GPS can now measure ice melt, change in Greenland over months rather than years

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Composite photograph of a GNET GPS unit implanted in the southeastern Greenland bedrock. Image by Dana Caccamise, courtesy of Ohio State University.

Researchers have found a way to use GPS to measure short-term changes in the rate of ice loss on Greenland - and reveal a surprising link between the ice and the atmosphere above it.

The study, published in the early online edition of the *Proceedings of the National Academy of Sciences*, hints at the potential for GPS to detect many consequences of climate change, including ice loss, the uplift of bedrock, changes in air pressure - and perhaps even sea level rise.

The team, led by earth scientists at Ohio State University, pinpointed a period in 2010 when high temperatures caused the natural ice flow out to sea to suddenly accelerate, and 100 billion tons of ice melted away from the continent in only 6 months.

They were able to make the measurement because the earth compresses or expands like a spring depending on the weight above it, letting them use the Greenland bedrock like a giant bathroom scale to weigh the ice atop it. As ice accumulates, the bedrock sinks, and as the ice melts away, the bedrock rises.

Measurements revealed that Greenland sank by about 6 mm (about one quarter of an inch) over the winter of 2010, and the researchers determined that half of the sinking (3 mm, or one eighth of an inch) was actually due to high air pressure above the ice, and the other half was due to ice accumulation.

Further, they determined that the bedrock lifted 11 mm (less than half an inch) over the course the summer. Air pressure appeared to affect the bedrock less during this time, so that the bounce-back appears to be mostly due to ice loss.

This method has been used to study ice loss before, in Antarctica as well as Greenland. But previously, GPS could only detect changes over a period of several years, said project leader Michael Bevis, Ohio Eminent Scholar in Geodynamics and professor in the School of Earth Sciences at Ohio State.

While shortening the detection time to six months is a substantial advance, Bevis thinks his team will soon do even better.

"Within the next year or so, we should be able to process the GPS data within a month of its being collected," he said, "and then we can monitor abrupt changes in ice mass only a month or two after they occur."

The key to the improvement is the network of GPS stations that the researchers stationed around the Greenland ice sheet. More than 50 transmitters are planted close enough together to detect changes in uplift along most of the Greenland coast. These GPS antennas are supported on poles anchored into bare rock, and so they record the rise of the bedrock itself.

The network is called the Greenland GPS Network (GNET).

GNET's measurements were so detailed that the researchers were able to determine what portion of bedrock motion was due to the ice melting away

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and what portion was due to seasonal swings in air pressure above the ice.

It's startling to think that changes in the weight of the air could push down on the ice with enough force to compress the bedrock below, Bevis said. Though researchers strongly suspected that this was happening, GNET has provided the first chance for them to isolate the air pressure signal from the overall motion of the bedrock.

The "bathroom scale" movement of the bedrock is thus reacting to the weight of the ice and the weight of the air.

"It surprises most meteorologists that there is such a strong seasonal signal in surface pressure in Greenland. But it amazes almost everyone to learn that seasonal changes in air mass push on the bedrock just as strongly as seasonal changes in ice mass. It is highly counterintuitive, but true!" Bevis said.

They compared GNET measurements to eight years worth of air pressure data, and were able to see patterns in the rise and fall of the bedrock.

The changes due to the ice and the air aren't exactly in sync - the air pressure rises steadily over the spring and drops off slowly over the summer and fall, while the weight of the ice grows through the spring, drops off quickly over the summer, and begins to recover in the fall.

The seasonal cycle of bedrock displacement is due to the interplay of those two cycles.

Now that researchers can isolate the air pressure signal, they can make more accurate measurements of ice mass. The idea is to calibrate GNET as an 'ice-weighing machine' by correlating daily displacements of the GPS stations with daily changes in surface pressure fields produced by numerical weather models.

Although this study revealed a dramatic six-month period of melting in Greenland in 2010, that short-term ice loss isn't necessarily a sign of a long-term trend, Bevis cautioned.

"It is dangerous to assume that rates observed over even two or three years reflect a long-term trend. Rates are known to change. So, it would be even more dangerous to assume that the record breaking summer of 2010 is the new norm."

"That being said, the summer of 2011 was also very hot. And this summer is starting off hot, too. So, I do expect to see a sustained increase in uplift rates when we compare 2010-2012 to 2007-2009," he added.

The researchers are continuing to monitor Greenland. In the meantime, they are investigating the possibility of detecting changes in sea level rise via GPS units planted at coastlines and in small ocean islands. Not all mechanisms of sea level rise produce variations in seafloor pressure, Bevis explained, but some of them do.

More information:
www.pnas.org/content/early/201 … /1204664109.abstract

Provided by Ohio State University