Polar warming may be underestimated by climate models, ~50 million year old climate variability suggests

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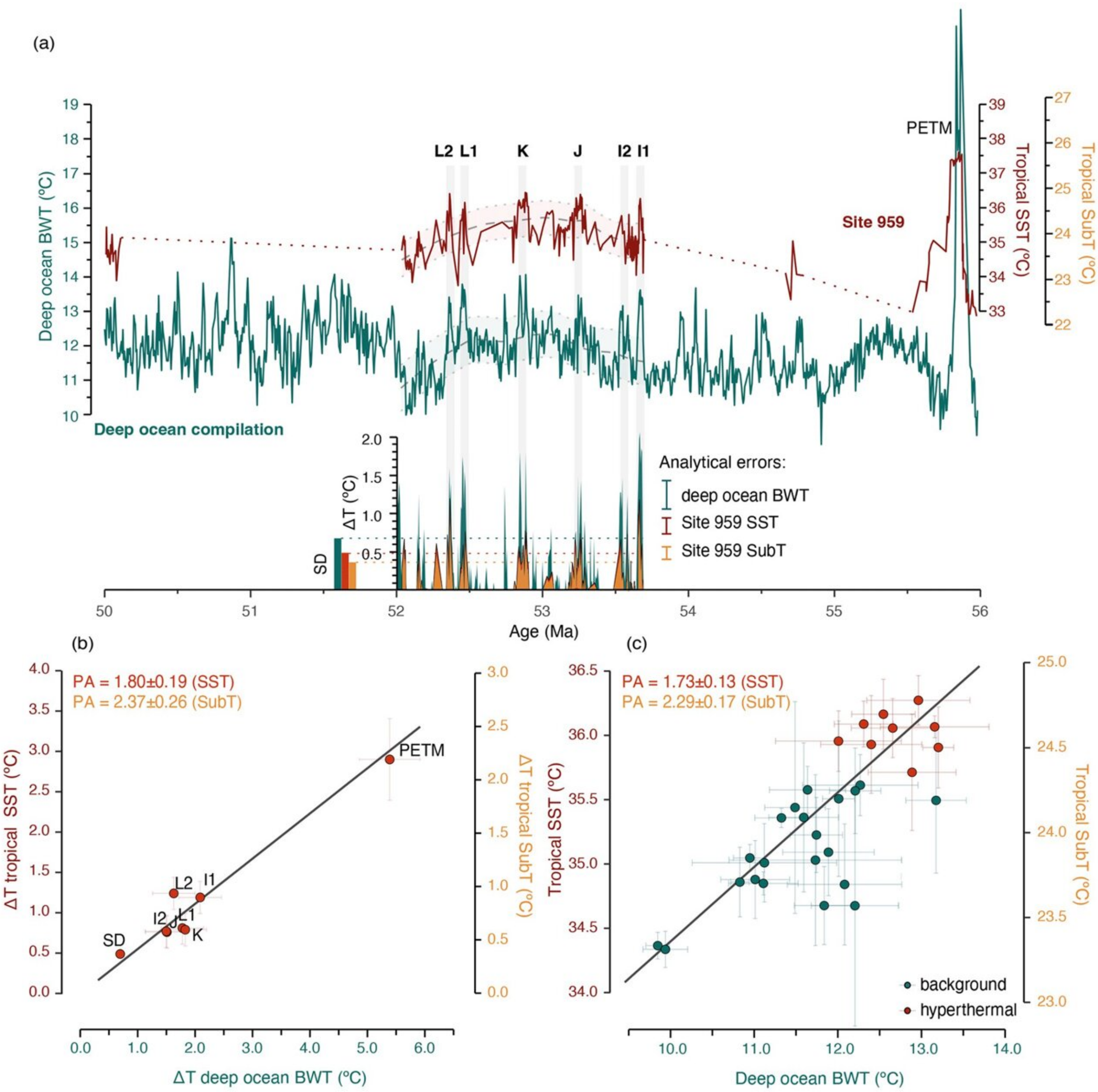

Comparison of reconstructed tropical surface, tropical subsurface and deep ocean temperatures during the Eocene. Credit: Fokkema et al. 2024.

Polar regions are known to be warming at an enhanced rate compared to lower latitudes, with the Intergovernmental Panel on Climate Change citing a ~5 °C increase in air temperature over Arctic land masses during the 20th century and the highest rates of ~1 °C per decade since the 1980s. Clearly, this so-called "polar amplification" of warming, defined as the ratio of high-latitude (>60 ºN/S) to low-latitude (36 ºC of the early Eocene tropics."

The scientists analyzed sediments from Ocean Drilling Program cores in the tropical Atlantic Ocean off the coast of North Africa (Site 959) and found that temperature variability in the tropics was time-equivalent with that at high latitudes during the hyperthermals, but also across Milankovitch cycles, providing strong evidence that these variations were global.

This proves a link between the orbital cycles, global temperature variability and the carbon content of the atmosphere. Given all of this, the scientists attribute orbital forcing as a major driver of changes in the carbon cycle, which relates to the input of carbon dioxide into the atmosphere that exacerbates global warming. They cite soils, peats, permafrost and methane hydrates as potential major sources of the carbon release.

The research team also identified that high latitude ocean temperatures during hyperthermals and orbital cycles varied about two times (1.7 to 2.3) stronger than the tropical surface ocean, therefore implying warmer polar regions. So even during the ice-free Eocene, high latitudes warmed and cooled twice as much as tropical regions, without ice-albedo feedbacks, suggesting strong atmospheric feedbacks.

Furthermore, because of polar amplification, the temperature gradient between the pole-derived deep ocean waters and tropical sea surface temperature was lower during hyperthermals. Global mean sea surface temperature for the Eocene hyperthermals increased ~1–1.5 °C during the events, which is comparable to modern rates of ~1 °C.

Fokkema and colleagues then compared this Eocene polar amplification factor with that calculated by the same climate models that are used to project future climate change, but then adapted for Eocene geography and ice-free conditions.

This showed that models underestimate polar amplification (1.1–1.3x). Consequently, this may imply that models underestimate the impact of warming in the Arctic and Antarctic. Understanding how polar amplification may progress in the future is vital to assess how thawing of permafrost and melting of ice sheets may influence sea level rise, as well as the carbon cycle.

"Our new study shows that the current warming is already on the same scale of some of these hyperthermals, which strongly impacted climate and oceans," Fokkema concludes. "By comparing this new record to previously published open ocean bottom water temperatures we were able to calculate polar amplification on short timescales during multiple orbitally-forced global temperature changes.

"We found a polar amplification factor of ±2. Interestingly, this is slightly larger than the polar amplification that climate models predict in an ice-free, early Eocene world, which may imply that climate models underestimate polar warming for the future."

More information: Chris D. Fokkema et al, Polar amplification of orbital-scale climate variability in the early Eocene greenhouse world, *Climate of the Past* (2024). [DOI: 10.5194/cp-20-1303-2024](https://dx.doi.org/10.5194/cp-20-1303-2024)