Throwing a warm sheet over our understanding of ice and climate

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Temperatures at Earth's highest latitudes were nearly as warm after Antarctica's polar ice sheets developed as they were prior to glaciation, according to a new study led by Yale University. The finding upends most scientists' basic understanding of how ice and climate develop over long stretches of time.

The study, based on a reconstruction of global surface temperatures, gives researchers a better understanding of a key moment in Earth's climate history—when it transitioned from a "greenhouse" state to an "icehouse" state. The study appears in the journal *Proceedings of the National Academy of Sciences* the week of Sept. 28.

"This work fills in an important, largely unwritten chapter in Earth's surface temperature history," said Pincelli Hull, assistant professor of earth and planetary studies at Yale, and senior author of the study.

Charlotte O'Brien, a former Yale Institute for Biospheric Studies (YIBS) Donnelley Postdoctoral Fellow who is now a postdoctoral research associate at University College London, is the study's lead author.

During the Eocene period (from 56 to 34 million years ago), temperatures at Earth's higher latitudes were much higher than they are today. The formation of polar ice sheets began near the end of the Eocene period—and has been linked by many scientists to the onset of global cooling during the Oligocene period (33.9 to 23 million years ago).

Although there has been much scientific focus on the development of Antarctic glaciation, there have been relatively few sea surface temperature records for the Oligocene period.

The researchers generated new sea surface temperature models for the Oligocene at two ocean sites in the western tropical Atlantic and the southwestern Atlantic. They combined the new data with other existing sea surface temperature estimates for the Oligocene and Eocene epochs, plus data from climate modeling.

The result was a reconstruction of how surface temperatures evolved at a key moment in Earth's climate history, as it transitioned from a

greenhouse state to an icehouse state with Antarctic glaciation.

"Our analysis revealed that Oligocene 'icehouse' surface temperatures were almost as warm as those of the late Eocene 'greenhouse' climate," O'Brien said.

The study estimated that global mean surface temperatures (GMSTs) during the Oligocene were roughly 71 to 75 degrees Fahrenheit, similar to late Eocene GMSTs of about 73 degrees Fahrenheit. For context, in 2019 the GMST average was 58.7 degrees Fahrenheit, according to the National Oceanic and Atmospheric Administration.

"This challenges our basic understanding of how the climate works, as well as the relationship between climate and ice volume through time," O'Brien said.

More information: Charlotte L. O'Brien et al. The enigma of Oligocene climate and global surface temperature evolution, *Proceedings of the National Academy of Sciences* (2020). DOI: 10.1073/pnas.2003914117

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