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RESEARCH SPOTLIGHT

Highlighting exciting new research from AGU journals

Data from Apollo missions show how lunar dust degrades instruments

Apollo astronauts encountered very fine, powdery, abrasive lunar dust, which stuck to scientific instruments and caused damage and sometimes overheating and failure. To measure the effects of lunar dust, each of the first four Apollo expeditions left a set of solar cells on the Moon, and data were transmitted to Earth from 1969 to 1976.

Because accumulated dust reduces sunlight reaching the solar cells, a lower voltage produced by the cells provides a measure of the dust accumulation. The measurements were recently revisited and analyzed by *Hollick and O'Brien* to estimate the rate of dust accumulation and to compare the effects of energetic solar particle radiation and dust.

The authors estimated that as much as 100 micrograms of dust could accumulate per square centimeter per year, creating a coating about 1 millimeter thick after 1000 years. Although this rate of accumulation is slow, the authors were able to measure significant degrading of the performance of solar cells over 5 to 6 years.

Because solar particle radiation was also a known hazard, some of the cells were shielded against it. The authors examined in particular how much the output of cells declined during the highly intense August 1972 solar particle event. They found that dust accumulation caused more long-term damage to shielded solar cells than did all the solar par ticle radiation. However, for bare cells the long-term damage by particle radiation was about 3 times larger than the total dust effects. The dust results may be important to future lunar experiments. (*Space Weather,* doi: 10.1002/2013SW000978, 2013) —EB

Apollo 17 Astronaut Gene Cernan, covered in some lunar dust. Lunar dust also degrades solar cell performance, as shown by Hollick and O'Brien. (NASA Image AS17-140-21391; photo by Harrison Schmitt.)

Even industrial-scale carbon removal would not fully undo modern warming

Unless the world embarks on a massive program to deliberately remove carbon dioxide from the atmosphere, with the scale of the carbon withdrawal industry ramping up to eventually mirror the size of the modern fossil fuel industry, the bulk of modern anthropogenic warming will persist for at least the next 10,000 years, previous studies have shown. New research by *MacDougall* shows that if widespread active carbon removal is initiated, temperatures could be brought nearly in line with preindustrial levels by the year 3000. However, to counterbalance the release of carbon dioxide and methane from former permafrost soils, from 115% to 181% of the carbon dioxide emitted since the dawn of the industrial era would need to be drawn out of the atmosphere. Regardless of how aggressively carbon is drawn out of the air, some changes, such as the melting of Greenland's glaciers, would not be fully reversed by the year 3000.

To reach these conclusions, the author used the University of Victoria Earth System Climate Model to simulate anthropogenic warming following the Intergovernmental Panel on Climate Change's representative concentration pathways (RCPs). For each RCP, once the atmospheric concentration of carbon dioxide hit its peak, the author then modeled an idealized withdrawal such that the concentration was reduced in a mirror of how it had increased—that is, for RCPs where carbon dioxide had climbed quickly, it was also then removed more aggressively. The author's simulations also included a reduction in greenhouse gases other than carbon dioxide and a reversion of land to preindustrial usage levels—an abandonment of agricultural, industrial, or urbanized land in favor of forests. Despite these intensive reductions, he found, there would still be between 0.1° and 1.7°C of residual warming by the end of the millennium. (*Geophysical Research Letters,* doi:10.1002/2013GL057467, 2013) —CS

How much methane could be released from Arctic hydrates?

In Arctic seafloor sediments, methane, a potent greenhouse gas, is trapped in chemical structures called hydrates. Methane hydrates form at low-temperature, high-pressure conditions, and methane can be released if the temperature rises. Previous studies have raised concern that global climate change could lead to release of significant amounts of methane from Arctic hydrates.

In 2008, more than 250 plumes of methane gas were discovered escaping from the seafloor of the West Svalbard continental margin. *Marín-Moreno et al.* used two climate models to study the response of methane hydrate–bearing sediments in the West Svalbard region over the next 3 centuries. Their study included a low greenhouse gas emissions scenario (representative concentration pathway (RCP) 2.6) and a high-emissions scenario (RCP8.5).

The authors found that over the next 3 centuries, between 5.3 gigagrams per year (in the lower-emissions scenario) and 29 gigagrams per year (in the high-emissions scenario) of methane could be released into the Arctic Ocean on the West Svalbard margin.

They note that if they extrapolate their calculations for the West Svalbard margin to an area of more than 150,000 square kilometers along the entire Eurasian margin, the potential release could be between 6.1 and 33 teragrams per year. Although this is a rough estimate, the authors note that this amount is about the same order of magnitude as the annual methane release from Arctic tundra (8–29 teragrams per year) and about 5 times smaller than the global annual methane emission from all natural wetlands (about 150 teragrams per year). (*Geophysical Research Letters*, doi:10.1002/grl.50985, 2013) —EB

New ice core record shows climate variability in West Antarctica

A 308-year ice core record provides new data on climate variability in coastal West Antarctica and shows that a clear warming trend has occurred in recent decades. To study climate over the past 3 centuries, *Thomas et al.* analyzed stable isotopes in the ice core, which provide a record of past temperatures. They observed that climate variability in coastal West Antarctica is strongly driven by sea surface temperatures and atmospheric pressure in the tropical Pacific.

Liz Thomas

Researchers at this Antarctic field camp collected ice core samples that provide a new record of climate variability in coastal West Antarctica.

The authors report that their ice core record shows that the region warmed since the late 1950s at a rate similar to that observed in the Antarctic Peninsula and central West Antarctica. However, the authors note that this recent warming trend is similar in magnitude to warming and cooling trends that occurred in the mid-nineteenth and eighteenth centuries in their record, indicating that in this coastal West Antarctic location the effects of human-induced climate change in recent years have not exceeded natural climate variability over the past 300 years. (*Geophysical Research Letters,* doi:10.1002/2013GL057782, 2013) —EB

Laboratory experiments examine earthquake precursors

Although it is not possible to predict when an earthquake will occur, many earthquakes have been found to have had some precursor activity. To study precursors of stick-slip behavior, *Johnson et al.* conducted laboratory experiments on a sheared granular material under normal stress ranging from 2 to 8 megapascals as an analog for a fault under tectonic stress. They found that acoustic emissions and microslips are a precursor to larger movements. Very similar results were obtained in a discrete element simulation of sheared beads. These types of experiments could help scientists better understand when earthquakes are more likely to occur. As shown by a number of researchers, very similar activity preceding faulting can occur in the Earth. (*Geophysical Research Letters,* doi:10.1002/2013GL057848, 2013) —EB

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