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RESEARCH SPOTLIGHT

Highlighting exciting new research from AGU journals

Seasonal algae plays critical role in North Pacific carbon uptake

The role of the North Pacific Ocean as a net carbon sink may prove to be more precarious than previously thought as researchers work to isolate the contributions of biological and physical processes to air-sea gas exchange. Scientists have long known that physical processes, such as the seasonally changing solubility of carbon dioxide in seawater, combine with a biological pump driven by seasonal shifts in phytoplankton growth to control the carbon dioxide flux in the region. A dearth of on-site evidence regarding biological pump function, however, has prevented researchers from assessing the relative importance of either mechanism to known carbon uptake rates. Using data collected during four cruises from 2003 to 2008, *Juranek et al.* determined the strength of the biological pump, finding that for the northern Pacific Ocean it was strong enough to counteract solubility-induced outgassing in summer, turning a net source region into a carbon sink.

The North Pacific is split into three sections: an anticyclonic subtropical gyre, a cyclonic subarctic gyre, and a transition zone sandwiched between. Superimposed on these largely stationary features, the transition zone chlorophyll front (TZCF) travels from 30°N in winter to 40°N in summer. Using dissolved gas concentration and isotope ratio detections, satellite measurements of chlorophyll concentrations, and other data sources, the authors mapped the oxygen and carbon dioxide budgets of the different North Pacific regions. They found that in TZCF, biological productivity was 2–4 times higher than in adjacent regions. This spike was driven by the confluence of enhanced ocean mixing, increased nutrient availability, and a change in the TZCF's algal ecosystem composition. Given the newly realized power of the biological pump, the authors suggest that understanding how North Pacific algal populations could be affected by changing climate or hydrological conditions is a pressing concern. (*Journal of Geophysical Research-Oceans*, doi:10.1029/2011JC007450, 2012) —CS

New corrections for skylight estimates

Skylight, also known as diffuse solar radiation, accounts for about 16% of the total solar radiation reaching the Earth's surface; the percentage varies depending on external factors, such as the angle of the Sun with respect to the zenith and the composition of the atmosphere as well as on properties of the surface, such as albedo and tilt. Of all the factors, the composition of the atmosphere changes most frequently, primarily due to changing cloud cover and the amount and type of aerosols in the atmosphere in a given region.

G. Sánchez

A shadow ring for measuring skylight.

At present, numerical methods used to calibrate measuring devices such as shadow rings, which are bands held parallel to the sunbeam to block direct sunlight and measure the diffuse light reaching a sensor, assume an unchanging atmosphere. Such assumptions do not account for local conditions and hence can introduce large errors in skylight measurements.

In a new study, *Sánchez et al.* investigated how shadow rings affect measured diffuse radiation. They also compared six of the most commonly used numerical models and identified possible sources that cause inconsistencies between the different models. The authors found that the shadow ring itself blocks about 11% of the diffuse radiation reaching a sensor. Suitably correcting for this effect reduces errors in shadow ring measurements. Further, the researchers found that local factors, such as the amount of aerosol and cloud cover, significantly affect estimates of diffuse radiation; adjusting for local factors improved estimates of diffuse radiation and led to better agreement between the different models. This investigation has implications for climate studies and renewable energy technologies that require precise and accurate estimates of solar radiation reaching a given surface on Earth. (*Journal of Geophysical Research-Atmospheres*, doi:10.1029/2011JD017346, 2012) —AB

Reanalyses find rising humidity in the Arctic but miss fine details

Direct, reliable observations of atmospheric conditions stretch as far back as the midseventeenth century, with otherwise consistent records being punctuated by periodic updates in methods, practitioners, and observational equipment. To bridge these shifts in technique and technology, scientists develop reanalysis models designed to tie together diverse observations into a coherent picture of the system's evolution. But, like all models or analytical techniques, reanalysis of data sets can suffer from errors or biases. Identifying how the records produced by different reanalyses vary can be a difficult practice, but determining if a cluster of models consistently produces biased results can be even more difficult.

A number of reanalyses have recently been developed to track the rapidly changing Arctic atmosphere, and *Serreze et al.* compared them with one another and with the observational record. The authors focused on how the reanalyses represent the change in Arctic tropospheric water vapor from 1979 to 2010. They compared three of the most recent and complex reanalyses with meteorological measurements made using radiosondes at nine sites north of 70°N. They found that the reanalyses consistently overestimated low-altitude temperatures and winter humidity. It is important to note that these positive biases caused the reanalyses to miss low-altitude wintertime temperature and humidity inversions identified by the radiosondes.

A finding shared by both reanalyses and radiosonde observations, however, is of an increasing availability of precipitable water in the low-altitude Arctic, which the authors suggest is associated with increasing air-sea surface temperatures, reduced sea ice extent, and other markers consistent with the polar amplification of global warming. Increasing Arctic humidity is a troubling result, as heightening atmospheric water vapor could further drive up regional temperatures. (*Journal of Geophysical Research-Atmospheres*, doi:10.1029/2011JD017421, 2012) —CS

Area-based approach improves global sediment discharge modeling

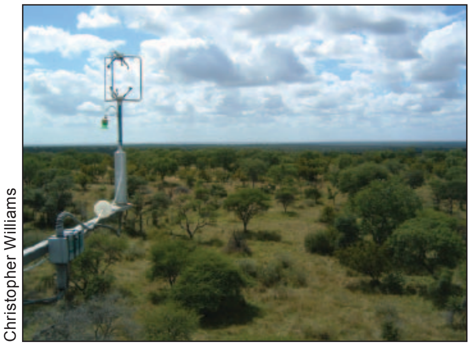
By approaching the challenge of calculating global sediment discharge rates from a new angle, *Pelletier* developed a model that outperforms many existing simulations while minimizing the number of free parameters. Knowing how sediment is transported by the world's rivers is a key factor in understanding how landscapes change over time, with important consequences for agricultural viability, ecological health, and soil properties.

Traditionally, the majority of discharge models calculate sediment redistribution at the watershed or drainage basin scale, using watershed average values of the physical properties known to affect sediment transport. The author's model, on the other hand, partitions the planet into sections that are 5 arc minutes wide—roughly 10 kilometers across at the equator and smaller at higher latitudes. This decision to use an area-based grid rather than drainage basin averages allows for an improved representation of small-scale processes that are often washed out at the watershed scale.

Drawing on decades of published research into the effects of various physical parameters on sediment discharge rates, the author's model breaks the calculation for the amount of sediment flowing through each grid square into two distinct steps. First, the model uses observations of leaf area index, temperature, rainfall rate, soil type, and topographic variables to calculate how much sediment will become available through erosion. Then, the model calculates the balance between the slope, water depth and flow rate, and sediment properties to estimate how much of the available suspended sediment will be carried from each pixel. Compared against an observational database representing 128 rivers, the model's calculated long-term average sediment discharge rates matched observations reasonably well. (*Journal of Geophysical Research-Earth Surface,* doi:10.1029/2011JF002129, 2012) —CS

Local factors important for water availability

One important issue that has grabbed the attention of scientists and policy makers alike is the amount of freshwater that will be available to populations across different climate settings, especially as rain belts reorganize in response to warming temperatures over the 21st century. The amount of freshwater available on land, calculated from runoff, is a function of supply and demand, where annual rainfall determines the supply and the dryness determined by solar radiation largely controls the demand. Local factors, such as vegetation and soil types that are directly tied to regional climate, modulate the surface water supply and demand. However, there are no observations to quantify the effect of regional climate on surface water availability.



Christopher Williams

Eddy covariance sensors monitoring surface-atmosphere exchanges over a savannah in South Africa, contributing to the global FLUXNET database. Williams et al. *used FLUXNET data to study how factors such as climate and vegetation modulate the regional surface water balance.*

In a new study, *Williams et al.* investigate how such climate and vegetation factors modulate the regional surface water balance and associated freshwater supply. They incorporate new meteorological data from 167 FLUXNET sites across the globe. The researchers found that, consistent with previous studies, annual average solar radiation and rainfall control 62% of the surface water supply and demand. However, 13% of the supply and demand balance is controlled by vegetation type and other regional climatic factors.

Further, they found that in grasslands, evaporation rates are 9% higher than in forests in the same climate setting, contrary to common expectations. On the basis of their study, the researchers recommend that climate models investigating water availability should take into account local factors, regional climate, and even topography for more accurate prediction of future water resources. (*Water Resources Research,* doi:10.1029/2011WR011586, 2012) —AB

Abyssal plains heat exchange could explain global deficit

When researchers measure the amount of heat flowing conductively from the seafloor to the ocean waters and then compare that value against a theoretical prediction of that heat loss, they observe that the global average measured heat flow is lower than expected. Researchers think that advection, a heat transfer mechanism that is difficult to measure, makes up this difference between predicted and observed heat exchange. They suggest that as seawater circulates through the permeable upper layers of the seafloor crust, driven by a thermal gradient, the water accumulates heat, drawing it into the ocean.

Scientists have recently proposed that seafloor sediment plays an important role in controlling the geometry of such intraocean crust circulation. In the abyssal plains, the accumulation of millions of years' worth of low permeability sediment limits direct contact between the ocean and the crust. Where the sediment is thin or absent—for example, at outcrops—water is thought to be able to move between the ocean and the crust. Scientists propose that seawater can travel through the crust for tens of kilometers beneath the sediment, moving laterally from outcrop to outcrop.

To determine whether such outcrop-to-outcrop flow can account for the heat flow deficit, *Anderson et al.* modeled the global distribution of abyssal plain outcrops. Using a range of seafloor spreading, sediment deposition, and post-deposition sediment transfer rates, they found that outcrops are closer together than previously estimated. The authors suggest that outcrop-to-outcrop hydrothermal flow could be an important mechanism for heat loss from abyssal plain crust where a sufficient sediment layer has accumulated—a process which takes, on average, a few million years. (*Journal of Geophysical Research-Solid Earth,* doi:10.1029/2011JB009052, 2012) —CS

—Atreyee Bhattacharya and Colin Schultz, Writers