

Ancient Indonesian climate shift linked to glacial cycle

March 24 2014

Using sediments from a remote lake, researchers from Brown University have assembled a 60,000-year record of rainfall in central Indonesia. The analysis reveals important new details about the climate history of a region that wields a substantial influence on the global climate as a whole.

The Indonesian archipelago sits in the Indo-Pacific Warm Pool, an expanse of ocean that supplies a sizable fraction of the [water vapor](#) in Earth's atmosphere and plays a role in propagating El Niño cycles. Despite the region's importance in the [global climate](#) system, not much is known about its own [climate history](#), says James Russell, associate professor of geological sciences at Brown.

"We wanted to assess long-term [climate](#) variation in the region," Russell said, "not just to assess how global climate influences Indonesia, but to see how that feeds back into the [global climate system](#)."

The data are published this week in the *Proceedings of the National Academy of Sciences*.

The study found that the region's normally wet, tropical climate was interrupted by a severe [dry period](#) from around 33,000 years ago until about 16,000 years ago. That period coincides with peak of the last ice age, when glaciers covered vast swaths of the [northern hemisphere](#). Climate models had suggested that glacial ice could shift the track of tropical monsoons, causing an Indonesian dry period. But this is the first

hard data to show that was indeed the case.

It's also likely, Russell and his colleagues say, that the drying in Indonesia created a feedback loop that amplified ice age cooling.

"A very large fraction of the Earth's water vapor comes from evaporation of the ocean around Indonesia, and water vapor is the Earth's most important greenhouse gas," Russell said. "As you start varying the hydrological cycle of Indonesia, you almost have to vary the Earth's water vapor concentration. If you reduce the water vapor content it should cool the climate globally. So the fact that we have this very strong drying in the tropics during glaciation would argue for a strong feedback of water vapor concentration to the global climate during glacial-interglacial cycles."

Surprisingly absent from the data, Russell says, is the influence of other processes known to drive climate elsewhere in the tropics. In particular, there was no sign of climate change in Indonesia associated with Earth's orbital precession, a wobble caused by Earth's axis tilt that generates differences in sunlight in a 21,000-year cycle.

"There's very little indication of the 21,000-year cycle that dominates much of the tropics," he said. "Instead we see this very big set of changes that appear linked to the amount of ice on earth."

To arrive at those conclusions, the researchers used sediment cores from Lake Towuti, an ancient lake on the island of Sulawesi in central Indonesia. By looking at how concentrations of chemical elements in the sediment change with depth, the researchers can develop a continuous record of how much [surface runoff](#) poured into the lake. The rate of runoff is directly related to the rate of rainfall.

In this case, Russell and his colleagues looked at titanium, an element

commonly used to gauge surface runoff. They found a marked dip in titanium levels in sediments dated to between 33,000 and 16,000 years ago—a strong indicator that surface runoff slowed during that period.

That finding was buttressed by another proxy of rainfall: carbon isotopes from plant leaf wax. Leaves are covered with a carbon-based wax that protects them from losing too much water to evaporation. Different plants have different carbon isotopes in their leaf wax. Tropical grasses, which are adapted for dryer climates, tend to have the C-13 isotope. Trees, which thrive in wetter environs, use the C-12 isotope. The ratio of those two isotopes in the [sediment cores](#) is an indicator of the relative abundance of grass versus trees.

The cores showed an increase in abundance of grass in the same sediments that showed a decrease in surface runoff. Taken together, the results suggest a dry period strong enough to alter the region's vegetation that was closely correlated with the peak glaciation in the northern hemisphere.

The next step for Russell and his colleagues is to see if this pattern is repeated in multiple glacial cycles. Glacial periods run on cycles of about 100,000 years. Core samples from deeper in the Lake Towuti sediment will show whether this drying evident during the last [ice age](#) also happened in previous ice ages. It's estimated that Lake Tuwuti sediments record up to 800,000 years of climate data, and Russell recently received funding to take deeper cores.

Ultimately, Russell hopes his work will help to predict how the region might be influenced by human-forced global warming.

"This provides the kind of fundamental data we need to understand how the climate of this region operates on long timescales," he said. "That can then anchor our understanding of how it might respond to global

warming."

More information: "Glacial forcing of central Indonesian hydroclimate since 60,000 y B.P.," by James M. Russell et al. *PNAS*, www.pnas.org/cgi/doi/10.1073/pnas.1402373111

Provided by Brown University

Citation: Ancient Indonesian climate shift linked to glacial cycle (2014, March 24) retrieved 19 April 2024 from <https://phys.org/news/2014-03-ancient-indonesian-climate-shift-linked.html>

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