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RESEARCH SPOTLIGHT

Highlighting exciting new research from AGU journals

Variability of transparent organic particles in Arctic floodplain lakes

The Mackenzie River in the North American Arctic courses into the Beaufort Sea, the outlet of a watershed that drains a vast swath of the western Canadian landscape. At the river's mouth the Mackenzie Delta is a broad floodplain peppered with roughly 45,000 lakes carved into the permafrost. Depending on their connectivity to the river, these floodplain lakes have different mixtures of organic compounds, and such differences affect carbon cycling and sediment processes in the lakes.

Among the organic compounds prevalent in these Arctic lakes are transparent exopolymer particles (TEP), a gel-like substance formed by the spontaneous aggregation of sticky chains of organic molecules that are secreted by algae, bacteria, and other organisms. Previous research found that aggregates of TEP form habitats for microscopic life and reaction surfaces for aqueous chemicals and can help promote sedimentation. In the ocean, TEP is a key component of ocean "snow." The role and variability of TEP in Arctic lakes and other inland waters, however, have been relatively unstudied.

Collecting weekly water samples from three Mackenzie Delta lakes over a 2-month span in 2006, *Chateauvert et al.* measured how the concentrations of TEP and other organic compounds varied following the annual flooding of the Mackenzie River. The authors found that the concentration of TEP varied by up to 2 orders of magnitude over the course of the study period, peaking immediately following the June flood and declining steadily afterward. They also found that the lake that was best connected to the river had the highest TEP concentrations. These findings ran directly counter to the authors' initial hypothesis of how TEP concentrations should evolve in the lakes. The authors found that changes in the concentration of chromophoric dissolved organic matter—a form of organic material derived almost exclusively from river water in the region—could account for more than half of the measured TEP variability. (*Journal of Geophysical Research-Biogeosciences*, doi:10.1029/2012JG002132, 2012) —CS

Lance Lesack

The lakes within the Mackenzie Delta floodplain, shown here, have varying degrees of connectedness to the Mackenzie River.

Land area burned by fires 35% larger than previous estimates

The predominant technique for tracking wildfires uses repeat satellite observations to look for and measure the size of burn scars, the charred remains of once-lush terrain. Because it relies on moderate-resolution imagery, this approach has a tendency to miss the smaller fires that, though less widely devastating, can still account for a sizeable portion of the total burned area. Small fires can also have an important effect on the global carbon budget and on air quality.

Using a new technique to calculate the global occurrence of small fires, *Randerson et al.* found that previous measurements had underestimated the total annual burned area by roughly 35%, a difference of about 119 million hectares of land per year. Using a biogeochemical emissions model, the authors suggest that small fires also account for about 35% more global carbon emissions over previous estimates, the equivalent of 0.6 petagram of carbon per year. Though some regions saw only a slight increase in estimated burned area compared with the traditional approach, the authors calculated a 75% spike in burned area for the continental United States after incorporating small fires—an increase in line with other independent estimates. Even larger increases were calculated for regions with tropical forests, including Southeast Asia and Central America.

The authors used satellite thermal imaging, which has a much higher spatial resolution than the visible detectors typically used, to calculate the number of active fires both within and outside of observed burn scars. They then tracked surface reflectance changes for these two sets of fires, using the information to estimate the area burned by fires in the different zones. (*Journal of Geophysical Research-Biogeosciences*, doi:10.1029/2012JG002128, 2012) —CS

Tropical cyclone waves detected with infrasound sensor array

The strong winds of a tropical cyclone whip up the sea surface, driving ocean waves a dozen meters high. When one such ocean wave runs into another wave that has an equal period but is traveling in the opposite direction, the interaction produces low-frequency sound waves that can be detected thousands of kilometers away. The infrasound signals produced by interacting ocean surface waves—known as microbarom—have typical frequencies around 0.2 hertz. Researchers previously determined that as a hurricane travels along its track, early waves generated by the storm will interact with those generated later on, producing a strong microbarom signal in the storm's wake. Researchers also found, however, that microbarom signals are produced by regular surface ocean behavior, including swell, surface waves, and nontropical cyclone storms.

To identify how tropical cyclone–produced waves interact with ambient surface ocean waves and to determine whether the tropical cyclone microbarom signal could be isolated from the background noise, *Stopa et al.* examined the infrasound signals detected by an International Monitoring System infrasound sensor array in Hawaii during the passage of Hurricanes Neki and Felicia in 2009.

The authors used modeled wind speeds to simulate the wave conditions during the hurricanes, then used these estimates to drive an acoustic model that enabled them to calculate the microbarom infrasound activity. They found that the microbarom signals observed by the Hawaiian sensor array aligned with their modeled estimates. The authors noted that the infrasound signal of the cyclone-generated waves tended to swamp the detectors, drowning out the much weaker signals of the ambient wave interactions. They suggest that given further refinements, measuring the infrasound signal of microbarom waves could be a good way to detect and measure the wave conditions near a tropical cyclone. (*Journal of Geophysical Research-Oceans*, doi:10.1029/2012JC008257, 2012) —CS

Aftershocks to Philippine quake found within nearby megathrust fault

On 31 August 2012 a magnitude 7.6 earthquake ruptured deep beneath the sea floor of the Philippine Trench, a powerful intraplate earthquake centered seaward of the plate boundary. In the wake of the main shock, sensors detected a flurry of aftershocks, counting 110 in total. Drawing on seismic wave observations and rupture mechanisms calculated for the aftershocks, *Ye et al.* found that many were located near the epicenter of the main intraplate quake but at shallower depth; all involved normal faulting. Some shallow thrusting aftershocks were located farther to the west, centered within the potentially dangerous megathrust fault formed by the subduction of the Philippine Sea plate beneath the Philippine microplate, the piece of crust housing the Philippine Islands.

In the past century the most powerful earthquakes have occurred within megathrust faults. The particular portion of the megathrust fault nearest the 31 August intraplate earthquake and the section that housed the shallow thrusting aftershocks have not experienced a strong earthquake since at least 1600. That aftershocks from the main intraplate shock took place within the interplate boundary suggests that the two systems may be coupled. Previous research in other locales suggests that the rupture of a nearby megathrust fault sometimes follows on the heels of a large offshore intraplate thrust earthquake. Similarly, previous research has found that the stress accumulation that could lead to the rupture of an intraplate thrust earthquake can be explained at least in part by the buildup of stress in a nearby interplate boundary. The authors suggest that more work needs to be done to identify whether there is an accumulating slip deficit within the Philippine Trench megathrust fault. (*Geophysical Research Letters*, doi:10.1029/2012GL054164, 2012) —CS

U.S. cities less susceptible to water scarcity than previously thought

The past few years have seen powerful droughts across the United States, with water shortages threatening crop production, shipping traffic, energy production, and groundwater stores. Water scarcity issues are particularly relevant for those living in cities, a demographic that now includes roughly four out of five Americans. Previous research has tallied average daily water needs, estimated at 600 liters per person per day, and the availability of natural renewable water resources. The results suggest that up to 47% of the U.S. population is vulnerable to water scarcity issues. In many cases, urban water managers cope with natural variability through the use of infrastructure designed to pump, import, or store freshwater. Nationwide water resource assessments, however, overlook such infrastructure-based approaches to water management, instead assessing only water derived from local streamflow, runoff, or groundwater storage.

To more accurately assess the vulnerability of U.S. urban areas to water shortages, *Padowski and Jawitz* compiled publicly available records of water management resources for 225 cities across the country—those with populations of 100,000 or more for which adequate records were available. When they included in their tallies both natural renewable water resources and the capacity to import, pump, and store water, the authors found that only 17% of the U.S. population—not 47%—is vulnerable to water scarcity issues. They found that when water management infrastructure resources were taken into consideration, every U.S. city studied could provide the needed annual mean of 600 liters per person per day or more, even in areas where the local availability of water is scarce.

However, the authors found that some cities, such as Miami, Fla., appear more vulnerable to water scarcity under the new assessment. Although Miami receives a high volume of water, a lack of storage or import capacity suggests that it is less resilient to natural variability than cities with more robust water management infrastructures. (*Water Resources Research*, doi:10.1029/2012WR012335, 2012) —CS

First direct evidence that breaking waves cause horizontal eddies

As ocean waves pass from deeper water into the shallow coastal regions, they begin to break, churning up the surf zone waters. At the edges of the crests of the breaking waves, horizontally rotating eddies (vertical vortices) are generated, converting some of the waves' kinetic energy into turbulence. These horizontally rotating eddies are an important mechanism for dispersing nutrients, larvae, bacteria, sediments, and other suspended objects along the coastline.

Using a 10-meter-diameter ring of submerged current sensors, *Clark et al.* directly measured for the first time the generation of horizontal eddies by breaking coastal waves in the water off North Carolina. In line with theoretical and numerical modeling efforts, the authors found that turbulent eddies are created at the edges of breaking waves and that the eddies rotate in different directions depending on whether they are produced by left- or right-handed waves. They also found that the eddies decayed after 20 to 60 seconds. Further, they found that the eddies were strongest at low tide and weakest at high tide, a finding that they attribute either to the sensor array's changing position in the surf zone due to the shifting tide or to an increase in the amount of energy dissipated by waves breaking in the shallower low-tide water. They suggest that such horizontal eddies are an important source of dispersive energy for the near-shore environment. (*Geophysical Research Letters*, doi:10.1029/2012GL054034, 2012) —CS

Improving flood frequency analysis with more information

Flood frequency estimates can be improved by combining local flood data with three additional types of information, *Viglione et al.* show. The authors combined local flood data with temporal information on historic floods, spatial information on floods in nearby catchments, and causal information on the flood process. Previous studies combined flood data with only one additional type of information.


Steve Elgar

Short-crested waves break at the Duck, North Carolina, study site.

Some engineering hydrologists have suggested that adding these extra types of information would not be helpful in predicting flood return periods because each type has subjective assumptions and uncertainties. However, the authors show that by accounting for the uncertainties in the different information sources in a Bayesian framework, the overall estimated uncertainty in the flood frequency analysis is reduced when more information is included.

They illustrate their method for combining the additional information to improve flood frequency analysis by providing a case study of the Kamp River region in northern Austria, where an extraordinary flood occurred in 2002. They show that this outlier flood significantly affects flood frequency estimates if only local flood data are used, but the effect of this outlier flood is lessened significantly if all three types of additional information are used. (*Water Resources Research*, doi:10.1029/2011WR010782, 2013) —EB

Assessing the Great Whirl, despite all the pirates

Each year, the powerful southwest monsoon ramps up in midsummer, bringing life-giving rains to the Indian subcontinent. The monsoon winds also drive dramatic changes in the regional ocean currents, including a reversal in the circulation of the Arabian Sea, an energetic eddy field, and strong coastal upwelling. Off the east coast of Somalia, a large (300- to 550-kilometer wide) anticyclone appears—known since 1876 as the Great Whirl—with surface currents as strong as 2.5 meters per second. The Great Whirl, while associated with the seasonal arrival of the southwest monsoon, is not caused entirely by it; the circulation of the Great Whirl starts a month before and persists for a month after the monsoon.

Although the existence of the Great Whirl has been known for more than a century, rampant piracy in the waters off Somalia have prevented researchers from directly observing its behavior using modern oceanographic tools and techniques. To get around this limitation, *Beal and Donohue* used satellite observations of sea surface height to measure the intraseasonal evolution and interannual variation of the powerful anticyclone.
The satellite altimetry measurements, collected from 1993 to 2010, supplemented

measurements made during five research cruises conducted in 1995.

The authors found that the Great Whirl persists for roughly 166 days each year, initiating around May, strengthening and intensifying with the June arrival of the monsoon, and dissipating by November. They found that the Great Whirl is often ringed by smaller anticyclones that travel clockwise around its outside edge. Further, they found that rather than evolving gradually over the summer season, the anticyclone's size and shape can vary quickly. (*Journal of Geophysical Research-Oceans*, doi:10.1029/2012JC008198, 2013) —CS

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