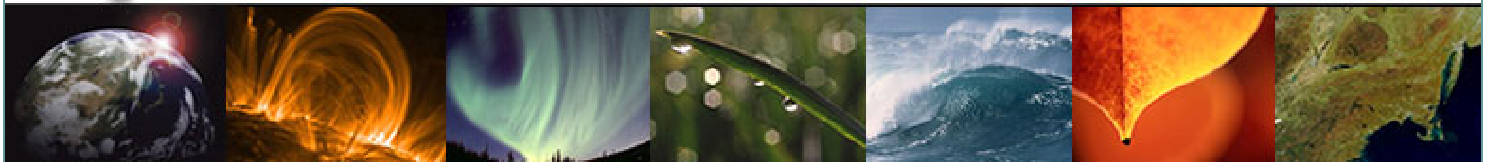
Institute for the Study of Earth, Oceans, and Space

Spheres Online

UNIVERSITY of NEW HAMPSHIRE



Welcome to Spheres Online

the University of New Hampshire Institute for the Study of Earth, Oceans, and Space electronic newsletter.

Subscribe to *Spheres* Online

Spheres Archives

www.eos.unh.edu

Fall 2012
In this Issue of *Spheres*…

Institute for the Study of Earth, Oceans, and Space (EOS)
EOS Director: Harlan Spence
Editor: David Sims
Designer: Kristi Donahue
Circulation: Laurie Pinciak

Morse Hall, 8 College Road,
Durham, NH 03824
www.eos.unh.edu
eos.director@unh.edu

Fall 2012

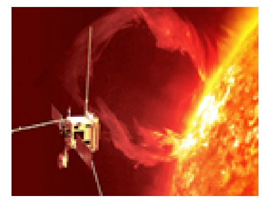
Earth Systems Science

Composing an Aquatic Symphony

IN A MEMORABLE scene from the movie "Amadeus," Emperor Joseph II tells an incredulous Wolfgang Amadeus Mozart that although the young composer's symphony he'd just premiered was indeed ingenious, it simply had "too many notes" to digest in one sitting. Read More…

Space Science

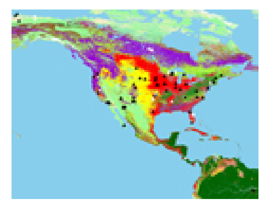
In the Hot Seat



SINCE THE DAWN of the space age, scientists and engineers in the Space Science Center have been highly successful designing and building instruments for satellites that help solve fundamental mysteries of the universe and push the bounds of discovery forward. Read More…

Earth Systems Science

Synergistic Science



OF THE PROPOSAL from NASA's Earth Science program recently won by Earth Systems Research Center scientists Scott Ollinger, Jingfeng Xiao, and Heidi Asbjornsen, it could be said that their recipe for success was to just add water. Read More…

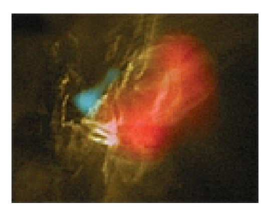
Ocean and Earth Systems Science

Doing Spadework in Scientific Trenches

IF AND WHEN, years hence, the Geostationary Coastal and Air Pollution Events satellite gets lofted into orbit to measure aspects of Earth's atmosphere and oceans, few people will recollect the time when the spacecraft was a mere twinkle in scientists' eyes. Read More…

Space Science

Space Weather PREDICCSion



EVEN IF the technology were available to blast astronauts off to Mars, a potential "showstopper" for such a mission would be the potential radiation hazards the intrepid explorers would face on the months' long ride to the Red Planet. Read More…

Earth Systems Science

Linking Water with the Landscape

HOW MUCH WATER does a forest drink? Give Heidi Asbjornsen a tree and a heat ratio sensor and she'll give you an answer. Read More…

Around the Hall

News and Notes

- Faculty, Staff, and Student News Read More…
- From the Director: All for One, One for All Read more…

[an error occurred while processing this directive]

Welcome to Spheres Online

the University of New Hampshire Institute for the Study of Earth, Oceans, and Space electronic newsletter.

Subscribe to *Spheres* Online

Spheres Archives

www.eos.unh.edu

Institute for the Study of Earth, Oceans, and Space (EOS)
EOS Director: Harlan Spence
Editor: David Sims
Designer: Kristi Donahue
Circulation: Laurie Pinciak

Morse Hall, 8 College Road,
Durham, NH 03824
www.eos.unh.edu
eos.director@unh.edu

Fall 2012

Composing an Aquatic Symphony

Earth Systems Research Center projects will provide unprecedented insight into watershed dynamics

IN A MEMORABLE SCENE from the movie "Amadeus," Emperor Joseph II tells an incredulous Wolfgang Amadeus Mozart that although the young composer's symphony he'd just premiered was indeed ingenious, it simply had "too many notes" to digest in one sitting.

Lamprey River, New Hampshire
Photo by Lisa Nugent, UNH Photo Services

On the contrary, scientist Wil Wollheim is hoping a current NOAA/New Hampshire Sea Grant-funded project he's heading up will provide a rare cascade of "notes" to allow composition of what he calls an "aquatic symphony." Such a score would be rich in scientific detail and provide unprecedented insight into the chemical and physical processes of stream and river networks.

The symphony will be made possible by a suite of state-of-the-art underwater sensors Wollheim and colleagues are strategically deploying throughout the Lamprey River watershed that drains into coastal New Hampshire's Great Bay. Moreover, the same work will be broadened statewide through a separate National Science Foundation/NH Experimental Program to Stimulate Competitive Research (EPSCoR) program currently ramping up.

Wil Wollheim and Richard Carey secure an aquatic sensor suite in the Lamprey River near Packer's Falls in Durham, N.H. Photo by Dick Lord.

"Historically, what we've done is grab samples out of a river once per month or maybe once per week," notes Wollheim, an assistant professor in the EOS Earth Systems Research Center and UNH department of natural resources and environment (NREN). "And that's like trying to listen to a symphony by hearing only one note in every hundred. You have no idea what it really sounds like, it's just a few random tweets."

Now, with the miniaturized, high-tech sensor suites, a host of measurements will be made round-the-clock allowing the researchers to see things in great detail, including patterns that emerge through space and time. Sensors will be deployed over a two-year span on the main stem of the Lamprey River, and for several months at a time in selected tributaries.

Says Wollheim, "Through this we should be able to identify certain themes that occur and reoccur within a particular watershed. And, for example, if you have ten instruments working together making different measurements, now you can really begin to appreciate how the watershed works, begin to hear that symphony."

"Through this we should be able to identify certain themes that occur and reoccur within a particular watershed…and begin to hear that symphony."

Also working on the project as co-investigators are professor William McDowell of NREN, scientists from the United States Geological Survey (USGS), research scientist Gopal Mulukutla, postdoctoral researcher Richard Carey, and graduate student Allison Price. The USGS is responsible for the deployment of aquatic sensors at one of the sites as well as housing the data on their website. The UNH Agricultural Experiment Station is also supporting this work.

Great, yes, but nitrogen "impaired"

The NOAA/NH Sea Grant-funded project is looking primarily at the flux of nitrogen to Great Bay from the Lamprey River watershed in an effort to quantify and understand the patterns of this flux to the coastal zone, particularly during storm events.

The overarching objective of the research is to understand the mechanisms that control nitrogen exports over a range of climate and flow conditions so that local land use planners and decision makers can craft mitigation strategies for reducing locally generated nitrogen inputs to the watershed and, eventually, into Great Bay.

Gopal Mulukutla, Wollheim, and Carey look at newly downloaded data from the Lamprey River deployment site near Packer's Falls. Photo by Dick Lord.

Great Bay is considered a "nitrogen impaired" water body due to elevated inputs from the surrounding watershed. Elevated nitrogen loads result from both point sources like wastewater treatment plants and non-point sources associated with intensified suburbanization as well as residual agricultural activity.

"We need to know more about how quickly the levels go up and down… The sensors being deployed on the Lamprey will help untangle the drivers of this weekly variation in nitrogen levels."

Nitrogen pollution causes algal blooms that consume oxygen and, in some cases, lower levels so severely that fish and shellfish die. Such algal blooms can also block sunlight to underwater grasses—like Great Bay's vital eelgrass beds—and prevent their growth.

A large proportion of non-point nitrogen export occurs during storm events due to enhanced mobilization and transport. But very little information exists regarding storm event nutrient dynamics because of the inherent logistical difficulties of collecting sufficient in situ samples throughout entire storm events and through the seasons.

Enter the new optical sensor technology and the Lamprey River project that will focus specifically on non-point sources of nitrogen. Each sensor suite will make ten critical measurements including nitrate (the compound created when nitrogen binds with water), phosphate, dissolved oxygen, etc. every half hour year-round. The multiple signatures will create a unique landuse/headwater "fingerprint" that can subsequently be identified downstream.

The work dovetails with the longer-term EPSCoR project to deploy water quality sensors at multiple stations on the Lamprey River, and several other sites throughout the state, over the next four years. To date, weekly sampling by McDowell's lab has shown that nitrate concentrations in the Lamprey increased substantially through 2009, but week-to-week variation was very high, ranging above and below the "safe" level of nitrogen for protecting Great Bay.

"This variation is really hard to understand with our current data set," says McDowell. "We need to know more about how quickly the levels go up and down, and whether that variation is related to season, extremes in stream flow, or variation in other chemical constituents. The sensors being deployed on the Lamprey will help untangle the drivers of this weekly variation in nitrogen levels."

Fingerprinting the watershed

"We want to understand the role of storms in controlling the flux of nitrogen to the

To gauge the source of nitrogen input to the Lamprey watershed, ESRC/NREN master's student Price has been deploying the aquatic sensors in strategic headwater locations—forest, agricultural, and suburban. By making direct measurements in these waters well upstream of the mouth of the river, and during storm events in particular, the researchers will be able to *coastal zone… understand how storms interact with different land use types, different watersheds."*

discern how much nitrogen is coming from a specific land use type and compare these headwater readings with measurements taken lower down in the river's reach.

"We're hoping this comparison will show us which of the land uses explains most of the fingerprint or pattern we see at the watershed mouth as it enters Great Bay," says Wollheim. "And if there's a divergence, we hope to be able to explain that and figure out if there's some sort of process occurring that has mitigated the problem."

Allison Price deploys the in situ sensor suite in a small, forested headwater stream at Saddleback Mountain in Northwood, N.H. where the Lamprey River originates.
Photo by Richard Carey, UNH-EOS.

In other words, if there's distinctly less nitrogen making its way to the mouth of the river, the river system itself must have effectively removed the nutrient, but how?

One possible answer could be the phenomenon of "spiraling" in which nitrogen is temporarily taken up by algae that eventually settle to the bottom and re-release the nitrogen to the water. Another, and permanent, method of nitrogen removal is denitrification—a process in which microbes turn nitrogen into the gaseous molecular form that makes up the bulk of our atmosphere. But the project aims to put a finer point on nitrogen removal by the river system.

Says Wollheim, "We want to understand the role of storms in controlling the flux of nitrogen to the coastal zone. Storms could be flushing nitrogen but we need to understand how storms interact with different land use types, different watersheds. We need to know how different storm types—length of time between storms, their intensity, et cetera—affect all this."

This latter part is the climate variability aspect of the project and ties into the projected changes the region will see as our climate shifts in the coming years and decades and brings higher temperatures, drought, and more intense precipitation events.

"…we're hoping through modeling we'll discern more about the ability of the aquatic system to cleanse itself of excessive nitrogen."

Improving the models

The work will also aid ongoing efforts within the EOS Water Systems Analysis Group, which Wollheim co-directs with ESRC research assistant professor Richard Lammers, to model these complex aquatic processes.

For example, getting high-resolution measurements directly at headwaters and downstream will provide clearly defined data that can be plugged into models and improve their ability to replicate the physical and chemical processes that occur.

"Once all these different sources have mixed together it becomes harder to sort out but with this new dataset we'll hopefully begin to model all this—how are different sources mixed together, where is it raining in the watershed compared to the different land uses, how far upstream is it, et cetera," says Wollheim. He adds, "And we're hoping through modeling we'll discern more about the ability of the aquatic system to cleanse itself of excessive nitrogen."

All of which will further the ultimate goal of mitigating nitrogen input into Great Bay and maintaining it as a healthy, functioning ecosystem for generations to come.

A video of the EPSCoR Lamprey River Water Study is available at the EPSCoR You Tube channel.

by David Sims, Science Writer, Institute for the Study of Earth, Oceans, and Space.

[an error occurred while processing this directive]

Welcome to Spheres Online

the University of New Hampshire Institute for the Study of Earth, Oceans, and Space electronic newsletter.

Subscribe to *Spheres* Online

Spheres Archives

www.eos.unh.edu

Fall 2012
In this Issue of *Spheres*…

Institute for the Study of Earth, Oceans, and Space (EOS)
EOS Director: Harlan Spence
Editor: David Sims
Designer: Kristi Donahue
Circulation: Laurie Pinciak

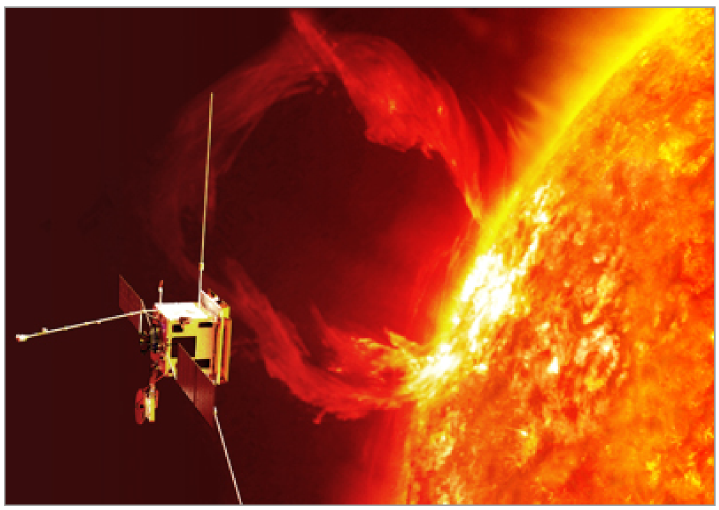
Morse Hall, 8 College Road,
Durham, NH 03824
www.eos.unh.edu
eos.director@unh.edu

Fall 2012

In the Hot Seat

The Solar Orbiter mission, with a UNH instrument on board, will use a series of gravitational slingshots around Venus to get closer to the sun than ever before

SINCE THE DAWN of the space age, scientists and engineers in the Space Science Center have been highly successful designing and building instruments for satellites that help solve fundamental mysteries of the universe and push the bounds of discovery forward.



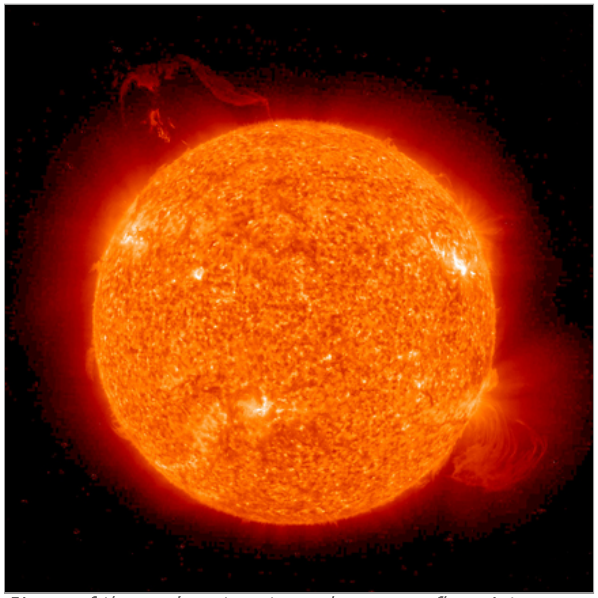
Artist's depiction of Solar Orbiter exploring the sun's realm.
© ESA/AOES.

This has led to a heritage of in-house expertise and the ability to craft similar instrumentation for successive missions with related science goals. Indeed, a telescope currently being developed for the Solar Orbiter mission is based on one built at UNH and currently aboard NASA's twin Solar-Terrestrial Observatory (STEREO) spacecraft.

The Solar Orbiter telescope will do work similar to its predecessor, but will do so under much more stressful conditions; it will have to sweat it out in a region where spacecraft temperatures reach 500 degrees Fahrenheit, squint at light 13 times more intense than at Earth, and withstand highly energetic particles able to go through metal as if it was butter.

"That's one of the biggest challenges for this mission," says research professor Antoinette Galvin, who leads the UNH team developing the Ion Composition Time-of-Flight/Energy Telescope that will be part of the Heavy Ion Sensor. The work is being done under a $4.67 million subcontract from the Southwest Research Institute (SwRI)—lead institution for the sensor aboard the joint European Space Agency/NASA mission. Professor Lynn Kistler is a co-investigator and is responsible for making sure all UNH hardware is designed to meet mission science requirements.

“The closer you are to the sun, the more intense it gets in terms of the number of particles, and we have to worry about the lifetime of our detector.”



Pieces of the sun's outer atmosphere were flung into space as the STEREO spacecraft observed in extreme ultraviolet light from November 23-25, 2010. Photo courtesy of NASA.

The UNH telescope is not an optical telescope but, rather, a detector that can measure individual, high-energy particles. It's at the very heart of the mission because it will measure—closer to the source than ever before—the particles that explode directly off the sun to create the million-mile-per-hour solar wind, which in turn creates the "space weather" conditions that can have profound effects on society.

"Most of the orbiter's instrumentation will be behind a state-of-the-art heat shield, but because we have to look directly at the sun and measure these particles, part of our telescope will actually reside in an area cut from the main heat shield specifically for this purpose," says Galvin.

The instrument, in other words, will occupy the hot seat for the entire seven-year mission. A miniature heat shield will afford additional protection, but the telescope aperture must be fully exposed to the elements. Galvin adds, "This is new territory as far as radiation and heat and even just the photo flux, or how brilliant it will be. The closer you are to the sun, the more intense it gets in terms of the number of particles, and we have to worry about the lifetime of our detector because the very thing we measure can destroy it."

“By the time we see the solar wind it has been processed and changed… and one thing we're trying to uncover is how the solar wind originates and is released.”

During periods of its elliptical orbit, Solar Orbiter will be closer to the sun than Mercury, which has a sun-facing surface temperature of 800 degrees Fahrenheit. That's getting into the range of a self-cleaning oven, which essentially cremates whatever's inside.

Close in to "pristine" particles

Solar Orbiter, which is set to launch in 2017, will address today's central heliophysics question: how does the sun create and control the heliosphere—the immense magnetic bubble containing our solar system, solar wind, and the entire solar magnetic field.

To uncover the mysteries, in situ measurements of the solar wind plasma, fields, waves, and energetic particles have to be made close enough to the sun so that they are still relatively pristine and have not had their properties modified by subsequent transport and propagation processes.

Moreover, to get a true measure of the pristine nature of these phenomena, the spacecraft needs to find a perch at least 30 degrees above the ecliptic plane in which the planets orbit the sun.

"A lot of what we observe is within the ecliptic or planetary plane. This is where the majority of our spacecraft are located," Galvin says.

But not everything originates in that narrow band. For example, plasma, particles, and processes can come from regions at high latitudes and get pushed down to the ecliptic.

"And we know this is occurring because we've been able to make observations with STEREO imaging," adds Galvin—the principal investigator for the Plasma and Suprathermal Ion Composition instrument on the STEREO mission.

To get into an orbit above the ecliptic plane, the spacecraft will do a series of Venus fly-bys over a period of years using the planet's gravity to hurl itself ever closer to the sun and achieve progressively higher latitudes.

Being high up and close in as never before will provide scientists with the best view for looking at the evolution of the sun's phenomena and the origin of the solar wind.

Says Galvin, "By the time we see the solar wind it has been processed and changed by interactions in space, and one thing we're trying to uncover is how the solar wind originates and is released. Being closer in with Solar Orbiter, we should be able to more clearly pinpoint what part of the sun is releasing the solar wind in the first place."

"It's kind of like skipping a stone on a pond where you're kicking up a wave and the water's splashing all around you. So, we're on the backside of the stone."

The UNH-designed telescope will make direct measurements of the pristine materials the solar wind is made of—carbon, oxygen, silicon, iron, etc., which in turn will help identify the source region. By having higher spatial and temporal resolution (being close to the source) combined with imagery provided by other onboard instruments, "means we'll be able to link things together without having to worry how much they changed before our instrument saw it," Galvin says.

Mark Popecki inspects a prototype particle detector in a Space Science Center cleanroom.
Photo by Kristi Donahue, UNH-EOS.

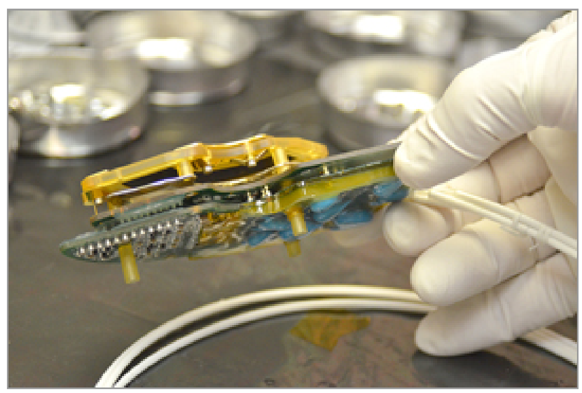
Built to last

Being a mere 21 million miles from the sun (that's 71,960,000 miles closer than is Earth), the engineering of Solar Orbiter has to be otherworldly indeed. And that presents a challenge to Space Science Center mechanical engineer John Nolin in particular.

"A lot of what's being measured requires highly specific timing in the electronics… and heat and radiation can cause electronics to behave differently and alter the measurements."

Working with thermal engineers at SwRI, Nolin has to figure out the best means of building the instrument to withstand both punishing heat and radiation. This entails weighing the options between heat- and radiation-resistant materials versus cost and mass.

"Radiation-hardened parts are more expensive and usually bigger," notes Galvin, "but we only have so much space on board the spacecraft so we have to be creative."



The particle detector shown from below.
Photo by Kristi Donahue, UNH-EOS.

Nolin notes the spacecraft's heat shield, which will always face the sun, is nearly a foot thick and built of multiple, composite layers of metals, and heat-resistant coatings."

"This will take the brunt of it and the heat will just spill around the edges," Nolin says. "It's kind of like skipping a stone on a pond where you're kicking up a wave and the water's splashing all around you. So, we're on the backside of the stone."

Even though it will be in the hot seat in the cutaway portion of the main heat shield, the instrument's internal temperature is expected to get no higher than 86 degrees Fahrenheit thanks to it's own smaller heat shield for all but the telescope's aperture.

"That's as hot a temperature as our electronics will face, and it's the electronics—circuit boards and such—that have to be protected from the heat and radiation," Nolin says. "A lot of what's being measured requires highly specific timing in the electronics to identify one element from another and the energies of incoming particles, and heat and radiation can cause electronics to behave differently and alter the measurements."

Nolin notes that even though the UNH-built telescope stands on the shoulders of work done previously by Space Science Center scientists and engineers, every new mission requires numerous modifications to attain the science goals at hand. This is achieved by stepping through a rigorous series of design reviews before actual flight instruments can be built and tested. The project is currently in the preliminary design phase with the first prototype instrument parts being fabricated.

In addition to Nolin, team members include research project engineers Chris Bancroft on electronics, David Heirtzler on telescope design and system engineering, senior research scientist Mark Popecki as instrument scientist, John Gaidos on test support electronics, and Jim Tyler as instrument manager. Also participating are Stan Ellis, Steve Turco, Jon Googins, Todd Jones, Keven Mello, Kristin Simunac, and Aaron Bolton. UNH student interns Anne Lamontagne, James Kilpeck, and Benjamin Kramer are assisting in the design and testing.

by David Sims, Science Writer, Institute for the Study of Earth, Oceans, and Space.

[an error occurred while processing this directive]

Welcome to Spheres Online

the University of New Hampshire Institute for the Study of Earth, Oceans, and Space electronic newsletter.

Subscribe to *Spheres* Online

Spheres Archives

www.eos.unh.edu

Fall 2012
In this Issue of *Spheres*…

Institute for the Study of Earth, Oceans, and Space (EOS)
EOS Director: Harlan Spence
Editor: David Sims
Designer: Kristi Donahue
Circulation: Laurie Pinciak

Morse Hall, 8 College Road,
Durham, NH 03824
www.eos.unh.edu
eos.director@unh.edu

Fall 2012

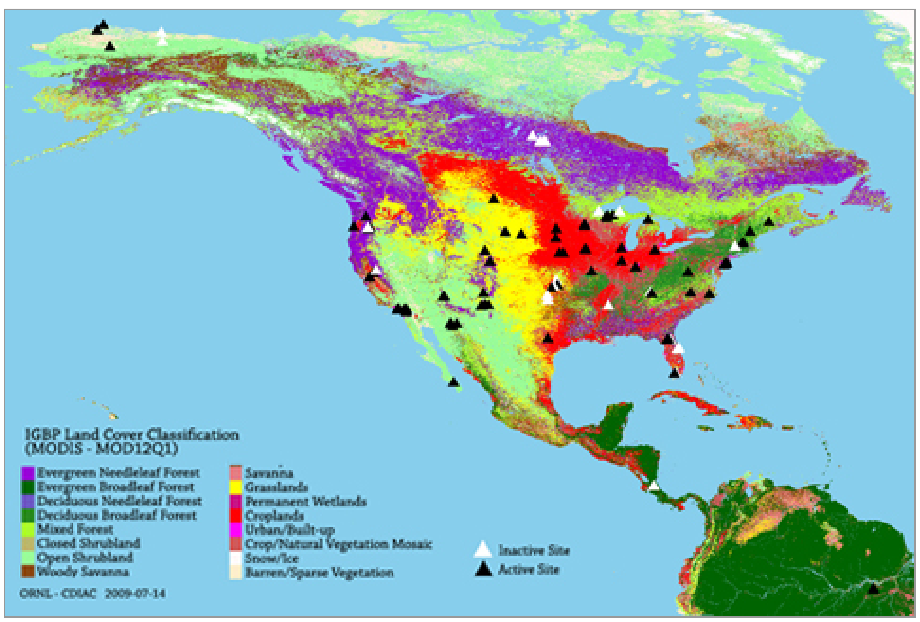
Synergistic Science

Exploring the tightly coupled relationship between nitrogen, carbon, and water in terrestrial ecosystems unites three researchers in a multidisciplinary project

OF THE PROPOSAL from NASA's Earth Science program recently won by Earth Systems Research Center scientists Scott Ollinger, Jingfeng Xiao, and Heidi Asbjornsen, it could be said that their recipe for success was to just add water.

The study, titled "Exploring relationships among water use efficiency, canopy nitrogen and carbon cycling across North American ecosystems to improve land surface models," is a direct follow-on to groundbreaking remote sensing work Ollinger led several years ago that investigated the relationship between leaf nitrogen content, carbon sequestration, and albedo, or surface reflectivity.

The earlier project found that forests with high levels of leaf nitrogen may have a two-fold effect on climate by simultaneously reflecting more solar radiation and absorbing more carbon dioxide than their low-nitrogen counterparts. These findings had implications for how forests regulate climate but the researchers weren't able to nail down the overall effects without knowing the water piece of the puzzle.



Network of AmeriFlux towers. Courtesy Oak Ridge National Laboratory.

Notes Ollinger, professor of ecosystem ecology/remote sensing in EOS and the department of natural resources and the environment, "The evaporation of water from plants is a critical thing to understand, so we wanted to look more carefully at how forests use water and how that's affected by the nitrogen status of trees. This has implications for climate that we couldn't consider before, and it also influences the amount of water that ends up in rivers and streams."

The climate part of the equation has to do mostly with the formation of clouds from the massive amounts of water vapor sent skyward by plants. Indeed, because a lot of clouds over continents are born of water released by plants, if there were fewer plants in the world there would be less cloud cover.

"When you look at the planet from space, it's bathed in clouds and that affects Earth's albedo or its capacity to either reflect or absorb the sun's heat."

"When you look at the planet from space, it's bathed in clouds and that affects Earth's albedo or its capacity to either reflect or absorb the sun's heat. And, of course, cloud cover determines how much rainfall there is. So, the planet's surface changes because of clouds, making it critical to understand how plants use water" says Ollinger, principal investigator for the three-year, $775,000 NASA project.

View of a cloud-covered Earth as seen from the Gemini 3 spacecraft in March 1965.
Courtesy NASA Johnson Space Center.

The in-house ability to examine water use by plants was made possible with the arrival of associate professor Heidi Asbjornsen, who came to UNH from Iowa State University. Asbjornsen is an ecosystem ecologist who, among other subdisciplines, specializes in ecohydrology—an interdisciplinary field studying the interactions between water and ecosystems (see profile of Asbjornsen' work "Linking Water with the Landscape" in this issue of *Spheres*).

As in the earlier study, Ollinger's thrust in the current NASA project will be using remotely sensed canopy leaf measurements of nitrogen and albedo derived from a novel combination of NASA satellite- and aircraft-based instruments. By teaming up with Asbjornsen, the group will be able to compare nitrogen levels with plant water use and examine the efficiency with which plants use water.

The final lynchpin of the study will be supported by ESRC research assistant professor Jingfeng Xiao whose work uses data from the large network of micrometeorological towers strategically located throughout North America. The Ameriflux network of "eddy covariance flux" towers measure the turbulence or "eddies" of air above treetops thus allowing scientists to monitor the exchange of carbon dioxide and water between the biosphere and the atmosphere. Xiao has been a leader in scaling data from individual towers to encompass the entire North American continent. Drawing upon his expertise helped cement the new project into an innovative, focused investigation.

"The eddy covariance technique is revolutionizing both ecosystem and global ecology."

Says Xiao, "The eddy covariance technique is revolutionizing both ecosystem and global ecology. The continuous observations from these towers will allow us to look at carbon and water dynamics at the ecosystem level, and the translation of fluxes from towers to North America will help us better understand the linkages among carbon, nitrogen, and water cycles at the continent scale."

From breakthrough to follow-through

Ollinger's previous work involving nitrogen, photosynthesis, and the albedo of forests was a breakthrough in that it uncovered the relationship between these variables for the first time.

"What we'd like to do in this present study is figure out how the amount of water that plants use changes as we go from sites with low nitrogen and low albedo to high nitrogen and high albedo," he says. "This will provide very basic information about how plants use water, how they adapt to drought and how the atmosphere ends up being influenced by forests."

The study will use twelve Ameriflux sites as the basis for intensive measurements, including onsite tree analysis by Asbjornsen, with Xiao using additional data from roughly 100 towers from a network of 154 across North America.

At the heart of the project is the process of evapotranspiration—the sum total of water returned to the atmosphere via evaporation from surfaces, including soils, and that transpired or "breathed" through plant leaves. Flux tower data will show how much water is going in and out of a forest (without distinguishing between evaporation and transpiration) while Asbjornsen's measurements using tree cores and isotope analysis will bring the study right down to the individual species level.

"This will provide very basic information about how plants use water, how they adapt to drought and

how the atmosphere ends up being influenced by forests."

Says Asbjornsen, "For this project, we're looking at what's known as water use efficiency, or how much growth you get per unit of water a forest uses. This will also provide us with a view of the historical responses of ecosystems to climate fluctuation, drought in particular."

The flux tower in Chibougamau, Quebec, part of the Fluxnet-Canada Network, is one of several towers in the Northeast used by ESRC scientists.

The work should allow the researchers to not only gauge current leaf- and landscape-scale responses of trees to shifts in climate but also make more accurate predictions at larger scales of how different ecosystems are responding to climate—the latter being the modeling part in the study's title.

To that end, the project adds a component to examine the affects of biodiversity on how ecosystems respond to climate changes—a much-debated topic in which definitive answers have been elusive.

Says Ollinger, "We hypothesized in this proposal that the resilience to drought will be higher in ecosystems with a greater number of species—essentially, the idea that there's safety in numbers."

"We hypothesized in this proposal that the resilience to drought will be higher in ecosystems with a greater number of species — essentially, the idea that there's safety in numbers."

In other words, if an ecosystem comprised of a dozen different species gets hit by drought, one or two species might be better adapted, can "pick up the slack" for the other species, and buffer the effects for the whole system.

But because the flux tower data will not separate out the species within the footprint responsible for taking up the slack, Ollinger notes, "you've got to sample individual species, look at their water use efficiency, and their physiology. So this is where Heidi's measurements will allow us to take a more tree-based approach."

Flux tower in Howland, Maine.
Photos courtesy of Michelle Day, UNH-EOS.

Tried and true track record

The most recent award from NASA's Earth Science program represents more than just another win for ESRC or building upon a successful previous study. For Ollinger, the new funding also means that his lab has garnered funding from the NASA program for 18 consecutive years.

The Terrestrial Ecosystem Analysis Laboratory has shifted and evolved through time, its footprint growing from a focus on New Hampshire forests to encompass a broader reach of ecosystems. But as the unbroken record of NASA funding represents, it has continuously done cutting-edge science.

Ollinger notes, "It's challenging to win competitive federal grant funding in three-year increments, and so this means we've been successful at competing with other well-known institutions elsewhere in the country and have been in a good spot for doing quality science for a long time."

Many individuals past and present share in this sustained record of success, he stresses. "UNH has been a leader in this discipline for a very long time and the colleagues I've been able to work with here have been invaluable. It would be hard to imagine maintaining this kind of pace in too many other places."

by David Sims, Science Writer, Institute for the Study of Earth, Oceans, and Space.

[an error occurred while processing this directive]

Institute for the Study of Earth, Oceans, and Space (EOS)
EOS Director: Harlan Spence
Editor: David Sims
Designer: Kristi Donahue
Circulation: Laurie Pinciak

Morse Hall, 8 College Road,
Durham, NH 03824
www.eos.unh.edu
eos.director@unh.edu

Fall 2012

Doing Spadework in Scientific Trenches

Oceanographer Joe Salisbury and atmospheric scientist Carolyn Jordan take a turn at the behind-the-scenes process that helps chart the nation's space-based scientific future

IF AND WHEN, years hence, the Geostationary Coastal and Air Pollution Events satellite gets lofted into orbit to measure aspects of Earth's atmosphere and oceans, few people will recollect the time when the spacecraft was a mere twinkle in scientists' eyes.

But among those who will are oceanographer Joe Salisbury of the Ocean Process Analysis Laboratory and atmospheric scientist Carolyn Jordan of the Earth Systems Research Center. Both are part of a large scientific working group charged with taking the raw mission concept and putting meat on the bones.

http://geo-cape.larc.nasa.gov

Scientists from around the country are currently dedicating long hours teleconferencing and brainstorming for little or no monetary compensation to come up with what's called a Science Traceability Matrix that will define the mission.

Says Jordan, fresh off a two-hour telecon, "The matrix is a one-page synopsis of the science questions the mission needs to answer and the instrument/mission requirements needed to do so, and it's the job of the working group to actually define all that."

Indeed, the mission, known as GEO-CAPE for short, was hatched from a very broad and general scientific notion—in this case the need to get detailed, continuous measurements of air quality and ocean color from a spacecraft "parked" above Earth in a geostationary orbit.

"In order to answer the science questions that were broadly disseminated in the National Research Council's Decadal Survey," notes Salisbury, co-leader of the mission's ocean science working group, "they needed to look down at a water mass or plume or the atmosphere repeatedly over the course of a day. This provides information about the temporal dynamics to a higher degree than you'd get with a satellite in a polar orbit around the globe."

Among other things, Salisbury specializes in coastal ocean color work, which reveals the presence of varying amounts of phytoplankton, sediments, and dissolved organic chemicals. Ocean color data provide information on the ocean's essential functions and resources, and can be used to assess long-term climate changes, evaluate support of fisheries production, and detect harmful algal blooms, etc.

As Salisbury notes, the 2007 NRC report, "Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond," provided a basic blueprint for how best to attain critical scientific information about the Earth system from space. This included a three-tiered group of recommended satellites, with Tier 1 missions slated for quickest development and launch. GEO-CAPE is a Tier II mission originally recommended for launch in the 2013-2016 time frame.

"The decadal survey basically states that we should be able to make certain measurements and understand certain processes as they relate to some burning scientific issue such as climate change, for example," Salisbury says. "Within that context, it's up to the initial science working groups to define what we specifically need to measure, how we'll measure it, and where we want the sensor to be—what slice of space above Earth do we want to reside in."

"…they needed to look down at a water mass or plume or the atmosphere repeatedly over the course of a day."

Currently, there are no U.S. geostationary satellites dedicated to ocean color work, and continuous monitoring of one location over coastal oceans in particular is needed because of the highly dynamic and fast-moving nature of these waters. If, for example, a polar-orbiting satellite snaps a single image of an area at noon and then does the same thing 24 hours later, what was pictured the day before could be 30 kilometers away due to the currents.

Louisiana coast and the dynamic coastal region showing the suspended sediments, organic matter and phytoplankton.
Image courtesy of NASA Sea-viewing Wide Field-of-view Sensor (SeaWiFS) Project.

"So if you want to watch how a water parcel evolves, and there are really good reasons to do that, then a geostationary sensor is the only practical way to go," Salisbury says.

Imagine how uninformative a weather forecast based on just one picture per day of a certain region on Earth would be; NOAA's Geostationary Satellite system makes accurate weather tracking and forecasting possible via a time series of images from the GOES-East and GOES-West satellites parked in the upper atmosphere.

"The decadal survey basically states that we should be able to make certain measurements and understand certain processes as they relate to some burning scientific issue such as climate change…"

Some of the "really good reasons" why Salisbury's particular work requires a geostationary satellite are the measurement of three critical variables in ocean color, which is literally the light or "water leaving radiance" as detected by the satellite sensor. Ocean color is generated by various chemicals and critters and Salisbury's quarry includes chlorophyll, phytoplankton biomass, and sediments, among other things.

Phytoplankton biomass is a core part of the global carbon cycle and important to understand because its variability helps drive the "biological pump" that takes atmospheric carbon dioxide and sinks it to the deep ocean where it doesn't interact with the ocean/air interface. This huge carbon "sink" helps slow the pace of global warming.

In coastal ocean waters, there's often a great deal of tea-colored material pouring in from rivers and estuarine systems. Ocean color satellite readings of this sediment-laden water can be used to discern different material properties and physical processes that are important to understand as part of the whole complex ocean-air system.

Letting the air out

So why a satellite mission dedicated to investigating the seemingly distinct questions of air quality and ocean color?

The short answer, says Jordan, is that both the air quality and ocean color scientific communities wanted a geosynchronous satellite to achieve their respective goals. Ironically, one of the biggest challenges for the ocean color community in making these measurements from space is to "remove" the atmosphere between the satellite sensor and the ocean surface.

Explains Jordan, who specializes in atmospheric aerosol and trace gas analysis, "Between the signal of water leaving radiance at the ocean's surface and what the satellite sees at the top of atmosphere is a lot of interference from aerosols, ozone, nitrogen dioxide, and water vapor. To get a clear, accurate ocean color reading you have to correct the signal by 'removing' the atmosphere, which is 90 percent or more of the signal that's being picked up."

Thus, the joint atmosphere/ocean geostationary mission provides the opportunity to get high-quality 90/10 percent measurements at the same time, and then correct the signal for ocean color by subtracting the atmosphere.

“So if you want to watch how a water parcel evolves, and there are really good reasons to do that, then a geostationary sensor is the only practical way to go.”

Carolyn Jordan
Photo by Kristi Donahue, UNH-EOS

Simple enough, but it turns out the spatial, temporal, and spectral requirements for the atmospheric science goals are different from those of the oceanic science goals. Back to the drawing board.

"There has been some tension between the two camps," Jordan says adding, "the instrument requirements are different enough that being joined at the hip makes it a more expensive mission and, ultimately, everyone worries that could mean we'll run out of money and never fly."

One workaround to this problem the scientists are now pursuing is, instead of the one, dedicated satellite as originally envisioned, the mission could get off the ground via a "hosted payload" with atmosphere and ocean color instruments each hitching a ride on separate commercial satellites.

Notes Jordan, "They would still both be in a geostationary orbit, and both still look at what they need to, respectively, but hopefully this would reduce the cost the mission. And, because this approach is now on the drawing board, the tension has mostly gone away."

Biggest science bang for nebulous bucks

There is always some inherent tension in the working group process, since the mandate is to come up with the best science for a mission within the context of a rather vague budgetary framework.

"We are not allowed, at this point in the process, to get very much budgetary guidance," says Salisbury. "For example, we can't go directly to a vendor and get a cost estimate for a multispectral instrument that scans the coastal region at certain wavelengths. So in that respect, we're operating at a disadvantage."

This is all part of the demanding spadework required of these groups, who largely volunteer their time and talent to help chart the nation's future space-based science capabilities.

Says Jordan, "Our mandate is to think about the best possible science, but since everything isn't possible, there will always be tradeoffs. And it can be hard to make those tradeoffs when we don't know what the associated costs are."

“To get a clear, accurate ocean color reading you have to correct the signal by 'removing' the atmosphere…”

Salisbury notes that the working group may get a bit more budgetary guidance in fiscal year 2013 but, regardless, the process as designed *does* result in the all-important Science Traceability Matrix that gives tangible definition to the science particulars and can serve as the playbook for making the required tradeoffs. For example, agreed-upon options juxtaposed with the actual, physical limitations of the spacecraft will drive clear choices between, say, having better spatial or temporal or spectral resolution for the instrument chosen to do the job. Salisbury calls this the "trade-space matrix."

"So, if your interest is in identifying phytoplankton groups, and being able to distinguish the little critters from the big ones, you'll need really high spatial and spectral resolution, which will require a certain type and size of instrument. Someone else's interest/goal will demand yet another type of instrument. Each time you choose one option you have to sacrifice the other—this is 'trade space' in three dimensions, with the fourth being cost."

Salisbury and Jordan are just entering the third year of what could be a four-year effort for the science working group. Once their work is done, the group is disbanded and a mission science team is formed via a call for proposals. Then, design studies are initiated and the science *and* associated costs are finally pinned down. At which point the mission will be that much closer to go, no-go status.

It's true, the two scientists note, in the end their efforts could seemingly be all for naught should the satellite *not* get off the ground. But, says Salisbury, "The mission concept would be picked it up again in a decade. It was a mission recommended by the last decadal survey, people have been talking about it for years, and its finally gotten to the point where we're really trying to get it into the queue."

Of their front-end work Jordan says, "You move the ball forward, nudge it further down the path, and hopefully we'll be part of the science when the satellite finally goes up and starts making those measurements."

At the moment, the earliest possible launch date for the mission occurs sometime after 2020.

For more on the mission, visit the newly available GEO-CAPE website at http://geo-cape.larc.nasa.gov.

by David Sims, Science Writer, Institute for the Study of Earth, Oceans, and Space.

[an error occurred while processing this directive]

Welcome to Spheres Online

the University of New Hampshire Institute for the Study of Earth, Oceans, and Space electronic newsletter.

Subscribe to *Spheres* Online

Spheres Archives

www.eos.unh.edu

Fall 2012

In this Issue of *Spheres*...

Institute for the Study of Earth, Oceans, and Space (EOS)
EOS Director: Harlan Spence
Editor: David Sims
Designer: Kristi Donahue
Circulation: Laurie Pinciak

Morse Hall, 8 College Road,
Durham, NH 03824
www.eos.unh.edu
eos.director@unh.edu

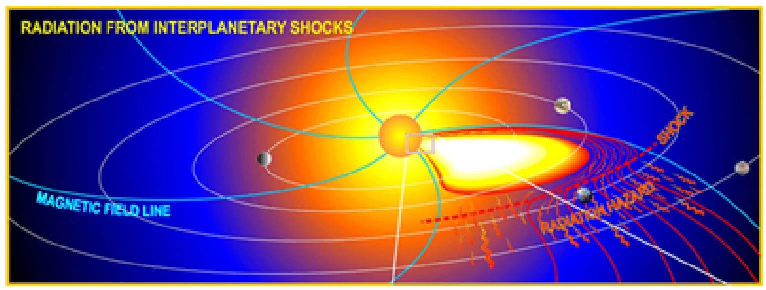
Fall 2012

Space Weather PREDICCSion

Space Science Center astrophysicists create first near real-time window on space radiation hazards

EVEN IF the technology were available to blast astronauts off to Mars, a potential "showstopper" for such a mission would be the potential radiation hazards the intrepid explorers would face on the months' long ride to the Red Planet.

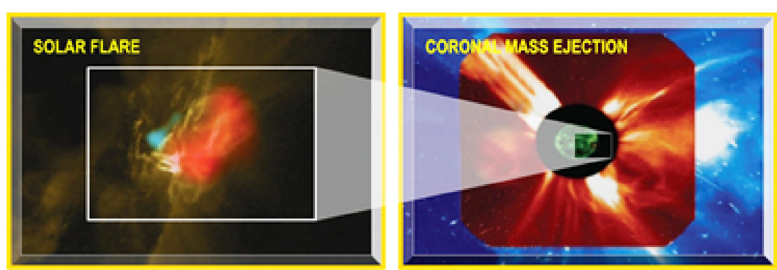
Bombardment from high-energy galactic cosmic rays and solar energetic particles present formidable immediate and cumulative radiation risks for both human and robotic missions beyond low Earth orbit of approximately 1,200 miles.



In this artist's rendition, particle radiation from a solar flare speeds away from the sun along curved magnetic field lines (blue lines) and arrives before the coronal mass ejection (orange mass from the sun) and its driven shock. PREDICCS provides a real-time window on spaceweather events like this. Image courtesy of Nathan Schwadron, UNH-EOS.

That's because even miniscule particles like the electrons or protons driven outward from the sun or by cosmic rays to nearly the speed of light can inflict serious damage to any matter they encounter. This can be extremely dangerous for both spacecraft and spaceman working in or passing through the region where "space weather" occurs.

That potential hazard has been tempered by the development of the first online system for predicting and forecasting the radiation environment in near-Earth, lunar, and Martian space environments. The near real-time tool known as PREDICCS will provide critical information as preparations are made for potential future manned missions to the moon and Mars.



Solar flare observed by the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI) and associated coronal mass ejection observed by the Solar and Heliospheric Observatory (SOHO) spacecraft.
Image courtesy of Nathan Schwadron, UNH-EOS.

"If we send human beings back to the moon, and especially if we're able to go to Mars, it will be critical to have a system like this in place to protect astronauts from radiation hazards," says associate professor of physics Nathan Schwadron of the Space Science Center. "This web-based tool provides awareness about the degree to which deep space poses hazards to spacecraft and astronauts."

Schwadron is the lead developer of the new tool that integrates numerical models of space radiation, a host of near-real-time measurements being made by satellites currently in space, and "propagation codes" that can accurately project radiation levels out as far as Mars. EOS director and astrophysicist Harlan Spence is a co-developer.

“If we send human beings back to the moon, and especially if we're able to go to Mars, it will be critical to have a system like this in place to protect astronauts from radiation hazards.”

The under-the-hood complexity of PREDICCS is matched only by the components that make up its name. The tool could perhaps win an award for the best amalgam of nested acronyms strung together for the sake of "simplicity."

That is, PREDICCS is short for Predictions of radiation from REleASE, EMMREM, and Data Incorporating CRaTER, COSTEP, and other SEP measurements.

To decipher this, let's start at the tail end of this alphabet soup and move backward—all the while introducing yet more acronyms into the mix.

What's in an acro-name?

SEP is the acronym for solar energetic particles—high-energy particles consisting of protons, electrons, and heavy ions with the fastest particles reaching speeds up to 80 percent the speed of light.

COSTEP stands for Comprehensive Suprathermal and Energetic Particle Analyzer—an experiment mounted on the Solar and Heliospheric Observatory (SOHO) spacecraft, which makes a halo orbit around the sun.

The Cosmic Ray Telescope for the Effects of Radiation (CRaTER) is an instrument currently on NASA's Lunar Reconnaissance Orbiter (LRO) and characterizes the global lunar radiation environment and its biological impacts by measuring radiation from behind a "human tissue-equivalent" plastic. CRaTER, whose principal investigator is EOS director Spence, has made the most accurate and comprehensive measurements of radiation at the moon since the dawn of the space age.

The Earth-Moon-Mars Radiation Environment Module (EMMREM) is a UNH-developed model that predicts the real-time radiation environment by combining two other models—the Energetic Particle Radiation Environment Module (EPREM) and the Baryon Transport Module (BRYNTRN)—to nowcast and forecast the radiation environment at various observation points, including the Earth, moon, Mars.

Lastly, the Relativistic Electron Alert System for Exploration (REleASE) very accurately forecasts SEP events up to one and a half hours ahead of the event.

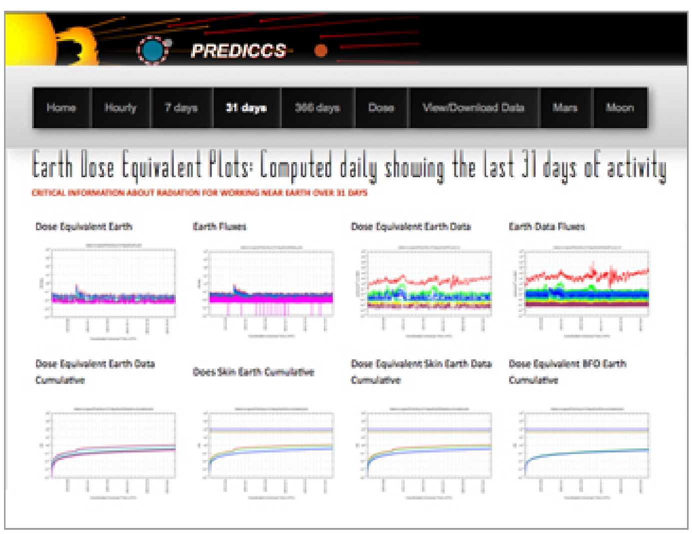
Other satellites that provide measurements used by PREDICCS include NOAA's Geostationary Satellite system GOES spacecraft, the Advanced Composition Explorer, and additional validation from the Ulysses and Mars Odyssey missions.

“What we really need to know is how hazardous this cycle of radiation is.”

Know dose

The website provides updates of the radiation environment on an hourly basis and archives the data weekly, monthly, and yearly. This historical record provides a clear picture of when a safe radiation dose limit is reached for skin or blood-forming organs, for example.

Says Schwadron, "What we really need to know is how hazardous this cycle of radiation is. How often do we see large events that have significant risk associated with them? Those questions can only be answered if you're continually building up the database of events and the risk associated with them."



http://prediccs.sr.unh.edu/

During several recent large solar events in which the sun, waking from an unusually long quiet period, sent billions of tons of high-energy particles rippling through space, the radiation levels measured by CRaTER as it orbited the moon were matched almost perfectly by PREDICCS.

"For the whopping solar events of January 23 and March 27 of this year, our predictions seem to be within 20 to 30 percent of what was observed, which is incredible. These types of highly accurate comparisons have never been made before," Schwadron says.

“…for the very first time, people are able to see the effects of space radiation playing out in near real-

time, and this opens a new window to an otherwise invisible world."

Because CRaTER gauges radiation doses using the high-tech plastic that mimics human muscle, not only has it provided the validation that PREDICCS models are accurate, but has done so in the context of how the radiation data would impact human beings on the moon or on a mission to Mars.

"We needed to accurately assess what the biological impacts are to make the best quantitative comparisons between models and observations," says Schwadron, "and having a system like this in place now is sort of like flying a trial balloon in preparation for a return to the moon and a trip to Mars."

The tool's plots of radiation over time can, for example, show that under the right circumstances and even with thick shielding, astronauts in space could approach one-year radiation dose limits well before that year was up. Pointing to a graph line on the PREDICCS website, Schwadron notes that readings taken during solar maximum are just such a case in point.

"If you were up during these periods, these events, even with thick shielding, would definitely cause you to approach the one-year dose limit because they were so large. You wouldn't die, but you would experience some effects —vomiting in extreme cases, fatigue, risk of cancers would go up."

He adds, "So with PREDICCS, for the very first time, people are able to see the effects of space radiation playing out in near real-time, and this opens a new window to an otherwise invisible world."

by David Sims, Science Writer, Institute for the Study of Earth, Oceans, and Space.

[an error occurred while processing this directive]

Welcome to Spheres Online

the University of New Hampshire Institute for the Study of Earth, Oceans, and Space electronic newsletter.

Subscribe to *Spheres* Online

Spheres Archives

www.eos.unh.edu

Fall 2012
In this Issue of *Spheres*…

Institute for the Study of Earth, Oceans, and Space (EOS)
EOS Director: Harlan Spence
Editor: David Sims
Designer: Kristi Donahue
Circulation: Laurie Pinciak

Morse Hall, 8 College Road,
Durham, NH 03824
www.eos.unh.edu
eos.director@unh.edu

Fall 2012

Linking Water with the Landscape

Ecohydrologist Heidi Asbjornsen adds a vital new dimension to Earth Systems Research Center work and brings experience to UNH's nascent agro-ecosystems research

HOW MUCH WATER does a forest drink? Give Heidi Asbjornsen a tree and a heat ratio sensor and she'll give you an answer.

Using three separate probes inserted into sapwood, the sensor emits a pulse of heat and then takes two temperature readings. The combined measurements provide a tree's water flow velocity. Add a few additional "whole tree physical measurements," do a bit of multiplication to scale things up and, voilà, you have the estimated total water usage for the trees in the forest.

Heidi Asbjornsen installs heat ratio sensors in sapwood to measure water flow velocity. Photos by Michelle Day, UNH-EOS.

It is a powerful scientific tool, and when Asbjornsen arrived at UNH from Iowa State University in 2010 as part of an eight-faculty, interdisciplinary, agro-ecosystems cluster hire, she added a new dimension within the Earth Systems Research Center (ESRC) that immediately infused previous research with new life.

That previous research, led by Scott Ollinger and detailed in the story "Synergistic Science" in this issue of Spheres, used remotely sensed techniques to establish the relationship between leaf nitrogen content, carbon sequestration, and albedo. Now, Ollinger, Jingfeng Xiao, and Asbjornsen are collaborating on a new NASA project that adds the role of water to the mix.

Says Asbjornsen, an associate professor with a joint appointment in EOS and the UNH department of natural resources and the environment (NREN), "Once you've established these strong patterns based on observations, for example, between foliar nitrogen and spectral data, the next question is, what are the underlying reasons or mechanisms that explain these patterns?"

"Once you've established these strong patterns

based on observations… the next question is, what are the underlying reasons or mechanisms that explain these patterns?”

She adds, "To understand these mechanisms, it's important to measure the leaf- and plant-level physiological processes, such as water and carbon uptake. Then, scaling information from leaves to landscapes requires directly linking information about plant physiology to larger scale measurements obtained from remote sensing and flux towers."

Working in the disciplines of ecophysiology—an experimental science that seeks to describe the physiological mechanisms underlying ecological observations—and ecohydrology, Asbjornsen's ground-level, leaf-to-whole-plant research will complement the larger scale remote sensing and flux tower work done by Ollinger and Xiao.

She'll use tree cores and stable isotope analysis to look at growth over time, going back at least 50 years to determine how trees responded to climate variability.

"We can extract wood from individual tree rings and analyze it for stable isotopes of carbon-13, which serves as an indicator of water use efficiency," Asbjornsen says.

Water use efficiency is a measure of a plant's ability to simultaneously take in or "fix" atmospheric carbon dioxide through tiny leaf pores called stomata without losing too much water during the process of photosynthesis. Among other things, it is an important indicator of the capacity of trees and forests to maintain their productivity during environmentally stressful periods, such as extreme drought events or heat waves.

“There is an inherent trade-off between carbon fixation and water use, and when vegetation is changed on a landscape, for example a forest is converted to crops, this can change the balance.”

"There is an inherent trade-off between carbon fixation and water use," notes Asbjornsen, "and when vegetation is changed on a landscape, for example a forest is converted to crops, this can change the balance."

Agro-ecosystem trade-offs

Analyzing these inherent trade-offs when landscapes are significantly altered is part and parcel of work Asbjornsen is doing as a member of a group of UNH faculty members brought together under the recent sustainable agro-ecosystem cluster hire through the College of Life Sciences and Agriculture. The eight faculty members, including assistant professor Wil Wollheim of the ESRC and NREN, are, among other things, working as a group investigating various environmental implications of increasing food production in New Hampshire and New England.

This initiative encompasses analyzing how changes in land use could affect water resources, water quality, regulation of hydrologic flows (flooding and water scarcity), as well as other ecosystem services such as carbon sequestration.

Asbjornsen on the páramo—an alpine tundra ecosystem—in Colombia this past summer.
Photo by L. Bruijnzeel, Free University-Amsterdam.

"My work in Iowa was more agriculturally focused and included research in prairie systems as well as savannah/woodlands and how the integration of these perennial vegetative covers within agriculturally dominated landscapes can help reduce negative environmental impacts," says Asbjornsen. "Here, the situation is kind of flipped because the landscape is primarily forested."

“My work in Iowa was more agriculturally focused and included research in prairie systems… Here, the situation is kind of flipped because the landscape is primarily forested.”

Indeed, compared to Midwest agriculture, the Northeast is a mere bump on the landscape and part of the initial work for the agro-ecosystem group is to get a better understanding of current and potential future trajectories of agriculture in New England and how the public at large perceives and values these changes—the latter being anything but clear, according to Asbjornsen and others on the project.

"The first step for us is to establish the relevance and importance of agriculture and agricultural expansion in New England," Asbjornsen says. "We need to understand the implications and potential environmental impacts of increased local food production."

With these data in hand, the researchers will then look into how landscapes could be designed and configured to maximize agricultural production while at the same time maintaining key ecosystem services that ensure water and soil quality and biodiversity, for example.

"If we want to increase food production in 30 years by, say, 50 percent, what will the specific trade-offs be? We need to understand those and justify them before we actually go down that road."

To this end, establishing an agro-ecosystem experimental station on UNH land similar to the Hubbard Brook Experimental Forest in New Hampshire's White Mountains is being considered. The long-term ecosystem study at Hubbard Brook has involved many researchers from different fields of expertise including hydrology and water quality, vegetation dynamics, soils, nutrients, biogeochemistry, etc.

"Part of the challenge is that, compared to a purely forested ecosystem, we'd need a very different type of experimental framework to answer questions in a mixed agro-ecosystem setting," says Asbjornsen.

For example, that framework would require being able to look at watersheds with different configurations of agricultural crop production and forests that could be experimentally manipulated.

The upshot of the group's work is to evaluate the potential impacts of expanding food production in the Northeast so that decision makers can accurately assess the situation as public demand grows for more locally grown food. This evaluation will analyze expected trade-offs between key ecosystem services (e.g., carbon sequestration, nutrient cycling and retention, and hydrologic flow regulation) under different land use change scenarios.

"It's possible that the growing demand for local products will result in more intensive agricultural production and/or conversion of existing forests to cropland or pasture. Thus, before embarking on this path, it's important that society first understands the potential impacts of different land use practices on multiple ecosystem services," Asbjornsen says. "If we want to increase food production in 30 years by, say, 50 percent, what will the specific trade-offs be? We need to understand those and justify them before we actually go down that road."

by David Sims, Science Writer, Institute for the Study of Earth, Oceans, and Space.

[an error occurred while processing this directive]

Welcome to Spheres Online

the University of New Hampshire Institute for the Study of Earth, Oceans, and Space electronic newsletter.

Subscribe to *Spheres* Online

Spheres Archives

www.eos.unh.edu

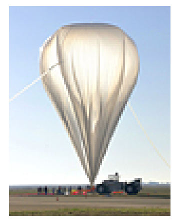
Institute for the Study of Earth, Oceans, and Space (EOS)
EOS Director: Harlan Spence
Editor: David Sims
Designer: Kristi Donahue
Circulation: Laurie Pinciak

Morse Hall, 8 College Road,
Durham, NH 03824
www.eos.unh.edu
eos.director@unh.edu

Fall 2012

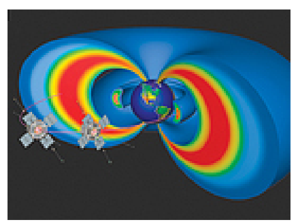
Faculty, Staff, and Student News

Space Science Center



GRAPE

The Gamma Ray Polarimeter Experiment, or **GRAPE**, was recently renewed for another three years with $1.1 million in funding from the NASA Astrophysics program, says principal investigator **Mark McConnell**. The balloon-based experiment had an initial flight in 2011 and the new funding will provide for instrumentation improvements and a second balloon launch scheduled to take place in the fall of 2014 from Ft. Sumner, New Mexico. **Peter Bloser** and **Jason Legere** will continue to play a significant role in the project.



RBSP

Launched on August 30th, the twin **Radiation Belt Storm Probes** (RBSP) wasted no time gathering seminal data from this complex, dynamic, and hazardous region of geospace. Indeed, only days after launch, the Relativistic Electron Proton Telescope on the Energetic Particle, Composition, and Thermal Plasma Suite, or ECT, witnessed a remarkable radiation belt event, an event that is already generating much scientific excitement. And in early October the Electric and Magnetic Field Instrument Suite and Integrated Science (EMFISIS) experiment recorded what has been dubbed "Earthsong." It is clearest recording ever made of an electromagnetic phenomenon known as "chorus" and thought to be one of the most important waves for energizing the electrons that make up the outer radiation belt. Since then, the other ECT instruments, the Magnetic Electron Ion Spectrometer and the Helium Oxygen Proton Electron instruments have been commissioned and are collecting outstanding science data. EOS director **Harlan Spence** is the principal investigator for ECT and SSC director **Roy Torbert** is a coinvestigator on EMFISIS. All of the RBSP science instrument teams completed adjusting and fine-tuning their instruments before heading into the full-scale science phase, which began officially on October 29.

Chuck Smith reports that several undergraduate students working with him, **Bernie Vasquez**, and **Phil Isenberg** have attended key space physics conferences and are working on papers for publication. **Jesse Coburn** attended the Solar Wind 13 and SHINE 2012 conferences in June where he presented work on analyses of energy cascade rates in the solar wind. **Brad Cannon** was awarded a summer internship to continue a collaboration with Jet Propulsion Laboratory

From the Director

All for One, One for All

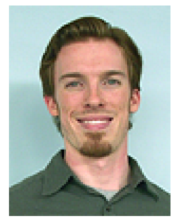
Harlan Spence

I AM OFTEN asked a question that I myself posed three years ago during my UNH interview process: "How do you pronounce EOS?" The answer is at the same time both trivial and deep. Some enunciate it as if speaking the name of the Greek goddess of the dawn, Eos. Others incant our institute's name as if reading it letter by letter, E-O-S. Both are commonly accepted, nearly equally used, and well understood by all.

Before I even arrived at UNH, I had already become enamored with the former pronunciation. For me, it is not a subtle distinction nor was it a trivial decision. E-O-S does accurately spell the major domains—Earth, Oceans, and Space—that define our institute's research foci. Without a doubt, the "E" (Earth Systems Research Center), "O" (Ocean Processes Analysis Laboratory), and "S" (Space Science Center) research pillars are our strengths and brand us nationally and internationally.

However, for as strong as we are individually in these core disciplinary areas, I believe there is even greater strength when considered collectively. EOS research frequently blurs the traditional boundaries that delimit disciplines and even their sub-disciplines; this resonates well in a new era where funding agencies increasingly look to support interdisciplinary research. To paraphrase a quote oft attributed to Aristotle, "EOS is greater than the sum of our parts." Accordingly, and decisively, I think of EOS as a whole, instead of as three separate centers. Hence, to me, EOS is a colleague Neil Murphy and is finishing two papers on newborn interstellar pickup ions as a result of his summer's work. **Steve Orlove** is preparing a paper on solar dynamics using solar wind measurements within large-scale rarefaction regions. **Matt Stemkowski** coauthored a paper on correlation functions in solar wind turbulence that has been submitted to the proceedings of Solar Wind 13. And graduate student **Kristoff Paulson**, along with RPI undergraduate **David Taylor**, who worked within EOS this summer, had a paper accepted that details how weak interplanetary shocks can serve as important harbingers of approaching transient solar wind.

The **Interstellar Boundary Explorer** (IBEX) has completed its fourth year in orbit after being launched October 19, 2008. Last year, the spacecraft was maneuvered into a unique, stable orbit that should accommodate a lifetime of several decades for the mission. IBEX has opened a new window onto the global heliosphere and properties of the local galactic environment.

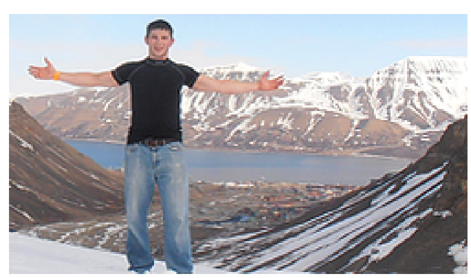

Trevor Leonard

At the end of October, the IBEX Science Working Team Meeting was held in Santa Fe, N.M. and was supported by UNH-SSC faculty **Harald Kucharek**, **Martin Lee**, **Eberhard Möbius**, and **Nathan Schwadron**, as well as graduate students **Jeewoo Park** and **Trevor Leonard**. While Lee, Schwadron, Park, and Leonard presented new findings on the four species of the interstellar wind that IBEX is capturing, Kucharek and Möbius discussed two models of how to explain the surprising "IBEX Ribbon," which was discovered by the mission and has since caused intense, ongoing debates as to its origin. Future mission science operations led by UNH had a prominent place in the meeting, as did work on a Senior Review proposal to NASA in which the anticipated operations and expected future observations of the mission are laid out. Says Schwadron, "As IBEX continues to track the evolution of the global heliosphere and properties of the local galactic environment over the solar cycle, it enables us to tackle fundamental open questions about the outer boundaries of our solar system."


Taylor Connor

In additional IBEX news, physics Ph.D. candidate Leonard is one of three co-chairs for an IBEX session at the upcoming 2012 AGU Fall Meeting—a "great feat for a graduate student," notes Möbius. The title of the oral and poster sessions is "Our Heliosphere, IBEX, and the Cosmos." Leonard has been working with Möbius studying the neutral interstellar medium flow inside the heliosphere. "Organizing the session has provided invaluable experience, exposed me to a variety of studies related to my field, and forced me to examine each study critically," Leonard says.

Ph.D. candidate **Taylor Connor** will defend his dissertation in November. His doctoral work describes the development of the Gamma Ray Polarimeter Experiment (GRAPE), which is designed to measure the polarization of gamma rays from astronomical sources. GRAPE has largely defined Connor's doctoral experience. His results are derived from the successful 2011 balloon campaign that focused on observations from the Crab Nebula. The measurements lead to a better understanding of both the emission mechanisms and source geometries of celestial bodies.


Drummond Biles

Senior mechanical engineering major **Drummond Biles**, working with advisor **Marc Lessard** in the Magnetosphere-Ionosphere Research Laboratory, has been developing a method for calibrating an all-sky camera for use at the Kjell Henriksen Observatory. The project, which took him to Svalbard, Norway this past summer, is in collaboration with the University Centre in Svalbard in Longyearbyen, Spitsbergen, which supplemented funding in addition to the UNH International Research Opportunity Program grant Biles received.

name to be spoken as a whole, not to be spelled out aloud.

The power of the "EOS gestalt" is well expressed in this issue of *Spheres*. The lead story concerns new, comprehensive underwater analysis that should allow composition of a seminal scientific "symphony" to help society understand and protect precious water resources and estuarine environments. On the other end of the spectrum, EOS scientists are taking part in a mission to the sun as never before—making paradigm-changing measurements as close to our star as mankind has ever ventured. While individual disciplines shine through in these stories, you need not dig too deep to identify common unifying threads—we collectively explore the ways by which our connected domains behave and interact. And through this interdisciplinary EOS research spirit, our collective effort helps bring us out of darkness and into the light, just like our goddess namesake, Eos.
– Harlan Spence

Ocean Process Analysis Laboratory


Doug Vandemark

Director of OPAL **Doug Vandemark** attended a string of international meetings over the past few months that were focused primarily on satellite oceanography. He presented ongoing work under four NASA-sponsored grants to EOS at the Aquarius/SAC-D Science Team Meeting in Buenos Aires (for the Aquarius ocean salinity observing satellite), the NASA Ocean Vector Winds Science Team Meeting in Utrecht, Netherlands, the European Space Agency's 6th Coastal Altimetry Workshop in Riva del Garda, Italy, which he helped organize, and the ESA-hosted "20 years of Progress in Radar Altimetry" symposium also held in Italy. Most recently Vandemark attended the Aquarius Satellite Calibration and Validation Meeting held in October in Washington, D.C.

Tim Moore received a grant from the National Institutes of Health of nearly $600K for a three-year collaborative project between UNH, Michigan Tech University, and Wetlabs—a private company in Rhode Island. The team will develop remote sensing algorithms for the detection and prediction of Microcystis—a poisonous alga that proliferates in freshwater lakes, in particular Lake Erie and Saginaw Bay in Lake Huron. They will deploy in-water instrumentation to gather environmental data and develop algorithms using optical and environmental data collected in the region. Ultimately, the algorithms will help agencies with public notification and mitigation strategies.


Jamie Cournane

Jamie Cournane co-authored a paper titled "Organismal biology in the age of ecosystem-based management" with Jacob Kritzer of the Environmental Defense Fund that was published in October in *Advancing an Ecosystem Approach in the Gulf of Maine* by the American Fisheries Society. Cournane has another paper, "Spatial and temporal patterns of anadromous alosine bycatch in the Atlantic herring fishery," in-press in the journal Fisheries Research with co-authors Kritzer and Steven Correia of Massachusetts Division of Marine Fisheries. Cournane also reports that she and **Christopher Glass** presented their fisheries research at the International Council for the Exploration of the Sea Annual Science Conference in Bergen, Norway in September.

Emily Klein was a co-author with Michael Fogarty of NOAA and David Townsend of the University of Maine on a paper titled "Advances in Understanding Ecosystem Structure and Function in the Gulf of Maine." The paper was also published in the book *Advancing an Ecosystem Approach in the Gulf of Maine*. The special publication summarizes proceedings of the Gulf of Maine Symposium held in St. Andrews, New Brunswick, Canada in October 2009.


Chris Hunt

Chris Hunt participated in the Surface Ocean Carbon ATlas (SOCAT) Coastal Data workshop in Seattle, October 2-4. The SOCAT database compiles surface ocean carbon dioxide measurements from around the world and the workshop was part of developing Version 2 of the database. That will bring the total number of measurements to over nine million. The workshop brought together data contributors from the USA and Japan, who graded and quality-controlled over 900 submissions of new shipboard carbon dioxide data.

Earth Systems Research Center

Mark Twickler and **Joe Souney** received an award from the National Science Foundation's Division of Polar Programs for their proposal "Collaborative Research: A 1500m Ice Core from South Pole." A joint project with UC-Irvine, the University of Washington, and NASA-Goddard, the goal is to collect an ice core during the 2014-15 and 2015-16 Antarctic field seasons to provide an environmental record spanning approximately 40,000 years. Twickler is the scientific coordinator for the National Ice Core Laboratory Science Management Office housed in the ESRC. Souney is project operations manager. The South Pole project will support a wide range of ice core science projects and contribute to the societal need for a basic understanding of climate and the capability to predict climate and ice sheet stability on long time scales.


Elizabeth Burakowski

Cameron Wake and **Elizabeth Burakowski** kicked off the new Seacoast Science Café series at the Portsmouth Brewery September 19 and October 17, respectively. The Wednesday evening series, a collaboration between the New Hampshire EPSCoR program, UNH, and the brewery, offers the opportunity for members of the public to discuss trends and perceptions of our changing climate directly with scientists. Wake, along with **Larry Hamilton** of the Carsey Institute, fielded questions from a packed house attending the "What Do We Really Know and Believe About Climate Change?" inaugural event. "The whole idea is to create a comfortable atmosphere for dialogue as opposed to us lecturing," notes Wake, adding that the audience was "totally engaged" with discussion focused on finding solutions rather than questioning the validity of climate change science. Burakowski, a Ph.D. student, and state climatologist **Mary Stampone** from the UNH department of geography, addressed issues around the theme "Getting to Know Snow: Volunteer Climate Scientists Take an In-Depth Look at NH Snow." Burakowski's doctoral work is funded through a NH EPSCoR project titled "Ecosystems and Society" and involves a citizen-science group making measurements of snow reflectance or "albedo" throughout the state. On November 14, **Scott Ollinger** will present "Forest Ecosystems and the Winds of Change: The History and Future of Forests as a Cog in the Earth System."

The UNH Foundation announced that **Cameron Wake** has been named as the first recipient of the Josephine A. Lamprey Fellowship in Climate and Sustainability, a gift that supports a five-year fellowship designed to promote more focus on the climate and energy issues that interconnect with biodiversity and ecosystems, food systems and culture under sustainability. The gift was made to the university's Sustainability Institute by Jo Lamprey, retired president of Lamprey Brothers, a local company providing heating and cooling solutions since the late 1800s. The support provided to Wake will allow him to advance the Sustainability Institute's regional efforts aimed at shifting New England towards energy independence, as well as adapting to changes in climate that the region is already experiencing.

Erik Hobbie attended the 2012 Association of Ecosystem Research Centers Symposium in Washington, D.C. on October 18-19. The conference theme was "The Role Of Ecosystem Science In National Security" and included talks on human ecology and human security, global freshwater resources, food security, environmental consequences of energy production in the US, and infectious diseases and biosecurity. Talks were webcast and can be accessed at http://www.ecosystemresearch.org/2012-meeting/index.htm.


Ryan Cassotto

In August, graduate student **Ryan Cassotto** deployed a ground-based portable radar interferometer at a Greenland tidewater outlet glacier to gain a better understanding of the dynamics along the glacier's terminus. Cassotto, a second-year Ph.D. student, is studying the deformation and flow properties of materials at the Earth's surface. He will use the Greenland observations to demonstrate how stress changes along the glacier's periphery affect the overall flow of the glacier. Cassotto is working with co-advisor **Margaret Boettcher**, assistant professor of geophysics in the UNH department of Earth sciences, to perform a similar study of landslide properties in the western U.S. The radar is manufactured by Gamma Remote Sensing and was procured by ESRC affiliate associate professor and glaciologist **Mark Fahnestock** of the University of Alaska Fairbanks, also Cassotto's co-advisor, through a research grant from the Betty and Gordon Moore Foundation.


Calvin Diessner

Master's student **Calvin Diessner** is conducting an investigation into an alternative form of aquaculture known as aquaponics—an innovative method of farming where fish are grown in conjunction with plants in a closed recirculating system. Although fish waste provides the nutrients necessary for plant growth, essential macronutrients are deficient when fish are fed standard diets. Supplements often added to optimize plant growth create "enriched" water tolerated by only certain species of fish. Diessner's research uses hybrid striped bass to investigate the co-culture of this fish with plant species that have lower requirements for these macronutrients.

EOS affiliate professor and UNH provost and vice president for academic affairs **John Aber** was honored by the Yale University Graduate School of Arts and Sciences with the Wilbur Lucius Cross Medal, which recognizes alums for distinguished achievements in the areas of scholarship, teaching, academic administration and public service. Aber, a forest ecologist, received his Ph.D. from Yale in 1976. He is internationally known for his groundbreaking work on nitrogen cycling, sustainable ecosystem management, climate change, and the effects of acid rain on forests.

by David Sims, Science Writer, Institute for the Study of Earth, Oceans, and Space.