

'Calm before storm' may foreshadow climatic tipping point

17 September 2008, By Lisa Zyga



Taipei 101 in Taiwan endures a typhoon in autumn 2005. Image credit: Alton Thompson.

(PhysOrg.com) -- Abrupt climate change has occurred on earth many times over the past millions of years. Climate scientists hypothesize that these sharp transitions may be caused when the earth system reaches a tipping point, or a critical value, resulting in a change of several degrees. These abrupt transitions have caused, for example, the formation and melting of glaciers throughout the earth, North Africa's change from savannah to desert 5,000 years ago, and various other changes.

Over the past few decades, researchers have been gathering evidence showing that earth's current climate has been slowly warming over the past century, leading to the question of whether it might reach another tipping point. But because determining the specific mechanisms that may cause tipping points is extremely difficult, scientists are simply unable to predict if and when future climate change might approach a critical threshold.

Now, a recent study has shown that there might be an early warning signal that heralds climatic tipping points. By analyzing the geological records of eight

ancient abrupt climate shifts, scientists have found that each shift is each preceded by a period in which the system becomes increasingly slower in responding to natural perturbations, which is reflected as a decrease in the rate of change.

The scientists, from Wageningen University in The Netherlands and the Potsdam Institute for Climate Impact Research in Germany, have published their study in a recent issue of the *Proceedings of the National Academy of Sciences*.

Because the researchers wanted to see if this information could be used as an early warning signal in the future, they only used data from before the actual transitions. They found that, while some of these "slowing down" periods were more extreme than others, it is highly unlikely that such behavior would appear randomly for the combined eight examples (less than a 0.3% chance).

"Our study has a dual significance," co-author Marten Scheffer of Wageningen University told *PhysOrg.com*. "It shows that climate has tipping points, and it shows that the theoretically predicted early warning signal can really be detected in a large complex system."

As the scientists explain, a climate system's slowing down is not based on a specific mechanism (e.g. carbon levels or ozone depletion) but is instead a universal property of systems approaching a tipping point. Because of this, they hope that it will be possible to detect slowing down signs that may foreshadow a future tipping point. One such tipping point, they note, may be a situation in which human-induced climate change is no longer buffered but amplified by parts of the earth system.

However, the researchers add that the slowing down signs will only occur if the system is moving fairly gradually toward a critical point. If a future transition occurs more quickly than the eight

transitions the researchers analyzed, slowing down may not precede the tipping point. The researchers note that, compared with the past transitions (which involved dynamics such as the ice caps and ocean heat contents), current trends in atmospheric carbon are occurring at a faster rate.

Right now, the researchers are looking for evidence that the current climate is slowing down. "We do that by looking at the faster subsystems, as we expect the slower parts of the system (oceans and ice) will not give a signal of slowing down that can be detected in the relatively small stretch of time, since humans have a large effect on greenhouse gases," Scheffer said.

Besides climate change, slowing down may also be an early warning sign for other systems, since it is a universal property of systems approaching a tipping point. The scientists suggest that slowing down could precede tipping points in areas such as disease dynamics, physiology, and social and ecological systems. In different systems, Scheffer explained, the time between the slowing down and the tipping point varies.

"The time-span depends entirely on the typical rates of change of the system you study," he said. "For instance, comparable (but different) early warning signals may be detected hours before a shift in a physiological system (such as epileptic seizures). In the climate examples, the system becomes slower right until the moment of the shift. It shows that the system is heading for a critical point, but it is difficult in practice to say how close that point is."

More information: Dakos, Vasilis; Scheffer, Marten; van Nes, Egbert H.; Brovkin, Victor; Petoukhov, Vladimir; and Held, Hermann. "Slowing down as an early warning signal for abrupt climate change." 14308-14312, *PNAS*, September 23, 2008, vol. 105, no. 38.

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APA citation: 'Calm before storm' may foreshadow climatic tipping point (2008, September 17) retrieved 25 October 2021 from <https://phys.org/news/2008-09-calm-storm-foreshadow-climatic.html>

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