The Earth Observer

Editor's Corner
Michael King
EOS Project Scientist

On behalf of *The Earth Observer* staff, I would like to express my condolences to the many thousands of people that have been impacted by Hurricane's Katrina, Ophelia, and Rita. NASA and its employees have been significantly impacted by these hurricanes. The Michoud Assembly Facility in New Orleans, where space shuttle external tanks are assembled, suffered some minor water damage from Katrina but none of the eight external tanks that were all in various stages of retrofitting were damaged significantly. Meanwhile, NASA's Stennis Space Center near Bay St. Louis, Mississippi suffered water and roof damage courtesy of Katrina, though the full extent of the damage is still being assessed. Hundreds of Stennis employees and their family members took shelter at the Center during the storm. Marshall Space Flight Center (MSFC) in Huntsville, Alabama also sustained minor damage from Katrina, but the facility is supporting recovery efforts at both Stennis and Michoud.

As Hurricane Rita approached a few weeks later, the Houston area was evacuated, including the shutdown of NASA's Johnson Space Center. Control of the International Space Station was temporarily transferred to Russian Mission Control in Moscow, Russia but has now been returned to JSC. Rita also threatened the Michoud and

New Orleans, Louisiana, after Hurricane Katrina struck, as captured by the Advanced Land Imager on NASA's EO-1 Satellite on September 6, 2005. Flooded regions appear dark gray. Image courtesy: Lawrence Ong, EO-1 Mission Science Office, NASA GSFC.

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In This Issue

Earth observing satellites have been hard at work observing the areas affected by these hurricanes and have captured numerous images. The Multi-angle Imaging Spectroradiometer (MISR) captured a pair of scenes of Louisiana and Mississippi—one before the storm on August 14 and one the day after the storm on August 30—that highlight how the hurricane impacted rivers and crops in the region. MISR also viewed cloud spirals on August 30 as Katrina weakened over the Tennessee Valley. For more information, see the article titled *MISR Sees Hurricane Katrina* in this issue. The images can also be viewed at the Earth Observatory website: *earthobservatory.nasa.gov*.

The Moderate Resolution Imaging Spectroradiometer (MODIS) flying on both Terra and Aqua obtained numerous images of the flooded areas in the aftermath of both Katrina and Rita. Two MODIS images acquired 3 days apart compare the same scene before the storm on August 27 and after the storm on August 30, and highlight how much the landscape was changed by flooding caused by Katrina. Even at the relatively coarse 250 m spatial resolution of MODIS, the change is very easily seen from space. A similar pair of images from September 21 and September 25 taken along the Louisiana coast highlights the flooding caused by Rita. MODIS also viewed Ophelia as the storm lingered off the Florida coast on September 8. All of these images can be viewed on the Earth Observatory site and additional images can be found at the MODIS Rapid Fire site: *rapidfire.sci.gsfc.nasa.gov*.

There have also been numerous higher resolution NASA images of the affected areas. The Advanced Land Imager (ALI) on the Earth Observing-1 (EO-1) spacecraft captured a detailed image of the flooding in New Orleans [cover image] caused by the breech in the levees on Lake Pontchartrain on September 6 while the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) obtained a high resolution image pair—compares data from September 8 to a composite of data from June 4, 2005 and April 22, 2001—that shows the barrier islands of the Louisiana coast in Gulf Islands National Seashore before and after the storm. There was also an image pair that showed a picture of the flooding as viewed by the International Space Station taken on September 8 alongside a Landsat 7 Enhanced Thematic Mapper Plus (ETM+) image obtained before the hurricane for comparison. These images can also be viewed on the Earth Observatory.

Additionally, data from a quartet of satellites, including NASA's TOPEX/Poseidon and Jason satellites, monitored sea surface height during Rita's journey toward the Gulf Coast [following page]. This map shows results from a combination of data from these satellites collected on September 21. This image shows ocean circulation patterns in the Gulf of Mexico, framed by

Stennis facilities; however, the worst of the storm passed well to the west of them and they suffered no significant damage.
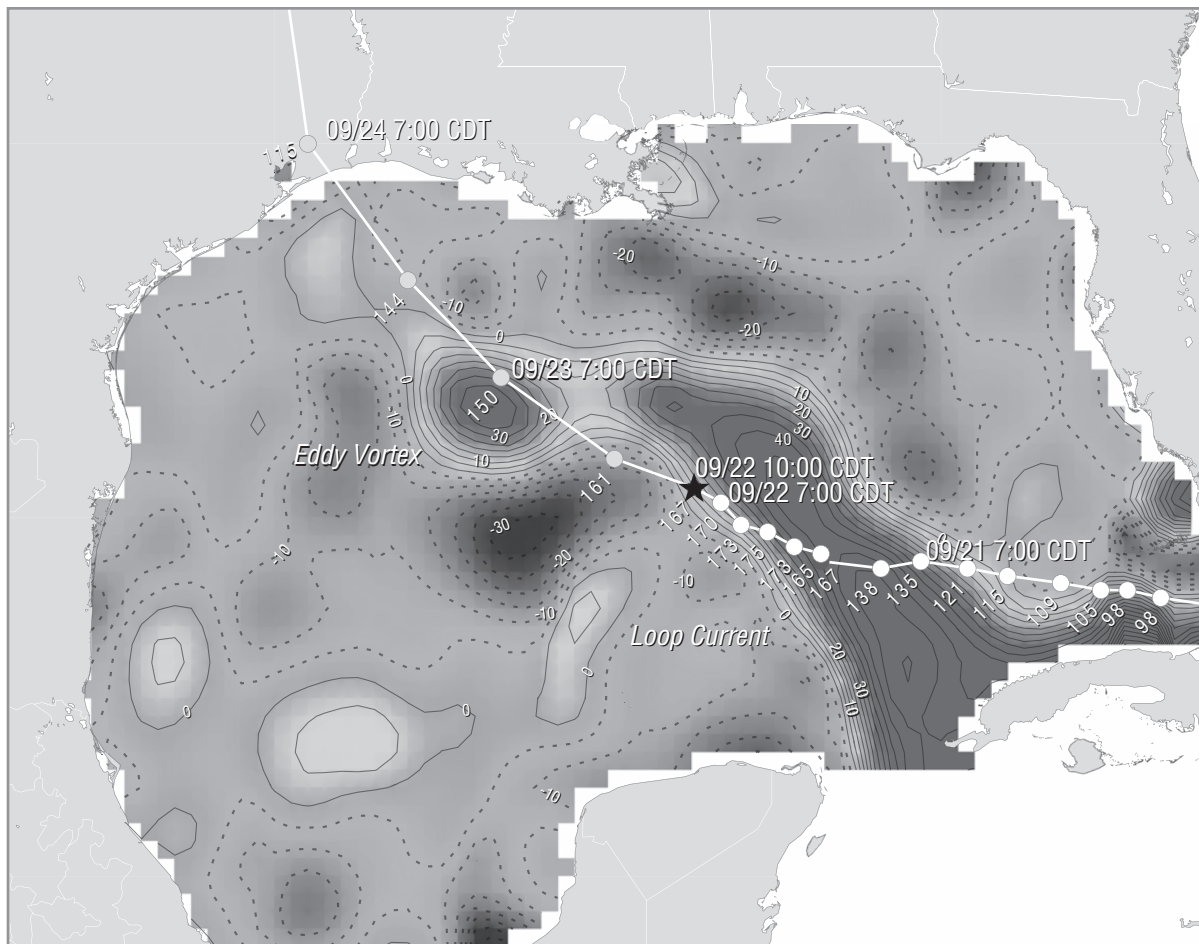
NASA Earth scientists were featured prominently in the coverage of Hurricane Katrina. **Marshall Shepherd** (Deputy Project Scientist for the Global Precipitation Measurement Mission) appeared on Larry King Live and led off his interview segment with an animation of AMSR-E SST data overlaid with coincident GOES Katrina imagery up to August 29, 2005, the date of the live show. A still shot from this animation also appeared in a recent issue of *Newsweek* magazine and the full animation can be found on the Aqua website—*aqua.nasa.gov*. **Jeff Halverson** (Education and Outreach Scientist on the Tropical Rainfall Measuring Mission) was also interviewed on Larry King Live.

A quartet of satellites, including NASA's Topex/Poseidon and Jason, monitored sea surface height during Rita's journey toward the Gulf Coast. This map results from a combination of data from these satellites collected on September 21, 2005. The white circles show measured positions of the hurricane, while grey circles show forecasted positions. Maximum sustained wind speeds at each location are shown in miles per hour (white numbers). This image also shows ocean circulation patterns in the Gulf of Mexico, framed by the Florida peninsula on the right and the Texas-Mexico Gulf Coast on the left (shown in gray). Dark patches surrounded by solid lines indicate strong circulation of warm waters. Sea surface height is a useful measure of potential hurricane activity because storm-fueling warm water is higher than surrounding cooler water. This area is approximately 35 to 60 centimeters (roughly 13 to 23 inches) higher than the surrounding Gulf. Image courtesy NASA/JPL/University of Colorado CCAR.

the Florida peninsula on the east and the Texas-Mexico Gulf Coast on the west (shown in gray). Sea surface height is a useful measure of potential hurricane activity because storm-fueling warm water is higher than surrounding cooler water. The water around the line showing Rita's track is approximately 35 to 60 centimeters (roughly 13 to 23 inches) higher than the surrounding Gulf.

In other news, previously I reported on problems with the High Resolution Dynamics Limb Sounder (HIRDLS) on Aura—a kapton blocks a portion of the scan mirror and prevents horizontal scans. The HIRDLS team has been hard at work trying to prove that they can still make valuable science contributions despite its limited scanning capabilities. I'm pleased to report that the HIRDLS team seems to have some genuinely promising results. For example, they are successfully retrieving temperature profiles—the results clearly show Kelvin waves in the atmosphere. The blockage impacts calibration/validation and thus HIRDLS data

won't be useful for trend analysis, but this was never part of what they hoped to do.

Meanwhile, the Ozone Monitoring Instrument (OMI) has been monitoring the progression of the annual ozone hole in the Antarctic. This year's hole is quite large but is not likely to be a record setting event. OMI has also been providing measurements of SO_2, such as during the eruption of the Anatahan Volcano in the Mariana Islands, and also provisional data on NO_2 concentrations. To see more of the science results from Aura go to *aura.gsfc.nasa.gov/science/sciencegallery.html.*

Finally, NASA Administrator, Michael Griffin, recently spoke at Goddard Space Flight Center and promised to restore some of the funding for NASA's Earth Science Research. This was welcome news in the face of all the cuts we have experienced in the past year. My hat is off to the Administrator for his recognition that NASA's Earth Science Research is an important element in the welfare of this country, and indeed the entire world. ◾

Matter in Motion: Earth's Changing Gravity

Laura Naranjo, naranjol@nsidc.org, National Snow and Ice Data Center

According to legend, Isaac Newton discovered gravity after watching an apple fall from a tree. Using the word *gravitas* (Latin for *weight*), he described the fundamental force that keeps objects anchored to the Earth. Since Newton's time, scientists have used maps of the Earth's gravity to design drainage systems, lay out road networks, and survey land surfaces. But Newton probably didn't imagine that gravity could reveal new information about the global hydrology cycle.

Traditionally, scientists constructed gravity maps using a combination of land measurements, ship records, and, more recently, remote sensing. However, those measurements weren't accurate enough to capture the slight changes in water movement that cause gravity to vary over time. With the help of a new satellite mission, scientists can now weigh water as it circulates around the globe and relate these measurements to changes in sea level, soil moisture, and ice sheets.

To better assess these gravity variations, an international team of engineers and scientists developed the Gravity Recovery and Climate Experiment (GRACE) mission. Launched in March 2002 as a joint venture between NASA and the Deutsches Zentrum für Luft und Raumfahrt (German Aerospace Center), the mission was implemented through collaboration between the University of Texas Center for Space Research, the GeoforschungZentrum (Germany's National Research Centre for Geosciences), and the NASA Jet Propulsion Laboratory (JPL).

GRACE relies on two identical satellites, each about the size of a car. As the satellites fly approximately 220 km (137 mi) apart, one following the other, a microwave ranging system monitors the distance between them to within a micrometer (micron)—smaller than a red blood cell. Scientists can map gravity anywhere on the Earth's surface by measuring tiny changes in distance between the two satellites as each of them speeds up and slows down in response to gravitational force.

Archived at NASA's Physical Oceanography Distributed Active Archive Center (PO.DAAC) in Pasadena, California, and the GeoForschungZentrum Information System and Data Center (GFZ/ISDC), GRACE data are changing the way scientists and modelers view gravity. GRACE provides monthly maps that are at least 100 times more accurate than previous maps at detailing changes in the Earth's gravity field. "The classic idea of gravity being something that you measure once is no longer accepted. Gravity is an element that scientists must continue to monitor," said **Byron Tapley**, director of the Center for Space Research and principal investigator for the GRACE mission.

This map, created using data from the Gravity Recovery and Climate Experiment (GRACE) mission, reveals variations in the Earth's gravity field. Dark areas show areas with lower than normal gravity, such as the Indian Ocean (left of center) and the Congo river basin in Africa. Light areas indicate areas with higher than normal gravity. The long white patch stretching along the western coast of South America indicates the Andes Mountains, while a similar patch on the upper left side of the image indicates the Himalayan mountains in Asia. (Image prepared by The University of Texas Center for Space Research as part of a collaborative data analysis effort with the NASA Jet Propulsion Laboratory and the GeoForschungsZentrum in Potsdam, Germany)

-60   -30   0   30   60
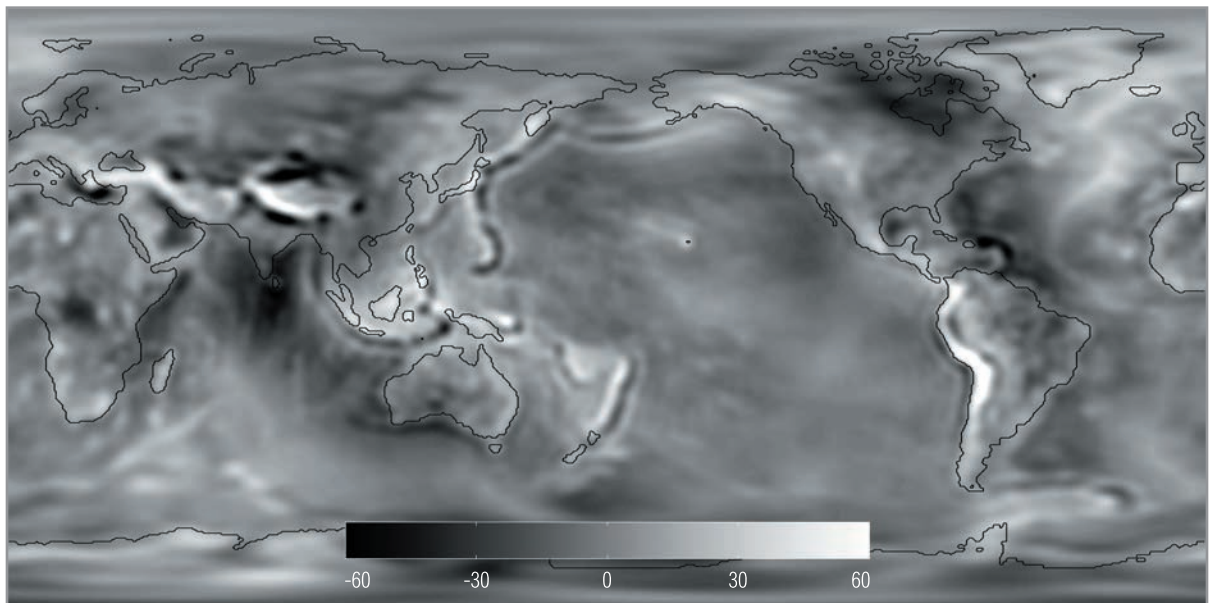
Because scientists can't see, feel, or directly observe gravitational forces, they map the Earth's gravity using a mathematical model that describes an imaginary spherical surface called the *geoid*. The geoid represents oceans as smooth, continuous surfaces unaffected by tides, winds, or currents. It creates a locally horizontal surface against which scientists can measure the downward pull of gravity.

Gravity is determined by how much mass a given material has, so the more mass an object has, the stronger its gravitational pull. For example, granite is a very dense material with a high concentration of mass, so it will exert a greater pull than the same volume of a less-dense material, such as water. Earth's mass is distributed between various landforms and features—such as mountain ranges, oceans, and deep sea trenches—that all have different mass, which creates an uneven gravity field.

Consequently, the geoid doesn't form a perfect sphere, and in maps based on the geoid, the Earth's gravity field exhibits bulges and depressions. "Because the distribution of materials deep inside the Earth varies, its gravity field has hills and valleys [see **Figure 1**]. The ocean tries to lie along that hilly surface," said **Michael Watkins**, GRACE project scientist at JPL. For instance, the ocean surface off the tip of India is about 200 m (650 ft) closer to the Earth's core than the ocean surface near Borneo. Without tides, currents, and wind, the ocean surface would follow the hills and valleys of the geoid, reflecting the variations in the strength of Earth's gravitational force.

"The Earth's gravity field changes from one month to the next mostly due to the mass of water moving around on the surface," said Watkins. "Because water in all its forms has mass and weight, we can actually weigh the ocean moving around. We can weigh rainfall, and we can weigh changes in the polar ice caps."

GRACE observes the Earth's hydrologic cycle and allows scientists to track water as it evaporates into the atmosphere, falls on land in the form of rainfall or snow, or runs off into the ocean. "The biggest freshwater hydrologic events that GRACE detects are the rainfall runoff in the larger river basins, like the Amazon and the monsoon cycle in India," said Tapley.

Detecting how much water is entering the oceans is key to learning about sea-level changes. Other remote-sensing instruments can observe sea level change, but they can't discriminate between thermal expansion (when warmer water expands) and additional mass in the form of water being added to the ocean. "GRACE is sensitive only to the portion of sea-level change that is due to water mass being added," said **Don Chambers**, research scientist at the Center for Space Research. "Most models assume that the total mass of the ocean is constant—that

there is no water being added to it or taken away. With GRACE measurements, modelers will need to account for fluctuations in mass."

Developing a more-accurate account of sea-level change is important for low-lying countries such as Tuvalu. Situated in the Pacific Ocean between Hawaii and Australia, the country is a combination of nine islands and atolls (ring-like coral islands that enclose a lagoon). But because the islands reach a mere 5 m (16 ft) above sea level at their highest point, they are vulnerable to rising oceans. GRACE data can reveal long-term climate trends that may affect sea-level changes.

In addition to gauging changes in water mass on the Earth's surface, GRACE can detect large-scale moisture changes underground. For instance, during record heat waves in Russia in 2002 and Europe in 2003, GRACE data enabled scientists to measure the amount of moisture that evaporated from the soil during those very dry periods. This ability will also alert hydrologists to changes in aquifers and underground water supplies. "It's very hard to measure how much water is deep in the ground and how much it changes from one year to the next. GRACE is one of the few tools we have to do that," said Watkins. "It can help us understand local hydrology, evapotranspiration, precipitation, and river runoff, and it can give us an idea of how much water is available deep in the Earth for irrigation and agriculture."

Scientists are also using GRACE data to survey frozen water in the form of ice sheets and large glaciers. **Isabella Velicogna**, a research scientist at the University of Colorado, studies mass changes in the Greenland ice sheet. "Some components of the seasonal cycle in Greenland are not very well understood, like ice discharge and subglacial hydrology. GRACE '*sees*' some of these components that are difficult to measure," she said. Other instruments, such as altimeters, can determine elevation changes in the ice sheet, but GRACE *can measure* the total mass, alerting scientists to how much ice and water are draining off the ice sheet. "GRACE provides information that you can't get from any other satellite instrument," said Velicogna.

After analyzing two years of data, Velicogna reported a longer-term trend: the ice sheet is losing mass. Although other Greenland research supports this finding, she added that scientists need a longer time series of data to understand what is happening to the ice sheet. Greenland holds about 2,600,000 km³ (624,000 mi³) of ice, which, if melted, would result in a sea-level rise of about 6.5 m (22 ft). Since the late nineteenth century, melting ice sheets and glaciers have increased global sea level by about 1 to 2 cm (0.3 to 0.7 in) per decade.

Even glaciers that melted long ago affect sea level today. For instance, a large mass of ice covered the Hudson Bay

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area during the last Ice Age, which ended around 15,000 years ago. Now, without the weight of glaciers, the land beneath that area is slowly rebounding at a rate of about 1 cm (0.3 in) per year. Over time, this *postglacial rebound* affects regional coastlines, complicating tide-gauge readings and making it harder to monitor changes in global sea level. GRACE data will allow scientists to measure the change that can be attributed to postglacial rebound, making it easier to determine how much other factors— such as global warming—contribute to rising sea levels.

Investigators designed GRACE as a five-year mission, but scientists hope to gather data for up to 10 years. Continuing the mission life will allow them to explore new applications for GRACE data. "We're combining gravity measurements with other data, like those from ice-sheet altimetry or radar altimetry. But we're still trying to understand what all these data tell us," said

Watkins. "It's a very impressive engineering accomplishment that allows us to make such detailed measurements. GRACE gives us high-resolution gravity mapping—it's a pioneering remote-sensing tool."

Reference(s):

Tapley, B.D., S. Bettadpur, M. Watkins, and C. Reigber. 2004. The gravity recovery and climate experiment: mission overview and early results. *Geophysical-Research-Letters*, **31**, L09607, doi:10.1029/2004GL019920.

Chambers, D.P., J. Wahr, and R.S. Nerem. 2004. Preliminary observations of global ocean mass variations with GRACE. *Geophysical-Research-Letters*, **31**, L13310, doi:10.1029/2004GL020461. ▬

Announcement

ESIP Federation Elects 6 New Partners

September 1, 2005—The Federation of Earth Science Information Partners ("Federation") has elected six new partners for full membership. The following projects and company represent the latest class of Federation members:

- The Invasive Species Data Service: Towards Operational Use of Earth Science Data in the USGS Invasive Species Decision Support System, John Schnase, NASA Goddard Space Flight Center, Greenbelt, vMaryland
- Sensor to User - Applying NASA/EOS Data to Coastal Zone Management Applications Developed from Integrated Analyses, Erick Malaret, Applied Coherent Technology, Herndon, Virginia
- Development and Maintenance of An Ocean Color Time Series, Watson Gregg, NASA Goddard Space Flight Center, Greenbelt, Maryland
- Detection and Evaluation of Change in Glacier Systems Using the GLIMS Database, Richard Armstrong, National Snow and Ice Data Center, Boulder, Colorado
- A Geospatial Extension to the NASA Information Power Grid, Rod Bordeaux, Sinte Gleska University, Mission, South Dakota
- Itri Corporation, Jim Etro, Springfield, Virginia

"The Federation's growth during the past few years has been phenomenal," says Thomas Yunck, Federation President. "Together, Federation partners leverage expertise across science, technology, and education to create new products and services for people who care about exploring and protecting Earth. Broadly speaking, the Federation seeks to promote a deeper understanding of Earth's behavior which will result in informed decisions about our planet."

The Federation now has a total of **83** partners representing a wide range of Earth science data interests. Federation partners include science data centers, environmental research groups, innovators in the application of environmental data, educators, and technologists. Across these diverse interests, public, private and non-profit organizations are represented.

The Federation is a consortium of Earth science data centers, researchers, scientists, technologists, educators, and applications developers. The Federation promotes increased accessibility, interoperability, and usability for Earth science data and derivative products. Initiated by NASA in 1997, the Federation provides data, products, and services to decision makers and researchers in public and private settings. The Foundation for Earth Science provides administrative and staff support to the Federation of Earth Science Information Partners.

MISR Sees Hurricane Katrina

Sharon Okonek, sharon.okonek@jpl.nasa.gov, Jet Propulsion Laboratory

Flooding in the Aftermath of Hurricane Katrina

The views of the Louisiana and Mississippi regions in **Figure 1** were acquired before (left) and one day after (right) Katrina made landfall along the Gulf of Mexico coast, and highlight many of the changes to the rivers and crops caused by Hurricane Katrina. NASA's Multi-angle Imaging SpectroRadiometer (MISR) on Terra acquired these images August 14 and August 30, 2005 respectively. These gray-scale images represent multi-angular, multispectral false-color composites that were created using red-band data from MISR's 46° backward- and forward-viewing cameras, and near-infrared data from MISR's nadir camera. Such a display causes water bodies and inundated soil to appear relatively dark while highly vegetated areas appear relatively bright. This differentiation is a result of both spectral effects (living vegetation is highly reflective at near-infrared wavelengths while water is strongly absorbing at near-infrared wavelengths) and of angular effects (wet surfaces preferentially forward scatter [and backward scatter] sunlight). The two images were processed identically and extend from the regions of Greenville, MS (upper left) to Mobile Bay, AL (lower right).

There are numerous rivers along the Mississippi coast that were not apparent in the pre-Katrina image; the most dramatic of these is a new inlet in the Pascagoula River that was not apparent before Katrina. The post-Katrina flooding along the edges of Lake Pontchartrain and the city of New Orleans is also apparent. In addi-tion, the agricultural lands along the Mississippi flood-plain in the upper left exhibit stronger near-infrared brightness before Katrina. After Katrina, many of these agricultural areas exhibit a stronger signal to MISR's oblique cameras, indicating the presence of inundated soil throughout the floodplain. Note that clouds appear in a different spot for each view angle due to their height above the surface.

The Multi-angle Imaging SpectroRadiometer observes the daylit Earth continuously, viewing the entire globe between 82°N and 82°S latitude every nine days. This image covers an area of about 380 km by 410 km. The data products were generated from a portion of the imagery acquired during Terra orbits 30091 and 30324 and utilize data from blocks 64-67 within World Reference System-2 path 22.

Image credit: NASA/GSFC/LaRC/JPL, MISR Team. Text acknowledgment: Clare Averill (Raytheon RIS/Jet Propulsion Laboratory), David J. Diner and Barbara J. Gaitley (Jet Propulsion Laboratory).

Cloud Spirals and Outflow in Tropical Storm Katrina

On Tuesday, August 30, 2005, MISR retrieved cloud-top heights and cloud-tracked wind velocities for Tropical Storm Katrina, as the center of the storm was situated over the Tennessee Valley [see **Figure 2**]. At this time Katrina was weakening and no longer classified

Figure 1: Louisiana and Mississippi regions before and after Katrina made landfall.
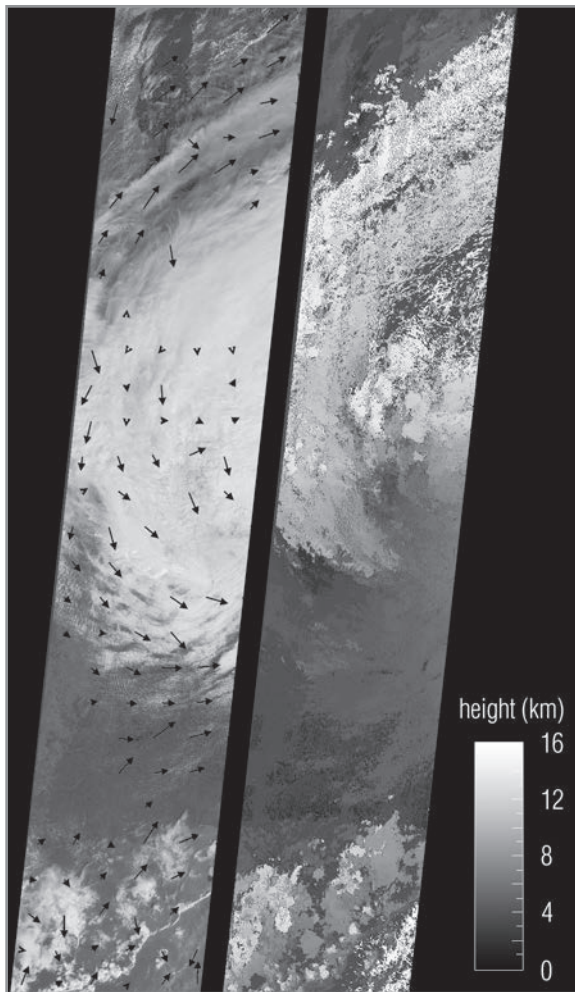

August 14, 2005   August 30, 2005
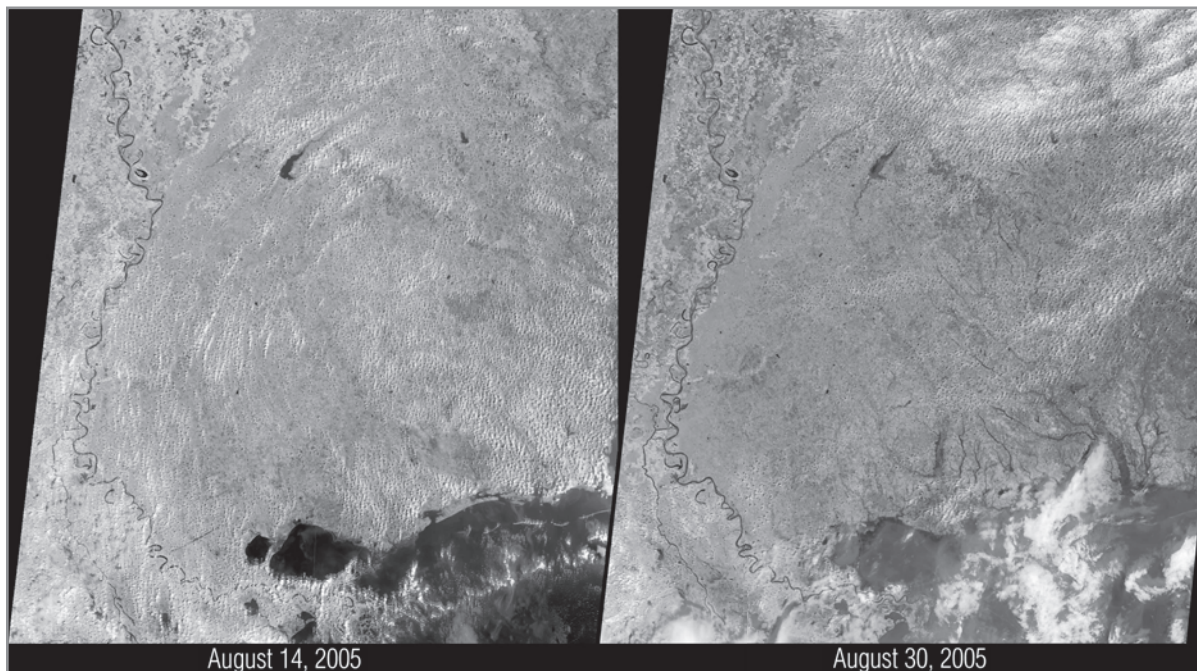
Figure 2: Cloud top heights and cloud-tracked wind velocities for Tropical Storm Katrina, as retrieved by MISR on August 30, 2005.

mph), weakening with distance from the storm center. The image on the right displays the cloud-top height retrievals. Areas where cloud heights could not be retrieved are shown in dark gray. Both the wind-velocity vectors and the cloud-top height field were produced by automated computer recognition of displacements in spatial features within successive MISR images acquired at different view angles and at slightly different times.

This image covers an area of about 380 kilometers by 1970 kilometers. These data products were generated from a portion of the imagery acquired during Terra orbit 30324 and utilize data from blocks 55-68 within World Reference System-2 path 22.

Image credit: NASA/GSFC/LaRC/JPL, MISR Team.

MISR observes the daylit Earth continuously, viewing the entire globe between 82°N and 82°S latitude every nine days. MISR was built and is managed by NASA's Jet Propulsion Laboratory, Pasadena, CA, for NASA's Science Mission Directorate, Washington, DC. The Terra satellite is managed by NASA's Goddard Space Flight Center, Greenbelt, MD. JPL is managed for NASA by the California Institute of Technology.

Text acknowledgments: Clare Averill (Raytheon RIS/ Jet Propulsion Laboratory), David J. Diner, Mike Garay (Jet Propulsion Laboratory), and Greg McFarquhar (University of Illinois at Urbana-Champaign). ▄

as a hurricane and would soon become an extratropical depression. Measurements such as these can help atmospheric scientists compare results of computer-generated hurricane simulations with observed conditions, ultimately allowing them to better represent and understand physical processes occurring in hurricanes.

Because air currents are influenced by the Coriolis force (caused by the rotation of the Earth), Northern Hemisphere hurricanes are characterized by an inward counterclockwise (cyclonic) rotation towards the center. It is less widely known that, at high altitudes, outward-spreading bands of clouds rotate in a clockwise (anti-cyclonic) direction. The image on the left shows the retrieved cloud-tracked winds as black arrows superimposed across the view from MISR's nadir (vertical-viewing) camera. Both the counter-clockwise motion for the lower-level storm clouds and the clockwise motion for the upper clouds are apparent in these images. The speeds for the clockwise upper-level winds have typical values between 40 and 45 m/s (144-162 km/hr, 89-100 mph). The low-level counterclockwise winds have typical values between 7 and 24 m/s (25-86 km/hr, 16-54

NASA's hurricane web site contains interesting up-to-date information on hurricanes. It can be found at *www.nasa.gov/hurricanes*.

Feature Articles

CloudSat and CALIPSO: Unveiling the Mysteries of Clouds and Aerosols

Alan Ward, alan_ward@ssaihq.com, NASA Goddard Space Flight Center
Charlotte Griner, clgriner@earthlink.net, NASA Goddard Space Flight Center
Deb Vane, Deborah.G.Vane@jpl.nasa.gov, NASA Jet Propulsion Laboratory
Chip Trepte, C.R.Trepte@larc.nasa.gov, NASA Langley Research Center
Alan Buis, alan.d.buis@jpl.nasa.gov, NASA Jet Prouplsion Laboratory
Chris Rink, Christopher.P.Rink@nasa.gov, NASA Langley Public Affairs
Katie Lorentz, k.e.lorentz@larc.nasa.gov, NASA Langley Research Center

Aerosols and clouds play important roles in regulating the Earth's weather and climate, and yet there is still much that is unknown about them. NASA will soon launch two more Earth System Science Pathfinder missions—CloudSat and Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO)—that will serve as powerful new Earth-observing tools and advance our understanding of aerosols, clouds, and how the two interact with one another to influence Earth's energy balance and, ultimately, Earth's weather and climate.

CloudSat: Improving the Accuracy of Cloud Predictions to Improve Forecasts of Weather and Climate

Clouds exert an enormous influence on our weather and climate; they are the key element of the Earth's water cycle that carries precipitation and redistributes fresh water over the planet's surface. Perhaps more importantly, clouds are the primary regulator of the Earth's *energy balance*. Earth's energy balance refers to the balance between the sunlight (also called *shortwave radiation*) that the land, oceans, clouds, and aerosols capture or reflect back to space and the heat released to space by the Earth's surface and atmosphere (also called *longwave radiation*).

Our climate exists in a delicate and complicated balance of energy. The balance between incoming sunlight and outgoing energy determines the planet's temperature and ultimately its climate. Clouds exert such a major influence on the energy balance because they directly regulate the amount of the Sun's energy that reaches the Earth's surface and the heat that leaves the Earth's surface and atmosphere. Clouds reflect sunlight to space, which has a cooling effect on the Earth's atmosphere and surface, and they absorb outgoing radiation from the Earth, creating a warming effect on the climate system. The balance between the heating and cooling effect of a cloud depends upon the clouds' physical and microphysical characteristics including its altitude, water and ice content, and the size of the cloud particles. In general, high, thin, ice-crystal clouds like cirrus have a net heating effect, whereas low, thick clouds like stratocumulus tend to have a net cooling effect. Even small changes in the amount of global cloud cover could cause a significant change in the planet's energy balance.

But, which of these two opposing processes dominates? To say this another way, is the net impact of clouds causing the climate to warm or cool? The answer is still not well known and is an important research topic for NASA. The answer depends on many factors that CloudSat will help scientists investigate, including:

- the height of clouds in the sky;
- the size of the tiny particles that make up the cloud;
- the physical structure of the cloud;
- the amount of cloud cover present;
- the amount of water and ice in the cloud; and
- the extent to which clouds at different altitudes overlap each other.

These factors all affect how heat is distributed in the atmosphere and at the Earth's surface, influencing the circulations of the atmosphere and oceans that largely regulate our climate. While scientists currently have excellent information from existing satellite measurements about how radiation is distributed at the top of the atmosphere, they lack good sources of information on the processes at work on the inside of clouds and how energy is actually distributed within the atmosphere.

This lack of understanding of cloud processes is widely believed to be the major obstacle that prevents credible prediction of climate change. Many scientists believe that the biggest unknown is the response of clouds to increased heating caused by greenhouse gases like carbon dioxide.

What's been missing from models used to predict climate change until now is detailed information about the vertical structure and properties of clouds around the world. Since they have such a large influence on the climate and weather, scientists need an improved picture of what clouds do, where they are, and how their structure varies.

CloudSat is a joint U.S./Canadian mission that carries a powerful Cloud Profiling Radar (CPR) with 500-m vertical resolution, and will provide a never-before-seen perspective on clouds. Its unique, powerful radar system is much more sensitive than a typical weather radar and will allow scientists to see the water droplets and ice crystals inside the large cloud masses that make our weather.

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The CloudSat radar is not a passive, scanning device like many of the instruments currently flying on other satellites. The radar sends out an active pulse of energy directly below the spacecraft and receives a return signal. Since it transmits in the upper microwave region (94 GHz) where the signal is not significantly attenuated by clouds, the radar should be able to detect 90% of all ice clouds and 80% of all water clouds.

Cloudsat's cloud observing capabilities represent a significant advance over present observing capabilities and have many applications, especially in improving the models that are used in weather and climate forecasting. CloudSat will answer basic questions about how rain and snow are produced by clouds and how rain and snow are distributed worldwide. This improved information will help us better manage our freshwater resources.

More fundamentally, CloudSat's data will increase our understanding of the critical role clouds play in sustaining life on Earth. Clouds are the key element in the Earth's water cycle, providing the only means for recycling life-sustaining water and delivering it from clouds to the Earth by condensing water vapor into rain. They affect our weather, climate, water supply, and air quality. Improving our weather and climate forecasts will help public policy makers and business leaders make more informed, long-term environmental decisions about public health and the economy.

CloudSat will also help scientists gain a greater understanding of if and why the climate is warming and what the long-term impact of climate change will be on both regional and global scales. Policy makers need this type of information well in advance of potential problems in order to protect islands and coastal regions all over the world.

CALIPSO: Studying Aerosols and Thin Clouds to Improve Forecasts of Weather, Climate and Air Quality

From hazy days, to hurricanes, to summer heat waves, we have all experienced our complex atmosphere at work. Poor air quality days, catastrophic weather events,

Figure 1: The satellite image shown here shows an example of how clouds and aerosols interact. As ships cross the Pacific Ocean, their exhaust releases tiny aerosol particles around which water droplets cluster resulting in narrow strips of clouds in the ships' wakes that standout from the backdrop of lower clouds. CloudSat and CALIPSO provide new tools to help us better understand the interplay between clouds and aerosols. MODIS on NASA's Terra spacecraft obtained this image over the Pacific about 200 to 600 kilometers off the coast of Canada's British Columbia and Washington, Oregon, and California. There is a visible smoke plume trailing out over the ocean from a fire west of Eugene, Oregon. Image courtesy of Jeff Schmaltz, MODIS Rapid Response Team.
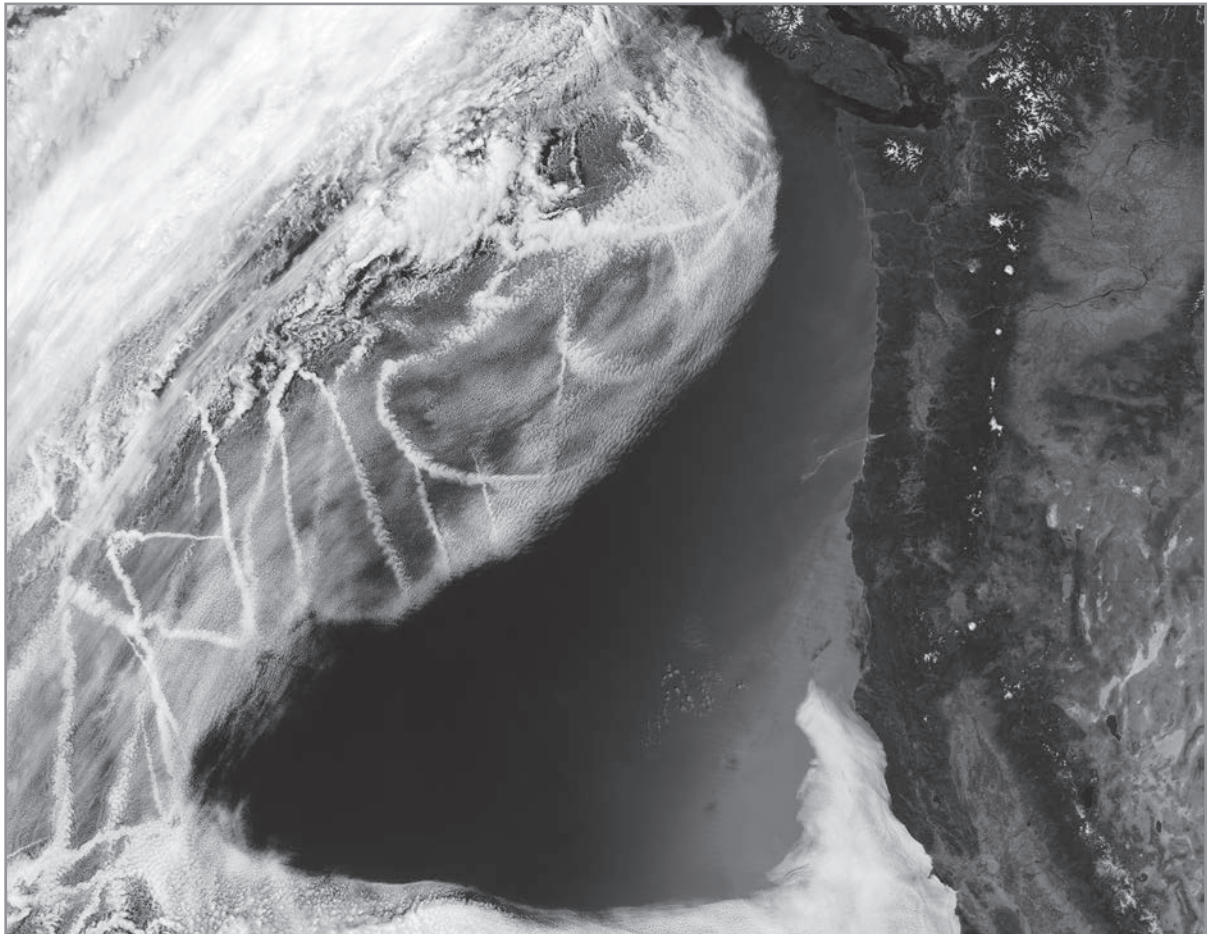
and long-term changes in climate are all matters that can affect our quality of life, our economy, and even our health. Small particles in the air, called aerosols, together with thin clouds, play a major role in regulating Earth's air quality and climate. Scientists are studying both of these atmospheric constituents to answer many difficult questions about our planet and to better predict atmospheric conditions and changes.

Aerosols, from both natural processes and human activities, can also affect the energy balance. Like clouds, aerosols have complex properties. Depending upon their shapes, sizes, and composition they can either reflect sunlight back to space and cool the atmosphere, or absorb sunlight and warm the atmosphere. The haze layer that is commonly seen in the summertime is one example of an aerosol that primarily reflects sunlight. Soot emitted by diesel engines is an example of an aerosol that absorbs sunlight. Each type of aerosol has a distinctively different impact on incoming and outgoing solar energy, so it is critical that scientists distinguish among the different types of aerosols and learn their altitudes in order to know their effect on climate change.

Aerosols also have an influence on clouds. Cloud particles almost always form around aerosols such as natural sea-salt particles or human-made sulfate particles. The presence of additional aerosols can change the way clouds radiate energy and the length of time they stay intact. An example of this radiative effect is the way that exhaust particles emitted into the atmosphere by ships can increase the brightness of clouds along their course [see **Figure 1**].

To better predict the ultimate fate of aerosols, to help devise strategies for limiting pollution, and to improve forecasts of harmful air quality conditions, scientists need better information on aerosol sources and how they enter the atmosphere and interact with weather patterns. A key piece of information that is not provided by currently operating observational satellites is the altitude of aerosol layers in the atmosphere. Aerosols confined to the lowest part of the atmosphere are likely to be removed quickly by rain. On the other hand, those that are lifted to higher altitudes are much more likely to travel long distances and affect air quality in distant countries.

As was the case with clouds, aerosols are poorly represented in climate models. At best, scientists are making only rough estimates of the effects of clouds and aerosols on the atmosphere, rather than using actual data to represent these variables in the simulations. Researchers need to learn more about how clouds and aerosols help cool and warm the Earth, how they interact with each other, and how human activities will change them and their effect on the climate in the future.

CALIPSO, a joint U.S./French collaboration, provides vertical, curtain-like images of the atmosphere on a global scale using a lidar called CALIOP—short for Cloud Aerosol Lidar with Orthogonal Polarization—that uses short pulses of laser light to probe the atmosphere. The lidar sends a signal into the atmosphere and the amount of signal that bounces back to the instrument is used to determine the characteristics of the atmosphere in the signal area. The data from the lidar allow scientists to determine precisely the altitudes of clouds and aerosol layers and the extent of layer overlap, so they can identify the composition of clouds and estimate the abundance and sizes of aerosols.

What is especially exciting about CALIPSO is its ability to collect information about the vertical structure of clouds and aerosols unavailable from other Earth observing satellites. These observations, when combined with coincident data from other missions, will greatly enhance our understanding of how clouds and aerosols interact, the quantity of aerosols produced worldwide, how aerosols are transported, and how long aerosols remain in the atmosphere. CALIPSO measurements will ultimately contribute to improved predictions of weather, climate, and air quality.

CALIPSO's lidar is designed to provide information on the different types of aerosols being measured, as well as the presence of ice and water droplets in the thin clouds. Some particles, such as the ice crystals in cirrus clouds absorb infrared radiation, while other particles reflect the infrared radiation. Ice crystal shapes are infinitely varied, and the shape influences the quantity of sunlight reflected back into space. Scientists don't know which shapes are dominant, or which causes difficulty when trying to predict climate change.

Each lidar measurement is a 100-m wide snap-shot or profile of the atmosphere. Lidar measurements are unique because the *slices* of the atmosphere taken from multiple orbits can be combined to create a 3-D view of the entire globe, much like a CAT scan of the human body. Scientists, like doctors, can look at the individual slices or at the 3-D composite as a whole to examine the properties within the atmosphere.

A passive sensor called an Imaging Infrared Radiometer, or IIR, serves as a complement to the lidar. The three-channel IIR is provided by the Centre National d'Etudes Spatiales (CNES), one of CALIPSO's partners. This instrument has a swath of 65 km (about 40 miles) and measures outgoing thermal radiation emitted toward space from the atmosphere and surface of the Earth. The IIR is designed to allow scientists to estimate the size of ice-cloud crystals and helps
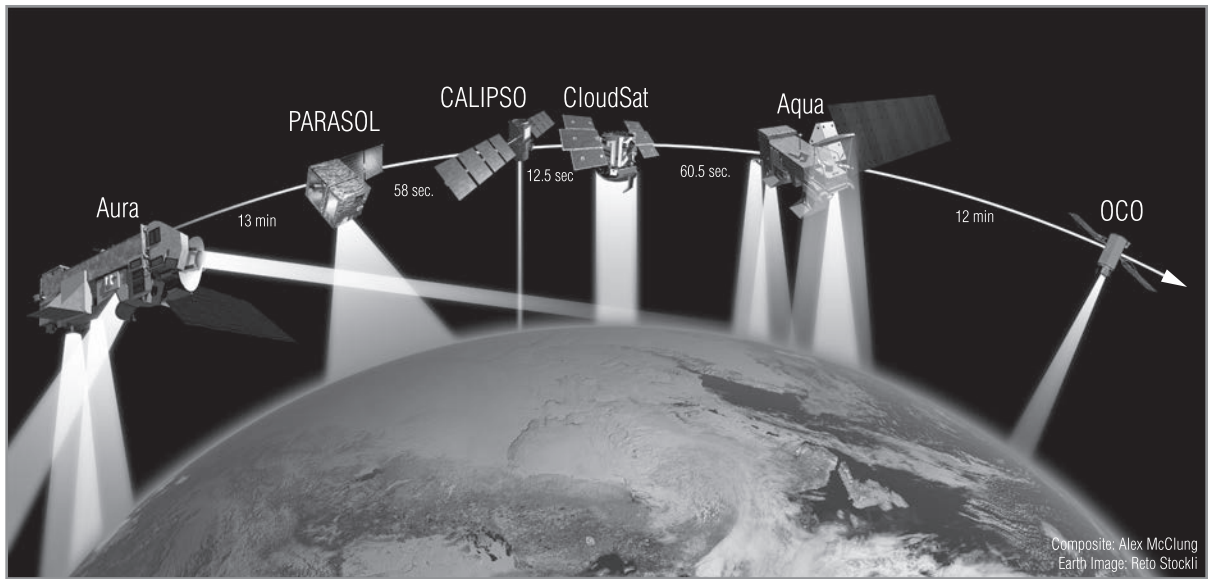
Figure 2: This graphic shows the Afternoon Constellation [or *A-Train*] of satellites. CloudSat and CALIPSO will be situated very close to one another in the formation so that CALIPSO observes a point on the Earth's surface a mere 15 seconds before CloudSat. CALIPSO views a particular point one minute after Aqua passes over. CloudSat will be carefully maneuvered from time to time so that it stays in formation with CALIPSO and with Aqua. It is necessary to maintain this very precise formation flying so the measurements obtained by the various satellites in the *A-Train* can be intercompared.

them estimate the amount of heat these clouds absorb and emit. The lidar is able to give very precise measurements of the altitudes of clouds, improving our interpretation of the IIR measurements. Together, the innovative combination of the lidar and the IIR strengthens our ability to understand cloud properties like never before.

CALIPSO also carries a high-resolution digital Wide-Field Camera (WFC) with a swath of 60 km (about 37 miles) that provides a large-scale view of the atmosphere surrounding the thin column of air probed by the lidar. Camera images will allow scientists to determine if the lidar measurements are from a small, isolated cloud or a cloud that is part of a larger air mass.

CloudSat and CALIPSO Join the A-Train to Study Clouds and Aerosols

Clouds and aerosols are vitally linked to one another. Without aerosols, cloud formation would be next to impossible in our atmosphere. The amount and type of aerosols present help determine the physical characteristics of clouds that form. The properties of the cloud in turn impact how much sunlight is reflected from clouds and how much precipitation falls. There is still a great deal we do not understand about the interplay between clouds and aerosols in our atmosphere. CloudSat and CALIPSO should help us better understand how much influence aerosols are having on cloud formation and precipitation worldwide.

CloudSat Key Facts

Dimensions	Main Structure: 2.54 m x 2.03 m x 2.29 m Solar Array: 5.08 m
Weight	848 kg fully fueled
Power	570 W from solar array
Instrument	Cloud-Profiling Radar (CPR)

CALIPSO Key Facts

Dimensions	Main Structure: 1.9 m x 1.6 m x 2.46 m Solar array: 9.7 m
Weight	587 kg fully fueled
Power	550 W from solar array
Instruments	Cloud-Aerosol Lidar (CALIOP) Imaging Infrared Radiometer (IIR) Wide-Field Camera (WFC)

The two missions will be launched on the same Delta II rocket from Vandenberg Air Force Base and will both be part of the Afternoon Constellation (also called the *A-Train* [see **Figure 2**]) of satellites that already includes the NASA missions Aqua and Aura, and a French CNES mission called Polarization and Anisotropy of Reflectances for Atmospheric Science coupled with Observations from a Lidar (PARASOL). It may also eventually include NASA's Orbiting Carbon Observatory (OCO). The A-Train provides carefully coordinated science observations of the Earth and its atmosphere. The formation is carefully controlled [see **Figure 3**] so that the satellites all observe the same location on the Earth's surface within a few minutes (in some cases, seconds) of one another. The observations are thus *synergistic*, meaning that more information about the condition of the Earth is achieved by the formation than would be possible if all of the missions were flying separately. Combining data from the CloudSat and CALIPSO mis-

sions with observations from the other A-Train satellites will help us:

- improve the computer models used to simulate Earth's climate;
- answer significant questions about climate processes; and
- create a better understanding of global climate change.

Credits: Information for portions of this article was taken from:

- the CloudSat/CALIPSO brochure;
- the ESSP (CALIPSO/CloudSat/GRACE) Science Writer's Guide;
- the CloudSat and CALIPSO entries in the Earth Science Reference Handbook; and
- the CloudSat/CALIPSO Press Kit. ▬

The Baltic Sea blooms with life two times per year, once in the spring and once in the late summer. This photo-like Moderate Resolution Imaging Spectroradiometer (MODIS) image shows the swirls of the summer bloom around the Swedish island of Gotland. The summer bloom is usually caused by blue-green algae growing on the surface of the water. The algae thrive when ocean waters are warm and winds are calm. Strong winds would churn the ocean, stirring the plants down into the water's depths. MODIS flying on board NASA's Aqua satellite captured this image on July 5, 2005. Image courtesy Jeff Schmaltz, MODIS Land Rapid Response Team at NASA GSFC.
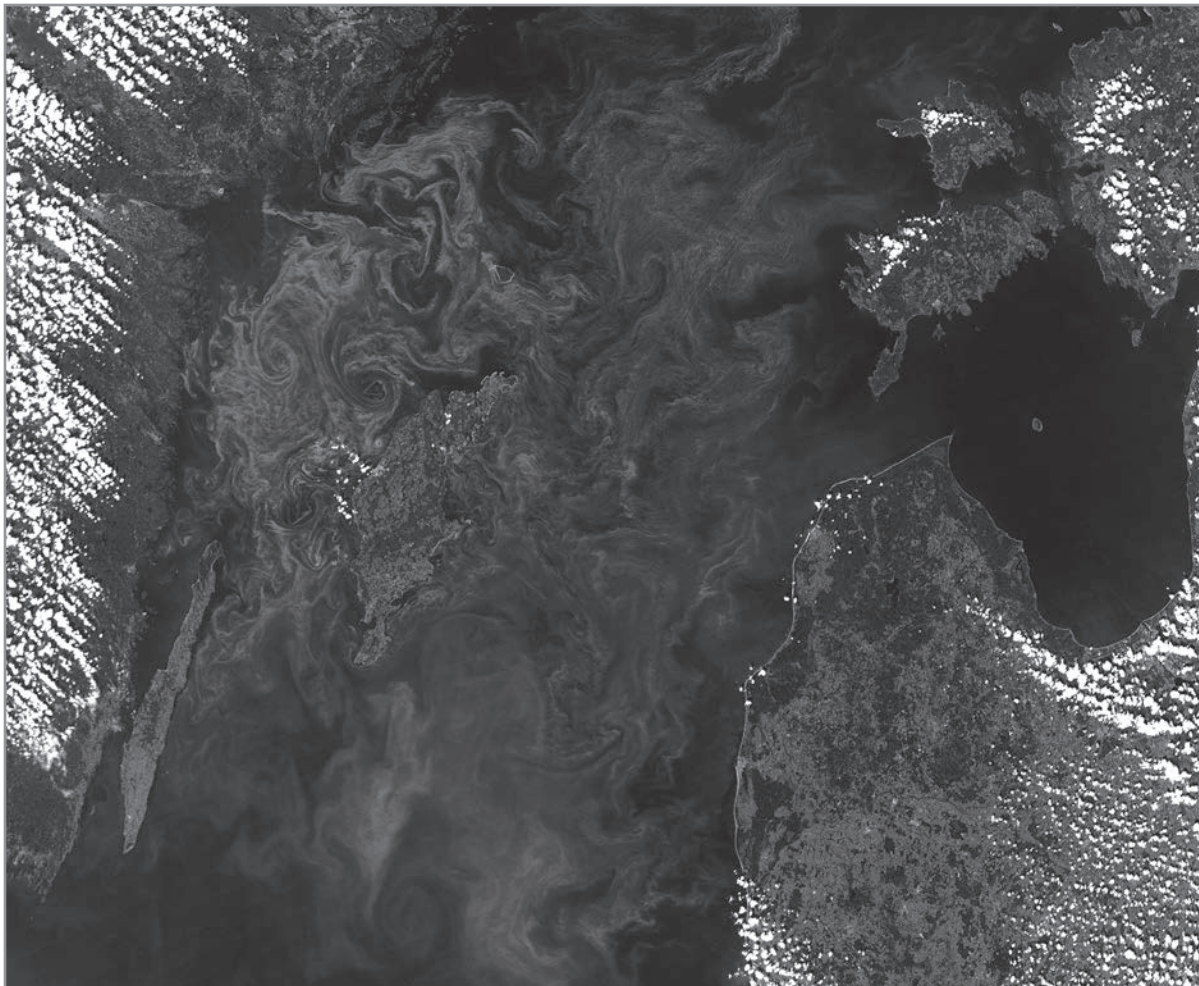
Feature Articles

Featured Articles from the AIRS Quarterly Newsletter

Sharon Okonek, sharon.okonek@jpl.nasa.gov, NASA Jet Propulsion Laboratory

AIRS Improves Weather Forecasts

The Joint Center for Satellite Data Assimilation (JCSDA), established by NASA, NOAA, the U.S. Navy, and the U.S. Air Force to accelerate the assimilation of satellite observations into operational weather forecast models, has just announced that **significant improvement in forecast skill has been achieved with the assimilation of Atmospheric Infrared Sounder (AIRS) data.**

When compared to the rate of forecast improvement over the last ten years, the improvements made in global forecast capability in a relatively short time are quite significant—a several-hour increase in forecast range at five or six days normally takes several years to achieve.

In the study, headed by JCSDA Director **John LeMarshall**, two series of parallel tests were run consisting of 27 consecutive 10-day weather forecasts from January 2004. In the control series, only conventional sources were used to initialize the forecast. For the experimental series, conventional sources plus AIRS observations were used.

To understand how the tests were conducted, three definitions need to be made clear. The term *analysis* refers to the combination of both the forecast model and the real weather data that drives the model. *Forecast* refers to results generated by the model only, and *assimilation* is the process of generating the analysis.

Picture a 27-day timeline that represents the analysis. At each 6-hour interval along the length of the timeline a 10-day weather forecast is generated, initialized by the weather data at that time. Two timelines of analyses were run, one with AIRS data and one without.

A comparison of conventional weather prediction methods (black line) against methods that use AIRS data (gray line) show a significant increase in accuracy.

Southern Hemisphere 500 mb AC Z
20S-80S   Waves 1-20
January 1-31, 2004
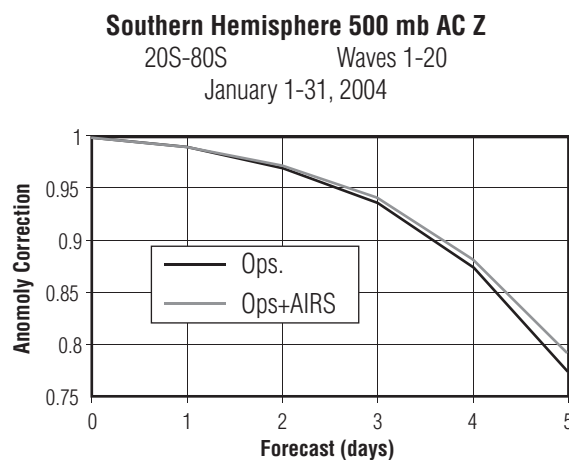
When the results of the 10-day forecasts for both cases were compared to statistics from the National Weather Service, it became clear that the AIRS data had a significant effect on forecast skill over both hemispheres during this period. But because there is more-extensive conventional data coverage in the northern hemisphere than the southern, and because the use of AIRS data over land is currently limited, the forecast impact was slightly less in the northern hemisphere. The AIRS data were also used at less than full spatial and spectral resolution. Ongoing tests continue to be carried out with additional AIRS data.

The JCSDA has determined that if the accuracy gained in the experimental forecasts is mirrored when the AIRS data are used in operational weather forecasting, a significant gain in forecast skill will be realized.

To Catch a Wave

In 1971 while studying zonal winds in the tropical Pacific, **Roland Madden** and **Paul Julian** of the National Center for Atmospheric Research noticed what appeared to be the signature of a large-scale wave moving through the atmosphere. Now referred to as the *Madden-Julian Oscillation*, or simply MJO, this slow eastward-moving wave was found to stretch almost halfway around the world in a band that spanned the equator. In one phase of the wave, air slowly rises, triggering showers and thunderstorms, while in the other phase air slowly sinks, inhibiting clouds and rainfall. Changes between these phases occur approximately every 25-30 days.

The MJO wields its greatest influence in the Indian and western Pacific oceans where it affects the onset and break activity of the Asian-Australian monsoon system. But more than being a major factor in weather fluctuations in the tropics, the MJO can affect the winter jet stream and atmospheric circulation in the northern Pacific and western North America, causing anomalies that can lead to extreme rainfall events. In the summer, the oscillation can cause changes in rainfall patterns in parts of Mexico and South America. The MJO is even being looked at as playing a role in triggering variations in the El Niño Southern Oscillation.

Because of the wide range of weather phenomena associated with the MJO and the profound impacts these phenomena can have, it becomes essential that weather prediction supercomputers contain an accurate model of the wave. And a good model of the MJO will help forecasters better predict its effects, allowing people to better prepare for what's to come. But because of its complex nature, this has been no easy task.

Enter **Duane Waliser** and **Baijun Tian**. Duane, a Principal Scientist at the Jet Propulsion Laboratory and Baijun, a staff scientist at CalTech, are working together with members of JPL's AIRS science team to shoulder the task. The two have taken on the job of trying to properly represent the MJO in the general circulation models (GCMs) used for weather prediction and climate simulation. The most difficult challenge has come from trying to model the wave's hydrological components: water vapor and cloud condensation, and evaporation processes. Most of the research on this problem has involved analysis of data in two dimensions—a horizontal plane in either the upper or lower troposphere. But Duane and Baijun are coming at the problem with something new—3-dimensional data from AIRS.

The 3D structure of the high-resolution AIRS data may be the net that best traps the imprint of the MJO. Duane and Baijun are working to capture its signature in the AIRS data to create a depiction of the wave that can be compared to the model currently contained in the GCMs. The difference between the two should identify how the GCM should be corrected to properly represent the tricky MJO. If Duane and Baijun meet with success, it could be hard to calculate what the improvement in forecast prediction could save in both money and lives. You could say there's a lot riding on the wave.

Traveling Down a Bent Pipeline

In the business of forecasting the weather, there are two over-arching requirements levied on data fed into weather-prediction supercomputers: they must be as accurate as possible and as immediate as possible. **Mitch Goldberg**, head of the Satellite Meteorology and Climatology Division at NOAA/NESDIS, knew that data coming from the AIRS instrument would be accurate enough to make the grade. But how could its extremely rich data, already stored on the spacecraft for up to 90 minutes after acquisition, get from satellite to ground, then processed and routed to numerical weather prediction (NWP) centers around the world in less than the required 3-hour time limit?

Because of limitations in both communication bandwidth and computational resources at NWP centers, Mitch knew the first step had to involve thinning the AIRS data. But how?

To acquire data in both clear and cloudy conditions, the AIRS infrared instrument works with a microwave instrument, Advanced Microwave Sounding Unit (AMSU)-A, on the Aqua spacecraft. As both instruments scan Earth, each microwave field-of-view (FOV) footprint contains a 3x3 array of AIRS infrared FOV footprints. And each AIRS footprint contains 2378 data channels. Because of this large amount of AIRS data, simulations were run to see if a representative set of AIRS channels

actually contained most of the atmospheric signal—and they did. Approximately 300 of the 2378 AIRS data channels were found to contain nearly all the signal of the full 2378-channel set. So the scheme to thin the data was set: Along with all 15 microwave data channels, a subset of AIRS data channels from the centermost footprint of the 3x3 grid is extracted for use by the NWP computers. The 9-fold reduction from using only the center footprint plus the roughly 8-fold reduction from using only 300 channels gave an almost 70-fold reduction in bandwidth.

Now that the data could be thinned enough, a new pathway to the computers at the NWP centers had to be created. The existing pipeline from spacecraft to ground had the data downlinked to receiving stations located in Norway and Alaska. These stations then routed the data via landline to a repository in White Sands, New Mexico, where it was funneled on to the EOS Data and Operations System (EDOS) at the Goddard Space Flight Center in Greenbelt, Maryland. At EDOS the raw data was converted to instrument packet records and archived. The newly formatted data was then sent on to Goddard's Distributed Active Archive Center (DAAC) where it was further processed and finally archived. From end-to-end this pipeline took up to 3 days to traverse—a delay that was acceptable for the DAAC's climate-oriented customers. But clearly this would not work for the people in the business of weather forecasting.

And there was another problem. Spacecraft ephemeris tells exactly where the spacecraft is at any time—you need to know where the instrument is to know where it's looking. But the high-precision ephemeris files take about 30 hours to calculate, so another solution needed to be found. Fortunately, one was readily available. As part of the calculation of spacecraft ephemeris, predicted ephemeris files are generated that forecast the position of the spacecraft over the next few days. While the predicted files are not as accurate, it was found that the 100–meter difference was small enough to be acceptable. In the end, a little spatial accuracy would be given up for speed.

It was time to implement the plan. With the help of NOAA's **Walter Wolf**, a new additional pathway—a *bent pipe*—for the data was devised. After the data stream reached the EDOS it would still get routed to the DAAC, but now it would also be simultaneously sent to a group of powerful Near–Real–Time (NRT) computers, owned by NOAA but located at the same NASA facility which houses the DAAC's computers. No more time would be lost making the data travel from place to place. The NRT computers would prepare the data for use by the NWP centers by applying the thinning scheme and converting it to Binary Universal Format Representation (BUFR), the type used by NWP computers. Several other thinning schemes are applied to create data sets for

Feature Articles

other purposes, but this single–FOV thinned–radiance data set became the type used by most weather forecasting centers assimilating AIRS data into their systems. Once the data were prepped, they could be distributed to the NWP centers.

In October of 2002 the effort to create a fast way to get AIRS data into the weather forecasting supercomputers became a reality—data flow through the bent pipe commenced.

Beyond the Sun—On the Hunt for Other Earth-Like Worlds

Imagine being far out in space and looking back at Earth. Are there characteristics that could be deduced about our home planet even as a distant fuzzy ball? **Thomas Hearty** and **Inseok Song** think there might be. Thomas, a scientist at the Jet Propulsion Laboratory and Inseok, an astronomer at the Gemini Observatory in Hawaii, are using AIRS data to create spectra of the entire Earth as it would be seen by a distant observer. They believe that by examining the signature our own planet makes, we can come closer to understanding the signatures that other

planets make. The two will be using what they find to help define requirements for the Terrestrial Planet Finder, a mission aimed at detecting Earth-like planets around other stars.

Previous whole-Earth spectra have been constructed indirectly using *Earthshine*, i.e., reflected light from the dark side of the Moon. But this approach has only been able to produce spectra in the optical and near-infrared regions and is limited to edge-on viewing angles. Although some low-resolution spectra of the whole Earth have been obtained in the mid-infrared using the Thermal Emission Spectrometer onboard the Mars Global Surveyor, AIRS spectra are the first directly observed high-resolution infrared spectra that span all four seasons. Because AIRS also provides spatial information, its spectra can be weighted to simulate the spectra of extra-solar planets that could be similar to Earth. If Earth was a desert planet, what would its spectral signature look like? If Earth were an ocean planet or snow-covered, what would we see? The data from AIRS may one day provide an important clue in interpreting the characteristics of planets beyond our solar system. ▬

Announcement

The Space Science and Engineering Center (SSEC) has released updated International Moderate-Resolution Imaging Spectroradiometer (MODIS)/Atmospheric Infrared Sounder (AIRS) Processing Package (IMAPP) MODIS Level 2 software for the Cloud Mask, Cloud Top Properties, Atmospheric Profiles, and Ancillary packages. These updates represent the improvements in the algorithms made for the Distributed Active Archive Center (DAAC) collection 5 MODIS reprocessing. A short list of changes include:

Cloud Mask: Improvement of cloud retrieval in sun-glint, nighttime, and high-latitude regimes. Code now requires the Global Data Assimilation System (GDAS) and Sea-Surface Temperature (SST) ancillary files to be used as input.

Cloud Top Properties: New 101 level forward model is now used. New fast-model-coefficient files have been generated. The numerical data month must now be used as an input argument. SST files are now used as input to improve the estimation of the surface temperature over water.

Profiles: Updates to the training data used to create the regression coefficients, including new profiles and better characterization of the surface.

Ancillary: *extract_ncep_gdas1.csh* now extracts 54 fields out of the GDAS grib file instead of 30. These extra fields are used by the cloud-top properties software. Near-Real-Time Special Sensor Microwave Imager (SSM/I) Equal-Area Scalable Earth (EASE)-Grid Daily Global Ice Concentration and Snow Extent (NISE) files sizes are now 218 MB instead of the former 222 MB. You must install this new routine before running the other packages.

The package can be accessed through the IMAPP web page: *cimss.ssec.wisc.edu/~gumley/IMAPP/IMAPP.html*

NASA Technology Monitors Wildlife Habitats From the Air

Mike Bettwy, michael_bettwy@ssaihq.com, Goddard Space Flight Center

Two rare species, California spotted owls in the Sierra Nevada and the Delmarva fox squirrel in the mid-Atlantic U.S. have something in common. Using NASA technology, scientists have been able to identify habitats to help forest managers monitor and protect these species and other wildlife.

The recent research shows that airborne laser scanning with Light Detecting And Ranging (LIDAR) can be especially valuable in ensuring that forests and other lands continue to be diverse, healthy, and productive, while still meeting the needs of society and the environment. The study, funded by the NASA/University of Maryland Vegetation Canopy LIDAR (VCL) mission and a NASA Interdisciplinary Science (IDS) Program grant, was published in the June 2005 issue of the journal *Remote Sensing of the Environment*.

"When we compared the data gathered from the LIDAR, including information on canopy height and cover, to measurements taken on the ground, we found that LIDAR was very accurate, even in extremely rugged mountainous terrain," said **Peter Hyde** of the Department of Geography, University of Maryland-College Park, and lead author of the study. "The use of such technology is advantageous compared with field-based measurements of forest structure that are very time consuming and often limited by accessibility, resulting in relatively small field studies."

The research flights, using NASA's C-130 aircraft, took place in the Sierra Nevada mountains in northern California in 1999. A unique LIDAR, called the Laser Vegetation Imaging Sensor (LVIS), was used. It was built at NASA's Goddard Space Flight Center (GSFC)

This map shows the level of population pressure on wildlife habitats (red shows areas of greatest pressure, where development and other activities threaten wildlife). Image credit: USDA.

Population Pressures on Wildlife Habitat (Local, 2020)

Legend:
- Negligible
- Light
- Moderate
- Moderately Heavy
- Heavy
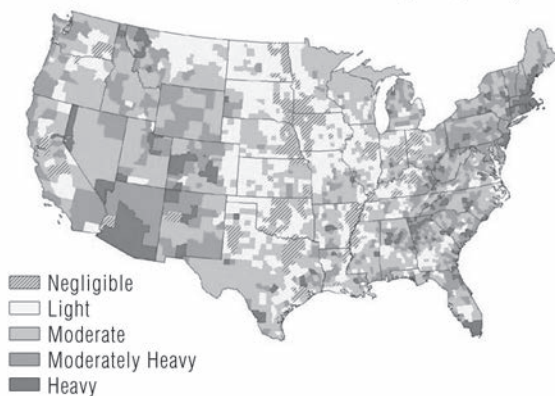
in Greenbelt, Md., and contains five lasers that send pulses of energy to the Earth's surface. Photons from the lasers bounce off leaves, branches, and the ground and reflect back to the instrument.

By analyzing returned LIDAR signals, scientists receive measurements of a forest's canopy, the layer formed by the leaves and branches of the forest's tallest trees. They also get information on tree height and biomass, the amount of living material in a given area. All of this provides a three-dimensional look at forests and represents a significant improvement over earlier radar and other technology that were not able to penetrate thick forest cover very well.

"LIDAR can also effectively distinguish and map old-growth forests, a feat that is difficult with other technology, said Principal Investigator **Ralph Dubayah**, also of the Department of Geography, University of Maryland-College Park.

A similar study looked at the role of forest structure on a specific animal habitat, and was led by **Ross Nelson**, a physical scientist at GSFC. By using data from NASA's airborne LIDAR, called the Portable Airborne System (PALS), the researchers examined about 800 miles of forest in Delaware in the summer of 2000. They also found LIDAR to be successful, especially in locating tall, dense forests that might support endangered Delmarva fox squirrel (DFS) populations. The study was also published in the June 2005 issue of the journal *Remote Sensing of the Environment*.

"Perhaps the most surprising finding was that about 80% of the forests that we identified as tall and dense could serve as a suitable habitat for the DFS," said Nelson. "But, ground visits would be needed to determine if each site is suitable for DFS reintroduction."

DFS, which plays an important role in its ecosystem by distributing tree and other plant seeds, live in mature pine and hardwood forests, especially near farmland. Large trees provide an abundant supply of acorns and seeds for food and provide suitable nests. The conversion of forests into agricultural land, development, timber harvesting, sea level rise, and over-hunting have all contributed to the decline in DFS populations.

In order to protect the DFS habitat, biologists rely on up-to-date information to identify habitats where food and potential nest locations are plentiful. "In the future, say every 5 years, we can follow the same flight paths

In The News

used in this study to determine if habitat has been lost or gained," said Nelson.

Airborne LIDAR and similar techniques are also being used to help monitor and reintroduce other endangered species around the world, like the northern spotted owl that typically resides in old forests in Oregon and California, where trees are more than 100 years old. ▬

Eastern Africa was cloaked in darkness when the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Aqua satellite caught this image on October 3, 2005. The inky blackness that covers much of Ethiopia, Kenya, Uganda, and parts of Sudan and the Democratic Republic of the Congo in this image was caused when the Moon crossed in front of the Sun in an annular solar eclipse. During such an eclipse, the Sun is visible as a fiery circle around the black disk of the moon. In the dimness beneath the Moon's shadow, very little light remained for MODIS to capture this image. Gradations of darkness within the shadowed area can be seen in the clouds. Bright white clouds reflect light well, so they are easily visible, even in the shadow. Since some light reached the Earth, the clouds remain bright along the outer edges of the shadowed region. NASA image courtesy of the MODIS Rapid Response Team at NASA GSFC.
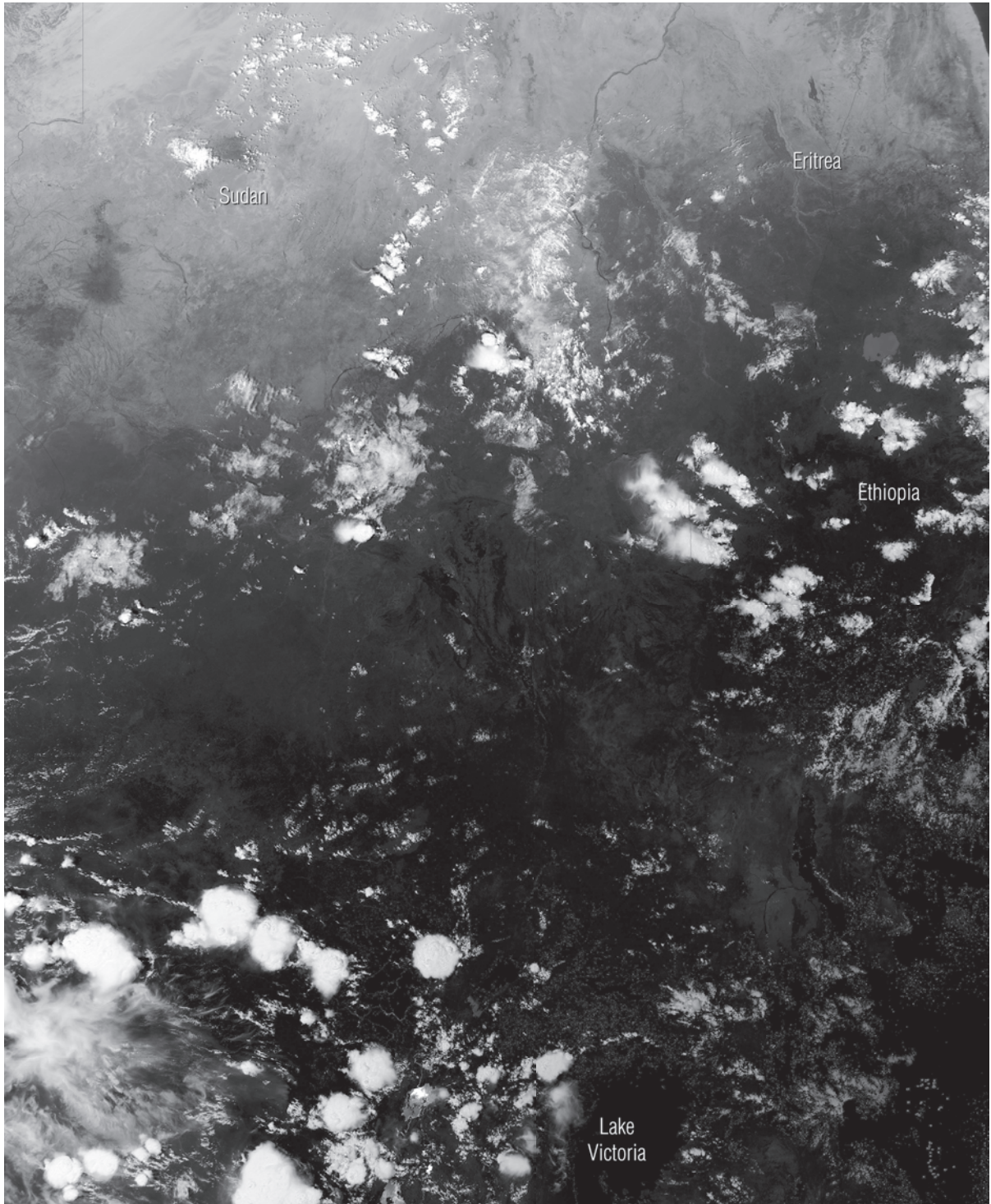
A Warmer World Might Not Be a Wetter One

Mike Bettwy, michael_bettwy@ssaihq.com, Goddard Space Flight Center

A NASA study is offering new insight into how the Earth's water cycle might be influenced by global change. In recent years, scientists have warned that the water cycle may be affected by temperature changes, as warmer temperatures can increase the moisture-holding capacity of air.

The global water cycle involves the transfer of water molecules between the Earth's land masses, cryosphere, oceans and atmosphere. It's a gigantic system powered by the sun, fueling a continuous exchange of moisture between the oceans, atmosphere and land.

Most climate models have shown that a warmer climate will increase global evaporation and precipitation, but the atmospheric storage of water vapor has not yet been well studied.

Recently, researchers from NASA Goddard Space Flight Center, Greenbelt, Md., produced climate simulations of the early and late 20th century. They used sea surface temperature (SST) data and two computer models designed at Goddard Space Flight Center to determine how long water stays in the atmosphere. This is one way of measuring how the global water cycle might be influenced by changes in many variables, including temperature and precipitation.

Despite model differences, both simulations showed an increase in global evaporation and precipitation during this period. But, it is important to recognize that simulated atmospheric temperatures also increased during this period, raising the atmosphere's "total precipitable water"—the amount of liquid water in the atmosphere if all water vapor were suddenly condensed. "By computing a diagnostic for the water cycle rate, which accounts for total atmospheric water vapor and the average rate of precipitation, the models show the water cycling rate is reduced as the temperature warms," said **Michael Bosilovich**, lead author of the study, published in the May 2005 issue of the American Meteorological Society's *Journal of Climate*.

When the researchers studied precipitation simulated over land and sea, they found it decreased over land as the local recycling of water vapor was reduced. Oceanic precipitation, however, had an upward trend along with increased sea surface temperatures, consistent with historical data and earlier studies.

"But, it should be noted that these contrasting land and ocean trends are not universally applicable to all regions," said Bosilovich. "For instance, the precipitation over the North American continent increases, while it decreases over the Gulf of Mexico."

The study also found that land sources of water for precipitation vary considerably within individual regions. Over time, the continental cycle of water appeared to decline, except in the central United States, where it might increase. But, further study is needed with a regional focus to accurately determine local recycling rates. "In regard to the global scale, satellite data is an essential tool in assessing the rate and intensity of the global water cycle. It helps to identify the background state of the climate, but is limited by its short duration of record and deficiencies within historical products," said Bosilovich. "This study highlights the importance of continued high quality, well-maintained observations of atmospheric water content and precipitation rates over both the land and ocean well into the future so that we can more accurately assess changes in the water cycle."

Today, NASA's Aqua and Terra satellites are providing such data by giving new, detailed information on processes that contribute to the water cycle. Ultimately these findings, coupled with data from future satellites, will be incorporated into regional and global computer models, improving both short-term weather forecasts and long-term climate forecasts. Such seasonal predictions carry significant economic implications and are also critical to water resource managers in determining water availability and management.

Other research programs like the NASA Energy and Water Cycle Study also use data from NASA satellites to help scientists learn more about the link between climate and the water cycle, improving their ability to predict events like floods and droughts.

Co-authors of the study include **Siegfried Schubert** and **Gregory Walker** of NASA GSFC. ▬

In celebration of the deployment of its Earth Observing System, NASA is pleased to share the newest in its series of stunning Earth images, affectionately named the "Blue Marble." This new Earth imagery enhances the Blue Marble legacy by providing a detailed look at an entire year in the life of our planet (the image below shows August, 2004). In sharing these Blue Marble images, NASA hopes the public will join with the agency in its continuing exploration of our world from the unique perspective of space.

Blue Marble: Next Generation offers greater spatial detail of the surface and spans a longer data collection period than the original. The original Blue Marble was a composite of four months of MODIS observations with a spatial resolution (level of detail) of 1 square kilometer per pixel. Blue Marble: Next Generation offers a year's worth of monthly composites at a spatial resolution of 500 meters. These monthly images reveal seasonal changes to the land surface: the green-up and dying-back of vegetation in temperate regions such as North America and Europe, dry and wet seasons in the tropics, and

advancing and retreating Northern Hemisphere snow cover. From a computer processing standpoint, the major improvement is the development of a new technique for allowing the computer to automatically recognize and remove cloud-contaminated or otherwise bad data—a process that was previously done manually.

For access to and more information about Blue Marble: Next Generation, see *bluemarble.nasa.gov*.

Monthly imagery shows seasonable variability, like the change in ▶ Alpine snow-cover from January (opposite page, top left) to July (opposite page, top right). (NASA images by Reto Stöckli)

In The News
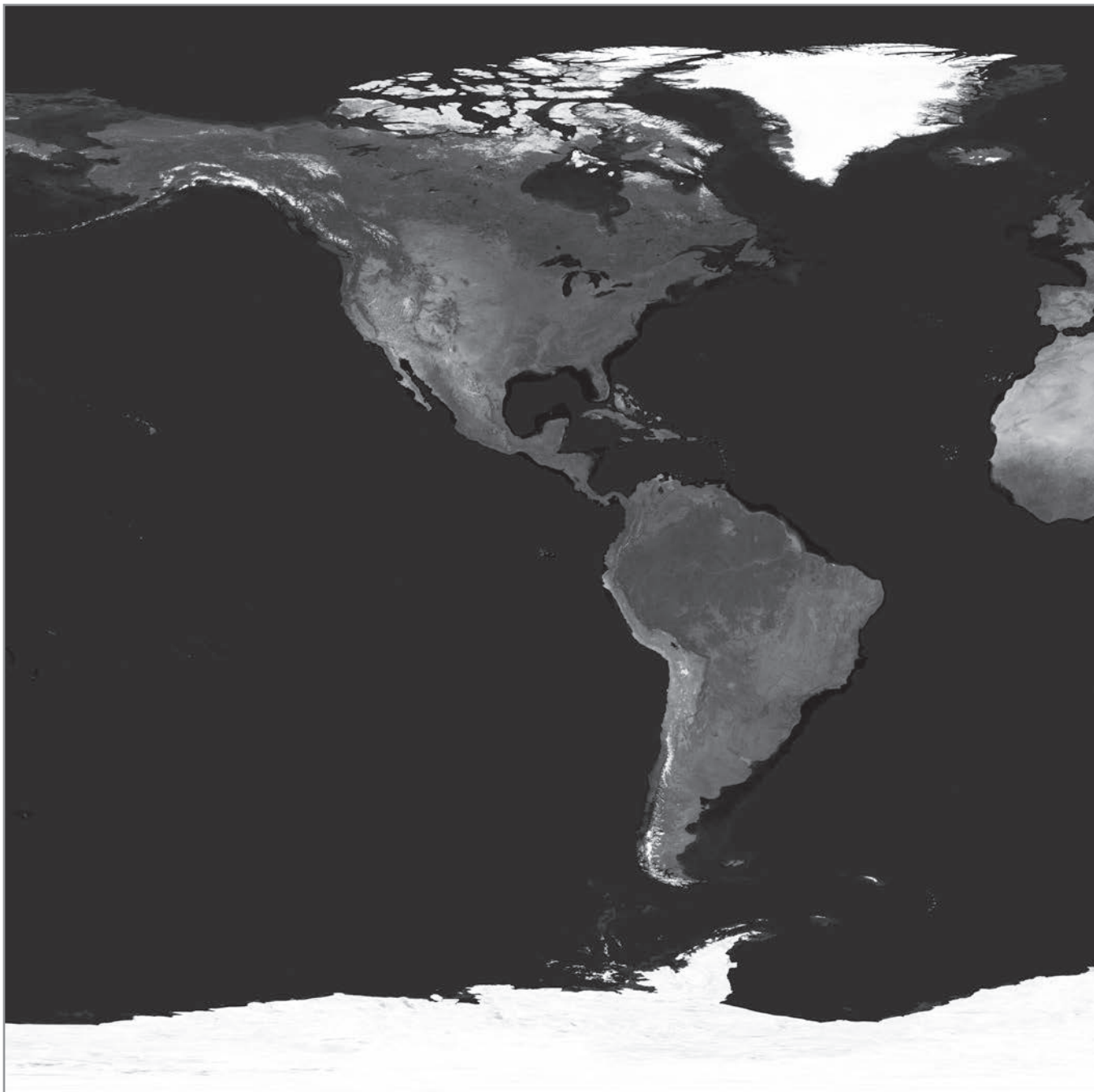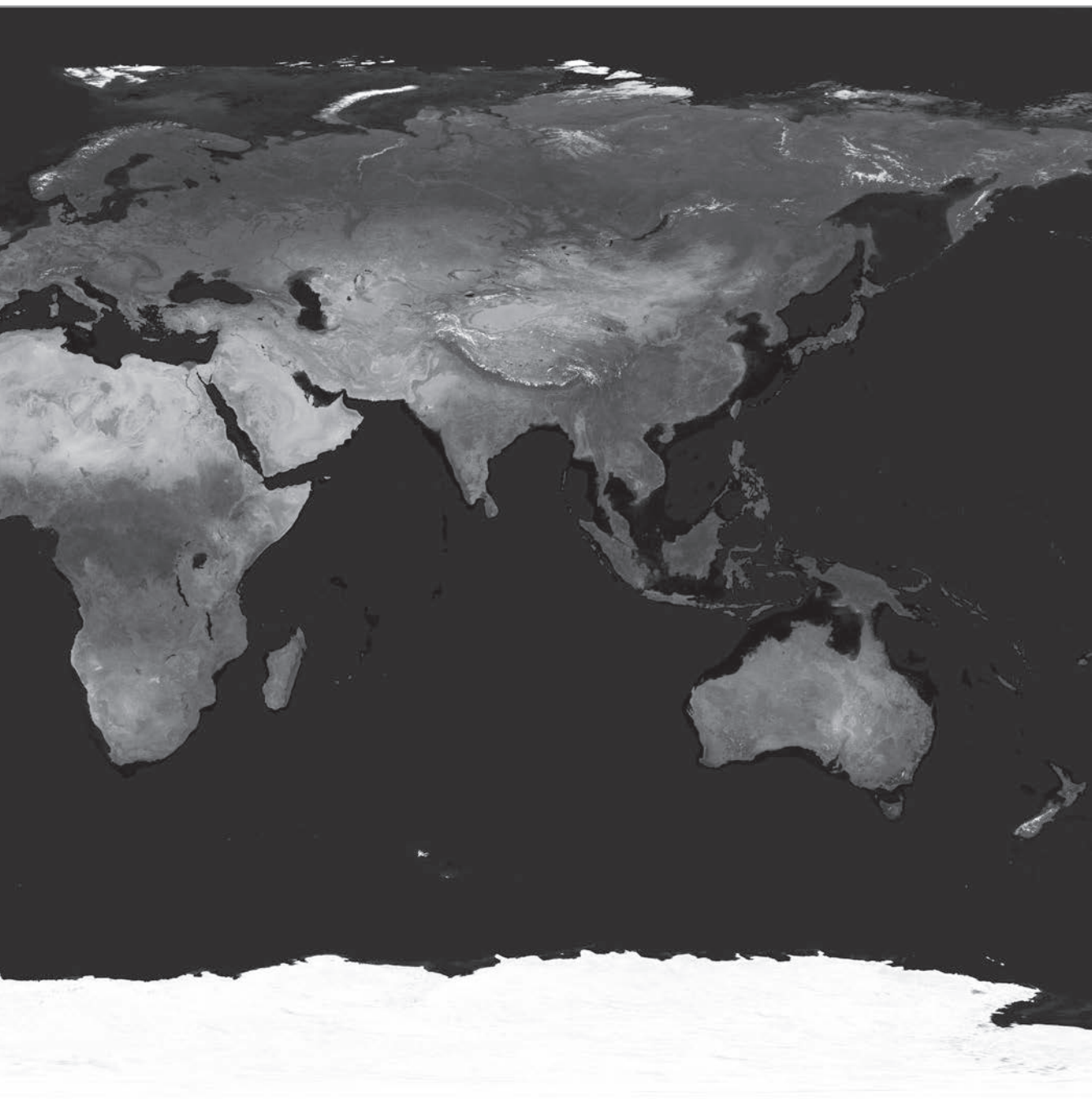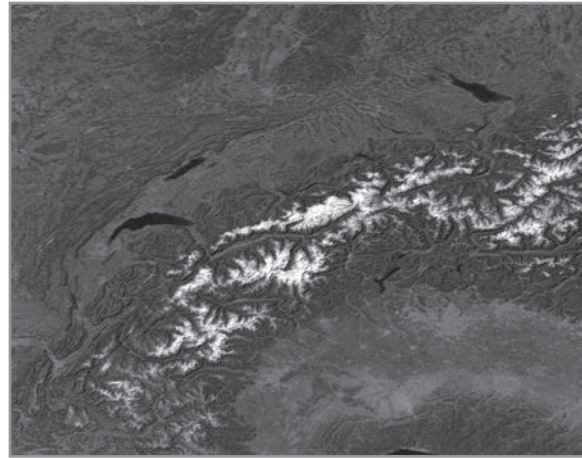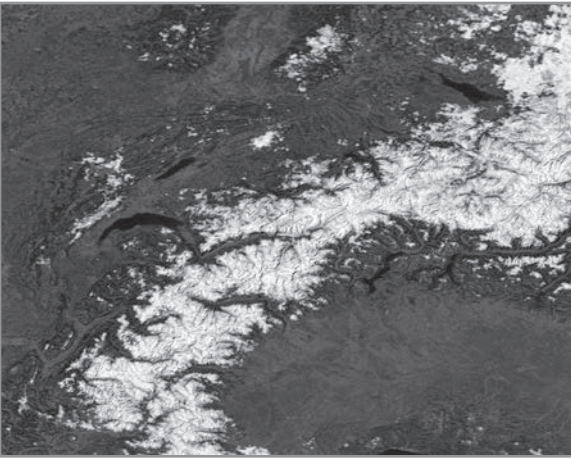
Satellites Spot Mighty Mississippi – In The Atlantic

Mike Bettwy, michael_bettwy@ssaihq.com, Goddard Space Flight Center

Scientists using satellite imagery found that at least 23% of the water released from the mouth of the Mississippi River from July through September 2004 traveled quite a distance—into the Gulf of Mexico, around the Florida Keys, and into the Atlantic Ocean.

The researchers combined data from the Moderate Resolution Imaging Spectroradiometer (MODIS) aboard NASA's Terra and Aqua satellites with information collected from ships to study the water discharge, appearing as a dark plume that stretched from the Mississippi Delta, around Florida and up to the Georgia coast. MODIS detects the color of the ocean due to changes in the amount of tiny ocean plants floating on the ocean's surface known as *phytoplankton*, or algae and other decaying materials.

"This is the first time we have been able to estimate the amount or volume of freshwater discharged and carried over such remote distances. By combining the very detailed data from MODIS with observations from ships, we got a three-dimensional view of the Mississippi plume," said **Chuanmin Hu**, of the College of Marine Science, University of South Florida, St. Petersburg, Fla., and lead author of the study. By using MODIS

This image taken August 14, 2002, by the Moderate-resolution Imaging Spectroradiometer (MODIS), flying aboard NASA's Terra satellite, shows black water off Sanibel Island, Florida, the hook-shaped island on the western coast at the midway point of the image. Credit: NASA GSFC.

Sanibel Island

data with information on sea surface currents and sea salt levels (salinity), the scientists estimated that about 20 billion tons of Mississippi River discharge reached the Florida Straits and Gulf Stream off the Georgia coast. This is equivalent to about four times the volume of Lake Okeechobee, the largest lake in Florida.

In early July 2004, the dark water plume traveled south along the eastern edge of the Loop Current off southwest Florida, reaching the Florida Keys by late July 2004. By early August, MODIS images showed that the plume had expanded along the Gulf Steam as far away as the Georgia coast. The plume was typically 30 to 65 feet (9-20 meters)deep with a width of 6 to 12 miles (9-19 kilometers); although occasionally was as wide as 30-37 miles (48-60 kilometers), before dissipating in October 2004.

While many factors, like *ocean eddies*—that mix waters of varying characteristics—influence the evolution of such events, climate and weather patterns also play a role. For instance, following the Great Midwest Flood of 1993, Mississippi River water also moved into the Florida Current. In 2004, heavy summertime rainfall may have contributed to the plume's large size and persistence. But "it's still too early to know if there is a concrete connection between climate and the occurrence of these events, as much further study is needed," said Hu.

Researchers try to go beyond mapping the dispersal of the river water, by combining satellite information with direct observations from ships and ocean surface drifters, to get a better idea of how these events may affect marine life.

"Mississippi River water may have some impact on marine life in remote delicate ecosystems like the Florida Keys. But we are still not clear about the potential impacts of pollutants and pesticides," said Hu. "Not all effects will be bad; in fact, some light dark water events might actually protect bottom ocean dwellers, like coral, by providing them with shade."

The study is published in the July 2005 issue of *Geophysical Research Letters* under support of NASA, NOAA, and ONR as a contribution to the SouthEast Atlantic Coastal Ocean Observing System (SEACOOS). Coauthors include oceanographers **James Nelson** from the Skidaway Institute of Oceanography, **Elizabeth Johns** from NOAA's Atlantic Oceanographic and Meteorological Laboratory, and **Zhiqiang Chen**, **Robert Weisberg**, and **Frank Muller-Karger** from the University of South Florida. ■

Arctic Sea Ice Continues to Decline, Arctic Temperatures Continue to Rise In 2005

Rob Gutro, Robert.J.Gutro@nasa.gov, Goddard Space Flight Center

Researchers from NASA, the National Snow and Ice Data Center and others using satellite data have detected a significant loss in Arctic sea ice this year.

On September 21, 2005, sea ice extent dropped to 2.05 million sq. miles, the lowest extent yet recorded in the satellite record. Incorporating the 2005 minimum using satellite data going back to 1978, with a projection for ice growth in the last few days of this September, brings the estimated decline in Arctic sea ice to 8.5% per decade over the 27 year satellite record.

Scientists involved in this research are from NASA's Goddard Space Flight Center, Greenbelt, Md., NASA's Jet Propulsion Laboratory, Pasadena, Calif., the National Snow and Ice Data Center at the University of Colorado, Boulder, and the University of Washington, Seattle.

Satellites have made continual observations of Arctic sea ice extent since 1978, recording a general decline throughout that period. Since 2002, satellite records have revealed early onsets of springtime melting in the areas north of Alaska and Siberia. In addition, the 2004-2005 winter season showed a smaller recovery of sea ice extent than any previous winter in the satellite record and the earliest onset of melt throughout the Arctic.

With the exception of May 2005, every month since December 2004 has seen the lowest monthly average since the satellite record began, but more data are needed to fully understand this pattern. Sea ice records prior to late 1978, for example, are comparatively sparse, but they do imply that the recent decline exceeds previous sea ice lows.

Arctic sea ice typically reaches its minimum in September, at the end of the summer melt season. The last four Septembers (2002-2005) have seen sea ice extents 20% below the mean September sea ice extent for 1979-2000.

Perennial ice cover is ice that survives the summer melt, consisting mainly of thick multiyear ice floes that are the mainstay of the Arctic sea ice cover. "Since 1979, by using passive microwave satellite data, we've seen that

Sea ice minimum from 1979.

In The News
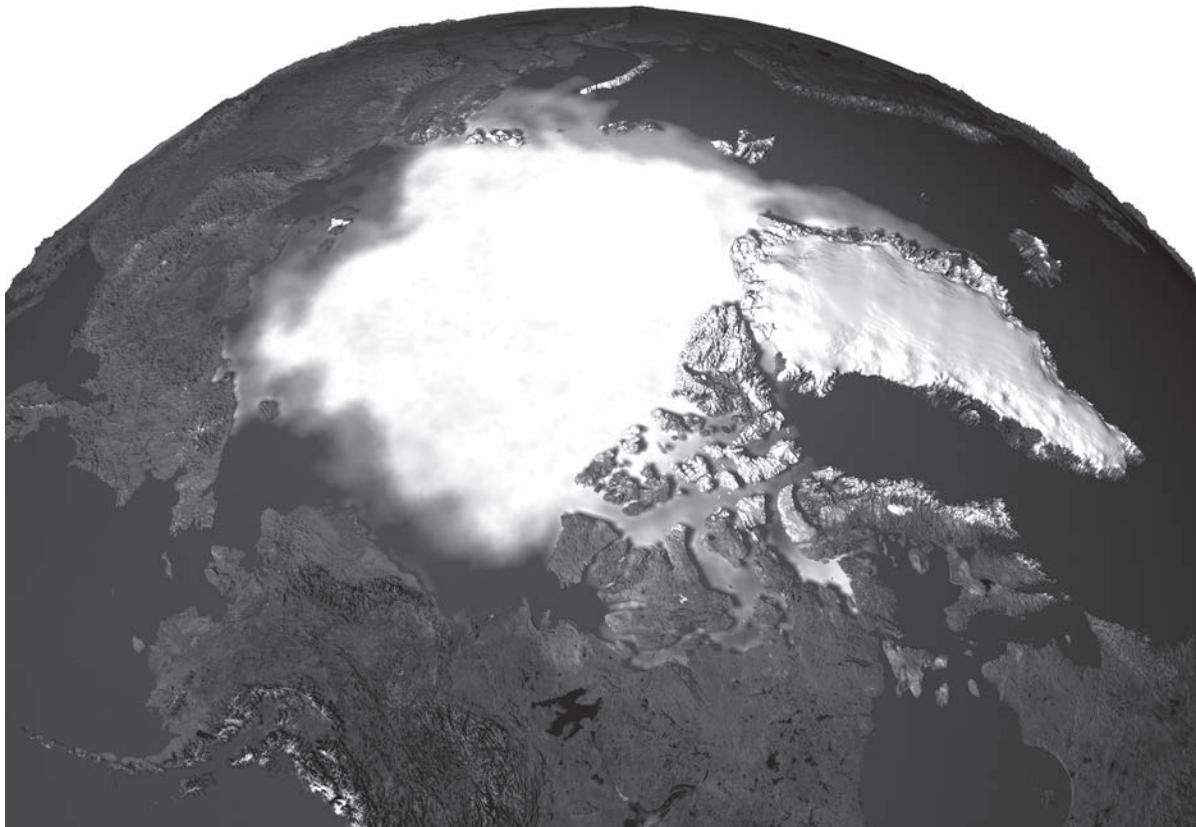
the area of Arctic perennial sea ice cover has been declining at 9.8% per decade," said **Joey Comiso**, senior scientist at Goddard.

For the perennial ice to recover, sustained cooling is needed, especially during the summer period. This has not been the case over the past 20 years, as the satellite data show a warming trend in the Arctic, and it is not expected to be the case in the future, as climate models project continued Arctic warming. If ice were to grow back in these areas, the new ice would likely be thinner and more susceptible to future melt than the thick perennial ice that it replaces.

Scientists are working to understand the extent to which these decreases in sea ice are due to naturally occurring climate variability or longer-term human influenced climate changes.

Scientists believe that the Arctic Oscillation, a major atmospheric circulation pattern that can push sea ice out of the Arctic, may have contributed to the reduction of sea ice in the mid-1990s by making the sea ice more vulnerable to summertime melt.

Sea ice decline could also affect future temperatures in the region. Ice reflects much of the sun's radiation back

into space. As sea ice melts, more exposed ocean water reduces the amount of energy reflected away from the Earth. "Feedbacks in the system are starting to take hold," says the National Snow and Ice Data Center's lead scientist **Ted Scambos**.

Claire Parkinson, senior scientist at Goddard, cautions against thinking that Arctic sea ice is gone for good, especially with such limited data. "The reduced sea ice coverage will lead to more wintertime heat loss from the ocean to the atmosphere and perhaps therefore to colder water temperatures and further ice growth," said Parkinson.

There are many factors beyond warmer temperatures that drive changes in the Arctic. A longer data record, combined with observations from additional environmental parameters now available from NASA satellites, will help scientists better understand the changes they are now seeing.

The study used data from the Defense Meteorological Satellite Program Special Sensor/ Microwave Imager and data from NASA's Scanning Multi-channel Microwave Radiometer (SMMR) on the NIMBUS-7 satellite.

Sea ice minimum from 2005.
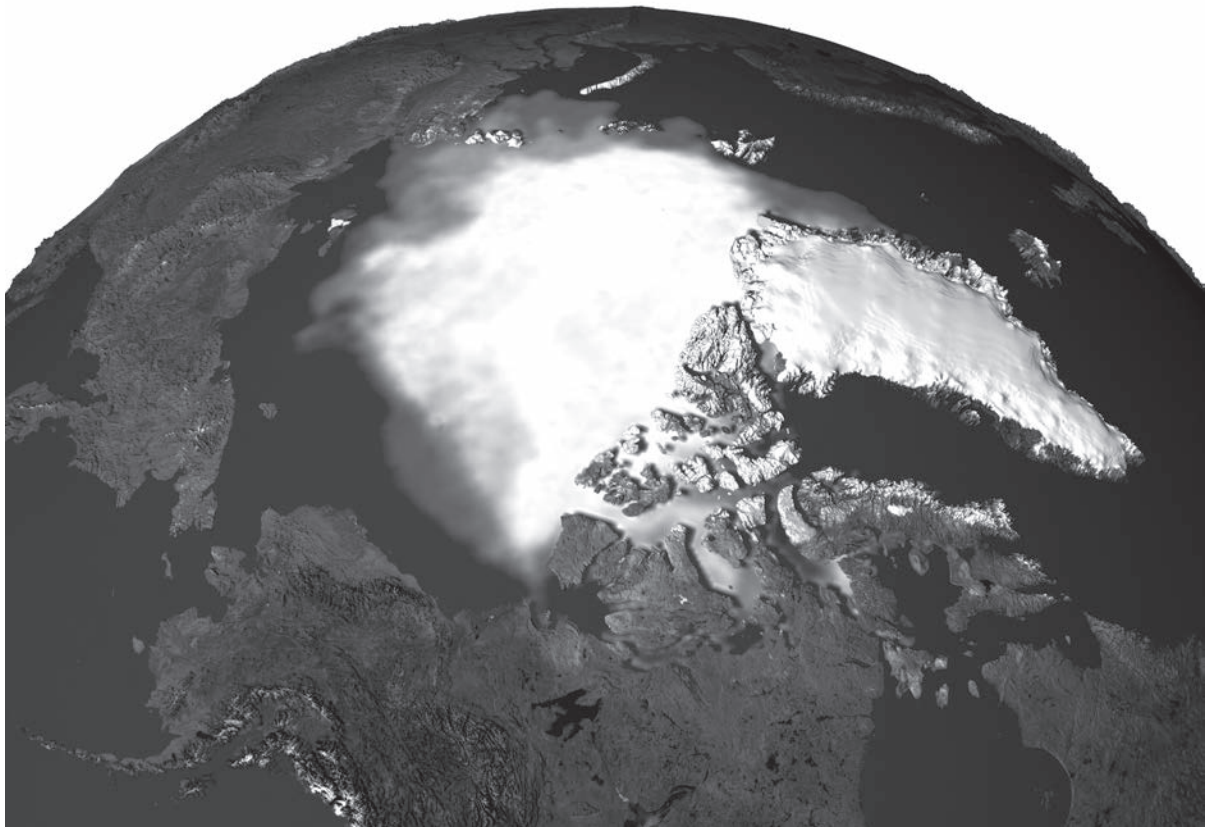
NASA Science Mission Directorate – Earth Science Education Update

Ming-Ying Wei, mwei@hq.nasa.gov, NASA Headquarters
Theresa Schwerin, theresa_schwerin@strategies.org, IGES

Educator Workshop—NASA Satellites Study Earth's Atmosphere: CALIPSO, CloudSat and Aura Partner with the GLOBE Program (CCAG)
Applications due: March 10, 2006

CALIPSO, CloudSat and Aura will provide students worldwide with a link to NASA research through their education and outreach programs. These satellites will be part of a formation of satellites called the Afternoon Constellation or A-Train (because they cross the equator within minutes of each other at 1:30 p.m. local time). The *A-Train* satellites will fly in close proximity, providing combined, detailed observations about the condition of Earth and assisting scientists with making predictions related to climate change.

CCAG will be held July 9-15, 2006, in Hampton, Virginia. This workshop will primarily target middle school educators who will work with the missions by involving their students in collecting and reporting cloud observations and sun photometer data at the GLOBE Program Website. Participants will receive both a stipend and travel expenses. Support will also be provided for participants to present at regional workshops. Applications are due March 10, 2006 and are available at: *calipsooutreach.hamptonu.edu/va2006.html*.

2005-06 Odyssey of the Mind: The Jungle Bloke

NASA is once again partnering with Odyssey of the Mind to sponsor a long-term Earth science problem for their 2005-06 competition. Founded in 1978, Odyssey of the Mind is an international creative problem-solving program for students from kindergarten through college. The competitions involve creative exercises in which teamwork, cooperation, and ingenuity are applied to complete various tasks. Students choose from one of six long-term "problems" and form teams to develop open-ended solutions. Problems range from the technical to the artistic, and solutions are judged for creativity, originality, and other criteria. Each spring, teams take their solutions to official competitions at the regional, state, country, and world level.

For the 2005-06 NASA-sponsored problem, teams will create and present a performance about a Bloke, a person who has the ability to talk with and understand animals from a jungle. Part or all of the performance will take place in a jungle selected from a list. The animals will tell the Bloke about a problem that exists there and get the Bloke to help. The animals will also help the

Bloke in some way. The Bloke will convince someone else that he has the ability to talk with the animals. The presentation will include an original song and dance. Cost limit: $125 USD. For more information, visit: *odysseyofthemind.com/materials/2006problems.php*.

NASA Earth Explorers Equal to the Task

University of Connecticut oceanographer **Heidi Dierssen** spends days at sea and hours in the laboratory, all the while thinking about her two daughters, ages 5 and 3. Dierssen is a perfect example for her children and young girls everywhere that women are as capable as men in math and science.

Look for NASA Earth Explorers at *www.nasa.gov/home* (click on "*For Educators*" or "*For Students*," then look for "*Meet This Month's NASA Earth Explorer!*" graphic or find an article under "*Educational Features*"). Versions of the article appearing in the "*For Students K-4*" and "*For Students 5-8*" sections are specially written for those grade levels. To access the full collection of Earth Explorers articles, go to *science.hq.nasa.gov/education/earth_explorers/*. An index of articles by topic, can be found at *strategies.org/EarthExplorers/EEIndex.htm*.

Hurricane Resources and Articles

The NASA Hurricane Resource Page (*www.nasa.gov/vision/earth/lookingatearth/hurricane_2005.html*) includes the latest NASA news stories, feature articles, satellite images, and bios of NASA hurricane experts. This site also includes links to NOAA hurricane resources.

Researchers Explore Mystery of Hurricane Formation (*earthobservatory.nasa.gov/Newsroom/NasaNews/2005/2005092320505.html*). All Atlantic hurricanes begin as a small disturbance in the atmosphere above equatorial Africa, but only some develop into tropical depressions, grow into tropical storms, and finally evolve into full-blown hurricanes.

ENVISAT and ERS-2 Reveal Hidden Side of Hurricane Rita (earthobservatory.nasa.gov/Newsroom/MediaAlerts/2005/2005092320503.html). As Hurricane Rita entered the Gulf of Mexico, ESA's Envisat satellite was able to pierce through swirling clouds to show how the storm churned the sea surface.

Heat in the Gulf (www.nasa.gov/vision/earth/lookingatearth/katrina_seaheight.html). Research using NASA

and NOAA satellite data are helping us to better understand the link between ocean temperature under hurricane storm tracks, and its role in intensifying storms.

NASA Satellites Record a Month for the Hurricane History Books (*www.nasa.gov/vision/earth/lookingatearth/hurricane_record.html*). July 2005 was a record-setting month in the world of Atlantic Ocean hurricanes with a record high of five named storms. According to NASA satellite data, the winds and sea surface temperatures were perfect during the month of July to help these five tropical cyclones form.

Massive Oil Spills Stain Louisiana (sciencebulletins.amnh. org/bio/s/katrina_oil.20050926/index.php). Check out the latest Hurricane Katrina images at Science Bulletins from the American Museum of Natural History. On this Web page, you can explore satellite images that highlight current topics in biodiversity research and conservation. ▬

The Strange Days on Planet Earth Project

Desperate Housewives, *Survivor*, *Fear Factor*—we all know the power of television to tantalize. But what about its potential to educate young adults, to advance scientific literacy, and to inspire environmental stewardship? Surprisingly few studies have actually explored the role television can play in advancing adult science education.

The *Strange Days on Planet Earth* takes on this task and more. The project investigates how television, the Internet and a nationwide consortium of informal science centers can work together to raise public awareness of Earth system science and human impacts on the environment while inspiring conservation action. Tackling the vital issues of invasive species, climate change, loss of top predators, and pollution in our waterways, the project features a PBS award-winning 4-hour documentary series accompanied by an in-depth Web site, *www.pbs.org/strangedays*, with a 150-page activity guide for 12-14 year olds. This guide is correlated to national science education standards and conforms to the North American Association for Environmental Education (NAAEE) Excellence in Environmental Education—Guidelines for Learning (K-12).

In addition, the project is catalyzing the creation of an exciting nationwide early detection and reporting system for invasive species that enlists and trains volunteer citizen scientists at *www.desertmuseum.org/invaders/*.

David Herring
dherring@climate.gsfc.nasa.gov
Program Manager for Education & Outreach
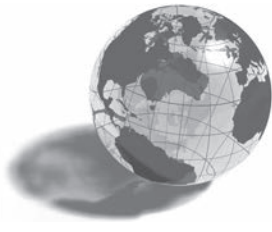
EOS Scientists in the News

Rob Gutro, rgutro@pop900.gsfc.nasa.gov, NASA Earth Science News Team

A Warmer World Might Not Be a Wetter One, October 17; *Scientific American*, *Innovations Report*, *RedNova.com*, *BrightSurf.com*. Research conducted by **Mike Bosilovich** (NASA GSFC), **Gregory Walker** (NASA GSFC), and **Siegfired Schubert** (NASA GSFC) shows that a warmer planet might actually "weaken" the Earth's water cycle.

Hurricane Charley Slices a Florida Island, October 11; *RedTram.com*, *Innovations Report*, *The Florida Statesman*, *St. Petersburg Times*; NASA, NOAA and Army Corps of Engineers researchers, including **C. Wayne Wright** (NASA Wallops) discuss how technology is being used to assess the impacts of Hurricane Charley, including its damage to North Captiva Island, Florida.

A Heated 3-D Look into Hurricane Erin's Eye, October 6; *Science Blog, Science Daily*. International coverage included: China, Germany and the United Kingdom. **Jeff Halverson** (NASA GSFC) discusses hurricane tracking and intensity predictions and how projects like CAMEX-4, which studied several hurricanes, including Erin, are allowing meteorologists to provide more accurate and timely warnings to the public.

NASA Scientists Confirm Toxic Seas during Earth's Evolution, October 6; *Science Daily*, *Terra Daily*, *SpaceFlightNow*. NASA exobiology researchers, including **Carl Pilcher** (NASA HQ) confirmed Earth's oceans were once rich in sulfides that would prevent advanced life forms, such as fish and mammals, from thriving.

Santa Ana Winds Whip Fires across Southland / The Fire Season is Not Over / Wildfires Rage Across Southern California, September 30; *The Washington Post*, September 29; *Los Angeles Times.* September 28; *Ventura County Star News*. **Bill Patzert** (NASA/JPL) is interviewed about Southern California blazes fueled by brush and fanned by Santa Ana winds, burning more than 17,000 acres.

Satellites Continue to See Decline in Arctic Sea Ice in 2005, September 28; *Associated Press*, *Reuters*, *ABC*, *BBC*, *CBS*, *CNN*, *CTV*, *The New York Times*, *San Francisco Chronicle*, *The Washington Post*, *USA Today*, and many others. Researchers **Joey Comiso** (NASA GSFC), **Claire Parkinson** (NASA GSFC), and **Ted Scambos** (NSIDC) discuss findings based on satellite data indicating a significant loss in Arctic sea ice this year.

Long-Term, L.A. Feels the Warmth, September 27; *Los Angeles Times*, *KFWB News Radio 980AM*. **Bill Patzert** (NASA JPL) is interviewed about long-term temperature rises that persist, despite cooler than normal summer temperatures in California.

Researchers Explore Mystery of Hurricane Formation, September 23; *PhysOrg.com*, *RedNova.com*, *La Canada Valley Sun* (CA), *HometownSource.com*. Scientists have a more advanced understanding of hurricanes because of ongoing research, including this summer's Tropical Cloud Systems and Processes Mission, conducted by scientists **Bjorn Lambrigtsen** (NASA JPL) and colleagues off Costa Rica.

La Nada, September 23; *KPCC NPR 89.3 FM Los Angeles*, *KABC 790AM Los Angeles*. **Bill Patzert** (NASA JPL) is interviewed on NPR's "*Talk of the City*" about "La Nada," forecasting difficulty, and Hurricane Rita.

NASA Technology Monitors Wildlife Habitats from the Air, September 22; *YubaNet.com* (CA), *Science Daily*, *Terra Daily*. LIDAR technology developed by NASA is helping wildlife managers and researchers track two rare species, California spotted owls in the Sierra Nevada and the Delmarva fox squirrel, say scientists **Ross Nelson** (NASA GSFC), **Peter Hyde** (University of Maryland), and **Ralph Dubayah** (University of Maryland).

NASA, NOAA, and Aerosonde Team Up on Hurricane Observation Milestone, September 22; *Scripps Howard*, *LiveScience.com*, *UVOnline.com* (UK), *Biloxi Sun Herald.* NASA, NOAA, and Aerosonde North America teamed up to mark a new milestone in hurricane observation on September 16 as an unmanned aircraft flew into Hurricane Ophelia—researchers **Cheryl Yuhas** (NASA HQ), **Greg Holland** (Aerosonde North America), and **Joe Cline** (NOAA AOML) say the aircraft provided the first ever detailed observations of the near-surface, high wind hurricane environment.

Hurricanes and California?, September 22; *KNX News Radio 1090 AM Los Angeles*. **Bill Patzert** (NASA

EOS Scientists in the News

JPL) is interviewed about the possibility of a hurricane hitting Southern California.

Satellites Spot Mighty Mississippi—in the Atlantic, September 15; *Big News Network*, *Innovations Report*, *PhysOrg.com*, *RedNova.com*, *Science Daily*, *Space Daily*, *Terra Daily*. Scientists **Chuanmin Hu** (University of South Florida), **James Nelson** (Skidaway Institute of Oceanography), **Elizabeth Johns** (NOAA/Atlantic Oceanographic and Meteorological Laboratory), **Zhiqiang Chen** (University of South Florida), **Robert Weisberg** (University of South Florida), and **Frank Muller-Karger** (University of South Florida) discuss results from a study using satellite imagery finding that at least 23% of the discharge from the mouth of the Mississippi River between July and September 2004 traveled into the Gulf of Mexico, around the Florida Keys, and into the Atlantic Ocean.

NASA Will Reveal Secrets of Clouds and Aerosols, September 15; *ABC News*, *the Associated Press*, *MS-NBC*, *United Press International*, *The Washington Post*, *WTOP Radio,* and more. CloudSat principal investigator **Graeme Stephens** (Colorado State University) and CALIPSO principal investigator **David Winker** (NASA Langley Research Center [LaRC]) discuss how the combined set of measurements from these two satellites will provide new insight into the global distribution and evolution of clouds, leading to improvements in weather forecasting and climate prediction.

NASA Satellite Data Provides Rapid Analysis of Amazon Deforestation, September 13; *Terra Daily*, *Science Daily*, *Innovations Report*. **Douglas Morton** (University of Maryland) discusses how MODIS data is allowing researchers and officials to more quickly and accurately assess deforestation in the Amazon.

Tropical Deforestation Affects Rainfall in the U.S. and Around the Globe, September 13; *Science Daily*, *BiologyNews.net*, *Terra Daily*, *RedNova.com*, *Innovations Report*. New research, led by **Roni Avissar** (Duke University) finds that deforestation in different areas of the globe affects rainfall patterns over a considerable region.

Hurricane Katrina, September 8; *KNBC-TV Los Angeles*; **Bill Patzert** (NASA JPL) is interviewed about how JPL instruments MISR, QuikScat, and NASA satellites are being used to understand hurricanes and assist in the Hurricane Katrina relief work.

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

In the state of Acre in western Brazil, farms and pastures are surrounded by large, undisturbed areas of Amazon Rainforest. Since January 2005, many areas in the state have been experiencing severe drought, and the forests have become tinder dry. Since August, agricultural fires—many of them ignited in violation of a state-declared ban—have been escaping control, racing through adjacent fields and spreading into the forests. The situation deteriorated through September, and record amounts of previously undamaged rainforest may burn before the episode is over. Several NASA-funded scientists have helped the Brazilians respond to the disaster by providing daily summaries of fire detections made by satellite, aircraft, and ground observations.

These images from the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite shows a pattern of forest and farmland east of the city of Rio Branco before (top) and after (bottom) the peak of the 2005 agricultural burning season. The images are made from visible, shortwave, and near-infrared light detected by MODIS. Light gray is unburned forest, dark gray is cleared, but unburned land, and very dark gray is recently burned areas. Next to some burned fields, the forest appears dark, or "bruised," probably indicating places where fires escaped from fields and burned into the forest understory.

NASA images by Jesse Allen (NASA Earth Observatory) and Jeff Schmaltz (MODIS Rapid Response).

July 24, 2005
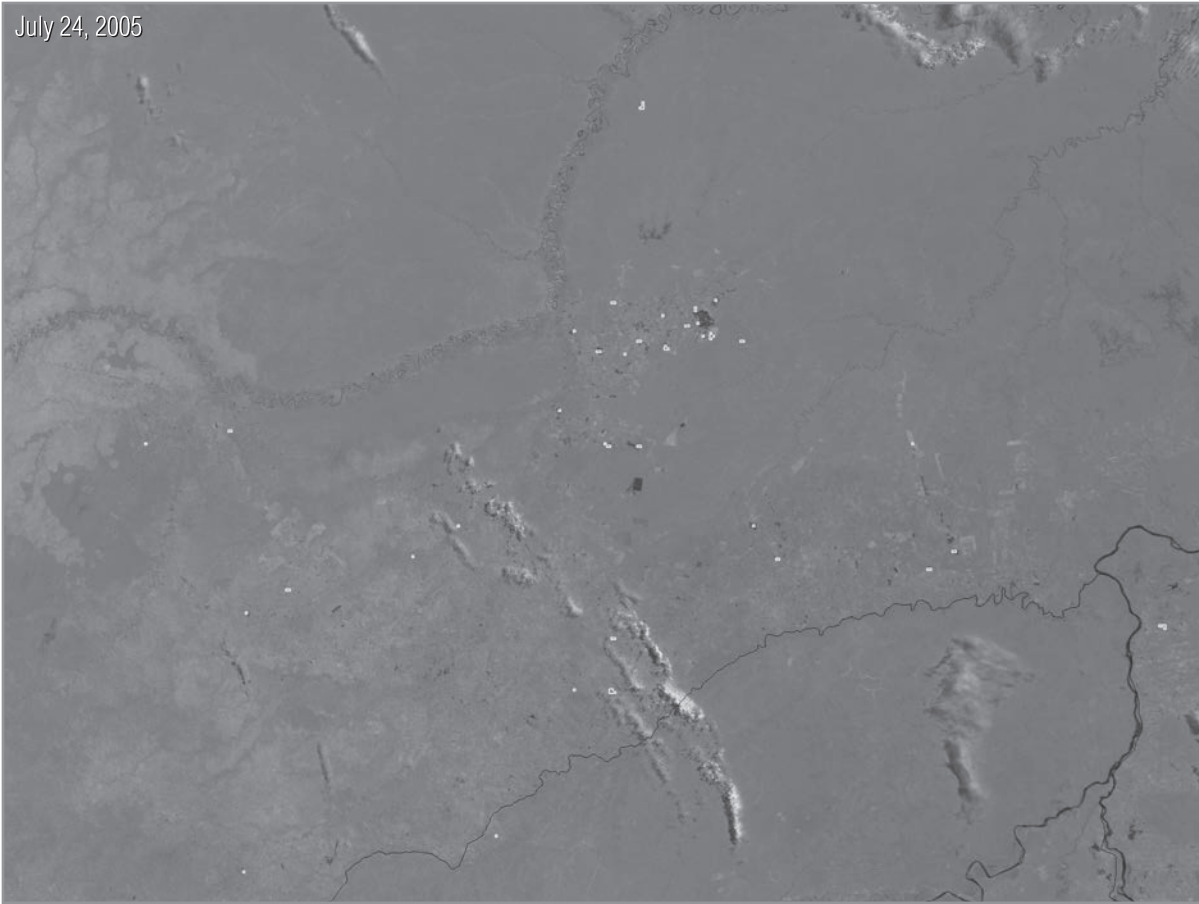
September 28, 2005
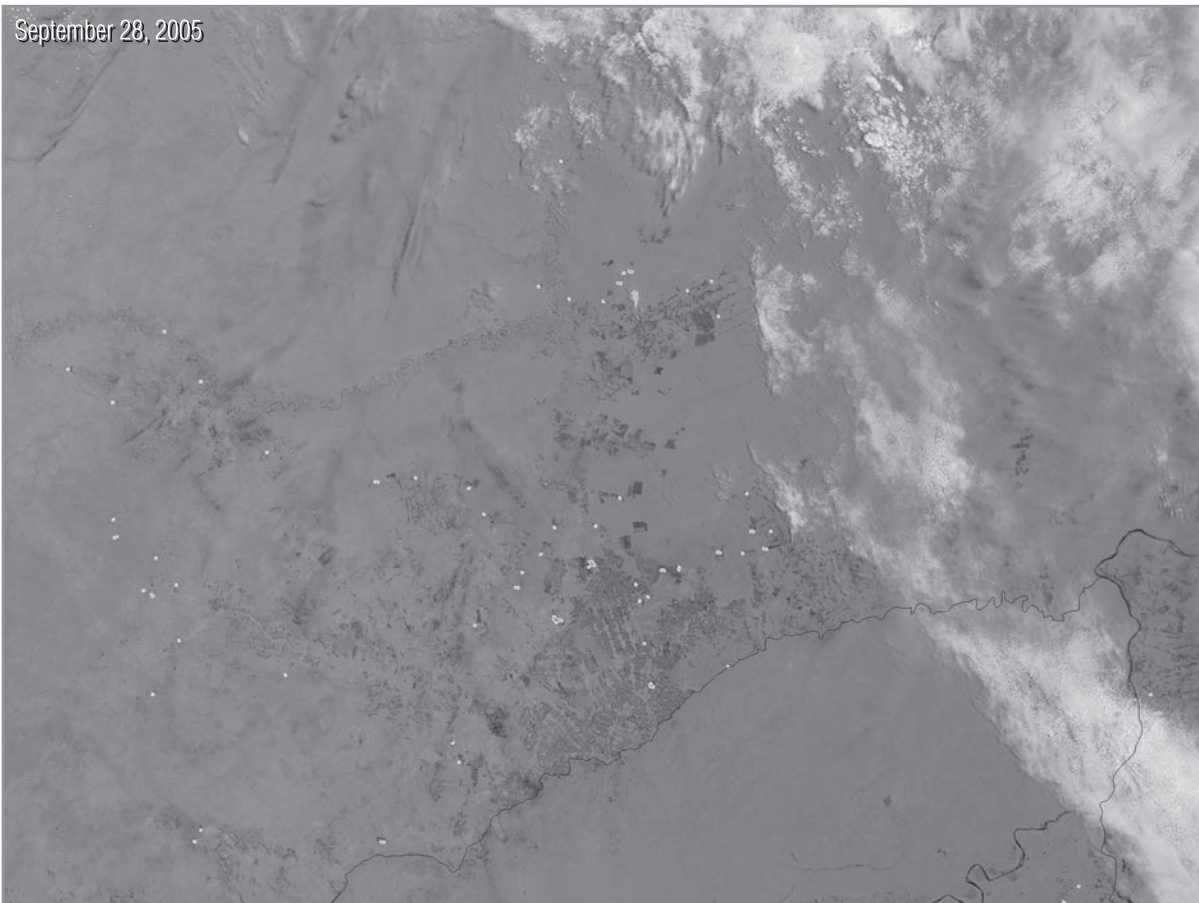
Meeting / Workshop Summaries

International Conference on Land-Cover and Land-Use Change Processes in the North-East Asia Region

Jiaguo Qi, qi2msu.edu, Michigan State University
Garik Gutman, garik.gutman@nasa.gov, NASA Headquarters

Introduction

An International Conference on Land-Cover and Land-Use Change Processes in the North East Asia Region (NEAR) was held from February 2-5, 2005 in Harbin, China. The conference was hosted by the Heilongjiang Bureau of Surveying and Mapping (HLJBSM) and sponsored by Michigan State University (MSU), Ministry of Science and Technology (MOST)—China, Institute of Geographic Sciences and Natural Resources Research (IGSNRR), Chinese Academy of Sciences (CAS), Jiangxi Normal University (JNU), and Heilongjiang Bureau of Surveying and Mapping (HLJBSM). More than 80 participants attended the conference from six countries including the U.S., Russia, Japan, France, Netherlands, and China. The conference focused on land-cover and land-use change (LCLUC) processes and ecosystem dynamics of the region.

Participants presented their state-of-the-art research findings. It was clear that the region is going through rapid changes, and the environmental and climatic impacts are significant. The LCLUC processes in this region have many similarities to those in other geographical areas, but the region also has its unique features as pointed out at the conference. A better understanding of the specific issues of the region will require improved understanding of available data resources, current research activities, and specific issues facing the region. This North East Asia regional conference on LCLUC processes is designed to promote research activities, foster collaboration and the development of research infrastructure among the scientists in the region to address regional environmental issues. It was hoped that this conference would contribute to the international projects, like the Global Observations of Forest-Cover and Land-Cover dynamics (GOFC/ GOLD) and the Global Land Project (GLP). The specific objectives of this international conference were to:

- Present the state-of-the-art knowledge on LCLUC processes, their root causes and consequences, modeling of most important processes, and examples of sustainable development in the region.
- Improve our understanding of ecosystem dynamics, including boreal forests, woodlands, wetlands, and managed ecosystems.
- Establish a regional network and identify major programs/projects of the region to foster collaborations among scientists in the region.

The themes of this conference focused on the LCLUC processes in the region east of 105°E longitude and north of 40°N latitude and addressed specific issues in this region. The conference began with introductory remarks by **Jiaguo Qi** (MSU) followed by opening speeches by **Garik Gutman** (NASA), **Jiyuan Liu** (CAS), **Alexander Sheingauz** (Economic Research Institute [ERI]), and **Zhigang Li** (HLJBSM).

A total of 34 presentations were made during the three-day conference and what follows is a summary of the results from the presentations in the order of: Land-cover and Land-use Dynamics, Research Advances, Research Programs and Projects, and Database and Regional Networks of the North East Asia Region (NEAR). **Appendix A** provides a list of some of the data sets available in the NEAR, and **Appendix B** lists acronyms used in this report.

Land-Cover and Land-Use Dynamics

The NEAR comprises about 30% of the boreal ecosystems within the geographic domain of the Northern Eurasia Earth Science Partnership Initiative (NEESPI) (*neespi.org*). Similar to other geographic regions, deforestation, wetland reduction, grassland degradation, soil salinity, soil erosion, loss of biodiversity, and rapid urbanization in the NEAR are becoming pressing issues.

LCLUC—In China, LCLUC is occurring at an unprecedented rate due to several root causes that include economic reform and policy changes over the past 30 years. Rapid urban expansions in major cities such as Beijing and Shanghai, deforestation in the upper stream of the Yangtze River and land degradations across most parts of northern China [**Jiyuan Liu** (CAS), **Xiang Qing (**MSU)] are major forms of land-cover and land-use changes. Similar land-cover and land-use changes are also happening across the border in Russia, especially in the Russian Far East [**Alexander Sheingauz** and **Vladimir Karakin** (Russian Academy of Sciences, RAS)]. However, there were significant differences in land-cover and land-use patterns between Russia and China, most likely due to different management practices, including policy. One of the most significant differences across the two countries is the fire regime [**Sheingauz** and **Karakin** (RAS), **Masek** (NASA)]. The fire occurrence in China was shown to be less frequent than that in Russia, and to understand these differences across the border would require the analysis of if socioeconomic and policy data. Such data was not presented at this conference.

Fire regime—Coupled with LCLUC are changes in fire regime in the region. Using historical field observations and Systeme Pour l'Observation de la Terre (SPOT) VEGETATION images, fire frequency, or fire return interval (FRI) in the Siberia region was shown to have decreased [**Kharuk**, (RAS)]. The reduction of FRI in the 20th Century, in comparison with 19th Century (100 and 65 years, respectively), was most likely the result of two factors: (1) an increase in anthropogenic impact; and (2) influence of a warm climatic trend with resulting extreme temperature and drought conditions in the 20th Century. Since the main cause of wildfires in the study area was lightning, it is likely that the primary reason for the FRI reduction was due to climate change. Furthermore, it was found that the FRI depends on the topography and varies between 61±8 yr for southwest slopes to139 ±17 yr for the bog areas. Citing examples from the Brazilian tropical region, **Cochrane** (MSU) showed that the intensity, severity, and frequency were related to land use and human activities such as deforestation. However, the same links are not evident in data from Siberia [**Kharuk** (RAS)].

Socioeconomic and policy practices—Policy and management practices appear to be playing a significant role in the fate of forests in the region. In China, significant investments by the federal and local governments as well as by international organizations have been made to assess national forest cover. Initially aimed at reducing sand and dust storms, reforestation or afforestation efforts were initiated about two decades ago and have been reported to result in an increase of the forest cover by about 0.4%. However detailed studies [**Sun**, (University of Maryland, UMd)] suggested a net loss in forest cover by -0.4% from 1990 to 2000. These small differences may suggest that there were no significant changes in forest cover. However, these inconsistent estimates suggest that there is a need to improve forest-mapping accuracy in the region. Due to recent economic reform and policy changes in the major agricultural provinces in China, there is a major shift in management practices in the most agriculture-intensive province—Heiloingjiang—from state-owned management to private farms [**Xu** (HLJBSM)]. Agricultural intensification is occurring but its environmental consequence is unknown. Almost all swamp areas have been converted to agricultural lands from 1990 to 2003, but little or no ecological assessment was made.

Climate—In addition to the socioeconomic and human population drivers, climate is another important factor that drives LCLUC in the NEAR [**Tchebakova** (RAS)]. The predicted change in climate (a predicted increase in temperature of up to 9° C in January by 2090) would result in a significant change both in spatial distribution of vegetation species and species composition. Clearly, some species in the region will fare better if temperature increases while others will decline. Research conducted

using ground-based meteorological stations suggested an increase in degree-days above 15°C by 12 days from 1965 to 2004 and the growing season extended by 8 more days during the same period [**Groisman** (NOAA)]. The change in temperature resulted in increased evaporative water loss and, consequently, increased the water demand. Although total precipitation may increase, most of the rainfall occurred in the form of extreme events. Drier summers were reported to increase fire frequency and severity, which has resulted in a tendency for more severe agricultural droughts. Advanced studies using a combination of optical and microwave remote sensing suggested that the green-up dates became earlier in the region at a rate of about 0.5—1 day per year [**Le Toan,** Centre d'Etudes Spatiales de la Biosphére (CESBIO)] during the period from 1982 to 2001. However, the earlier green-up phenomenon is region-specific and some areas may experience a later spring. Snow-cover extent shrank during this period from 28.5 to 24.7 million km², a reduction of 13%. However, there was no indication that the earlier green-up was due to an earlier thawing of soils in the region, even though thawing frozen soil may release significant carbon. These observations, however, need to be coupled with human-induced disturbances such as fires and land-cover conversion [**Le Toan** (CEBSIO)] for improved understanding of the root causes.

Land degradation—Rapid increases in city population and economic structures have resulted in significant environmental degradations. Case studies in Daqing, China showed significant desertification and salinization of the adjacent wetland ecosystems [**Zang** and **Zheng** (Harbin Normal University, HNU)]. Environmental degradation, especially wetlands shrinking was most obvious near Daqing City [**Zang** and **Zheng** (HNU)] and Xingka Lake across the border between China and Russia [**Xu** (HLJBSM)). Wetland reductions may have significant impact on regional peat soil losses that have significant carbon stocks [**Osaki** (Hokkaido University, HU)].

Biodiversity—Very few studies looked into biodiversity issues of the region. However, due to different management practices across international borders of Russia, China, and Korea, biodiversity appears to be a major issue [**Kachur** (RAS)], even in natural reserved areas in each country. Wetlands around Khanka Lake seem to have been over-exploited by an increase of tourists, for example, on both sides of Russia and China. Although efforts are being made to mitigate this problem, the results seem to be ineffective due to international borders.

Research results presented in the conference showed that there have been significant changes in land-cover/use, climate, policy, management, and their associated environmental consequences in the NEAR. Substantial efforts have been made to quantify these changes and

assess the consequences. However, the observed patterns of land-cover/use dynamics need to be further analyzed in the context of social processes and drivers. Furthermore, their climate consequences are still uncertain.

Research Advances

To address the issues identified and answer some of the key science questions peculiar to the NEAR region, advanced methods and technologies have been developed. The participants presented their latest research methodologies.

Optical and microwave synergistic methods—Using high-frequency, long historical records of optical data and microwave imagery, **Le Toan** (CESBIO) developed a synergistic approach to assess the snow-cover extent, growing-degree-days, and the earlier snow-melting occurrence in the NEAR. Clearly, synergistic use of microwave and optical measurements helps overcome the difficulties that clouds pose for optical remote sensing.

High-spatial resolution, large-area forest-cover mapping—Traditional methods in forest-cover inventory were limited to small geographic coverage or larger areas viewed at coarse spatial-resolution images. **Masek** (NASA) and **Sun** (UMd) used high spatial resolution of the NEAR to show that forest cover estimated from satellite images differs from that derived from ground-field inventory.

LCLUC patterns and processes—LCLUC mapped from high-spatial resolution satellite images reveals the inherent patterns in the region. However, the processes associated with these patterns need to be modeled in order to understand the drivers of LCLUC in this area and predict future changes. Geospatial tools are effective at linking deforestation and construction of transportation and utilities, thus allowing prediction of future deforestation [**Cochrane** (MSU)]. In Siberia, where the major changes in vegetation were believed to be caused primarily by climate change, vegetation change was modeled by looking at the ratio of growing-degree-days to the precipitation. Under different scenarios, vegetation change was predicted into the future (2090) for both Siberia and Mongolia [**Tchebakova**, (RAS)]. Siberian vegetation may be greatly altered in a new climate at both biome and species levels. Biomes and major tree species may shift northwards by as far as 600-1000 km. Even if the climate warms as much as some models predict, permafrost will not thaw deep enough to support dark taiga. The larch taiga will remain the dominant forest biome in Siberia. If the climate dries as the model predicts, forest-steppes and steppes rather than forests will cover half of Siberia.

Improved estimation of ecosystem productivity—Several research projects focused on the development of new approaches that would yield better estimates of total net

primary production [**Xiao**, (University of New Hampshire, UNH)]. A conceptually new land-surface-water index was introduced and a new satellite-based vegetation photosynthesis model was used in the region by taking advantage of existing MODIS products such as the Enhanced Vegetation Index (EVI) to better estimate spatial and temporal dynamics of net ecosystem productivity. By combining two very different kinds of models—an ecological model of forest succession and a forest-canopy-reflectance model—**Song** (University of North Carolina [UNC]) showed that improved understanding of the manifestation of forest succession could be achieved. Forest-ecosystem-carbon budget was shown to be dependent on forest age; secondary growth can be a carbon sink for up to 200 years while old-growth forests maintain a neutral system with net carbon flux of zero, which leads to a conclusion that land use is essential for carbon sequestration and carbon fluxes. In addition to improved methods for carbon sequestration by plants, carbon stored in soil, especially in peat soils has also been studied in the region [**Osaki** (HU)]. It was clear that human activities such as fire events and cultivation of peat lands for agricultural purposes can release carbon from the soil.

Advanced techniques for improved information extraction—Remote-sensing applications in the NEAR are often complicated by the ability to ensure a radiometric calibration of satellite imagery. The region is characterized by substantial variation in elevation, and therefore topographic impacts on satellite data are significant [**Zhao**, (Nanjing University, NU)]. Appropriate correction procedures can improve land-cover and land-use classification accuracy, but the classification procedure used must be chosen carefully. **Zhang** and **Zhang** (NU) presented a new operational method for generating land-cover and land-use maps for hydrological modeling applications. This new technique takes existing land-use/cover maps and aggregates them to grid cell size by selecting the majority land-use/cover within each grid. This allows a scaling up of land-use/cover from local-to-regional scale for hydrological modeling. To further improve land-use and land-cover classification, approaches that use a combination of thermal bands and normalized vegetation index (NDVI) were introduced [**Qi** (JNU)] to yield a new normalized temperature-vegetation-angle index (NTVAI). This index was tested in China and proved to be quite effective to achieve an overall classification accuracy of ~80%. Soil-moisture distribution can also be retrieved from remotely sensed data. This has been proven to be difficult due to the lack of appropriate microwave data and of effective methodology. Attempts have been made to map large-scale soil moisture with limited ground sampling [**Ye** (BFU)] but the spatial variability of soil moisture is dependent on topography, which makes soil-moisture mapping of the region even more difficult due to the mountainous nature of the region. In addition, advanced techniques

using permanent scatter interferometry SAR data to examine land motion were presented [**Kuzuoka** (ImageONE)], which may add additional information for improved land-use/land-cover classifications, or for flood-plain monitoring.

Modeling LCLUC Dynamics—Modeling land-cover dynamics of the region, and determining its root causes and consequences in terms of global carbon sequestration and the regional climate variation was a major theme of the conference. Various models were developed and used to study the land-cover dynamics of the region. **Messina** (MSU) introduced a complex-systems approach to relate a complexity theory to LCLUC by using a Cellular Automata (CA) model in the GIS environment. The CA model was able to operate with dynamic and discrete space-time data sets, at regular grid cells iteratively to achieve optimal space allocation of future land-use changes. This modeling framework is being implemented in Northern China for LCLUC analysis.

The drivers of LCLUC, especially the driving forces of deforestation in China [**Xiang** (MSU)], were demonstrated using the data within the Yangtze River watershed. Although these drivers may differ, they are not expected to be significant when applied in the LCLUC model in the NEAR.

A modeling method for best land-use practices was presented at the conference. A *Real coding*-based Accelerating Genetic Algorithm (RAGA) optimization method was introduced [**Fang** (Northeast Agricultural University, NEAU)] to optimize future land uses. The RAGA method was demonstrated with a case study in Acheng County to show that this method has the potential to be used by policy makers for future land-use planning.

A holistic framework for modeling LCLUC, along with biogeochemical modeling was introduced [**Salas** (AGS)] to highlight the need to combine the LCLUC models with biogeochemical models for improved assessment of the consequences of LCLUC. Using De-Nitrification and De-Composition (DNDC) modeling, **Salas** (AGS) demonstrated how changes in agricultural land management practices would impact the carbon and nitrogen emissions to the atmosphere. A total of 1.6% of soil carbon was lost since 1990 based on the modeling in China. In addition to the carbon and nitrogen modeling, it was demonstrated that other greenhouse gases could also be modeled.

Research Programs and Projects of the NEAR

Many international research programs and projects have been developed, and some of them have provided significant understanding of the issues, problems, and consequences in the NEAR. Many current research

projects are supported by the Chinese federal programs and science foundations. Many satellite images, ground-based station measurements, and products are readily available for analysis. The ongoing research programs and projects include the following:

Land-cover and land-use dynamics in China—More than half a dozen research programs in the region have been supported by various federal funding agencies in China (Liu, CAS). The major research foci include : 1) LCLUC analysis from the 80s, 90s, and 2000s at the country level ranging from deforestation, grassland degradation, agricultural land conversion, wetland reduction, to snow-cover reduction; 2) estimating carbon stocks and their spatial distribution of all of China using spatially explicit models and *in situ* China Flux towers measurements; and 3) monitoring natural disasters such as dust/sand storms and flooding during the monsoon seasons. Detailed information about research projects/programs conducted in China in this region can be found at *english.igsnrr.ac.cn.*

NEESPI—The Northern Eurasian Earth Science Partnership Initiative was introduced [**Gutman** (NASA)] to outline the rationale of the NEESPI program. One of the NEESPI goals is to contribute to international programs and projects, such as the GOFC-GOLD. **Groisman** (NOAA) then presented a more-detailed discussion of NEESPI missions that focused on visions, research initiatives, and specific research issues facing the Northern Eurasia region. Clearly, much-more-detailed work needs to be done in the region including database development, LCLU dynamics, deriving and measuring carbon and water fluxes, studying environmental and climatic consequences, and associated human and natural drivers.

China's plan for Earth observations in the coming 5-10 years—China has allocated substantial financial resources to support the development of satellite technologies to observe the Earth from space [**Shao** (MOST)]. The earth observation program of China focuses on the improvement of spatial and temporal resolutions of space satellites with advanced processing techniques, with an aim of improving observational capabilities. The program has plans to continue launching meteorological satellites (2006, 2009, and 2012), environmental satellites, and resources satellites (the China-Brazil Earth Resources Satellite [CBERS]—2, 3, and 4). In 2005 the Chinese government plans to launch micro-small satellites that would have a spatial resolution of 32 m, equivalent to the Landsat satellite series, but with a 4-m CCD.

China remote-sensing activities and services—The Chinese satellite receiving stations [**Wang** (CAS)] have been operational since the early 1980s and represent the Chinese space-observing capabilities and fundamental

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infrastructure for Earth observations. In addition to routine satellite-image acquisition, many land-cover and land-use products have been developed at the country level over three periods of time: 1980s, 1990s, and 2000s. Chinese receiving stations have been receiving satellite images acquired by LandSat 7, LandSat 5, RADARSAT-1, Envisat, ERS-1, ERS-2, JERS-1, SPOT-1, 2, 4, 5, QuickBird, Ikonos, IRS-1C/1D, ResourceSat Data. The Chinese CBERS is managed by the Chinese Academy of Science and Technology (*www.cast.ac.cn*).

Database and Regional Networks

Many years of research activities in the region have produced a large body of knowledge and data sets (See **Appendix B** for a list of available data sets) that can be made available to support new research activities or to improve our understanding of the LCLUC dynamics of the region. The participants of the conference revealed the availability of some important data sets that were not previously known to the general research community. However, these data sets are scattered around in various institutions and some of them may have limited access. This report lists existing data sets but there is no guarantee that all of them are available.

Raw remote sensing images—Many satellite images have been acquired in this region and some of them are available for sharing or for purchase. **Appendix B** lists satellite images that have been acquired over the region. These satellite images include sensors ranging from fine-resolution Landsat-like to MODIS moderate-resolution images. They are available at various institutions, including ScanEx (Gershenzon), IGSNRR (Liu), JNU (Bao), and MSU (Qi)

Land-cover and land-use products—Some of the satellite images have been classified into various levels of land-cover and land-use products. For example, Landsat images were used to derive 1:50,000 scale, 24 class maps for the entire three northeast provinces (Jilin, Liaoning, and Heilongjiang) within the NEAR for 1999 [**Xu** (HLJBSM)]. Forest-cover products for the NEAR were also mapped using various sensors [**Gershenzon** (ScanEx)]. In addition to these observational data and corresponding derivatives (products), socioeconomic data for all of China were also shown to be available from the China Data Center at either University of Michigan or Jiangxi Normal University (Bao). These GIS data layers are critical in the analysis of LCLUC dynamics of the region to examine driving forces and root causes.

China Flux Towers—There is a multi-institutional consortium focused on studying carbon and water cycles of managed ecosystems in the eastern U.S. and in China. The goal is to develop a suite of study sites sponsored by the partner institutions in hopes that data and results will be shared so that syntheses can be generated at broader spatial scales to assess the importance of human influences on carbon and water fluxes in a changing climate. These towers have been in place for years and substantial data volumes have been accumulated [**Chen** (UTO)]. Based on the discussions, more flux towers are to be built over the next five years to enhance the *in situ* carbon and water fluxes measurements.

Asia Network for LCLUC—One of the major objectives of this conference was to build capacity over the region by establishing a regional land-cover and land-use network [**Qi** (MSU)]. Based on the previous effort from the *4th International Colloquium on LCLUC and Environmental Problems* [**Zhang and Liu** (CAS)], an Asia Land Network (ALN) was presented (**Qi**, **Zhang**, and **Liu**). The ALN mission is to promote collaborations among Asian scientists to jointly observe, understand, and predict land-use changes and their environmental, social, and economic impacts, and to explore land-use planning and management for achieving sustainable development in the region. In addition, the ALN is to engage Asian scientists in the larger international community through developing cooperation with global and other continental research networks. More and more scientists are participating in the ALN network, and it is expected that the ALN will contribute significantly to the understanding of LCLUC dynamics in the most populated and most diverse regions. The network has an office at IGRNRR of the Chinese Academy of Sciences for a period of 4 years. After that, a new project office will be selected from other countries of the region. These ALN activities are conducted in close interaction with the GOFC-GOLD project,

Northern Eurasia Regional Information Network (NERIN)—In a much broader context, the framework of the Northern Eurasia Regional Information Network was presented [**Masek** (NASA) on behalf of **Krankina** (OSU)] to highlight the rationale of such network and implementation strategies. It was emphasized that there is a need to coordinate data collection activities within the NEAR and to establish a protocol to effectively share data across disciplines and international borders.

Presentations at the Conference

    Bao, Shuming (Jiangxi Normal University, China)—*An Introduction to China Global Data Viewer*
    Chen, Jiquan (University of Toledo, U.S.)—*US-China Carbon Consortium (USCCC)*
    Cochrane, Mark (Michigan State University, U.S.)—*Spatial Modeling of Forest Resource Changes: A Geospatial Tool for Monitoring, Managing, and Predicting Land-Cover Change*
    Fang, Tiangfang (Northeast Agricultural University, China)—*Method Study on Multi-object Optimization of Regional Land-Use/Cover Change*

Gershenzon, Olga (ScanEx, Russia)—*Mapping of Northern Eurasia Intact Forests and Forest Dynamics Using Space Imagery*

Groisman, Pavel (NOAA, U.S.)—*Characteristics of dryness over North East Asia Region: Changes during the 20th Century in Russia*

Groisman, Pavel (NOAA, U.S.)—*Northern Eurasia Earth Science Partnership Initiative Overview and First Steps*

Gutman, Garik (NASA Headquarters, U.S.)—*NASA Contribution to NEESPI*

Kachur, Anatoly (Pacific Institute of Geography, Russian Academy of Sciences, Russia)—*International Especially Protected Nature Territories as Nucleus for Preservation of Unique Ecosystems of North East Asia Region*

Karakin, Vladimir P. (Pacific Institute of Geography, Russia) and **Sheingauz, Alexander S.** (Economic Research Institute, Russia)—*Problems, Methods, and Results of Land-Cover Dynamics Research in the Russian Far East*

Kharuk, Vladimir (Sukachev Institute of Forest, Russia), **Ranson, I. J.** (NASA Goddard Space Flight Center, U.S.), and **Sun, Guoqing** (University of Maryland, U.S.)—*Wildfires in the Larch Forests: Frequency and Trends*

Krankina, Olga N. (Oregon State University, U.S.)—*Northern Eurasia Regional Information Network*

Kuzuka, Shigeki (ImageONE, Japan)—*Land Motion Monitoring in Japan using PSInSAR Techniques*

Le Toan, Thuy (CESBIO, France)—*Multi-sensor observations of vegetation and snow in Northern Eurasia*

Liu, Jiyuan (Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Science, China)—*China's Changing Landscape During the 1990s: Large-scale land transformations estimated with satellite data*

Messina, Joseph (Michigan State University, U.S.)—*Modeling Integration: A Complex Systems Approach*

Osaki, Mitsuru (Hokkaido University, Japan)—*Introduction of study on carbon flux and biomass production in Northern Eurasia*

Qi, Jiaguo (Michigan State University), **Liu, Jiyuan** (IGSNNR, Chinese Academy of Science, China) and **Zhang, Yili** (IGSNNR, Chinese Academy of Science)—*Asia Network for Land Use and Land Cover*

Qi, Shu-hua (Jiangxi Normal University, China)—*Study on Land Cover Classification for China with NDVI-Ts Space Dynamics*

Salas, William (Applied Geospatial Solutions, U.S.)—*Changes in Agricultural Land Use: Quantifying Soil Carbon Dynamics in Northeast China with an Integrated Model-Database Decision Support System*

Shao, Liqin (Ministry of Science and Technology, China)—*China: Earth Observation in the coming 5-10 years*

Song, Conghe (University of North Carolina, U.S.)—*Monitoring Changes in Forest Ecosystems with Multitemporal Remotely Sensed Imagery: Implications for Estimating Regional Carbon Budget*

Sun, Guoqing (University of Maryland, U.S.) and **Masek, Jeffrey** (NASA Goddard Space Flight Center, U.S.)—*Changes in Forest Cover, Northeastern China, 1990-2000*

Tchebakova, N. (Sukachev Institute of Forest, Russia) and **Parfenova, E.** (Sukachev Institute of Forest, Russia)—*A Vegetation Cover Dynamics in Siberia in a Changing Climate*

Wang, Chao (China Remote Sensing Ground Stations, Chinese Academy of Sciences, China)—*China RSGS Activity and Service*

Xiang, Qing (Michigan State University, U.S.) and **Yin, Runsheng** (Michigan State University, U.S.)—*Driving Forces of Land Use and Cover Changes in the Jinsha River Basin*

Xiao, Xiangming (University of New Hampshire, U.S.)—*Satellite-based Vegetation Photosynthesis Model—leaf-chlorophyll and leaf-water content*

Xing, Yanqiu (Northeast Forestry University, China) **Wang, Lihai** (Northeast Forestry University, China), and **Eduard Westinga** (International Institute for Geo-Information Sciences and Earth Observations, Netherlands)—*Assessment of degraded matorral land using remote sensing imagery in Guadalteba Area, Spain*

Xu, Kaiming (HLJBSM, China)—*Investigation of LU/LC in Heilongjiang Agricultural Reclamation Area Using SPOT-5*

Ye, Min-Sheng, **Zhang, Na-Na**, and **Guang, Wen-Bin** (Beijing Forestry University, China)—*Spatial Distribution of Soil Moisture of Daqianggou Nature Reserve in the Southern Margin of Horqin Sandy Land, Inner Mongolia, China*

Zang, Shuying and **Zheng, Shufeng** (Harbin Normal University, China)—*Landscape Change and its effect on the environment of Daqing City*

Dong, Zhang and **Wanchang, Zhang** (Nanjing University, China)—*An Operational Method for Generating LULC map Based on Area-dominating and Spatial-smoothing Techniques*

Zhao, Denghong and **Zhang, Wanchang** (Nanjing University, China)—*Removal of Topographic Effects on the Supervised Classification in the Rugged Terrain*

APPENDIX A: Acronyms

AGS—Applied GeoSolutions, LLC, U.S.
BFU—Beijing Forestry University, China
CAS—Chinese Academy of Sciences, China
CESBIO—Centre d'Etudes Spatiales de la Biosphère,

France
ERI—Economic Research Institute, Russia
GSFC—Goddard Space Flight Center, U.S.
HLJBSM—Heilongjiang Bureau of Surveying and Mapping, China
HNU—Harbin Normal University, China
HU—Hokkaido University, Japan
IGSNRR—Institute of Geographic Science and Natural Resource Research, CAS, China
JNU—Jiangxi Normal University, China
MOST—Ministry of Science of Technology, China
MSU—Michigan State University, U.S.
NEAR—North East Asia Region

NEAU—Northeast Agricultural University, China
NEESPI—Northern Eurasia Earth Science Partnership Initiative
NOAA—National Oceanic and Atmospheric Administration, U.S.
NU—Nanjing University, China
OSU—Oregon State University, U.S.
RAS—Russian Academy of Sciences, Russia
RFE—Russian Far East Forest, Russia
UMd—University of Maryland, U.S.
UNC—University of North Carolina, U.S.
UNH—University of New Hampshire, U.S.
UTO—University of Toledo, Ohio, U.S.

APPENDIX B: LCLU Data and Products in NEAR

Data/Products	Sensors	Description	Coverage	Location
Images	Resurs-O1, MSU-SK and, MSU-E	5 spectral bands, 140-m resolution	NEAR	ScanEx
Images	IRS	PAN /LISS	NEAR	ScanEx
Images	Meteor	3M	NEAR	ScanEx
Images	Landsat 7	8 bands,30/60-m resolution	NEAR	ScanEx, UMd/NASA, MSU, HLJBSM
Images	MSS	4 bands 80-m resolution	NEAR	ScanEx
Images	TM	7 bands 30/120-m resolution	NEAR	ScanEx
LCLU		1:50,000 (24 classes)	Northeast China	HLJBSM
LCLU		1:100,000 (1990,1996, 2000)	All of China	IGSNRR
Soil		1:4,000,000 (1990)	All of China	IGSNRR
Topography	1:4,000,000	IGSNRR	All of China	
DEM		1:100,000 (Raster and vector)	All of China	IGSNRR
Road / Rivers		1:4,00,000 (Raster and vector)	All of China	IGSNRR
Wetlands		1:4,00,000 (Raster and vector)	All of China	IGSNRR
Weather data	670 stations, 50 years, 1950-2000)	Monthly mean T, Daily mean T, Daily PPT, Daily Pressure, Daily humidity, Daily light duration, Daily mean wind speed		IGSNRR
NPP, NEP, HR, VEGC, SOILC	Simulated 1980-2000	10-km grid	All of China	IGSNRR
CERNS China Flux	30 stations, C Flux (2002 – 2004), Humidity, T, P, W (40-50 years)	Spread over China	IGSNRR	
TM/ETM images		Various	All of China	JNU
Flux Tower	20 sites	Point-based	20 sites in China	Chen/IGSNRR

Report on the Annual PO.DAAC User Working Group

Jorge Vazquez, jv@pacific.jpl.nasa.gov, NASA Jet Propulsion Laboratory

The following is a summary of the Annual Physical Oceanography Distributed Active Archive Center (PO. DAAC) User Working Group Meeting held June 7 and 8 at Raytheon in Pasadena, California.

Members present: *Chair*, **Robert Evans** (University of Miami), **David Glover** (Woods Hole), **CK Shum** (Ohio State University), **Kenneth Casey** (NOAA National Oceanographic Data Center [NODC]), **Victor Zlotnicki** (*ex-officio* JPL), **John Lillibridge** (NOAA National Environmental Satellite Data and Information Service [NESDIS] Office of Research Applications [ORA]), **Steven Worley** (National Center for Atmospheric Research [NCAR]), **Jorge Vazquez** (PO.DAAC Task Scientist), **Patricia Liggett** (PO.DAAC Manager), **Robert Benada** (PO.DAAC Deputy Manager). **Eric Lindstrom** (Physical Oceanography Program Scientist NASA Headquarters).

New UWG Member: Welcome Steve Worley

The meeting began by introducing **Steven Worley** from NCAR as a new member of the User Working Group. Steve is the Manager for the Data Support Section, Scientific Computing Division, at NCAR. PO.DAAC actively sought Steve to join our UWG in response to the increasing demand for modeling and assimilation capability within NASA.

PO.DAAC Status

Pat Liggett (PO.DAAC Manager) presented an overview of the status of the PO.DAAC. The status report included an overview of statistics gathered by the PO.DAAC. These statistics include the number of distinct users of PO.DAAC data as well as volume transfers through FTP. An impressive 600 gigabytes of data transferred through the PO.DAAC Ocean Earth Science Federation Partners (ESIP) tool (POET) in the last year. The POET functionality, although centered on subsetting data sets regionally, has the additional capability of reformatting data sets into netCDF, GeoTIFF. ASCII, binary, GIF, etc. It also allows data sets to be animated using gif images.

An update was given on the status of missions and their relationship to ongoing PO.DAAC work, in particular to the upcoming Aquarius and Ocean Carbon Observatory (OCO) missions. Additional questions focused on the role of the PO.DAAC in the National Polar-Orbiting Operational Environmental Satellite System (NPOESS) and the NPOESS Preparatory Project (NPP). Current plans for the JPL PO.DAAC include distributing and archiving salinity data from the Aquarius mission, scheduled for launch in March of 2009. The review of the current status of the PO.DAAC was followed by discussions centered on the future direction and vision for the PO.DAAC.

Future

There was a consensus that the PO.DAAC would move from a mission-oriented data center to one driven by measurements. This would include the implementation of a community data portal that would automatically link people to the right source for their data needs. A long-term goal for the PO.DAAC is to become a *Knowledge Discovery Center* as well as *Data Discovery Service*. These issues were all tied into the PO.DAAC effort to redesign its database and web interface around measurement-driven services. The discussion of measurement-driven services was then tied into the creation of value-added services and products. These are the features needed for Knowledge Discovery.

Value-Added Products

Issues that were discussed with respect to value-added products included how to prioritize the products based on demand and available resources. Priority would be based on the cost of producing, distributing, and maintaining the product, as well as its value to the user community. Consensus arose that co-located, multi-parameter, gridded products were extremely popular and useful within the oceanographic community. Other products discussed included the derivation of the divergence and curl from wind stress and Level 3 gridded sea-surface-height products. **Eric Lindstrom** of NASA headquarters endorsed the issue of continuing with the sea surface height and sea surface temperature gridded products developed by PO.DAAC in cooperation with the World Ocean Circulation Experiment (WOCE) Data Products Committee.

The PO.DAAC would, of course, continue to stand behind any and all value-added products it produces and would maintain the appropriate level of expertise in the products it distributes. It was recommended that an atlas of satellite data overlapping with hydrographic data would prove extremely useful. The PO.DAAC, in deciding what value-added products will be produced, will focus on the value to the user community and what can be achieved within budget constraints and resources. Value-added products will also be considered in terms of what user community will be served.

Value Added Services

The PO.DAAC continues to support the ESIP POET tool. Improvements by **Robert Raskin** to POET focus on making it as accessible to as many different users as possible. The tool includes subsetting and the ability to output in any of 13 file formats. An off-line version is being tested to enable larger data requests to be handled.

OCEANIDS, the data management software used by the PO.DAAC to acquire data streams as well as its sister user interface, the near-real-time image distribution server (NEREIDS) which allows for distribution of near-real-time data, are consistently being improved to add additional data streams and operational interfaces for data-quality control and increased capability for user access. This effort is led by **Andrew Bingham**.

Other issues discussed with regards to Value Added Services included the redesign of the PO.DAAC database to facilitate the move to a Knowledge Discovery Service, examining the issue of on-demand processing and services, as well as future cooperation with NOAA. Although a role for PO.DAAC in the NPOESS is not yet defined, PO.DAAC is working closely with both NASA and our NOAA partners to identify a role that would be beneficial to both NASA and NOAA.

International Altimetry Service (IAS)

C.K. Shum led a discussion on the participation of the PO.DAAC in the International Altimetry Service (IAS). Consensus was that the PO.DAAC would continue to provide expertise to the community for altimetry data products. Discussions will continue as the idea of the IAS develops and matures.

GHRSST-PP

The PO.DAAC will continue to work with the Global Data Assimilation Experiment High Resolution Sea Surface Temperature Pilot Project (GHRSST-PP). This is a separately funded Research and Development Effort through NASA that will leverage PO.DAAC distribution, management, and user support infrastructure in exchange for the GHRSST developed value added services that will be integrated into the PO.DAAC. Acting as the Global Data Assembly Center (GDAC) or distribution point for all the GHRSST-PP sea surface temperature products, PO.DAAC will provide data from multiple Sea-Surface Temperature (SST) sensors delivered in near real time to the operational and climate community. The GHRSST-PP effort at the PO.DAAC is led by investigators **Edward Armstrong**, **Andrew Bingham**, and **Jorge Vazquez**.

Summary

The PO.DAAC is transitioning to an emphasis on measurements, along with value added products and services. Discussions at the meeting centered on the future of the data center and collaborative efforts with NOAA and other partners. Additional discussions addressed how to integrate the PO.DAAC into national ocean programs such as the Data Management and Communications Steering Committee (DMAC), the Integrated Ocean Observing System (IOOS) and regional efforts such as the Southern California Ocean Observing System (SCOOS). All these discussions focused on the future direction of the PO.DAAC, including topics ranging from supporting technology development efforts for value-added services and products, to the introduction of regional and/or coastal oceanography support. ■

One of the highest mountain reliefs on Earth can be found in the tiny ▶ country of Bhutan. Sandwiched between eastern India and the Tibetan plateau, Bhutan hosts peaks that reach between 5,000 and 7,000 meters (16,000-23,000 feet) in height. These mountains are neighbors to Mount Everest, Earth's highest peak at 8,850 meters (29,035 feet). The impressive Bhutan Himalayas are permanently capped with snow, which extends down valleys in long glacier tongues. Because of weather patterns on each side of the Himalaya and differences in topography, the glaciers on each side of the mountain are distinctly different from one another and are likely to react very differently to climate change.

This image, taken by the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) on November 20, 2001, is one of a series of images used to study the glaciers of the Bhutan Himalayas. By tracking the movement of surface features like crevasses and debris patterns, Andreas Kaab of the University of Zurich measures the speed at which glaciers flow down the mountain. He found that glaciers on the north side of the range move as much as ten times faster than glaciers on the south side.

Glaciers move under their own weight. As more and more snow piles on the glacier, the ice compresses, deforms, and eventually begins to slide. One of the reasons the glaciers on the south side of the Bhutan Himalaya are moving so slowly—10-20 meters per year compared to 100-200 meters per year on the north—may be that their supply of ice is dwindling. Without new weight pressing on the glaciers, they are stagnating.

One reason the southern glaciers may be losing weight is the rock and gravel that rests on top of them. As this image clearly shows, the northern glaciers form in plateaus as high as 7,000 meters in elevation. The glaciers slide from the plateaus down the steep mountainside in long glacier tongues, which are white, tinted gray where the snow is very compressed. The mountains are no less steep on the south side, but the glaciers have no plateaus on which to form. Instead, the glaciers cling to steep rock walls, which shower the glaciers with debris. The glaciers on the south are tinted darker gray in this image because of the debris. Because the dark-colored debris absorbs energy from the Sun, the surface of the glacier is more susceptible to melting than it would be if its surface remained a reflective white. Indeed, the close view of a southern glacier, shown in the lower left image, shows pale ponds of liquid water, "supraglacial ponds" on the glacier's surface. The northern glacier, lower right, is free of both debris and ponds. NASA image courtesy the NASA/GSFC/METI/ERSDAC/JAROS, and U.S./Japan ASTER Science Team.

▌ EOS Science Calendar ▌   ▌ Global Change Calendar ▌

November 1-3
CERES Science Team Meeting, Hampton, VA. Contact: Shashi Gupta, *S.K.Gupta@larc.nasa.gov*.

November 7-11
Aura Validation Workshop, Netherlands. Contact: Anne Douglass, *Anne.R.Douglass@nasa.gov*.

2006

February 21-23
Community Workshop on Air Quality Remote Sensing from Space: Defining an Optimum Observing Strategy, Boulder, CO. URL: *www.acd.ucar.edu/Meetings/ Air_Quality_Remote_Sensing*. Contact: David Edwards, *edwards@ucar.edu*.

December 5-9
American Geophysical Union (AGU) Fall Meeting, San Francisco, CA. URL: *www.agu.org/meetings/fm05/*

2006

January 29-February 2
American Meteorological Society (AMS) 86th Annual Meeting, Atlanta, GA. URL: *www.ametsoc.org/meet/annual/index.html*.

July 12-14
4th IEEE Workshop on Sensor Array and Multi-Channel Processing (SAM), Westin Hotel, Waltham, MA. URL: *www.sam2006.org*. Call for presentations, due February 1, 2006.
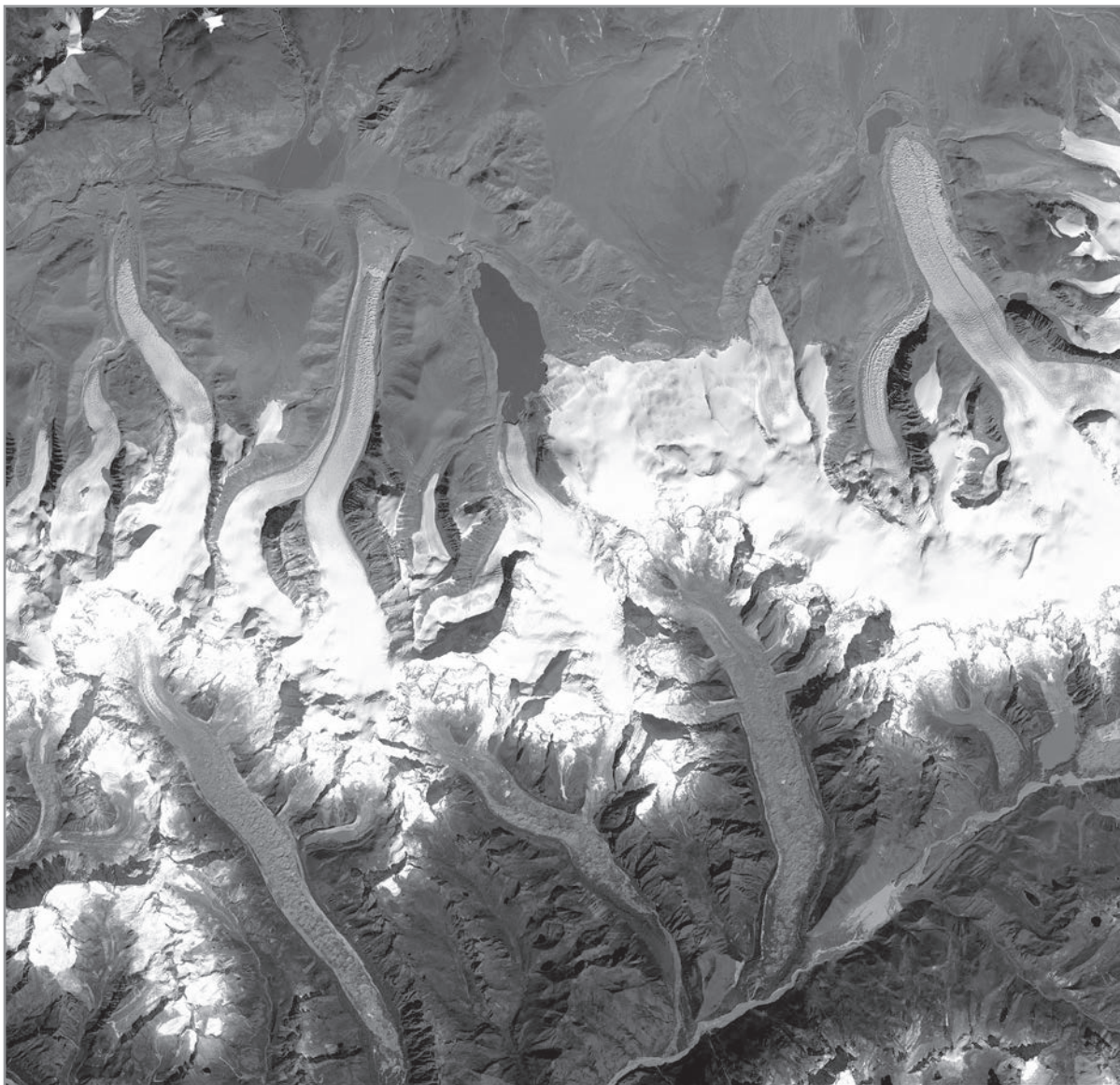
Science Calendars

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The Earth Observer

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The Earth Observer Staff