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RESEARCH SPOTLIGHT

Highlighting exciting new research from AGU journals

Technique improves ability to detect subsurface carbon dioxide leaks

One method to reduce atmospheric carbon dioxide concentrations is geologic carbon sequestration, often referred to as carbon capture and storage (CCS). In CCS, carbon dioxide is stored within stable geologic formations deep underground. Part of implementing CCS involves monitoring for unusual carbon dioxide emissions that could indicate a leak. Currently, monitoring requires a long-term assessment so that researchers can identify the range of variability for natural carbon dioxide emissions, in which shifts are driven by seasonal changes. Traditional monitoring methods falter when tasked with identifying a leak for a storage site without a background record or with finding a small leak, which could be swamped by the naturally varying emissions.

To overcome these shortcomings, *Romanak et al.* devised a new monitoring technique that relies on measuring concentrations of multiple gases within the subsurface soil. The authors then use the paired relationships between different gases to determine if a jump in carbon dioxide is due to a leak or natural processes. For instance, carbon dioxide and oxygen concentrations vary predictably with oxidation and respiration rates. Comparing carbon dioxide with the ratio between nitrogen and oxygen can yield clues to methane oxidation and plant respiration rates. In addition, nitrogen concentration data can be used to detect an influx of new gas, and hence a potential leak.

Hilary Olson and Thomas Ogilvie prepare a soil gas sampling well to investigate claims of carbon dioxide leakage beneath a farm in Saskatchewan, Canada.

Using their technique, the authors identified a methane leak near a decommissioned oil well in Mississippi. They suggest that this analysis can be used to identify gas leaks in sites without established background records. (*Geophysical Research Letters,* doi:10.1029/2012GL052426, 2012) —CS

Tracking the Antarctic water flows that feed the Benguela Current

As the initiator of the northbound branch of the Atlantic Meridional Overturning Circulation (AMOC), the Benguela Current is a key component in the large-scale circulation system that transports energy, salt, and biogeochemical tracers around the Atlantic basin. Water flowing in the Benguela Current derives from several sources, but the bulk originates as Antarctic Intermediate Water (AAIW). The relatively fresh AAIW is formed when northbound water from the Antarctic Circumpolar Current sinks below warmer northern waters. AAIW's depth and salinity varies depending on where it is formed. AAIW from both the Atlantic and Indian oceans feeds the Benguela Current, so knowing its properties and pathways is important for understanding AMOC. After performing a particle-tracking analysis in a high-resolution regional ocean circulation model, *Rimaud et al.* calculated how AAIW of the Indian and Atlantic oceans evolve into the Benguela Current.

The authors found that AAIW generated in the Atlantic Ocean is shallower and fresher than that from the Indian Ocean. Some of the Atlantic AAIW that formed in the south-central Atlantic flows to the east at a depth between 600 and 1000 meters where it enters the Cape Basin off the southwest coast of Africa. A portion of the Indian AAIW flows in the Agulhas Current west around South Africa at a depth of 1000–1400 meters, also ending up in the Cape Basin. Bounded by a series of seafloor mountains, the Cape Basin is a region of enhanced mixing that blends the Atlantic and Indian AAIWs. The mixed waters then leave the basin heading north at a depth of 700–1100 meters. The authors found that though the water leaving the Cape Basin has a salinity similar to that of the Indian AAIW's initial value, three quarters of it stems from the Atlantic AAIW. (*Journal of Geophysical Research-Oceans,* doi:10.1029/2012JC008059, 2012) —CS

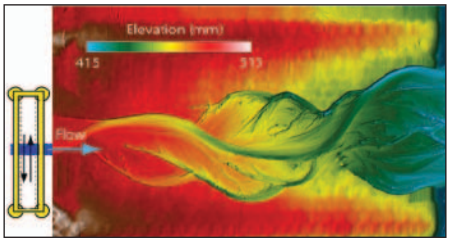
Understanding temporal rainfall intensity scaling

Understanding how rainfall intensity scales with time is useful for determining how often and for how long the most intense rainfall bursts are likely to occur. The most common way to study temporal rainfall scaling is to analyze continuous rainfall measurements, including rainstorms and dry interstorm periods. However, *Veneziano and Lepore* now show that continuous analysis produces spurious results that mainly reflect the alternation of dry and wet periods. Analyzing within-storm intensity rather than continuous records gives results showing higher intermittency.

The researchers developed an approach for analyzing within-storm scaling and found that within-storm fluctuations conform to a mathematical model known as a beta-lognormal distribution. They suggest that future applications of their analysis method could lead to revised estimates of historical extreme rainfall events as well as possible future rainfall variation as Earth's climate changes. (*Water Resources Research*, doi:10.1029/2012WR012105, 2012) —EB

For first time, meandering river created in laboratory

Natural rivers are not straight, and they are rarely idle. Instead, they bend and curve and sometimes appear to wriggle across the Earth's surface over time. That rivers can meander is obvious but how and why they do so is less well known. These questions are complicated by the fact that researchers have for the most part been unable to realistically create a meandering river in a laboratory. Scientists have previously created simulated streams that bend and branch, but they were not able to limit the river to only a single main flow path or maintain such dynamic motion past the initial bend formation. Working with a 6- by 11-meter river simulator, the Eurotank, *van Dijk et al.* created a dynamically meandering river. In so doing, the authors identified two conditions necessary to induce meandering: the availability of mixed sediment and a continuously varying upstream water source.



Researchers used a continuously varying sediment and water input source to produce a dynamically meandering river, seen here 213 hours into the experiment.

For 260 hours the authors pumped a steady stream of water and mixed sediment onto a sediment-filled basin. First they held the inflow point steady, which resulted in a straight channel. Then they moved the inflow point horizontally, which caused the downstream flows to bend. Finally, the authors reversed the horizontal motion of the input point, which further increased the downstream complexity. Photographs taken every 10 minutes and high-resolution laser topography scans captured every 7 hours captured the details of the river's evolution.

The authors suggest that the drifting inflow point caused the channel to meander, while the presence of mixed sediments sealed off defunct paths, preventing the single channel from turning into a multithreaded braided system. The finding suggests that meandering at any point in a river depends on lateral drift in upstream reaches, such that an immobile bottleneck at any one site will decrease downstream complexity. (*Journal of Geophysical Research-Earth Surface*, doi:10.1029/2011JF002314, 2012) —CS

Assessing skill of operational forest fire emissions model

Across the continental United States, the BlueSky Smoke Modeling Framework provides hourly forest fire emissions forecasts and calculates the concentrations of hazardous compounds 72 hours in advance. Though a traditional computational model itself, the BlueSky Framework pulls together the results from a number of different independent models for fire and fuel information, combustion of fuel, and speciated emissions calculations to produce its operational forecasts of fire-related emissions and smoke dispersals. One aspect of forest fire emissions that is of particular concern is small particulate matter, particularly microscopic particles with diameters less than 2.5 micrometers. These particles, known as PM2.5, are small enough to penetrate lung tissue and cause serious health problems in high concentrations. To assess the skill of the BlueSky Gateway, a system that uses the BlueSky Framework and the Community MultiScale Air Quality (CMAQ) model to forecast PM2.5 surface concentrations, *Strand et al.* compared the modeled estimates for two Californian forest wildfire events against observations.

Over the course of 2 weeks in October 2007, fires burned 202,000 hectares between Los Angeles and San Diego in southern California. In another incident, several lightning-sparked fires torched 400,000 hectares near Sacramento, in northern California. The authors compared ground level PM2.5 observations made nearby against the modeled forecasts. They found that, in general, the emissions were well predicted for the northern fires. For the southern fires, however, they found that PM2.5 concentration estimates were biased low. Looking more closely, the authors found a bifurcation in the model's skill depending on the direction of the surface level winds. When the wind was blowing onshore the model performed well, while estimates made for offshore winds were very low. The authors suggest that a number of factors can come together to throw off the modeled emission estimates, including topographic and resolution issues with the models themselves but also tangential things such as changing fire activity or the suppression efforts by fire fighting crews. (*Journal of Geophysical Research-Atmospheres*, doi:10.1029/2012JD017627, 2012) —CS

China's Changbaishan volcano showing signs of increased activity

Roughly 1100 years ago, the Changbaishan volcano that lies along the border between northeastern China and North Korea erupted, sending pyroclastic flows dozens of kilometers and blasting a 5-kilometer-wide chunk off of the tip of the stratovolcano. The eruption, known as the Millennium eruption because of its proximity to the turn of the first millennium, was one of the largest volcanic events in the Common Era. In the subsequent period, there have been three smaller eruptions, the most recent of which took place in 1903. Starting in 1999, spurred by signs of resumed activity, scientists established the Changbaishan Volcano Observatory,

Jiandong Xu

The Tianchi Caldera Lake was formed when the Changbaishan volcano in northeastern China erupted 1100 years ago.

a network to track changing gas compositions, seismic activity, and ground deformation. Reporting on the data collected over the past 12 years, *Xu et al.* found that these volcanic indices each leapt during a period of heightened activity from 2002 to 2006.

The authors found that during this brief active period, earthquake occurrences increased dramatically. From 1999 to 2002, and from 2006 to 2011, they registered 7 earthquakes per month using 11 seismometers. From 2002 to 2006, this rate increased to 72 earthquakes per month, peaking in November 2003 with 243 events. Further, tracking the source of the earthquakes, the authors tied the bulk of the events to a region located 5 kilometers beneath the volcanic caldera, a source that slowly crept upward throughout the study period, suggestive of an ongoing magmatic intrusion. Gas composition measurements collected from hot springs near the volcano showed spikes in carbon dioxide, hydrogen, helium, and nitrogen gases, which the authors suggest could be related to magmatic outgassing. Ground deformation studies, too, showed a brief period of rapid expansion. The authors suggest that though Changbaishan is likely not gearing up for an imminent eruption, one could be expected in the next couple of decades. (*Geophysical Research Letters*, doi:10.1029/2012GL052600, 2012) —CS

Coupled model identifies effect of ozone stress on vegetative growth

An intricate feedback system ties together the activity of vegetation and tropospheric ozone. Ground level ozone, drawn from the atmosphere through dry deposition, stresses plants, inhibiting their growth. Plants, in turn, release biogenic volatile organic compounds (VOCs), chemicals that can either enhance or inhibit the deposition of ozone depending on the availability of another class of chemicals, nitrous oxides. Adding to important vegetative processes such as photosynthesis or evapotranspiration, biogenic aerosols can also increase or decrease ozone formation by modulating heat waves. Therefore, understanding the bidirectional interaction between ozone and vegetative growth is important for accurately representing the climate.

Using the CHIMERE chemical transport model (CTM) and the Organizing Carbon and Hydrology in Dynamic Ecosystems (ORCHIDEE) land surface model, *Anav et al.* calculated the effect ground level ozone had in 2002 on vegetative behavior in Europe and northern Africa. The authors ran their models in two configurations—independently and coupled; the coupled system considered the effects of ozone stress while the independent mode did not.

Considering the direct effect of ozone on vegetation, the authors found that canopy conductance was always depressed compared to the control run. The result of this perturbed canopy conductance was a drop in gross primary production of 200 grams of carbon per square meter per year, or a roughly 23% drop over the control run, and a 16% drop in leaf biomass, findings consistent with previous research. The authors found that representation of carbon fluxes and the performance of the CTM could be improved by improving the representation of land surface processes and of atmosphere-vegetation feedbacks. They state that to more accurately represent such feedbacks, future models should see complex land surface models fully coupled to chemical transport models. (*Journal of Geophysical Research-Biogeosciences*, doi:10.1029/2012JG001976, 2012) —CS

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