RESEARCH SPOTLIGHT

Highlighting exciting new research from AGU journals

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Effect of vegetation die-off on tidal marshland tested

Consisting of densely vegetated platforms raised slightly above sea level, and interwoven by channels of water meandering inland from the coast, tidal marshlands help buffer against strong storm surges, protect against flooding, limit coastal erosion, and provide a valuable habitat for a vast array of coastal species. Continued global climate change, however, has researchers worried about the stability of coastal marshlands in light of rising temperatures and sea levels and a declining ocean pH. Of particular concern over shorter time scales are the potential consequences for marsh dynamics should there be a mass die-off of marshland vegetation.

https://beeldbank.rws.nl, Rijkswaterstaat, Joop van Houdt

An aerial view of the Scheldt estuary, Belgium, shows the typical components of tidal marshlands, including raised vegetated platforms and branching flow channels.

Investigations of the effects of mass vegetative death on marshland behavior have been conducted almost exclusively using computer simulations, but *Temmerman et al.* sought to bolster this previous research with empirical evidence. The authors measured water flow rates and directions in Kijkverdriet, a freshwater tidal marsh in northern Belgium, both before and after they clear-cut 0.04 square kilometer of vegetation. They found that flow rates increased over the previously vegetated land and decreased in the vegetation-free channels, essentially equalizing the flows over the whole area. They found that, following their intervention, the water flow direction over the freshly barren platforms became increasingly parallel to the nearby channel's flows.

Finding good agreement between their observations and the predictions of modeling efforts, the authors suggest that a large-scale plant die-off would lead to sediment infilling of marsh channels and reduced sedimentation to the previously vegetated platforms. They say that this would further reduce the survival of future marshland vegetation, triggering a runaway feedback cycle culminating in permanent marsh loss. (*Geophysical Research Letters*, doi:10.1029/2011GL050502, 2012) —CS

Measuring mercury in coastal fog water

Mercury, a heavy metal neurotoxin, accumulates in sea life, in some cases reaching levels that make seafood unsafe for humans to eat. How mercury gets into aquatic organisms is debated, but part of the pathway could include mercury carried in precipitation, including rain, snow, and fog. The contribution of mercury in fog water in particular is not well known, especially in foggy coastal areas such as coastal California.

Daniel Fernandez, California State University, Monterey Bay

A new study measured mercury in coastal fog water around Monterey Bay, California.

To learn more, *Weiss-Penzias et al.* measured total mercury and monomethyl mercury concentrations in fog water and rainwater samples taken from four locations around Monterey Bay, California, during spring and summer 2011. They found that the mean monomethyl mercury concentrations in their fog water samples were about 34 times higher than the mean concentrations in their rainwater samples. Therefore, the authors believe that fog is an important, previously unrecognized source of mercury to coastal ecosystems. They also explored potential sources of mercury, finding that biotically formed monomethyl mercury from oceanic upwelling may contribute to monomethyl mercury in fog. (*Geophysical Research Letters*, doi:10.1029/2011GL050324, 2012) —EB

Model estimates soil permeability using induced polarization

The speed at which water flows through the ground depends on a number of physical parameters, including the density of the soil and the number and sizes of open pores, with the cumulative effect of these parameters dictating the soil's permeability. When exposed to an electric field, sediment grains within the soil get polarized because of an extremely thin structure that surrounds each grain known as the electrical double layer. The electrical double layer consists of a thin layer of adsorbed ions and a diffuse layer of ions that encircle each soil particle. Researchers are able to measure the polarization of the soil to nonintrusively estimate the soil's textural properties, and hence its permeability, with the polarization of the soil being controlled by the polarization of the electrical double layer.

To understand how the electrical double layers of different types of soil get polarized in an electric field and the effect this has on their electrical conductivities, *Revil* developed the spectral induced polarization model POLARIS. The model uses the temperature, salinity, and grain size distribution, among other properties, to estimate the electrical conductivity of both the diffuse and adsorbed ion layers for a particular type of soil. The author assessed the effect of the electrical double layer on soil conductivity for clay soils, adding to previous research on silica soils. Comparing the model's estimates against two independent databases, the author found that POLARIS was able to estimate the observed soil permeability to within an order of magnitude. (*Water Resources Research*, doi:10.1029/2011WR011260, 2012) —CS

Regional models expect drier, stormier western United States

As American southwestern states struggle against ongoing drought and the northwest braces for a projected shift from a snow- to a rain-dominated hydrological system, climate researchers strive to provide precipitation projections that are fine-grained enough to be of value to municipal water managers. Estimates derived from large general circulation models show that in a warming world, water availability in the western United States will be increasingly dictated by extreme events. However, such large models tend to lack necessary detail for the small-scale interactions and topographic influences that dominate daily changes in local precipitation. To convert the broad predictions of global models into practical predictions, *Dominguez et al.* use an ensemble of regional models, set to fit within the projections of general circulation models, to estimate future winter average and extreme precipitation for the western United States.

The authors calculate that for the years 2038–2070, winter average precipitation in the southwestern states will be 7.5% below 1979–1999 levels. They also estimate a 12.6% increase in the magnitude of 20-year-return-period winter storms and a 14.4% increase for 50-year winter storms for the entire areal-averaged western United States. In some regions, like Southern California and northwestern Arizona, this increase in strength of 50-year storms was pushed as high as 50%. Although the temporal and spatial granularity of the regional climate models is much improved over that of general circulation models, workable and useful measurements for hydrological engineering and water management design will need ever better estimates of future rainfall patterns. (*Geophysical Research Letters*, doi:10.1029/2011GL050762, 2012) –CS

Persistent regional carbon dioxide anomalies driven by land use

Researchers have traditionally used measurements from remote locations, such as Hawaii's Mauna Loa Observatory and other isolated stations, to determine atmospheric carbon dioxide (CO_2) concentrations and estimate the strengths of various carbon sources and sinks. The prevailing wisdom was that attempts to measure regional differences in CO_2 over land would end up with signals that were either so small that they were undetectable or that were dominated by high-frequency variability due to atmospheric turbulence or weather. Measurements drawn from a moderately dense network of atmospheric gas composition sensors distributed across the upper midwestern United States, however, showed that large regional variations in tropospheric CO_2 are readily observable. Drawing on measurements made at nine sensors spread over 400,000 square kilometers between 2007 and 2009, *Miles et al.* found that seasonal variations in atmospheric CO_2 depend strongly on the type of ecosystem lying at the foot of each sensor tower.

Natasha Miles

Regional depressions in atmospheric carbon dioxide caused by growing corn, soybeans, and grasses can be detected at seasonal time scales, despite shifting weather and atmospheric mixing.

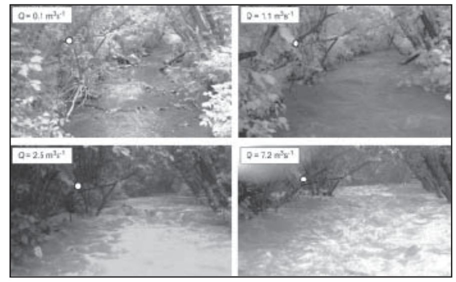
In their agriculture-dominated study area, the authors found that sensors surrounded by cornfields saw atmospheric CO_2 concentrations from 358 to 364 parts per million during the summer growing season, a sizable difference from the current global average tropospheric concentration of 390 parts per million. They also found significant persistent effects at sensors surrounded by soybeans, grasslands, and forests. Though seasonal variations in tropospheric CO_2 concentration depended on the biosphere near each tower, the authors were also able to detect daily and interannual changes, which they ascribed to shifts in ecosystem productivity owing to changing weather and climatic conditions. The atmospheric measurements used in the research were drawn from an experimental network designed to assess the utility of dense regional networks of gas concentration sensors, an approach that is growing in prominence as researchers seek increasingly detailed measurements of spatial and temporal variations in atmospheric CO_2. (*Journal of Geophysical Research-Biogeosciences*, doi:10.1029/2011JG001781, 2012) —CS

River bed transport measurements show bed dilation and contraction

A new study of bed load transport—the movement of the gravel or other grains on a stream bed—has turned up a previously undetected effect. *Marquis and Roy* used several different methods to monitor bed load activity in a gravel bed river, Beard Creek in Quebec, Canada. They examined streamflow, bed load, and bed morphology before, during, and after 20 flood events. The researchers found that two of the methods—measuring changes in bed topography between successive floods and surveying bed activity—gave inconsistent results. Changes in elevation of the bed did not always correspond to movement of bed load.

The authors believe that this can be explained by dilation or contraction of sections of the bed following a flood, as gravel grains can become more or less tightly packed, with the grain-grain interactions playing a key role. The dilation or contraction results from complex interactions between flow intensity, flood history, sediment supply, and the initial conditions of the gravel bed before flooding.

The authors believe the study is the first reported observation of gravel bed dilation and contraction and highlights the need for future studies considering interactions between grains in the gravel bed when investigating bed load dynamics. It also shows that it is important to use multiple observational methods to get a complete picture of the bed load dynamics of a gravel bed river. (*Journal of Geophysical Research-Earth Surface*, doi:10.1029/2011JF002120, 2012) —EB



A series of four pictures showing the stream studied by Marquis and Roy *at different water stages. The white dot on each picture is a reference point.*

Statistical technique seeks to reduce climate uncertainty

Three measures of the climate system—climate sensitivity, vertical ocean diffusivity, and sulfate aerosol forcing—underpin current understanding of the power of anthropogenic climate change. Climate sensitivity reflects the equilibrium temperature change that would occur given a doubling of atmospheric carbon dioxide, vertical ocean diffusivity affects the rate at which the ocean is able to redistribute heat, and sulfate aerosol forcing describes how anthropogenic sulfate aerosols affect the radiation budget. Other projections rest on these measures, such as changes in weather patterns or precipitation rates, with the derivative predictions sensitive to changes in the more fundamental properties.

Given their importance, a key research effort revolves around minimizing the uncertainty in the portrayal of climate sensitivity, ocean diffusivity, and aerosol forcing in climate models. A conventional approach to doing so is to systematically vary climate model parameters in an attempt to minimize the discrepancy between model results and the observational record. The time and financial requirements of running large-scale climate models, however, reduce this technique's viability. To overcome these barriers, *Olson et al.* refined an approach to statistically emulate a complex climate model, allowing them to simulate a massive number of model runs at a fraction of the cost.

Using a Bayesian statistical approach and basing their investigation on the intermediately complex University of Victoria Earth System Climate model, the authors tested 300,000 combinations of various model parameters. The authors assessed the model's outputs with observational records of atmospheric surface temperatures and the changing surface ocean heat storage. The authors found values for climate sensitivity, vertical ocean diffusivity, and sulfate aerosol forcing that fit well within those drawn from previous research. They suggest that their statistical technique can be used with more complex climate models with the potential to reduce the uncertainty surrounding these fundamental variables. (*Journal of Geophysical Research-Atmospheres*, doi:10.1029/2011JD016620, 2012) —CS

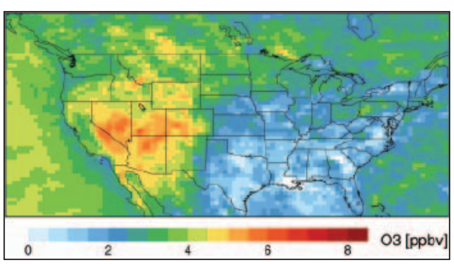
Asian emissions contribute to western U.S. air pollution

As Asian countries develop, they are emitting more ozone precursors that pollute surface-level air. Many studies have documented this pollution being carried by air currents to the western United States. To learn more about the mechanisms that transport air pollution across the ocean and determine the effects of Asian air pollution on air quality in the western United States, *Lin et al.* analyzed in situ and satellite measurements from May to June 2010 using a global high-resolution climate chemistry model.

They quantified the contribution of Asian pollution to surface ozone levels in densely populated regions such as the Los Angeles area and rural areas such as national parks. They found that Asian pollution contributes as much as 20% of total ozone during springtime pollution episodes in western U.S. surface air.

Current guidelines from the Environmental Protection Agency dictate that surface-level air should have no more than 75 parts per billion (8-hour average) by volume of ozone. Although local pollution plays a large role on days when that standard is not met in Southern California, the authors estimate that 53% of the instances where that limit was exceeded would not have occurred without the contribution from Asian air pollution.

The researchers also found that an index based on satellite observations of Asian pollution plumes could serve as a qualitative early warning indicator, with a lead time of 1–3 days, of Asian pollution influence on western U.S. air quality. (*Journal of Geophysical Research-Atmospheres*, doi:10.1029/2011JD016961, 2012) —EB



Mean Asian impacts on U.S. surface ozone in spring.

Efficiency of organic aerosols as cloud condensation nuclei

Secondary organic aerosols—aerosols produced through chemical reactions in the atmosphere from volatile compounds—affect climate directly by reflecting sunlight and by acting as cloud condensation nuclei, promoting cloud formation. The efficiency with which different types of secondary organic aerosols act as cloud condensation nuclei is important to understanding their effects on climate. Secondary organic aerosols can be composed of many different compounds, making it difficult to model their efficiency as cloud condensation nuclei. *Suda et al.* present a new laboratory method of breaking the complex organic aerosol into subcomponents and measuring the corresponding cloud condensation nuclei efficiencies. They believe that their measured values will be useful for validating models of organic aerosols in the atmosphere. (*Journal of Geophysical Research-Atmospheres*, doi:10.1029/2011JD016823, 2012) —EB

Model describes New Zealand's complex tectonic environment

At the Hikurangi fault, off the eastern coast of New Zealand's North Island, the Pacific tectonic plate sinks beneath the Australian plate. Farther south, in the Marlborough Fault System, which cuts through the country's larger South Island, the interaction between the two slabs turns such that the plates grind edge-on. From north to south, over a relatively short length of the plate boundary, the interaction switches from subduction to strike-slip. Though the fault systems near each of New Zealand's major islands have been studied extensively, the intervening region that harbors the transition between the two modes of interaction is much less well understood. Exploring the subduction-to-strike-slip transition region could help explain whether and, if so, how the fault systems that populate the country are connected and potentially improve estimates of seismic risk.

Seeking to fill out the picture of New Zealand's tectonic environment, *Wallace et al.* modeled the independent fragments of the Earth's crust that make up the larger plate boundary. Using measurements of known fault locations and stresses, combined with recordings of ground velocity measurements drawn from 800 GPS ground stations distributed across the country, the authors reverse-engineered the complex system of faults that crosses New Zealand. The authors found that the switch from subduction in the north to strike-slip in the south is due to what they describe as a kink in the Australian plate that cuts across the northern South Island. They suggest that this deformation acts as a hinge about which the northern part of the Pacific plate takes on a clockwise rotation. Further, the authors' model allowed them to estimate the slip rate deficit for each fault, a measure of the expected but as yet unobserved plate motion that could indicate an ongoing buildup of energy within the fault. (*Journal of Geophysical Research-Solid Earth*, doi:10.1029/2011JB008640, 2012) —CS

Geomagnetic data reveal unusual nature of recent solar minimum

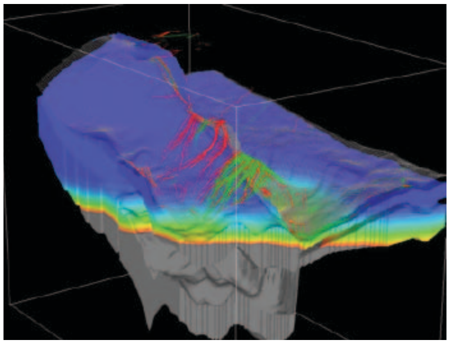
Since the mid-1800s, scientists have been systematically measuring changes in the Earth's magnetic field and the occurrence of geomagnetic activity. Such long-term investigation has uncovered a number of cyclical changes, including a signal associated with 27-day solar rotation. This is most clearly seen during the declining phase and minimum of each 11-year solar cycle, when the Sun's magnetic dipole is sometimes tilted with respect to the Sun's rotational axis. With the Sun's rotation and the emission of solar wind along field lines from either end of the solar magnetic dipole, an outward propagating spiral-like pattern is formed in the solar wind and the interplanetary magnetic field that can drive 27-day, and occasionally 13.5-day, recurrent geomagnetic activity. Recurrent geomagnetic activity can also be driven by isolated and semipersistent coronal holes, which can emit concentrated streams of solar wind.

During the most recent solar minimum, which took place from 2006 to 2010, however, several research groups noticed 6.7-day and 9-day recurrent changes in geomagnetic activity, and similar patterns in the interplanetary magnetic field and the solar wind. Using modern data covering the previous two solar minima, these higher-frequency occurrences were judged to be unusual. *Love et al.* analyzed historical geomagnetic activity records from 1868 to 2011 and found that the 6.7-day and 9-day recurrent changes were actually unique in the past 140 years. They suggest that the higher-frequency changes in geomagnetic activity are due to an unusual transient asymmetry in the solar dynamo, the turbulent, rotating plasma deep within the Sun that generates the magnetic field. (*Geophysical Research Letters*, doi:10.1029/2011GL050702, 2012) —CS

Early Eocene climate warming increased petroleum production

From the late Paleocene, about 58 million years ago, to the early Eocene, about 51 million years ago, Earth's surface temperatures warmed by about 5°–10°C. Also in the early Eocene, there was an increase of carbon-13-depleted carbon in the oceans that cannot be accounted for by changes in carbon cycling at the surface. To better understand the source of that carbon, *Kroeger and Funnell* modeled the thermal evolution of four sedimentary basins in the southwestern Pacific Ocean.

The authors show that the rising surface temperatures of the early Eocene eventually led to warming of the sedimentary beds deep beneath the surface. Petroleum



Basin temperature, oil flow (green), gas flow (red), and leakage in the southeastern Taranaki Basin, New Zealand. Created using the PetroMod™ model; software provided by IES/Schlumberger.

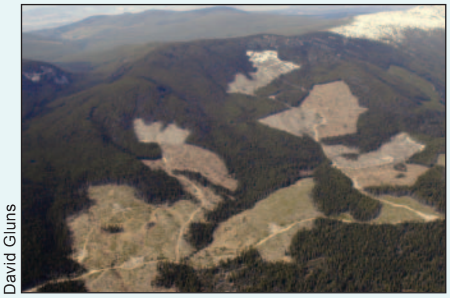
can be produced at only a certain range of temperatures; rising temperatures at greater depths would bring more potential source rocks into temperature conditions under which oil and gas can be produced and released.

In fact, the researchers found that the early Eocene warming led to the production and release of 50% more oil and gas than would have occurred under a constant temperature scenario. Some of this newly produced oil and gas would not have been trapped in sedimentary layers deep in the basin but would have leaked to the surface and potentially reached the atmosphere, where it could have acted as a climate feedback, causing further warming. (*Geophysical Research Letters,* doi:10.1029/2011GL050345, 2012) —EB

Model investigation overthrows assumptions of watershed research

A 2009 study revealed serious flaws in a standard technique used by hydrological researchers to understand how changes in watershed land use affect stream flow behaviors, such as peak flows. The study caused academics and government agencies alike to rethink decades of watershed research and prompted *Kuraś et al.* to reinvestigate a number of long-standing assumptions in watershed research using a complex and well-validated computer model that accounts for a range of internal watershed dynamics and hydrologic processes.

For the test site at 241 Creek in British Columbia, Canada, the authors found not only that deforestation increased the severity of floods but also that it had a scaling influence on both the magnitudes and frequencies of the floods. The model showed that the larger the flood, the more its magnitude was amplified by deforestation, with 10- to 100-year-return-period floods increasing in size by 9%–25%. Following a simulated removal of half of the watershed's trees, the authors found that 10-year-return-period floods occurred twice as often, while 100-year-return-period events became 5–6.7 times more frequent. This proportional relationship between the increase in flood magnitudes and frequencies following deforestation and the size of the flood runs counter to the prevailing wisdom in hydrological science.



David Gluns

Using the moderately deforested experimental watershed at 241 Creek, British Columbia, Canada, researchers investigated the effect of tree removal on flood magnitudes and frequencies.

The authors suggest that this finding has major implications for the lifespan and safety of structures like bridges and dams, human settlements, drinking water quality, and the sustainability of river ecosystems. (*Water Resources Research*, doi:10.1029/2011WR010705, 2012) —CS

Active and passive microwave data improve soil moisture estimates

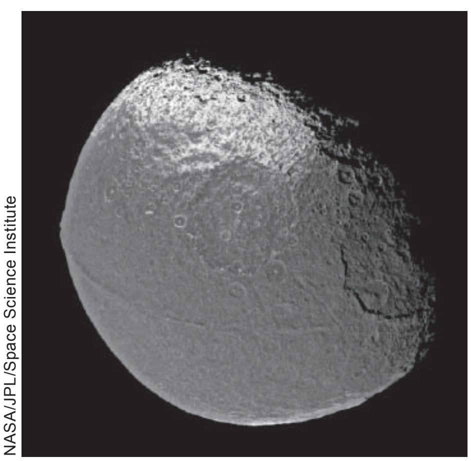
Assimilating satellite observations from active or passive microwave sensors into models can improve soil moisture estimates, a new study shows. Passive sensors detect radiation emitted naturally from the land surface, while active sensors emit a radiation pulse toward the Earth surface and measure the energy reflected back to the satellite. *Draper et al.* assimilated soil moisture derived from the active Advanced Scatterometer (ASCAT) and passive Advanced Microwave Scanning Radiometer for the Earth Observing System (AMSR-E) satellite sensors into a land surface model and assessed the resulting soil moisture estimates against in situ observations from 85 sites in the United States and Australia.

The researchers found that the active and passive microwave data similarly improved the model's soil moisture estimates. Following the recent failure of AMSR-E, the new study shows that systems designed to assimilate AMSR-E soil moisture can switch to ASCAT data without loss of accuracy. Improved soil moisture estimates could be useful for applications such as weather and drought forecasting. (*Geophysical Research Letters,* doi:10.1029/2011GL050655, 2012) —EB

How did the equatorial ridge on Saturn's moon Iapetus form?

Saturn's moon Iapetus is one of the most unusual moons in our solar system. Perhaps the most bizarre feature of Iapetus is its equatorial ridge, a 20-kilometer-high, 200-kilometer-wide mountain range that runs exactly along the equator, circling more than 75% of the moon. No other body in the solar system exhibits such a feature; as *Dombard et al.* show, previous models have been unable to adequately explain how the ridge formed.

The authors propose that the ridge formed from an ancient giant impact that produced a subsatellite around Iapetus. Tidal interactions with Iapetus ultimately led to orbital decay, eventually bringing the subsatellite close enough that the same forces tore it apart, forming a debris ring around Iapetus. Material from this debris ring then rained down on Iapetus, the researchers say, creating the mountain ring along the equator.



NASA/JPL/Space Science Institute

A new study explains how the unusual ridge along the equator of Saturn's moon Iapetus could have formed.

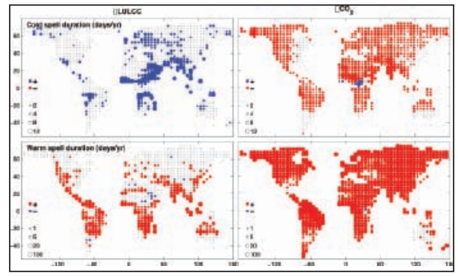
(*Journal of Geophysical Research-Planets*, doi:10.1029/2011JE004010, 2012) —EB

Land use changes contribute to climate extremes

Temperature extremes such as severe heat waves and cold spells are likely to occur more frequently in a warming climate as carbon dioxide (CO_2) concentrations rise. But land use change, such as clearing forests for agriculture, also has a large impact on extreme temperature events. To determine the relative contribution of the two effects, *Avila et al.* ran simulations using a climate model coupled to a sophisticated land surface model.

They found that land use changes can have a significant effect on temperature extreme indices. On regional scales, land use changes in some cases amplified the effects of increased CO_2 concentrations, while land use changes in other cases masked their effects. In some regions, the effects of land use changes on temperature extremes were similar in magnitude to those of doubling CO_2. The authors conclude that land use changes are a major source of human influence on the climate. (*Journal of Geophysical Research-Atmospheres*, doi:10.1029/2011JD016382, 2012) —EB

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



In some regions, land use change (left) could oppose changes due to increased carbon dioxide (right), potentially increasing the duration of cold spells, but it could also amplify the warming signal, increasing the duration of warm spells.