EOS SPHERES

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He's Got the Whole World in His Hands

Fifteen years in the making, Changsheng Li's global ecosystem is ready for prime time

SHOULD THE CHINESE GOVERNMENT ever allow it, Changsheng Li would happily go home to help save the country from its own success. His return just might buy our warming planet a bit more time, too.

For 15 years, as China's industrial revolution churned ahead leaving in its wake a profoundly befouled environment, Li – from his adopted home in New Hampshire – developed a unique mathematical model that can precisely simulate greenhouse gas emissions across a variety of terrestrial ecosystems, under any climatic condition, anywhere in the world.

Photo: Changsheng Li

Picturesque scenes like this belie the fact that nearly all the rivers and lakes in the entire eastern portion of China are badly polluted. Changsheng Li would like to return home to help solve this severe environmental problem.

To the non-scientist that might not sound like something to write home about. But in fact, a "biogeochemical" model that can be applied that broadly and accurately is nothing short of revolutionary, and Li plans on contacting some well-placed Chinese officials in hopes of sparking a different kind of revolution.

"I may suggest that they must pay attention to the environment in rural areas and that Americans could provide the best tools and work with them collaboratively to solve their problems," the soft-spoken Li asserts.

With China poised to perhaps overtake the energy-guzzling U.S. as the world's largest emitter of greenhouse gases, any tool that could help lighten the load would benefit that country as well as the planet at large.

For example, the overuse of nitrogen fertilizer, which is widespread in rural China and elsewhere, creates a cascade of environmental problems, including water pollution and increased greenhouse gas emissions.

If a computer model can quantitatively replicate the impacts of environmental conditions on crop growth as well as water and air quality, it can then accurately predict what changes in management practices (fertilization, irrigation, tillage, etc.) will lead to a reduction in greenhouse gas emissions while simultaneously keeping optimum crop yield, soil fertility, and water use and safety.

This is precisely what Li's intricate model does because it is built upon the universal foundations of biological,

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A Star Sensor is Born

MORGAN O'NEILL makes a "V" with two fingers and tips them to the left. The sophomore isn't making a lopsided gesture of peace. O'Neill is illustrating the shape and angle for the opening of a little instrument she and fellow physics major George Clark helped design and test for the upcoming Interstellar Boundary Explorer or IBEX mission.

The V-shape represents the aperture for the star sensor the two students have been working on for nearly two years with the mission's UNH principal investigator Eberhard Möbius and a team of Space Science Center scientists and engineers.

The star sensor will help pinpoint the precise direction that energetic neutral atoms – IBEX's quarry – are hurtling straight into our solar system from the far reaches of space. (Because they are neutral the atoms are unaffected by electric charge or magnetic pull.) With this key directional information from the star sensor, the data on the interstellar flow will be much more useful.

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Photo: David Sims, UNH-EOS

Undergraduates Morgan O'Neill (left) and George Clark helped design and build the star sensor for the IBEX mission.

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Associate Director: David Bartlett
Editor: David Sims
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Space Science

Star Sensor

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Listening to O'Neill and Clark describe their work on the sensor makes it clear why talented undergraduates can be tasked with key responsibilities for a fast-paced project aiming to deliver instruments that will help "map" the boundary that separates our solar system from interstellar space.

"The star sensor is an optical column with a photomultiplier tube at the base of it that reads incoming photons and turns them into a voltage signal," O'Neill pours forth. "And the most important aspect of the sensor, what makes it so useful, is that it has a 'broken' V aperture, so it has two distinct openings about 30 degrees apart."

And it's the "broken" part that is, in O'Neill's characteristically enthused delivery, "so cool."

The IBEX star sensor showing the V-shaped aperture.
Photos: David Heirtzler, UNH-SSC

Working with Möbius, Clark and O'Neill helped design the V-shaped aperture with one large opening at the top and a smaller opening at the bottom. This seemingly trivial design feature simplifies the math required to interpret the resulting data by, in essence, doubling the amount of data collected.

"Every star will 'blip' twice," says O'Neill referring to the energy transferred from each passing star "seen" by the star sensor. In other words, the sensor on the spinning IBEX spacecraft will take two distinct readings of a single star, which will nail the star's position in the sky. The end result of this will be a dataset with which to accurately mark the direction of the gas flow through the boundary between the region where the Sun's magnetic bubble or heliosphere edges into the interstellar medium or the "space between the stars."

Part of IBEX's goal is to be aloft when the Voyager 2 spacecraft punches through the ever-shifting termination shock within the next few years. And so it is a project in a hurry.

Despite the pace, Clark and O'Neill had lots of room for exploration and growth as budding scientists. Möbius, EOS engineers, staff scientists, and even the students' math professor have entertained many questions and given much guidance as the undergraduates encounter new challenges, some of which have not yet or will not be covered in a classroom setting.

Says Clark, "Dr. Möbius is a very patient man. He does a great job understanding your learning ability, making sure you get up to speed, and explaining things very effectively. His door is always open."

"…I had no idea about the breadth and depth of research in which students could get involved."

Both undergraduates note that UNH was *not* their first choice for college for the simple reason that they didn't think there would be any hands-on research available to undergraduates.

Says O'Neill, "Before I visited UNH and walked around Morse Hall I had no idea about the breadth and depth of research in which students could get involved."

Last summer the two undergraduates presented their IBEX work at a poster session of the annual meeting of the Solar Physics Division of the American Astronomical Society, held at UNH.

"We defended our poster at a national conference. That was kind of like getting published, which is so cool," O'Neill says.

O'Neill will continue her IBEX work after completing her sophomore year when she goes to Warsaw, Poland under a Summer Undergraduate Research Fellowship. There she will help mission team members working on software that relates the star sensor data to the position of stars, planets, and the moon in the sky.

Clark hopes to go to Germany in the summer of 2008 on an International Research Opportunities Program project to tap into the rich data set on sky background "noise" (nuisance data that needs to be weeded out for the star sensor to accurately take readings), accumulated at the Ruhr Universität Bochum, Germany, – Möbius' former alma mater. -DS

From the Director

Education, Research, and Globalization

AS WE WELL KNOW today, the world *is* flat. On a global scale it is digitally connected and barrier-free. For the United States, and New England in particular, this means that if industry can move offshore it will, or already has. This is nothing new for New Hampshire; one hundred years ago most of the fabric and leather industries moved "offshore"—to South Carolina.

Today, the educational and R&D "business" generated in New England and New Hampshire offers a promising pathway toward a non-flat Earth business scenario with intrinsic national and international appeal: globalization in demand, not in supply.

While UNH certainly does not sustain the entire regional effort, the $100-million research enterprise at the university is, in fact, an extraordinary pump-primer for high technology industries in our region. For example, NASA's recently launched twin STEREO spacecraft have onboard the PLASTIC instrument (Plasma and Suprathermal Ion Composition) built in the Space Science Center at EOS. That six-year effort involved nearly 100 vendors and subcontractors—most of them based in New England and many in New Hampshire. Moreover, the fact that our students were directly engaged in PLASTIC's development and this R&D enterprise is another multiplier—when they graduate they will become part of this new fabric, a fabric that does not depend upon water power but, rather, upon brain power and innovation. The signs are encouraging, as evidenced by a growing collaboration with BAE Systems, Inc. and other technology firms.

Some say that research costs the university money. Perhaps. Like everything else of value, there is a cost. But for UNH the end result is a net positive cash flow, and it returns far more than dollars: it sets a direction and the foundation for the emerging business of New Hampshire—education and research and development—that cannot be sent offshore. EOS is proud of the role it plays in this new future for New Hampshire and her students.

– Berrien Moore III

He's Got the Whole World in His Hands – continued from page 1

physical, and chemical principles and can thus be applied with confidence universally. Is it any wonder it took 15 years to bring such a tool to maturity?

Called the Denitrification-Decomposition model or DNDC for short, the model only recently evolved to the point where it was posted on the Internet to be downloaded for free. Scientists worldwide have validated and calibrated the model through many independent observations and published their results in peer-reviewed journals.

Says Li, "More and more publications have demonstrated the applicability of the model for different terrestrial ecosystems, such as cropland, grassland, forests, or wetlands, so we have moved from development to application of this model, and we are directly serving the needs in different countries," including the U.S. and Canada, Australia and New Zealand, Russia, European nations, India, and China.

While Li has been invited to lecture at universities in China about his model, the powerful tool has yet to be applied broadly across a nation plagued with a wide spectrum of growing environmental ailments.

Photo: Changsheng Li

Farmers rake their harvest into a road where vehicle tires help the threshing process, much to motorists' consternation.

For example, one of the most serious environmental problems is pollution of the countryside. Nearly 100 percent of rivers and lakes are badly polluted in the entire eastern side of China because farmers overuse fertilizers and pesticides trying to increase crop yield, and due to extensive municipal pollution from the hyper-development taking place from Shanghai to Beijing.

"That means you cannot find a single clean stream in eastern China and many villagers die of cancers due to pollution of the drinking water," says Li. "They have no other options, they must drink from local wells and streams."

Adds Li, who once served as a top administrator of China's fledgling environmental protection agency and still has family, friends, and colleagues in China, "Watching what's happening there is painful."

Li has had to watch from afar because of actions he took in June 1989 in the wake of student protests in Beijing's Tiananmen Square.

At the time, Li, along with his wife Ruilan Lu, was in Washington, D.C. at the behest of the Chinese government being schooled at the U.S. Environmental Protection Agency on how to run a large, government environmental bureau. But after tanks rolled into Tiananmen Square to squash the pro-democracy uprising and many civilians were killed, Li felt compelled to show support for the protesters. After doing so very publicly, Chinese authorities demanded he return home.

"I need to go back to face the environmental challenges, not only for the Chinese people, but for the world as well."

Fearing imprisonment if he returned while at the same time agonizing about the safety and future of his two daughters who had remained in China, Li disobeyed the orders to return and made a new life for himself and his wife in the U.S. After several years of incessant work and the help of many people, the two were reunited with their daughters.

Although exiled from his homeland, Li, who received his Ph.D. in biogeochemistry from the University of Wisconsin, could turn his attention away from administrative duties and back to pure science – specifically, the complex and growing problem of greenhouse gas emissions.

When Li arrived at the UNH Institute for the Study of Earth, Oceans, and Space in 1992 as a research professor, he brought with him the unique biogeochemical model he had been working on for several years. He's been working on it ever since and even though it took 15 years to get the model "on the market," the work will never be done.

"A model is like a running river, everyday it receives freshwater from different sources," says Li adding, "It's like the ancient philosopher said, 'You can never enter the same river twice.'"

And so onward the DNDC flows. When a new scientific finding appears in a journal, into the model it goes. When some bit of data becomes too old or is replaced by something more accurate, the model is updated.

"So the model is improved everyday by scientific findings and comments from users," Li says. "And, because there's a very high demand in different countries to reduce greenhouse gas emissions, governments are watching closely for what kind of model they can use."

Currently, all the nations of the European Union are using Li's model under a program called "NitroEurope" – a five-year project investigating the global nitrogen cycle, a little-known but important cause of global warming, air and water pollution, and biodiversity loss.

Li recently returned from the second annual NitroEurope workshop in Italy where, he says, UNH was nearly a household name. "It was mentioned in the workshop almost everyday because the model was produced here," he says.

Photo: Changsheng Li

Changsheng Li, left with colleagues in 1986. Li started his career as a biogeochemist doing intensive field investigations in rural China where people suffered from endemic diseases and environmental pollution.

Li, a Complex Systems Research Center research professor, notes that, over the years, many people in CSRC were involved in the model's development, including the field investigation, database construction, and model validation and application. Li feels "very fortunate" to have stayed in the U.S. where officials in high-ranking government positions, including people at NSF, NASA, EPA, USDA, and NOAA, had the vision to see this long-term project through.

"It was not always easy to support this model at the beginning because it seemed very theoretical. It was almost like supporting the development of a dream," he says.

With that dream now a reality, Li's model should help sustain or even increase the recent shift in agricultural management from its singular focus on crop yield.

"Now people realize that agricultural practice plays a critical role in protecting our environment because it can release greenhouse gases, pollute lakes, rivers, and groundwater, turn soil to sand, and affect global climate. Building the capacity of modeling prediction is a key step to multi-goal agricultural management," Li says.

As for his next dream, Li is confident it won't take another 15 years before that is realized. "I think China is changing, mainly economically of course, but I hope that someday the political situation will change as well. I need to go back to face the environmental challenges, not only for the Chinese people, but for the world as well," Li says. -DS

From SMART to Finish

Inquiry-based high school science that's out of this world

THE KID with scraggly, shoulder-length hair is wearing a black sweatshirt embossed with a white, bat-winged skull and crossbones and the words "Avenged Sevenfold" – his favorite heavy metal band. He peels off the garment to reveal a black T-shirt advertising the Scandinavian Goth metal/alternative rock band "His Infernal Majesty."

Meet Stephen Wright-Eaton, high school senior, avid alternative music fan, devoted paintball player, and, coincidentally, an expert on the spectral features of mineral-based polyhydrated sulfates on the planet Mars.

At last December's 14,000-strong American Geophysical Union meeting held in San Francisco, Wright-Eaton, along with high school junior Matt Vaillancourt, presented results of the Mars spectral analysis work they've been doing at UNH with professors Barry Rock and Chuck Smith.

The two high schoolers began the work last summer as Project SMART students. With encouragement from Rock and Smith, they continued their project after returning to Oyster River High School (Wright-Eaton) in Durham and Marshwood High School (Vaillancourt) in South Berwick, Maine.

SMART, for Science and Mathematics Achievement through Research Training, is a summer institute that pairs talented high school students with UNH researchers on specific scientific projects. Students focus their research in one of three modules: Bio- and Nanotechnology, Marine and Environmental Science, and Space Science (http://www.smart.unh.edu).

Smith is a solar wind specialist and coordinates the Space Science module. Rock is faculty for the Environmental Science module. The professors took an interdisciplinary approach to create the Mars Remote Sensing project.

Rock, a Complex Systems Research Center botanist, is expert in hyperspectral remote sensing techniques and helped the high-schoolers apply the tools he uses to study forests to their keen interest in analyzing surface features of Mars.

Photo courtesy of NASA

Meridiani Planum

The project culminated in the weeklong trip to San Francisco (made possible with funding support from the New Hampshire Space Grant Consortium) to present their research to, in some cases, renowned scientists doing the very same kind of analysis using data being gathered on or above Mars by surface rovers and satellites.

> *"The work they had done was very substantive and scientifically valid and these are high school students…"*

In their case, Wright-Eaton and Vaillancourt used spectral data derived by an instrument aboard the European Space Agency's (ESA) Mars Express orbiter, called OMEGA, to study the Meridiani Planum region.

The students, who Rock says were more than slightly nervous, figured their work would pale to that of the assembled horde of "real scientists," but Rock and Smith knew better.

"The work they had done was very substantive and scientifically valid and these are *high school* students," says Rock. And so, he adds, it made a lot of sense to find a way to get "the boys" out to AGU to showcase their accomplishments and tout the merits of Project SMART.

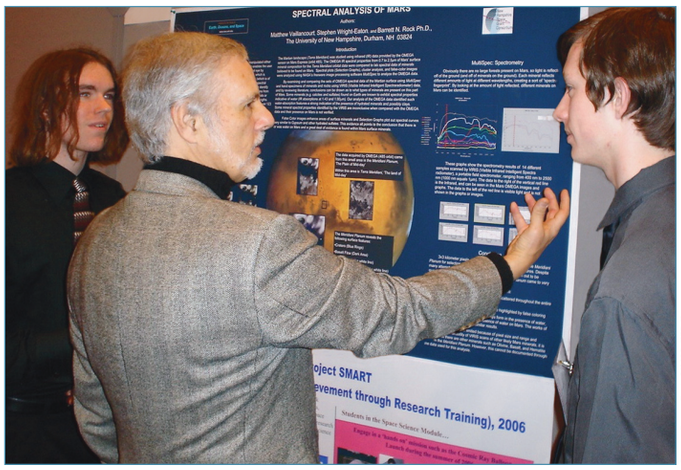


Photo: Barry Rock UNH-CSRC

High-school students Stephen Wright-Eaton (left) and Matt Vaillancourt (far right) discuss their Mars findings with one of the many scientists who viewed their work at the AGU meeting in San Francisco.

At AGU the boys turned more than a few heads and they themselves were taken aback when a team of French OMEGA scientists showed up in front of their poster to ponder the science and ask questions.

"The OMEGA team was amazed that high school students were able to do this and were extremely pleased that ESA's decision to make the Mars data available to the pubic was being put to good use," says Rock referring to the fact that mission data is often proprietary.

Indeed, says Yves Langevin, the instrument scientist of the OMEGA experiment on Mars Express, "I was very supportive of the use of our data for creating interest in planetary science among high school students and was very pleased with professor Rock's success using the data set."

Of the high-schoolers work Langevin adds "They managed to grasp the methodology of working with spectral images, using the spectra for identifying, and then characterizing regions of interest on Mars."

Of the project and the opportunity to conduct research under the wings of university scientists Vaillancourt says, "It helped us, at least to some extent, think like actual scientists – how they approach methods, solve problems."

The high-school students' analysis of Martian spectral data had revealed a wide range of minerals, including some formed by liquid water. To the boys' surprise and delight, an AGU session on the Mars Express mission revealed that the scientists were finding similar results from the data set using similar techniques.

Says Rock, "At one session we heard all this. The boys kept nudging each other as the French scientists explained their findings. It was really wonderful to see them gain confidence and go through this transition from feeling like they'd be laughed at to seeing their findings verified."

Rock stressed to Wright-Eaton and Vaillancourt that, in fact, they had done pioneering work by showing that high school students can both understand the processes of science and become actively involved in them. He adds that this was not lost on the French OMEGA scientists or the stream of NASA scientists who viewed the poster.

"Project SMART is a way of priming the pipeline, if you will, and getting students at an early age interested in science and engineering, which is something NASA will benefit from," Rock notes. -DS

Last Man Standing

EIGHTEEN YEARS AGO, EOS director Berrien Moore was selected by NASA to be a principal investigator for the agency's inaugural Interdisciplinary Science Investigation. Recently, when NASA announced its latest round of IDS awards, Moore once again made the cut – meaning that he is one of only two principal investigators "left standing" from the old days.

Moore and Mark Schoeberl of NASA's Goddard Space Flight Center are the sole principal investigators to have consistently received funding for their teams under the program's many proposal cycles over the years – a legacy that IDS program manager Diane Wickland of NASA characterizes as being "quite remarkable."

Part of NASA's Earth Science Enterprise Earth Observing System, the IDS addresses the primary biogeochemical cycles – water, carbon, nitrogen, and selected trace gases – of planet Earth and considers, in particular, how humans are changing them. The core tools of the work are mathematical modeling and remote sensing.

The current field of investigations is comprised of 60 teams, one of which, "Understanding the Changing Carbon, Nitrogen and Water Cycles in the Earth System," is headed up by Moore.

Perhaps one reason for Moore's perennial success with IDS is his consistent ability to get the right people for the job.

"Berrien has always been good at assembling a team of experts not just from within EOS, which has incredible breadth as a single unit, but also experts from other institutions where appropriate," notes Complex Systems Research Center associate professor George Hurtt.

Hurtt is a co-investigator on Moore's current IDS proposal and has been a team member on several of the last go-rounds, which have also included CSRC team members Scott Ollinger, Bobby Braswell, Xiangming Xiao, Changsheng Li, and Steve Frolking. In addition, scientists from Princeton University, Rutgers University, the University of Colorado, Boulder, and the Marine Biological Laboratory have also been team members. The current project is in partnership solely with Princeton.

Charles Vörösmarty, director of the EOS Water Systems Analysis Group, has been a part of the IDS effort from the beginning as a co-investigator with Moore. Vörösmarty and his group have contributed the water-related data or hydrological models to the larger Earth system modeling work.

For the most recent IDS go-round, Vörösmarty won a separate award as a principal investigator in part, he notes, because the hydrological aspects of this modeling work have over the years matured enough to stand on their own.

"Our early contributions to the IDS project provided support to the terrestrial ecosystem models. But over the years we have branched off a bit and began to articulate water resource and pollution issues for their own sake," Vörösmarty says.

This branching off is part of the natural evolution of the whole IDS Earth system, carbon-cycle investigation Moore's team has been conducting for years. As time passes, tools develop, data accumulates, and the study itself morphs into something more sophisticated. That sophistication can include either a more interdisciplinary *or* independent approach – the latter being the case for Vörösmarty's hydrological emphasis.

For example, as the investigation matured it became clear that the carbon cycle – the focus of the inaugural IDS proposal – was intimately linked to water and nitrogen cycles and, thus, a broader, more interdisciplinary approach to the study was required.

And for the latest award, work on which will begin this summer, the carbon-nitrogen-water cycle work has morphed further and will now be coupled with the whole, vast climate system.

Says Hurtt, "So this idea that the carbon cycle is not a standalone thing but is coupled to other nutrient cycles like nitrogen or water or, now, to the climate at large, is one way in which these projects have matured over the years. The whole field has matured."

The remote sensing aspect of IDS relies on NASA's fleet of Earth Observing System satellites and a variety of onboard sensors. The primary modeling support for the current IDS project comes from the partnership with the NOAA Geophysical Fluid Dynamics Laboratory at Princeton University where one of the world's most robust and sophisticated Earth system models is operated.

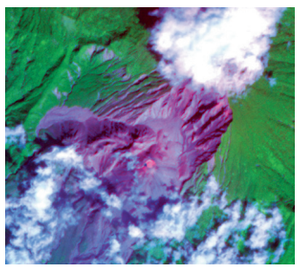
And to answer the kinds of questions being asked, big tools indeed are required. The IDS Earth system investigation is seeking to answer three main questions: what are the past, current, and future global distributions of sources and sinks of CO_2 to the atmosphere; what are the effects of changes in land use, climate, nitrogen deposition, and atmospheric composition on the carbon and climate system; what is the potential of alternative management strategies to avoid, slow, or mitigate adverse change to the Earth system?

Explains Hurtt, "What we're looking for are feedbacks to climate change. As climate starts to change will ecosystems around the world help buffer or amplify and make it happen faster? That's the fundamental scientific question we're getting at."

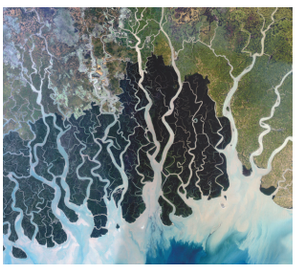
In Vörösmarty's IDS work, his team will continue forging new ground where, instead of being able to make only broad, general statements about the environmental state of entire river basins, specific statements – from models and remote sensing – can now be made about any piece of a river basin as it shifts with seasonal dynamics.

"We've really moved beyond this rather clunky view to something that's very spatially and temporally resolved. That's a very interesting new horizon for the community," he says adding, "And we'd like to lead the community in this kind of work." -DS

NASA Earth Observing Imagery http://earthobservatory.nasa.gov/Observatory/



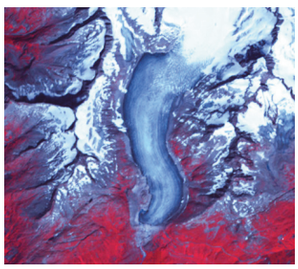
Santa Maria volcano, in Guatemala's Pacific coastal plain taken from NASA's Terra satellite on January 10, 2007. Pink area indicates a hot spot. A plume was released in mid-January 2007.



Stretching across southwestern Bangladesh and southeastern India, the Sundarbans, is the largest remaining mangrove forest in the world. The image was created with NASA's Landsat 7 satellite observations.

Oregon's Columbia River Basin vegetation index as measured on August 27, 2006 by NASA's Terra satellite. Dark green squares are poplar plants, circles are crops watered with pivot irrigation systems.

Australian bushfires in Victoria's Great Dividing Range Mountains captured by the Moderate Resolution Imaging Spectroradiometer on NASA's Aqua satellite on January 11, 2007.



The Rhone Glacier, high in the Swiss Alps, is a primary contributor of water to Lake Geneva. This NASA Terra satellite image shows snow as white, vegetation as red, and water as blue.

A Big Showing at the Big Show

EOS faculty, staff, and students leave a footprint at AGU

IT IS THE MOTHER of all geophysical science meetings and, every year, the UNH Institute for the Study of Earth, Oceans, and Space makes its mark as measured by numbers of faculty, staff, and students attending and presenting, and scientific abstracts submitted. This past year was no exception.

A search of the AGU website by number of abstracts per institution for the 2006 AGU Fall Meeting held last December in San Francisco, shows that UNH, at 268, ranks right up there with the other heavy hitters; CalTech (279), University of California, Berkeley (272), Desert Research Institute (272), Lamont-Doherty Earth Observatory of Columbia University (270), University of Colorado-Boulder (269), University of Arizona (267), Stanford (265), Georgia Tech (263), University of Maryland (259), MIT (201), Harvard University (198), and so on.

And the great preponderance of UNH's 268 abstracts – ranked sixth in the above list – are from EOS researchers.

Of course, the abstract web search by institution is *not* a flawless measure – the search engine picks up similar but unrelated references and thus bloats the numbers a bit – but it is at least democratic; the same flaws apply to everybody.

People-wise, despite that fact that there were some 14,000 scientists milling about the gargantuan Moscone Center, it was easy to spot a familiar EOS face among the assembled horde.

One of those faces was EOS and Department of Natural Resources associate professor George Hurtt. "Big numbers out there means a lot of activity here," Hurtt says putting into context the large UNH-EOS presence at AGU. He adds, "For us to have numbers comparable to Berkeley, Harvard, etcetera, says to me that in terms of Earth system science activity we're comparable to some of the biggest and most well-known universities in the country." And beyond.

Charlie Vörösmarty, EOS and Department of Earth Sciences research professor and one of several faculty who chaired sessions at AGU, asserts that while EOS's national reputation is stellar indeed, the institute is perhaps even better known outside the U.S. because of its unique and longstanding interdisciplinary, Earth system science approach – an approach that has a longer history outside the U.S.

"I circulate in lots of international circles and we are quite well known in these circles," Vörösmarty says. He adds, "By global standards we are really one of the major Earth system science players on the scene."

The AGU "gathering of the clans" or "Boy Scout jamboree of science," as Vörösmarty puts it, is at once inspiring and overwhelming according to many who attend the extravaganza.

Chuck Smith, Space Science Center and Department of Physics research professor, likens the whole experience to "drinking from a fire hose."

"You really get hit with a lot, but it's not so much learning in detail – like you do reading papers – at AGU sessions you're learning what people are doing and what kind of stuff they're getting out of it," Smith says.

One thing Smith got out of attending AGU was a better sense of how his own work was being received by the scientific community. "I published two papers this past year and I had no indication that anybody had even read them," he says. However, Smith notes with delight, at a space physics session the very first morning, even before he got to make his presentation late morning, "More than half of the speakers had used my work in their presentations. It just completely changed my view of how this work is being received, people had really caught onto it."

From a student perspective, the AGU experience is invaluable and, as Hurtt notes, the number of graduate and undergraduate students from UNH-EOS rises every year.

In addition to his presentation on the value and progress of the Research & Discover program, Hurtt had six R&D students present at AGU this year, including four undergraduate interns. Last year he invited just two graduate students.

"The idea was," Hurtt notes, "that if they got a paper accepted by AGU as lead author we'd pay their way. At the undergradate level, four of the nine I had in the program last summer took me up on the deal, and the significance of that is that it shows ambition on their part and the quality of the work they achieved."

> *"To have a student be the lead author and stand up in front of a roomful of scientists and professors and say, 'This is what I did' that's the mission of our university."*

And that, says Hurtt, is what it's all about. "To have a student be the lead author and stand up in front of a roomful of scientists and professors and say, 'This is what I did,' that's the mission of our university."

Furthering that mission, Hurtt adds, R&D will be able to double its number of graduate students in the wake of recently winning a three-year award in excess of $275,000 from the UNH Office of the Vice President for Research." -DS

Faculty/Research News

Eberhard Möbius reports that hardware development for the IBEX mission is in the final stages. The IBEX-HI collimator was delivered to the Los Alamos National Lab and delivery of the IBEX-Io Time-of-Flight unit, the collimator, and the star sensor to the University of Bern for integration and full sensor calibration is slated for March. "We have successfully tested and calibrated these units at UNH over the past few months. The IBEX project is moving forward to a launch in June 2008," Möbius notes.

Ocean Process Analysis Laboratory director **Janet Campbell** has been appointed a faculty fellow at the College of Engineering and Physical Sciences. As the college's first associate dean for research, Campbell works directly with the department heads and individual faculty members to promote research and plan the development of research programs throughout CEPS. In the wake of Campbell's part-time appointment, research associate professor

Doug Vandemark has assumed new duties as associate director of the Coastal Ocean Observing Center within OPAL.

George Hurtt, **Charlie Vörösmarty** (and former Ph.D. student Manoel Cardoso) were among the authors of the Millennium Ecosystem Assessment awarded the 2005 Zayed International Prize for the Environment. Called for by United Nations Secretary-General Kofi Annan in 2000 and carried out between 2001 and 2005, the assessment cataloged the condition of the globe's ecosystems and their life-giving services.

Space Science

GRAPE Seed

An experiment hitches a ride to "near space" in hopes of a dedicated mission

WHEN THE BALLOONWINDS mission finally lifts off from the desert sands in New Mexico in mid-May, a little hitchhiker named "GRAPE" with distinctly different scientific objectives will be onboard the big gondola. What the two experiments do have in common is the need for measurements high above Earth's atmosphere and the extreme difficulty of making those measurements.

Indeed, says Mark McConnell, principle investigator for the Gamma-ray Polarimeter Experiment or GRAPE project, "We've been working on developing this technology for roughly a dozen years, trying to convince the X-ray and gamma-ray astronomy community that this is worthwhile research. And that's been difficult in large part because this is such a tough measurement to make."

But McConnell and colleagues, including Peter Bloser, John Macri, and Jason Legere (along with several engineers) are close enough and confident enough that they can piggyback onto Balloonwinds for the 12-hour ride up into "near space" to test the detectors – called "polarimeters" – they've built to make those tricky measurements. The ultimate goal, after this engineering test flight, is a balloon launch with a dedicated payload – an array of detectors (like the one pictured) for studying polarized X-rays.

Natural, visible light, one form of electromagnetic radiation, has no particular direction of vibration. However, under certain conditions, radiation is produced that does have a preferred direction of vibration, and this is called "polarized" light.

Astronomical studies of polarization can provide useful insights regarding the processes by which the radiation is generated. The principal scientific objective of GRAPE is to look at the polarized X-rays and gamma-rays emitted by solar flares and gamma-ray bursts. These data will serve as a probe of the region where the radiation is generated. In particular, the data should provide the ability to measure the magnetic field structures in the source.

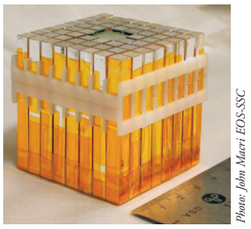


Photo: John Macri EOS-SSC

This array of gamma-ray sensitive material, called "scintillators," make up a single GRAPE detector.

According to McConnell, the polarimeters need to be at high altitude to get above the gamma-ray absorbing effects of the atmosphere and get a true measure of the "background noise" the detectors will encounter.

"You want to know what the background noise is at that height so you can determine if the instrument can really detect the signal we're after," McConnell says.

The Balloonwinds mission will be the first attempt to measure both high- and low-altitude atmospheric winds in an effort to vastly improve weather prediction, the tracking of severe storms, and the pinpointing of hurricane landfall. Like GRAPE, the upcoming launch is the final step, after years of development, towards a dedicated mission. In both cases, measurements made from an Earth-orbiting satellite would be the preferred platform. -DS

Student News

As lead author, former EOS student **Cary Girod** published a paper in the journal *Earth Interactions*. Entitled "The Tension between Fire Risk and Carbon Storage: Evaluating U.S. Carbon and Fire Management Strategies through Ecosystem Models," the paper is based on work Girod did as a master's student. Co-authors include George Hurtt – Girod's EOS advisor, John Aber, and Tony King of the Oak Ridge National Lab, whom Girod met while in residence at ORNL during the summer of her Homeland Security Fellowship, which she secured while at EOS. Girod was also a NH Space Grant Consortium fellow while at EOS.

Research & Discover student **Catherine Walker** and UNH senior physics major **Jay Carroll** both successfully competed for a spot at the NASA Academy this summer. The academy is a national educational, training, and research resource for college undergraduate and graduate students dedicated to promoting current and future opportunities for innovation and leadership in aerospace-related careers. Some 1,500 students apply annually for just 50 openings. Both Walker, who attends Mount Holyoke College, and Carroll have worked in the Space Science Center on the STEREO-PLASTIC mission.

Another Research & Discover student, **Claire Treat**, published her work in the *Journal of Geophysical Research*. Her study, conducted at Sallie's Fen in Barrington, N.H. under the guidance of research assistant professor Ruth Varner of the Climate Change Research Center, examined daily, seasonal, and interannual variations in methane emissions at a temperate peatland over a five-year period.

Space Science

A Beacon from Beyond

AFTER A SUCCESSFUL launch and multiple loop-de-loops around the Moon to catapult them into proper orbit, the twin STEREO spacecraft have begun their work studying our Sun from a unique three-dimensional perspective. Onboard imagers will show the Sun's stormy environment and its effect on the inner solar system. The data are vital for understanding how the Sun creates space weather.

But not all of the spacecrafts' instruments are designed to look at the Sun. The Space Science Center's Plasma and Supra-thermal Ion Composition (PLASTIC) instrument was designed to take *in situ* samples of the protons, alpha particles, and heavy ions hurled into space by the Sun's coronal mass ejections.

What's more, in addition to PLASTIC's "normal" science data, each day it delivers a stream of real-time space weather data to ground stations around the globe for purposes of predicting what's heading our way. This "beacon" data is transmitted via special telemetry onboard the spacecraft and is used by NOAA for forecasting. Other science data is stored and then "dumped" once per day to the STEREO Space Center at NASA's Goddard Space Flight Center.

"We do science, we don't do weather forecasting," laughs SSC scientist Lynn Kistler who, along with information technologist Lorna Ellis and Ph.D. student Kristin Suminac, worked on the beacon data project.

But, Kistler notes, there is a large community – including the military, power, and airline companies – that needs to know what is coming from the Sun in real-time because of its potentially negative effects. "We are happy to have our data available to be used in this way," Kistler says.

Ellis wrote the software that takes the beacon data and plots it out. "And so, in real time, from our instrument, you can look at the density and speed of particles, primarily protons, that come from the Sun – from the solar wind," says Kistler. -DS

UNIVERSITY of NEW HAMPSHIRE

Institute for the Study of Earth, Oceans, and Space
Morse Hall
39 College Road
Durham, New Hampshire, USA 03824-3525

800280

Heavenly Science

IN FEBRUARY, two Space Science Center scientists participated in two separate, successful launches to study the underlying phenomena behind the aurora borealis or Northern Lights and its lesser-known cousin, pulsating aurora.

Marc Lessard is principle investigator on the NASA Rocket Observations of Pulsating Aurora or ROPA mission, which launched a 65-foot sounding rocket 460 miles above Poker Flat, Alaska to investigate small, circular, pulsating aurora. And Jimmy Raeder is a co-investigator on NASA's THEMIS mission, which successfully deployed five identical satellites that will investigate what causes auroras in the Earth's atmosphere to dramatically change from slowly shimmering waves of light to wildly shifting streaks of color.

Photo: Todd Valentic, SRI, Inc.

All four stages fire as a 65-foot-tall sounding rocket soars above Alaska to study pulsating aurora.

Both missions are designed to study auroral "substorms" or the storage and release of energy in Earth's geomagnetic tail that cause sudden bright displays of aurora. -DS

WAIS Deep

THE WEST ANTARCTICA ICE SHEET (WAIS) Divide is a United States deep ice core project funded by the National Science Foundation. The purpose of the project is to collect a 3,400-meter-deep ice core from the flow divide (similar to a watershed divide) in central West Antarctica in order to develop records of global climate, ice sheet stability, and biological activity for the last 100,000 years. The WAIS Divide ice core will provide Antarctic records of environmental change with the highest possible time resolution and will be the Southern Hemisphere equivalent of similar Greenland ice cores. The ice core is expected to produce the best atmospheric gas records of the past 100,000 years ever obtained.

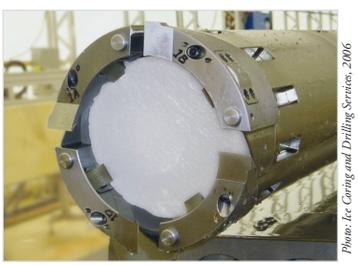


Photo: Ice Coring and Drilling Services, 2006

The Deep Ice Sheet Coring (DISC) drill that will be used to recover the 3,400-meter ice core from WAIS Divide, West Antartica.

Joe Souney of the Climate Change Research Center is the systems manager for the WAIS Divide Science Coordination Office. In December, Souney returned from three weeks in Antarctica where a pilot hole was drilled and cased. Souney reports that, after two seasons of work and preparation, more than 1,300,000 pounds of cargo, passengers, and fuel have been flown to the WAIS Divide camp, a seasonal field camp has been established, and a facility to house the state-of-the-art drill (pictured) and handle the core has been constructed. Deep drilling is slated to begin during the 2007-2008 Antarctic field season beginning in November. -DS