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Editor's Corner

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At approximately 5 a.m. Eastern Daylight Time on August 30, NASA's Orbital Debris Program at Johnson Space Flight Center reported that debris from the Ice, Clouds, and land Elevation Satellite (ICESat) fell to Earth over the Barents Sea near Marmarisk, Russia.

As we reported in our January–February 2010 issue, the last of three lasers in the Geoscience Laser Altimeter (GLAS) on ICESat failed in October 2009—ending science data collection after nearly seven years in orbit. Attempts to restart the lasers ceased in February 2010, after which NASA began pursuing options for satellite decommissioning.

Since the spacecraft remained in operating condition, NASA's Science Mission Directorate accepted proposals for engineering tests to be performed using ICESat. These tests were designed to reduce risks for future missions by better understanding the effects of seven years of spaceflight on ICESat components, and were completed on June 20, after which NASA's Earth Science Division authorized the decommissioning of ICESat. After completing a review of decommissioning activities, the agency directed that ICESat be decommissioned by August.

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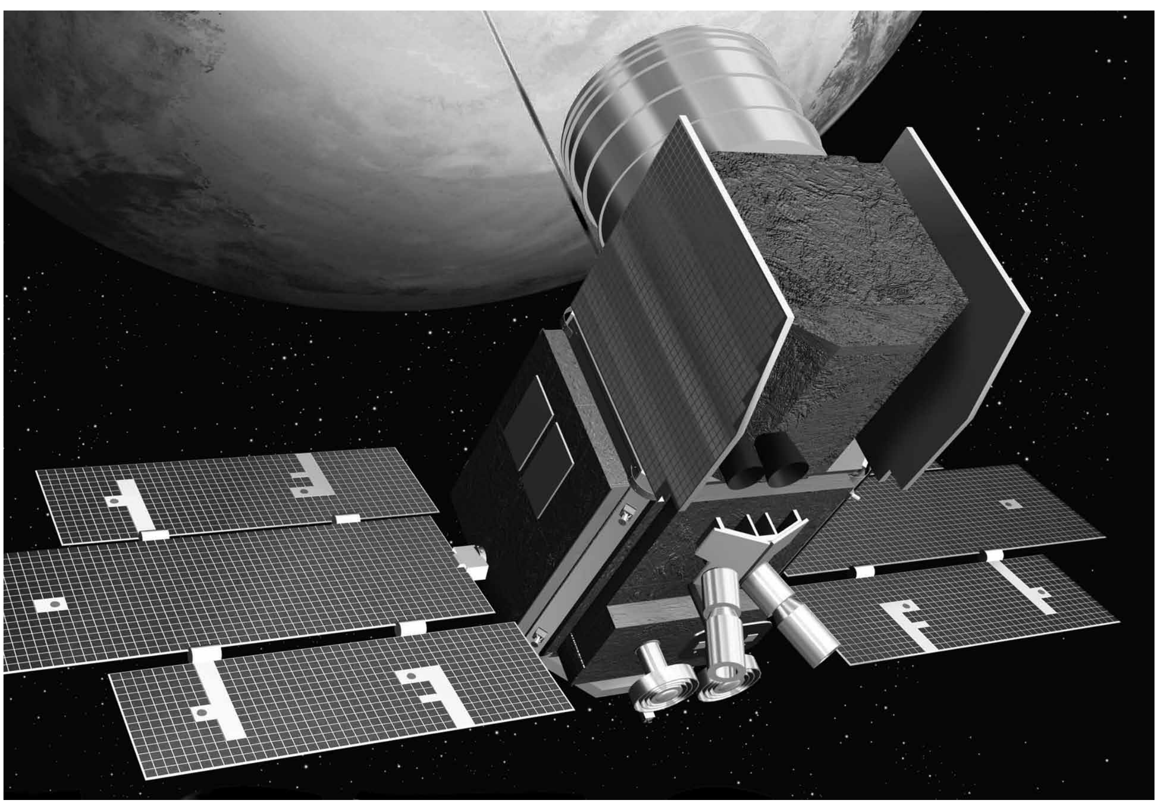

Artist's illustration of the ICESat spacecraft. After seven years in orbit and 15 laser-operations campaigns, ICESat's science mission was successfully decommissioned from operations and powered down on August 14, 2010. Debris from the satellite fell to Earth over the Barents Sea on August 30. **Credit:** NASA

In This Issue

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And so on June 23 the de-orbit process began for the ICESat spacecraft. Thruster firings ended on July 14 as the onboard fuel was exhausted, reducing the lowest point of the spacecraft's orbit to 125 miles (200 km) above Earth's surface. The orbit then began to naturally decay. ICESat was successfully decommissioned from operations and powered down on August 14.

ICESat was launched in January 2003, as a three-year mission with a goal of returning science data for five years. The team worked hard to manage technical challenges that arose during the mission, coaxing as much life as possible out of the three GLAS lasers, including planning and executing a series of 15 science operations campaigns.

"ICESat has been a tremendous scientific success," said **Jay Zwally**, ICESat's project scientist at NASA's Goddard Space Flight Center. "It has provided detailed information on how the Earth's polar ice masses are changing with climate warming, as needed for government policy decisions. In particular, ICESat data showed that the Arctic sea ice has been rapidly thinning, which is critical information for revising predictions of how soon the Arctic Ocean might be mostly ice free in summer. It has also shown how much ice is being lost from Greenland and contributing to sea level rise. Thanks to ICESat we now also know that the Antarctic ice sheet is not losing as much ice as some other studies have shown."

Congratulations to the entire ICESat Team on completion of a successful mission!

In anticipation of the completion of the ICESat mission, and in accordance with the National Research Council's Decadal Survey of future NASA Earth science missions, NASA has begun development of ICESat-2, planned for launch in 2015. In the meantime, the *Operation Ice Bridge* airborne mission, started in 2009, is the largest airborne survey of Earth's polar ice ever flown[1]. The mission is designed to partially fill the data gap between the ICESat and ICESat-2 satellite missions. For the next five years, instruments on NASA aircraft will target areas of rapid change to yield an unprecedented three-dimensional view of Arctic and Antarctic ice sheets, ice shelves, and sea ice.

The Genesis and Rapid Intensification Processes (GRIP) experiment took place from August 15–September 30. GRIP is a NASA Earth science field experiment aimed at improving our understanding of how tropical storms form and develop into major hurricanes. GRIP is intended to help understand the science of why some storms develop into full-blown hurricanes while others fizzle out. The GRIP team has been fortunate to have

[1] For a report on *Operation Ice Bridge*, refer to the May–June 2010 issue of *The Earth Observer* [**Volume 22, Issue 2**, pp. 4–7].

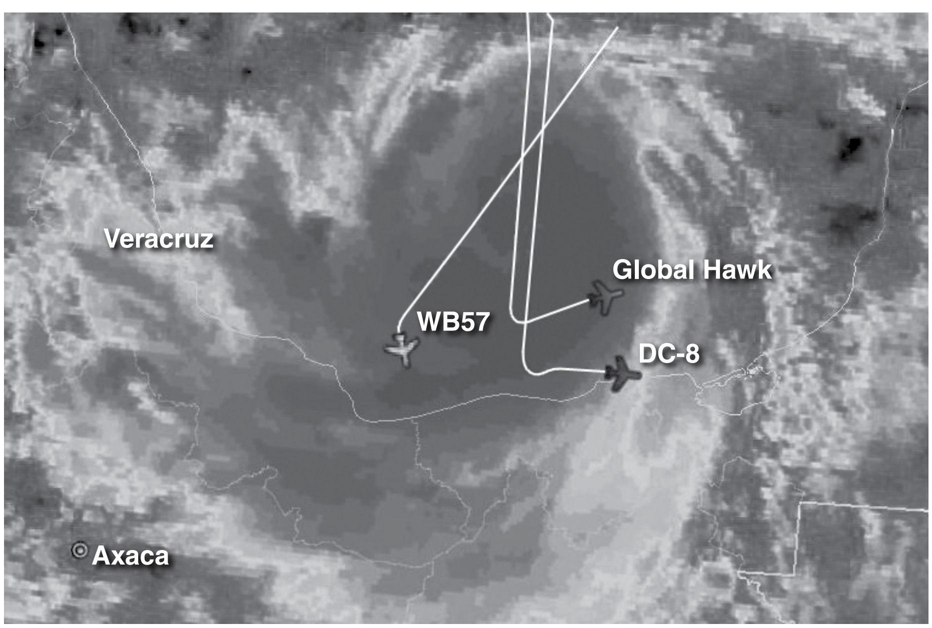
a number of tropical cyclones to observe over the past month and a half, some of which developed into strong hurricanes and others that did not.

NASA is using the DC-8 aircraft, the WB-57 aircraft, and the Global Hawk Unmanned Airborne System (UAS) configured with a suite of *in situ* and remote sensing instruments that are observing and characterizing the lifecycle of hurricanes. The DC-8 flies out of Ft. Lauderdale, FL, the WB-57 out of Houston, TX, and the *Global Hawk* out of NASA Dryden Flight Research Facility, CA. This campaign also took advantage of a number of ground networks, airborne science platforms (both manned and unmanned), and space-based assets.

The spaceborne and airborne observational capabilities of NASA put it in a unique position to assist the hurricane research community in addressing shortcomings in the current state of the science. The prospect of using a high-altitude UAS for hurricane surveillance and the emergence of new remote sensing technologies offer new research tools that need to be explored and validated. Of great importance are new remote sensing instruments for wind and temperature that can lead to improved characterization of storm structure and environment. **Ramesh Kakar** [NASA Headquarters—*Weather Focus Area Leader,* and *Atmospheric Dynamics/Precipitation Program Manager*] is the GRIP Program Scientist. There is a news article on GRIP on page 47 of this issue; we plan more in-depth coverage in a future issue of *The Earth Observer*.

There have been some changes to the *Earth Observatory* team. **Rebecca Lindsey** had been part of the team since coming to Goddard, and served as Editor for the site since 2005, but recently moved on to become Managing Editor of NOAA's *Climate Watch* website. **Michael Carlowicz**, who previously served as lead for the NASA Earth Science News Team since coming back to Goddard in 2008, has replaced Lindsey as Editor. While we will miss Rebecca's enthusiasm and experience, and wish her well in her new endeavor, we are delighted to have Carlowicz join the team. He has a distinguished resume that includes work as a science writer at Woods Hole Oceanographic Institution (2002–2008), at Goddard coordinating outreach for the International Solar Terrestrial Physics Program (1997–2002), as an Adjunct Professor in the Writing Seminars Department at Johns Hopkins University (1993-2002), and with the American Geophysical Union (1995–1997), and Discovery Channel (1991–1993).

The goal of the Earth Observatory is to share images, stories, and scientific discoveries about climate and the environment that emerge from NASA research, including its satellite missions, field work, and modeling efforts. Earlier this summer, the site had nearly one million unique visitors in a single month! If you are not familiar with the site or haven't visited in a while, please take a moment to stop by *earthobservatory.nasa.gov*. ■



This image from the GRIP Real Time Mission Monitor system shows the location of the three NASA aircraft participating in the study, the *Global Hawk*, *WB-57,* and *DC-8*, as they fly over and around Hurricane Karl on September 16, 2010. This is the first time all three aircraft have flown the same storm system at the same time. To view this image in color, please visit: *www.nasa.gov/mission_pages/hurricanes/missions/grip/main/GRIP_status_09_16_10.html*. **Credit:** NASA

Flying High: NASA's Global Hawk and GloPac Mission

Nicole Miklus, NASA Goddard Space Flight Center/Wyle Information Systems, nmiklus@sesda2.com

The Global Hawk is fully autonomous, can fly for as long as 30 hours, and has a range up to 11,000 nautical miles (12,658 mi), making it ideally suited for use in Earth Science research.

*In our May-June 2010 [**Volume 22, Issue 3**] **Editorial** and **Blog Log**, we directed your attention to the recent success of the **Global Hawk** Pacific (GloPac) mission, completed in April 2010. GloPac was the first demonstration of the **Global Hawk** unmanned aircraft system (UAS) for NASA science. This article provides a summary of GloPac, technical specifications and descriptions of the aircraft and its payload instruments, and the **Global Hawk's** involvement in future missions.*

History of the (NASA) Global Hawk

NASA's *Global Hawks* first flew as part of the Advanced Concept Technology Demonstration program sponsored by the Defense Advanced Research Projects Agency. Seven *Global Hawks* were built for the program, with the first flight occurring in 1998. In a 2008 Space Act Agreement between Northrop Grumman and NASA's Dryden Flight Research Center at Edwards Air Force Base in California, Dryden acquired three of the original seven—the first, sixth, and seventh built—for Earth science research. Following completion of their use by the U.S. Air Force, two were transferred to Dryden in 2007, and the third in 2009.


[*Left*] In this September 2009 photo, one of NASA's *Global Hawks* prepares for an early morning taxi test. The sky is darkened by a Southern California wildfire. **Credit:** NASA/Tony Landis [*Right*] One of NASA's *Global Hawks* lifts off the main runway at Edwards Air Force Base while Air Force F-22 and F-16 aircraft await their turn. Here, the *Global Hawk* was on its first checkout flight after being transferred to NASA. **Credit:** NASA/Tony Landis

The *Global Hawk* is 44 ft long and 15 ft tall. Its large wingspan of more than 116 ft allows the aircraft to reach a maximum altitude of 65,000 ft (higher than the record of 35,000 ft set by the vulture *G. rueppellii* in 1973!). The aircraft is fully autonomous, can fly for as long as 30 hours, and has a range up to 11,000 nautical miles (12,658 mi). The *Global Hawk* has a gross takeoff weight of 25,600 lbs, including a 1,500-lb payload capacity, and is powered by a single *Rolls-Royce* AE3007H turbofan engine. The aircraft is constructed with graphite composite (the V-tail, engine cover, aft fuselage, and wing), conventional aluminum (center fuselage), and fiberglass composite (fairings and radomes) materials.

A demonstration flight and four science flights comprised the GloPac mission, whose logo is shown above.

The GloPac Mission

In the years following the acquisition of the sixth *Global Hawk*, over 130 researchers and technicians worked to refit and prepare the aircraft for its first mission—GloPac—that was also the first demonstration of the *Global Hawk* UAS for Earth science research. The mission took place in March and April, 2010, and included project scientists **Paul Newman** [Goddard Space Flight Center] and **David Fahey** [National Oceanic and Atmospheric Administration (NOAA) Earth System Research Laboratory], along with individuals from NASA's Goddard Space Flight Center, Jet Propulsion Laboratory, Ames Research Center, and Dryden; NOAA's Earth System Research Laboratory; Northrop Grumman; the University of California, Santa Cruz; Droplet Measurement Technologies of Boulder, CO; and the University of Denver.

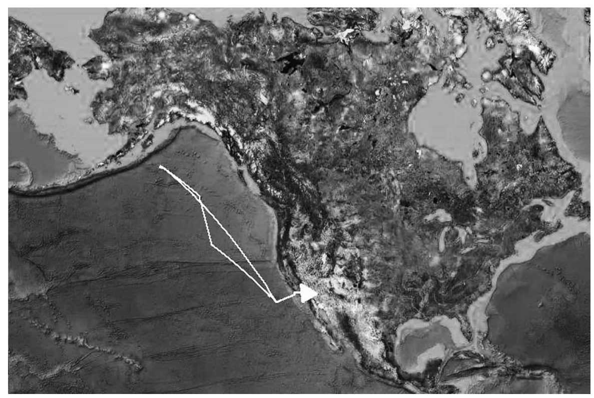
The mission had these main objectives:

(1) To use long duration Pacific Ocean and Arctic flights to demonstrate the first use of the *Global Hawk* UAS for NASA and NOAA Earth science research and applications, and to test the science operation protocols and processes developed for such;
(2) To conduct experiments of trace gases, aerosols, and dynamics of the upper troposphere and lower stratosphere, specifically for validation of Aura satellite instruments, and for sampling the Arctic vortex and plume structure; and
(3) To provide risk reduction for future *Global Hawk* missions, such as the NASA Genesis and Rapid Intensification Processes (GRIP) experiment and Earth Venture-1 missions.

The GloPac team stands in front of the *Global Hawk* in the hangar at Dryden. **Credit:** NASA

Mission Summary

The GloPac mission consisted of five flights (including a test flight), with a total of 82.5 hours of flight time—mostly over the Pacific Ocean—logged in less than a month. One of these flights lasted over 28 hours, making it the longest airborne flight ever conducted for Earth science. On March 8, 2010, the GloPac team started to arrive at Dryden to install scientific instruments, fuel the plane, and solve pre-flight hardware and software glitches. On April 2, the *Global Hawk* performed a six-hour test flight—its first flight carrying a science payload. Eleven instruments were flown during GloPac (see **GloPac Instruments**) and the *Global Hawk* underflew several of the Afternoon Constellation (*A-Train*) satellites.



The flight path of the *Global Hawk*'s first science flight took it from Dryden to just south of Alaska's Kodiak Island and back on April 7. **Credit:** NASA

Flight Details

The first of the four GloPac science data-collection flights took place on April 7 and lasted 14.1 hours. During the flight, the plane flew up to 60,900 ft (18.6 km) and covered approximately 4,500 nautical miles (5,178 mi). It traveled from Dryden to just south of Alaska's Kodiak Island and flew under the track of the Cloud-Aerosol LIDAR and Infrared Pathfinder Satellite Observation (CALIPSO). In the second flight of the mission on April 13, the *Global Hawk* logged more than 24 hours and covered approximately 7,821 nautical miles (9,000 mi). It flew on a pre-programmed flight path over the Pacific Ocean to just south of Alaska, then went southward to the east of Hawaii, before heading back to Dryden. The plane flew under the tracks of Aura and CALIPSO and also experienced two planned data-collection descents. The third science flight on April 23, marked the longest science mission flown when the *Global Hawk* flew for 28 hours and 36 minutes. The plane became the first *Global Hawk* to reach 85°N latitude and it flew north of 70°N for more than eight hours. The mission ended April 30 when the loss of electrical power to the instruments caused the fourth science flight to last 9.3 hrs instead of the approximately 24-hour flight initially planned.

The HDVis camera mounted on the belly of the *Global Hawk* took this photo of cloud formations over the North Pacific Ocean on April 7. The forward fuselage and inner portions of the wings of the aircraft are visible at the top of the photo. **Credit:** NASA

Ground Operations

During GloPac, the *Global Hawk* Operations Center (GHOC) at Dryden served as the cockpit and control room for the plane. The Forward Operations Room (FOR) contained five stations where pilots and engineers monitored the plane's computers and communications equipment, as well as the flight path and altitude. Although the aircraft is fully autonomous—taking off, flying, and landing on its own using a flight path pre-programmed by pilots—changes in course and/or altitude can still be made manually from the ground. This capability was used, for example, when it was necessary to end the final flight of the mission sooner than expected. The Payload Operations Room (POR) housed 14 stations where scientists could communicate with their instruments onboard the plane.

[*Left*] From the Flight Operations Room pilots assess the aircraft's systems and performance to determine if any overrides are needed. **Credit:** NASA/Tony Landis [*Right*] Scientists monitor and control their instruments onboard the *Global Hawk* in the Payload Operations Room (POR). **Credit:** NASA/Tony Landis

GloPac Instruments

The eleven instruments listed here flew on the *Global Hawk* during the GloPac campaign. Together, the measurements from these instruments provide extensive data on the chemical composition and dynamics and meteorology of the stratosphere and troposphere, and the distribution of clouds and aerosol particles. Instrument descriptions are modified from: *www.nasa.gov/centers/dryden/research/GloPac/glopac_instruments.html*.

Airborne Compact Atmospheric Mapper (ACAM)

The ACAM is about the size of a microwave oven and has two miniature spectrometers and a high-definition video camera. With the spectrometers, scientists are able to detect the presence of trace gases such as nitrogen dioxide (NO_2) and ozone (O_3), as well as how ultraviolet (UV) light is absorbed or scattered by aerosol particles. The video camera is used to visually identify clouds and features on Earth's surface. ACAM has flown on previous air quality missions, and is also used to aid in refining science requirements for future air quality observation satellites.

Cloud Physics Lidar (CPL)

The CPL pulses laser light into the atmosphere and observes the reflections in a process known as light detection and ranging, or *lidar*. By revealing the structure and brightness of clouds and aerosols, data from the CPL sheds insight on how clouds and aerosols affect Earth's radiative balance. The measurements are also used for validation of instruments on Earth-observing satellites, like Aura. The CPL team has deployed its instruments for a decade on NASA's ER-2 high-altitude planes. For more information, please visit: *cpl.gsfc.nasa.gov*.

Focused Cavity Aerosol Spectrometer (FCAS) and Nuclei-mode Aerosol Size Spectrometer (NMASS)

FCAS and NMASS measure the size and abundance of particles in the atmosphere that are between 4–1000 nm. Aerosols play an important, but incompletely understood, role in climate and atmospheric dynamics; FCAS and NMASS measurements are used to improve our understanding of the properties, origin, fate, and climate impacts of these particles. The instruments have flown on NASA's DC-8, ER-2, and WB-57F aircraft from 72° S latitude to 90° N.

High-Definition Video System (HDVis)

The HDVis camera provides forward-looking time-lapse video imagery to identify cloud types and provide "situational awareness" for the aircraft. It has a wide-angle lens and is pointed forward at 45°, allowing the camera to show everything from the horizon forward to the ground directly below. The science and operations teams can change course or altitude based on atmospheric phenomena viewed ahead, and can adjust instrument measurements. Earlier versions of the video system have flown on missions with NASA's ER-2 and DC-8 to identify smoke plumes over the Amazon and convective cloud systems in the tropics.

The eleven instruments that flew on the Global Hawk during the GloPac campaign provided extensive data on the chemical composition and dynamics and meteorology of the stratosphere and troposphere, and the distribution of clouds and aerosol particles.

Meteorological Measurement System (MMS)

MMS measures atmospheric pressure, temperature, air turbulence, and the direction and speed of winds (both horizontal and vertical) immediately around the *Global Hawk*. These meteorological measurements describe the environment surrounding the aircraft and are intertwined with other measurements, such as relative humidity. The MMS has flown on numerous NASA and NOAA manned and unmanned aircraft since it was first deployed in 1986. It has been used to study ozone depletion, exchanges between layers of the atmosphere, cloud formation, hurricanes, and aerosols.

Microwave Temperature Profiler (MTP)

MTP is a radiometer that detects the naturally-occurring emission of microwaves from oxygen molecules in the atmosphere. This measurement is translated into a picture of the *temperature field* near the aircraft, to help scientists identify the height of the *tropopause*—the boundary between the troposphere and the stratosphere. Since the 1970s, variations of the MTP have been deployed 51 times on more than 800 flights in North, Central, and South America; Europe; Australia; the tropical Pacific Ocean; and from the North Pole to the South Pole over the Pacific Ocean. For more information, please visit: *mtp.jpl.nasa.gov*.

Ultra-High Sensitivity Aerosol Spectrometer (UHSAS)

UHSAS measures the concentration and size of atmospheric aerosol particles by collecting air samples and detecting laser light scattered from individual particles in the sample chamber. By providing a close-up view of the atmosphere, UHSAS data contribute to the validation of satellite measurements. The instrument has flown on missions sponsored by the National Science Foundation, including work in the North Pacific between Japan and Alaska. For more information, please visit: *www.dropletmeasurement.com/products/airborne/71*.

Unmanned Aircraft System Chromatograph for Atmospheric Trace Species (UCATS)

UCATS uses two gas chromatographs (GCs) to separate out the different molecules from air, and two absorption photometers to measure ozone (detectable in the ultraviolet) and water vapor (detectable in the infrared). The GCs detect the presence and amount of greenhouse gases such as nitrous oxide (N_2O), sulfur hexafluoride (SF_6), and methane (CH_4). The instrument also measures ozone-depleting gases (such as CFC-11, CFC-12, and halon-1211), carbon monoxide (CO), and hydrogen (H_2). Earlier versions of UCATS have flown on NOAA, NASA, and National Science Foundation missions from 2005 to the present. For more information, please visit: *www.acd.ucar.edu/start/ucats.shtml*.

The GloPac mission's successful flights and preliminary research results prove the Global Hawk to be an indispensable vehicle for future airborne Earth science research.

NOAA Unmanned Aerial System Ozone Instrument (UAS Ozone)

The UAS Ozone Instrument directly samples ozone (O_3) in the atmosphere, by passing a sample of air from outside the aircraft between a lamp that emits ultraviolet (UV) radiation and a UV detector. Since ozone strongly absorbs ultraviolet light, more ozone in the air results in less UV at the detector and vice versa. Understanding ozone depletion is important, given that ozone shields us from harmful UV rays and, as a greenhouse gas, contributes to climate change. The UAS Ozone team's instruments have flown on NASA's WB-57F high-altitude research aircraft in Houston. For more information, please visit: *sine.ni.com/cs/app/doc/p/id/cs-12343*.

In preparation for the GloPac mission, scientists examine their instruments in a hangar at NASA Dryden prior to installation aboard the *Global Hawk*. **Credit:** NASA/Tom Tschida

Unmanned Aerial System Laser Hygrometer (ULH)

ULH uses a continuous beam of laser light and two mirrors to sense the amount of water vapor present in packets of air around the *Global Hawk*. These measurements are important because the amount of water vapor in the upper troposphere and lower stratosphere impacts climate. Accurate measurements of water vapor provide *ground truth* data for remote measurements made by space-based instruments such as the Aura satellite's Microwave Limb Sounder. ULH has flown previously on the NASA WB-57F high-altitude aircraft.

Preliminary Conclusions

The GloPac mission's successful flights and preliminary research results prove the *Global Hawk* to be an indispensable vehicle for future airborne Earth science research. The findings from GloPac provide a glimpse into the extensive array of atmospheric data now within wings' reach and include:

1. Observing the breakup of the *stratospheric polar vortex*—a large-scale cyclone with influential roles in Arctic winter weather patterns and Northern Hemisphere ozone depletion;
2. collecting data on stratospheric trace gases;
3. sampling Asian dust from a plume traveling across the Pacific;
4. sampling very cold air at temperatures as low as -148°F (-100°C) in the stratosphere above the tropics;
5. making vertical profiles of cloud structures; and
6. making observations that will be used to validate measurements from the Aura and CALIPSO satellites.

On the Horizon

Using risk reduction data from GloPac, NASA's *Global Hawks* are being prepared for additional studies. The *Global Hawks* are participating in two NASA-funded airborne missions—the GRIP experiment and the Hurricane and Severe Storm Sentinel

(HS3). The six-week GRIP mission, which began on August 15, uses NASA's DC-8 and WB-57 to probe areas within and near tropical storm systems. If hurricane conditions form or intensify, the *Global Hawk* further investigates. The High-Altitude Imaging Wind and Rain Profiler (HIWRAP) it carries measures horizontal winds and precipitation—data critical to understanding and predicting hurricane intensity. More accurate hurricane forecasts minimize costly and unnecessary evacuations of coastal areas. Pre-launch simulation data for the Global Precipitation Mission (GPM), expected to launch in 2013, will be obtained from HIWRAP as well.

GRIP lays the foundation for HS3, one of five missions in the new Earth Venture program—to learn more about the Venture program, see the article on page 13 of this issue. HS3 will allow scientists to study the life cycle of tropical storms to better understand their evolution. Two *Global Hawks* will fly one-month-long missions during the Atlantic hurricane season, with a demonstration flight occurring next year and science flights running from 2012 – 2014. Four instruments—including the Cloud Physics Lidar (CPL) and Tropospheric Wind Lidar Technology Experiment—will fly on one *Global Hawk* to study environmental conditions surrounding the storm. The second aircraft, carrying HIWRAP and two other instruments, will fly directly above the hurricane vortex. A mobile GHOC is being built so HS3 can operate from Wallops Flight Facility in Virginia.

For more news and information on NASA's *Global Hawks*, please visit: *www.nasa.gov/centers/dryden/research/GloPac/index.html*.

To view more photos of NASA's *Global Hawk* and the GloPac mission, please visit: *www.nasa.gov/centers/dryden/multimedia/imagegallery/Global_Hawk/index.html*. ▬

Using risk reduction data from GloPac, NASA's Global Hawks are being prepared for additional studies. The Global Hawks are participating in two NASA-funded airborne missions—the GRIP experiment and the Hurricane and Severe Storm Sentinel (HS3).

NASA to Participate in COP-16

November 29–December 10, 2010
Cancun, Mexico

Mexico has been chosen to host the sixteenth Conference of the Parties (COP-16) and the sixth Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol (CMP-6). Cancun is one of Mexico's most beautiful resorts, but on this occasion it will be the sight of an important dialogue on global climate change. The participants will include Parties to the United Nations Framework Convention on Climate Change and the Kyoto Protocol, observers, international officials, media representatives, and a variety of other participants from around the world. The discussions are intended to build understanding among the Parties that will lead to the enactment of concrete strategies for responding to global climate change. Mexico urges broad participation in the conference and hopes to facilitate an inclusive and extensive dialogue in the collective search for common solutions to one of the daunting global crises of the early 21^{st} century.

NASA, StormCenter Communications Inc., the National Oceanic and Atmospheric Administration, the Department of Energy, and the U.S. State Department have joined together to sponsor a side-event during COP-16 to promote *Global Collaboration and Enhanced Decision Support*. The event will showcase cutting-edge commercial technology that has been adapted in ways that allow users to collaborate in real-time, sharing data sets and response plans via a *geobrowser (e.g., GoogleEarth)* and other integrated software.

For more information on this event please visit: *cc2010.mx/en/*.

NASA Ames DEVELOP Interns: Helping the Western United States Manage Natural Resources One Project at a Time

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Every summer for the past seven years, students ranging from high school to graduate level gather at NASA Ames Research Center as part of the DEVELOP Internship Program.

Introduction

The western half of the United States is made up of a number of diverse ecosystems ranging from arid desert to coastal wetlands and rugged forests. Every summer for the past seven years, students ranging from high school to graduate level gather at NASA Ames Research Center (ARC) as part of the DEVELOP Internship Program[1]. Under the guidance of **Jay Skiles** [ARC—*Ames DEVELOP Manager*] and **Cindy Schmidt** [ARC/San Jose State University—*Ames DEVELOP Coordinator*], they work as a team on projects exploring topics such as: invasive species, carbon flux, wetland restoration, air quality monitoring, storm visualizations, and forest fires. The study areas for these projects have been in Washington, Utah, Oregon, Nevada, Hawaii, Alaska, and California. Interns combine data from NASA and partner satellites with models and *in situ* measurements to complete prototype projects demonstrating how NASA data and resources can help communities tackle their Earth Science-related problems.

Invasives Threaten Western Ecosystems

Invasive plants and animals can become a serious threat to ecosystems by consuming resources that native species need to survive, including water, nutrients, and space. During the summer of 2003, a team of interns worked with the Pyramid Lake Paiute Indian Tribe located in Nevada to map the spread of *Lepidium latifolium*—also known as "tall white top" or "perennial pepperweed." They also created a model to predict the future spread under two scenarios: intensive weed management practices and unmanaged practices. The tribe used these results to inform future management decisions.

Surrounded by "tall white top" in Nevada, **Douglas Gibbons** [Utah State University] collects data during the summer of 2003.

Another way invasive species can be detrimental to surrounding plant communities is to render the environment inhospitable to native plants. *Tamarix ramosisima*, common name "tamarisk" or "salt cedar," has invaded *riparian*—stream or river bank—ecosystems in much of the Southwest. By secreting salt from its leaves, tamarisk can redistribute salt from the soil profile to the soil surface, inhibiting germination and growth of other plant species. In 2008, DEVELOP interns conducted a project in Utah, where there is an ongoing study relating to the use of a beetle, *Diorhabda elongata*, as a biocontrol for tamarisk. Interns used Landsat data to analyze the feasibility of using remote sensing to monitor the spread of the beetles. Tamarisk defoliation and decreased plant health are the primary indicators of beetle presence and can be detected with remote sensing imagery. Interns also used the vertical salt profile and other *in situ* data to produce habitat suitability maps for tamarisk and the beetle in Dinosaur National Monument.

[1] To read more about the DEVELOP program, please see pp 7-9 in *The Earth Observer's* March-April 2010 issue [**Volume 22, Issue 2**], pp 11-13 in the May-June 2010 issue [**Volume 22, Issue 3**], and pp 10-12 in the July-August 2010 issue [**Volume 22, Issue 4**].

Protecting Pacific Rim Ecosystems

Ames DEVELOP interns have also conducted studies in Alaska and Hawaii. In 2006, the International Polar Year, a team of interns worked with Synthetic Aperture Radar (SAR) and Moderate Resolution Imaging Spectroradiometer (MODIS) data to characterize ice thickness in the Yukon–Kuskokwim Delta region of Alaska. These data were then compared with airborne thermal imagery of Pacific walrus (*Odobenus rosmarus divergens*) populations. The results of the study suggest that walrus prefer medium and some thin ice floes, possibly for predator avoidance purposes. These insights can be useful for the conservation and stewardship of the walrus.

Supriya Iyer [Leland High School - San Jose, CA] presents her team's poster and animations at the American Geophysical Union conference in San Francisco in December 2008.

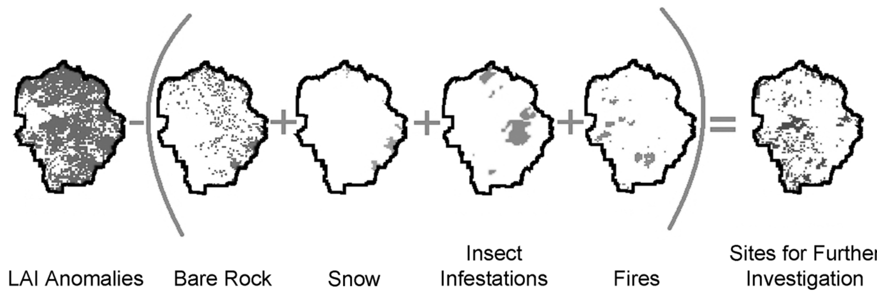
Cyclones and typhoons in the Pacific Ocean cause large amounts of destruction every year, and are equivalent in size and strength to hurricanes experienced along the Atlantic and Gulf coasts of the U. S. Scientists from the National Oceanic and Atmospheric Administration (NOAA) and other countries around the Pacific Basin are studying past storms in order to better prepare for future events. In 2007, NOAA asked Ames DEVELOP to create a series of geo-visualizations of major storm and high water events that could be incorporated into the Pacific Region Integrated Climatology Information Products (PRICIP) Portal. Interns spent the summers of 2007 and 2008 incorporating storm tracks with surface wind speed and direction, precipitation accumulation, sea surface temperature, and sea surface height data, from NASA's Quick Scatterometer (QuikSCAT), Tropical Rainfall Measuring Mission (TRMM), Jason-1, and Aqua satellites.

Fighting Fire with Fire: Remote Sensing for Forest Management

Forest managers have to consider a wide range of issues, such as carbon budgets, fires, and forest health in their decision-making processes. Located in southern Oregon, the Fremont–Winema National Forest's timber is harvested yearly, both for monetary return and to reduce standing fuel load. During the summer of 2004, DEVELOP interns studied how tree harvesting and wildfires could affect the carbon budget using Landsat and *in situ* data, along with *FlamMap*—a fire behavior mapping and analysis program—and NASA Carnegie-Ames-Stanford-Approach (CASA) models. It was determined, based on the interns' inputs to the NASA–CASA model, that regardless of how long a forest is left to regenerate after selective cuts, Net Ecosystem Productivity will not equal pre-fire productivity if timber is harvested. Additionally, the interns produced fire rate-of-spread and flame length maps to highlight areas of high risk for severe fires.

Casey Cleve [San Francisco State University] takes a soil sample to be analyzed for carbon in the Fremont–Winema National Forest of Oregon during the summer of 2004.

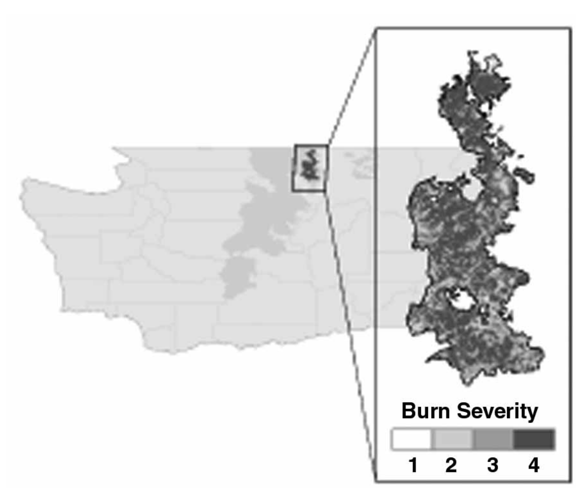
The DEVELOP internship program not only offers valuable research experience to the students, but is also an important community resource. Local, statewide, tribal, and national partners have benefited from Ames DEVELOP's projects.



A visual representation of steps taken to remove known causes of LAI anomalies in Yosemite National Park (outlined in black) is shown here. The final map highlights sites for further investigation from the 2006 study.

According to the National Park Service, Yosemite National Park hosted 3.7 million visitors in 2009. Leaf Area Index (LAI) is one of several indices derived from satellite imagery that are used to monitor forest health. In 2006, interns mapped unexplained Leaf Area Index (LAI) anomalies to aid the National Park Service in monitoring ecological disturbances. MODIS LAI data were processed by the Terrestrial Observation and Prediction System (TOPS) model from 2001–2005. Known areas of insect infestations, snow cover, and recent wildfires were removed. The resulting map showed areas where additional investigation was needed to improve the understanding of the anomalies.

Until recently, fire suppression was a common practice in forest management. This has led to a high buildup of fuels on the forest floor and, thus, an increase in fire severity. In 2008, a DEVELOP team performed a burn severity assessment on the Tripod Complex Fire. This fire burned 175,000 acres in 2006 in Washington's Okanogan–Wenatchee National Forest. The interns combined *in situ* data with data from Landsat and MODIS imagery to create a burn severity map. These data have since been used in additional studies relating to the impact of the Tripod Fire.



A DEVELOP team produced this burn severity classification of the Tripod Complex Fire in Washington State during the summer of 2008.

As the 10-week intensive summer projects end, the results are handed off to the partners, allowing them to make new decisions about the topic using completed maps, datasets, and results. The interns are also given the opportunity to present the results at conferences such as those of the American Society of Photogrammetry and Remote Sensing (ASPRS) and the American Geophysical Union (AGU). The DEVELOP internship program not only offers valuable research experience to the students, but is also an important community resource. Local, statewide, tribal, and national partners have benefited from Ames DEVELOP's projects. These projects have supplied them with an impressive set of data and information produced in a relatively short time; this allows not only for a rapid assessment of project results but also provides information to inform policy decisions.

If you have any questions about other projects Ames DEVELOP interns have completed, or the DEVELOP internship program in general, please visit: *develop.larc.nasa.gov*. ■

A New Venture for NASA Earth Science

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In our last issue[1] we reported that on May 27, NASA announced the first investigations to be funded under the new Venture class series of missions. The following article provides additional background on the Venture class and how it fits into the broader scope of NASA's Earth Science Program. The article also provides some additional details on the winners of the EV-1 solicitation.

The primary source for this information on the Venture class was a presentation that Steve Volz [NASA HQ—Associate Director for Flight Programs for the Earth Science Division of the Science Mission Directorate] gave at NASA Goddard Space Flight Center on July 19. A pdf of Volz's presentation can be downloaded from: eospso.gsfc.nasa.gov/eos_homepage/mission_profiles/docs/201007EarthScience&Venture.pdf

Introduction

The *Venture* program is best understood in the context of the broader Earth Science Program at NASA, whose elements are summarized below—see **Table 1**. The program is intended to help develop new sub-orbital (i.e., aircraft) and orbital (i.e., satellites) missions, as well as instruments that could be flown on various orbital platforms as instruments or missions of opportunity. There will be a series of *Venture* Mission *calls* every other year—the first was in 2009. These *calls* will alternate between sub-orbital and orbital missions, with the first soliciting sub-orbital investigation proposals, the next soliciting orbital mission proposals, and so on. Concurrently, there will also be a series of *Venture* Instrument calls beginning in 2011, and each year thereafter. (More specific program details appear below.)

Program Elements	Task
Flight Projects	Planning, building, and operating Earth Observing satellite missions, most with international and/or interagency partners.
Data Systems	Making high-quality data products available to the broader science community.
Research & Analysis	Conducting and sponsoring cutting-edge research in six thematic focus areas: 1) atmospheric composition; 2) weather; 3) climate variability & change; 4) water & energy cycles; 5) carbon cycle & ecosystems; and 6) Earth surface and interior. Efforts here include: 1) field campaigns to complement satellite measurements; 2) modeling; and 3) analyses of non-NASA mission data.
Applied Science	Improving the utilization of NASA data and technology through the U.S. and beyond. Developing partnerships that use the information to address real societal needs—NASA science serving society.
Earth Science Technology	Developing technologies to improve Earth observation capabilities and provide the seed technologies for the next generation of Earth observing instruments.
Education and Public Outreach	Telling the story of NASA Earth Science to a diverse audience that includes students, scientists, stakeholders, and more... The goal is to increase public awareness that NASA does Earth Science and educate them about why it matters and how they benefit.

Table 1. The NASA Earth Science Program is organized into six elements as described above.

Context for Venture: The Broader NASA Earth Science Program

The political and economic realities of the last decade have not boded well for NASA—especially for Earth Science, and for flight missions (i.e., satellites) in particular. Graphing the status of our current Earth Science flight missions based on their position in the typical ***Flight Project Life Cycle*** (see sidebar on page 14 for details) would reveal a shape resembling an "inverse bell curve." That is to say, we have many missions (e.g., those called for by the Decadal Survey) that are at the "beginning" of their lives—i.e., at the conceptual or preliminary stages (*Pre-Phase A* or *Phase A*), and many of the older missions that are nearing the "end" of their lives—i.e., either complete (*Phase F*) or in Mission Operations or Extended Mission Operations stages

[1] See the Editorial of the July–August issue of *The Earth Observer* [**Volume 22**, **Issue 4**, pp.1-2].

(*Phase E*). However, we don't have that many missions "in the prime" of their lives as it were—i.e., missions that are being actively designed and developed (*Phase C* or *Phase D*) at present. (For a summary of NASA Earth Science missions that are currently in development and in formulation, see **Tables 2 & 3** respectively.) Prior to the development of the last two Administration budgets, very few missions have been able to move out of the conceptual stage into the development stage. Under these circumstances, the total number of NASA Earth observing satellites in orbit would have seen a precipitous drop as the 2010 decade wore on. Such a drop-off would have seriously jeopardized NASA's ability to maintain its current observational and predictive capabilities for regional and global scale environmental changes, much less allow for significant advancements in these capabilities. Therefore, there was a clear need to move more missions into development in the near future, to replenish the ones currently in operation.

Typical Life Cycle for a NASA Flight Project

Every flight project, including Earth Science missions, follows the same basic life cycle as it progresses through its development. Formal reviews are typically used as "control gates" at *Key Decision Points* in the full system life cycle to determine whether the system development process should continue from one phase to the next, or what modifications may be required.

- *Pre-Phase A:* Conceptual Study
- *Phase A:* Preliminary Analysis
- *Phase B:* Definition
- *Phase C/D:* Design and Development
- *Phase E:* Operations Phase (includes Mission Operations/Data Acquisition)
- *Phase F:* Mission Complete

The good news looking toward the future is that the Obama Administration has thus far been much more supportive of Earth Science. The President's proposed FY'11 Budget for NASA includes increases in funding for Earth Science over what was proposed for FY'10, and the FY'10 budget already included a significant increase over the previous administration's last budget in FY'09. NASA replied to the Administration's increased budget guidance with a detailed implementation plan[2]. Based on this increased level of funding, NASA can now pursue an even more ambitious schedule than it had originally planned. With the new funding levels, NASA will be able to fly one or two Earth observing missions every year well into the next decade—but the additional funds will make it possible to do even more. The *Venture* class program will be a beneficiary of this increased funding.

NASA plans to complete the so-called *foundational missions* (which include Aquarius, Glory, the NPOESS Preparatory Project, the Landsat Data Continuity Mission (LDCM), and the Global Precipitation Measurement (GPM) Core Observatory) as fast as possible—with the last, GPM, flying in 2013. Furthermore, NASA plans to

[2] *Responding to the Challenge of Climate and Environmental Change: NASA's Plan for a Climate-Centric Architecture for Earth Observations and Applications from Space.* This may be found at: *science.nasa.gov/earth-science/*.

Table 2. NASA Earth Science missions currently in development

Satellite Mission—Measurement Type	**Description**
NPOESS Preparatory Project[1] Strategic—Continue Systematic	Required for continuity of several key climate measurements between EOS and the Joint Polar Satellite System—formerly known as the National Polar-orbiting Operational Environmental Satellite System (NPOESS).
Glory Strategic—Initiate New and Continue Systematic	Addresses high priority objective of the U.S. Climate Change Science Program and provides continuity for Total Solar Irradiance measurements.
Aquarius[2] Competed—Earth System Science Pathfinder	First dedicated global measurement of sea surface salinity from space.
LDCM[1] Strategic—Continue Systematic	Continues the 30+ year Landsat moderate resolution multispectral land imaging data record; includes new high sensitivity thermal instrument.
Global Precipitation Measurement[2] Strategic—Continue Systematic	Measures rain microphysical properties and vertical structure; improves weather, climate, and hydrological predictions and water resource management.

[1]represents Interagency Partnership; [2]represents International Partnership

Table 3. NASA Earth Science missions currently in formulation

Satellite Mission—Measurement Details	**Description**
Orbiting Carbon Observatory–2 (OCO) Directed reflight of lost OCO mission—originally an Earth System Science Pathfinder mission.	First dedicated global measurement of carbon dioxide from space.
Soil Moisture Active/Passive Mission (SMAP) First Decadal Survey—Systematic	Will use a combined radiometer and high-resolution radar to measure globally surface soil moisture and freeze–thaw state.
Earth Venture–1 (EV-1) First Decadal Survey Venture class announcement.	Complete suborbital, principal investigator-led investigations to conduct innovative, integrated, hypothesis or science question-driven approaches to pressing Earth system science issues.
Ice, Cloud, and land Elevation Satellite–2 (ICESat-2) Second Decadal Survey—Continues Systematic	Will measure the dynamic state of the Earth's ice sheets, their seasonal and annual variations, and volumetric change.

complete the *Tier 1* Decadal Survey missions by 2017, and move forward with implementing the *Tier 2* missions[3] as well as the additional climate missions funded under the *Climate Initiative*[4].

And of course, Earth Science observations consist of far more than flight missions—see **Figure 1**. NASA deploys aircraft to conduct observations, test instruments that are planned for future satellites, and to support continuing satellite validation activities. Presently, aircraft observations are actively engaged in mission definition and development activities. Aircraft are supporting mission definition for both the Deformation, Ecosystem Structure, and Dynamics of Ice (DESDynI) and Active Sensing of

NASA deploys aircraft to conduct observations, test instruments that are planned for future satellites, and to support continuing satellite validation activities. Presently, aircraft observations are actively engaged in mission definition and development activities.

[3] Under the current plan, the Active Sensing of Carbon Dioxide Emissions (ASCENDS) and Surface Water and Ocean Topography (SWOT) missions will be the first *Tier 2* missions developed, with launches possible by 2020.
[4] These missions include the Orbiting Carbon Observatory (OCO)-2, Stratospheric Aerosol and Gas Experiment (SAGE) III (to be deployed on the International Space Station), Gravity Recovery and Climate Experiment (GRACE)-Follow-on, and Pre-Aerosols–Clouds–Ecosystem (ACE)—ACE is a planned *Tier 2* mission. Under the current schedule, all would be in orbit by 2019.

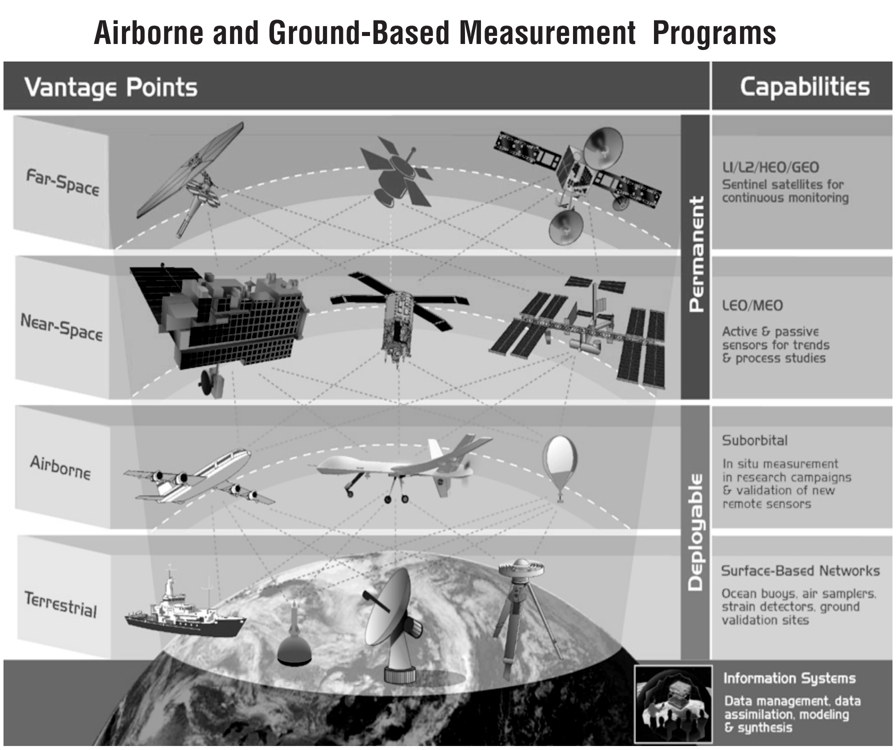

Figure 1. The diagram gives a feel for all of the vantage points covered by the various components of the Research and Analysis and Flight elements of NASA's Earth Science Program. Each vantage point has advantages and limitations for conducting Earth Science research. Satellites in space, for example, can observe much more area, and more continuously than sensors mounted on aircraft or surface-based networks, but satellites are not nearly as flexible or quickly deployed to the field as the other components.

Carbon Dioxide (ASCENDS) mission—*Tier 1* and *Tier 2* Decadal Survey missions, respectively. They are also being utilized for data gathering as gap-fillers—e.g., *Operation IceBridge* bridges the gap between the Ice, Clouds, and land Elevation Satellite (ICESat) and ICESat-2 missions[5]. Aircraft missions also serve as testbeds for future missions—e.g., the Earth Science Technology Office's Instrument Incubator Program (IIP). Many of the instruments flying in space today were originally flown on aircraft before being deployed in orbit.

The Agency also has robust surface-based observation programs whose observations are used to improve the calibration of instruments and thus achieve better absolute accuracy. Both airborne and surface-based observations are also used for *validation*—measurements on the ground are used to confirm that what the satellite measures in a given area is actually correct.

Specific Details of Venture

*The **Venture** mission line is a recommendation of the Decadal Survey, which suggested NASA maintain a line of competitively selected, moderate size missions and opportunities. As described above, the program is being implemented in the broader context of NASA's Earth Science Program and intended to help restore more frequent launch opportunities.*

The Earth Venture (EV) series of missions were called for in the Earth Science Decadal Survey[6] and received funding last year. The first series of airborne science investigations funded under the Venture Program (called EV-1) are now in the beginning stages of execution—see below for descriptions. These missions are part of NASA's Earth System Science Pathfinder (ESSP) program. They are relatively smaller than satellite missions—although large by airborne science campaign standards—with budgets of up to $30M spread over no more than five years, and meant to provide focused science investigations amenable to extended airborne campaigns. These investigations are stand-alone, their science is not meant to replace satellite missions, but complement them. EV-1 science results will support NASA's broad Earth system science research. All data, once calibrated and validated, will be open and available to all researchers.

Features of All Venture Class Missions

The Venture mission line is a recommendation of the Decadal Survey, which suggested NASA maintain a line of competitively selected, moderate size missions and opportunities. As described above, the program is being implemented in the broader context of NASA's Earth Science Program and intended to help restore more frequent launch opportunities. The following foci have been identified for the *Venture* class missions:

- Measurement and observation innovations;
- demonstration of innovative ideas allowing the use of higher-risk technologies;
- establishing new research avenues; and
- possible demonstration of key application-oriented measurements, although the selection criteria are based primarily on the direct science return from the measurement.

The missions may include:

- Stand-alone missions that use simple small instruments, spacecraft, and launch vehicles;
- more complex instruments of opportunity flown on partner spacecraft and launch vehicles; or
- complex sets of instruments flown on suitable suborbital platforms.

Venture class missions are intended to address "exploratory" science—as opposed to missions "named" within the Decadal Survey that are directed and covered within

[5] For more information on *Operation IceBridge* see the article in the May–June issue of *The Earth Observer* [**Volume 22**, **Issue 3**, pp. 4-7].
[6] *Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond*, National Academy of Sciences, 2007

the Earth Systematic Missions program. The Decadal Survey has recommended Announcements of Opportunity (AO) on a yearly basis, competitive selections, and Principal Investigator (PI)-led projects. The range of science could encompass any of the six Earth science themes.

The Three "Legs" of Venture

Through the *Venture* class, NASA would like to obtain a mix of sub-orbital, instrument, and orbital mission opportunities. To achieve this mix, three different kinds of AOs are anticipated under the *Venture* class line[7].

- *EV-Odd* (i.e., EV-1, 3, 5, …)—These AOs call for proposals for complete sub-orbital, PI-led investigations to conduct innovative, integrated, hypothesis or scientific question-driven approaches to pressing Earth system science issues. The first of these was EV-1, whose winners were announced on May 27—see details below. The next solicitation in this series in anticipated in 2013.
- *EV-Even* (i.e., EV-2, 4, 6, …)—These AOs call for proposals for complete orbital, PI-led missions to conduct innovative, integrated, hypothesis or scientific question-driven approaches to pressing Earth system science issues. The first of these (EV-2) is anticipated in Spring 2011, with the winning selections early in FY'12. The next solicitation in this series is anticipated in 2015.
- *EV-Instrument* (e.g., EV-I1, I2, I3,…)—These AOs call for proposals for a complete, PI-led instrument to conduct innovative, integrated, hypothesis or scientific question-driven approaches to pressing Earth system science issues. The PI will retain a central role on the instrument when it is finally manifested and flown—could be more than one instrument. The first solicitation in this series will come out in FY'11, with the first selection in FY'12. Subsequent AOs in this series are anticipated each year thereafter.

All *Venture* class missions will need to have a schedule for completion within five years of receiving their funding, and projects will be cost-capped. **The Venture class is decidedly not intended to be a mechanism for accelerating the implementation of Decadal Survey missions**. However, it is possible that the orbital calls could fund missions whose objectives overlap with those of planned Decadal Survey missions—assuming they meet other criteria in terms of innovation, cost, schedule, and science.

Details on the EV-1 Selections

The five sub-orbital investigations selected for funding in the first *Venture* class call (EV-1) were announced May 27, and are detailed on page 18. These flight projects were selected from among 35 proposals submitted in response to the solicitation that came out in July 2009[8]. Each project will be funded for five years at a total cost of not more than $30M.

The selected proposals under EV-1 encompass a wide range of Earth science including research on hurricanes, air quality, a number of different ecosystems, carbonaceous greenhouse gases, and tropospheric–stratospheric exchange. Collectively, the missions make use of NASA's *Global Hawk*, Gulfstream-III, and P-3B aircraft, as well as the *King Air* B-200 and *Twin Otter* aircraft. Six NASA centers, twenty-two educational institutions, nine U.S. or international government agencies, and three industrial partners are involved in these missions.

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[7] More specific details about each of the three "legs" of the *Venture* class missions are summarized in pp. 17-28 of Steve Volz's presentation referenced above.

[8] The Earth Venture-1 solicitation was a new proposal opportunity funded under element A.39 of the 2009 NASA Research Announcement: Research Opportunities in Space and Earth Science (ROSES).

Airborne Microwave Observatory of Subcanopy and Subsurface (AirMOSS) – PI: **Mahta Moghaddam** [University of Michigan]

Gulfstream-III

North American ecosystems are critical components of the global exchange of the greenhouse gas carbon dioxide (CO_2) and other gases within the atmosphere. To better understand the size of this exchange on a continental scale, this investigation addresses the uncertainties in existing estimates by measuring soil moisture in the root zone of representative regions of major North American ecosystems. Investigators will use NASA's *Gulfstream-III* aircraft to fly synthetic aperture radar that can penetrate vegetation and soil to depths of several ft.

Airborne Tropical Tropopause Experiment (ATTREX) – PI: **Eric Jensen** [NASA's Ames Research Center]

Global Hawk

Water vapor in the stratosphere has a large impact on Earth's climate, the ozone layer and how much solar energy the Earth retains. To improve our understanding of the processes that control the flow of atmospheric gases into this region, investigators will launch four airborne campaigns with NASA's *Global Hawk* remotely piloted aerial systems. The flights will study chemical and physical processes at different times of years from bases in California, Guam, Hawaii, and Australia.

Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE) – PI: **Charles Miller** [NASA/Jet Propulsion Laboratory]

Twin Otter

This investigation will collect an integrated set of data that will provide unprecedented experimental insights into Arctic carbon cycling, especially the release of important greenhouse gases such as CO_2 and methane. Instruments will be flown on a *Twin Otter* aircraft to produce the first simultaneous measurements of surface characteristics that control carbon emissions and key atmospheric gases.

Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality (DISCOVER-AQ) – PI: **James Crawford** [NASA Langley Research Center]

B-200

The overarching objective of the DISCOVER-AQ investigation is to improve the interpretation of satellite observations to diagnose near-surface conditions relating to air quality. NASA B-200 and P-3B research aircraft will fly together to sample a column of the atmosphere over instrumented ground stations.

Hurricane and Severe Storm Sentinel (HS3) – PI: **Scott Braun** [NASA Goddard Space Flight Center]

P-3B

The prediction of the intensity of hurricanes is not as reliable as predictions of the location of hurricane landfall, in large part because of our poor understanding of the processes involved in intensity change. This investigation focuses on studying hurricanes in the Atlantic Ocean basin using two NASA *Global Hawks* flying high above the storms for up to 30 hours. The aircraft will deploy from NASA's Wallops Flight Facility in Virginia during the 2012-14 Atlantic hurricane seasons. ■

Blog Log

Nicole Miklus, NASA Goddard Space Flight Center/Wyle Information Systems, nmiklus@sesda2.com

Blog introductions modified from text on the Earth Observatory and featured blogs, images also from the Earth Observatory (earthobservatory.nasa.gov/blogs) and featured blogs

In our November–December 2009 [**Volume 21**, **Issue 6**] issue of *The Earth Observer*, we introduced you to the *Blog Log*. This periodic installment features new blogs about NASA Earth science research and fieldwork and provides links where you can access the full story and view color photographs online. In this issue, we highlight three blogs for you to bookmark and check for updates. If you know of a blog about NASA science that perhaps deserves some attention (maybe your own!), please let us know.

Urban Aerosols: Who CARES

The month-long Carbonaceous and Aerosol Radiative Effects Study (CARES) took place in June 2010 in Sacramento, CA. A team of more than sixty researchers participated in the campaign, with the goal to study the evolution of aerosols, particularly those that are *carbonaceous* (contain carbon), as they travel and age. Scientists used a *Gulfstream* G-1 aircraft, NASA's *King Air* B-200, and ground-based stations to make simultaneous measurements of aerosols over Sacramento—an area where winds drive the city's plume of pollution towards the forests in the east each day. Tracking the movement of the plume throughout the day, and observing it mixing with natural emissions from forests, gave insight into how aerosols affect climate differently as they travel and age. **Matteo Ottaviani**, a scientist at the NASA Goddard Institute for Space Studies (GISS), wrote about the CARES campaign and his adventures with it, at: *earthobservatory.nasa.gov/blogs/fromthefield/category/urban-aerosols-who-cares/.*

[*Left*] NASA's *King Air* B-200 takes flight, carrying two instruments—the High Spectral Resolution Lidar (HSRL) and the Research Scanning Polarimeter (RSP). [*Right*] Trailers behind Northside Elementary School house a dozen different instruments to sample the air downwind from sources in Sacramento.

ICESCAPE

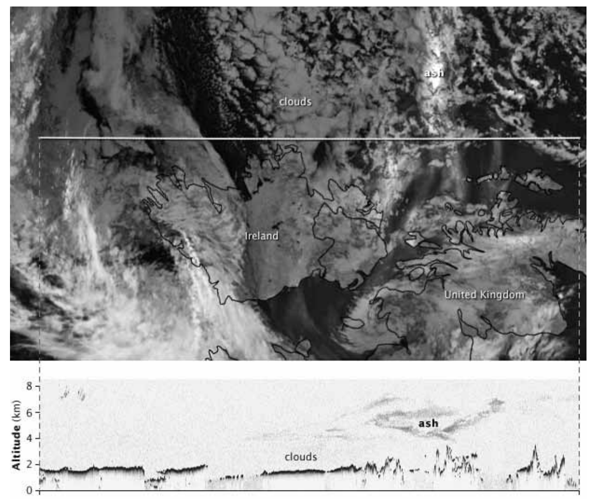
On June 15, 2010, the U.S. Coast Guard Cutter *Healy* departed from Dutch Harbor, AK, for its five-week-long journey north through the Bering Strait to the Chukchi and Beaufort Seas. Along the way, 43 NASA-funded scientists studied how climate change is affecting the ecology of the Arctic. They collected samples and disembarked for extended periods to work directly on the sea ice and, in the process, studied a myriad of topics, from the Arctic Ocean's *optical properties* (how it reflects and absorbs light) to the physiology of phytoplankton. In the *In the News* section of *The Earth Observer's* July–August issue [**Volume 22, Issue 4**], we featured an article on the goals of ICESCAPE. To read about how the scientists worked to achieve these goals, and to view stunning Arctic imagery, check out the ICESCAPE blog at: *blogs.nasa.gov/cm/blog/icescape/posts/post_1275666455782.html.*

The U.S. Coast Guard Cutter *Healy* is shown leaving Dutch Harbor, AK, on June 15, as it embarks on the ICESCAPE expedition. **Credit:** NASA

[*Left*] Newbies to *Gumby Suits* learned how to don these protective neoprene immersion suits in the event they needed to abandon ship. **Credit:** Karen Romano Young [*Right*] Technicians deploy the optical package from the fantail of the *Healy*. The package measured light absorption and scattering by diverse contents in the water column such as water molecules, algae, and bacteria cells. Its frame carried optical equipment from several research groups. **Credit:** Haley Smith Kingsland

Elegant Figures

The *Elegant Figures* blog began in August 2010, as a place to showcase some of the data visualization and information design featured on NASA's Earth Observatory. **Robert Simmon**, the Earth Observatory's lead visualizer, is author of the blog and posts topics in data visualization, satellite imagery, and case studies, as well as general information on design and topography. In the blog's first post, Simmon describes an image made in May that showed ash from the Eyjafjallajökull Volcano in Iceland. Simmon goes step-by-step to explain how data from the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) satellite and the Moderate Resolution Imaging Spectroradiometer (MODIS) on Aqua are used to create a nighttime image and vertical profile of ash from the volcano. To learn about this, and other design topics, please visit: *earthobservatory.nasa.gov/blogs/elegantfigures/*.



Nighttime data from MODIS and CALIPSO's vertical profiling of the atmosphere were used to make this image showing the extent of ash from the Eyjafjallajökull Volcano. If you have ever wondered how these images are produced, this blog is for you!

The Western Siberia Expedition 2010

In our September-October 2007 [**Volume 19**, **Issue 5**] and January-February 2009 [**Volume 21**, **Issue 1**] issues of *The Earth Observer*, we shared condensed blogs about field expeditions in Siberia led by **Jon Ranson** [Goddard Space Flight Center (GSFC)—*Deformation, Ecosystem Structure and Dynamics of Ice (DESDynI) Lidar Project Scientist, Head of GSFC Biospheric Sciences Branch*]. Ranson and colleagues from NASA, along with scientists from Russia's Academy of Science trekked through the fields of Siberia, making *ground-truth* measurements to validate satellite data. In August 2010, a team led by Ranson and **Slava Kharuk** [Sukachev Forest Institute] headed to the Chylum–Ket River region in Siberia for a two-week long investigation. The data they collect will be used to study the role of the region in Earth's carbon budget and to help design more accurate satellite instruments. To read more about their adventure, please visit: *earthobservatory.nasa.gov/blogs/fromthefield/category/the-western-siberia-expedition-2010/page/3/*. ▬

The expedition team poses in front of their field vehicle, nicknamed "The Pill." From left to right: **Slava Kharuk**, **Jon Ranson**, **Marsha Dvinskaya**, **Pasha Oskorbin**, **Ross Nelson**, **Bruce Cook**, **Sergei Im**, and **Mikal**, the driver.

Continuity of Earth Radiation Budget (CERB) Observations: Post-CERES Requirements

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Introduction

The activities of humans produce by-products that impact climate through the release of greenhouse gases (e.g., carbon dioxide) and aerosols into the atmosphere. These byproducts modify the atmospheric composition slightly and cause a small change in the delicate balance between the solar radiation the Earth absorbs from the Sun and the thermal radiation Earth emits to space—scientists call this the *energy balance*.

Scientists would like to determine the amount of change human activities are causing to the Earth's energy balance, as a way of quantifying the impact we humans are having on our planet's climate. Unfortunately, however, it's not an easy task because human activities aren't the only things that impact the total energy balance of the planet. There are a wide variety of natural factors as well. So one has to find a way to parse out the so-called *anthropogenic effect* from other changes.

And that's where we run into a problem. The absolute value of the global net Top of Atmosphere flux imbalance due to the projected *anthropogenic effect*—as estimated from climate models and changes in the ocean heat content—is about 0.85 W/m^2 [*Hansen et al.*, 2005]. This is a small number in comparison to the total change in the other individual components of the so-called *Earth radiation budget* (ERB), which can be up to 4 W/m^2 averaged over the globe. And over a small area of the globe, those changes can be even larger due to the effects of climate feedback on the components of the ERB—caused mainly by the changes in cloud, water vapor, and surface properties on regional scales. So the challenge scientists face in determining how much of the total change in energy balance can be attributed to the activities of humans is considerable.

This helps to understand why scientists are so interested in maintaining a long-term, global, uninterrupted time record of stable ERB measurements (as described in the **Background** section below). As science and technology continue to advance, the precision and accuracy of the ERB measurements continue to improve, and scientists are hopeful that the measurements will soon be precise and accurate enough that they can more conclusively determine what portion of the total observed climate change can be attributed to *anthropogenic* origins.

Earth Radiation Budget Measurements: Past, Present… and Future

Measurements of regional and global ERB date to the 1960s when the first satellites were launched, and were further enabled with the launch in the late 1970s of Nimbus 6 and 7. These pioneering satellites carried the first true broadband radiation scanning sensors into space. NASA's three-satellite Earth Radiation Budget Experiment (ERBE) consisted of a series of experiments on the NASA Earth Radiation Budget Satellite (ERBS) as well as on the NOAA-9 and -10 satellites that flew in the mid-1980s. These investigations provided the second generation of true broadband data and were the first scanners with sufficient spatial resolution to separate clear-sky scenes and allow for the direct observation of cloud radiative effect. The third-generation instrument, Clouds and the Earth's Radiant Energy System (CERES), is currently flying on NASA's Tropical Rainfall Measuring Mission (TRMM), and on the Terra and Aqua satellites—launched in 1997, 1999, and 2002, respectively. Calibration and data analysis accuracy have improved with each generation of ERB instruments as has data processing; the CERES instruments are now near the accuracy required to monitor decadal trends in ERB. A CERES instrument will fly on both the NPOESS[1] Preparatory Project (NPP), planned for launch in 2012, and the first Joint Polar Satellite System mission (JPSS-1) planned for 2015. These upcoming launches will extend the continuous record of ERB measurements into the next decade and beyond.

Motivation for the CERB Workshop

Prior to the launch of JPSS-2 (currently planned for 2019) another round of improvement of the ERB instrument and data analysis capabilities is expected that will incorporate advances in technology and science that are expected in the next ten years. In anticipation of these improvements, the National Environmental Satellite, Data, and Information Service (NESDIS) of the National Oceanic and Atmospheric Administration (NOAA) needs to reevaluate the ERB requirement for the period beyond JPSS-1. In support of this effort, the

[1] NPOESS stood for National Polar-orbiting Operational Environmental Satellite System and was the former name for the system that is now reorganized and named JPSS as mentioned above.

National Climate Data Center (NCDC) of NESDIS organized an international workshop, entitled Continuity of Earth Radiation Budget (CERB) Observations – Post-CERES Requirements, in Asheville, North Carolina from July 13–14, 2010.

Workshop Organization and Objectives

Over thirty scientists from NOAA, NASA, the European Space Agency, academic universities, and industrial companies attended the workshop. Three breakout working groups were formed: a User Requirements Group; an Instrument Requirements Group; and a Data Processing Requirements Group. The morning of the first day was spent in a plenary presentation session. The afternoon of the first day and the morning of the second day were devoted to working group discussions and to writing opinions and recommendations centered around the following three objectives of the workshop:

1. Identify the purposes and current uses of Earth radiation budget observations;
2. document the current status of research and applications of Earth radiation budget; and
3. identify observing system requirements for the continuity of the Earth radiation budget climate data records (CDR).

Summary of Working Group Reports

The working groups were asked to document their discussions and recommendations and form a group report. The summary of the working groups' reports appears below.

User Requirements Working Group

Long-term, consistent, and continuous Earth radiation budget measurements, including related surface radiation budget (SRB) estimates, provide fundamental metrics on the integrated effects of the entire climate system. Therefore, ERB data are critical for monitoring, analyzing, and assessing the states of Earth's climate system, for time scales from weeks to decades. ERB values are also fundamental products of climate models so that ERB measurements can provide observations that facilitate model improvements and allow scientists to assess the confidence in long-term climate predictions. In particular, ERB measurements have played prominent roles in previous Intergovernmental Panel on Climate Change (IPCC) assessments. As the data-record of ERB measurement lengthens, the critical role of ERB observations in future assessments will grow. The benefits of long-term, consistent, and continuous ERB observations further extend to the government and industry sector for decision-making in a wide range of applications (e.g., renewable energy) that involve investment and resource allocation. To meet the user requirements, the user requirement working group made three recommendations:

- Future ERB measurement should follow the suggestions from the two community workshops aimed at specifying instrument accuracy and stability requirements for a range of ERB and atmospheric variables [*Ohring et al.*, 2004; *Ohring et al.*, 2007].

- A minimum stability requirement for reflected solar radiation is 0.3 W/m^2 per decade. This is the minimum threshold for resolving changes over a decade to within current estimates of climate noise, and to be consistent with potential climate variability. Accuracy is not required at the same level, and 1 W/m^2 is adequate. In the longwave, a minimum stability requirement of 0.2 W/m^2 is needed to resolve changes over a decade to within current estimates of climate noise, and the accuracy requirement is at the same level as shortwave (i.e., 1 W/m^2). These accuracy levels must be achieved equally under all-sky conditions as well as for individual scenes types whose spectral content is concentrated at either end of the Earth's reflected solar and emitted thermal spectra (e.g., clear ocean, clear desert, deep convective clouds).

- In order to ensure continuity with the existing CERES ERB record, follow-on missions (i.e., those planned after CERES Flight Model 6 on JPSS-1) must ensure that any changes in instrumentation, orbit, spatial resolution, and ancillary inputs do not introduce an artificial "jump" in the record. This means every effort should be taken to ensure that instrument spatial resolution is similar to existing CERES instruments and that the orbit chosen for these future missions be close to that for CERES Aqua, NPP, and JPSS-1. **It is also of utmost importance (for calibration purposes) that successive missions overlap by at least one year.**

Instrument Requirements Working Group

The difficulty in documenting climate variability and change lies in the calibration stability requirements. Instrument calibration uncertainty is the dominant error source at long-time (e.g., decades) and large-spatial (e.g., global) scales. The goal of the Instrument Requirements breakout group was to provide guidance as to the design and implementation of an observational strategy which, ensures continuity of the existing ERB Climate Data Records (CDRs)—i.e., backwards compatibility and no gaps in observations, while simultaneously addressing the needs of the user community as documented in the User Requirements breakout group. This guidance should enable the development of a sensor and overall calibration and validation plan that is capable of characterizing the complete spectrum (i.e., temporal, spatial, spectral, etc.) of observations with sufficient accuracy from independent paths of traceability. Inherent in this goal is the concept that a rigorous calibration and validation program is integral to the entire lifecycle of an observational program [*Datla et. al*, 2009]. Calibration improvements implemented in future ERB observational systems should be in line with the recommendations in the 2006 Achieving Satellite Instrument Calibration for Climate Change (ASIC3) report [*Ohring et al.*, 2007] as well as the NIST publication: *Best Practice Guidelines for Pre-Launch Characterization and Calibration of Instruments for Passive Optical Remote Sensing, NISTIR 7637* [*Datla et al.*, 2009]. The following specific recommendations are also provided by the instrument working group:

- Ensure continuity of observations;
- develop an implementation plan that minimizes the risk of a gap in the record;
- establish a dedicated sensor *Calibration Science Team* early in the program;
- design an onboard calibration system as the principle source of information for detecting and correcting sensor calibration drifts;
- ensure an onboard calibration system monitors performance across the entire spectrum;
- design calibration subsystems to ensure calibration targets are viewed through the entire optical train;
- perform ground characterization procedures;
- develop the first principle sensor model;
- develop rigorous contamination control plans;
- establish a hardware archive to preserve key witness samples, optical components, and calibration materials;
- provide programmatic implementation; and
- develop a long-term strategic plan to sustain CDRs.

Data Processing Requirements Working Group

While instrument calibration uncertainty is the dominant ERB error source at long-time and large-spatial scales, algorithm implementation strategies (e.g., radiance-to-flux conversion, diurnal corrections) are the main sources of uncertainty at short-time and small-spatial scales [*Wielicki et. al.*, 1995]. The data processing working group described the data processing aspects of determining the Earth's radiation budget from broadband satellite measurements and discussed the potential improvement in the data processing for the time period after JPSS-1 compared to the current CERES ERB data processing. The group also addressed the importance of producing retrospectively consistent long-term ERB CDRs. Based on the discussions, the group reached several major conclusions and put forth some recommendations regarding the ERB data processing system of the future:

- In order to determine whether user requirements could be better met, errors introduced in the data processing system should be studied and minimized. Careful study and attention should be paid to the following processing steps and components: spectral correction, angular distribution correction, and diurnal averaging.

- Input and ancillary data and observations from the improved satellite observations and model simulations in the next 10 years should be used in the future ERB data processing, especially the new operational observations from the JPSS-2 satellite instruments. The reanalysis data and assimilated data used should include these new operational observations, especially the measurements from the new sounders.

- The future Geostationary Operational Environmental Satellite (GOES) observations (e.g., GOES-R) should be used to replace the current GOES observations for a better retrieval of cloud properties and improvement of diurnal averaging. Specifically, currently used three-hour GOES observations should be increased to at least 60 minutes from GOES-R observations to better capture the diurnal variation of cloud and radiation fields. Multi-channel GOES-R cloud retrievals should replace the dual-channels (0.65 and 11 µm) GOES cloud retrieval used in the current CERES data production.

- More channels (such as 0.83 and 8.5 µm) should be used for a better retrieval of the cloud and surface properties from the polar-imager JPSS/Visible–Infrared Imaging Radiometer Suite (VIIRS) compared to the channels (0.65, 1.6, 3.7, 11, and 12 µm) used for the EOS/Moderate Resolution Imaging Spectroradiometer (MODIS) imager in the current CERES data processing. Aerosol absorbing properties (single-scattering albedo) and vertical profiles from Glory's Aerosol Polarimetry Sensor (APS) observations and globally assimilated aerosol data should be added to the aerosol optical thickness and particles' size for a better quantification of aerosol radiative forcing (direct and indirect).

- In order to ensure backward compatibility with the CERES ERB data products, Terra and Aqua CERES Angular Distribution Models (ADMs) should be used for the JPSS-2 ERB data processing if the JPSS-2 ERB instrument is on the sun-synchronous (afternoon or morning) polar orbiter. If new ADMs are developed, they need to be applied to all the data record through reprocessing. At the same time, there is a need for producing ERBE-like and CERES-like ERB products through reprocessing by using retrospectively consistent algorithms and inputs in addition to the improved products and algorithms in the phase of JPSS-2.

- Both radiative transfer models (RTM) and parameterized inversion models (PIM) should be used to determine the ERB products for redundancy. Aside from the top-of-atmosphere (TOA) products and surface ERB products, products in the atmosphere (e.g., at the 680, 440, and 100 mb levels) are also needed to better estimate cloud–radiative feedback. Narrowband radiation observations with high calibration accuracy and spatial resolution are needed for inter-comparison and cross-validation with the broadband radiation observations and for filling the potential gaps in the broadband data.

- Ground-based observations of surface radiation budget, cloud, and aerosols for various climate regimes are required for the validation and improvement of the satellite products. Both long-term observations from ground-based networks and short-term intensive field campaigns are needed.

Conclusion

In response to the recommendations from this workshop, NOAA should consider awarding a conceptual design study of the Earth Radiation Budget Instrument (ERBI) for the time period beyond JPSS-1 and forming an international science team to guide planning, implementation, and construction of the ERBI and related operational production of ERB CDRs. Other countries are also developing ERB satellite instruments, and international collaboration on the development of future ERBI and ERB data production should be actively pursued. With the appropriate improvements of ERB instruments and data processing procedures and investments in ground processing hardware and software, we can look forward to timely and high quality ERB measurements and operational production of ERB CDRs. As indicated in the User Requirements Working Group discussion, such information is urgently needed for understanding and monitoring climate change and for improving climate and long-range weather forecasting.

CERB Workshop Website: *www.ncdc.noaa.gov/oa/rsad/conferences/cerb2010/index.html*

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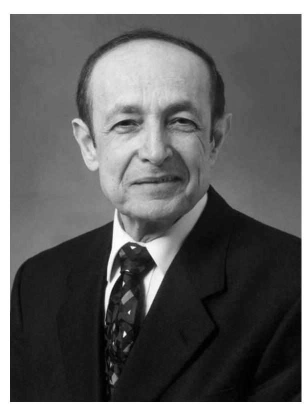
Kudos



Moustafa T. Chahine [Jet Propulsion Laboratory (JPL)—*Atmospheric Infrared Sounder (AIRS) Team Leader for Aqua*] was recently elected to the Lebanese Academy of the Sciences. From the AIRS Team, "Dr. Moustafa Chahine, AIRS Science Team Leader, was elected a Full Member of the Lebanese Academy of Sciences (Academie des Sciences du Liban). His election carried the citation: 'For his leadership in the theoretical modeling and space observation of Earth and planetary Atmospheres.' A press release will follow on the Academy's webpage at: *www.asliban.org/Announcements.html.*" The staff at the *The Earth Observer* and the entire scientific community congratulate Chahine on his accomplishment!

The GOFC–GOLD Fire Implementation Team Workshop Summary

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The Global Observation of Forest and Land Cover Dynamics (GOFC–GOLD) Fire Implementation Team (IT) workshop was held at the European Space Research Institute (ESRIN), European Space Agency (ESA), Frascati, Italy on March 23-25, 2010. The workshop reviewed the current state of global fire observations and identified the priorities and next steps in the area of fire science and applications. The workshop brought together 40 participants, including representatives from international, government, and non-government organizations. Workshop participants identified the need to: continue and improve global product validation; blend geostationary and polar-orbiting fire products ensuring global coverage; develop community consensus on fire essential climate variables; develop procedures for establishing dynamic data continuity between sensors; improve fuel type and moisture content data for assessing fire danger and early warning and risk;, organize training programs to build regional expertise; and improve data availability and product dissemination for enhanced understanding of human–climate–fire relationships.

Introduction

GOFC–GOLD is an organization focused on international coordination of enhanced Earth observations. Its overall aim is to improve the quality and availability of space-based and *in situ* observations at regional and global scales and to encourage the production of appropriate, timely, and validated information products. Originally developed as a pilot project by the Committee on Earth Observation Satellites (CEOS) as part of their Integrated Global Observing Strategy, GOFC–GOLD is now a panel of the Global Terrestrial Observing System (GTOS). The essence of the GOFC–GOLD implementation strategy is to develop and demonstrate operational monitoring at regional and global scales by conducting pilot projects and developing prototype products in three different themes: land cover characterization and change, fire mapping and monitoring, and biophysical processes.

The GOFC–GOLD Fire Mapping and Monitoring Implementation Team (Fire IT) is composed of experts from national and international space agencies, governmental, and non-governmental environmental organizations and universities. The Fire IT aims to refine and articulate international observation requirements and encourage the use of satellite-derived fire products and information from existing and planned systems for global change research, fire management, and policy decision-making. This includes identifying the observation priorities and needs of the fire community, facilitating collaborative research in recognized priority areas, periodic identification of critical observation gaps, promoting the use of spaceborne assets for fire research, provision and validation of fire products, improved data distribution,

The GOFC–GOLD Fire IT Workshop participants

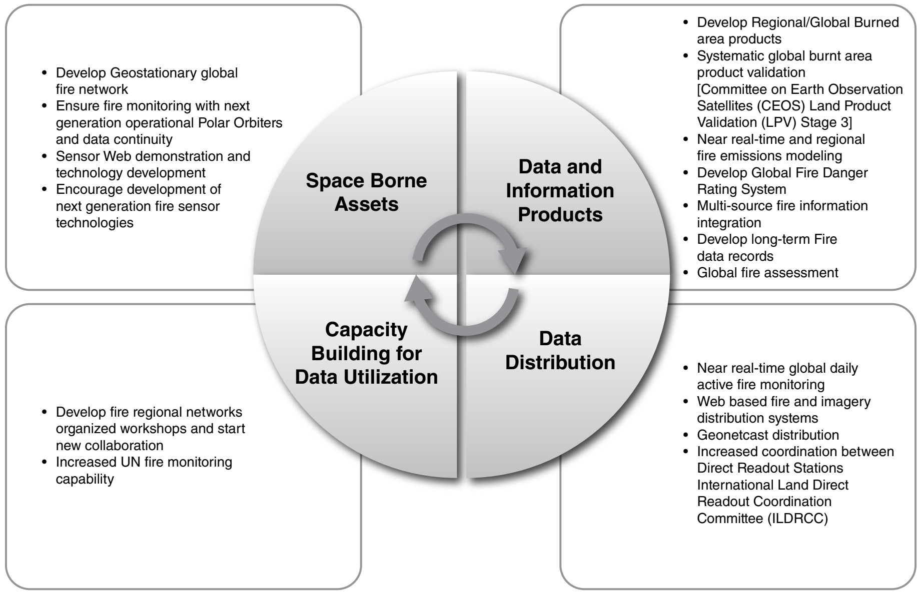

Figure 1. GOFC-Fire IT emphasis areas and sub-tasks

and capacity building. The Fire IT is actively pursuing these goals and the associated sub-tasks— see **Figure 1**—through international and national contributory projects, involving regional experts and strategic partnerships with the relevant international organizations.

The Workshop

The Italy 2010 Fire IT meeting followed previous IT meetings that were held in Thessaloniki, Greece (2008) and Montreal, Canada (2005). The meeting was organized around several focus areas: polar satellite active fire and burned area products; the Global Geostationary Fire Network; fire product validation; the Fire Disturbance Essential Climate Variables (ECVs) of the Global Climate Observing System (GCOS); data continuity; the Global Fire Early Warning System; global fire emissions estimation; Fire in the United Nations Reduced Emissions from Deforestation and Degradation (UN-REDD) Program; fire observations from new and planned instruments; the Global Fire Assessment; and the regional fire network status and direct broadcast initiatives. For each focus area, two experts from the team were identified to present an overview on the topic, assessing the status and future needs, followed by group discussion.

Opening Remarks

The meeting started with an introductory welcome address from the host **Olivier Arino** [European Space Research Institute (ESRIN)]. Arino highlighted the ESA's activities and emphasized the importance of long-term global systematic Earth observations for climate research. In this context, he presented the upcoming ESA Sentinel missions and ESA's planned free and open data policy.

Chris Justice [University of Maryland—*Fire-IT Co-chair*] then provided an overview on the GOFC–GOLD Fire IT organizational structure and function and the details on regional fire network activities. Justice emphasized the importance of product accuracy assessment and described the activities of the CEOS Land Product Validation (LPV) sub-group. He presented some of the current obstacles for fire science, including the fragility of product continuity, inconsistent fire product validation, and varying data policies. Justice also highlighted some opportunities including new algorithms and application areas, new and planned missions [e.g., NPOESS Preparatory Project (NPP)/Joint Polar Satellite System (JPSS); Sentinels; Landsat Data Continuity Mission (LDCM); and Deformation, Ecosystem Structure (DesDynI)], and using the current satellite record to develop a comprehensive Global Fire Assessment and explore the relationships between fire, climate, and global change.

Johann Goldammer [Freiburg University—*Fire-IT Co-chair*] presented an overview of the global fire networks, the Global Fire Monitoring Center, and GOFC–GOLD, and how they have been serving users at both the global and regional scale. Goldhammer emphasized the Global Fire Early Warning System and international efforts to strengthen regional fire network activities, and noted that regionally focused studies are needed since the role of fire in many ecosystems remains poorly understood.

Science Presentations

David Roy [South Dakota State University] reviewed active fire and burned area products generated from polar-orbiting satellites. Roy summarized the current GOFC–GOLD requirements for these products. For active fire these include: 1-km global with 24-hr detection summaries, burned area: 500-m global with monthly statistics; and 30-m regional products periodically. He also highlighted the potential product generation benefits of data fusion approaches using both polar and geostationary satellite data. Roy stated that to date, fire product developers have not definitively demonstrated the accuracy and consistency of their products and that limited product comparison and validation exercises have revealed significant discrepancies in area estimates, timing, and location. He reiterated the need for systematic fire product validation and the importance of making the resulting accuracy information comprehensible to non-scientists including policy makers. Roy stressed that consensus community-endorsed validation is of increasing importance as satellite products are getting easier to generate—driven by factors including space agency support for free satellite data, decreasing computer costs, increasing computer processing and storage capabilities, and the proliferation of satellite direct-broadcast reception systems.

Ivan Csiszar [National Oceanic and Atmospheric Administration (NOAA)] highlighted the global geostationary network activities. Csiszar presented details on the NOAA/National Environmental Satellite, Data, and Information Service (NESDIS) Wildfire Automated Biomass Burning Algorithm (WF ABBA) wildfire product, its validation, and long-term data records over South America. Csiszar demonstrated the utility of a probabilistic approach for correction for cloud obscuration. This approach could reduce omission errors (43–59%) over areas affected by clouds. Csiszar described the international coordination efforts to develop the Geostationary Fire Network and the activities within the Coordination Group of Meteorological Satellites (CGMS) to specify user requirements for fire detection on operational geostationary systems. Plans include the incorporation of fire detection from the Multi-Functional Transport Satellite-2 (MTSAT-2); the Communication, Ocean, and Meteorological Satellite (COMS); and the Indian National Satellite System-3D (INSAT-3D) satellites into the global system.

Kevin Tansey [University of Leicester] emphasized the need to validate the satellite fire products at a variety of scales. Tansey highlighted that an unbiased estimate of burnt area validation at a coarser resolution is needed to fully characterize the uncertainty. This would need to include a transition from CEOS *Stage 2* Validation (expert-based selection of representative validation sites) to *Stage 3* Validation (model-based statistical sampling). He described the accuracy problems in L3JRC, Moderate Resolution Imaging Spectroradiometer (MODIS) *MCD45*, *GFED2*, and *GFED3* datasets and stressed the need for more comprehensive validation of these products. He also described the CEOS Global Burnt Area Validation Protocol and mentioned that a validation effort through the *Wiki* site has started (*lpvs.pbwiki.com*).

Olivier Arino [ESRIN] described the GCOS Fire Disturbance ECV objectives and requirements (which include achieving high accuracy of 5% error in omission/commission, spatial resolution of 250 m, daily temporal resolution, and stability of 5%). Arino described the variables within the Fire Disturbance ECV [which includes active fires, burned areas, and fire radiative power (FRP)], their status, and requirements as highlighted in the GTOS T13 Food and Agriculture Organization of the United Nations (FAO) document and the NASA White Paper on Fire Earth System Data Records (ESDR). He also described the ESA's Climate Change Initiative and ECV activities stressing the need to explore data fusion methodologies for effective fire monitoring.

Krishna Vadrevu [University of Maryland] provided an overview of the coarse, medium, and high-resolution satellite data useful for fire research and applications and their associated data continuity needs. Vadrevu discussed the potential and limitations of different sensors useful in generating active fires, burnt areas, and FRP products. He summarized the data availability and utility of the NOAA Advanced Very High Resolution Radiometer (AVHRR), Systeme Pour l'Observation de la Terra (SPOT), MODIS, Visible Infrared Imager Radiometer Suite (VIIRS), Landsat, ESA satellites, Indian Remote Sensing satellites (IRS), and China–Brazil Earth Resources Satellite program (CBERS), in fire research.

Bill de Groot [Canadian Forest Service] described the Global Fire Early Warning System (EWS) initiative and how fire danger information can aid in the implementation of fire management action plans and in mitigating or preventing wildfire disasters. De Groot discussed the EWS inputs, which include fire weather/activity products, fire behavior products, and fire management response tools, as well as presented a recent pilot demonstration for Southern Africa. He also highlighted some of the ongoing international collaborative efforts and the need for incorporating satellite observations in the global EWS.

Alessandro Brivio [Institute for Electromagnetic Sensing of Environment (IREA)] highlighted the Burnt Biomass and Satellite Observations (BBSO) activities undertaken as a part of the Global Emissions Inventory Activity (GEIA)/Atmospheric Composition Change the European Network of Excellence (ACCENT) programs. BBSO has two major activities: database generation for global and regional emission inventories, and an inter-comparison exercise for carbon monoxide (CO) emission estimates. Both of these studies recommended using MODIS burnt-area products for emission estimation in herbaceous/shrub/boreal forests; burnt-area and Fire-Radiation-Power (FRP) products for evergreen forests; and MODIS active-fire products for characterizing the temporal distribution of fires at the seasonal scale. Brivio called for enhanced collaboration between different international programs for validation of fire products and emissions estimation.

Danillo Mollicone [FAO] highlighted the UN-REDD mechanism and national REDD activities in some countries. Mollicone pointed out the need for a multiphased approach involving a variety of datasets for monitoring, reporting, and verification to reduce the errors in REDD projects. He called for increased capacity-building activities in the tropical countries for successful implementation of the REDD mechanism.

Luigi Boschetti [University of Maryland] provided details on the role of fire in REDD and outlined the fire component of the GOFC–GOLD REDD Sourcebook. Boschetti explained that the current version [*Conference of the Parties (COP)-Ver.15*] includes the methods and procedures for monitoring, measuring, and reporting anthropogenic greenhouse gas (GHG) emissions and carbon stocks in the forestry sector. He stressed the need for high-resolution satellite datasets for GHG emissions estimation. Boschetti also emphasized the importance of capacity-building activities from GOFC–GOLD focusing on REDD and involving regional experts for effective REDD project implementation.

Louis Giglio [University of Maryland] provided extensive details on fire observations from new instruments, which included the Sentinel/Sea and Land Surface Temperature Radiometer (SLSTR), NPP/National Polar-orbiting Operational Environmental Satellite System (NPOESS) Visible Infrared Imager Radiometer Suite (VIIRS), Technologieerprobungsträger 1 (TET-1), Global Climate Observation Mission-Second generation Global Imager (GCOM-SGLI), Hyperspectral Infrared Imager (HyspIRI), Landsat Data Continuity Mission (LDCM), and Geo-Africa. Giglio highlighted the instruments' potential and limitations for fire mapping and monitoring.

Chris Justice and **Johann Goldammer** provided an overview on the importance of implementing an international Global Fire Assessment and problems associated with finding a donor to fund the initiative. Justice stated that there are now satellite time-series data to quantitatively describe fire at a global scale with national-scale reporting and that useful metrics need to be developed. He recommended an active role for the regional network scientists in providing an interpretation of recent fire trends. Justice stressed the need for a comprehensive Global Fire Assessment, and the need to fund such an assessment.

Everett Hinkley [United States Department of Agriculture (USDA) Forest Service] described the International Land Direct Readout Coordination Committee (ILDRCC) activities, formed under the auspices of GOFC–GOLD in early 2008. ILDRCC acts as a voice of the international land direct readout community that interfaces with space agencies and science teams responsible for direct broadcast capability, data quality, and official science product development. Emphasis from the ILDRCC is currently focused on the NPP/JPSS VIIRS system but it would like to encourage direct readout from other international sensors. More details about ILDRCC can be found at: *landdirectreadout.org*.

After the science presentations came a series of overview presentations on the various regional GOFC–GOLD Fire Network activities, including reports from:

- **Check Mbow** [Université Cheikh Anta Diop de Dakar] on fire aspects of the West Africa Regional Network (WARN) activities.
- **Narisara Thongboonchoo** [King Mongkut's University of Technology] on the Southeast Asian Regional Research and Information Network (SEARIN).
- **Magsar Erdenetuya** [National Remote Sensing Center, Mongolia] on fire activities in Mongolia and the emerging Central Asia regional network initiated at Urumqi, China—formally established during the Land Cover Land Use Change Workshop in Almaty.
- **Johann Goldammer** on developments with the UN Global Wildland Fire Network.
- **Isabel Cruz** [National Commission for the Knowledge and Use of Biodiversity (CONABIO)] on the Latin American Fire Network (Red LaTIF) activities.
- **Phillip Frost** [Council for Scientific and Industrial Research] on the Southern Africa Fire Network (SAFNET) remote sensing and fire management activities.

An extended discussion session followed these presentations that focused on identifying key issues and fire research needs. Participants identified nine priority areas for emphasis in the short term (1–1.5 yrs) and long term (2–3 yrs)—see **Table 1**.

Emilio Chuvieco [University of Alcala] gave an introductory presentation and suggested several priority areas for the GOFC–GOLD Fire IT, which included fire danger/risk estimation, validation of fire products, processing of long-term data records, active participation of regional networks, emission estimations, etc. Chuvieco also emphasized generating new higher-order fire products, including fuel type maps and live fuel moisture content datasets.

Table 1. GOFC–GOLD Fire IT Priority Areas

Global validation protocols and implementation	Complete the burnt area validation protocol as a part of CEOS calibration/validation sub-group activity. Develop the validation protocol for active fire products.	Implement *Stage-3* validation for Burned Area through international cooperation.
Global Geostationary Network	Obtain full GEO-SAT agency response to CGMS suggestions. Generate fire products for all GEO network satellites. Enable NRT access. Validate products against data (e.g., higher spatial resolution data). Generate blended "global" geostationary product, including links to global NRT emissions models.	Long-term processing of geostationary fire data from archives. Generate Meteosat active fire/FRP product from early mission years (e.g., 2003 onwards). Validate composite product and ultimately blend in polar-orbiting fire products to ensure global coverage.
Data requirements for global ECV	Conduct user consultation exercise (questionnaire and workshop) with modelers and fire technicians on ECV. Work with GTOS to refine ECV requirements. Propose GOFC–GOLD Fire to provide ECV oversight.	Develop community consensus Fire ECV products and provide oversight. Revisit VIIRS IORD for Fire.
Long-term data record (LTDR) generation	Complete scoping and assemble 1-km AVHRR archive from LAC and HRTP data. Develop procedures for establishing dynamic continuity between sensors.	Generate LTDRs for active fire and burned area products, including validation datasets and produce continuity products from NPP/JPSS and Sentinel 3.
Global fire danger including early warning and risk	Prepare global fuel type map. Calibrate Fire Weather Index (FWI) over different regions. Organize workshop on fire risk assessment (Coimbra, November 2010).	Prepare databases of field measurements on live fuel moisture content estimation and other Global EWS inputs.
Global fire emissions estimation	Contribute to the BBSO dataset development and model inter-comparison. Organize fuel consumption workshop (regional experts + inventory developers). Comparison of inventories using top-down constraints (CO and aerosols).	Develop experimental datasets on fuel moisture, biomass, fire severity, FRP, combustion completeness. Use LTDRs to produce long-term fire emissions estimates. Explore new input products (e.g., using radar products and emission factors).
Regional network issues, capacity building, accessibility, etc.	Organize training programs for building regional expertise and provide project-based training on data validation and application. Improve data availability and product dissemination. Provide SPOT archive data to African regional networks.	Improve visibility of the regional networks to national end-users and policy decision makers. Prepare training and education materials. Promote training in developing countries on fire data from new missions.
User outreach and feedback	Expand the fire component of the GOFC–GOLD REDD Sourcebook. Promote the involvement of GOFC–GOLD regional networks in the REDD process. Develop user friendly products and documentation.	Provide information on fire data and products from new missions. Promote training in developing countries on the use of fire data from new missions. Explore distance-learning outreach modules.
New fire-related missions and products	Initial evaluation of TET-1 data and products. Publish review of fire sensors: instruments, calibration, and data-related data quality.	Development of fused products. Characterization of the NPP/JPSS/VIIRS, Sentinel 3, and new geostationary sensors, data, and products. Use of satellite-based lidar for fuel characterization.

Participants gave priority to the development of international validation protocols for the polar and geostationary active fire products and the need to consider ecosystem type, timing, and biophysical characteristics. The Fire IT agreed to work on implementing *Stage 3* Validation of the fire products, in partnership with CEOS, and to encourage the involvement of regional scientists. The participants emphasized on data fusion methodologies combining multi-resolution data from both the polar and geostationary satellites for effective and timely fire monitoring. Further, they recommended extending GEONETCast data dissemination beyond Africa and with increased bandwidth.

Participants agreed that urgent clarification is needed about roles and responsibilities for product generation of the ECVs and their validation and oversight, as a number of individual organizations are starting to develop them. The question as to what is an acceptable level of accuracy for the fire ECV was raised. While they didn't have a specific answer, the team did reiterate the fundamental need for a well-calibrated long-term data record and an international effort by the CEOS Calibration-Validation (Cal-Val) Working Group to validate fire products from different sensors in a consistent manner. With respect to data and product continuity, participants called for better international coordination of data acquisition and open data sharing for past, current, and future moderate resolution sensors. More emphasis on developing a moderate-resolution satellite constellation with global coverage and near real-time distribution was also recommended to increase the frequency of observations and to enhance moderate-resolution burned area monitoring. For coarse resolution sensors, emphasis should be given to developing common processing and fire products for NPP/JPSS/VIIRS and Sentinel 3/SLSTR with an internationally coordinated *Stage 3* Validation. It was also noted that NOAA has initiated a study to scope the compilation and processing of the historical 1-km AVHRR data from the available Local Area Coverage (LAC) and High Resolution Picture Transmission (HRPT) available archives worldwide.

The discussion of the fire-danger rating system identified the need for locally calibrated and frequently updated data, improved fuel type and moisture content maps, and improved information on anthropogenic impacts and drivers. With respect to greenhouse gas emissions estimation, participants noted that satellite-derived FRP products have potential to provide useful spatially explicit biomass burned data. Relating to UN-REDD, the team recognized the potential role of reducing fire emissions; some projects are already being developed in this area and there is a need to broaden the GOFC–GOLD REDD Sourcebook to include accuracy assessment.

Brainstorming discussions revealed that the GOFC–GOLD regional fire networks are seeking different types of training, including undergraduate and graduate education in remote sensing and Geographic Information Systems (GIS), and training to build regional expertise related to specific programs [e.g., UN-REDD and Intergovernmental Panel on Climate Change (IPCC) National Emissions Inventory]. Participants noted that bilateral training and professional exchanges between the regional networks could help develop regional capacity and that the Global Change System for Analysts, Research, and Training (START) and GOFC–GOLD should help identify support for such activities. The NASA Land Cover/Land Use Change Program is supporting the GOFC–GOLD Fire Project Office. Financial support for the workshop was provided by NASA, ESA, the Canadian Space Agency, the GOFC–GOLD Secretariat, Canadian Forest Service, Natural Resources Canada, START, and the host institutions of the members. The workshop agenda, participants list, and presentations are available at: *gofc-fire.umd.edu/Frascati_Meeting/index.asp*. ■

Kudos

The EOS Project Science/Science Mission Directorate (SMD) Support Office submitted outreach products to the Washington, DC chapter of the *Society for Technical Communication's (STC)* "2009-2010 International Technical Publications Competition." This year, the *Ocean Surface Topography Mission's (OSTM) Science Writer's Guide* received an ***Award for Distinguished Technical Communication*** and the book *Our Changing Planet: The View from Space* (Cambridge University, December 2007) received an ***Award for Excellence***. The Project Science Office team (and all those who collaborated on these products) are commended for producing high-quality outreach materials that help promote NASA science! For more information on STC's competitions, please visit: *www.stc.org*.

Summary of NASA-NOAA-DoD Joint Center for Satellite Data Assimilation (JCSDA) 8th Workshop on Satellite Data Assimilation

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Some 100 scientists, representatives of Joint Center for Satellite Data Assimilation (JCSDA) partner agencies, program managers, and JCSDA management/staff participated in the 8th Annual JCSDA Workshop on Satellite Data Assimilation, held at the University of Maryland Baltimore County, May 4-5, 2010. The purpose of these annual workshops is to review the ongoing and planned scientific development sponsored by the Center, and to plan and coordinate future efforts. The JCSDA supports scientific development work with proposal-based, internally directed funds as well as with external grants awarded via a competitive Federally Funding Opportunity open to the broader scientific community. In addition, JCSDA individual partners undertake their own research that overlaps with JCSDA objectives.

Overview of Workshop

In the first session, **Lars Peter Riishojgaard** [JCSDA—*Director*] presented a JCSDA Program Update and Overview. Riishojgaard highlighted progress in development of four-dimensional variational assimilation (4D-Var) systems, including operational implementation of the Navy's system and NASA and the National Oceanic and Atmospheric Administration's (NOAA's) work to develop a 4D-Var infrastructure. He also discussed a JCSDA initiative to secure a supercomputing resource that can be made available to external investigators to test algorithms in the context of operational partner systems. Riishojgaard also mentioned that the JCSDA's first summer school in 2009 was very successful. He discussed the characteristics of successful research to operations projects including strong collaboration with JCSDA partners and access to JCSDA code, infrastructure, and computing resources.

Riishojgaard reminded workshop participants that the first joint European Center for Medium Range Weather Forecasting (ECMWF)/JCSDA Workshop on Assimilating Satellite Observations of Clouds and Precipitation into Numerical Weather Prediction (NWP) Models is planned for June 15-17, 2010, in Reading, UK. There are also tentative plans for JCSDA to host the World Meteorological Organization's Global Observing System Impact Workshop in 2011.

Representatives of the JCSDA partner agencies then reviewed recent accomplishments at their organizations. Chairs of the JCSDA Working Groups on the Community Radiative Transfer Model, Microwave Sensors, Oceans, Land, and Atmospheric Composition, presented progress reports.

The second and third sessions featured 36 oral and poster presentations by JCSDA investigators. Session four consisted of breakout group discussions of the JCSDA science priority areas. In the final plenary, breakout group chairs summarized issues and recommendations to JCSDA management for their scientific areas.

Specific Highlights

The following are a sample of some of the interesting results presented at the workshop:

Will McCarty [NASA Goddard Space Flight Center (GSFC) —Global Modeling and Assimilation Office (GMAO)] and collaborators are conducting Observing System Simulation Experiments (OSSEs) to evaluate the impact of Doppler Wind Lidar Observations on weather forecasts in preparation for ESA's Atmospheric Dynamics Mission (ADM-Aeolus). Initial findings indicate reduced wind forecast errors throughout the troposphere and stratosphere.

Vince Wong and **Michael Ek** [NOAA—National Weather Service/National Centers for Environmental Prediction (NCEP)] showed that the use of a new 25-yr climatology of Green Vegetation Fraction (GVF) or real-time weekly global 0.144 x 0.144º GVF, both based on Advanced Very High Resolution Radiometer (AVHRR) observations, decreases surface temperature forecast biases over the continental US by about 0.6º C, a significant reduction.

Alexey Kaplan and **Mark A. Cane** [Lamont–Doherty Earth Observatory] presented a method to parameterize sea surface height errors from altimeter measurements in terms of sampling errors affecting grid box averages and verified the parameterization by comparisons with tide gauge records.

Banghua Yan [University of Maryland, College Park—Earth Science System Interdisciplinary Center] and collaborators evaluated assimilation of satellite microwave water vapor sounding channel data in NCEP's Global Forecast System (GFS). They found that an improved Quality Control (QC) scheme developed for Microwave Humidity Sounder (MHS) water vapor sounding channels resulted in more positive forecast impacts of Metop-A MHS water vapor data in the GFS. They also reported that assimilation of Special Sensor Microwave/Imager Sounder (SSMIS) water vapor sounding channel data, using an ice water path algorithm developed by Sun and Weng to check (ice) cloud-contaminated data, produced a positive forecast impact over the Northern Hemisphere (NH) from the F16 SSMIS Unified Preprocessor (UPP) water vapor data but had little impact over the Southern Hemisphere (SH).

Dan Birkenheuer and **Seth Gutman** [NOAA—Earth System Research Laboratory, Global Systems Division], in their poster presentation, reported progress in using data from the ground-based Global Positioning System-met total precipitable water network for calibration/validation of satellite retrievals of water vapor.

Copies of the oral presentations, poster papers, and breakout group reports from the workshop are posted at: *www.jcsda.noaa.gov/meetings_Wkshp2010_Agenda2.php*. ■

ESIP Federation Elects Three New Partners

The Federation of Earth Science Information Partners (ESIP Federation) has elected three new partners for full membership. This new class of applicants demonstrates the continued interest in the ESIP Federation from the broad continuum of Earth science data and technology interests.

The new partners include:

University of Delaware/Department of Geography Global Climate Data Resources (Type II)—University of Delaware, Newark, DE
Northrop Grumman Information Systems (Type III)—Aurora, CO
Sonoma Technology, Inc. (STI) (Type III)—Petaluma, CA

"The ESIP Federation continues to attract Earth science data and information experts to its membership. Our diversity and ability to work across disciplines, sectors, and federal agencies has enabled this community to advance in ways greater than the sum of its parts," says **James Frew**, ESIP Federation President. "The ESIP Federation's reputation is growing as the place for community-driven collaboration in the Earth sciences."

Now in its second decade, the ESIP Federation has 118 partners representing a wide range of Earth Science data interests. The ESIP Federation is a consortium of Earth science data and technology professionals spanning government (NASA, NOAA, EPA, USGS), academia, and the private sectors (both commercial and nonprofit). Initiated by NASA in 1997, the ESIP Federation provides data, products, and services to decision makers and researchers in public and private settings. For more information, please visit: *www.esipfed.org*.

Collaborative Energy and Water Cycle Information Services (CEWIS) Workshop: How to Tame the Flood of Hydrological Data and Datasets

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On June 15-16, 2010, the Goddard Earth Sciences Data and Information Services Center and **Jared Entin** [NASA Headquarters—*NASA Energy and Water Cycle Study (NEWS) Program Manager*] co-hosted a workshop on the use of expanding and proliferating data volumes and datasets related to Earth's intertwined global energy dynamics and water cycle. The workshop covered the data preparation challenges and roadblocks that NEWS investigators encounter when they perform research with multiple heterogeneous datasets, and aimed to acquire community insight regarding potential solutions to such challenges. The outcomes of the workshop and continuing community interest may warrant the need for an expanded workshop or meeting session in the future. (Presentations from the workshop are posted at: *disc.sci.gsfc.nasa.gov/water-cycle/CEWIS/cewis_workshop_presentations*.)

The workshop welcomed researchers from NASA Goddard Space Flight Center (GSFC), NASA/Jet Propulsion Laboratory (JPL), NASA Langley Research Center (LaRC), Massachusetts Institute of Technology (MIT), the University of Maryland – Baltimore County (UMBC), George Mason University (GMU), the National Science Foundation (NSF), the University of Maryland – College Park (UMCP), and the University of North Dakota (UND)—clearly indicating the broad scope of energy and water cycle science under the NASA umbrella.

After opening remarks, the workshop participants set the stage for future discussions by providing answers to three basic questions:

1. What steps do you take to gather and prepare data so that you can perform multi-dataset inter-comparisons?
2. What data-related roadblocks do you encounter when bringing heterogeneous datasets together?
3. Do you prefer to perform these services yourself or use services provided by others?

The answers to the first question indicated 19 different steps that might be performed just to prepare the data for analysis! For the second question, the scientists broke down the "roadblocks" into five major categories: data access, data characteristics, combining datasets (with eight different complexities noted), combined dataset verification, and dataset documentation. On the last question, several of the participants were accustomed to preparing the data themselves, but the majority of participants would prefer to have basic services done by others—particularly if dataset quality was maintained and documentation was complete.

Following this stage-setting exercise, the workshop attendees heard two informative presentations: the *Multi-Dataset Collection Research Scenario – Global Precipitation Climatology Project (GPCP) and TRMM Multi-satellite Precipitation Analysis (TMPA),* presented by **George Huffman** [GSFC] and the *Multi-Dataset Collection Research Scenario—Air France Flight 447 Case Study***,** given by **Zhong Liu** [GMU/GES DISC]. Huffman's presentation described how he and his colleagues had compiled the Global Precipitation Climatology Project dataset and the Tropical Rainfall Measuring Mission (TRMM) Multi-satellite Precipitation Analysis—with a detailed description of the numerous considerations and decisions required to create these datasets. Liu's presentation described how several different datasets—including data from the TRMM Microwave Instrument, the Atmospheric Infrared Sounder (AIRS) on Aqua, the Moderate Resolution Imaging Spectroradiometer (MODIS) on Aqua and Terra, and merged infrared data from geostationary meteorological satellites and the SeaWinds scatterometer on QuikScat—were all used to examine the fierce storm that led to the tragic crash of *Air France* Flight 447 over the Atlantic Ocean between South America and Africa.

After a break, **Steve Kempler** [GES DISC—*Head*], and **Bill Teng** [GES DISC/Wyle Information Systems] presented a possible vision for the future—the *CEWIS data portal* prototype. This live demonstration showed the potential types of tools and services that could be used to facilitate multi-dataset data preparation and analysis. The GES DISC's current discovery and distribution engine, *Mirador*, was used as the framework to host several different datasets that had been provided by several NEWS investigators. The *Giovanni* system enables data examination, and provides rapid insight into data characteristics. On the Portal landing page, links to *Mirador* and *Giovanni* were dynamically provided, depending on the dataset selected. In *Mirador*, four options were provided for NEWS Principal Investigators (PIs) to make their datasets searchable and accessible, three of which used state-of-the-art *OpenSearch* technology. For the prototype demonstration, the team created three instances of *Giovanni*—monthly, daily, and 3-hourly datasets. The demonstration showed examples of multi-dataset plot outputs from the 3-hourly instance. The Portal included a subset of the capabilities and services that could be leveraged for NEWS. As an example, Kempler demonstrated the ability of the Grid Analysis and Display System (GrADS) Data Server [GDS] to return a time-series for a given requested geographical point.

On the afternoon of the first day, the first of two breakout group sessions took place. One breakout group during this session was focused on *Modeling and Water Cycle Prediction*. **Mike Bosilovich** [GSFC—*Global Modeling and Assimilation Office*], and **Zhong Liu** [GMU/GES DISC] facilitated this discussion and **Christa Peters-Lidard** [GSFC—*Head of Hydrospheric and Biospheric Sciences Laboratory*] provided important points of discussion. The group formulated three detailed research scenarios. The first was the *LandFlux* scenario, where a global land flux dataset would be processed through the National Center for Computational Sciences (NCCS), accessing Modern Era Retrospective analysis for Research and Applications (MERRA) data and other CEWIS datasets. The question of high-speed data connections came up in this scenario. The second scenario was the *DataIntegrator* (kitchen sink), which would provide a means to validate models with a variety of datasets, most of them not sharing similar data characteristics and formats. The MERRA data subsetter provided by the GES DISC is a starting point for necessary software development related to this scenario. The third scenario was called *Routine Data Assimilation*, where land data and forcing data would be downloaded on a daily basis and provided to researchers.

A second breakout group focused its attention on *Energy and Water Cycle Climatology*—following the session break, this same group also considered *Evaporation and Latent Heating* (see below). These groups, led jointly by **Carol Anne Clayson** [Florida State University] and **Thomas Hearty** [GES DISC], synthesized their deliberations into a list of the common steps required to merge multiple datasets for research, emphasizing the need for flexible and comprehensive search capabilities, exemplary documentation, and useful analysis tools. One of the major roadblocks described was data formats: one participant stated that *"90% of the time is spent getting data into the right format."* Other participants expressed that it would be nice to see simple data maps prior to downloading large datasets, and that dataset searches should be robust enough to distinguish datasets that actually contain a parameter from datasets that merely mention a parameter.

These two breakout groups created two multi-dataset research scenarios:

- ***The "non-expert" user scenario***: In this scenario, the need is for a simple analysis tool to examine data, with the example identified as the TRMM Online Visualization and Analysis System (now incorporated into *Giovanni*). It would also be desirable to provide subsetting, reformatting, and visualization tools. Simplified access to documentation for the datasets, including metadata, was described as an important adjunct capability. Under this scenario, the group also explored the idea of providing usage guidelines based on dataset parameters, such as how to deal with discontinuous fields. They also felt it was important to provide standards for definitions and keyword searching. This scenario was clearly focused on *Level 3* gridded global datasets, potentially accessible at a single point from multiple data centers.

- ***The Level 2 Process Study scenario***: Recognizing that process studies tend to be regional and thus require higher spatial and temporal resolution data, the second scenario focused on utilizing higher resolution *Level 2* data, usually in satellite swath format instead of a gridded mapped format. The group felt that the most important step in this scenario would be the assembly of a process study dataset from multiple instrument datasets—and thus being able to search for such data by time and location would be an essential capability. The main technological challenge in this scenario was likely to be retrieving and then subsetting large data products according to the needs of the process study; it would also be important to maintain dataset integrity and a "chain-of-ownership" to acknowledge the authors of the data. Ultimately, for this scenario, a science processing system would generate the products and potentially utilize Web services (visualization tools, semantic descriptions) to intuitively describe relationships between data products.

Immediately after the session break, the entire CEWIS workshop heard **Eric Fetzer** [JPL] describe the creation of two hydrological datasets in a presentation entitled *Merged Atmospheric Water Dataset from A-Train and a Multi-Sensor Water Vapor Climate Data Record using Cloud Classification.*

After Fetzer's talk, came a second set of breakout sessions. The first group in the second breakout session examined considerations related to *Evaporation and Latent Heating*—this was the continuation of the group that met in the first breakout session and is described previously. The next group, led by **Baike Xi** [UND] and **James Acker** [GES DISC] was concerned with *Drought* *and Flood Extremes*. This group formulated five research scenarios that would utilize multiple datasets:

1. *Events within context:* This scenario would require multi-resolution analysis, scaling up to global dataset resolution;
2. *Events and Seasons:* This scenario would involve creation of comprehensive, cross-discipline datasets describing drought and flood events, or fully characterizing a season;
3. *Combined datasets:* This scenario would define monthly data with statistics based on daily data;
4. *New datasets:* This scenario would ingest new and relevant datasets, such as those for cryospheric data, oceanographic data, and climate indices [El Niño-Southern Oscillation (ENSO), Palmer Drought Severity Index (PDSI)]; and
5. *Points and Regions:* This scenario would utilize geostationary meteorological satellite data to make point data fully representational of an area.

The group made considerable progress on the first day of the meeting (as described previously), and spent the second day merging the reports from the breakout groups and formulating a set of potential next steps. Prior to this activity, **Baike Xi** presented a view of multiple dataset creation, entitled, *The Merged Surface and Satellite Observed Cloud, Radiation, and Precipitation Datasets*. Xi's presentation described how ground and space-based cloud, radiation, and precipitation data from the state of Oklahoma were combined, making a dataset applicable to validating satellite retrievals and improving model simulations. She described the use of several operations to combine datasets, including regridding, merging, co-registration, and correlation. The merged dataset provided a detailed view of hydrological processes occurring in the study area.

The summary discussions of the CEWIS workshop produced an extensive list of ideas for the next steps that could address the primary motivation for the workshop—e.g., dealing systematically with the large number and variety of applicable datasets being produced by NEWS investigators, as well as many other data sources that could provide products useful to the NEWS program. The ideas fell into four main categories: *Dataset Usability, User Access, Data Management Technology*, and *Long-Term Considerations*.

Under *Dataset Usability*, some of the items discussed included:

- Providing information on historical usage of datasets (e.g., peer-reviewed papers, whether a dataset has been used as input to another dataset), information on related datasets, and maps of dataset-to-dataset relationships (i.e., provenance).
- Widening the network bandwidth between NCCS and GES DISC.
- Defining and implementing data co-registration (e.g., pixel matching, common grid).
- Providing metrics on data usage.

With regard to *User Access*, the main considerations produced by the workshop were:

- Utilizing Mirador's gazeteer feature—field experiment names should be added to the gazeteer.
- Simplifying and shortening the OpenSearch results list.
- Providing the capability to run user code on the "data side" of energy and water cycle data archives.
- Creating usage guidelines for measurements vs. modeled outputs.
- Enabling data access latency for remote data as if it were located on a local disk.

The discussion of *Data Management Technology* emphasized the following four points:

- Providing usage guidelines, documentation, and context-sensitive information.
- Ensuring dataset maintenance (i.e., ensuring prompt/accurate update of documentation) following dataset updates.
- Maintaining standards on data description, documentation, and terminology.
- Expanding the CEWIS portal prototype to address the workshop scenarios.

A fair number of longer term questions and concepts were discussed that could lead to more accessible and usable energy and water cycle data. Such questions and concepts were:

- Maintaining and improving dataset documentation;
- engaging the NEWS community to assist in organizing datasets according to their requirements;
- determining how to query PIs regarding dataset questions;
- holding a second CEWIS workshop that would address available community wide multi-dataset research tools and services, and specifically focus on addressing the scenarios, issues, and roadblocks discussed in the first CEWIS workshop;
- reporting on the CEWIS workshop findings at a NEWS PI meeting;
- conducting a workshop at the American Meteorological Society annual meeting (or a 1-day minicourse), on NEWS dataset utilization;
- addressing data harmonization—i.e., quality analysis, data formats, incompatible resolution;

- potentially funding the development of operational systems;
- responding to the workshop scenarios, with cost estimates, etc. that could lead to implementation;
- having NEWS PIs provide prioritized lists of needed datasets, converging on a "Top 10" list;
- engaging the broader energy and water cycle community;
- further expanding data access services to datasets generated by all NEWS PIs, guided by advances in *OpenSearch* technology;
- formulating a Community Advisory Committee to seek community consensus on desirable tools and CEWIS type functionality direction; and
- establishing a series of mutually beneficial data and service exchanges with pertinent projects [e.g., The Global Energy and Water Cycle Experiment (GEWEX), NEWS, the Coordinated Enhanced Observing Period (CEOP)]. ■

New Edition of HITEMP Database Available

A new edition of the HITEMP database has now been placed on the anonymous *ftp* site at the Harvard-Smithsonian Center for Astrophysics Atomic and Molecular Physics Division. This new edition is described in the article, "HITEMP, the high-temperature molecular spectroscopic database," by L.S. Rothman, et al., 2010, *J. Quant. Spectrosc. and Rad. Transfer*, vol. **111**:2139-2150. The new HITEMP replaces the earlier edition ("HITRAN, HAWKS and HITEMP High-Temperature Molecular Database," L.S. Rothman, et al., 1995, *Proc. Soc. Photo Optical Instrumentation Engineers*, vol. **2471**:105-111).

To access the HITEMP data, please go to:

ftp://cfa-ftp.harvard.edu
User name = anonymous
Password = your e-mail address

Open the directory, cd /pub/HITEMP-2010. The directory contains five folders:

Folder	*Total number of transitions*
H_2O line list	114,241,164
CO_2 line list	11,167,618
CO line list	113,631
NO line list	115,610
OH line list	41,557

Due to the very large files for water and carbon dioxide, the line-parameter files within the H_2O and CO_2 folders have been broken up into wavenumber intervals and are also in compressed format (see *readme* file in top directory for a description).

The format of the line transitions is currently the same as HITRAN (160 characters per transition). Please cite the HITEMP article as well as the original sources of data when using this database.

For more information or questions regarding HITEMP, please contact **Laurence Rothman** at *LRothman@Cfa.Harvard.edu* or **David O'C. Starr** at *David.Starr@nasa.gov*. The HITRAN database can be accessed at: *www.cfa.harvard.edu/HITRAN/*.

Summary of the 37th Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Science Team Meeting

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The 37th ASTER Science Team Meeting was held at Ikebukuro Station Conference in Tokyo, Japan from June 8-11, 2010. ASTER Science Team members and members of other relevant teams attended the meeting. Participants heard reports on the status of the ASTER science project and the status of projects related to the ASTER project at the Opening Plenary. They then split up into working groups for more focused discussions about particular topics of interest. The reports from each working group were presented at the Closing Plenary.

Opening Plenary

H. Tsu [Earth Remote Sensing Data Analysis Center (ERSDAC)—*Japan ASTER Science Team Leader*] and **M. Abrams** [NASA/Jet Propulsion Laboratory (JPL)—*U.S. ASTER Science Team Leader*] made opening remarks, in which the achievements of the Global Digital Elevation Model (GDEM) were highlighted. **M. Kato** [ERSDAC] presented the meeting schedule.

W. Turner [NASA Headquarters] outlined the current status of NASA, including NASA's organization, future projects, and budget. Turner noted that in the budget allocation plan, greater emphasis is placed on Earth Science.

M. Abrams updated the team on the U.S. ASTER Team status. Abrams reported that an article on ASTER GDEM appeared in the April issue of *Photogrammetric Engineering & Remote Sensing*. Abrams then presented observations of three natural disaster events.

M. Ramsey [University of Pittsburgh] provided an update on the Mineral And Gas Identifier (MAGI), a whiskbroom airborne demonstrator sensor with 128 bands covering 7.5–13 μm spectral range. **B. Eng** [JPL] discussed the status of the Landsat Data Continuity Mission (a.k.a., Landsat 8). The spacecraft primary structure assembly is completed with launch scheduled for December 2012. A Thermal Infrared (TIR) instrument is also expected to be mounted, but the spacecraft will be launched without it if the development of the sensor is delayed. **S. Hook** [JPL] summarized the status of the planned Hyperspectral Infrared Imager (HyspIRI) mission and of the airborne Hyperspectral Thermal Emission Spectrometer (HyTES).

M. Kikuchi [Japan Resources Observation System and Space Utilization Organization (JAROS)—Instrument Team,] reported on the instrument status. Kikuchi spoke on the instrument lifetime management and radiometric calibration.

M. Hato [ERSDAC] reported on the Ground Data System (GDS) status. Hato gave an update of the production and distribution at GDS. He also reported on a change of operation working time and the Science Data Processing Segment (SDPS) replacement timeline.

D. Meyer [U.S. Geological Survey Land Processes Distributed Active Archive Center (USGS LPDAAC)] reported on the status of operation, distribution, science, and development at LPDAAC.

M. Fujita [ERSDAC] presented the Science Scheduling Support Group/Operations and Mission Planning (SSSG/OMP) report. Fujita discussed the observation status for Global Mapping (GM) and GDEM, and management of the pointing device lifetime.

To close the plenary, **Y. Yamaguchi** [Nagoya University] raised two points for further discussion in the working groups: status of GM, Night TIR GM and other Science Team Acquisition Requests (STARs) and GDEM update.

Working Group Sessions

Level 1/Geometric/Digital Elevation Model (DEM) Working Group

In the first half of the session, the validation results of ASTER Level 1 algorithm/software were presented. No appreciable problem was found. There was some discussion on the geolocation error of the nighttime TIR data. The cause of the error was not determined and will be further investigated. The second half of the session was devoted to the ASTER GDEM project. Firstly, **H. Fujisada** [Sensor Information Laboratory Corporation (SILC)] reported on the plan for GDEM version 2 (*v2*) generation. There will be some delay due to the Science Data Processing Segment (SDPS) update at GDS. Then, **D. Meyer** proposed the validation plan for GDEM *v2*. **B. Crippen** [JPL] presented the results of validation of GDEM *v2* (trial version). The topographic expression was much improved.

Radiometric Calibration/Atmospheric Correction Working Group

At the beginning of this session, the instrument team shared the results of onboard calibration. The radiometric database for both visible-near infrared (VNIR) and thermal infrared (TIR) needs to be updated. Following the instrument team's report, **K. Arai** [Saga University], **A. Kamei** [National Institute of Advanced Industrial Science and Technology (AIST)], **S. Biggar** [University of Arizona], **H. Tonooka** [Ibaraki University], **T. Matsunaga** [National Institute for Environmental Studies (NIES)], and **S. Hook** reported on the results of field campaigns and plans for future campaigns. Finally, **K. Arai** reported on future work, sensitivity degradation trend analysis, 10 years of vicarious calibration and recommendable radiometric calibration coefficient (and biases) for users. In atmospheric correction, **B. Eng** [JPL] gave a status report of current *Level-2* software.

Temperature-Emissivity Separation (TES) Working Group

A. Gillespie [University of Washington] presented a study of stripe noises of emissivity images particularly over lakes and oceans. **H. Tonooka** and **S. Hook** discussed the status of development of large-scale emissivity datasets. **H. Tonooka** reported on water temperature retrieval from the Lake Senba site and the method for small water bodies. **M. Fujita** presented the status of Night TIR Global Mapping and **H. Tonooka** reported on the update of cloud assessment.

Operations and Mission Planning (OMP) Working Group

A. Miura [ERSDAC] reported on the changes in ASTER Operations, namely, working time and updates on some parameters in the scheduler. **M. Fujita** reviewed the status of the fourth round of Global Mapping (GM4), Nighttime TIR Global Mapping, Underserved Area STARs, and Gap Filler STARs. GM4 is progressing well and likely to be accomplished in approximately three years. TIR Global Mapping will continue as it is for the time being. Underserved Area STARs will continue until the completion of GDEM *v2*. The observation resource was increased by a scheduling parameter update and divided appropriately. **H. Tonooka** presented results using a new cloud assessment method for identifying gaps in coverage. **K. Duda** [USGS] discussed the status of expedited data support. The website address to access the expedited data will remain not advertised.

STAR Committee

In the current process, STAR proposals require approval by two chairs. It was decided that approval would be granted by one chair and the review period would be reduced to one week from two weeks for prompt processing. Priority of the Global Land Ice Measurements from Space (GLIMS) STAR will be checked to ensure the GLIMS STAR acquisitions that will start in June.

Ecosystem/Oceanography Working Group

First, **T. Matsunaga** and **G. Geller** [JPL] reviewed action items and STAR status. Since the last ASTER Science Team meeting seven new STARs were submitted. After that, five project reports (Japan Biodiversity Observation Networks (J-BON), GEO Biodiversity Observation Networks, 100 Cities Project, Global Road and Human Settlements Mapping and Terra Look) and six research reports were presented.

Geology/Spectral Working Group

Action items and discussion items from the opening plenary were reviewed. Seven research activities, four in the fields of glaciology, and three in volcanology were presented. **D. Pieri** [JPL] gave an update of JPL ASTER Volcano Archive (AVA).

Closing Plenary

After the splinter sessions, the groups reconvened for a Closing Plenary to hear the outcomes of each working group session. **M. Abrams** announced that the next (38th) ASTER Science Team Meeting would be held in the U.S. December 6-9 and closed the meeting. ■

4th Global Precipitation Measurement (GPM) International Ground Validation (GV) Meeting Summary

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Introduction

The Global Precipitation Measurement (GPM) Mission [*Hou et al.*, 2008] is an international satellite mission designed to use both active and passive microwave remote sensors to unify and advance precipitation measurements by a constellation of satellites. The GPM constellation will consist of a network of satellites provided by a consortium of international and domestic space agencies including NASA, the Japanese Aerospace and Exploration Agency (JAXA), the Centre National d'Etudes Spatiales (CNES), the Indian Space Research Organization (ISRO), the National Oceanic and Atmospheric Administration (NOAA), and the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT). NASA and JAXA will deploy a reference satellite known as the "Core Observatory" carrying a Dual-frequency Precipitation Radar (DPR) and a GPM Microwave Imager (GMI) to be launched in July 2013. NASA will also provide a second GMI to fly on a partner-provided Low-Inclination Observatory (LIO) with a target launch date in late 2014. In support of both pre-launch algorithm development and post-launch product assessment, the GPM Mission has set in motion a variety of dedicated Ground Validation (GV) activities.

The GPM GV activity is designed around three basic approaches that provide verification of products, characterize uncertainties in satellite and ground-based precipitation estimates, and refine the physical assumptions used in the retrieval algorithms. These three approaches include: direct statistical validation of GPM precipitation estimates (e.g., use of large national networks to verify precipitation rates); physical validation of retrieval algorithms (i.e., assessment and testing of algorithm physics and physical assumptions); and integrated hydrologic validation of GPM products (i.e., assessment of product utility in hydrometeorology, water budget studies, and numerical weather prediction as a function of scale and application).

To support the pre-launch phase of international GPM GV activities, the 4th GPM International Ground Validation Workshop was held in Helsinki, Finland, June 21-23, 2010. The meeting, hosted by the Finnish

Photo Credit: John Kwiatkowski [George Mason University, NASA GSFC]

Meteorological Institute (FMI) in coordination with NASA, featured 50 oral presentations and two poster sessions and was attended by 90 participants from 18 countries. Additional information about the workshop and all presentations can be found at: *gpm.fmi.fi.*

This 4th GPM GV Workshop represents the latest in a series of international ground validation meetings. The first three meetings took place in Chilbolton, UK (2003); Taipei, Taiwan (2005); and Buzious, Brazil (2008). Through this series of meetings, GPM has developed a framework for international cooperation and established numerous international GV science projects jointly with the NASA Precipitation Measurement Missions (PMM) Program.

The technical objectives of the 4th Workshop were to:

- Report science results from current GV projects;
- clarify linkages between GV measurements and algorithm needs;
- propose recommended GV practices and uncertainty characterization; and
- discuss innovative methods for integrated hydrological validation and applications.

Discussion and planning of the Light Precipitation Validation Experiment (LPVEx) field campaign, taking place September–October 2010 in Helsinki, illustrated both the scientific progress and significance of GV for the success of the GPM mission and broader scientific community. Current GV activities and specific accomplishments of this workshop are described below.

Connecting GV measurements to algorithm needs

Direct Validation

The workshop participants heard multiple presentations on the continued international efforts to identify significant discrepancies between satellite products and ground-based measurements, with a focus on high-latitude validation.

Chris Kidd [University of Birmingham, UK] introduced the challenges of detecting light rainfall and snowfall in high latitudes (beyond 60° N) given the dearth of surface GV coverage at these latitudes. Kidd emphasized the importance of high-latitude precipitation in the water cycle and the need for better coverage and characterization of precipitation retrievals.

Christian Klepp [Meteorological Institute, Clisap, University of Hamburg] presented on high-latitude precipitation validation over the ocean and **Ralf Bennartz** [University of Wisconsin] discussed validation efforts over land. Both researchers identified existing challenges in accurate microphysical characterization and snowfall retrievals and introduced several current and future projects to improve GV coverage.

Tuomo Lauri [Finnish Meteorological Institute (FMI)] outlined the major error sources of ground-based radar and gauge snowfall measurements, noting that wind drift and wind-induced gauge errors are most significant. He also discussed how to minimize these errors for improved *in situ* snowfall observations.

David Hudak [Environment Canada] described the challenges associated with making direct or remotely-sensed snowfall measurements from both gauge and radar instruments due to the intrinsically complex scattering of snow caused by variations in their shape, size, and water-phase properties.

Gail Jackson [NASA Goddard Space Flight Center (GSFC)] discussed the current status of satellite-based snowfall retrieval algorithms for the GPM mission, citing the challenge of extracting falling snow signatures from "background" contributions in Brightness Temperature (T_b) values and providing a summary of recommendations for needed GV measurements of snow and precipitation phases.

There were also status reports of direct GV activities from the network of international projects, including representation from:

- ***South Korea,*** **Mi-Lim Ou** [National Institute of Meteorological Research];
- ***Israel,*** **Efrat Morin** [Hebrew University of Jerusalem];
- ***Argentina,*** **Paola Salio** [Centro de Investigaciones del Mar y la ATmosfera (CONICET) UBA];
- ***Ethiopia,*** **Mekonnen Gebremichael** [University of Connecticut], **Shuji Shimizu** [Japan - JAXA/EORC);
- ***Finland,*** **Jarkko Koskine**n [FMI]; and
- ***Spain,*** **Francisco Tapiador** [University of Castilla-La Mancha (UCLM)].

Each presenter described the development and framework of their national observational networks of gauges, radar, and disdrometers in their respective nations and discussed promising results on radar reflectivity and instrument inter-comparison as well as potential GPM application activities.

Physical Validation

The workshop also focused on GV measurements for physical validation, seeking to provide a translation between GV measurements, algorithm inputs, and physical assumptions associated with the use of the inputs. Several meeting participants stressed the importance of accurate modeling and verification of microphysical properties and associated remote-sensing signatures. Specific topics included collaboration in radar/radiometer simulator development and improved characterization and analysis of the multi-dimensional properties of drop and snow size distributions (DSD) and how they may impact retrieval algorithms in different regimes. Discussion topics included assumptions regarding beam-filling corrections, the vertical profile of the rain DSD, appropriate integration times or spatial resolutions for comparison to satellite products, the ability of dual-frequency retrieval algorithms to extract salient features of the snow and rain DSD at DPR pixel, and gate-spacing scales.

Christa Peters–Lidard [GSFC] described an example of innovative physical validation using improved surface emissivity characterization to better estimate satellite retrievals. **Francisco Tapiador** [UCLM] presented new results suggesting that rain DSD variability can be quantified using a high-density network of Parsivel disdrometers.

Chris Kummerow [Colorado State University] and **Walt Petersen** [NASA Marshall Space Flight Center (MSFC)] described a variation of the physical validation approach based on *hypothesis testing*. In this framework, hypothesis testing begins with an *a priori* set of satellite algorithm assumptions that can be systematically adjusted or modified (e.g., the assumed rain rate profile) to attain consistency between measurement constraints (e.g., a given brightness temperature and radar reflectivity used in a combined radar-radiometer retrieval). The job of ground validation in this instance is to then confirm that the algorithm parameter has been or can be modified in a physically consistent fashion based on the results of GV information.

Chris Kummerow further described how hypothesis testing can be less computationally intensive and more efficient in identifying inaccurate assumptions in algorithm parameterizations, including rain DSD, ice retrieval, and cloud water retrievals. **Robert Meneghini** [GSFC] described how hypothesis testing may be used to determine solutions for DSD estimates and identify precipitation phase states given DPR retrievals. The final day of the workshop featured a discussion on hypothesis testing and transforming the framework into guidelines for GV measurements. **V.N. Bringi** [Colorado State University] described a robust bootstrapping methodology for using both disdrometer and C-band polarimetric radar to retrieve characteristic DSD behavior as a function of meteorological regime in both northern Alabama and northern Australia.

Jussi Leinonen [FMI] demonstrated the use of C-band dual-polarimetric radar data in combination with W-band CloudSat information over the Helsinki testbed to regenerate realistic profiles of radar reflectivity at Ka- and Ku-band frequencies. This methodology may be employed for creating a Ka–Ku band reflectivity database for DPR algorithms using future field campaign datasets. **Alessandro Battaglia** [University of Leicester] presented ADvanced MIcrowave RAdiometer for Rain Identification (ADMIRARI) radiometer and micro-rain radar measurements from both Germany and Brazil. These results demonstrated the promise of passive polarimetric radiometer partitioning of cloud from rainwater in light-raining mid-latitude clouds. However, based on recent Pre-CHUVA (Portuguese for 'rain') field campaign results from Brazil, Battaglia also illustrated new challenges for remotely retrieving the cloud and rainwater contents in tropical warm rain situations using ADMIRARI.

Recommended GV practices and characterization of uncertainties

A common theme among the presenters was the identification of error sources associated with ground-based precipitation retrievals and the importance of accurately characterizing the uncertainties and biases of each monitoring system. Several presentations described standard practices for GV such as setting tolerances for radar and radiometer equipment and scanning control for research radar. **V. Chandrasekar** [Colorado State University] is currently working to develop a "best practices" plan for ground radar calibration and suggested several simple calibration activities for research radar such as metal sphere and sun calibration. **Luca Baldini** [National Research Council, Institute of Atmospheric Science and Climate (ISAC)] discussed recommended practices for radar scanning and emphasized the need for "community accepted" standards and protocols to maintain data and metadata quality.

Ali Tokay [Joint Center for Earth Systems Technology/NASA] compared the results of several types of disdrometer and rain gauge instruments, concluding that differences exist between the various instruments at small drop sizes but can serve as a valuable network for GPM field campaigns. Within the context of measurement errors and GV, **Witold Krajewski** [University of Iowa] outlined a design for test sites to provide a proof-of-concept demonstration of how retrieval error methodologies can be implemented to characterize uncertainties in gauge, ground radar, and satellite precipitation estimates. Results of the recommended practices discussions will be synthesized and presented at the annual PMM meeting in early November.

Integrated hydrological application and validation

The workshop departed from the discussion of instrument-based GV to discuss how to better understand the space-time scales at which satellite precipitation data are useful for hydrologic applications as well as how these studies may be useful for validation. **Ana Barros** [Duke University] presented a water budget study in the Great Smokey Mountains area, identifying what was known about water budgets in the past and pointing to the level of detail (in the form of good GV) that is needed for accurate hydrological models to model flow and small-scale processes. **Christa Peters-Lidard** described how land-surface models may also be used as a validation tool, employing satellite products in hydrological models to characterize errors and pinpoint uncertainty through forward and backward modeling.

Field campaign design and implementation

Field campaigns related to the GPM Mission are intended to move GV activities forward and better understand precipitation microphysics and variability in the context of satellite retrievals. A planning meeting took place the day following the workshop to discuss the LPVEx field campaign (a collaboration between CloudSat, GPM, the Finnish Meteorological Institute, and Environment Canada), which will occur in the vicinity of Helsinki for six weeks in September and October 2010. The field campaign is intended to characterize the ability of CloudSat (*cloudsat.atmos.colostate.edu*) and other passive microwave (PMW) sensors to characterize the microphysical characteristics of light rainfall and to evaluate their estimates of rainfall intensity in high-latitude land and ocean environments characterized by shallow freezing levels. The experiment also seeks to increase understanding of liquid and ice microphysics along with melting layer microphysics in order to improve GPM pre-launch algorithm development. The field campaign will focus on ground radar, disdrometer and gauge instrumentation networks designed around the Helsinki testbed and will employ detailed *in situ* airborne sampling (U. Wyoming *King Air*) with possible coordination of satellite overpasses. Additional information on the LPVEx field campaign can be found at *lpvex.atmos.colostate.edu*.

The overarching themes of the field campaigns center on five main objectives:

- Coordinating high-altitude and *in situ* airborne sampling;
- performing high resolution sampling of DSD and rain rates;
- creating three-dimensional (3-D) profiles of the solid, liquid, and mixed and melting layer phases of precipitation using radar, profiler, and disdrometer estimates
- accurately sampling land-surface radiance and backscatter from both the air and ground; and
- creating a coupled database of cloud-resolving models, land surface models, and radiative transfer models for testing and validation of satellite retrievals.

As discussed by **Walt Petersen,** there are several future field campaigns to address various aspects of precipitation microphysics, ground retrievals, and latitudinal differences in precipitation sensing. These campaigns include:

NASA-Department of Energy (DOE) MC3E: (April–June 2011). ARM CF N. Oklahoma. Focus: *Mid-latitude continental precipitation retrievals*

NASA-EC-CloudSat Cold Season Experiment: (January–February 2012). EC CARE Facility, Ontario, Canada. Focus: *Snowfall retrieval algorithms*

NOAA–NASA Hydrometeorological Testbed-Southeast: (August–September 2013). Tar/Neuse River Basins, North Carolina. Focus: *Integrated validation* [preliminary discussion phase]

Conclusions

The presentations and discussions at this workshop represented a marked step forward in developing GV practices, outlining existing uncertainties, and drawing a more direct linkage to how GV can help improve algorithm development. The presenters noted that some challenges remain with retrievals, including the issues of light rainfall over oceans, complex terrain, land-surface impacts, and snowfall; however, advancements in DPR and radiometer retrievals may help to fill some of these gaps. The discussion of recommended practices for GV activities as well as the establishment of scattering tables to relate radar and radiometer retrievals may help to decrease errors and improve uncertainty estimates and algorithm functionality. The workshop concluded with a set of action items, which will be developed and presented at the next PMM Science Team Meeting taking place November 1– 4, 2010 in Seattle, WA.

References:

Hou, A. Y., G. Skofronick-Jackson, C. D. Kummerow, and J. M. Shepherd. 2008. Global precipitation measurement. In *Precipitation: Advances in Measurement, Estimation, and Prediction* (Ed. Silas Michaelides), Springer-Verlag, 131-169.

Advanced Microwave Scanning Radiometer for EOS (AMSR-E) Meeting

Elena Lobl, AMSR-E Science Team Manager, Earth System Science Laboratory, University of Alabama, Huntsville, AL, Elena.lobl@nsstc.uah.edu

The Advanced Microwave Scanning Radiometer for EOS (AMSR-E) Science Team Meeting took place in Huntsville, Alabama, June 2-3, 2010. Even though the Japanese AMSR team has been absorbed by the Global Change Observation Mission-Water (GCOM-W1)/AMSR2 Science Team, quite a few Japan Aerospace Exploration Agency (JAXA) scientists and support team attended. The meeting was, as always, beneficial: we exchanged information about new research and algorithm updates, as well as introduced the new near-real-time processing at the AMSR-E Science Investigator-led Processing System (SIPS) [called Land, Atmosphere Near-real-time Capability for EOS (LANCE)] and Instant Karma, a new project that is collecting provenance for AMSR-E products. All presentations made at the meeting are available at the NASA AMSR-E home page: ***www.ghcc.msfc.nasa.gov/AMSR****. To visit the JAXA Aqua/AMSR-E page, please go to:* ***www.jaxa.jp/projects/sat/aqua/index_e.html****.*

After the introduction by Science Team Leaders **Roy Spencer** [University of Alabama, Huntsville (UAH)] and **Akira Shibata** [JAXA], **Rama Ramapriyan** [Goddard Space Flight Center (GSFC)—*Earth Science Data and Information System (ESDIS) Project*] spoke about LANCE. LANCE was initiated by NASA Headquarters in order to ensure the availability of near-real-time products to users that need these type of data for decision support. Thus far, there are four near-real-time systems within NASA processing data—from the Atmospheric Infrared Sounder (AIRS), Microwave Limb Sounder (MLS), Ozone Monitoring Instrument (OMI), Moderate Resolution Imaging Spectroradiometer (MODIS), and AMSR-E. One of the main goals of these systems is to deliver data products within three hours of observation. These data products will be available from the different processing facilities. Data will be available for five to seven days after processing. Many more details about LANCE are available in Ramapriyan's presentation on the AMSR website.

Dawn Conway [UAH—*Lead Software Engineer at the Team Lead Science Computing Facility (TLSCF)*] described the changes that were made to the different processing algorithms in the last year. One of the changes in the AMSR-E products list was the deletion of the sea ice temperature product and the introduction of the sea ice drift product. This product was deemed important by users of AMSR-E sea ice data at a sea ice symposium more than four years ago. At the moment, the algorithm for this new product is in integration and test at the TLSCF. This product will be in its *Beta* version at the AMSR-E SIPS by the end of the year.

Kathryn Regner [UAH—*System Engineer at the Science-led Investigator Processing System,Global Hydrology Climate Center (SIPS-GHCC)*] reviewed the planned, third-generation hardware configuration, which will lead to a much greater flexibility for processing and reprocessing. AMSR-E processing has been progressing very smoothly, with just a couple of new algorithm updates. Regner then presented the status of the AMSR-E LANCE project, which is co-located with the AMSR-E SIPS. This facility will have two fully redundant processing and distribution strings, at separate locations, and on separate networks; a seven day rolling archive, with *Level 0* (*L0*) data ingested directly from the EOS Data and Operations System (EDOS). *Phase 1* of AMSR-E LANCE was completed at the end of June 2010. *Phase 1* included preliminary validation, initial user registration, and authentication and collection of metrics. *Phase 2* (July and August 2010) was the implementation of the initial near-real-time capability on both strings. *In Phase 3* (September 2010 to January 2011), the latest AMSR-E algorithms will be implemented using the new *Level-2A* (*L2A*) algorithm from Remote Sensing Systems.

Amanda Leon [National Snow and Ice Data Center (NSIDC)—*AMSR-E Lead*] presented the status of the distribution of archived science and validation data. Leon reviewed the four ways to access data from NSIDC: the Warehouse Inventory Search Tool (WIST), Data Pool, Data Subscriptions, and Preliminary Data. Thus far, there have been 18 terabytes of AMSR-E data archived with a total distribution to date of 330 terabytes. A majority (59%) of the users are foreign.

Hiroshi Sasaki [JAXA] presented the status of the first GCOM-W1 and its only payload: the AMSR2. GCOM-W1 passed the system *Critical Design Review* (*CDR*) in October 2009. The AMSR2 flight unit has been integrated on the spacecraft and is undergoing system tests. GCOM-W1 will become part of the *A-Train* (immediately ahead of Aqua) when it is launched in November 2011—see **Figure 1**.

The improvements made to AMSR2 are: a larger reflector (2 meters), an additional channel for Radio Frequency Interference (RFI) mitigation (7.3 GHz), an improved warm calibration load, and a redundant mo-

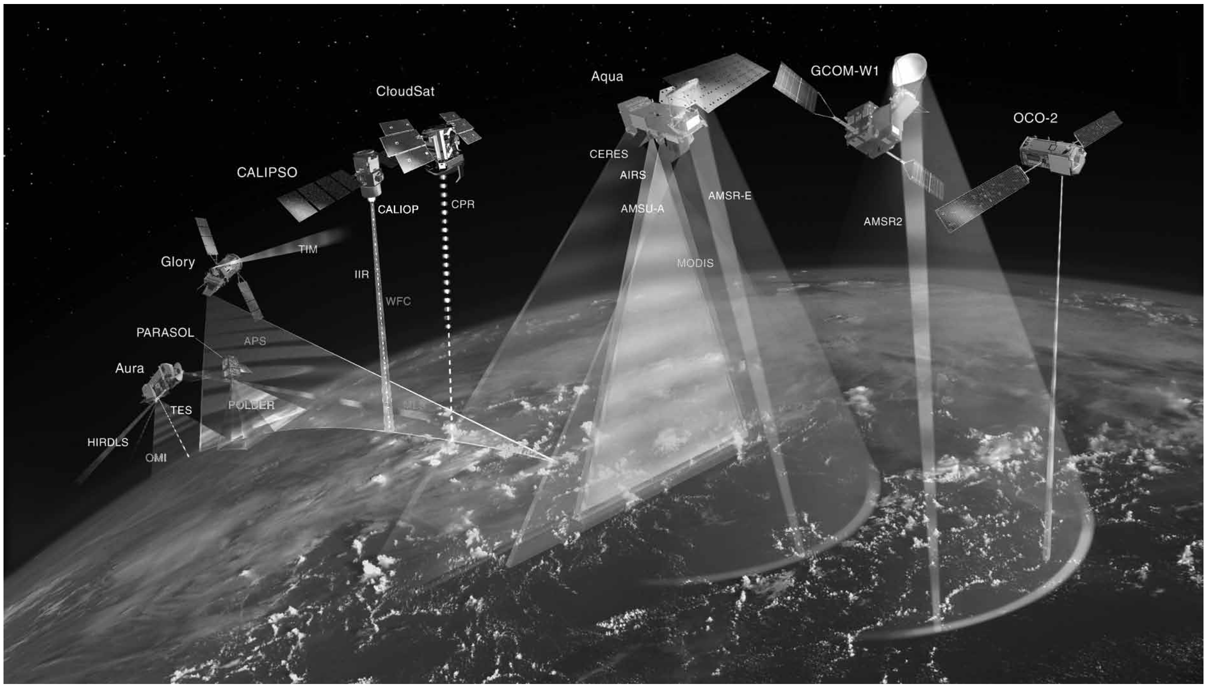


Figure 1. This *A-Train* graphic shows all the current missions and instruments in the formation. (Since December 2009, PARASOL has been slowly drifting out and exits completely by 2012.) It also depicts the three planned additions to the A-Train by 2014: Glory, GCOM-W1, and OCO-2.

mentum wheel. Access to the AMSR2 data will start at launch plus three months for the Research and Development (R&D) or operational organizations that have a cooperative agreement with JAXA, and launch plus one year for all other users.

In the presentation that followed, **John Christy** [UAHe—*Director of Earth System Science Center (ESSC)*] addressed issues with building climate datasets from various sources.

Following that, the team heard about a new project that has the AMSR-E SIPS involved with Indiana University, called *Instant Karma*. The presentation was jointly given by **Beth Plale** [Indiana University—*Director of Data to Insight Center*], and **Helen Conover** [UAH—*Information Technology and Systems Center*]. The main objective of this tool is to improve the collection, preservation, utility, and dissemination of provenance information within the NASA Earth Science community. The *Instant Karma* project aims to collate most of the provenance information already available scattered across multiple locations. For more detail on this project, please see the Conover/Plale presentation on the AMSR-E website.

The science presentations started with **Chris Kummerow** [Colorado State University (CSU)] discussing the latest changes to the Goddard Profiling algorithm (GPROF), which is the AMSR-E standard *Level 2* rainfall algorithm. This new algorithm—GPROF 2008—is a *Bayesian Inversion* algorithm, with the pixels classified by background sea surface temperature (SST) and total precipitable water (TWP). GPROF 2008 does not have rain screens and no convective/stratiform separation. The input to this algorithm is a database created with the Tropical Rainfall Measuring Mission (TRMM) precipitation radar (PR)/passive microwave (TMI) and cloud models. The outputs are surface precipitation, structure, and probability of precipitation.

Matt Lebsock [CSU] followed with a study that showed the possibility of limiting the ratio between precipitation to cloud water in liquid clouds. The main application of this finding is improving the GPROF 2008 database.

Tom Wilheit [Texas A&M University] briefly discussed rain retrievals at an ice edge and the intercalibration of different radiometers.

Ralph Ferraro [National Oceanic and Atmospheric Adminstration (NOAA)/National Environmental Satellite, Data, and Information Service (NESDIS)] provided updates to the rainfall over land algorithm. Ferraro's work in the past year has involved reducing the warm season bias by improving the temperature/rain rate relationship, and improving the convective/stratiform separation. Long-term goals are developing a generic land surface characterization for inclusion in future GPROF algorithms, and restructuring the existing GPROF databases for different rainfall regimes.

Grant Petty [University of Wisconsin-Madison] reviewed the validity of Jan Mayen Island as a high-latitude ocean precipitation validation site. Even including both a wind and an orographic correction, the observations obtained from the island's World Meteorological Organization (WMO) gauge can still only be used to provide qualitative information about the precipitation on Jan Mayen.

Richard Kelly [University of Waterloo, Ontario—*Interdisciplinary Centre on Climate Change*] presented the recent AMSR-E snow validation activities. Kelly presented results obtained from observations taken at three distinct areas in the world: Yukon Field (2007-08 and 2008-09), the U.K. (2009 and 2010), and Churchill, Canada (2009-10). The findings from these field experiments were: (1) mountain terrain in the Yukon made obtaining accurate field data challenging, which led to combining satellite data and models in order to map snow accumulation in this area; (2) the RFI existing at 10 gigahertz (GHz) over the U.K. made it necessary for the algorithm to avoid using this frequency; (3) the adjusted algorithm will likely produce retrievals with reduced sensitivity; and (4) the capability to test seasonal changes exists at the Churchill site, which together with models will provide insight into snow retrievals.

Gabrielle De Lannoy [GSFC] presented on work she has done with **Rolf Reichle** in the assimilation group**.** They are both working on the assimilation of AMSR-E products in models showing better analysis skill, for both soil moisture and snow water equivalent.

Steven Chan and **Eni Njoku** [both Jet Propulsion Laboratory (JPL)] work on the AMSR-E standard soil moisture algorithm. Chan presented the variability the AMSR-E soil moisture products have shown since launch. The monthly soil moisture time-series model, based on autoregression, showed a correlation better than 0.6 over 85% of global land area.

Jean-Luc Moncet [Atmospheric and Environmental Research, Inc. (AER)] talked about the estimation of land surface temperatures from AMSR-E observations. This estimate starts with the AER-developed dynamic surface emissivity atlas, which only works in non-precipitating conditions. Moncet showed some issues with the microwave-derived land surface temperature when compared with MODIS products. He is implementing corrections due to dew on vegetation, surface penetration in desert regions, and possible incorrect calibration of the AMSR-E data. Other planned corrections are the open water correction and the refinement of the quality control (snow/RFI flags, surface classification, dew index).

Akira Shibata discussed the application of the AMSR wind speed algorithm to retrieve the WindSat wind vector, employing the observed Stokes 3rd/4th parameter. This scheme works well for winds greater than 7 m/s; more work is needed to obtain wind direction for slower winds.

Marty Brewer [Remote Sensing Systems (RSS)] presented three different topics: validation of atmospheric water vapor and cloud liquid water, intercalibration of AMSR-E and WindSat brightness temperatures over tropical forest scenes, and an update of the AMSR-E observed RFI. Carl Mears [RSS] has done the validation analysis. He has used radiosondes, and ground Global Positioning Systems (GPS) stations for the atmospheric water vapor *in situ* data. All of these data have some detracting issues. In the case of the cloud liquid water, there are no *in situ* data; **Thomas Meissner** validated the data using statistical analyses. One main conclusion is that the measured brightness temperature can be directly compared to the temperature obtained over dense tropical rainforest scenes with a relatively simple radiative transfer model (RTM). In the AMSR-E case, it seems that this comparison yields relatively good results (most channels are well calibrated) except for both polarizations of the 18.7 GHz channel.

Yuji Taniguchi [Mitsubishi Space Software Co., Ltd.] under the direction of Akira Shibata, has looked at a different method to handle the RFI occurring at the lower frequency channels (6.9, 10.7, and 18.7 GHz). Taniguchi showed that the RFI shows up in the calibration load counts/voltage, which can be removed, resulting in corrected brightness temperatures.

Keiji Imaoka [JAXA] showed that the RFI at 6.9 GHz is clearly due to "human utilization of the radio spectrum." He concludes that, "*Static (fixed) RFI mask does not work for C-band RFI over land…"* The plans for mitigating the RFI in AMSR2—the next Japanese microwave radiometer—are to keep the 6.925 GHz channel (for continuity of SST data) and add another channel at 7.3 GHz. This new frequency was shown to be RFI-free in an airborne field experiment along the coast of Japan.

Roy Spencer described how the AMSR-E measurements can be used to estimate cloud feedbacks over the global oceans. Spencer started the presentation with the same premise he has used in several of his recent papers: "temperature change => cloud change has been confused with cloud change => temperature change." **Figure 2** shows how global warming in models is greatly magnified by positive cloud feedback.

John Kimball [University of Montana, Flathead Lake Biological Station] presented the means for development of a global land parameter database for terrestrial ecosystem studies using AMSR-E data. This database is available from NSIDC (*nsidc.org/data/nsidc-0451.html*).

Masahiro Kazumori [JMA] reviewed the recent activities utilizing AMSR-E data at the Numerical Prediction Division of JMA. Activities range from verifying

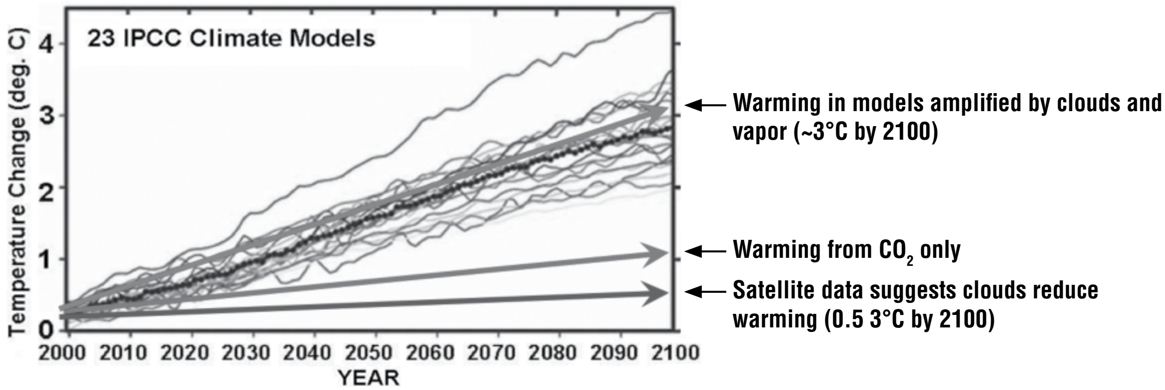
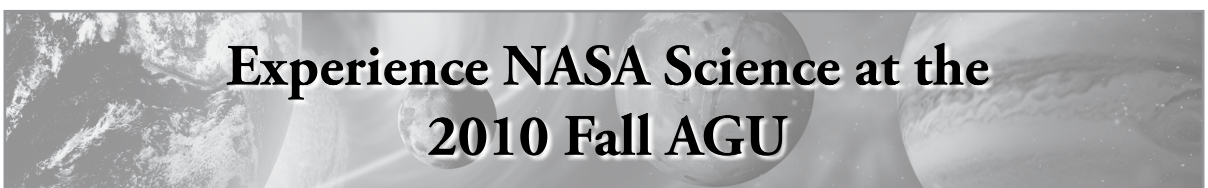


Figure 2. Global warming in models is greatly magnified by positive cloud feedback.

the total precipitable water (TPW) retrievals with ground-based GPS TPW data, to the assimilation of retrieved TPW and Rain Rate (RR) from the Special Sensor Microwave Imager/Sounder (SSMIS) in JMA's Meso-Scale Model (MSM).

The meeting was adjourned with no distinct plans for future meetings; all members are awaiting the results of the latest Terra/Aqua Research Opportunities in Space and Earth Sciences (ROSES) competition. ■



Please join us at the NASA booth (#111) during this year's Fall Meeting of the American Geophysical Union (AGU), where we will offer a wide variety of science presentations, demonstrations, and tutorials for a variety of data tools and services. This year's exhibit will feature a *hyperwall*—a dynamic, interactive, nine-screen display that will showcase a variety of different NASA Science datasets throughout the week.

This year's program begins on Tuesday, December 14 and will continue through Thursday, December 16, 2010. There are sixteen different programs and missions scheduled to participate—representatives from Dryden, Ames, Jet Propulsion Laboratory, Goddard, Langley, and Wallops are expected.

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

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

We look forward to seeing you in San Francisco!

NASA Embarks on a Hurricane Quest

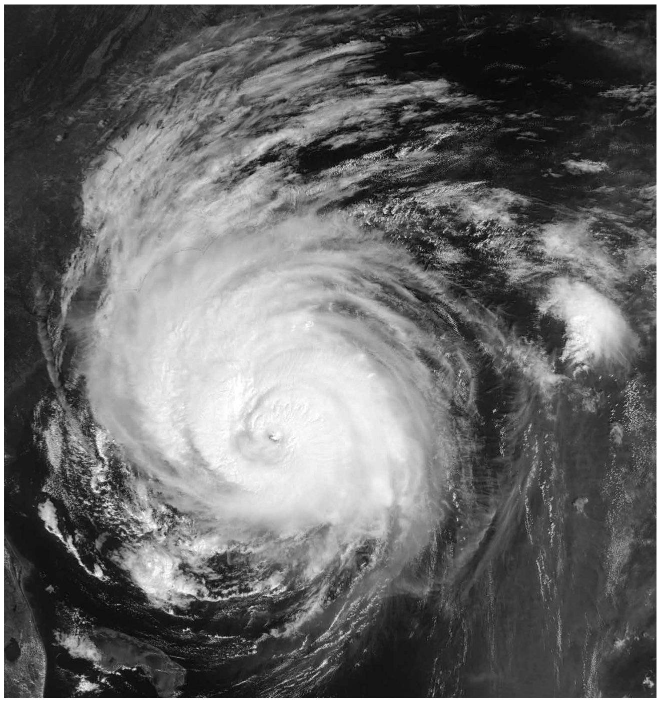
Patrick Lynch, NASA's Earth Science News Team, Goddard Space Flight Center, patrick.lynch@nasa.gov

NASA scientists have begun a quest for the "holy grail" of hurricane research.

The exact conditions required to kick-start a tropical depression into a hurricane largely remain a mystery. Though scientists know many of the ingredients needed, it is unclear what processes ultimately drive depressions to form into the intense, spinning storms that lash the U.S. coasts each summer.

"Hurricane formation and intensification is really the 'holy grail' of this field," said **Ed Zipser**, an atmospheric scientist at the University of Utah and one of three program scientists helping to lead the Genesis and Rapid Intensification Processes (GRIP) field experiment this summer.

With GRIP, NASA's first domestic hurricane project since 2001, the agency has assembled the largest-ever hurricane research experiment to investigate these questions. Three NASA planes, multiple NASA satellites, and four planes from research partners the National Oceanic and Atmospheric Administration (NOAA) and the National Science Foundation (NSF) will combine to make unprecedented measurements of tropical storms as they are forming (or dying out) and intensifying (or weakening). The intense scientific focus on these meteorological processes could provide new insight into the fundamental physics of hurricanes and ultimately improve our ability to forecast the strength of a storm at landfall. Predictions of hurricane strength continue to lag behind the accuracy of storm track predictions, but accurate predictions of both are needed for the best possible preparation before landfall.



NASA scientists have recently concluded an intense, six-week research investigation into how hurricanes—like Hurricane Earl, pictured here—form and how they often rapidly intensify. This hurricane image was captured on June 30, 2010 by the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument onboard NASA's Terra satellite. **Image credit:** NASA

With each aircraft outfitted with multiple instruments, scientists will be taking a closer look at hurricanes with hopes of gaining insight into which physical processes or large-scale environmental factors are the key triggers in hurricane formation and intensification.

The GRIP fleet includes NASA's *Global Hawk* (the unmanned drone built by Northrop Grumman and also used by the U.S. Air Force), WB-57, and DC-8. The NASA aircraft will be deployed from Florida (DC-8), Texas (WB-57), and California (*Global Hawk*) and will fly at varying altitudes over tropical storms in an attempt to capture them at different stages of development.

"One of the potential data-gathering breakthroughs of GRIP could be to continuously observe a tropical storm or hurricane for 24 hours straight, by including aircraft from all three agencies," said GRIP Project Manager **Marilyn Vasques**. The *Global Hawk* alone could fly continuously over a storm system for up to 16 hours.

While geostationary satellites used for forecasting can observe the basic movement of a storm across the Atlantic, these aircraft instruments will be able to "see" below the cloud-tops and uncover what is happening in the internal structure of the storm.

"That's what makes this really unique, the ability to observe one of these storms up close as it changes over its life-cycle. Before we've only been able to get a few hours of data at a time," Vasques said. "We want to see storms that become hurricanes, and we want to see some that don't become hurricanes, so we can compare the data. The same is true for hurricane intensification."

"When you think of analyzing it later, we want to break down what the temperatures were, what the winds were doing, what the aerosol concentration was, to see if we can start detecting a pattern," Vasques said.

Gerry Heymsfield [*pushing cart*] and **Lihua Li** prepare to integrate the High-Altitude Imaging Wind and Rain Airborne Profiler (HIWRAP) instrument on NASA's *Global Hawk* this week in advance of the Genesis and Rapid Intensification Processes (GRIP) hurricane experiment. Heymsfield is a GRIP project scientist and HIWRAP principal investigator; Li is a Goddard Space Flight Center engineer. The *Global Hawk*'s extended flight range will allow scientists to make continuous measurements over changing tropical storms and hurricanes of an unprecedented length. **Image credit:** NASA's Dryden Flight Research Center

The variety and number of instruments will allow scientists to investigate multiple science questions at once:

- What role does dust from the Sahara play in hurricane formation?
- Can lightning be used as a predictor of a storm's change in intensity?
- Do widespread environmental conditions such as humidity, temperature, precipitation, and clouds lead to cyclone formation, or are smaller-scale interactions between some of these same elements the cause?

Scientists at NASA and the many academic and government research partners in GRIP are excited to put several new state-of-the-art hurricane observing instruments in the field. A powerful microwave radiometer and a radar will provide insight into the massive *hot towers* of convection found in cyclones, and a NASA-designed and built *lidar* (laser radar) will provide the first-ever measurements of wind speed in three dimensions—not just east, west, north and south, but also vertically.

These instrument advancements, in addition to the deployment of the *Global Hawk* in a major Earth science campaign for the first time, have NASA scientists anxious to take to the field.

"This is one of the most exciting points in my career," said **Ramesh Kakar**, GRIP Program Manager and lead of NASA's recently formed Hurricane Science Research Team. "Satellites can only get a brief glimpse of what is happening inside a hurricane, and we get very excited about seeing that. Now imagine if you could watch a storm unfold for 20 hours."

The ability to keep an eye on developing storms for that length of time will largely depend on a complex deployment of the various planes, from different locations, at different times, and at different altitudes. The NASA planes have different flight ranges, with the DC-8 able to fly for eight hours, the WB-57 for four hours and the *Global Hawk* for 30 hours. Those flight ranges include the time required to get to the storm and back to home base.

"In general, when the aircraft are deployed to study potentially developing hurricanes, they will fly a basic grid pattern over the weather system," Zipser said. "Ideally this pattern will be repeated on consecutive days. Once planes are flying over an established hurricane, they'll fly repeatedly over the eye of the storm and covering its breadth, creating somewhat of an asterisk pattern centered on the eye. Flights on consecutive days will deliver the best cache of data on how the storm changed over time."

Flights began on August 15 and will last until September 25. ■

HIWRAP is a new, advanced radar instrument that will allow NASA scientists to measure surface winds above the ocean inside a hurricane. **Lihua Li** [*left*], Goddard Space Flight Center engineer, **Steve Crowell** [*sitting*], Northrop Grumman mechanic; and **Ken Wilson** [*kneeling*], NASA's *Global Hawk* crew chief, worked earlier this week to integrate the HIWRAP instrument onto NASA's *Global Hawk*. HIWRAP is one of 14 instruments that will be deployed on three NASA aircraft during GRIP. **Image credit:** NASA's Dryden Flight Research Center

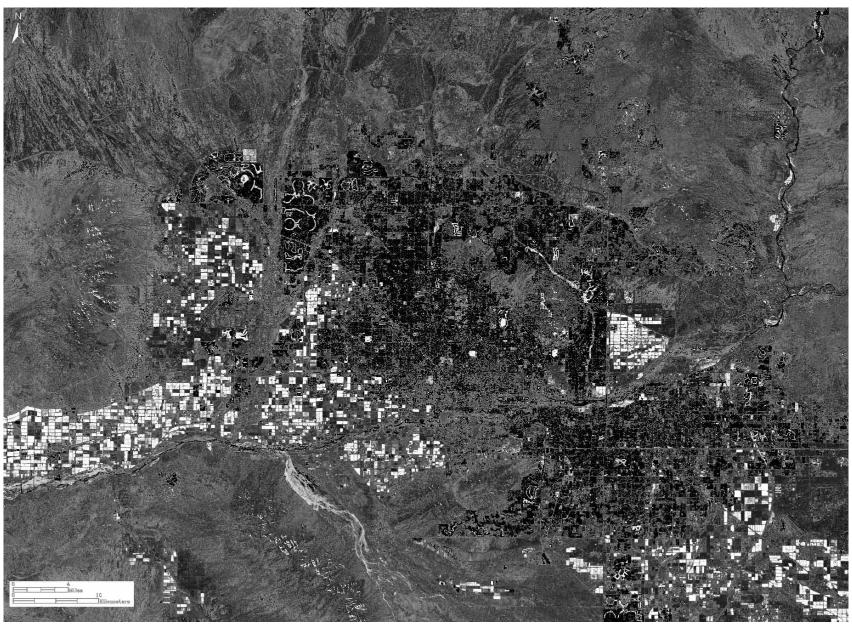
NASA Assets Provide Orbital View to Study Phoenix Heat Waves

William Jeffs, NASA Johnson Space Center, william.p.jeffs@nasa.gov

Where you live may say a lot about your socioeconomic status. It also may suggest how vulnerable you are to long periods of excessively hot weather.

Researchers at NASA's Johnson Space Center (JSC), Arizona State University (ASU) and the University of California at Riverside are studying the relationship between temperature variations and socioeconomic variables across metropolitan Phoenix. They have found that the urban poor are the most vulnerable to extreme heat.

Those in higher incomes tend to live in areas that are cooler due to the increased amount of vegetation, such as lush lawns and canopy trees, that surrounds homes or on higher-elevation hillslopes above the hotter Salt River valley floor. The urban poor tend to live in the urban core of metro Phoenix where the heat island effect is intense. These neighborhoods are located near industrial areas, commercial centers, and transportation corridors. There are few amenities, such as parks, and the landscaping has little or no grass or trees.



Multiple endmember spectral mixture analysis of Landsat Enhanced Thematic Mapper Plus data is being used to obtain historical per-pixel abundances of soil/pervious surface (medium tones), vegetation (lightest tones), and impervious surface (darkest areas) land cover endmembers for the Phoenix metropolitan area. This example uses data acquired July 24, 2000. Land cover endmember abundances provide the ability to "fine tune" urban climate models, which in turn are used to understand the historical development of the Phoenix urban heat island and to build predictive and spatially discrete models of risk from extreme heat events across the urban area. To view this image in color, please visit: *www.nasa.gov/topics/earth/features/phoenix_heatwaves_feature.html.* **Image credit:** NASA

Propelled by a $1.4 million grant from the National Science Foundation as part of its Dynamics of Coupled Natural and Human Systems Program, the research team is compiling a history of the development of the metro Phoenix urban heat island. Urban heat islands result when existing soil and grass is replaced with materials such as asphalt and concrete that absorb heat during the day and reradiate it at night, thus causing increased temperatures especially during nighttime.

Sharon Harlan, a sociologist in the School of Human Evolution and Social Change at ASU, has pulled together the interdisciplinary team, which is comprised of social and natural scientists, public health experts, and educators.

Harlan is excited about the potential for this pioneering research.

"The problem of heat-related deaths and illnesses is very serious," said Harlan. "Each year, heat fatalities in the U.S. occur in greater numbers than mortality from any other type of weather disaster. Global climate changes and rapidly growing cities are likely to compound and intensify the adverse health effects of heat islands around the world. Our research is integrating data with sophisticated modeling tools to analyze urban systems while keeping health equity considerations and the well-being of vulnerable populations at the center of attention. We want our research to be used to promote better decision-making about climate adaptation in cities."

The primary objective of the research is to study *high heat wave events*—unexpected long-duration heat waves. Many cities including Chicago, Phoenix, and Paris have encountered these events over the past several years.

Data from numerous sources, including remotely sensed imagery from NASA, are being used to create an historical record of how temperatures and vegetation patterns changed across metro Phoenix from the early

1970s to 2000. **William Stefanov**, senior geoscientist with Jacobs Technology in JSC's Astromaterials Research and Exploration Science Directorate, is providing the orbital view of the metropolitan area.

The remotely sensed information is collected from satellites or airplanes and includes vegetation, temperature, and land cover. Together it provides a map of the urban and suburban surface at a moment in time—see example in image on page 49. In addition, researchers will use the data to do what is called *change detection analysis*. Images from one year or one season can be compared with those from another. The changes, such as those in vegetation, can be highlighted.

"We're using a series of Landsat data for historical vegetation and surface temperature, high-resolution airborne imagery to get detailed maps of the land cover in our study neighborhoods and the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) on board NASA's Terra satellite, for current surface temperature data," said Stefanov.

An airborne data flight over Phoenix by the NASA MODIS/ASTER Simulator (MASTER) sensor is planned for next year to coincide with a ground data collection campaign. Among other biophysical information, high-resolution measurements of ground surface temperature will be obtained from the MASTER data throughout the metropolitan area to compare with and validate other airborne and satellite datasets used in the project.

According to several global climate change models, the Southwestern U.S. is predicted to experience higher temperatures and more droughts over the coming century. If that happens, Phoenix is expected to experience more heat wave events.

The remotely sensed data are fed into high-resolution urban climate models to build predictive simulations of what will happen to the Phoenix metropolitan area if predicted climate change occurs there. Maps of *riskscapes* produced by this project will show where people in Phoenix are most vulnerable to high heat events.

"This project has theoretical aspects, but it also has an applied focus," said Stefanov. "We are trying to develop tools that city planners and emergency responders can use. Urban planners also can use this data so that they can help plan the city's growth and perhaps replace materials that absorb heat with those that are more reflective."

"A lot of urban development is taking place around the world in arid or semiarid climates," said Stefanov. "By studying Phoenix, researchers can better understand what these developing cities may face and how their environments may change as populations expand."

For more information on the project, visit *http://shesc.asu.edu/node/552.*

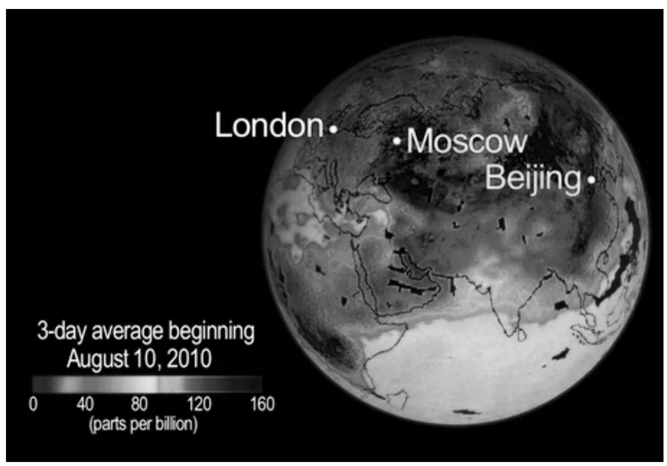
Data provided by the United States Geological Survey EROS Data Center, Sioux Falls, S.D. This material is based upon work supported by the National Science Foundation (NSF) under Grant No. GEO-0816168, "Urban Vulnerability to Climate Change." Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the NSF.

NASA Data Shows Global Reach of Pollution from Russian Fires

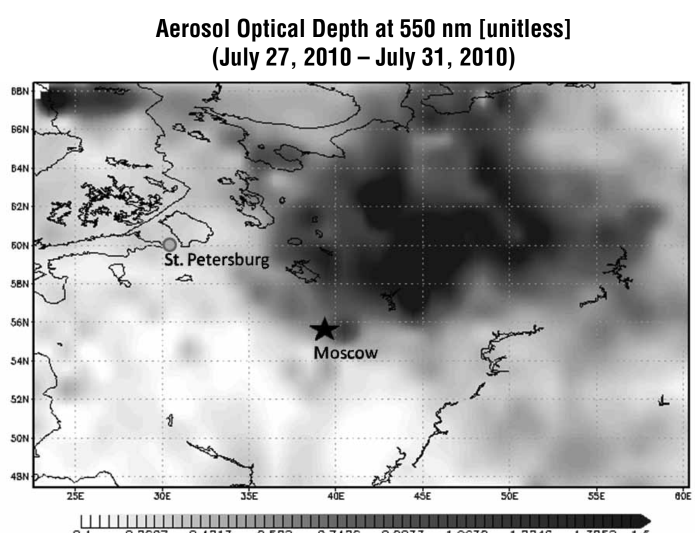
Alan Buis, NASA Jet Propulsion Laboratory, Alan.buis@jpl.nasa.gov

A series of large wildfires burning across Western and Central Russia, Eastern Siberia, and Western Canada has created a noxious soup of air pollution that is affecting life far beyond national borders. Among the pollutants created by wildfires is carbon monoxide (CO), a gas that can pose a variety of health risks at ground level. CO is also an ingredient in the production of ground-level ozone, which causes numerous respiratory problems. As the CO from these wildfires is lofted into the atmosphere, it becomes caught in the lower bounds of the mid-latitude jet stream, which swiftly transports it around the globe.

Two movies were created using continuously updated data from the *Eyes on the Earth 3-D* feature on NASA's global climate change website: *climate.nasa.gov/*. They show three-day running averages of daily measurements of CO present at an altitude of 18,000 ft (5.5 km), along with its global transport. The data are from the Atmospheric Infrared Sounder (AIRS) instrument on NASA's Aqua spacecraft. AIRS is most sensitive to CO at this altitude, which is a region conducive to long-range transport of the smoke. The abundance of CO is shown in parts per billion, with the highest concentrations shown in yellows and reds. The first movie, centered over Moscow, highlights the series of wildfires that continue to burn across Russia. It covers the period between July 18–August 10, 2010. The second movie is centered over the North Pole and covers the period from July 16–August 10, 2010. From this vantage point, the long-range transport of pollutants is more easily visible. AIRS is managed by NASA's Jet Propulsion Laboratory, under contract to NASA. JPL is a division of the California Institute of Technology in Pasadena. More information about AIRS can be found at: *airs.jpl.nasa.gov*. ■



Frame from *Eyes on the Earth 3-D* feature showing carbon monoxide (CO) concentrations on August 10, 2010. The darkest areas on the globe indicate the highest concentrations of CO. To view the animation in color, please visit: *www.jpl.nasa.gov/video/index.cfm?id=924.*



Aerosol optical depth (AOD) data at 550 nm from the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor on the EOS Aqua satellite, showing the extent of smoke from central Russian wildfires. The MODIS data were averaged over the five-day period July 27–31, 2010, with *Giovanni*. Smoke aerosols appear to be rising into the atmosphere and drifting aloft away from the fires, so that the thickest aerosol cloud lies considerably northwest of the source of the smoke. To view this, and other images from the Russian wildfires in color, please visit: *disc.sci.gsfc.nasa.gov/gesNews/russian_fires_july_2010.*

EOS Scientists in the News

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

Bill Patzert on Hurricane Alex and 2010 Hurricane Season, July 2; *EarthSky.* EarthSky spoke with research climatologist and oceanographer **Bill Patzert** (NASA JPL) about how Hurricane Alex ushered in what some scientists say might be a busy 2010 Atlantic hurricane season.

ICESCAPE, July 4-28; *Scientific American.* **Haley Smith Kingsland** (Stanford University) wrote a series of blog posts from the field describing the science and life aboard NASA's shipborne mission to the Arctic this summer—see Blog Log on page 19 of this issue for more details.

16,000 Feet Under the Sea: Deepest Hydrothermal Vent Discovered, July 21; *Discover.* Scientists including **Chris German** (Woods Hole Oceanographic Institute) and **Max Coleman** (NASA JPL) studied three hydrothermal vents, found along an underwater ridge in the Caribbean called the Mid-Cayman Rise.

Supercomputer Predicts Cyclones 5 Days Ahead, July 22; *MSNBC.* Researcher **Bo-wen Shen** (University of Maryland College Park) employed a supercomputer housed at NASA's Ames Research Center in Moffett Field, CA, to predict the birth of a cyclone five days in advance, a first for storm-modeling that might improve forecasting and emergency preparedness.

New Map Details Height of the World's Forests, July 26; *USA Today.* **Michael Lefsky** (Colorado State University) used data from three NASA satellites—ICESat, Terra and Aqua—to create the first map that details the height of forests across the entire globe.

***NASA Readies Hurricane Study**, August 2; *Daily Press*. Engineer **Michael Kavaya** (LaRC) is part of the Genesis and Rapid Intensification Processes (GRIP) mission to explore basic unresolved questions about hurricanes. Among them: How do tropical storms form? And how do they become major hurricanes?

Why is Climate Change Still Doubted? August 9; *Countdown with Keith Olbermann*. **Jay Zwally** (NASA GSFC) puts the break up of Greenland's Petermann Glacier in context with climate change.

Ground Shaken by Mexico Quake Still Moving, August 9; *msnbc.com/OurAmazingPlanet.* **Andrea Donnellan** (NASA JPL) is the principal investigator of a project that uses radar from an uninhabited aerial vehicle to map and assess seismic hazards in Southern California, which found that the 7.2-magnitude earthquake that rocked the American Southwest and Mexico's Baja California in April is continuing to deform the ground there.

NASA Drone Will Fly Into Hurricanes to Look at Lightning, August 9; *space.com/OurAmazingPlanet.* **Ramesh Kakar** (NASA HQ) and **Richard Blakeslee** (MSFC) explain how the Lightning Instrument Package (LIP), a high-tech flight instrument to be flown on the remotely piloted *Global Hawk* airplane, will track and document lightning as hurricanes develop and intensify.

***Urban Poor Most Vulnerable to Extreme Heat**, August 11; *International Business Times*. **Sharon Harlan** (Arizona State University) and **William Stefanov** (NASA JSC) evaluated the relationship between temperature variations and socioeconomic variables across metropolitan Phoenix, revealing that urban poor are the most vulnerable to extreme heat, while the higher income people tend to live in areas that are cooler.

Science and Climate Change, August 11; *National Public Radio.* **Claire Parkinson** (NASA GSFC) spoke with NPR's **Kojo Nnamdi** about the science behind our changing environment and about her work studying the globe's sea ice.

JPL Scientists Track Russian Fire Pollution, Consider Broader Impact, August 13; *sgvtribune.com.* Using the Atmospheric Infrared Sounder (AIRS) instrument aboard NASA's Aqua satellite, scientists including **Ralph Kahn** (NASA JPL) and **Thomas Painter** (NASA JPL) are tracking the flow of pollutants from Russia's wildfires high in the Earth's atmosphere.

State of the Union With Candy Crowley, August 15; *CNN*. **Tom Wagner** (NASA HQ) answers questions from CNN anchor **Candy Crowly** about what

NASA and other federal agencies are doing to try to understand how the planet, particularly North America, is going to change.

***Global Hawk* Turns Sights on Hurricanes**, August 16; *Florida Today*. Program scientist **Ramesh Kakar** (NASA HQ) explains how a drone's hawk-eye view of cyclones is expected to boost hurricane research through the stratosphere.

Plant Growth Declines as Warming Causes Drought, August 19; *Associated Press*. NASA-funded research by **Steven Running** (University of Montana) and **Maosheng Zhao** (University of Montana) found a drought-related decline in plant growth from 2000–2009, as temperatures continued to climb.

Death Valley Mystery: What Makes Rocks Wander, August 23; *msnbc.com/Our Amazing Planet*. **Brian Jackson** (NASA GSFC) has been studying a section of California's Death Valley, home to a strange phenomenon: Rocks that litter the landscape seem to move on their own, leaving long trails behind them in the cracked, bone-dry clay.

Researchers Race to Catch Up With Melting, Shifting Polar Realities, August 16; *The New York Times*. **Robert Bindschadler** (NASA GSFC/UMBC) explains what could happen to the Petermann Glacier after it calved an ice island four times the size of Manhattan earlier this month.

El Niño has Grown More Intense and Shifted Westward in Last Three Decades, Data Show, August 27; *Los Angeles Times*. New research by **Tong Lee** (NASA JPL) and colleagues show that El Niño has doubled in intensity and warmth and shifted westward over several decades.

Interested in getting your research out to the general public, educators, and the scientific community? *Please contact Kathryn Hansen on NASA's Earth Science News Team at khansen@sesda2.com and let her know of your upcoming journal articles, new satellite images, or conference presentations that you think the average person would be interested in learning about.*

*See news article in this issue.

announcement

Make Plans Now to Attend the 34th International Symposium on Remote Sensing of Environment

Sydney Convention and Exhibition Centre, Sydney, Australia
April 10-15, 2011

The ISRSE provides a unique opportunity for remote sensing practitioners, scientists, system engineers and policy makers to share their knowledge and gain an excellent coverage of the current status of a range of remote sensing applications and developments now critical for the sustainability of the Earth's environment. More details will be forthcoming about NASA's involvement, but begin making plans now to join us in Sydney! For more detailed information please visit: *www.isrse34.org/default.asp*.

NASA Science Mission Directorate – Science Education Update

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"Know Your Earth" Takes NASA To The Movies

The *Know Your Earth* project is a venture between NASA's Earth observing missions and National CineMedia. NASA has released two short videos that are playing on television screens in almost 300 movie theater lobbies across 41 states. The videos, which played throughout the month of July, emphasize that while NASA's well known for space exploration, it also studies our home planet.

The first video, *Know Your Earth*, shares a series of fascinating facts about how climate change affects oceans, land, the atmosphere, and ice sheets around the world. The three-minute video explains how NASA's Earth observing satellite fleet helps scientists gather accurate data to understand those changes. The second video, called *NASA Reveals a Most Unusual Planet*, runs 30 seconds and uses dramatic, high-tech space animations to show that NASA has uncovered the most unusual planet in the known universe—Earth.

A website (*www.nasa.gov/topics/earth/features/KnowYourEarth.html*) features links to free downloadable versions of the videos for use in classrooms, science centers, and by the general public. It also includes information on each of the satellite missions involved in the project and how each makes a significant scientific contribution in our understanding of climate change.

2010 GLOBE Xpedition to the Roof of Africa

Join the second Xpedition of GLOBE students, alumni, and scientists on a *GLOBE Africa and Seasons and Biomes* trek to the summit of Mt. Kilimanjaro, as they observe firsthand the shifting biomes and shrinking glaciers of the mountain. The nine-day trek may be followed online. New features to the website include 3D Google Earth Tours of the mountain, as well as daily video blogs that include updates and GLOBE protocol demonstrations. For more information, please visit: *www.globe.gov*.

NASA Blast Back to School

NASA offers educational resources for use with kindergarten through college, as well as resources for the informal education community. Many of NASA's educational products are quick and easy to find on the NASA website. Visit the NASA *Blast Back to School page* to find educational resources and NASA events taking place in your area. From the site, you can find information on NASA *Explorer Schools* and the NASA *Summer of Innovation*, opportunities for students and educators, homework topics, NASA teaching materials, and other helpful resources. For more information, please visit: *www.nasa.gov/audience/foreducators/blast-back-to-school-2010.html*.

***Climate.nasa.gov* Introduces New Features**

NASA's climate website, *climate.nasa.gov*, has introduced three new features:

- **Interview Series**: features ongoing interviews with climate researchers at Goddard, Langley, and the Jet Propulsion Laboratory on climate science topics;
- **Facebook Page**: allows you to stay up-to-date on climate change through Facebook—*en-gb.facebook.com/pages/NASA-Climate-Change/353034908075*; and
- **Expanded Educational Resources**: contains a new section listing professional development opportunities for educators, and a new section featuring selected climate education resources.

Tour of the Electromagnetic Spectrum

The website, *missionscience.nasa.gov/nasascience/ems_full_video.html*, includes eight video clips, ranging from approximately 3-5 minutes, that explain the different types of electromagnetic waves, connections to various NASA satellite science missions and the data each collects. ■

EOS Science Calendar

November 1–4, 2010
Precipitation Measurement Mission Science Team Meeting, Seattle, WA.

November 3–5, 2010
NASA Sounder Science Team Meeting, Marriott, Greenbelt, MD. URL: *airs.jpl.nasa.gov/meetings/science-team-greenbelt/*

November 8–10, 2010
Sea Surface Temperature Science Team Meeting, Crowne Plaza Seattle Hotel, Seattle, WA. URL: *depts.washington.edu/uwconf/sst2010/*

November 11–12, 2010
GRACE Science Team Meeting, Potsdam, Germany.
URL: *www.csr.utexas.edu/grace/GSTM/*

December 6–9, 2010
ASTER Science Team Meeting, Pasadena, CA

Global Change Calendar

October 25–28, 2010
International Symposium on the A-Train Satellite Constellation 2010, Sheraton Hotel, New Orleans, LA.
URL: *a-train-neworleans2010.larc.nasa.gov/*

November 3–5, 2010
GEO VII Plenary Session, and GEO Ministerial Summit, Beijing, China. URL: *www.earthobservations.org/meetings/geo7.html*

November 15–18, 2010
VI International Conference on Forest Fire Research, Coimbra, Portugal. URL: *www.fire.uni-freiburg.de/course/meeting/2010/1st_announcementICFFR.pdf*

November 16–20, 2010
2010 National Association for Interpretation National Interpreters Workshop, Las Vegas, NV.
URL: *interpnet.com/workshop/*

November 29–December 10, 2010
Sixteenth Conference of the Parties, (COP16)
Cancun, Mexico.
URL: *cc2010.mx/en/*

December 13–17, 2010
American Geophysical Union Fall Meeting,
San Francisco, CA.
URL: *www.agu.org/meetings/fm10/*

January 23–27, 2011
American Meteorological Society 91st Annual Meeting, Seattle, WA. URL: *www.ametsoc.org/meet/annual/*

January 27–28, 2011
International Year of Chemistry (IYC), Opening Ceremony: *Chemistry—Our life, Our future*, UNESCO HQ, Paris, France. URL: *www.chemistry2011.org/*

April 10–15, 2011
34th International Symposium on Remote Sensing of Environment (ISRSE): *The GEOSS Era: Towards Operational Environmental Monitoring*, Sydney, Australia.
URL: *isrse34.org/*

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