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RESEARCH SPOTLIGHT

Highlighting exciting new research from AGU journals

Yellowstone geysers influenced by internal processes

Barb Richman

Eruption of Old Faithful geyser. Old Faithful erupts about every 90 minutes with a fountain that can reach higher than 50 meters.

The intervals between geyser eruptions depend on a delicate balance of underground factors, such as heat and water supply, as well as on their interactions with surrounding geysers. Some geysers are highly predictable, their intervals between eruptions (IBEs) varying only slightly. The predictability of these geysers offers Earth scientists a unique opportunity to investigate what may influence their eruptive activity and to apply that information to rare and unpredictable types of eruptions, such as those from volcanoes.

Hurwitz et al. took advantage of a decade of eruption data—from 2001 to 2011—for two of Yellowstone's most predictable geysers, the cone geyser Old Faithful and the pool geyser Daisy. The authors focused their statistical analysis on possible correlations between the geysers' IBEs and external forces such as weather, Earth tides, and earthquakes. The authors found no link between weather and Old Faithful's IBEs, but they did find that Daisy's IBEs correlated with cold temperatures and high winds. In addition, Daisy's IBEs were significantly shortened following the 7.9 magnitude earthquake that hit Alaska in 2002.

The authors note that atmospheric processes exert a relatively small but statistically significant influence on pool geysers' IBEs by modulating heat transfer rates from the pool to the atmosphere. Overall, internal processes and interactions with surrounding geysers dominate IBE variability, especially in cone geysers. (*Journal of Geophysical Research: Solid Earth*, doi:10.1002/2013JB010803, 2014) —JW

Observing trends in total ozone and extreme ozone events

The ozone layer in the stratosphere has been recovering since the 1989 Montreal Protocol reduced the use of ozone-destroying chlorofluorocarbons. *Fitzka et al.* observed trends in total ozone levels and the vertical distribution of ozone at Hoher Sonnblick, a mountain in Austria, from 1994 to 2011.

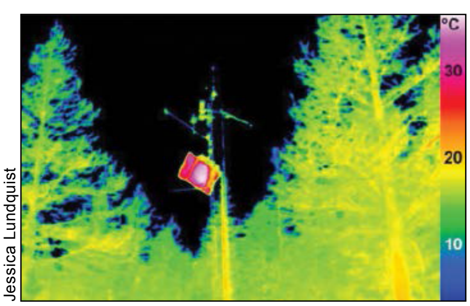
Their observations, made using a spectrophotometer to measure the intensity of light as a function of wavelength, rely on a phenomenon known as the Umkehr effect, in which the ratio of the intensities of two different wavelengths of ultraviolet light—one of which is strongly absorbed by ozone and one of which is weakly absorbed—decreases when the Sun is near the horizon. These measurements provide information about the vertical distribution of ozone.

The authors established a set of conditions to define extreme low- and high-ozone events. During the study period, they found a significant decrease in the number of low-ozone events and an increase in the number of high-ozone events but no trend in the magnitude of the extremes.

Total ozone was observed to be increasing by about 2% per decade. In the upper stratosphere, ozone levels have been flat or declining, but the loss of ozone in the upper stratosphere has been offset by increases in ozone in the lower stratosphere, especially during winter, the researchers found. (*Journal of Geophysical Research: Atmospheres*, doi:10.1002/2013JD021173, 2014) —EB

Snowmelt decreases in lower-density forests

As climate change threatens global freshwater supplies, researchers are looking for better ways to manage water sources like snowmelt. Many regions of the world depend on annual snowmelt for water, and portions of these regions are also forested. Forest dynamics are complex and can vary widely depending on region, precipitation, altitude, and many other factors, which makes it difficult to determine whether dense forests retain snowpack or accelerate melt.



Jessica Lundquist

An infrared photograph shows that trees emit more radiation than colder things, like clouds in the sky.

Conventional wisdom would say that denser forests retain snowpack because they provide a shield from wind and sunlight, but *Lundquist et al.* found just the opposite in certain climates. The authors analyzed 21 previous studies of regions across the globe and modeled the effects of temperature and precipitation on snowpack within the forest and in the open. For regions with warmer than average winter temperatures, the authors found that forests actually accelerate melt due to longwave radiation emissions from the trees themselves. Open areas, in turn, retained snow.

The authors note that these new data can be extrapolated and applied globally, thus providing an important framework—especially in the face of a warming climate—for the future of forest management. (*Water Resources Research*, doi:10.1002/wrcr.20504, 2013) —JW

Trees, more than shrubs, protect against soil erosion

Soil erosion and saltation—the transport of ground particles by wind—are significant producers of dust and can damage crops or lead to nutrient-poor soil in semiarid regions. These regions are particularly vulnerable to climate warming and increased human activity, which can exacerbate erosion and induce dust bowl–like conditions. Previous research and observations have shown that vegetation such as shrubs and trees can reduce soil erosion, but existing models do not account for variations in wind direction or strength.

Dupont et al. used a previously existing saltation model and combined it with a wind flow prediction system to simulate the effects of saltation on land sparsely vegetated with shrubs and trees. The authors found that saltation and erosion were reduced by vegetation, which confirmed existing models, but also that placement of trees and shrubs in relation to wind direction can influence the extent of reduction. They also found that trees are better at reducing the effects of saltation than shrubs. The authors note that this new model can be applied to more complex landscapes, where simpler models may not be as precise. (*Journal of Geophysical Research: Earth Surface*, doi:10.1002/2013JF002875, 2014) —JW

Bedrock topography influences erosion rate

Even small bumps in a river's bedrock can change how sediment grains erode bedrock, a new modeling study shows. Observations have indicated that bumpy bedrock erodes more quickly, but most previous models of bedrock erosion assumed approximately planar beds.

To create a more realistic model of bedrock erosion, *Huda and Small* included bumps several centimeters high, spaced approximately 50 centimeters apart. As sediment grains flow along with the water, they hit the bumps, transferring energy to the bed and increasing erosion.

The authors found that erosion by moving sediment grains occurred 10 to 1000 times faster in the model with bumpy bedrock topography than in a planar bed model, depending on the size of sediment particles.

In addition, in their model, erosion increases with river stage, suggesting that the greatest erosion should occur during floods. In models with planar beds, maximum erosion occurs at low to medium stages. The results show that even small bumps can make a big difference in how sediment erodes bedrock, indicating that it is important to include bedrock topography in models of erosion. (*Journal of Geophysical Research: Earth Surface*, doi:10.1002/2013JF002872, 2014) —EB

Bowl-shaped deformation found in Earth's magnetosphere

The decade-long Cassini mission has yielded invaluable information about Saturn's magnetosphere. One feature of Saturn's magnetosphere that has puzzled scientists is a bowl-shaped deformation of Saturn's equatorial current sheet—the disk-like sheet of charged particles across which the planet's magnetic field abruptly reverses direction. So far, there are few data available to explain this deformation, which is seen only during periods when the planet's magnetic axis is not perpendicular to the solar wind flow.

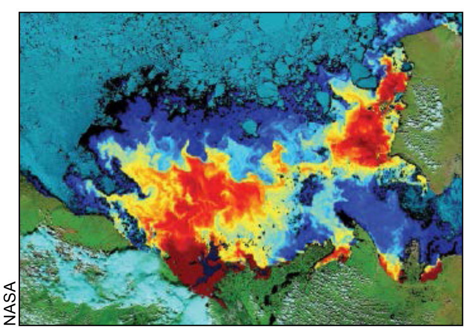
Earth's magnetosphere, it turns out, also features a bowl-shaped deformation like Saturn's. *Tsyganenko and Andreeva* used large sets of space magnetometer data to discern the deformation and attempt to explain its existence. The authors found that the deformation has to do with the asymmetries within the magnetosphere caused by the fact that the Earth's magnetic axis is tilted away from its rotational axis, which in turn is tilted away from the orbital plane normal. They also found a similar effect in a modeled magnetosphere with a tilted planetary dipole. (*Geophysical Research Letters*, doi:10.1002/2014GL059295, 2014) —JW

Warm river waters contributed to melting Arctic sea ice

In 2012 Arctic sea ice extent reached a record low in the satellite-observed record. A new study by *Nghiem et al.* suggests that warm waters discharged into the Arctic's Beaufort Sea from the Mackenzie River could have contributed to that low ice extent.

The authors used satellite measurements to observe sea surface temperatures, and the large area covered by warm waters extended from the mouth of the Mackenzie River in the Beaufort Sea in June and July 2012. Before 14 June, the warm Mackenzie waters were blocked from entering the Beaufort Sea by a landfast sea ice barrier. Then the river waters surged onto the ice barrier and began to break through.

The authors found that by 5 July the surface temperature in an open water area had increased by 6.5°C and the extent of open water occupied by warm waters had increased by 50%. They conclude that the Mackenzie and other large rivers bring a substantial amount of heat into the Arctic Ocean, which contributes to melting sea ice. In a stark contrast, there is no such large river in the Antarctic, where sea ice has little change. (*Geophysical Research Letters*, doi:10.1002/2013GL058956, 2014) —EB


NASA

Warm waters from Mackenzie River discharge were observed via the surface temperature pattern (red to blue) measured by the NASA Moderate Resolution Imaging Spectroradiometer Terra satellite on 5 July 2012. Sea ice is delineated by cyan in the image.

Antarctica's Whillans Ice Plain ice flows are highly variable

The Whillans Ice Plain (WIP) is a roughly 20,000-square-kilometer region of the West Antarctic Ice Sheet that acts as a massive conveyor, driving glacial ice into the Ross Ice Shelf. As the climate changes, knowing how large bodies of ice like the WIP behave will be important to assessing sea level rise.

Since measurements first began in 1963, researchers have found that the WIP ice flows have been slowing. On the basis of what were initially decadal observations, researchers calculated that the slowdown was occurring at a constant rate.

Starting in 2007, *Beem et al.* began collecting annual measurements about WIP. The authors found that rather than undergoing a steady deceleration, ice flow rates fluctuate on interannual time scales. The ice flow rate is controlled by a range of resistive stresses, such as side drag, basal drag, and other factors, but previous research, combined with the current findings, suggests that changes in basal drag are responsible for the WIP's interannual variability.

What would cause this increase in basal drag? The authors speculate the cause to be water loss from the surface beneath the ice—caused by water freezing to the glacier's underside or by subglacial streams being diverted along a new path. Both mechanisms are supported by existing research. The authors note that changes to ice flow at WIP are linked to changes in internal glacier dynamics rather than to climate variability. (*Journal of Geophysical Research: Earth Surface*, doi:10.1002/2013JF002958, 2014) —CS

New model describes toppling of salt marsh banks

Salt marshes are coastal habitats that store important nutrients and serve as shelter for many estuarial species. These habitats are threatened by rising seas and human expansion, so it has become increasingly important to improve models of how these habitats degrade.

There are many ways that salt marshes retreat naturally, including surface erosion and widespread slumping into the sea, via processes such as sliding or toppling. Studying the way the edge of a salt marsh erodes is important for determining morphological changes in the marsh, but so far, no mechanical models exist that describe how toppling occurs.

Bendoni et al. present the first model for toppling induced by wind waves—waves of water pushed by the wind. The authors conducted laboratory experiments to investigate the effects of wind waves on salt marsh edges and found that failure occurs when water fills tension cracks, putting stress on the soil that causes it to fail. The authors then created a model based on their findings that replicates lab results well. These models may help improve salt marsh management strategies. (*Journal of Geophysical Research: Earth Surface*, doi:10.1002/2013JF002967, 2014) —JW

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