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Editor's Corner

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A valued member of the Earth Observing System (EOS) and the Terra team is leaving NASA. **Marc Imhoff**, the Terra Project Scientist since 2005, is departing after a 32-year career at the Goddard Space Flight Center (GSFC) to become Deputy Director of Pacific Northwest National Laboratory's Joint Global Change Research Institute (located at the University of Maryland, College Park). Imhoff's other EOS involvement included being Instrument Manager for the EOS Project Office in the late 1980s and an EOS Interdisciplinary Science Team Member. From 2001 to 2004 he served as the Earth System Science Pathfinder Program Project Scientist. Imhoff's research has spanned studies of vegetation, to targeting malaria vector breeding habitats in the tropics, to developing one of the first satellite-based methodologies to assess the vulnerabilities of populations to climate change and food production. We are grateful to Imhoff for his many years of service to NASA and the EOS, and wish him all the best in his new endeavor.

Kurtis Thome will be succeeding Imhoff. Thome came to GSFC in 2008 from a tenured position in the College of Optical Sciences at the University of Arizona, with an expertise in the vicarious calibration of solar reflectance imagers. With a doctorate in atmospheric sciences, he was part of the original EOS calibration/validation (cal/val) effort serving as a member of the science team for both the Moderate Resolution Imaging Spectroradiometer

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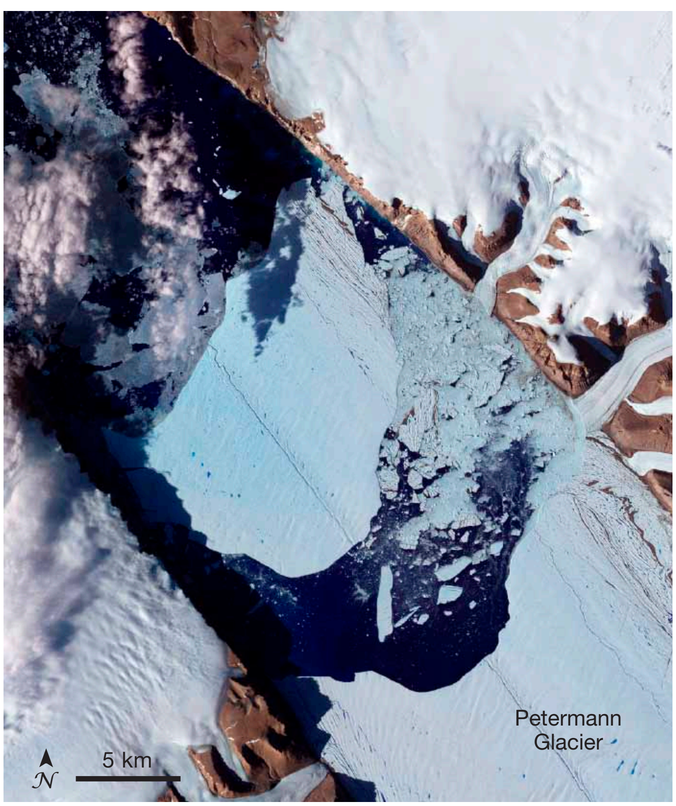

In July 2012, a massive iceberg broke free of the Petermann Glacier in northwestern Greenland. The iceberg—named PII-2012—covered an area of about 12.5 mi² (32.3 km²), and calved along a rift on the glacier that had been visible in satellite imagery for several years. On July 21, the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) instrument on NASA's Terra satellite captured this detailed image of the iceberg as it drifted away from the Peterman glacier toward Nares Strait.

Satellite imagery later revealed that the iceberg was still intact on August 31, but had started to fragment by September 4. On September 13, the iceberg and two smaller fragments could be seen drifting through Nares Strait between Greenland and Ellesmere island. **Credit:** NASA's Earth Observatory eos.nasa.gov

In This Issue

Reminder: To view newsletter images in color, visit: *eospso.gsfc.nasa.gov/eos_homepage/for_scientists/earth_observer.php*

(MODIS) and Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER). He has worked closely with the instrument teams for those sensors as well as the instrument teams for Landsat, the Multi-angle Imaging Spectroradiometer (MISR) on Terra, and several NASA airborne facility imagers (e.g., MODIS Airborne Simulator, MODIS/ASTER Airborne Simulator). Thome's NASA instrument science team experience also includes Earth Observing-1, Landsat-7, and the Suomi National Polar-orbiting Partnership (NPP). He also serves as the Instrument Scientist for the Visible/Infrared Imager–Radiometer Suite (VIIRS) on Suomi NPP, calibration lead for the Thermal Infrared Sensor (TIRS) on the Landsat Data Continuity Mission, and the Deputy Project Scientist for the Climate Absolute Radiance and Refractivity Observatory (CLARREO) mission. With his broad science and instrument experience, Thome is an excellent fit to continue leading the successful multi-instrument and multi-disciplinary Terra mission. Please join me in welcoming Thome to his new position.

October 28 will mark the first anniversary of the launch of Suomi NPP, a partnership between NASA and the National Oceanic and Atmospheric Administration (NOAA). The mission provides a link between several key instruments that are part of the current generation of EOS missions and the next generation Joint Polar Satellite System (JPSS). Suomi NPP instruments are all working well and sending back important new data about our home planet. **Page 16** of this issue contains an article that presents a sampling of what Suomi NPP has accomplished so far as it pioneers the path forward to JPSS.

Meanwhile, progress continues toward developing two of the *Tier 1* missions called for in the Earth Science Decadal Survey[1]. NASA's Soil Moisture Active Passive (SMAP) mission is on schedule to launch in October 2014. SMAP will fly an L-band radiometer and L-band radar that share a 6-m rotating mesh antenna, producing a fixed incidence angle conical scan at 40° across a 1000-km swath and a 2-3 day global revisit to provide high-resolution, frequent revisit global mapping of soil moisture and freeze/thaw state for science and application users. By combining data from these two instruments, SMAP will produce a soil moisture product at the intermediate resolution of 9 km. SMAP data will be used in a variety of applications of national significance ranging from agriculture to human health.

[1] The 2007 National Research Council (NRC) Decadal Survey report, *Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond*, provides the basis for the future direction of NASA's space-based Earth observation system.

SMAP successfully passed its mission level Critical Design Review this past July. At the same time, NASA Headquarters (HQ) announced the selection of the Delta II launch vehicle for SMAP. On the science side, SMAP, along with its Canadian partners, just completed the 2012 SMAP Validation Experiment (SMAPVEX12), a field campaign that took place in Winnipeg, Manitoba, during which six weeks of aircraft microwave data and associated ground truth were acquired to be used in refining retrieval algorithms for SMAP products. The status and performance of these retrieval algorithms will be reviewed during SMAP's ninth Science Definition Team Meeting at the NASA/Jet Propulsion Laboratory in October. In November SMAP will host its third community Calibration/Validation Workshop in Oxnard, California, in part to discuss plans for a cal/val rehearsal campaign prior to launch involving SMAP's global cal/val partners. Finally, solicitation of proposals for the SMAP Science Team has been announced[2], with proposals due in February 2013.

NASA's second Ice, Cloud, and land Elevation Satellite (ICESat–2) is a next-generation laser altimetry mission scheduled for launch in 2016, and designed to monitor changes in ice sheet elevation, sea ice thickness, and vegetation height. The spacecraft passed its Preliminary Design Review (PDR) in September, and as we go to press, the team is preparing for the mission PDR in October. ICESat-2 will use a measurement strategy called photon-counting, which uses low-energy pulses of green light and single-photon sensitive detectors. In order to develop ICESat–2 algorithms and verify instrument models, the project developed an airborne simulator: the Multiple Altimeter Beam Experimental Lidar (MABEL). MABEL flies on NASA's ER-2 and has completed a month-long polar science deployment to Iceland (April 2012) and recently completed an ecosystem campaign in the Eastern U.S. operating out of Goddard's Wallops Flight Facility. To learn more about ICESat-2 and MABEL, please read the feature article on **page 4** of this issue.

[2] This solicitation is contained in the latest Research Opportunities in Space and Earth Science (ROSES) Announcement of Opportunity.

NASA's Earth Science Data and Information System (ESDIS) project has been working with several EOS science and instrument teams to develop methods for assigning Digital Object Identifiers (DOIs) to various EOS data products. Most readers are probably already familiar with DOIs for identification of publications and other documents. More generally, a DOI is a unique, permanent alphanumeric character string used to identify any entity, i.e., a physical or digital object. By assigning DOIs to EOS products, authors and publishers will find it easier to unambiguously cite the EOS data products used in their research and publications. We hope you will find the article on **page 10** of this issue (by **John Moses** and **Jeanne Behnke** of NASA's Earth Science Data and Information System) a helpful introduction to the topic.

On September 19–20 the AMSR-E Recovery Working Group completed six short duration attempts to start the spinning of AMSR-E. The instrument rotation rate improved slightly with each subsequent attempt (to about 25% of the desired 4 rpm value) allowing speculation that a higher rotation may be achievable with longer duration attempts. The recovery group is currently evaluating the test data and discussing plans for additional restart attempts in October. The goal is to get the instrument rotate at 4 rpm in order to obtain cross calibration data with AMSR2 aboard the recently launched Global Change Observation Mission-Water (GCOM-W1) spacecraft.

And finally, the draft Science Definition Team (SDT) Report for the Pre-Aerosol, Clouds, and ocean Ecosystem (PACE[3]) mission has been posted at *decadal.gsfc.nasa.gov/PACE.html*. The PACE mission will make global ocean color measurements to provide data records on ocean ecology and global biogeochemistry, possibly along with measurements to extend important aerosol and cloud data records. The SDT draft report is open for public comment until October 1, 2012. ■

[3] The PACE mission was described in the 2010 NASA report *Responding to the Challenge of Climate and Environmental Change: NASA's Plan for a Climate-Centric Architecture for Earth Observations and Applications from Space* found at *science.nasa.gov/earth-science*.

feature articles

MABEL and the ICESat-2 Mission: Photon-counting Altimetry from Air and Space

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The primary goals of the ICESat-2 mission are consistent with the NRC's directives: ***to deploy a spaceborne sensor to collect altimetry data of the Earth's surface optimized to measure ice sheet elevation change and sea ice thickness, while also generating an estimate of global vegetation biomass.***

Mission Overview

Understanding the causes and magnitudes of changes in the cryosphere[1] remains a priority for Earth science research. Over the past decade, NASA's Earth-observing satellites have documented a decrease in both the areal extent and thickness of Arctic sea ice, and an ongoing loss of grounded ice from the Greenland and Antarctic ice sheets. Understanding the pace and mechanisms of these changes requires long-term observations of ice-sheet mass, sea-ice thickness, and sea-ice extent.

NASA's Ice, Cloud, and land Elevation Satellite (ICESat) mission, which operated from 2003 to 2009, pioneered the use of laser altimeters in space to study the elevation of the Earth's surface and its changes. Among other contributions to the cryospheric sciences, ICESat proved adept at making the centimeter-level elevation measurements—required to document subtle changes in the elevation of ice sheets—that indicated an ongoing loss of ice to the ocean. Subsequent investigation revealed that the Greenland ice sheet discharges some 175 billion tons of ice—every year—into the sea, either by calving icebergs or melting at the ice-sheet surface. Similarly, ICESat sea-ice data were used to determine the thickness of sea ice in the Arctic and how that thickness distribution changed over time. These data revealed that approximately 40% of the multi-year sea ice that was lost during the ICESat observation period was replaced by much thinner and less-stable first-year sea ice. In addition, ICESat contributed to a wider range of Earth science disciplines that also require precision elevation measurements, disciplines that range from geodesy to geology, and from atmospheric science to land-use management.

As a result of ICESat's success, the National Research Council's (NRC) 2007 Earth Science Decadal Survey recommended a follow-on mission to continue the ICESat observations. In response, NASA tasked its Goddard Space Flight Center (GSFC) with developing and deploying the ICESat-2 mission—now scheduled for launch in 2016. The primary goals of the ICESat-2 mission are consistent with the NRC's directives: *to deploy a spaceborne sensor to collect altimetry data of the Earth's surface optimized to measure ice sheet elevation change and sea ice thickness, while also generating an estimate of global vegetation biomass*. As a result of this direction, the ICESat-2 science definition team developed the following four science objectives:

- Quantify polar ice-sheet contributions to current and recent sea-level change and the linkages to climate conditions.

- Quantify regional signatures of ice-sheet changes to assess the mechanisms driving those changes and improve predictive ice sheet models; this includes quantifying the regional evolution of ice sheet change, such as how changes at outlet glacier termini propagate inward.

[1] Cryospheric research at NASA addresses the physics of ice sheets and glaciers, sea ice, snow on ice and land, and their roles in the global climate system.

- Estimate sea-ice thickness from *freeboard*[2] measurements to examine ice–ocean–atmosphere exchanges of energy, mass, and moisture.
- Measure vegetation canopy height as a basis for estimating large-scale biomass and biomass change.

These objectives subsequently lead to eight primary science requirements related to monitoring ice sheet elevation change, on scales ranging from that of outlet glaciers [100 km^2 (~38.6 mi^2)] to the entire ice sheet [10^6 km^2 (~386,102 mi^2)], measuring sea ice thickness change, and generating an independent estimate of the global vegetation biomass. In particular, ICESat-2 has a requirement to produce an ice-surface elevation product that enables determination of whole ice-sheet elevation changes to an accuracy of 0.4 cm/yr (~0.16 in/yr) on an annual basis. This is a demanding requirement that drives pointing knowledge, measurement signal-to-noise ratio, and orbital considerations.

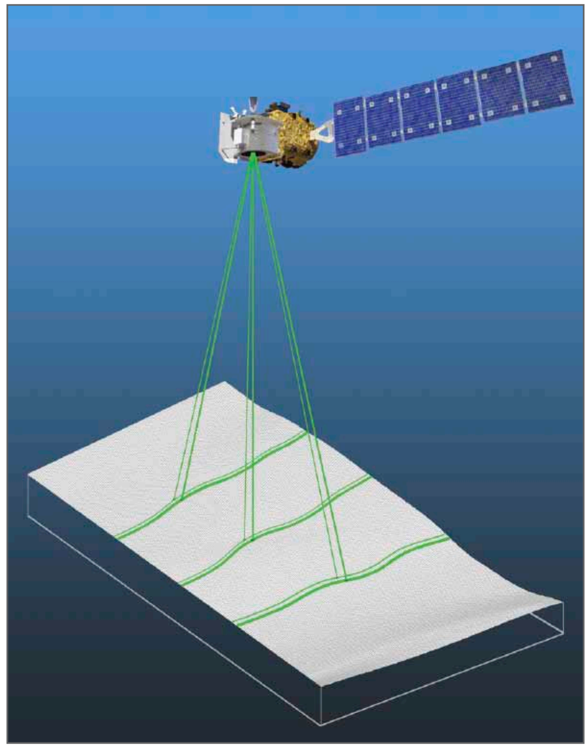

Figure 1. Schematic drawing of the six beams of ICESat-2—an advancement over ICESat, which had only one beam. **Image Credit:** ICESat-2 Mission.

Mission Design

In developing the mission concept for ICESat-2, GSFC and the science definition team sought to correct some of the limitations that arose in ICESat's design and on-orbit performance. ICESat was launched into a 94° inclination orbit that collected data between 86° N and S latitudes. The altimeter on ICESat—the Geoscience Laser Altimeter System (GLAS)—operated in the infrared at 40 Hz and used an analog detection system to record reflected laser energy by digitizing a waveform. This approach led to discrete *footprints*, with a nominal 70-m (~230-ft) diameter spot spaced every 170 m (~558 ft) in the direction of flight. Operationally, ICESat was designed to run continually for three to five years, although unforeseen manufacturing defects caused a substantial reduction in the laser's planned lifetime. Instead, ICESat subsequently operated in *campaign mode*, conducting 18 discrete 33-day campaigns over the seven years ICESat was on orbit.

While retaining many of the same measurement objectives, ICESat-2 differs in design from ICESat in several important ways.

The current design for ICESat-2 makes use of a more-rapid laser repetition rate (10 kHz, in contrast to the original 40 Hz); it also uses low pulse energy on the transmitter side and sensitive single-photon detectors on the receiver side to measure the range to the Earth using green light at 532 nm. This detection strategy allows ICESat-2 to use lower-energy laser pulses than the waveform-digitization strategy of ICESat. The mission planners have elected to use a much smaller footprint of 10 m (~33 ft)—compared with the 70 m (~230 ft) of ICESat—to limit the impact of surface slope and roughness that reduce the precision of each measurement. The high repetition rate causes overlap between each successive footprint, as the along-track spacing of the footprints is ~70 cm (~27.6 in). The orbit for ICESat-2 is both lower—500 km (~310 mi), compared with 600 km (~373 mi) for ICESat—and has a lower inclination angle of 92°, leading to coverage between 88° N and S latitude. Perhaps most

[2] Sea ice floats in the ocean, as an ice cube floats in a glass of water. Due to the differences in the density of water and ice, about 10% of the thickness of the ice floats above the waterline. The difference in height between the top of the ice and the waterline is called the *freeboard*. The news article on page 48 of this issue discusses freeboard in more detail, as well as other topics mentioned in this article.

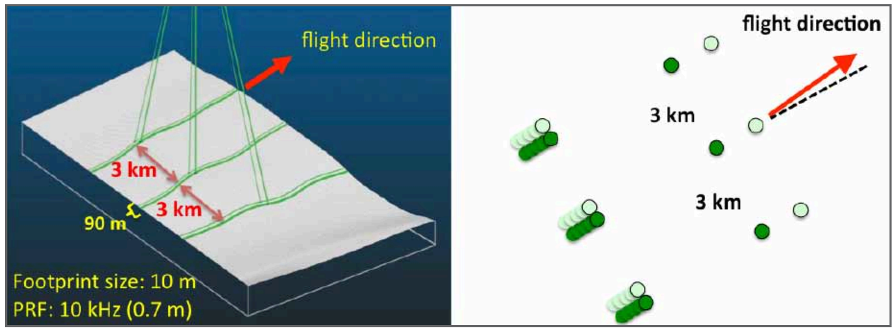

Figure 2. Details of the ICESat-2 measurement concept. Each laser pulse is split into six beams, arranged into three pairs. The ~3-km (~2-mi) separation of the beam pairs improves spatial coverage, while the ~90-m (~295-ft) spacing within the pairs allows measurement of the surface slope.

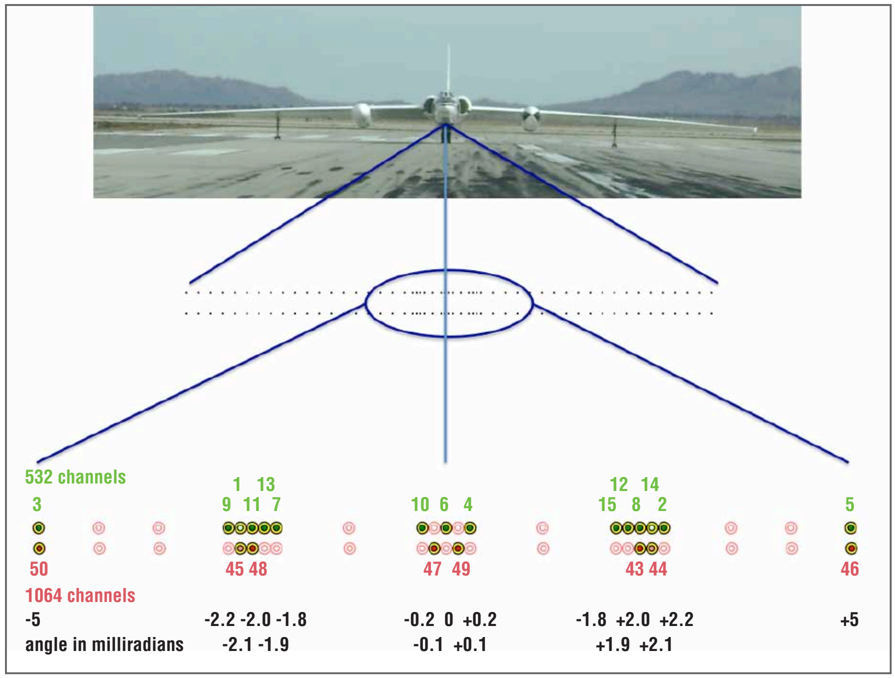

Figure 3. MABEL has 105 different channels available in either the green (532-nm) or infrared (1064-nm) parts of the spectrum. Users can select up to 16 green channels and 8 infrared channels to use for a specific flight. The lower half of the figure shows a configuration where the channels nearest to *nadir* have been illuminated, providing dense sampling directly beneath the aircraft; the angles of each channel are provided in milliradians.

importantly, ICESat-2 splits each laser pulse into six separate beams, arranged in pairs of three. The ~3-km (~1.9-mi) separation between beam pairs substantially improves the spatial coverage over the single beam of ICESat, while the 90-m (~295-ft) spacing of beams within a pair allows measurement of the surface slope—**Figures 1** and **2** illustrate the ICESat-2 measurement concept.

MABEL: The Airborne ICESat-2 Simulator

Given the substantially different design of ICESat-2 as compared with ICESat, the ICESat-2 project elected to develop an airborne simulator to generate ICESat-2-like data for algorithm development, and to verify ICESat-2 instrument models over the very cryospheric targets that are the science focus of the mission. The Multiple Altimeter Beam Experimental Lidar (MABEL) is not an exact copy of the ICESat-2 instrument, but it has enough similarity to allow MABEL data to be scaled to space-like geometry and radiometry, and includes additional flexibility to explore the capabilities of ICESat-2.

Like ICESat-2, MABEL uses a high-repetition-rate, low-power laser transmitter mated to a sensitive single-photon detection system. To compare the differences between altimetry measurements made with green light (such as used in ICESat-2) and those made with infrared light (such as used in ICESat), MABEL makes concurrent measurements at both frequencies. To better understand how to effectively use and combine information from multiple beams, MABEL is configured to simultaneously use up to 16 channels in the green part of the visible spectrum, and eight additional channels in the infrared. While the angles of ICESat's six beams are fixed with respect to each other, MABEL uses what is essentially a telephone-switchboard design to allow users to choose from 105 different channels in the green, and another

105 different channels in the infrared. Prior to a flight, users select which channels are to be illuminated, and connect fiber optic cables to the appropriate channels as desired. The maximum view angle for MABEL is ±3°, or just over ~1 km (~3281 ft) across the direction of flight. A schematic of the channels available on MABEL is shown in **Figure 3**.

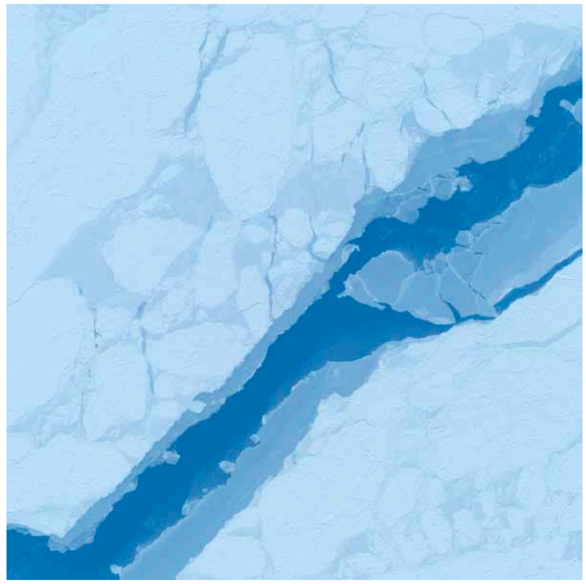

Figure 4. A *lead* in the sea ice, as viewed from the ER-2 digital camera system.

To sample as much of the atmosphere as possible, MABEL operates at an altitude of 20 km (~12 mi) aboard NASA's ER-2 aircraft, operated out of NASA's Dryden Aircraft Operations Facility, which is inside Edwards Air Force Base, in California. This single-pilot, zero-passenger aircraft has long been used as a means to fly as close to space as possible, yet still permit researchers to adjust instruments and analyze data between flights. A small stream of housekeeping data is downlinked in real time, but science instruments aboard the ER-2 operate autonomously, much like a spaceborne instrument.

First light for MABEL came during a campaign out of Dryden in December 2010, and subsequent Dryden-based campaigns followed in March–April 2011 and February 2012. Goals of these early flights were to work out residual issues with MABEL operation and to collect science-quality data over vegetation targets in the Sierra Nevada mountain range, Mojave Desert, and Colorado; over salt flats in Utah and New Mexico; over the densely populated urban centers in the Los Angeles basin; and over Lake Mead, the Great Salt Lake, and the Pacific Ocean.

MABEL to the Arctic

In an effort to collect data more appropriate for ice-sheet and sea-ice algorithm development, a substantially larger Arctic campaign took place in April 2012. Based out of Keflavik, Iceland, MABEL was used for surveys over Greenland, the Arctic Ocean, Svalbard, Norway, and Iceland.

Over the course of the Arctic campaign, other instruments were flown concurrently to aid ICESat-2 researchers interpreting MABEL data. The Cloud Physics Lidar (CPL), a mature instrument that has used routinely since 2000, provided algorithm developers with a sense of the atmospheric conditions and cloud-cover surveyed simultaneously by MABEL. To provide sea-ice algorithm developers with a sense of the size and distribution of stretches of open water within the sea ice called *leads*—see **Figure 4**—a digital camera system, with 1-m (~3.3-ft) spatial resolution, was also flown concurrently with MABEL—see **Figure 5**.

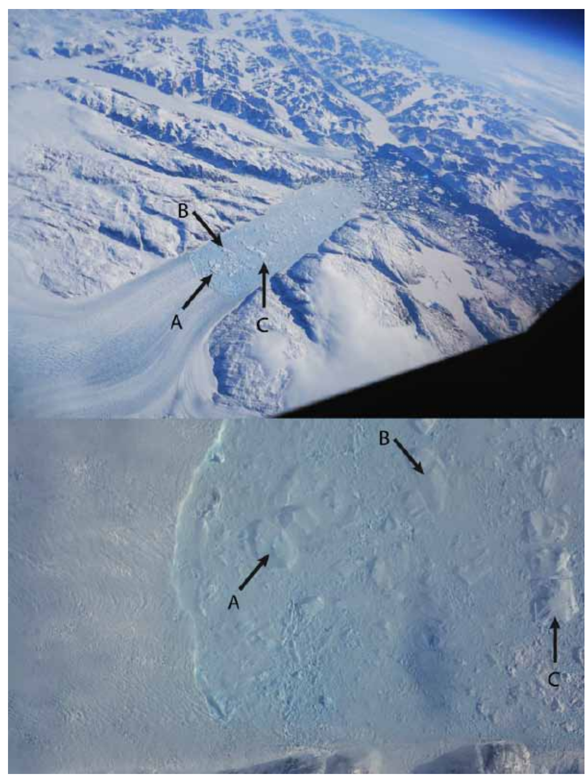

Figure 5. [*Top*] Image taken by NASA pilot **Tim Williams**, at 20-km (~12-mi) altitude. [*Bottom*] A sample image from MABEL's digital camera system. Three icebergs in each image are labeled to provide reference; iceberg 'A' is approximately 1 km (~0.6 mi) across.

Two MABEL flights were flown simultaneously with another NASA mission working in the Arctic—*Operation IceBridge*[3]. The laser altimeters associated with Operation IceBridge—the Airborne Topographic Mapper (ATM) and the Land, Vegetation, and Ice Sensor (LVIS)—are more mature than MABEL, providing ICESat-2 researchers with an external means of validating their ground-finding algorithms. Additionally, the Operation IceBridge camera system—referred to as the Digital Mapping System

[3] NASA's Operation IceBridge images Earth's polar ice in unprecedented detail to better understand processes that connect the polar regions with the global climate system, and serves as a "data bridge" between ICESat and ICESat-2.

(DMS)—is highly sophisticated, with a nominal 10-cm (~3.9-in) spatial resolution and more-precise image geolocation than that of the camera flown on the MABEL ER-2. The coordination of the MABEL and Operation IceBridge flights was so precise with respect to both space and time that the digital camera system flown on the ER-2 captured the Operation IceBridge P-3 aircraft and its shadow—see **Figure 6.**

Figure 6. Operation IceBridge P-3 *Orion* aircraft (and its shadow), flying at approximately 450 m (~1476 ft) over the Greenland Ice Sheet, captured in an ER-2 digital camera system image, flying at approximately 20 km (~12 mi).

Further validation of MABEL data involved coordination with collaborators who were already in the field—on the ice sheet itself. These collaborators offered various kinds of MABEL support, including providing field photos and descriptions of the ice-sheet surface; conducting a 6-km (~3.7-mi) GPS traverse of a MABEL data line; and installing precisely located corner-cube reflectors, whose signatures proved to be visible in the MABEL data.

The Arctic deployment received necessary and eminently useful weather forecasting support from the Icelandic Meteorological Office (*en.vedur.is*), and experienced very favorable conditions for an airborne laser altimetry campaign. Therefore, MABEL was able to successfully complete 12 missions based out of Keflavik, for a total of nearly 80 flight hours, or more than 50,000 km (~31,069 mi) of science flight lines, and approximately 5 terabytes of data. **Figure 7** (next page) is a map associated with the Arctic campaign that offers a sense of the distribution of these flight lines. The map also indicates sections of the survey where validation data were provided by other airborne or field-based collaborators.

The next set of MABEL flights was based out of NASA's Wallops Flight Facility in September 2012 and focused on targets of interest to the ecosystem-science community. These data will be a key component in developing algorithms to recover tree canopy height (used as an input to biomass estimates) from the ICESat-2 mission.

Summary

ICESat-2, slated for launch in 2016, will continue the important observations of ice-sheet elevation change, sea-ice freeboard, and vegetation canopy height begun by ICESat in 2003. Together, these datasets will allow for continent-wide estimates in the change in volume of the Greenland and Antarctic ice sheets over a 15-year period, and long-term trend analysis of sea-ice thickness.

Our airborne ICESat-2 simulator—MABEL—has proven to be an excellent platform to help the research community prepare for the unique challenges and opportunities the ICESat-2 data will provide. MABEL data have proven useful for both science algorithm development and in processing and handling the large data-rate that these types of systems generate, and has been invaluable in helping the team to prepare for handling ICESat-2 data. The team expects to conduct additional MABEL campaigns in the coming months and years, to generate further test data needed to prepare for the launch of ICESat-2.

For more information about ICESat and ICESat-2, visit: *icesat.gsfc.nasa.gov/icesat2/index.php.* ■

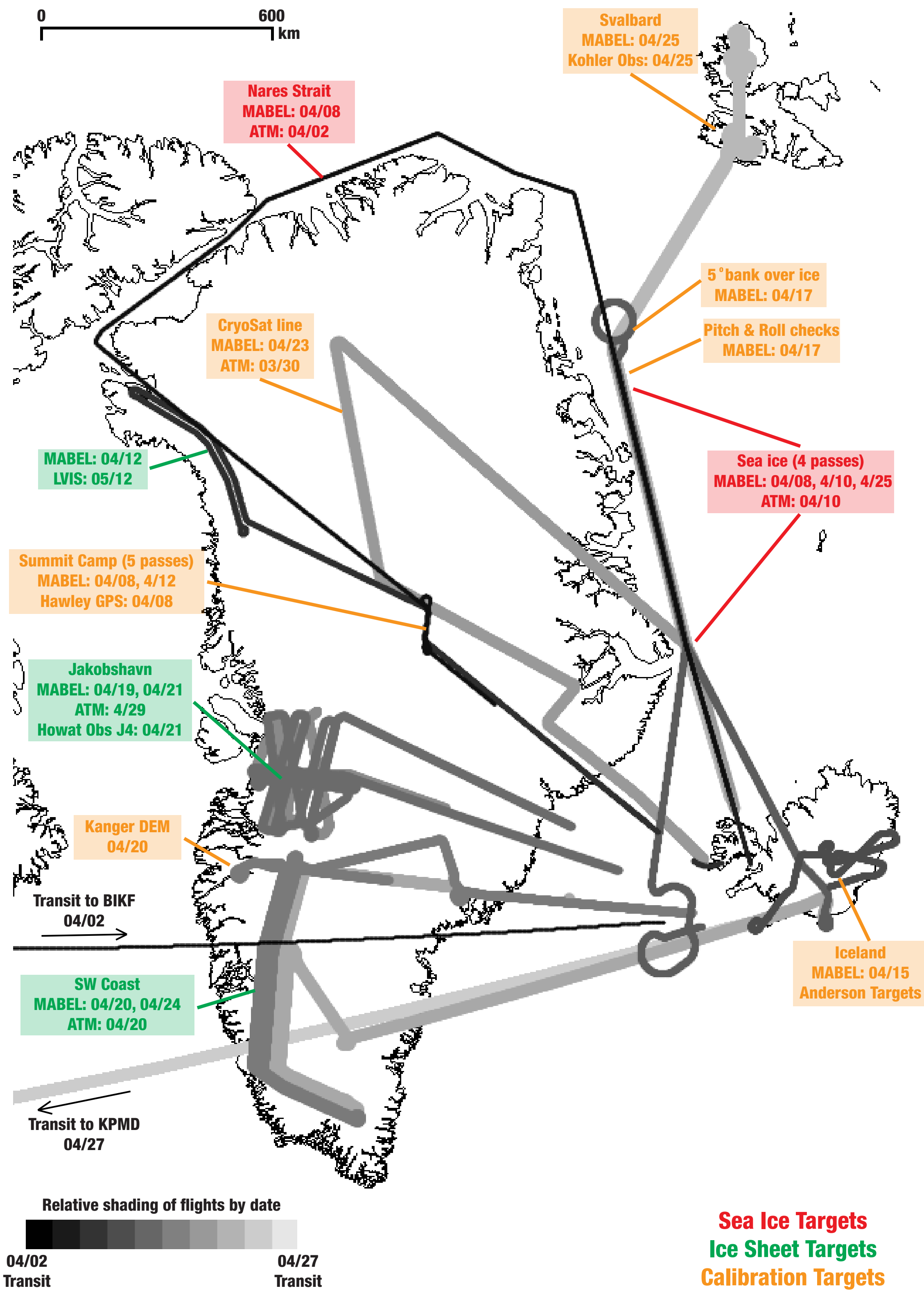

Figure 7. *Map of the April 2012 MABEL Arctic campaign.* MABEL flew 12 missions based out of Keflavik, Iceland, for a total of nearly 80 flight hours, resulting in more than 50,000 km (~31,069 mi) of science flight lines.

Digital Object Identifiers for NASA's Earth Observing System

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This article will briefly describe the function and "fit and finish" of DOIs and their utility in the Earth Observing System (EOS) framework. Members of NASA's Earth Science Data and Information System (ESDIS) Project are working with several EOS science and instrument teams and principal investigators to develop methods for assigning DOIs to EOS products.

Introduction

The science community has long recognized the importance of citing data in published literature to encourage replication of experiments and verification of results. Authors who try to cite their data often find that publishers do not accept Internet addresses. These addresses are viewed as transient references, frequently changed by the data provider after the paper is published. *Digital Object Identifiers* (DOIs) were created to avoid this problem by providing a unique and persistent reference to online data. An indicator of the value of DOIs is the fact that they have emerged as the most accepted data identifier in the publishing community.

This article will briefly describe the function and "fit and finish" of DOIs and their utility in the Earth Observing System (EOS) framework. Members of NASA's Earth Science Data and Information System (ESDIS) Project are working with several EOS science and instrument teams and principal investigators to develop methods for assigning DOIs to EOS products. By assigning DOIs to EOS products, authors and publishers should find it easier and more compelling to cite EOS data products in their research and publications.

What Is a DOI?

A DOI is a unique alphanumeric character string used to identify any entity, i.e., a physical or digital object. The identification occurs via the DOI System[1]—a *resolution service* that works much the same way a uniform resource locator (URL) is resolved to a specific Web site by the Internet's *domain name system resolver*. The DOI System was developed by the International DOI Foundation (IDF) to support the publishing industry, and first placed into operation in 2000.

A DOI is permanent, such that when it is assigned and registered, it can always be used to locate the data object it refers to. In published citations, DOIs are used in place of Internet addresses (or URLs) along with other information arranged in accordance with the publisher's requirements. For example, a typical data citation would include the author (creator), publication year, (data product) title, publisher (distributer), DOI, and Internet access date.

The alphanumeric strings that comprise a DOI have two components, which together form the *DOI name*. The components are separated by the "/" character and take the form doi: [prefix]/[suffix]. The prefix consists of "10.[number]" where "10" is the assigned value for the DOIs in the Handle System®[2]. The prefix "number" value is assigned by a registration agency for use by the organization that wishes to register DOI names (e.g., the publisher; in our case, NASA). The "/" delimiter identifies the data item as decided by the registrant or agent. There are no significant restrictions on the suffix string; however, the guidance is to keep it simple and short for ease of use; more on this later.

In practice, a DOI name is typed or pasted into the text box of the DOI system's permanent online resolver service at *dx.doi.org*. The browser returns the specific Web page that provides access to the data object. The relationship between the DOI name and Internet location is maintained in the DOI system, usually by the publisher through services

[1] To learn more about the DOI® System, visit: *www.doi.org*.
[2] The Handle System® provides efficient, extensible, and secure resolution services for unique and persistent identifiers of digital objects. See *www.doi.org/doi_handbook/3_Resolution.html* for details of the Handle System.

offered by a DOI registration agency. The registration agency works under agreement with the International DOI Foundation and interfaces with the DOI system.

One of the key values of defining a permanent identifier is that if the Internet location of the object changes, the DOI is still valid. This means that an archive can change the URL of a data product without destroying previous references in already published literature. In addition, the publisher (or archive-distributer) of the object can change, and the new owner/publisher can still support the same DOI as the object's permanent locator. To make this work however, it is important that DOI names be universally acceptable among the research and publication community. For example, the DOI name should not contain information that may change in the future, such as references to the publisher or distributer of the data object.

One of the key values of defining a permanent identifier is that if the Internet location of the object changes, the DOI is still valid. This means that an archive can change the URL of a data product without destroying previous references in already published literature.

Implementing DOIs for EOSDIS

ESDIS is developing an operations concept and scope for ESDIS and Distributed Active Archive Center (DAAC) roles and responsibilities. Specifically, ESDIS is working to:

- Prepare guidelines for DOI suffix profile, citation, and location information, drawing on the experience of others;
- make DOIs attractive to users, soliciting feedback from EOS science teams, DAAC user working groups, and the Earth science research community;
- assign DOI and maintain citation, and location information in the DOI system;
- add DOIs to DAAC product citation Web pages;
- add DOIs to DAAC product databases, the Global Change Master Directory (GCMD), and the EOS Clearinghouse (ECHO) through metadata updates;
- embed DOIs into existing product metadata at next reprocessing;
- add DOI metadata to the NASA Technical Report Server (NTRS) for searchable documentation; and
- set up metrics collection based on journal citation reports.

The ESDIS DOI-Assignment Infrastructure

To provide the best possible platform for creating EOS-related DOIs, ESDIS joined the California Digital Library (CDL)'s EZID—pronounced *easy-eye-dee*—service in February 2012 to facilitate creating and managing unique, long-term identifiers. The EZID Web service supports assigning an unlimited number of DOIs, and provides an application programming interface (API) for developing custom DOI management tools. CDL is a member of the DataCite Registration Agency[3], and as such requires compliance with the relatively simple DataCite metadata standard. The DataCite citation profile requires at minimum a URL, creator (organization or person), title, publisher, publication year, and resource type (e.g.,"Dataset"). ESDIS assigns DOI values and provides corresponding metadata in accordance with DataCite mandatory requirements using the EZID service. Upon subscribing to EZID, the unique prefix number *10.5067* was assigned for NASA ESDIS use.

Using this infrastructure, ESDIS is responsible for managing the "uniqueness" of DOI suffixes when creating new DOIs; they are also responsible for maintaining the DataCite-mandatory metadata. The value of DOIs assigned by ESDIS through EZID will always begin with the prefix 10.5067. This unique prefix assures that whatever alphanumeric string follows in the suffix portion can co-exist with all other DOIs in the

[3] DataCite is an international entity organized to facilitate access to research data. For more detail, see *datacite.org*.

DOI system, as well as with all other identifiers in the Handle System®. *DOIs are case-insensitive,* so letters coded in upper or lower case will refer to the same DOI.

ESDIS is exploring a strategy for determining DOI suffix names that will correspond to each EOS product. Since the development of the DOI System, DOIs have often been used to locate research papers in journal publications. In these cases, the suffix has often been a combination of a few letters from the initials of the journal, followed by a sequence number incrementally assigned for each new article. In other cases, internal data center identifiers have been combined with prefixes to quickly establish a DOI structure for scientific data products. The German World Data Center for Climate has used this approach to assign DOIs to output from climate model simulations for reference by published literature. A legacy model data reference syntax is used for the suffix, based on codes for various components such as activity, product, institute, model, experiment, frequency, modeling realm, variable name, version number, and more—which tends to be quite long and complex. CDL EZID recommends random generation of an alphanumeric number. Systems have been devised that range from random to formal controlled vocabularies.

ESDIS is exploring a strategy for determining DOI suffix names that will correspond to each EOS product. Since the development of the DOI System, DOIs have often been used to locate research papers in journal publications.

DOIs Are Valuable for EOS Product Users

Currently there are approximately 1850 EOS products archived and distributed by Earth Observing System Data and Information System (EOSDIS) DAACs. EOS products can be composed of thousands of files that contain observational data covering orbits and suborbital scenes. New versions of products can replace older versions. A DOI could be assigned to an aggregate of products (i.e, for an EOS mission or instrument), to all versions of a product within the instrument/mission, to each individual version, or to each digital file. To this end, ESDIS has not only been focusing their efforts on assigning DOIs to EOS products, but is also working to ensure that identifiers at multiple levels can co-exist and complement each other where appropriate, as individual projects will want to explore and develop applications.

In addition, for active on-orbit satellite missions, observations are continuously being added to each product. DOIs assigned to products from active missions cannot alone determine an accurate data citation because the data products will continue to grow as new observations are added. For an accurate and complete data citation—i.e., to uniquely determine all of the observations, or files, in a product—DOIs that were used in the publication citing the data must be accompanied with a product *access* date-time.

An overarching goal is for DOI names to be attractive for researchers to use in publication applications: Keeping their structure and content short and simple is, therefore, paramount. On the other hand, since DOIs are to be used with corresponding citation information, the suffix should have enough recognizable meaning so that a user will have confidence in knowing that they are correctly paired with the other citation information, without referring to any information that may not be permanent—e.g., publication information. The primary purpose is to add just enough meaning so that the reader knows the DOI value is likely for the cited data (e.g., an approximate match with the dataset title).

DOIs in the Product Metadata

Most users of EOS data download files to their local facilities for further analysis or for use in applications. Local software extracts attributes from the file metadata for visual examination or further processing. By embedding DOIs in the file metadata, users have access to the DOI name, which provides the potential for users to find documentation about the product in the future—long after it has left the contextual environment of the data provider. ESDIS is cognizant of this reality and has promoted and encouraged standard ways in which DOIs should be embedded in science product metadata.

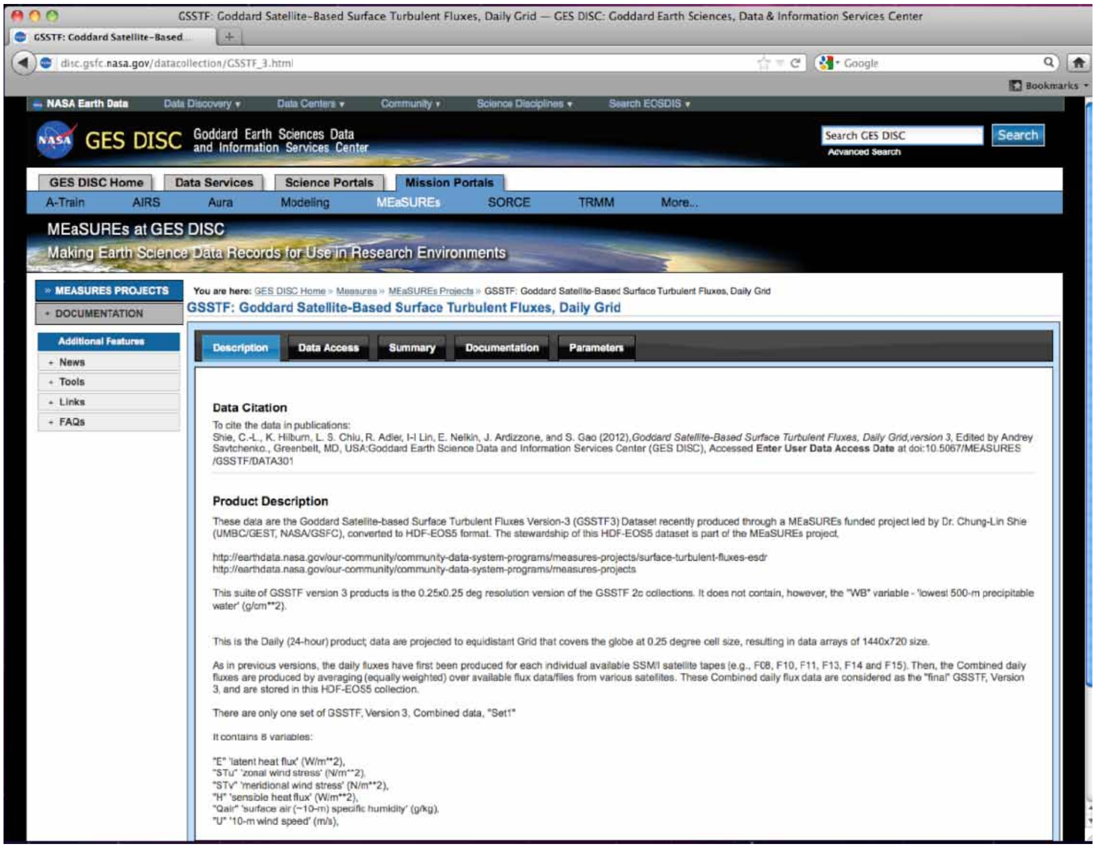

Figure 1. This image depicts the *landing page* for *doi: 10.5067/MEASURES/GSSTF/DATA301*. **Image credit**: GES DISC

Landing at the Publisher

The next step is for the NASA DAACs to prepare the Internet location for access to the data product. The concept of a *landing page* refers to the Internet web page that the DOI service takes the DOI user to—i.e., it is the Internet address part of the DOI metadata. Since the DOI user has a specific product reference, the landing page accesses a product specific location. This requires a landing page (or section of a page) for each product.

The page should have enough information such that upon arrival, users know they have reached the source of the product and can gain access to it. A summary description of the product, as well as all of the other citation information about the product would satisfy the first requirement. Direct access to the product can be tricky because in many cases there are multiple versions of the product and each version consists of thousands of granules. As mentioned earlier, new versions of products will receive new DOIs. Of particular interest is how we handle the "old" DOIs that point to the previous product versions that are replaced with new versions. Since the old DOI is permanent, the landing page information will need to be updated or the corresponding URL in the DOI system will need to point to a new landing page. In either case, the DAACs will need to provide a landing page with explanation (i.e., disposition of the old version, availability of the new version) so that the old DOI will still work.

*The concept of a **landing page** refers to the Internet web page that the DOI service takes the DOI user to—i.e., it is the Internet address part of the DOI metadata.*

The DAACs have search tools—or advocate use of the ESDIS *Reverb*[4] search tool—as their primary means for searching through all products within geospatial and temporal constraints. If a search tool is used as the primary access method for a product-specific landing page, it should be prepopulated with a keyword (e.g., product shortname and version) that will uniquely identify the product within the search database. The search tool uses the keyword to find the product version and then allows the user to define additional spatial and temporal qualifications as desired to retrieve all or some of the product granules. **Figure 1** shows an example of the landing page at the God-

[4] For more information about Reverb, read *Reverb—The Next Generation Earth Science Discovery Tool* in the September-October 2011 issue of *The Earth Observer* [**Volume 23**, **Issue 5**, pp. 24-25].

dard Earth Sciences Data and Information Services Center (GES DISC) Website for the Making Earth System data records for Use in Research for Earth Science (MEaSUREs) Program[5] product titled *Goddard Satellite-Based Surface Turbulent Fluxes, 0.25x0.25 deg, Daily Grid, V3, (GSSTF)*. Included on this page is descriptive information about how to format the data citation in publications, and a text-based description of the data product. Other tabs accessed from this page show how to access the data; details of the data product's short name, version format, coverage, and data resolution; an extensive set of references about the data, its provenance, and its utility; and a list of the parameters in the data file, with descriptions and units.

ESDIS is collaborating with algorithm implementers of the EOS Science Investigator-led Processing Systems (SIPS,) and with MEaSUREs data providers to investigate and test various implementation options in ***pilot study*** *efforts.*

Pilot Studies

ESDIS is collaborating with algorithm implementers of the EOS Science Investigator-led Processing Systems (SIPS), and with MEaSUREs data providers to investigate and test various implementation options in *pilot study*[6] efforts. Pilot studies for products from the High Resolution Dynamics Limb Sounder (HIRDLS), the Atmospheric Infrared Sounder (AIRS), the Advanced Microwave Scanning Radiometer for the Earth Observing System (AMSR-E), the Moderate Resolution Imaging Spectroradiometer (MODIS), the Geoscience Laser Altimeter System (GLAS), and four MEaSUREs Projects[7] have already begun. In addition, two new missions—the Soil Moisture Active Passive (SMAP) and the second Ice, Clouds, and land Elevation Satellite (ICESat-2)—are also involved in the collaboration, planning early for implementation of DOIs in their products.

At this time ESDIS has worked through the entire process with two MEaSUREs projects and two DAACs. Two examples of the DOIs from each project are offered below. They can be examined using the DOI resources mentioned previously. The products can be retrieved and product metadata can be examined using standard tools to see the embedded DOI attribute names and DOI names.

doi: 10.5067/MEASURES/DMSP-F17/SSMIS/DATA301
doi: 10.5067/MEASURES/DMSP-F17/SSMIS/DATA304

doi: 10.5067/MEASURES/GSSTF/DATA301
doi: 10.5067/MEASURES/GSSTF/DATA302

Future Steps

The official archive for NASA scientific and technical documentation is the NASA Scientific and Technical Report Server (NTRS). NTRS—managed by the NASA Scientific and Technical Information (STI) Program—holds most of the definitive documents and research publications about EOS data products. ESDIS has discussed a concept and prototype for linking EOSDIS with the NTRS. In this concept, EOS would provide to NTRS product DOIs and lists of the related STI documentation. NTRS would add the DOI to their document's metadata database. A new NTRS search service would enable users to search for all the definitive documentation associated with a particular EOS product using the product DOI.

[5] MEASURES was funded under the Research Opportunities in Space and Earth Sciences (ROSES) 2006 Announcement of Opportunity.
[6] A *pilot study* is a small-scale preliminary study conducted in an attempt to improve the methods used in a larger study or full-scale research project.
[7] Including principal investigators **F. J. Wentz** [Remote Sensing Systems], **C. L. Shie** [Joint Center for Earth Systems Technology, University of Maryland Baltimore County, and NASA's Goddard Space Flight Center (GSFC)], **J. R. Herman**, [GSFC], and **P. K. Bhartia** [GSFC].

Shown in **Figure 2** is an overall view of how DOIs will flow through the EOSDIS architecture. As mentioned earlier, the product DOI names will be embedded in the EOS data products at the time of product generation, as depicted in the diagram; DOIs are also extracted from the products and added to the NASA DAAC's metadata repository. For missions that have ended and the resulting observational datasets finalized, DOIs will be assigned and entered separately into the DAAC's product metadata repository, since they are not available in the products.

By assigning DOIs, DataCite citation metadata, and data center landing pages for EOS products, ESDIS will make consistent citation information easily assessable for use by the research community.

Conclusion

ESDIS plans to continue developing DOI governance policies and distributed maintenance functions through integration with existing metadata infrastructures. By assigning DOIs, DataCite citation metadata, and data center landing pages for EOS products, ESDIS will make consistent citation information easily accessible for use by the research community. ■

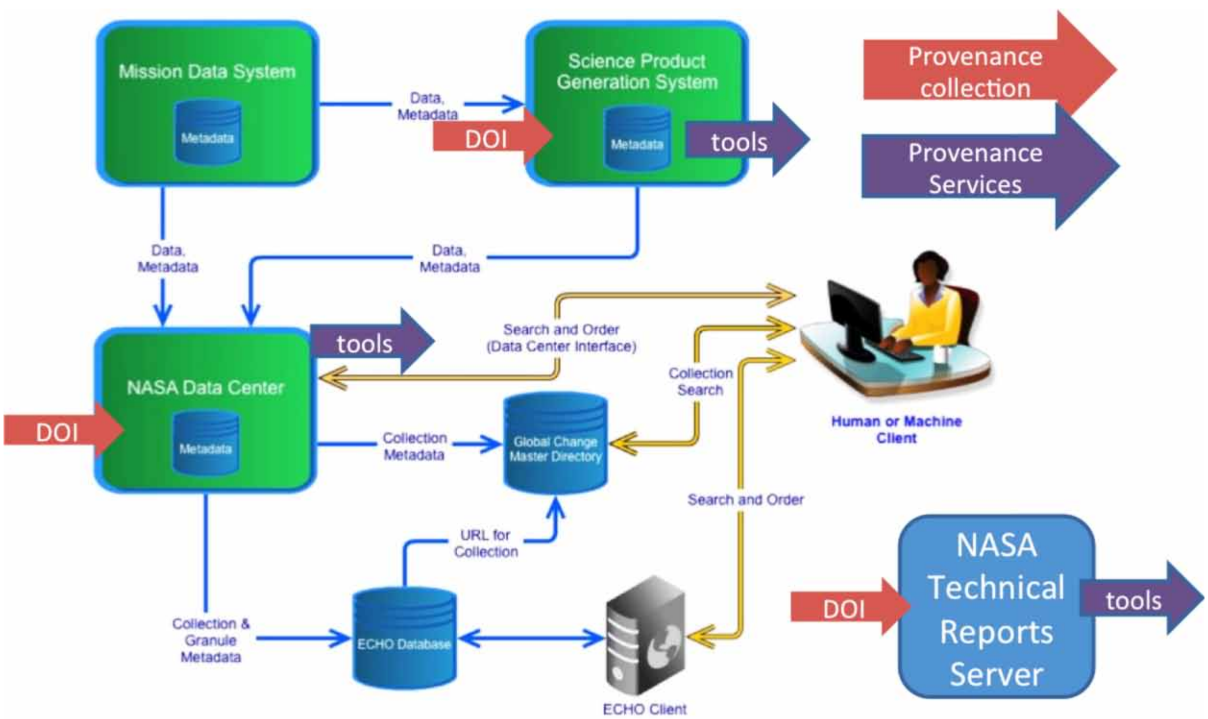

Figure 2. DOIs and provenance services in the EOSDIS architecture. **Image credit**: ESDIS Project

Suomi NPP: Approaching the One-Year Anniversary of its Launch

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The image that arguably received the most Internet views in 2012 comes from an Earth-observing satellite that circles our planet in a polar orbit, i.e., from pole to pole, 14 times a day—a satellite that is not yet even a year old.

On October 28, 2011, at 2:48 AM PST, the NPOESS[1] Preparatory Project (NPP) satellite—now referred to as Suomi NPP (see *What's In a Name?* on page 18)—was launched into space from Vandenberg Air Force Base in Lompoc, CA. Suomi NPP—NASA's newest Earth-observing satellite—is the result of a partnership between NASA, the National Oceanic and Atmospheric Administration (NOAA), and the Department of Defense. It is an important link between the current generation of Earth-observing satellites—the Earth Observing System (EOS)—and the next generation—the Joint Polar Satellite System.

Approximately two months after its launch, NASA released four images, one of which captured the public's admiration and imagination, dubbed the *2012 Blue Marble*—see **Figure 1**.

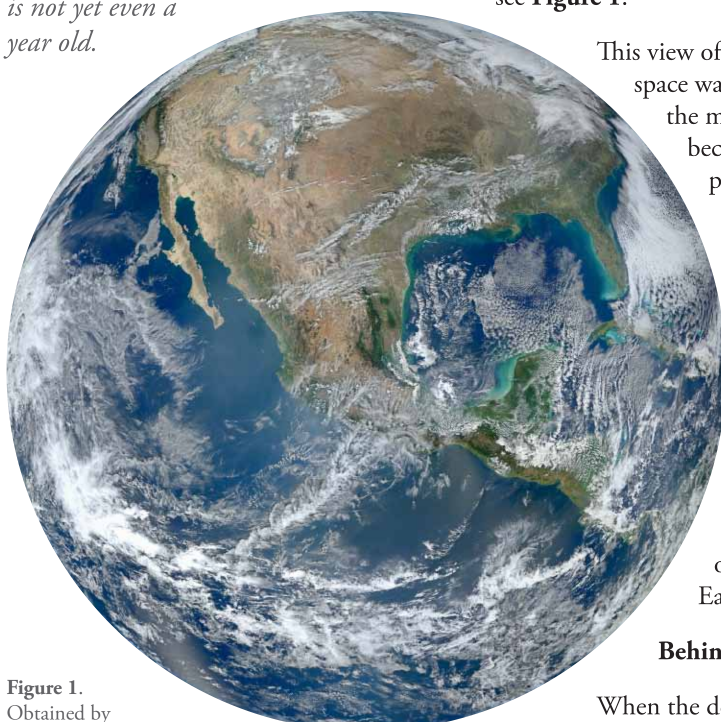


Figure 1. Obtained by the Visible Infrared Imager Radiometer Suite on the Suomi NPP spacecraft, this image of Earth's Western Hemisphere is, to-date, one of the most popular images in the world. **Image credit**: NASA/NOAA/GSFC/Suomi NPP/VIIRS/**Norman Kuring**

This view of Earth's Western Hemisphere as seen from space was posted to *Flickr*—a photo sharing website—the morning of January 25, 2012, and immediately became a sensation. Once the image had been posted, the number of downloads skyrocketed—so much so that Flickr released a statement one week later, on February 2, that acknowledged the record-breaking number. By August 2012 the number of views that the image received on Flickr reached 4.4 million—and Flickr is just one of the many photo-sharing websites where the image has been posted. Major media outlets, such as the *NBC Nightly News* and *The Washington Post*, requested high-resolution versions of the image. In addition to the high number of downloads, it has become an icon for many Earth-science news stories worldwide.

Behind the "Blue Marble"

When the decision came in January 2012 to rename the satellite *Suomi NPP* in honor of the meteorological pioneer Verner Suomi, scientists chose four images to commemorate the event. **Norman Kuring** [NASA's Goddard Space Flight Center (GSFC)] stitched together six adjacent swaths of data acquired on January 2, 2012, from Suomi NPP's Visible Infrared Imager Radiometer Suite (VIIRS) to create the awe-inspiring view of the Earth's Western Hemisphere. The now-famous image—referred to as the 2012 Blue Marble—is actually a *disk image*—an image that does not show an entire hemisphere. The first—and still most famous—Blue Marble is a photograph of the Earth taken on December 7, 1972, by the crew of the *Apollo 17* spacecraft, at a distance of about 45,000 km (~28,000 mi). Later missions of Earth-observing satellites (e.g., Terra and

[1] NPOESS stands for National Polar-orbiting Operational Environmental Satellite System, a partnership between NASA, the National Oceanic and Atmospheric Administration (NOAA), and the U.S. Air Force. The original partnership was reorganized in February 2010; components of it have become the Joint Polar Satellite System (JPSS), which NASA is developing for NOAA.

Aqua) obtained data over swaths of the Earth's surface; scientists with expertise in visualization then combined those swaths to create views of the entire Earth.

The resulting popularity of Kuring's 2012 Blue Marble image led not only to the production of other views of our planet, but also to a very popular *infographic*, showing how a disk image is created—see **Figure 2**. The public impact of such images is clear: It had only been two months since launch, and the observations and images from Suomi NPP had already inspired individuals, worldwide.

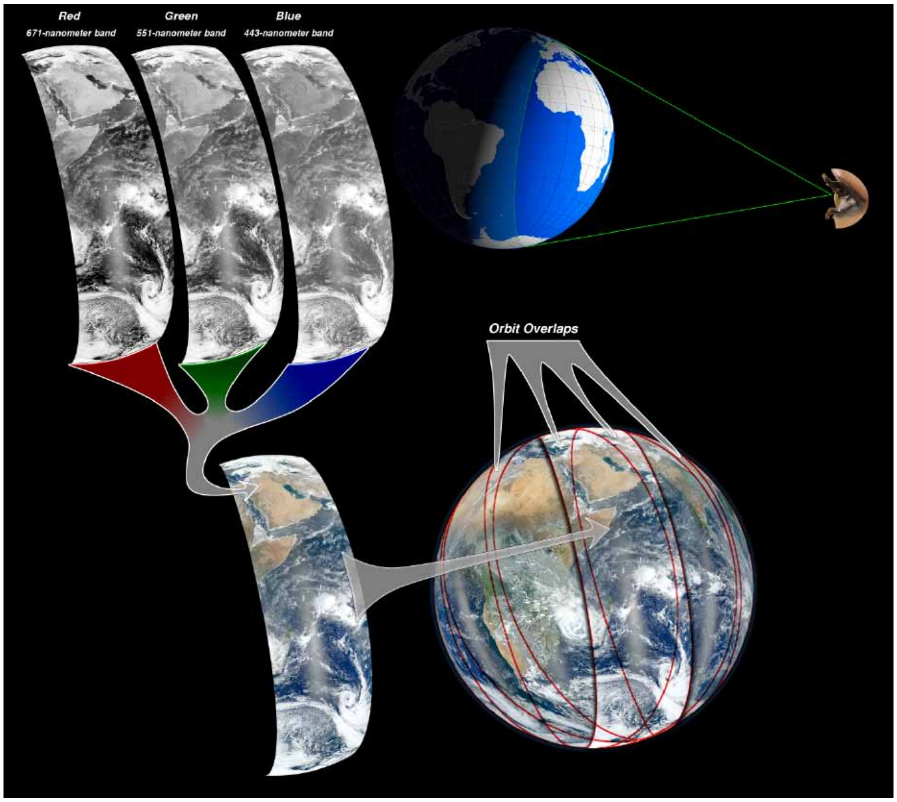


Figure 2. This graphic illustrates how separate images in red, green, and blue wavelengths of light are combined to make natural-color imagery, and how multiple, adjacent swaths—slices of Earth viewed on each satellite pass—are merged into a composite image. The width of the swaths covered by each pass of VIIRS is about 3001 km (1865 mi). **Image and caption credit**: NASA/NOAA/GSFC/Suomi NPP/VIIRS/**Norman Kuring**/ NASA's Earth Observatory

The Suomi NPP Instruments

In addition to VIIRS, mentioned above, there are four more instruments aboard Suomi NPP. Four out of the five instruments are new—i.e., have a new instrument design—and all of the instruments will help continue long-term data records for Earth's land surfaces, ocean, and atmosphere[2].

The VIIRS instrument (the largest aboard Suomi NPP) collects data from 22 spectral channels. It builds on the legacy of the Moderate Resolution Imaging Spectroradiometers (MODIS) that orbit aboard NASA's Earth Observing System (EOS)-era platforms: Terra, launched in 1999, and Aqua, launched in 2002. A feature of the detectors on VIIRS is the Day/Night Band (DNB), a visible channel that has the capability to image the Earth under nocturnal illumination. Suomi NPP's Cross-track Infrared Sounder (CrIS) works in concert with the Advanced Technology Microwave Sounder (ATMS) to provide global, high-resolution temperature and moisture profiles that are used to produce improvements in both short- and long-term weather forecasting models. Both CrIS and ATMS, together referred to as the Cross-track Infrared Microwave Sounder Suite (CrIMSS), are comparable to the Atmospheric Infrared Sounder (AIRS) and Advanced Microwave Sounding Unit (AMSU) aboard the Aqua spacecraft. The Ozone Mapping Profiler Suite (OMPS) builds on the 30-year uninterrupted legacy of atmospheric ozone- and aerosol-measuring instruments using the backscatter ultra-violet (BUV) technique. The

[2] For more information about each of Suomi NPP's instruments, visit: *npp.gsfc.nasa.gov/spacecraft_inst.html*.

For nearly a year, Suomi NPP has been orbiting 824 km (512 mi) above the Earth's surface, covering the entire planet twice a day—once during daylight and once at night. Suomi NPP's instruments are sending back significant new data about our home planet.

fifth instrument is the Clouds and the Earth's Radiant Energy System (CERES) instrument[3], which measures both the solar energy reflected by Earth and the heat emitted by the planet that are key components of the Earth's radiation budget. Additional information on the role the CERES plays in weather analysis and forecasting is found later in this article.

A Suomi NPP Sampler

For nearly a year, Suomi NPP has been orbiting 824 km (512 mi) above the Earth's surface, covering the entire planet twice a day—once during daylight and once at night. Suomi NPP's instruments are sending back significant new data about our home planet. What follows is a sample of a few of Suomi NPP's contributions to-date.

Ozone Monitoring

One of the longest-term series of data obtained by NASA about our world comes from measurements of Earth's ozone layer, which protects Earth's surface from dangerous levels of solar ultraviolet radiation. This record began with measurements from the Solar Backscatter Ultraviolet (SBUV)[4] experiment and the Total Ozone Mapping Spectrometer (TOMS) on the Nimbus 7 satellite, launched in 1978. These measurements continued with the Earth Probe TOMS, and were extended with Aura's Ozone Monitoring Instrument (OMI)—see **Figure 3**. These observations led to the discovery of

[3] CERES instruments are also onboard the Tropical Rainfall Measuring Mission (TRMM) and the Terra and Aqua satellites; one will also be onboard the JPSS-1 platform.
[4] The Solar Backscatter Ultraviolet Radiometer (SBUV/2) flew on a series of NOAA missions launched from 1984 through 2009.

What's In a Name?

The first public unveiling of Suomi NPP data took place during the January 2012 meeting of the American Meteorological Society in New Orleans, LA. At that time, NASA renamed the former NPOESS Preparatory Project satellite in honor of **Verner Suomi**, a meteorologist at the University of Wisconsin-Madison (UWM), who is recognized today as the father of satellite meteorology. In addition to naming the satellite for Suomi, the acronym NPP was also changed to National Polar-orbiting Partnership.

"Verner Suomi's many scientific and engineering contributions were fundamental to our current ability to learn about Earth's weather and climate from space," said **John Grunsfeld** [NASA's Science Mission Directorate—*Associate Administrator*]. "Suomi NPP not only will extend more than four decades of NASA satellite observations of our planet, it also will usher in a new era of climate change discovery and weather forecasting."

Suomi pioneered remote sensing of Earth from satellites in polar orbits a few hundred miles above the surface with Explorer 7 in 1959, and from geostationary orbits thousands of miles high with the Applications Technology Satellite (ATS-1) in 1966. While Suomi was involved in planning interplanetary spacecraft missions to Venus, Jupiter, Saturn, Uranus, and Neptune, he was best known for his invention of the "spin-scan" camera that enabled geostationary weather satellites to continuously image Earth, yielding the satellite pictures commonly used on television weather broadcasts today.

Suomi spent nearly his entire career at UWM, where in 1965 he founded the university's Space Science and Engineering Center with funding from NASA. The center is known for Earth-observing satellite research and development. In 1964, Suomi served as chief scientist of the U.S. Weather Bureau and received the National Medal for Science in 1977. He passed away in 1995 at the age of 79.

"The new name now accurately describes the mission," said **Michael Freilich** [NASA's Science Mission Directorate, Earth Science Division—*Director*]. "Suomi NPP will advance our scientific knowledge of Earth and improve the lives of Americans by enabling more accurate forecasts of weather, ocean conditions, and the terrestrial biosphere."

the "ozone hole" in the mid-1980s, and offered the world conclusive evidence of the need to take immediate action to phase out the use of ozone-depleting chemicals. These conclusions were a key impetus to the enactment of the Montreal Protocol[5].

OMPS continues these observations and offers some new capabilities. The suite is actually comprised of three instruments, a *nadir mapper,* that looks straight down from the sensor through the atmosphere and maps global ozone at or near the ground with about 50-km (31-mi); a *nadir profiler,* that will measure the vertical distribution of ozone in the stratosphere; and a *limb profiler,* that views through the atmosphere toward the Earth's *limb*—the halo of atmosphere that surrounds our planet. It will measure ozone in the lower stratosphere and troposphere with high vertical resolution. This combination of views will improve our understanding of the vertical distribution of ozone, which is important in understanding the chemistry of ozone's interactions with other gases in the atmosphere.

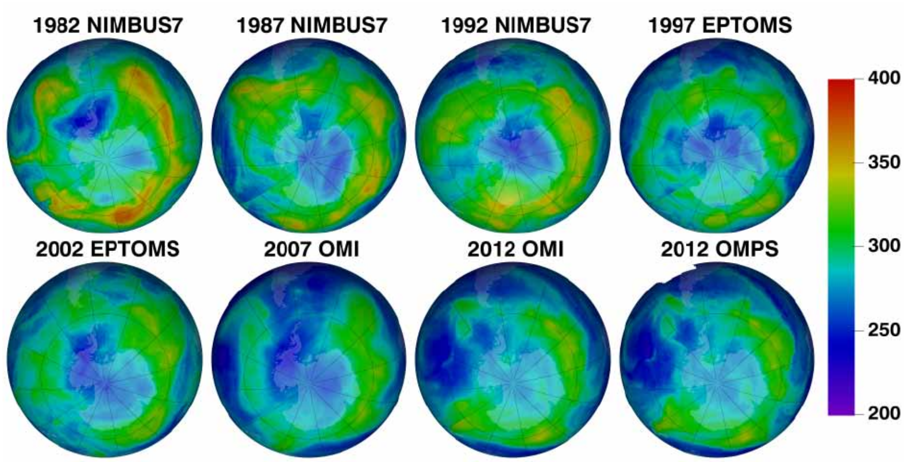


Figure 3. This series of images shows the thickness of the Earth's ozone layer on January 27 for select years from 1982 to 2012, in Dobson units—as measured by instruments on several different satellites. In this image, smaller amounts of overhead ozone are shown in blue, while larger amounts are shown in orange and yellow. **Image and partial text credit**: NASA/NOAA

Nighttime Imagery

The ability of the VIIRS to obtain nighttime imagery surpasses the capabilities of its predecessors, and has resulted in some remarkable images—see **Figures 4** and **5**.

Steven Miller [Colorado State University, Cooperative Institute for Research in the Atmosphere] noted that images from VIIRS's DNB sensor could be combined with thermal images to provide a more-complete view of volcanic activity on Earth's surface than earlier capabilities. Acquiring thermal data near a volcano with conventional

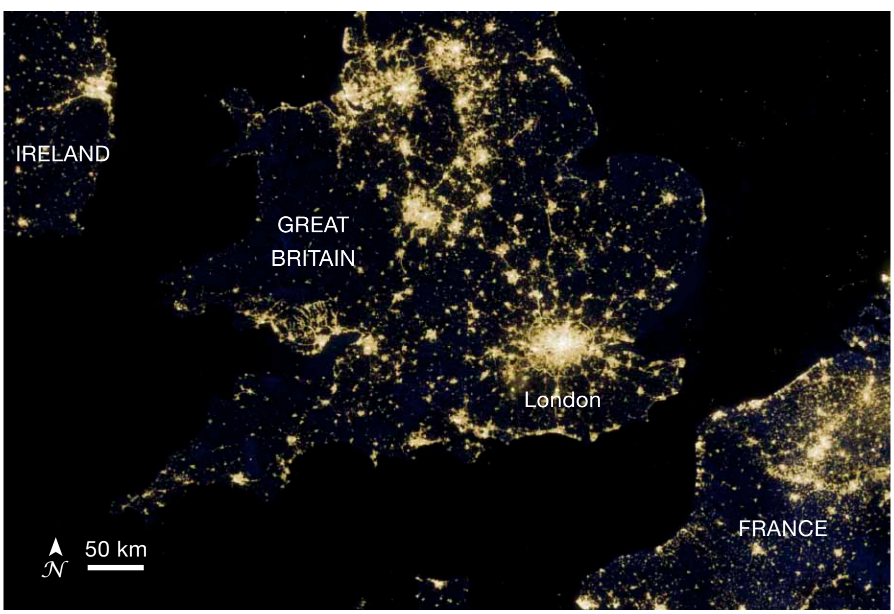


Figure 4. This image, acquired by the VIIRS instrument on Suomi NPP, shows London and the southern half of Great Britain as they appeared on the night of March 27, 2012. **Image and partial text credit**: NASA's Earth Observatory

[5] In the 1980s, governments around the world began to understand the mechanisms leading to the destruction of the ozone layer. As a result, in 1987 representatives from over 200 countries negotiated the Montreal Protocol—an international treaty designed to protect the ozone layer by banning chlorofluorocarbons, or CFCs, and similar ozone-depleting chemicals.

infrared sensors is difficult, but VIIRS can detect these "hot spots" both close to the source and lower in the atmosphere. "Such information can give forecasters a heads-up in terms of changes in ash production and low-level wind shifts that may redirect these hazardous plumes," said Miller.

Specifically, Suomi NPP flew over New Zealand's Mount Tongariro at 12:55 AM local time on August 7 (12:55 PM UTC on August 6), just an hour after the eruption began. Using only moonlight for illumination, VIIRS captured an image of the volcanic ash plumes released during Tongariro's first eruption in 115 years (Figure 5). The volcano is located in a mostly undeveloped part of the country; no injuries were reported as a result of the eruption, although roads were closed and domestic flights were canceled. The 1978-m (6490-ft) peak is a popular spot for hikers and is right next to Mount Ngauruhoe—the stand-in for Mount Doom in the *Lord of the Rings* movies.

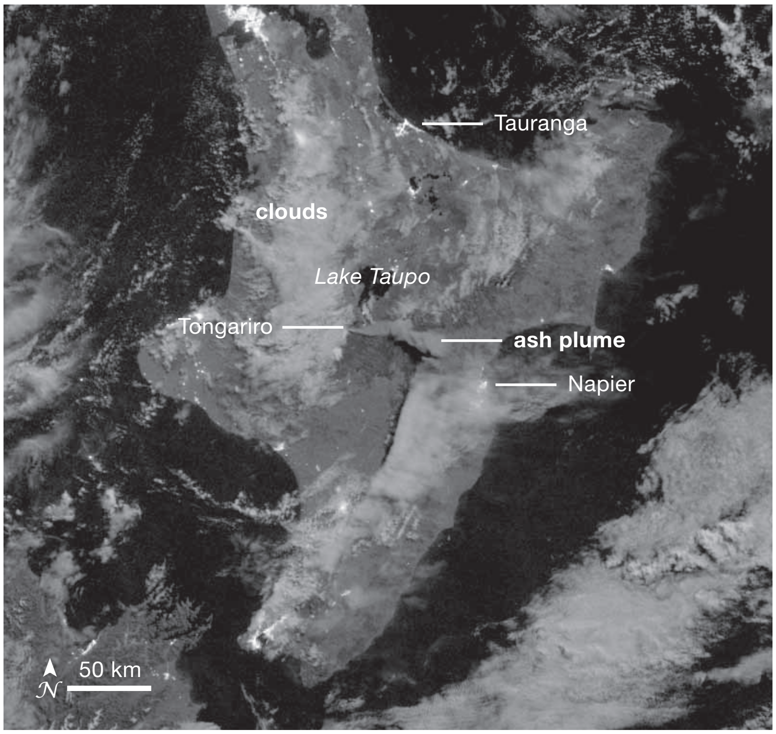
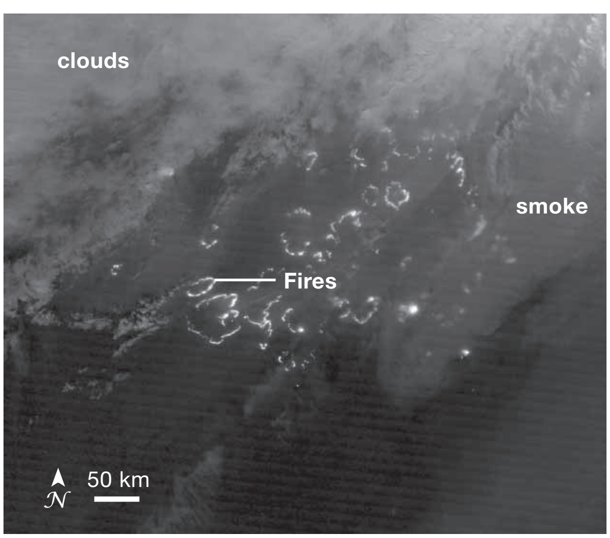


Figure 5. Lit by moonlight alone, Suomi NPP's VIIRS instrument captured this view on August 7, 2012, of the ash plume from Mount Tongariro in New Zealand. **Image credit**: NASA's Earth Observatory

Combining Measurements

As was the case with its EOS predecessors, Terra, Aqua, and Aura, Suomi NPP scientists often integrate information from the platform's several instruments to investigate different aspects of the same or related phenomena. For example, VIIRS has the capability to observe fires—both thermal signatures and smoke thickness and extent—see **Figure 6**—and OMPS has the ability to detect—and distinguish between—smoke and dust (i.e., aerosols), nearly simultaneously. "One of the biggest uncertainties we've had in terms of understanding our climate has to do with aerosols and what exactly aerosols do to the climate," said **Colin Seftor** [GSFC—*Atmospheric Scientist*]. He emphasized that OMPS adds to and expands upon decades of related scientific research. "Climate changes often occur over long periods, and it takes decades of data and [very accurate] measurements to detect and understand them." Seftor said that, unlike photographs, satellite data show researchers the difference between reflections from smoke and dust from those from snow, ice, or the tops of clouds. This assessment is evident in a series of images Seftor developed showing how pollutants from Siberian wildfires travel across the Pacific Ocean and affect Alaska, Canada, and Northern California that combines data from Suomi NPP OMPS and Aqua MODIS—as shown in **Figure 7** (next page). The sensitivity provided by the OMPS allowed Seftor to identify the pollutants amidst the clouds and snow-covered areas in this northern area of the world.

Figure 6. On August 3, 2012, VIIRS acquired this image of wildfires in eastern Siberia. The image is from the instrument's DNB, which sensed the fire in the visible portion of the spectrum. The brightest fires are white; smoke is light gray. **Image and partial text credit**: NASA's Earth Observatory



Weather and Climate

As discussed previously, governments worldwide have agreed on a way to protect the ozone layer; however, agreements on the presence and effects of global climate change have been harder to come by. Long-term and verifiable data on global temperatures can inform these discussions.

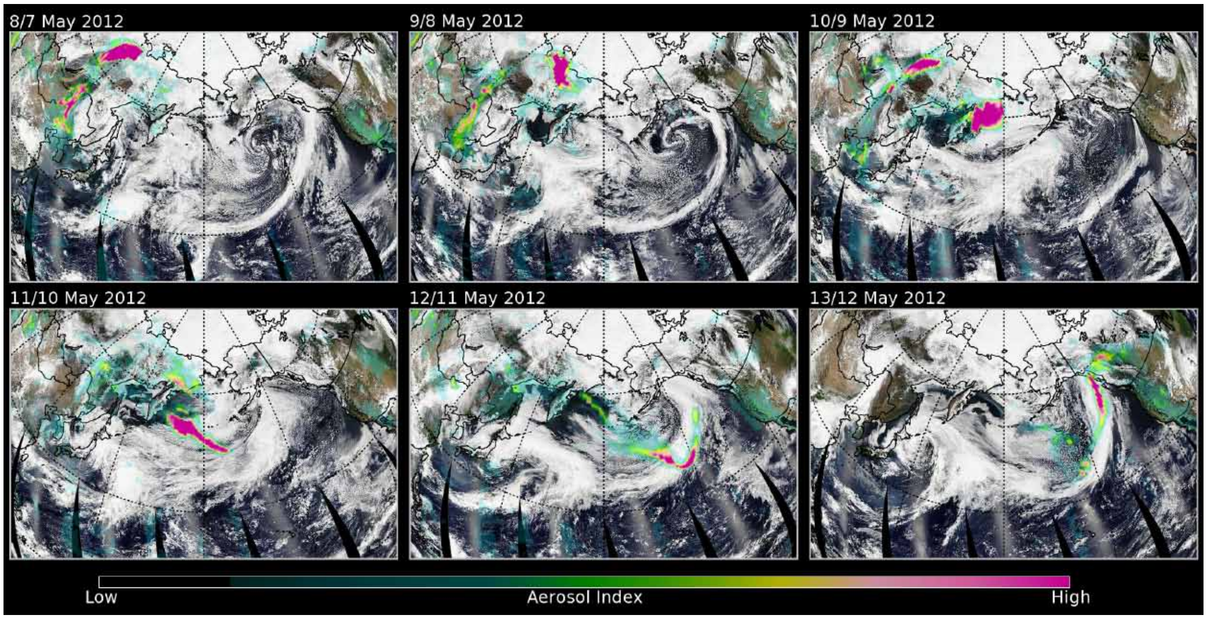
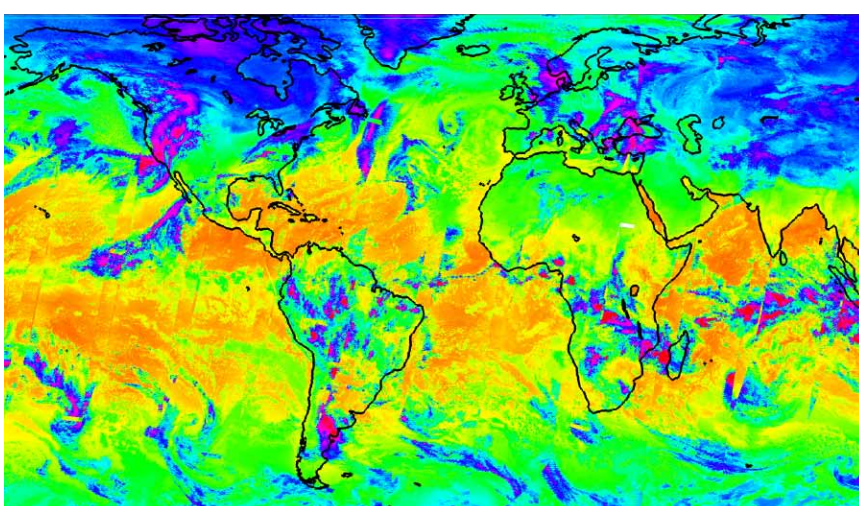


Figure 7. These images track smoke from Siberian Wildfires as it wafts across the Pacific Ocean from May 7 to 13, 2012. They were created by superimposing Suomi NPP OMPS aerosol index measurements on visible images of clouds and land surface from Aqua's MODIS. The densest part of the smoke plumes shows up in pink and yellow, while less dense parts of the plume appear in blue and green. **Image credit:** NASA/Suomi NPP/**Colin Seftor**

The CrIS instrument that flies aboard Suomi NPP is a powerful new infrared instrument that gives scientists more-refined information about Earth's atmosphere than has been provided by legacy instruments. This improves our understanding of both *weather*—extant and near-term atmospheric conditions—and *climate*—atmospheric conditions over longer timescales.

The CrIS instrument is a Fourier transform spectrometer with 1305 infrared spectral channels, designed to provide three-dimensional, high-vertical-resolution temperature and water vapor data. These data, in addition to being crucial for studying climate change, are also used by NOAA scientists—along with ATMS data—in their numerical weather predictions to forecast severe weather days in advance. Furthermore, over longer periods, data from CrIS will help NOAA and NASA better understand climate phenomena (e.g., El Niño and La Niña) that impact global weather patterns. The formation and effects of El Niño and La Niña depend on a number of factors, such as the temperatures of the world's oceans. The ability of CrIS to continue the ongoing long-term data record of these continuously fluctuating data can help researchers track the reasons why these phenomena occur, and better predict their effects and intensity—see **Figure 8**.

Figure 8. This composite image shows CrIS data from January 21, 23, and 25, 2012. The orange colors represent very warm sea surface temperatures; magenta represents very cold temperatures (e.g., high-altitude cloud tops). **Image credit**: NASA/NOAA



CrIS and ATMS are not the only instruments on Soumi NPP that study weather. One of the many measurements provided by VIIRS is its capability to acquire images of large-scale weather phenomena, such as hurricanes and typhoons. Moreover, the CERES instrument on NPP continues the long line of existing CERES-derived data in tracking the roles that clouds play in the Earth's *energy balance*. This balance is the calculated difference between the energy that enters the Earth's system, primarily from the Sun, and the energy that leaves the Earth's system, by thermal radiation emitted back into space from the Earth itself and the much larger amount that's reflected from sea ice, the Earth's surface and, significantly, from clouds. The CERES measurements from Suomi NPP will continue a 27-year record of energy balance observations. Such long term observations, when accurate enough, allow researchers to detect energy balance *trends*—i.e., how a particular parameter, in this case energy balance, changes with time. Analysis of the

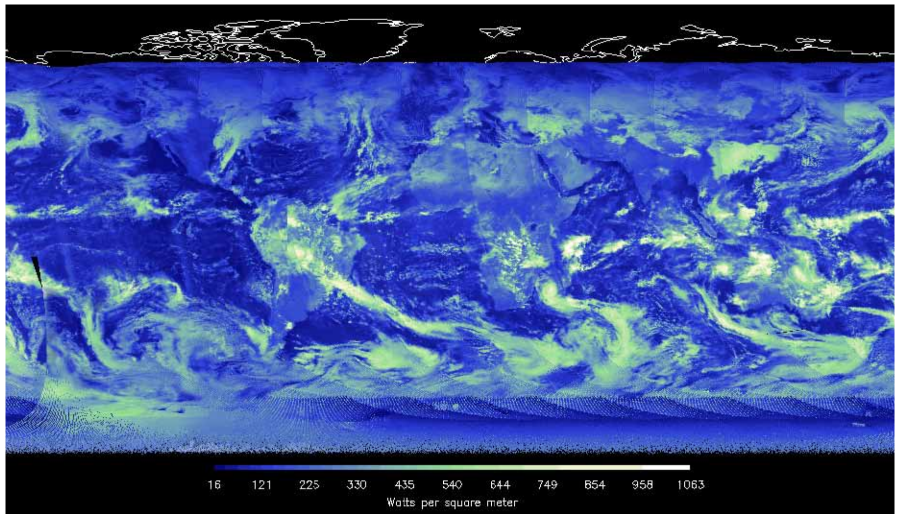


Figure 9. This image shows the amount of energy that is reflected back out to space. Thick cloud cover tends to reflect a large amount of incoming solar energy back to space, but at the same time, reduces the amount of outgoing heat lost to space. **Image credit**: NASA/NOAA/CERES Team

CERES data also leads to better understanding of the relationship between clouds and energy balance, which is crucial to understanding Earth's climate change. These two images (**Figures 9** and **10**), showing just one day of CERES data, clearly demonstrate the roles that clouds play in both reflecting sunlight and blocking energy from radiating back into space.

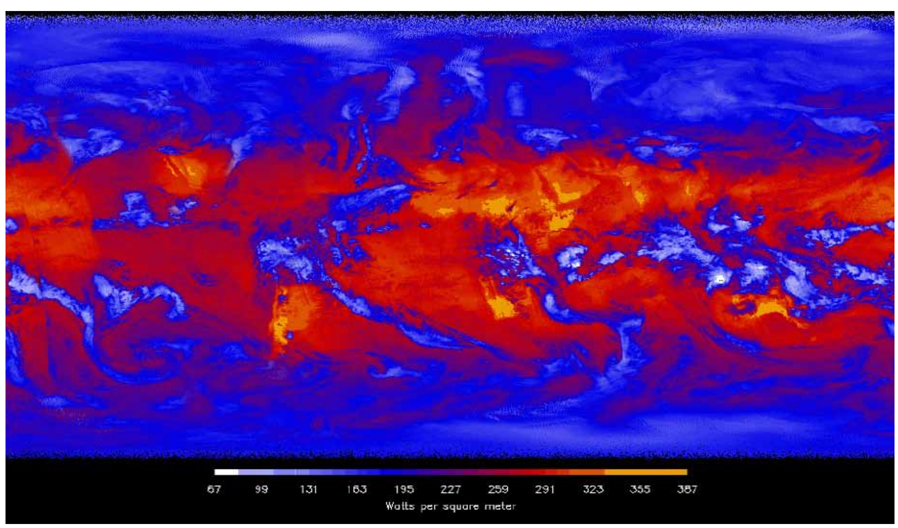


Figure 10. This image shows how longwave radiation, or heat energy, is radiated from Earth. The blue areas and the bright white clouds are much colder emitting the least energy; the red and orange areas are the hottest and are emitting the most energy out to space. In the red locations, the Earth radiates to space from lower, warmer parts of the troposphere, cooling the Earth more effectively than the blue regions.
Image credit: NASA/NOAA/CERES Team

Ground Control to Suomi NPP

Suomi NPP sends all its data back to Earth in two different ways. The main data returns are via a dump that takes place when Suomi NPP passes over its ground station in Svalbard, Norway, which occurs 14 times every 24 hours. The second data return is via the satellite's High Rate Data link, a communications system that provides *direct broadcast* data to users in real-time. Customized mathematical formulas convert the raw data into images that help users manage quickly changing regional events, such as rapidly spreading forests fires, rushing flood waters, and icebergs that could affect shipping and the fishing industries.

Conclusion

In all, Suomi NPP is a powerful tool that is assisting researchers to understand, monitor, and predict the course of long-term climate change and short-term weather fluctuations. These tasks are of profound importance for economic competitiveness, human health and welfare, and global security, all of which depend in part on our ability to understand and adapt to environmental changes. Suomi NPP makes a major contribution to these efforts. ■

In all, Suomi NPP is a powerful tool that's assisting researchers to understand, monitor, and predict the course of long-term climate change and short-term weather fluctuations.

Unearth NASA Science at the 2012 Fall AGU Meeting

Please plan to visit the NASA booth (# 225) during the American Geophysical Union's (AGU) forty-fifth annual Fall Meeting. This year's exhibit hall will open on Tuesday, December 4, and will continue through Friday, December 7.

Throughout the week, representatives from several different programs and missions are scheduled to give presentations using the NASA Hyperwall—a nine-screen video wall that will be the centerpiece at our exhibit. Presentations will cover a diverse range of research topics, science disciplines, and programs within NASA's Science Mission Directorate.

At the booth there will also be a wide range of other science presentations, demonstrations, printed material, and tutorials on various data tools and services.

Learn about new and upcoming missions: Aquarius, the Suomi National Polar-orbiting Partnership (NPP), the Global Precipitation Measurement (GPM), the Soil Moisture Active Passive (SMAP), the Radiation Belt Storm Probes (RBSP), the Gravity Recovery and Interior Laboratory (GRAIL), Juno, the Mars Science Laboratory/Curiosity Rover, and others.

A daily agenda will be posted on the Earth Observing System Project Science Office website—*eos.nasa.gov*—in late November.

We hope to see you in San Francisco!

Blog Log

Heather Hanson, NASA's Goddard Space Flight Center/Wyle, heather.h.hanson@nasa.gov

This periodic installment features new blogs about NASA's Earth-science research and fieldwork, and provides links where you can access the full blog and view color photographs, online. In the realm of science, a lot can be said for working out in the field, along a river, and out at sea. In this issue, we highlight three new *Notes from the Field* blogs: *Siberia 2012—Ebenchime River Expedition, SMAP and SMAPVEX2012,* and *Salinity Processes in the Upper Ocean Regional Study (SPURS)*—where you'll learn about the trials and tribulations from an outsider's perspective. If you know of any blogs that should be shared in the *Blog Log*—perhaps one of your own—please let us know!

[Blog introductions are modified text from featured blogs; images are also from featured blogs.]

Siberia 2012—Embenchime River Expedition

To many people, the Arctic is an almost unimaginably remote area at the "end of the Earth"—more a land of fable and fantasy than a real part of the everyday world. Most people have very little day-to-day connection with the forests, the fields, and the people who are all part of the vast boreal ecosystem. Yet, in a very real way, the health of every person and every ecosystem on Earth is connected to the health of the Arctic—and, in a word, that *connection* is through stored carbon.

It is because of this vital connection to the Earth that it is imperative to understand the boreal ecosystem. Driven by the desire to learn more about a vital—yet sparsely studied—region, a team of dedicated scientists from NASA and Russia's Academy of Science embarked on a two-week expedition in the remote boreal forests of northern Siberia. To learn more about the international team and their journey through larch forests (taiga) along the Embenchime (pronounced *Em-bem-chee-may*) River in far northern Siberia, follow their blog at *earthobservatory.nasa.gov/blogs/fromthefield/category/siberia-2012-embenchime-river-expedition*[1].

The Embenchime River Expedition scientific team posed for a group photo. Behind the group is a basaltic hill, with a forest killed by fire. A small regeneration is apparent under the dead trees. A band of healthy larch, unburned by fire, lines the riverbank. **Image credit**: NASA

SMAP and SMAPVEX12

The Soil Moisture Active Passive (SMAP) mission is a NASA Earth science satellite that uses microwave radar and radiometer instruments to measure soil moisture from space[2]. The instrument system is mounted on a dedicated spacecraft that is scheduled for launch in October 2014. *SMAPVEX12* stands for the 2012 Soil Moisture Active Passive (SMAP) Validation Experiment, and was the primary prelaunch field campaign for SMAP that took place near Winnipeg, Canada during the six-week period from June 6 to July 17, 2012.

SMAPVEX12 team members measure crop height and diameter out in the field. **Image credit:** NASA

Participants in the campaign blogged every few days about the field study and provided insights into the field sampling and soil and vegetation conditions along the way. We have enjoyed reading about everyone's experiences. If you haven't been following along in near-real-time, we hope you will check it out at *smap.jpl.nasa.gov/blogs*.

[1] You can learn about some previous expeditions to Siberia in the September–October 2007 issue of *The Earth Observer* [**Volume 19**, **Issue 5**, pp. 13-21] and January–February 2009 issue [**Volume 21**, **Issue 1**, pp. 9-20].

[2] The National Research Council's 2007 Earth Science Decadal Survey identified SMAP as a *Tier 1* priority mission.

Salinity Processes in the Upper Ocean Regional Study (SPURS)

On September 6 a group of NASA-funded scientists departed on an expedition across the North Atlantic Ocean to study seawater salt concentrations. The group will embark on the Research Vessel *Knorr*, leaving from Woods Hole Oceanographic Institution in Massachusetts, and head toward Punta Delgada, Azores (territory of Portugal), where they plan to arrive on October 9. The cruise is part of a multi-year research project called Salinity Processes in the Upper Ocean Regional Study (SPURS).

You may ask, "Why do they want to spend six weeks at sea measuring ocean saltiness?" By following the blog entries over the coming months, you will come to understand that motivation, and get caught up in the action as **Eric Lindstrom** [NASA's Physical Oceanography Program—*Project Scientist*] posts to the blog at *earthobservatory.nasa.gov/blogs/fromthefield/category/spurs*. He plans to introduce the science, the scientists and technicians, their individual contributions to the field campaign, and the amazing technology that makes it all possible. ■

Eric Lindstrom is the project scientist for NASA's Physical Oceanography program. He will be telling his version of the story of SPURS over the next six weeks. **Image credit:** NASA

Hyperwall Team Receives 2012 Agency Honor Award

A contingent of civil servants and contractors who support the NASA Science Hyperwall received a Group Achievement Award during the 2012 Agency Honor Awards ceremony held at NASA Headquarters on August 2, 2012. This prestigious NASA certificate is awarded to any combination of government and/or non-government individuals for an outstanding group accomplishment that has contributed substantially to NASA's mission. The group was selected to receive the award for their outstanding efforts in developing the *Science Mission Directorate Presentation Hyperwall* and using it to communicate the wonder and impact of NASA scientific endeavors.

A key to its success is that outreach support staff from NASA's Earth Observing System Project Science Office (EOSPSO) proposed that a portable Hyperwall system be developed to display NASA content at high-profile venues worldwide. The Hyperwall has since become the primary focus at many of NASA's outreach exhibits. Through tireless dedication and effort, the entire team has implemented an exciting presentation platform that has garnered praise and generated abiding interest in NASA Earth and space sciences in the U.S. and worldwide. Congratulations and a job well done!

Group Achievement Award Recipients: Science Mission Directorate Presentation Hyperwall

William Bridgeman [NASA's Goddard Space Flight Center (GSFC)]; **Daniel Duffy** [GSFC]; **Steve Graham** [GSFC]; **Chris Henze** [NASA Ames Research Center (ARC)]; **Winnie Humberson** [GSFC]; **Heather Hyre** [GSFC]; **Marit Jentoft-Nilsen** [GSFC]; **Joycelyn Jones** [GSFC]; **Alex Kekesi** [GSFC]; **Helen-Nicole Kostis** [GSFC]; **Mark Malanoski** [GSFC]; **Horace Mitchell** [GSFC]; **Lori Perkins** [GSFC]; **Trent Schindler** [GSFC]; **Gregory Shirah** [GSFC]; **Eric Sokolowsky** [GSFC]; **Cindy Starr** [GSFC]; **Jim Williams** [ARC]; and **Ernie Wright** [GSFC].

Recipients from NASA's EOSPSO posed for a group photo following the ceremony [Clockwise from top left] **Marit Jentoft-Nilsen** [GSFC], **Lawrence Klein**, **Mark Malanoski** [GSFC], **Steve Graham** [GSFC], **Heather Hyre** [GSFC], and **Winnie Humberson** [GSFC]. **Image credit:** NASA

Chesapeake Modeling Symposium 2012

Interfacing Between Modeling, Management, and the Public: TMDLs, Politics, Litigation, and Conflicting Stakeholder Interests

David Jasinski, Chesapeake Community Modeling Program, dave@communitymodeling.org
Raleigh Hood, Horn Point Laboratory, University of Maryland Center for Environmental Science, rhood@umces.edu
Maria Tzortziou, Earth System Science Interdisciplinary Center, University of Maryland, maria.a.tzortziou@nasa.gov

The Chesapeake Community Modeling Program's goal for the symposium was to foster a dialogue about the use of models in environmental management and the potential impacts to the various stakeholder communities in the Chesapeake region—including the general public, watermen, farmers, local government officials, and even managers and model developers.

Introduction

The Chesapeake Community Modeling Program (CCMP) held its third biennial Chesapeake Modeling Symposium (CheMS12) May 21-22, 2012, in Annapolis, MD. The meeting brought together environmental modelers, experimentalists, managers, and local government representatives to discuss the state of environmental modeling in the Chesapeake region, and how model output, integrated with field and satellite observations of physical and biogeochemical processes in the Bay system, can inform management decisions.

The goal of the CCMP is to foster the development and use of open-source watershed and estuary models specific to the Chesapeake Bay region. Every two years the program hosts a symposium focused on this topic; this year's focus was on the complex interplay between modeling and environmental management, and stakeholder and public perceptions and understanding of this interplay. This topic is timely, given that the Chesapeake Bay Program (CBP)—an office of the U.S. Environmental Protection Agency (EPA) charged with coordinating the Chesapeake restoration effort—is in the process of developing Total Maximum Daily Loads[1] (TMDL) to regulate the quantities of nitrogen, phosphorus, and sediment that enter the Bay[2]. These loads will be allocated across all of the municipalities within the 64,000 mi^2 (165,759 km^2) watershed of Chesapeake Bay; the allocations are being developed using the CBP's modeling suite. Given that the municipalities will be responsible for making potentially expensive nutrient and sediment reductions as dictated by the allocations, the validity of the CBP modeling suite has come under increased scrutiny, and this scrutiny will continue.

The CCMP's goal for the symposium was to foster a dialogue about the use of models in environmental management and the potential impacts to the various *stakeholder communities* in the Chesapeake region—including the general public, watermen, farmers, local government officials, managers and model developers. To that end, a series of focused plenary talks and panel discussions ensued that are summarized herein[3].

Keynote and Plenary Presentations

Raleigh Hood [CCMP—*Program Coordinator*] kicked off CheMS12 by welcoming all those in attendance. He then briefly reviewed the format of the symposium and covered a few logistical details. Hood then introduced the keynote speaker, **Jeff Corbin** [EPA—*Senior Advisor to the Administrator for the Chesapeake and Anacostia Rivers].*

[1] *Total Maximum Daily Loads* are standards imposed under Section *301(d)* of the Clean Water Act (1972) that stipulate maximum amounts of certain pollutants that a body of water can receive and still be considered "safe." Please refer to *water.epa.gov/lawsregs/lawsguidance/cwa/* to learn more.

[2] Enacted in December 2010, the *Chesapeake Bay Total Maximum Daily Load (TMDL)* prescribes a "pollution diet" for the Bay that aims to substantially reduce the amount of nitrogen (25% reduction from 2010 levels), phosphorous (24%), and sediment (20%) entering the Chesapeake and its tributaries by 2025. To learn more, please visit: *www.epa.gov/reg3wapd/tmdl/ChesapeakeBay/tmdlexec.html.*

[3] The two plenary presentations and panel discussion are briefly summarized here; to read more detailed descriptions please visit: *ches.communitymodeling.org/downloads/ChesapeakeModelingSymposium2012.pdf.*

Corbin began his presentation—*World Class Modeling in the Chesapeake Bay: May No Good Deed Go Unpunished*—with a description of the current status of TMDL development. He emphasized that the world is actually watching how things develop in the Chesapeake. The CBP has had inquiries from Japan, China, the Philippines, Korea, and Canada as well as management agencies from Long Island Sound (between CT and NY), Puget Sound (WA), and Albemarle and Pamlico Sounds (NC). Corbin indicated that complaints about the TMDL for the Chesapeake Bay are for the most part the same complaints that any environmental regulation encounters. They range from the political, where people feel the government is overreaching; to the financial, where there are questions about who is going to foot the bill; to the logistical, where the science behind the process is questioned. Corbin then spent some time reviewing the evolution of the CBP model since the 1980s, discussing the vast improvements to both model resolution and the questions it can address; this is illustrated in **Figure 1**. His presentation then turned to how the model technical review process at the CBP

"…. The world is actually watching how things develop in the Chesapeake."

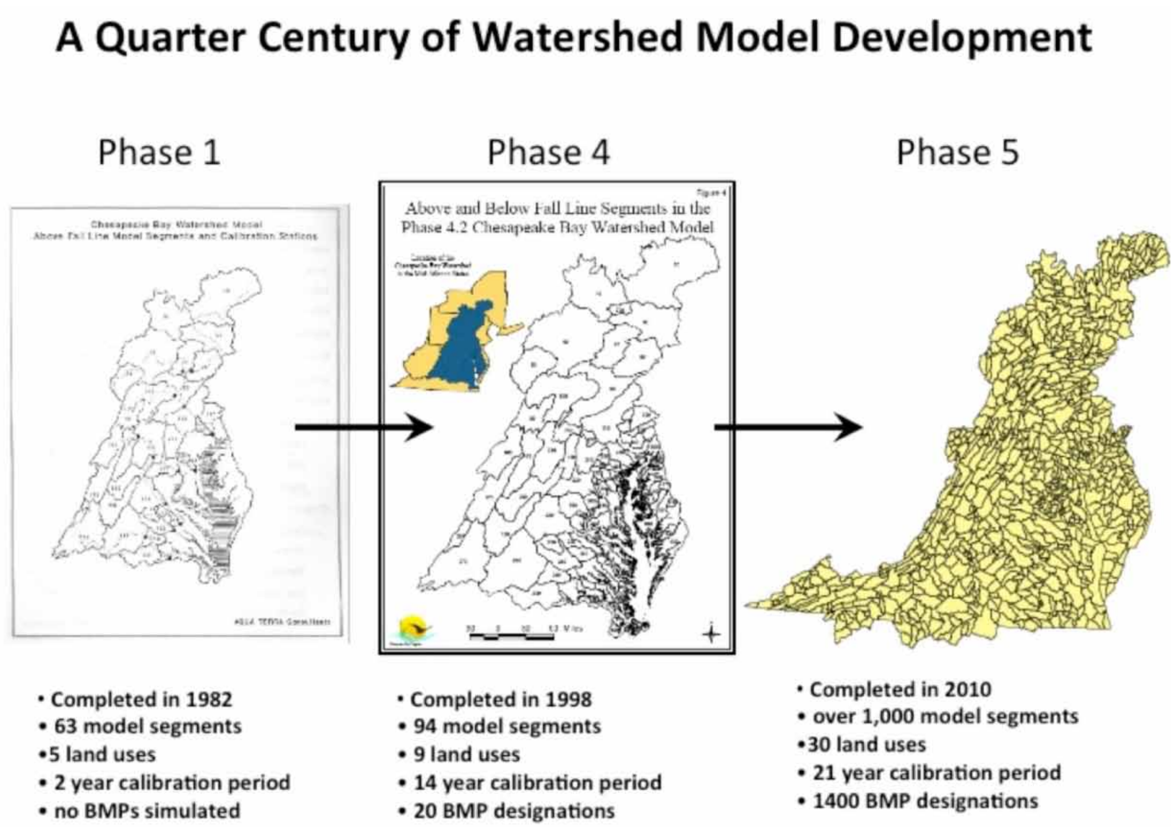


Figure 1. An image from Jeff Corbin's keynote speech, showing the evolution of the Chesapeake Bay Program's watershed model. **Image credit: Jeff Corbin**

has also evolved over time and, using the CBP Agricultural Workgroup as a specific example, illustrated how—in addition to federal, state, and academic representation—the working group now included representatives from industry groups, conservation districts, and nongovernmental organizations. The CBP is also forming expert review panels to investigate proposed best management practices (BMPs) that will help municipalities meet their TMDLs. There will be expert panels for agriculture, urban, and forestry BMPs.

Corbin's presentation then turned to some of the lessons learned during the TMDL process, and how model developers could help as the process moves forward. He shared that a state representative once told him that he wanted to be able to explain models to his stakeholders and be certain that they understood. As a result, Corbin asked the modelers to be better communicators, and that better communication needed to be part of the model refinement process. He made it clear that the public relations world would be where the battle for Bay restoration would be won or lost.

On May 22, 2012, the Louisiana Legislature unanimously approved the 2012 Coastal Master Plan. It will serve as the blueprint for all future coastal protection and restoration efforts in Louisiana.

Denise Reed [University of New Orleans] discussed *Using Models to Inform Restoration Decision Making*, focusing on two real-world examples, where models were used to inform management and restoration decisions. The first example described using conceptual models in ecosystem restoration planning in the Sacramento–San Joaquin Delta, and was an example of *adaptive management*, where managers set goals and then adjust the goals based on model outputs—see **Figure 2**. The second example described how more-complex analytical models were used to develop a Louisiana Coastal Master Plan. On May 22, 2012, the Louisiana Legislature unanimously approved the 2012 Coastal Master Plan. It will serve as the blueprint for all future coastal protection and restoration efforts in Louisiana.

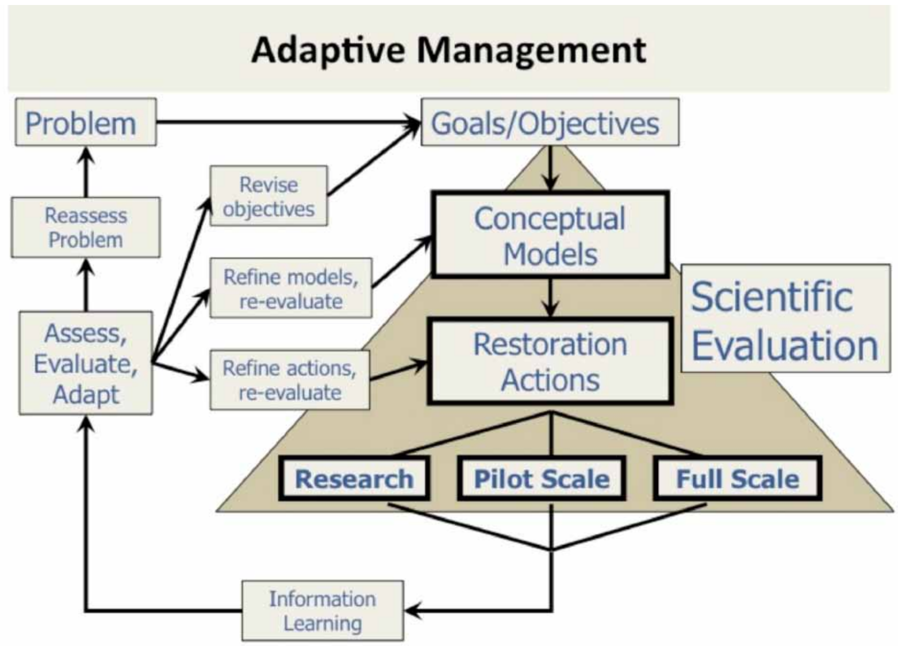


Figure 2. Denise Reed described the role of conceptual models in the adaptive management process.

Gerard Learmonth [University of Virginia (UVA)] discussed *The University of Virginia Bay Game,* a large-scale participatory simulation developed at UVA that is based in the Chesapeake Bay watershed—*www.virginia.edu/baygame*. Learmonth gave a brief introduction to the UVA Bay Game and some of the science behind it before he and his associates from UVA led the approximately 140 people in attendance in playing a few rounds—see *Symposium Participants Play the University of Virginia Bay Game* on the following page.

Panel Discussion: TMDLs, Politics, Litigation, and Conflicting Stakeholder Interests

Panel members answer questions during the panel discussion on day two of the symposium.

On the morning of the second day of the symposium, a panel discussion took place—see photograph. **Jon Kramer** [National Socio-Environmental Synthesis Center] moderated the panel, whose members included: **Anne Swanson** [Chesapeake Bay Commission], **Beth McGee** [Chesapeake Bay Foundation], **Rich Batiuk** [EPA/CBP], **Kim Burgess** [Baltimore Department of Public Works Surface Water Management Division]; **Arthur Butt** [Virginia Department of Environmental Quality], **Ken Staver** [University of Maryland's Wye Research and Education Center] **Jason Keppler**

Symposium Participants Play the University of Virginia Bay Game

In this innovative game, developed at University of Virginia (UVA), players take the role of farmers, developers, watermen, and local policy makers. In these roles they make decisions about their livelihood or environmental regulations. They then get real-time feedback on the impacts of their decisions on their own personal wealth, the local economy, and the health of the Bay watershed. The model behind the game is based on statistical relationships between land use, river flow, and Chesapeake Bay water quality.

Gerard Learmonth gives a status update to symposium attendees playing the UVA Bay Game.

CheMS12 participants got a chance to play the game. Each of the tables in the conference room was assigned to one of the major Chesapeake rivers (e.g, Susquehanna, Potomac, James, York), with symposium attendees being assigned roles (e.g., waterman, developer, environmental manager) based on cards placed on the table beforehand. Attendees then proceeded to play using their laptops and iPads connected through the Web to UVA's server. Players proceeded through several "years," making financial and environmental decisions based on their respective roles. After each year of play, the team from UVA would review how the players' decisions for that year and natural phenomena impacted the health of the Chesapeake. An entertaining aspect of the game is that players can post messages to the entire group on a live discussion board while they are playing.

The attendees' reactions to the Bay Game were very positive. Because the game is based on how Chesapeake stakeholder decisions impact the Bay's health, it was right in line with the theme of the symposium, and helped to set the tone for the next two days.

[Maryland Department of Agriculture], **Lee Curry** [Maryland Department of Environment], and **Michael Paolisso** [University of Maryland, College Park]. Kramer began and then led the discussion by asking panelists to take five minutes to introduce themselves and explain which constituency or stakeholders they represented.

All of the panelists support the idea that the TMDL was a necessary step in protecting the Chesapeake. There was also consensus that the TMDL process is an incredibly complex and groundbreaking effort. While they all agreed that the TMDL would have a positive impact on Bay health, each panelist had a unique perspective on what would be the impacts of new regulations on various stakeholders. While everyone agreed that models play a pivotal role in the process, all had their own opinions, born of experience, about how models are perceived by various Chesapeake stakeholders.

While they all agreed that the TMDL would have a positive impact on Bay health, each panelist had a unique perspective on what would be the impacts of new regulations on various stakeholders.

Kramer then posed some specific questions to the panelists to help foster discussion about TMDLs, models, and Chesapeake Bay management; he also fielded some questions from the audience. These questions and a synopsis of the responses are detailed in the full report of these proceedings referenced above.

Special Sessions

Each afternoon featured special sessions that addressed a range of topics, from general process and modeling issues for the Chesapeake Bay and similar systems, to integrating model output with field and space-based observations in coastal margin ecosystems, to building model decision-support tools for the upcoming *2017 Assessment*[4] and beyond. Brief summaries of each session are included below.

The rest of the symposium was taken up by various sessions, summaries of which follow. The individual presentations in each session are not described here, but many can be viewed at the website referenced above. In addition, the chairpersons for each session are listed in the full report.

Each afternoon featured special sessions that addressed a range of topics, from general process and modeling issues for the Chesapeake Bay and similar systems, to integrating model output with field and space-based observations in coastal margin ecosystems, to building model decision-support tools for the upcoming 2017 Assessment and beyond.

General Processes and Modeling Aspects of the Chesapeake Bay and Estuaries with Similar Settings (Day 1 and 2)

This session addressed process and modeling issues for the Chesapeake Bay and similar systems—including the estuary and its watershed, airshed, and aquifers—in a general and synergistic way. This was a general modeling session that brought together a diverse and interdisciplinary set of researchers who are addressing issues within the Chesapeake Bay and similar estuarine systems. The session showcased a range of modeling issues and approaches relevant to studying various aspects of these estuaries, and generated exchanges of ideas and discussion.

There were so many relevant presentations that this session was distributed over two afternoons. Many of the talks on the first day focused on sediment modeling in the Chesapeake Bay. Other topics included unstructured grid modeling, submerged aquatic vegetation habitat, sediment processes, model coupling, the Chesapeake and Delaware (C&D) Canal and its impact on the two-bay system, hurricane flood hazards, data assimilation, spatial interpolation methods, and marsh sedimentation and morphology.

The eight presentations on the session's second day featured topics ranging from the Finite Volume Coastal Ocean (FVCOM) model and its implementation in the Chesapeake Bay to modeling of submersed aquatic vegetation (SAV) habitat in the Bay.

Building Blocks for the 2017 Assessment (Day 1)

As noted above, in 2017 the CBP will assess the progress of the Chesapeake TMDL and make plans to implement the last phase of nutrient and sediment reductions prior to the 2025 TMDL deadline. To get to the 2017 Assessment, many of the modeling and assessment building blocks that are available today must be expanded and refined to provide a range of the best available model decision-support tools for the 2017 Assessment and beyond. This session explored some of the planned extensions and applications of the current CBP modeling toolkit, working toward a goal of developing a toolkit that might be applied to future CBP environmental management challenges. This was a very popular and full session, with 13 presentations ranging from tools to help stakeholders use model output, to new and ongoing modeling efforts in the Chesapeake basin.

Observations and Physical-Biogeochemical Modeling at the Fringes—Land, Water, and Air-Water Interactions (Day 1)

Among our most biologically and economically valuable natural resources, estuaries are "hot spots" for biogeochemical exchanges. Due to their location, estuarine systems are also particularly vulnerable to climate variability, coastal urban development, land-use changes, and other anthropogenic disturbances. Despite recent advances in

[4] The Chesapeake Bay TMDL stipulates that by 2017, 60% of the targeted reductions in nutrient and sediment loads should be obtained. The *2017 Assessment* will be used to determine progress to-date and plan for the last phase of nutrient and sediment reductions prior to the 2025 deadline.

modeling biogeochemical cycles in coastal and open ocean waters, a large gap still exists in our ability to accurately model and predict changes in the sources, quality, and fate of carbon, nutrients, and pollutants in estuarine margin ecosystems. Improved understanding and predictive modeling of biogeochemical processes and exchanges in shallow waters and at the land-estuarine interface is imperative for effective management of estuarine resources and decision-making support. It is also crucial for gaining insights into how future changes will affect estuarine biogeochemical cycles, metabolism and ecosystem functioning, and—subsequently—the role of wetlands and estuaries in regional and global carbon cycling and atmospheric carbon dioxide (CO_2) control.

Developing complex, deterministic models of fringing habitat interactions with the water column is a formidable task in view of the complexity of associated processes and the variety of these habitats in the Bay system. Modules of moderate complexity—i.e., incorporating reasonable empiricism as well as mechanistic processes—have been found to be most effective. These modules should be designed, to the greatest extent possible, to interact with a variety of eutrophication models and to be true community models. The point of this session was to bring together experimentalists, modelers, managers, and stakeholders to exchange information and understanding of the current state of the art, missing components, and future directions in integrated observations and modeling of biogeochemical cycles in Chesapeake Bay estuarine margin ecosystems.

Many of the presentations in this session focused on applications of remote sensing techniques and space-based observations to water quality monitoring and assessment in the Chesapeake Bay.

The session featured 12 presentations, dealing with many different aspects of modeling and monitoring the shallow water areas of Chesapeake Bay. This has become an increasingly important topic over the last few years, as Bay scientists and managers have come to recognize the importance of quantifying the dynamics of the shallow-water environment. Many of the presentations in this session focused on applications of remote sensing techniques and space-based observations to water quality monitoring and assessment in the Chesapeake Bay.

Interfacing Between Modeling, Management, and the Public: TMDLs, Politics, Litigation and Conflicting Stakeholder Interests (Day 2)

Environmental models are increasingly taking on higher-profile roles in the management process. In the Chesapeake Bay, the CBP Watershed and Water Quality models are now being used to support regulatory decisions such as TMDLs, instead of voluntary decisions. One of the effects of this changing role is that it brings to light concerns and conflicting interests within different stakeholder communities affected by the regulatory process. Another effect is that the models are increasingly under scrutiny with respect to their scientific validity and forecasting skill. It is anticipated that the TMDL thresholds set by these models will face numerous scientific and legal challenges in the coming months and years. This session attempted to shed light on these emerging concerns and conflicts as they relate to regulatory thresholds and the environmental models that are used to set them, focusing on topics such as understanding, communication, and credibility. Bringing together modelers, managers, scientists, and stakeholders for a series of broadly assessable presentations and discussions provided a forum to discuss the unique issues and concerns of each of these groups and a venue for open dialogue that could lead to identifying and planning for the development of vetted, useful, and accepted models and modeling tools for routine application by the management and non-modeling community. This half-afternoon session was developed as a follow-on to the themes of the panel discussion held immediately prior to it. Presentations focused on the interaction between models and management, and how to communicate scientific information to the public.

Big Science and Chesapeake Bay—Embracing the National Academy of Sciences Recommendations: Options for a Modeling Laboratory (Day 2)

The long history of modeling the Chesapeake Bay has produced many research groups and several competing models. As a result, the question arises: *Is the Chesapeake modeling effort ready to coalesce into a Big Science model, where many smaller groups band together and form a large collaboration, spanning several universities and* *state institutions?* There was a discussion of how Big Science is working in other communities as well as the pitfalls of creating such large collaborations. In moving forward with the Big Science model, many questions will need to be addressed, such as:

- What should the structure of a large collaboration be?
- How can the group include new members?
- What funding opportunities could be opened up as a result of a larger collaboration?
- How desirable is the idea of many smaller groups merging their various modeling efforts?

Overall response to the Chesapeake Modeling Symposium 2012 has been very positive. The biennial symposium is a unique opportunity for the regional Chesapeake modeling community to assemble and discuss issues unique to modeling in this area.

The National Academy of Sciences recently released a report—*Achieving Nutrient and Sediment Reduction Goals in the Chesapeake Bay: An Evaluation of Program Strategies and Implementation*[5]—in which they made several recommendations about environmental management of the Chesapeake Bay. One of these suggestions was the creation of a modeling laboratory, focused on the development of Chesapeake Bay ecosystem models. The two presentations and discussion in this session focused on this recommendation and what such a laboratory might look like.

Modeling Approaches to Water Resource/Water Supply Issues (Day 2)

A number of models, including the CBP's *Phase 5* Watershed model (schematic shown in Figure 1) provide scientists and water managers in the Chesapeake Bay watershed with tools to support investigations and management decisions concerning water quantity. This session provided an opportunity for presenters to report on hydrologic modeling applications to water resource and water supply management problems. In regions that depend on stream flow for water supply, flow forecasts are needed to assess whether or not future demand can be met by future resources under the impact of projected changes in climate and land use. Stream-flow predictions are also needed in environmental flow studies currently underway or planned in a number of states in the Chesapeake Bay watershed. These efforts benefit from efficient simulation of multiple flow scenarios at ungagged locations to understand how flow alteration affects biota. Finally, since many urban streams are devastated by the high flows that occur during storm events, some states may be considering the possibility of *flow TMDLs* to address biological impairments in streams. This half-afternoon session featured presentations that focused on modeling water management and water use issues.

Modeling Alternative Future Land-Cover and Land-Use Scenarios to Inform Chesapeake Bay Restoration Efforts (Day 2)

This half-afternoon session featured five presentations intended for both modelers and the managers who make use of model results in decision making. The session covered current and future work in land-change modeling (LCM) in the Chesapeake Bay Watershed, and emphasized the role of LCM in understanding the potential drivers of land change in the Bay watershed and the role of loosely coupling LCM and watershed models for quantifying the impacts of land-use planning on nutrient and sediment loads to the Bay. The session also introduced the U.S. Geological Survey's National Land Change Modeling Framework, consisting of a set of open-source software tools and standards for building customized regional LCMs.

Conclusion

Overall response to the Chesapeake Modeling Symposium 2012 has been very positive. The biennial symposium is a unique opportunity for the regional Chesapeake modeling community to assemble and discuss issues unique to modeling in this area. The Chesapeake Community Modeling Program recognizes the importance of this, and will continue to pursue this and other opportunities for open dialogue about models and their applications. ■

[5] View this report at *www.nap.edu/catalog.php?record_id=13131#toc*.

Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Science Team Meeting

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The forty-first meeting of the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Science Team was held at Kikai Shinko Kaikan in Tokyo, Japan, June 11-14, 2012. In addition to the Science Team, participants in ASTER-related and other projects also attended. The opening plenary session included discussions of ASTER status and of future Earth-observing satellite instruments; this was followed by splinter sessions for each working group. The meeting concluded with a closing plenary session that included reports from the working groups.

Opening Plenary

H. Tsu [Japan Space Systems (J-spacesystems)—*Japan ASTER Science Team Leader*] and **M. Abrams** [NASA/Jet Propulsion Lab (JPL)—*U.S. ASTER Science Team Leader*] made opening remarks. Tsu announced that as of March 30, 2012, the Earth Remote Sensing Data Analysis Center (ERSDAC), the Japan Resources Observation System and Space Utilization Organization (JAROS), and the Institute for Unmanned Space Experiment Free Flyer (USEF) have merged to establish a new organization, to be known as Japan Space Systems (J-spacesystems). **M. Kato** [J-spacesystems] presented the meeting logistics.

M. Abrams outlined NASA's current status, addressing its organization, future missions, and budget. He reported on the Terra platform's predicted propellant usage and battery status, and presented an update on the status of the U.S. component of ASTER's science activities. He showed examples of global digital elevation models (GDEM) currently in use, and reported on the publication of papers, meeting participation, and other science team activities. Further, he introduced several other missions/instruments, including the Landsat Data Continuity Mission (LDCM), the Hyperspectral Thermal Emission Scanner (HyTES)[1], and the Mineral And Gas Identifier (MAGI)[2].

[1] HyTES is an airborne simulator designed to test spaceborne thermal imaging technology that will be used on the Hyperspectral Infrared Imager (HyspIRI)—a proposed *Tier 2* Decadal Survey mission—that recently successfully completed its first test flight.

[2] MAGI is an airborne simulator designed to demonstrate key technologies planned for a proposed satellite called MAGI-L (or MAGI in Low Earth Orbit), which is being considered as a possible follow-on to HyspIRI. The design is based on ASTER, with particular focus on volcano monitoring, natural-resources mapping, surface-temperature determination, drought monitoring, air pollution studies, and acute-pollution-event monitoring.

M. Kikuchi [J-spacesystems—*Instrument Team*] reported on the status of the ASTER instrument. He provided an update on instrument lifetime management, radiometric degradation, and the action plan for the mission's end. As of now, there are no actions planned or being taken.

T. Matsunaga [National Institute for Environmental Studies (NIES)] provided an update on the Hyperspectral Imager Suite (HISUI)[3]. He described the mission structure, project timeline, instrument development, and activities of science working groups.

M. Hato [J-spacesystems—*Ground Data System (GDS)*] reported on GDS status. He gave an update on production and distribution at GDS. Hato also reported on the changes associated with the merger that resulted in J-spacesystems on GDS.

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

M. Fujita [J-spacesystems—*Science Scheduling Support Group (SSSG)*] presented the SSSG and Operations and Mission Planning (OMP) report. He discussed the status of scheduling and observations.

To close the plenary, **Y. Yamaguchi** [Nagoya University] raised three issues for discussion in the working groups: data acquisition monitoring, GDEM updates, and radiometric calibration coefficients.

Working Group Sessions

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

In the first half of the session, the focus was on validation results from ASTER Level-1 (L1) algorithm/software; there are no major issues or concerns. The group discussed the update of the L1 algorithm in relation to power reduction. The consensus was that the update

[3] HISUI is composed of both a hyperspectral and multispectral imager, and planned as part of the payload of the Japanese Advanced Land Observation Satellite-3 (ALOS-3), planned for launch in 2014.

should be performed regardless of the power issue, as it increases observation resources by 25%. This will be discussed further, and is subject to budget limitations.

The second half of the session focused on the ASTER GDEM project. **H. Fujisada** [Sensor Information Laboratory Corporation (SILC)] reported on the plan for GDEM *Version 2* and later. **T. Tachikawa** [J-spacesystems] reported that the GDEM has the regular striped pattern that is due to geolocation error caused by ASTER pointing. **M. Urai** [National Institute of Advanced Industrial Science and Technology (AIST)] suggested that the GDEM may be improved by the registration of ASTER DEMs. **B. Crippen** [JPL] described the fusion and differentiation of data from various DEMs. **M. Abrams** introduced the land-water mask and demonstrated the improvements in the ASTER DEMs. **D. Meyer** reported on the L1 software update at the USGS.

Radiometric Calibration/Atmospheric Correction (RC/AC) Working Group

B. Eng [JPL] reported on the status of an atmospheric correction (Level-2 software) update. The instrument team reported the results of onboard calibration. **S. Biggar** [University of Arizona], **S. Tsuchida** [AIST], **H. Tonooka** [Ibaraki University], and **S. Kato** [NIES] reported on the results of *vicarious calibration* from field campaigns—where the radiometric properties measured during ground campaigns are used for comparisons. **H. Yamamoto** [AIST] pointed out the significant radiometric error in shortwave infrared (SWIR) Bands 8 and 9. **H. Yamamoto** and **K. Arai** [Saga University] reported the results of visible/near infrared (VNIR) *cross calibration*—comparing with a sensor on another satellite. The results of cross calibration agree with those obtained through vicarious calibration but differ from those obtained through *on-board calibration*—comparing with the lamp onboard the spacecraft. The Science Calibration Working Group (WG) recommends the use of vicarious and cross calibration data for radiometric correction as they are considered more accurate than onboard calibration.

Temperature-Emissivity Separation (TES) Working Group

H. Tonooka presented the regression imputation with ground air temperature for the satellite-based lake and reservoir temperature database in Japan, and reported on the mapping of stationary "hot spots" around Xinjiang, China. **H. Tonooka** and **G. Hulley** [JPL] described the ongoing efforts to develop large-scale emissivity datasets. **A. Gillespie** [University of Washington] introduced the results of an experiment that showed emissivity rise with increasing temperature. **G. Hulley** and **S. Kato** reported on validation for the TES product. **M. Fujita** presented the status of nighttime thermal infrared (TIR) global mapping (TGM), and **H. Tonooka** reported on the updates for cloud assessment and new areas of interest (AOIs) for TGM.

Operations and Mission Planning (OMP) Working Group

The group began its time together by reviewing all previous action items. Only one item, regarding the GDEM Science Team Acquisition Request (STAR), and based on **B. Crippen's** input, was still open. **M. Fujita** then reviewed the status of Global Mapping 5th Round (GM5), TGM 5th Round (TGM5), and Underserved Area (UA) STAR. The GM5 started on February 25, 2012; GM4 was suspended at that time. The TGM5 in Africa is difficult to schedule; the supporting Data Acquisition Request (DAR) will be submitted. When an important observation request is not scheduled, related or all GM5 and/or TGM5 requests will be suspended or temporarily given a zero priority. The number of scheduled scenes for UA STAR was decreased recently; it will be resubmitted. Fujita also reported on Global Land Ice Measurements from Space (GLIMS) and a Volcano STAR. The current GLIMS STAR will be terminated at the end of June 2012; the next round must be prepared in a timely fashion. **M. Urai** presented data acquisition strategies for the ASTER GDEM, which will be also presented at the August 2012 International Society of Photogrammetry and Remote Sensing (ISPRS) meeting in Melbourne, Australia. **L. Maldonado** [JPL] reported on the update for U.S. DARs. **T. Tachikawa** suggested the possibility of improving the performance of cloud avoidance algorithms by adjusting the scheduling parameter. **K. Duda** [USGS, LPDAAC] reported on the status of LPDAAC Expedited Data Set operations.

Ecosystem/Oceanography Working Group

K. Iwao [AIST] and **M. Ramsey** [University of Pittsburgh] began the session by reviewing the group's action items and STAR status. After that came a series of seven presentations, describing project and research activities—see **Table 1** (next page).

Table 1. Science presentations from the Ecosystems/Oceanography Working Group

Topic	Presenter
J Earth and the 100 Cities Project	**L. Prashad** [Arizona State University]
ASTER and MODIS Observations of Dust Storms in the Middle East	**M. Ramsey** [University of Pittsburgh]
Terra Look Update and Related New Activities	**M. Abrams** [JPL]
Understandings of Paddy Fields in the World Using ASTER Data	**G. Saito** [Tokyo Institute of Technology]
Mangrove Tree Morphology Estimation with Remote Sensing for Tsunami Inundation Simulation	**W. Ohira** [Asian Institute of Technology (AIST)]
Louis Gonzalez Alvarez: Simulated True-Color ASTER Images	**H. Yamamoto** [AIST]
A Method for Developing High-Accuracy Global Urban Extent Map by Integrating Synthetic Aperture Radar and Optical Data	**Y. Duan** [University of Tokyo]

Geology/Spectral Working Group

There were six research activity presentations given during this group's meeting—see **Table 2**. After the presentations, continuing action items were discussed and assigned.

Table 2. Research presentations from the Geology/Spectral Working Group.

Topic	Presenter
Identification of Rare Earth Minerals by Near-Infrared Reflectance Spectra	**S. Miyatake** [Japan Oil, Gas and Metals National Corporation (JOGMEC)]
ASTER Observations Near the Source Vents of Volcanic Plumes	**V. Realmuto** [JPL]—presented by **M. Abrams**
Statistical Analysis of the Expanded ASTER Urgent Request Protocol Program for Volcanic Observations	**M. Ramsey** [University of Pittsburgh]
Update on Development of Hot Spot Detection Systems Using GeoRSS[4]	**N. Yamamoto** [AIST]
Seti River Flood, Nepal: The Disaster and Its Causes	**R. Wessels** [USGS]
Multispectral Observations of Terrestrial Impact Craters Using Spectral Data Obtained by ASTER	**S. Yamamoto** [NIES]

[4] GeoRSS is an emerging standard for embedding location as part of a web feed.

STAR Committee

There were no STAR proposals that needed review. Therefore, the STAR Committee WG went over the agreed-upon points from the OMP WG session, described above.

Closing Plenary

After the splinter sessions, the groups reconvened for a closing plenary to hear the outcomes of each working group's session. Based on the recommendation of the RC/AC WG, there was a proposal to use vicarious and cross-calibration for radiometric correction instead of onboard calibration. However, the team concluded that a consensus proposal should be submitted after discussing the issue more thoroughly in the RC/AC WG.

M. Abrams announced that the next (forty-second) ASTER Science Team meeting would be held in Pasadena, CA, in the U.S. the week of December 10, and then closed the meeting. ■

A Joint NASA GOFC-GOLD and NEESPI Workshop to Examine the Natural, Socio-economic, and Land-use Impacts of the 2010 Drought in European Russia

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Introduction

A joint workshop, organized by NASA's Global Observations of Forest and Land Cover Dynamics (GOFC-GOLD) program and the Northern Eurasia Earth Science Partnership Initiative (NEESPI) took place June 17-22, 2012 in Yoshkar-Ola, Russia. At this regional conference, 78 scientists from the U.S., Europe, Russia, and Kazakhstan came together to develop a comprehensive view of the devastating drought that impacted most of European Russia in the summer of 2010 and its immediate and long-term impacts on ecosystems and society. The meeting was held at the Volga State University of Technology (Volga Tech) and was supported by the Global Change SysTem for Analysis Research and Training (START) program and the ScanEx Research and Development Center (a commercial satellite data provider in Russia); information support was provided by Sovzond (a private-sector satellite imagery enterprise), the European Forest Institute, and the International Union of Forestry Research Organization.

The extreme drought that gripped much of European Russia for most of the summer of 2010 captured the attention of the media worldwide, Russian governmental agencies, and the international research community. **Pavel Groisman** [National Oceanic and Atmospheric Administration (NOAA), U.S.] reported that absolute temperature records were exceeded in many locations across European Russia. The uncharacteristically high temperatures during this period were sustained—even at night—as far as 60° N latitude. In Moscow, daily temperatures held at 6–8 °C (10.8–14.4 °F) above the long-term mean from mid-July through mid-August. According to an article from **D. Guha-Sapir** [The International Disaster Database, Centre for Research on the Epidemiology of Disasters][1], the drought was accompanied by widespread fires that, when combined with the prolonged intense heat, was responsible for an estimated 55,736 deaths in Russia. In addition to the direct toll on human life and well-being in Russia and the burden on the economy of the Russian Federation, the drought resulted in widespread crop failure across one of the largest wheat-exporting regions of the world. This, in turn, led to a spike in global grain prices that impacted the global food supply. The severity of the immediate impacts and the ripple effects within the global economy highlight the importance of deconstructing the drivers, consequences, and management of the event in order to develop mitigation strategies for future disaster management—not only in Russia, but for similar events, worldwide.

Opening Remarks and Discussion

The significance of the meeting was well-recognized by various international and national scientific and operational agencies. Public interest was served by interviews with selected scientists who attended the meeting, broadcast on the regional television network.

Evgeny Romanov [Volga Tech, Russia—*Rector*] opened the meeting and highlighted the importance of international cooperation in research. He also praised ongoing collaborations between Volga Tech faculty and staff with partners abroad. **Larisa Polushina** [Ministry of International Relations, Republic of Mari El, Russia] welcomed the meeting participants, and encouraged the scientists to consider disaster preparedness within the broader scope of climate-change science. **Garik Gutman** [NASA Headquaters, U.S.—*Land Cover Land Use Change Program Manager*], **Chris Justice** [University Maryland, College Park (UMCP), U.S.], **Olga Krankina** [Oregon State University, U.S.], and **Pavel Groisman** introduced the framework of relevant international programs, and explained how the international communities of scientists and decision makers can come together to evaluate the consequences of the 2010 drought event, They also discussed how the findings of the workshop could influence future directions for scientific research and development of global monitoring systems to support early-warning systems and disaster-mitigation strategies.

In addition to a robust scientific agenda, the meeting brought together academic, operational, and com-

[1] This value comes from a presentation titled *Disaster Numbers* by **Guha-Sapir, D.** (2010). The presentation is accessible at *cred.be/sites/default/files/Disaster_numbers_presentation_2010.pdf.*

NASA Science Meeting, GOFC-GOLD, and NEESPI workshop participants. **Image credit:** Volga State University of Technology

mercial satellite data users and providers. The meeting had a specific focus on evaluating available satellite-based information, its utility in operational monitoring and scientific studies, and identifying the potential (and shortcomings) of existing data products, as well as focusing on future needs for satellite-derived information. **Olga Gershenzon** [ScanEx, Russia] described the ScanEx Research and Development Center, outlining its capabilities and value-added products that were used operationally by Russian management agencies and news outlets to monitor and report on the development of wildfire events in the summer of 2010. Gershenzon also focused on ScanEx's efforts to build a cadre of image analysts at various Russian academic institutions.

The next two presentations, from **Nina Yaldigina** [Sovzond, Russia] and **Eldar Kurbanov** [Volga Tech], reiterated the emphasis on training experts in satellite image analysis. To that end, this meeting opened its doors to numerous early-career scientists from the Volga region, and also organized a focused training session that was attended by over 30 participants who were mostly early-career scientists. During the training session, **Tatiana Loboda** [UMCP] and **Olga Krankina** explored the fundamentals of spectral image analysis for land-cover mapping. **Peter Potapov** [UMCP] presented existing approaches to large-scale mapping of agricultural objects, and **Vladimir Ermakov** and **Georgy Patopov** [both from ScanEx] described current methods for operational fire monitoring, based on *crowdsourcing* approaches.

Science Presentations

The meeting's scientific program began with an exploration of the large atmospheric circulation patterns that led to the establishment of a persistent high-pressure center over most of European Russia, and the subsequent extreme drought. **Pavel Groisman** showed that since 1965 summer precipitation patterns over this region have been changing gradually, resulting in a redistribution of rainfall patterns from multiple events of lower intensity to fewer events of higher intensity, leading to a higher frequency of flood and drought events. Over the past 70 years the length of the growing season has increased by 6-11 days (5-6%): A longer period when temperature is above freezing and supports evaporation of moisture in addition to earlier melting of snow cover leads to generally drier conditions over most of Russia, and repeated drought events in major wheat-producing areas of southern Russia and Kazakhstan. While European Russia has seen an overall increase in the amount of moisture, the shift towards fewer, more-intense precipitation events also resulted in a higher number of prolonged (≥30 day) dry episodes. **Alexander Shiklomanov** [University of New Hampshire, U.S.] reported that these patterns were also evident in observed changes in surface hydrology. The extreme drought of 2010 was well tracked through indices characterizing hydrological drought for most of the Volga and Don watersheds. **Igor Savin** [V.V. Dokuchaev Soil Science Institute, Russia] explained that this drought was exacerbated by a multi-year low in snow cover during the winter of 2009-2010 that preceded the extreme temperatures during the summer of 2010. **Evgeny Volodin** [Institute of Nummerical Mathematics, Russia] added that hydrological drought, and specifically large soil-moisture deficits, may have created a positive feedback loop that amplified the extreme drought conditions.

It has been 35 years since scientific studies first linked geographic patterns of drought in the Northern Hemisphere, expressed through increases in wildfire occurrence, to oscillation patterns of the jet stream. However, **Susan Conard** [U.S. Forest Service, U.S.] reported that these connections were only recently rediscovered and confirmed using the fire record recorded over the past 50 yearsfor North America, and since the mid-1990s for Russia. The strength of the jetstream drives the depth and distribution of *Rossby Waves*[2] that in turn result in the creation of *blocking highs* that contribute to the observed weather patterns: For example, the Rossby Wave pattern of the 2010 summer season redirected frontal rains around European Russia towards

[2] *Rossby Waves*, or planetary waves, are large-scale variations in the path of the mid-latitude jet stream that affect weather and climate patterns.

Western Siberia for most of July and August. In a similar vein, **Geoff Henebry** [South Dakota State University, U.S.] demonstrated a link between the North Atlantic Oscillation (NAO) and the development of blocking highs over the wheat belt of Northern Eurasia. The results indicate that the negative phase of the NAO has a connection to past droughts in this region that were tracked using the *Palmer Drought Index*[3].

Numerous scientists showed how satellite imagery for May 2010 chronicled the development of drought conditions months before the scope of the catastrophic event was widely recognized. Although the drought was centered over European Russia, **Alexey Terekhov** [Research Institute of Ecology and Climate, Kazakhstan] explained that it extended far south into northern Kazakhstan where the drought progression was evident in both vegetation condition and land surface temperature. The meteorological conditions over northern Kazakhstan were dominated by the same anticyclone positioned over European Russia. This was evident in the uncharacteristically low amount of cloud cover in July and August of 2010, as observed by the Moderate Resolution Imaging Spectroradiometer (MODIS).

Satellite imagery demonstrated that the continuously observed changes in crop condition throughout the duration of the drought were a logical consequence of the persistent meteorological pattern described earlier. However, the next several presentations highlighted some longer-term impacts of the drought that are only now emerging; these impacts are somewhat surprising both in terms of their magnitude and characteristics.

Sergey Bartalev [Space Research Center, Russia] reported on the impact that the 2010 drought had on vegetation state in 2011; and **Alexander Maslov** [Institute of Forest Sciences and ScanEx, Russia] described vulnerabilities in the weakened vegetation, which set the stage for the fall 2010 bark beetle outbreak.

Related research, conducted by **Igor Savin,** has shown that crop rotation practices, which were in effect over many of the impacted regions prior to the 2010 drought, contributed to the drought-related crop failure. A large portion of the area was dominated by late-season crops that placed a high demand on water resources, and thus made the region all the more susceptible to drought-induced crop failure. These findings emphasize the need to develop interdisciplinary studies that focus on crop management practices, in order to develop mitigation tactics in anticipation of similar events in the future.

Alexander Shiklomannov explained how the fire events that accompanied the 2010 drought were dangerous primarily because of their spatial extent, their occurrence within relatively densely populated regions of Russia, and the extremely high content of carbon monoxide in their emissions. **Luigi Boschetti** [UMCP] stated that global MODIS fire detections and burned-area products were used to monitor the progression of these extreme fires in Russia, and made available to the international community, Russian fire management services, and nongovernmental organizations. **Emilio Chuvieco** [University of Alcala, Spain] described how similar efforts to develop burned-area products, developed using a different suite of sensors, including the Spinning Enhanced Visible and Infrared Imager (SEVIRI), the Système Pour l'Observation de la Terre-Vegetation (SPOT-VGT), the Along Track Scanning Radiometer (ATSR), and the Medium Resolution Imaging Spectrometer (MERIS), are underway in Europe; new products, including global fire danger assessments, are also being developed and tested in the GOFC-GOLD framework. However, the global satellite data products are not always sufficiently fine-tuned to regional characteristics, and thus require regional adaptations and accuracy assessment.

Ioannis Gitas [Aristotle University of Thessaloniki, Greece] and **Vladimir Ermakov** explained how new approaches, based on regionally specific temporal trends in vegetation state or *crowdsourcing validation* efforts, have been developed and tested by regional research centers in support of regional fire monitoring. **Petr Dolgov** [Ministry of Forestry, Republic of Mari El, Russia] stated that although satellite data provide a unique synoptic view of fire occurrence and evolution, local fire management agencies in Mari El indicated that the frequency of observations from satellites is insufficient to support fire suppression efforts within small administrative units during rapidly unfolding fire events. However, **Tatiana Loboda** explained that satellite data do play a central role in assessing the impacts of fire emissions on population health.

Research conducted by **Amber Soja** [NASA's Langley Research Center, U.S.] and others in 2009 suggests that the rapid climate change observed in Northern Eurasia, and projected to occur in the future, will likely cause droughts and large fire events to become more frequent. Soja reported that observed air temperatures in the last decade in the Tuva region have already exceeded the previous projections from the Hadley Center's HadCM3GGa1 scenario for 2090. Indeed, modeling specific future wildfire conditions at the regional scale remains a challenge. **Igor Shkolnik** [Voeikov Main Geophysical Observatory, Russia] explained that, while reliable estimates of temperature extremes can be modeled with relative certainty, obtaining robust projections of precipitation and its extremes is not feasible at present. **Nadejda Tchebakova** [V.N. Sukachev Institute of Forest, Russia] and **Amber Soja** explained that the projected climate change is also likely to be accompanied by large-scale

[3] The Palmer Drought Index measures short-term drought on a monthly scale.

changes in vegetation patterns, potentially expanding the area suitable for agricultural production in northern regions, while reducing the extent of forest cover in the southern regions. **Qianlai Zhuang** [Purdue University, U.S.] added that the amplitude of the shift in vegetation distribution could be mitigated by targeted management policies.

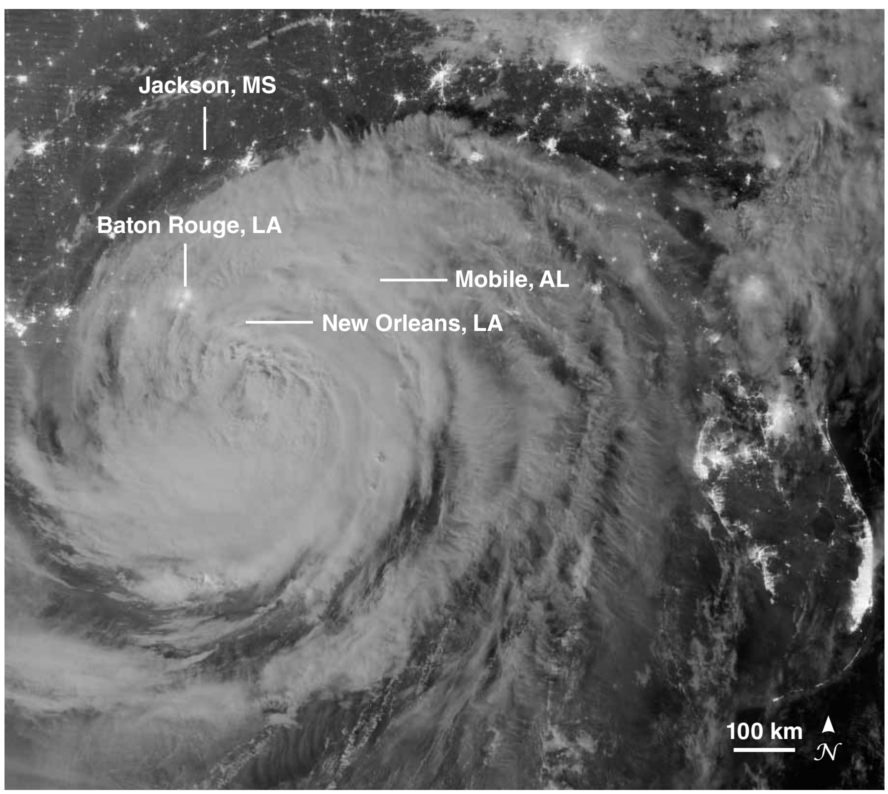
Conclusion

The meeting participants concluded that the scientific community has built a solid understanding of the physical and biological conditions (ranging from large-scale atmospheric circulation and regional temperature and precipitation regimes to impacts from local-scale crop and forest management decision on vegetation composition and state) that led to the development of extreme drought of 2010, and for detecting and monitoring the direct impact of drought on forested and agricultural systems. However, there remains a need for more research to enhance their understanding of the long-term impacts of the drought and to explore approaches for early warning and mitigation of similar events in the future. For example, information flow to land managers and decision makers also needs improvement. Thus, a scientific synthesis activity aimed at exploring interdisciplinary connections and feedbacks and linking the observed biophysical conditions to economic and health impacts involving international, national, and regional participants would be highly beneficial. In addition to the scientific advances, a synthesis activity would aid in building a regional network connecting academic and management institutions of the Volga region to facilitate scientific support for decision-making. ■

Suomi-NPP VIIRS Tracks Hurricane Isaac at Night

Early on August 29, 2012, the Visible Infrared Imager Radiometer Suite (VIIRS) on the Suomi NPP satellite captured this nighttime view of Hurricane Isaac and the cities near the Gulf Coast of the United States. The image was acquired at 1:57 AM local time (6:57 Universal Time) by the VIIRS "day-night band," which detects light in a range of wavelengths from green to near-infrared and uses light intensification to enable the detection of dim signals. In this case, the clouds were lit by moonlight.

Isaac, a slow-moving storm, made landfall as a Category 1 hurricane near the mouth of the Mississippi River in southwestern Louisiana at about 6:45 PM local time on August 28. It then moved westward and back out over water until making a second landfall near Port Fourchon at around 4 AM on August 29. **Credit:** NASA's Earth Observatory



Spring 2012 NASA Land-Cover Land-Use Change Science Team Meeting

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The NASA Land-Cover Land-Use Change (LCLUC) program hosted its annual spring science team meeting, held April 3-5, 2012, in Rockville, MD. This year's meeting focused on *urban land dynamics*. More than 100 scientists and graduate students from the LCLUC community attended the meeting, which, in addition to offering presentations on urban land use, included a review of the final results from the project's third year of activities, posters and discussion sessions on improving the social science component of LCLUC, and the role of collaborative synthesis research. Representing international partners at the meeting were **Giovana Espindola** [Global Land Project (GLP)—*Executive Officer*]**, Lei Wang** [Chinese Academy of Sciences, Institute of Remote Sensing], and **Oganes Targulyan** [ScanEx[1]—Russia]. Representing regional partnerships were **Pavel Groisman** [Northern Eurasian Earth Science Partnership Initiative (NEESPI)—*Project Scientist*] and **Hassan Virji** [Global Change SysTem for Analysis Research and Training (START)—*Director*].

Spring LCLUC Science Team meeting participants take a break to pose for a photo.

Garik Gutman [NASA Headquarters—*LCLUC Program Manager*] and **Chris Justice** [University of Maryland, College Park—*LCLUC Program Scientist*] cochaired the two-and-a-half-day meeting. **Gutman** began the meeting with a brief review of the program, including a description of the current suite of recently funded projects. He explained that the urban component of the LCLUC program is aligned with the International Human Dimensions Program (IHDP) Urbanization and Global Environmental Change (UGEC) Project, which promotes assessments of urban land-use-change effects on global environmental change, including the impacts of built-up environments on energy use, carbon emissions, air quality, and climate. The urban-change component of the LCLUC program is also responsive to the deliberations of the Intergovernmental Panel on Climate Change (IPCC). The IPCC's Fourth Assessment Report (AR4) focused on the effects of anthropogenic greenhouse gases; the next IPCC report (AR5) will put more emphasis on the role of urban land use in climate systems.

Gutman also emphasized implementing NASA's priority of free and open sharing of data, and described the recently introduced opportunity for LCLUC scientists to use the NASA Earth Exchange (NEX) portal that provides access to state-of-the-art supercomputing for Earth system modeling. He reiterated the LCLUC program's expectation that principal investigators (PIs) of funded projects make both their results and associated datasets available to the broader community in a timely fashion. Gutman highlighted an emerging international initiative to develop cooperation between the Landsat program and the European Space Agency's (ESA's) Sentinel-2 program on merged data processing and products, with an initial focus on more-frequent observations for agricultural land use. He also described the program's continuous efforts to involve early-career scientists through the current Research Opportunities in Space and Earth Science (ROSES) solicitation or as an integral part of each international LCLUC science team meeting. Gutman also mentioned a new Trans-Atlantic Training Initiative led by NASA and ESA. He finished by describing the 2012 funding solicitation, which includes two elements: mapping industrial forests from Landsat-class observations, and synthesis of LCLUC studies in Eurasia. *Synthesis studies* involve advancing the conceptual underpinnings of LCLUC science with state-of-the-art knowledge; increasing our understanding of processes, drivers, and impacts of LCLUC; and developing new understanding and conceptual frameworks. Gutman explained that the LCLUC program recognizes the need to include aspects of social science when studying land use, and

[1] ScanEx is the leading Russian company for remote sensing applications.

that the program evaluates a proposal's social science responsiveness in terms of a meaningful integration of social-science theories, methods, and quantitative or qualitative data in all proposed research.

Chris Justice outlined the current science direction for the program, and identified new study areas in land-use and sustainability research. Such study areas include land-use vulnerability to climate change (particularly in marginal areas), and creation of a new generation of satellite-derived land-use products for parameterizing the new class of integrated assessment models. He emphasized that with NASA's increased access to fine-resolution data, there is a need for automated methods for fine-resolution classification and for change detection. Justice highlighted the adaptation science element of the U.S. Global Change Research Program (USGCRP)'s Strategic Plan, the emerging international Future Earth Research for Sustainability initiative, and the current National Research Council (NRC) Study on Land-Use Modeling. He concluded with some thoughts on LCLUC research, using data from new and upcoming NASA missions. Further information on the LCLUC program can be found at *lcluc.hq.nasa.gov*.

The agenda provided time to discuss the roles of synthesis initiatives in LCLUC research. **Karen Seto** [Yale University] chaired the session, beginning the conversation by identifying the USGCRP Strategic Plan as a guide for integrating *social science research*, and emphasizing the importance of finding experts to evaluate the "human component" of LCLUC research proposals. Discussion followed on defining social science research in terms of LCLUC, the role of anthropogenic drivers on land-use change, and the importance of identifying indicators of sustainability and understanding the anthropogenic aspects of LCLUC. Seto acknowledged that synthesis studies can vary widely in the their scope, as reinforced by the next two presentations.

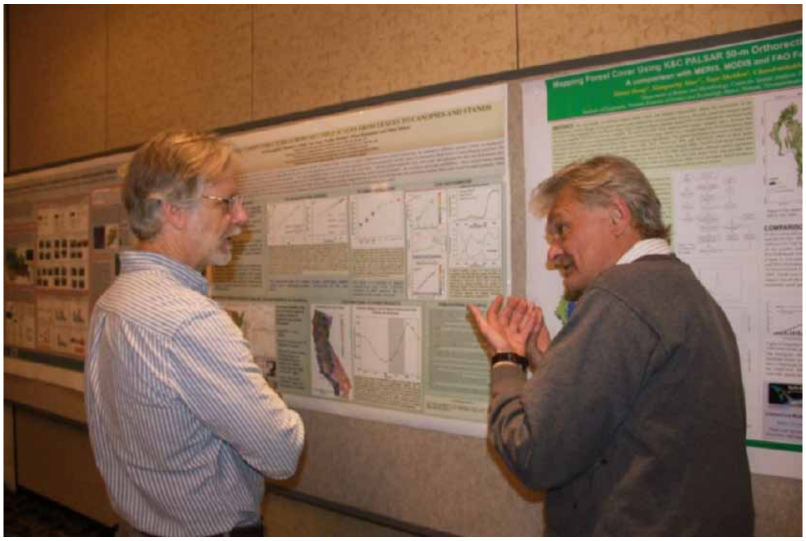
The discussion continued with presentations by two PIs currently funded for synthesis studies. **Kathleen Bergen** [University of Michigan] emphasized the importance of clearly articulating the goals and methods of the synthesis project and the difficulties her study encounters when integrating across different scales and topics. **Volker Radeloff** [University of Wisconsin, Madison (UWM)] stressed the importance of government policies on LCLUC for his synthesis project, and how they influence land-use change in different countries; there is also a need to frame the synthesis so that research objectives are manageable. He suggested that international collaboration can strengthen synthesis, and that existing in-country projects can provide an indication to international researchers of what may be possible. During the discussion, participants concluded that, with the growing number of local research studies on LCLUC funded by different agencies around the world, there is a real need—and opportunity—for synthesis, but that a compelling case needs to be made for each synthesis study, with a clear statement of rationale and a conceptual framework for the study.

Earth's population is becoming increasingly urban, with projections that 70% of the world's population will be living in urban areas by 2050. Commonly, the growth comes from areal expansion of urban areas rather than density increases, with the *built environment*—land used for urban development—often occurring at the expense of productive agricultural land. Such urban sprawl changes the land surface—altering surface fluxes of heat, water, and carbon—which in turn impact the water, carbon, and energy cycles, changes weather patterns, and ultimately alters climate. While clear on the grand scale, the details describing actual rates of urban expansion and increased density and the corresponding impacts these changes have on biophysical properties in the environment remain largely unknown. NASA is currently supporting several projects that explore this urbanization phenomenon in the context of land-cover and land-use change; several of the PIs presented relevant research progress and preliminary results at the meeting.

Eric Brown de Colstoun [NASA's Goddard Space Flight Center (GSFC)] opened the *Science of Urban Land-Use Change Session* with an overview of his project, titled *Using Landsat Global Land Survey (GLS) Data to Measure and Monitor Worldwide Urbanization*. The project uses the Landsat surface-reflectance dataset to develop a baseline global estimate of the percentage of *impervious surface* (*i.e.* urban) cover for 2000 and 2010. These data are then used to detect and map urbanization "hot spots." Field measurements of urban areas will be gathered as part of a youth education and outreach program, through which the project will train primary and secondary school children to collect impervious surface presence data near their schools. This is a component of the GLOBE Program, a worldwide project engaging children in hands-on science[2].

Marc Imhoff [GSFC] provided a summary of his recent publication in *Remote Sensing of the Environment* [3]. There are numerous consequences of urbanization, including the loss of fertile soils, changes in net primary production (NPP) potential, and increases in local temperature. The study investigated the correlation between land surface temperature (LST), impervious surface area (ISA), the normalized difference vegetation index (NDVI), and their varying relationships within U.S. biomes. The conclusion is that there is considerable variability in the impact of change as a function of biome, and that the *legacy of fluxes* determines the intensity of the degree of the observed

[2] Visit *globe.gov* to learn more about GLOBE.
[3] Imhoff, M.L., P. Zhang, R.E. Wolfe, and L. Bounoua, 2010: Remote Sensing of the Urban Heat Island Effect Across Biomes in the Continental USA. *Remote Sensing of Environment*, **114**: 504-513, doi:10.1016/j.rse.2009.10.008.



Robert Wolfe [GSFC] and **Yuri Knyazikhin** [Boston University] converse during the poster session.

change: Variations in ISA explain 88% of the variation in LST for urban areas in forested biomes, whereas in desert environments the LST's response to ISA presents a "U-shaped" horizontal gradient, decreasing from the urban core to the outskirts of the city, and then increasing again in the suburban-to-rural zones. The study also found that there is a decrease in LST for cities in deserts during summer days—potentially caused by increased shading in these areas. The next step for the project will be to use a combination of satellite and ecological map data to extend the characterization of the urban heat island response to global urban settlements. Imhoff proposed that the urban heat island effect may result in phenological change to the biome, which involves longer growing degree days for vegetation in these areas. He also mentioned the importance of local influences, explaining that the concept of ISA as applied in the U.S. may not transfer to developing country cities where urban infrastructure characteristics and environmental properties are often different.

Peilei Fan [Michigan State University] described her LCLUC project, titled *China's Urbanization and Its Sustainability Under Future Climate Change*, which investigated causal linkages between urbanization, urban sprawl, and climate change. The project simulated LCLUC and local-scale IPCC-generated climate scenarios, considering different urbanization circumstances for a variety of future climate change predictions, and provided adaptation recommendations on various LCLUC and future climate scenarios for Shanghai and Urumqi, two major cities in China. Fan used the Conversion of Land Use and its Effects at Small regional extent (CLUE-S) model, with historical data describing LCLUC over the past 50–60 years to forecast potential urbanization and land-cover conversion dynamics for each city under different growth scenarios. The project also modeled climate change scenarios using the Regional Atmospheric Modeling System (RAMS) to investigate the impact of potential changes in land cover on atmospheric dynamics overall, to test whether recent trends in land-cover change will act to suppress rainfall, and to examine how urban expansion will affect these variables from the present through 2050. Fan also used modeled urbanization and climate scenarios to forecast a change in intensity of the thermal environment at the urban core and the spread of heat island effects to the city's periphery. Further model development is currently being conducted, and will continue this year.

Annemarie Schneider [UWM] is leading an LCLUC-funded project that focuses on urban systems in China, and seeks to monitor and model urbanization using mixed methods and a multiscale approach. Schneider described the difficulties associated with the use of moderate-resolution remote-sensing data for urban analysis—difficulties that arise because of the fine spatial and temporal scales of changes that occur at the city level. She also described a number of different drivers that have led to drastic land-cover change in China over the past 30 years. The 1978 economic land reforms resulted in *decentralization*, a change in land-use rights, liberalization of the household registration system (*hukou*) and the work unit (*danwei*), and provided a gateway for the great western development program of the 1990s and early 2000s. These reforms resulted in rapid rural-urban migration and land-use change, agricultural expansion and intensification, and a rise in both gross domestic product (GDP) and incomes in China. Schneider explained that the variation in the rate of change in an area can stem from multiscale planning, preferential policy or development zones, foreign direct investment, fiscal transfers, road development, economic transition, and migration. Moderate-resolution data can be used for supervised multitemporal classification of urban growth, although independently measuring each variable's relationship to change is more difficult. Schneider recommended keeping the analysis simple by isolating independent variables to identify their influence on the phenomenon.

Karen Seto described her LCLUC-supported research in India, currently conducted as an international collaborative effort using multiscale and multisensor analysis of urban cluster development and its relationship to agricultural land loss. Substantial urbanization throughout India can be attributed to nonlocal actors and global markets, and can be identified and monitored using a combination of data from the Moderate Resolution Imaging Spectroradiometer (MODIS), a Night Time Lights indicator, Landsat Thematic Mapper/Enhanced Thematic Mapper, and Système Pour l'Observation de la Terre-Vegetation (SPOT-VGT) data. These satellites' observations are complemented by local demographic statistics and discussion from meeting with public and private policy shapers to describe current urban clustering throughout the region. Preliminary results show that it is possible to monitor urbanization using these datasets; therefore, database development, algorithm refinement, model building, and fieldwork are planned for next year to further the analysis of urban growth and agricultural land loss in and between cities in India.

Cristina Milesi [NASA's Ames Research Center] showed how her project, titled *Mapping of Urban Expansion Using Multi-Decadal Landsat and Nightlights Data over North America*, will characterize urban expansion using Landsat and Quickbird data from 1990 to the present. She is using a robust linear spectral mixture model to distinguish between heterogeneous urban areas across different geographic, environmental, and socio-economic regions, to identify rapid land-cover changes, and to characterize the land covers that are being replaced. The dark fraction of spectral reflectance can be used to identify impervious fraction by masking water and high-albedo regions, rural areas, and agricultural lands near urban areas. Preliminary results from the Spectral Mixture Analysis display very strong similarities with National Landcover Database (NLCD) 2006, though overall values are higher than the NLCD 2006 urban land cover. The preliminary results show that the largest urban growth can be found at the periphery, with some intensification of pixels previously characterized as urban. The next steps for the project involve refining end-member selection for atmospherically corrected global Landsat mixing space, vicariously validating[4] impervious fractions with multispectral high- resolution Web-based Access and Retrieval Portal (WARP) datasets, and extending the multitemporal analysis to North America for 1991, 2000, and 2010.

After a vibrant discussion and several informative presentations on project progress and results, several issues needed further debate. A survey will be circulated throughout the LCLUC community, requesting input from the meeting participants and project investigators to help address synthesis research, the social science component of LCLUC research, and the program's direction. **Garik Gutman** closed the meeting, expressing the importance of the annual science team meeting as a forum for sharing results, enabling discussion and feedback to the program, and for initiating collaboration and building teams. He also emphasized the importance of enhancing linkages with international programs, such as the Global Observations for Forest and Land Cover Dynamics (GOFC–GOLD) and Group on Earth Observations (GEO), and regional programs like NEESPI and Monsoon Asia Integrated Regional Study (MAIRS), in which regional networks, supported by START, play a critical role. Gutman concluded by stating that each science team meeting has a specific focus, and that important aspects of the meetings would be enhanced by inviting international partners and early-career scientists. The presentations, posters, and other details from the meeting can be downloaded from *lcluc.umd.edu/meetings.php?mid=37*. ■

[4] In this context *vicarious validation* means the measurements will be compared with another well-known and very stable dataset—i.e., WARP.

ESIP Federation Summer 2012 Meeting

Carol Meyer, Foundation for Earth Science, carolbmeyer@esipfed.org

The Earth Science Information Partners (ESIP) Federation held its summer meeting July 17-20, 2012, at the University of Wisconsin-Madison (UWM). A total of 229 participants attended the meeting (201 on-site, and 28 remote participants), making it the largest ESIP Federation event ever held. This diverse consortium of leaders in thought and technology is generating innovative approaches to developing future interoperable data systems, and has built a community where cutting-edge knowledge is shared openly. Hosted by the Cooperative Institute for Meteorological Satellite Studies, the group focused on the theme *ESIP Community Leadership: Innovating Throughout the Data Life Cycle*. **Karl Benedict** [University of New Mexico, Earth Data Analysis Center—*ESIP Federation President*] noted that, "With the continued growth of the Federation, membership across the entire Earth-science data-value chain, from data and research centers to application developers and educators, the Federation provides a unique opportunity for the community to share ideas across these otherwise somewhat-separate focus areas."

The meeting offered technical, scientific, educational, and professional development workshops on cloud computing, geospatial tools, data documentation and data stewardship, energy and climate change, project evaluation, and teacher training.

To set the tone and to put the meeting in context, the opening plenary session included talks from **Deborah McGuiness** [Tetherless World Constellation, Rensselaer Polytechnic Institute], on *Linked Data and Next Generation Science;* **Lea Shanley** [Woodrow Wilson Center, Commons Lab], on *Opportunities and Challenge in Crisis Informatics*; and **Francis Lindsay** [NASA Applied Sciences Disasters Program], on *Insights and Opportunities in NASA's Disasters Program*.

These were followed by thirteen *lightning,* or *Ignite-style talks*—talks that lasted five-to-nine minutes each. Called *Innovators Among Us,* these provided ESIP members an opportunity to learn about many of the pioneering activities taking place in the community. According to **Annette Schloss** [University of New Hampshire—*ESIP Federation Vice President*], "The Ignite-style talks gave several people the chance to show their work as true innovators among us. They were also an effective way to showcase the impressive work of our colleagues using a fast-paced and lighter presentation approach. I heard a lot of good feedback, and hope these will become a staple of future summer ESIP meetings." Videos of the talks can be found at *vimeo.com/album/2042150*.

ESIP Federation Teacher Workshop participants. **Image credit: Margaret Mooney**

Karl Benedict announced that, "Once again there was an embarrassment of riches at this summer's meeting, with the primary challenge being [that participants were] forced to choose only one session at a time. I was particularly impressed with the progress made by the Energy and Climate Working Group. They have brought together a diverse group of energy and climate experts, and started engagement with the broader community of stakeholders in this critical domain. [This group's] work on a prototype decisions tool catalog for aiding in alternative energy site selection is an exemplar of how the ESIP Federation works across communities, agencies, and sectors to get something valuable done."

During the meeting **Margaret Mooney** [Space Science and Engineering Center] facilitated a two-day teacher workshop at UWM. The workshop—sponsored by the National Oceanic and Atmospheric Administration's (NOAA) National Environmental Satellite, Data, and Information Service—provided 30 teachers with hands-on training on ESIP member-created resources designed for use in education.

In addition to the NOAA sponsorship, the workshop leveraged grant funds from NASA's Global Climate Change Education program to loan each workshop participant an iPad for one year. The iPad was pre-loaded with resources useful for teaching Earth science at the middle- and high-school levels. The workshop participants will document their experiences using the iPad in their classrooms via the ESIP teacher wiki, a potentially valuable source of user feedback for member educational product developers. The iPads will be returned at the end of the academic year and used for a new cohort of teachers who will attend next summer's ESIP teacher workshop. **Annette Schloss** added that,

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User-Friendly TES Lite Products Released!

NASA's Aura Tropospheric Emission Spectrometer[1] (TES) group has recently released a set of *Lite* products intended to make TES data easier to use for scientific analysis. Currently, TES Lite products exist for ozone (O_3), carbon monoxide (CO), water (H_2O) and semi-heavy water (HDO), carbon dioxide (CO_2), ammonia (NH_3), and methane (CH_4). Future releases will include methanol (CH_3OH) and formic acid (HCO_2H). The TES group is also assessing the instrument's capability to measure tropospheric peroxyacetyl nitrate (PAN) and carbonyl sulphide (COS). TES Lite products (along with a README file) are available at *avdc.gsfc.nasa.gov/index.php?site=635564035&id=10* or *tes.jpl.nasa.gov/data*.

The key features of the Lite products are as follows:

- Each NetCDF[2] Lite product file contains all observations taken during a given month. Please note that the data in each product file are individual observations—not monthly averages.
- All data come with the constraint vectors, averaging kernels, covariances, and quality flags needed to compare the TES data to model fields—see **Figure** (next page).
- Each data type has been redimensioned from the original TES forward model, 67-level pressure grid to a subset that is sufficient to capture vertical variations in each species. The resulting data sizes are much smaller than earlier releases, and therefore easier to manipulate for analysis. Mapping matrices are provided within the Lite product file to change these data back to the TES 67-level pressure grid if needed.
- Known biases in the CH_4 and HDO data have been corrected as discussed in Worden *et al.*, 2012 and Worden *et al.,* 2011[3].
- Within the HDO Lite product files, the HDO and H_2O vectors, averaging kernels, and covariances are packed together to simplify HDO–H_2O profile and model (or *in situ*) comparisons.
- Only *Version 5* data are provided. Updates will be provided at the beginning of each month as the TES record is processed, and are expected to be finished by October 2012.

The NASA Aura TES group will attempt to incorporate user feedback into the Lite products on a monthly basis. If you intend to use TES Lite products, please contact the appropriate TES staff—see **Table 1**.

Table 1. Contact information for TES staff by product.

Product	TES Staff
Ozone (O_3)	**Kevin Bowman**: kevin.bowman@jpl.nasa.gov **John Worden**: john.worden@jpl.nasa.gov
Carbon monoxide (CO)	**Ming Luo**: mluo@jpl.nasa.gov
Carbon dioxide (CO_2)	**Susan Kulawik**: susan.kulawik@jpl.nasa.gov
Water (H_2O) and semi-heavy water (HDO)	**John Worden**: john.worden@jpl.nasa.gov
Methane (CH_4)	**John Worden**: john.worden@jpl.nasa.gov **Vivienne Payne**: vivienne.payne@jpl.nasa.gov
Ammonia (NH_3)	**Karey Cady-Pereira**: kcadyper@aer.com

[1] TES is an infrared spectrometer flying aboard the Aura satellite; its high spectral resolution enables it to measure concentrations of the chemicals listed above, from the ground to the middle stratosphere (i.e., including the entire troposphere), using both nadir- and limb-viewing techniques.
[2] NetCDF stands for Network Common Data Form.
[3] To view these peer-reviewed publications, visit: *tes.jpl.nasa.gov/documents/publications*.

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announcement

User-Friendly TES Lite Products Released! (cont.)

Comparison of TES (Lite-Product) Methane to GEOS-Chem Model

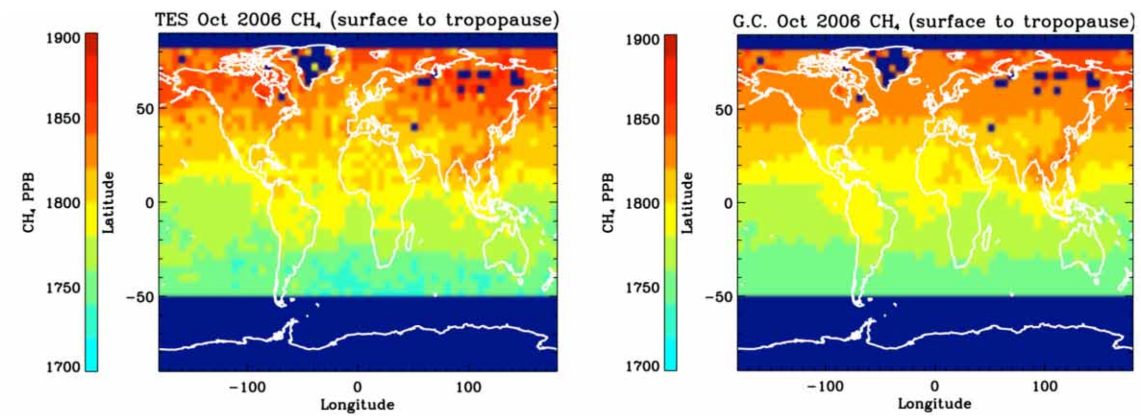

Figure. The left panel shows TES free-tropospheric methane estimates using observations from the TES methane (CH_4) October 2006 Lite product file. Individual observations from the product file are averaged in volume-mixing-ratio (VMR) from the surface to the tropopause and then onto the GEOS-Chem 2 x 2.5° horizontal grid. The right panel shows GEOS-Chem model estimates of methane for October 2006. GEOS-Chem model estimates are first matched with TES data using the latitude, longitude, and UTC variables in the Lite products. These model estimates are then adjusted by the corresponding TES averaging kernel and constraint vector and then averaged from the surface to the tropopause.

ESIP Federation Summer 2012 Meeting

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"During the teacher workshop, participants were highly engaged with the loaner iPads. The lending library at the University of Wisconsin provides a useful tool to the teachers and provides an incentive for data providers to create apps and content for this popular platform."

NASA made many valuable contributions to the ESIP meeting and to ESIP's member community. There were several NASA-inspired sessions, including presentations on:

- the NASA Mini-Summit for Open Source Software and Science;
- the Discovery Hack-a-thon;
- the ESIP Testbed: Encouraging Technology Innovation for Earth Science;
- Innovation Applied through Geospatial Application;
- NASA HDF/HDF-EOS[1] Data for Dummies (and Developers)—Making Data Access Easier;
- the Earth Science Collaboratory Hack-a-thon; and
- Data and Information Quality.

NASA also contributed to many ESIP *collaboration areas* during the meeting, including Data and Informatics, Education, and Societal Benefits.

The meeting's activities and notes are documented on the ESIP Commons website at *commons.esipfed.org*.

The ESIP Federation meets twice annually to share the latest advances affecting environmental data systems. The next ESIP Federation meeting will be January 8-10, 2013, in Washington, DC. If you are interested in participating in any of the ESIP community activities, email the person listed under the appropriate *collaboration area* found online at *esipfed.org/collaboration-areas*. ■

[1] HDF/HDF-EOS stands for Hierarchical Data Format—Earth Observing System.

Arctic Sea Ice Shrinks to New Low in Satellite Era

Maria-José Viñas, NASA's Goddard Space Flight Center, mj.vinas@nasa.gov

The frozen cap of the Arctic Ocean appears to have reached its annual summertime minimum extent and broken a new record low on September 16, the National Snow and Ice Data Center (NSIDC) has reported. Analysis of satellite data by NASA and the NASA-supported NSIDC showed that the sea ice extent shrunk to 1.32 million mi^2 (3.41 million km^2).

The new record minimum measures almost 300,000 mi^2 (776,996 km^2) less than the previous lowest extent in the satellite record—set in mid-September 2007—of 1.61 million mi^2 (4.17 million km^2). For comparison, the state of Texas measures around 268,600 mi^2.

NSIDC cautioned that, although September 16 seems to be the annual minimum, there's still time for winds to change and compact the ice floes, potentially reducing the sea ice extent further. NASA and NSIDC will release a complete analysis of the 2012 melt season next month, once all data for September are available.

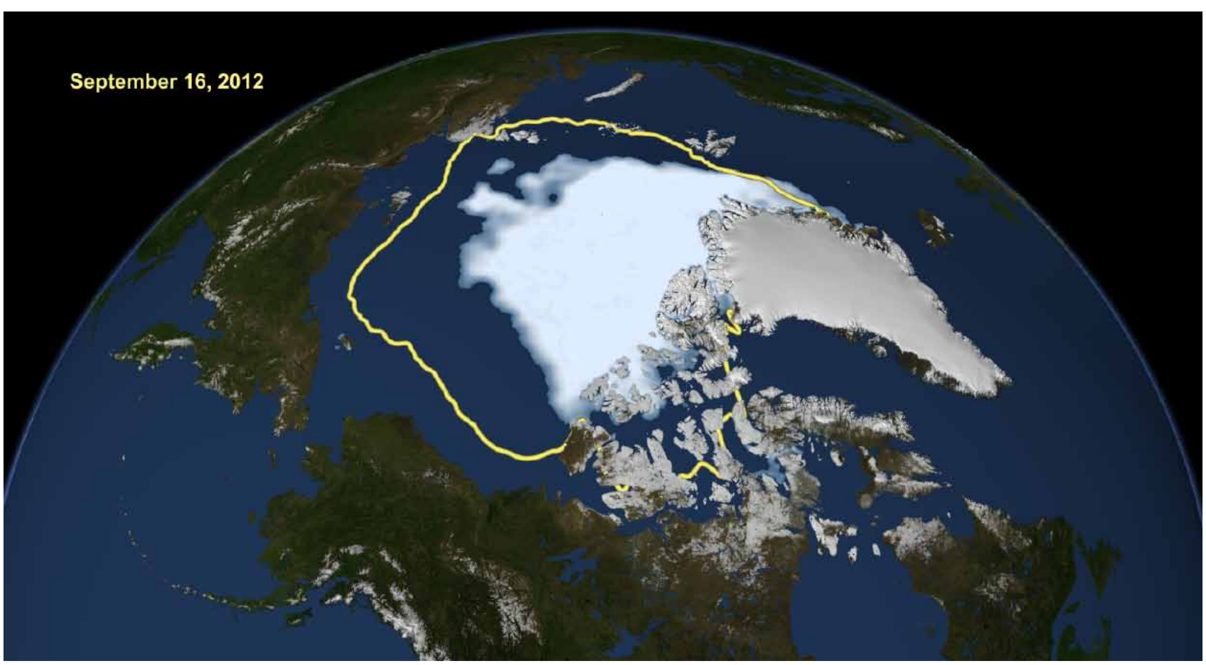
The sea ice minimum summertime extent, which is normally reached in September, has been decreasing over the last three decades as Arctic ocean and air temperatures have increased. This year's minimum extent is approximately half the size of the average extent from 1979 to 2000. This year's minimum extent also marks the first time Arctic sea ice has dipped below 4 million km^2.

"Climate models have predicted a retreat of the Arctic sea ice; but the actual retreat has proven to be much more rapid than the predictions," said climate scientist **Claire Parkinson**, [NASA's Goddard Space Flight Center (GSFC)]. "There continues to be considerable inter-annual variability in the sea ice cover, but the long-term retreat is quite apparent."

The thickness of the ice cover is also in decline. "The core of the ice cap is the perennial ice, which normally survived the summer because it was so thick," said senior scientist **Joey Comiso** [GSFC]. "But because it's been thinning year after year, it has now become vulnerable to melt."

The disappearing older ice gets replaced in winter with thinner seasonal ice that usually melts completely in the summer. This year, a powerful cyclone formed off the coast of Alaska and moved on August 5 to the center of the Arctic Ocean, where it churned the weakened ice cover for several days. The storm cut off a large section of sea ice north of the Chukchi Sea and pushed it south to warmer waters that made it melt entirely. It also broke vast extensions of ice into smaller pieces more likely to melt.

"The storm definitely seems to have played a role in this year's unusually large retreat of the ice," Parkinson said. "But that exact same storm, had it occurred decades ago when the ice was thicker and more extensive, likely wouldn't have had as prominent an impact, because the ice wasn't as vulnerable then as it is now." ■



Satellite data reveal how the new record low Arctic sea ice extent, from September 16, 2012, compares to the average minimum extent over the past 30 years (yellow line). **Image credit:** NASA/Goddard Scientific Visualization Studio

NASA's IceBridge Seeking New View of Changing Sea Ice

George Hale, NASA's Goddard Space Flight Center, george.r.hale@nasa.gov

This year, scientists working on NASA's *Operation IceBridge*, a multi-year airborne science mission to study changing ice conditions at both of Earth's poles, debuted a new data product with the potential to improve Arctic sea-ice forecasts.

Using new data processing techniques, IceBridge scientists were able to release an experimental "quick look" product—see **Figure 1**—before the end of the 2012 Arctic campaign. The main challenge faced when producing data for seasonal forecasts is the time needed to crunch the numbers—something that has in the past taken IceBridge scientists more than six months to do after the data were collected in the spring. This is too late to use for Arctic sea ice forecasts of the annual seasonal minimum, which takes place in September.

The new product could potentially be used in future seasonal sea-ice forecasts. "The community is excited about it," said IceBridge science team co-lead **Jackie Richter-Menge** of the U.S. Army Corps of Engineers Cold Regions Research Laboratory, in Hanover, NH. "We're hoping to build on this season's momentum and interest."

Scientists have been keeping an eye on Arctic sea ice in recent years because it is changing and they want to understand what those changes might mean. Arctic sea ice grows and recedes in a seasonal pattern, with a maximum coverage in March and a minimum in September. These high and low points vary from year to year, but there is a clear trend toward smaller minimums that mean more open water in the Arctic each summer and fall. This decrease in ice is already affecting ocean and terrestrial life in the Arctic, accelerating warming in the region, and leading to economic and social changes.

"Sea ice is a sensitive indicator of a changing climate," said NASA researcher **Nathan Kurtz** at NASA's Goddard Space Flight Center. It can also act as a feedback to warming in the Arctic. Because ice is much lighter in color than ocean water it has a higher albedo, meaning it reflects more sunlight than water. "A loss of sea ice can cause the Earth as a whole to warm," Kurtz said. The loss of sea ice has also been linked to shifts in weather patterns and distribution of nutrients in the ocean.

Getting the Whole Picture

Sea ice modulates a complex interaction between two systems—the ocean and the atmosphere—and is affected by a number of factors; surface temperature is the one that most readily comes to mind. Warming air and ocean temperatures melt the ice over time. But ice thickness and the amount of snow that accumulates on it are important in controlling the amount of growth and melt. As anyone who has been to a summer barbecue knows, larger masses of ice melt slower than smaller ones. Thicker sea ice will stay around longer than thin ice.

The largest portion of sea ice is hidden under the water's surface, which makes measuring its thickness trickier than getting its extent. To find thickness, researchers rely on a variety of advanced instruments

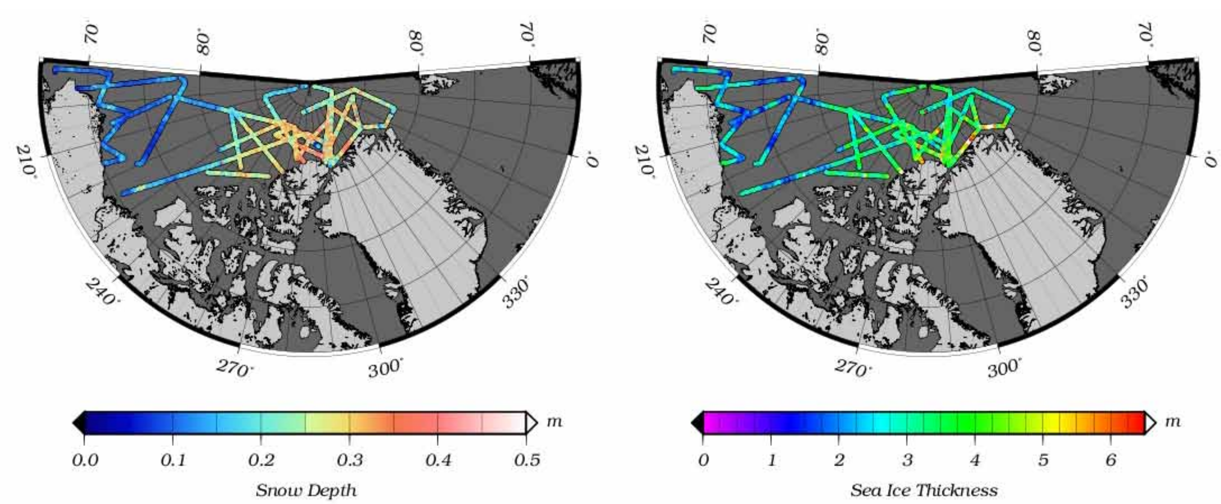


Figure 1: Snow depth and sea ice thickness data from the new quick-look data product. **Credit:** NASA

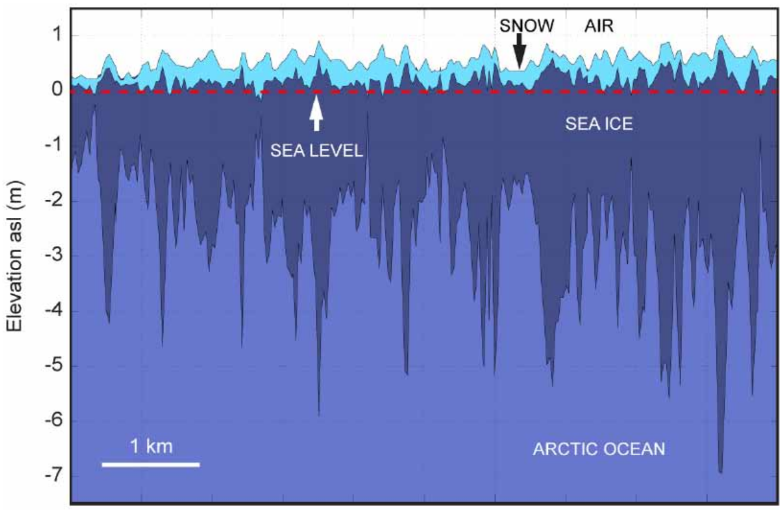


Figure 2: This diagram shows the relationship between snow and sea ice. The amount of ice above the water's surface is proportional to what lies below. Snow cover can lead to incorrect thickness estimates if not accounted for. **Credit:** NASA

and a law of physics that goes back to ancient Greece—*the Archimedes Principle*. "If you know how much ice is above the water and know its density, you can calculate the thickness," said Kurtz. "On average 80 to 90% of the ice is below the surface." With this knowledge, it's possible to take the ice *freeboard*—the amount above the water's surface, and calculate its thickness. IceBridge's Airborne Topographic Mapper (ATM) instrument uses a laser to measure how high the ice surface is above sea level. But snow accumulation means that what ATM measures is not just ice. To address this complication, IceBridge uses one of its radar instruments to measure snow thickness, and then, using simple subtraction, researchers can figure out the true ice freeboard—see **Figure 2**.

It's important to factor for snow thickness because, while it adds height to sea ice, it adds less mass than an equivalent thickness of ice. But snow thickness is a valuable measurement in its own right. "There's growing interest in our snow depth measurements as a standalone product," Richter-Menge said.

Snow affects how sea ice grows and melts by insulating it, slowing growth, and further increasing albedo as snow is even lighter colored than ice. But snow can also speed up melting. Snow melts, forming ponds of water that—due to increased albedo—absorb more heat than either snow or ice would. Snow also plays a role in the Arctic ecosystem. "For instance, snow needs to be a certain depth for the survival of seal pups," said Richter-Menge.

Putting It All Together

Creating a new data product calls for new processing methods and a good understanding of how data are collected. To facilitate this, Kurtz traveled to Greenland during the 2012 Arctic campaign. For about two weeks in March, Kurtz participated in survey flights on the NASA P-3B aircraft to see how instrument operators gathered sea ice data. "I asked a lot of questions," Kurtz said. "And I got a good impression for a short stay." Although it is tempting to use these data in this year's seasonal forecasts, both Kurtz and Richter-Menge caution that while they are optimistic about the new product, it still needs testing. After the upcoming sea-ice minimum, researchers can compare the quick-look and traditional products and test models by comparing the quick-look data with observations. "As the season goes on, we'll see how useful the quick-look product is," Richter-Menge said. Next year's Arctic campaign will see further refinement of the methods used to create the quick-look product. "The key is knowing how to deal with the data," Kurtz said. He plans to return to Greenland in 2013 to work on ways to speed up processing. "I learned a lot this year," Kurtz said. "It should be easier now that I've done it once." ■

The sun reflects over thin sea ice and a few floating ice bergs near the Denmark Strait off of eastern Greenland, as seen from NASA's P-3B aircraft on April 14, 2012. **Credit:** NASA/ **Jefferson Beck**

Satellites Observe Widespread Melting Event across Greenland

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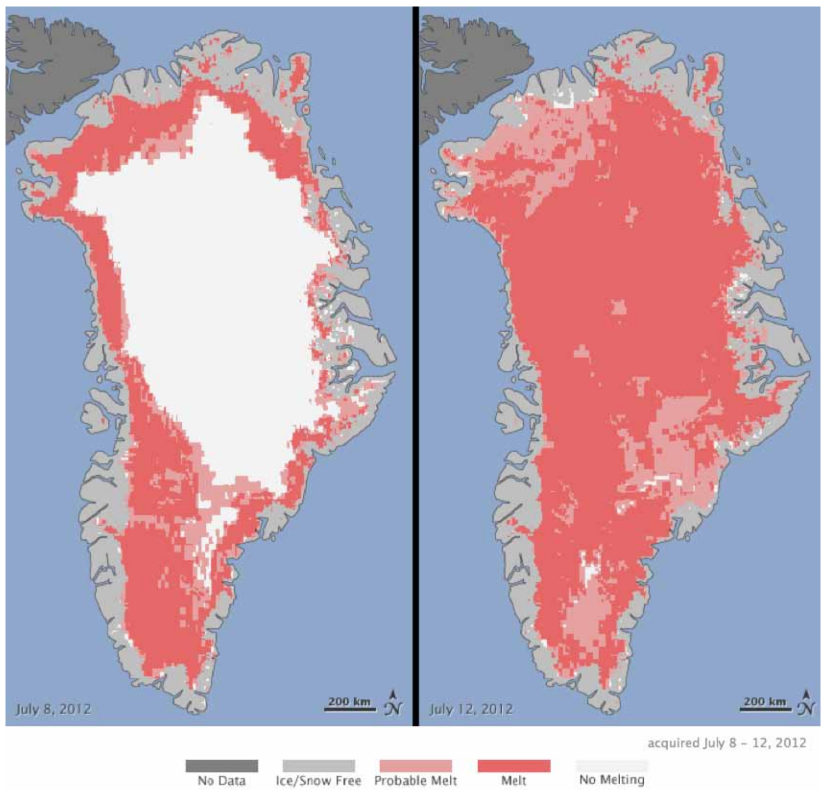
Mike Carlowicz, NASA Goddard Space Flight Center, michael.j.carlowicz@nasa.gov

In mid-July 2012 **Son Nghiem** of NASA's Jet Propulsion Laboratory was analyzing radar data from the Indian Space Research Organisation's Oceansat-2 satellite when he noticed that most of Greenland appeared to have undergone surface melting on July 12. "This was so extraordinary that at first I questioned the result," said Nghiem.

He knew that every summer, up to about 45% of the surface of the Greenland ice sheet typically experiences melt and then quickly refreezes in-place, especially at the higher elevations. Near the coast some of the melt is retained by the ice sheet and the rest is lost to the ocean. But the level of melting he observed was without precedent in the satellite era. So he needed to know: *"Was this real or was it due to a data error?"*

To help him answer this question, Nghiem turned to his scientific colleagues. He consulted with **Dorothy Hall** at NASA's Goddard Space Flight Center (GSFC), who studies the surface temperature and melt of Greenland using data from the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra and Aqua satellites. MODIS showed unusually high temperatures over the ice sheet surface—and she confirmed that the melt was unusually extensive on July 12. Colleagues Thomas Mote (University of Georgia) and Marco Tedesco (City University of New York) also confirmed the melt with passive microwave data from the Special Sensor Microwave Imager/Sounder (SSMI/S) on a satellite from the U.S. Air Force's Defense Meteorological Satellite Program (DMSP). Hall and her team produced melt maps that blended MODIS, Oceansat-2, and SSMI/S data providing high confidence in the location of melt especially for areas on the ice sheet where all three of the melt maps agreed.



As the investigation continued, it became clear that data from the three different sources were painting the same picture—that of an *extreme melt event*.

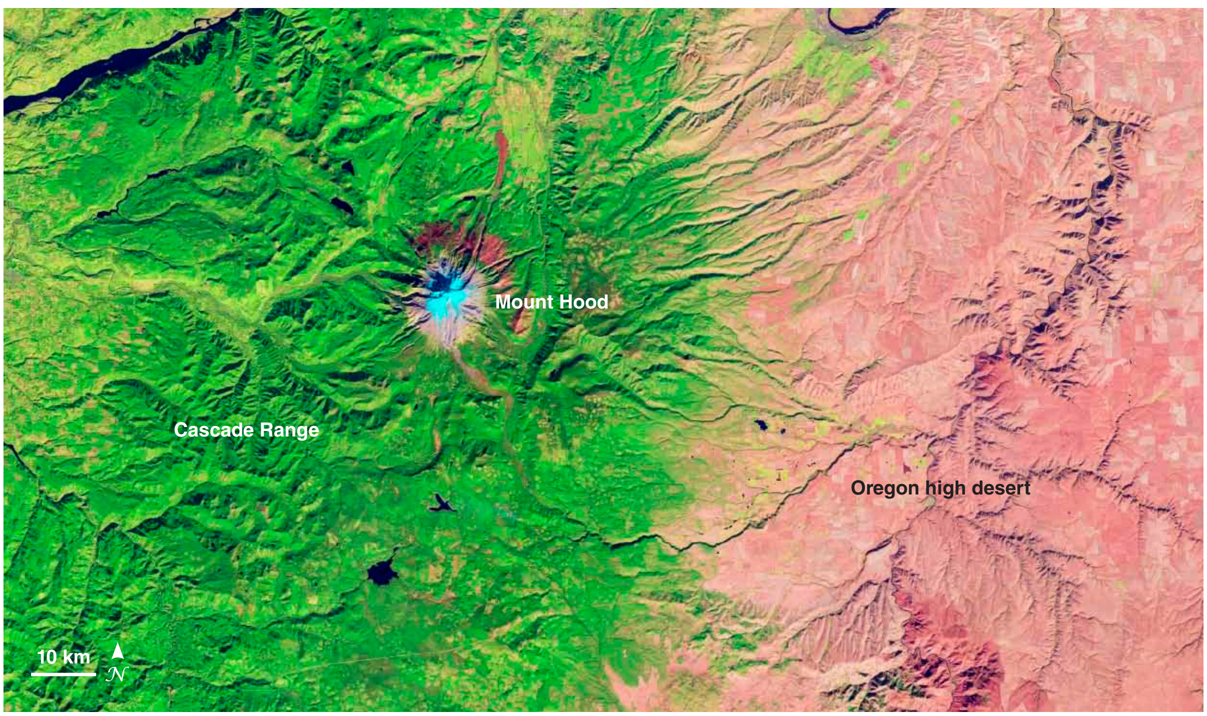
Nearly the entire surface of the ice sheet covering Greenland—from its thin coastal edges to its two-mile-thick center—experienced some degree of melting in July 2012. Indeed, more than 98% of the top layer of the ice sheet had thawed at some point in mid-July.

Though this is the largest extent of surface melting observed in three decades of satellite observations, ice core records, such as those analyzed by **Kaitlin Keegan** at Dartmouth College, reveal that such extreme melt events are not without precedent—with the last one occurring in 1889.

The image pair shown here reveals the extent of surface melting in Greenland on July 8 [*left*] and July 12, 2012 [*right*]. The maps are based on observations from SSMI/S on DMSP, from Oceansat-2, and from Terra's MODIS. These satellites each measure different physical properties at different scales, and pass over Greenland at different times. On July 8 satellites showed that about 44% of the ice sheet had undergone thawing at or near the surface. By July 12 the extent of melting had spread dramatically beyond the norm. In the images on the previous page, areas classified as "probable melt" correspond to sites where at least one satellite detected surface melting. Areas classified as "melt" correspond to sites where at least two or all three satellites detected melting.

The extreme melting coincided with a high-pressure system that had "parked" over Greenland, bringing with it warmer temperatures, calm winds, and sunny skies. The high-pressure dome was one in a series that dominated Greenland's weather between May and July 2012. Even the area around Summit—which at two miles above sea level is near the highest point of the ice sheet—showed signs of melting. A National Oceanic and Atmospheric Administration weather station at Summit confirmed that air temperatures hovered above or within a degree of freezing for several hours from July 11 to July 12.

"The Greenland ice sheet is a vast area with a varied history of change," said **Tom Wagner**, Cryosphere Program Manager at NASA Headquarters. "This event, combined with other natural but uncommon phenomena such as the large calving event earlier this week on Petermann Glacier, are part of a complex story." ■



Oregon Rain Shadow

Within a three-hour drive across Oregon, you can visit a beach, a temperate rainforest, a mountain glacier, and the high desert. The diversity of the landscape is mostly driven by the interaction of air masses and the mountains.

This image from the Landsat 5 satellite was acquired on October 27, 2011. The false-color view shows the bare soil and sparse vegetation of the high desert in shades of brown and pink, and the vegetation on the west side of the Cascade Mountains in green. The bright blue circular area is the glacial cap of Mount Hood.

The transition from green to pink is indicative of a *rain shadow*. Winds blow in from the west, carrying moisture from the Pacific Ocean. As the air moves across the landscape and up into the high elevations of the Cascade Range, air pressure decreases. The air cools and becomes unable to hold as much moisture, causing water to fall out as rain or snow. For this reason, the Cascades spend most of the year blanketed by cloud cover, and the frequent precipitation provides ample water for lush vegetation and gigantic trees.

On the eastern, leeward side of the mountains, the elevation drops, the air warms, and the air pressure increases. This effectively shuts off the rain because the air can better hold the remaining moisture. This effect is called a rain shadow and is largely responsible for the desert landscape beyond the mountains. **Credit:** NASA's Earth Observatory

NASA Earth Science in the News

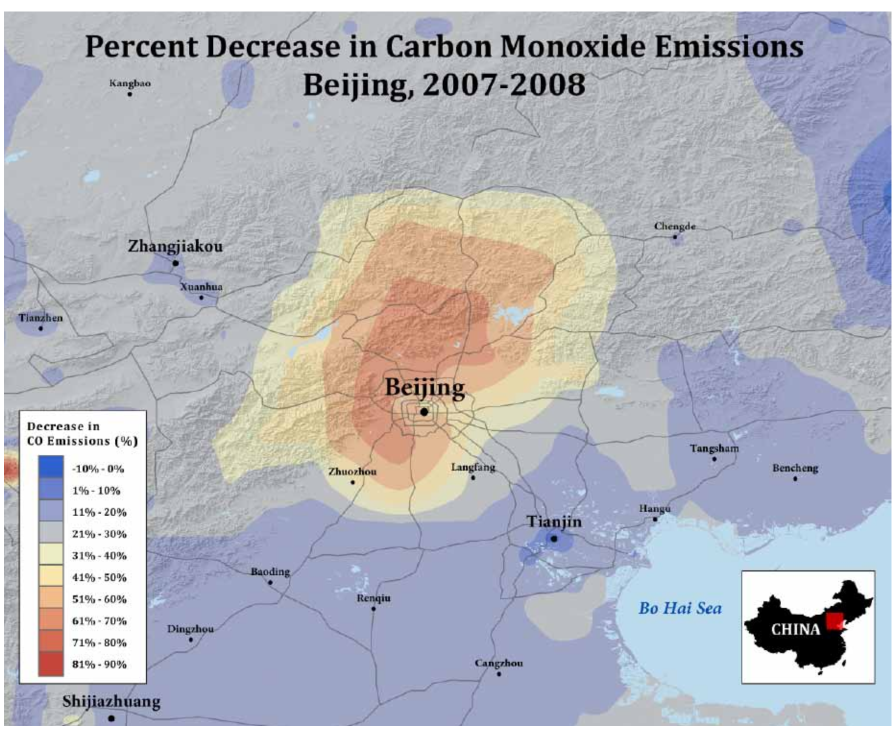
Patrick Lynch, NASA's Earth Science News Team, patrick.lynch@nasa.gov

Landsat's 40 Years Showing How the Earth is Changing—In Pictures, July 19, *The Guardian*. A collection of satellite images showed the range of Earth's natural and anthropogenic features that Landsat has observed over the past four decades. The gallery was assembled to mark the fortieth anniversary of the Landsat program. The Landsat platforms have long monitored changes caused by natural processes and human practice—for example, marine algal blooms and desertification—and is managed jointly by NASA and the U.S. Geological Survey.

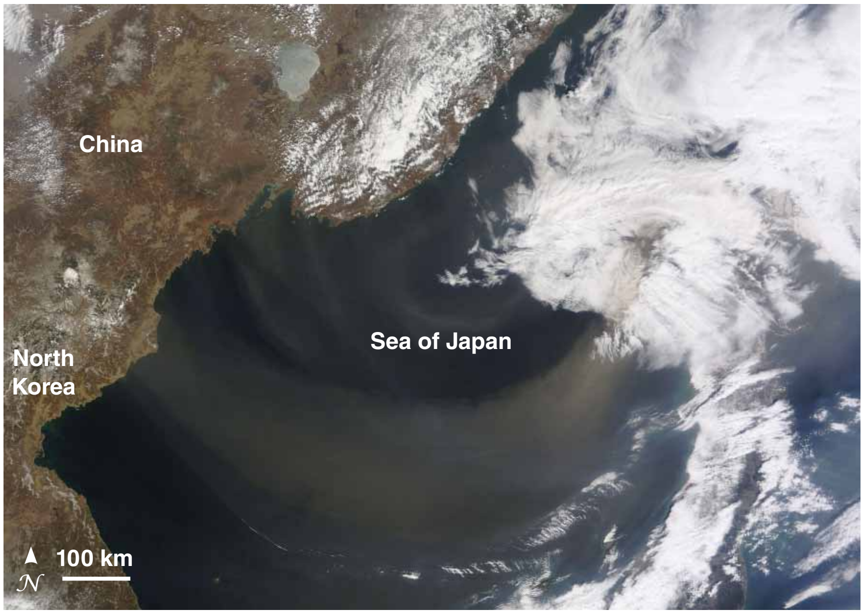
China Olympics Traffic Measures Cut Carbon Emissions, July 24, *esciencenews.com*. A NASA-funded study of the impacts of China's traffic restrictions for the 2008 Summer Olympics in Beijing shows how widespread changes in transportation patterns could greatly reduce the threat of climate change. New research by an international team of scientists, led by the National Center for Atmospheric Research (NCAR), indicates that China's restrictions on motor vehicles designed to improve air quality during the games had the side benefit of dramatically cutting emissions of carbon dioxide by between 26,500 (on the outskirts of the city) and 106,000 U.S. tons (closer to the center) [or between 24,000 and 96,000 metric tons] during the event. Carbon monoxide data from the NCAR/University of Toronto Measurements of Pollution in the Troposphere (MOPITT) onboard NASA's Terra satellite were used to infer the carbon dioxide emissions.

Maps Show Every Major Fire In America Since 2001, August 1, *BusinessInsider.com.* Designer **John Nelson** of IDV Solutions culled information from the Moderate Resolution Imaging Spectroradiometers onboard NASA's Terra and Aqua satellites to map major fires across the U.S. The sensors collect thermal information twice a day and can detect unusually high temperatures associated with burning fires. Limiting himself to information for fires with thermal output greater than 100 megawatts, Nelson mapped the location and intensity of major fires for the last 11 years.

Flights Safer and More Reliable with NASA Cloud Modeling Technique, August 3, *katc.com*. Airplane passengers can count on their flights across North America being safer and more reliable now that scientists have begun using data products developed using formulas derived by NASA scientists to get a more-



New research shows that levels of carbon monoxide dropped sharply in the Beijing area between 2007 and 2008, due to traffic restrictions imposed because of the 2008 Summer Olympics. **Image credit:** UCAR. Illustration by **Lex Ivey**, based on NCAR data.



A dust plume arose over Inner Mongolia and on April 9, 2012, began its eastward journey over the Sea of Japan. New research shows that dust accounts for most of the (~65 million metric tons) of foreign aerosol imports that arrive in the air over North America each year. **Credit:** NASA's Earth Observatory/ **Jeff Schmaltz**

accurate representation of clouds in weather forecast models. "Clouds are an important factor to consider when planning a flight," says **Patrick Minnis** [NASA's Langley Research Center]. Minnis' team, the Langley Cloud and Radiation Group, works on developing ways to represent cloud information collected for NASA's satellite project, Clouds and the Earth's Radiant Energy System (CERES). The team fused CERES data with geostationary satellite observations to produce the new and improved information, which is now being fed into forecasts produced hourly by NOAA's National Weather Service in near-real time.

Nearly Half of North America's Aerosols Come From Asia, Sahara, August 3, *Christian Science Monitor.* Nearly half of the tiny droplets and particles suspended high in the atmosphere over North America come from other continents, an examination of satellite data reveals. "That is a big number: half. I wasn't expecting anything like that," study researcher **Lorraine Remer** [University of Maryland, Baltimore County (UMBC)] says in a video released in conjunction with the new study on aerosols. Specifically, the research team found that 70.5 million tons (64 teragrams) of foreign aerosols—which include naturally occurring dust as well as pollution—arrive over North America every year. Meanwhile, people and natural processes in North America produce 76.1 million tons (69 teragrams) of aerosols on their own, or 52% of the total. There is another surprise as well: The research team, led by **Hongbin Yu** [University of Maryland, College Park/ NASA's GSFC], found that most of the aerosols are naturally occurring dust, not man-made pollution, such as sulfates produced by the combustion of fossil fuels.

* **Greenland Ice Sheet Melted at Unprecedented Rate During July,** July 24, *The Guardian.* The Greenland ice sheet melted at a faster rate this month than at any other time in recorded history, with virtually the entire ice sheet showing signs of thaw. The rapid melting over just four days was captured by three satellites. Scientists admitted the satellite data were so striking they thought at first there had to be a mistake. "This was so extraordinary that at first I questioned the result: Was this real or was it due to a data error?" said **Son Nghiem** [NASA/ Jet Propulsion Laboratory]. He consulted with several colleagues, who confirmed his findings. **Dorothy Hall** [NASA's GSFC], who studies the surface temperature of Greenland, confirmed that the area experienced unusually high temperatures in mid-July, and that there was widespread melting over the surface of the ice sheet.

*See news story in this issue for more details.

Interested in getting your research out to the general public, educators, and the scientific community? Please contact ***Patrick Lynch*** *on NASA's Earth Science News Team at* ***patrick.lynch@nasa.gov*** *and let him know of your upcoming journal articles, new satellite images, or conference presentations that you think would be of interest to the readership of The Earth Observer.* ■

NASA Science Mission Directorate – Science Education and Public Outreach Update

Theresa Schwerin, Institute of Global Environment and Society, theresa_schwerin@strategies.org
Morgan Woroner, Institute of Global Environment and Society, morgan_woroner@strategies.org

NASA Postdoctoral Fellowships

Application Deadline—November 1

The NASA Postdoctoral Program offers scientists and engineers unique opportunities to conduct research in space science, Earth science, aeronautics, exploration systems, lunar science, astrobiology, and astrophysics.

Awards: Annual stipends start at $53,500, with supplements for specific degree fields and high cost-of-living areas. There is an annual travel budget of $8000, a relocation allowance, and financial supplement for health insurance purchased through the program. Approximately 90 fellowships are awarded annually.

Eligibility: An applicant must be a U.S. citizen, lawful permanent resident, or foreign national eligible for J-1 status as a research scholar to apply. Applicants must have completed a Ph.D. or equivalent degree before beginning the fellowship, but may apply while completing the degree requirements. Fellowships are available to recent or senior-level Ph.D. recipients.

Fellowship positions are offered at several NASA centers. To obtain more information and to apply for this exciting opportunity, visit: *nasa.orau.org/postdoc*.

Lifelines for High School Climate Change Education—Webinar for High School Teachers

Webinar Date—October 30

Lifelines for High School Climate Change Education, a project for high school teachers, is holding a webinar this fall that is open for anyone to access. For more information, visit: *bit.ly/QLk0Ov*.

October 30: This webinar will cover *PicturePost*. **Annette Schloss** [University of New Hampshire, Durham—*Research Scientist*] will discuss PicturePost, which is part of the Digital Earth Watch (DEW) network that supports environmental monitoring by citizens, students, and community organizations through digital photography and satellite imagery. Participants will learn how teachers and students can contribute to the DEW using digital images in a growing archive aimed at measuring environmental change.

The World's a Place of Living Things—IGES Art Contest Grades 2-4

Entries Due—November 5

This year's art contest invites young scientists and artists to explore biodiversity. Learn about all the forms of life in a particular place; then create a piece of artwork to show what you have learned! Students in grades 2–4 may submit one two-dimensional entry that does not exceed 16 x 20 in. Winners will have their artwork featured on the Institute for Global Environmental Strategies (IGES) website. To find out more, to see the complete rules, and to download an entry form, visit: *www.strategies.org/artcontest*.

Earthzine Call for Papers on Environmental Awareness

Submissions accepted between September 1 and December 1

Earthzine.org—an online source for news, articles, and educational materials about Earth science—is soliciting articles for its fourth-quarter 2012 theme on environmental awareness. Earthzine seeks contributions addressing theory and practices related to creating and expanding awareness of the Earth's environment. For full details on desired themes and how to submit, please visit: *bit.ly/QL2PfS*.

Opportunity for Middle and High School Students to Publish Climate Research

Notice of Intent Deadline—November 30, 2012

Harvard University's *Journal of Emerging Investigators* (JEI), in collaboration with the Institute for Earth Science Research and Education (IESRE), is now accepting manuscripts to publish a series of climate-related papers written by middle- and secondary-school students.

JEI is an open-access, peer-reviewed, online journal, whose mission is to encourage and publish authentic student research. In addition to standalone research papers, *JEI* also encourages students who are developing science-fair projects to submit journal articles based on those projects. Instructions on how to submit and guidelines for articles, including some practical suggestions for converting a science-fair project into a journal article submission, can be found at *bit.ly/LYXdDx*. The first deadline for manuscripts describing work done during the 2012–2013 school year is to be provided as an e-mail, due by November 30, 2012, indicating your intention to submit an article. This e-mail should include a tentative title and a brief description of no more than 250 words, summarizing your proposed research. For more information and questions, please email **David Brooks** [IESRE—*President*] at *brooksdr@instesre.org*. ■

EOS Science Calendar

October 16–18, 2012
HyspIRI Workshop, Pasadena CA.
URL: *hyspiri.jpl.nasa.gov/events/2012-hyspiri-workshop*

October 17–18, 2012
SMAP/GPM/GRACE-FO/SWOT Joint Mission Tutorial Workshop, Reston, VA.
URL: *smap.jpl.nasa.gov/science/workshops*

October 22–26, 2012
CERES Science Team Meeting, Princeton, NJ.
URL: *ceres.larc.nasa.gov/ceres_meetings.php*

November 14, 2012
SMAP Cal/Val Workshop #3, Oxnard, CA.
URL: *smap.jpl.nasa.gov/science/workshops*

Global Change Calendar

November 5–9, 2012
Pan Ocean Remote Sensing Conference (PORSEC) 2012: Water and Carbon Cycles, Kochi, India. URL: *www.porsec2012.incois.gov.in*

December 3–7, 2012
American Geophysical Union Fall Meeting, San Francisco, CA. URL: *www.agu.org/meetings*

January 1–14, 2013
Land-Cover and Land-Use Change Dynamics and its Impacts in South Asia, Karunya University, Coimbatore, India. URL: *lcluc.umd.edu/meetings.php?mid=40*

January 6–10, 2013
Americal Meteorological Society, Austin, TX. URL: *annual.ametsoc.org/2013/?CFID=599140&CFTOKEN=30157218*

January 15–17, 2013
National Conference on Science Policy and the Environment, Washington, DC. URL: *www.environmentaldisasters.net*

March 24–28, 2013
American Society of Photogrammetry and Remote Sensing, Baltimore, MD. URL: *www.asprs.org/Conferences/Baltimore-2013/blog*

April 15–17, 2013
Joint Aquarius–SMOS Workshop, Brest, France
URL: *congrexprojects.com/13c07/announcement*

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Articles, contributions to the meeting calendar, and suggestions are welcomed. Contributions to the calendars should contain location, person to contact, telephone number, and e-mail address. Newsletter content is due on the weekday closest to the 15th of the month preceding the publication—e.g., December 15 for the January–February issue; February 15 for March–April, and so on.

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