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RESEARCH SPOTLIGHT

Highlighting exciting new research from AGU journals

Increased erosion rates due to uplift and glacial erosion

Matthew Fox

The Bergell intrusion in the Swiss Alps has served as a natural laboratory for scientists studying changes in erosion rates.

Around the world, geologists have found overwhelming evidence that starting about 5 million years ago, erosion rates began to increase. Geoscientists, puzzled about the cause of this increase, are specifically debating whether it is due to climate change or an increase in rock uplift as the Earth's topography evolved.

In the Swiss Alps, the Bergell intrusion—a massive igneous sequence that is exposed in several locations—has the lithology and high relief needed to test hypotheses of why erosion rates dramatically changed. Recently, *Fox et al.* developed a new model linking radiometric ages, recording the cooling of mineral grains as they approached Earth's surface, across the Bergell to the topographic evolution of the region. The authors identified a period of slow uplift that corresponded to slow erosion rates from 20 to 5 million years ago, then an increase in erosion rates up to 0.7 kilometer per million years.

The authors propose that this change is due to increased glacial erosion and rock uplift that started 4 million years ago, rather than a changing climate. (*Geochemistry, Geophysics, Geosystems,* doi:10.1002/2013GC005224, 2014) —JW

Understanding the behavior of charged particles in the magnetotail

When the Sun spews charged particles toward Earth, they can enter the magnetosphere and become energized as they move closer to the Earth's surface. These energetic particles can induce the bright colors of auroras, disrupt navigational satellites, and even distort terrestrial telecommunications.

Previous research has found that the energization and transport of these particles—a process known as "particle injection"—may be correlated with the emergence of narrow, fast-flowing channels of plasma within the magnetosphere that travel earthward after energy is released in the Earth's magnetotail. Curious about how far out these particle injections can be detected in the magnetotail and whether they are actually caused by these narrow, fast-flowing bursts of plasma, *Gabrielse et al.* studied data from NASA's Time History of Events and Macroscale Interactions during Substorms (THEMIS) mission, which observes large-scale space weather events beyond the orbits of geosynchronous satellites.

The authors found that energetic particle injections could, in fact, be seen approaching Earth well beyond the previously recorded distance of 6.6–12 Earth radii, even up to 30 Earth radii away and possibly farther. The scientists also showed statistically that these particle injections are indeed related to the narrow channels of fast-flowing plasma, where particles are energized by the flow channels' electric fields. Understanding how these particle injections behave at points within the radiation belts to distances greater than 30 Earth radii away will help scientists develop better forecasts of potentially damaging space weather events. (*Journal of Geophysical Research: Space Physics,* doi:10.1002/2013JA019638, 2014) —JW

Earth's magnetotail investigated as an electrical circuit

The Earth's magnetosphere has profound influences on space weather: Geomagnetic storms born in the magnetosphere have the potential to disrupt satellite and terrestrial communications. The most dynamic part of the magnetosphere is the magnetotail, which appears on the nightside of the Earth and is composed of many different complex structures.

The magnetotail is inundated with smaller magnetic disturbances called substorms, sometimes multiple times a day. Substorms are characterized by explosive bursts of highly energetic particles that are injected into the magnetotail from plasma streams moving away from the Sun, which spur auroras. Scientists still are not sure what causes the injections, but they do know that substorms occur when the Sun's interplanetary magnetic field (IMF) is oriented southward, when it can reconnect with the Earth's magnetic field.

Ohanti and Uozumi discuss characteristics of the nightside magnetosphere using an electrical circuit as an analogue to the magnetotail. An electric circuit has different components, such as the inductor, capacitor, resistor, and energy source. By finding parallel components in the magnetotail, the authors were able to determine how the circuit would behave under different "voltages," or amounts of energy from the Sun. They came to several conclusions based on the estimates of time constants, including that during a substorm growth phase, when energy is being "stored" in the magnetotail, the cross-tail current increases continuously even if the IMF does not change after a southward turning. This may help explain why substorms vary in strength. (*Journal of Geophysical Research: Space Physics,* doi:10.1002/2013JA019680, 2014) —JW

Seeding cirrus clouds could drive global net cooling

Cirrus clouds—thin, wispy streamers that form in the upper troposphere when ice crystals nucleate around small dust or metallic particles—have a net warming effect on climate. Previous studies have suggested that seeding cirrus clouds with an overload of dust particles reduces their formation and lifespan, thus leading to a net cooling effect on global climate. Recently, however, research has raised questions regarding how exactly cirrus clouds form, which has implications for seeding strategies.

It was previously thought that cirrus clouds form primarily through homogeneous freezing—spontaneous freezing by water

Trude Storelvmo

Cirrus clouds cover 30% of Earth's surface and could be seeded with particles to reduce their net warming effect.

droplet solutions—but recent research has found that the majority of cirrus clouds likely form by heterogeneous ice nucleation, whereby atmospheric ice nuclei gradually build into droplets as different particles freeze to them at different times.

Storelvmo and Herger incorporate these new findings into investigations on the effects of cirrus cloud seeding. The authors ran several simulations and found that seeding cirrus clouds that form by a mix of heterogeneous and homogeneous processes allowed for net cooling effect. The biggest cooling effect in their simulations occurred when only half the globe's cirrus clouds were seeded, rather than uniform global seeding, which had been suggested in previous studies. (*Journal of Geophysical Research: Atmospheres,* doi:10.1002/2013JD020816, 2014) —JW

—JoAnna Wendel, Staff Writer