**Long-Overlooked "Ice Quakes" Data Provides Insights into Calving Glaciers**

May 2, 2014 |By [Marianne Lavelle](http://www.scientificamerican.com/author/marianne-lavelle) and [The Daily Climate](http://www.scientificamerican.com/author/the-daily-climate)



For years, analysts at the [Alaska Earthquake Center](http://www.aeic.alaska.edu/), while tracking about[100 temblors a day](http://www.dailyclimate.org/tdc-newsroom/2014/05/05fotos/Seismic-Graph.jpg) in the most seismically active U.S. state, have dutifully filtered out some of the Earth-shaking events that trip the sensors.

The analysts would mark these distinctive readings with the letter, "G," for "glacier."

The readings, considered a curious by-product of the effort to track earthquakes, were from calving glaciers. Some registered as high as magnitude 3.

Now, Alaska's state seismologist Mike West, the center's director, argues that this data is a valuable record that could yield new understanding on climate change. In a presentation Thursday at the [Seismology Society of America's](http://www.seismosoc.org/) annual meeting in Anchorage, West showed that long-ignored data within the state's earthquake records faithfully capture dynamic change occurring above ground: ice breaking off of glaciers and falling into water, the phenomenon known as calving.

Some calving occurs quietly; ice can slip off a glacier beneath the water without generating seismic waves. But when blocks of ice topple off the front of glaciers into the water, much like swimmers doing cannonballs into a pool, the impact resonates and is picked up by sensors.

"It turns out to be a spectacular data set in its own right," he said. "We have many years of records of these activities at these glaciers – winter versus summer, glacier 'X' versus glacier 'Y' – all kind of sitting there."

Sensors have captured several thousand so-called "ice-quakes." Hundreds happen annually along the south-central coast of Alaska, where glaciers reach the sea. Records at the center, located at the University of Alaska, Fairbanks, date back to the 1970s, when seismologists first recognized that calving glaciers created unmistakable seismic signals hundreds of kilometers away, West said. But after the Alaska earthquake network's hardware was upgraded in 2007, the number of ice-quakes picked up by the sensors increased.

"We have a half-dozen years of really high-quality glacier data," West said. "We're in the early stages of being able to look [at what has happened] over a period of years."

Glacier seismology is a relatively new area of science, but interest has been growing in the possibilities for detecting the extent of global warming's impact in the vibrations it causes beneath the Earth's surface.

**Atmospheric measurements, from below ground**

It may seem incredible that atmospheric change can be measured below ground, but seismic sensors record all types of surface movement – even delineating day from night, or weekends from weekdays when placed near cities. "It doesn't matter if it's an earthquake, or a train going by, or an animal, or a nuclear explosion, or glaciers," West said. "Our sensors don't know any better – they just measure how the ground shakes."

Seismologists can distinguish ice-quakes from tectonic earthquakes by location and the unique shape of the waveforms they generate. This has led to significant findings. Seismologists at Harvard and Columbia Universities [first reported](http://www.sciencemag.org/content/302/5645/622.abstract) on their tracking of[ice-quakes from glaciers in Greenland](https://www.sciencemag.org/content/311/5768/1756) in 2003, and later showed this glacial earth-shaking was on the rise. Scientists from University of Colorado, Boulder [detailed](http://profile.usgs.gov/myscience/upload_folder/ci2012Feb2216185044121Oneeletal_seismics.pdf) the seismic signals produced at the rapidly retreating Columbia Glacier in Alaska in 2007.

West singled out Columbia as the best example to date of an Alaska glacier with a clear change in ice-quake production in recent years. After it retreated into shallow waters and became grounded in 2009 and 2010, the end of the glacier rose high enough above sea level that it led to "tall icebergs that fall over, smacking the water" – and a corresponding increase in seismic signals.

**Opening up possibilities**

West's new findings are different from previous studies where scientists instrument and study a single glacier in a targeted way. His research opens up the possibility of tracking what is happening over all of Alaska, one of the most dynamic glaciated regions of the world.

[Alaska is the most glaciated U.S. state](http://pubs.usgs.gov/pp/p1386k/pdf/02_1386K_part1.pdf), with glaciers covering about 29,000 square miles, about 5 percent of its surface. More than 99 percent of the state's low-lying glaciers are retreating.

"The ability to routinely monitor calving events is a new approach," said Bruce Molnia, research geologist with the U.S. Geological Survey, who has written extensively on Alaska's glaciers and has documented their change over time. He noted that the equipment to track the seismic signals from calving glaciers is expensive, and it's necessary to have a number of sensors in place – as the Alaska network does – because to pinpoint the location of a calving, glacier scientists have to triangulate data from several sensors. "And most people who have the equipment are more focused on bigger seismic events," said Molnia. "But the data is there."

Only a subset of glaciologists have focused on the potential of seismology to inform their research, while the vast majority of seismologists are focused on tectonic and volcanic events. The two branches of geology have not fully recognized the potential ways their research could intersect.

**Elephant Seals Reveal Anti-Inflammatory Secrets of Carbon Monoxide**



Blood samples from elephant seals may help to explain how carbon monoxide — a poison — can stop inflammation, researchers have found.The seals routinely dive to depths of 500 meters and stay underwater for 25 minutes at a time, surfacing for just a few minutes between plunges. During these forays, blood flow to nonessential tissues and organs is restricted, but the tissues are not damaged. Researchers at the Scripps Institution of Oceanography in San Diego, California, suggest that high levels of carbon monoxide in the seals' blood has a protective effect — echoing laboratory research on rats and mice that has found the gas has anti-inflammatory properties and can lead to better outcomes after organ transplant.

This unusual physiology was first observed in the mid-1950s by Lewis Pugh of the National Institute for Medical Research in London. Pugh monitored carbon monoxide levels in the blood of the men living in an Antarctic base to ensure that their stoves were not poisoning them. While there, Pugh also found surprisingly high carbon monoxide concentrations in the blood of Weddell seals killed to feed sled dogs,.

In the 1960s, researchers discovered that mammals produce carbon monoxide when haemoglobin and myoglobin proteins in their cells degrade. Decades later, in the early 1990s, scientists realized that the gas — previously thought of only as a toxin — can be therapeutic at some concentrations. Experiments in animals including rats and mice have shown that inhaling carbon monoxide improves outcomes after organ transplants and heart attacks, and carbon monoxide treatments for organ transplants are beginning human clinical trials. Yet the mechanism behind the gas's benefits remains unknown.

Now, in research presented this week at the Experimental Biology 2014 meeting in San Diego, California, seals return to the picture.

When Michael Tift, a comparative physiologist at Scripps, analysed blood samples from 24 elephant seals on a California beach, he found high levels of haemoglobin. In adult seals, up to 10% of that haemoglobin was bound to carbon monoxide, implying high levels of carbon monoxide in the blood.

The levels of carbon monoxide in the seals' blood was comparable to that of “someone who is smoking more than 40 cigarettes a day,” Tift says. In nonsmoking humans, just 1–1.5% of haemoglobin is bound to carbon monoxide.

Tift thinks that the seals’ carbon monoxide levels and the gas’s therapeutic benefits in medical studies have a common explanation. Just as elephant seals restrict blood flow to their nonessential tissues during deep dives, blood flow is interrupted in humans during organ transplantation, stroke, heart attack and other injuries. In humans, when oxygen-rich blood floods back into tissues, it prompts an onslaught of chemical reactions that cause inflammation, cell death and even tissue necrosis. The seals have none of these effects.

“These animals are constantly holding their breath,” Tift says, “but they don’t have any injuries.” He proposes that elevated carbon monoxide may prevent damage from the returning blood flow.

“Carbon monoxide seems to slow the metabolism of the tissue,” says Leo Otterbein, a physiologist at Harvard Medical School in Boston, Massachusetts, who pioneered therapeutic uses of carbon monoxide. Slowing metabolism — and thus oxygen use — would delay or eliminate the formation of molecules that cause inflammation and cell death, he says.

The seals may provide a useful system to better understand how carbon monoxide works in the body to prevent problems, says Roberto Motterlini, a vascular biologist at the French medical research agency (INSERM) in Paris. Carbon monoxide may stimulate mitochondria production, he notes, something researchers could test in elephant seals.

**Proof that the Universe Inflated Rapidly After the Big Bang**

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Score one for inflation. The idea that the universe ballooned rapidly after the big bang received a boost in March, when physicists confirmed a prime prediction of inflation theory. The Background Imaging of Cosmic Extragalactic Polarization 2 (BICEP2) experiment at the South Pole found evidence for primordial gravitational waves, ripples in the fabric of space and time, that were created when the early universe swelled. The discovery is not just a major validation of inflation, physicists say, but a good way to narrow down the many possible versions of inflation that might have taken place. “This really collapses the space of plausible inflationary models by a huge amount,” says Marc Kamionkowski of Johns Hopkins University, who was not involved in the discovery but who co-predicted back in 1997 how these gravitational-wave imprints could be found. “Instead of looking for a needle in a haystack, we'll be looking for a needle in a bucket of sand.”

BICEP2 found a pattern called primordial B-mode polarization in the light left over from just after the big bang known as the cosmic microwave background. This pattern, basically a curling in the polarization, or orientation of the electric field, of the light, can be created only by inflation-induced gravitational waves. “We've found the smoking-gun evidence for inflation, and we've also produced the first image of gravitational waves across the sky,” says Chao-Lin Kuo of Stanford University, who designed the BICEP2 detector and co-leads the collaboration.

Such a groundbreaking finding requires confirmation from other experiments to be truly believed, physicists say. Nevertheless, the result was heralded as a huge win for cosmology. “There's a chance it could be wrong, but I think it's highly probable that the results stand up,” says Alan Guth of the Massachusetts Institute of Technology, who first predicted inflation in 1980.

Physicists are now parsing the finding for clues about the timing and details of inflation. The BICEP2 measurement suggests that inflation began a trillionth of a trillionth of a trillionth of a second after the big bang, a time when the universe would have been so energetic that all the fundamental forces of nature—the electromagnetic, strong and weak forces, with the exception of gravity—might have been unified into a single force. The new results could also quell any remaining doubters of inflation. “If this discovery is confirmed,” says Andrei Linde of Stanford, one of the main authors of inflation, “inflationary theory does not have any real alternatives.”

**Winter Floods Linked to Global Warming**



Britain’s warm, wet winter brought floods and misery to many living across southern England, with large parts of Somerset lying underwater for months. When in January rainfall was double the expected average over wide areas, many people made cautious links between such extreme weather and global climate change. There were nay-sayers at the time but it now seems that there is evidence for those links.

Speaking at the European Geosciences Union [annual meeting](http://www.egu2014.eu/) here in Vienna, Myles Allen, a professor of geosystem science at the University of Oxford, presented his take on the issue. At the gathering of more than 12,000 geoscientists, Allen reported an ambitious computer experiment that his team has undertaken over the last two months to test whether the winter floods could be attributed to climate change. And [it seems that they can be linked](http://www.climateprediction.net/weatherathome/weatherhome-2014/results/).

The floods of January 2014 certainly were [extreme](http://www.theguardian.com/uk-news/2014/feb/27/england-and-wales-hit-by-wettest-winter-in-nearly-250-years). According to Oxford’s records of daily rainfall, they were unprecedented in 250 years. The records at the UK Met Office from the 20th century also show that this winter was, historically, uniquely bad.

The IPCC report does suggest that extreme weather events should be expected as the world warms but the prediction is couched in cautious terms and the risk is assessed as “medium” confidence.

At the [Environmental Change Institute](http://www.eci.ox.ac.uk/) in Oxford, researchers Nathalie Schaller and Friederike Otto analysed results from almost 40,000 climate model calculations to test the impact of climate change on Britain’s winter rains. Their calculations modelled the weather across the country on a 50km grid. They compared the results of 12,842 simulations based on the current global sea surface temperatures, with 25,893 results computed on the assumption that global warming had never occurred – that fossil fuel burning had not raised CO2 to today’s levels and ocean surfaces were cooler.

Such a huge number of calculations was needed to tease out the statistical differences between the two scenarios. It was only possible through the participation of thousands of members of the public in the work’s biggest ever climate modelling exercise: they offered up spare processing capacity on their home computers to run the calculations via the [Climate Prediction](http://www.climateprediction.net/) citizen science climate modelling programme.

The results showed a subtle bias towards more extreme weather in today’s warming world. Events that would have been expected once in 100 years before global warming can now be anticipated to occur once in 80 years. In essence, the probability of extreme winter floods appears to have increased by 25% on pre-industrial levels.

Allen pointed out that this is the first quantitative evaluation of the influence of global warming on Britain’s 2014 floods. [Thomas Stocker](http://www.climate.unibe.ch/~stocker/), a professor of climate and environmental physics at the University of Bern and chairman of the IPCC working group charged with assessing the physical origins of climate change, said that the Oxford group’s results had “shown movement in one direction only – toward greater risk”.

Although the results from the models cannot yet give definite measures of the probability of a flood, they do provide an insight into how those risks have changed and continue to change – information that is of great interest to insurance underwriters, among others.

Otto said: “Past greenhouse gas emission and other forms of pollution have loaded the weather dice”, adding that she and others were still working on investigating the implications of the results, for river flows, flooding and ultimately the threat to property and lives.

Some will, no doubt, question the result on the basis that it is “simply” a statistical test. The results from the two modelling scenarios are, at first sight, very similar. But the fact remains that they are distinct, showing that rising global ocean surface temperatures directly influence UK winter rainfall.

The results affirm the strong and growing scientific consensus developing from the understanding of the physical origins and consequences of climate change, as outlined in the IPCC’s Fifth Assessment Working Group 1 report last [September](http://www.climatechange2013.org/). Those that choose to ignore them, or contradict them, will (I predict) still be directly affected by them. And we will be hit where it hurts most – in our wallets. How likely is it that the insurance industry will ignore such results?