National Aeronautics and Space Administration

The Earth Observer. March - April 2010. Volume 22, Issue 2.

Editor's Corner

Steve Platnick
EOS Senior Project Scientist

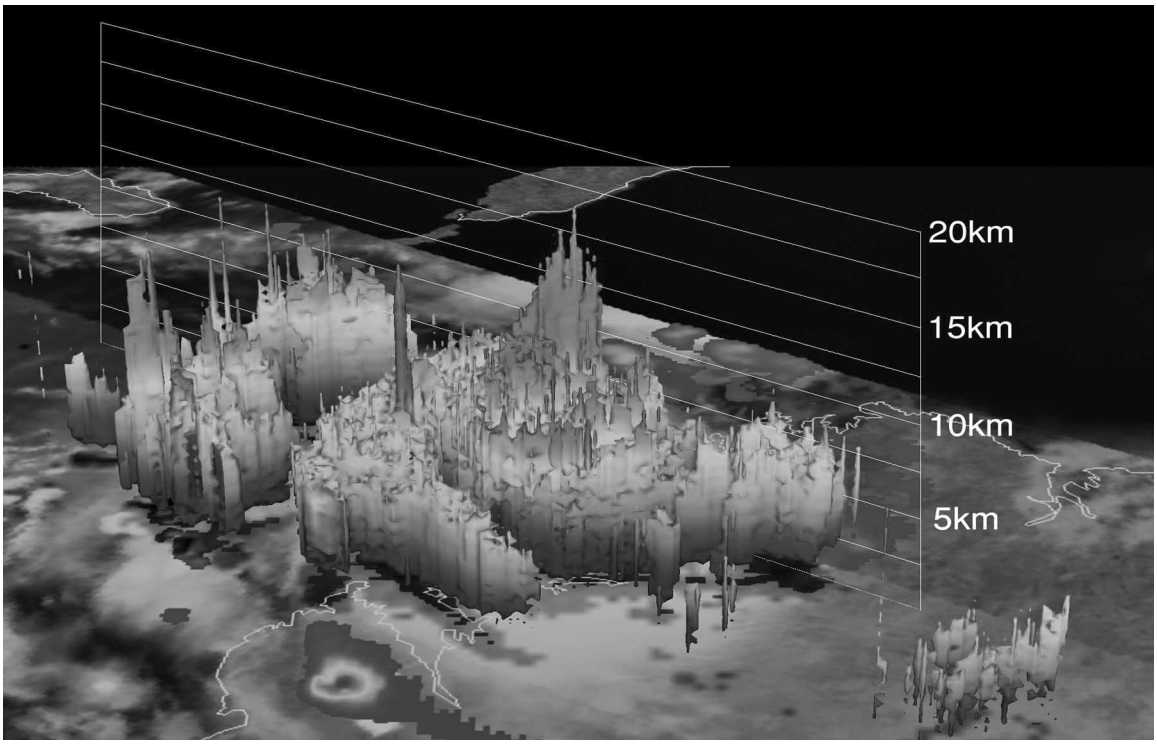
On February 1, 2010, the Obama Administration submitted details of its Fiscal Year (FY11) budget request to Congress, where it was proposed that NASA receive $19 billion—an increase of 1.5% over the FY10 enacted budget with a total increase of $6.0 billion over five years (FY 2011-15) compared to the FY10 budget.

If Congress approves the budget as proposed, Earth Science will be a clear beneficiary. The proposed FY11 Budget for Earth Science is $1.8 billion, about a 27% increase over FY10 enacted, and a total augmentation of $2.4 billion over five years (FY 2011-15). Significantly reversing a decadal-long downward trend in NASA Earth Science funding in fixed year dollars, this budget represents a strong show of support in tough economic times.

The FY11 budget includes funding for continued operation of the Earth Observing missions currently in orbit[1]. It provides for the launch of Glory and Aquarius (both to be launched towards the end of this year) and the planned September 2011 launch of the National Polar-orbiting Operational Environmental Satellite (NPOESS)

[1] The fifteen missions funded include ICESat and QuikSCAT, which both recently ended their core science missions—see the Editorial in the January–February 2010 issue of *The Earth Observer* [**Volume 22, Issue 1**] for details.

continued on page 2



NASA's Tropical Rainfall Measuring Mission (TRMM) passed over tropical cyclone Magda on January 21, 2010 when it was off Western Australia's northern coast and soon to make landfall. TRMM's Precipitation Radar (PR) and TRMM Microwave Imager instruments (TMI) revealed that Magda had developed an eye before coming ashore with hurricane force winds and powerful thunderstorms were dropping rainfall at a rate greater than 2 in (~50 mm) per hour in an area west of the eye. TRMM's three-dimensional perspective of Magda showed that some of the intense thunderstorms near its eye reached heights above 52,493 ft (~16 km). To view this image in color, please visit: *www.nasa.gov/mission_pages/hurricanes/archives/2010/h2010_Magda.html.* **Credit:** NASA

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In This Issue

Preparatory Project (NPP). The budget also provides for the completion of the remaining "foundational" missions—the Landsat Data Continuity Mission (LDCM), including the Thermal Infrared Instrument (TIRS), targeted for launch in December 2012, and the Global Precipitation Measurement (GPM) core mission, targeted for launch in July 2013.

The budget also accelerates or initiates Systematic Missions recommended by the National Research Council's 2007 Decadal Survey. The Soil Moisture Active-Passive (SMAP) and ICESat-2 missions will be accelerated for launches in late 2014 and late 2015, respectively. *Phase A* formulation activities will be initiated for the remaining *Tier-1* Decadal Survey missions, the Climate Absolute Radiance and Refractivity Observatory (CLARREO) and the Deformation, Ecosystem Structure, and Dynamics of Ice (DESDynI), with launches moved up to 2017.

Under the Earth System Science Pathfinder (ESSP) program, the FY11 budget request continues funding to initiate the development of an Orbiting Carbon Observatory reflight (OCO-2), replacing the mission that failed to reach orbit in 2009, with a target launch of early 2013. NASA will also begin development of a Gravity Recovery and Climate Experiment (GRACE) follow-on mission working towards a launch in FY16. As part of an effort to more fully utilize the International Space Station as the laboratory it was originally intended to be, the President's Budget will fund NASA to start the refurbishment of a Stratospheric Aerosol and Gas Experiment (SAGE-III) instrument to be hosted by the station as early as 2013.

A restructuring of the NPOESS program was also announced. NASA and the National Oceanic and Atmospheric Administration (NOAA) will take responsibility for the afternoon orbit under the newly created Joint Polar Satellite System (JPSS) program. Funding will come from NOAA, with NASA having an acquisition role for development and launch similar to the current Polar Operating Environmental Satellite (POES) and Geostationary Operational Environmental Satellite (GOES) satellite programs. The program office, located at NASA Goddard, will report to a new Division within the Science Mission Directorate at NASA HQ. **Marcus Watkins** has been selected as the Director of this new Division. **Preston Burch** will be the Program Manager and **Jim Gleason**, currently the NPP Project Scientist, will become the JPSS Senior Project Scientist. Details on the JPSS implementation are ongoing. Concurrent with this change, the Department of Defense will have responsibility for the early morning (terminator) orbit and the U.S. will continue its partnership with the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) for the mid-morning orbit.

Further details about the NASA and Earth Science budgets are available at *www.nasa.gov/news/budget/index.html*.

There are a number of recent EOS Project Scientist and Deputy Project Scientist appointments to report.

- **Jeff Masek** has been named the Landsat Project Scientist, replacing Darrel Wiliams who recently retired from NASA[2]—he had been serving as Deputy Project Scientist for LDCM since 2002. Masek is a Re-

[2] See the Editorial in the January–February 2010 issue of *The Earth Observer* [**Volume 22, Issue 1**] for details on Williams' role in Landsat.

search Scientist in the Biospheric Sciences Branch at Goddard whose research interests include mapping land-cover change in temperate environments, application of advanced computing to remote sensing, and satellite remote sensing techniques.

- **Bruce Cook** will replace Masek as the LDCM Deputy Project Scientist. Cook is a terrestrial biologist and Earth scientist in the Biospheric Science Branch at Goddard whose research interests include the fusion of lidar, radar and multi/hyperspectral data for improving remotely sensed estimates of aboveground woody biomass, plant production, and exchange of carbon dioxide, methane, and water vapor between the atmosphere and terrestrial biosphere. Cook is also a member of the DESDynI Science Team.

- **Lazaros Oreopoulos** has been named Aqua Deputy Project Scientist. (I had served in this role since 2002 but vacated it recently when the *Acting* qualifier was officially removed from my title.) Oreopoulous is a research physical scientist in the Climate and Radiation Branch at Goddard whose research interests include the modeling and remote sensing of clouds, cloud-aerosol interactions, and many aspects of atmospheric radiative transfer for climatic applications. Oreopoulos is also a member of the Landsat Science Team, the AMS Atmospheric Radiation Committee, the International Radiation Commission, and the GEWEX Radiation Panel.

- **Ellsworth "Judd" Welton** is now the Glory Deputy Project Scientist. Welton is part of the Mesoscale Atmospheric Processes Branch at Goddard, and has specialized in aerosol research since 1994. His research has focused on the retrieval of the optical and physical properties of various aerosol species, and he is an expert in the use of lidar and radiometry to retrieve aerosol and cloud properties. Welton is the Principal Investigator for the NASA Micro Pulse Lidar Network (MPLNET), was an atmospheric team member on NASA's Geoscience Laser Altimeter System (GLAS), and is a science team member for the Cloud–Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) mission. He is also a member of the science working group for the Aerosols, Clouds, and Ecosystems (ACE), a *Tier 2* Decadal Survey mission.

I extend my congratulations to everyone on their new appointments[3].

In closing, this year marks the 40th anniversary of Earth Day and a number of special events will take place the week of April 17-25 on the National Mall in Washington, DC. This year's theme is *climate change*. NASA is working with the Earth Day Network to plan a number of activities, including a new eco-friendly, dome-shaped exhibit space. Plans are in the works to have a series of "dynamic interactive" presentations showcasing NASA Earth Science during the event. If you live in the Washington area, or just happen to be passing through, I encourage you to consider taking time to attend the Earth Day celebration and visit the NASA exhibit.

[3] A full list of current EOS Project Scientists can be found at: *eos.nasa.gov/directory/eospso_members/index.php*.

The latest (and the last) Geostationary Operational Environmental Satellite (GOES-P) lifted off aboard a *Delta IV* rocket from Space Launch Complex 37 at the Cape Canaveral Air Force Station, FL at 6:57 p.m. (EST) on March 4. The new National Oceanic and Atmospheric Administration (NOAA) satellite joins four other similar spacecraft already in orbit to improve weather forecasting and monitoring of environmental events. Approximately four hours and 21 minutes after liftoff, the spacecraft separated from the launch vehicle. The NASA Deep Space Network tracking site in Canberra, Western Australia, monitored the spacecraft separation. GOES-P is the third and final spacecraft in the GOES-N series of geostationary environmental weather satellites. Upon reaching final orbit, the satellite's name changed to GOES-15 and NOAA took responsibility for day-to-day operations. Keep up with new photos and status updates at: *www.nasa.gov/goes-p*. **Credit:** NASA

feature articles

Earth to Sky: a partnership between NASA, National Park Service, and U.S. Fish and Wildlife Service

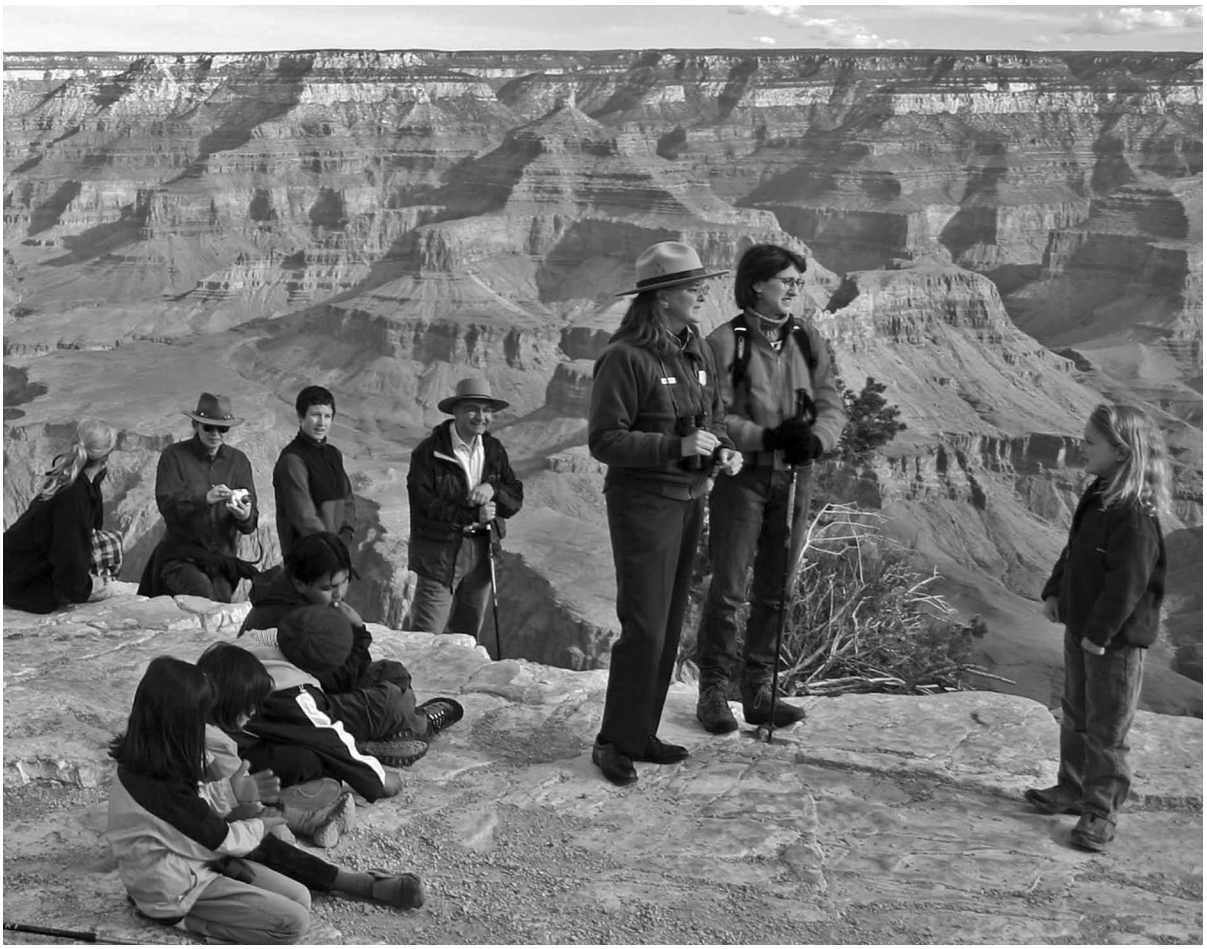
Anita Davis, NASA Goddard Space Flight Center/Sigma Space, anita.l.davis@nasa.gov

America's 392 national parks and 551 wildlife refuges connect people to the cultural and natural heritage of our nation. Amidst such deeply meaningful settings, visitors can see first-hand the consequences of climate change and, through NASA science, can gain an appreciation of global processes at work.

Over 430 million people visit national parks and wildlife refuges each year.

From Cape Cod National Seashore, Gettysburg National Battlefield, Yellowstone and Yosemite National Parks, to the Prairie Wetlands Learning Center, Sevilleta, Bosque del Apache and Blackwater National Wildlife Refuges, America's 392 national parks and 551 wildlife refuges connect people to the cultural and natural heritage of our nation. Amidst such deeply meaningful settings, visitors can see first-hand the consequences of climate change and, through NASA science, can gain an appreciation of global processes at work. The opportunity for combining NASA's science and educational resources with the communication capabilities, skills, and talents of the U.S. Fish and Wildlife Service (USFWS) and the National Park Service (NPS) forms the foundation of a unique partnership called *Earth to Sky*.

The Earth to Sky (ETS) partnership began in 2004, when **Ruth Paglierani** [University of California, Berkeley—*Center for Science Education*]; **Anita Davis** [Goddard Space Flight Center—*Landsat Education and Outreach Coordinator*]; and **Deanne Adams** [National Park Service—*Chief of Interpretation for NPS, Pacific West Region (retired)*] collaborated to produce professional development that brought relevant NASA science content into the hands of NPS interpretive rangers. Initial funding was provided through a NASA Explorer Institutes grant. It was the beginning of a multi-year effort that created a new community of practice within the interpretation and



Amidst breathtaking landscapes, rangers connect visitors with our nation's cultural and natural heritage; NASA's unique content helps them place resource stewardship into a global context. **Photo courtesy:** Grand Canyon National Park

education communities of NPS and USFWS, and has brought NASA scientists face-to-face with powerful communication methodology.

The first year (ETS I) showcased the breadth of NASA science and illustrated proven informal education methodology. During two simultaneous weeklong workshops, fifty rangers wrote action plans to incorporate NASA science from a variety of divisions into public programs, exhibits, displays, and publications that they would create at their parks. In some cases, entirely new extensive programs were developed. For instance, at Craters of the Moon National Monument and Preserve, ranger **Ted Stout** developed an on-line curriculum-based program, *Visiting the Moon—Without Leaving Idaho*, and a Lunar Jr. Ranger program. Ranger **Steve Zachary** launched the Lassen Astrobiology Student Internship Program in partnership with Ames Research Center, and hosted graduate student tours at Lassen Volcanic National Park.

With a second NASA Explorer Institutes grant, year two (ETS II) brought together selected participants from ETS I, to create examples of interpretive products for use in future training efforts. One outcome was a NPS color brochure, *Climate Change in National Parks*, and an accompanying traveling display, *Arrange for Change*, created by **John Morris** [NPS Alaska Region Office]. The brochure was so popular that a variety of parks chipped in to fund reprints, and over 450,000 copies have been distributed. Due to high demand, a second display was also created. The popularity of the brochure and travelling displays shows that visitors to national parks are interested in learning about climate change.

Earth to Sky facilitators and organizers (*left to right*) Dave Hutson, Anita Davis, Kevin Poe, Ruth Paglierani, and John Morris displayed the *Arrange for Change* traveling exhibit at the National Association of Interpretation's annual conference in November 2007.

In response to this need, the third and fourth years (ETS III and IV) addressed NASA's extensive work on climate change, the effects of climate change on park and refuge natural and cultural resources, and the challenges rangers are facing in communicating about this complex topic.

Peter Hildebrand [NASA GSFC], Jon Jarvis [NPS], and Jay Slack [USFWS] enjoyed the panel discussion on climate change communication that took place at Goddard Space Flight Center.

ETS III (funded by GSFC) was held in January 2009. It marked the expansion of the partnership to welcome USFWS, as well as participants from the California State Parks and the Cleveland Metroparks Zoo. The workshop's thirty-five participants have reached over 2.5 million people with climate change information gleaned from the NASA science presentations. In addition to ranger-led walks and narrated slide programs, new exhibits have been created in visitor centers and on trails; a national podcast series involving several parks has begun; several Junior Ranger programs have been produced; and a national climate change *Web Ranger* effort is under development. Participants have also trained over 1,100 additional educators in climate science basics.

In each ETS workshop, NASA scientists are paired with rangers who help target the presentations to best meet the needs of these highly skilled informal education specialists. Scientists are encouraged to remain at the workshop for the entire day of their presentation, to enable more extensive dialogue with participants. Abundant NASA

*A panel discussion on communicating climate change outlined agencies' roles and responsibilities with respect to climate change. Panelists noted the value of the interagency **Earth to Sky** partnership, and encouraged the rangers from NPS and USFWS to boldly communicate the science of climate change, including the known human impacts.*

resources are made available, and NASA education and public outreach (EPO) staff provide educational products related to the science. The project has also benefited greatly from formative and summative evaluation, improving the workshops and strengthening the partnership. A highlight of all ETS workshops has been the visit to a NASA center. Participants have repeatedly emphasized that the opportunity to see the real thing in action is inspirational for them, and helps them to put NASA's science into a more understandable context.

Earth to Sky IV: Communicating Climate Change was held the first week of February 2010. Thirty-two participants, chosen from over 80 applications, joined eight ETS alumni, sixteen NASA scientists, and many EPO staff. As part of the workshop's visit to NASA, **Peter Hildebrand** [GSFC—*Deputy Director of the Sciences and Exploration Directorate*] joined **Jon Jarvis** [NPS—*Director*], and **Jay Slack** [USFWS—*Director of National Conservation Training Center*] in a panel discussion focused on communicating climate change—see photo on page 5. The panelists outlined agencies' roles and responsibilities with respect to climate change. They also noted the value of the interagency *Earth to Sky* partnership, and encouraged the rangers from NPS and USFWS to boldly communicate the science of climate change, including the known human impacts.

A stimulating session exploring techniques for communicating about controversial issues preceded the panel discussion. Master interpreter **David Larsen** [NPS—*Training Manager for Interpretation, Education, Recreation and Conservation*] facilitated the discussion. Both activities were open to the entire GSFC community. While at GSFC, workshop participants also attended a *Science On a Sphere* presentation by NASA Chief Scientist **Jim Garvin**, a synopsis of the ocean's role in climate given by GSFC's **Chuck McClain**, and an overview of the James Webb Space Telescope provided by Systems Engineer **Ray Lundquist.**

Throughout the ETS partnership, both NPS and (more recently) USFWS have made substantial in-kind contributions, including use of their training facilities at no cost, as well as enormous contributions of time and talent. A NASA Research Opportunities in Space and Earth Sciences (ROSES) grant, led by Davis, Paglierani, and ETS alumni John Morris and **Sandy Spakoff** [USFWS National Conservation Training Center], supported the ETS IV workshop. The grant is also funding development of distance learning components and the next ETS workshop—a pilot course at the USFWS National Conservation Training Center in Shepherdstown, WV—slated for September 2011. All sessions and action plans from ETS III and IV will eventually be posted to the project website at *earthtosky.org*. ■

Mark Your Calendar

An international A-Train Symposium is planned for October 25-28 in New Orleans, LA. The "A-Train" (Afternoon Constellation) of satellites allows coordinated multi-instrument measurements of the Earth system. The symposium will provide an opportunity for new and veteran users to learn more about "A-Train" measurements and to engage colleagues with similar interests. On-line registration is available at: *a-train-neworleans2010.larc.nasa.gov*.

NASA Applied Sciences' DEVELOP National Program: Training the Next Generation of Remote Sensing Scientists

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Since its inception over a decade ago, the DEVELOP National Program has provided students with experience in utilizing and integrating satellite remote sensing data into real world applications. In 1998, DEVELOP began with three students and has evolved into a nationwide internship program with over 200 students participating each year. DEVELOP is a NASA Applied Sciences' training and development program extending NASA Earth science research and technology to society. Part of the NASA Science Mission Directorate's Earth Science Division, the Applied Sciences Program focuses on bridging the gap between NASA technology and the public by conducting projects that innovatively use NASA Earth science resources to research environmental issues. The goal of these projects is to examine how NASA science can better serve society. DEVELOP students accomplish this goal through research with global, national, and regional partners aimed at identifying the widest array of practical uses for NASA data to help communities better understand environmental change over time. Projects focus on practical applications of NASA's Earth science research results. Each project is designed to address at least one of the Applied Sciences' focus areas[1], use NASA's Earth observation sources, and meet partners' needs. DEVELOP research teams partner with end-users and organizations who use project results for policy analysis and decision support, thereby extending the benefits of NASA science and technology to the public.

Since its inception over a decade ago, the DEVELOP National Program has provided students with experience in utilizing and integrating satellite remote sensing data into real world applications.

DEVELOP was established under the Digital Earth Initiative (DEI), a federal interagency project dedicated to creating a virtual representation of the Earth. DEI piloted an effort to increase public access to federal information about the Earth and the environment. A proposal that combined NASA's DEI and a *white paper* written by three students advocating for a student program resulted in DEVELOP's official formation in 1999. Since then, the DEVELOP Program has focused on student training and development, scientific research, and stakeholder interaction. The program fosters a high-quality corps of early career researchers possessing advanced skills in NASA Earth science research applications and partner agencies' decision support tools, as well as experience delivering results to officials in government, academia, and industry. Projects are developed in response to community demand, with each project dem-

[1] The Applied Sciences' focus areas include: Agriculture; Air Quality; Climate; Ecological Forecasting; Natural Disasters; Public Health; Water Resources; and Weather.

DEVELOP students at Langley Research Center meet the newly appointed NASA Administrator Charles Bolden (*front row, center*) during the 2009 summer term.

onstrating how NASA science can address local environmental and policy concerns. DEVELOP expands the network of organizations and individuals contributing to, and benefiting from, the Applied Sciences Program by forming partnerships and demonstrating project results.

DEVELOP is unique in that projects are student led, with science advisors and mentors from NASA and partner organizations providing guidance and support. This allows students to gain valuable management and leadership experience, in addition to developing and applying research skills. Activities are conducted year round during ten-week terms in the spring, summer, and fall. Students are given the opportunity to present their research each term to a variety of audiences. Students have presented at various government organizations, live on television, and at national science and policy conferences such as the American Geophysical Union, American Meteorological Society, Southern Growth Policies Board, and Council of State Governments annual conferences and meetings. Conference posters, papers, and presentations are important for the program and students. These activities foster contact with potential partners, extend NASA science and technology to a wider audience, generate project ideas, and aide in new student recruitment. Equally important, conferences give students experience in presenting their work and interacting with the international science community and policy makers.

DEVELOP students not only receive relevant hands-on experience with NASA science data products, remote sensing, and GIS, but they also learn the importance of team work, business development, and invaluable presentation and leadership skills.

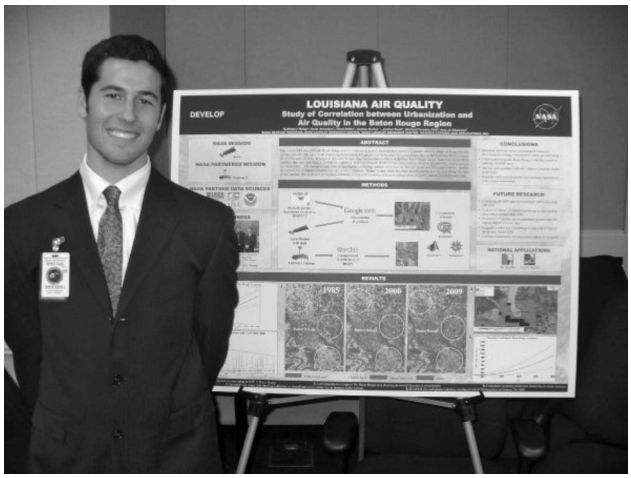
Admission to the program is based upon a competitive application process, with applications available online at the DEVELOP website (*develop.larc.nasa.gov/*). Eligible applicants are currently enrolled in high school through graduate school levels, and have at least a 3.0 grade point average. In particular, students with a strong interest in environmental, atmospheric, and the Earth sciences, computer science, Geographic Information Systems (GIS), and/or remote sensing are encouraged to submit an application. "Students not only receive relevant hands-on experience with NASA science data products, remote sensing, and GIS, but they also learn the importance of team work, business development, and invaluable presentation and leadership skills," says **Brandie Mitchell** [Stennis Space Center—*DEVELOP Center Lead*].

DEVELOP teams are located across the U.S., six in association with NASA centers—Ames Research Center, Goddard Space Flight Center, Jet Propulsion Laboratory, Langley Research Center, Marshall Space Flight Center, and Stennis Space Center—and three in regional offices—Mobile County Health Department (AL), Wise County

A DEVELOP student team works with science advisor Richard Brown at Stennis Space Center.

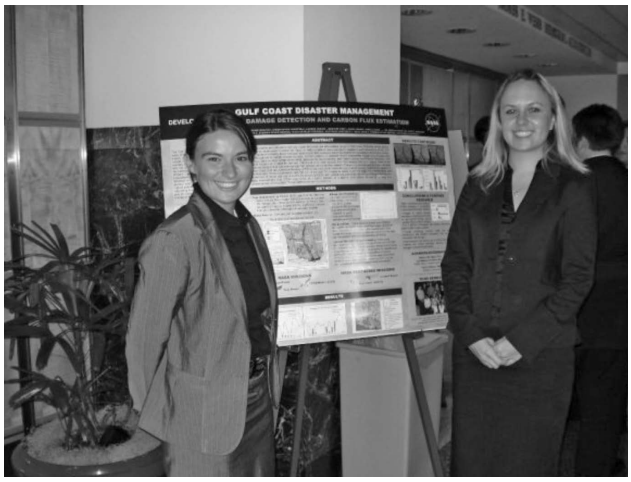
Clerk of Court's Office (VA), and the Great Lakes and St. Lawrence Cities Initiative (IL). Each team location varies in size and engages students of differing educational backgrounds. Summer terms typically host the largest number of participants, while the students participating in the spring and fall work flexible hours around their school schedules. The program actively recruits students from high schools and universities throughout the country, with student center leads and team members at each location leading recruiting efforts. Students are sought who demonstrate academic excellence, community service commitment, passion, and enthusiasm for applied science research. These qualities have contributed to the considerable growth and success of the program during the last decade.

The DEVELOP Program is mentoring today's students in preparation for careers as tomorrow's scientists and leaders. Challenged to think outside the box, take initiative, and employ innovative ideas, students who participate in the DEVELOP Program are better prepared to handle the challenges that face our society and future generations. DEVELOP students explore the frontiers of science and remote sensing to prepare the future American workforce, all while extending NASA Earth science research results for societal benefit. The DEVELOP National Program has provided over 1,800 internships, giving students the opportunity to perform applied science research and interact with industry, non-profit, and local government sectors. The DEVELOP National Program strives to be innovative and forward thinking, which is made possible by NASA's investment in students dedicated to learning.



Langley Research Center DEVELOP student Chad Robin presents his 2009 summer project at NASA Headquarters during the summer close out briefing.

More information is available about the Applied Sciences Program at *nasascience.nasa.gov/earth-science/applied-sciences,* and the DEVELOP National Program at *develop.larc.nasa.gov/.* Watch future issues of *The Earth Observer* for DEVELOP project and team highlights. ■



DEVELOP students Madeline Brozen and Lauren Childs present their research at NASA Headquarters following a live broadcast on NASA Television.

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Blog Log

Nicole Miklus, NASA Goddard Space Flight Center, nmiklus@sesda2.com

Blog introductions modified from text on featured blogs; images come from featured blogs.

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

What on Earth?

NASA does Earth Science? Have you heard this before? The *What on Earth?* blog began in Fall 2009 as a way to tell more about the inner workings of NASA Earth Science. Written by members of NASA's Earth Science News Team [**Michael Carlowicz**—Goddard Space Flight Center —*News Team Task Lead*], *What on Earth?* features information about the latest studies conducted by NASA Earth scientists. The blog also includes conference highlights, such as those from December's American Geophysical Union meeting in San Francisco, and updates on Earth science education activities. To check it out, go to: *blogs.nasa.gov/cm/blog/whatonearth.*

my big fat planet

Amber Jenkins, a science writer at NASA's Jet Propulsion Laboratory (JPL) hosts *my big fat planet* which features stories, science, and interesting tidbits from the world of climate change and climate research. Some stories are cross posted and adapted from the *What on Earth?* blog. *my big fat planet* also includes guest posts from scientists and other individuals involved in NASA climate change studies. One particularly interesting series of guest posts came from **Tony Freeman** [JPL—*Earth Science Manager*] and gave an inside look at his experience in Copenhagen, Denmark attending the United Nations Framework Convention on Climate Change's (UNFCCC) 15th Conference of the Parties (COP15) held in December 2009. To check out *my big fat planet,* please visit, *climate.nasa.gov/blogs/index.cfm?FuseAction=ListBlogs*. Freeman's series is available at: *climate.nasa.gov/blogs/index.cfm?FuseAction=ListBlogs&Date=200912.*

The Uphill Road to Measuring Snow

Hydrologist **Edward Kim** of NASA's Goddard Space Flight Center, along with colleagues **Michael Durand** [Byrd Polar Research Center], **Noah Molotch** [University of Colorado], and **Steve Margulis** [University of California, Los Angeles] embarked on a short field campaign in late February 2010 to measure snow from the Storm Peak Laboratory at Steamboat Springs, CO. The group's goal is to test and improve the accuracy of satellite-based snow measurements, since estimates of snow totals from weather modeling and satellite remote sensing can vary as much as 30% when compared with one another. One-sixth of the world's population relies on melted snow for freshwater, making estimates of snow critical for realistic predictions of a region's water supply. At the laboratory atop Storm Peak, the scientists will install their equipment to observe snow on the ground and dig pits in the snow to make measurements of snow depth and type. To read more, please visit: *earthobservatory.nasa.gov/blogs/fromthefield/category/the-uphill-road-to-measuring-snow/.* ■

Deep snow drifts around Storm Peak Lab in Steamboat Mountain, CO. **Image courtesy**: Argonne National Laboratory

36th ASTER Science Team Meeting Report

Nina Cole, NASA/Jet Propulsion Laboratory/California Institute of Technology, Nina.L.Cole@jpl.nasa.gov

The 36th Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Science Team Meeting was held December 8-11, 2009 in San Francisco, CA.

Opening Plenary Session

H. Tsu [Earth Remote Sensing Data and Analysis Center (ERSDAC)—*Japan ASTER Science Team Lead*] and **M. Abrams** [NASA/Jet Propulsion Laboratory (JPL)—*U.S. ASTER Science Team Lead*] welcomed approximately 43 U.S. and Japanese Science Team Members and other interested participants to the 36th ASTER Science Team Meeting.

M. Abrams reviewed the U.S. ASTER budget and presented science highlights. Terra received two additional years of funding (FY2010 and 2011) following the 2009 NASA Senior Review. The release of the Global Digital Elevation Model (GDEM) was highly visible in the media, with over 500 stories published and more than 3.5M tiles distributed to users.

S. Hook [JPL] provided an update on the Hyperspectral Infrared Imager (HyspIRI), a National Research Council (NRC) Decadal Survey *Tier II* mission containing a Visible Shortwave Infrared (VSWIR) imaging spectrometer and a multispectral Thermal Infrared (TIR) scanner. Subsequently, Hook introduced the Hyperspectral Thermal Emission Spectrometer (HyTES) instrument, which will be mounted on an airborne platform.

B. Eng [JPL] discussed the status of the Landsat Data Continuity Mission (LDCM). The eighth instrument in the Landsat series will provide continuing moderate resolution multispectral imagery of the Earth's surface with seven heritage reflective bands, two new reflective bands, and two thermal bands. LDCM expects to launch in December 2012, with a five-year design life.

N. Ohgi [Japan Resources Observation System and Space Utilization Organization (JAROS)] reported on ASTER instrument status. Ohgi reviewed lifetime management of the instrument and, aside from the SWIR detector temperature, reported nominal performance of all systems.

B. Macomber [Lockheed Martin/NASA Goddard Space Flight Center (GSFC)] informed the audience of a battery anomaly onboard the Terra spacecraft. Despite a failed battery cell, Terra can continue nominal operations with little modification to power management.

M. Hato [ERSDAC] reported on ERSDAC Ground Data System (GDS) status, providing updates on observation scheduling, processing, and distribution. Additionally, he presented ASTER GDEM distribution statistics.

D. Meyer [U.S. Geological Survey Land Processes Distributed Active Archive Center (USGS LPDAAC)] reported on the distribution status of ASTER products at the LPDAAC, including GDEM metrics. Meyer also discussed transitioning to an online archive, implementing new cloud cover metadata, and routing all billable ASTER product orders through Japan.

T. Narita [ERSDAC] discussed the replacement of servers and workstations in the Science Data Processing Segment (SDPS) and the Communications and System Management Segment (CSMS) with a new system that will be fully operational by 2011. Certain functions will be discontinued after the switch: archiving Level 0, 1B, and 3A01 data; producing Level 2 data products; and processing Expedited Data Sets (EDS). Narita confirmed the modification of ASTER GDS cloud metadata in the search catalog.

M. Fujita [ERSDAC] presented the Scientific Scheduling Support Group (SSSG) and Operations Mission Planning (OMP) report. He reviewed the status of Global Mapping (GM), nighttime TIR GM (TGM), GDEM, and the Underserved Area Science Team Acquisition Request (UA STAR). Furthermore, Fujita reported that an update to the Acquisition Window (AW) scheduling parameter was successful.

K. Iwao [Group on Earth Observations (GEO) Secretariat] gave a detailed presentation on the Global Earth Observation System of Systems (GEOSS). GEOSS facilitates the exchange of data through the linkage of coordinated and sustained EOS platforms with free or low-cost open access for interested research and education users. A data sharing scheme is under development for the ASTER GDEM.

Geology Working Group

A. Mushkin [Geological Survey of Israel (GSI)] gave a talk on employing ASTER stereoscopic imaging to determine surface roughness and date alluvial surfaces in arid environments.

J. Kargel [University of Arizona] discussed the use of ASTER in comparing and contrasting Himalayan and Alaskan glacier dynamics. Time series differencing and

various classification schemes were used to analyze glaciers in each study area.

M. Pritchard [Cornell University] presented his research on measuring glacier velocities using ASTER and Synthetic Aperture Radar data. Pritchard applied pixel tracking and DEM differencing to his areas of study, Patagonia and Juneau, Alaska, which both contribute to current sea level rise.

B. Sneed [University of Maine] reported on glaciology work done with colleagues at the Climate Change Institute. Studies include mapping the velocity, elevation, and terminus changes of Greenland outlet glaciers using ASTER and other data sources, and deriving depths of melt ponds and surface water using ASTER Visible and Near Infrared (VNIR) Bands 1 and 3.

J. Mars [USGS] discussed regional alteration mapping of porphyry copper deposits using ASTER data. Potential deposits are ranked by physical characteristics derived from ASTER alteration maps.

M. Ramsey [University of Pittsburgh] updated the audience on volcano monitoring using the ASTER rapid response program designed for urgent acquisitions and the new Forward-Looking Infrared (FLIR) camera received in August 2009. Ramsey discussed the filter specifications and also showed some preliminary field test results.

M. Urai [Geological Survey of Japan (GSJ), National Institute of Advanced Industrial Science and Technology (AIST)] presented his work on the 2009 Sarychev Peak eruption. Urai demonstrated how to estimate the volume of discharged deposits by combining the stereoscopic capabilities of ASTER and the Panchromatic Remote-Sensing Instrument for Stereo Mapping (PRISM) with ASTER's broad spectral coverage.

M. Pritchard introduced his Andean volcano project, which combines thermal [ASTER and Moderate Resolution Imaging Spectroradiometer (MODIS)], radar, and field seismic data to characterize background activity at 2500 volcanoes in the region.

D. Pieri [JPL] discussed the current status of the JPL ASTER Volcano Archive (AVA), featuring public access to full resolution *jpgw* files. Pieri also discussed the UAV-borne *in-situ* Compact Mass Spectrometer (ICAMS) (used for calibration and validation of ash/gas transport and retrieval models), a new low thermal anomaly algorithm, and volcano DEM challenges.

Operations and Mission Planning Working Group

A. Miura [ERSDAC] opened the session with a presentation on mission-related topics. Working time of mission operations was reduced from 24-hour shifts to 12-hour shifts with no adverse results. The AW scheduling parameter was modified to correctly reflect seasonal input variables. Pointing control parameters were updated, improving scheduler efficiency and increasing daily scene acquisitions.

M. Fujita provided an update on ASTER observation status. GM3 successfully achieved 83% coverage worldwide. GM4 was submitted October 1, 2009 and will continue until April 1, 2015. TGM3 and TGM4 are acquiring approximately 70 scenes per day, with future requirements determined by the Temperature-Emissivity Separation (TES) Working Group (WG). The UA STAR and Gap-Filler STAR are effectively collecting data. The success rate of Urgent STARs was reviewed, as well as the status of the Global Land Ice Measurements from Space (GLIMS) STAR. Lastly, Fujita presented a graph summarizing the distribution of observation resources.

L. Maldonado [JPL] confirmed that no relevant changes had occurred to the Data Acquisition Request (DAR) User Survey results since the last team meeting.

D. Meyer updated attendees regarding the modification of cloud cover metadata at the LPDAAC. The new values will be implemented in March 2010 to mirror the revised values used at ERSDAC.

A. Hall [Earth Science Data and Information System (ESDIS) DAAC] presented preliminary plans for long-term ASTER data retention. The science team will decide in the near future what data to archive, which services to offer, and the necessary documentation needed.

The session concluded with a discussion of EDS changes. EDS processing will halt at GDS in 2011. The LPDAAC will process all EDS and post the data on an *ftp* site for both Japan and U.S. requestors.

Level 1/DEM Working Group

H. Fujisada [Sensor Information Laboratory Corporation (SILC)] reported no changes to the Level 1 algorithm, and that both inter- and intra-telescope registration are satisfactory. The geolocation accuracy of nighttime TIR data in the east-west direction is off between 100–400 m, depending on look angle. The TES WG will investigate this issue. Next, Fujisada presented the new GDEM algorithm developed by SILC, with a 5 x 5 kernel size and enhanced water body detection. GDEM *Version 2* will incorporate the new algorithm and additional source data, with release planned for June 2011.

T. Tachikawa [ERSDAC] presented validation results for the new GDEM algorithm, concluding that the updated version is significantly improved.

G. Hulley [JPL/California Institute of Technology (Caltech)] described the North American ASTER Land Surface Emissivity Database (NAALSED) Cloud Mask Algorithm. His hybrid approach enables accurate cloud detection.

R. Crippen [JPL] analyzed ASTER GDEMs and Shuttle Radar Topography Mission (SRTM) DEMs, discovering that DEM data is most reliable when the ASTER scene stacking number is three or greater, with or without SRTM. A scene stack of 1–2 also produces acceptable results when assured by SRTM.

Temperature-Emissivity Separation Working Group

G. Hulley reported on the status of NAALSED, a mean-seasonal emissivity mosaic of North America. The *Version 3.0* release, with increased temporal coverage, an improved cloud mask, and enhanced atmospheric correction, produces superior results.

H. Tonooka [Ibaraki University] presented an update on the East Asia Land Surface Temperature and Land Surface Emissivity mosaic.

S. Kato [National Institute for Environmental Studies (NIES)] discussed using ASTER data for temporal and spatial analyses of surface temperatures in shaded areas. Kato found similar surface temperatures in shaded areas regardless of surface material.

S. Rose [University of Pittsburgh] reviewed a possible method for improving the accuracy of compositional, textural, and heat flux measurements over volcanic surfaces, and assessed ASTER data using a deconvolution algorithm.

R. Lee [University of Pittsburgh] described TIR spectroscopy analysis of quartzofeldspathic glasses using a high temperature micro-furnace. Glasses are prevalent in hazardous locations, such as active volcanoes, yet seldom studied in the TIR.

A. Gillespie [University of Washington] presented an analysis of spatial-temporal variability in the ASTER surface emissivity product (*AST05*). The primary cause of the variability appears to be an incomplete atmospheric correction, and accuracy of *AST05* may be improved by using MODIS profiles.

A. Mushkin discussed the use of roughness data derived from ASTER stereo images to correct the reduction in emissivity spectral contrast caused by cavity radiation.

S. Hook provided an update on in-flight validation of ASTER land surface temperature and emissivity products (*AST08* and *AST05*) using the Lake Tahoe and Salton Sea automated validation sites. Results indicate a problem over high emissivity targets due to a recent change in the ASTER Temperature-Emissivity algorithm. Consequently, using a split window approach over water targets is recommended.

H. Tonooka introduced Lake Senba, a new site for validation of water temperature retrievals and for monitoring ASTER TIR radiometric calibration. Additionally, Toonoka presented a cloud assessment update. The revised cloud assessment uses MODIS cloud mask (*MOD35*) products. The new cloud cover values are available through GDS, and will be available at the LP-DAAC by March 2010.

M. Fujita summarized current TGM STAR status. TGM3 (Southern Hemisphere) and TGM4 (Northern Hemisphere) do not overlap temporally. There is interest in the user community in gathering summer-winter pairs to study emissivity values. The SSSG will investigate the possibility of additional nighttime collects.

Radiometric Calibration/Atmospheric Correction Working Group

B. Eng reviewed the U.S. ASTER Level 2 software status.

M. Moriyama [Nagasaki University] presented a detailed analysis of the terrain and atmospheric effect correction algorithm implemented on the AIST/GEO Grid server.

F. Sakuma [AIST] reviewed the ASTER VNIR, SWIR, and TIR instrument status. No changes were made to the VNIR Radiometric Calibration Coefficients (RCC) since the last team meeting. Since May 2008, SWIR data has been saturated, but the detector temperature and telemetry data remain stable. TIR analyses are based on fitting function *Version 3.10*, implemented September 27, 2009. TIR long-term calibration trends continue to be monitored.

S. Tsuchida [AIST], **K. Arai** [Saga University], **T. Matsunaga** [NIES], and **S. Biggar** [University of Arizona] reported on their respective field campaigns. **S. Hook**, **H. Tonooka,** and **S. Kato** presented TIR field campaign results.

A. Iwasaki [University of Tokyo] discussed correcting stray light in ASTER images with MODIS images.

T. Tachikawa provided a Science Web update. The website—*www.science.aster.ersdac.or.jp*—provides ASTER project information, science highlights, and other relevant news in both English and Japanese.

A. Gillespie reviewed his presentation given in the TES WG, attributing errors in *AST05* to incomplete atmospheric correction rather than calibration issues.

G. Hulley illustrated how the accuracy of the ASTER surface radiance product (*AST09T*) may be improved using MODTRAN *Version 5.0*.

H. Tonooka provided a TIR recalibration update. Recalibration for ASTER data acquired before October 26, 2009 is available through: *tonolab.cis.ibaraki.ac.jp/ASTER/RECAL.*

Ecosystem/Oceanography Working Group

A. Mushkin discussed vegetation effects on sub-pixel roughness measurements from ASTER stereo pairs. ASTER 3B/3N corresponds to age for bare surfaces, percent vegetation for scrublands, canopy roughness for fully vegetated areas, and structural stage/stand age in forests.

K. Iwao explained GeoGRID activities associated with the GEO 2010 Baseline Initiative. Global dataset development includes global road and human settlement mapping.

L. Prashad [Arizona State University] provided an update on *JEarth*, an open source Java-based GIS and remote sensing analysis and visualization tool built from the Java Mission-planning and Analysis for Remote Sensing (JMars) application.

M. Ramsey reported on research conducted with **S. Scheidt** [University of Pittsburgh] focusing on Saharan dust emission events. Data collected with a field-based FLIR instrument was analyzed along with orbital measurements from several remote sensing instruments. ASTER [like the Spinning Enhanced Visible and Infrared Imager (SEVIRI) and MODIS] can be used as a dust detection tool.

T. Gubbels [Science Systems and Applications, Inc.] offered an update on **J. Masek's** [GSFC] Landsat Ecosystem Distributive Adaptive Processing System (LEDAPS) that provides forest disturbance mapping and other large area, reflectance-based Landsat analyses. Activities are currently underway to integrate ASTER imagery.

STAR Committee

The STAR committee agreed to run TGM3 and TGM4 simultaneously, allowing the number of nighttime TIR acquisitions to increase to approximately 75 per day. The committee recommended that the TES WG submit a DAR to evaluate the need for a multi-season TGM5. A support STAR will supplement the UA STAR to increase coverage. Gain settings will be changed to Low Low Normal (LLN) for ice-covered areas. The GLIMS STAR will be monitored for three months to determine the need for a support STAR.

Closing Plenary Session

The meeting concluded with summaries from each working group chairperson. The 37th ASTER Science Team Meeting will be held June 8–11, 2010 in Tokyo, Japan. ■

In Memoriam

A giant in the field of Earth Science, Joanne Simpson passed away March 4 at 2:45 a.m. Simpson specialized in tropical meteorology, and in 1949, she became the first woman to earn a Ph.D. in meteorology. She went on to serve on the faculty of the University of Chicago, the University of California at Los Angeles, and the University of Virginia. She also served for a period as the head of the National Oceanic and Atmospheric Administration's (NOAA) Experimental Meteorology Laboratory in Miami, FL. Simpson joined NASA in 1979 as the Chief of NASA's Laboratory for Atmosphere's Severe Storms Branch, and became the inspiration and founding Project Scientist for the Tropical Rainfall Measuring Mission (TRMM). Until her recent retirement, Simpson was Chief Scientist for Meteorology in the Earth Sciences Division. Simpson worked with a science group on cloud and mesoscale modeling and studied hurricanes. She authored or co-authored over 190 scientific articles and won many awards and honors for her research achievements, including the Carl-Gustaf Rossby Award (the highest honor bestowed by the American Meteorological Society). She was a member of the National Academy of Engineering, and served as President of the American Meteorological Society. The world has indeed lost a great scientist and a true inspiration to many generations of researchers. For more information on her career, see: *earthobservatory.nasa.gov/Features/Simpson/*.

Precipitation Measurement Missions (PMM) Science Team Meeting Summary

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Introduction

The NASA Precipitation Measurement Missions (PMM) Science Team held its annual meeting in Salt Lake City, Utah, on October 26-29, 2009. The team currently has 69 Principal Investigators (PIs) from the U.S. and the international science community carrying out a wide range of scientific activities in support of the Tropical Rainfall Measuring Mission (TRMM) and the Global Precipitation Measurement (GPM) Mission. The TRMM satellite jointly developed by NASA and the Japan Aerospace and Exploration Agency (JAXA) was launched in 1997 and is now in its 12th year of operations. The GPM Core Observatory is scheduled for a July 2013 launch. This year's team meeting had 160 registrants. In addition to the general session, the PMM algorithm developers held a two-day splinter meeting to discuss joint GPM sensor algorithms with JAXA, and the NASA–JAXA Joint PMM Science Team (JPST), which oversees PMM science activities in the U.S. and Japan, met on October 31 to confer on programmatic matters.

The general sessions of the meeting were organized around 60 oral and 75 poster presentations. The meeting opened with programmatic updates and overviews of international activities, followed by sessions on remote sensing algorithms, ground validation, data processing, and science applications. This report provides brief summaries of sample presentations. The full meeting agenda and copies of oral presentations are available from the PMM science website at: *pmm.gsfc.nasa.gov*.

Programmatic Updates

In the opening session, **Ramesh Kakar** [NASA Headquarters—*TRMM/GPM Program Scientist*] welcomed the participants and presented an overview of the NASA precipitation science program, including the upcoming transition from the current PMM science team ending December 2009 to a new science team now being selected through NASA Research Opportunities in Space and Earth Sciences (ROSES).

Arthur Hou [NASA Goddard Space Flight Center (GSFC)—*GPM Project Scientist*] introduced seven new international team members from Argentina, Australia, Brazil, Canada, Italy, and Israel, all of whom had become part of the team since the last meeting. These new members join existing PIs from Finland, France, Germany, and the U.K. In reviewing the PMM science highlights from the past year, Hou reported on progress made in international collaboration on radiometer inter-calibration and partnerships with the Instituto Nacional de Pesquisas Espaciais (INPE) (Brazil's National Institute for Space Research), the Finnish Meteorological Institute (FMI), the Department of Energy Atmospheric System Research (DOE/ASR) Program, NOAA/Hydrometeorology Testbed, and the CloudSat mission, in conducting a series of ground validation field campaigns to support GPM pre-launch algorithm development.

Scott Braun [GSFC—*TRMM Project Scientist*] reported that TRMM had successfully completed the 2009 NASA senior review and that the TRMM satellite may have enough fuel to collect data until 2014 or beyond. Braun also reviewed the status of TRMM *Version 7* algorithm implementation, with release of new products beginning in late Spring 2010.

Art Azarbazin [GSFC—*GPM Project Manager*] gave an update on the NASA GPM instrument and engineering development status, noting that the GPM Mission Confirmation Review is scheduled for mid-November 2009, followed by the Critical Design Review in December 2009[1].

Programmatic status presentations from the Japanese included **Riko Oki** [JAXA Earth Observation Research Center] and **Kenichi Okamoto** [Tottori University], who reported on a recent hardware anomaly of the TRMM Precipitation Radar (PR) and its subsequent correction. The PR is undergoing recalibration and processing of PR data (*Version 6*) is expected to resume operations in December 2009. The next three presentations were from **Tetsuo Nakazawa** [Japan Meteorological Agency], **Kenji Nakamura** [Nagoya University], and **Toshio Iguchi** [National Institute of Information and Communications Technology] who gave updates on TRMM science, GPM research, and Dual-frequency Precipitation Radar DPR development in Japan respectively.

International Partner Activities

International science team members and invitees gave 12 oral presentations during the meeting. Of these, 10 were related to ground validation, including project descriptions and status reports from **Liuz Machado** [Brazil], **Jussi Leinonen** [Finland], **Alessandro Battaglia**

[1] **Update:** GPM has since successfully completed both of these reviews.

[Germany], **Francisco Tapiador** [Spain], **Luca Baldini** [Italy], **Chris Kidd** [U.K.], **Efrat Morin/Eyal Amitai** [Israel], **Palio Salio** [Argentina], and **Sungwook Hong** [South Korea]. In an overview of European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT's) Hydrology Satellite Application Facility (H-SAF), **Bozena Lapeta** [Institute of Meteorology and Water Management of Poland] showed how Europeans are using operational hydrological models and stream flow measurements to assess the practical benefits of satellite precipitation products. Representing the Indian–French Megha-Tropiques mission scheduled to be launched in 2010 as a potential GPM partner, **Remy Roca** [France], **Nicolas Viltard** [France], and **Marielle Grosset** [France] described the mission status, algorithm development status, and calibration/validation program, respectively.

PMM Science and Applications

A number of presentations described ways that TRMM or ground-based precipitation estimates are being integrated into applications such as hydrological modeling, flood and landside prediction, and climate change studies. **Emmanouil Anagnostou** [University of Connecticut] discussed error propagation through hydrological modeling in complex terrain, with key sources of errors related to total rain volume and the horizontal and temporal resolution of satellite precipitation estimates. **Eric Wood** [Princeton University] showed that satellite precipitation products can provide the basis for quantitative prediction of large floods and the monitoring of drought and available fresh water with usable skill, especially in data sparse regions of the world.

Several presentations emphasized issues related to interannual and longer-term variations in climate and the impacts of changes in land-use patterns. **William Lau** [GSFC] described potential decade-scale climate changes detected by satellite estimates of the frequency and intensity of precipitation. **Franklin Robertson** [NASA Marshall Space Flight Center (MSFC)] suggested that most of the interannual variability seen in the past 12 years of TRMM observations is due to El Niño rather than a linear trend. **Chris Funk** [University of California, Santa Barbara] described how rainfall, water vapor transport, and wind estimates can be used to monitor African drought. In the area of land-use, **Rafael Bras** [University of California, Irvine] discussed the potential enhanced occurrence of heavy rainfall in a narrow border region surrounding de-forested areas of the Amazon rainforest.

In contrast to the vast ocean coverage in the deep tropics, the middle and high latitudes have larger landmasses and complex terrains, making it more difficult to estimate surface precipitation accurately. **Edward Zipser** [University of Utah] described how in southern Brazil, 70–80% of the annual total precipitation in the La Plata basin comes from heavy rainfall inside Mesoscale Convective Systems that form on mountains to the west. In contrast, **Robert Houze** [University of Washington] described how the heavy rainfall that dominates northern India's monsoon is not associated with large baroclinic systems but comes predominately from convective cells when boundary layer flow is funneled toward high elevations with dry, continental flow above. **Steve Rutledge** [Colorado State University] reported on tropical rainfall characteristics and the ensuing implications for TRMM PR rainfall estimation. **Daniel Cecil** [University of Alabama] used severe weather reports to research satellite-based climatologies of hailstorms and reported on the challenges they present for precipitation retrievals.

GPM Algorithm Development

In preparation for the GPM mission, a high priority PMM science activity is the development of remote-sensing algorithms utilizing new sensor capabilities offered by the GPM Core Observatory. The 65°-inclination orbit of GPM core satellite will extend coverage beyond the TRMM domain into the middle and high latitudes, where light rain and falling snow account for significant fractions of precipitation occurrences. **Chris Kidd** [University of Birmingham] estimated that approximately 85% of precipitation accumulation over Northern Europe falls at rates under 1 mm/hr. **Wesley Berg** [Colorado State University (CSU)] showed that the ability of TRMM and CloudSat to detect the full probability distribution function of rainfall is dependent on the total precipitable water (TPW) in the environment, with TRMM underestimating light rainfall in low TPW regimes.

Chris Kummerow [CSU], **Robert Meneghini** [GSFC], and **Bill Olson** [University of Maryland Baltimore County/GSFC], gave important updates on the radar-enhanced radiometer algorithm, the radar algorithm, and the combined *radar+radiometer* algorithm, respectively. These talks described the theoretical frameworks for each algorithm and the need for consistent physical parameter assumptions, among other topics. **Grant Petty** [University of Wisconsin] suggested a new method for microwave radiometer retrievals that use covariance matrices to separate a rain signal and noise (from the land surface). **George Huffman** [Science Systems and Applications Inc./GSFC] described several challenges and proposed solutions for making multi-satellite composite precipitation estimates in real-time during the GPM era.

The next two presentations reviewed two different multi-satellite retrieval approaches. **Bob Joyce** [National Atmospheric and Oceanic Administration (NOAA)/Wyle Information Systems] presented on the Climate Prediction Center Morphing Technique (CMORPH). **Kasumasa Aonashi** [Japan Meteorological Agency] summarized the Global Satellite Mapping Project (GSMAP).

Several presentations focused on the detection and potential estimation of falling snow, including **Gail Skofronick-Jackson** [GSFC], **David Staelin** [Massachusetts Institute of Technology], and **Gousheng Liu** [Florida State University]. These techniques use information from multiple sources including the Advanced Microwave Scanning Radiometer for the Earth Observing System (AMSR-E) and the Advanced Microwave Sounding Unit (AMSU) on Aqua, the Cloud Profiling Radar on CloudSat, and special field observations such as the Canadian CloudSat/Cloud–Aerosol Lidar and Infrared Pathfinder Satellite Observatinos (CALIPSO) Validation Project (C3VP) and the Japanese Wakasa Bay experiment.

Modeling Activities

Models are either involved in algorithm development or make use of satellite observations via data assimilation. A theme throughout the modeling presentations was error analysis. **Mircea Grecu** [University of Maryland/Goddard] demonstrated the use of high-resolution simulations to derive synthetic observations to test GPM algorithm strategies and assess sensitivity of algorithm outputs to *a priori* assumptions. **Sara Zhang** [Science Applications International Corporation (SAIC)/GSFC] showed that model assimilation of precipitation improves when the model is used as a "weak constraint" rather than assuming the model is perfect. In addition, Zhang demonstrated the use of ensemble data assimilation techniques for dynamic downscaling of precipitation. **Tiruvalum Krishnamurti** [Florida State University] showed that satellite and ground-based rainfall data can be used to improve seasonal forecasts of precipitation through construction of a multi-model super-ensemble approach. **Aiguo Dai** [National Center for Atmospheric Research] and **Anthony Del Genio** [NASA Goddard Institute for Space Studies] reviewed some of the issues with convective parameterizations, such as models triggering rainfall too soon in the day and not permitting the rain to continue falling long enough. They presented new approaches utilizing cloud resolving models to define better key assumptions regarding convective initiation and entrainment.

Ground Validation

Walter Petersen [MSFC] presented the GPM ground validation (GV) plans. The pre-launch GV and aircraft activities, which support algorithm development, include C3VP (Winter 2006–2007), a Brazilian campaign named CHUVA (March 2010), the Light Precipitation Validation Experiment (LPVEx) in Finland (Fall 2010), the Mid-Latitude Continental Clouds and Convection Experiment (MC3E) planned for Spring 2011, and a cold-season experiment in Canada early in 2012. Following the launch of the GPM core satellite, GPM will conduct its first post-launch experiment, geared to the evaluation of GPM satellite products, in NOAA's Hydrometeorological Testbed in the southeastern U. S. in late Summer 2013. There is a large international contribution to these field campaigns and related ground validation efforts. Significant tools to be used in the field campaigns will be the recently upgraded NASA dual-polarimetric radar (NPOL), which has an upgraded transmitter/receiver and a new antenna, and a new GPM Ka/Ku-band dual-frequency, dual polarization Doppler radar.

Data Processing

Erich Stocker [GSFC] presented the schedule for algorithm developers to deliver the at-launch GPM algorithms to the Precipitation Processing System. On-time deliveries of intermediate code ensure the availability of precipitation products upon the launch of GPM Core Observatory. There appeared to be consensus that single-orbit algorithms should use common physical assumptions regardless of whether they are working on passive microwave observations or satellite radar observations. Scheduled deliveries are to begin in 2010 for information related to these algorithms with at-launch algorithm deliveries in the fall of 2012.

Working Group Reports

The PMM Science Team has a number of working groups tackling specific issues in precipitation estimation and applications. Many working groups held evening sessions during the week and gave status reports in a plenary session on the final day. Reporting for the drop size distribution (DSD) working group, Chris Kummerow updated activities on developing a framework for validating DSD information and ensuring that DSD parameters derived from ground- and space-based sensors are consistent. **Christa Peters-Lidard** [GSFC] and **Ralph Ferraro** [NOAA] made a joint report on the land-surface working group, whose goals are to assess the current state of land surface emissivity models/retrievals and to use land surface information to improve precipitation retrievals over land. They showed recent progress using C3VP data and strongly recommended that pre-launch GPM field campaigns include measurements of ground emissivity, temperature, and snow depth. **Tom Wilheit** [Texas A&M University] reported on the inter-satellite calibration working group, which is developing a method for making the microwave brightness temperatures as consistent as possible between the various satellite instruments that are used as inputs to the GPM constellation precipitation data products. **Wei-Kuo Tao** [GSFC] reported on the results of several recent workshops convened by the latent heating working group to evaluate and improve satellite latent heating estimates.

continued on page 28

meeting/workshop summaries

Land and Atmosphere Near Real-Time Capability for EOS (LANCE) Workshop Summary

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NASA's Earth Observing System Data and Information System (EOSDIS) provides a wealth of data and products supporting scientific research of the atmosphere, oceans, and land. Data from the Earth Observing System (EOS) instruments onboard the Terra, Aqua, and Aura satellites make global measurements daily. The measurements are processed into higher-level "standard" products within 8–40 hours of observation and then made available to users, primarily Earth science researchers. However, application users, operational agencies, and even researchers desire EOS products to support research and applications, such as numerical weather and climate prediction; forecasting and monitoring natural hazards, ecological/invasive species, agriculture, and air quality; providing help with disaster relief; and homeland security. These users often need data much sooner than routine science processing allows, usually within three hours, and are willing to trade science product quality for timely access. In response to this need, NASA has developed a new Land Atmosphere Near Real-time Capability for EOS (LANCE).

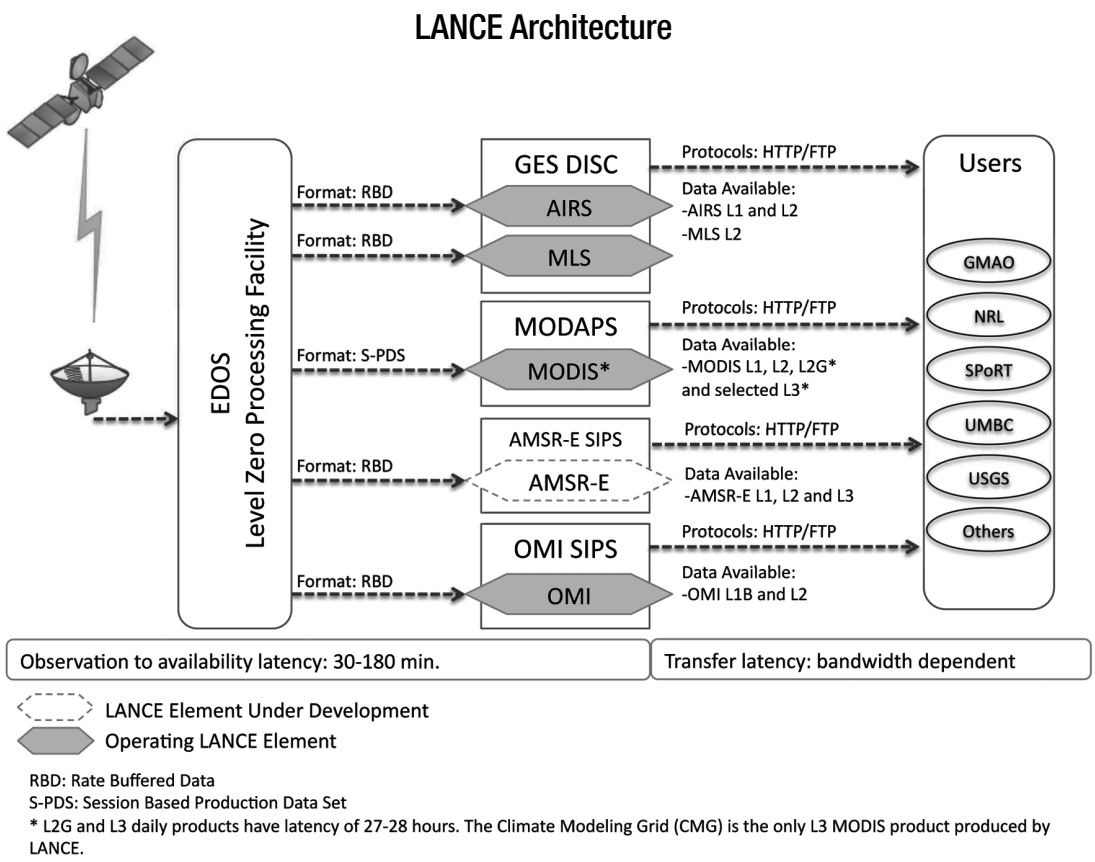
Origins of LANCE

The EOSDIS was not originally designed to provide data with sufficient latency to satisfy the requirements for near real-time users. In 2002, a joint initiative between NASA and the National Oceanic and Atmospheric Administration (NOAA) was undertaken to provide data from EOS instruments in *near real time*—within three hours of satellite observation—to NOAA's operational users. Following the large wildfires in Montana in 2001, the U.S. Forest Service (USFS) asked for routine and timely delivery of Moderate-Resolution Imaging Spectroradiometer (MODIS) fire data. In response to this request and with partial support from the USFS, the MODIS Land Rapid Response system was developed. This system, which tapped into the Level 1 data feed from the NASA–NOAA system, provided easy-to-view imagery highlighting active fires. This system was subsequently developed to provide imagery that would enable flood, agriculture, and air quality monitoring. As the EOS processing and products have matured, there has been growing interest from other NASA data users to access data in near real time. As the NASA–NOAA system aged and the demand for near real-time data increased and broadened across Earth science application areas, the NASA Earth Science Division (ESD) decided to implement a near real-time capability within the EOSDIS.

Building on the existing EOSDIS capabilities, NASA's Earth Science Division sponsored the development of LANCE (*lance.nasa.gov*). LANCE consists of special processing elements, co-located with selected EOSDIS data centers and processing facilities. These elements process expedited data from the EOS Data and Operations System (EDOS) using optimized science algorithms to provide data in near real time. The LANCE system development is jointly sponsored by the Flight, Research and Analysis, and Applied Sciences Programs within NASA's ESD.

The LANCE architecture leverages existing near real-time satellite data processing systems that are managed by the Earth Science Data and Information System (ESDIS) Project at Goddard Space Flight Center (GSFC). Near real-time data are currently available for MODIS, the Ozone Monitoring Instrument (OMI), the Atmospheric Infrared Sounder (AIRS), and the Microwave Limb Sounder (MLS) instruments. Implementation of the Advanced Microwave Scanning Radiometer – Earth Observing System (AMSR-E) near real-time system is under development. The diagram on page 19 shows the four LANCE elements at the GSFC Earth Sciences Data and Information Services Center (GES DISC), the OMI Science Investigator-led Processing System (SIPS), AMSR-E SIPS, and the MODIS Adaptive Processing System (MODAPS). These elements are supplied with rate-buffered data and/or session-based production datasets from the EDOS as soon as they are downlinked from satellites or transmitted from ground stations, generally within 30 minutes to two hours after observation. Each element then processes raw data into higher-level products before they are made available to users. A key NASA tenet, that of product validation and documentation by science instrument team members is being applied here as well as to the standard products, to ensure that user feedback and evolving user needs will translate into appropriate product modifications and new products.

Building on a significant investment by NASA in developing algorithms and products, LANCE provides



a range of products that have demonstrated utility for applications requiring near real-time data. From lower level data products such as calibrated geolocated radiances to higher-level products such as sea ice extent, snow cover, and cloud cover, users have integrated LANCE data into forecast models and decision support systems. The table below shows the current near real-time product categories by instrument and average latency. All LANCE elements are currently operating and data from AMSR-E is expected to be available to users by the summer of 2010.

The Workshop

To improve the understanding of the LANCE system and obtain feedback from users to improve LANCE services, the ESDIS Project sponsored a two-day workshop focusing on existing near real-time applications of MODIS, OMI, AIRS, MLS, and AMSR-E by land surface and atmosphere/aerosols communities. The LANCE workshop was held at the University of Maryland University College Conference Center in College Park, MD on December 8–9, 2009. Over 30 attendees representing NASA, the U.S. Geological Survey (USGS), the U.S. Naval Research Laboratory (NRL), the U.S. Air Force Weather Agency, the U.S. Department of Agriculture (USDA), and academia were present. **Chris Justice** [University of Maryland, Department of Geography] co-chaired the meeting with program executives from NASA Headquarters.

LANCE Product Categories			
Instrument	**Product Categories**	**Average Latency**	**Status**
AIRS	Ephemeris/Attitude, Radiances, Temperature and Moisture Profiles, Clouds, and Trace Gases	75 – 140 minutes	Operating
AMSR-E	L1A Raw Data, Soil Moisture, Snow Water Equivalent, Temperature	Under Development	Under Development
MLS	Ephemeris/Attitude Data, Ozone, Temperature	75 – 140 minutes	Operating
MODIS	Radiances, Cloud/Aerosols, Water Vapor, Fire, Snow Cover, Sea Ice, Land Surface Reflectance, Ephemeris/Attitude	90 – 145 minutes	Operating
OMI	Ozone, Clouds, Aerosols, Trace Gases	100 – 165 minutes	Operating

The primary objectives of the workshop were to:

- identify gaps in functionality and areas for improvement in current capabilities and requirements;
- determine what future capabilities and requirements should be investigated to make LANCE a more robust and usable system;
- provide a forum for current users to present how near real-time data are used within specific application areas, including impacts of data latency, product availability, and data formats;
- conduct an open discussion on user interfaces for accessing data and mechanisms for capturing and acting on user feedback; and
- understand users' decision support system needs for near real-time data.

The LANCE workshop provided an opportunity for the users and producers of near real-time products to share their experiences and plan for the future. The first day of the workshop consisted of a programmatic overview of the LANCE architecture and implementation status of each current subsystem, followed by presentations from representative LANCE users. Closing the day, breakout sessions covered specific application needs by land surface and atmosphere/aerosol users. The second day consisted of reports from the breakout sessions and an open discussion on crosscutting issues, pitfalls, and next steps.

Karen Michael [NASA ESDIS] led the LANCE system presentations, and presented an overview of the LANCE architecture, core requirements, and current capabilities. Michael particularly focused on how differences in downlinking capabilities from the Terra, Aqua, and Aura spacecraft are the primary drivers of product latency. **Mike Teague** [MODAPS], **Bruce Vollmer** [GES DISC], and **Curt Tilmes** [OMI SIPS] presented details on data flows, near real-time product vs. science product quality, data access, and the current development status and implementation schedule for the MODIS, AIRS/MLS, and OMI near real-time systems, respectively. Teague also covered the forthcoming availability of AMSR-E near real-time data.

For the user presentations, **Jeff Hawkins** [NRL Monterey] presented how data from MODIS, AMSR-E, and AIRS are used for dust, cloud, and snow detection in the Middle East. Latency of data products is of prime importance because this application is used to warn armed forces of impending dust storms. **Jim Verdin** [USGS Sioux Falls] presented the Famine Early Warning System (FEWS NET), a decision support system sponsored by the United States Agency for International Development (USAID) Office of Food for Peace. The system uses near real-time MODIS data to provide early warning and vulnerability information on emerging agricultural drought and evolving food security issues globally. **Gi-Kong Kim** [NASA GSFC] of the Global Modeling and Assimilation Office (GMAO) described how data are used in analysis, observing system modeling and design, climate and weather prediction, and basic research. **Gary Jedlovec** of NASA Short-term Prediction Research and Transition Center (SPoRT) at Marshall Space Flight Center closed the user presentation session by presenting how the data are used to improve the accuracy of short-term (0–24 hr) weather prediction at the regional and local scale. All of the user presentations stressed the value of timely data for applications.

The workshop participants made several recommendations that will be studied by the LANCE team in the coming months.

- LANCE must have a strong relationship with the instrument science community to ensure the quality and stewardship of near real-time products.
- LANCE should develop mechanisms that allow new products and services to be added to existing capabilities. LANCE needs a clear governance model for handling new requirements in general, and for adding new products, in particular.
- LANCE should provide documentation and examples of differences between near real-time products and science products.
- NASA Headquarters should charter a LANCE User Working Group to provide guidance regarding the scope of LANCE and future system evolution, and also for vetting proposed new requirements or changes to the system, based on the soon-to-be established governance model.
- LANCE needs well-defined and documented processes for transitioning algorithm changes into operations. Many applications users are focused on looking for environmental and physical change, and, in many instances, consistency of the input products is more important than using the latest algorithm. LANCE should consult with the user community and provide documentation well in advance on proposed algorithm changes. LANCE should also provide pre-production examples of revised products to the user community, prior to their inclusion in the system so that users can understand the differences, assess the compatibility, and make any necessary adjustments to their decision support software, prior to the revised products being put into production.
- Reliable system performance is extremely critical to near real-time data users. Each of the LANCE elements should implement redundancy to eliminate single points of failure, and increase the reliability of their system components.

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NASA Atmospheric Sounding Science Team Meeting Summary

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The NASA Atmospheric Sounding Science Team meeting was held on October 13-17 in Greenbelt, MD. With over 65 presentations and over 100 participants, the NASA Sounding Science Team meeting was one of the largest to date. The scientific community has discovered many uses for hyperspectral infrared data from weather forecast prediction and studying atmospheric composition to describing processes affecting climate. As the project matures, we see a wider variety of applications of data from Atmospheric Infrared Sounder (AIRS), and a growing interest in the capabilities of the Infrared Atmospheric Sounding Interferometer (IASI) and the Cross-track Infrared Sounder (CrIS). Most presentations are posted at the AIRS website: ***airs.jpl.nasa.gov/documents/science_team_meeting_archive/science_team_meeting_2009.10/***

Session 1: Introduction and Science Highlights

Mous Chahine [NASA/Jet Propulsion Laboratory (JPL)—*AIRS Science Team Leader*] opened the meeting, welcomed the participants, and showed the progress made by the team on completing the science objectives laid out at the beginning of the mission.

Jack Kaye [NASA Headquarters (HQ)—*Associate Director for Research, Earth Science Division*] explained that climate research is a high priority for the Obama administration and talked briefly about the upcoming opportunities in Research Opportunities in Space and Earth Science (ROSES).

Ramesh Kakar [NASA HQ—*Aqua Program Manager*] discussed the favorable results of the 2009 Aqua Senior Review, showed NASA plans for the Genesis and Rapid Intensification Process (GRIP) field experiment, and gave a status report on the Aqua instruments and spacecraft**.**

Mitch Goldberg [National Oceanic and Atmospheric Administration/National Environmental Satellite Data and Information System (NOAA/NESDIS)] discussed current work at NOAA on adapting processing tools that have been developed for use on AIRS and Aqua's Advanced Microwave Sounding Unit (AMSU) for use on CrIS and the Advanced Technology Microwave Sounder (ATMS) instruments planned for the National Polar-orbiting Operational Environmental Satellite System (NPOESS) and the NPOESS Preparatory Project (NPP)—the "bridge mission" between EOS and NPOESS. The capabilities included a shared retrieval system and tools for comparing products including the NOAA products Validation System (NPROVS).

Claire Parkinson [NASA Goddard Space Flight Center (GSFC)—*Aqua Project Scientist*] presented more details from the Aqua 2009 Senior Review. Parkinson reported that, both the Science and National Interest Panels gave Aqua their highest ratings.

Tom Pagano [JPL—*AIRS Project Manager*] showed the AIRS instrument is in good health, however, AMSU Channel 5 continues to degrade. Science interest in the project is high with over 306 Aqua AIRS/AMSU related peer review publications in the literature.

Sharon Ray [JPL—*AIRS Education and Public Outreach Lead*] shared the latest updates to the AIRS website including feature stories and animations, and ongoing preparations for the upcoming Fall American Geophysical Union meeting.

Session 2: Climate Trends and OLR

George Aumann [JPL—*Session Chair*] defined *climate quality* as data that have accuracy, stability, and global coverage such that trends derived directly from radiances or from the statistical analysis of derived processes can be securely interpreted in the context of climate change, and absolute results can be related to past and future measurements. This means 100 mK absolute accuracy and 100 mK/decade stability. Comparison of data from AIRS, AMSU, and from the IASI on the European Organisation for the Exploitation of Meteorological Satellite's (EUMETSAT) operational meteorological satellite (MetOp) satellite. Measurements taken at the surface, 400 hPa and 2 hPa channels confirm that the trends agree at the 10 mK/yr level.

Antonia Gambacorta [NOAA/NESDIS] presented results that indicate traditional assumptions of model simulations of constant relative humidity and close

adherence to the Clausius–Clapeyron equation are only partially supported by AIRS temperature and moisture retrievals. Two contrasting lapse rate feedbacks appear to take place over the Pacific region: positive feedbacks over the west side induced by a decrease in temperature, and negative feedbacks over the east side induced by a temperature increase to surface changes. These results appear to be in disagreement with the typical global circulation model assumption of a more uniformly negative lapse rate feedback across the whole tropics.

Bill Smith [University of Wisconsin – Madison (UWM)] discussed *The Use of Hyperspectral Sounding Radiances for Climate Analysis – Experience with AIRS*. Smith compared six years of AIRS Single Field of View retrievals with the European Center for Medium-range Weather Forecasting's (ECMWF) ERA-Interim reanalysis—ERA-15 is an interim reanalysis covering 1989–Present. ECMWF ERA compares well with the independent 1500-channel Dual Empirical Orthogonal Function (EOF) Regression using AIRS. Smith's next step is to produce five-decade regional trend results using data from the 1970 Infrared Interferometer Spectrometer (IRIS) on the Nimbus 4 spacecraft and AIRS and IASI data degraded to IRIS spectral (1.4 cm-1, unapodized) and spatial (100-km) resolution.

Mitch Goldberg [NOAA/NESDIS] presented work on *AIRS Climate Quality Limb Adjusted Radiances and Outgoing Longwave Radiation (OLR)* using slant-path corrected clear (i.e., cloud-filtered) radiances. The objective is to develop the very first accurate Spectrally Resolved Infrared (SRIR) Climate Data Record (CDR) (with high spatial coverage) from AIRS and demonstrate its utility to:

1. Detect and monitor climate change of temperature, moisture, greenhouse gases (GHGs), and clouds;
2. validate weather and climate models—i.e., test the realism of the model-derived atmospheric states with very high certainty; and
3. assess changes in model-derived fields due to assimilation of new data or an operational change in processing.

The first results show that the model accuracy looks very good in comparison with ECMWF from 2003–2005, the so-called "Golden Years".

Joel Susskind [GSFC] discussed the *Validation of Anomalies and Trends of AIRS Version 5 OLR Over the Seven Year Period September 2002–August 2009*. Susskind compared AIRS *Version 5* monthly OLR products with Clouds and Earth's Radiant Energy System (CERES) monthly mean OLR products for the time period September 2002–August 2009. He used AIRS monthly mean data obtained from the Goddard Earth Sciences Data and Information Center (GES DISC) (Level 3) and CERES monthly means obtained from the Langley Atmospheric Sciences Data Center (ASDC). AIRS and CERES (on Terra) OLR anomalies and trends agree well in every detail in the seven-year period under study.

Jonathan Wright [Columbia University] discussed *Event-based Climatologies Using Satellite Data: A Trajectory Approach*. The trajectory approach is a new way to investigate the natural atmosphere and to constrain parameterizations in Global Climate Model (GCMs). Wright discussed this in his recent paper: *Tropical Deep Convection and Upper Tropospheric Water Vapor*.

Session 3: Clouds and Dust Products and Science

Brian Kahn [JPL—*Session Chair*] summarized several ongoing cloud-related efforts with AIRS, often in synergy with other Afternoon Constellation (or *A-Train*) measurements. Kahn reported progress on the integration of a scattering code that uses a *delta-four stream approximation* into the Stand Alone AIRS Radiative Transfer Algorithm (SARTA). He also discussed cloud phase determination and issues regarding subpixel-scale cloud heterogeneity—on behalf of Shaima Nasiri [Texas A&M]—and summarized some of the salient findings of the AIRS-Moderate Resolution Imaging Spectroradiometer (MODIS) synergy—effort led by Mathias Schreier [JPL].

Bryan Baum [UWM] presented an update on the ice cloud scattering database that is used for MODIS *Collection 6*. (JPL will use this database for the ice-cloud retrievals.) This includes particle roughening, hollow habits, and the updated index of refraction database. Baum also reported on the improvements to MODIS cloud products with spectral calibration changes based on comparisons with AIRS data.

George Aumann [JPL] showed evidence (or the lack thereof) for cloud trends using the visible reflectance channels in AIRS, cloud fraction at two infrared (IR) channels, and tropopause-penetrating clouds. There is no statistically significant trend in the visible channels. Using IR bands, the cloud fraction has decreased along with the cloud-top temperature, although the results of this study are only marginally significant. In particular, the cloud fraction has decreased 1%/year at night, but only 0.2%/year during the day.

Mathias Schreier [JPL/University of California at Los Angeles (UCLA)] updated the team on progress using the spatial response functions of AIRS to combine data from AIRS and MODIS together. Schreier showed that by including the spatial response function, the variability and *skewness* in the brightness temperature differences at several channels were reduced. However, only by including the spectral response shifts reported by

Tobin was he able to reduce the biases in the radiances. By combining the spectral and spatial information in an optimal way, he has shown that AIRS and MODIS can be viewed as a single instrument platform.

Bill Blackwell [Massachusetts Institute of Technology] updated everyone on progress using a combined linear regression and neural network retrieval approaches for temperature and water vapor from AIRS. In summary, the neural network approach exceeded the linear regression approach in practically all types of retrieval scenes, including clear, cloudy, and low/high noise scenes.

Thomas Hearty [GSFC] presented an update on the GES DISC activities associated with AIRS.

Session 4: Forecast Improvement and Data Assimiliation

Fiona Hilton [U.K. Meteorological Office] discussed assessments of IASI retrievals of temperature and water vapor profiles in clear sky over ocean coincident with the Joint Airborne IASI Validation Experiment (JAIVEx) field campaign. The objective was to determine if fine atmospheric structure that is not present in the "first guess" but is revealed by JAIVEx drop sondes can be retrieved from the IASI data. Several different retrieval system variants were applied and results compared.

Louis Garand [Environment Canada] discussed methods to improve cloud height retrievals from AIRS and IASI. (This is an important aspect of assimilation of radiances in cloudy scenes, where a channel is accepted or rejected based on its weighting function relative to estimated cloud heights.) This study resulted in a revised set of channel pairs to be used in the carbon dioxide (CO_2) slicing technique to determine cloud height giving slightly improved performance.

Lars Peter Riishojgaard [Joint Center for Satellite Data Assimilation (JCSDA)] discussed progress in assimilating AIRS water vapor channels. Previously, attempts to assimilate such channels have yielded negative forecast impact. The reported efforts have resulted in good progress in the troposphere. Experiments with using AIRS cloud-cleared radiances were also discussed. This is of great interest, since the cloud filtering methods currently used by most Numerical Weather Prediction (NWP) centers admit only very sparse data, given that most of the global domain (~95%) is affected by clouds.

Joel Susskind [GSFC] reported on experiments assimilating quality-controlled AIRS temperature profiles into the Goddard Earth Observing System Model, Version 5 (GEOS-5). This contrasts with the almost universal practice of assimilating radiances. Data filtering was based on the quality control parameters generated by the AIRS retrieval system. Results were improved forecast skill and significantly better performance than radiance-based assimilation for the same case study. The next step is to test this approach in an operational context.

Oreste Reale [GSFC] showed the impact of temperature profile assimilation into the GEOS-5 General Climate Model (GCM) on tropical cyclone prediction. Assimilation of these data in cloudy regions substantially changes the depiction of developing and/or weak tropical cyclones. Reale also showed that the assimilation containing AIRS retrievals also produces the best precipitation "analysis." Validation is made against data from the Defense Meteorological Satellite Program's Special Sensor Microwave Imager (SSM/I), as well as from NASA's Tropical Rainfall Measuring Mission Microwave Imager (TMI), and Aqua AMSU.

Brad Zavodsky [NASA Marshall Space Flight Center (MSFC)/Short-term Prediction Research and Transistion Center (SpoRT)] reported SpoRT's efforts to assimilate AIRS retreived profiles into a Weather–Research Forecast (WRF)-based regional forecast system. Results show that proper assimilation of AIRS profiles yields improved precipitation forecasts and produces improved temperature and moisture forecasts at most times and pressure levels.

Zhaoxiu Pu [University of Utah] discussed experiments with assimilating AIRS retrieved temperature and moisture profiles for simulation of tropical cyclones. Comparisons were made with *in-situ* data from the NASA African Monsoon Multidisciplinary Analyses (NAMMA) field campaign. However, an ensuing discussion suggested that this may be due to an incorrect interpretation of pressure levels as reported in the AIRS data products; this will be re-examined.

Session 5: Temperature and Water Vapor Products Validation & Science

Eric Fetzer [JPL—*Session Chair*] described plans for validation of *Versions 5 and 6* of the AIRS Level 2 data products, with emphasis on comparisons of temperature and water vapor retrievals with a set of dedicated radiosondes. Approximately 1500 radiosondes have been launched over the past seven years to support validation of AIRS and other *A-Train* instruments. These are closely matched to AIRS overpasses, and often include highest quality *in-situ* water vapor sensors.

Fredrick W. Irion [JPL] reported on comparisons with operational radiosondes for validation and testing of AIRS processing software. Irion showed trends in AIRS temperature retrievals of about 0.1 K/year relative to the radiosonde observations. He described plans for more complete comparisons, and noted the lack of radiosondes sites on islands, important for AIRS over-water validation and trending.

Mark Zelinka [University of Washington] described composites of tropical deep convective systems, based on thousands of individual events observed by multiple satellite sensors. Zelinka showed that outgoing longwave radiation is significantly modulated during the composite life cycle, with most of the modulation due to increased upper tropospheric relative humidity. The effect of relative humidity was most pronounced 9–12 hours after peak rainfall.

Murty Divakarla [NOAA] discussed plans for creation of *proxy radiances* and associated retrievals for CrIS and ATMS. The proxy radiances are created from AIRS, and from IASI. Divakarla also described efforts to create proxy validation data sets for CrIS and ATMS based on existing radiosondes.

Mark Zondlo [Princeton University] presented comparisons of AIRS water vapor and temperature with observations from the Vertical Cavity Surface Emitting Laser (VCSEL) sensor flown on the National Science Foundation's (NSF) *Gulfstream* aircraft. The VCSEL instrument is sensitive to the full range of water vapor concentrations found in the troposphere, so it is well suited to AIRS validation; current and planned coverage includes a wide range of latitudes and altitudes. The two datasets show good agreement.

Nikita Pougatchev [Utah State University] described results of comparison of AIRS and IASI retrievals of temperature with observations from dedicated and operational radiosondes. Pougatchev's methodology accounts for non-coincidence, and weights the *in-situ* observations by the satellite instruments' averaging kernels. His results were broadly consistent with earlier studies, while accounting for non-coincidence and cloud-induced effective noise.

Glynn Hulley [JPL] validated AIRS surface emissivity retrievals over the Namib and Kalahari deserts in Southern Africa. Hulley also examined emissivity changes over Africa and the Arabian Peninsula. He showed that AIRS is able to retrieve changes in surface emissivity caused by rainfall, and is also sensitive to day/night emissivity differences likely caused by nighttime dewfall.

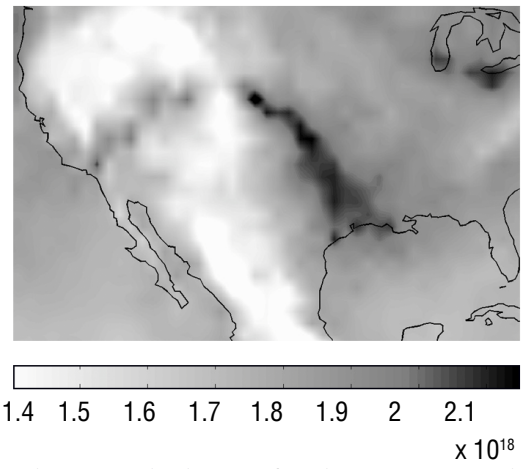
Nicholas Nalli [NOAA] reported on the 2009 Prediction and Research Moored Array in the Atlantic (PIRATA) Northeast Extension [PNE]/Aerosol and Ocean Science Expedition (AEROSE-V) cruise in the tropical Atlantic. This cruise is one in a series to examine conditions in the vicinity of the Saharan Air Layer (SAL). This associated data set includes radiosonde observations of temperature, humidity and ozone, appropriate for AIRS validation. Other observations are relevant to the SAL tropical storm formation, as well as tropospheric ozone, carbon, and aerosol chemistry and transport.

Session 6: Trace Gases: Carbon Monoxide and Ozone

Wallace McMillan [University of Maryland, Baltimore County (UMBC)] presented AIRS *Version 5* carbon monoxide (CO) results showing a 10% high bias for AIRS as compared to *in-situ* aircraft profiles from the Intercontinental Chemical Transport Experiment A & B (INTEX-A/B) and the High Performance Instrumented Airborne Platform for Environmental Research (HIAPER) Pole-to-Pole Observations [HIPPO] campaigns in the northern hemisphere. In the southern hemisphere, a much larger high bias exists in total column CO under the cleaner atmospheric conditions typical there. Initial testing of a candidate *Version 6* CO optimal estimation retrieval algorithm (developed by Eric Maddy with NOAA/Perot Systems) appears to remove much of this high bias. AIRS *Version 5* CO retrievals track the transport of CO from the 2009 Station Fire near Los Angeles to Houston where ground-based measurements indicate the CO decreased local air quality—see the figure below.

Leonid Yurganov [UMBC] presented results of Measurements of Pollution in the Troposphere (MOPITT) *Version 3* and AIRS *Version 5* CO validation using seven sun-viewing spectrometers in both hemispheres and analyses of CO interannual variations up to present time. Linear positive instrumental drift is found for MOPITT during 2000–2008 globally, while AIRS shows insufficient sensitivity to the lowermost CO total columns in the southern hemisphere. The global decrease in CO detected by both sounders during 2008 is explained by fewer tropical fires and economic recession.

Juying Warner [UMBC] compared AIRS *Version 5* operational CO products and research retrievals using optimal estimation techniques (developed by Warner and Zigang Wei). Results were compared against CO products from NASA airborne *in-situ* measurements



Four-day AIRS Total Column CO from the *Station Fire* in Pasadena.

and from the Tropospheric Emission Spectrometer (TES) on Aura. Optimal estimation techniques improve the retrievals significantly where the instrument sensitivity is low, such as in the lower troposphere and over the southern hemisphere ocean.

Hiroshi Tanimoto [Japanese National Institute for Environmental Studies] showed AIRS satellite measurements successfully tracked CO plumes over Siberia. Comparison of CO total column measured by AIRS and simulated by a global chemistry–transport model revealed that the Global Fire Emissions Database, *Version 2* (GFED*v2*)—one of the state-of-science inventories for biomass burning—still needs improvement for boreal fires in Siberia.

Jennifer Wei [NOAA] implemented a new tropopause-referenced climatology for ozone as the *a priori* for better shapes and gradients of profiles across the tropopause, and presented improved results using a new optimal estimation algorithm. For methane (CH_4), the most sensitive layers for the AIRS retrieval (based on the tropopause height in mid-to-high latitude regions) can be used to approximately characterize the variation of tropospheric CH_4.

Session 7: NPP, Sounder PEATE, GOES

Steve Friedman [JPL—*Session Chair*] gave a report of the NASA Sounder Product Evaluation and Test Element (PEATE). The Sounder PEATE matchup products will be stored in the Real-time Transport Protocol (RTP-3) Format that includes standard product attributes and matched correlative attributes in the same file. The PEATE features now available include data ingest, archive, granule maps, calibration subsets, and an analysis Product Generation Executable (PGE).

Chris Barnet [NOAA] gave a brief overview of the Cross-track Infrared and Microwave Sounder Suite (CrIMSS) Environmental Data Record (EDR) Calibration/Validation Plan. The strategy builds on the experience of Subject Matter Experts (SMEs) from the sounding community. Users of CrIMSS data will be of two types: 1) the *heritage user* (primarily for weather forecasting); and 2) the *hyperspectral era user* (primarily for composition studies). Three proxy datasets exist: NOAA/Star using forward model, AIRS/AMSU/Humidity Sounder for Brazil (HSB) proxy products from IASI and AMSU, as well as from the Microwave Humidity Sounder (MHS) on NOAA's Polar Orbiting Environmental Satellites (POES).

Evan Fishbein [JPL] presented considerations with comparison of datasets from instruments from cross-platforms at the NPP Sounding PEATE. Many complexities exist due to scanning geometry, temporal granularity, file context, and quality control.

Gail Bingham [Space Dynamics Laboratory (Utah State University)] gave a brief overview of the performance of the CrIS instrument and discussed progress in the development of the Cal/Val Plans. Bingham discussed pre-launch and post-launch Cal/Val processing support through the Government Resource for Algorithm Verification Independent Testing and Evaluation (GRAVITE) system.

Denise Hagan [Northrop Grumman Space Technology] gave a summary of the status of the CrIS instrument, the algorithms under development, and changes to in-orbit monitoring strategy using the Neon Lamps, and the calibration of nonlinearity.

Kevin Garret [NOAA] gave an update on the NOAA Microwave Integrated Retrieval System (MIRS) for NPP ATMS. The MIRS is a unique physical algorithm for processing retrievals from a variety of microwave systems. Demonstration of MIRS using proxy data shows good results.

Bob Knuteson [UWM] showed results of calibration of the broadband imagers using the hyperspectral sounders. Intercalibration is the primary means by which the calibration of the geostationary imagers can be assessed. AIRS allowed the geostationary community to have the confidence to make alterations to the calibration of two imagers: NOAA's Geostationary Operational Environmental Satellite (GOES)-13 prior to operation and the Japanese Multifunctional Transport Satellite (MTSAT-1R) during operations.

Bob Schweiss [GSFC] gave a poster on the NPOESS Preparatory Project (NPP) Science Data Segment.

Session 8: Special Session on Sounding Community Needs

Bjorn Lambrigtsen [JPL—*Session Chair*] reported on the Sounding Science Community Workshop that was held in May 2009 in conjunction with the last AIRS Science Team Meeting in Pasadena, CA. The presentations made at that meeting as well as reportage of the discussions can be viewed at: *soundingscience.jpl.nasa.gov.*

Eric Fetzer [JPL]—presenting on behalf of Joao Teixeira [JPL]—reported on two workshops on climate feedback and future observational needs, sponsored by the Caltech Keck Institute for Space Studies (KISS) and held in Pasadena in August–September 2009. Participation was by invitation, but a report will be published. The agendas and a list of participants can be viewed at: *kiss.caltech.edu/workshops/cloud2009/.*

Wallace McMillan [UMBC] discussed future needs in the atmospheric composition community, with focus on the Geostationary Coastal Ocean and Air Pollution

Events (GEO-CAPE) mission (proposed as a *Tier II* mission in the Earth Science Decadal Survey) and a future high spatial resolution sounder from Low-Earth Orbit (LEO).

A discussion followed that focused on the future observational needs to support *sounding science*—i.e., atmospheric research related to the hydrologic cycle. It was agreed that an effort should be undertaken to draft a "community letter" to NASA HQ expressing concern about the expected inadequacy of NPP and NPOESS to meet the research needs of this community and recommending steps that NASA could take.

Session 9: Trace Gases: Carbon Dioxide and Nitrogen Dioxide

Julie Wallace [McMaster University] presented *The Effect of Temperature Inversions on Ground Level NO_2 and $PM_{2.5}$ using Temperature Profiles from AIRS - A Community Level Application*. Wallace's research uses AIRS Level 3 temperature profiles over the period 2003–2007 to identify and characterize temperature inversions over Hamilton, Ontario to assess changes in air quality resulting from the inversions.

Larrabee Strow [UMBC] presented *Mid-Tropospheric Measurements of Global CO_2 with AIRS*. Strow's retrieval technique uses AIRS Level 1B radiances of two channels in clear fields of view and the ECMWF temperature profile. He compares his retrievals using two radiative transfer algorithm implementations: SARTA (*Version 1.07*)—a fast model—and the k-Compressed Atmospheric Radiative Transfer Algorithm (kCARTA)—a line-by-line code. The observed growth rate of CO_2 from 2003–2008 is 2.28 ± 0.07 ppm/yr with a seasonal cycle amplitude of 3–4 ppm—with a peak in the Northern Hemisphere in March, and in the southern in September. The growth rate exhibits significant geographical variability. Comparison with *CarbonTracker* shows good agreement except in the fall season. CO_2 excesses shown over Germany, Sweden, Mexico, and the east coast of the U.S. indicate that AIRS can detect anthropogenic CO_2.

Strow then presented *Direct, Simultaneous Retrieval of Minor Gas Trends from AIRS Clear Radiances*. In this analysis, clear ocean fields of view of AIRS Level 1B radiances are used to determine what trace gas trends may be derived directly from the measured radiance rates by simple simultaneous least-squares fits. He finds that CO_2, CH_4, nitrogen dioxide (N_2O), and chlorofluorocarbon-11 (CFC-11) rates can be derived. The derived rates are larger in the deep tropics than elsewhere. CH_4 exhibits enhanced growth rates in the tropics and very accurate CFC-11 decay rates are retrieved.

Edward Olsen [JPL] presented *Seven Years of AIRS Mid-Tropospheric CO_2*. Olsen announced the release of AIRS Level 2 and Level 3 CO_2 products and documentation to the scientific community through the GES DISC. The data products span the entire mission to date—from September 2002–December 2009. Averaging kernels are included in the Level 2 data products. Olson presented the results of validation studies using aircraft [e.g., results from INTEX-North America, the German Spurenstofftransport in der Tropopausenregion (SPURT) campaign, and the Japanese Comprehensive Observation Network for TRace gases by AIrLiner (CONTRAIL) program] as well as Fourier Transfer Infrared Spectrometer measurements of total column measurements from Park Falls, WI. The AIRS CO_2 retrieval's statistical bias with respect to the aircraft measurements is within 2 parts per million [ppm], and there is no interannual or latitudinal trend detectable with comparison to CONTRAIL for latitudes ≤ 30° over the seven-year period.

Eugenia Kalnay [University of Maryland, College Park] presented *AIRS CO_2 Data Assimilation with Ensemble Kalman Filter in NCAR Carbon-Climate Model: Preliminary Results*. Kalnay's comparison of the AIRS annual mean distribution of CO_2 over the globe in 2003 with the National Center for Atmospheric Research's Community Atmosphere Model (CAM3.5) highlighted differences between the measurements and the model that are likely due to the inaccuracies in the vertical mixing and boundary flux forcing assumed in the model. The northern hemisphere seasonal cycles for both CAM3.5 and AIRS were similar, but the model's seasonal cycle was weaker than the AIRS observations. The AIRS CO_2 maximum is delayed by about a month with respect to the surface maximum, but the model is delayed by another month beyond the AIRS observations. Initial studies of assimilation of AIRS CO_2 result in a correction to the forecast, which is consistent with the difference between observation and background.

Steven Wofsy [Harvard University] presented (via telecon) *Global CO_2 and CH_4 data at 200-m Resolution: The HIPPO Aircraft Program*. Wofsy gave an overview of the HIPPO aircraft program and provided the initial results of measurements of trace gas profiles from the January 2009 flight. Even at this early stage of the program, some major transport processes are clearly delineated that are not captured well by models—e.g., the warm conveyor belt. In addition, source regions for various exotic trace gases (e.g., dimethyl sulfide, methyl nitrate, methyl iodide, and ethyne to name a few) are revealed.

Bill Irion [JPL] presented *Progress on CO_2 Retrieval from AIRS using Optimal Estimation*. The TES Earth Limb and Nadir Operational Retrieval (ELANOR) op-

timal estimation code has been adapted for use on AIRS 15-km footprints and the AIRS SARTA forward model to retrieve CO_2 using nighttime ocean clear scenes over the western Pacific. Temperature profiles used were from ECMWF and surface temperatures were from AMSR-E or ECMWF. The first 100 observations in each month from 2003–2007 in each 15º latitude band were processed. The analyzed subset of retrievals are those for which the CO_2 degree of freedom exceeded 0.7 and the fitting *chi square* fell in the range 0.5–1.5. After removing a bias of +5 ppm from the AIRS retrievals, comparison with CONTRAIL interannual and seasonal variations over the same latitude and longitude are encouraging.

Anna Michalak [University of Michigan] presented *Mapping Global CO_2 using AIRS Data*. The goal of this effort is to develop geostatistical methods that can provide Level 3 products that represent the full information content of the Level 2 data, together with an accurate assessment of uncertainties associated with mapped products. Special emphasis is placed upon minimizing the loss of resolution relative to the Level 2 data and inclusion of a formal uncertainty assessment, while minimizing sensitivity to spatially and temporally coherent sampling limitations. Initial daily maps based on AIRS data show coherent structure but also involve larger uncertainties relative to maps created at coarser temporal resolution. The initial monthly maps show differences relative to the published Level 3 product in areas with sparser sampling. The next step is to identify an optimal time scale for the trade-off between minimizing uncertainty and maximizing temporal resolution.

Session 10: Level 1 and AIRS, IASI Calibration

Denis Elliott [JPL—*Session Chair*] summarized the changes for the AIRS Level 1 software for *Version 6*. There will be new radiometric calibration coefficients and a new spectral calibration. All changes are being put into a new PGE, Level 1C, which must be considered a research product. The output from an unchanged Level 1B remains the primary radiance product for AIRS. The radiometric calibration coefficients for *A-side* and *B-side* detectors are being determined. A variety of ways to determine the spectral shifts have been demonstrated. The present plan is to use a method based on historical fitting to atmospheric absorption lines. Once the instantaneous shifts have been determined, spectra will be gap-filled, cleaned, and resampled to a fixed frequency grid in the new Level 1C.

Evan Manning [JPL] provided some technical details regarding the new spectral calibration for *Version 6*. Manning began by going over the rationale for doing spectral calibration. It is not necessary for weather prediction and even some climate studies. However, when assessing long term trends, for channels on spectral lines, the frequency shifts can (if ignored) introduce radiometric errors that affect the studies. Manning proceeded to discuss the shifts in terms of equivalent focal plane motion, providing a scaling between the amount of the wavelength shift and the equivalent amount of focal plane movement (if that is the cause of the shifts). After discussing the various approaches for correction and their pros and cons, he ended by stating that the new Level 1C product should correct for about 90% of the effects of frequency shifts, qualifying the *Version 6* Level 1C product as being of climate quality.

Larrabee Strow, **Scott Hannon**, and **Paul Schou** [all from UMBC] described the technical details of how the AIRS frequency calibration is performed. They noted that the magnitude of the effect of shifts on radiometry is highly channel-dependent. After demonstrating how they calculate the shifts for all modules, they showed the frequency shift model (for predicting future shifts) which consists of: a fixed offset, and exponential decay term, and an oscillating term containing a sinusoid and two harmonics of the base frequency. The model does not yet account for the 24-hour cycle. For IASI, analysis is made more complicated by the fact that the four IASI fields of view (FOV) have different frequency scales and ECMWF only assimilates one IASI FOV. The presentation also discussed progress in spectral calibration of CrIS Bands 1 and 2, although systematic errors remain. Little progress has been made yet in Band 3 because of a lack of spectral features.

Strow, **Hannon**, and **Schou** also presented radiometric intercomparisons between IASI and AIRS using a double difference Observation minus Calculation (Obs – Calc) technique relative to ECMWF. The analysis is complicated by the orbital difference, ringing in IASI shortwave bands, and less accurate radiometric and spectral calibration at AIRS array edges.

Session: 11: Level 2 AIRS Version 6 Development

Steve Friedman [JPL] discussed the schedule for the transition from Level 2, *Version 5* to Level 2, *Version 6*. A number of significant improvements have been made, including improved boundary layer sensitivity and improved retrieval of surface emissivity. The yield has also improved. However, two significant challenges, having to do with the trend in the bias of the retrievals relative to radiosonde observations, need to be resolved for *Version 6*. He proposed a milestone chart that shows start of *Version 6* production on August 17, 2010.

Evan Manning [JPL] compared one day of *Version 5* temperature profile retrievals (available from the

DAAC) to the current *Version 6* candidate (*Version 5.4.12*) using the retrieval skill methodology. Manning showed that the skill for temperature profiles of *Version 5.0* and *Version 5.4.12* is very similar, but the yield for the surface temperature has improved significantly without any change in accuracy.

Eric Maddy [NOAA/NESDIS] discussed the AIRS *Version 6* algorithm from the NOAA perspective. The work plan includes installation of the new radiative transfer algorithm, installation of an Optimal Estimation (OE) algorithm for CO, upgrading the first guess algorithm (minus AMSU Bands 4, 5 and 7), and understanding and mitigating of spurious time-dependent trends in the Level 2 retrievals. About 50–75% of the spurious trend appears to be related to the way the increase in the CO_2 is handled in the Level 2 algorithm and the inseparability of the atmospheric temperature profile and CO_2.

Joel Susskind [GSFC] showed results using the current *Version 6* candidate algorithm. This is very close to the *Version 5.4.12* currently installed at JPL. The main improvement is with regard to surface skin temperature and spectral emissivity. As an additional improvement, the noisy AMSU-4 and AMSU-5 channels have been removed from the physical retrieval, but the cloudy regression still contains AMSU-4 and AMSU-5. The new version also provides a temperature and water vapor profile and cloud properties solution for 99% of the possible retrievals.

The next science team meeting will be held in Pasadena, CA on April 21-22, following the International Television Infrared Observation Satellite (TIROS) Operational Vertical Sounder [TOVS] Study Conference [ITSC-17] in Monterey, CA. ■

Precipitation Measurement Missions (PMM) Science Team Meeting Summary

continued from page 17

Closing

In addition to the oral presentations, two afternoon poster gatherings were held for participants to communicate research results as part of the annual review of the PMM program. Each U.S. PI presented at least one poster and international investigators were also invited to contribute. These poster sessions were well attended and served as an interactive forum for in-depth discussions of research results.

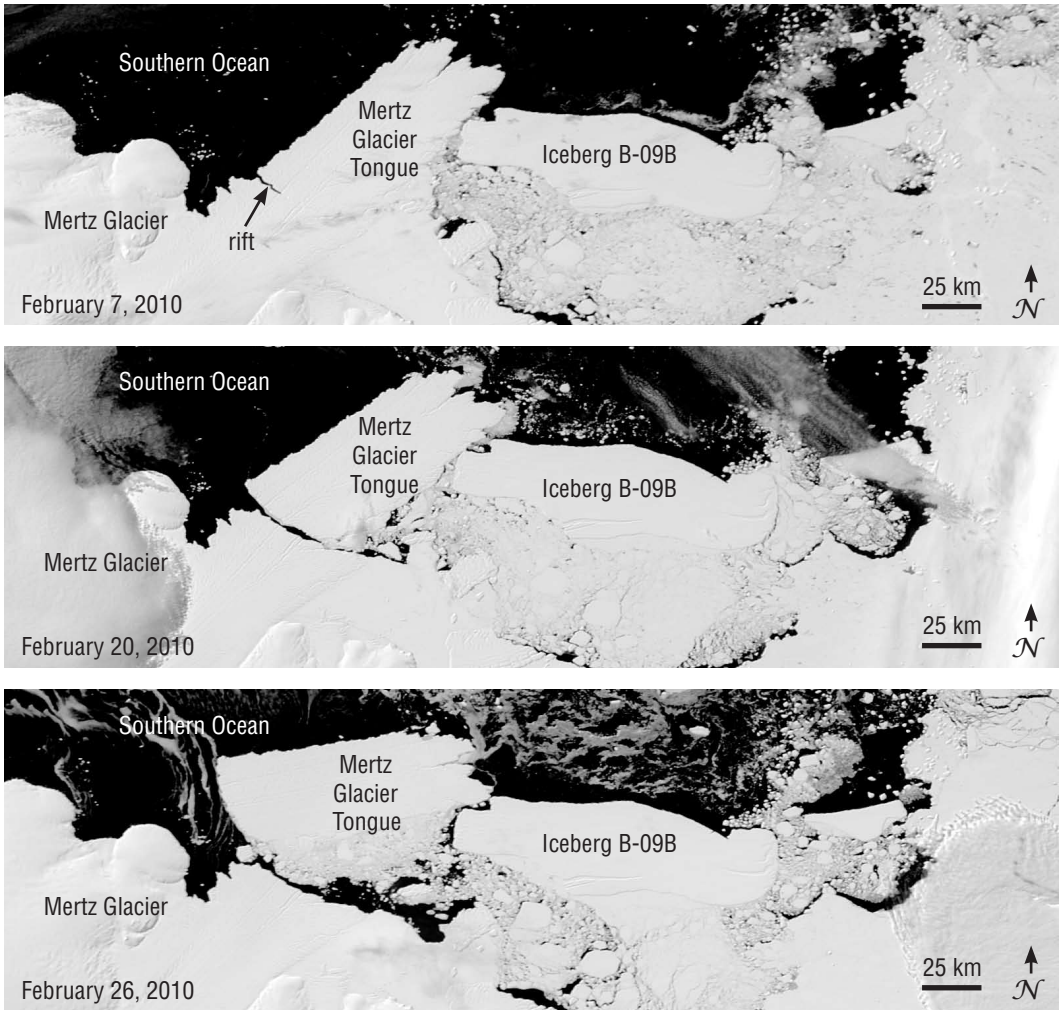
In closing, **Ramesh Kakar** reiterated his appreciation for the outstanding contributions made by the PMM Science Team to TRMM and urged the investigators to continue cutting-edge research to derive even greater benefits from the new capabilities offered by GPM. He expected the next three years to be a very exciting and busy period as the team prepares for the launch of the GPM Core Observatory in 2013. ■

Land and Atmosphere Near Real-Time Capability for EOS (LANCE) Workshop Summary

continued from page 20

- Data availability on a "timely" basis is critical for many near real-time users. Methods to decrease the latency from observation to data availability should be investigated and should include the Direct Readout community.
- A symposium should be held within the year to provide information on LANCE capabilities and solicit feedback and input from the wider user community.

This first LANCE workshop focused on a select number of users and applications of EOS near real-time data. Many thanks to all the participants for their time and valuable input to help NASA improve services for researchers and applications utilizing NASA's Earth Observing System. Future workshops will engage a wider community of near real-time data users to understand needs and prepare for future capabilities. Please visit *lance.nasa.gov* for more information. ■



Collision Calves Iceberg from Mertz Glacier Tongue, Antarctica

At 58 mi (94 km) by 24 mi (39 km) in size, the B-09B iceberg is comparable to the state of Rhode Island, which is wider but not quite so long. After lingering near the Mertz Glacier in Eastern Antarctica for several years, the massive iceberg collided with the glacier tongue on February 12 or 13, breaking it away from the rest of the glacier. The former glacier tongue formed a new iceberg nearly as large as B-09B. These images, all from the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor on NASA's Aqua satellite, show the iceberg and glacier tongue immediately before and after the collision.

On February 7, 2010, B-09B was approaching the Mertz Glacier Tongue (*top image*). Chunks of sea ice float in the water between the smooth iceberg and the coast. It is clear that the iceberg and the glacier tongue are trapping the ice in place. The water beyond the tongue and the iceberg is black in these images, and contains far less ice. The ice tongue itself is an extension of the Mertz Glacier, created as the ice flows down the mountain and onto the water. Glacier tongues grow longer year by year until they eventually break off, calving a new iceberg. The Mertz Glacier Tongue was beginning to break before the B-09B iceberg rammed it. Dark horizontal cracks were visible in the ice tongue on February 7.

Sometime on February 12 or 13, B-09B struck the ice tongue. Clouds prevented MODIS from viewing the event when it happened, but on the afternoon of February 13, the clouds had thinned just enough to reveal that the ice tongue had broken away in the collision. The next cloud-free view of the region on February 20 (*center image*) shows the two icebergs. The glacier tongue had clearly broken along the rifts that were visible in early February. Over the course of the next week, the former Mertz Glacier Tongue pivoted away from the glacier like a door hinged at the point where B-09B hit it (*lower image*).

The iceberg formed from the Mertz Glacier Tongue is 48 mi (78 km) long by 24 mi (39 km) wide and has a mass of 700-800 billion tons, reported BBC News. The glacier tongue had previously contributed to keeping a section of the ocean free of ice, a condition known as a *polynya*. The polynya provided a significant feeding site for wildlife like penguins. The shorter tongue may not protect the area from sea ice, reducing or even eliminating the polynya and the access to food it provided.

The B9 iceberg broke from the Ross Ice Shelf in West Antarctica some time in 1987. It took the massive iceberg more than two decades to drift slowly out of the Ross Sea and along the coast to the Mertz Glacier in East Antarctica. Along the way, it broke apart, one segment becoming the massive B-09B iceberg that collided with the glacier tongue in February 2010.
Credit: NASA MODIS Rapid Response Team

Cold Snaps Plus Global Warming Do Add Up

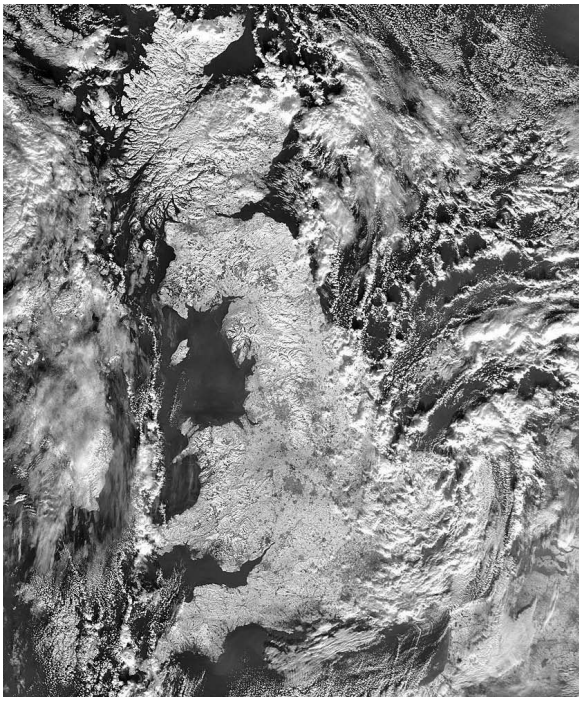
Patrick Lynch, NASA Langley Research Center, patrick.lynch@nasa.gov

That feeling of numbness in your toes, even inside your thickest boots, is not lying to you. It's been very cold so far this winter in most of the U.S. and many places at middle latitudes in the Northern Hemisphere. Washington, DC, London, U.K., and Seoul, South Korea have already shoveled themselves out from major snowfalls. And over the course of 2009, average temperatures across some parts of the U.S. were cooler than the average temperature for a baseline period of 1951–1980.

To many people's confusion, these weather events happened against a backdrop of increasing man-made greenhouse gas levels in the atmosphere that are gradually warming the planet. But scientists stress this weather does not mean that those gases are no longer exerting a warming influence. Nor does it go against the grain of basic global warming theory. Cold snaps and bouts of natural cooling that could last years are expected naturally even as the climate continues on a long-term warming trend, forced by man-made emissions.

It's snow joke

So, what has been going on out there these past two months? As for the Arctic winter weather, it is exactly that—Arctic. A pattern of high sea-level pressure over the Arctic has led to weaker westerly winds that typically pin cold air closer to the North pole. According to **John M. Wallace**, an atmospheric sciences professor at the University of Washington, the weakened jet stream has allowed cold Arctic air to creep into more southern latitudes over the U.S., Canada, Europe, and Asia.



A historic snowfall blanketed Great Britain on January 7. A strong high-pressure mode of a pattern called the Arctic Oscillation pushed the jet stream further south and allowed Arctic air masses to invade Northern Europe in December and January, making for unusually severe and cold weather. **Image Credit:** NASA, MODIS Rapid Response Team

This pattern of pressure is called the *Arctic Oscillation*. The oscillation comes in two phases: a *negative phase* where there is relatively high pressure over the North pole and low pressure at the mid-latitudes (at about 45°N); and a *positive phase* in which this pressure system is reversed. This winter, the Arctic Oscillation has been in an extremely negative state. This has caused unseasonably cold air masses to sweep over what are normally temperate latitudes, and unusually mild air masses to be brought in over much of the Arctic itself, Wallace explained.

"The unseasonable temperatures have been accompanied by well-above-normal sea-level pressure in the Arctic, especially over the Atlantic sector. That's how scientists characterize the Arctic Oscillation," Wallace said. ...this will be a winter to remember because of the Arctic Oscillation."

Nature's wiggles

"The bottom line is, I don't find it extraordinary," Wallace said. "With or without anthropogenic (man-made) warming, you're going to have big variations in these patterns."

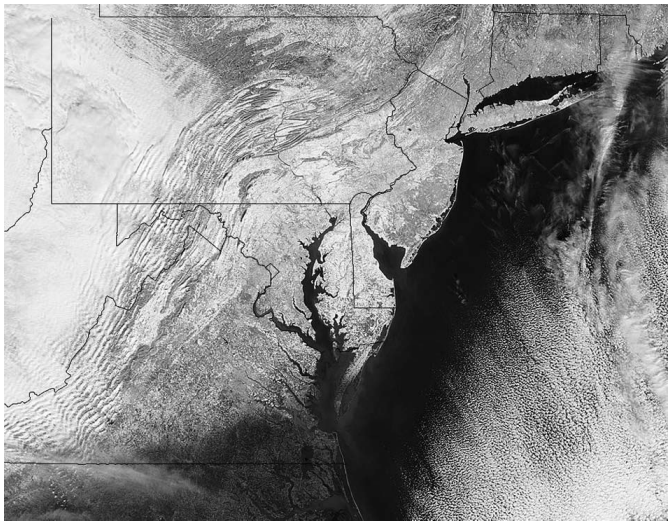
The 2009 global temperature analysis released by NASA's Goddard Institute for Space Studies (GISS) shows that, globally, 2009 was tied for the second hottest year on record. This comes as news reports and blogs question whether global warming is even occurring, given local weather conditions and the fact that warming did not occur at the same rate in the past 10 years as it did during the '80s and '90s. But here is the key: **While the rate of warming slowed, the decade ending December 31, 2009 was also the warmest since accurate records began in 1880, according to GISS. And neither the basic chemistry and physics of global warming nor the continuing increase in man-made greenhouse gas emissions has changed.**

One spell is not enough

"Frequently heard fallacies are that 'global warming stopped in 1998,' or that 'the world has been getting cooler over the past decade,'" GISS director **James Hansen** wrote in a recent essay called *The Tem-*

perature of Science. "These statements appear to be wishful thinking—it would be nice if true, but that is not what the data show."

Hansen explains that the 5-year and 11-year temperature averages, i.e., the planet's annual average temperature, averaged over 5 or 11 years, are valuable because they place less emphasis on single-year variability. These running averages show a consistent rise in the Earth's temperature over the past 30 years. Further, if the El Niño effect (when unusually warm ocean temperatures occur in the tropical Pacific Ocean) is as strong in 2010 as expected, Hansen said there is a greater than 50% chance that it could be the warmest year in the period of instrumental data.



Harsh winter conditions hit the mid-Atlantic region of the U.S. with major snowfalls just before Christmas and twice in February. The Washington, DC area has seen record snowfall this winter. **Image Credit:** NASA, MODIS Rapid Response Team

But even if it is, **like the recent harsh weather, one year or one particular spell of weather will never alone prove or disprove what is happening to the climate**. Even as man-made greenhouse gases exert a consistent pressure on the climate, trapping more heat close to the surface of our planet, surface temperatures from year to year will fluctuate depending on the naturally variable forces at work around the globe. In the early 90s, the mass of sulfates blasted into the atmosphere by the eruption of the Mt. Pinatubo volcano reflected sunlight and counteracted much of the man-made warming effect for several years. In 1998, El Niño combined with the man-made effect to give us one of the warmest years ever.

Allowing for this variability, global warming theory does not posit a linear, year-to-year increase in temperatures. Nor does it say that harsh winter weather will simply end. What it does say is that increasing concentrations of gases such as carbon dioxide and methane, with unchecked growth, will contribute a greater and greater warming influence on the world's climate.

"The bottom line is this: there is no global cooling trend," Hansen wrote in his 2009 temperature analysis. **"For the time being, until humanity brings its greenhouse gas emissions under control, we can expect each decade to be warmer than the preceding one."**

Key points

• Climate change is not proven nor disproven by individual warming or cooling spells. It's the longer-term trends, of a decade or more, which place less emphasis on single-year variability, that count.

• The past couple of months have seen a particularly cold winter in parts of the U.S. and elsewhere.

• This has been the result of the *Arctic Oscillation*—a see-sawing pressure system over the North pole—that has driven cold air into more southern latitudes.

• These cold spells, and other weather changes that are a result of naturally occurring patterns, are still consistent with a globally warming world. ■

On the other side of the world, Arctic weather was also brought to bear on the Korean Peninsula. This image was taken on January 3, 2010. Scientists say this year's severe winter weather is still to be expected from time to time, even as increased concentrations of man-made greenhouse gases create a long-term warming trend for the planet. **Image Credit:** NASA, MODIS Rapid Response Team

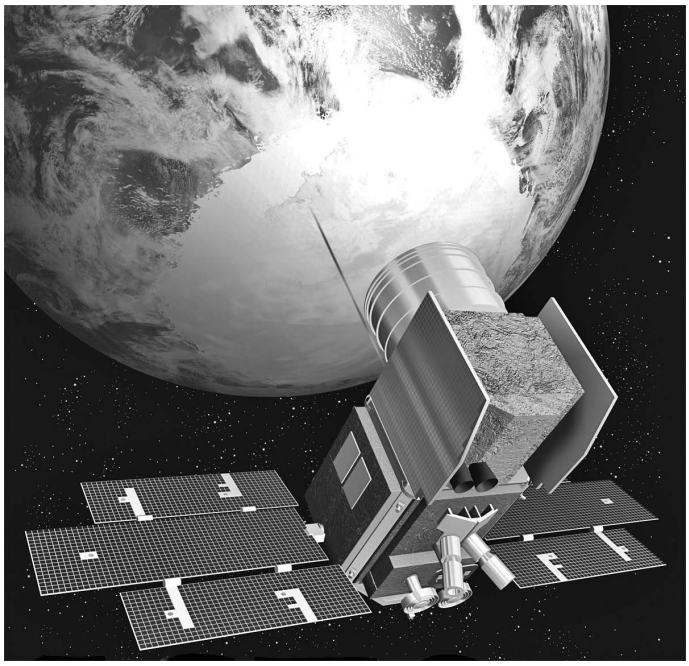
in the news

ICESat's Notable Moments in Science

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

Over the last decade, NASA has launched a series of satellites to monitor the health of our planet. One such satellite—the Ice, Cloud and land Elevation Satellite (ICESat)—has provided a sustained, big-picture look at ice thickness at Earth's polar regions.

Now, after seven years in orbit and 15 laser-operation campaigns, ICESat has stopped collecting science data. The last of three lasers on the satellite's Geoscience Laser Altimeter System (GLAS) ceased emitting light on October 11, 2009. Attempts to restart the lasers have ended, and NASA is pursuing options for satellite decommissioning.



The Ice, Cloud and land Elevation Satellite (ICESat) was designed to measure the mass balance of Earth's ice sheets, the height of clouds and aerosols, and the topography of the land. The measurements were made by three lasers on the satellite's Geoscience Laser Altimeter System (GLAS) instrument. GLAS was the first laser-ranging (lidar) instrument for continuous global observations of Earth. **Credit:** NASA

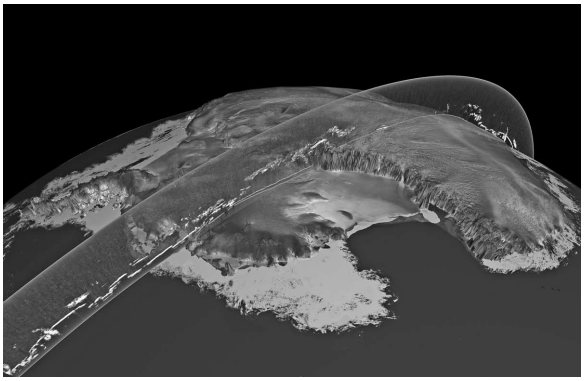
"ICESat's loss is disappointing and it comes at a critical time," said **Tom Wagner**, Cryosphere Program Manager at NASA Headquarters in Washington. "But we can't lose sight of the fact that ICESat and its team of talented scientists and engineers helped us see the Earth's polar ice caps in a new way. Those observations are feeding a new generation of models to help us figure out where the planet is headed."

As the world's first laser-altimeter satellite, ICESat has measured Earth's surface and atmosphere in "unprecedented 3-D detail," said **Jay Zwally**, ICESat's Project Scientist at NASA's Goddard Space Flight Center. "ICESat has been an outstanding success, despite disappointing limitations in the laser lifetimes. Scientific advances have been made in measuring changes in the mass of the Greenland and Antarctic ice sheets, polar sea ice thickness, vegetation-canopy heights, and the heights of clouds and aerosols."

In the Arctic, for example, scientists used ICESat to map Greenland's dramatic surface elevation, rising to 2.5 mi (4000 m) above sea level. They watched as thin, seasonal sea ice replaced thick, older sea ice as the dominant type in the Arctic Ocean. In Antarctica, scientists achieved a comprehensive inventory of lakes that actively drain or fill under the ice. At both poles, they have tracked glaciers along the coast of the Greenland and Antarctic ice sheets as they empty into the sea.

Despite the end of ICESat's mission, NASA's observations of Earth's polar regions continue. *Operation Ice Bridge* began in 2009, becoming the largest airborne survey of Earth's polar ice ever flown. For the next five years, instruments on NASA aircraft will target areas of rapid change to yield an unprecedented 3-D view of Arctic and Antarctic ice sheets, ice shelves, and sea ice. The mission will bridge the gap in satellite data until the launch of ICESat-2, planned for 2015.

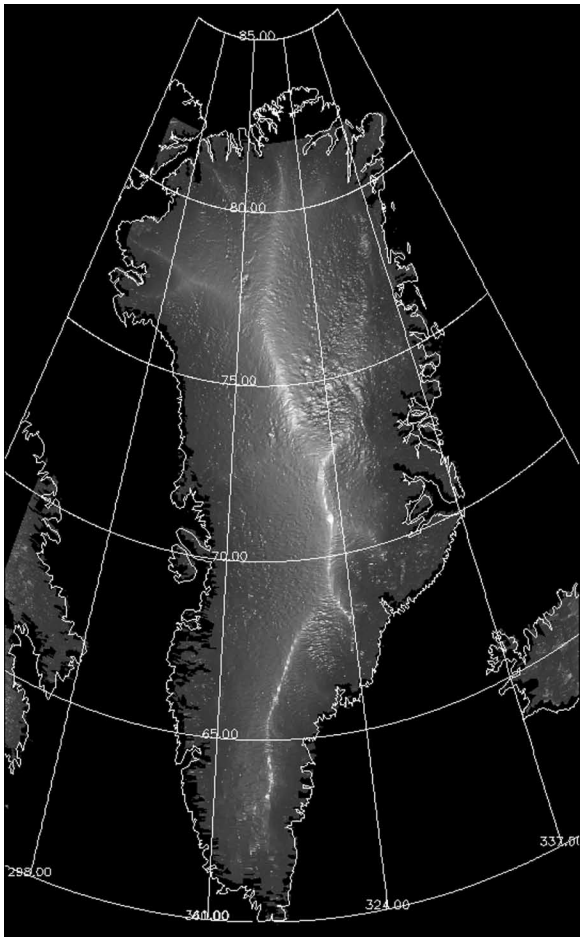
"Operation Ice Bridge is allowing us to get much higher resolution data over smaller, targeted regions," said **Lora Koenig** of NASA Goddard, and acting Project Scientist for the Ice Bridge mission.



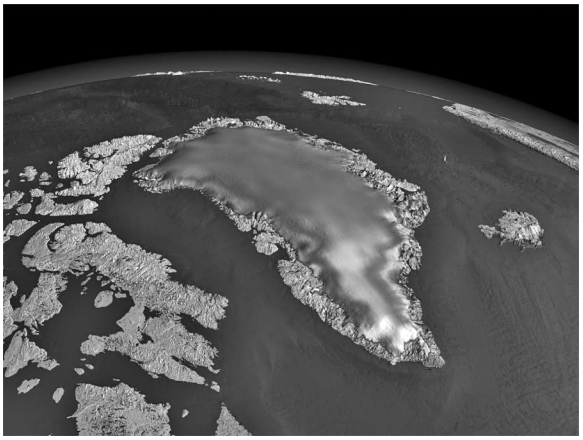
Ice sheet elevation and cloud data were captured from ICESat's GLAS instrument on its first day of operation, February 20, 2003. The elevation profile is depicted relative to Antarctica with *50x* vertical exaggeration. Clouds of various thicknesses are indicated by shading changing progressively from light gray (thin clouds) to white (opaque layers). **Credit:** NASA

Targeted information from aircraft combined with the broad and consistent coverage from satellites contribute to a more complete understanding of Earth's response to climate change, helping scientists make better predictions of what the future might hold.

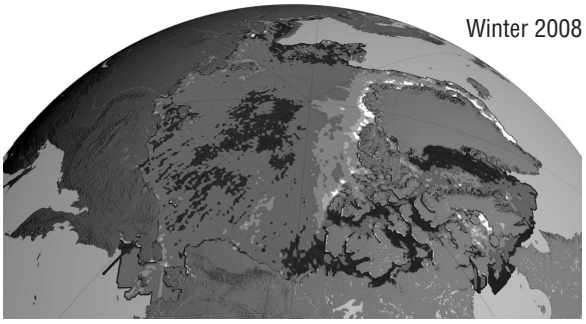
For additional images and to view the images from this article in color, please visit: *www.flickr.com/photos/gsfc/sets/72157623501738722/show/*.



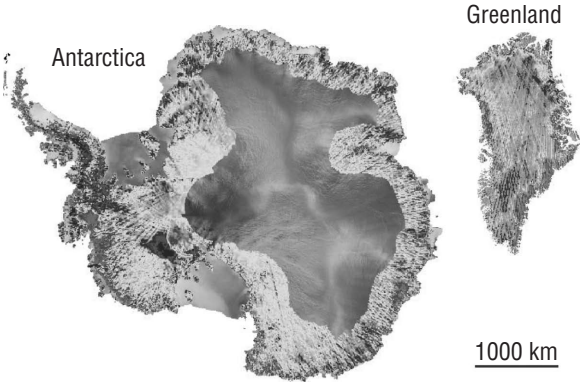
Greenland's unique ice sheets hold the key to Earth's past climate, and may provide some clues for future climate, too. But what do the ice sheets look like? On December 26, 2004, NASA's Earth Observatory posted this image of the topography of Greenland's ice sheet, created with ICESat data. Ice elevation rises dramatically between sea level around the coastline and the east-central interior, where elevations reach 2 mi (3,200 m). The bright line running north to south shows where the ice sheet peaks in a long island-spanning ridge. **Credit:** NASA/John P. DiMarzio and the ICESat Science Team



ICESat's precise elevation change measurements, combined with information from other technologies, are leading to a comprehensive look at the behavior of Earth's ice sheets—critical for quantifying forecasts of sea level rise. Scientists used ICESat data to show changes in elevation over the Greenland ice sheet between 2003–2006. White regions indicate a slight thickening, while the darker shades indicate a thinning of the ice sheet. Gray indicates areas where no change in elevation was measured. **Credit:** NASA Goddard's Scientific Visualization Studio



Sea ice extent grows in the summer and shrinks in the winter. While the sea ice extent might look similar from year to year, thickness data show dramatic thinning (darkest areas). Visualizations like this clip from an image sequence, generated with ICESat data acquired between February 17–March 21, 2008, are helping scientists and the public better comprehend the complex, dynamic evolution of Earth's sea ice and ice sheets. **Credit:** NASA Goddard's Scientific Visualization Studio



Research led by the British Antarctic Survey, published September 24, 2009 in *Nature*, used ICESat's high-density web of elevation measurements to compose the most comprehensive picture of changing glaciers along the coast of the Greenland and Antarctic ice sheets. The maps confirm that the profound ice sheet thinning of recent years stems from fast-flowing glaciers that empty into the sea. **Credit:** British Antarctic Survey/NASA

in the news

JPL Airborne Radar Captures Its First Image of Post-Quake Haiti

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

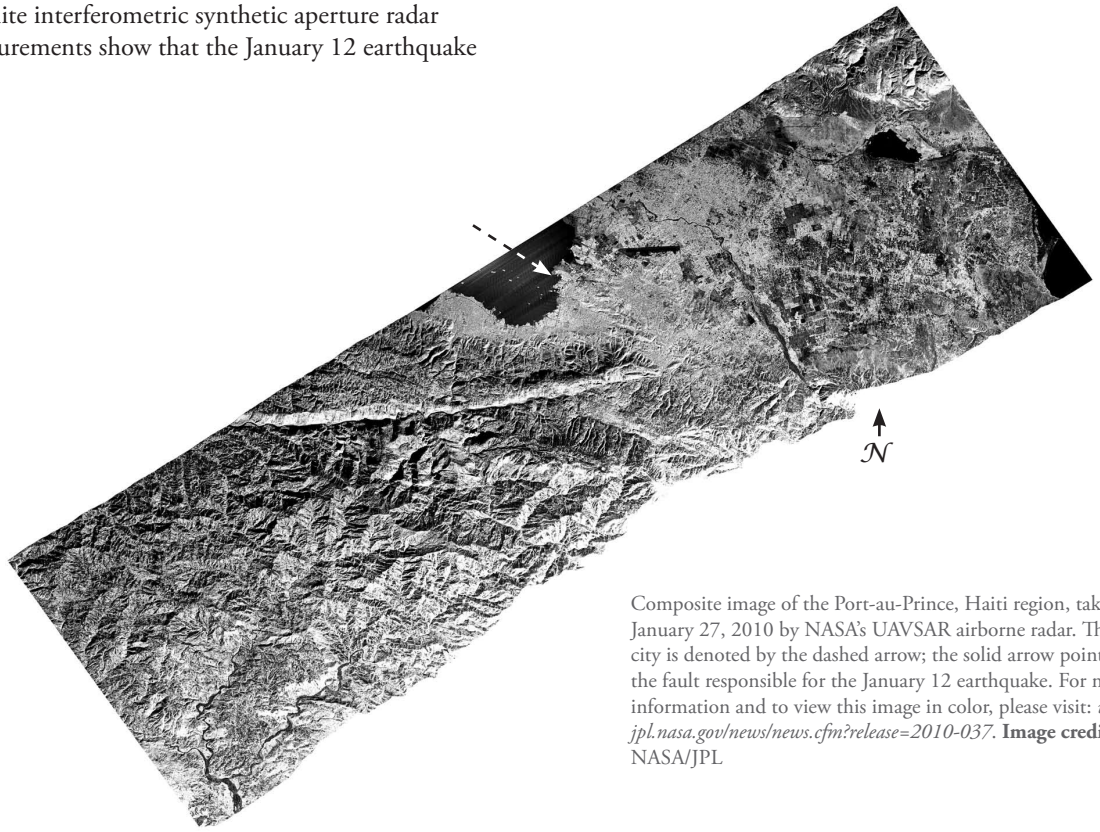
JPL's Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) captured composite image of the city of Port-au-Prince, Haiti, and the surrounding region on January 27, 2010. Port-au-Prince is visible near the center of the image. The large dark line running east-west near the city is the main airport. UAVSAR left NASA's Dryden Flight Research Center in Edwards, January 25, 2010, aboard a modified NASA *Gulfstream III* aircraft on a three-week campaign that will also take it to Central America.

Shortly before 5 p.m. local time on January 12, 2010, a magnitude 7.0 earthquake struck southern Haiti. The earthquake's epicenter was about 15 mi (25 km) west-southwest of Port-au-Prince, close to the west (*left*) edge of this image. The large linear east-west valley in the mountains south of the city is the location of the Enriquillo-Plantain Garden fault—the major active fault zone responsible for the earthquake. The fault extends from the western tip of Haiti past Port-au-Prince into the Dominican Republic to the east of this image. Historical records show that the southern part of Haiti was struck by a series of large earthquakes in the 1700s, and geologists believe those were also caused by ruptures on this fault zone.

Satellite interferometric synthetic aperture radar measurements show that the January 12 earthquake ruptured a segment of the fault extending from the epicenter westward over a length of about 25 mi (40 km), leaving the section of the fault in this image unruptured. The earthquake has increased the stress on this eastern section of the fault south of Port-au-Prince and the section west of the rupture. This has significantly increased the risk of a future earthquake, according to a recent report by the U.S. Geological Survey.

This image will be combined with other images of the same area to be acquired in the future in order to measure the motion of Earth's surface during the time between images using a technique called *interferometry*. The interferometric measurements will allow scientists to study the pressures building up and being released on the fault at depth.

UAVSAR is a reconfigurable polarimetric L-band synthetic aperture radar (SAR) specifically designed to acquire airborne repeat track SAR data for differential interferometric measurements. For more information about radar polarimetry, see *www.ccrs.nrcan.gc.ca/resource/tutor/polarim/index_e.php*. The radar will eventually be flown aboard an uninhabited, remotely-piloted aircraft such as *Global Hawk*. ■



Composite image of the Port-au-Prince, Haiti region, taken January 27, 2010 by NASA's UAVSAR airborne radar. The city is denoted by the dashed arrow; the solid arrow points to the fault responsible for the January 12 earthquake. For more information and to view this image in color, please visit: *www.jpl.nasa.gov/news/news.cfm?release=2010-037*. **Image credit:** NASA/JPL

KUDOS

Molly Brown [Goddard Space Flight Center (GSFC)—*Research Scientist*] recently received the **David Johnson Award**. This annual award, presented by the National Space Club, is given to young professionals who have developed an innovative application of Earth observation satellite data (alone or in combination with non-satellite data) that is, or could be, used for operational purposes to assess and/or predict atmospheric, oceanic or terrestrial conditions.

Eugenia Kalnay [University of Maryland, College Park] won the **54th International Meteorological Organization (IMO) prize** of the World Meteorological Organization (WMO)—the most prestigious prize awarded from that organization—this year. The prize was awarded January 14 at the National Academy of Sciences. Among her many accomplishments, her work with the Atmospheric Infrared Sounder (AIRS) was cited as well as her service at NASA GSFC as a branch head and developer of the model that was used for many years at Goddard in data assimilation and modeling experiments.

NASA and the U.S. Department of the Interior presented the **William T. Pecora Award** to the **Clouds and the Earth's Radiant Energy System (CERES) Team** and to **Forrest Hall** [GSFC/University of Maryland Baltimore County—*Senior Research Scientist*], at the 2009 AGU meeting in San Francisco. The two agencies present individual and group Pecora Awards to honor outstanding contributions in the field of remote sensing and its application to understanding Earth. To read the full announcement, please visit: *www.nasa.gov/home/hqnews/2009/dec/HQ_09-291_Pecora.html*.

Randal Koster [GSFC—*Researcher and Senior Scientist*] and **Paul Newman** [GSFC—*Atmospheric Physicist*] were among 58 scientists named as **2010 Fellows of the American Geophysical Union** (AGU)—an international organization of Earth and space scientists. Fellows—nominated by AGU members and chosen by committees—are selected based on their exceptional contributions to the Earth and space science fields. Only 1 in 1000 members of the scientific community are elected as Fellows each year. To read the full award announcement and learn more about the Fellows, please visit: *www.nasa.gov/centers/goddard/news/releases/2010/10-011.html*.

Robert Cahalan [GSFC—*Head of the Climate and Radiation Branch*], **Jack Fishman** [Langley Research Center—*Senior Research Scientist*], **Jack Kaye** [NASA Headquarters—*Associate Director for Research, Earth Science Division*], and **Patrick Minnis** [Langley Research Center—*Senior Research Scientist*] were elected as **2010 Fellows of the American Meteorological Society** (AMS). The AMS Executive Council elects new fellows each year from a slate submitted by the Fellows Committee of not more than one-tenth of one percent of all AMS members. The formal announcement of the election took place at the 90th AMS Annual Meeting in Atlanta, GA in January.

The Earth Observer staff and the entire scientific community congratulate these award recipients on their achievements.

The EOS Project Science/Science Mission Directorate (SMD) Support Office (PSO) once again submitted outreach products to the Washington DC Chapter of the *Society for Technical Communication's* annual Technical Publications Competition. For the 2009-2010 competition, both *Our Changing Planet: The View from Space* (published by Cambridge University in December 2007) and the *Ocean Surface Topography Mission's (OSTM) Science Writers' Guide* received an ***Award for Distinguished Technical Communication***. *Our Changing Planet* was voted ***Best of Show***. In addition, both *The Earth Observer* newsletter and the *OSTM/Jason-2 Mission Brochure: Watching Over Our Ocean* received ***Awards for Merit***. The PSO team (and all who worked on these and other products) should be commended for continuing to produce such high-quality outreach materials that help to promote science at NASA.

EOS Scientists in the News

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

Combating Climate Change by Observing Earth, December 30; *Scientific American*. At the Copenhagen summit on climate change, **Jack Kaye** (NASA HQ) narrated a display of a decade's worth of climate data collected by NASA satellites, but warned that many are already or soon to be defunct, and scientists will have to get creative and work with international partners more than ever before; open data policies could help the situation, according to **Tony Freeman** (NASA JPL).

Climate Numerology: How Much Atmospheric Carbon Dioxide is Safe? January 1; *Scientific American*. Despite decades of effort, scientists do not know what "number"—in terms of temperature or concentrations of greenhouse gases in the atmosphere—constitutes a danger, and **Gavin Schmidt** (NASA GISS) said "we may have to wait 20 or 30 years before the data set in the 21st century is good enough to pin down sensitivity."

Scrutinizing Swamp Gas: Model Helps Predict Global Wetland Greenhouse Emissions, January 22; *Scientific American*. Researchers created a new model that uses gravity measurements from a NASA satellite and weather data to predict methane emissions from wetlands in different regions; **Elaine Matthews** (NASA GISS) suggested that data from a microwave-based satellite could further improve the model.

January Rain Totals Still Short of Record, January 23; *LA Daily News*. Powerful downpours from the Pacific pounded Southern California in January, but **Bill Patzert** (NASA JPL) said that rainfall amounts that month were just a little larger than normal and far shy of record-breaking amounts.

Graeme Stephens Describes Satellite's Look at Earth's Water Cycle, January 25; *EarthSky*. **Graeme Stephens** (Colorado State University) is principle investigator on NASA's CloudSat mission—a satellite designed to investigate how clouds affect Earth's water cycle—and explains that as scientists learn how clouds interact with other forces in the atmosphere, models predicting future climate will become much more accurate.

Melting Season in the Arctic Increases, January 28; *Softpedia*. Recently-published results by **Thorsten Markus** (NASA GSFC) and colleagues determined that, on average, the lengths of the melting season in the Arctic have increased by as much as 6.4 days per decade, for a total increase of 20 days over 28 years.

Is Water Vapor in the Stratosphere Slowing Global Warming? January 29; *Scientific American*. NOAA-led research found that since 2001 there has been less water vapor in a narrow, lower band of the stratosphere thanks to cooler temperatures in the tropopause, and that may just be holding back global warming at ground level; **Drew Shindell** (NASA GISS) and **Gavin Schmidt** (NASA GISS) explain how the amount of water vapor in the atmosphere is also affected by methane, which has not increased in recent years.

The Secret Life of Scientists, January 22 – February 2; *PBS*. In a Web-only series that shows—via blogs and videos—what happens when the lab coat comes off, climate scientist **Gavin Schmidt** (NASA GISS) reveals his secret life as a juggler, and how he was inspired to pursue what would become his life's work in climate science.

L.A. County's Handling of Mudslide Warnings is Questioned, February 9; *Los Angeles Times*. **Bill Patzert** (NASA JPL) said residents of La Canada Flintridge, CA, should play it safe any time it rains, as was expected early February; it will be years before the fire-ravaged hills are stable, he said, and the threshold for major slides and mud flows gets lower with each storm.

An Alien View of Earth, February 12; *National Public Radio*. **Candice Hansen-Koharcheck** (NASA JPL) and **Edward Stone** (NASA JPL) recall how the *Voyager 1* spacecraft captured a radical view of Earth twenty years ago.

Fjords Contribute to Melting Glaciers, February 15; *The New York Times*. **Eric Rignot** (NASA JPL) looked at the rates of undersea melting at four glaciers in West Greenland and calculated the rates of melting to be up to two orders of magnitude larger than surface melting rates, suggesting that fjords play an important role in the changes taking place in the region's glaciers.

JPL Officials are on the Case of the Missing CO_2, February 16; *Pasadena Star-News*. A decade after the first carbon observatory was designed, there is still a need for something that can measure where carbon dioxide is being absorbed; according to **David Crisp** (NASA JPL) and **Moustafa Chahine** (NASA JPL), having more than one way to measure the greenhouse

gas from space will help scientists better understand the gas' affect on climate.

NASA Satellites Track Vanishing Groundwater, February 17; *National Geographic News*. NASA's GRACE mission measures seasonal water mass variations on a wide scale or in real time, and GRACE science team researcher **Jay Famiglietti** (University of California, Irvine) has been using the satellite data to monitor California's groundwater fluctuations.

Road Transport Comes under Fire in "Smart Climate Policy," February 18; *environmentalresearchweb.com*. A team of U.S. scientists including **Nadine Unger** (NASA GISS) has analyzed the net effect on climate of regulating emissions from individual economic sectors; cleaning up the air by removing certain aerosol-forming chemicals, for example, could actually increase warming in the short-term.

Drew Shindell on Regulating Greenhouse Gases and Improving Air Quality, February 22; *EarthSky*. Climate scientist **Drew Shindell** (NASA GISS) wants to help policy makers decide how to regulate greenhouse gas emissions that drive climate change; at a science meeting in late 2009, he spoke with *EarthSky* about his approach to studying the way emissions interact in Earth's atmosphere.

Jay Zwally Warns Greenland Ice Loss is Canary in Cole Mine, February 22; *EarthSky*. **Jay Zwally** (NASA GSFC) spoke with *EarthSky* about changes to Earth's ice sheets and sea level, and explained how NASA is studying these changes.

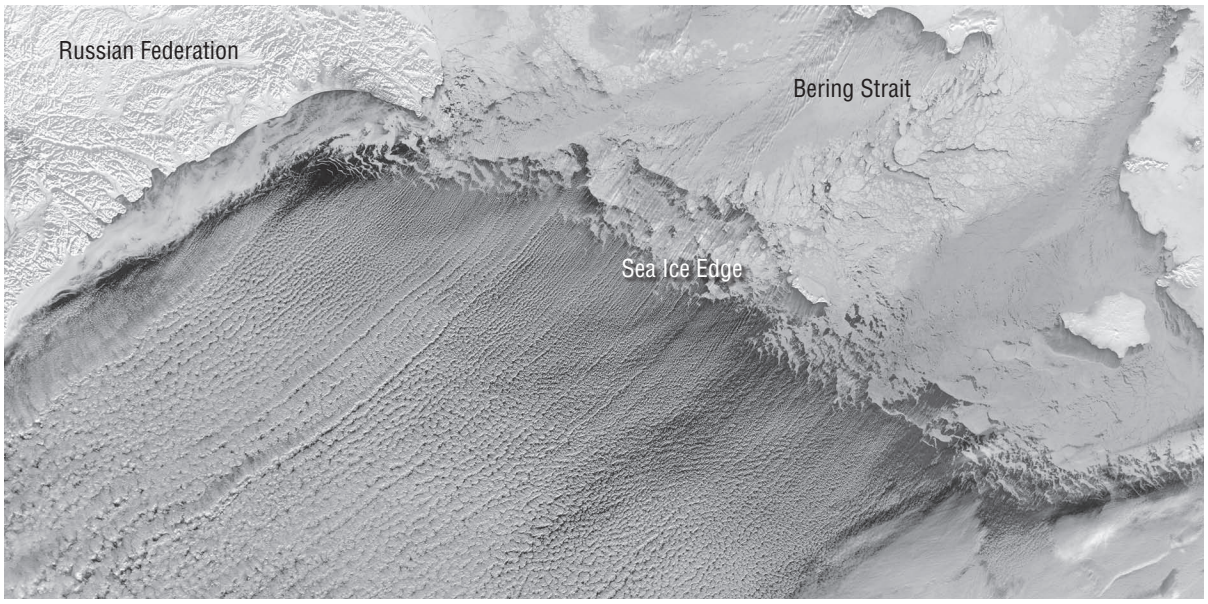
With a Name like GOES-P, This Satellite Has to be Good, February 23; *Universe Today*. The final spacecraft in the "GOES" series of NASA and NOAA geostationary environmental weather satellites successfully launched on March 4, 2010. GOES program manager **Steve Kirkner** (NASA GSFC) explains that the system of satellites monitors the conditions that spawn hurricanes, tornadoes, floods, and other hazards.

The Ocean's Role in Global Warming, February 24; *Softpedia*. **Bill Patzert** (NASA JPL) says that the ocean has a long history of capturing and giving up heat in a process that regulates Earth's temperature, and **Josh Willis** (NASA JPL) explains how this ocean-atmosphere interaction influences climate effects such as El Niño.

ICESat Mission Complete After Seven Years in Orbit, February 25; *Spaceflight Now*. NASA has ceased trying to restart the primary laser instrument of the Ice, Cloud and land Elevation Satellite (ICESat) which stopped emitting light on October 11, and the mission has been declared complete; **Tom Wagner** (NASA HQ) and **Jay Zwally** (NASA GSFC) describe science achievements of the seven-year ice-mapping mission*.

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

** For more details on this topic, see News Article on page 32 in this issue.*



On January 16, 2010 the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite captured this photo-like image of ice and clouds over the Bering Strait. Winds from the north pushed sea ice southward and formed cloud streets—parallel rows of clouds. The easternmost reaches of the Russian Federation, blanketed in snow and ice, appear in the upper left corner of this image. East of that, sea ice spans the Bering Strait. Along the southern edge of the sea ice are wavy tendrils of newly formed, thin sea ice. **Credit:** NASA's MODIS Rapid Response Team

NASA Science Mission Directorate – Science Education Update

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Free Climate Change Web Seminars (March and April)

Join *Windows to the Universe* educators this spring for free 90-minute live seminars highlighting science content and classroom activities on topics related to climate change. Offered through the National Science Teachers Association (NSTA), these seminars are a part of the NASA-funded Global Climate Change Educator Professional Development Network. Remaining seminars in the series include:

April 6 – Global Climate Change and the Earth System
April 14 – Effects of Climate Change: Ocean and Ice
April 22 – Effects of Climate Change to Life on Earth
April 28 – Predicting Future Climate and Considering Solutions

For more information, Web seminar registration and other climate change education resources associated with the project, visit: *www.windows.ucar.edu/tour/link=/teacher_resources/main/gccepdn_main.html.*

NASA Sponsors Odyssey of the Mind

For the 10th time, NASA's Earth Observing System Project Science Office (EOSPSO) is sponsoring an Odyssey of the Mind Long Term Problem. This year's problem, *Nature Trail'R*, requires teams to design, build, and drive a human-powered vehicle and camper that will go on a camping trip. When the vehicle arrives at the campground, the camper will be disconnected and the vehicle will travel on a team-created Nature Trail. On the Nature Trail, the vehicle will overcome an obstacle, clean up the environment, encounter wildlife, and undergo a repair. The performance will include a character in or near the camper that explains the experience as part of its role.

Odyssey of the Mind is an international educational program that provides creative problem-solving opportunities for students from kindergarten through college. For more information, including team registration and practice problems, visit: *www.odysseyofthemind.com/*.

Climate Kids: NASA Gives Elementary School Students Their Own Guide to Climate Change

A blinking red-eyed tree frog and flitting butterfly greet visitors to the new *NASA Climate Kids* Web site. Targeting grades 4–6, this kid-friendly guide demystifies one of the most important science issues of our time. The site answers the "big questions" about global climate change using simple illustrations, humor, interactivity, and age-appropriate language. For example, one interactive feature, the "Climate Time Machine", reveals how global changes have affected or will affect our planet over time. "Climate Tales" has animal cartoon characters coping—more or less good-humouredly—with the effects humans are having on their habitats. A collection of Earth science-related games offers such experiences as "Wild Weather Adventure" and "Missions to Planet Earth." A Green Careers section profiles real people doing jobs that help slow climate change. Visit *Climate Kids* at *climate.nasa.gov/kids*.

Already a Star, NASA's Calandrelli Tells Students To Aim High

In 2009 alone, **Emily Calandrelli** was named to USA Today's All-USA College Academic First Team, received two prestigious scholarships, and was voted West Virginia University's *Ms. Mountaineer* for her exemplary academic achievement and extracurricular involvement. Read about Calandrelli's connection to NASA—and why she encourages students to pursue majors in science, technology, engineering, and mathematics—on the NASA portal.

Article for Grades 9-12 and College-level:
www.nasa.gov/audience/foreducators/already-a-star.html

Article for Grades 5-8:
www.nasa.gov/audience/forstudents/5-8/features/already-a-star-58.html

EOS Science Calendar

April 20–22, 2010
LCLUC Spring Science Team Meeting, Marriott Bethesda North Hotel & Conference Center, Bethesda, MD. URL: *lcluc.umd.edu/*

April 21–22, 2010
AIRS Science Team Meeting, Caltech Beckman Auditorium, Monterey, CA. URL: *airs.jpl.nasa.gov/meetings/science-team-pasadena/*

April 27–29, 2010
CERES Science Team Meeting, Marriott Hotel at City Center at Oyster Point, Newport News, VA.
URL: *science.larc.nasa.gov/ceres/meetings.html*

May 19–21, 2010
SORCE Science Team Meeting, Keystone, CO.
URL: *lasp.colorado.edu/sorce/news/2010ScienceMeeting/index.html*

June 8–11, 2010
ASTER Science Team Meeting, Tokyo, Japan.

September 27–30, 2010
Aura Science Team Meeting, Boulder, CO.

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

Global Change Calendar

June 8–12, 2010
International Polar Year Oslo Science Conference 2010, Oslo, Norway. URL: *www.ipy-osc.no/*

June 24–27, 2010
American Meteorological Society 38th Conference on Broadcast Meteorology, Miami, FL. URL: *www.ametsoc.org/meet/fainst/201038broadcast.html*

June 28–July 2, 2010
13th Conference on Cloud Physics/13th Conference on Atmospheric Radiation, Portland, OR. URL: *www.ametsoc.org/MEET/fainst/201013atmosrad13cloudphysics.html*

July 12–16, 2010
ESRI International User Conference, San Diego, CA.
URL: *www.esri.com/events/user-conference/index.html*

July 25–30, 2010
2010 IEEE International Geoscience and Remote Sensing Symposium, Honolulu, HI.
URL: *www.igarss2010.org/*

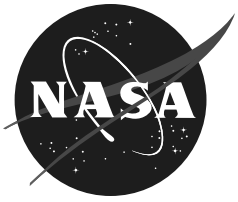
August 8–13, 2010
AGU Meeting of the Americas, Iguassu Falls, Brazil.
URL: www.agu.org/meetings/ja10/

October 2–7, 2010
35th Annual Meeting of the National Weather Association, Marriott University Park Hotel, Tucson, AZ.
URL: *www.nwas.org/events.php*

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

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

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



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