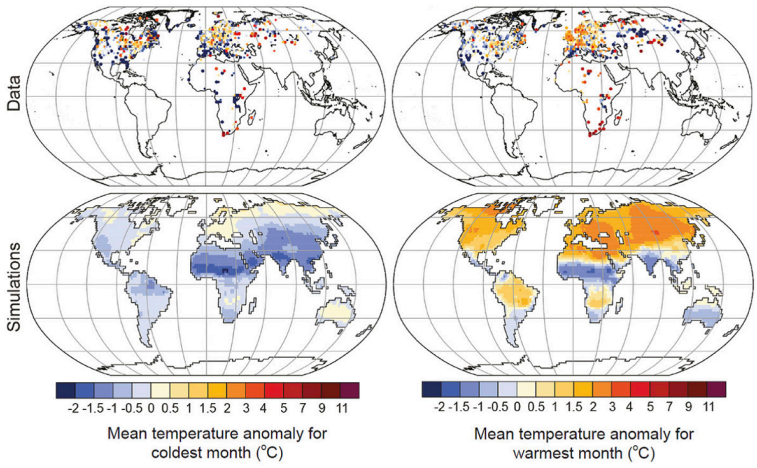
Paleoclimate Data Before 2,000 Years Ago

Mid-Holocene Warm Period – About 6,000 Years Ago

Paleoclimatologists have long suspected that the "middle Holocene," a period roughly from 7,000 to 5,000 years ago, was warmer than the present day. Terms like the Altithermal or Hypsithermal or Climatic Optimum have all been used to refer to this warm period that marked the middle of the current interglacial period. Today, however, we know that these terms are obsolete and that the truth of the Holocene is more complicated than originally believed.

What is most remarkable about the mid-Holocene is that we now have a good understanding of both the global patterns of temperature change during that period and what caused them. It appears clear that changes in Earth's orbit have operated slowly over thousands and millions 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 the Northern Hemisphere should have been warmer than today during the mid-Holocene in the summer and colder in the winter. The combination of warmer summers and colder winters is apparent for some regions in the proxy records and model simulations. There are some important exceptions to this pattern, however, including colder summers in the monsoon regions of Africa and Asia due to stronger monsoons with associated increased cloud cover during the mid-Holocene, and warmer winters at high latitudes due to reduction of winter sea ice cover caused by more summer melting.

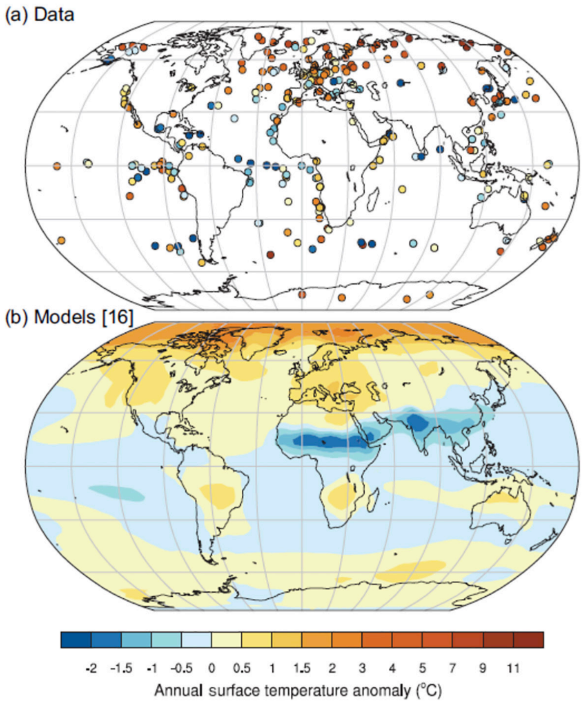
In summary, the mid-Holocene, roughly 6,000 years ago, was generally warmer than today during summer in the Northern Hemisphere. In some locations, this could be true for winter as well. Moreover, we clearly know the cause of this natural warming, and we know without doubt that this proven "astronomical" climate forcing mechanism cannot be responsible for the warming over the last 100 years.



Model-data comparison of surface temperature anomalies for the mid-Holocene (average of 5,500 to 6,500 years ago). Top panels are pollen-based reconstructions from Bartlein et al. (2011) with anomalies defined as compared to recent. Bottom panels are corresponding surface temperature anomalies simulated by the Paleoclimate Modelling Intercomparison Project Phase 2 and 3 (PMIP2 and PMIP3). Graphic from the Intergovernmental Panel on Climate Change Fifth Assessment Report.

Penultimate Interglacial Period – About 125,000 Years Ago

We are in the current "Holocene" interglacial, which began about 11,500 years ago. As mentioned elsewhere, the middle of the Holocene was warmer than today, at least during summer in the Northern Hemisphere, due to changes in Earth's orbit changing the distribution of solar radiation received on Earth. For similar reasons, the penultimate interglacial (also commonly called the "Eemian") also had a climate different from today. In contrast to the Holocene, we have far fewer records from the Eemian interglacial because it took place about 125,000 years ago. It appears, based on proxy evidence, that global mean annual surface temperatures were warmer than preindustrial by about 1° to 2°C and that high-latitude surface temperature was at least 2°C warmer than present, but for reasons that are well known—the changes in Earth's orbit. Additionally, and similar to the mid-Holocene, warming was not uniform across the globe.

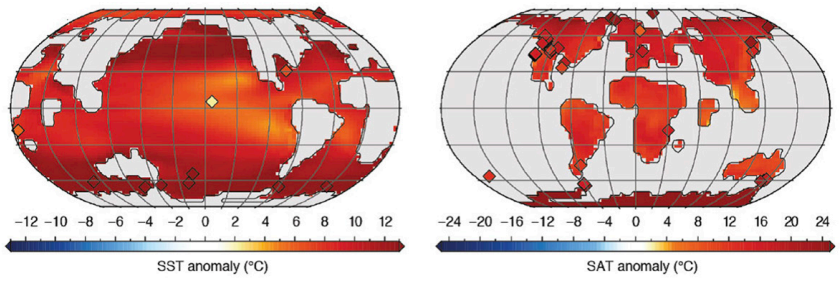


Changes in mean annual surface temperature for the Last Interglacial compared to the recent period as reconstructed from data and simulated by an ensemble of 16 climate model experiments in response to orbital and well-mixed greenhouse gas forcings. Proxy syntheses published by Turney and Jones (2010) and McKay et al. (2011). Graphic from the Intergovernmental Panel on Climate Change Fifth Assessment Report.

Early Eocene Period – 54 to 48 Million Years Ago

The Early Eocene period is one period in the geologic past that stands out as distinctly warmer than today, particularly at high latitudes. During the Early Eocene Period, 54–48 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 1,000 and 2,000 parts per million. Scientists think that increased volcanic activity was an important cause of these high levels of carbon dioxide. Temperatures during the Eocene can be reconstructed from geochemical measurements of ocean sediments and from vegetation types preserved on land. The reconstructed global mean surface temperature for the Early Eocene is 9° to 14°C higher than today. As seen by proxy evidence and model simulations, this warming was widespread across the globe. There is good agreement between model simulations incorporating high CO_2 concentrations and proxy evidence, providing strong support for the role of CO_2 in maintaining the high temperatures of the Early Eocene.



Comparison of paleoclimate proxy data and the mean of multiple model simulations, showing sea surface temperature (SST) anomalies and surface air temperature (SAT) anomalies for the Early Eocene Climatic Optimum. Model temperature anomalies are calculated relative to the pre-industrial values. Site-specific temperature anomalies estimated from proxy data are calculated relative to present site temperatures and shown by the colored diamonds. Proxy data compilations are from Hollis et al. (2012) and Lunt et al. (2012). Model simulations are from Lunt et al. (2012). Graphic from the Intergovernmental Panel on Climate Change Fifth Assessment Report.