RESEARCH SPOTLIGHT

Highlighting exciting new research from AGU journals

Measuring the electron density of the magnetosphere

Researchers have demonstrated the potential use of a new way to measure properties of Earth's magnetosphere, the magnetic bubble that surrounds the planet. *Zhai et al.* used a property known as Faraday rotation for radio tomographic imaging of the magnetosphere. Faraday rotation occurs when a linearly polarized light wave travels through a magnetized medium such as the magnetosphere. The magnetic field causes the plane of polarization to rotate, and the amount of rotation is directly proportional to the electron density in the medium and to the magnetic field. Because Earth's magnetic field is known, researchers therefore can use measurements of Faraday rotation to reconstruct electron density in the magnetosphere.

Using receivers on the Wind spacecraft, the researchers measured the polarization of radio signals transmitted by the Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) spacecraft. They used the polarization data to reconstruct a two-dimensional electron density image of Earth's magnetosphere in the north polar region. The researchers found that the electron density determined by this method agreed well with empirical models of electron density. Such measurements could lead to improved understanding of large-scale processes in the magnetosphere. (*Journal of Geophysical Research-Space Physics,* doi:10.1029/2011JA016743, 2011) —EB

Sea ice controls variability in microseismicity

When an ocean wave swells, the sudden change in water column mass sends a pressure wave down to the ocean bottom. If the wave lasts long enough to strike the shore, its kinetic energy is transferred to the rock. Both processes induce microseismicity—low-powered seismic waves with periods of between 1 and 20 seconds—which is picked up by seismic monitoring stations as regular background motions of the Earth. The observed amplitude of the microseismic signal varies with the distance from the source and shows pronounced seasonality because big winter storms kick up larger waves.

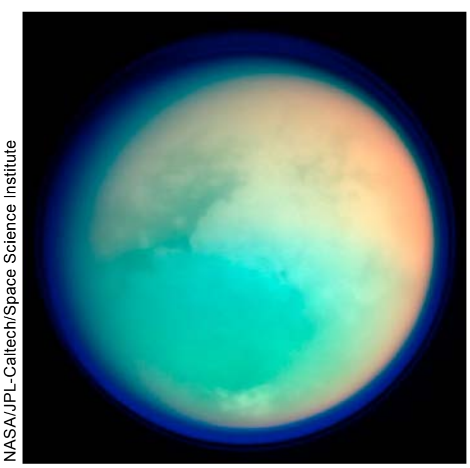
Because microseismicity depends on the formation and propagation of surface ocean waves, *Tsai and McNamara* wondered if sea surface ice may have an appreciable effect on the signal. To find out, the authors built a simple computer model and pulled together twice-weekly observations of sea ice extent, along with hourly readings of three seismic stations, for the Bering Sea. Of the three stations, two were surrounded by the seasonal encroach of sea ice, while the third lay too far south and served as a control. The authors found that changes in sea ice concentration could explain between 75% and 90% of the variability in the amplitude of the microseismicity for the two northern stations.

The authors hope their model, whose analyses should be less costly and more frequent than current satellite-based techniques, will eventually allow for remote estimations of the concentration and strength of sea ice. Such information would have important applications in the shipping industry and could be valuable for climate change research. (*Geophysical Research Letters,* doi:10.1029/2011GL049791, 2011) —CS

Evaluating the global energy balance of Titan

To understand the weather and climate on Earth as well as on other planets and their moons, scientists need to know the global energy balance, the balance between energy coming in from solar radiation and thermal energy radiated back out of the planet. The energy balance can provide interesting information about a planet. For instance, Jupiter, Saturn, and Neptune emit more energy than they absorb, implying that these planets have an internal heat source. Earth, on the other hand, is in near equilibrium, with energy coming in approximately equaling energy going out, though a small energy imbalance can lead to global climate change.

Saturn's moon Titan is the only moon in the solar system with a thick atmosphere, and scientists have been interested in exploring ways in which Titan is similar to Earth. To learn more about Titan, *Li et al.* calculated its energy balance. The absorbed energy has been measured by various telescopes and spacecraft; the emitted energy was recently measured by instruments on board NASA's Cassini spacecraft. The authors compared total absorbed solar power with total emitted thermal power and found that the global energy budget of Titan is in equilibrium within the measurement error. (*Geophysical Research Letters*, doi:10.1029/2011GL050053, 2011) —EB



NASA/JPL-Caltech/Space Science Institute

A global view of Titan from the Imaging Science Subsystem on the spacecraft Cassini.

Dusty plasma around Enceladus affects Saturn's magnetosphere

Scientists have been puzzled by periodic bursts of radiation, known as the Saturn kilometric radiation (SKR), that occur in the planet's magnetosphere. These emissions occur at a rate that is close to, but not quite the same as, the rate at which the planet rotates.

New observations from the Cassini spacecraft's flybys of Saturn's moon Enceladus in 2008 are revealing new details about the plasma environment around Enceladus and how it may affect Saturn's magnetosphere. These observations could also shed some light on the SKR rotation rate.

Enceladus sprays out a plume of water vapor and ice from its south pole. This plume produces ionized gas that is a significant source of plasma for Saturn's magnetosphere and E ring. Observations described by *Morooka et al.* show that the plume also produces negatively charged dust that affects the motion of the plasma in this region. This dust-plasma interaction impacts the dynamics of Saturn's magnetosphere, possibly influencing the rate of SKR emissions. (*Journal of Geophysical Research-Space Physics*, doi:10.1029/2011JA017038, 2011) —EB

Estimating hyperconcentrated flow discharge

Determining flow discharge in torrential mountain floods can help in managing flood risk. However, standard methods of estimating discharge have significant uncertainties. To reduce these uncertainties, *Bodoque et al.* developed an iterative methodological approach to flow estimation based on a method known as the critical depth method along with paleoflood evidence. They applied the method to study a flash flood that occurred on 17 December 1997 in the Arroyo Cabrera catchment in central Spain. This large flow event, triggered by torrential rains, was complex and included hyperconcentrated flows, which are flows of water mixed with significant amounts of sediment.

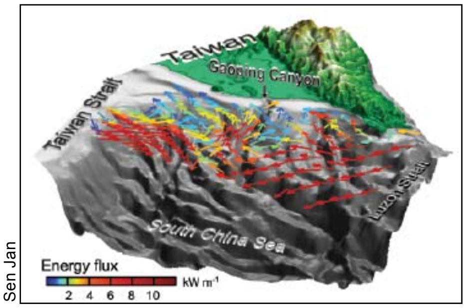
Using their technique, the researchers avoided some of the simplifications usually used in standard hydraulic approaches. For instance, standard approaches simplify the geometry of stream cross sections, while the researchers used the accurate, more complicated cross section. In addition, standard approaches to estimating discharge often assume clear water flow, but real flows can include high concentrations of sediment. Furthermore, standard approaches were developed for less steep channels, but the new method takes into account the steepness of the channels. Using their more accurate method, the authors estimated that peak discharge in this event was about 1080 cubic meters of water and sediment per second. The authors believe the methodology used could be applied to other basins and could be useful for helping analyze and manage flood risk. (*Water Resources Research*, doi:10.1029/2011WR010380, 2011) —EB

Interacting ocean waves explain powerful seafloor canyon flows

Off the southwestern coast of Taiwan the Gaoping Submarine Canyon meanders in a giant backward S shape as it stretches southwestward toward the South China Sea. In the canyon, a 200-meter-deep cut into the seafloor that lies 300 meters below the sea's surface, the waters carry an usually large amount of internal tidal power—9.1 megawatts from the canyon's mouth to its head. Along with the strong flows a region of enhanced vertical mixing sits at the canyon's head. Researchers had previously attributed the anomalous flows to internal waves pushing through the Gaoping Canyon, though the source of the energy remained an open question.

When tide-driven waves pass over a sudden change in seafloor topography, the shift in pressure triggers gravity waves (known as internal waves) that propagate through the ocean's interior. Using a three-dimensional model of the surrounding ocean, *Chiou et al.* isolated the likely source of the internal waves. The authors found that the powerful waves traveling through the Gaoping Canyon were not generated on site. Instead, they spawned at the nearby Taiwan and Luzon straits, each the site of a 6000-meter change in relief. However, these remote waves were not enough to fully explain the energy seen in the flows in the Gaoping Canyon.

From their model, the authors found that at the head of the canyon, a large standing wave was amplifying other incoming waves. The authors suggest that this standing wave was formed by one of two mechanisms: Either the internal waves from the Taiwan and Luzon straits were positively interfering, or the Luzon Strait waves were interfering with other Luzon Strait waves that had previously reflected off the steep walls of the Taiwan Banks. The authors suggest



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Colored arrows indicate the energy flux of the internal tide flowing in and around Gaoping Canyon, with warm colors denoting high flux and cool colors denoting low flux. The internal waves are heavily influenced by steep drops in the seafloor at the Taiwan and Luzon straits.

that this standing wave is also responsible for the enhanced vertical mixing seen near the Gaoping Submarine Canyon. (*Journal of Geophysical Research-Oceans*, doi:10.1029/2011JC007366, 2011) —CS

Bark beetle outbreaks affect regional carbon cycle

Bark beetle outbreaks can kill a large number of trees—in fact, insect outbreaks affect an area similar in size to that affected by forest fires annually across North America. Trees absorb carbon dioxide, so bark beetle outbreaks can significantly affect regional carbon dynamics. In general, immediately after an outbreak, carbon uptake by trees decreases. Dead trees become snags, which may fall to the ground several or more years after the outbreak. After snags fall, decomposition increases. Carbon uptake begins to recover years to decades after a bark beetle outbreak. There have been few studies of biogeochemical cycling following outbreaks, and those studies have shown a variety of effects in different forests.

To learn more about these varying responses, *Edburg et al.* used an ecosystem model to study how the severity and duration of a mountain pine beetle outbreak alter carbon and nitrogen fluxes. They compared control simulations with no bark beetle outbreak to situations with varying levels of outbreak severity and duration. The fraction of trees killed, the delay in snag fall, and the rate of snag fall can affect carbon fluxes for decades after the bark beetle outbreak. The severity of the outbreak, as determined by the fraction of dead trees, was a key factor in the initial decrease in carbon uptake and in the forest's recovery. Outbreak duration was an important factor in short-term carbon fluxes.

J. Hicke

Lodgepole pine trees killed by mountain pine beetles in Colorado.

Furthermore, the fate of the dead trees makes a difference: If trees were cut immediately after an outbreak and left on site, the area became a large source of carbon, but if dead trees were removed from the site, the amount of carbon emitted was small. (*Journal of Geophysical Research-Biogeosciences*, doi:10.1029/2011JG001786, 2011) —EB

Pulling regional weather from the climate record

At its core, weather is fueled by the redistribution of energy, and the medium for this regional shuffling is the surface atmosphere. Adjacent air masses are characterized by different physical properties, with atmospheric fronts demarcating the boundaries between them. A passing front can bring storms and heat waves, or, expressed more mundanely, sudden changes in atmospheric conditions: temperature, humidity, and pressure. Despite the power of atmospheric fronts in explaining regional weather, little effort has been put into understanding front frequency or dynamics from a climatic perspective.

In previous research, *Berry et al.* developed a technique to draw information on atmospheric fronts out of historical climate data, building on the work of previous researchers. By looking for sudden changes in the wet-bulb potential temperature at the 850-hectopascal level, the authors could identify a passing front, with the measurement of wet-bulb potential temperature integrating changes in temperature, pressure, and humidity. In the present study, the team applied its front detection technique to four independent climate reanalysis data sets. The authors found that between 1989 and 2009, atmospheric front frequency in the North Atlantic dropped by between 10% and 20%, which they note corresponds with the idea of a recent poleward shift in the North Atlantic storm track. In the subtropical North Pacific, front frequencies rose substantially. *Berry et al.* point out that because the records of front frequency span only 21 years, they were unable to isolate the effects of decadal-scale climate dynamics. Though the relationship between atmospheric fronts and specific weather conditions varies regionally, the ability to identify changes in front frequency will be important for predicting the local effects of climate change. (*Geophysical Research Letters,* doi:10.1029/2011GL049481, 2011) —CS

—Ernie Balcerak, Staff Writer, and Colin Schultz, Writer