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RESEARCH SPOTLIGHT

Highlighting exciting new research from AGU journals

Everglades restoration could decrease carbon sink potential

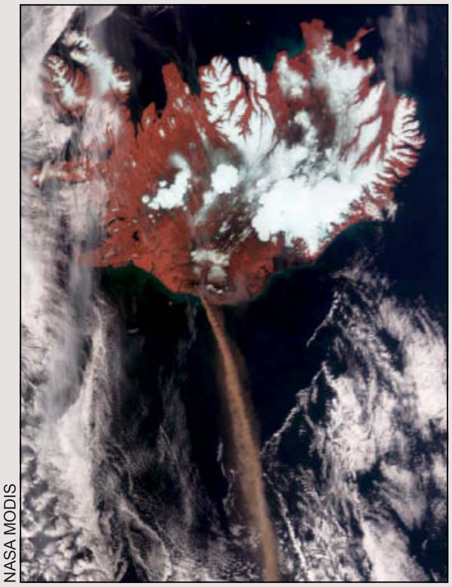
Starting more than a century ago and ramping up to a massive scale in the 1950s, canal building and drainage projects in the Florida Everglades steadily degraded the sprawling wetland ecosystem. In the coming years, a massive 30-year multibillion-dollar restoration program is set to naturalize the Florida Everglades, returning the drained land to a closer approximation of its original structure. Restoring the Everglades, however, will have consequent effects on wetland dynamics, as plants and soil processes adjust to the changing water levels. Using eddy covariance measurements of surface-atmosphere gas exchange, *Jimenez et al.* tracked the roles of two different types of Everglades wetlands in the regional carbon cycle. Based on their findings, the authors suggest that, contrary to previous research, restoring the Everglades will likely diminish the potential of the region to serve as a carbon sink.

The authors studied two different types of wetlands, peat and marl, using half hourly measurements from 2008 to 2009. The peatland region, Shark River Slough, was submerged for 16 of 18 months for which reliable observation could be obtained. The marl site, Taylor Slough, was inundated only half of the time. The authors found that during 2008, the peatland site was a weak net carbon source, emitting 19.9 grams of carbon per square meter. In 2009, this value jumped to 80.0. The marl site, on the other hand, was a net carbon sink in 2008, drawing 78.8 grams of carbon from the atmosphere per square meter. In 2009, the marl site was neutral.

Analyzing the relationship between net ecosystem exchange and various environmental parameters, the authors found that the air temperature and water table depth were the most important factors affecting carbon exchange, with the two types of wetlands having opposite reactions to shifts in each. (*Journal of Geophysical Research-Biogeosciences*, doi:10.1029/2012JG002117, 2012) —CS

First satellite detection of volcanogenic carbon monoxide

Measuring and tracking the gases that vent from an erupting volcano is a project fraught with potential dangers and difficulties. Taking measurements on the ground places researchers in harm's way, as does taking airborne samples. These approaches also may suffer from issues around accurately representing the spatial and temporal shifts in gas emissions rates. As such, satellite-based remote sensing techniques are becoming a preferred way to assess the dispersion and concentrations of various volcanic gases. Devising a functional remote sensing scheme, however, depends on identifying a satellite sensor that can reliably identify the chemical species in question and pick the volcanic emissions out from the background concentrations. Such efforts have so far been successful for only a few volcanic gases: sulfuric acid, hydrochloric acid, and hydrogen sulfide.



NASA MODIS

A false color image of the volcanic plume from Eyjafjallajökull on 11 May 2010.

Working from satellite observational records from the 2010 Eyjafjallajökull and 2011 Grímsvötn eruptions, *Martínez-Alonso et al.* found that the Measurements of Pollution in the Troposphere sensor aboard NASA's Terra satellite and the Infrared Atmospheric Sounding Interferometer on the European Space Agency's Meteorological Operational satellite MetOp-A could be used to remotely detect volcanic carbon monoxide emissions. The two sensors measured atmospheric carbon monoxide in different ways and hence each could be used to support the other's observations. The authors found that the remotely sensed volcanogenic carbon monoxide was not a misdiagnosis of atmospheric water vapor or aerosols. Further, their concentration measurements aligned with airborne surveys.

Based on their detections, the authors estimate that the global emission of volcanic carbon monoxide is approximately 5.5 teragrams per year, a small but not insignificant fraction of total annual emissions. (*Geophysical Research Letters*, doi:10.1029/2012GL053275, 2012) —CS

Debating how to assess hydrological model uncertainty and weaknesses

The projections of hydrological models, as numerical abstractions of the complex systems they seek to represent, suffer from epistemic uncertainty due to approximation errors in the model, incomplete knowledge of the system, and, in more extreme cases, flawed underlying theories or faulty data. These errors can result in complex nonstationary biases in model predictions. Improving hydrological models—whether they be dynamic models attempting to represent the physical system from first principles or statistical, data-driven models—depends on having a way to determine the amount of uncertainty associated with the model's projections and a reliable way to deduce which model components or forcing data are responsible for it.

Exactly how models' uncertainty should be assessed and how such assessments can be used to judge the weaknesses in hydrological models or model components is the focus of a debate between two groups, *Beven et al.* and *Clark et al.* Both sets of authors agree on some of the major pitfalls facing hydrological models, including the risk of overfitting data, of rejecting a sound model based on poor data, and of nonstationary, often arbitrary biases due to epistemic uncertainty.

In a commentary, *Clark et al.* proposed a multihypothesis approach to rejecting and refining hydrological models that included the use of formal Bayesian inference for quantifying model uncertainty. This proposal was met by *Beven et al.*, who criticized *Clark et al.*'s discussion of the differences between the formal Bayesian method and an alternative approach, the Generalized Likelihood Uncertainty Estimation (GLUE). *Beven et al.* argued that GLUE provides a more flexible way of thinking about the issues affecting hypothesis testing in a context of nonstationary epistemic errors. *Clark et al.*'s reply to *Beven et al.* challenged the utility of GLUE and argued that many of the hydrological advances and insights obtained in GLUE studies are easier to elucidate using more controlled approaches to model evaluation.

Both sets of researchers agree on the importance of testing hydrological models as hypotheses to improve their representations of the physical system. (*Water Resources Research*, doi:10.1029/2012WR012282, 2012 and doi:10.1029/2012WR012547, 2012) —CS

Dispersion model maps spread of Fukushima radiation

When water flooded the Japanese Fukushima Daiichi nuclear power plant on 11 March 2011, killing power to the plant and destroying its backup generators, the earthquake-triggered disaster resulted in a major nuclear accident, with the plant pouring radioactive material into the air and the water. Research into the effects of the radiation on humans and the environment has been ongoing, but to ensure the accuracy of these aftermath investigations requires understanding the precise concentrations, distribution patterns, and timing of the radionuclide emissions. To provide such an assessment for the marine environment, *Estournel et al.* used an ocean and atmosphere dispersion model to simulate the movements of radioactive cesium-137 throughout the Japanese coastal waters for 3.5 months following the earthquake.

The authors began with radionuclide concentration measurements from two sites near the power plant, then used modeled ocean and atmospheric circulation patterns to calculate the cesium's dispersion. They found that for roughly a month following the plant failure, strong southerly winds kept the cesium largely trapped in a narrow band along the shore. When the southbound winds gave way to northerly ones in mid April, the radionuclides were swept offshore and diluted by the larger ocean circulation. The authors validated the model calculations with seawater samples collected at 13 sites within 30 kilometers of the plant. By inverting their modeled cesium concentrations, the authors calculated a total emission to the ocean from the failed Fukushima Daiichi plant of 5.1–5.5 petabecquerels. (*Journal of Geophysical Research-Oceans*, doi:10.1029/2012JC007933, 2012) —CS

Chamber measurements find plants are potentially important methane sink

As a greenhouse gas, methane has a much higher heat-trapping potential than carbon dioxide when considered over the course of a few decades. In recent years, researchers discovered a potentially important new source of atmospheric methane—emissions from green plants. Although estimates of the extent of vegetative methane emissions vary greatly, previous research suggests they could amount to as much as a tenth of global annual emissions. The mechanism behind such emissions is a matter of considerable debate, with questions remaining regarding the effects of atmospheric or soil conditions, local hydrological influences, and variability for different plant species. Also under investigation are various potential plant methane uptake mechanisms and the effects of methane-consuming bacteria—aspects of the methane cycle that could dampen plants' role as a methane source.


Elin Sundqvist

Using branch chamber measurements, researchers found that spruce trees are a sink for atmospheric methane.

To determine the overall effect of some boreal tree species on atmospheric methane, *Sundqvist et al.* used branch chamber measurements to directly assess the net gas exchange for birch, spruce, pine, and rowan trees in a Swedish forest. The authors found that all four tree species were net absorbers of atmospheric methane. The authors analyzed how the methane exchange varied with changes in the availability of photosynthetically active radiation (PAR), temperature, photosynthesis rate, and ultraviolet radiation levels. For birch, spruce, and rowan trees (but not pine), they found that an increase in PAR caused the trees to take up more methane. They found that temperature changes had inconsistent effects on methane exchange. The authors suggest that plants could actually be an important global sink, rather than source, for atmospheric methane. (*Geophysical Research Letters*, doi:10.1029/2012GL053592, 2012) —CS

Global ocean salinity changing due to anthropogenic climate change

Rising sea surface temperatures, climbing sea levels, and ocean acidification are the most commonly discussed consequences of anthropogenic climate change for the global oceans. They are not, however, the only potentially important shifts observed over recent decades. Drawing on observations from 1955 to 2004, *Pierce et al.* found that the oceans' salinity changed throughout the study period, that the changes were independent of known natural variability, and that the shifts were consistent with the expected effects of anthropogenic climate change.

The authors analyzed 50 years of salinity and temperature observations drawn from the National Oceanographic Data Center's records. The observations spanned the top 700 meters of the water column from 60°N to 60°S. Using 20 global general circulation models, they assessed whether the observed changes in ocean salinity and temperature could be explained by known natural cycles: the El Niño–Southern Oscillation, the Pacific Decadal Oscillation, the effects of volcanic eruptions, and changes in solar activity. They found that the observed trends, which varied regionally, did not relate to any of these forcings. However, the observed trends are consistent with model estimates of the effects of human-caused climate change.

The slowly shifting global salinity field is known to be affected by changes in the hydrological cycle, including changes in evaporation and precipitation rates, ocean currents, river discharge, and other forces. As such, the authors suggest that the observed human-driven trends in the global salinity field demonstrate an ongoing, long-term shift in the global hydrological cycle that is likely to continue into the future. (*Geophysical Research Letters*, doi:10.1029/2012GL053389, 2012) —CS

Statistical framework for assessing uncertainty in hydrological models

For regional managers trying to make long-term investments in hydrological infrastructure, having a reliable forecast of how their watershed may evolve in a changing climate is a significant boon. To make a projection of the regional effects of climate change, researchers often use the calculations of a global general circulation model to determine a set of initial conditions—for either historical or future climes—which can then be used to run a regional hydrological model. Using this approach, uncertainty can arise from a number of sources, including from the difficulties of projecting climate change, from errors within either the general circulation model or the hydrological model, from uncertainty surrounding modeled parameterizations, or from data sampling errors.

In prior research, attempts to explicitly quantify the uncertainty involved in such a projection have generally overlooked many of these sources of error. To combat this, *Steinschneider et al.* developed a statistical framework that would allow researchers to quantify and propagate uncertainty from all of these sources throughout a climate effects assessment, giving a better sense of the total uncertainty enveloped in a hydrological projection. The authors suggest that only by accurately tracking all sources of uncertainty can spurious projections be isolated from realistic ones. The authors note that the total uncertainty will typically be greater than the sum of the uncertainty from each source.

To test their framework, the researchers used a conceptual rainfall-runoff model, fed by a number of general circulation models, to assess the effects of climate change on the White River Basin in Vermont. They found that the projected changes in streamflow were larger than the uncertainty from all sources, suggesting that the region will experience real, nonspurious shifts in hydrological dynamics due to climate change. (*Water Resources Research*, doi:10.1029/2011WR011318, 2012) —CS

—Colin Schultz, Writer