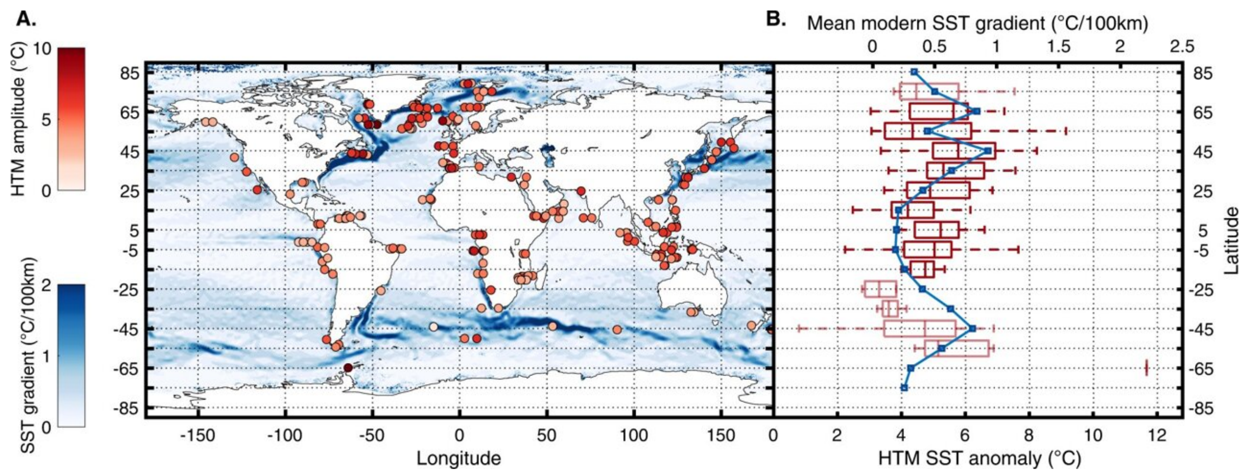
The last 12,000 years show a more complex climate history than previously thought

October 4 2022



A Mean sea surface temperature (SST) gradient (defined as g=‖∇SST‖, calculated based on a 0.25° resolution map) and median marine HTM anomalies compared to mean Holocene (dots). B Marine Holocene Thermal Maximum anomalies (bottom axis) and mean modern latitudinal SST gradient for 10° latitudinal bands (blue line, top axis). Box-whisker plots show 0% (bottom whiskers), 25, 50, 75, and 100% (top whiskers) quantiles. Semitransparent boxes are for latitudinal bands with fewer than 10 records. Credit: *Nature Communications* (2022). DOI: 10.1038/s41467-022-33362-1

We rely on climate models to predict the future, but models cannot be fully tested as climate observations rarely extend back more than 150 years. Understanding the Earth's past climate history across a longer period gives us an invaluable opportunity to test climate models on longer timescales and reduce uncertainties in climate predictions.

In this context, changes in the average surface temperature of the Earth during the current interglacial Epoch, the Holocene (approximately the past 12,000 years), have been thoroughly debated over the past decades. Reconstructions of past temperature seem to indicate that global mean temperature showed a maximum around 6,000 years ago and has cooled until the onset of the current climate crisis during the industrial revolution. Climate model simulations, on the other hand, suggest continuous warming since the start of the Holocene. In 2014, researchers named this major mismatch between models and past climate observations the "Holocene Temperature Conundrum."

In this new study published in *Nature Communications*, scientists used the largest available database of past temperature reconstructions extending back 12,000 years to carefully investigate the geographic pattern of temperature change during the Holocene. Olivier Cartapanis and colleagues find that, contrary to previously thought, there is no globally synchronous warm period during the Holocene. Instead, the warmest temperatures are found at different times not only in different regions but also between the ocean and on land. This questions how meaningful comparisons of the global mean temperature between reconstructions and models actually are.

According to the lead author Olivier Cartapanis, "the results challenge the paradigm of a Holocene Thermal Maximum occurring at the same time worldwide." And, while the warmest temperature was reached between 4,000 and 8,000 years ago in western Europe and northern America, the surface ocean temperature cooled since about 10,000 years ago at mid-high latitudes and remained stable in the tropics. The regional variability in the timing of maximum temperature suggests that high latitude insolation and ice extent played major roles in driving climate changes throughout the Holocene.

Lukas Jonkers, co-author of the study and researcher at the MARUM—Center for Marine Environmental Sciences in Bremen, Germany, says, "Because ecosystems and people do not experience the mean temperature of the Earth, but are affected by regional and local changes in climate, models need to get the spatial and temporal patterns of climate change right in order to guide policy makers."

Thus, the new work by Cartapanis and colleagues presents a clear target for climate models as the ability to reproduce Holocene climate variations in space and time will increase confidence in their regional projections of future climate change.

More information: Olivier Cartapanis et al, Complex spatio-temporal structure of the Holocene Thermal Maximum, *Nature Communications* (2022). DOI: 10.1038/s41467-022-33362-1

Provided by MARUM