EOS SPHERES

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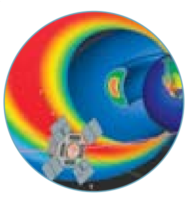

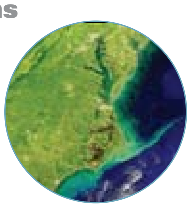

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Here Comes the Sun, Not!

WHEN NASA'S TWIN STEREO satellites rocketed into space back in October of 2006, doctoral student Kristin Simunac was looking forward to the rich, three-dimensional data the Sun-orbiting observatories would gather on coronal mass ejections – the focus of her dissertation. Our star, however, had other plans, so Simunac had to change hers.

STEREO, with the UNH-built Plasma and Suprathermal Ion Composition (PLASTIC) instrument onboard, was launched near the tail end of solar minimum. This quiet period is when the Sun is least active – compared to solar maximum – but still detonates the occasional coronal mass ejection.

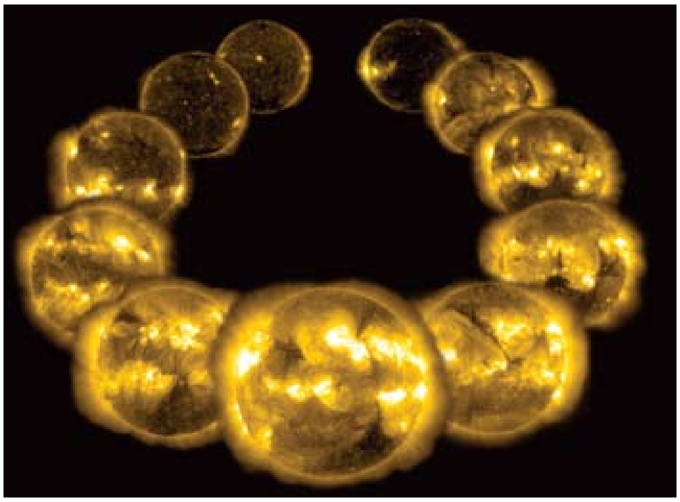

Image courtesy of NASA and ESA

Composite of extreme ultraviolet images of the full solar maximum cycle from 1996 to 2006 (counterclockwise from upper left) taken by the Solar and Heliospheric Observatory (SOHO).

However, during this particular minimum period, the Sun has been practically comatose. In fact, it's been the sleepiest cycle in the 50 years since the space age began. So instead of waiting for the Sun to wake up to carry on with her Ph.D., Simunac changed her focus to the quiet side of things – specifically a phenomenon known as corotating interaction regions.

These regions are ubiquitous, spiral-shaped masses of plasma where the two different types of solar wind emanating from the rotating Sun – fast and slow – collide. This collision creates an area of increased temperature and density as fast solar wind pushes into its slow counterpart.

Says Simunac, "The analogy I like to use for corotating interaction regions is what happens in New England when leaf peepers are out on the road and suddenly up from behind come the commuters. The leaf peepers can either speed up or get out of the way…the overall traffic density increases, tempers flare, heat rises."

It is because of this build up in density and temperature that the interaction regions have been identified, but the

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Water, Water Everywhere

As the Arctic sea ice unexpectedly melted away, thousands of scientests were already focused on the polar region's hydrologic system

Photo by Mark Dornblaser, USGS.

Birch Creek (foreground) and Yukon River in central Alaska.

IN THE FALL OF 2003, when Jonathan Pundsack was just settling in as coordinator of a large, national scientific investigation of the Arctic's complex hydrological system, neither he nor anyone else involved in the effort would have imagined that the biggest, single component of the region's water system would be fast disappearing from the face of the Earth as the program drew to a close.

In 2007, Pundsack notes, the melting of the Arctic sea ice was "completely off the charts" and 2008 was only slightly less dramatic.

The big meltdown, which briefly opened up normally ice-clogged sea routes for the first time in recorded history, has served as a wake-up call to both scientists and the public at large. The top of our world is losing its icy grip.

Given the circumstances, it was fitting, then, that the National Science Foundation's Arctic Community-wide Hydrologic Analysis and Monitoring Program or Arctic CHAMP – the study Pundsack has coordinated for over five years – had dozens of scientists under 22 separate research grants poised to investigate the polar region's unnerving metamorphosis.

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From the Interim Director

Search for the New EOS Director


Photo by K.Donahue, UNH-EOS

IN THE LAST ISSUE OF *Spheres,* I noted that the search for Berrien Moore's successor had begun in earnest. We are now closing in on the final stages of that process with off-campus interviews of a pool of candidates slated for late March and meetings with three to five finalists later in the spring. It is our hope to select a new director sometime this coming summer. President Huddleston continues to be informed of our progress and considers it a high priority.

My previous column also noted that our search comes at a time of "great flux" on many fronts. While this continues to be true, and while the economic landscape that lies ahead appears more challenging than ever, there is room for optimism with respect to Washington's renewed commitment to science under the Obama administration. In the latest stimulus bill, there is significantly higher commitment for Earth and ocean sciences, and, in particular, help for NASA commitments overall that would allow some high-priority programs to progress.

Our new director will be starting his or her tenure at a time when the global challenges confronting humankind will be met with greater leadership at the national level. In combination with new EOS leadership, our talented and resourceful faculty, staff, and students can look forward to continued, full participation in research that improves our understanding of the Earth as an integrated and balanced system requiring our full attention. – Roy Torbert

Earth System Science

Water, Water Everywhere

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"We've made a lot of advances in characterizing some of the changes taking place in the pan-Arctic with respect to freshwater on the land, in the atmosphere, and in the ocean," says Pundsack of the Complex Systems Research Center. The program has officially ended but Pundsack's management office will continue to synthesize data and coordinate outreach and education components. Moreover, smaller component projects are continuing and a second phase of the overarching program is planned.

The fundamental work of the NSF project, alternatively referred to as the Freshwater Integration study, was to synthesize a large number of interdisciplinary research projects in an effort to better understand the Arctic's vast water cycle. Research assistant professor Richard Lammers and research scientist Alexander Shiklomanov of the EOS Water Systems Analysis Group participated in the Arctic study.

Says Lammers, "Water, in all its forms, is the ultimate integrator of something that's occurring to the Earth system and I believe the Freshwater Integration study has helped people to think outside their particular domains of expertise." For example, with the dramatic disappearance of the Arctic sea ice hammering home the need for outside-the-box thinking, the ocean modelers involved in the multidisciplinary study had to start paying more attention to how much freshwater was coming in from the land.

Lammers notes that the focus Arctic CHAMP put on the region was made that much sharper by the occurrence of the International Polar Year, which ran from March of 2007 to 2009.

The IPY, which also included investigations in the Antarctic, involved over 200 projects, with thousands of scientists from over 60 nations examining a wide range of physical, biological, and social research topics relative to Earth's polar regions.


Photo by Laurence C. Smith, UCLA.

The Saskatchewan River Delta in northern Saskatchewan.

"So all of this put the high-latitude science community in a good position to probe further into all the changes we've been seeing, and the impact on freshwater systems in the Arctic in particular," Lammers says.

An example of the interdisciplinary, synthetic approach the initiative took can be seen in the separate working groups that were formed to "transcend" the 22 different projects and generate some big-picture data.

One such group, the "Budgeteers," was tasked with no less than getting a better handle on the entire freshwater budget of the Arctic ocean – all the water that flowed into the sea via all the processes occurring on the land and in the air.

Lammers was a Budgeteer. "We tried to get a snapshot of how much freshwater was there and where it was moving to."

Space Science

Here Comes the Sun, Not!

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actual geometry, known as a Parker Spiral, is purely theoretical. "This spiral picture is fine in theory but until now it's been difficult to experimentally verify that's really what's going on," says Simunac.

Now, with STEREO providing the first three-dimensional views of the Sun and its activities, a more detailed picture will emerge of just what these corotating regions look like. (See related story on page 7.)

This clearer picture will, among other things, provide a better understanding of the "background medium" through which the more explosive coronal mass ejections and solar flares – the primary components of "space weather" – must travel.

All of this solar energy, including the less intensive corotating regions, can disrupt and damage Earth-orbiting satellites, Earth-bound technologies and power supplies, and can pose a danger to astronauts as well as aircraft at Earth's polar regions. Knowing the structure of all this solar plasma barreling towards Earth and beyond will allow better predictive capabilities when an explosive event takes place on the Sun.

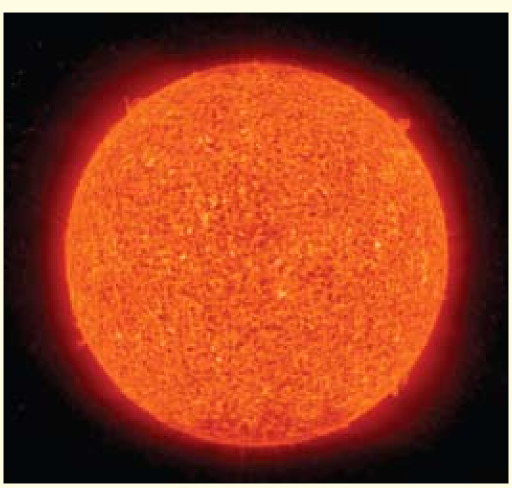


Image courtesy of NASA.

An image of a "quiet" Sun taken by STEREO's Sun Earth Connection Coronal and Heliospheric Investigation (SECCHI) on February 21, 2009. Like the Sun images on page 1, this was taken in extreme ultraviolet light but at a different wavelength.

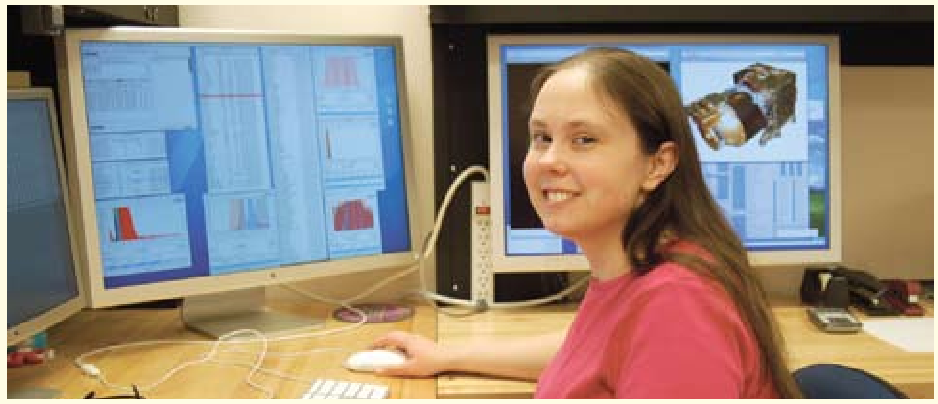


Photo by K.Donahue, UNH-EOS

Kristin Simunac

Says Simunac, "One thing we're trying to figure out is the limit under which we can assume the Parker Spiral geometry is reasonable – because modelers have to put in some assumptions and the fewer assumptions the more accurate the model can be." And, in turn, the more accurate space weather predictions can be.

The STEREO spacecraft, which after two years in orbit reached a 90-degree separation on January 24, provide the perfect perch from which to study the "before and after" shifting shapes of the corotating interactive regions as they spin away from the Sun. (The same can be said, of course, about the twin spacecraft taking measure of coronal mass ejections and solar flares from widely separated orbits.)

Simunac notes that should the Sun remain unusually quiet as the STEREO mission proceeds there will be some disappointment, since mission scientists hoped to study the Sun's more explosive side from the new, three-dimensional view.

"But it's also good to understand the supposedly simpler case," Simunac says, "this gives us a good opportunity to better understand the Sun's quiet time."

Indeed, says Toni Galvin, UNH's principle investigator for STEREO-PLASTIC, some interesting data on particle acceleration is being gathered by another graduate student, Josh Barry, while the Sun slumbers.

"Josh's work includes looking at ionized particles that are being accelerated or energized within the compression areas of the corotating interaction regions as well as particles that have been accelerated near the Earth's bow shock and then shot past the STEREO spacecraft," says Galvin. (Earth's "bow shock" is the region where our planet's magnetic field or magnetosphere meets the solar wind.)

> *"The spiral picture is fine in theory but until now it's been difficult to experimentally verify what's going on..."*

These bow shock events would likely not be identifiable if there was a lot of other particle activity going on during a more active solar period. The significance of the finding, Galvin notes, is that bow shock events at these distances have never been identified before STEREO and were thought to be impossible. "What Josh's work means is that particles being accelerated near the Earth are being tracked into the heliosphere for vaster distances than previously expected." -DS

Another working group tackled all the linkages and feedbacks of the Arctic freshwater cycle to get a better understanding of what might happen when a piece of the puzzle gets removed – Arctic sea ice or permafrost, for example. And the "Intensifiers" working group tried to shed some light on whether or not the Arctic region was seeing an intensification of the hydrologic cycle – heavier precipitation, greater evaporation, etc.

Because the problems the working groups have wrestled with are critical to answer, and because a wealth of data is now in hand, momentum has been created that will keep Arctic CHAMP's work going beyond the life of the program.

In order to fully understand what the Arctic of the future may look like, and what that may mean for humans and our environment, scientists have to first understand the underpinnings of how the Arctic system functions, and understanding the hydrology of the Arctic is one of the most important aspects of the system.

Notes Pundsack, "The Arctic hydrologic cycle links every major component of the Arctic system – the biology, physics, and biogeochemistry. It is critical to our understanding of human-induced change, natural variability, and human vulnerability." -DS

Faculty Profile

Muddy Waters

MOST OF JAMIE PRINGLE'S RESEARCH papers are co-authored with colleagues working in other disciplines. It's just part of his modus operandi as he straddles investigations in his own areas of expertise in both physical and biological oceanography.

While such an approach can cloud the waters of research with extra complexity in the short term, "Anything you do at the interface of disciplines, if successful, is likely to be more interesting," Pringle asserts.

Photo by K.Donahue, UNH-EOS

Jamie Pringle

Take, for example, a scientific investigation into why an invasive crab is suddenly and surprisingly expanding its habitat in the Gulf of Maine along the coast of Nova Scotia – something Pringle and colleagues are currently working on with respect to the species *Carcinus maenas* or the European green crab. The crab is listed among the top 100 of the planet's worst invasive alien species.

Carcinus maenas,
the European green crab

The multidisciplinary team is tackling the problem from the perspective of physical ocean processes, population genetics, and reproductive strategies, among other aspects. All of which means things can get a little confusing.

"If you're *not* working directly with folks in other disciplines the tendency is to try and get rid of at least part of the confusion by assuming that the other side is more or less worked out," says Pringle, an associate professor in the Ocean Process and Analysis Laboratory and Department of Earth Sciences. He adds, "And the easiest way to do that is simply not talk to them."

> *For Oceanographer Jamie Pringle interdisciplinary research provides richer, if harder earned, results.*

But by working with colleagues in other fields Pringle et al. can build a stronger case with fewer assumptions, fewer gray areas.

Pringle has built his career by, in a sense, muddying his research waters. He took a Ph.D. in physical oceanography from MIT and the Woods Hole Oceanographic Institution and did post-doctoral work at the Scripps Institution of Oceanography in biological oceanography.

"There's always the question of whether you should be more concentrated or more diluted in your research. I'm more diluted," Pringle says.

What this means, for example, is that as a physical oceanographer Pringle has better mathematical modeling skills than many of his biological counterparts.

"I'm bringing simple, quantitatively realistic models of the physics to the biological side of things," he says. Moreover, as a physical oceanographer, Pringle can stress to his colleagues that they have to pay attention to the complexities of the circulation of the ocean – the mean flow, the eddies – all aspects of reality for larvae drifting in the ocean.

"It's applying what we understand of the physics of the ocean to a biological problem, and that's a new thing," he says.

For example, in the case of *Carcinus maenas*, Pringle is looking at the physical processes, like ocean currents, that cause crab larvae to drift and, eventually, expand their territory.

In contrast, when just looking at the biological side of the equation the focus is typically on mortality and temperature: species will spread north until it gets too cold – end of story. True enough, but what Pringle and his co-authors stress in their work is that the flow of the ocean modifies that result greatly, that the physics can't be ignored or excessively oversimplified for convenience sake.

"The art of science is to make things as simple as you can and no simpler," Pringle says. "A lot of the discussion of what sets range boundaries in organisms with drifting larvae in the ocean, or what maintains genetic differences between populations that are geographically close to each other, has become too simple. The explanations are not right because they've left out things that are not *less* important but, rather, more important."

In late December of last year, Pringle was invited to give a talk at the American Geophysical Union annual meeting in San Francisco on the research he and colleagues are conducting to better understand how newly introduced variants of *Carcinus maenas* are spreading, displacing the existing crabs, and changing the genetic makeup of the population.

Although this was thought to be a simple case of range expansion, genetic analysis done by Pringle's colleague Joe Roman of the University of Vermont has shown that the northern population is genetically distinct from its southern counterpart, and thus appears to be a new introduction from northern Europe.

Says Pringle, "So these are two distinct populations of *Carcinus maenas* in the north and south and, with funding from the Census for Marine Life, we've been researching the downstream invasion of the new, northern population via the mean currents." The work shows that the spread has not occurred as far as scientists would have expected.

Carcinus maenas can fundamentally alter the ecosystems it invades – it eats many commercially important shellfish and will damage the livelihoods of those who depend on these species.

However, Pringle points out, the importance of the work he and colleagues are doing goes farther than just this particular invasive species on this particular coast. As climate change gathers steam, and the temperature and currents in the coastal ocean change, many species will be unable to live in their altered habitat.

For many species, their ability to survive and adapt to a rapidly changing climate will be controlled by how quickly they can invade new coastal regions whose climates are capable of supporting them. If a species can shift its range poleward towards cooler waters faster than the climate is changing, and if there is suitable habitat, it will likely persist. If not, it could go extinct.

"How quickly species can expand their ranges into more favorable areas will ultimately control how they can adapt to a changing climate. Understanding these processes will give us insights into which species will adapt, and which will not." -DS

Braving the Storm

IN 2012, NASA WILL LAUNCH TWO SPACECRAFT into Earth's radiation belts to brave the harsh environment and probe its inner workings as never before. Onboard each of the identical twins will be a computer built in the Space Science Center.

The Radiation Belt Storm Probes will explore the two donut-shaped regions of high-energy particles trapped by the magnetic field of the Earth. The radiation belts are often referred to as the "Van Allen Belts" due to their discovery by James Van Allen and his team at the University of Iowa in 1958.

Fittingly, the University of Iowa is one of four lead institutions for the mission. Professor Craig Kletzing, a former research associate professor at UNH, is leading the Iowa team in the Electric and Magnetic Field Instrument Suite and Integrated Science experiment.

Partnering with Kletzing's group are professor Roy Torbert, UNH co-investigator for the mission (and Kletzing's former research advisor), software engineer Jerry Needell, digital engineer David Bodet, research project engineer Jon Googins, and project manager Jim Tyler.

The mission will provide unprecedented insight into the physical dynamics of the radiation belts and give scientists the data needed to make predictions of changes in this critical region of space – the region where "space weather" occurs and where hundreds of spacecraft operate.

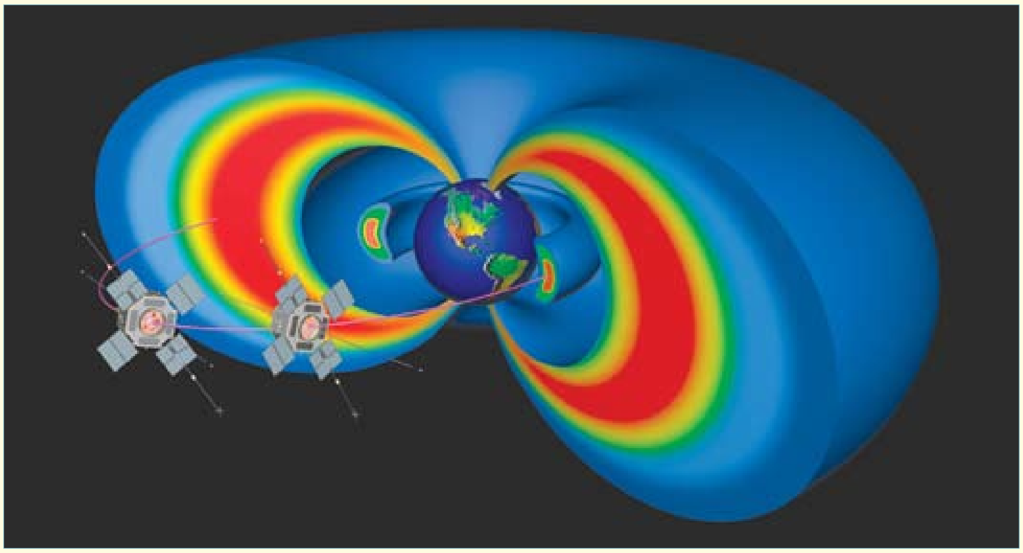
The term space weather generally refers to conditions on the Sun, in the solar wind, and within Earth's magnetosphere and upper atmosphere that can influence the performance and reliability of space-borne and ground-based technological systems and can endanger human life or health.

> *"These will be the best measurements in the radiation belts ever achieved, which makes for a very exciting mission."*

Besides emitting a continuous stream of plasma (solar wind), the Sun periodically releases billions of tons of matter via coronal mass ejections. These immense clouds of material, when directed towards Earth, can cause large magnetic storms in the space environment around Earth, the magnetosphere, and the upper atmosphere.

The two radiation belt probes will measure the particles, magnetic and electric fields, and waves that fill the region of space surrounding Earth or "geospace." Only with two spacecraft taking identical measurements and following the same path can scientists begin to understand how the belts change in both space and time.

Says Torbert, "The RBSP mission will greatly advance our understanding of the dynamics of the radiation around the Earth, making significant improvements in what the science community learned in the last mission to this region, the Combined Release and Radiation Effects Satellite mission launched in 1990."



Courtesy of Johns Hopkins University Applied Physics Laboratory

Artist's conception of RBSP satellites.

Most spacecraft in Earth's orbit operate partly or entirely within the radiation belts. During periods of intense space weather the density and energy of the trapped particles can increase, posing a danger to astronauts, spacecraft, and even some ground-based technologies.

Modern society relies on more than 800 satellites for communication and navigation and increasingly complex systems to power activities on Earth. Understanding the radiation belts and the dangers they pose to technologies will help engineer better ways to protect them.

But first, the data must be gathered, and a critical component in that process will be the UNH-built computer that will be tasked with coordinating the timing of the onboard field and wave experiments and "packaging" the data for transmission back to Earth.

Software engineer Jerry Needell says his biggest challenge for the mission is writing "bulletproof" code that is both robust and can also be reprogrammed as data comes in and the mission evolves.

Explains Needell, "After analyzing some of the findings, scientists might understand some things better and want to take a different tack to improve the mission. So we need to provide the capability to reprogram the operational science software on the fly."

Needell notes that another hurdle to overcome is being able to transmit the plethora of data gathered back down to Earth through the "very small pipe" of telemetry.

"We collect data much faster than it can be transmitted to the ground so you have to be selective about what you send," Needell says.

To achieve this, the onboard computer must perform some data analysis but, Needell notes, "The drawback is that the original data is never sent to the ground, so if the analysis is flawed, the data cannot be recovered."

Kletzing notes that through the combined expertise of UNH in flight computers, Iowa in wave measurements, and NASA's Goddard Space Flight Center in magnetometers, "We will be able to optimize what we send to the ground and get the biggest scientific 'bang for the buck'. These will be the best measurements in the radiation belts ever achieved, which makes for a very exciting mission."

The $550 million, two-spacecraft project is part of NASA's Living With a Star Geospace program to explore fundamental processes that operate throughout the solar system, in particular those that generate hazardous space weather effects near the Earth and phenomena that could affect solar system exploration. -DS

A River Runs Into It

As climate change ensues, springtime plumes of acidic river water may add further stress to coastal ocean creatures

FOR SOME FIVE YEARS, researchers from the Ocean Process and Analysis Laboratory have been faithfully going to sea at least once a month to take measure of the waters along two transects: from Portsmouth Harbor up to the mouth of Maine's Kennebec River, and from Portsmouth out to the Wilkinson Basin in the Gulf of Maine.

The effort has generated a wealth of unique data that will, among other things, help scientists monitor how sea life will fare in warmer, more acidic waters as global warming continues and atmospheric carbon dioxide levels rise. One particular concern is how increasingly acidic waters will impact shellfish and, in turn, the related $1.6 billion U.S. industry.

Image courtesy of NASA

Satellite image of Cape Fear River in North Carolina from NASA's Sea-viewing Wide Field-of-view Sensor (SeaWiFS).

Shellfish larvae, including those of lobsters, clams, mussels, and scallops, begin their lives in shallow coastal waters where they must begin building their protective shells immediately. They do so by pulling calcium carbonate out of seawater. But as seawater becomes more acidic the critical ingredient is in shorter supply as it is used to buffer (make more alkaline) the water itself. Indeed, if the acidity level exceeds a certain threshold shells begin to disintegrate.

> *"The combination of these factors could have severe consequences for high-latitude calcifying organisms..."*

The five-year dataset collected by OPAL scientists, including research assistant professor Joe Salisbury, clearly show that both carbon dioxide and acidity have risen modestly in seawater sampled over that period. The data also show that a specific, crystalline form of calcium carbonate, aragonite, used by many shellfish drops to very low levels at certain times of the year.

"The levels of aragonite were low in general but even lower than expected in springtime," notes Salisbury, "so we looked more carefully at the data with respect to springtime river plumes, which we know are acidic relative to the receiving ocean waters."

Analysis of Kennebec River data uncovered episodes where acidic water with very low levels of aragonite had indeed occurred. And, as bad luck would have it, these acidic plumes can coincide just as shellfish larvae are making a go of it in shallow coastal waters. Should prevailing winds and currents cause a river plume to hug the coastline rather than push it further offshore, the shellfish larvae will be swimming in an acid soup devoid of aragonite.

All of which is not good news for the Gulf of Maine's $450-million-per-year shellfish industry.

Salisbury, along with OPAL colleagues Chris Hunt and Janet Campbell and Mark Green of Saint Joseph's College, wondered if these conditions observed in the western Gulf of Maine might be occurring elsewhere around the globe.

Writing in a paper published on the topic last December in the American Geophysical Union's *EOS Transactions*, Salisbury et al. noted that while many of the world's rivers are acidic and nearly all have aragonite levels that are lower than the ocean water they discharge into, little is known about the relationship between discharge, low aragonite in coastal waters, and the potential negative impact on early stages of early shellfish development.

In *EOS Transactions* the team identified areas in need of further investigation relative to this topic and stated that the Arctic and sub-Arctic coastlines were the priority regions. These are areas with cool temperatures, which further suppress the already low aragonite levels, and dramatic increases in river discharge due to global warming.

"The combination of these factors could have severe consequences for high-latitude calcifying organisms, particularly shelled pteropods, which contribute to the diet of commercially important species including salmon, herring, cod, and mackerel," the authors wrote. -DS

WAIS Divide, Season Two

THE PHOTOGRAPH to the right is the tip of a 4.8-inch diameter core of ancient, frozen snow dating back 7,700 years ago – roughly around the time Sumerians of Mesopotamia were developing irrigation systems for agriculture. Trapped in and between the ice crystals are pockets of air and chemicals that circulated the globe at the time and can now be analyzed by scientists for clues of Earth's past climate.

The shaft of ice was pulled up from a depth nearly a mile (4,960 feet) below the surface of the Western Antarctic Ice Sheet. It is the end result of around-the-clock drilling operations that began December 22, 2008 and ended late in the polar evening on January 22, 2009, drawing to a close the second season of the National Science Foundation's West Antarctic Ice Sheet Divide Ice Core Project.

The WAIS Divide project is an unprecedented, multi-year effort to retrieve the most detailed record of greenhouse gases in Earth's atmosphere over the last 100,000 years, including a yearly record of the last 40,000 years.

Photo by Logan Mitchell, Oregon State University

"The success of this year's field season, even after a delayed start, was in part due to the science technicians hired by UNH," says Mark Twickler, manager of the WAIS Divide Science Coordination Office within EOS. He adds, "We hope to reach the 40,000-year-old depth next year." -DS

STEREO, Two Years On

UNH'S LEAD SCIENTIST FOR THE STEREO mission, research associate professor Toni Galvin, reports that despite the Sun's relatively quiet conditions the STEREO mission has already accomplished a number of "firsts." These include the first true three-dimensional imaging of solar features, such as the twisting in solar jets. The observed spiral structure confirms theoretical models regarding the role of twisted magnetic field lines in small-scale ejection of plasma from the Sun, which may be a significant contributor to the solar wind as measured by PLASTIC.

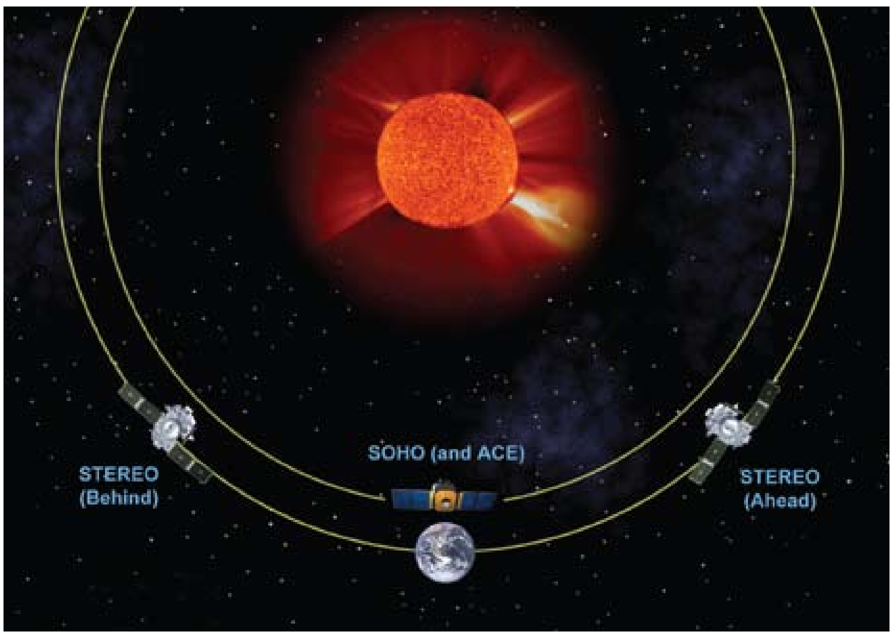


Image courtesy of NASA

The SOHO and ACE spacecraft, which orbit about 1 million miles closer to the Sun, provide a head-on view of what's headed toward Earth while STEREO A and B allow a side view perspective.

STEREO has also provided the first detailed images showing the flow of matter from the surface of the Sun all the way to one astronomical unit (the radius of the orbit of the Earth around the Sun, or about 90 million miles). This included the first imaging of the collision between an interplanetary coronal mass ejection and a comet, in which the tail of the comet was ripped off and reformed – an occurrence termed a "disconnection event."

> *"Like watching a pitch from first and third base simultaneously...we will now have a side view perspective of any coronal mass ejections..."*

For these and other achievements, the STEREO mission was ranked number one in last year's NASA Senior Review of Heliophysics Operating Missions. The senior review is the space agency's periodic, detailed evaluation of how well current satellite missions are meeting their science objectives.

Galvin notes that STEREO is also playing a key role in space weather predictions being made by the National Oceanic and Atmospheric Administration Space Weather Prediction Center (http://www.swpc.noaa.gov/stereo/index.shtml).

The NOAA center provides real-time data from STEREO, including solar wind measurements by the PLASTIC experiment. (See page 5 for a related space weather story on NASA's upcoming Radiation Belt Storm Probes mission.)

These data are obtained through an international collaboration of ground tracking stations, including those located in France, the United Kingdom, and Japan. Key elements for predicting magnetic storms at the Earth are the observation of coronal mass ejections, and the tracking of their passage through interplanetary space. With STEREO now proceeding past the point where the twin spacecraft are 90 degrees apart – 45 degrees between each spacecraft and the Earth, the mission is well positioned for the current rise toward solar maximum.

Says Galvin, "Like watching a pitch from first and third base simultaneously, instead of only having a home plate point of view, we will now have a side view perspective of any coronal mass ejections launched from the Sun making their way toward Earth. This will allow us to determine if the mass ejection will indeed hit the Earth, and if so, when to expect it to hit and initiate a magnetic storm." -DS

EOS News

Alex Pszenny of CCRC is on assignment this year as a program director of the National Science Foundation's Atmospheric Chemistry Program.

Scott Ollinger recently published an article titled "Canopy nitrogen, carbon assimilation, and albedo in temperate and boreal forests: Functional relations and potential climate feedbacks" in the *Proceedings of the National Academy of Sciences*. CSRC colleagues **Andrew Richardson**, **Mary Martin**, **Steve Frolking**, **Lucie Plourde** and **Michelle Day** were coauthors. Also, Ollinger was recently elected to the board of directors of the National Ecological Research Network.

Ben Chandran was awarded a grant titled "Turbulence and Perpendicular Ion Heating in the Corona and Solar Wind" from the NSF's Solar, Heliospheric, and Interplanetary Environment program.

George Hurtt was appointed chair of the Oak Ridge National Laboratory Distributed Archive and Analysis Center User Working Group.

Doug Vandemark and **Joe Salisbury** of OPAL gave an invited plenary talk at the second meeting of the North American Carbon Program in San Diego in February. The meeting involved many carbon cycle scientists, including others from EOS, in terrestrial, air, and ocean studies with a goal to synthesize all that is currently known about carbon in this continental region. Vandemark and Salisbury have also been awarded an NSF proposal related to improved understanding of CO_2 flux into and out of the Gulf of Maine.

Former Research & Discover fellow and graduate student **R. Quinn Thomas** published his master's thesis work in the *Canadian Journal of Forest Research*.

Physics senior **Jeffrey Tessein** and recent graduate **Benjamin MacBride**, both of whom have worked in the Space Science Center, were co-authors of an article published in *The Journal of Astrophysics*.

For the second consecutive year, EOS *Spheres* received top honors in the Society for Technical Communication-Boston/Northern New England's annual competition. *Spheres* picked up an Award of Distinction at the 2009 STC Technical Achievement in Communication Information banquet in February.

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The Little Observatory That Could

ANTARCTICA IS THE COLDEST, WINDIEST, DRIEST spot on our planet and is bathed in darkness six months a year. Not the easiest place for scientists to gather data. But design a robot of sorts to do the job for you and a stream of vital information pours forth 24/7, 365.

That's precisely what scientists from the Space Science Center, as part of a multi-institutional, collaborative team, have achieved with the successful deployment of the Autonomous Real-time Remote Observatory at Antarctica's McMurdo Station.

Called ARRO for short, the observatory is a heavily insulated, eight-foot modular cube powered by solar and wind energy. The maintenance-free facility uses only a small bank of batteries and two five-gallon water jugs to act as "phase change material" to store the thermal energy needed to keep things operating.

The observatory sends it's data back in real-time by passing it off relay-race style to a series of satellites circling the globe like "cell phone towers in space," says co-investigator for the project, EOS space physicist Marc Lessard. The data stream received via Iridium satellite phone ultimately gets captured by an antenna perched atop Morse Hall almost directly above Lessard's EOS office.

With darkness now engulfing the South Pole, the observatory is running on the power generated only by three, small wind turbines working in parallel.

"It's down there now chugging away," says Lessard, who compares the observatory to "The Little Engine That Could" for its ability to keep on keeping on despite hardships.

Photo by Chris Seymour, UNH-EOS

The Autonomous Real-time Remote Observatory at McMurdo Station in Antarctica.

When the wind dies down and any residual power and heat is used up, the whole unit goes into a state of torpor called "cold soak." "Everything freezes, and when the wind comes back the whole system powers up again, chugga, chugga, and we start getting data again," he says.

ARRO is the latest in a generation of observatories that gather data on the interaction of solar wind energy with Earth's magnetic field lines, which arc high above our atmosphere and connect at both the North and South poles. Gathering such information in Antarctica is significantly more challenging in comparison to the more populated and relatively milder northern polar region.

But, notes Lessard, "The global electrical circuit is incredibly complicated and there are a lot of gaps in our knowledge about how it works. In order to fully understand the phenomena we're studying, you have to know what happens with the field lines at both the poles." -DS