RESEARCH SPOTLIGHT

Highlighting exciting new research from AGU journals

Constraining bubbling of methane from thermokarst lakes

In northern thermokarst lakes, which form in depressions left as permafrost thaws, methane, a greenhouse gas, can be released from lake sediments to the atmosphere through bubbling, or ebullition. Constraining the amount of methane released through bubbling would help scientists understand the role of thawing permafrost in the carbon cycle and global climate change. However, bubbling is highly variable in both space and time and thus difficult to measure accurately, so there are large uncertainties in estimates of methane emissions from northern ecosystems.

Walter Anthony and Anthony sought to better understand the spatial distribution of bubbling in lakes. They note that in many northern lakes, the bubbling sources, which they call ebullition seeps, cluster together in regular spatial patterns. The researchers combined field data from individual seeps with models to describe the spatial patterns of ebullition in three thermokarst lakes in different regions of Alaska. The authors used these models to create simulated ebullition data sets, on which they tested various methods for estimating lake ebullition. They found that the standard method of measuring ebullition with randomly placed bubble traps is biased toward underestimating methane flux, while a method using survey transects to map ebullition bubbles trapped in lake ice only slightly underestimated methane flux. The authors suggest that transect field data from a large number of widely distributed lakes can be combined to give a good estimate of regional lake ebullition. (*Journal of Geophysical Research-Biogeosciences,* doi:10.1002/jgrg.20087, 2013) —EB

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Katey Walter Anthony mapping methane bubbles on a lake ice transect.

Flexible statistical models allow improved prediction of coastal nitrate

Inflows of nitrate brought to the surface by coastal upwelling are essential for ocean life near the shore. Despite its importance, consistent long-term records of nitrate do not exist for much of the ocean. As a stand-in for direct nitrate concentration measurements, researchers have relied on water temperature measurements because research has shown that there is an inverse relationship between temperature and nitrate concentration. To investigate the viability of using temperature to estimate nitrate concentrations, *Palacios et al.* studied the region of the California Current, where long-term observations of nitrate going back to 1959 exist. Studies in this region also tracked properties such as temperature and salinity and the concentrations of oxygen, phosphorus, and silicate.

The authors found that water temperature alone is able to account for more than 70% of observed nitrate variability. However, biases driven by season, depth, and latitude affect the accuracy of the results. When they considered salinity in addition to temperature, they could explain 91.2% of the nitrate variability. When they considered oxygen concentration as well, the authors could model 96.6% of the observed nitrate concentration variability.

The authors note that because salinity, like temperature, can now be assessed through satellite remote sensing, improved predictions of surface nitrate could be attempted on a global scale. (*Journal of Geophysical Research-Oceans,* doi:10.1002/jgrc.20216, 2013) —CS

No alarming ozone loss from stratospheric water vapor

At sufficiently low temperatures, water vapor in the lowermost stratosphere can cause ambient sulfate aerosol to grow, providing surfaces on which chlorine can activate to a form that destroys ozone. Ozone depletion in the stratosphere can allow harmful ultraviolet radiation to reach Earth's surface.

A previous paper reported in situ measurements that suggested a high level of water vapor in the lowermost stratosphere in the summer over North America. That paper reported water vapor at levels that occasionally exceeded 12 parts per million by volume persisting for several days over regions extending 100 kilometers horizontally.

A new paper by *Schwartz et al.* confirms that North American summers have among the wettest lowermost stratospheres in the 8-year, daily, global water vapor record from the Microwave Limb Sounder instrument on NASA's Aura satellite. However, the authors note that these observations are consistent with the presence of extensive, thin layers with water vapor concentrations of 12 parts per million by volume in less than 3% of these observations and that sufficiently low temperatures for aerosol growth are rarely found where high levels of water vapor, ozone, and chlorine-bearing molecules are collocated. They also found that small observed reductions in ozone and chlorine are at least in part explained as dilution of stratospheric air by injections from below. They found no indication of an alarming depletion of ozone. (*Geophysical Research Letters,* doi:10.1002/grl.50421, 2013) —EB

Past decade saw unprecedented warming in the deep ocean

Since 1975 the global surface ocean has shown a pronounced—though wavering—warming trend. Starting in 2004, however, that warming seemed to stall. Researchers measuring the Earth's total energy budget—the balance of sunlight streaming in compared to the amount of light and heat leaving from the top of the atmosphere—saw that the planet was still holding on to more heat than it was letting out. However, with that energy not warming the surface ocean—a traditionally important energy sink—scientists were not sure where it went. It became known, in some circles, as a case of "missing heat."

Through a reanalysis of global ocean heat content measurements, *Balmaseda et al.* found the missing heat. The authors show that though the upper ocean waters, from the surface to 700 meters depth, showed no warming from 2004 to 2008, the waters from 700 to 2000 meters were warming at an unprecedented rate. They found that during the past decade, of the excess energy trapped by the anthropogenic greenhouse effect that has gone into warming the ocean, 30% of it has contributed to warming the deep ocean.

The authors also found that throughout the observational record the warming of the surface ocean has stalled before because of large volcanic eruptions or swings of the

El Niño–Southern Oscillation. They also note that changes in surface wind patterns are an important factor in driving ocean heat content from the surface layers to the deep ocean. (*Geophysical Research Letters,* doi:10.1002/grl.50382, 2013) —CS

Identifying slow slip events with satellites

Slow slip events (SSEs), in which tectonic plate interfaces slip slowly and generate seismic rumbling, have been observed in many subduction zones around the world. These events can provide insight into the accumulation and release of seismic stress, potentially giving scientists information on the processes generating megathrust quakes.

In southwest Japan, megathrust earthquakes tend to occur along the Nankai Trough, where the Philippine Sea plate subducts beneath the Amurian plate. SSEs have previously been observed along the Nankai Trough using seismological and geodetic instruments. Now *Nishimura et al.* show that SSEs can also be identified remotely using Global Navigation Satellite System (GNSS) data.

They were able to successfully detect more than 150 short-term SSEs with moment magnitudes ranging from 5.5 to 6.3 that occurred along the Nankai Trough between 1996 and 2012. Comparing the SSEs identified with GNSS with those identified from tiltmeter data, they found that both methods may have missed some short-term SSEs. The researchers note that GNSS is better for detecting large SSEs, while tiltmeters are better for detecting small ones. (*Journal of Geophysical Research-Solid Earth,* doi:10.1002/jgrb.50222) —EB

Tidal oscillations in Mars's atmosphere

Atmospheric tides—global oscillations in pressure, temperature, and wind that are subharmonics of a solar day—mainly affect the upper atmosphere on Earth, but on Mars they tend to have effects throughout the atmosphere. Tidal variations in Mars's atmosphere are mainly introduced by diurnal variations in surface temperature as the planet rotates. The absorption of radiation by aerosols in the atmosphere provides an additional forcing, which complicates the tidal structure.

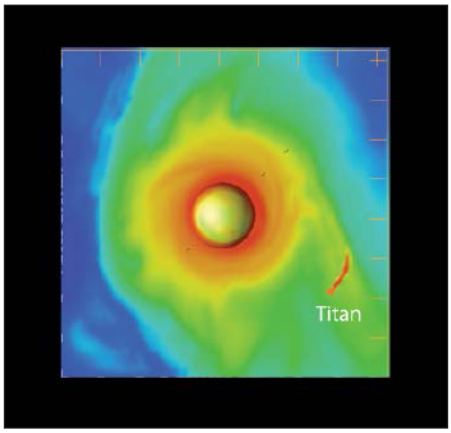
Kleinböhl et al. review recent observations and modeling of migrating tides in the middle atmosphere of Mars. While some previous research had indicated that the diurnal tide is the dominant driver of variations in the Martian atmosphere, recent observations suggest that the semidiurnal tide is a dominant feature, the authors show. In addition, recent model simulations indicate that water ice clouds that are radiatively active likely play a key role in driving the tidal oscillations, and there is a feedback loop between the cloud distribution and the tides. Further research on these tides and their forcing by cloud and dust aerosols could improve scientists' understanding of Martian atmospheric circulation and weather and climate. (*Geophysical Research Letters,* doi:10.1002/grl.50497, 2013) —EB

Saturn's moon Titan contributes to periodicity in magnetosphere

Saturn has been observed to have periodic radio emissions known as Saturn kilometric radiation (SKR) as well as periodicities in its plasma and magnetic fields. These periodicities have puzzled scientists because they would be expected if the planet's magnetic field were not aligned with its rotational axis, but Saturn's magnetic field and rotational axis are, in fact, closely aligned. The puzzle is further complicated by the fact that the Saturn kilometric radiation has slightly different periods in the northern and southern hemispheres and shows some variability in time.

Some possible mechanisms for generating the observed periodicities have been proposed. Some of these involve a phenomenon known as the interchange instability, in which "fingers" of plasma from Saturn's moon Enceladus move outward through the planet's magnetosphere and plasma from the solar wind flows inward. These fingers affect processes in Saturn's magnetosphere, but *Winglee et al.* note that the fingers alone do not produce the observed periodicities. However, the authors suggest that these interchange instability fingers are modulated by interaction with another of Saturn's moons, Titan.

The authors conducted simulations both with and without Titan and found that interaction between Titan and the interchange instability fingers damps the fingers in a way that could drive the observed periodic signatures in the planet's magnetic field. In addition, drag from Titan may also affect the northern and southern hemispheres differently, contributing to the north-south difference in the SKR periods. The study could help shed light on the puzzling periodicities in Saturn's magnetosphere. (*Journal of Geophysical Research-Space Physics,* doi:10.1002/jgra.50397, 2013) —EB



Titan's interaction with an interchange finger originating from the Enceladus plasma torus. The sphere represents the inner boundary, which is at 2.25 Saturn radii. Warmer colors represent a higher density of ions.

Low-cost solution optimizes water quality of reservoir effluent

A large reservoir can provide reliable access to water, control flooding, and be used to generate hydroelectricity. On the other hand, large dams can upset local ecosystems by changing river flow patterns or by affecting nutrient and oxygen concentrations in downstream flows. Damming a river and constructing a reservoir requires balancing these benefits and risks.

In tropical reservoirs, water often becomes highly stratified, with nutrient-depleted but well-oxygenated upper layers and nutrient-rich but oxygen-depleted waters at depth. When water is let out of the reservoir to power turbines or stave off drought, its quality has consequences for life downstream.

Engineers are planning to use the dam at the Itezhi-Tezhi Reservoir that blocks the Kafue River in Zambia for power generation. Compared with more industrialized regions, the Kafue River area is poor in nutrients, as farmers do not use fertilizers. Therefore, the presence of the Itezhi-Tezhi Reservoir is currently removing nutrients needed for productivity in the downstream regions. Using the reservoir as a case study, *Kunz et al.* have devised an approach that should allow for optimizing the quality of the water being loosed from a reservoir without affecting the dam's capacity for power generation.

The authors' approach revolves around drawing from the two layers of the stratified reservoir water, balancing the mix of oxygenated shallower water and nutrient-rich deeper water. The authors note that though technology exists to reoxygenate depleted reservoir water, the necessary equipment is often expensive to operate and maintain. Using a biogeochemical model of nutrient cycling, the authors calculated that by using a mix of water from around 13 meters depth and from more than 30 meters depth from the Itezhi-Tezhi Reservoir, they could maximize the nutrient load while avoiding releasing hypoxic water. (*Water Resources Research,* doi:10.1002/wrcr.20358, 2013) —CS

Water and sediment supply affect basin-filling sedimentation patterns

The spatial and temporal variability of sedimentation can affect models that scientists use to interpret the stratigraphic record. To better understand the influence of sedimentation variability, *Straub and Wang* quantify basin-filling trends in three experiments with fluvial deltaic systems experiencing subsidence. They note that sediment fills some basins randomly, while in other basins sediment fills in an even, structured way.

The authors characterize the evenness with which the basins fill through a measure they call the "compensation index," which tracks the tendency of flow deposits to preferentially fill in topographic lows. They show that the compensation index depends on the ratio between water input and sediment discharge. The study could help scientists better interpret stratigraphy in sedimentary settings. (*Journal of Geophysical Research-Earth Surface*, doi:10.1002/jgrf.20095, 2013) —EB

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