Eos, Vol. 94, No. 18, 30 April 2013

RESEARCH SPOTLIGHT

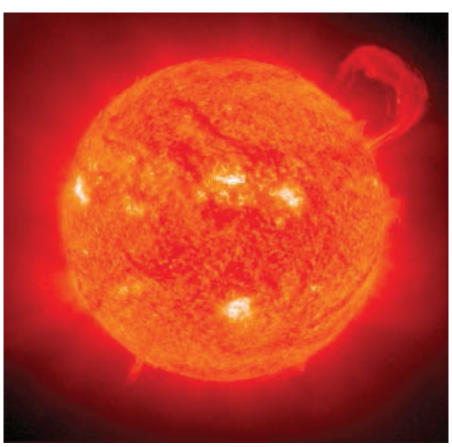
Highlighting exciting new research from AGU journals

Large solar proton event explains 774–775 CE carbon-14 increase

Tree ring records indicate that in 774–775 CE, atmospheric carbon-14 levels increased substantially. Researchers suggest that a solar proton event may have been the cause. In solar proton events, large numbers of high-energy protons are emitted from the Sun, along with other particles. If these particles reach Earth's atmosphere, they ionize the atmosphere and induce nuclear reactions that produce higher levels of carbon-14; the particles also cause chemical reactions that result in depletion of ozone in the ozone layer, allowing harmful ultraviolet radiation to reach the ground.

A previous group of researchers suggested that to cause the observed eighth century carbon-14 increase, a solar proton event would have had to be thousands of times larger than any that has been observed from the Sun. However, *Thomas et al.* believe that group's calculations were incorrect. They modeled the atmospheric and biologic effects of three solar proton events with different energy spectra and fluences (number of protons per area). They found that an event with about 7 or more times greater fluence (depending on the spectrum) than an observed October 1989 solar flare event could explain the 774–775 CE carbon-14 enhancement. With a hard (high-energy) spectrum, an event with this fluence would result in moderately damaging effects on life but would not cause a mass extinction. They rule out an event with a softer spectrum because such an event would cause severe ozone depletion and mass extinction, which were not observed in the eighth century.

The authors estimate that solar proton events of this magnitude occur on average once in a thousand years—more often if the estimate is based on astronomical observations of flares on Sun-like stars. They note that although that number may seem low, such an event would have severely damaging effects on the technology on which society relies. (*Geophysical Research Letters*, doi:10.1002/grl.50222, 2013) —EB



SOHO-EIT Consortium/ESA/NASA

A solar flare event, captured in 1999 by the Solar and Heliospheric Observatory (SOHO) spacecraft. Thomas et al. *investigate whether a large solar event could have caused a substantial increase in atmospheric carbon-14 levels in 774–775 CE.*

Climate models sensitive to tuning of cloud parameters

One of the largest sources of uncertainty in climate model projections of future warming is the effects of clouds. Clouds have both warming and cooling effects, and their interactions with aerosols are complex and not fully understood. To predict future climate using models, researchers commonly tune uncertain cloud parameters to fit current observations, then run the model to project future warming. However, as *Golaz et al.* show, the choice of parameterization can have a large effect on the simulated warming. The authors studied the effects of tuning cloud parameters in the CMIP5 GFDL CM3 model, a commonly used coupled climate model. They constructed two alternate configurations with plausible but different combinations of parameters. The different configurations showed only very slight differences in modern day climate, but their simulations of warming from preindustrial times to the present differed greatly. This indicates that climate model simulation results depend strongly on cloud parameterization. (*Geophysical Research Letters*, doi:10.1002/grl.50232, 2013) —EB

Eyjafjallajökull's iron-rich ash fertilized North Atlantic Ocean

In about a third of the global ocean, the abundance of life is limited by the amount of biologically available iron. When a region is depleted of this important nutrient, algal productivity can be stimulated by added iron, resulting in a temporary boom in biological activity. For much of the surface ocean, the wind-borne transport of iron-rich dust and the upwelling of nutrient-filled water are the major sources of iron. Another potentially important source is the deposition of the iron-rich ash produced by volcanic eruptions. Though satellite observations and modeling work suggest that volcanic ash could seed life in such a way, there have been only a limited number of direct observations of the effects of ash deposition on surface ocean waters.

Thanks to a bit of serendipitous scheduling, *Achterberg et al.* conducted a series of research cruises in the Iceland Basin region of the North Atlantic Ocean during and after the month-long eruption of Iceland's Eyjafjallajökull volcano in the spring of 2010. Three cruises allowed the authors to measure surface ocean iron concentration before, during, and after the eruption in a region directly affected by the towering ash plume. Beneath the plume the authors found peak dissolved iron concentrations up to 10.2 nanomolars, compared to 0.23 to 0.45 nanomolar concentration detected before ash deposition. Using a model of the ash plume trajectory and ash deposition rates, along with measurements of iron dissolution, the authors calculated that up to 570,000 square kilometers of North Atlantic waters could have been seeded with at least 0.2 nanomolar concentration of iron. In controlled biological incubation experiments, the authors added volcanic ash collected under the plume to seawater and found that iron leached from the ash could drive an increase in biological productivity and a drawdown of nutrient levels. (*Geophysical Research Letters*, doi:10.1002/grl.50221, 2013) —CS

Canadian Arctic glacier melt is accelerating and irreversible

Ongoing glacier loss in the Canadian high Arctic is accelerating and probably irreversible, new model projections by *Lenaerts et al.* suggest. The Canadian high Arctic is home to the largest clustering of glacier ice outside of Greenland and Antarctica—146,000 square kilometers of glacier ice spread across 36,000 islands. In the past few years, the mass of the glaciers in the Canadian Arctic archipelago has begun to plummet. Observations from NASA's Gravity Recovery and Climate Experiment (GRACE) satellites suggest that from 2004 to 2011 the region's glaciers shed approximately 580 gigatons of ice. Aside from glacier calving, which plays only a small role in Canadian glacier mass loss, the drop is due largely to a shift in the surface mass balance, with warming-induced meltwater runoff outpacing the accumulation of new snowfall.

Using a coupled atmosphere-snow climate model, the authors reproduced the observed changes in glacier mass and sought to forecast projected changes given a future of continued warming. Driving the model with a climate reanalysis data set for the period 1960 to 2011 and with a potential future warming pathway, the authors found that their model accurately reproduced observed glacier mass losses, including a recent up-tick in the rate of the ice's decline.

The authors calculate that by 2100, when the Arctic archipelago will be 6.5 degrees kelvin warmer, the rate of glacier mass loss will be roughly 144 gigatons per year, up from the present rate of 92 gigatons per year. In total, the researchers expect Canadian Arctic archipelago glaciers to lose around 18% of their mass by the end of the century. Given current warming trends, they suggest that the ongoing glacier loss is effectively irreversible. (*Geophysical Research Letters*, doi:10.1002/grl.50214, 2013) —CS

Arctic Ocean not likely to become a significant carbon dioxide sink

One effect of declining summer Arctic sea ice extent in a warming climate is that it would expose more surface water to the air, potentially allowing for more air-sea gas exchange and thus possibly improving the Arctic Ocean's ability to act as a sink for atmospheric carbon dioxide (CO_2). However, some recent research has shown that the southeastern Canada Basin in the Arctic Ocean actually has a relatively weak capacity to act as a sink for atmospheric CO_2.

Confirming that recent study, *Else et al.* analyzed data collected in late summer 2009, when there was some ice coverage. They measured a high partial pressure of CO_2 in the ocean water, which indicates that it would be difficult for the water to absorb additional carbon dioxide.

The researchers then created a simple model to examine how much CO_2 could be absorbed by those waters under summertime ice-free conditions, which are expected to occur in the near future. Their model showed that the southeastern Canada Basin had only a weak capacity to absorb atmospheric CO_2. The shallow mixed layer of water at the surface would warm rapidly as ice melted, and the higher surface water temperatures would inhibit CO_2 uptake. This suggests that increased warming would further weaken the Arctic Ocean CO_2 sink. (*Geophysical Research Letters*, doi:10.1002/grl.50268, 2013) —EB

Brent Else

The research icebreaker CCGS Amundsen, *used by* Else et al. *to study the Arctic Ocean's potential to act as a sink for carbon dioxide.*

New type of radio burst observed in Earth's magnetosphere

Myriametric radio emissions—radio emissions with wavelengths of 10 to 100 kilometers—coming from Earth's magnetosphere have been observed previously. Now a new type of myriametric radio emission known as a terrestrial myriametric radio burst (TMRB) has been reported.

Fung et al. report simultaneous detection of a TMRB by the widely separated Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) and Geotail satellites on 19 August 2001. The radio burst occurred over a period of about an hour and a half and had a frequency range of about 12 to 50 kilohertz. The authors found that the TMRB was beamed directly from a discrete source and had a fan beam radiation pattern.

They compared their observations to characteristics of known types of terrestrial myriametric radio (TMR) emissions and found that the timing, frequency range, and spectral characteristics of the TMRB emissions are distinct from the known types of TMR. In addition, no other TMRB events were similarly identified during the period from 2001 to 2005 when both satellites were operating, leading the authors to suggest that observations of such events are rare because their identification requires multiple spacecraft to be in the right locations during the time of the burst, which depends on a particular combination of solar wind and magnetospheric conditions. They suggest that TMRB was likely caused by magnetic reconnection (breaking and rejoining of magnetic field lines) at high latitude in the dayside of Earth's magnetosphere due to a northward orientation of the interplanetary magnetic field (the magnetic field carried outward from the Sun by the solar wind). (*Journal of Geophysical Research-Space Physics*, doi:10.1002/jgra.50149, 2013) —EB

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