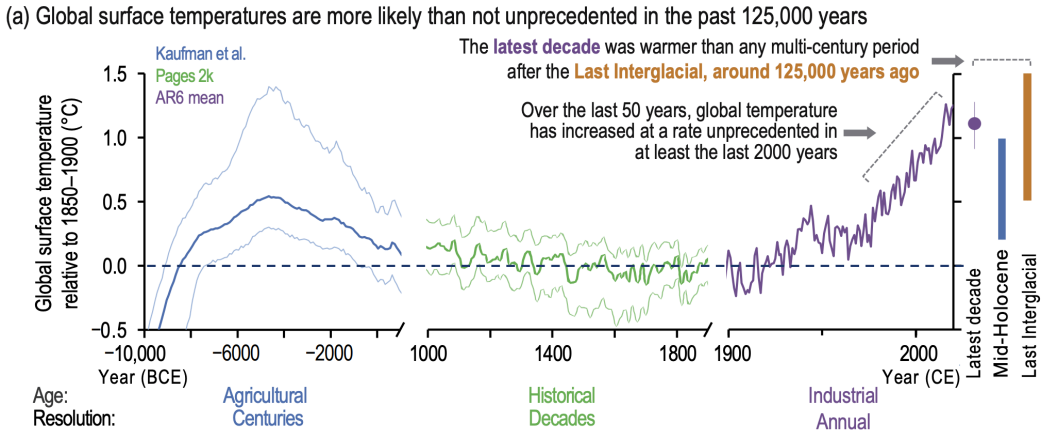
Paleoclimate Data Before 2,000 Years Ago

Past Interglacial Warm Periods - About 6,000 and 125,000 Years Ago

Paleoclimatologists have long questioned whether the warmest periods of our current interglacial period, the Holocene, and of the last interglacial period were warmer than the present day.

Warm conditions during interglacial periods are caused by changes in Earth's orbit that operate slowly over thousands of years to change the amount of solar radiation reaching each latitudinal band of Earth during each month. These orbital changes can be easily calculated and predict that, in the absence of greenhouse gas changes, the Northern Hemisphere would have been warmer than today during peak interglacial conditions in the summer and colder in the winter. Even though interglacial warming varied by season and location, reconstructions show a warming of global mean annual temperature during the peaks of the Holocene, at about 6,000 years ago, and of the last interglacial, about 125,000 years ago. Comparing these reconstructed temperatures to present-day, the most recent decade is likely warmer globally than any multi-century period during the Holocene and is within the range of probable temperatures for the warmest millennia of the last interglacial period.

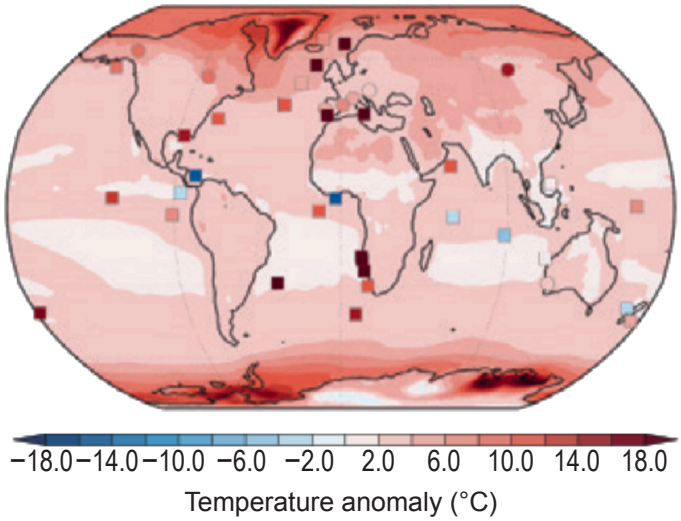


Global surface temperature over the Holocene divided into three time scales: (a) 12,000 to 1000 years ago (10,000 BCE to 1000 CE) in 100-year time steps, (b) 1000 to 1900 CE, decadally averaged, and (c) 1900 to 2020 CE, annual values. Bold lines show the most likely value of the reconstruction, and thin lines show the 5% and 95% likelihood range. Vertical bars on the right are the 5%–95% likelihood range of global surface temperature for the Last Interglacial (~125,000 years ago)and mid-Holocene (~6,000 years ago). Graphic is from the Intergovernmental Panel on Climate Change Sixth Assessment Report. Data sources: Turney et al. 2020, Kaufman et al. 2020, PAGES2k Consortium 2019.

Atmospheric carbon dioxide levels during both the middle Holocene and the Last Interglacial were lower than they are today. It is also informative to study time periods deeper in the past when atmospheric greenhouse gas concentrations and temperatures were both high.

Mid-Pliocene Warm Period – 3.3 to 3.0 Million Years Ago

The most recent period of the past with atmospheric carbon dioxide levels similar to today was the Mid-Pliocene Warm Period. Carbon dioxide concentrations then were between 360 and 420 parts per million, compared to levels of about 420 parts per million in 2022. Temperatures during the Pliocene can be reconstructed from geochemical measurements of ocean sediments and from vegetation types preserved on land. Reconstructed global mean temperature for the Mid-Pliocene is 2.5 to 4.0°C warmer than the second half of the 19th century and about 1.5 to 3.0°C warmer than the last decade. Important impacts of warmer temperatures during the Pliocene include a rise in sea level of about 5 to 25 meters compared to the start of the 20th century and a poleward shift of northern treeline by 4 to 10 degrees latitude.

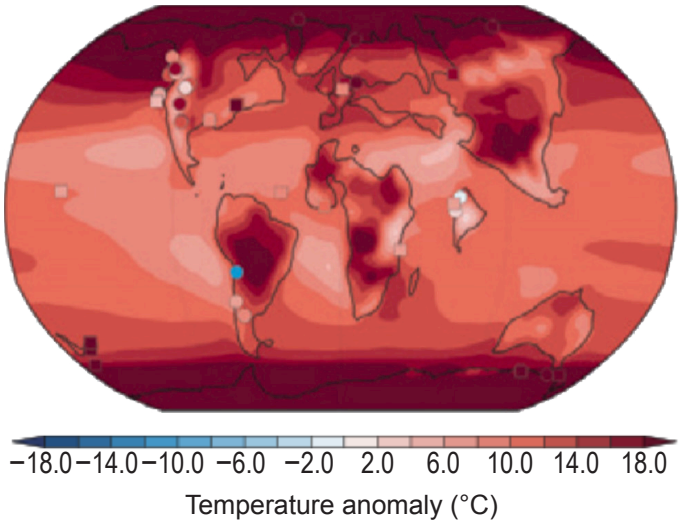


Changes in mean annual surface temperature for the Mid-Pliocene compared to the recent period as reconstructed from data (circles and squares) and simulated by climate models (colored contours). Graphic from the Intergovernmental Panel on Climate Change Sixth Assessment Report. Reconstruction data from: Salzmann et al. 2013, Vieira et al. 2018, McClymont et al. 2020.

Early Eocene Period – 53 to 49 Million Years Ago

The Early Eocene period is another period in the geologic past that stands out as distinctly warmer than today, particularly at high latitudes. During the Early Eocene Period, 53–49 million years ago, fossil remains of plants and animals believed to inhabit warm environments were found at much higher latitudes and the poles had little or no ice. The Eocene period occurred far enough in the past that continents were in slightly different positions, with different mountain chains and shallow seas in some places that do not exist today.

The Early Eocene was characterized by high carbon dioxide levels, inferred to be between 1150 and 2500 parts per million. Scientists think that increased volcanic activity was an important cause of these high levels of carbon dioxide. The reconstructed global mean surface temperature for the Early Eocene is 10° to 18°C warmer than the second half of the 19th century . As seen by proxy evidence and model simulations, this warming was widespread across the globe. There is reasonably good agreement between model simulations incorporating high CO_2 concentrations and proxy evidence, providing support for the role of CO_2 in maintaining the high temperatures of the Early Eocene.



Changes in mean annual surface temperature for the Early Eocene compared to values from 1850-1900, as reconstructed from paleoclimate proxies (circles and squares) and as simulated by climate models (colored contours). Graphic from the Intergovernmental Panel on Climate Change Sixth Assessment Report. Reconstruction data from: Hollis et al. 2019.