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Editor's Corner

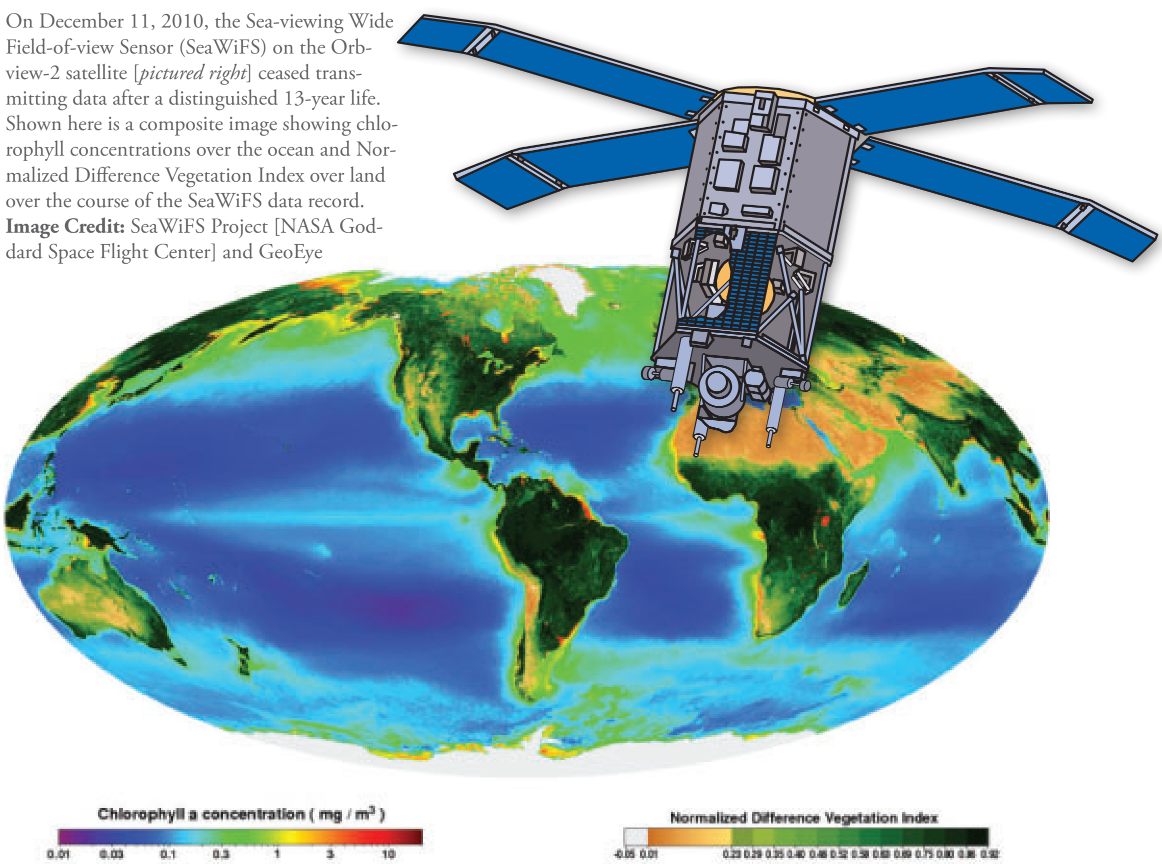
Steve Platnick
EOS Senior Project Scientist

There is a lot to report since our last issue, and I regret that little of it is good news.

As I expect most of you are already aware, NASA's **Glory** spacecraft failed to reach orbit after being launched on an Orbital Sciences Corporation *Taurus XL* rocket from Vandenberg Air Force Base in California on March 4, 2011. About three minutes after the 5:09 AM EST launch, telemetry indicated that the *fairing*—the protective shell atop the rocket—did not separate as expected and the spacecraft likely fell into the South Pacific. This comes just two years after a similar failure mode occurred for the Orbiting Carbon Observatory (OCO)—also launched on a *Taurus XL*. There was an extensive investigation following that February 2009 failure; the fairing underwent a redesign of its separation system and had been cleared for use for the Glory mission. A mishap investigation board has been selected to analyze the Glory launch failure and make recommendations to the NASA administrator.

continued on page 2

On December 11, 2010, the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) on the Orbview-2 satellite [*pictured right*] ceased transmitting data after a distinguished 13-year life. Shown here is a composite image showing chlorophyll concentrations over the ocean and Normalized Difference Vegetation Index over land over the course of the SeaWiFS data record. **Image Credit:** SeaWiFS Project [NASA Goddard Space Flight Center] and GeoEye



SeaWiFS Global Biosphere
September 1997–December 2010

eos.nasa.gov

In This Issue

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

This is an extremely disappointing setback for NASA's Earth Science program, and of course all those directly involved in the Glory mission. With the Aerosol Polarimetry Sensor (APS) instrument, Glory was to obtain unique polarimetric observations of reflected solar radiation that would help quantify the role of aerosols in climate. The mission would also have continued our ongoing measurements of the Total Solar Irradiance with an improved Total Irradiance Monitor (TIM) instrument that was first flown on the SORCE mission. In addition to working to determine the cause of the launch vehicle failure, NASA's Earth Science Division is conducting parallel studies to determine first if a rapid reflight of an APS-2 instrument would be a scientifically viable and valuable mission today, and second, what would be the minimum cost, risk, and schedule implementation approach that could complete such a mission.

On February 14, President Obama's **FY12 budget** was released. The new budget proposal contains both good and bad news for NASA Earth Science. The perceived balance between the two depends on one's inclination to see a glass as half full or half empty, and recognition of the current U.S. budget environment.

For clarity, it's easier to start with the bad news. NASA's overall spending would be frozen at $18.7 billion (B). Earth Science would remain flat at about $1.8B through at least 2016, representing a removal of $1.24B from the $2.08B increase proposed in the president's FY11 budget for the years FY12-15. The result of those cuts is that funding for further development of two *Tier 1* Decadal Survey missions—Climate Absolute Radiance and Refractivity Observatory (CLARREO) and Deformation, Ecosystem Structure and Dynamics of Ice (DESDynI)—will be eliminated. The multiyear budget plan NASA sent Congress a year ago called for spending $1.2 billion from 2012–2015 to develop these two missions. Both had recently completed their Mission Concept Reviews (MCRs) and were expected to proceed to *Phase A*—as reported in the last issue's editorial. However, the Office of Management and Budget (OMB) specifically removed those funds from its 2012 budget proposal. Further, NASA was directed to stop work on the second GPM Microwave Imager (GMI #2) instrument, that NASA had been building while looking for an international partner to complete the GPM Low Inclination Orbiter (GPM-LIO) mission.

More specifically, all funding for CLARREO and DESDynI for FY12–FY16 was removed from the NASA budget. For CLARREO, NASA has been directed to hold the mission in preformulation through FY16. The first year of the recently awarded CLARREO Science

Definition Team will be funded. The DESDynI lidar is cancelled, and NASA was directed to find an international partner to contribute a space-based lidar mission. NASA was directed to look for affordable alternatives to the DESDynI radar, though no funds were provided to do so. The DESDynI Science Team solicitation may be revised with a delayed release. For both CLARREO and DESDynI, support commensurate with a mission in early pre-formulation is expected to continue.

Now, the good news. With the exception of the individual missions or mission elements above, the president's FY12 budget fully funds all other requested Earth Science Division flight activities. The overall budget secures funding for the other two *Tier 1* Earth Science missions identified in the 2007 Decadal Survey—Soil Moisture Active-Passive (SMAP) and ICESat-2. The missions remain budgeted for launch in 2014 and 2016, respectively; both are currently in *Phase A* of their development. The budget also continues to support the so-called foundational missions currently in the implementation phase (Aquarius, NPP, LDCM, GPM Core Observatory) and climate missions (SAGE-III, OCO-2/-3, GRACE-FO, PACE). The current operating missions, all of which submitted mission-continuation "Senior Review" proposals on March 4, are funded in the President's budget (a graphical timeline of recent past, operating, and future Earth Science missions is available at *eospso.gsfc.nasa.gov/eos_homepage/mission_profiles/docs/mission_profile.pdf*). Further, the Earth Venture-class solicitations and funding continue as planned, including the release of the EV-2 small mission Announcement of Opportunity (AO) in Spring 2011, and the EV-Instrument facility mission AO expected to be released before the end of FY11.

Given the challenging federal budget environment, continued support of these missions signifies the administration's strong belief in the importance of NASA's Earth Science efforts. But a caveat is warranted. Adding to the budget complexities is the fact that the President's 2011 budget was never enacted by Congress, leaving the Agency and the rest of the federal government funded at lower FY10 levels under a series of Continuing Resolution stopgap spending measures—the latest of which expires in early April (as of this writing).

On December 11, 2010, the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) on the OrbView-2 spacecraft stopped transmitting data. After an extensive two-month investigation and numerous attempts at communication with the spacecraft, GeoEye has determined that SeaWiFS is no longer recoverable. **Gene Feldman**, SeaWiFS Project Manager, had this to say: *"The international scientific community certainly could not have asked for a more tenacious little spacecraft and instrument that has served us so well for the past 13+ years. Not bad for a spacecraft and mission that so many people thought would never get off the ground let alone make it through the projected five-year mission life."*

SeaWiFS was NASA's first *data-buy*—meaning that instead of NASA designing, building, and operating the instrument and spacecraft, NASA defined the data and mission specifications and we purchased the data from a private company. The data have been distributed far and wide, and in the minds of many people, have revolutionized the way we view our world. Since its launch in August 1997, the SeaWiFS project has distributed nearly 20-million data files, has over 3500 authorized SeaWiFS researchers, has an international collaboration of 132 ground receiving stations, and has been the basis for more than 2600 peer-reviewed science papers. Says Feldman, "*I have no doubt that this data set will continue to provide new discoveries and insights into the workings of this incredible planet that we call home.*"

Our periodic *Perspectives on EOS* series returns this issue with the first of two planned articles from **Ghassem Asrar** on page 4. In these articles, we have been sharing reflections on EOS from those who participated in its development. In addition to providing historical information, the hope is that these articles and lessons-learned might help inform those tasked with planning future Earth observing missions. Asrar actively participated in EOS (as a Science Program Manager, Program Scientist, and Associate Administrator), and brings us recollections from those days at NASA as well as a unique perspective on EOS and how it fits into our overall Earth observing capabilities. Asrar's article will appear in two parts. **Part I** focuses on the efforts that went into *"Forging an EOS Community"*; **Part II** (slated for our May–June issue) will focus on both the challenges of incorporating new technology into the EOS Program and how these new innovations have created opportunities for the "evolution" of NASA's Earth observing capabilities (i.e., EOS and beyond). I am grateful to Ghassem for taking time from his current duties as director of the World Climate Research Progamme (WCRP) to provide his recollections and perspective.

Finally, our thoughts go out to the people of Japan, and in particular to our many Japanese colleagues and their families, in the aftermath of the tragic earthquake and tsunami of March 11. Initial reports are that the various facilities in Japan used for NASA-related Earth science satellite instrument operations and future mission activities have generally faired well. We extend our sincere sympathies and hopes for a speedy recovery to the people and communities affected. ■

The Enduring Legacy of the Earth Observing System Part I: *Forging An "EOS Community"*

Ghassem R. Asrar, Director of the World Climate Research Progamme, GAsrar@wmo.int

Editor's Note:** Asrar shared with us his perspectives on a number of topics of interest to the Earth Science community.* ***The Earth Observer *has arranged his remarks into two parts. Part I appears in this issue and focuses on the efforts that the EOS Program made from its earliest days to establish a broad, interdisciplinary, multi-generational, and international community. Part II will appear in our May–June issue and will focus on the challenges associated with integrating new technology into the EOS Program and how NASA has turned those challenges into opportunities as it plans and implements the Earth observing system of the future—i.e., the post-EOS era.*

Ghassem Asrar currently serves as director of the World Climate Research Progamme (WCRP). Prior to this, he had a long tenure at NASA that dates back to 1987. Asrar moved to NASA Headquarters in December 1987 as a distinguished visiting professor and served as NASA Remote Sensing Science and Hydrology Program Manager. In 1992, he became a NASA civil servant and assumed the role of EOS Program Scientist. In 1998 he was appointed as the Associate Administrator for the former Earth Science Enterprise. Following the Agency's transformation in 2004 he became Deputy Associate Administrator for the Science Mission Directorate. Asrar was a key player in the development of EOS from the beginning; he led an international science team responsible for promoting and guiding the EOS development. It was during his tenure that NASA successfully launched the first series of EOS satellites and developed the EOS Data and Information System (EOSDIS)—a comprehensive data and information system for managing the wealth of information resulting from these missions. While at Headquarters, Asrar also helped to articulate NASA's vision for Earth Science in the 21st century, a vision he continues to pursue with his current endeavor as director of the WCRP.

Before joining NASA, Asrar combined his interest and expertise in research with his keen desire to educate the next generation of Earth system scientists. Upon completing his PhD program at Michigan State University, he worked for about a decade in academia as a research associate and professor. Asrar has published more than 100 peer-reviewed papers and edited several reference and text books with a focus on biosphere-atmosphere interactions and remote sensing methodologies. He established the NASA Earth System Science Fellowship and the New Investigators Postdoctoral Programs that continue to this day, and have supported and trained well over 1000 young scientists.

During the *Terra@10* celebration at the American Geophysical Union's (AGU) fall meeting in December 2009, **Steve Platnick** approached Asrar on behalf of *The Earth Observer* and asked if he would be willing to share his reflections on the legacy of EOS during the past 20 years as part of our periodic *Perspectives on EOS* series. Asrar agreed and we are pleased to present Part I of his report below.

Introduction

Before I started writing my article I had an opportunity to read some of the previous contributions to the *Perspectives on EOS* series. These articles were quite helpful in deciding what I might say that would be hopefully complementary and provide some additional insight to what it took to make the EOS concept a reality. I can sum it up in just a few key words: vision, dedication, hard work, and willingness to take risk. Over the past thirty years, several thousand individuals have been so convinced of the potential of the long-lasting impact of the Program and they have been (and continue to be) willing to devote much of their professional career to making the vision of EOS a reality. It is impossible to identify and name all of the unsung heroes of EOS; previous articles in this series have identified some of these individuals by name and given them due credit for their contributions, but countless others are not mentioned; I, too, will fall short in this regard.

Ghassem R. Asrar

I do hope all those who have read previous articles and take time to read this one will pause to reflect on their own contribution and experience throughout the years of their involvement in the EOS Program and share their perspective with the rest of us. Sharing our stories and our "lessons learned" with those who will carry forward the successful legacies of this truly visionary program is the best way to encourage them to stay focused, never give up hope, and believe in the democratic process because, despite all its trials and tribulations, it actually works for the greater good of society.

Promoting Interdisciplinary Cooperation

A major legacy of the EOS Program has been its community building through intentional investments in research, technology, and education. This has been part of EOS from the very beginning and encompasses a whole host of traditional Earth and environmental sciences, as well as computer, information, communication, and aerospace technologies and disciplines. The establishment of so-called Interdisciplinary Science (IDS) Teams composed of more than 20 different interdisciplinary research, modeling, and data analysis projects with active involvement of a large number of universities, national, and international laboratories and other research organizations contributed to this community building from early on. These IDS Teams forged new alliances by bringing together representatives from a wide range of disciplines, organizations, and scientific experts across the globe that, prior to EOS, had little reason to interact with one another.

There were countless sessions and discussions within and among these teams about what constitutes an IDS team. Some felt that they were mere combinations of the organizations banded together to write a proposal[1]. Others thought the teams were meant to embody the diversity and combination of observational parameters derived from different EOS instruments to be used by these projects. Still others thought they represented the coupled interactions between/among the components of the Earth system, and thus required having requisite experts from various disciplines to address the scientific questions under study by these teams.

Sharing our stories and our "lessons learned" with those who will carry forward the successful legacies of this truly visionary program is the best way to encourage them to stay focused, never give up hope, and believe in the democratic process because, despite all its trials and tribulations, it actually works for the greater good of society.

Beyond the debate over the identity and purpose of IDS Teams were concerns over whose responsibility it should be to coordinate between and integrate the multiple teams when such cooperation was deemed necessary. And if we proceed on this interdisciplinary path would this inhibit individual investigators' ability to focus on their own research on fundamental biological, chemical, and physical processes? And what about metrics? That is to say, how would we measure scientific progress on both fronts—i.e., disciplinary versus interdisciplinary—and how should we evaluate such

[1] **Piers Sellers** was involved in the early days of what became known as EOS and expressed this view of the IDS Teams in the January–February 2009 issue of *The Earth Observer* [**Volume 21, Issue 1**, pp. 4-8].

Instead of viewing EOS as a new and innovative initiative for studying the Earth and environmental sciences both at home and abroad, some of our colleagues and friends considered EOS as a major competitor for already limited resources.

progress? These were some of the contentious issues that we had to struggle with in those early days.

The IDS initiative was also the focus of much discussion and controversy among the sister agencies involved in the U.S. Global Change Research Program (USGCRP), international partner agencies, and even among NASA Program Managers and some segments of the Earth science community funded by NASA science programs—despite the fact that they were coordinated and co-managed at the time by NASA Research and Analysis (R&A) program managers. Some considered establishing these research teams to be in direct competition with the existing funding mechanisms within NASA and other agencies. Others, including some distinguished leaders in U.S. Science, realized the missed opportunity that arose by not responding to the initial EOS Announcement of Opportunity (AO) because they did not think EOS would become a reality. Once the program received funding they suddenly found themselves on the outside looking in at a program that appeared as if it was going to be around for a long time as it had identified "multi-decadal" objectives. Other community members believed that the resources allocated to the research and modeling part of EOS program could have been better spent on baseline NASA R&A programs. All of these topics and issues would come up during the multitude of reviews that were cited in previous articles in the *Perspectives on EOS* series; in some cases, these issues served as the basis of such reviews.

Part of the reason for all of this misunderstanding can be attributed to wording in the EOS AO that conveyed a strong message that if one did not respond to this call any future opportunity for them to participate would be at least a decade into the future. Thus, instead of viewing EOS as a new and innovative initiative for studying the Earth and environmental sciences both at home and abroad, some of our colleagues and friends considered EOS as a major competitor for already limited resources. It was therefore hard to convince these individuals to take the long-term view because they worried that they and their respective organizations would effectively be excluded from the new community that EOS was hoping to build.

Fostering Cooperation and Communication Within NASA

If the tone of the AO created the impression that EOS would be an "exclusive" club, the way NASA Headquarters was organized at the time probably did not help to assuage those concerns. On the scientific front, **Dixon Butler** was responsible for managing the EOS-related activities, including the EOS Data and Information System (EOSDIS), while **Robert Watson** was responsible for R&A and all historical scientific activities. This separation of resources and responsibilities resulted in some inevitable tension among the science program managers at NASA Headquarters, and this tension was also conveyed to the scientific community at large.

Similarly, the management of the space component of EOS program was assigned to a newly hired team of engineers headed by **Ray Roberts**, while **Bill Townsend** and his team managed the traditional programs—e.g., Upper Atmospheric Research Satellite (UARS), Tropical Rainfall Measuring Mission (TRMM), Ocean Topography Experiment (TOPEX), etc. There was also some tension/competition between these two groups of engineers at the time. The NASA senior management was very well aware of this situation and made every effort to find ways and means of reducing the tension. However, the fact remained that the EOS program was a major new initiative and required a significantly greater number of engineers and scientists to oversee its implementation both at Headquarters and Goddard Space Flight Center (GSFC) which, at that time, had the lead with project implementation.

It is noteworthy that in the beginning there was some "intra-agency" competition for assignment of project management between GSFC and the Jet Propulsion Laboratory (JPL)[2]. The issues (associated with science and hardware management and assignments) were brought up and documented in several of EOS independent reviews and were sometimes the subject of Congressional hearings, especially by those legislators who could not associate their respective constituencies with the Program.

NASA used every opportunity to develop greater coordination and cooperation at Headquarters and beyond. Several of the review teams challenged us to develop a science strategy for the EOS program that would articulate clearly the scientific questions EOS hoped to answer, and why it required its own combination of interdisciplinary and instrument science teams, data assimilation, and modeling capabilities, unlike other NASA- and USGCRP-funded activities. **Jeff Dozier** (EOS Project Scientist at GSFC at the time) and I managed to develop and publish the first *EOS Science Strategy*—cover shown on page 11 [*top left*]—with active involvement and great support by the entire EOS science teams. That strategy would later evolve into a much more detailed and technical document known as the *EOS Science Plan*—see page 11.

As the EOS Program Scientist, one of my major duties was to promote greater coordination and support between the various aspects of EOS research, modeling, and analysis with "baseline" R&A programs and their respective managers. For example, we invited the R&A Program Managers to become actively involved in the evaluation and selection of the EOS-sponsored graduate student and post-doctoral fellows, as well as the management and oversight of the interdisciplinary research investigations. The Program Managers served as the Program Scientists for individual EOS satellites and instruments—despite the fact that management of satellites and instrument science teams had been assigned initially to GSFC.

A Perspective on the Role of Project Scientist

Serving as a Project Scientist has never been a glamorous role; it's often a lot of work for not a great deal of recognition or *tangible* reward. At that time EOS was ramping up, the main criteria for a scientist's professional advancement were their publications and the number of grants/projects they could obtain, so it was difficult for us to offer these distinguished scientists much in return for their service. The best we could provide these Project Scientists was funding for a postdoctoral fellow or a part-time assistant who could help them with some of their regular scientific or management duties. And yet, remarkably, they were willing to take on the responsibility! It is a testament to the value they saw in what we were trying to do and the significant role they could play as advocate for the science of these EOS missions in the face of the many engineering trade-offs that were required to keep each mission within its budget, schedule, and scope. These efforts by the Project Scientists over the years have been critical in allowing EOS to fulfill its science objectives.

When I became Associate Administrator for the Office of Earth Science, **Vince Salomonson** and I worked closely with GSFC Director **Al Diaz** and his deputy **Bill Townsend** (who moved from NASA Headquarters to GSFC in 1998) to ensure that serving as a Project Scientist was recognized as being worthy of award and recognition among NASA scientists—i.e., above and beyond their individual scientific accomplishments.

We also worked closely with **Vince Salomonson**, **Dorothy Zukor**, and **Franco Einaudi** (all at GSFC)—who had the overall responsibility for implementing Earth science activities—to identify and convince a number of distinguished scientists at GSFC to take on the role of Project Scientist for the various EOS missions. The same efforts were extended at JPL and the Langley Research Center (LaRC) that also had leading responsibilities for some of the EOS instruments and satellites. Our thinking was that for EOS and its mission to have credibility with the greater national and international community, NASA must assign its best scientists and engineers to its advocacy, management, and stewardship. These efforts were ultimately delegated to **Michael King** (at GSFC) who became the EOS Senior Project Scientist following **Jeff Dozier's** return to academia.

[2] **Darrel Williams** mentions some of these "intra-agency" tensions and shares his memories of the tumultuous early days of EOS in the May–June 2008 issue of *The Earth Observer* [**Volume 21**, **Issue 3**, pp. 4-5].

Our thinking was that for EOS and its mission to have credibility with the greater national and international community, NASA must assign its best scientists and engineers to its advocacy, management, and stewardship.

In 1993—for the first time in NASA's history—the Earth Science Program (which at that time was called *Mission to Planet Earth*) was elevated to an Office level at Headquarters. **Charlie Kennel**, a solar physics expert, served as its first Associate Administrator through a temporary arrangement of Intergovernmental Personnel Act (IPA) with the University of California in Los Angeles (UCLA). Meanwhile, **Robert Harris** was chosen as director of the newly formed Research Division. In 1998 the *Mission to Planet Earth* (MTPE) was renamed the *Earth Science Enterprise* (to be consistent with the nomenclature that NASA used for its other offices and space science programs) and I became its first permanent Associate Administrator.

Some of the issues and tensions I have discussed here concerning roles and responsibilities were resolved during this period with the greater integration of all EOS science-related activities with the rest of NASA Earth Science programs. Similarly, engineering management tasks for the space and ground segments were integrated into a single Flight Systems Division with William Townsend as its initial director. When **Charlie Kennel** became Associate Administrator of MTPE, he appointed Townsend to be his Deputy, and **Mike Luther** succeeded him as head of the Flight Systems Division. (**Dan Goldin** was the NASA Administrator during this period.)

In my roles as EOS Program Scientist and later as Associate Administrator for the newly established Office of Earth Science, I was able to build very productive relationships and establish ongoing constructive dialogue with EOS stakeholders. These rela-

From 1989–2002, EOS Investigators Working Group (IWG) Meetings provided an important forum for communication between EOS Investigators. They were an opportunity for the participants to interact with their colleagues from around the world and receive updates on the progress of the program. The rise of the Internet made peer-to-peer communication much easier, and these very large face-to-face meetings became less frequent, but these meetings played a vital role in forging the EOS Community. Shown here are a few snapshots of past IWG meetings from *The Earth Observer* archives.

[*left to right*] Darrel Williams, Bruce Barkstrom, and Alexander Goetz at the November 1990 IWG.

[*left to right*] Bruce Guenther, Bill Barnes, Les Thompson, and Dot Zukor at the November 1990 EOS IWG.

Ghassem Asrar [*left*] and Michael King [*right*] at the March 1993 EOS IWG.

[*left to right*] Peter Brewer, Jeff Dozier, Bruce Barkstrom, Mark Abbott, and Dave Glover [*seated*] at the 1994 IWG.

tionships and conversations were invaluable to me as they allowed me to gain better understanding of the perspectives and expectations of the stakeholders. They helped other NASA colleagues and me to feel more at ease with the idea of opening all aspects of the EOS program[3] to new solicitation and competition from the broader science community. This opportunity for broader participation in EOS has been a major contributor in fostering the creation of the "EOS community" as we know it today.

Training the Next Generation of Scientists

Another key contributor to building and broadening the "EOS Community" has been the Program's ongoing investment in training and education of the next generation of Earth system scientists. This commitment has been present since the very early days of EOS. I recall vividly a conversation early on when **Len Fisk** and **Joseph Alexander**[4] encouraged Dixon Butler and me to develop and administer the NASA Global Change Fellowship Program that later on would become known as the NASA Earth System Science Fellowship Program.

Those who planned and implemented the EOS program knew all along that we were establishing a solid foundation for the EOS program of the future in a way that its capabilities will be used and supported by future generations.

NASA also sponsored some K-12 education-related activities under the EOS program[5], and funded a large number of train-the-trainers workshops and symposia where teachers received training so they could, in-turn, train other teachers about Earth Science. NASA also funded Earth System Science curriculum and course development at some major universities and community colleges through partnerships with teachers' associations and many other organizations—e.g., the Universities Space Research Association (USRA) under the leadership of **Don Johnson** [University of Wisconsin, Madison] together with **Mike Kalb** and **Martin Ruzek** [USRA]. It was a win-win for all parties involved. EOS provided access to its unique network of scientists and engineers—and their knowledge—along with some funding for these activities. In return, the program gained tremendous visibility and access to these other organizations' pre-existing networks for dissemination of its observations and science results. The ultimate goal was to create the necessary network of next-generation interested and enlightened leaders to carry forward the EOS legacy across generations. I had most enjoyable experiences in presenting the EOS program goals, objectives, and results to students, teachers, and educators—this task often occupied a significant fraction of my time as EOS Program Scientist.

Over the past three decades a combination of the Fellowship program and, later on, the New Investigators Program have supported a few thousand early-career scientists who will undoubtedly carry forward the EOS legacy across multiple generations. These EOS fellows, together with a perhaps equal, if not greater, number of graduate and post-doctoral fellows supported by the EOS instruments and IDS Teams, make up today's EOS generation who will mentor and train future leaders. Those who planned and implemented the EOS program knew all along that we were establishing a solid foundation for the EOS program of the future in such a way that its capabilities will be used and supported by future generations.

The "EOS Community" Goes Global

On the whole, NASA has been very successful in capturing the interest and participation of international partners in EOS[6]. While the partnerships were by and large not

[3] This included the space component, ground segment, data and information system, and research, analysis, and modeling associated with all instruments and missions involved, as well as the interdisciplinary research projects.

[4] Fisk and Alexander were at the time the Associate Administrator and Chief Scientist, respectively, of the Office of Space Science and Applications (OSSA) at NASA Headquarters.

[5] A good example is the Global Learning and Observations to Benefit the Environment (GLOBE) program, a worldwide hands-on, primary and secondary school-based science and education program. Many people credit former Vice President Al Gore with coming up with the idea, but GLOBE was actually initiated through the EOS Program.

[6] **Lisa Shaffer** described the EOS legacy contributions in international community building and partnerships in the January–February 2010 issue of *The Earth Observer* [**Volume 22, Issue 1**, pp. 7-11].

those that were proposed when the program was originally conceived[7], every single EOS mission has included significant contributions from international partners.

The only exception to this legacy of successful international community building is NASA's attempts at partnership with the European Space Agency (ESA). After the EOS A-1 platform was reconfigured to smaller platforms and the placement of the Terra satellite into a mid-morning orbit (which, under the original plan for EOS, was to be developed by ESA), we could not reestablish a partnership with the ESA. NASA identified many opportunities to pursue with ESA over the lifetime of EOS, but could not implement any of them[8].

On the other hand, the partnerships NASA developed with individual European nations (e.g., Germany, France, Netherlands, Italy, and the Russian Federation, to name a few) have been very fruitful. They have resulted in the development of many first-time capabilities that would never have materialized if pursued independently—or at the very least, would have taken a longer time to materialize due to required technologies and the significantly higher level of investments required by individual partners. These partnerships also greatly benefited the global research community at large because they enabled free and open exchange of resulting observations not only among the partners, but also with the rest of the world. Today, about 30 years since the EOS concept was first introduced, everywhere I visit in my new capacity as the Director of World Climate Research Program (WCRP) everyone talks about the ease of access and the open and unrestricted data-sharing policy and principles as a major success and legacy of the Program.

I recall the endless meetings and exchanges of letters and notes among lawyers representing our international partners in the context of the Earth Observations International Coordination Working Group (EO-ICWG) forum[9], in trying to reach some acceptable terms and conditions towards a set of unified policies and principles. We could only succeed partially with a subset of our partners in reaching such agreement; notable among the successes was Japan. The *open data* sharing principles have proved that it is in the best interest of countries and organizations involved to share the observations to enable major innovations and breakthroughs by entraining the intellectual power and vast resources of the worldwide community of experts. This, in turn, results in demonstrating the beneficial impact of public investments in the space technologies and associated capabilities which, in most cases, has resulted in greater future support for the respective programs—a win-win situation for the providers and users of such capabilities. ■

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[7] These changes came about because of the evolution in the configuration of the EOS Program, re-balancing of its priorities, and/or the changes in the priorities and interests of our international partners. **Greg Williams'** article in the March–April 2009 issue of *The Earth Observer* [**Volume 21**, **Issue 2**, pp. 4-12] details how the EOS concept evolved over a series of "re"-assessments during the 1990s, eventually emerging in the form it exists today.

[8] This was indeed a missed opportunity that was on my mind throughout my tenure at NASA. We came very close to an exciting opportunity to cooperate with ESA in addition to Japan Aerospace Agency (JAXA) in development of the Global Precipitation Measurement (GPM) constellation, but in the end, we did not succeed in retaining the ESA interest.

[9] See **Lisa Shaffer's** article (cited above) for details.

In 1994, Asrar and Jeff Dozier worked with the EOS Community to articulate a *Science Strategy for the Earth Observing System* [*back*]. That document would evolve over time, first into a *Mission to Planet Earth Science Research Plan* [*middle*], and later into a more and technical detailed *EOS Science Plan* (edited by Michael King) [*front*].

1994

1996

1999

EOS Publications

1990

1991

1993

1995

1999

2006

A series of Reference Handbooks chronicled the evolution of the EOS Program through its many reviews and assessments. The individual volumes also contained other background information on the individual elements of the program, detailed descriptions of every planned mission and instrument, information on interagency and international partnerships, and (until 1999) information on the various IDS Investigations. The latest version (2006) changed its name to *Earth Science Reference Handbook* to reflect the program's continuing evolution beyond EOS.

Let It Snow, Let It Snow…Let Us Know!

Mitchell K. Hobish, Sciential Consulting, LLC, Manhattan, MT, mkh@sciential.com

I love snow, snow,
and all the forms of
radiant frost.
—Percy Bysshe Shelley

Snow.

It's such a simple word, yet there are few among us who can just ignore it when we hear it in a weather forecast.

School kids look forward to snow with eager anticipation. More-serious adults (who may secretly look forward to at least a few hours off from work) are probably more concerned with how much will fall, and how it will affect—usually negatively—their endeavors. Those who are responsible for the efficient working of society and its infrastructure will pay close attention to what it may mean for near-term activities—such as snow removal—and for longer-term portents—such as how it will affect snowpack levels and what that may mean for recreation and useful water for agriculture, come warmer temperatures.

It's easy enough to measure how much snow is in your backyard (and its increasing depth as snow keeps falling) by sticking some kind of demarcated rod into a convenient pile of the stuff.

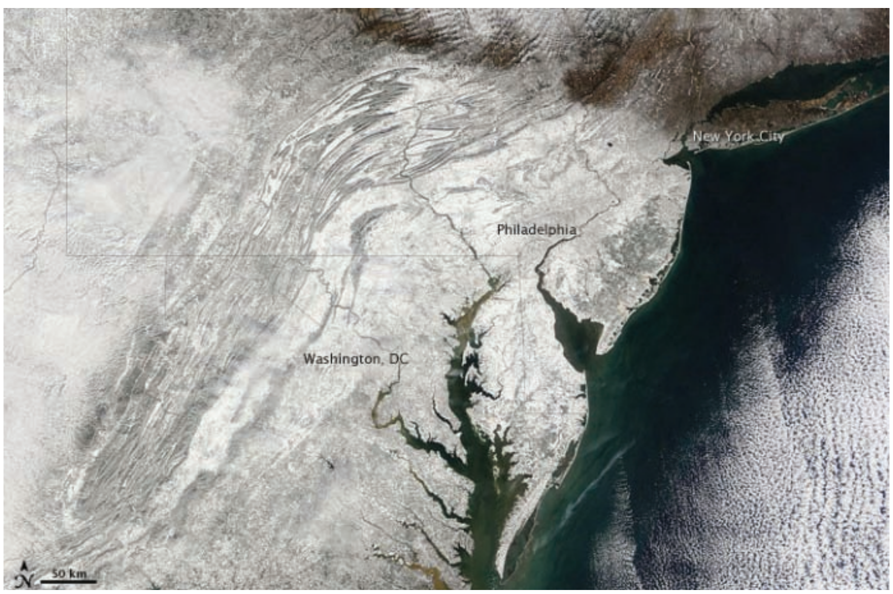


Figure 1. Terra MODIS image showing heavy snow across the Mid Atlantic region on February 7, 2010 **Image Credit:** NASA

But understanding the connection between falling snow and snow depth is not so easy, as there are several factors involved in projecting from the one to the other. Such factors include atmospheric moisture content and temperature, both of which affect the size and shapes of snowflakes. These, in turn, affect the intensity of the snowfall and how fast it accumulates.

Over the past few decades, scientists have developed techniques to use instruments in Earth orbit to provide large-scale global views of snow cover. But, as you might imagine, such a measurement is not trivial. There are some confounding components that make it challenging to accurately determine the amount of snow on the ground—both in extent and thickness. For example, distinguishing between falling precipitation (i.e., snow, rain, and sleet) and the presence of clouds can be a challenge. And then sometimes what we thought were clouds turns out to be snow on the ground. Even once we're pretty sure that what we're seeing from space is indeed snow, that doesn't mean it's easy to measure it from space. Other factors come into play: For example, is the snow in an open or forested area? Or, is the snowfall heavy or light? These, and other factors, make retrievals from satellite sensors challenging.

A Living Laboratory

The unprecedented snowfalls that occurred in the Washington, D.C. and Chesapeake Bay area in February 2010 [*see* **Figure 1**] provided an excellent opportunity to observe falling snow in conjunction with observation of the snowpack. For falling snow observations, on-orbit instrumentation was used together with newly developed algorithms designed to help distinguish and quantify the various confounding factors described above.

The February 2010 snowfalls were record-setters, approaching six feet (almost two meters) in total accumulation for the month. That ground-level temperatures consistently stayed below normal allowed month-long observations, providing ample opportunity to explore the remote sensing possibilities using passive microwave radiometers. Because of the frequencies at which passive microwave radiometers operate on several satellites, they're well suited for acquiring data on snow on the ground (i.e., snow pack) and snow in the atmosphere (i.e., as precipitation).

The February 2010 snowfalls were record-setters, approaching six feet (almost two meters) in total accumulation for the month. That ground-level temperatures consistently stayed below normal allowed month-long observations, providing ample opportunity to explore the remote sensing possibilities using passive microwave radiometers.

Three well-characterized passive scanning microwave radiometers—the Advanced Microwave Scanning Radiometer for EOS (AMSR-E), the Advanced Microwave Sounding Unit-B (AMSU-B), and the Microwave Humidity Sounder (MHS)—were used in a study undertaken by **James L. Foster** [NASA Goddard Space Flight Center (GSFC)] and **Gail Skofronick-Jackson** [GSFC]. Others who helped in this investigation include **Huan Meng** [National Oceanic and Atmospheric Administration (NOAA)/National Environmental Satellite, Data and Information Service (NESDIS)], **George Riggs** [Science Systems & Applications, Inc. (SSAI)], **Benjamin T. Johnson** [GSFC, Joint Center for Earth Systems Technology (JCET)], **James R. Wang** [GSFC, SSAI], **Dorothy K. Hall** [GSFC], and **Son V. Nghiem** [NASA/Jet Propulsion Laboratory (JPL)].

Acquiring and Reducing the Data

AMSU-B and MHS

The AMSU-B, designed to examine atmospheric water vapor in its various phases, has been orbited on several satellites, including NOAA-15, NOAA-16, and NOAA-17, all operating in sun-synchronous orbits in the range of 503–528 miles (810–849 km) altitude. By using several detection channels, AMSU-B can be used with suitable algorithmic modification, to determine levels of falling snow by e*xamining brightness temperature* (T_b)—the apparent surface temperature assuming a surface emissivity of 1.0. The MHS has been orbited on the NOAA-18 and the European Space Agency's MetOp satellites, beginning with MetOp-A. While its design is similar to that of AMSU-B, its detection channel frequencies are different; nevertheless, it is suitable for detection of falling snow.

An algorithm to determine the amount of snowfall over land [*Land Snowfall Detection* (LSD)] is routinely generated at NOAA/NESDIS. The data product is considered robust, but subject to "false alarms" owing to several confusing factors, including misclassification of snow as rainfall, and difficulties distinguishing between snow on the ground and snow in the overlying atmosphere. Such false alarms have been mitigated with a recent improvement to the LSD algorithm based on temperature and water vapor profiles at two selected pressures (700 mb and 850 mb) from Global Data Assimilation System (GDAS) data. This improved algorithm was used in the study described here.

AMSR-E

The AMSR-E is currently orbiting on the Earth Observing System (EOS) *Aqua* satellite. It provides input to algorithms designed to generate snowpack products, measured as *Snow Depth* (SD) and *Snow Water Equivalent* (SWE)—a measure of the amount of water in the snowpack. SWE is the amount of water that would result from instantly melting a given amount of snow.

Several channels on AMSR-E are sensitive to microwave scattering by snow crystals: In essence, since deeper snowpacks have more crystals than shallower packs, the upwelling microwave energy is scattered more; consequently, the T_bs are lower. Differences in T_b in specified channels provide an estimate of SD. SD is converted to SWE by gauging the density of the snowpack—it's rarely exactly known, but can be reasonably inferred.

Does It Work?

While there is significant variability in observations from AMSU-B and MHS because of interference from signals due to falling snow and surface emission in the field of view, data from these two instruments show a tight relationship with the existence and amount of falling snow—given appropriate conditions [*see* **Figure 2**]. Some constraints

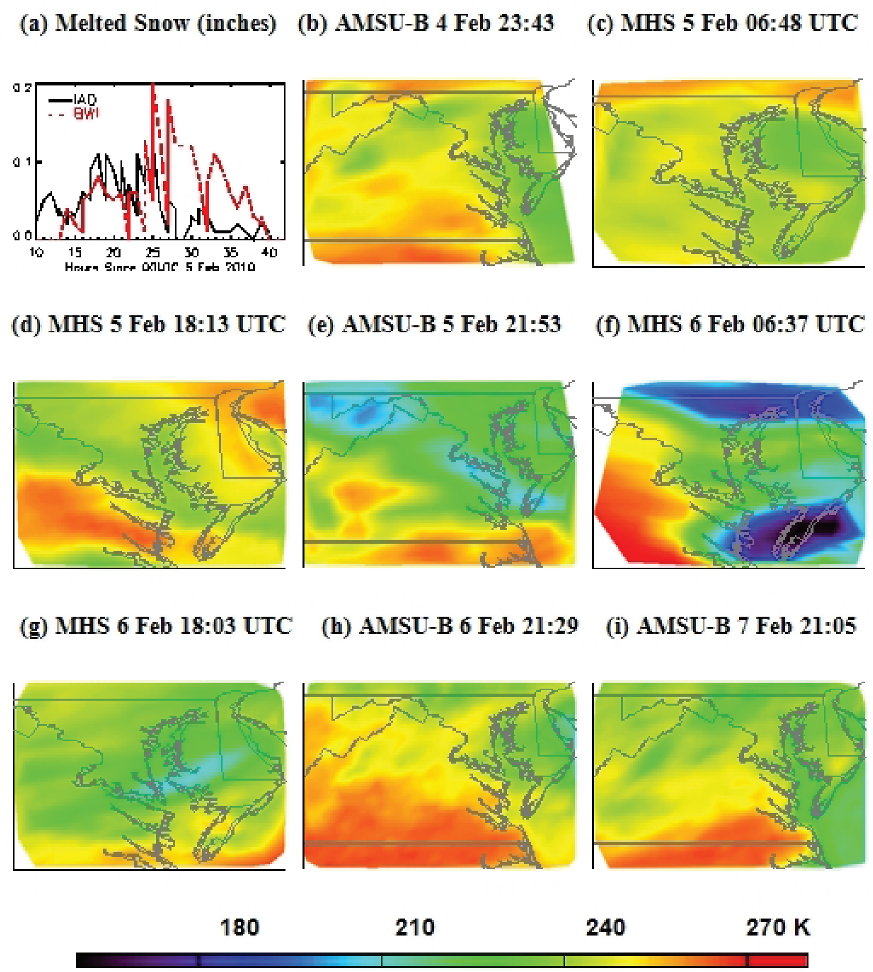


Figure 2. (a) Melted accumulation rates for the February 5-6, 2010 snow events at the Baltimore/Washington International Thurgood Marshall (BWI) and Dulles International (IAD) airports, and (b–i) AMSU-B 150 GHz time series for February 5-6, 2010 showing decreases in brightness temperature when falling snow is present. **Reminder:** The color data can be viewed at: *eospso.gsfc.nasa.gov/eos_homepage/for_scientists/earth_observer.php.*

on these conditions include clear air (where surface snow and ice can cause some difficulty), and the basic, cross-track nature of the instruments' scans.

Data for SWE were similarly strong for AMSR-E retrievals—again, under appropriate conditions, such as where snow cover is greater than about two inches (five cm), and where forest cover is minimal. The performance of the SWE algorithm is uneven because of the complexity of the snowpack, i.e., variations in crystal size and the presence of ice/melt layers within the snow. In addition, when snowfall is heavy and occurs at near-freezing temperatures, snow on the ground cannot be easily discerned.

Looking Forward

Despite the complex physiographic conditions found in the Baltimore/Washington, D.C./Chesapeake area, data combinations from AMSU-B/MHS and AMSR-E were successfully used here to detect falling snow and derive SWE. Given the number and types of constraints on such retrievals, work must be done to generate approaches that mitigate the effects of such constraints, especially under drier atmospheric conditions and widely varying precipitation signatures. Making both the falling snow and the SWE algorithms more complementary and physically based will be the thrust of future efforts.

Acknowledgments

This article summarizes the results reported in:

Foster, J.L., G. Skofronick-Jackson, *et al.*, "Remote Sensing of the Historic February 2010 Snow Storms in the Baltimore/Washington D.C. Region," *submitted to Remote Sensing of Environment* (2011)

The reader is referred here for a much more detailed discussion of this topic.

The author would also like to specifically thank **Jim Foster** and **Gail Skofronick-Jackson** for reviewing drafts of this summary article and offering helpful comments.

Other Resources

AMSU-B
www.ncdc.noaa.gov/oa/pod-guide/ncdc/docs/klm/html/c3/sec3-4.htm

MHS
goespoes.gsfc.nasa.gov/poes/instruments/mhs.html

AMSR-E
goespoes.gsfc.nasa.gov/poes/instruments/mhs.html

February 7, 2010 Terra MODIS image of snow storms
earthobservatory.nasa.gov/IOTD/view.php?id=42568

SNOTEL Snow Water Equivalent Products
www.wcc.nrcs.usda.gov/snow/snotel-wereports.html

Snow Water Equivalent (SWE) Field Measurements
nsidc.org/data/swe/

NOAA Snow Depth
www.nasa.gov/audience/foreducators/son/winter/snow_ice/stations/F_Snow_and_Ice_WS_NOAA_Snow_Depth.html ■

O beauteous Earth!
fantastic groves,

With glittering towers
and white alcoves,

And miracles of
splendor glow,

In bold relief, of
spotless snow.

–O.M. Livingston

NASA Supports UNESCO Kickoff for International Year of Chemistry

Jack Kaye, NASA Headquarters, jack.kaye@nasa.gov
Winnie Humberson, NASA Goddard Space Flight Center, winnie.h.humberson@nasa.gov

Introduction

On January 27–28, 2011, representatives from NASA's Earth Observing System Project Science Office (EOSPSO) and Science Mission Directorate attended the International Year of Chemistry (IYC) kickoff ceremony held at the United Nations Educational, Scientific and Cultural Organization (UNESCO) headquarters in Paris, France.

NASA was invited to join in the celebration as a result of its long-standing effort to advance our understanding of Earth's atmospheric chemistry. NASA's satellite and aircraft missions are integral in investigating and monitoring the composition and chemistry of Earth's atmosphere.

IYC aims to celebrate the *"achievements of chemistry and its contributions to the well-being of humankind."* The Year's ultimate goals are to "*increase the public appreciation of chemistry in meeting world needs, to encourage an interest in chemistry among young people, and to generate enthusiasm for the creative future of chemistry.*" Under the theme, "*Chemistry—our life, our future*," the IYC celebration included lectures, exhibits, hands-on experiments, and other activities.

NASA was invited to join in the celebration as a result of its long-standing effort to advance our understanding of Earth's atmospheric chemistry. NASA's satellite and aircraft missions are integral in investigating and monitoring the composition and chemistry of Earth's atmosphere. The unparelleled insight they provide through studies of air quality, clouds, aerosols, and ozone is critical to understanding Earth's changing climate.

More than 800 participants from the international community were involved in the event. Many of the plenary talks focused on the role of chemistry in global change, and how industry can respond to this change through energy production, materials, and agriculture. Notable presentations included an introductory talk by **Yuan Lee** [International Council of Science—*President-Elect*] and a plenary talk by **Rajendra Pauchari** [Intergovernmental Panel on Climate Change—*Chair*].

The hyperwall is capable of displaying one large visualization [*left*], or individual ones, such as the nine shown here [*right*].

Hyperwall

Attendees were intrigued by NASA's hyperwall, a 3 x 3 display consisting of nine 42" plasma screens that ran for both days of the meeting. The hyperwall demonstrated how NASA uses remote sensing to measure and examine chemical components of the atmosphere. With its visualizations running almost continuously and its location outside the main meeting hall, the exhibit attracted many visitors. Several of the visualizations featured atmospheric chemistry data sets, such as ozone, aerosols, nitrogen dioxide (NO_2), and carbon monoxide (CO). The hyperwall also displayed visualizations relevant to the region such as British Isles snow cover from the recent record cold winter and the Eyjafjallajökull volcanic eruption in Iceland.

Jack Kaye [NASA Headquarters (HQ)—*Earth Science Division Associate Director*], **Mark Malanoski** [NASA Goddard Space Flight Center (GSFC)—*Senior Technical Specialist*], and **Eric Sokolowsky** [GSFC—*Visual Programmer*] staffed the exhibit. Kaye provided a "narrated guided tour" of the visualizations at the start of lunch on January 28 that was well attended. Over the two days, several individuals representing meetings planned in Europe next fall expressed interest in having NASA bring the hyperwall to their events.

Meeting with UNESCO

While in Paris, Kaye met with representatives from UNESCO to discuss future NASA–UNESCO collaborations. The meeting included UNESCO's **Gretchen Kalonji** [*Assistant General Director for Natural Science*], **Robert Missotten** [*Chief, Global Earth Observation Section*], **Albert Fischer** [*Program Specialist, Intergovernmental Oceanographic Commission*], and **Anne Candau** [*Office Coordinator*].

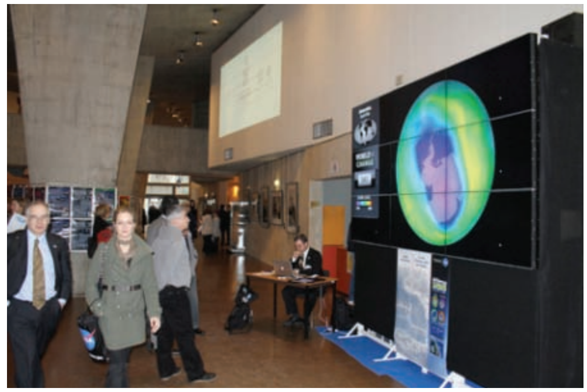
NASA frequently provides content for UNESCO's exhibits, having built particularly strong connections in the fields of hydrology and oceanography. This relationship is mainly a product of the work by long-standing Principal Investigator **Soroosh Sorooshian** [University of California Irvine—*Distinguished Professor*], **Jared Entin** [HQ—*Program Manager for Terrestrial Hydrology*], **David Toll** [GSFC—*Deputy Program Manager, Water Resources, Hydrological Sciences*], and **Eric Lindstrom** [HQ—*Oceanography Program Scientist*].

The meeting explored increased NASA–UNESCO partnerships in different areas—e.g., education and outreach activities. UNESCO has access to much of the world, especially developing countries, and NASA could utilize this to advance its international communications. NASA has the content and tools that are of value to UNESCO, and the ability to demonstrate these with exhibits, visualizations, and speakers. There are potential benefits for both agencies and a clear outline and goals will help map out future collaborations.

Conclusion

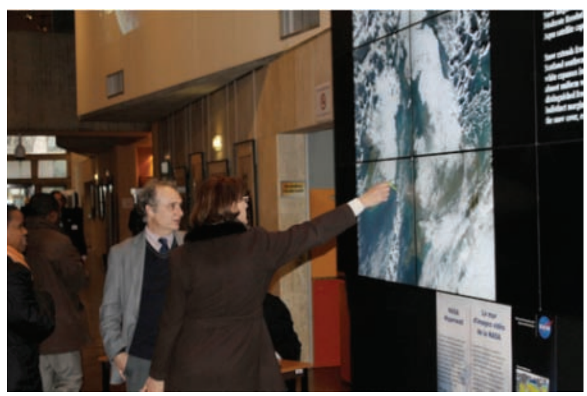
NASA's support to the IYC Kickoff at UNESCO was an effort well spent. The hyperwall was very popular; the visualizations communicated some of NASA's involvement in chemistry-related studies. The success of the event draws on the previous relationships developed by **Winnie Humberson** [GSFC—*Task Lead, EOSPSO*] and the EOSPSO.[1] NASA is working with the American Chemical Society (ACS) to identify potential opportunities for which NASA may contribute to IYC in the U.S.

More information on IYC is available at: *www.chemistry2011.org/*. ■



The NASA hyperwall projects a visualization of Earth's ozone hole.

A visitor reads about how NASA remote sensing was used in the study of the Icelandic volcano eruption.



Jack Kaye and a meeting attendee discuss snow cover from a record winter in the British Isles.

A crowd gathers for Kaye's narrated "tour" of the visualizations.

[1] Read about the EOSPSO's support to the UNESCO Kickoff for the International Year of Planet Earth in the May-June 2008 [**Volume 20, Issue 3,** pp. 19-20] issue of *The Earth Observer*.

The Evolution of the ESIP Federation

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

The ESIP Federation was formed in 1998 in response to a National Research Council recommendation calling for the involvement of community stakeholders in the development of NASA's EOSDIS as a critical element of the U.S. Global Change Research Program.

From NASA Mandate to Vibrant Multi-Agency Forum—A Brief History

The Federation of Earth Science Information Partners (ESIP Federation) is a broad-based community comprising researchers and associated groups that produce, interpret, and develop applications for Earth and environmental science data. The ESIP Federation was formed in 1998 in response to a National Research Council recommendation calling for the involvement of community stakeholders in the development of NASA's EOSDIS as a critical element of the U.S. Global Change Research Program. It now includes 127 member organizations, including all National Oceanic and Atmospheric Administration (NOAA), NASA, and U.S. Geological Survey (USGS) Earth observing data centers, government research laboratories, research universities, education resource providers, technology developers, and various nonprofit and commercial enterprises. The work of the ESIP Federation is facilitated and managed by the Foundation for Earth Science (Foundation), created in 2001 to serve as the secretariat for the ESIP Federation.

The ESIP Federation partners span the value chain of Earth science data and technology interests. Within the ESIP Federation, partners are classified as being *Type I* partners (data centers), *Type II* partners (researchers), *Type III* partners (application developers), and *Type IV* partners (sponsors). While the ESIP Type designations largely are vestigial labels, they accurately describe the breadth and functions of organizations that comprise the community.

The ESIP Federation has evolved from its NASA-seeded roots into a dynamic, multi-agency forum for Earth science data and technology collaboration. NASA continues to support the ESIP Federation and actively participates in the broad-based forum to evolve best practices, standards, and projects that benefit the community of Earth science data providers, researchers, and applications developers.

Volunteer Leaders

The ESIP Federation is run by volunteers, who each year are elected from partner organizations. The current leadership, elected in January 2011, consists of:

Officers

- *President* – **Chris Lenhardt**, Oak Ridge National Laboratory DAAC
- *Vice President* – **Karl Benedict**, Earth Data Analysis Center, University of New Mexico
- *Type I ESIP Representative* – **Nettie Labelle-Hamer**, Alaska Satellite Facility, University of Alaska, Fairbanks
- *Type II ESIP Representative* – **Brian Wilson**, Jet Propulsion Laboratory
- *Type III ESIP Representative* – **Stefan Falke**, Northrop Grumman Corporation

Committee Chairs

- *Constitution and Bylaws* – **Rob Raskin**, Jet Propulsion Laboratory
- *Education* – **Bruce Caron**, The New Media Studio
- *Finance and Appropriations* – **Charles Hutchinson**, University of Arizona
- *Information Technology and Interoperability* – **Rahul Ramachandran**, Oak Ridge National Laboratory
- *Partnership* – **Annette Schloss**, University of New Hampshire
- *Products and Services* – **Ken Keiser**, University of Alabama in Huntsville

Where the Real Work is Done—Working Groups and Clusters

The ESIP Federation, now in its second decade, continues its evolution to make important connections between, across, and among organizations that provide, analyze, and use Earth science data and associated technologies. Often hidden from the outside world, the ESIP Federation is working toward improving access, usability, and understanding of Earth science data. Through ongoing committee and *ad hoc* activities, the community is tackling difficult problems associated with complex and large data sets. Highlighted below are some of the active collaboration topics that are ongoing through ESIP Federation working groups and clusters:

Working Groups

- *Air Quality* – The overarching objective of this working group is to build better connections, both technical and interpersonal, between and among air quality data providers and data users. Recent efforts have been focused on building an air quality community data and information system.
- *Climate Change Education* – This working group seeks to foster connections between educators, educational product developers, and scientists who are concerned about climate change education. Resource review, outreach, and regional educational program development are key activities.

Clusters

- *Data and Information Quality* – This is a new cluster whose objective is to bring together people from various disciplines to assess aspects of quality for remote sensing data. The cluster will identify and share best practices with a goal to build a framework for consistent capture, harmonization, and presentation of data quality in support of climate change studies, Earth science, and applications.
- *Data Preservation and Stewardship* – The objective of this cluster is to support the long-term preservation of Earth system science data and information. The hope is to provide a forum for ESIP members to collaborate on data preservation issues.
- *Discovery* – This cluster was formed to address interoperability and standards issues related to data discovery. The objective is to enable data centers to agree on an open and interoperable discovery standard.
- *Energy* – The objective of this cluster is to facilitate interactions and build better connections, both technical and interpersonal, among policy and decision makers, climate change and energy data providers, decision support tool providers, and end users.
- *Environmental Decision Making* – Earth Science data and research can play an important role in informing decision making activities and applications in the commercial and public sectors. One of the main priorities of this cluster is to support ESIP member evaluation activities and assessments concerning the value of Earth Science data.
- *Semantic Web* – The objective of this cluster is to facilitate application areas of ESIP using semantic web methodologies and technologies. It provides a forum for dissemination of best practices, technical infusion experience and lessons learned, and continuing education for emerging semantic technologies. The cluster also plays a governance role in the development of community vocabularies and ontologies relevant to ESIP members.

ESIP Federation Fast Facts

- 127 partner organizations
- 700+ active contributors
- 12+ active community collaborations (committees, working groups, and clusters)
- Multi-agency involvement (e.g., NASA, National Oceanic and Atmospheric Administration (NOAA), Environmental Protection Agency (EPA), U.S. Geological Survey, National Science Foundation)
- NASA, NOAA, and EPA sponsored

To learn more about the Federation, check us out on the web at: *www.esipfed.org.*

Within each of these areas, individuals from partner organizations contribute their expertise on important issues. Each subgroup sets its own agenda, based on community input and need. Consensus processes are followed and the collective wisdom of expert practitioners results in different types of outputs. The end results of these efforts might include workshops, best practices, technical papers, standards recommendations, and actual technology development. The grassroots nature of the ESIP Federation allows the community to solve timely and relevant problems that challenge many of our partner organizations and the community as a whole.

In the process of collaboration, the community shares its expertise and emerging technology assets. Increasingly, the ESIP Federation is being looked at as a forum for professional development, identifying project collaborators, and general networking.

Mark Your Calendar for the ESIP Federation Summer Meeting

The ESIP Federation will hold its summer meeting, July 12-15, 2011 in Santa Fe, NM. The summer meeting will focus on Data and Information Quality, and will be a technical meeting. Visit our website to learn more about the meeting at: *esipfed.org/meetings*.

Add Your Voice

The ESIP Federation invites other organizations to participate in the dialogue on important issues facing the Earth science data and technology community. To see what is current, visit the organization's wiki (*wiki.esipfed.org*) to view if there is something of interest to you. You can request to join any of the listservs from the wiki or simply dial into one of our many conference calls to learn about what is happening. You are invited to help us in *Making Data Matter*.

ESIP Federation Partners Elect Seven New Partners

At its winter meeting on January 5, 2011 in Washington, DC, the ESIP Federation elected seven new member organizations, bringing total membership to 127 organizations. (The seven new members are listed below.)

ESIP Federation membership is strictly voluntary and the continued growth of its membership reflects the recognition that the ESIP Federation is a dynamic and collaborative forum where data providers, researchers, and users gather to exchange valuable information. According to Chris Lenhardt, ESIP Federation President, *"The steady growth of our membership during the past decade and the growing interest in partnering with the ESIP Federation is a sign that the organization is not only healthy but relevant to the Earth science information community. The ESIP Federation is member-driven and is agile in responding to new trends and ideas in the data and information field. Its ability to do so has allowed it to be the venue where Earth science information professionals gather."*

The new member organizations include:

- *Center for Spatial Analysis, University of Oklahoma*—**Xiangming Xiao**, Professor
- *City of Chicago*—Peter Mulvaney, Sustainable Infrastructure Director
- *DataONE (University of New Mexico)*—**William Michener**, Professor and Director of E-science Initiatives at UNM Libraries
- *Information Technology and Systems Center* (ITSC)—**Sara Graves**, Director
- *National Earth Science Teachers Association* (NESTA)—**Roberta Johnson**, Executive Director
- *National Ecological Observatory Network* (NEON)—**Brian Wee**, Chief of External Affairs
- *USA National Phenology Network* (USA-NPN)—**Alyssa Rosemartin**, Information Technology Coordinator

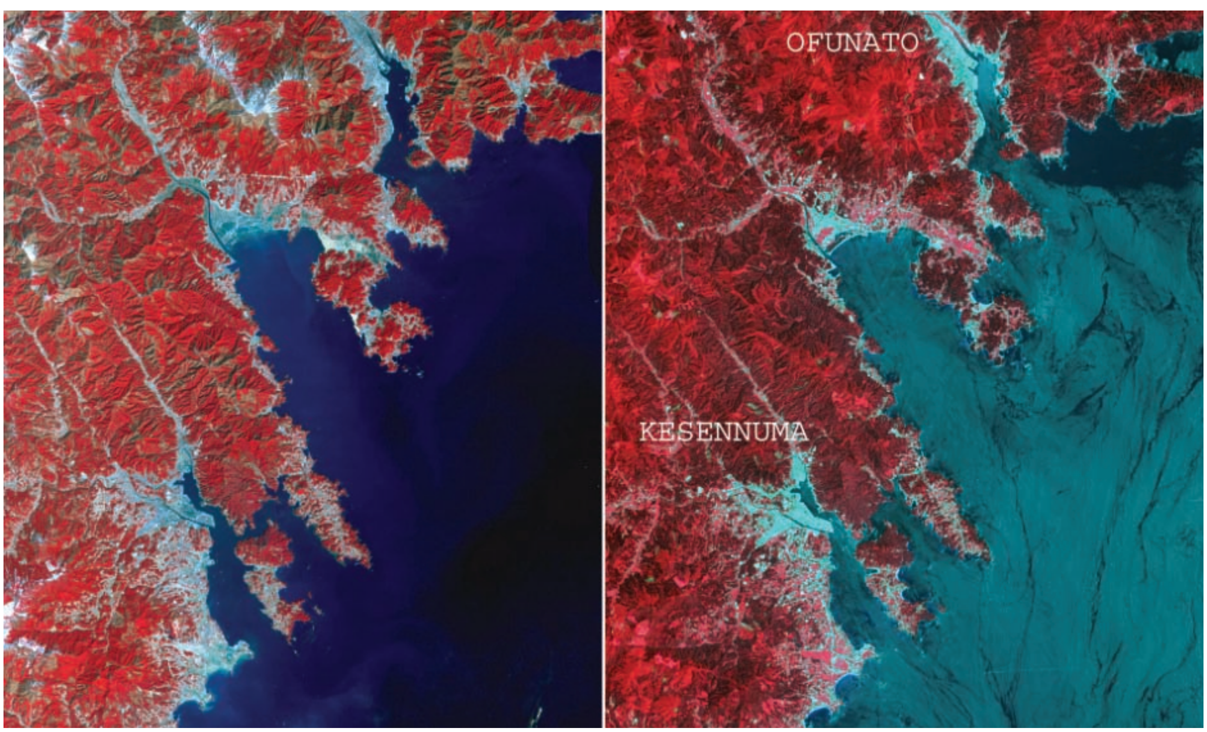
For more information about joining the ESIP Federation, visit the Partnership section of the wiki at: *wiki.esipfed.org/index.php/Partnership*. ■

John Townshend Receives the Martha Maiden Award for Lifetime Achievement for Service to the Earth Science Information Community

During the Winter 2011 ESIP Federation meeting, the Martha Maiden Award for Lifetime Achievement for Service to the Earth Science Information Community was presented to **John Townshend**, Dean of the College of Behavioral and Social Sciences, University of Maryland, College Park (UMCP). Townshend was the first President of the ESIP Federation and held many other positions during its formative years. His Global Land Cover Facility at UMCP vastly increased the availability of terrestrial remote sensing data to all.

John Townshend and Martha Maiden
Photo Credit: Dave Jones

Created in 2008 in honor of **Martha Maiden's** leadership, dedication, and tireless efforts to nurture the ESIP Federation, the award recognizes outstanding service to the Earth Science information community. This award honors individuals who have demonstrated leadership, dedication, and a collaborative spirit in advancing the field of Earth Science information. In accepting the award, Townshend noted that the ESIP Federation is a *"focused activity on the intersection between environmental science and applications and information technology,"* while *"mixing many different types of people and organizations—research, operational, non-profit and commercial entities—each bringing its special contributions, believing that making data freely available is the best way to help science progress and for commercial activities to take wing."* The vision that Townshend and others put forth for the ESIP Federation continues to be shaped, and the community takes great pleasure in recognizing these important contributions, both past and present.



On March 14, 2011, the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) instrument on NASA's Terra spacecraft captured an image [*left*] of the northeastern Japan coastal cities of Ofunato and Kesennuma, about 55 mi (90 km) northeast of Sendai. This region was significantly affected by the tsunami that followed the March 11, 2011, magnitude 9.0 earthquake that was centered offshore about 80 mi (130 m) east of Sendai. The image [*right*] was acquired in August 2008. This before-and-after image pair reveals changes to the landscape that are likely due to the effects of the tsunami. Areas covered by vegetation are indicated by the darkest shades, while cities and unvegetated areas are shown in the lightest shades. When compared closely, the March 14th image shows that vegetation is no longer present in many coastal areas, particularly around Kesennuma. **Credit:** NASA/GSFC/METI/ERSDAC/JAROS, and U.S./Japan ASTER Science Team

NASA DEVELOP Students at the Mobile County Health Department Utilize Earth Observations to Address Public Health Issues in the Gulf Coast Region

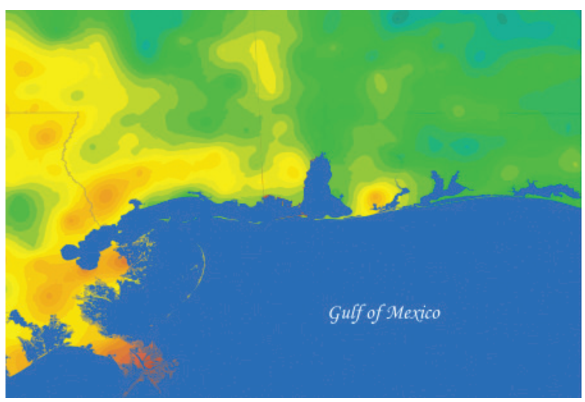
Josh Stodghill, DEVELOP National Program, Mobile County Health Department, jdstodghill@msn.com
Alyson Cederholm, DEVELOP National Program, Mobile County Health Department, alyson.cederholm@gmail.com

DEVELOP is part of NASA's Earth Science Division Applied Sciences Program, and began in 1998 with three students at NASA Langley Research Center. From those humble beginnings, DEVELOP has expanded to ten locations in the U.S. and Mexico, providing internship opportunities to approximately 200 students per year.

Introduction

Since 2003, through a unique partnership between the NASA DEVELOP National Program and the Mobile County Health Department (MCHD), students in Mobile, AL have been able to serve the Gulf Coast community while learning about Earth science and NASA technology. DEVELOP is part of NASA's Earth Science Division Applied Sciences Program[1], and began in 1998 with three students at NASA Langley Research Center. From those humble beginnings, DEVELOP has expanded to ten locations in the U.S. and Mexico, providing internship opportunities to approximately 200 students per year. The DEVELOP office in Mobile accepted its first students in the fall of 2003 thanks to the support of **Bernard Eichold II** [MCHD—*Health Officer*]. Eichold first learned about the DEVELOP Program at the Southern Growth Policies Board Annual Conference in 2002. There, DEVELOP students presented research project results that utilized NASA Earth observations to address local community concerns for enhanced decision support. This interaction sparked Eichold to partner with DEVELOP and establish an office for students in the Mobile County Health Department.

Since the formation of the DEVELOP team in Mobile, Eichold has challenged the students to serve society by investigating public health concerns through the lens of the NASA Earth Observing System (EOS). DEVELOP students in Mobile have conducted multiple cross-disciplinary projects featuring the use of EOS data to investigate the impacts of air quality, water quality, weather, and land use/land cover on public health in the Gulf Coast region. These projects have partnered with Gulf Coast region organizations to extend the user community of NASA Earth science research and technology, while providing students scientific research experience.



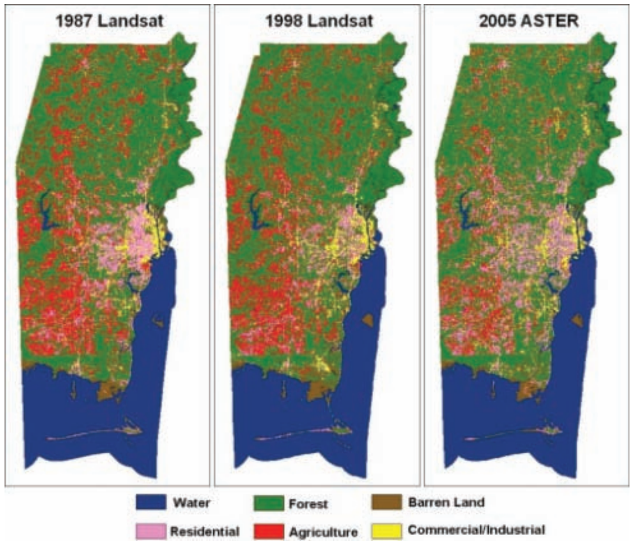
This image, taken on October 1, 2004, by the Ozone Monitoring Instrument (OMI) on the Aura satellite shows ozone levels along the northern coast of the Gulf of Mexico, with Mobile Bay in the center of the image. Lighter shades represent areas of higher ozone levels, which transition to darker shades representing lower ozone measurements.

Air Quality Research

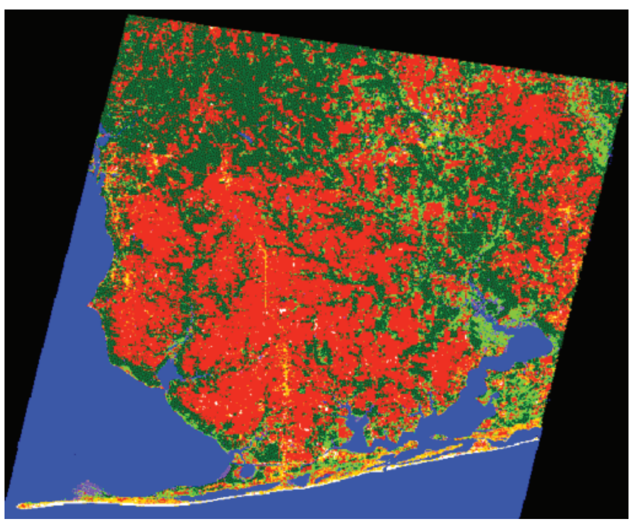
The Mobile DEVELOP team has conducted multiple research projects investigating the application of NASA Earth observations to public health concerns in the region. Poor air quality poses a threat to the health of Gulf communities, making it a major concern for the Mobile team. Partnering with the South Alabama Regional Plan-

[1] To read more about the DEVELOP Program, please see *The Earth Observer's* March-April 2010 issue [**Volume 22, Issue 2,** pp. 7-9], May-June 2010 issue [**Volume 22, Issue 3,** pp. 11-13], July-August 2010 issue [**Volume 22, Issue 4,** pp. 10-12], September-October 2010 issue [**Volume 22, Issue 5,** pp. 10-12], November-December 2010 issue [**Volume 22, Issue 6,** pp. 14-19], and January-February 2011 issue [**Volume 23, Issue 1,** pp. 4-7].

ning Commission (SARPC), the Mobile DEVELOP team conducted three air quality projects between 2004 and 2008. The first project employed air quality data from the Ozone Monitoring Instrument (OMI), aboard the Aura satellite, to investigate the effects of tropospheric ozone on public health by comparing Mobile County hospital emergency respiratory illness records to OMI-derived tropospheric ozone data.



Surface-type classifications for Mobile County, AL. Landsat imagery is from April 24, 1987 and April 6, 1998, and ASTER image is from April 17, 2005. Students investigated correlations by utilizing this time series to compare to changes in air quality measurements.

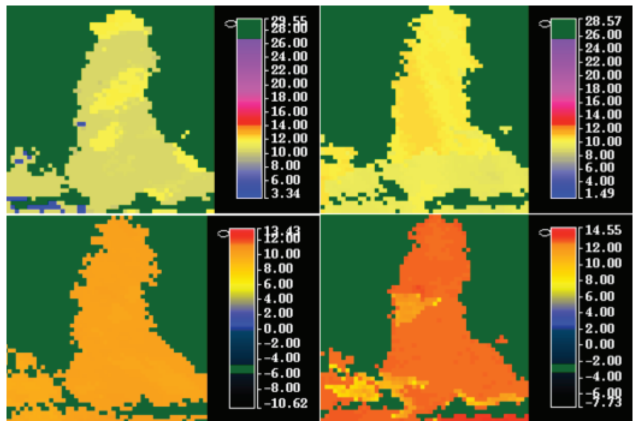


An ASTER image showing land-use/land-cover classifications for Baldwin County, AL from October 11, 2006, that they used to investigate the relationship between urbanization and air quality.

The second project investigated the effects of urbanization on ground-level ozone within Mobile County. The students utilized the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) on the Terra satellite and the Thematic Mapper (TM) instrument on the Landsat 4 and 5 satellites to create current and historical land use/land cover maps of Mobile County. These classifications were compared to historical ground-level ozone readings from the Environmental Protection Agency (EPA) to demonstrate how urbanization and ground-level ozone correlate. Additionally, the SARPC requested that a parallel study be performed for neighboring Baldwin County; consequently, a third project was conducted using ASTER and Landsat TM data to investigate urban sprawl and its impact on air quality in the county. The results of these projects were used by the SARPC to support policy decision making in southern Alabama, as well as to provide opportunities for further education and student development.

Water Quality Research

Mobile Bay is the fourth largest estuary in the U.S., making water resource management extremely important to the region, as well as water quality and its potential impact on public health. From 2005–2008, DEVELOP students partnered with the MCHD to explore new ways of applying NASA Earth observation data to monitor water quality in Mobile Bay with the intention of learning how other environmental factors might impact fecal coliform levels. Mobile Bay oyster and shellfish fisheries are closed due to an increased risk to public health when high fecal coliform levels are detected. Additionally, current *in situ* monitoring methods for water quality in the bay are costly and time-consuming. The Mobile DEVELOP team investigated remote sensing capabilities to enhance monitoring capacity and improve the decision-making process relating to shellfish bed closures. In the spring 2005 term, students investigated correlations between bacteria levels and turbidity in Mobile Bay. This study initiated further research into other environmental indicators of bacteria levels in Mobile Bay, such as sea surface temperature, river stage, and sea surface salinity. Students utilized the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument aboard the Aqua and Terra satellites to gather data on the sea surface temperature product. SeaStar's SeaWIFS photosynthetically active radiation product and *in situ* data from the Naval Research Laboratory were also used. These data were uploaded into the Sea-viewing Wide Field-of-view Sensor (SeaWIFS) Data Analysis System (SeaDAS) to generate geospatial visualizations of predicted fecal coliform levels within Mobile Bay. The predictive models were found to be moderately accurate when compared to *in situ* data. Students presented these project results to the MCHD, scientists at the Dauphin Island Sea Lab, and local community leaders.



Estimated fecal coliform levels in Mobile Bay, AL produced by the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) Data Analysis System (SeaDAS) from: December 9, 2008 [*upper left*]; December 17, 2008 [*upper right*]; December 15, 2008 [*lower left*]; and January 22, 2009 [*lower right*].

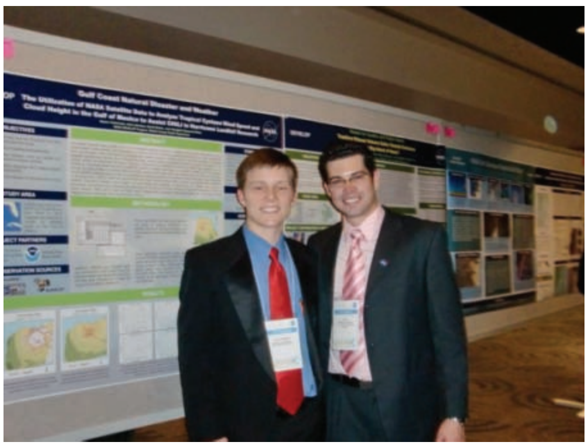
Vector-borne Disease Research

Mobile DEVELOP students have employed various geospatial data to assess the effects of weather, land use, and vegetation on *vectors* that carry West Nile Virus and Eastern Equine Encephalitis. In 2007, the DEVELOP team partnered with the MCHD Department of Vector Control (DVC) to examine the possible correlation between rainfall events and local mosquito populations. The DVC established light traps in three locations across Mobile County to collect mosquito samples. Rainfall data from NASA's Tropical Rainfall Measuring Mission (TRMM) satellite were complemented by *in situ* measuring from privately operated weather stations near the trap sites to correlate daily rainfall totals with the mosquito population counts. Although this study found no significant correlation between rainfall and mosquito populations, the DVC requested that additional satellite imagery be utilized to assist in the identification of likely mosquito habitats. To continue this project, the Spring 2011 DEVELOP team is conducting a project that will employ NASA remote sensing data to locate potential mosquito breeding grounds within Mobile County. These students expect to utilize land classifications from ASTER and Landsat imagery, elevation data from the Shuttle Radar Topography Mission, and soil moisture data from the Advanced Microwave Scanning Radiometer - EOS (AMSR-E), to assess likely mosquito breeding sites. DEVELOP students will also use complementary Health Department and Census Bureau *in situ* data to assist the Department of Vector Control by delivering vector-borne disease risk maps for Mobile County.

Conclusion

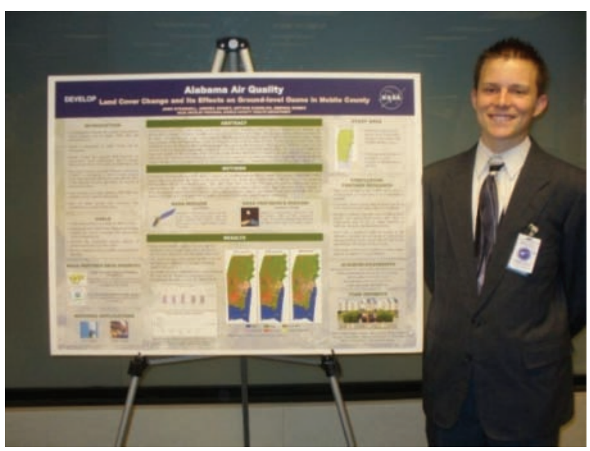
Being located in the Mobile County Health Department, the Mobile DEVELOP students are afforded a unique opportunity that gives them a distinct perspective on public health issues in the Gulf Coast region. Combining remote sensing data and geographic information systems (GIS) to address public health concerns is challenging and provides students with a variety of learning experiences. Projects, such as those described above, have given nearly 50 students in the Mobile region the opportunity to learn about and work with NASA science data and capabilities. Through their participation, MCHD DEVELOP students gain hands-on experience that furthers their education and strengthens their skill set to equip them with skills they can use in their future careers. In turn, the students are directly giving back to their community by establishing partnerships and demonstrating the use of NASA Earth science data. The MCHD and DEVELOP Program partnership is a successful reminder of what can be accomplished when the passion and enthusiasm of students is backed by NASA science, partner mentorship, and community involvement.

For more information on the NASA DEVELOP Program, visit: *develop.larc.nasa.gov/*.



Josh Stodghill, MCHD DEVELOP Center Lead [*left*], and **Steve Padgett-Vasquez**, Marshall Space Flight Center DEVELOP Center Lead [*right*], present project results at the International A-Train Symposium in New Orleans, LA in October 2010.

MCHD DEVELOP team member **Alyson Cederholm** represents the DEVELOP National Program at the American Meteorological Society Annual Conference in Seattle, WA in January 2011, where she presented project results.



Current MCHD DEVELOP Center Lead **Josh Stodghill** presents the team's Alabama Air Quality project at NASA Headquarters at the 2009 Summer Close Out presentation.

Ocean Surface Topography Science Team Meeting

Josh Willis, Jason-1 Deputy Project Scientist, NASA Jet Propulsion Laboratory, joshua.k.willis@jpl.nasa.gov
Rosemary Morrow, Project Scientist, Laboratoire d'Etudes en Géophysique et Océanographie Spatiale, rosemary.morrow@legos.obs-mip.fr

Introduction

The 2010 Ocean Surface Topography Science Team (OSTST) meeting was held in Lisbon, Portugal. The meeting was the central part of a 10-day program of altimetry workshops, starting with the Coastal Altimetry Workshop in Porto, Portugal on October 14–15, followed by three events at the Lisbon International Fair that included the Ocean Surface Topography Science Team (OSTST) meeting, and two workshops that took place on October 21–22: an altimetry workshop entitled *Towards High-Resolution of Ocean Dynamics and Terrestrial Surface Waters from Space*, and in parallel, the *International Doppler Orbitography and Radiopositioning Integrated by Satellite (DORIS) Service (IDS)* workshop.

The primary objectives of the OSTST meeting were to:

- provide updates on the status of Jason-1 and Ocean Surface Topography Mission OSTM/Jason-2 (hereafter Jason-2);
- review the progress of science research;
- conduct splinter meetings on the various corrections and altimetry data products;
- discuss the science requirements for future altimetry missions; and
- make recommendations on the choice of orbit for the end-of-life period for Jason-1, and for the Jason-CS (continuation of service) series of altimeters.

The full OSTST report, along with all the presentations from the plenary, splinter, and poster sessions, are available on the AVISO website: *www.aviso.oceanobs.com/oststl*.

Program and Mission Status

Lionel Suchet [CNES] and **François Parisot** [EUMETSAT] opened the meeting and welcomed the participants. They noted the long international co-operation of the OSTST group, its work in maintaining precise sea level observations for scientific and operational applications, and the extension of the Memorandum of Understanding (MOU) that now includes four-partner agencies—NASA, the Centre National d'Études Spatiales (CNES), the National Oceanic and Atmospheric Administration (NOAA), and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT). They also introduced the celebrations for the 20th anniversary of the DORIS measurements, which were the focus of the IDS meeting discussions. **Rosemary Morrow** [Laboratoire d'Etudes en Géophysique et Océanographie Spatiale (LEGOS)] and **Sophie Coutin–Faye** [CNES] presented the meeting overview and meeting logistics.

Lionel Suchet [CNES] introduced the program managers who spoke on the status of altimetry and oceanography programs at NASA, CNES, EUMETSAT, NOAA, and the European Space Agency (ESA).

Peter Hacker [NASA Headquarters (HQ)—*Oceanography Program Scientist*] represented Eric Lindstrom and spoke about the NASA program status. Amongst the NASA altimetry program events, the Surface Water Ocean Topography (SWOT) mission partnership has now been established between NASA and CNES, with an expected launch date in 2019. The four-party MOU has been signed by NASA, NOAA, CNES, and EUMETSAT for the upcoming Jason-3 mission, with an expected launch date in June 2014. The Jason-CS orbit and the Jason-1 end-of-life orbit requirements are to be discussed at the current OSTST meeting in Lisbon. The call to construct the new OST Science Team for the next four years will likely appear in NASA's 2011 ROSES solicitation.

Eric Thouvenot [CNES—*Ocean Program Manager*] reported on the CNES altimetry program, with a focus on the operational altimetry outcome, with CNES/Service d'Altimetrie et Localisation Precise (SALP) supporting the Jason-1, Jason-2 series, and preparing for the future Satellite with ARgos and ALtika (SARAL)/Altika, Jason-3, Jason-CS, and SWOT. CNES also contributes DORIS and data processing for the ESA altimeters on the Earth Research Satellite (ERS-2), ENVISAT, and Sentinel-3, and for the future HY-2A (with the Chinese Space Agency). In addition, support is given to operational oceanography groups, such as Coriolis and Mercator. Thouvenot noted that SARAL/AltiKa is tentatively scheduled for launch in mid 2011. The CNES payload module is ready and waiting for the delivery of the Indian Space Research Organization (ISRO) platform. In other supporting work, the Principal Investigator (PI) selection process has been completed; 64 teams were selected; and the calibration/validation (cal/val) plan and science plan are being drafted. An international workshop is planned in 2011 in India, to be confirmed by ISRO.

François Parisot [EUMETSAT] and **Stan Wilson** [NOAA] discussed their respective organizations' involvement in altimetry programs with a focus on Jason-3 and its potential follow-on, Jason-CS. For Jason-3, the four-agency partnership is the same as for Jason-2, but with NOAA and EUMETSAT—the operational agencies—taking the lead. The planned early 2014 launch is to allow for at least a six-month overlap with Jason-2. After Jason-3, the Continuity of Service program (Jason-CS) will be the follow-on reference mission, spanning a 15- to 20-year period, but with a new satellite bus based on the ESA Cryosat-2 platform. The choice of altimeter may be changed to take into account the most recent technology, and the choice of orbit also needs to be decided. The scientific requirements for the orbit will be discussed during the OSTST in Lisbon; the final decision will be made by the agencies in early 2011.

Jerome Benveniste [ESA] gave a presentation on the status of ESA missions. The Gravity field and steady-state Ocean Circulation Explorer (GOCE) was successfully launched in March 2009, and is working well. First science assessment shows good results; three gravity field solutions are already available on the ESA website, and a user toolbox is also available (see: *earth.esa.int/goce*). Cryosat was launched in April 2010. The priority is to provide data over the cryosphere, but early results from the Synthetic Aperture Radar (SAR) Altimeter Ocean Retracker are promising; data may be available to users in early 2011. A validation workshop for Cryosat data will be held at the ESA Center for Earth Observation (ESRIN) in Frascati, Italy, February 1-3, 2011. The Soil Moisture and Ocean Salinity (SMOS) mission was launched in November 2009. Preliminary results of ocean salinity show an accuracy of 0.5 practical salinity units [psu] at 25 km resolution, although the validation phase is still ongoing.

ENVISAT, now eight-years old, will enter a new orbit in October 2010, and has been financed for a further three years. The new orbit will be at 30-day repeat, with a slowly drifting inclination. First data products on the new orbit will be available from early November, with validated products available in January 2011. Sentinel-3 is under development. ESA has started the "Climate Change Initiative" in response to requirements set out by the Global Climate Observing System reports. One of the essential variables to be monitored is sea level change, for which the altimetry component is essential. A brief outline of this is presented in the full OSTST report referenced above.

Current Altimetry Missions

Thierry Guinle [CNES] provided an overview of Jason-2 status. The Ocean Surface Topography Mission on Jason-2 (OSTM/Jason-2) was launched in June 2008 on the former ground track of Jason-1 and TOPEX/Poseidon (T/P). All systems are in excellent condition and the satellite is operating nominally.

The calibration and validation of the Jason-2 geophysical data record (GDR) data show that all the missions meet the requirements; however, some discrepancies have been highlighted in terms of mean geographically correlated errors or mean-sea-level trend, and need to be further investigated. Moreover, the need for improved long-term wind-speed time series for climate studies highlighted that this quantity should be more carefully calibrated and validated with homogeneous standards for the different missions. The long-term stability of on-board radiometers continues to be a key issue for high-accuracy altimetry.

The origin of the relative range bias between Jason-1 and Jason-2 (~70 mm) has been discovered recently and presented at the Seattle OSTST (see *Summary of the in situ analysis key findings* in **Section 9.1.2** of the full summary report). This needs further investigation (notably on the C-band). If confirmed, both satellites are measuring sea surface consistently, but are both about 20 cm higher than T/P. The biases to be applied to both Jason-1 and Jason-2 will not be included in the current Geophysical Data Record (GDR) versions[1] to maintain continuity. However, the reprocessed Jason-2 products (to be issued in mid-2011) will be corrected for the 25-mm bias found (sea level will increase by 25 mm). Concerning the Jason-1 bias, it should be applied in the next generation of the products that should be available before the end of the Jason-1 mission.

The Jason-2 orbit comparisons between CNES and JPL or GSFC solutions show minor differences which are under investigation. The EnviSat/Jason-1 geographically correlated signals emphasize the importance of having good communication between the Cal/Val and the Precision Orbit Determination (POD) communities for all missions.

Glenn Shirtliffe [JPL] provided an overview of Jason-1 status. The mission continues to exceed all Level-1 Science Requirements on its interleaved orbit, despite the loss of a reaction wheel in 2003, the loss of half-satellite (PMB) in 2005, and the loss of a gyro in March 2010. Both GPS receivers (Turbo Rogue Space Receivers) have now failed; however, Jason-1 POD continues to meet the mission requirements based on DORIS and Laser Retroreflector Array (LRA). Although the mission lifetime is uncertain, the thermal, power, and propulsion systems all have significant margins remaining.

One problem for Jason-1 is that it is in the same orbital plane as T/P (now non-operational), OSTM/Jason-2 (operational), and Jason-3 (planned). T/P is inoper-

[1] The current Geophysical Data Record (GDR) for Jason-1 is referred to as *GDR-C*, the current Jason-2 product is called *GDR-T*, and the next generation data product (set to debut near the end of the Jason-1 mission) will be called *GDR-D*.

able, and has a nearly-full tank of hydrazine (~200 kg) that cannot be depleted. Since Jason-1 is single-string on several key component systems, the permanent loss of one of these key components would end the mission and could possibly leave Jason-1 adrift, with ~22 kg of hydrazine onboard. Under joint agency direction, an End/Extension-of-Life (EOL) Joint Working Group was established in early 2010 to study future options for Jason-1.

As background, the following actions and strategies were approved by the Jason Steering Group (JSG)[2] in July 2010:

- That Jason-1 should remain in its current interleaved orbit until another high-accuracy repeat-track altimeter is launched and validated. [Most likely to be SARAL/AltiKa in June 2011 + nine months calibration/validation (Cal/Val)], with a science recommendation to be provided by the OSTST meeting in October.

- To immediately begin a fuel depletion campaign to mitigate the intrinsic explosive breakup risks.

- To develop and implement emergency decommissioning procedures to move to graveyard orbit in the event of a sudden mission-ending failure.

In line with this, in July 2010 a series of maneuvers was performed to deplete the Jason-1 tanks. Approximately 70% of the desired depletion goal had been achieved when a problem occurred with one thruster, as a result of which the depletion campaign was suspended. The thruster problem is currently being evaluated. Meanwhile, Jason-1 continues to provide excellent quality science data on its interleaved orbit.

The results of the EOL Joint Working Group, whose task was to study future orbit options for Jason-1, were presented for discussion by the OSTST on October 20. The OSTST endorsed the actions and strategies approved by the JSG in July, with the science recommendation to allow Jason-1 to remain in its current interleaved orbit until another high-accuracy repeat-track altimeter is launched and validated, and then move it to an appropriate geodetic orbit. An overview of the presentation and discussion are provided in detail in the section on recommendations below. The formal recommendations are given in the full report.

Future Altimetry Missions

A series of discussions was also undertaken concerning the choice of a future orbit for the Jason-CS series of altimeters. During the OSTST meeting this topic was discussed in the different splinter sessions. A special town hall meeting was held on October 19 to discuss the different Jason-CS orbit options, and the results were presented with a final discussion in a plenary session on October 20. After a lot of discussion, the majority of the OSTST supported the overriding importance of maintaining the precise climate record of sea-surface-height time series, so that Jason-CS should stay on the 1,336 km reference orbit flown by T/P and Jason-1, 2, and 3. Secondary considerations included the lack of a clear net scientific benefit of a change of orbit, and the challenges of calibrating and validating a precise climate record without a formation flight period between Jason-3 and Jason-CS.

At the 2009 OSTST Meeting in Seattle, the radiometer was identified as the largest source of error in the estimate of global mean sea level, and a recommendation was made that future altimetric missions work on improving radiometer stability. The OSTST considered the mean-sea-level requirements, and performed an assessment of current techniques to meet the long-term radiometer-stability requirement. JPL is performing a feasibility study to address long-term radiometer stability for Jason-3, which is currently under development. The outcome of this study and others was discussed in the plenary session on October 20; the recommendations are given in the full report.

Keynotes

Seven keynote lectures were given during the meeting, on a wide range of altimetric subjects. Three talks addressed a variety of different altimetric programs and projects. **Charles Elachi** [JPL—*Center Director*] gave an overview of present and future satellite oceanography projects at JPL. **Jacques Verron** [Centre National de la Recherche Scientifique (CNRS)—*Project Scientist for SARAL/AltiKa*] presented the status of the CNES/ISRO SARAL/AltiKa Ka-band altimeter project, to be launched in 2011. This mission will provide finer-resolution measurements over the oceans and coastal and hydrological surfaces. **Joanna Fernandes** [University of Porto—Portugal] then gave an overview of the main results discussed at the 4th Coastal Altimetry Workshop, held in Porto in October 2010.

In preparation for the upcoming altimeter missions, **Jean-Claude Souyris** [CNES] presented an overview, explaining the technical aspects of Ka-band altimetry, and the SAR and interferometric SAR modes which will be used on the upcoming missions (e.g., SARAL/Altika and SWOT in Ka-band, SAR mode on ENVISAT and Cryosat-2, interferometric SAR on SWOT). Two science talks followed: **Weiqing Han** [University of Colorado] presented recent results on Indian Ocean sea-level change in a warming climate, and **Javier Za-**

[2] The Jason Steering Group is the decision-making body for Jason-1.

vala-Garay [Rutgers University] gave an example of an operational prediction of the regional ocean circulation near the Mid-Atlantic Bight. A plenary keynote talk from a group of high-school students in the Midi-Pyrénées region of France demonstrated how altimetry was being used in school projects to help track drifting buoys, including buoys that were built by the students.

Recommendations from OSTST

Recommendations concerning Jason-1 Extension of Life

During the OSTST meeting, the science recommendations for the Jason-1 end-of-life orbit were discussed in the different splinter sessions, and in the plenary meeting on October 20. These discussions considered the scientific value of Jason-1 in its tandem mission, the errors induced by moving Jason-1 off its long-term repeat track, and Jason-1's role in the present and future constellation of altimeters. The following recommendations were given:

1) Jason-1 Recommendation: In light of the move of ENVISAT to a new orbit, and the current gap in exact-repeat, high-inclination altimeter data, moving Jason-1 to an alternative orbit would cause unacceptable errors for users of high-resolution sea-surface-height observations due to a combination of asynchronous sampling with Jason-2 and errors in gridded mean-sea-surface products. The OSTST therefore recommends that Jason-1 be maintained on its current orbit until data from the upcoming SARAL/AltiKa mission can be validated. However, because the science team recognizes the broad scientific value of a geodetic mission for Jason-1, we further recommend that Jason-1 be moved to a geodetic orbit in the range of 1286 +/- 2 km, or a suitable geodetic orbit in line with the spacecraft's capabilities at the time, after data from SARAL/AltiKa are validated.

2) Altimeter Constellation Recommendation–CryoSat-2: Although it is recognized that CryoSat-2 is primarily a cryosphere mission, the OSTST recommends that all efforts be made to make available validated Cryosat-2 GDR and Interim Geophysical Data Record (IGDR) data over ocean surfaces to scientific users, for their crucial use in multi-mission altimetric ocean applications, and for improving the ocean mean sea surface determination.

3) Altimeter Constellation Recommendation–SARAL/Altika: The OSTST recognizes that the SARAL/Altika mission will be an essential component of the altimetry constellation from 2011 onwards, re-occupying the long-term ERS and ENVISAT ground track. SARAL/Altika will also provide the first demonstration of Ka-band altimeter capabilities for fine-resolution along-track applications, including for coastal and inland water applications, which will be further developed for the future SWOT mission. The OSTST recommends that all efforts be made to launch SARAL/AltiKa as soon as possible in 2011.

Radiometer Drift Requirements

The discussion on the radiometer drift requirement was presented in terms of goals or requirements, depending on the mission advancement. The objective is that future altimeter missions shall measure globally-averaged sea level relative to levels established during the cal/val phase with zero bias +/- 1 mm (standard error) averaged over any one-year period.

4) Jason-3 Drift Requirement Recommendation: The OSTST recommends that the Jason-3 project continue to study the feasibility of improving the Advanced Microwave Radiometer (AMR) stability through on-board calibration for the Jason-3 mission.

Lee-Lueng Fu and Yves Menard Honored

The annual **COSPAR International Cooperation medal**, was presented jointly to **Lee-Lueng Fu** [JPL] and (posthumously) to **Yves Menard** [CNES]. This medal is awarded to scientists who have made distinguished contributions to space science and whose work has contributed significantly to the promotion of international scientific cooperation. **J.L. Fellous** [COSPAR—*Executive Director*] presented the award in the presence of the awardees' families. **Felisa Menard** accepted the award on behalf of her husband.

Lee-Lueng Fu

Yves Menard

5) Jason-CS Drift Requirement Recommendation: The OSTST also recommends that Jason-CS meet the following requirement at the mission level:

> **Requirement:** Jason-CS shall measure globally averaged sea level relative to levels established during the cal/val phase with zero bias +/- 1 mm (standard error) averaged over any one-year period.

6) Recommendations concerning Jason-CS future orbit: Given the overriding importance of maintaining the precise climate record of sea-surface height, the challenges of calibrating and validating without formation flight between Jason-3 and Jason-CS, and the lack of a clear net scientific benefit of a change of orbit, the OSTST recommends that Jason-CS maintain the 1336 km reference orbit flown by T/P and Jason-1, -2, and -3.

Three plenary sessions provided a forum for formulation of recommendations from the science team on: 1) the potential change of orbit for Jason-1 end-of-life phase; 2) the optimal orbit for Jason-CS; and 3) the radiometer drift requirements for future missions. The full discussion can be perused in the final report (*www.aviso.oceanobs.com/fileadmin/documents/OSTST/2010/oral/final%20report/10_lisbon_OSTST_meeting_report.pdf*).

In summary, the OSTST recommendations are:

1) Jason-1 end-of-life orbit:

- Jason-1 should remain in its current orbit until repeat-track data from the SARAL/AltiKa can be validated.

- Because the OSTST recognizes the broad scientific value of a geodetic mission for Jason-1, we further recommend that Jason-1 be moved to a geodetic orbit in the range of 1286 +/- 2 km, or a suitable geodetic orbit in line with the spacecraft's capabilities at the time, after data from SARAL/AltiKa are validated.

2) Optimal orbit for Jason-CS:

- Given the importance of maintaining the precise climate record of sea-surface height, the challenges of calibrating and validating without formation flight between Jason-3 and Jason-CS, and the modest scientific benefits from a change of orbit: the OSTST recommends that Jason-CS maintain the 1,336 km reference orbit flown by T/P and Jason-1, 2, and 3.

3) Radiometer drift requirements:

- Jason-3 shall measure globally averaged sea level relative to levels established during the cal/val phase with zero bias +/- 1 mm (standard error) averaged over any one-year period.

- The Jason-3 project should continue to study the feasibility of improving the Advanced Microwave Radiometer (AMR) stability through on-board calibration for the Jason-3 mission.

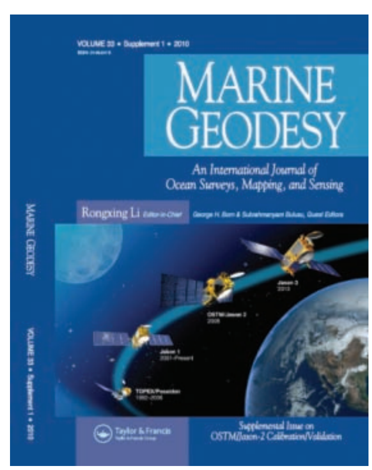
- Jason-CS shall meet the following requirement at the mission level: Jason-CS shall measure globally-averaged sea level relative to levels established during the cal/val phase with zero bias +/- 1 mm (standard error) averaged over any one-year period.

Presentations and detailed summaries of the splinter sessions can be found in the full report at: *www.aviso.oceanobs.com/en/courses/sci-teams/ostst-2010/index.html.*

Special Issue of Marine Geodesy Highlights OSTM/Jason-2

The first special issue on OSTM/Jason-2 Calibration/Validation results has just been published in *Marine Geodesy*, dedicated to the late **Yves Menard**. **George Born** and **Subrahmanyam Bulusu** were guest editors. Twenty-five papers addressing early Cal/Val and science results with Jason-2 data were included; copies are being distributed to authors.

A second OSTM/Jason-2 special issue is planned, and 28 letters of intention have been received. The deadline for submission was November 15, 2010, and publication is scheduled for mid-2011. Due to popular demand, **Volume 3** is also being planned, with a deadline sometime in 2011 (exact date TBD).



38th ASTER Science Team Meeting Report

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

The 38th Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Science Team Meeting was held December 6-9, 2010, in Pasadena, CA.

Opening Plenary Session

H. Tsu [Earth Remote Sensing Data and Analysis Center (ERSDAC)—*Japan ASTER Science Team Lead*] and **M. Abrams** [NASA/Jet Propulsion Laboratory (JPL)—*U.S. ASTER Science Team Lead*] welcomed approximately 50 U.S. and Japanese Science Team Members and interested participants to the 38th ASTER Science Team Meeting.

M. Abrams summarized news from NASA Headquarters and reviewed the U.S. ASTER budget. Terra is currently funded through September 2011, with a new proposal due March 2011 for the upcoming NASA Senior Review. Selections from the Earth Observing System (EOS)/Science of Terra and Aqua recompete were discussed, pending release later in the week. Abrams presented highly visible science activities, including rapid response imaging of the Gulf oil spill, along with recent publications, highlighting the just-released Springer book *Land Remote Sensing and Global Environmental Change: NASA's Earth Observing System and the Science of ASTER and Moderate Resolution Imaging Spectroradiometer (MODIS)*, co-edited by B. Ramachandran, C. Justice, and M. Abrams. The presentation concluded with an update of Terra's fuel consumption.

S. Hook [JPL] provided an update on the Hyperspectral Infrared Imager (HyspIRI), a National Research Council (NRC) Decadal Survey *Tier II* mission containing a Visible Shortwave Infrared (VSWIR) imaging spectrometer and a multispectral Thermal Infrared (TIR) scanner. Subsequently, Hook introduced the Hyperspectral Thermal Emission Spectrometer (HyTES) instrument, which will be mounted on an airborne platform. Hook ended the presentation with an introduction to his Instrument Incubator Program (IIP) proposal for HyspIRI TIR risk reduction, *The Prototype HyspIRI Thermal Infrared Radiometer (PHyTIR) for Earth Science*.

T. Matsunaga [National Institute for Environmental Studies (NIES)] introduced the Hyperspectral Imager Suite (HISUI), a spaceborne instrument developed by the Japanese Ministry of Economy, Trade, and Industry (METI). HISUI, consisting of both hyperspectral and multispectral imagers, will be one of the instruments onboard the Japan Aerospace Exploration Agency's (JAXA) Advanced Land Observing Satellite-3 (ALOS-3).

B. Eng [JPL] discussed the status of the Landsat Data Continuity Mission (LDCM), the eighth instrument in the Landsat series. The launch readiness date is slated for December 2012.

M. Kikuchi [Japan Resources Observation System and Space Utilization Organization (JAROS)] reported on ASTER instrument status. All systems, aside from the SWIR detector, continue to operate normally.

M. Hato [ERSDAC] reported on ERSDAC Ground Data System (GDS) status, providing updates on observation scheduling, processing, and distribution. Hato summarized the ASTER Global Digital Elevation Model (GDEM) distribution statistics and gave an overview of the Science Data Processing System (SDPS) replacement schedule.

D. Meyer [U.S. Geological Survey Land Processes Distributed Active Archive Center (USGS LP DAAC)] presented LP DAAC ASTER product distribution statics, including GDEM metrics. Additional topics included the successful transition to an online archive, Level 1A (L1A) backup capabilities, and plans for the ASTER data long-term archive (LTA).

M. Fujita [ERSDAC] presented the Science Scheduling Support Group/Operations and Mission Planning (SSSG/OMP) report. Fujita reviewed the status of major Science Team Acquisition Requests (STARs), such as Global Mapping (GM), nighttime TIR GM (TGM), and the Underserved Area (UA) and Gap-Filler STARs.

The opening plenary concluded with **M. Abrams** and **Y. Yamaguchi** [Nagoya University] proposing a list of issues for further discussion in the working groups: 1) data acquisition monitoring status; 2) GDEM updates; 3) TIR-only mode geolocation error; and 4) orbit drift after 2017.

Geology Working Group

M. Willis [Cornell University] presented ongoing work conducted with M. Pritchard [Cornell University] analyzing glacier velocities and elevation changes in Patagonian icefields. Glacier retreat and thinning at lower elevations were observed in both Northern and Southern Patagonian icefields. Mass loss acceleration continues to be monitored as additional data are acquired. Willis then updated the audience on the Cornell Andes Project. Principal Investigator M. Pritchard and team combined ASTER TIR data with Interferometric Synthetic Aperture Radar (InSAR) data and seismic observations to identify background activity at 2500 volcanoes in the Southern and Central Andes region.

B. Sneed [University of Maine] reported on glaciology research projects utilizing ASTER imagery undertaken by himself, G. Hamilton [University of Maine], and colleagues at the Climate Change Institute.

J. Kargel [University of Arizona] presented results of his work, combining ASTER data and field studies, on glacier-fed landslide-dammed Lake Gojal in Pakistan and ice-cored moraine-dammed Imja Lake in Nepal. ASTER time series data have aided in tracking the development and stability of landslide-, moraine-, and glacier-dammed lakes.

R. Wessels [USGS] reported on the use of high-resolution remote sensing data for hazard assessment and risk mitigation in the 2010 eruption of Merapi Volcano. Indonesia's Center for Volcanic and Geologic Hazard Mitigation (CVGHM) correctly anticipated a large, explosive eruption and called for the evacuation of affected areas, potentially saving thousands of lives. The USGS Volcanic Disaster Assistance Program (VDAP) facilitated activation of the International Charter for Space and Major Disasters, allowing for the acquisition of near real-time multiple remote sensing resources, including ASTER.

M. Ramsey [University of Pittsburgh] provided an update on the ASTER Urgent Request Protocol (URP) program, a rapid response volcano alert system. Ramsey then reported on research conducted with S. Rose [University of Pittsburgh], using ASTER TIR emissivity data and a linear spectral deconvolution algorithm to create compositional maps of the basalt flows at Cerro Negro Volcano in Nicaragua. Lastly, Ramsey presented C. Hughes' [University of Pittsburgh] work using super-resolved ASTER and Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) data to analyze compositional variations at Lunar Lake Playa.

J. Mars [USGS] discussed the use of ASTER data for spectral analysis and lithologic mapping of the Khanneshin carbonatite volcano in southern Afghanistan. Research and fieldwork were conducted with the late L. Rowan [USGS].

M. Urai [Geological Survey of Japan (GSJ)/National Institute of Advanced Industrial Science and Technology (AIST)] discussed the East Asia DEM Dataset Project, a joint undertaking with GSJ/AIST, Ibaraki University, and Nagasaki University. The project, completed in 2009, created time series DEMs and ortho-rectified ASTER images as byproducts of the DEM mosaic. These byproducts can be used to conduct time series data analyses and create image mosaics. The project will be expanded worldwide over the next five years.

D. Pieri [JPL] provided updates on several ASTER related projects. Pieri began with a progress report on *in situ* gas sampling techniques at Turrialba Volcano in Costa Rica. Field data are combined with satellite measurements for detailed volcano emission analysis. He then discussed ASTER Volcano Archive (AVA) statistics and goals. Future plans include incorporating nighttime data and adding DEMs for all volcanoes. Pieri discussed geologic mapping of Tiede Volcano, a potential sector collapse site, as well as landslide imaging of Poas Volcano. He concluded his presentation with an introduction to S. Baxter's [JPL] work using smoothed particle hydrodynamics to model lava flow and terrain.

Level 1/DEM Working Group

H. Fujisada [Sensor Information Laboratory Corporation (SILC)] reported no changes to the L1 algorithm, and noted that both inter- and intra-telescope registration are satisfactory. The geolocation accuracy of nighttime TIR data in the east-west direction is off between 100–400 m, depending on look angle. L1A software will be modified to remove the offsets. Next, Fujisada provided GDEM *version 2* (*v2*) updates. The new version, with enhanced water body detection and additional source data, has a public release date set for mid-August 2011.

T. Tachikawa [ERSDAC] presented validation results for the GDEM *v2* algorithm, concluding that the updated version is significantly improved.

D. Meyer detailed U.S. validation plans for GDEM *v2,* with continuing contributions from the USGS and the National Geospatial-Intelligence Agency (NGA). Additional validation support will be provided by the Ice, Cloud, and land Elevation Satellite (ICESat) and R. Crippen [JPL]. Meyer also presented George Mason University's DEM Explorer, an open geospatial consortium (OGC) web mapping service (WMS) and web coverage service (WCS) for the ASTER GDEM. His final presentation showed the societal benefits of free and open data distribution, using the ASTER GDEM as a case study for the Global Earth Observation System of Systems (GEOSS) data-sharing action plan.

M. Abrams relayed a method developed by the governmental agency Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) to identify GDEM anomalies and to replace bad values through interpolation.

R. Crippen reported on methods to identify bad elevation values in ASTER DEMs using correlation maps developed from ASTER orthoimage stereo pairs. This method could be used to validate non-ASTER DEMs.

M. Kobrick [JPL] summarized NASA's plan to create a new, seamless global DEM. Global Shuttle Radar Topography Mission (SRTM) data would be reprocessed at one arcsecond resolution, and merged with ASTER GDEM data to fill in voids/holes in GDEM mosaic.

J.-P. Muller [University College London] described his involvement with the Committee on Earth Observing Satellites (CEOS) and the mission of the Terrain Mapping Subgroup (TMSG) in developing universal standards for DEMs. Muller introduced the DEM quality information service (DEMqis), a centralized site for the online analysis of global DEMs. Pre-approved users would have the ability to validate DEMs and share their scientific assessments with other registered users. Validation results would then be accessible to the public.

Operations and Mission Planning Working Group

T. Tachikawa [ERSDAC] proposed updating scheduler parameters to increase the number of ASTER scenes acquired and to improve overall scheduler efficiency.

M. Fujita analyzed ASTER observation resources and provided status updates for various STARs. GM4, UA STAR 2010, and TGM 3 and 4 will continue as originally submitted. The Temperature-Emissivity (TE) WG will discuss TGM progress and future requirements. Gap-Filler STAR 2010, designed to cover GDEM holes, ended in December and will be resubmitted in March 2011. The status of the Global Land Ice Measurements from Space (GLIMS) STAR 2010 was reviewed, with plans for a 2011 resubmission to be discussed in the STAR Committee WG. Fujita's presentation concluded with an evaluation of the success rate of urgent STARs.

D. Meyer reviewed the status of expedited data set (EDS) processing at the LP DAAC, addressing known issues and providing access information to U.S. and Japanese science team members. Subsequently, Meyer presented long-term archive plans for ASTER data following the end of the mission. All L1B and higher-level data products will be processed from the L1A archive, forming a static archive. A draft version will be completed by February 2011.

Temperature-Emissivity Separation Working Group

H. Tonooka [Ibaraki University] began the session with updates on ASTER time series ortho land surface TE products. East Asia maps were completed last year, with future plans for Africa and worldwide products.

G. Hulley [JPL] reported on the status of the North American ASTER Land Surface Emissivity Database (NAALSED) *v3.0* release. The new version has increased temporal coverage, an improved cloud mask, and enhanced atmospheric correction. The expected release date for NAALSED summertime *v3.0* is January 2011. The wintertime NAALSED is undergoing completion, with future plans to create mean-seasonal emissivity mosaics for northern Africa and the Arabian Peninsula.

M. Ramsey presented work done with R. Lee [University of Pittsburgh] on the emissivity of silicate melts using TIR methods.

G. Hulley summarized research from A. Gillespie [University of Washington] on incomplete TE separation in ASTER standard products caused by residual atmospheric effects and striping. Atmospheric correction can be improved with water vapor scaling, while Fast Fourier Filtering has destriping effects over water.

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

M. Fujita summarized current TGM STAR status. TGM3 (southern hemisphere) and TGM4 (northern hemisphere), submitted in 2009, are scheduled to collect data through 2014.

T. Tachikawa summarized his proposal to update scheduler parameters. The TE WG will formulate a revised TGM plan based on scheduler results following the parameter updates.

H. Toonoka presented a cloud assessment update. The revised cloud assessment uses the Moderate Resolution Imaging Spectroradiometer (MODIS) *MOD35* cloud mask product. The new cloud cover values are available through GDS and the LP DAAC.

Radiometric Calibration/Atmospheric Correction Working Group

B. Eng reviewed the U.S. ASTER L2 software status. *v3.4* is undergoing testing at the LP DAAC, with release expected in January 2011.

F. Sakuma [JAROS] reviewed Visible/Near-Infrared (VNIR), Shortwave Infrared (SWIR), and TIR instrument status. The radiometric response of VNIR and TIR has been decreasing gradually. The degradation was corrected by updating the radiometric calibration coefficient (RCC) parameters to *v3.11* in July 2010.

M. Kikuchi reported the use of fault tree analyses to investigate possible causes for sensitivity degradation of VNIR and TIR.

K. Arai [Saga University] presented a detailed analysis of the effects of contaminant accretion from thruster plumes on ASTER's optical sensors. Hydrazine hydrate is one of the suspected causes of sensor degradation.

F. Sakuma reported on studies examining hydrazine absorption as a possible cause for the sensitivity decrease of the ASTER TIR sensor.

A. Iwasaki [University of Tokyo] analyzed ASTER VNIR stripe noise and presented his findings to the WG.

N. Leisso [University of Arizona], **S. Tsuchida** [AIST], and **K. Arai** [Saga University] reported on their respective VNIR field campaigns. **H. Tonooka**, **T. Matsunaga** [NIES], and **S. Hook** presented TIR field campaign results. Plans for upcoming field campaigns were also discussed.

G. Hulley demonstrated the use of Moderate Resolution Atmospheric Transmission (MODTRAN) *v5.2* in improving the accuracy of the ASTER surface radiance product (*AST09T*).

H. Suto [JAXA] summarized vicarious calibration activities for the Greenhouse gases Observing SATellite (GOSAT) and onboard Thermal And Near infrared Sensor for carbon Observation (TANSO) sensors at Railroad Valley.

Ecosystem/Oceanography Working Group

T. Matsunaga presented research conducted by Y. Sakuno [Hiroshima University] and H. Kunii [Shimane University] aimed at classifying "Aoko" algal bloom events, which occurred at Lake Shinji and Lake Nakaumi, using satellite imagers.

M. Ramsey reported on research conducted with S. Scheidt [University of Pittsburgh] focusing on emission events of large dust plumes in arid lands. Instruments such as ASTER, MODIS, and the Spinning Enhanced Visible and Infrared Imager (SEVIRI) [on Meteosat] can be used as dust detection tools, aiding in tracking source locations and identifying mineral compositions.

T. Matsunaga relayed M. Kishino's [Tokyo University] use of ASTER VNIR in determining the relationship between ocean color and sea surface reflectance. Chromaticity coordinate values were calculated from sea surface reflectance in three VNIR channels, and chlorophyll-a concentration was determined from these values.

L. Prashad [Arizona State University (ASU)] provided an update on ASU's *100 Cities Project.* The application of satellite remote sensing data in monitoring slow-onset disasters is being explored with support from the World Bank and United Nations. Additionally, collaborations were forged with the University of Newcastle and the Tyndall Center for Climate Change Research. New functionalities for *JEarth,* an open source Java-based geographic information system (GIS) and remote sensing analysis and visualization tool built from the Java Mission-planning and Analysis for Remote Sensing (*JMars*) application, were also reviewed.

S. Kato [NIES] presented his analysis of the relationship between surface temperature and shade in Tokyo. ASTER TIR data were compared to shaded areas extracted from high-resolution ALOS Panchromatic Remote-Sensing Instrument for Stereo Mapping (PRISM) DEMs.

J. Kargel demonstrated the use of ASTER imagery and DEMs in mapping animal habitats. Kargel related the ecological habitat of the Tibetan snowcock, found in the Imja Glacier region of Nepal, to glacial processes, vegetation densities, slopes and slope aspects, elevation, landscape stability, and geomorphic units.

T. Matsunaga presented research conducted by T. Ishiyama [Chiba University] that monitors land cover change in the Marginal Taklimakan Desert. Using imagery from multiple satellites, the investigators chronicled a rapid increase of cotton-producing areas.

M. Abrams presented a brief report on behalf of G. Geller (JPL) detailing the latest progress with *TerraLook,* a program that provides no-cost access to ASTER and historical Landsat images, along with a suite of simple visualization and analysis tools. The *beta v2.0* release is slated for early 2011.

STAR Committee

One new STAR proposal was presented, reviewed, and accepted by the STAR committee. GLIMS STAR progress was evaluated, with future requirements discussed by the GLIMS team and committee members. A GLIMS STAR with updated parameters will be submitted January 2011.

Closing Plenary Session

The meeting concluded with summaries from each working group chairperson. The 39th ASTER Science Team Meeting will be held June 6-9, 2011 in Tokyo, Japan. ■

Land Atmospheres Near-real-time Capability for EOS (LANCE) User Working Group Meeting Summary

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The Land Atmospheres Near-real-time Capability for EOS (LANCE) system [managed by NASA's Earth Science and Data Information System (ESDIS)] provides a wide variety of near-real-time data products from the Aqua, Terra, and Aura spacecraft to the applications user community. The LANCE Level 1 (L1) and L2 applications data products are available for distribution within three hours of observation, in contrast to the standard science-quality products that are available within 8–40 hours of observation. To facilitate faster data availability, the system uses predicted attitude and ephemeris data and the algorithm codes used in LANCE include less-restrictive rules for the use of the ancillary data products. As a consequence, in some cases there are minor differences between the standard products and the near-real-time data products. Science and near-real-time product comparisons are available from *lance.nasa.gov*; user services can provide additional information. **Table 1** shows the instruments from which products are presently generated by LANCE, along with a list of the broad product categories available.

The goal of LANCE is to provide near-real-time data to NASA's various of *end users*—who range from scientists to operational agencies. NASA's Applied Sciences Program has supported the development of some near-real-time applications that help to discover and demonstrate innovative uses and practical benefits of NASA Earth science data, scientific knowledge, and technology.

At the first LANCE Workshop held in December 2009 at the University of Maryland[1], representative users were invited to provide valuable guidance that has influenced the evolution of LANCE and its elements since that time. A key recommendation from that workshop requested a governance model containing mechanisms for future system evolution, as well as vetting proposed new requirements. As a result, a User Working Group (UWG) composed of a representative section of active LANCE users from application developers and operational agencies to universities and Non-Government Organizations (NGOs) was convened. This group provides advice and helps steer future development of the LANCE Program.

ESDIS hosted the first LANCE UWG meeting at the University of Maryland in November 2010. In addition to the UWG members, 20 other individuals attended representing NASA HQ, ESDIS, the LANCE elements and other data providers, and other members of the

[1] The meeting summary for the first LANCE Workshop is in the March-April 2010 issue of *The Earth Observer* [**Volume 22**, **Issue 2,** pp. 18–20].

Table 1. Instruments [Mission(s)] with data products currently available through LANCE

Instrument[2] [Mission(s)]	**Product Category**
AIRS [Aqua]	Radiances, temperature and moisture profiles, clouds and trace gases
MLS [Aura]	Ozone and temperature
MODIS [Aqua and Terra]	Radiances, clouds/aerosols, water vapor, fires, snow, sea ice, land surface reflectance, and land surface temperature
OMI [Aura]	Ozone, sulfur dioxide, aerosols, cloud top pressure
AMSR-E [Aqua]	Brightness temperature, soil moisture, rain rate, ocean products, snow water equivalent, and sea ice

[2]AIRS—Atmospheric Infrared Sounder; MLS—Microwave Limb Sounder; MODIS—Moderate Resolution Imaging Spectroradiometer; OMI—Ozone Monitoring Instrument; AMSR-E—Advanced Microwave Scanning Radiometer – EOS.

user community. The purposes of the two-day meeting were to:

- review the existing LANCE system and identify ways in which the services may be improved;
- solicit suggestions for future additions and upgrades to LANCE; and
- provide a forum for discussion of potential system changes and solicit UWG feedback.

The first day of the meeting consisted of presentations by representatives from NASA HQ, ESDIS staff, UWG members, LANCE element staff, and representatives of the user community with specific suggestions for LANCE upgrades. The second day was dedicated to a discussion of the candidate system changes and upgrades, and a determination of which of these would be endorsed by the UWG.

Martha Maiden [NASA HQ] opened the meeting and identified its scope and objectives. **Dawn Lowe** [ESDIS] presented the ESDIS project management plans for LANCE and delineated the responsibilities of ESDIS and the individual LANCE data production elements. The LANCE products are freely available following registration. At present, there are in excess of 500 registered users from U.S. civilian and military government agencies, foreign government agencies, universities, and private sector organizations. In excess of 1 *terabyte* (TB) of data products are distributed by LANCE every day. A wide variety of applications areas are supported, including hurricanes, volcanoes, floods, fires, oil spills, dust storms, air quality, snow and ice, and weather.

Kevin Murphy [ESDIS] summarized recent LANCE progress. A LANCE website has been established to provide a common interface for the end users. It includes access to the products and services of the individual elements (*lance.nasa.gov*). The website provides information on LANCE, including registration, data access, products lists, and metrics.

A registration and authentication system has been established that allows a determination of the data distribution by user and permits the elements to provide announcements to the user community, e.g., when new products and services are added and to identify system problems and issues. A variety of post-processing tools have been provided for LANCE Moderate Resolution Imaging Spectroradiometer (MODIS), including parameter, band, and geographic subsetting, reprojection, mosaicing, and products in the GeoTiff format. The initial complement of Ozone Monitoring Instrument (OMI) products has been expanded to include sulfur dioxide (L2) and gridded column ozone (L3). Advanced Microwave Scanning Radiometer - Earth Observing System (AMSR-E) products—including L3 daily land, ocean, sea ice, and snow products—are now available. Atmospheric Infrared Sounder (AIRS) L1A products are also available in the Binary Universal Form for the Representation of meteorological data (BUFR) format. AIRS products are available through a web mapping service in PNG, GeoTiff, and KMZ formats.

Chris Justice [University of Maryland—*LANCE UWG Co-Chair*] presented the roles of the UWG, which represents the LANCE user communities and includes members who are familiar with both the applications and the science aspects of the data products. The UWG is charged with: 1) providing guidance on LANCE priorities and long-term goals; 2) assessing the quality of the products and services provided by LANCE and the progress made by the elements against prior UWG recommendations; and 3) developing a prioritized list of recommendations for LANCE development and system changes for the 12 months following the UWG meeting.

Nine members of the UWG gave presentations on their applications areas, including the U.S. Forest Service (USFS) Remote Sensing Applications Center (RSAC), the Dartmouth Flood Observatory (DFO), and the United States Agency for International Development (USAID) Famine Early Warning Systems Network and their use of LANCE data. All of the presentations are included on the LANCE website. A number of members discussed the latency requirements and relationship between LANCE and EOS Direct Readout data.

The EOS Data and Operations System (EDOS), the AMSR-E Science Investigator-led Processing System (SIPS), the Goddard Earth Sciences Data and Information Services Center (GES DISC), the OMI SIPS, and the MODIS Adaptive Processing System (MODAPS) all gave status updates. The presentations by the LANCE elements focused on the changes made to the system since the December 2009 workshop (summarized above), ongoing developments, and user-suggested upgrades. The EDOS provides the L0 and the attitude and ephemeris data to the LANCE elements.

Bruce McLemore [EDOS] described the EDOS architecture and the timeline for providing products to the LANCE elements. McLemore described the plans for three specific system changes designed to reduce LANCE latency that include: 1) removal of the Reed-Solomon decoding bits prior to network transfer—with an anticipated latency reduction of two minutes; 2) addition of lossless data compression following data receipt at EDOS—with an anticipated latency reduction of two minutes; and 3) inclusion of a L0 processing and distribution capability at White Sands to replace the Goddard Space Flight Center (GSFC)/EDOS function—with an anticipated latency savings (Terra only) of 15-20 minutes.

Helen Conover [University of Alabama at Huntsville] described recent developments with the LANCE-AMSR-E element. This included the installation of a new L2A algorithm and the addition of pixel-by-pixel comparisons of the standard and the near-real-time data products. The suggested system upgrades included generation of LANCE-AMSR-E products in the BUFR format, addition of incremental L3 products, addition of a geographic subsetting capability, addition of browse products, and use of the LANCE-MODIS Rapid Response system for displaying AMSR-E products.

Bruce Vollmer [GES DISC] discussed the LANCE-AIRS and LANCE-Microwave Limb Sounder (MLS) elements. Proposed system upgrades included installation of new and improved MLS algorithms, addition of an MLS water vapor product, provision of data access through the Open-source Project for a Network Data Access Protocol (OPeNDAP) (*disc.sci.gsfc.nasa.gov/AIRS/data-holdings/by-access-method*) and Giovanni (*disc.sci.gsfc.nasa.gov/giovanni*), and addition of geographic subsetting and products in the netCDF format.

Curt Tilmes [OMI SIPS] discussed the LANCE-OMI element. Ongoing developments included installation of a redundant system, and addition of three new L3 products. Proposed system upgrades included generation of data products in netCDF and GeoTiff formats.

Michael Teague [MODAPS] discussed the LANCE-MODIS element. Ongoing developments included installation of a redundant system, incorporation of the MODIS Collection 6 (C6) algorithms, and generation of both C6 and C5 products through Q2 of FY12, completion of the transition of the MODIS Rapid Response and Fire Information for Resource Management Systems (FIRMS) into LANCE-MODIS, and addition of a web mapping service and a web coverage service. Suggested system upgrades included use of Direct Broadcast in LANCE-MODIS, generation of global flood maps, and generation of a Naval Research Laboratory (NRL) assimilation product. Representatives of three user communities presented proposed upgrades to LANCE-MODIS.

Fritz Policelli [GSFC] described the generation of flood maps by the DFO. At present, the LANCE-MODIS subsetted land surface reflectance products are generated for a small number of tiles; the flood maps are generated manually. The thrust of this presentation was the proposal that LANCE-MODIS should generate and distribute global flood maps using the DFO flood-extent algorithm. The ensuing discussion concerned peer review of this nonstandard MODIS product algorithm, current levels of NASA Applications support for this activity, and the desirability of an operational partner to support this important product.

Kim Richardson [NRL] discussed the six-hour aerosol assimilation product (filtered, gridded aerosol optical depth with error estimation) generated for the U.S. Navy using the LANCE-MODIS L2 aerosol and geolocation products. It was pointed out that the product had been developed in concert with the MODIS Aerosol Team. Since NRL is not constituted for such data production and distribution, it was suggested that LANCE-MODIS should be upgraded to generate the product.

Bruce Davis [Department of Homeland Security (DHS)/Federal Emergency Management Agency (FEMA)] discussed FEMA requirements for LANCE-MODIS data products. Given the nature of disaster response, it would be very desirable if data products were made available based upon data from MODIS Direct Broadcast stations.

Chris Justice and **Michael Goodman** led an extensive discussion of all proposed modifications and updates. The discussion focused on whether image visualization and analysis tools should be incorporated into LANCE and how such external services could be linked. ESDIS was asked to develop a short *white paper* on how to address this issue. The relationship between Direct Readout and LANCE data was also discussed. There are a large number of Direct Readout stations around the world in various stages of development and operation. These stations downlink EOS data and generate products within 20 minutes of acquisition. The NASA Direct Readout Laboratory (DRL) *(directreadout.sci.gsfc.nasa.gov/)*, managed by Pat Coronado [GSFC], provides facilitation and coordination of these stations. Some of these ground stations use DRL-provided algorithms while others generate regional products using their own algorithms. A large number of stations make their data available to users. Some initiatives are underway to coordinate between ground stations on products of common interest, e.g., *landdirectreadout.org/*. Although the group recognized that improved latency was important for some time-critical applications, the task of coordinating a global data initiative, setting up agreements, and managing ingest of L1 data from the various stations was deemed to be beyond the current scope of the LANCE program. Users are encouraged to contact ground stations providers with coverage of their regions of interest directly.

The UWG also discussed the desirability of a LANCE User Symposium in the coming year, to provide visibility to EOS near-real-time data users, and a forum for exchange of experience and feedback on LANCE capabilities from the broader user community. **Table 2** identifies activities endorsed by the UWG for FY11 with associated levels of priority. These include a number of investigations, all of which will lead to study reports, and some of which will include prototyping efforts. The UWG agreed to meet by teleconference to discuss these results as needed.

Table 2. LANCE activities funded for FY11 and priority assigned to each topic

UWG Action Topic	Description	Priority
Reduced Latency	Investigate the use of AMSR-E Direct Broadcast data and the provision of L1 and L2A algorithm codes to the Direct Readout Laboratory at GSFC	High
New/Enhanced Products	Investigate adding a rolling daily Nadir Bidirectional Reflectance Distribution Function (BRDF) adjusted Reflectance (NBAR) product to LANCE-MODIS	Medium
	Investigate generating incremental AMSR-E products to reduce the L3 latency	Low
	Extend the period for overlap of MODIS Collection 5 and 6 products	High
	Investigate adding other element products, e.g., AMSR-E rain rate data to Rapid Response	High
Data Access	Perform trade studies for LANCE data distribution techniques	Medium
	Perform trade studies for visualization techniques	Medium
	Complete the Web Mapping Service and the Web Coverage Service for LANCE-MODIS	High
Additional Tools	Investigate adding product formats such as BUFR, netCDF, and GeoTiff for all elements	Medium
	Investigate using standard tool sets (e.g., sub-setting) for all elements and investigate software re-use across elements	Low
LANCE Web Site	Investigate generating browse products for all LANCE elements	Low
	Add interactive area for users	Medium
	Add links for access to Direct Broadcast data	High
	Plan Near-Real Time Symposium to include data providers other than LANCE	Medium

GRACE Science Team Meeting Summary

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The 2010 Gravity Recovery And Climate Experiment (GRACE) Science Team Meeting was held at the German Research Center for Geosciences, the GeoForschungsZentrum (GFZ) in Potsdam, Germany from November 11-12. The meeting consisted of 53 presentations in moderated discussions on nine main topics:

- science applications to multidisciplinary problems;
- solid earth;
- cryosphere;
- oceans;
- hydrology;
- atmosphere (i.e., using radio occultations);
- status of the GRACE follow-on mission; and
- geodesy and analysis techniques, including complementary applications of GRACE and the European Space Agency's Gravity field and Ocean Circulation Explorer (GOCE).

Each session consisted of invited and contributed presentations and included a period for questions and answers. In addition, 23 posters relevant to each topic were posted for discussion. Over 140 scientists and engineers attended this science team meeting.

The GRACE science team meeting program, abstracts, as well as presentations and posters, are available on the *GFZ website*. There is a link to this site, as well as to the prior Science Team meetings, at: *www.csr.utexas.edu/grace/GSTM/*.

The meeting opened with a brief **Project Status** session, starting with a summary of the CHAllenging MiniPayload (CHAMP) satellite mission that ended September 19, 2010. CHAMP was a heritage mission for GRACE; GRACE inherited several of the subsystems used on CHAMP and the GRACE team learned from its flight experiences.

Discussion on current status and plans for the GRACE mission continued the opening session. Over the past year, the project has been working to maintain accurate, global, and homogeneous measurements and derived gravity data products. Efforts have been focused on ensuring measurement continuity by optimizing satellite operations in order to extend the life of the mission, supporting efforts to realize a GRACE continuity mission, and developing possible methods for bridging the gap between GRACE and a GRACE Follow-On mission. In addition, a reanalysis of nearly nine years of GRACE data is underway to obtain the next generation of data products. The report also included a review of the status and information on the latest operational and reprocessed data releases from the GRACE Science Data System. This group of talks closed with a summary of science data and operational impacts to science results. Presenters in this session included: **Frank Flechtner** [GFZ]; **Joseph Beerer** [NASA/Jet Propulsion Laboratory (JPL)]; **Byron Tapley** [University of Texas Center for Space Research (CSR)—*GRACE Principal Investigator*]; **Gerhard Kruizinga** [JPL]; and **Srinivas Bettadpur** [CSR].

GRACE Follow-On: The GRACE-Follow On (GRACE-FO) mission may launch as early as 2016. Another potential future mission configuration discussed in this session consists of two pairs of GRACE-type satellites that will provide substantial improvements in resolving mass variations from hydrologic and ocean-bottom pressure changes as well as from earthquakes. Technological advances that will be incorporated into the GRACE-FO include fiber-based lasers, improved accelerometers (including electrostatic accelerometers), and advances in satellite-to-satellite tracking. Presenters in this session included: **Bernard Foulon** [Office National d'Etudes et de Recherches Aerospatiales (ONERA)]; **Peter Bender** [University of Colorado (CU)]; **Jordan Camp** [NASA Goddard Space Flight Center (GSFC)]; **Thomas Gruber** [Technical University, Munich (TUM)]; **Benjamin Sheard** [Albert Einstein Institut (AEI) Hannover]; and **David Wiese** [CU].

GRACE Geodesy: Improvements to the methods, algorithms, and results from GRACE data analysis and error assessments, including assessments of the GRACE flight regimes and their impact on Level-1 data dominated this session. Presentations also addressed methods to improve the spatial and temporal resolution of the GRACE signal content, to reduce the need for *aposteriori* error corrections in the gravity fields, to develop alternative and improved methods of data processing, and to provide improved error estimates of GRACE data products. Also discussed were results of combination and complementary results from GRACE and GOCE. Presenters in this session included: **Frank Lemoine** [GSFC]; **Ulrich Meyer** [University of Bern]; **Enrico Kurtenbach** [University of Bonn (U Bonn)]; **Leiselotte Zenner** [TUM]; **Thomas Gruber**; **Bernard Foulon**; **Roland Pail** [TUM]; **Luciana Fenoglio-Marc** [TU Darmstadt]; **Tamara Bandikova** [University of Hanover]; **Christian Gruber** [GFZ]; **Martin Horwath**

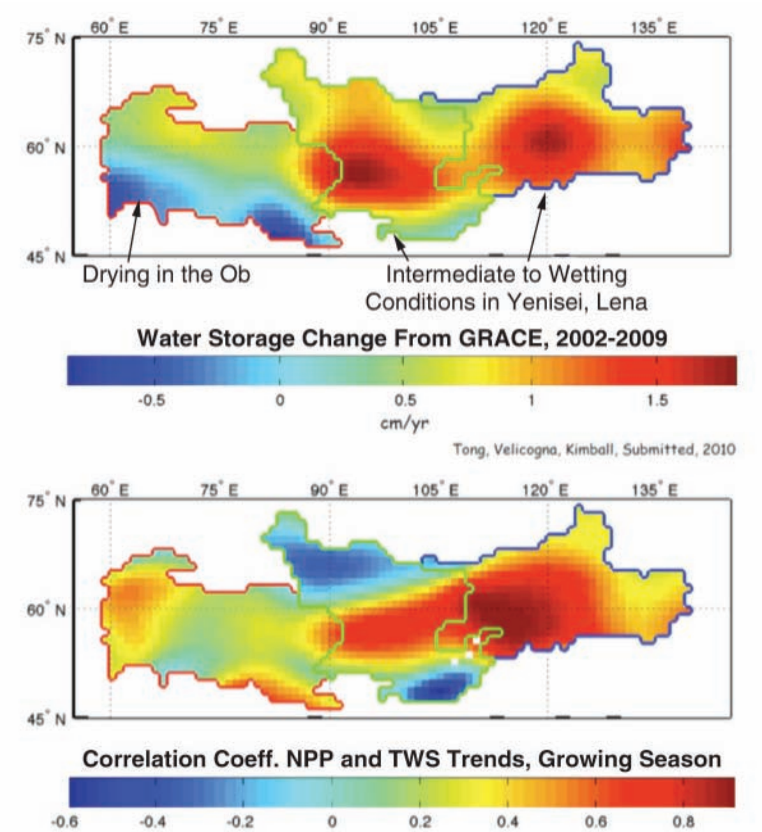


Figure 1. GRACE-derived water storage trends over the permafrost areas in the Eurasian–Pan Arctic region for 2002–2009, in cm of water per year, are shown [*top panel*] along with the correlation coefficient between the Total Water Storage (TWS) change and net primary production (NPP) in gC/m^2/yr [*bottom panel*]. NPP appears to be directly proportional to TWS—consistent with the hypothesis that moisture controls productivity in this region. These results from GRACE are consistent with findings from other remote sensing instruments. **Credit: Isabella Velicogna**

[TUM]; **Nadja Peterseim** [TUM]; and **Leonid Zotov** [Sternberg Astronomical Institute].

Hydrology: Discussion in this session focused on the use of GRACE data in hydrology studies, including improvements to GRACE hydrology products. A particular emphasis was placed on development of GRACE products for terrestrial hydrology. A working group within the science team has been created to work on this task. To help guide further development of these products, the results from evaluations of several such candidate products were shown. The new products were either compared with terrestrial measurements and/or assessed in terms of their contribution to model assimilation skills. Other results shown during this session highlighted how the use of GRACE data products in hydrological models improves total-water-storage estimates at all scales. Presentations also indicated increasing attention to the smaller river basins that have historically lacked data coverage—e.g., the Siberian river basins, or the Nile, Niger, and Congo basins in Africa. Another growing area of application was the study of high-latitude permafrost, where GRACE water-storage trends are showing changes consistent with other remote sensing data [see **Figure 1**]. Presenters in this session included **Annette Eicker** [U Bonn]; **Felix Landerer** [JPL]; **Laurent Longuevergne** [Geosciences Rennes]; **Matthew Rodell** [GSFC]; **Mohamed Sultan** [Western Michigan University]; **Sibylle Vey** [University of Hannover]; and **Isabella Velicogna** [University of California – Irvine (UCI)].

Oceanography: This session opened with a summary of findings from a workshop at the University of Hamburg in September 2010, dedicated to the application of GRACE to ocean sciences. Key findings from that workshop indicated that while GRACE clearly contributed to the study of ocean processes, to the sea-level budget, and to potential improvements in outcomes from data assimilating models, the signal-to-noise ratio of GRACE data were still of the order of one over the oceans, and that further understanding of post-processing error methods was needed. Other presentations in this session highlighted the advances in applications of GRACE data records to observe an increasing number of ocean processes. Examples included a wind-driven record high signal in bottom pressure and sea-surface height in the South Pacific, and sub-monthly bottom pressure variability in the Arctic Ocean and in the global oceans. There was also discussion of approaches for improvements in time-mean dynamic ocean topography (either through the combination of GRACE, GOCE, and radar altimetry data, or from the combination of GRACE, altimetry, and *insitu* data, constrained by ocean dynamics. Presenters in this session included: **Carmen Boening** [JPL]; **Saskia Esselborn** [GFZ]; **Tijana Janjic** [Alfred Wegener Institute for Polar and Marine Research]; **Steven Jayne** [Woods Hole Oceanographic Institute]; **Cecelia Peralta Ferriz** [University of Washington]; **Katherine Quinn** [Atmospheric and Environmental Research]; and **Victor Zlotnicki** [JPL].

The majority of the **Solid Earth** session presentations addressed two main topics: the studies of earthquake signals in GRACE and what they tell us about crustal deformation, and the problem of inferring global isostatic adjustment (GIA)—i.e., separating it from present day mass changes—and its impact on sea-level rise studies. Presentations related to earthquakes included studies of ocean contributions to co-seismic crustal deformation and geoid anomalies, constraints on the 2004 Sumatra earthquake (both co- and post-seismic changes), gravity changes following the 2010 central Chile earthquake [see **Figure 2**], as well as GRACE applications to infer the seismic cycle and mantle rheology. Presentations related to GIA covered GRACE contributions to studies of lower mantle dynamics; the effects of GIA on GRACE global-ocean-mass estimates; constraints on GIA and present-day ice loss in the Antarctic Peninsula and West Antarctica; and global inversion of data from GPS, GRACE, and the Estimating the Climate and Circulation of the Ocean (ECCO) model to simultaneously determine present-day surface-water and ice-mass transport as well as GIA. Other presentations in this session addressed connections between Antarctic ice accumulation (from GRACE) and the El Niño-Southern Oscillation; GRACE data filtering using independent component analysis; and modeling the crustal structure in Bangladesh using hydrographic, GPS, and GRACE data. Presenters in this session included: **Taco Broerse** [TU Delft]; **Michel Diament** [Institute Physique du Globe de Paris (IPGP)]; **Gabriele Cambiotti** [University di Milano]; **Ehsan Forootan** [U Bonn]; **Shin-Chan Han** [GSFC and University of Maryland Baltimore County]; **Eric Ivins** [JPL]; **Isabelle Panet** [IPGP]; **Ingo Sasgen** [GFZ]; **Michael Steckler** [Lamont Doherty Earth Observatory]; **John Wahr** [CU]; and **Xiaoping Wu** [JPL].

Cryosphere: This session included a critical review of the accuracy of ice-sheet mass-balance estimates as well as radio occultation data application for atmospheric mass corrections over Antarctica. Because of the close connection between the signals of present-day melt and GIA, several presentations in the **Solid Earth** session also shed light on the cryosphere. Presenters in this session included **Isabella Velicogna** and **Pangaluru Kishore** [both from UCI].

Multidisciplinary: This session included studies on the contribution of Satellite Laser Ranging (SLR) to GRACE science applications, the relationship between the Pacific Decadal Oscillation and Greenland ice melt, water-mass variations in small ocean basins using radar altimetry and GRACE data, the relationship between GRACE data and global hydrological modeling, and concluded with GRACE applications to SLR, the Terrestrial Reference Frame, and the proposed Laser, Relativity and Earth Science (LARES) laser ranging mission. Presenters in this session included: **Minkang Cheng** [CSR]; **Scott Luthcke** [GSFC]; **Annette Eicker**; **Jean Dickey** [JPL]; **Luciana Fenoglio-Marc**; **Jurgen Kusche** [U Bonn]; and **Erricos Pavlis** [UMBC].

Other (non-gravity) GRACE applications: This session focused on such studies as GRACE radio occultation data, GPS occultation measurements and results, and thermosphere density and wind investigations. Also covered were ionospheric electron-density measurements and atmospheric density and accelerometry. Presenters in this session included: **Harald Anlauf** [Deutscher Weterdienst]; **Christina Arras** [GFZ]; **Norbert Jakowski** [Deutsches Zentrum fur Luft-und Raumfahrt (DLR)]; **Hermann Luhr** [GFZ]; **Eelco Doornbos** [TU Delft]; and **Stefan Heise** [GFZ].

GRACE launched in 2002, and is a joint NASA and DLR mission designed to improve our understanding of the Earth's dynamical system by making pioneering measurements of the gravity signals associated with exchange of mass between the Earth system components. The twin GRACE satellites are entering their tenth year of operation, making precise measurements of changes in Earth's gravity field. Over 600 science articles have been published on geodesy, oceanography, hydrology, cryospheric sciences, and other science applications of GRACE data since 2004. ■

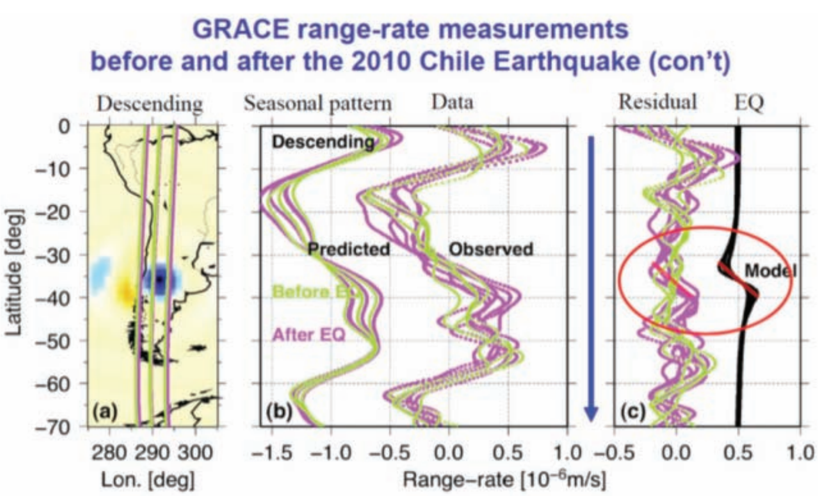


Figure 2. GRACE was able to detect the signal from the February 27, 2010, magnitude 8.8 earthquake near Maule, Chile [*left*]. Both the predicted and observed range rate (in microns/sec) between the twin GRACE satellites just before [*dark lines*] and just after the earthquake [*light lines*] are shown [*middle*] as well as the modeled difference between the two [*right*]. Note that these results show that GRACE is sensitive enough to detect changes on the order of 0.1 microns/sec in the approximately 180 km intersatellite distance. **Credit: Shin-Chan Han** during the Solid Earth session

Seeking Feedback and Improvement, NASA's Earth Data System Earns Praise

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

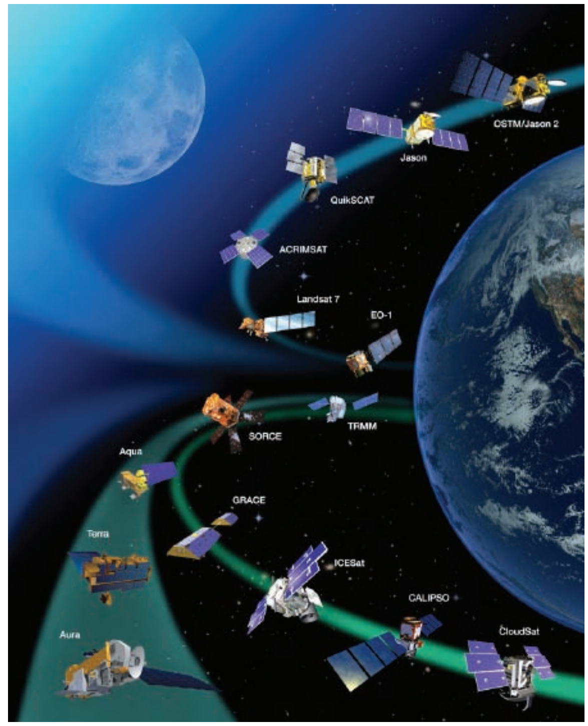
If you're distributing 412 million data products in a year to more than 1.1 million users, how do you ever make sure people are getting what they want? The Earth Observing System Data and Information System (EOSDIS) Project, based at Goddard Space Flight Center (GSFC), came up with a simple formula: **They ask.**

EOSDIS is the network of Earth science data centers that process, store, and make available the trove of data from NASA's past and current Earth-observing satellites. For the past seven years, EOSDIS management has collected thousands of responses from users of its system as a way to both gather *metrics* and improve on its delivery. EOSDIS works with the American Customer Satisfaction Index (ACSI) to systematically track its standing and progress through the eyes of its users.

In the recently released ACSI ratings for 2010, EOSDIS achieved a customer satisfaction score well above the standard for government agencies and even higher scores in several key categories. EOSDIS scored a 77 on a scale of 0–100, while the government benchmark is 65. EOSDIS has maintained scores in the high 70s over the past several years.

"This accomplishment is particularly noteworthy given its consistency, even though customer expectations rose during that period," said **Ron Oberbillig**, Chief Operating Officer of the Federal Consulting Group, the executive agent within the federal government that works with ACSI on behalf of all agencies. Oberbillig particularly lauded EOSDIS for scores in the upper 80s when customers were asked about their likelihood to use the data centers in the future and willingness to recommend the data centers to colleagues.

"We use the ACSI surveys as a way to measure our performance, but also as a way to keep improving on what we do," said **Jeanne Behnke**, EOSDIS Deputy Project Manager for Operations at GSFC.



EOSDIS enables the collection of Earth science data from EOS spacecraft. As NASA's Earth science data system, EOSDIS provides command and control, scheduling, data processing, and data archiving and distribution services for EOS missions. **Credit:** NASA/ **Jenny Mottar**

Behind the Scenes

Satellites have ushered in a new era of Earth science in the past few decades. A constantly orbiting fleet of NASA satellites keeps its sensors trained on our blue planet—capturing the intricacies of its atmosphere, the seasonal cycles of plant growth and sea ice, and the patterns in ocean circulation and temperature.

EOSDIS manages constant streams of data for scientists to dissect and discover new knowledge about how our planet's dynamic systems work and interact with one another. But before any scientific investigation can begin, the raw data itself must be received, stored, processed, and made available. It's a process that often occurs behind the scenes, but ultimately enables all the NASA-related studies of Earth and its climate. EOSDIS manages this flow of information—from satellites in space to data processing facilities to a scientist's desktop—with a network of 12 Earth science data centers in the U.S. These Earth science data centers are located at NASA centers or partner institutions, and specialize in specific types of datasets, such as snow and ice, atmospheric, or ocean data.

NASA's Earth Observing System (EOS) was devised to make long-term, comprehensive measurements of Earth's interrelated systems—to capture their fundamental nature and any natural or man-made changes. In the 1990s, EOS identified 24 key measurements of Earth systems, and EOSDIS manages the gathering and distribution of those measurements from end to end—from command and control of several satellites, to coordination of data gathering through ground stations the world over, to the distribution interface on NASA websites where scientists can download data.

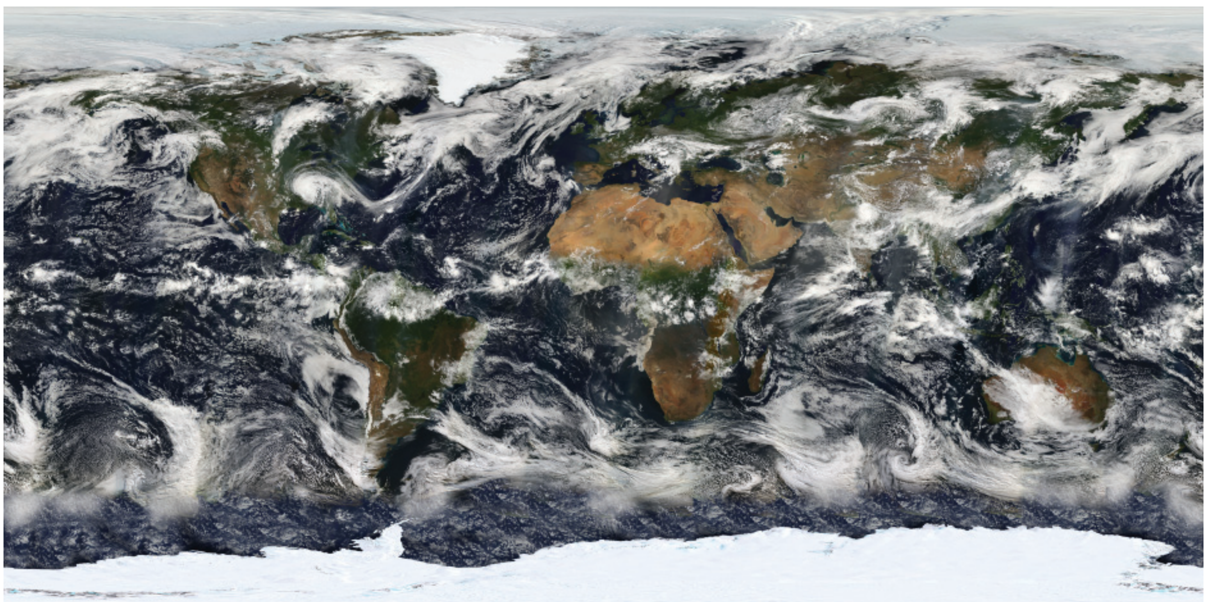
The wide-ranging effort essentially takes a long-term measure of the scope of Earth's land, atmosphere, and ocean systems. While EOS is only about 15 years old, these data records will become more valuable as they capture a longer period of time and more natural and man-made variability in the various Earth systems. That makes the EOSDIS task of not only processing but also archiving all NASA data a vital component to the future of Earth science.

Moving Forward

"Likewise, the annual use of the ACSI survey will become more valuable to EOSDIS over time, as the organization can see how users respond to changes prompted by their comments," EOSDIS outreach manager **Carol Boquist** said. The ACSI score is certain to remain a key metric for an organization whose goal is to make as much data available in as easy a manner as possible.

"At our core, we are delivering an extensive array of products to a national and international base of scientists, researchers, educators, and the general public," Boquist said. "With new data products always coming online and our users' needs constantly changing, the only way to make sure we're succeeding is to ask."

NASA's Earth Observing System has a website that has sections specifically written for scientists, educators, kids, or media and press. For more information about EOSDIS, visit: *eospso.gsfc.nasa.gov/*. ■



NASA's Earth Observing System Data Information System (EOSDIS) manages the constant streams of observational data from the agency's Earth-observing satellites. This composite image is compiled from data captured on July 11, 2005, by the Moderate-Resolution Imaging Spectroradiometer (MODIS). MODIS data—from instruments on satellites Terra and Aqua—represent just a fraction of the Earth observations that EOSDIS manages on a daily basis. The organization, which supplies data to more than a million users worldwide, was recently recognized by the American Customer Satisfaction Index (ACSI) for a high customer satisfaction score. **Credit:** MODIS/NASA Earth Observatory

JPL Airborne Sensor to Study 'Rivers in the Sky'

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

They're called *atmospheric rivers*—narrow regions in Earth's atmosphere that transport enormous amounts of water vapor across the Pacific or other regions. Aptly nicknamed "rivers in the sky," they can transport enough water vapor in one day, on average, to flood an area the size of Maryland 1 ft (0.3 m) deep, or about seven times the average daily flow of water from the Mississippi River into the Gulf of Mexico. The phenomenon was the subject of a recent major emergency preparedness scenario led by the U.S. Geological Survey (USGS), *ARk-Storm,* that focused on the possibility of a series of strong atmospheric rivers striking California—a scenario of flooding, wind, and mudslides the USGS said could cause damages exceeding those of Hurricane Katrina in 2005.

NASA's *Global Hawk* soars aloft from Edwards Air Force Base, CA, on a functional check flight of the WISPAR aircraft payload system and science instruments. **Image credit:** NASA Dryden Flight Research Center

While atmospheric rivers are responsible for great quantities of rain that can produce flooding, they also contribute to beneficial increases in snowpack. A series of atmospheric rivers fueled the strong winter storms that battered the U.S. West Coast from western Washington to Southern California from December 10–22, 2010, producing 11–25 in (28 to 64 cm) of rain in certain areas. The atmospheric rivers also contributed to the snowpack in the Sierras, which received 75% of its annual snow by December 22, the first full day of winter.

NASA scientists, aircraft, and sensors recently took part in a National Oceanic and Atmospheric Administration (NOAA)-led airborne field campaign to study atmospheric rivers and to improve our understanding of how they form and behave and evaluate the operational use of unmanned aircraft for investigating them.

Called Winter Storms and Pacific Atmospheric Rivers (WISPAR), the field campaign, ran from February 11–February 28. In addition to studying the characteristics of these rivers in the sky, the campaign was intended to aid NOAA in potentially conducting offshore monitoring of atmospheric rivers to aid in future weather predictions.

A NASA *Global Hawk* unmanned aircraft, operated out of NASA's Dryden Flight Research Center in Southern California, departed Dryden Friday morning, February 11, on the campaign's first science flight. The 24-hour flight studied an atmospheric river that developed in the Pacific Ocean off Hawaii that appeared as though it would impact the Oregon-California coast. Aboard the *Global Hawk* were new weather reconnaissance devices called *dropsondes* developed by the National Center for Atmospheric Research (NCAR) that take temperature, wind, and other readings as they descend through an atmospheric river. Also aboard was an advanced water vapor sensor—the High-Altitude Monolithic Microwave Integrated Circuit Sounding Radiometer (HAMSR)—created by NASA's Jet Propulsion Laboratory (JPL).

The remote-sensing HAMSR instrument analyzes the heat radiation emitted by oxygen and water molecules in the atmosphere to determine their density and temperature. The instrument operates at microwave frequencies that can penetrate clouds, enabling it to determine temperature, humidity, and cloud structure under all weather conditions. This capability is critical for studying atmospheric processes associated with bad weather, like the conditions present during atmospheric river events.

HAMSR Principal Investigator **Bjorn Lambrigtsen** of JPL says the instrument—the most accurate and sensitive of its kind in the world—will help scientists better understand these unique weather phenomena.

"The WISPAR campaign is intended to study the concentrated streams of tropical moisture that sometimes get connected with cold fronts and winter storms approaching the U.S. West Coast—sometimes called the "pineapple express," since they often originate near Hawaii—which can result in very intense rain events," Lambrigtsen said. "HAMSR, flying on NASA's unpiloted *Global Hawk* well above the weather but close enough to get a much more detailed picture than is possible from a satellite, will be used to map out this phenomenon and answer scientific questions about the formation and structure of these systems."

NASA's *Global Hawk* is an ideal platform from which to conduct WISPAR science because it is able to fly long distances, stay aloft for more than 24 hours, and travel at high and low altitudes that could be dangerous for humans. Lambrigtsen was at Dryden in the *Global Hawk* Operations Center during the flights, using data from the sensor and other information to adjust the *Global Hawk's* flight track, as necessary, to optimize the sampling of the atmospheric rivers.

During the flights, the public was able to monitor the progress of the WISPAR science flights in real time on a WISPAR version of JPL's hurricane portal website. The site displayed the most recent satellite images, the *Global Hawk* flight track, and a real-time subset of HAMSR data.

For more information about WISPAR, visit: *www.noaanews.noaa.gov/stories2011/20110210_atmosphericrivers.html*. For more on HAMSR, see: *microwavescience.jpl.nasa.gov/instruments/hamsr/*.

CALIPSO Spies Polar Stratospheric Clouds

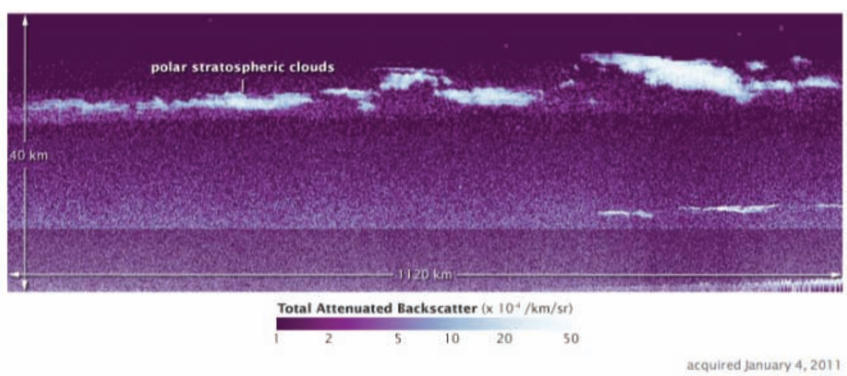
NASA's Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) satellite was in the right place at the right time in early 2011. On January 4, while flying past the east coast of Greenland, CALIPSO caught a top-down glimpse of an unusual atmospheric phenomenon—*polar stratospheric clouds* (PSCs), also known as *nacreous clouds*.

In the extremely low temperatures of the polar stratosphere in winter, nitric acid, and small traces of water vapor condense into clouds—primarily below 25 km altitude. When these clouds pass near mountains, atmospheric gravity waves in the lower atmosphere (troposphere) can provide enough vertical lift to push these clouds up to higher altitudes, where they play an important role in the depletion of stratospheric ozone.

The top image was assembled from data from CALIPSO's lidar, which sends pulses of laser light into Earth's atmosphere. The light bounces off particles in the air and reflects back to a receiver that can measure the distance to and thickness of the particle and air masses below. The data were acquired between 4:30 and 4:44 Universal Time on January 4, 2011, as the satellite flew 695 mi (1120 km) from north to south over the Greenland Sea and Denmark Strait, as depicted in the map below.

CALIPSO has observed stratospheric clouds before, but never one this high, says **Mike Pitts**, an atmospheric scientist at NASA's Langley Research Center. This cloud reached an altitude of more than 19 mi (30 km).

The cloud was the result of *mountain waves* in the atmosphere, which form when stable air masses pass over mountains, providing vertical lift. Pitts said mountain wave clouds at such high altitudes are rare because they only form when the jet stream is properly aligned with the edge of the *polar vortex*, a large air pressure system over the poles. The circulating air in the vortex needs to align with the jet stream to allow the gravity waves to propagate to the upper atmosphere. The January 4 cloud was formed when these conditions were met over the mountains of Greenland. **Credit:** NASA's Earth Observatory



in the news

Cleaning the Air Would Limit Short-Term Climate Warming

Adam Voiland, NASA's Earth Science News Team, adam.p.voiland@nasa.gov

An assessment report released in February by the United Nations Environment Program and the World Meteorological Organization shows that reducing emissions of two common air pollutants—black carbon and gases integral to the production of ground-level ozone—could slow the rate of climate change markedly over the next half-century.

For decades, scientists have known that both substances harm human health. More recently, evidence has emerged showing that the particles also affect climate, yet the magnitude of the impact has remained uncertain. Some studies have suggested reducing the pollutants could have a major and immediate climate impact, while others have shown the impact of such reductions would be minimal.

Now a panel of some 70 scientists, led by the Goddard Institute for Space Studies (GISS) climatologist **Drew Shindell**, has reviewed the best available science and concludes that just a handful of measures could yield major benefits in the next fifty years.

A NASA writer caught up with Shindell, who presented findings from the report this week in Washington, D.C. at a meeting of the American Association for the Advancement of Science, to learn more.

What is black carbon, and where does it come from?

Black carbon, or soot, is a type of dark particulate matter produced by the incomplete combustion of fossil fuels, wood, and other biofuels. It's linked to a number of health problems, and it also warms the atmosphere by intercepting sunlight. Black carbon, along with other particles, can come from motor vehicles, residential stoves, forest fires, and certain industrial processes. All in all, it's pretty nasty stuff.

What about ozone?

Ozone is a reactive gas that exists high in the stratosphere, as well as much nearer to and at the surface in the troposphere. Reactions between sunlight and certain precursor gases—especially methane, nitrogen oxides, volatile organic compounds, and carbon monoxide—produce ozone, which is a significant component of smog.

Why did you focus your attention on two substances—black carbon and methane?

What we really wanted to do was to look at substances that affect both air quality and climate negatively. There are many types of gases and particles in the air: some affect climate, some health, some neither, and some both. We wanted to look just at the substances that damage human health and also cause warming to explore ways to reduce the impact of both problems simultaneously. Of all the pollutants, reducing black carbon and methane, a key precursor to ozone, fit the criteria best.

Drew Shindell Credit: Chaim Jaskoll

So you tried to sort out the impact of eliminating a certain percentage of black carbon and ozone from the atmosphere?

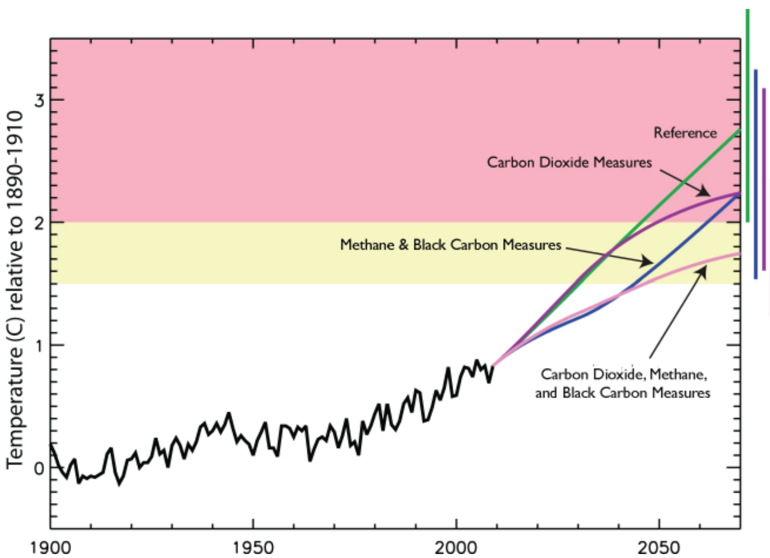
Not exactly. Studies that say what happens if we reduce x percent of black carbon from the air aren't very useful for policy makers because, in most cases, black carbon is co-emitted with other particles that can have opposing effects. What we really need to know is not the percent of black carbon that a particle filter can take out of, say, diesel truck exhaust, but what the net effect of putting particle traps on all the world's diesel engines would be for the whole suite of pollutants that diesel engines produce. And we also wanted to know how much emissions control measures like that would influence specific changes such as global temperatures, human health, and crop yields.

What were the control measures that you considered?

We looked at about 2,000 different measures, but there were 16 key measures that we analyzed closely because they likely have the most impact. For black carbon, for example, we looked at the impact that replacing traditional cook stoves with cleaner-burning options, putting particle filters on vehicles, or banning the burning of agricultural waste might have. For ozone, we looked at measures like fixing leaky gas pipes, limiting methane emissions from mines, upgrading wastewater treatment systems, and aerating rice paddies.

Have other research groups looked at specific control measures in the detail that you have?

We reviewed and assessed all the science that's out. However, we found that few groups have looked deeply at the potential impact of widespread use of known control measures, so we decided to do additional analysis and modeling by plugging extensive databases of economic activity information from the International Institute for Applied Systems Analysis into global aerosol–chemistry–climate models at GISS and the European Commission's Joint Research Center in Ispra, Italy.



According to modeling conducted by the Goddard Institute for Space Studies and the European Commission's Joint Research Center, controlling emissions of carbon dioxide is the only way to limit global warming in the long-term. In the next two decades, however, limiting emissions of black carbon and methane could have a significant impact. Limiting emissions of carbon dioxide, black carbon, and methane would have an even stronger short- and long-term impact. **Credit:** UNEP/Shindell

What did you find? Would reducing black carbon and ozone have a significant climate impact?

The answer is unequivocally yes. For climate, putting control measures in place could eliminate about half the warming we'll otherwise face over the next 40 years.

Does that mean reducing carbon dioxide isn't important?

No, not at all. Over the long-term, carbon dioxide increases are the primary driver of climate change. In order to mitigate climate change, there is no way we can ignore or overlook carbon dioxide. But we could make a major dent in climate change in the near term by controlling black carbon and ozone.

What about public health and agriculture?

Again, an unequivocal benefit. We estimate that adoption of the 16 control measures we considered would save about two million lives a year and save 50 million tons of crops a year.

Are there particular regions that would benefit most from the control measures you studied?

The Arctic is one of the regions where we have some of the largest impacts. A lot of pollution makes its way to the Arctic from the Northern Hemisphere. Black carbon not only warms the atmosphere, but it also darkens the surface of snow and ice, which causes them to melt faster than they would otherwise. We found that these 16 control measures could mitigate about two-thirds of the warming we'll likely otherwise see in the Arctic over the next half-century. We found the health and agricultural benefits would be greatest in Asia.

What surprised you most about your latest findings?

I found it remarkable that for incomplete combustion, which gives you black carbon, a group of just nine measures was able to pull down the emissions by about 70 to 80%. And all of the technologies already exist. There's no technological barrier whatsoever to reducing black carbon.

How do you hope people react to your results?

In an ideal world, I would say people would look at the results and say, wow, doing these kinds of measures will produce major benefits. I hope that some of the spirit and will people have to deal with climate change can energize us to improve air quality as well. Many nations are already pursuing many of these measures for air quality, but perhaps the recognition that there's a climate impact as well will help prod nations, states, and cities to take air quality more seriously.

What institutions were involved in the preparation of the report?

The United Nations Environment Program and the World Meteorological Organization convened the assessment, which was coordinated by the Stockholm Environmental Institute in York, U.K. and led by scientists from NASA GISS; the European Commission's Joint Research Center in Ispra, Italy; the Asian Institute of Technology in Bangkok, Thailand; Scripps Institute of Oceanography in San Diego; and the Catholic University of Chile in Santiago, Chile. ■

EOS Scientists in the News

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

Greener Climate Prediction Shows Plants Slow Warming, January 3; *Greenhouse Management.* Scientists including **Lahouari Baunoua** (NASA GSFC) showed that the additional growth of plants and trees in a world with doubled carbon dioxide levels would create a cooling effect in the Earth's climate.

Saving Water, One Field at a Time, January 6; *Technology Review (MIT).* NASA researchers including **Rama Nemani** (NASA ARC) have developed a computer program to help farmers better manage irrigation systems in real time; the software uses data from NASA satellites, local weather observations, and wireless sensor networks installed in agricultural fields to calculate water balance across a field and provide farmers with information on crop water needs and forecasts that can be accessed from computers or handheld devices.

La Niña Weather System Battering Australia, but California is Untouched So Far, January 13; *Los Angeles Times*. New satellite data released by NASA shows that the Pacific Ocean is in the grips of one of the strongest La Niña weather systems in the last 50 years, bringing deadly flooding to Australia; **Bill Patzert** (NASA JPL) notes that California has had a dry year except for one "freak week" in December when a strong jet stream from the Gulf of Alaska pounded Southern California with almost nonstop rain.

Region: Fire Agencies Benefiting From NASA Technology, January 19; *The Press-Enterprise (San Bernardino County).* NASA used technology developed by a group led by **Vince Ambrosia** (NASA ARC) that employs sophisticated thermal-imaging sensors affixed to the wing of aircraft to help California firefighters map the movement of blazes in real time and to quickly dispatch ground crews where they are needed most.

Greenland of 1770s Gives Clues to Chill Winters, February 9; *Reuters*. The icy winters suffered by Europe and North America for the last two years contrast with unusually mild weather in the Arctic, but **James Hansen** (NASA GISS) says that whether these last two years were a fluke or not will not be known until more years have passed.

2010 Ties Record for Warmest Year Yet, February 12; *Science News*. 2010 has tied with 2005 as the hottest year on record, according to two new studies; **Gavin Schmidt** (NASA GISS) notes that the baseline is getting warmer every year, and offers his prediction for a slight cooling in 2011 due to La Niña.

NASA Helps Airplanes Avoid Storms, Turbulence, Delays, February 16; *EarthSky*. When it comes to flight delays and cancellations, the main culprit is the weather, according to **John Murray** (NASA LaRC), who said Earth-orbiting satellites are helping scientists understand clouds, aerosols, and atmospheric chemistry, all of which play a role in creating Earth's weather and climate.

NASA Climate Change Study Back on the Launch Pad, February 17; *dailypress.com.* Engineer and project manager **Michael Cisewski** (NASA LaRC) and researchers at Langley are testing the Stratospheric Aerosol and Gas Experiment (SAGE III). If all goes well the satellite will join the International Space Station in 2014, and be used to scan sunrises and sunsets to measure greenhouse gases.

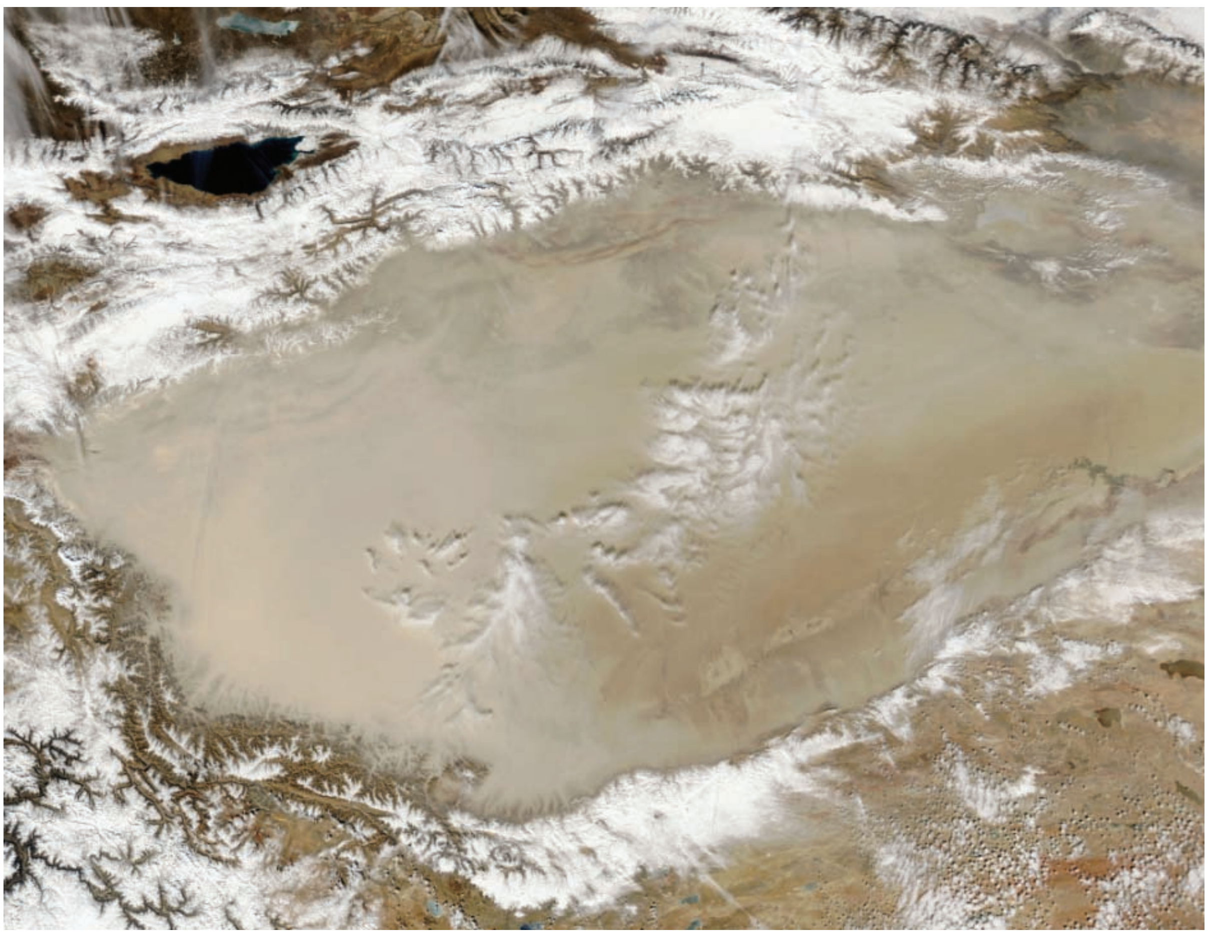
Small Nuclear War Could Reverse Global Warming for Years, February 22; *National Geographic News*. Even a regional nuclear war could spark "unprecedented" global cooling and reduce rainfall for years, according to research presented by **Luke Oman** (NASA GSFC) and colleagues at the meeting of the American Association for the Advancement of Science in Washington, D.C.

Cutting Black Carbon and Methane Promises Immediate Climate Change Impacts, February 22; *Scientific American*. **Drew Shindell** (NASA GISS) coordinated an international team that wrote the new U.N. report that suggests placing strict limits on a handful of common air pollutants could pay big dividends for efforts to limit climate change, improve public health, and increase agricultural productivity.

Why are Americans So Ill-Informed About Climate Change?, February 23; *Scientific American*. Scientists including **Gavin Schmidt** (NASA GISS) and journalists at the annual meeting of the American Association for the Advancement of Science discussed why the global research consensus on human-induced climate change remains contentious in the U.S.

The Mysterious Rumble of Thundersnow, February 27; *Lake County News*. NASA atmospheric scientists including **Walt Peterson** (NASA MSFC) got an unexpected chance to study a curious phenomenon called "thundersnow" when a recent storm unleashed it right over their heads.

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



Dust blew over the Taklimakan Desert for the third consecutive day on March 14, 2011. The Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Aqua satellite took this picture the same day. A nearly uniform veil of translucent dust hovers over the desert, especially its western half. The thin haze of dust along the desert's western margins—with well-defined valleys discernible underneath the dust—suggests that shifting wind patterns blew some of the dust back toward the west after it was airborne. The abundant sand dunes of the Taklimakan Desert provide ample material for dust storms. The dust often blows eastward over China, sometimes traveling as far as the Pacific Ocean. **Credit:** NASA's Earth Observatory and MODIS Rapid Response Team

NASA Science Mission Directorate – Science Education Update

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Earth Science Week 2011: Our Ever-Changing Earth (Oct. 9-15)

The American Geological Institute is pleased to announce the theme of Earth Science Week 2011: *Our Ever-Changing Earth.* This event will engage young people and the public in learning about the natural processes that shape our planet over time. Earth Science Week 2011 materials and activities will show how evidence of change can be found everywhere, from the ground beneath our feet to the oceans and atmosphere around us.

Earth Science Week offers opportunities to discover the Earth sciences and to engage in responsible stewardship of the Earth. The program is supported by the U.S. Geological Survey, the American Association of Petroleum Geologist (AAPG) Foundation, the U.S. Department of Energy, NASA, the National Park Service, Exxon Mobil, the Environmental Systems Research Institute (Esri), and other major geoscience groups. To learn more, please visit: *www.earthsciweek.org*.

Videos From NASA'S Global Climate Website

Earth: The Water Planet, *Frozen Earth*, and *Majestic Planet*, along with many others, are all available on the NASA Global Climate Change site at: *climate.nasa.gov/ClimateReel/*. Each video explores a different aspect of climate change, and encourages the viewer to explore the topic further.

MY NASA DATA: Scientist Tracking Network – Grades 8-9

This series of lessons is designed to answer the question: *How can we use data from NASA satellites to pinpoint a geographic location?* Students participate in a problem-based unit to investigate the relationships among three data sets located on the MY NASA DATA website. They will create products that discuss the relationship of surface irradiance to season and surface temperature. They will also compare total column ozone levels recorded at different latitudes. The lessons can be accessed at: *mynasadata.larc.nasa.gov/unit_lessons.html.* ■

EOS Science Calendar

April 26–28, 2011
CERES Science Team Meeting, Newport News, VA. URL: *ceres.larc.nasa.gov/ceres_meetings.php*

April 26–29, 2011
NASA Sounder Science Team Meeting, Caltech Beckman Institute Auditorium, Pasadena, CA. URL: *airs.jpl.nasa.gov/meetings/science-team-pasadena/*

May 3–5, 2011
SMAP Cal/Val Workshop #2, Oxnard, CA. URL: *smap.jpl.nasa.gov/science/workshops/*

June 6–8, 2011
CloudSat/CALIPSO Science Team Meeting, Montreal, Quebec, Canada.

June 6–9, 2011
39th ASTER Science Meeting, Tokyo, Japan.

September 13–16, 2011
SORCE Science Meeting: Symposium on the Decadal Variability of Earth's Climate, Solar Irradiance, and Sun-like Stars, Sedona, AZ. URL: *lasp.colorado.edu/sorce/news/2011ScienceMeeting/index.html*

Global Change Calendar

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

May 1–5, 2011
American Society for Photogrammetry and Remote Sensing 2011 Annual Conference, Milwaukee, WI. URL: *www.asprs.org/milwaukee2011/*

May 16–19, 2011
Year of Tropical Convection (YOTC) International Science Symposium and 8th Asian Monsoon Years (AMY) International Workshop, Beijing China. URL: *yotc-amy-2011.csp.escience.cn/dct/page/1*

June 21–24, 2011
Annual Air and Waste Management 104th Annual Conference and Exhibition, Orlando, FL. URL: *www.awma.org/ACE2011/*

June 27–July 8, 2011
XXV International Union of Geodesy and Geophysics General Assembly: Earth on the Edge: Science for a Sustainable Planet, Melbourne, Australia. URL: *www.iugg2011.com*

July 10–15
Gordon Research Conference: Clouds, Aerosols, Precipitation and their Role in Climate and Climate Change, Colby College, Waterville, ME. URL: *www.grc.org/programs.aspx?year=2011&program=radclimate*

August 1–5, 2011
2011 IEEE International Geoscience and Remote Sensing Symposium, Sendai, Japan. URL: *igarss11.org/*

August 30–September 1, 2011
GEWEX Radiation Panel (GRP) Meeting (by invitation), Tokyo, Japan.

September 19–22, 2011
SPIE Europe Remote Sensing 2011 Symposium, Clarion Congress Hotel Prague, Czech Republic. URL: *spie.org/remote-sensing-europe.xml*

October 24–28, 2011
World Climate Research Programme Open Science Conference, Denver, CO. URL: *www.wcrp-climate.org/conference2011/*

December 5–9, 2011
American Geophysical Union Fall Meeting, San Francisco, CA. URL: *www.agu.org/meetings/*

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