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RESEARCH SPOTLIGHT

Highlighting exciting new research from AGU journals

Regional shifts in snowfall, melt in the intermountain west

The freshwater supplies of the American West rely, for the most part, on snow. The Colorado River, the Rio Grande, and other rivers in the intermountain west—bounded by the Sierra Nevada and Cascade mountains to the west and the Rockies to the east—are the main sources of water for one of the driest parts of the continent, and their flows are predominantly fed by the springtime melt of snow accumulated over the winter. With winter mean temperatures rising in some places by as much as 2.5°C in the past 2 decades, some scientists are concerned that the current hydrological regime of the region could be overthrown, with snow giving way to rain as the dominant form of precipitation. Decreasing snow accumulation and earlier snowmelt onset have been observed in Colorado. Whether these trends extend to the larger intermountain west region, however, is unknown.

Drawing on daily observations from 202 snowpack telemetry (SNOTEL) stations, *Harpold et al.* found that although there have been changes in snowpack behavior, the effects of rising temperatures on snow properties are regionally variable. They suggest that a regime shift is not underway for the intermountain west.

Christopher Jones

Researchers conduct a snow survey in the Valles Caldera National Preserve, New Mexico.

Using daily observations of snow depth, snow-water equivalent, and the precipitation rate from 1984 to 2009, the authors calculated the length of the snow-covered season, the onset of melt, the date of maximum accumulation, and other parameters. Using a regional analysis the authors found that trends in these properties were highly variable across the intermountain west but that negative trends were most prominent in the Colorado River basin and in high-elevation regions that were above 2800 meters. (*Water Resources Research*, doi:10.1029/2012WR011949, 2012) —CS

Global tropical cyclone activity to decrease with climate change

Given its strong dependence on sea surface temperatures and atmospheric conditions, tropical cyclone activity is expected to be strongly affected by climate change. With observational records suggesting that tropical North Atlantic hurricane activity has increased in recent decades, some scientists have suggested that global tropical cyclone activity will increase as the planet warms. Using an ensemble atmosphere general circulation model, however, *Sugi and Yoshimura* found that global tropical cyclone activity has unde gone a long-term decline from 1872 to the present—a trend they found should continue throughout the coming century. They found that the rate of global tropical cyclone activity decreased by 12.4 hurricanes per century—8.7 fewer hurricanes per century in the Northern Hemisphere and 3.7 fewer in the Southern Hemisphere.

The authors used a high-resolution model that divided the Earth into 60-square-kilometer boxes with 64 atmospheric levels each. From 1872 to 2003, the authors prescribed sea surface temperatures, greenhouse gas concentrations, and aerosol forcings that aligned with observations. For 2003–2099, they used projected values reflective of a moderate societal push toward renewable energy sources. The researchers found that the drop in global hurricane activity was driven by a reduction in upward mass transport in hurricane formation regions. As the temperature increases, so does atmospheric stability, a shift that limits convective transport and thus tempers the formation of tropical cyclones. (*Geophysical Research Letters*, doi:10.1029/2012GL053360, 2012) —CS

Voyager observes magnetic field fluctuations in heliosheath

For the past several years, as the two Voyager spacecraft near the outer reaches of the solar system, they have been sending back observations that challenge scientists' views of the physics at the edge of the heliosphere, the bubble created by charged particles flowing outward from the Sun. A new study looks at magnetic field fluctuations and cosmic ray intensity observed by Voyager 1.

In 2004, Voyager 1 crossed the termination shock, the region where the solar wind begins to slow as it interacts with the interstellar medium. Just outside the termination shock is the heliosheath, where the solar wind continues to slow, reaching a stagnation region where solar wind speed drops to zero. *Burlaga and Ness* studied the magnetic field observed by Voyager 1 during 2010, when the spacecraft was moving through this stagnation region. Their analysis shows that magnetic field fluctuations outside the termination shock were primarily compressive fluctuations in field strength along the direction of the motion of the planets around the Sun. The fluctuations were observed on time scales of several hours.

The researchers also observed that the intensity of high-energy cosmic rays (above 70 megaelectron volts per nucleon) tended to rise with increasing magnetic field strength and increasing magnetic fluctuations. This was contrary to expectations, as theories predict that charged cosmic rays would be scattered by fluctuations in the magnetic field. The authors suggest that compressive fluctuations of the magnetic field may play a role in accelerating energetic particles in the heliosheath. (*Journal of Geophysical Research–Space Physics*, doi:10.1029/2012JA017894, 2012) —EB

Regional models do not add much value to climate change projections

Global general circulation models are the dominant tool in the effort to forecast the effects of climate change. Given the expansive scope of these models, some simplifications need to be made when representing smaller-scale processes, such as the effects of regional topography. To compensate, regional climate models are sometimes used to incorporate local influences and, in theory, improve the accuracy of projections of regional climate change. In testing the abilities of a regional model and a global model to represent historically observed climate change for the continental United States, however, *Racherla et al.* found that the regional model provided only a small increase in model accuracy and in some cases actually made the forecasts worse.

The authors used a regional model to dynamically downscale a global model, creating representations of the continental U.S. climate for two periods, 1967 to 1978 and 1994 to 2005. The authors ran the regional model in two modes: as a stand-alone model and with the calculations being nudged, or constrained, by the global model. They also operated the global model in two modes: at its standard resolution and with the results being interpolated to simulate a higher resolution. They then compared the model results against precipitation and temperature observations.

The authors found that when nudged, the regional model outperformed the interpolated global model in representing the climate of the individual decadal periods. The nudged regional model was also more accurate than the global model at representing observed climate changes between the two periods, though the authors suggest neither setup was particularly skilled. When left unnudged, the regional model was less accurate than the interpolated global model on all counts. The authors suggest that future efforts should focus on improving the ability of global models to accurately represent long-term climate changes. (*Journal of Geophysical Research–Atmospheres*, doi:10.1029/2012JD018091, 2012) —CS

High-frequency flux transfer events detected near Mercury

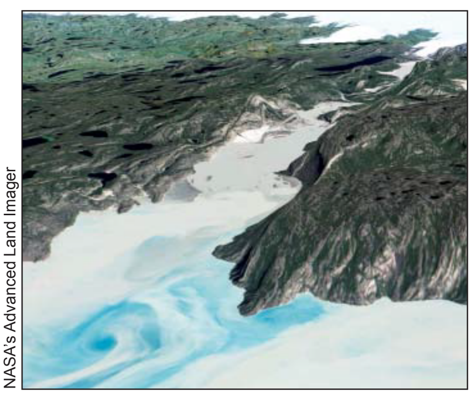
The physical process that creates connections between the magnetic fields emanating from the Sun and a planet—a process known as magnetic reconnection—creates a portal through which solar plasma can penetrate the planetary magnetic field. The opening of these portals, known as flux transfer events (FTEs), takes place roughly every 8 minutes at Earth and spawns a rope of streaming plasma that is typically about half of the radius of the Earth. As early as 1985, scientists analyzing the Mariner 10 observations, collected during their 1974–1975 flybys, have known that FTEs also occur at Mercury. However, using the measurements returned from the MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) spacecraft now orbiting Mercury, *Slavin et al.* found that Mercurial flux transfer events are proportionally much larger, stronger, and more frequent than those at Earth.

Over a 25-minute period on 11 April 2011, MESSENGER detected 163 FTEs near Mercury's magnetopause. The individual events took 2 to 3 seconds to move past the spacecraft, and the events were separated by 8 to 10 seconds. Using a model of FTE motion, the authors found that the events were likely initiated near the planet's southern magnetic pole before traveling to MESSENGER's location at the nightside magnetopause. Modeling the changes in the observed magnetic field as the flux transfer events passed over MESSENGER, the authors determined that FTEs had elliptical cross sections with a mean semimajor axis of about one sixth of the radius of Mercury. The authors suggest that if MESSENGER had not orbited out of the path of the events emanating from the southern magnetic pole, then FTEs likely would have continued to be detected until the interplanetary magnetic field conditions became unfavorable for reconnection. (*Journal of Geophysical Research–Space Physics*, doi:10.1029/2012JA017926, 2012) —CS

Near-total surface melt detected on the Greenland Ice Sheet

On 12 July 2012, 98.6% of the surface of the Greenland Ice Sheet melted, an event so expansive that a similar episode had not previously been seen in the satellite era. Ice core records indicate that the most recent melting event of this scale was 123 years ago. The one before that occurred another 7 centuries prior, during the Medieval Warm Period. Just 2 weeks following the near-total melt of the surface of the Greenland Ice Sheet, after the surface ice had refrozen to seasonal levels, a second episode pushed the melt area back up to 79.2%. Compiling measurements from three different satellite systems and from in-the-field observations, *Nghiem et al.* describe the extent of the melt. The authors suggest that warm air ridges stagnating over Greenland, coincident with the melt episodes, may have underlain the extensive melting.

Given the extreme nature of the event, the authors supported the detection with observations from three satellite- based sensors: a scatterometer aboard the Indian Space Agency's Oceansat-2 satellite, a passive microwave radiometer carried by a U.S. defense satellite, and the Moderate Resolution Imaging Spectroradiometer aboard NASA's Aqua and Terra satellites. The satellite sensors each detected the surface melt in different ways and thus, when taken together, supported the overall finding of the extensive melt. The authors also found melting at field sites around Greenland, including Summit Station, a high-altitude base that does not typically see seasonal melting, and the North Greenland Eemian Ice Drilling site, where it rained on the days surrounding the 12 July melt. The authors note that a series of similar melt events during the Medieval Warm Period were separated from the two contemporary instances by the Little Ice Age. (*Geophysical Research Letters*, doi:10.1029/2012GL053611, 2012) —CS



NASA's Advanced Land Imager

Extreme flooding in the Watson river in western Greenland following the extreme melt across nearly the entire surface of the Greenland Ice Sheet.

Soft electron precipitation explains thermosphere mass enhancements

From 2000 to 2010, a German satellite carrying the Challenging Minisatellite Payload (CHAMP) orbited the Earth, tracking the properties of the thermosphere—the atmospheric layer that starts roughly 90 kilometers above the surface and coincides with the lower layers of the ionosphere. In analyzing CHAMP's observations, researchers came across an anomaly: 400 kilometers above the Earth in two different regions in the thermosphere, the density was persistently higher than scientists expected given model calculations. The density enhancements were found in two places: at the dayside cusp—the polar region where terrestrial magnetic field lines create a funnel for the solar wind—and in the auroral region on the planet's nightside. Though researchers had identified these anomalous regions, they have so far been unable to identify a mechanism to explain them.

Using a coupled magnetosphere-ionosphere-thermosphere model, *Zhang et al.* found that the precipitation of low-energy electrons into the F region of the ionosphere could account for the differences between observations and previous modeling work. The authors ran the coupled model both with and without representations for soft electron precipitation. They found that the presence of low-energy electrons flowing into the ionosphere at the two anomalous regions—the dayside cusp and the premidnight auroral region—caused the electron density and the electron temperature to increase. These shifts led to an increase in conductivity and in the resistive heating of thermospheric plasma, which, in turn, caused an increase in the modeled mass density. (*Geophysical Research Letters*, doi: 10.1029/2012GL053519, 2012) —CS

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