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Editor's Corner

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On December 18, NASA's Terra satellite will celebrate the 10th anniversary of its launch. Terra was the first of the three larger multi-instrument Earth Observing System missions to launch—Aqua and Aura launched in 2002 and 2004, respectively. Its five instruments, with contributions from Canada and Japan, began transmitting science data in February 2000. Ten years later, Terra continues its mission to assess the planet by providing comprehensive information about Earth's land, oceans, cryosphere, and atmosphere.

From an altitude of 705 km, Terra orbits the Earth more than fourteen times a day in a morning sun-synchronous orbit. Sending home roughly 1 terabyte of data per day, Terra has helped scientists all over the world tackle important Earth system science questions. While Terra's name implies that her science has a focus on land processes, the data are used by the full range of science discipline communities and includes two common instruments with Aqua—Clouds and the Earth's Radiative Energy System (CERES) and Moderate Resolution

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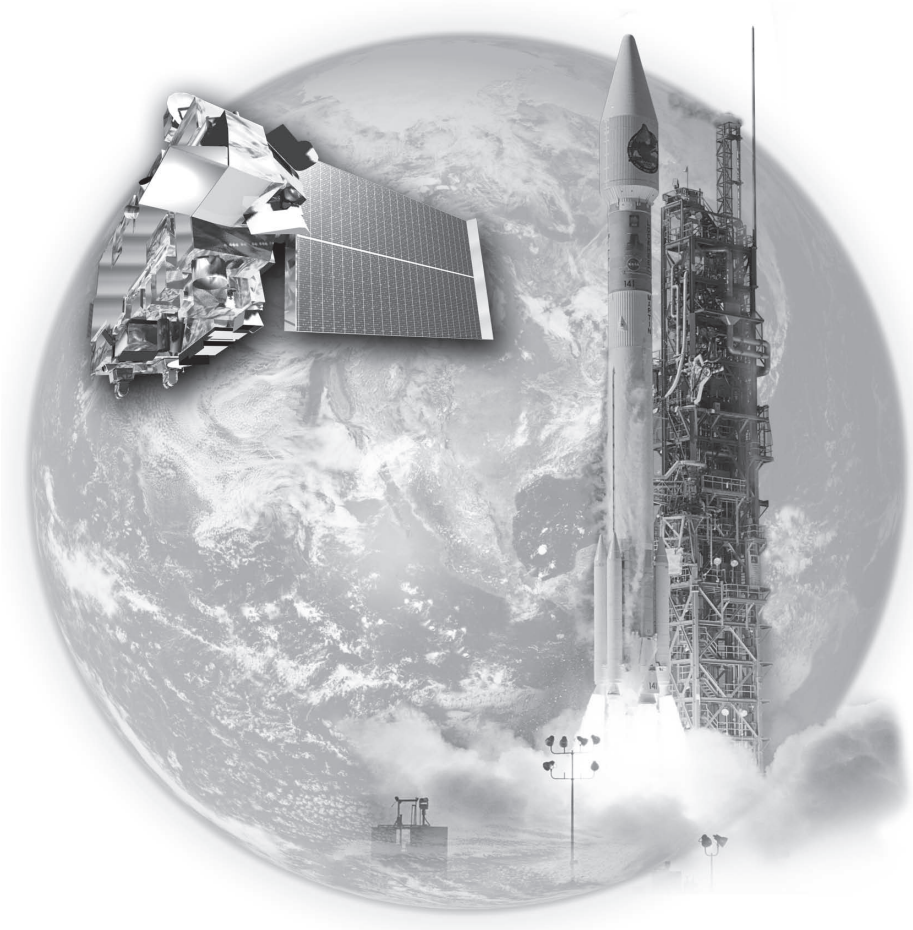

December 18 will mark the 10th anniversary of the launch of NASA's Terra satellite from Vandenberg Air Force Base in California. In February 2000, Terra made its first observations, ushering in a decade of observations from NASA's Earth Observing System—a coordinated series of satellites that monitor how Earth is changing and what the consequences might be. Terra is an international mission involving the U.S., Canada and Japan; it carries five state-of-the art sensors that have been studying the interactions among the Earth's atmosphere, land, oceans, and radiant energy. Each sensor has unique design features that enable scientists to meet a wide range of science objectives.

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In This Issue

Imaging Spectroradiometer (MODIS). The information from Terra has also been used in a wide variety of applications that have practical benefits for society, e.g., air quality forecasting, natural hazard monitoring, agricultural productivity monitoring, weather forecasting, carbon monitoring, etc. Terra's portfolio of achievements to date already marks the mission as a resounding success. Though well beyond its original six-year mission (there have now been three successful *Senior Review* mission extension proposals), all five of Terra's instruments continue to function and that portfolio of achievements continues to grow.

As of last spring (at the time of the Earth Science Senior Review), more than 3,200 peer-reviewed science articles had been published using Terra data, with more than 12,500 citations. That amounts to nearly one publication per day over a 10-year period, and the numbers of articles and citations continue to rise.

Terra Project Scientist, Marc Imhoff, had this to say about Terra's first 10 years in orbit. "For the past 10 years Terra has been providing the world community with an enormous wealth of information about the global environment at little to no cost to the user. These data are now widely distributed, and have been, and continue to be, used by scientists and governments around the globe to understand global change, better the lives of their people, and chart a path forward."

The 10th Anniversary of Terra (dubbed *Terra@10*) will be recognized at this year's Fall American Geophysical Union Meeting December 14-18, 2009 in San Francisco, CA. Four technical sessions (two oral and two poster) are planned to take place on Wednesday, December 16. Also, the NASA booth in the exhibit hall will feature presentations on the state of Terra science and the spacecraft on Tuesday, December 15, at 3:00 p.m. and 5:00 p.m., respectively.

Beyond the specific *Terra@10* activities mentioned above, if you plan to attend AGU this year, I hope you'll have time to visit the NASA Exhibit which will be staffed by representatives from throughout NASA, including our EOS Project Science Office staff. Also, as has been the case in recent years, our office has organized a series of informative presentations on NASA Science taking place at the exhibit booth—including the two mentioned above specifically related to Terra. This year's agenda is very full—*eos.nasa.gov/eos_homepage/announcements/fallAGU2009.php*—so you will find interesting talks going on most any time you stop by. In addition to our live presentations, we will have an 84" video wall that will be showing NASA movies and animations and we will debut a new version of our *Dynamic Planet* image visualization system. This system can project our NASA Science datasets on a compact sphere with vibrant high definition image quality on par with the larger *Science on a Sphere* projection system. For more information on our plans for AGU, see the ad on page 21 of this issue.

There have been several recent project scientist personnel changes. For the Aura mission, **Anne Douglass** has been chosen to be Project Scientist, replacing **Mark Schoeberl** who had served in this role since 1998. Her research focus is on stratospheric chemistry and transport and emphasizes the development and analysis of predictive models and the quantitative evaluation of satellite, aircraft and ground-based observations. In addition to having served as the Aura Deputy Project Scientist since 1998, Anne was the Deputy Project Science for Upper Air Research Satellite (UARS) from 1993 until its decommission in 2005. Anne's efforts

have contributed significantly to Aura's past success and I know the mission will continue to benefit from her participation and leadership. **Bryan Duncan** is a new Deputy Project Scientist for Aura. Duncan joins **Joanna Joiner** in this role; Joiner has served as Deputy Project Scientist since 2005. Like Douglass and Joiner, Duncan comes from the Atmospheric Chemistry and Dynamics Branch at Goddard. He works on issues related to tropospheric chemistry and supports activities involving global modeling, field mission support, and satellite data evaluation and interpretation. Duncan has been a co-chair of the Aura Air Quality Working Group since 2006.

In addition, **Tom Neumann** is now serving as Deputy Project Scientist for the Ice, Cloud, and Land Elevation Satellite (ICESat)—he is also Deputy Project Scientist for ICESat II, a *Tier 1* Decadal Survey mission. Neumann is a cryospheric scientist who focuses on ice sheet studies. His research includes both theoretical and experimental studies of the chemical, physical, and thermodynamic properties of polar snow and ice. He has been involved extensively in field work on the Greenland and Antarctic ice sheets, leading four expeditions and participating in five others between the two poles. Recent work has involved studies of snow chemistry on the East Antarctic plateau and calibrating ICESat altimetry data using ground-based GPS surveys in Antarctica. Tom joined NASA Goddard Space Flight Center in October 2008. Prior to that, he was an assistant professor in the Geology Department at the University of Vermont.

Please join me in welcoming everyone to their new roles.

Once again, it is hard to believe that another year is quickly drawing to a close. On behalf of the entire staff of *The Earth Observer*, I want to thank everyone for their continued support of our publication and wish everyone all the best in the year to come. ■

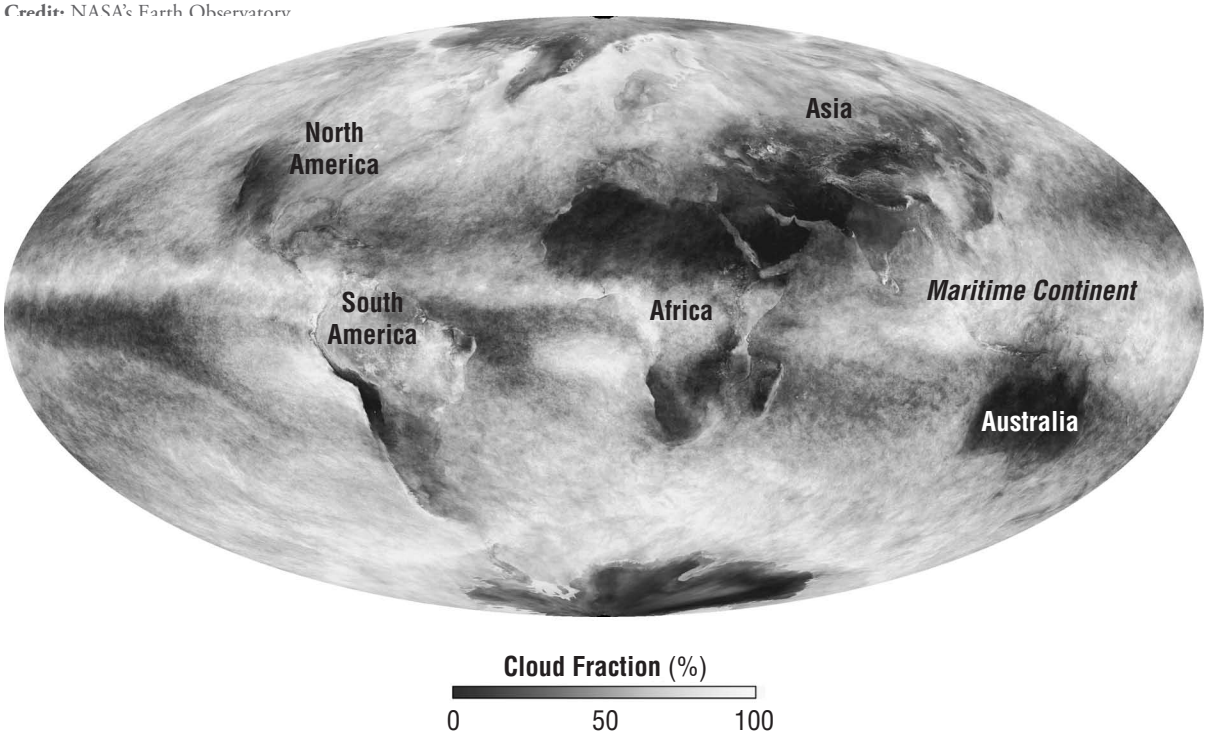
Clouds Can Reveal the Shape of Continents

In some parts of the world the difference in the amount of clouds over land versus ocean is so stark that the outlines of continents and other landmasses can be traced through observations of clouds alone. This image of October 2009's cloud fraction (the fraction of an area covered by clouds) demonstrates the pattern. The measurements were collected by the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite.

Not surprisingly, the most dramatic cloud boundaries occur in places where very dry land is surrounded by ocean, such as northern and southern Africa, the Arabian Peninsula (east of North Africa), and Greenland. The sharp boundary between water and land fades over humid regions. In west-central Africa, the contour of the coastline fades beneath clouds that are nearly as prevalent over the humid tropical forests as they are over the Atlantic Ocean to the west.

Over the islands, narrow peninsulas, and shallow seas between Southeast Asia and Australia, the difference between land and water virtually disappears; the entire region is extremely cloudy, and the outlines of the major land masses—including the Indonesia islands of Sumatra and Borneo are barely perceptible. This blurring of boundaries is reflected in the name meteorologists give this region: the Maritime Continent.

Credit: NASA's Earth Observatory



feature articles

NASA and USGS Invest in Invasive Species Modeling and Evaluate Habitat for Africanized Honey Bees.

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The invasive species modeling research team spans several agencies and organizations and has included physicists, remote sensing specialists, field ecologists, botanists, spatial modelers, and computer scientists. The scientific progress made has been remarkable, leveraging dozens of research grants and producing many scientific papers.

Introduction

Invasive non-native species, such as plants, animals, and pathogens, have long been an interest to the U.S. Geological Survey (USGS) and NASA. Invasive species cause harm to our economy (around $120 B/year), the environment (e.g., replacing native biodiversity, forest pathogens negatively affecting carbon storage), and human health (e.g., plague, West Nile virus). Five years ago, the USGS and NASA formed a partnership to improve ecological forecasting capabilities for the early detection and containment of the highest priority invasive species. Scientists from NASA Goddard Space Flight Center (GSFC) and the Fort Collins Science Center developed a long-term strategy to integrate remote sensing capabilities, high-performance computing capabilities and new spatial modeling techniques to advance the science of ecological invasions [*Schnase et al.*, 2002].

The invasive species modeling research team spans several agencies and organizations and has included physicists, remote sensing specialists, field ecologists, botanists, spatial modelers, and computer scientists. The scientific progress made has been remarkable, leveraging dozens of research grants and producing many scientific papers. The research team pioneered efforts in risk analysis for invasive species [*Stohlgren and Schnase*, 2006], mapped and modeled harmful invasive plants [*Morisette et al.*, 2006; *Kumar et al.*, 2009], and began investigating the effects of climate change on species invasions [*Jarnevich and Stohlgren*, 2009; *Holcombe*, 2009]. The science clearly demonstrated the importance of accurate, remotely-sensed time series from the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument, and the integration of remotely-sensed field observations, and spatial modeling. More importantly, it became apparent that as computer technologies changed, improved data management capabilities and web-based solutions would be increasingly important to address issues of climate change and deadly invasions [*Rodda et al.*, 2009].

In September 2009, the NASA–USGS partnership culminated in the installation of modeling software at a newly renovated facility at the USGS Fort Collins Science Center. The facility is known as the Resource for Advanced Modeling (RAM), which provides a collaborative working environment for up to 20 scientists. The RAM provides networked and wireless computing facilities, with the ability to run and test various models (e.g., Maximum Entropy (Maxent), Boosted Regression Trees, Logistic Regression, Multivariate Adaptive Regression Splines (MARS), Random Forest) for a variety of spatial scales (i.e., county, state, region, nation, or global), using predictor layers from MODIS time-series data as well as current and future climate layers (both near- and long-term projections). The purpose of the RAM is to bring together remote sensing and climate forecasting experts, habitat modelers, field ecologists, and land managers. The team from GSFC investigating migration of the Africanized Honey Bee (AHB) visited USGS collaborators in October 2009 for the first topical work session at the RAM facility. This article summarizes the AHB habitat suitability modeling project, the models tested during the workshop, some preliminary model results, discussion on the advantages of conducting habitat modeling in a highly interactive, collaborative setting as well as the future plans for the AHB project.

The NASA Africanized Honey Bee Project

The Africanized Honey Bee Project is funded under the Decisions Support ROSES 2007 Program to address national needs related to: a) prediction of the suitable habitat of the AHB as an invasive species; and b) agricultural requirements related to the health of the nation's honey bees with respect to climate impacts on forage availability. In addition to NASA and USGS, the U.S. Department of Agriculture (USDA) Agricultural Research Service (ARS), Arizona State University, and Apiary Inspectors from several states are participating as concerned decision makers. The spread of AHBs is not only a great concern to the general public health and safety but also impacts agricultural pollination. Once a feral population of honey bees converts to African from the European variety, beekeeping becomes more complex. State agencies require education of the general public, first responders, and pesticide control officers.

Production of docile European honey bee queens is also more complicated in regions where feral AHB colonies are present because virgin queens must mate in an open area with resident drones—difficult to accomplish without mixing and spreading AHB genetics. (About a million new queens and worker bees are required each year to replace heavy winter colony losses due to Colony Collapse Disorder and other causes such as mites and pathogens.) Improved understanding of how far north and east the AHB can successfully over-winter would be a great benefit to planning the timing of these production efforts. Current estimates of AHB habitat suitability in the U.S. vary widely, and have already proven incorrect in several locations. The focus for this effort is to apply new MODIS-derived vegetation phenology information along with climate variables to the problem using state-of-the-art habitat modeling techniques.

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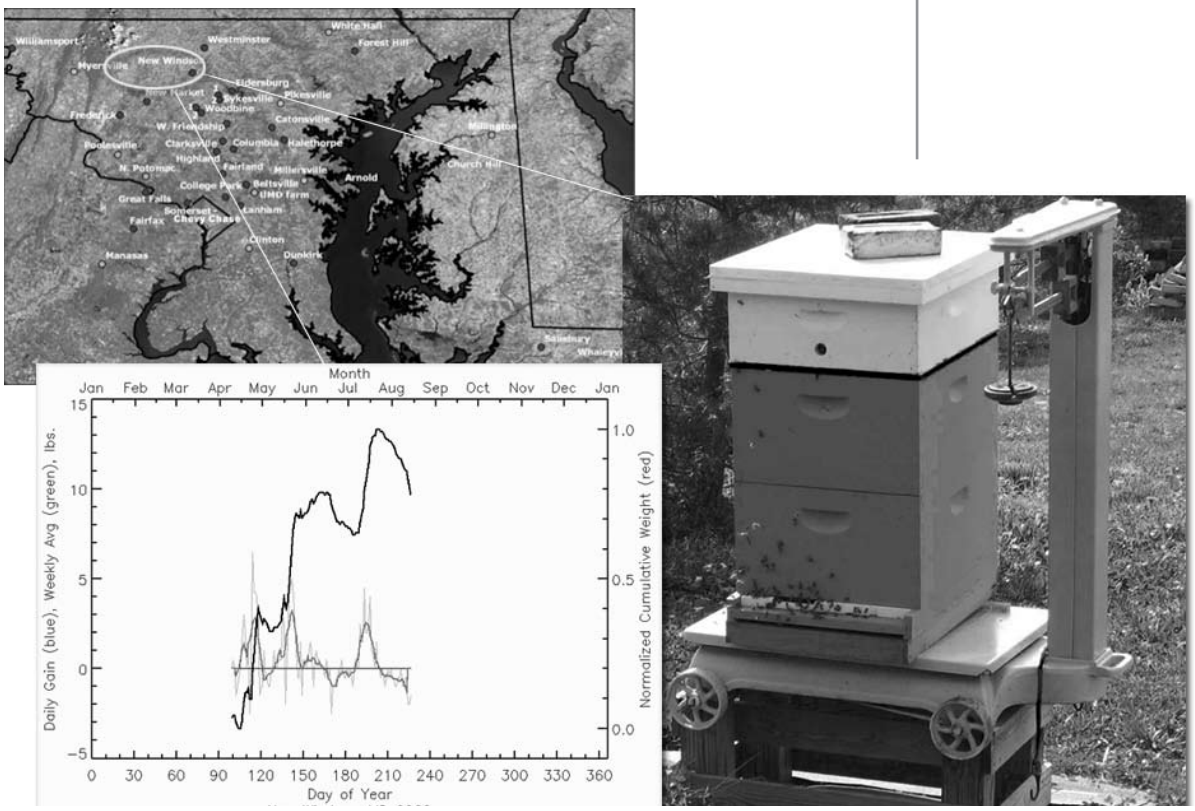
Research at NASA's Goddard Space Flight Center (GSFC) has shown that the timing in nectar flows in the Mid-Atlantic has advanced by about 26 days since 1970 due to regional warming.



A scale hive in New Windsor, MD. Volunteers provide scales, hives, and daily hive weight, at their own expense according to recommended protocol. The data are provided to NASA, sometimes including nectar plant blooming information. Data are given a quality assessment, plotted, and added to the *HoneyBeeNet* at GSFC. The data are available publicly and are used by NASA and collaborators for climate–pollinator impact analysis.

The data from HoneyBeeNet will enable regional relationships between satellite vegetation data and nectar flows and give a baseline for North America against which changes in response to climate and land use/land cover can be measured.

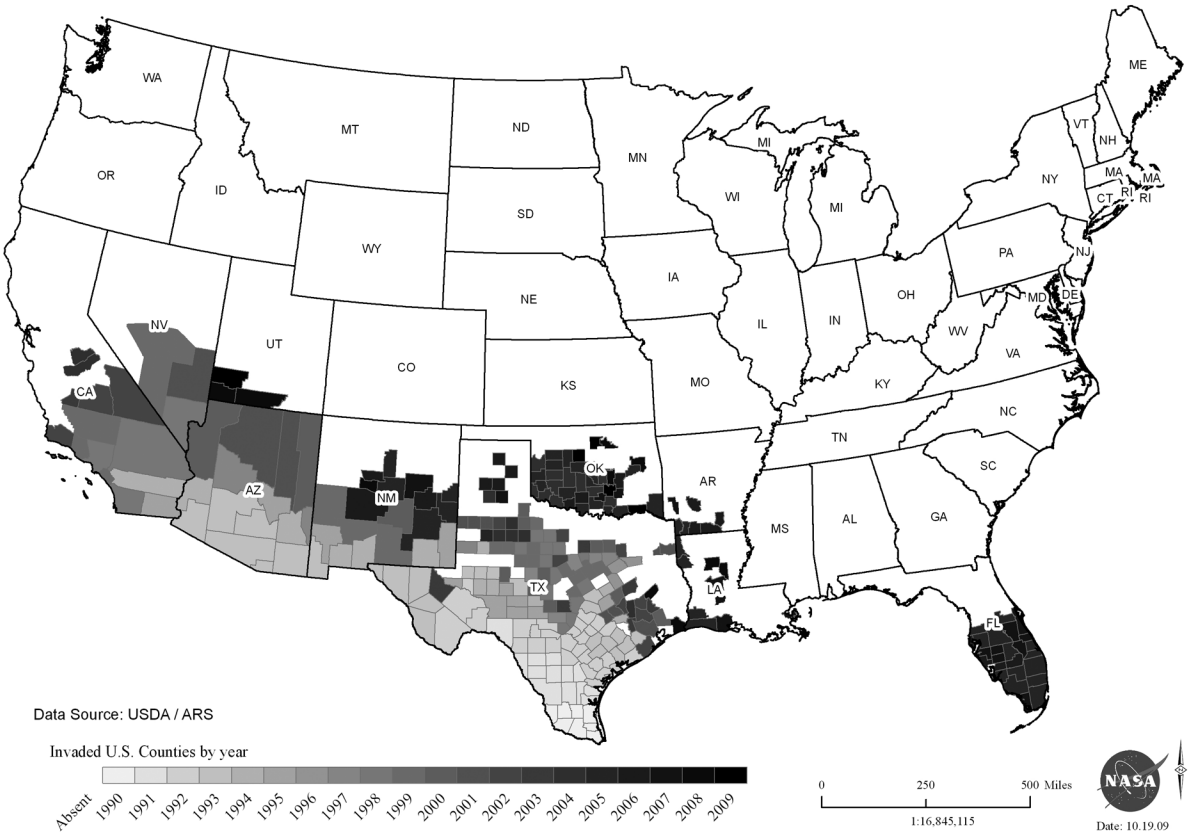
regional warming[1]. The phenology of the nectar flow is monitored by measuring the daily weight changes of honey bee hives that are kept on balance scales (*scale hives*—see photo on page 5), and varies significantly according to the regional floral composition and climate. This rate of advance (-0.57 days/year) in central Maryland is in excellent agreement with the local advance in spring green-up seen by the Advanced Very High Resolution Radiometer (AVHRR) and MODIS sensors, and is commensurate with advances in blooming dates of major nectar sources. Relationships between the dates of the nectar flow and the satellite-derived vegetation data for this region appear very robust, and suggest that the change extends throughout most of the Northeast U.S. ecosystems [*Nightingale et al.*, 2008]. The scale hive records depict the success of seasonal plant-pollinator interaction using the honey bee model. *HoneyBeeNet* is a network of volunteer beekeepers (*honeybeenet.gsfc.nasa.gov*) that has been established and is growing, to provide widespread monitoring of nectar flows. The data from this network will enable regional relationships between satellite vegetation data and nectar flows and give a baseline for North America against which changes in response to climate and land use/land cover can be measured. There is a direct link between the two areas of the project given that the suitable habitat of the AHB is determined by both physical climate and the nectar flow phenology.

Modeling Activities

The NASA and USGS collaborative modeling effort utilized the RAM resources to establish preliminary ecological habitat models of the AHB in the continental U.S. The working session primarily focused on the Maximum Entropy (Maxent) modeling technique and for the first time considered both seasonal climatic and phenological satellite-derived raster layers as predictors. A robust set of 19 monthly bioclimatic lay-

[1] Please see the article "Honey Bees Turned Data Collectors Help Scientists Understand Climate Change", in the September–October issue of *The Earth Observer* [**Volume 21**, **Issue 5**, pp. 46-47.]

Figure 1. County Level Map of Africanized Honey Bee



ers (*www.worldclim.org/bioclim.htm*) were assembled to provide average seasonal temperature and rainfall values. Satellite data considered MODIS data products including Vegetation Continuous Field (VCF) layers and MODIS Normalized Difference Vegetation Index (NDVI)-derived phenology products from the North American Carbon Project at GSFC. All of the data layers were assembled for the continental U.S. at 1-km spatial resolution and for each model a *cross correlation* analysis was undertaken to remove redundant information of highly similar variables.

The focus of the modeling session was on exploring potential ecological constraints driving the Africanized Honey Bee distributions in environmentally diverse regions of the country.

Over the past two years, preparatory work has focused on understanding the ecological impacts of the AHB across the contiguous U.S. The field data collection of AHB presence locations in the U.S has involved laborious coordination of agencies and state apiculturists (i.e., bee keepers) to establish the most up-to-date map of existing locations of the AHB in the U.S.—see **Figure 1**. The modeling session further explored the usefulness of regional models in helping to understand and identify the leading fronts of the invasion—commonly referred to as the *hybridization zones*. The focus was on exploring potential ecological constraints driving the AHB distributions in environmentally diverse regions of the country. Specifically, these regions were the arid southwest—where the AHB was originally introduced—and the wetter southeast, where there is currently a high level of threat to an existing queen breeding industry. Furthermore, **Danielle Downey**, biologist with the Utah Department of Agriculture & Food (DAF) Division, participated in the modeling exercise as a concerned decision maker and AHB location data provider. Downey contributed extensive knowledge of AHB biology and behavior to help us with investigation of a managed sub-region encompassing southern to northern Utah as well as similar surrounding areas across state administrative boundaries. Previous model outputs were used to aid locations of swarm traps by Utah Department of Food and Agriculture (DAF) personnel.

Preliminary Results

Results showed that the continental habitat suitability model was driven primarily by climatic data (particularly temperature limitations), although the VCF herbaceous layer and minimum NDVI were among the top five predictors contributing most to the model. The national model performed well according to a test dataset using the *Area Under the Curve (AUC)* measurement; with an overall value of 0.86. (AUC varies from 0.5 to 1 and can be considered the probability that, given one randomly selected presence point and one randomly selected absence points, the model will assign a higher score to the presence location than to the negative location.) Interestingly, the smaller regional models for the southwest and the southeast indicated that different drivers are important at regional scales. The southwest model performed well (test AUC 0.90), and was primarily driven by physical climate variables (particularly temperature limitations) and VCF-defined tree and herbaceous layers. The sub-region model for the Utah area provided similar results to the southwest regional model. However, the model for the southeast was more complex, with a test AUC of 0.67, and was driven primarily by remotely sensed vegetation products of the MODIS sensor, which included phenology variables in addition to the VCF herbaceous layer. The complexity and relatively low AUC value for this region highlights the need for continued work to better understand what is occurring in this zone of hybridization across very disparate habitats from eastern Texas to South Florida.

These preliminary results indicate that suitable habitat for Africanized Honey Bees may exist northward of its present range in the west, and supports the concept that floral phenology may limit expansion along the Gulf States.

These preliminary results suggest that remotely sensed data products continue to provide greater insight in regions where pronounced signals of vegetative phenological cycles inform investigators of the ecological intricacies in the surrounding environment. Apiculturists commonly agree that an AHB colonies' survival is based on both forage availability and temperature requirements. **In the end, it is the lack of available forage in combination with harsh climatic conditions or a sustained winter dearth in forage resources that determines colony survivability and geographic habitat limitations.** These complicated interactions are what NASA and USGS hope to unravel to better inform the general public and industries affected by the invasion of the AHB. **These preliminary results indicate that suitable habitat for**

Looking forward, both the AHB habitat suitability prediction work and the determination of the current Honey Bee nectar flow phenology using satellite products are limited by the relative small number of field observations. Over the next year this issue will be considered the focus for improving the current AHB habitat predictions in critical areas along the Gulf Coast and in the mid-west.

Africanized Honey Bees may exist northward of its present range in the west, and supports the concept that floral phenology may limit expansion along the Gulf States. Further work is necessary to confirm these conjectures.

Discussion

Utilizing RAM's state-of-the art facility to hold the modeling sessions and discussions, USGS and NASA researchers alongside land managers had a unique opportunity to interrogate model techniques, visualize satellite data products, and explore outcomes that were previously unavailable. Specifically, the major advantage of this meeting was demonstrating the linkage between the evolved behavioral synchrony of the honey bee and the phenology of nectar flows. This advancement in understanding was accomplished with satellite data products and the new modeling capabilities, which only recently have been made available through the collaboration. **Looking forward, both the AHB habitat suitability prediction work and the determination of the current Honey Bee nectar flow phenology using satellite products are limited by the relative small number of field observations.** Over the next year this issue will be considered the focus for improving the current AHB habitat predictions in critical areas along the Gulf Coast and in the mid-west. To the extent that floral phenology of the bee nectar plant community may be an important variable, long-term climate impact studies may have to involve plant species succession, including invasives, along with good regional physical climate models, to determine the eventual range of the AHB.

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Creating Successful Scientific Visuals

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Effective science visuals are an essential element of accurate and successful science communication and the need for them is growing. The long history of scientific thought and discovery is closely intertwined with the evolution of scientific visuals[1]. The science communicator must keep in mind that data by themselves are rather useless to the casual viewer [*Shedroff*, 2000]. It is the job of science communicators and designers (grouped together here as *information designers*) to elucidate and clarify the importance of scientific data [*Jacobson*, 2000].

Successful scientific visuals can be rapidly interpreted and understood by viewers. The information designer must be cautious not to overload the viewer with detail while simultaneously providing enough information for the viewer to understand relevant data relationships.

Gathered here are guidelines for creating valuable scientific visuals. These guidelines build on the work of **Jacques Bertin**, **John Tukey**, **William Cleveland**, and **Edward Tufte**, all champions of information design.

***Robert Horn** has defined visual language as the synthesis of words, images, and shapes into a unified whole. Research has verified that viewer comprehension is amplified when visual and textual elements are used together.*

Use Fluent Visual Language

Robert Horn has defined visual language as the synthesis of words, images, and shapes into a unified whole [*Horn*, 2000]. Research has verified that viewer comprehension is amplified when visual and textual elements are used together [*Baer*, 2008]. Accordingly, Tufte strongly advocates complete integration of words, numbers, images, and diagrams, pointing to maps as the pinnacle of successful integration [*Tufte*, 2006].

Dare to Compare

Scientific graphics often compare and contrast various datasets. Humans are adept at visually seeing patterns and making comparisons. Scientific visuals should capitalize on this [*Tufte*, 2006].

Weave a Narrative

A good data graphic should tell a story [*LeGates*, 2005]. Strive to illustrate cause and effect, mechanism, structure, and explanation.

Show Multiple Variables

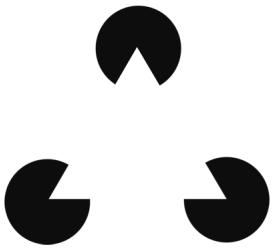
Most scientific data are *multivariate* (i.e., they have two or more variables); scientific graphics should reflect this.

Document, Document

Every scientific graphic should be titled and indicate the data source, scale of measurement, and graphic authorship.

[1] See the article "The Role of Visuals in Science Communication" in the September-October 2009 issue of *The Earth Observer* [**Volume 21, Issue 5**].

As Frank Lloyd Wright instructed, it's not "form follows function" rather, "form and function should be one, joined in a spiritual union."



According to Gestalt perceptual psychology, we see a triangle here.

Content is Paramount

A scientific graphic is only as good as the data. Be sure that the content has quality, relevance, and integrity [*Tufte*, 2006]. Focusing on the central message will safeguard against it getting lost in the mechanical details of production [*LeGates*, 2005].

Adjacency Principle

Humans are better at comparing, contrasting, and finding patterns when objects are within eye span, so whenever possible, keep comparative graphics adjacent to one another.

Keep it Clean

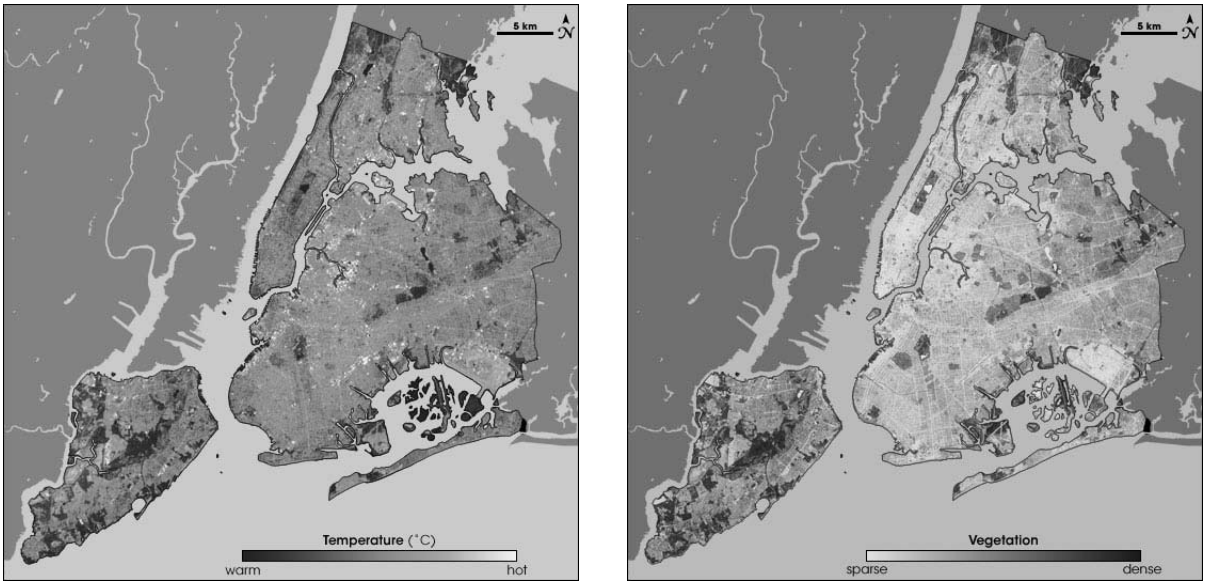
Like all good design, science graphics should be visibly uncluttered. Dispense with any undue decoration; data should be the focal point. By reducing noise, signal is enhanced, viewer fatigue is reduced, and comprehension increased [*Tufte*, 1990]. Good design practices should be used to cut through clutter and enhance the message [*Baer*, 2008]. Always be mindful of the lessons of Gestalt perceptual psychology: humans are eager to visually group elements into cohesive wholes (sometimes 1+1 = 3) [*Pauwels*, 2006; *Trumbo*, 1999; *Berger*, 2008].

Beauty Matters

Aesthetics influence cognitive processing and viewers use visual appeal to judge trustworthiness [*Anderson*, 2009]. *Time* magazine art director, **Nigel Holmes**, says that design attractiveness will affect whether or not a reader uses the graphic information. As **Frank Lloyd Wright** instructed, it's not "form follows function" rather, "form and function should be one, joined in a spiritual union."

Respect your Audience

Good data graphics make things clear, **not** simplistic.



Maps are one of the oldest forms of information design. The award-winning maps shown here closely follow the tenets of good scientific visual design. These maps show temperature and vegetation patterns in New York City. They were designed by NASA Earth Observatory data visualizer Rob Simmon using Landsat data. To view these in color, visit: *earthobservatory.nasa.gov/Features/GreenRoof/greenroof2.php*.

Good Examples: *The Science Times*

In 1978, the *New York Times* introduced its science section, the *Science Times*; since then, it has established itself as a reliable and influential guide to the science world [*Clark & Illman*, 2006]. In particular, its science graphics adhere to high standards.

Science Times senior editor and visual journalist **Archie Tse** reveals, "to really understand a dataset, you need to process it yourself. Seventy-five percent of our time is spent reporting, gathering, and distilling information" [*Baer*, 2008]. Accordingly, many of Tse's graphic editors have scientific or mathematical backgrounds. Tse says, "we know it's a balancing act. We need to provide enough detail to illuminate the content, but showing too much complexity may alienate some readers" [*Baer*, 2008].

As a scientist attempting to create successful visuals, closely studying the graphics used in the *Science Times* may help you better apply the guidelines given in this article. Additionally, NASA has resident experts, such as those in the Science Visualization Studio (*svs.gsfc.nasa.gov*). Talk with your center's public affairs office for more information about the NASA resources available to you.

Creating good scientific visualizations requires "...a balancing act. We need to provide enough detail to illuminate the content, but showing too much complexity may alienate some readers."

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Blog Log

Nicole Miklus, NASA Goddard Space Flight Center, nmiklus@sesda2.com
Blog Introductions modified from the Earth Observatory, earthobservatory.nasa.gov/blogs

In previous issues, we've featured condensed blogs from scientists conducting Earth science research. These firsthand accounts illustrate the obstacles of field research from equipment malfunctions to brutal weather. They also show the rewards of such hard work—scientific discovery, visits to remote and beautiful regions of Earth, and glimpses at wildlife. As part of *The Earth Observer's* continuing effort to be more economically and environmentally conscious, we have decided to adopt a more condensed format for reporting on blogs. With our new *Blog Log* feature, we'll introduce you to new blogs and direct you online where you can access the full story and view color photographs. We hope that the *Blog Log* will give you the chance to do some armchair exploring and that, perhaps on your next field experience, you'll consider writing a blog to share with us!

Operation Ice Bridge, In Progress

Operation Ice Bridge is a six-year NASA field campaign to complete the largest ever airborne survey of Earth's polar ice. The campaign began in March and April when NASA's P-3B research aircraft flew over Greenland and the Arctic Ocean, measuring glacier and ice sheet thickness[1]. The fall campaign, based out of Puntas Arenas, Chile, will use NASA's DC-8 to make flights over the Southern Ocean, West Antarctica, the Antarctic Peninsula, and coastal areas. The data will give an unprecedented three-dimensional view of Arctic and Antarctic ice sheets, ice shelves, and sea ice and will be used to bridge the gap between the Ice, Cloud and land Elevation Satellite (ICESat) and its follow-on mission, ICESat II. To read about the campaign from Ice Bridge scientists and other team members, go to: *blogs.nasa.gov/cm/blog/icebridge.blog/posts/index.html.* Be sure to check back for updates!

NASA's DC-8 flying laboratory will make up to 17 flights over the Antarctic region. **Photo credit:** Steve Cole.

North Woods, Maine 2009

Jon Ranson led a team to the Howland Research Forest and Penobscot Experimental Forest in central Maine in August 2009. Ranson is the Lidar Project Scientist for Deformation, Ecosystem Structure and Dynamics of Ice (DESDynI), a Decadal Survey mission planned to launch in 2017. By making accurate measurements of forest vegetation, Ranson and colleagues can validate lidar and radar data and improve algorithms for the remote sensors on DESDynI. During his visits to the forests of Siberia[2], Ranson collected ground-truth data for satellites, but the flat

[1] Chris Chrissotimos shared his experience during the first phase of Operation Ice Bridge in the July–August issue of *The Earth Observer.* [**Volume 21**, **Issue 4**, pp. 12–19.]
[2] Excerpts from Ranson's earlier blogs can be found in the September–October 2007 and January–February 2009 issues of *The Earth Observer.* [**Volume 19**, **Issue 5**, pp. 13–21 and **Volume 21**, **Issue 1**, pp 19–20.]

(Left) A hemispherical photograph taken through a fisheye type lens. Such photos will be digitized and analyzed to calculate canopy cover of the forest. **Photo credit:** Sassan Saatchi. *(Right)* A young moose spotted in the Howland Forest area. **Photo credit:** John Lee.

terrain, biodiversity, and variation in biomass present in Maine's forests provided an opportunity to see how remote sensing instruments respond to change in species and biomass. To view the full blog, please visit: *earthobservatory.nasa.gov/blogs/fromthefield/2009/08/18/introduction/#more-571.*

Journey to Galapagos

Gene Feldman, an oceanographer at Goddard Space Flight Center, traveled to the Galapagos Islands in July 2009 to study marine habitats and oceanographic conditions. Feldman has studied the Galapagos from space for the past 25 years, using satellite observations of ocean color to study the effects of El Niño on phytoplankton and wildlife. The Galapagos are home to many unique species not found elsewhere in the world and **Charles Darwin**'s studies made during his voyage there on the HMS *Beagle* inspired his book, *The Origin of Species*. This year (2009) marks the 150th anniversary of the book's publication and the 200th anniversary of Darwin's birth. In preparation for his journey, Feldman stepped back in time by reading the notebooks and logs of Darwin and *Beagle* captain **Robert Fitzroy**. To read about Feldman's adventures and see spectacular photos, visit: *earthobservatory.nasa.gov/blogs/fromthefield/2009/07/15/journey-to-galapagos/.*

(Left) Feldman and colleagues used the *M/V Queen Mabel* as their home and research platform. *(Right)* Feldman's first view of the Galapagos islands.

North America Land Data Assimilation System Phase 2 (NLDAS-2) Hourly Products Released to the Public

The NASA GSFC Hydrological Sciences Branch and Goddard Earth Sciences Data and Information Service Center (GES DISC) are pleased to announce the release of North America Land Data Assimilation System Phase 2 (NLDAS-2) data products in the Hydrology DISC.

NLDAS-2 products are a 30-year dataset (1979-present, in near, real-time) of hourly 1/8° surface meteorology and hydrology data over the continuous U.S. and parts of Canada and Mexico. NLDAS combines observations from many different sources (e.g., rain gauges, radar, satellite, model reanalysis) to generate a surface forcing dataset, which is used to drive several different land-surface models. The current data hosted at the GES DISC include both primary and secondary forcing data and Mosaic model outputs.

Users can access the data by searching and downloading via anonymous ftp or through the GES DISC search interface Mirador (*mirador.gsfc.nasa.gov*). Mirador is an innovative data search engine that makes use of keywords to find data quickly in a Google-like interface. NLDAS data are also provided through a GrADS Data Server (GDS) at *hydro1.gsfc.nasa.gov/dods/*. GDS users can access the data and perform subsetting and analysis operations online. More advanced tools will be provided in later releases, such as spatial and parameter subsetting, data format transformation, and access through the GES DISC online visualization and analysis system Giovanni.

Data access link: *disc.sci.gsfc.nasa.gov/hydrology/data-holdings*

meeting/workshop summaries

SORCE Science Team Gathers in Montreal

Tom Woods, Laboratory for Atmospheric and Space Physics, University of Colorado, woods@lasp.colorado.edu
Jerry Harder, Laboratory for Atmospheric and Space Physics, University of Colorado, jerry.harder@lasp.colorado.edu
Vanessa George, Laboratory for Atmospheric and Space Physics, University of Colorado, vanessa.george@lasp.colorado.edu

Since its launch in 2003, the SOlar Radiation and Climate Experiment (SORCE) has measured solar irradiance at the top of the Earth's atmosphere with unprecedented accuracy, precision, and spectral coverage across the ultraviolet, visible, and near-infrared regions of the spectrum. The SORCE science team usually convenes an annual meeting to both highlight SORCE's unique, state-of-the-art emerging solar irradiance database and to engage the broad scientific community in interdisciplinary scientific issues involving solar irradiance variability and its influence on climate and the Earth's atmosphere on multiple time scales. For 2009, the SORCE science team decided to expand their interactions with the broader international community by attending the International Association of Meteorology and Atmospheric Sciences (IAMAS) Symposium in Montreal, Canada. The majority of their presentations were on July 27-28 in IAMAS Session M03, called ***The Impact of Solar Variability on Earth.*** There were about 50 participants in this session, and they addressed many aspects of the impact of solar variations on Earth's environment including:

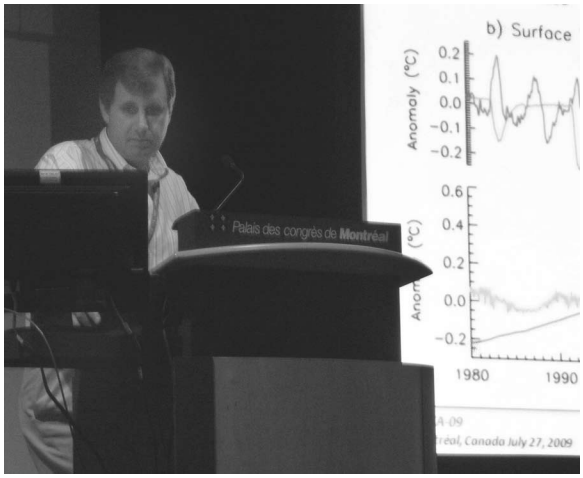
- Variability of the solar irradiance [Total Solar Irradiance (TSI) and Solar Spectral Irradiance (SSI) measurements and modeling];
- Variability of the solar energetic particles;
- Solar forcing in the atmosphere (observations, modeling, mechanisms); and
- Solar impact on climate change on centennial to millennial timescales.

Session M03 began on Monday, July 27, and featured four topics, beginning with presentations on **TSI Measurements and Modeling**, which included discussions of TSI measurements from SORCE, the SOLAR mission on the International Space Station (ISS), and the Variability of solar IRradiance and Gravity Oscillations instrument (VIRGO) on the Solar and Heliospheric Observatory (SOHO). **Greg Kopp** [Laboratory for Atmospheric and Space Physics (LASP), University of Colorado], **Wolfgang Finsterle** [Physikalisch–Meteorologisches Observatorium Davos (PMOD)/World Radiation Center (WRC)–Davos, Switzerland], and **Sabri Mekaoui** [Royal Meteorological Institute of Belgium] respectively gave the presentations. While there are still considerable differences in these TSI measurements—more than 0.3%—it is hoped that the next generation of TSI instruments, now being calibrated—with about 0.03% accuracy—at LASP's new TSI Radiometric Facility (TRF), will resolve these differences. These new TSI instruments are being flown on the Glory (Greg Kopp—TIM instrument PI), and PICARD (named

after the 17th century French astronomer Jean Picard) missions in 2010, and are also planned for the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Total Solar Irradiance Sensor (TSIS) in 2013.

The second topic of the day was **SSI Measurements and Modeling**, which included presentations on the SSI measurements from SORCE, ISS SOLAR, and the SCanning Imaging Absorption SpectroMeter for Atmospheric CHartographY (SCIAMACHY) on the European Space Agency's Envisat satellite. **Jerry Harder** and **Tom Woods** [LASP], **Gérard Thuillier** [Service d'Aéronomie du Centre National de la Recherche Scientifique (CNRS)—France], and **Mark Weber** [Institute of Environmental Physics (IUP)—Germany] respectively gave presentations. Of particular interest is the new result from the Spectral Irradiance Monitor (SIM) on SORCE that some wavelengths in the visible and infrared are *out of phase* with the solar cycle—i.e., some wavelengths have more irradiance at sunspot minimum than at sunspot maximum. In addition to comparison of the measurements, **Yvonne Unruh** [Imperial College, London—U.K.] compared the Spectral And Total Irradiance REconstruction (SATIRE) model of SSI variability to the new SIM results. Additional validation efforts are planned, but resolution of the differences might not become apparent until more measurements are obtained. Measurements taken during the rise of the new solar cycle 24 will be used to better validate the instrumental degradation trends.

The third topic of discussion for the session was **Energetic Particles. Susanne Rohs** [Forschungszentrum



Peter Pilewskie (LASP) gave a talk called, *TSIS: The Total and Spectral Solar Irradiance Sensor*.

Juelich—Germany] explored the role that galactic cosmic rays play in creating clouds. **Alexei Krivolutsky** [Central Aerological Observatory—Russia], **Kirill Semeniuk** [York University—Toronto, Canada], and **Bernd Funke** [Instituto de Astrofísica de Andalucía (CSIC)—Granada, Spain] discussed atmospheric chemistry changes during large solar storms. The solar energetic particles are enhanced most during solar cycle maximum conditions and can penetrate down into the upper stratosphere for the most energetic particles.

The last topic of the first day was **Solar Signal in the Thermosphere, Mesosphere, and Stratosphere** and continued the earlier discussion of solar forcing in Earth's upper atmosphere. **Hauke Schmidt** [Max Planck Institute for Meteorology—Hamburg, Germany] showed that the solar signal is most clearly seen in the atmosphere above 80 km due to direct deposition of solar energy. **Lesley Gray** [Reading University—U.K.] explained that the solar signal in the lower atmosphere is also seen, more so in the stratosphere than the troposphere, as related to ozone photochemistry and heating and also to dynamic coupling down from the stratosphere to the troposphere over a period of many months. In addition, **Erik Richard** [LASP] showed new solar cycle variation results from SORCE SIM that reveal subtle changes in atmospheric heating rates—see **Figure 1**.

On July 28, the discussions continued with **Lon Hood** [University of Arizona] and **Kunihiko Kodera** [Meteorological Research Institute—Tsukuba, Japan] explaining how the solar signal is enhanced in certain phases of the quasi-biennial oscillation (QBO) and the El Niño–Southern Oscillation (ENSO). Meanwhile, **Fangqun Yu** [University of Albany—New York] and **Dong Wu** [NASA/Jet Propulsion Laboratory (JPL)] demonstrated how changes in global cloud coverage correlate with changes in the solar cycle. Following these presentations, **Jae Lee** [JPL], **David Rind** [NASA Goddard Institute for Space Studies (GISS)], and **Robert Cahalan** [NASA Goddard Space Flight Center (GSFC)] addressed the expectations of solar forcing on the atmosphere as derived from atmospheric models. A key conclusion from NASA's GISS modeling (**David Rind**) is that the main solar driver for the troposphere is the delayed propagation of the solar ultraviolet heating in the stratosphere down into the troposphere.

The final topic of Session M03 was **Solar Impact on Centennial and Millennial Timescales (Reconstruc-**

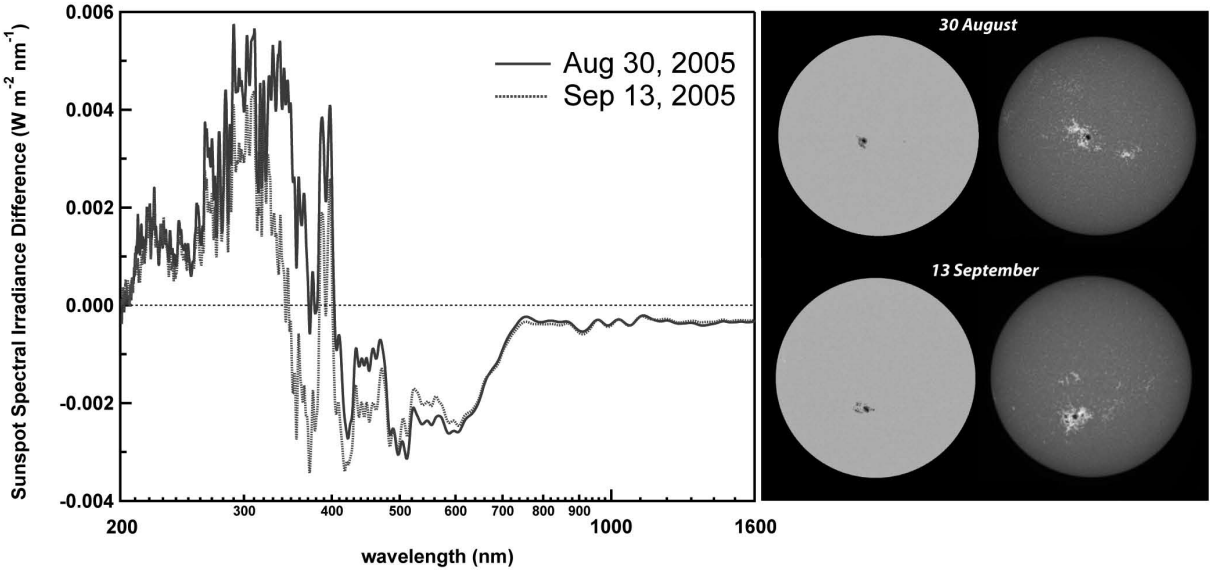


Figure 1. SORCE SIM measurements showing the faculae and sunspot spectral irradiance differences (200–1600 nm) between the days listed and the *quiet-Sun reference day*—November 9, 2007. These two days show comparable decreases in TSI due to isolated disc center sunspot groups. While TSI variability is similar, large relative differences in spectral variability are seen in the near UV and visible, whereas they are nearly identical in the near IR. Note also the highly wavelength dependent variability in the near UV where facular contributions dominate and in the visible where sunspot decreases dominate. **Credit:** Erik Richard, LASP.

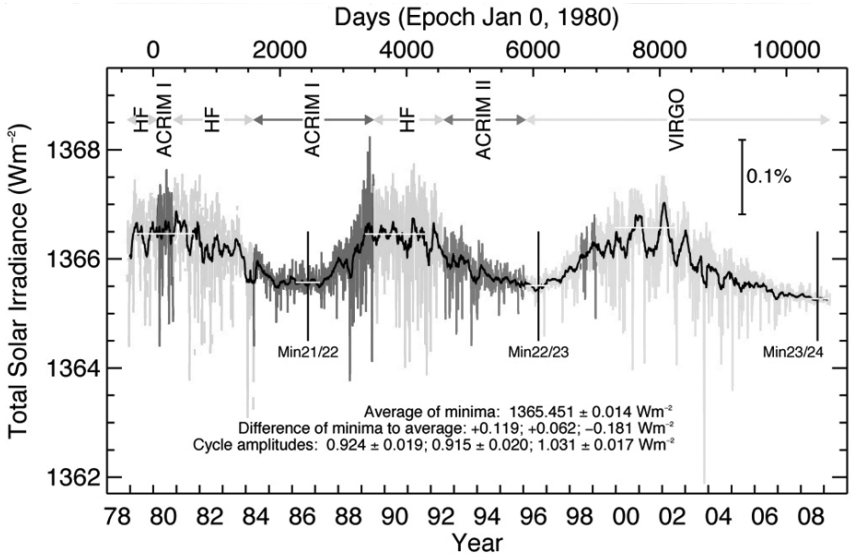


Figure 2. Composite TSI Record from Claus Fröhlich. The trend in this record indicates lower TSI during the sunspot minimum in 2008 than that in the 1996 minimum. For further information see "Evidence of a long-term trend in total solar irradiance", *Astronomy & Astrophysics*, **501**, 2009.

tions and Modeling. **Raimund Muscheler** [Lund University—Sweden] reviewed the long-term record (thousands of years) of solar magnetic activity derived from tree rings and ice cores. **Ulrich Cubash** [Freie Universität—Berlin, Germany] followed and explained how these long-term variations could be affecting climate. **Werner Schmutz** [PMOD/WRC] showed that the solar irradiance variations are also predicted from the solar magnetic activity record—this is one possible explanation of how the low solar activity during the *Maunder Minimum* in the 1600s could cause cooler

LASP attendees (left to right) Peter Pilewskie, Erik Richard, and Greg Kopp.

climate. The solar activity has been high over the past 60 years, referred to as the *Modern Maximum*, and **Claus Fröhlich** [PMOD/WRC] discussed SOHO VIRGO results that suggest that the solar irradiance is beginning to decline—see **Figure 2**. It is clear that the pre-industrial climate change has a strong solar component; however, the exact relationship of solar magnetic activity to these climate changes is debatable.

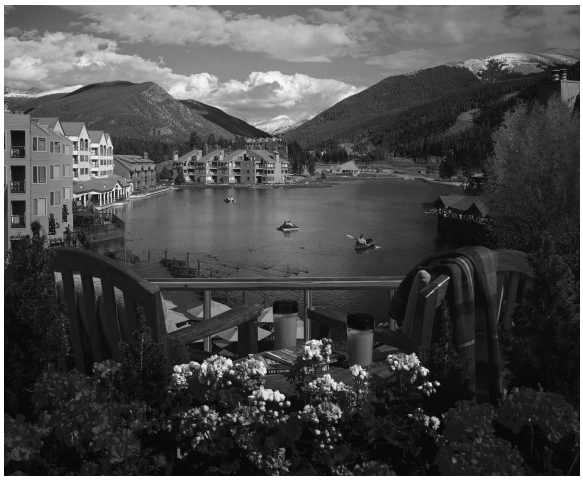
The M03 **poster sessions** on Monday and Tuesday, July 27-28, also provided a well-balanced program that complemented the oral session. There were 16 posters presented that provided detailed discussion of solar physics (5 posters), direct effects of solar forcing (5 posters), indirect effects of solar forcing (4 posters), and two posters concerning paleoclimate reconstructions. Listed below are a few representative examples of the work presented at the poster sessions.

- **Yvonne Unruh** [Imperial College—London, U.K.] discussed changes in the solar variability due to changes in the coverage area of small-scale magnetic elements. Measuring the contrast and, thus, the contribution of these small-scale magnetic features directly is difficult. A possible alternative is to use a theoretical approach and calculate the emergent intensities from 3-dimensional simulations of solar magneto-convection.
- **Steinhilber *et al.*** [Eidgenössische Technische Hochschule Zürich—Switzerland] presented a reconstruction of TSI since the *Maunder Minimum* using open solar magnetic field derived from data of the cosmogenic radionuclide of beryllium (^{10}Be) measured in polar ice cores. This result is consistent with other recent results predicting a change of TSI of about 1.2 w/m^2 since the *Maunder Minimum*. This increase is smaller—by about a factor of 3—than the increase indicated in other climate reconstructions.

Following Monday's M03 session, participants met for a special group science dinner at the *Fourquet Fourchette* restaurant near the Convention Center to continue discussing the science questions of the day. Shown are Jerry Harder [LASP] and Joanna Haigh [Imperial College—U.K.].

2010 SORCE Science Meeting

Plans are underway for the next SORCE Science Meeting, which will address ***Solar and Anthropogenic Impacts on Earth: The Current Solar Minimum and Predictions for Future Decades.*** The location and date will be in beautiful Keystone, Colorado, May 19-21, 2010. The organizing committee includes Tom Woods, Greg Kopp, and Peter Pilewskie from LASP; Judith Lean from Naval Research Laboratory (NRL), and



Keystone, CO will be the site of the 2010 SORCE Science Team Meeting.

Robert Cahalan from NASA GSFC. As in the past, this interactive meeting will be an opportunity for cross-disciplinary interaction between solar, climate, and atmospheric scientists. The agenda will consist of invited and contributed oral and poster presentations. A brief meeting summary is below.

Relative to the past three solar minimum epochs of the space era (1974, 1985, and 1996) the current solar minimum (2007-2009) between solar cycles 23 and 24 is unusually prolonged, with record numbers of sunspot-free days, record low solar polar magnetic fields, and record high levels of cosmic ray flux. Evidence is accumulating for broad ranging terrestrial responses to the current inactivity of the Sun. The lack of global warming since 2002 can be attributed in part to declining solar irradiance, which, together with La Niña cooling, has cancelled much of recent anthropogenic warming. Reduced solar UV irradiance and corresponding lower ozone levels may be obscuring the recovery from anthropogenic ozone depletion by chlorofluorocarbons (CFCs). In the upper atmosphere and ionosphere, temperatures are anomalously cool and densities are reduced relative to previous solar minima; but these changes may also be related to accumulated greenhouse gas cooling in the upper atmosphere.

- Are spectral and total solar irradiance levels lower now than during past minima, and how much will they increase during solar cycle 24?
- Are we entering a new prolonged period of anomalously low activity such as the *Dalton Minimum* in the early 1800s?
- Can we identify anomalous behavior in the solar dynamo and surface flux transport during the current minimum?
- How are heliospheric changes altering incident cosmic ray fluxes and the Earth's near-space environment?
- Can we reliably discern the terrestrial signatures of the current solar inactivity—at the surface, in the stratosphere and in space weather?
- What does understanding of the present (in the context of the past) infer for the future variability of Earth's environment?

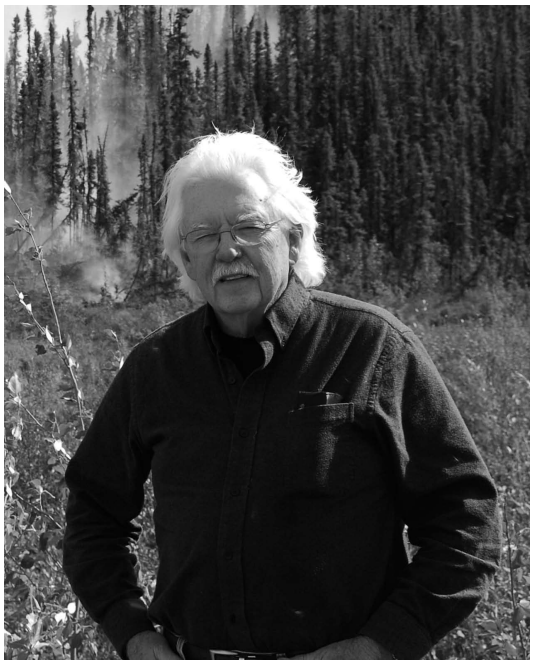
Motivated by these questions, the 2010 SORCE Science Meeting will address the current state of and future expectations for the integrated Sun-Earth system.

Planned Sessions at the 2010 SORCE Science Meeting

1. **This Unique Solar Cycle Minimum**
   - 1.1. Total Solar Irradiance (TSI): Comparison of Solar Cycle Minima and Recent Validation Results
   - 1.2. Solar Spectral Irradiance (SSI): Solar Cycle Variation and Model Comparisons
   - 1.3. Solar Physics: What do we learn about the Sun from this unique cycle minimum?
2. **Forcings During This Minimum and Forecast for the Next Solar Cycle**
   - 2.1. Space Weather Effects Observed during this Solar Cycle Minimum
   - 2.2. Atmosphere and Ozone Change: Has the ozone recovery started yet?
   - 2.3. Climate Change: What's the future going to be?
3. **Recommendations for the Future: How do we improve the climate data records?**

As new information becomes available on the 2010 SORCE Science Meeting, it will be posted on the SORCE website (*lasp.colorado.edu/sorce/news/meetings.html*). Registration materials will be available in early 2010, but mark your calendar today! We encourage your participation and hope you will join us. The meeting will be held at the *Keystone Resort and Conference Center*—see photo above. ■

KUDOS



Forrest G. Hall, Senior Research Scientist located at the NASA Goddard Space Flight Center and with the Joint Center for Earth Systems Technology (JCET) University of Maryland, Baltimore County, has received a **Career Achievement Award** from the Canadian Remote Sensing Society (CRSS) for his outstanding contributions to Canadian and international remote sensing science. An ageless scientist, in his early years at NASA in the 1960s, Hall designed space assembly for the *Gemini* and *Apollo* programs as well as lunar surface science investigations. Later, he led a series of terrestrial remote sensing and field campaigns, including the Boreal Ecosystem Atmosphere Study (BOREAS) in Western Canada in the mid-1990s. His current research includes modeling of vegetation structure, biomass, and carbon, and the design of next-generation sensors. The Award included a Certificate of Appreciation with the citation: "*For outstanding contributions to Canada as BOREAS Project Manager, and a career dedicated to excellence in training, mentorship, innovation and research.*" CRSS President Derek R. Peddle presented the award at the 30th Canadian Symposium on Remote Sensing held June 25, 2009 in Lethbridge, Alberta, Canada.

The Earth Observer staff and the entire scientific community congratulate Hall on his stellar career of international achievement as recognized by this award.

AMSR-E Data Available From NSIDC

Data products from Advanced Microwave Scanning Radiometer - Earth Observing System (AMSR-E) are available from the National Snow and Ice Data Center (NSIDC). The entire AMSR-E data archive can be accessed online through the Data Pool ftp site at *ftp://n4ft101u.ecs.nasa.gov/SAN/AMSA/*. The AMSR-E archive is also available for searching and ordering through the Warehouse Inventory Search Tool (WIST). The search tool allows data users to subset AMSR-E granules by parameter or spatial coordinates. Please see *nsidc.org/data/amsre/order_data.html* for access to WIST and other ordering options for AMSR-E data. More information about AMSR-E data at NSIDC is available at *nsidc.org/data/amsre/index.html.* For questions or assistance with data access, please contact NSIDC User Services at *nsidc@nsidc.org*.

Science Data Systems in the Decadal Survey Era Workshop

Frank Lindsay, NASA Goddard Space Flight Center, francis.lindsay-1@nasa.gov

On June 25 and 26, in the wood-paneled lecture room of the National Academy of Sciences, NASA's Earth Science Division (ESD) sponsored a workshop to begin the formal process of preparing for the next stage of evolution for NASA's Earth science data systems supporting the newly planned Earth science missions. This workshop, called ***Science Data Systems in the Decadal Survey Era***, promoted system level planning for the science data systems to accommodate the early missions, or *Tier 1*, identified in the January 2007 report from the National Research Council (NRC)— *Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond* (NRC, 2007). This report recommends that NASA continue and advance its Earth-observing capabilities, research, and associated information and application systems, specifically suggesting a series of missions over the next decade that will extend observations to provide long-term, continuous measurements of the Earth's complex physical systems. NASA ESD plans to leverage its successful experience and resources, like the Earth Observing System Data and Information System (EOSDIS), to help these new missions plan and deploy their data systems.

The Science Data Systems in the Decadal Survey Era Workshop followed the Earth Science Systems @20 (ESS@20) Symposium, held at the NAS for three days earlier in the week. ESS@20 brought together researchers, managers, and policy makers to examine the 20-year history of the NASA Earth system science program and its future. This symposium honored the significant achievements in advancing Earth science data collection and research going back as far as 60 years ago. The ESS@20 Symposium concluded with a session on **Earth Science in the Next 20 Years: Challenges/Vision for Earth System Science or Climate**[1] that provided a basis for the Science Data Systems in the Decadal Survey Era Workshop discussion of what the future of Earth science data systems should look like.

The Workshop

Organized and led by NASA's Earth Sciences Division Data and Information Systems Program, the workshop included an overview of NASA Earth science data system existing capabilities, presentations of science disciplines benefitting from the Earth science data, and status of the data system needs of the five new missions already underway. These missions are:

- Soil Moisture Active/Passive (SMAP)
- Ice, Clouds, and land Elevation Satellite (ICESat)-II
- Deformation, Ecosystem Structure and Dynamics of Ice (DESDynl)
- Climate Absolute Radiance and Refractivity Observatory (CLARREO)
- Hyperspectral InfraRed Imager (HyspIRI)

Bringing together scientists, data users, data center designers, data center operators, and policy makers, the workshop provided an open forum for the expression of issues, concerns, anecdotes, ideas, and, most of all, the data system challenges confronting the Earth science community. The open discussion and comments stimulated by the presentations introducing the Decadal Survey missions resulted in the expression of a number of challenges to designing the Earth science data systems of the future.

Summary of the Plenary Sessions Discussion

Throughout the workshop presentations and discussions, the participants expressed a variety of issues, ideas, and recommendations that present challenges to data system planning. From these comments themes emerged, serving as collection points for the group discussion results. The collected challenges are presented below grouped under the following themes:

- External Collaboration;
- Cross Mission Planning;
- Understanding Earth Science Users; and
- Data Pedigree or Provenance.

External Collaboration: Other organizations (both international and in the U.S.) collect data that the user communities supported by NASA would like to access. Questions include:

- How do we improve access to international (e.g., European, Japanese) data?
- How do we bridge the gap to NOAA?
- How do we influence the Europeans to adopt an open data policy?
- How do we work out incompatibilities across agencies?

[1] A summary of the ESS@20 Symposium ran in the September–October issue of *The Earth Observer.* [**Volume 21**, **Issue 5,** pp. 18-30].

Cross Mission Planning: Recognizing that the various missions can benefit from each other as they plan for their measurements and data systems, the group considered:

- How to coordinate data system planning when funding is tied to missions;
- How to coordinate soft dependencies across missions—realizing that preserving one mission's measurements or proof of concept technology may have a large influence on another mission;
- How to ensure the continuity of data systems when missions end;
- How to plan for integrated science—since a mission scientist tends to focus inside his/her mission; and
- How to share lessons learned in establishing multi-missions data and modeling interfaces.

Understanding Earth Science Users: The goal here is to define a process to build on what is known about how the Earth science community accesses data, and what the community would like to be able to do, in order to understand how to focus our resources. This will require considering issues such as:

- How to evaluate user access patterns;
- How to support competing data formats;
- How to characterize interdisciplinary users;
- How to determine what level of services (e.g., processing capability) should be provided to users; and
- How to support the non-science user who does not, or cannot, evaluate data quality on his own, or how to know enough detail to select among competing products.

Data Pedigree and Provenance: There is a need to capture details and information about datasets and algorithms that support the assessment of its quality, and to think about:

- How to inform users of plans to change data (e.g., reprocessing);
- How to report errors discovered in data products;
- How to capture the ideas and discussions that went into algorithm develop so that it can be easily accessed and searched; and
- How to capture the experience of users concerning the quality of datasets (i.e., "social tagging") that data centers cannot easily evaluate.

Breakout Sessions

After hearing and commenting on the current state of Earth science missions, research, and data systems, the participants separated into three concurrent breakout sessions to address the challenges. The breakout groups paralleled the existing NASA Headquarters-led Earth Science Data System Working Groups (ESDSWG) structure having teams that focused on:

- Standards;
- Data System Infrastructure and Interfaces; and
- Technology Infusion and Adaption.

Martha Maiden [NASA Headquarters—*Program Executive for Earth Science Data Systems*] charged the teams to consider:

- How shall we best reuse the current NASA data system infrastructure (including EOSDIS along with its Data Centers and Science Investigator-Led Processing Systems (SIPSs))?
- What new pieces will be needed?
- Is a Service Oriented Architecture the best approach to plan for future data access and usability?
- How should we best integrate the Decadal Survey mission data streams?
- How can we apply lessons learned from the past and best practices from today?

The breakout sessions began the process of recommending approaches to meet the challenges. These sessions resulted in the breakout reports found on the Data Systems Decadal Survey website: *dsds.nasa.gov/*.

Workshop Conclusions and Plans

In summary, the NASA Earth science data systems evolution needs are to[2]:

- Define an approach to evolve what is working now into what we want to have in 2020 and beyond;
- Keep what works within the existing systems, and identify what must be changed;
- Consider how best to identify and involve the end user communities in the data system and product definition;
- Define a recommended approach for guiding the new missions' data system definition and development; and
- Identify necessary actions and activities for the near term (0-2 years) that supports these developments.

[2] From **slide 23** of the presentation *Earth System Science, Flight Program in the Era of the Decadal Survey* by **Stephen Volz** [NASA HQ—*Associate Director for Flight Programs, Earth Science Division of the Science Mission Directorate*]

Follow-on activities will be defined by an ESD-led coordination committee. The committee plans to determine how to augment the existing Earth Science Data System Working Group structure to provide on-going support for initiating actions, evaluating concepts, and making recommendations for improvements to the overall Earth science data systems. ■

Experience NASA Science at the 2009 Fall AGU

Please join us at the NASA booth (#415) during this year's Fall Meeting of the American Geophysical Union (AGU), where we will offer a wide range of science presentations, interactive demonstrations, and tutorials for a variety of data tools and services. This year's program begins on **Tuesday, December 15** and will continue through **Friday, December 18, 2009**.

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

NASA Town Hall Meetings will provide an opportunity to learn more about NASA Earth Science activities. Three meetings will take place on Thursday, December 17. They are the NASA Earth Science Division Town Hall Meeting, Earth System Data Records (ESDRs), and NASA's Applied Sciences Program and Decadal Survey Missions. To view meeting descriptions, visit: *www.agu.org/meetings/fm09/lectures/town-halls.php*.

December 18, 2009, marks the 10th anniversary of the launch of NASA's Terra satellite. The first of NASA's Earth Observing System satellites, Terra's decade-long observations of Earth's land, atmosphere, and oceans have made remarkable contributions to our understanding of Earth systems and our changing climate. Terra carries sensors from Canada, Japan, and the United States, providing data used by scientists and governments worldwide. Please join the Terra team for a special session on Wednesday, December 16 from 8:00 AM to 6:00 PM, in Room 103 and Poster Hall, Moscone South. The NASA booth will feature presentations on the state of Terra science and spacecraft on Tuesday, December 15, at 3:00PM and 5:00PM, respectively.

A daily agenda is posted on the Earth Observing System Project Science Office (EOSPSO) web site—*eos.nasa.gov/eos_homepage/announcements/fallAGU2009.php*—in early December.

We look forward to seeing you in San Francisco!

meeting/workshop summaries

Aura and OMI Science Team Meeting Summary

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The Aura and Ozone Monitoring Instrument [OMI] science team meetings were hosted by the Royal Netherlands Meteorological Institute [Koninklijk Nederlands Meteorologisch Instituut (KNMI)] at the Holiday Inn Conference Center in Leiden, the Netherlands from September 14-17, 2009. About 150 scientists participated in the Aura meeting.

Working group sessions were held all day Monday. The plenary session (Tuesday–Thursday) included status reports from the Principal Investigator (PI) of each of the four instruments, science presentations, and a special session on future satellite missions. A poster session took place Wednesday afternoon. The OMI science team meeting was Friday.

Frits Brouwer [KNMI—*Director*] opened the plenary session, followed by a welcome from **Anne Douglass** [NASA Goddard Space Flight Center (GSFC)—*Aura Project Scientist*] who highlighted the outstanding results for Aura from this year's senior review. Aura's science value is rated outstanding. Aura also received high marks for operational and applied utility, based primarily on the near-real-time OMI sulfur dioxide (SO_2) and aerosol index products. One positive outcome of the review was that supplemental funding has been approved to develop improved retrievals of SO_2, ozone (O_3), and carbon monoxide (CO) by combining information from more than one Aura instrument or with information from another instrument in the A-train.

Ernest Hilsenrath [NASA HQ—*Aura Program Scientist*] stated that the majority of the Aura science team will be recompeted in 2010 through the NASA Research Opportunities in Space and Earth Sciences (ROSES) program. Final selection of proposals for the ROSES 2009 Atmospheric Chemistry Modeling and Analysis Program (ACMAP) is planned for January 2010.

Some highlights of the meeting are described below. The meeting agenda and all presentations are available from the Aura Validation Data Center website: *avdc.gsfc.nasa.gov/*.

Future Missions Session

Ernest Hilsenrath opened this session with an overview of the final report from the Committee on Earth Observation Satellites (CEOS) Atmospheric Composition Constellation. The report identifies likely data gaps between end-of-mission for currently operating Earth observing satellites and planned missions and provides recommendations to maintain specific long-term data records.

Joerg Langen [European Space Agency (ESA)] gave an overview of future European atmospheric missions through ESA's Living Planet Program.

Pieternel Levelt [KNMI] spoke about the Tropospheric Ozone Monitoring Instrument (TROPOMI), the next generation OMI instrument that is to be launched on ESA's Sentinel 5 precursor satellite. TROPOMI will make measurements similar to OMI at somewhat higher spatial resolution and is expected to launch in 2014.

Jay Al-Saadi [NASA HQ] reported on the NASA Geostationary Coastal and Air Pollution Events mission (GEO-CAPE—a *Tier-2* Decadal Survey mission). The goals of this mission are to measure atmospheric constituents related to air quality and climate, and to monitor the health of coastal ecosystems by measuring ocean color.

Nathaniel Livesey [NASA/Jet Propulsion Laboratory (JPL)] gave a presentation on the Global Atmospheric Composition Mission (GACM), the Aura follow-on—a *Tier-3* Decadal Survey mission.

James Gleason [GSFC] presented an overview of the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) mission that is expected to launch in early 2011. In addition to operational meteorological measurements, NPP will continue key tracer measurements initiated by NASA's Aqua, Aura, and Terra satellites.

Anne Douglass [GSFC] presented an overview talk on the Chemical and Aerosol Sounding Satellite (CASS) on behalf of **Jose Rodriguez** [GSFC]. CASS would continue the data record of chlorine species, ozone, aerosols, and other measurements beyond Aura and the Canadian Atmospheric Chemistry Experiment (ACE)—not to be confused with the *Tier-2* Decadal Survey mission with the same acronym.

Instrument Reports

High Resolution Dynamics Limb Sounder (HIRDLS): **John Gille** [University of Colorado and National Center for Atmospheric Research (NCAR)—*HIRDLS PI, U.S.*] and **John Barnett** [Oxford Uni-

versity—*HIRDLS PI, U.K.*] gave a joint presentation on HIRDLS science results and the status of Version 4 (V4) retrievals. V4 provides fine vertical scale retrievals of clouds, aerosols, ozone, and temperature. Chlorofluorocarbons (i.e., $CFCl_3$ and CF_2Cl_2) are included in this data release. Version (V5) is forthcoming and will offer improved retrievals as well as a new geopotential height product. Future versions will provide additional products, such as water (H_2O) and methane (CH_4). The chopper remains stalled despite extensive efforts to restart it. No scientific data have been collected since March 2008.

Microwave Limb Sounder (MLS): **Nathaniel Livesey** [JPL—*MLS PI*] presented science results from the past year and reported that the MLS instrument is operating nominally. Some subsystems show signs of aging, but the science impact thus far has been minimal. The MLS team expects to start reprocessing with Version 3.2 algorithms by the end of 2009. The new algorithm reduces the biases in several species including chlorine monoxide (ClO) and H_2O and includes a new product CH_3Cl. The MLS near-real-time (NRT) processing system continues to produce O_3 and temperature profiles available within 3 hours of observation. Collaboration with the Goddard Modeling and Assimilation Office (GMAO) on radiance assimilation is progressing.

Ozone Monitoring Instrument (OMI): **Pieternel Levelt** [KNMI—*OMI PI*] presented results and a status update of OMI. OMI is fully operational, but daily coverage has been affected by row anomalies. These anomalies are likely caused by material outside the instrument that is blocking part of the OMI nadir field of view. Approximately 30% of the swath is currently affected. For now, users are responsible for flagging the row anomalies. By the end of 2009, new software will provide automatic up-to-date flagging of the row anomalies. Optical degradation remains low after more than five years in orbit. Ozone profiles were recently released as a new OMI product. *Collection 3* processing of all products has been completed and users are advised to use this data version exclusively. Overall, the instrument performance is nominal with the expected level of degradation as the instrument enters its sixth year of operation.

Tropospheric Emissions Spectrometer (TES): **Annmarie Eldering** [JPL—*TES PI*] reported on recent TES findings and the continued nominal operation of TES. **Reinhardt Beer** [JPL], the former TES PI, officially retired September 2009 and **John Worden** [JPL] has taken on role of deputy PI. The bearings on the TES interferometer scanner continue to deteriorate slowly as the lubricant degrades. To extend TES lifetime, there has been reduced latitudinal coverage of the global surveys since June 2008.

Working Groups

Air Quality: **Bryan Duncan** [GSFC—*Aura Deputy Project Scientist (nominated)*], **Kenneth Pickering** [GSFC], and **Folkert Boersma** [KNMI] led the working group on Aura air quality studies. The topics discussed included new applications of Aura data for air quality, future geostationary missions for air quality forecasting, and plans and suggestions to improve OMI tropospheric nitrogen dioxide (NO_2). With respect to the NO_2 product, recommendations to provide *averaging kernels*, revisiting the NO_2 *a priori* profile shape, and on-going ground-based validation needs were discussed.

Climate: **Joanna Joiner** [GSFC—Aura Deputy Project Scientist] and **Hui Su** [JPL] led this new working group created to stimulate discussions on climate-related studies and products using Aura data. Current Aura climate-related products were highlighted, such as isotopic water vapor retrieval from TES, cloud products from OMI and MLS, aerosol measurements using HIRDLS and OMI, and tropospheric ozone from TES profiles and combined OMI–MLS. The goals of this working group include improving the interaction between satellite and modeling communities and developing better methods for using Aura data in model evaluation. One strategy is the JPL-led Climate Data Exchange Project (CDX) to facilitate access to specific climate-related products from Aura and other A-train satellite data, along with model output.

Data Systems: **Cheryl Craig** [NCAR] led the working group. Each instrument team provided information on processing status, hardware upgrades, and scheduling of upcoming version releases.

Education and Public Outreach (E/PO): **Brooke Hsu** [Sigma Space Corp—*Aura E/PO Lead*] gave a presentation on the role of Aura E/PO. The value of E/PO-related activities to the Aura Science Team is to promote and advertise Aura-related research to the public. A list of Aura E/PO products includes K–12 lessons on air quality using OMI NO_2 data, Aura data products for electronic displays (e.g., *Science On a Sphere*; *Dynamic Planet*), the Aura website, and Aura on *Facebook*. Hsu urged the Aura Science Team to participate in E/PO activities by communicating science results, serving as content experts, helping to recruit for internships, and participating in E/PO events, such as educator professional development workshops.

Mission Operations: **Angelita Kelly** [GSFC] led the Mission Operations Working Group (MOWG) on the status of the Aura spacecraft—see photo on page 25. Aura is performing well, although an anomaly in the Earth Sensor Assembly (ESA) is being investigated. It is anticipated that the degradation will level off and sta-

bilize when the sensor is re-calibrated. MLS, TES, and OMI are operating nominally, with no new anomalies detected in the past year. In mid-2010 Mission Operations will start automating the data downlink to reduce operating costs.

Validation: **Anne Douglass** [GSFC] and **Lucien Froidevaux** [JPL] led the discussion on upcoming validation campaigns and ongoing Aura validation needs. The Aura Validation Data Center (AVDC) continues to be a valuable source of correlative datasets. However, the availability of data in the standard Hierarchical Data Format (HDF) file format for AVDC remains an issue, particularly for longer-term validation. A suggestion for improving access to more validation data includes linking the AVDC to the European Validation Data Center (EVDC) and the World Ozone and UV Data Center (WOUDC). Expanding the current *ozonesonde* dataset on the AVDC was given high priority.

Summary of Selected Plenary Session Presentations

During the plenary sessions many presentations highlighted new results with Aura data and also results combining information from A-train instruments. A few noteworthy examples are highlighted below.

Ken Pickering [GSFC] showed that changes in U.S. nitrogen oxide (NO_2) emissions resulting from regulations and trading are reflected in NO_2 observations from OMI. There are observed reductions in NO_2 over much of the eastern seaboard from 2005–2008, while over Pennsylvania NO_2 concentrations during this same period increased.

OMI Science Team Meeting
September 17, 2009

Much of the discussion at the OMI science team meeting was devoted to issues related to the ongoing row anomaly. There were several talks from KNMI devoted to instrument status and health as well as the anomaly.

OMI measurements in the solar view mode indicate that the radiometric and spectral stability of the OMI instrument is very high. OMI is far superior to the previous instruments of this type in this regard. As expected, the dark current in the detectors has been increasingly linear since launch as the damage from charged particles accumulates. The trend monitoring facility at KNMI carefully monitors and corrects for the average dark current on a daily basis. However, the increase in dark current noise is now showing up in at least one OMI product that has very weak absorption in the OMI bands, the formaldehyde (HCHO) column. The quality of this product degraded in 2009.

Analysis of the OMI Earth-view data indicates that an object located outside the instrument is contaminating the OMI measurements in about one-third of the OMI rows. An OMI row consists of measurements at one swath angle from all wavelengths of the instrument from all three detector arrays. The effect on Level 2 products is highly variable from product to product.

The number and position of affected rows has changed over time in an unpredictable manner. This has made it difficult for Level 2 product developers and data users to automatically flag and filter the anomalous rows. The KNMI team has developed an approach to dynamically flag the anomalous rows. This involves over 100 separate tests to determine the affected rows. The tests are being applied on a daily basis. A human operator determines whether significant changes have occurred and updates the flagged rows as necessary. The resulting information will be stored in a new cross-track quality flag beginning in November 2009. Studies are in progress to develop methods to correct a few of the rows that are minimally affected.

Nick Krotkov [University of Maryland, Baltimore County (UMBC)] showed that SO_2 over China increased from 2005–2007, but has decreased since then, presumably due to the economic slowdown and controls that have been placed on new power plants. Krotkov and colleague **Simon Carn** [Michigan Technical University] also showed the extensive SO_2 plumes that were observed following the eruptions of several high latitude volcanoes in the past year or so.

Bryan Duncan [GSFC] showed how spatial and temporal variations in two tropospheric ozone precursors—nitrogen dioxide and volatile organic compounds—can be assessed with OMI data. This information on which precursor is the *limiting reagent* is important to develop strategies to control air pollution.

Jennifer Logan [Harvard University] presented analysis on the interannual variability of NO_2, CO, and O_3 in the tropics during the biomass burning season. Comparisons between the Aura NO_2 with the Global Fire Emissions Database, *version 2* (GFED2) emissions inventory, and Global Modeling Initiative (GMI) and Goddard Earth Ob-

Aura splinter meeting participants: *[Left side, front to back]*: Leo van Lent, OMI Instrument Engineer (Dutch Space); Angie Kelly, Aura Science Interface Manager (NASA GSFC); Bill Guit, Aura Mission Director (NASA GSFC); Dimitrios Mantziaras, Aura Flight Operations System Engineering Manager (Honeywell at GSFC); Jacob Williams, Aura Flight Operations Instrument Engineer (Honeywell at GSFC).

[Right side, front to back]: Marcel Dobber, OMI Science Team (KNMI); Jacques Claas, OMI Ground System Manager (KNMI); Dominick Miller, MLS Instrument Operations Lead (JPL); David Tracewell, Flight Dynamics Engineer (NASA GSFC); Josh Levi, Flight Dynamics Engineer (a.i.solutions at GSFC); Glenn Jaros, U.S. OMI Science Team (SSAI).

serving System (GEOS-CHEM) model[1] output show varying degrees of agreement underscoring the need to improve our understanding of the causes of tropical interannual variability.

John Worden [JPL] explained how TES water vapor and isotope measurements are being used to examine the global water cycle in the troposphere.

Steven Massie [NCAR] used HIRDLS cloud observations together with Cloud–Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO)-CloudSat to show how cirrus clouds near the tropopause are formed by deep convection.

Jonathan Jiang [JPL] looked at the effect of aerosols on ice cloud particle size using MLS CO and MODIS Aerosol Optical Thickness (AOT) in the upper troposphere as a proxy for aerosol in cloudy regions. CO-polluted clouds contained a smaller cloud particle size than in non-polluted clouds when co-located AOT and CO measurements are highly correlated.

Hui Su [JPL] examined the effect of cirrus clouds on tracer gas distribution in the tropical tropopause layer (TTL) using MLS and CloudSat. The cloudy-sky net radiative heating rate was found to be three to four times greater then the clear-sky rate and contributes to an increase in the ice water content in the TTL.

Richard Stolarski [GSFC] showed that the upper stratospheric relationship between ozone and temperature derived from measurements by the Limb Infrared Monitor of the Stratosphere (LIMS) instrument on Nimbus 7 (1979), the MLS instrument on the Upper Atmosphere Research Satellite (UARS) (1992–1997), and MLS on Aura (2004–present) varies with the temporal change in the importance of chlorine species to upper atmospheric ozone loss.

Mark Your Calendar

The next Aura Science Team meeting will be held in Boulder, CO from September 27–October 1, 2010. Information will be available by mid-2010 at the Aura website: *aura.gsfc.nasa.gov/*. ■

[Left to Rignt.] Pieternel Levelt, Angie Kelly, Ernie Hilsenrath, and Joanna Joiner pose for a photo during the Aura Science Team Dinner. **Photo Credit:** Angie Kelly.

Some local color at the meeting site—a windmill in Leiden, the Netherlands. **Photo Credit:** Angie Kelly.

[1] GMI and GEOS-CHEM are three-dimensional chemical transport models.

Report on the CEOS Land Product Validation Sub-group Meeting

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The Committee for Earth Observation Satellites (CEOS), recognized as the space arm of the Group on Earth Observations (GEO), plays a key role in coordinating the land product validation process. The Land Product Validation (LPV) sub-group of the CEOS Working Group on Calibration and Validation (WGCV) aims to address the challenges associated with global land product validation. GEO coordinates international efforts to build a Global Earth Observation System of Systems (GEOSS). This emerging public infrastructure is interconnecting a diverse and growing array of instruments and systems for monitoring and forecasting changes in the global environment. This *system of systems* supports policymakers, resource managers, science researchers, and many other experts and decision-makers. **Figure 1** depicts the interrelations among these international structures and how the LPV sub-group contributes to the GEOSS initiative.

The mission of the LPV sub-group is to foster and coordinate international validation activities for satellite-derived land products, to develop international validation protocols, to promote data sharing, and to ensure that data and results are available to the user community. Since the establishment of the sub-group in 2000, significant progress has been made toward the validation of several land products, including land cover, active fires, leaf area index (LAI), fraction of absorbed photosynthetically active radiation (*f*APAR), and albedo products. Additional global products such as burned area, soil moisture, vegetation phenology, and land surface temperature now require similar validation efforts.

The LPV sub-group held a one-day meeting to evaluate the status of current validation activities and define a strategy for the coming years. Twenty participants attended the meeting on June 15th in Missoula, Montana, which preceded the 4th Global Vegetation Monitoring workshop[1]. This article reports the main outputs of this meeting.

The need for a sustainable validation of Land Essential Climate Variables

Validation is the process by which the accuracy and consistency of satellite-derived land products are evaluated and associated uncertainties are quantified [*Justice et al.*, 2000]. Product accuracy is assessed by comparison with independent data sources such as ground-based measurements, higher resolution satellite data, or well-calibrated models. Intercomparison with other equivalent satellite products, while providing useful insights as to where and when datasets are in agreement or disagreement, does not constitute validation. Validation activities need to be coordinated at the international level in order to reach the necessary consensus from the community, while ensuring a traceable and transparent process.

Recently, international scientific initiatives such as Global Terrestrial Observing System (GTOS) and Global Climate Observing System (GCOS) identified a set of Essential Climate Variables (ECVs) that play an important role in understanding the land-surface interactions with climate. Among the 28 ECVs listed in the GCOS-107 document [*GCOS*, 2006], ten correspond to land surfaces, including: lakes, glaciers and ice caps, snow cover, land cover, fire disturbance, albedo, LAI, *f*APAR, biomass, and soil moisture. Long-term monitoring of ECVs provides critical information for the management and enforcement of international conventions signed under the United Nations Framework for Climate Change (UNFCC), particularly regarding greenhouse gases, desertification, and biodiversity. Although carbon sink and emissions reporting remain the responsibility of individual countries, provision of standard, internationally accepted land datasets will provide key inputs for each national monitoring system and enable independent evaluation of the plausibility of the reported figures.

Structure of the LPV sub-group

LPV sub-group activities have initially focused on land cover and fire products, in collaboration with Global Observation of Forest Cover and Land Cover Dynamics (GOFC-GOLD) as well as albedo, LAI, and *f*APAR products. The LPV sub-group is led by a chair and vice-chair that are nominated to serve 3-year terms. The current LPV chair, **Frédéric Baret** [Institut National de Recherche Agronomique (INRA), France] and co-chair, **Sebastien Garrigues** [Centre National d'Etudes Spatiales (CNES), France] are supported by two NASA

[1] See report in the September–October 2009 issue of *The Earth Observer* [**Volume 21, Issue 5 ,** pp. 32-33.]

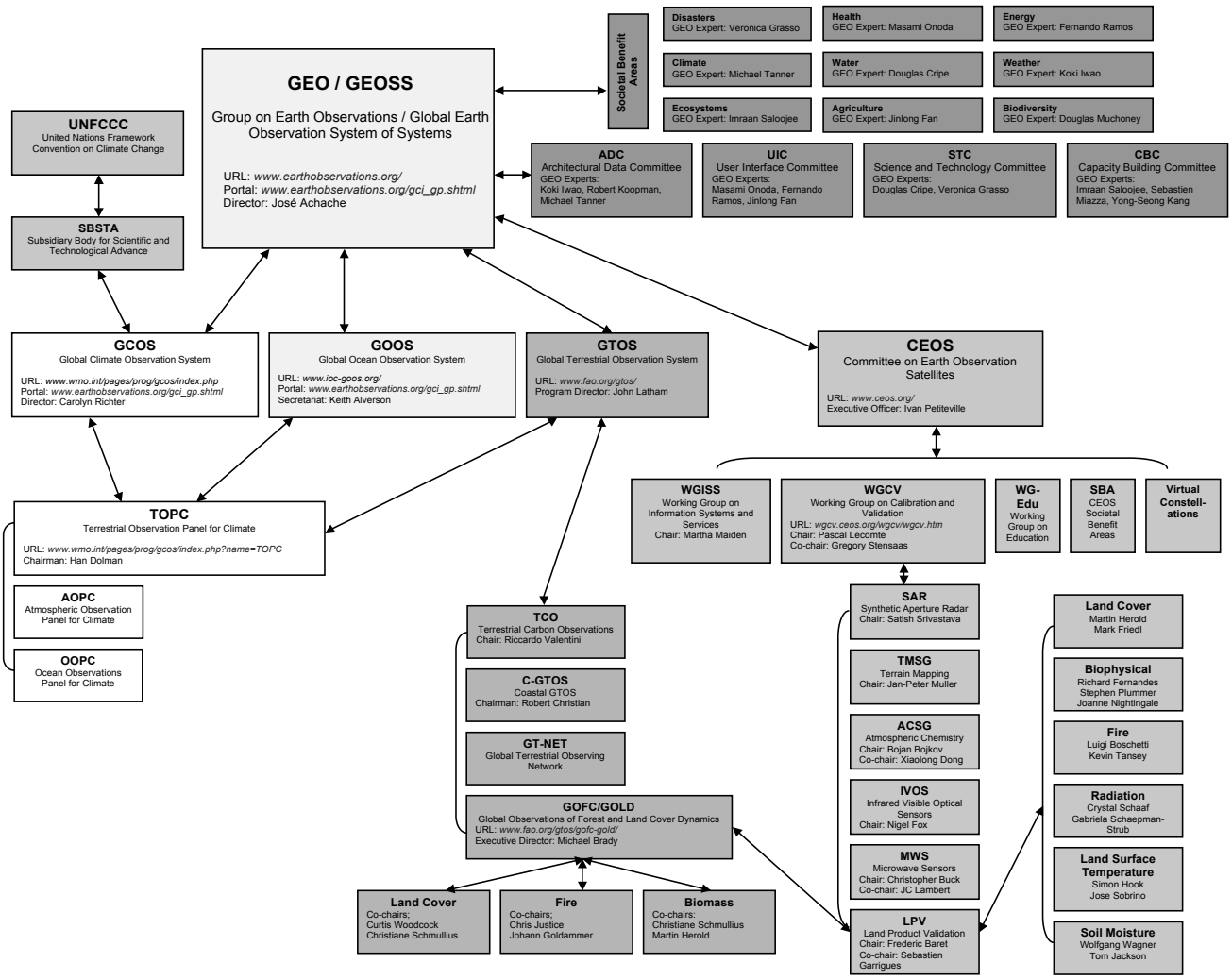

Figure 1. Linkages between international programs concerned with terrestrial Earth observations highlighted at the Global Vegetation Workshop

Goddard Space Flight Center, Earth Observation Satellite (EOS) land validation representatives, **Joanne Nightingale** and **Jaime Nickeson**.

Until recently, LPV members consisted of a group of practitioners who actively contributed to the development and implementation of validation procedures. The recent emphasis on the independent and systematic evaluation and validation of terrestrial ECVs has prompted the establishment of six corresponding focus groups, each with internationally independent co-chairs who have been actively involved in validation activities and are respected community members—see **Table 1**. This structure, adopted in June 2009, allows for a stronger task force (working group) and a closer proximity to the corresponding land community. It enhances feedback and collaborative efforts in relation to global independent validation and product intercomparison exercises, as well as increasing ground network and measurement databases. Although not yet labeled as an ECV by GCOS, Land Surface Temperature (LST) is addressed by the LPV sub-group because it plays a significant role for land cover and land use classification and the surface energy balance. It is also integral in the estimation of evapotranspiration.

The role of the co-chairs for each focus group will be to engage the appropriate research and operational communities and to coordinate global validation activities. This role, defined at the LPV focus leads meeting, involves three main components:

1. ***Development of protocols for the validation of satellite-derived products:***
   Validation protocol documents will define the community standard *best practices* in relation to current knowledge, available datasets, and validation methods that are tested and repeatable. LPV protocol documents will be peer-reviewed by the community and endorsed by the CEOS WGCV. They will be in-line with the CEOS Quality Assurance framework for Earth Observation (QA4EO) Strategy, which is based upon the adoption of a set of key operational guidelines derived from *best*

Table 1. The six LPV focus groups, associated co-leads, and collaborative networks (inclusion of snow cover, biomass, and vegetation phenology product focus groups is pending consideration)

Focus group	Products	Focus group co-leads	Affiliation	Collaboration[1]
Land Cover	Land cover/ change	**Martin Herold** **Mark Friedl**	University of Jena, Germany Boston University, U.S.	GOFC-GOLD
Fire	Active / burned area	**Kevin Tansey** **Luigi Boschetti**	University of Leicester, United Kingdom University of Maryland, U.S.	GOFC-GOLD
Albedo	Albedo	**Gabriella Schaepman-Strub** **Crystal Schaaf**	University of Zurich, Switzerland Boston University, U.S.	ARM/SGP BSRN/ SURFRAD
Biophysical	LAI *f*APAR	**Richard Fernandes** **Stephen Plummer** **Joanne Nightingale**	Canadian Center for Remote Sensing, Canada IGBP- European Space Agency, Italy NASA GSFC, U.S.	IGBP FLUXNET
Soil Moisture	Soil moisture	**Wolfgang Wagner** **Tom Jackson**	Vienna University of Technology, Austria United States Department of Agriculture Beltsville Agricultural Research Center, U.S.	GEWEX
Land Surface Temperature	LST and Emissivity	**Simon Hook** **Jose Sobrino**	NASA Jet Propulsion Laboratory, U.S. University of Valencia, Spain	IVOS

[1] ARM/SGP = Atmospheric Radiation Measurement Program/Southern Great Plains; BSRN = GEWEX Baseline Surface Radiation Network; SURFRAD = Surface Radiation Network; IGBP = International Geosphere-Biosphere Programme; GEWEX = Global Energy and Water Cycle Experiment; IVOS = WGCV Infrared and Visible Optical Sensors sub-group.

practices for implementation by the community. The document will be posted on the LPV web site (*lpvs.gsfc.nasa.gov/*) and the CEOS Calibration/ Validation Portal (*calvalportal.ceos.org/*), will undergo periodic review, and will be updated when new data or improved methods become available. An executive summary of the validation protocol document will be published in a peer-reviewed journal for a wider audience and appropriate referencing.

2. ***Coordination and implementation of global validation activities***:
Focus group co-leads and members will promote regional-to-global validation activities and implementation using the LPV protocols; encourage sharing of validation datasets (both input and output products), data compilation, and acquisition of new validation datasets. They will, where possible, facilitate coordination of validation exercises between different international agencies for current and planned global satellite missions.

3. ***Provide the interface between the community, CEOS, and other international structures***:
Focus group co-leads and members will convey validation requirements and results, and provide recommendations to CEOS and other international structures such as GEO, GCOS, and GTOS to generate the most pertinent and validated land surface variables.

CEOS land product validation stage hierarchy

In 2003, the LPV community reached a consensus that CEOS would adopt a hierarchical approach to classify land product validation stages [*Morisette et al.*, 2006]. Three broad validation stages were defined, however, given the ambiguity and difficulty associated with reaching the original *stage 3*-validation level, it was proposed at this meeting to include an advanced validation stage termed *stage 4*—see **Table 2**. The improved hierarchy provides a clearer definition of the requirements

to reach each validation stage and takes into account assessment of the spatial and temporal consistency of similar land products, as well as ongoing operational global validation efforts. Consensus agreement for this new validation hierarchy has been acquired from the recently expanded working group of the LPV sub-group, as well as the Moderate Resolution Imaging Spectroradiometer (MODIS) land science team, who annually classifies the validation status of the MODIS global land products using this validation hierarchy.

A guideline for best validation practices

The meeting of the LPV focus group leads enabled the development of a template guideline for validation protocol documents to ensure a consistent validation process across the products. The protocols may be adapted for individual products, however, they should be comprised of three mandatory and complementary components:

1. ***Product accuracy assessment***:
   The comparison of global products with reference *in situ* data is the only way to access the *accuracy* component of the validation, i.e., the degree of closeness to the reference value. This step is very important to approach the absolute value of the ECV, which is required in most process models.

2. ***Product precision assessment:***
   This corresponds to an evaluation of the spatial and temporal consistency of the products—i.e., the repeatability of the measure. The precision assessment could be derived from the comparison to reference *in situ* data if enough data are available and if they are associated with small uncertainties. This step is very important when analyzing long time series or comparing results for different regions.

3. ***Product intercomparison:***
   The increasing number of similar land products being produced from different satellite sensors drives the requirement to evaluate relative consistencies between products. This component of the validation is very important when combining several products into the *best available product*. However, if two products are in good agreement, they could both be wrong: accuracy assessment is thus mandatory through comparison with independently acquired reference data.

CEOS will endorse the land product validation protocol documents once the community reaches a consensus on them. A generic process for endorsement and then publication has been accepted, starting with a draft document prepared under the direction of the focus group leads. The document will then be peer reviewed by three independent scientists and posted on the LPV web site, with links in several other places such as the GEO portal. An executive summary of this document will be written for publication in one of the main remote sensing journals for proper referencing. A protocol document for the validation of global land cover products was published in 2006 [*Strahler et al.*, 2006] and will be revised and updated by the current land cover leads and LPV working group members. Protocol documents are currently in progress for global Burned Area and LAI/*f*APAR products.

Table 2. The revised four-stage CEOS Land Product Validation Hierarchy

Stage 1	Product accuracy is assessed from a small (typically < 30) set of locations and time periods by comparison with *in situ* or other suitable reference data.
Stage 2	Product accuracy is estimated over a significant set of locations and time periods by comparison with reference *in situ* or other suitable reference data. Spatial and temporal consistency of the product and consistency with similar products has been evaluated over globally representative locations and time periods. Results are published in the peer-reviewed literature.
Stage 3	Uncertainties in the product and its associated structure are well-quantified from comparison with reference *in situ* or other suitable reference data. Uncertainties are characterized in a statistically robust way over multiple locations and time periods representing global conditions. Spatial and temporal consistency of the product and consistency with similar products has been evaluated over globally representative locations and periods. Results are published in the peer-reviewed literature.
Stage 4	Validation results for **Stage 3** are systematically and regularly updated when new versions of the products are released and as the time series expands.

The way forward

Several important challenges for global land product validation have been identified: 1) validation is a difficult task that is both time- and resource-consuming; 2) global land product validation is generally conducted by individual organizations using different methodologies and datasets, with limited consensus; 3) validation exercises are typically conducted by the teams that developed the product; and 4) validation activities are often limited by a lack of both accurate and representative ground measurements and imagery with sufficiently high spatial resolution.

One of the principal issues that limits validation exercises and thus the maturity of the products is the lack of sustainable support from most space agencies. The CEOS LPV sub-group does not have a direct funding mechanism and as with most international coordination efforts, member support is essentially *best effort*. However, with the increasing number and importance of satellite datasets in the context of international conventions, there is an opportunity to put in place the mechanisms to provide products that have been validated to internationally accepted standards.

Global land product validation activities will benefit from increased access to high spatial resolution images and funding for *in situ* reference data acquisitions or contributions that complement already existing networks. In addition, promotion of data sharing and data compilation is required to ensure validation datasets are in user-friendly formats with appropriate metadata that can be used to validate similar products from different providers.

For further information about the CEOS LPV subgroup, validation activities, product focus groups, or to subscribe to the mailing list, please visit *lpvs.gsfc.nasa.gov/*.

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Snapshots From Space Cultivate Fans Among Midwest Farmers

Gretchen Cook-Anderson, NASA Earth Science News Team, cookander@gmail.com

Noreen Thomas' farm looks like a patchwork quilt. Fields change hue with the season and with the alternating plots of organic wheat, soybeans, corn, alfalfa, flax, or hay.

Thomas enjoys this view from hundreds of miles above Earth's surface—not just for the beauty, but the utility. She is among a growing group of Midwest farmers who rely on satellite imagery from Landsat to maximize their harvest and minimize damage to their fields. It's become another crucial tool like their tractors and sprinklers.

"Our farm is unconventional—we grow food and breed animals using all-natural approaches," said Thomas of her certified organic farm in Moorhead, MN, where they also grow heirloom tomatoes, lettuce, squash, and peas. "So we're happy to use unconventional methods to solve problems and keep our crops healthy."

On September 10, 2009, Landsat scanned this image of farmland across northwest MN, including a view of Noreen Thomas' organic farm on the banks of the Buffalo River near the middle of the image. To view this image in color please visit: *www.nasa.gov/topics/earth/features/farmer_imagery.html.* **Credit:** NASA Earth Observatory.

For $25 and an hour's drive to the Grand Forks campus of the University of North Dakota (UND), Noreen and **Lee Thomas** took a one-day class on how to download and interpret satellite images, like those provided by NASA and the U.S. Geological Survey (USGS).

Downloading the latest images takes mere minutes on the Digital Northern Great Plains system, a free Web-based tool developed by NASA-funded researchers in the Upper Midwest Aerospace Consortium. Thomas punches in GPS coordinates of the area she'd like to see, and moments later she has a bumper crop of information and images.

To the untrained eye, the false-color images appear a hodge-podge of colors without any apparent purpose. But Thomas is now trained to see yellows where crops are infested, shades of red indicating crop health, black where flooding occurs, and brown where unwanted pesticides land on her chemical-free crops.

The images help the Thomases root out problems caused by Canadian thistle and other weeds. They help confirm that their crops are growing at least 10 ft (3 m) from the borders of a neighboring farm—required to maintain organic certification. They can also spot the telltale signs of *bottlenecking* in the fields—where flooding is over-saturating crops—and monitor the impact of hail storms.

"We'd have to walk our entire 1,200 hundred-plus acres on a regular basis to see the same things we can see by just downloading satellite images," said Thomas, who recently began providing her farm's coordinates to her buyers in Japan. "There's no more ideal way I know to show how healthy our crops are to someone thousands of miles away."

Crops are not the only beneficiaries of snapshots from space. Just as remote imagery informs Thomas when it's best to rotate crops, she can also determine when her cows need a new pasture. When the large herd of cows chews its way through the landscape, satellite images show where the cows may be overgrazing.

Though Thomas believes she is the lone satellite ranger in her town, she's certainly not alone among farmers in general. According to **George Seielstad**, recently retired director of the UND Center for People and the Environment and founder of the consortium, more than 600 farmers in the region are now devotees of satellite data as an aid to farming.

Thomas has also become a resource to her community because of her unique ability to analyze satellite images. "We've been called by a couple of townships to pull satellite images to verify flooding so they can apply for aid from the Federal Emergency Management Agency," she said. "There are any number of ways these pictures have been helping farming communities like ours, and community is what farming is built on." ■

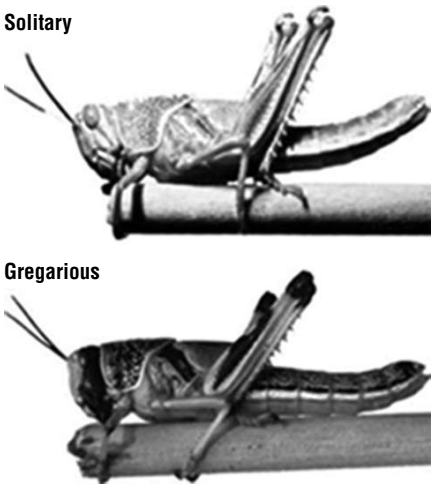
in the news

With an Eye on Locusts and Vegetation, Scientists Make a Good Tool Better

Adam Voiland, NASA Earth Science News Team, avoiland@sesda2.com

Locusts, the grasshopper-like insects of Biblical lore, are normally docile creatures that prefer solitary lives in the desert, away from other members of their species. But sometimes, when the rains come and patches of green begin to dot dry landscapes, their populations skyrocket and something extraordinary can happen. Hormonal changes, triggered by crowding, can cause the insects to change color, become more active and congregate in huge swarms capable of decimating crops.

In the 1980s, scientists at NASA's Goddard Space Flight Center and the United Nations' Food and Agriculture Organization (FAO) teamed up to develop a monitoring system that used satellite observations and other environmental data to monitor vegetation in the deserts of Africa, the Middle East, and Asia for signs that swarms may be imminent. The Desert Locust Information Service (DLIS) used the satellite-derived Normalized Difference Vegetation Index (NDVI)—based on the ratio of red and infrared radiation reflecting off the leaves of plants—to detect where deserts were *greening* the most.



Environmental conditions can cause desert locusts to enter a *gregarious* phase in which they change colors, become more active, and congregate in large swarms. **Photo Credit:** Compton Tucker.

Compared to previous attempts to study vegetation from space, NDVI represented a vast improvement. Scientists could determine whether plant growth was significantly more or less productive than usual over a given time period—just what they needed to predict whether locusts were likely to swarm. The advance gave officials precious time to target worrisome locust populations with pesticides before they could swarm and take their toll on crops.

Ironing Out the Wrinkles

Though state of the art at the time, the system had a few shortcomings. For instance, bare soil in deserts can register an NDVI value similar to that of sparse vegetation. As a result, DLIS has occasionally issued false alarms, interpreting vegetation growth where there was none and missing the development of some real vegetation.

"If DLIS warns locust control teams of a risk and then it doesn't materialize, or if it misses places where vegetation and swarms may be developing, then officials could be less apt to mobilize the next time," said **Pietro Ceccato**, an associate research scientist at Columbia University, who has also worked with the FAO on its locust monitoring system.

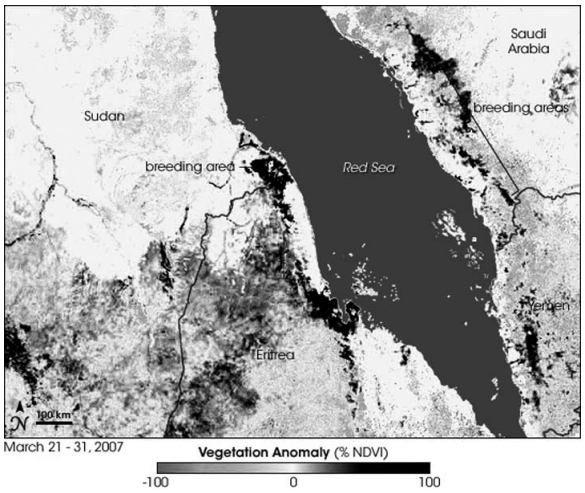
That system has evolved over the years, particularly since the arrival of the Moderate Resolution Imaging Spectroradiometer (MODIS) instruments on NASA's Terra and Aqua satellites, which offer a considerably better view than previous instruments. Since 2002, locust monitors at DLIS have supplemented NDVI with information from an additional channel—the shortwave infrared—to create composite images that better account for the differences between vegetation and bare soil.

While NDVI remains the most important tool available to monitor locusts from space, remote sensing specialists are hardly resting on their NDVI laurels. For instance, the Goddard group that helped create NDVI and FAO's locust monitoring system continues to refine its ability to screen out extraneous data and increase image resolution.

Beyond Locusts

The impulse to refine NDVI isn't limited to locust studies. Small particles in the atmosphere (aerosols) and water vapor can make interpreting NDVI measurements difficult in some situations, explained **Susan Ustin**, a remote sensing expert at the University of California-Davis. Clouds, especially thin cirrus clouds, also can contaminate short-term measurements. And the color of soil can cause complications because vegetation over dark soils produces higher NDVI values than the same amount of vegetation over light soils.

As technology has advanced, scientists have attempted to overcome such problems by developing dozens of



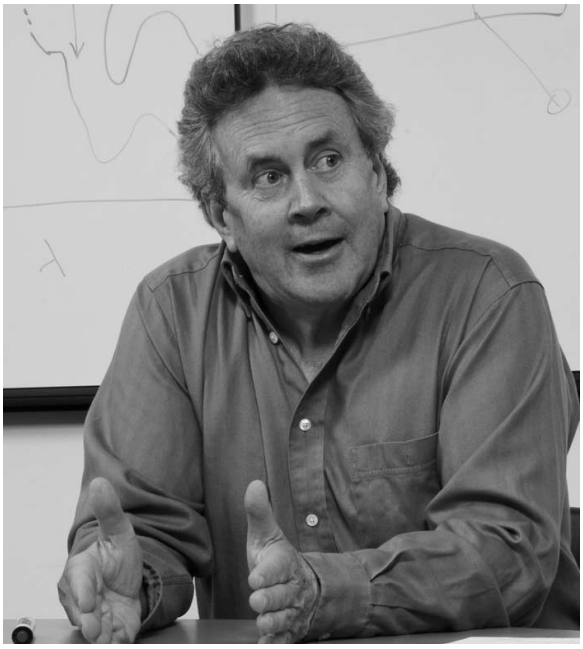
Swarms are not visible from space, but the vegetation that they depend upon is readily detectable. In this NDVI-based map, the darker areas over land indicate areas with especially lush vegetation, which serve as fertile breeding grounds for locusts. To view this image in color please visit: *www.nasa.gov/topics/earth/features/ndvi_locusts.html*. **Credit:** NASA Earth Observatory.

experimental indices, many of which are based upon NDVI. "It seems like a new index comes out every month," said Ustin. In fact, there are so many new indices being developed for such a variety of situations that's it's sometimes difficult for researchers to agree on which are worth pursuing.

Another problem with all the new indices, said **Compton Tucker**, a scientist at NASA Goddard who pioneered the use of NDVI, is that many are geared toward such specific ecosystems and environments that they aren't useful globally. There's a risk of creating *niche* products that won't allow researchers to see the bigger, global picture.

"Most of the new indices will never make it out of the lab," said **Steve Running**, a vegetation scientist at the University of Montana and member of the Intergovernmental Panel on Climate Change. "But I think that we'll eventually come up with one or two alternatives that we can use to complement NDVI." ■

KUDOS



Jeff Dozier, Professor of Environmental Science and Management and former EOS Senior Project Scientist, has received *Microsoft* Research's 2nd Annual **Jim Gray eScience Award**. The award, created in memory of *Microsoft* researcher Jim Gray, who went missing while sailing off the coast of San Francisco in 2007, honors significant contributions to the field of data-intensive computing. Dozier received the award for his "pioneering research on remote sensing, water resources, and climate change, and his contributions to the integration of environmental science and computer science." This work began during the early days of the EOS, when Dozier served as Senior Project Scientist for the program from 1990–1992. Dozier's current research uses the Moderate Resolution Imaging Spectroradiometer instruments on the Aqua and Terra satellites to study mountain snowpack and its response to climate change. Tony Hey, corporate vice president of Microsoft External Research, presented Dozier with the award at the 2009 eScience Workshop held at Carnegie Mellon University in Pittsburgh on October 16, 2009.

The Earth Observer staff and the entire scientific community congratulate Dozier on this remarkable achievement and his contributions to the study of hydrology and climate change. Further information is available at: *www.microsoft.com/presspass/features/2009/oct09/10-16jimgrayaward.mspx?rss_fdn=Custom*.

in the news

Arctic Sea Ice Extent Remains Low; 2009 Sees Third-Lowest Mark

Katherine Leitzell, National Snow and Ice Data Center, leitzell@nsidc.org

At the end of the Arctic summer, more ice cover remained this year than during the previous record-setting low years of 2007 and 2008. However, sea ice has not recovered to previous levels. September sea ice extent was the third lowest since the start of satellite records in 1979, and the past five years have seen the five lowest ice extents in the satellite record.

National Snow and Ice Data Center (NSIDC) Director and Senior Scientist **Mark Serreze** said, "It's nice to see a little recovery over the past couple years, but there's no reason to think that we're headed back to conditions seen back in the 1970s. We still expect to see ice-free summers sometime in the next few decades."

The average ice extent over the month of September, a reference comparison for climate studies, was 2.07 million mi^2 (5.36 million km^2)—see **Figure 1**. This was 409,000 mi^2 (1.06 million km^2) greater than the record low for the month in 2007, and 266,000 mi^2 (690,000 km^2) greater than the second-lowest extent in 2008.

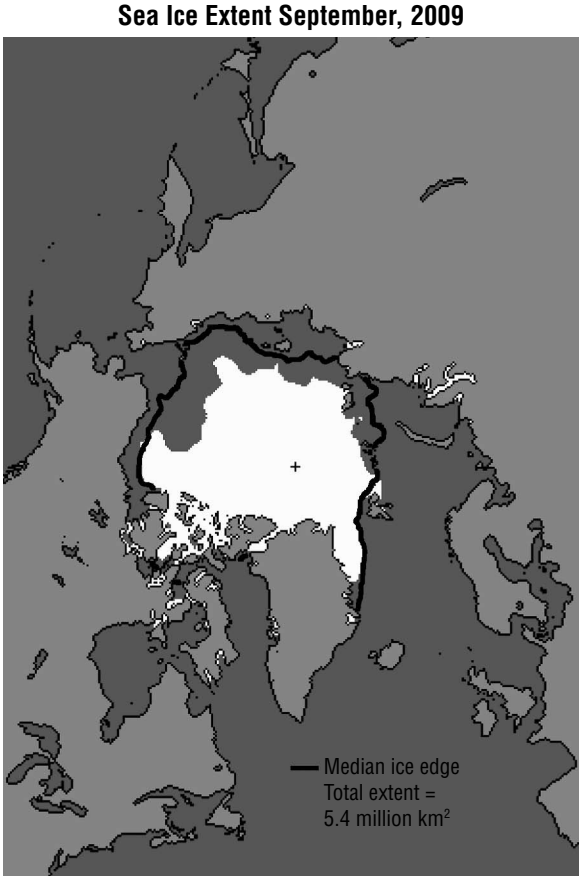


Figure 1. Arctic sea ice extent for September 2009 was 2.07 million mi^2 (5.36 million km^2), the third-lowest in the satellite record. The bold black line shows the median ice extent for the month of September 1979–2000. **Credit:** National Snow and Ice Data Center.

However, ice extent was still 649,000 mi^2 (1.68 million km^2) below the 1979 to 2000 September average —see **Figure 2**. Arctic sea ice is now declining at a rate of 11.2% per decade, relative to the 1979 to 2000 average —see **Figure 3**.

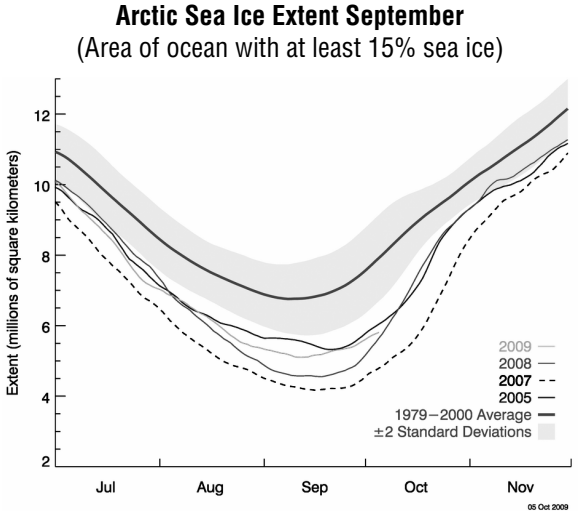


Figure 2. The updated time-series plot puts this summer's sea ice extent in context with other years. To view this image in color please visit: *nsidc.org/news/press/20091005_minimumpr.html*. **Credit:** National Snow and Ice Data Center.

Sea surface temperatures in the Arctic this season remained higher than normal, but slightly lower than the past two years, according to data from **Mike Steele** at the University of Washington in Seattle. The cooler conditions, which resulted largely from cloudy skies during late summer, slowed ice loss compared to the past two years. In addition, atmospheric patterns in August and September helped to spread out the ice pack, keeping extent higher.

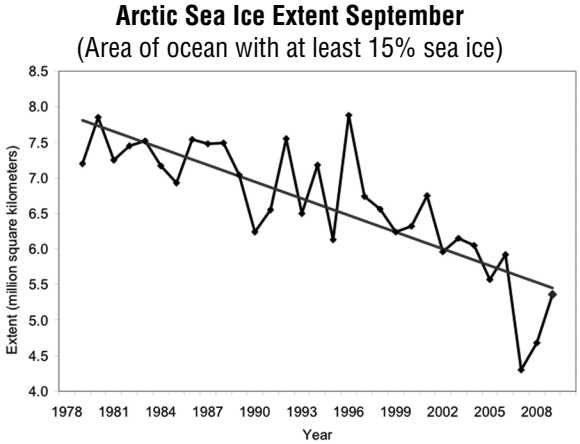


Figure 3. September ice extent from 1979 to 2009 shows a continued decline. The September rate of sea ice decline since 1979 has now increased to 11.2% per decade. **Credit:** National Snow and Ice Data Center.

The ice cover remained thin, leaving it vulnerable to melt in coming summers. Scientists use satellites to measure the age of the ice—a proxy for ice thickness. This year, younger (less than one year old), thinner ice, which is more vulnerable to melt, accounted for 49% of the ice cover at the end of summer. Second-year ice made up 32%, compared to 21% in 2007 and 9% in 2008. Only 19% of the ice cover was over 2 years old, the least in the satellite record and far below the 1981–2000 average of 52%. Earlier this summer, NASA researcher **Ron Kwok** and colleagues from the University of Washington in Seattle published satellite data showing that ice thickness declined by 2.2 ft (0.68 m) between 2004 and 2008.

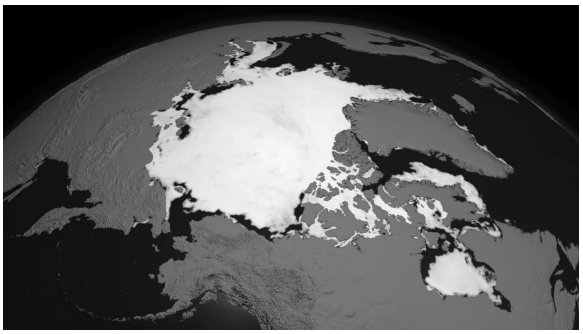
NSIDC Scientist **Walt Meier** said, "We've preserved a fair amount of first-year ice and second-year ice after this summer compared to the past couple of years. If this ice remains in the Arctic through the winter, it will thicken, which gives some hope of stabilizing the ice cover over the next few years. However, the ice is still much younger and thinner than it was in the 1980s, leaving it vulnerable to melt during the summer."

Arctic sea ice follows an annual cycle of melting and refreezing, melting through the warm summer months and refreezing in the winter. Sea ice reflects sunlight, keeping the Arctic region cool and moderating global climate. While Arctic sea ice extent varies from year to year because of changeable atmospheric conditions, ice extent has shown a dramatic overall decline over the past thirty years. During this time, ice extent has declined at a rate of 11.2% per decade during September (relative to the 1979 to 2000 average), and about 3% per decade in the winter months.

NSIDC Lead Scientist **Ted Scambos** said, "A lot of people are going to look at that graph of ice extent and think that we've turned the corner on climate change. But the underlying conditions are still very worrisome."

Reference:

Kwok, R., and D. A. Rothrock. 2009. Decline in Arctic sea ice thickness from submarine and ICESat records: 1958–2008, *Geophys. Res. Lett.*, **36**, L15501, doi:10.1029/2009GL039035.



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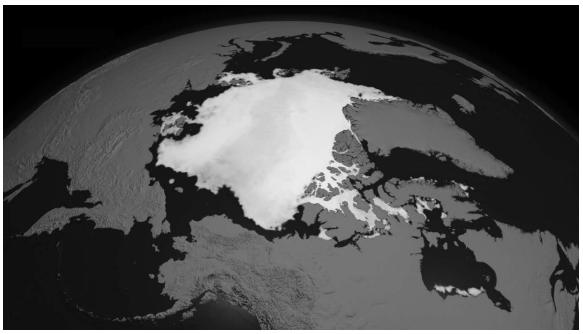

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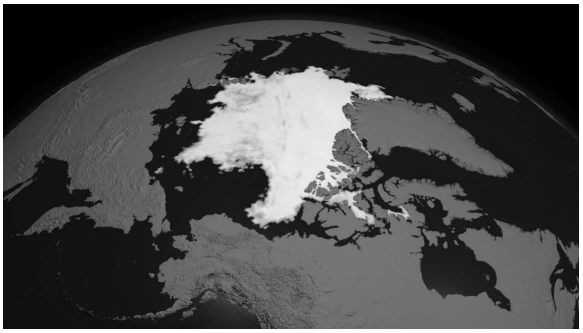

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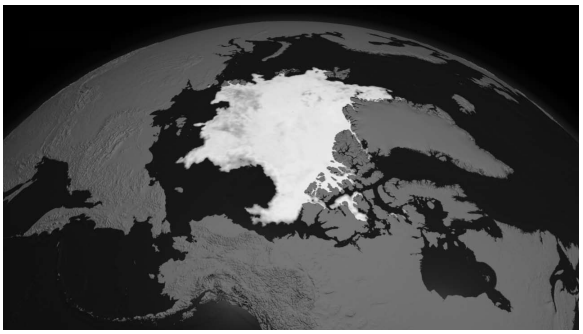

September 12, 2009

Sea ice is frozen seawater floating on the surface of the ocean. Some sea ice is semi-permanent, persisting from year to year, and some is seasonal, melting and refreezing from season to season. The sea ice cover reaches its minimum extent at the end of each summer and the remaining ice is called the perennial ice cover. These images show the summer retreat of sea ice over the Arctic from July 1–September 12, 2009, as recorded by the AMSR-E instrument on NASA's Aqua satellite. To view these images as a color animation please visit: *svs.gsfc.nasa.gov/vis/a000000/a003600/a003631/.* **Image Credit:** NASA Scientific Visualization Studio.

EOS Scientists in the News

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

For the Best Stargazing on Earth, Send Robots to Antarctica, August 31; *Wired Science*. Astronomers have found the very best place on Earth to observe the heavens; the Antarctic site, said co-author **Patrick Minnis** (NASA LaRC), was about as "close to space as you can get," and that's exactly what makes it so great—it's cold, dry, and nearly lacking weather or even clouds.

Arctic Sea Ice Thickness Down 53 Percent, September 2; *United Press International.* Scientists including **Ron Kwok** (NASA JPL) used satellite data and records from cold war submarine missions to find that Arctic Ocean ice thickness has declined 53% since 1980.

NASA Langley to Lead Climate-Change Study, September 2; *Daily Press*. NASA Langley has been chosen to lead the Climate Absolute Radiance and Refractivity Observatory (CLARREO), a key climate research mission; **Bruce Wielicki** (NASA LaRC) discussed a need for dedicated climate measurements, like CLARREO, rather than outdated day-to-day weather instruments that are not as accurate.

Claire Parkinson Discusses Uses of the Aqua Satellite Data, September 7; *EarthSky.* **Claire Parkinson** (NASA GSFC) noted that NASA has many Earth-observing satellites in orbit that are providing us with a phenomenal picture of the Earth system as a whole, and described how the Aqua satellite is used to track Earth's forest fires, dust storms and hurricanes.

Scientists Use Space Data to Map Ocean-Bottom Pressure, September 8; *Aviation Week*. **Michael Watkins** (NASA JPL), Project Scientist for the Gravity Recovery and Climate Experiment (GRACE) spacecraft, explained how scientists have used lunar-gravity algorithms, developed during the *Apollo* era, to measure pressure levels at the bottom of Earth's oceans.

Space Physicists Create New Model that Predicts Radiation Exposure for Frequent Fliers and Flight Crews, September 9; *Discoveries and Breakthroughs: Inside Science*. Space physicists, including **Chris Mertens** (NASA LaRC), designed a new model that predicts cosmic radiation exposure during airplane flights; the model estimates how much radiation will reach the Earth's atmosphere during solar storm activity, showing real-time exposure levels, which vary at different altitudes and latitudes.

Mous Chahine: 'No Area on Earth Immune From Effects of Greenhouse Gases', September 14; *EarthSky*. Senior researcher Moustafa Chahine (NASA JPL) talked about research using an instrument called the Atmospheric Infrared Sounder (AIRS) that works aboard NASA's Aqua satellite; AIRS tracks carbon dioxide, a greenhouse gas known to cause global warming.

NASA's Langley Research Center Selected to Lead CLARREO Mission, September 15; *Space News*. NASA's Langley Research Center has been tapped to manage one of the U.S. space agency's biggest climate research missions in recent years at a projected cost of $600 million to $800 million, according to NASA officials, and **Steve Sandford** (NASA LaRC) and **Bruce Wielicki** (NASA LaRC) discuss the mission.

JPL Oceanographer Expects Little Effect on Weather From El Niño, September 28; *The Press-Enterprise*. **Bill Patzert** (NASA JPL), a leading expert on the El Niño phenomenon, which can portend especially soggy winters for Southern California, said he doesn't see that happening this year.

NASA Flights Will Study Antarctic Ice Changes, October 8; *CNN.com.* Scientists including **William Krabill** (NASA WFF) and **Tom Wagner** (NASA HQ) described NASA's flights to study changes in Antarctic ice and collect data that may help scientists better predict the consequences of those changes.

NASA's Ice Bridge Team Heads to Antarctica, Where It's Warm, October 8; *Talk Radio News Service*. **Seelye Martin** (University of Washington), chief scientist of Operation Ice Bridge, and **Tom Wagner** (NASA HQ) explained how the Antarctic field campaign will provide the data scientists need to understand changes to sea ice, ice sheets and glaciers.

NASA prepares for its first Global Hawk mission, October 24; *Antelope Valley Press (Calif.)*. **Paul Newman** (NASA GSFC), Project Scientist for the upcoming Global Hawk Pacific mission, noted the successful completion of the first flight of a NASA Global Hawk under NASA operation. The flight took place October 23 at NASA's Dryden Flight Research Center located on Edwards Air Force Base, CA.

Lorraine Remer Tracks Airborne Dust From Outer Space, October 26; *EarthSky.* **Lorraine Remer** (NASA

GSFC) spoke about the instruments aboard the Aqua satellite and other Earth-orbiting satellites that study airborne dust; some instruments have a broad focus, while others have a more narrow focus but capture greater detail.

AP IMPACT: Statisticians Reject Global Cooling, October 26; *Associated Press*. In a story about the statistics behind Earth's temperature record, **Gavin Schmidt** (NASA GISS) noted that 2010 may break a record, at which point a cooling trend "will be never talked about again."

The Albedo Effect, October 27; *Scientific American*. In a blog that explores the degree to which solar panels both help the climate (by reducing the need to burn fossil fuels) and hurt it (by absorbing sunlight and warming the surface) **Gavin Schmidt** (NASA GISS) calculated that the albedo effect from solar panels is not negligible.

Sea Levels to Rise Faster than Expected, Scientists Say, October 28; *Daily Press, PR Web*. Scientists including **Robert Bindschadler** (NASA GSFC) presented data that show old estimates for rising seas due to global warming were overly optimistic; fresh data from the poles now indicate a minimum of three feet of rise by the year 2100 or sooner. ■

First Public Release of Aura-OMI Level-2 Atmospheric Ozone Profile Product

The Ozone Monitoring Instrument (OMI) Level-2 Version 3 Ozone Profile Product, *OMO3PR*, is now released and is publicly available (*disc.sci.gsfc.nasa.gov/Aura/data-holdings/OMI/omo3pr_v003.shtml*) from NASA's GSFC Earth Sciences (GES) Data and Information Services Center (DISC). OMI is a contribution of the Netherlands Space Office (NSO) in collaboration with the Finish Meteorological Institute (FMI), to the US EOS-Aura Mission. The Royal Netherlands Meteorological Institute (KNMI) is the official site of OMI and the institute of OMI Principal Investigator, **Pieternel Levelt**. Since Aura launched in July 2004, OMI has been providing daily global measurements of ozone and atmospheric trace gases in addition to aerosols, clouds, and a daily dose of harmful surface ultraviolet (UV) irradiances.

The OMI Level-2 ozone profile product, *OMO3PR*, at the pixel resolution 13 x 48 km (at nadir), is based on the optimal estimation algorithm [Rodgers, 2000][1] with climatological ozone profiles as *a-priori* information. The OMO3PR retrieval algorithm uses spectral radiance values from the UV1 channel (270–308.5 nm) and from the first part of the UV2 channel (311.5–330 nm). The algorithm team responsible for the *OMO3PR* data product consists of the KNMI scientists, **Johan de Haan** and **Pepijn J. Veefkind**.

The *OMO3PR* product provides daily global ozone values (in Dobson Units) for 18 atmospheric layers. It also provides *a-priori* ozone profile values, error covariance matrix, averaging kernel, and some ancillary information such as time, latitude, longitude, solar zenith, viewing zenith angles, and quality flags. Since *OMO3PR* profile data has been only validated for the pressure range 0.3–400 hPa, it is recommended that the user be extremely cautious with any conclusions on tropospheric ozone based on these data.

This ozone profile product joins a number of OMI atmospheric products already released, such as Total Column Ozone, Nitrogen Dioxide (NO_2), Sulfur Dioxide (SO_2), Bromine Oxide (BrO), Formaldehyde (HCHO), Chlorine Dioxide (OClO), Cloud, Aerosol, UV-B Surface Irradiance and Erythemal Dose, and Solar Spectral Radiance and Irradiance, which are available from the GES DISC OMI web site, *disc.sci.gsfc.nasa.gov/Aura/data-holdings/OMI/*.

For the full set of Aura products available from the GES DISC, please see *disc.sci.gsfc.nasa.gov/Aura/data-holdings/* or go directly to the data search and download system *mirador.gsfc.nasa.gov/*.

[1] Rodgers, C.D., 2000: Inverse Methods for Atmospheric Sounding: Theory and Practice. *World Scientific, Singapore*, 238.

NASA Science Mission Directorate – Science Education Update

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Online Climate Courses for Middle & High School Educators—Accepting Winter Registrations

Early Registration Deadline: January 1, 2009

The National Center for Atmospheric Research (NCAR) offers a series of six and seven week courses for middle and high school teachers that combine geoscience content, information about current climate research, easy to implement hands-on activities, and group discussion. The courses run concurrently from January 22–March 14, 2010. There is a $225 fee per course (save $25 if you register by January 1).

Courses are:
CD 501: Introduction to Earth's Climate
CD 502: Earth System Science: A Climate Change Perspective
CD 503: Understanding Climate Change Today.

For more specific course information, a course schedule and registration information, visit: e*courses.ncar.ucar.edu* or contact **Kirsten Meymaris** at *kirstenm@ucar.edu*.

NASA Announces Global Climate Education Awards

NASA has awarded $6.1 M in cooperative agreements to 15 U.S. organizations to enhance learning through the use of NASA's Earth Science resources. The selected organizations include colleges and universities, non-profit groups, museums, science centers, and a school district. The winning proposals illustrated innovative approaches to using NASA content to support elementary, secondary, and undergraduate teaching and learning, and through lifelong learning. There is a particular emphasis on engaging students using NASA Earth observation data and Earth system models.

The cooperative agreements are part of a program Congress began in fiscal year 2008. For a list of selected organizations and projects descriptions, click on "Selected Proposals" and look for "Global Climate Change Education" at: *nspires.nasaprs.com/*.

2010 Thacher Environmental Research Contest for Grades 9-12

The 2010 Thacher Environmental Research Contest, an activity of the Institute for Global Environmental Strategies, awards cash prizes to secondary school students (Grades 9-12) whose projects demonstrate the best use of satellites and other geospatial technologies or data to study Earth.

Three cash awards will be given: 1st place – $2,000; 2nd place – $1,000; and 3rd place – $500. Entries can be submitted by individuals or teams. In the case of team entries, the cash award will be split equally among the winning team members. In addition to prizes for the winning students, the teacher/coach of the winning students or teams will receive a $200 *Amazon.com* gift card.

Entries must be postmarked April 5, 2010. For more information, please visit *www.strategies.org/ThacherContest.*

GLOBE Partners with *Live Earth*

The GLOBE program is pleased to announce a partnership with *Live Earth* in support of the Dow *Live Earth* Run for Water, a worldwide series of events to occur on April 18, 2010, dedicated to finding solutions for the global water crisis. GLOBE is contributing to the educational component of these events.

Live Earth Run for Water will feature 6-km runs (the average distance that women and children in Africa, Asia and Latin America must walk every day to obtain drinking water), concerts, and education villages to raise awareness and support to help solve the water crisis. For more information, see: *liveearth.org/en/ or www.globe.gov/.*

Podcast Series Shares Harvest of NASA Advances in Agriculture

A new NASA Podcast series *Science for Hungry World*, spotlights scientific advances in monitoring agricultural and landscape changes that affect the sustainability of the world's food supply. The podcasts cover: land use and land cover change; sustainability of food availability and access; the essential interplay of water and agriculture; the future of the world's food system; and joint agriculture projects between NASA, the U.S. Department of Agriculture (USDA), and the U.S. Agency for the International Development (USAID). To view the podcast series (five videos) on the Web, visit: *www.nasa.gov/topics/earth/features/ag_casts/index.html.* ■

EOS Science Calendar

December 8–11
ASTER Science Team Meeting, San Francisco, CA. Contact: Elsa Abbott, *elsa.abbott@jpl.nasa.gov*

December 10–11
MISR Science Team Meeting, Pasadena, CA. URL: http://*www-misr2.jpl.nasa.gov/events/events-dinnerConcert.html*

January 19–21, 2010
Landsat Science Team Meeting, NASA Ames Research Center, Moffett Field, CA.

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

September 27–October 1, 2010
Aura Science Team Meeting, Boulder, CO.

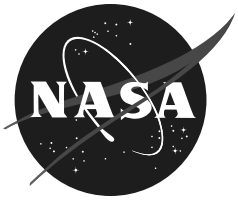
October 27–29, 2010
Landsat "Specialists" Meeting, Boston, MA.

Global Change Calendar

December 14–18
American Geophysical Union Fall Meeting, San Francisco, CA. URL: *www.agu.org/meetings/fm09/*

December 7-18
United Nations Climate Change Conference (COP-15) Copenhagen, Denmark. URL: *en.cop15.dk/*

January 17-21, 2010
American Meteorological Society Meeting Atlanta, GA. URL: *www.ametsoc.org/MEET/annual/*



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