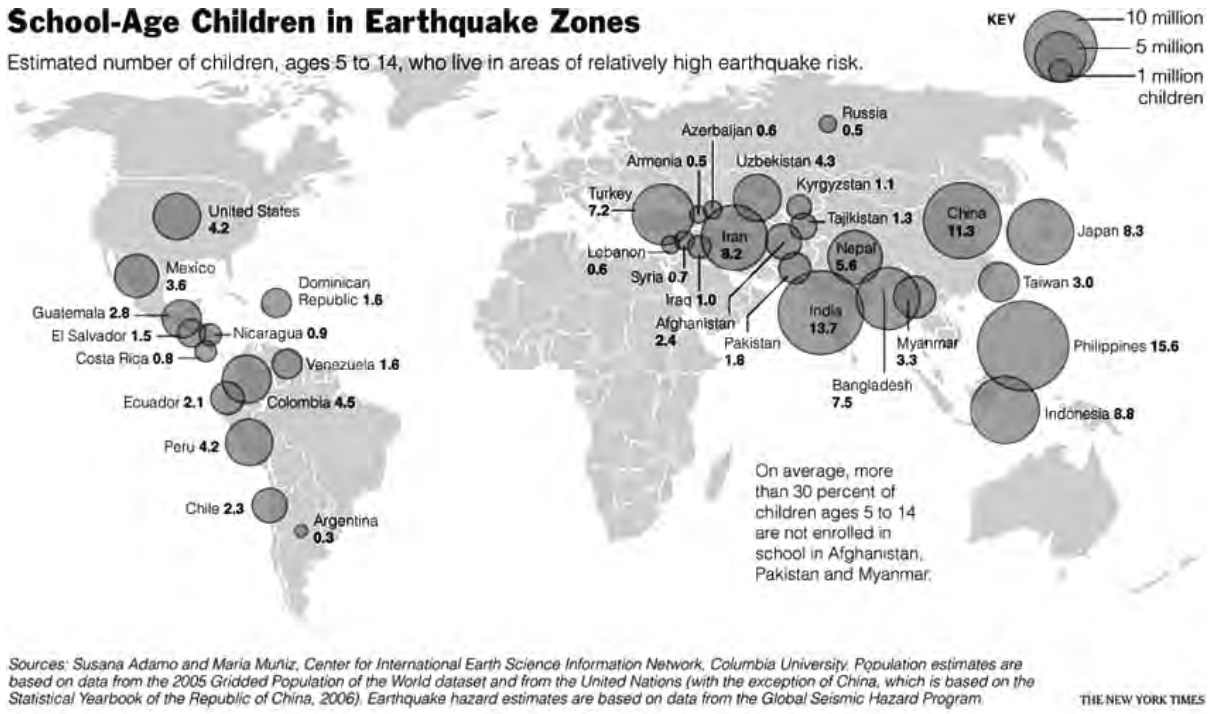
Using the SEDAC data, media were able to report that 25% of Myanmar's 57 million people resided in coastal areas overpowered by the cyclone. They also projected that a million people would likely face homelessness, a number calculated by the United Nations (UN) also by using data made available by SEDAC.

SEDAC, a part of NASA's Earth Observing System Data and Information System, collects, stores, processes, and distributes population, land use, and socioeconomic data. A significant mission of NASA's Earth-observing satellite program is to enable scientists and other users to conduct analyses and make decisions based on the resulting data. SEDAC advances this mission by developing and operating practical applications that merge social science and Earth science data to improve knowledge of how humans interact with Earth's environment.

SEDAC and CIESIN's joint staff of more than 60 is made up of a diverse array of demographers, geographers, Earth scientists, public health specialists, and information technologists. For the gridded population data, they collect two different types of input data: state and local population data for every country of the world and Geographic Information System (GIS) data on the boundaries of states, provinces, counties, and other administrative units within these countries.

Next, they integrate the population figures with the GIS data to produce density estimates for a given area. By converting these data to a regular latitude-longitude grid, they enable the data to be used with a range of remote sensing information, such as land-cover data from the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument aboard NASA's Terra and Aqua satellites, vegetation data from the NASA-built Landsat satellite, and high-resolution satellite images from the ASTER instrument on the Terra satellite.

Marc Levy, SEDAC's lead Project Scientist and CIESIN's Deputy Director, pointed out that a particular concern in the case of Sichuan is the location of built-up urban areas. "For that, SEDAC's Global Rural-



SEDAC and CIESIN aided media after the Sichuan quake with this population map that shows the number of children across the globe who are exposed to earthquake hotspots—a tool officials can also use in disaster planning. **Credit:** SEDAC/CIESIN.

Urban Mapping Project (GRUMP) has combined satellite data on night-time lights with population and other administrative data to estimate urban characteristics," said Levy. The GRUMP data available from SEDAC include urban versus rural population densities and the extent of "built-up" urban areas.

Columbia University researchers worked with the World Bank and other partners in recent years to develop integrated maps of global disaster risk *hotspots*. Many parts of the world, including the heavily populated Asia–Pacific region, are even susceptible to overlapping hazards like cyclones, earthquakes, landslides, and tsunamis. The team linked six natural hazards—earthquakes, volcanoes, landslides, cyclones/hurricanes, floods, and drought—with population exposure, historic mortality, and economic impacts data to identify areas at a relatively high risk of disaster. In fact, CIESIN researchers have recently used population maps in the wake of significant child casualties in the Sichuan quake to estimate the number of children around the world who live in areas of relatively high earthquake risk.

"Although our information is most useful for groups needing to know how many people were in the exposure zone where a disaster occurred, it also helps when looking downstream at secondary impacts like disease, homelessness, hunger, and even conflict," said Levy. "We have begun working with groups like the UN's World Food Programme and nongovernmental aid groups to develop new data and tools to assist with planning for disaster recovery and reconstruction."

SEDAC and CIESIN work with both U.S. and international agencies such as the U.S. State Department, the UN Geographic Information Support Team, and the World Health Organization to ensure that SEDAC's data are both accessible and usable. "Sometimes users just need a simple map, but at other times they need detailed data for analysis," said Chen. "We are working to provide both, in part by making our data available through tools such as *Google Earth* and NASA's World Wind that enable users to visualize data quickly and easily."

In the future, Chen says that the Center will try to gain more insight into a variety of issues: what types of structures people live in; how accessible they are through roads; how age, gender, and health affect vulnerability; and how other factors such as poverty, conflict, infectious disease, and water scarcity interact with natural hazards. "We need to improve our understanding of the human side of the equation using the data capabilities we have and will have in the future," said Chen. "This is very critical to the welfare of populations everywhere." ■

EOS Scientists in the News

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

Rainy Days and Weekdays, April 18, 2008; *ScienCentral News*. **Tom Bell** (NASA GSFC) found that, according to satellite data, it tends to rain more midweek during the summertime in the U.S. Southeast—the effect is likely caused by rises in midweek pollution.

Ice Escapades: Greenland's Ice Sheet is Speeding to the Sea, April 18, 2008; *Scientific American*. While research suggests that Greenland's glaciers are speeding up in their flow toward the sea, **Eric Rignot** (NASA/JPL) notes that there still needs to be more data to accurately predict how the ice sheet will flow in a warmer climate.

Greenland's Disappearing Lakes Leave Giant Ice Sheets Largely Unmoved, April 18, 2008; *The Guardian*. Meltwater in Greenland was found to play only a small role in glacier flow. Still, **James Hansen** (NASA GISS) says that the increase in the ice sheets' shrinking is an indication that the world's targets for reduction of carbon emissions are not stringent enough.

NASA Marks Earth Day, April 22, 2008; *CNN*. Former astronaut Bill Anders and co-Nobel Prize winner **Bruce Wielicki** (NASA LaRC) discuss NASA's efforts on Earth Day.

Eyes in the Sky Track Earth's Changes, April 30, 2008; *Scientific American*. The extended record of NASA satellite observations are helping researchers derive new information about changes in Earth's ecosystems, explains **Diane Wickland** (NASA HQ).

California Braces for Wildfire Season, May 3, 2008; *Associated Press*. **William Patzert** (NASA/JPL) explains how California's Santa Ana winds impact the severity of the wildfire season, comparing their variability to that of the El Niño weather phenomenon that warms the tropical Pacific.

Tornados Versus Hurricanes, May 5, 2008; *Virginian-Pilot*. In the aftermath of a devastating F-3 tornado in the Hampton Roads region, reporters asked, "Can the winds of a tornado this size cause the same damage as, say, a Category-4 or -5 hurricane?" The answer, according to **John Murray** (NASA LaRC), is of course, but it's not a one-to-one comparison.

It's Our Watch—Project Green: Researchers Study Pollution's Effects, May 14, 2008; *WVEC Channel 13*. In a continuing series on climate change and human influence on the environment, **Chris Hostetler** (NASA LaRC) and **Rich Ferrare** (NASA LaRC) discuss part of NASA Langley's involvement with a new project, Arctic Research of the Composition of the Troposphere from Aircraft and Satellites, more commonly known as ARCTAS.

Satellites, Beekeepers Track Climate Change Response, May 28, 2008; *Discovery News*. **Wayne Esaias** (NASA GSFC) is using satellites combined with ground-based methods to help understand how bees are responding to climate change, and to predict how far aggressive Africanized bees—sometimes called "killer bees"—will spread in North America.

Monitoring Antarctic Ice Movement is a Sticky Business, June 4, 2008; *Scientific American*. Scientists have found evidence that movement of the Whillans Ice Stream in West Antarctica is powered by seismic energy in the rocks below, and **Robert Bindschadler** (NASA GSFC) agrees that such stresses could be caused by tides, though exactly how that leads to the movement of such a large block of ice is unclear.

Climate Change: Is It a Hoax or is it True? June 5, 2008; *The Daily Press*. **Bruce Wielicki** (NASA LaRC) prepares to give a lecture to the public on climate change, approaching the topic with a basic question to get the audience thinking: *Is climate change a hoax?* However, he has no doubts about the science behind it and the basic measurements that show it happening now.

Satellite Imagery Drives U.S. Global Food Security Effort, June 7, 2008; *News Blaze*. Researchers, including **Molly Brown** (NASA GSFC), are using satellite technology to contribute to estimates of global food security as part of the Famine Early Warning System, which can be used to warn nations of food shortages.

Going Dry: Potential Freshwater Drought, June 8, 2008; *ABC Sunday World News.* Californians face water shortages as demand rises with a growing population and supply decreases due to factors such as climate change, according to researchers including **William Patzert** (NASA/JPL).

NASA Study Targets Northern Forest Fires, June 17, 2008; *Canadian Broadcasting Corporation*. A large international team of scientists, including **Hanwant Singh** (NASA ARC), launched a three-week field campaign using NASA aircraft to investigate the

impact of northern-latitude forest fires on the Arctic's lower atmosphere.

New Satellite to Study Rising Seas, June 18, 2008; *Space.com*. **Eric Lindstrom** (NASA HQ) described the feat of engineering that went into the Ocean Surface Topography Mission (OSTM), or Jason 2 satellite, and researchers including **Parag Vaze** (NASA/JPL) awaited the launch as it sat ready on the pad.

JPL Scientists Hoping Satellite Will Make Discovery of Global Proportions, June 19, 2008; *The San Marino Tribune*. Prior to the June 20 launch of the Jason 2 satellite, **Joshua Willis** (NASA/JPL) described how the mission would extend the record of sea level rise, calling such change "the yardstick of global warming."

Sea-Level Tracking Satellite Launched, June 20, 2008; *Agence France-Presse*. After the launch of the Jason 2 satellite, **Omar Baez** (NASA KSC) noted the satellite was operating and **Lee-Lueng Fu** (NASA/JPL) described how data from the mission will help researchers track changes in the oceans.

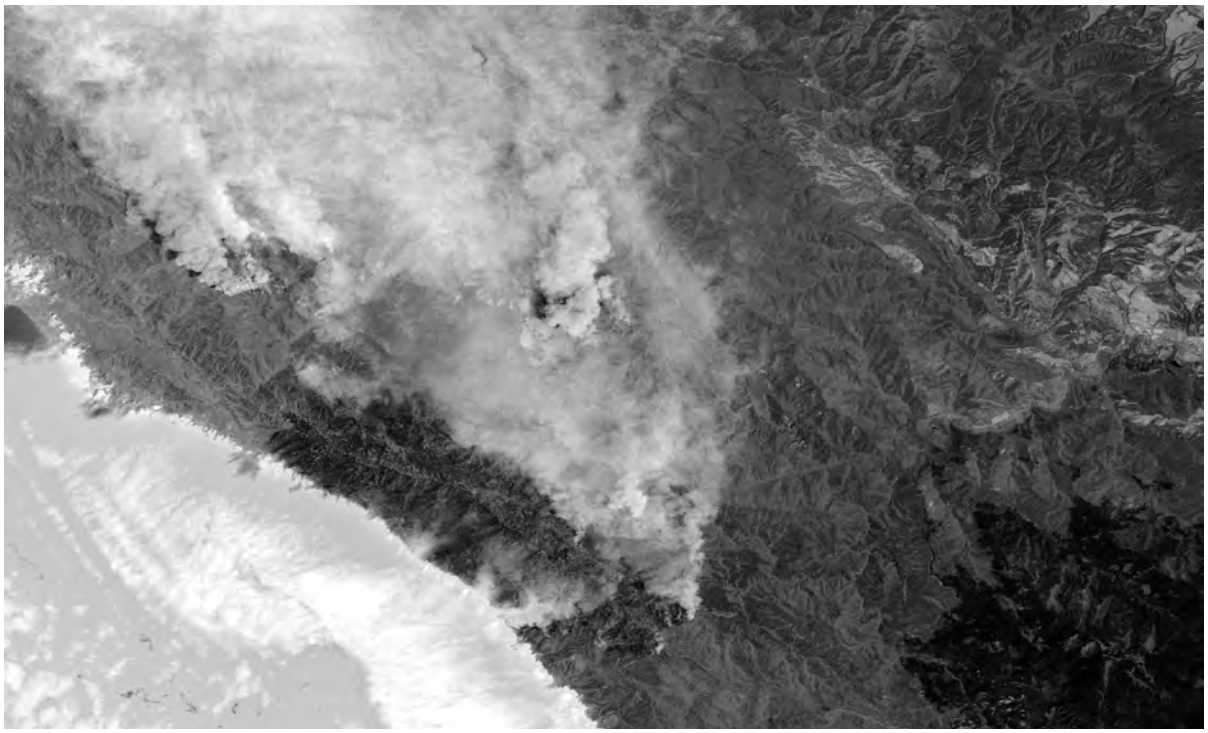
Ocean-Monitoring Satellite Blasts Off From California, June 20, 2008; *Associated Press.* **Marc Lavigne** (NASA KSC) described the gentle separation of the Jason 2 satellite from the rocket after it launched from the central California coast.

NASA to Test State's Air Quality, June 20, 2008; *Antelope Valley Press*. In June, NASA and the California Air Resources Board conducted flights over the state to study pollution and natural emissions in the region's lower atmosphere, and researchers, including **Frank Cutler** (NASA DFRC), describe the one-of-a kind opportunity.

NASA Launches Another Satellite to Map Oceans, June 23, 2008; *Daily Tech*. **Michael Freilich** (NASA HQ) explains some of the benefits of ocean surface height measurements from the new Jason 2 satellite including improved weather and climate forecasts.

Years Later, Climatologist Renews His Call for Action, June 23, 2008; *The New York Times*. Twenty years since **James Hansen** (NASA GISS) spoke at a Senate hearing about human influences on climate change, the climate scientist readdressed the issues on June 23 at a briefing organized by a House committee.

Interested in getting your research out to the general public, educators, and the scientific community? *Please contact Steve Cole on NASA's Earth Science News Team at* ***Stephen.E.Cole@nasa.gov*** *and let him know of your upcoming journal articles, new satellite images, or conference presentations that you think the average person would be interested in learning about.*



This image of the Santa Lucia Range Mountains near Big Sur, California, was captured by the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) on NASA's Terra satellite on June 29, 2008. Smoke plumes from the actively burning Basin Complex Fire are visible in the center and upper left portions of the image. The fire was only about 3% contained at the time the image was captured. The dark portion in the lower right shows the burned area from the less active Indians fire that was about 95% contained when this image was captured. The light area in the lower left are clouds over the Pacific Ocean. For more information and to view this image in false color please visit: *asterweb.jpl.nasa.gov/.* **Credit:** NASA/GSFC/METI/ERSDAC/JAROS.

NASA Science Mission Directorate – Science Education Update

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Theresa Schwerin, Institute of Global Environment and Society (IGES), theresa_schwerin@strategies.org

NO CHILD LEFT INSIDE: 2008 EARTH SCIENCE WEEK

Celebrate Earth Science Week October 12-18, 2008. This year's theme, *No Child Left Inside*, will encourage young people to learn about the geosciences by getting away from the television, off the computer, and out of doors.

NASA is a sponsor of Earth Science Week and contributes educational materials to toolkits that are available online. To order a kit or learn more about Earth Science Week and related educational events and contests, visit: *www.earthsciweek.org*.

POLAR-PALOOZA: COMING TO A CITY NEAR YOU THIS FALL

Over the Memorial Day weekend, more than 6,000 people participated in POLAR-PALOOZA weekend at the North Carolina Museum of Natural Sciences in Raleigh. This event featured a photo studio where visitors could try on cold-weather clothing, information and video booths, live arctic foxes, and seven stage presentations where Arctic and Antarctic scientists, including NASA's **Robert Bindschadler**, discussed the latest polar research.

POLAR-PALOOZA is an International Polar Year activity, sponsored by the National Science Foundation and NASA. The project is conducting a 26-stop tour at museums and science centers around the country with high-energy public presentations entitled, *Stories from a Changing Planet*.

The POLAR-PALOOZA tour will resume this fall with presentations scheduled for museums and science centers in Cleveland, Chicago, Salt Lake City, Richmond, St. Louis, Boise, and Denver. In the meantime, be sure to check out the POLAR-PALOOZA Website - *passporttoknowledge.com/polar-palooza/pp01.php* for multimedia resources including video and audio podcasts, blogs, and much more!

FIRST CONTACT: POLAR SCIENTIST ROBERT BINDCHADLER

Meet NASA scientist, **Robert Bindschadler**, as he reports on his recent field trip to Antarctica to begin research on the Pine Island Glacier ice shelf. Over the past month, the Website with Bindschadler's two-minute video has received more than 1.7 million hits. To download the video podcast, or read the transcript, go to the following link: *www.nasa.gov/multimedia/podcasting/PIGIceShelfVod.html* (click "View now" to download the MP4 file). To learn more about the Pine Island Glacier Project, go to: *pigiceshelf.nasa.gov*.

NEW ICESAT MUSEUM EXHIBIT

This new display focuses on the Ice, Cloud and land Elevation Satellite (ICESat) mission and how NASA studies polar ice sheet thickness, sea ice, vegetation, clouds, and aerosols from space. The exhibit is currently located in three public venues: the NASA Goddard Space Flight Center Visitor Center, Greenbelt, MD; the Orlando Science Center, Orlando, FL; and Reading Public Museum and Planetarium, Reading, PA. URL: *www.readingeagle.com/article.aspx?id=86570*. Contact Brian Campbell (*Brian.A.Campbell@nasa.gov*) for more information.

NASA EARTH EXPLORERS SERIES: ROBOTIC ROVERS TO THE RESCUE

Studying ice in extreme environments can be a bone-chilling challenge. Derrick Lampkin is doing what he can to make these challenges a bit less daunting for scientists. With a grant from NASA, the Penn State University geography professor is designing robotic rovers to help scientists study icy locations from the comfort of their laboratories. Read more about Lampkin and his rovers in the latest article appearing in the Earth Explorers Series. URL*: www.nasa.gov/audience/foreducators/k-4/features/F_Meet_the_Next_Earth_Explorers.html*. ■

EOS Science Calendar

October 15-17
HDF & HDF-EOS Workshop XII, Boulder or Denver, CO. URL: *www.hdfeos.org/workshops/ws12/workshop_twelve.php*

October 27-30
Aura Science Team Meeting, Columbia, MD. URL: *aura.gsfc.nasa.gov/*

October 27-31
CERES/GERB Science Team Meeting, NASA GISS, New York, NY. URL: s*cience.larc.nasa.gov/ceres/meetings.html*

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

Global Change Calendar

August 10-14
Earth Observing Systems XIII, SPIE International Symposium on Optical Engineering & Applications, San Diego, CA. URL: *spie.org/optics-photonics.xml*

September 7-12
10th IGAC International Symposium, Bridging the Scales in Atmospheric Chemistry: Local to Global, Annecy, France. URL: *www.igacfrance2008.fr/*

September 29-October 3
59th International Astronautical Congress (IAC), Earth Observation Symposium, Glasgow, Scotland. Call for Abstracts. URL: *www.iac2008.co.uk*

October 18-21
Association of Science - Technology Conference (ASTC) 2008. Philadelphia, PA. URL: *www.astc.org/conference/index.htm*

November 17-21
SPIE Asia-Pacific Remote Sensing 2008, Noumea, New Caledonia. URL: *spie.org/asia-pacific-remote-sensing.xml*

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*

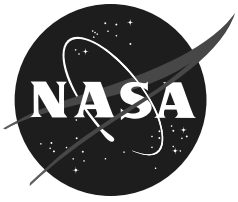
December 15-19
2008 Fall AGU, San Francisco, CA. URL: *www.agu.org/meetings/fm08/*

2009

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

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

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/*



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