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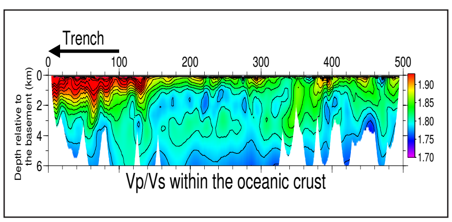
RESEARCH SPOTLIGHT

Highlighting exciting new research from AGU journals

Understanding the structure of subducting plates

Seismic studies are helping scientists learn more about the structure of subducting oceanic plates. Using an air gun array and 80 ocean bottom seismometers spaced along a 500-kilometer profile, *Fujie et al.* conducted a seismic reflection and refraction survey at the Kuril trench in the northwestern Pacific margin, where part of the Pacific plate is subducting beneath the Okhotsk plate. They estimated the water content of the subducting plate by measuring the velocity of seismic waves—both *P* waves and *S* waves—through the plate. The ratio of seismic wave velocities (V_p/V_s) is an indicator of the lithology, porosity, and presence of fluid in the plate. Their findings showed that the water content in the plate increased toward the trench, along with greater bending and fracturing, suggesting that water enters the plate through the fractures. The authors conclude that the bending and fracturing of the plate as it subducts play an important role in the water cycle in subduction zones. (*Geophysical Research Letters*, doi:10.1029/2012GL054340, 2013)—EB



The ratio of different seismic wave velocities (V_p/V_s) within the uppermost oceanic crust increases toward the oceanic trench, suggesting seawater percolation into the oceanic plate in the trench–outer rise region.

Low density of Earth's core due to oxygen and silicon impurities

During accretion and differentiation of the Earth, chemical interactions in a silicate magma ocean and liquid iron drove silicon and oxygen impurities into what went on to become the liquid outer core. Contrasting with previous research, which suggested that silicon and oxygen would only appear in very low concentrations (less than 1% by weight) in the liquid iron, *Tsuno et al.* found that at the base of a magma ocean 1200 kilometers deep, these light elements could simultaneously reach concentrations as high as 5% oxygen and 8% silicon by weight. Such impurity levels would decrease the density of the outer core, accounting for the so-called "density deficit" identified in previous research, whereby the outer core is roughly 10% less dense than a pure iron-nickel alloy.

The researchers also propose that at the present-day core-mantle boundary, high temperatures would drive additional silicon and oxygen into the core, creating a light, element-rich, buoyant layer on top of the liquid outer core. They suggest that evidence for such a layer may have been observed in seismic studies.

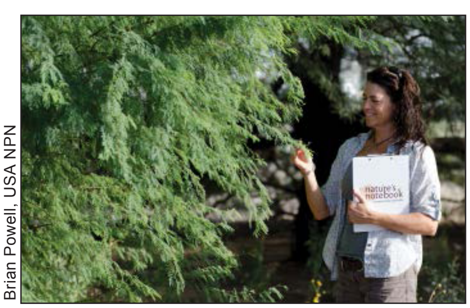
Using a multianvil press, the authors drove a mixture of iron, magnesium silicate, silicon dioxide, and the iron oxide wüstite to 25 gigapascals of pressure and temperatures from 2700 to 3080 Kelvin. They found that at temperatures below 3000 Kelvin, silicon and oxygen in the iron melt were mutually exclusive, with concentrations not rising above the low levels identified in previous research. Above 3000 Kelvin, however, they found that the presence of oxygen actually enhanced the partitioning of silicon into the iron, with the concentrations of both silicon and oxygen increasing. (*Geophysical Research Letters*, doi:10.1029/2012GL054116, 2013) —CS

Citizen science finds spring could come a month early to the United States

From a national collaboration among citizen scientists, educational institutions, environmental organizations, and federal agencies, *Jeong et al.* developed the first countrywide assessment of springtime tree budding based on in-the-field measurements. The phenological assessment, which measured the timing of bud burst for five tree species, was used to build a model of species-specific budding across the continental United States. Using their tree budding model in forecasts of future climate change, the authors found that by the end of the century, tree budding across the United States will occur more than 1 month earlier in some places.

From observations of tree leaf emergence collected by citizen and professional scientists working together as part of the USA National Phenology Network, the authors assessed projected changes in tree bud burst using seven Earth system or coupled global models. The authors' forecasts drew on four future emissions scenarios, or representative concentration pathways, that are to be used as the guiding scenarios for research to be included in the upcoming fifth assessment report of the Intergovernmental Panel on Climate Change.

The authors found that the earlier budding will predominantly affect northern trees. Under the climate scenario with the most warming, they found that trees in Maine, New York, Michigan, and Wisconsin will bud up to 38 days earlier. In southern states such as Florida, Alabama, and Georgia, however, bud burst will occur 10 days earlier under the same climate scenario. The result is that the annual latitudinal "green wave" of tree budding could take just 59.1 days by the end of the century, as compared with the 74.7 days that it takes now. The authors suggest that the changing bud burst dates could affect interspecies competition and the global carbon budget. (*Geophysical Research Letters*, doi:10.1029/2012GL054431, 2013) —CS



Brian Powell, USA NPN

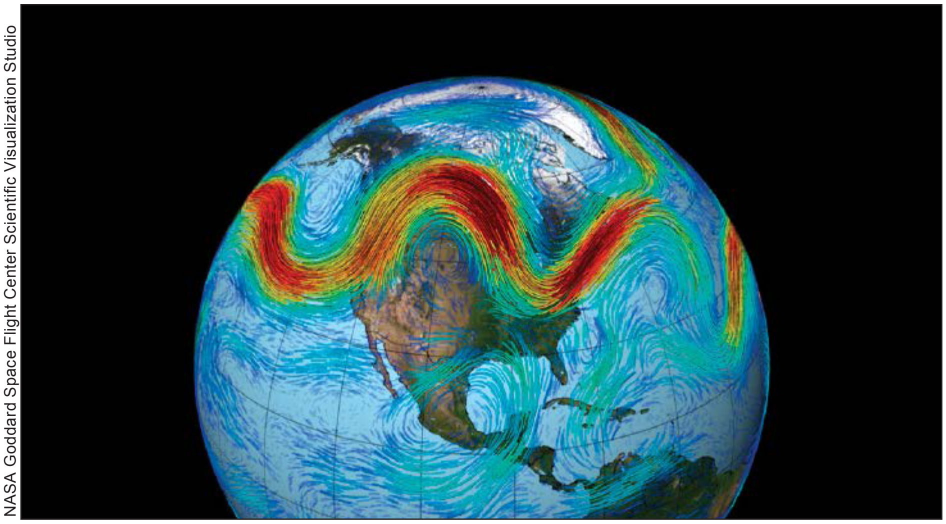
A volunteer in a leaf phenology program.

Is there a link between Arctic amplification and midlatitude weather?

As the Earth's climate warms, the Arctic has been warming more rapidly than the rest of the globe. Some previous studies have suggested that this Arctic amplification of warming is causing an increase in extreme weather events in the midlatitudes. They proposed that this occurs because Arctic warming induces changes in atmospheric circulation, including changes in atmospheric planetary waves that tend to promote persistent extreme weather conditions, such as heat waves, cold spells, droughts, and floods.

To evaluate this possibility, *Screen et al.* examined changes in atmospheric planetary wave amplitude over recent decades. Unlike previous studies, they considered two different descriptions of planetary wave amplitude: meridional amplitude, a measure of north-south meandering, and zonal amplitude, a measure of the intensity (height) of atmospheric ridges and troughs at 45°N. The authors also examined the planetary wave amplitude changes at all longitudes and over three separate longitudinal sectors to identify possible impacts of Arctic amplification over regions such as Europe or Asia.

NASA Goddard Space Flight Center Scientific Visualization Studio



A visualization of atmospheric waves. Screen et al. *examined whether atmospheric waves could provide a link between Arctic amplification and midlatitude weather extremes.*

They found that from 1979 to 2011, statistically significant changes in either measure were observed during only a few seasons, and the two measures showed different changes. For instance, in summers the authors found increases in meridional amplitude over Europe but found decreases in zonal amplitude. They concluded that any possible connection between Arctic amplification and planetary wave amplitude depends on how the atmospheric waves are defined, and thus, studies of a possible impact of Arctic amplification on weather extremes need to take this into account. (*Geophysical Research Letters*, doi:10.1002/grl.50174, 2013) —EB

Guiding future research on terrestrial ecosystem disturbance

With North American ecosystems responsible for drawing hundreds of teragrams of carbon from the atmosphere each year, the tenuous balance of the terrestrial carbon budget can be upset for decades by disturbances such as fires, storms, disease outbreaks, insect infestations, and logging. Research cataloging the effects of such disturbances on regional carbon cycling tends to be sporadic or of limited scope. Most research has focused on forests but is less extensive for other important ecosystems such as grasslands or permafrost peatlands.

With climate change set to alter disturbance patterns—and in turn the balance of the carbon budget—a more thorough understanding of the effects of disturbances on terrestrial ecosystems is needed. To drive this effort, *Kasischke et al.* provide an overview of an attempt by more than 100 scientists to synthesize existing research, and they have identified steps that can be taken to direct the future course of research in this field.

Drawing on research conducted under the banner of the North American Carbon Program and the CarboNA project, the authors identified trends in ecosystem disturbances over the past 2 decades. They found that across North America 32.8 million hectares of forest were disturbed to some extent, in particular by a widespread infestation of bark beetles in western North American and by tree harvesting.

The authors emphasize that to understand the full impact of a disturbance on the carbon cycle, scientists must consider the direct effects, such as tree mortality and emissions of carbon during fires, as well as the indirect effects, such as changes in the local climate or in abiotic ecosystem properties. To start, the authors suggest that an integrated database that includes all disturbance types should be developed, using a combination of information from satellite remote sensing systems and from disturbance-specific databases that currently exist. (*Journal of Geophysical Research-Biogeosciences*, doi:10.1002/jgrg.20027, 2013) —CS

Negative narrow bipolar lightning needs critical cloud height

High within towering thunderclouds, a distinct form of intracloud lightning, known as "narrow bipolar pulse" discharges, can occur. Like other forms of lightning, narrow bipolar events (NBE) can be either negative or positive discharges. These events are known for their high-powered, short-distance electrical discharges that produce strong emissions of very high frequency radio waves. Previous research has found that since NBEs take place at relatively high altitudes, it is possible to detect them remotely using satellites. To be able to use the detection of narrow bipolar events to measure cloud behavior or storm dynamics, however, requires a better understanding of the relationship between cloud properties and NBEs.

Using a high spatial resolution radar array and a low-frequency lightning location system, *Wu et al.* measured the properties of NBEs produced by 10 storms near Osaka, Japan, during the summer of 2012. From the sampled storms, the authors identified 232 instances of positive narrow bipolar lightning and 22 negative discharges. The authors found that positive narrow bipolar discharges are typically located deep within the cloud, either in or surrounding the region of deepest convection. Negative NBEs, on the other hand, almost exclusively occur near the cloud tops, with altitudes from 14 to 16 kilometers, they found.

Based on their observations, the authors suggest that there is a critical cloud height—around 15 kilometers altitude—below which negative narrow bipolar discharges will not occur. As a result of this finding, the authors suggest that the detection of negative NBEs could be used to estimate cloud top height remotely. Barring that, they say that the mere detection of negative NBEs can be used for a quick rough assessment of thundercloud height and hence of its likely severity. (*Geophysical Research Letters*, doi:10.1002/grl.50112, 2013) —CS

Ting Wu

Researchers used the phased array radar at Osaka University to observe narrow bipolar lightning.

Arctic sea ice thickness and volume declining

The record low extent of Arctic sea ice area in September 2012 made headlines. Studies using models have suggested that sea volume has also been declining. A new study by *Laxon et al.* confirms this with observational data. The authors used satellite radar observations from the European Space Agency CryoSat-2 mission to estimate Arctic sea ice thickness and volume for the falls and winters of 2010–2011 and 2011–2012. By comparing these new data with earlier estimates from NASA's ICESat satellite, they found that the average ice volume declined by 4291 cubic kilometers in fall and 1479 cubic kilometers in winter between the period from 2003 to 2008 and the 2010–2012 period. The average volume of ice loss over both the fall and winter periods was found to be about 500 cubic kilometers per year, equivalent to a 0.075 meter per year decrease in thickness. (*Geophysical Research Letters*, doi:10.1002/grl.50193, 2013) —EB

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