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Evidence disproving tropical 'thermostat' theory: global warming can breach limits for life

WEST LAFAYETTE, Ind. — New research findings show that as the world warmed millions of years ago, conditions in the tropics may have made it so hot some organisms couldn't survive.

Longstanding theories dating to the 1980s suggest that as the rest of the earth warms, the tropical temperatures would be strictly limited, or regulated by an internal 'thermostat.' These theories are controversial, but the debate is of great importance because the tropics and subtropics comprise half of the earth's surface area, greater than half of the earth's biodiversity, as well as over half the earth's human population. But new geological and climate-based research indicates the tropics may have reached a temperature 56 million years ago that was, indeed, too hot for living organisms to survive in parts of the tropics.

That conclusion is detailed in the article "Extreme Warmth and Heat-Stressed Plankton in the Tropics during the Paleocene-Eocene Thermal Maximum," published by the online journal Science Advances and co-authored by Matthew Huber, professor in the Earth, Atmospheric, and Planetary Sciences Department at Purdue University and member of the Purdue Climate Change Research Center. Huber's contribution focused on climate modeling and interpreting paleoclimate data within the context of modern theoretical understanding. Part of this work was performed while Huber was also at the University of New Hampshire.

The Paleocene-Eocene Thermal Maximum (PETM) period occurred 56 million years ago and is considered the warmest period during the past 100 million years. Global temperatures rapidly warmed by about 5 degrees Celsius (9 F), from an already steamy baseline temperature, and this study provides the first convincing evidence that the tropics also warmed by about 3 degrees Celsius (5 F) during that time.

"The records produced in this study indicate that when the tropics warmed that last little bit, a threshold was passed and parts of the tropical biosphere seems to have died," Huber said. "This is the first time that we've found really good information, in a very detailed way, where we saw major changes in the tropics directly associated with warming past a key threshold in the past 60 million years."

The study is unique because of the quality of the geological records utilized. Geological records from the PETM are difficult to find, especially from an area of the tropics, Huber said. The research was based on a shallow marine sedimentary section deposited in Nigeria.

"We don't find 50-million-year-old thermometers at the bottom of the ocean," Huber said. "What we do find are shells, and we use the isotopes of carbon and oxygen within the shells, complemented by temperature proxies from organic material, to say something about the carbon cycle and about the temperature in the past."

Two research methods were used to judge the temperature during the PETM, one utilizing isotopes in shells, while the other examined organic residues in deep-sea sentiments. The biotic records left behind from living organisms indicate they were dying at the same time the conditions were warming.

If the tropics are not able to control its temperature and do not possess an internal thermostat, that should reshape future thinking about climate change, Huber said.

"If you say there's no tropical thermostat, then half of the world's biodiversity — over half of the world's population, the tropical rainforests, the reefs, India, Brazil — these populous and very important countries have nothing to prevent them from warming up substantially above conditions that humans have been used to," he said.

The trends in temperature increases in the tropics are similar to those found in other parts of the world, but other records have been very sparse and limited until now.

Huber's work has been funded by the National Science Foundation through grants EPS 1101245 and OCE 0902882. The model used in the study is developed by the National Center for Atmospheric Research, which is also supported by the NSF. Computing was provided by ITaP's Research Computing.

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Note to Journalists: A copy of the research paper is available from Brian Peloza, Purdue News Service, at 765-496-9711, **bpeloza@purdue.edu (mailto:bpeloza@purdue.edu)**

ABSTRACT

Extreme warmth and heat-stressed plankton in the tropics during the Paleocene-Eocene Thermal Maximum

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Global ocean temperatures rapidly warmed by ~5°C during the Paleocene - Eocene Thermal Maximum (PETM; ~56 million years ago; Ma). Extra-tropical sea surface temperatures (SSTs) met or exceeded modern subtropical values. With such warm extra-tropical temperatures, climate models predict tropical SSTs >35°C—near upper physiological temperature limits for many organisms. However, few data are available to test these projected extreme tropical temperatures or their potential lethality. We identify the PETM in a shallow marine sedimentary section deposited in Nigeria. Based on planktonic foraminiferal Mg/Ca and oxygen isotope ratios and the molecular proxy TEX_86^H, late Paleocene equatorial SSTs were ~33 °C, and TEX_86^H indicates that SSTs rose to >36 °C during the PETM. This confirms model predictions on the magnitude of polar amplification and refutes the tropical thermostat theory. We attribute a massive drop in dinoflagellate abundance and diversity at peak warmth to thermal stress, showing that the base of tropical foodwebs is vulnerable to rapid warming.

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