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Extremely warm early Eocene marine and terrestrial temperatures on the Antarctic margin: implications for the persistent data-model mismatch problem in Greenhouse climate intervals

James Bendle (1), Peter Bijl (2), Lineth Contreras (3), Jörg Pross (3), Stefan Schouten (4), Ursula Röhl (5), Mark Pagani (6), Robert DeConto (7), Steven Bohaty (8), Henk Brinkhuis (2), and the Expedition 318 Scientists Team

(1) Glasgow Molecular Organic Geochemistry Laboratory (G-MOL), School of Geographical and Earth Sciences, University of Glasgow, Glasgow, United Kingdom, United Kingdom (James.Bendle@ges.gla.ac.uk), (2) Biomarine Sciences, Institute of Environmental Biology, Faculty of Science, Laboratory of Palaeobotany and Palynology, Utrecht University, Utrecht, The Netherlands, (3) Institute of Geosciences, University of Frankfurt, Frankfurt, Germany, (4) NIOZ Royal Netherlands Institute for Sea Research, Department of Marine Organic Biogeochemistry, Den Burg, Texel, The Netherlands, (5) MARUM-Center for Marine Environmental Sciences, University of Bremen, Bremen, Germany, (6) Department of Geology and Geophysics, Yale University, New Haven, USA, (7) University of Massachusetts-Amherst, Amherst, USA, (8) School of Ocean and Earth Science, University of Southampton, Southampton, United Kingdom

The early Eocene was characterised by high pCO2 (ca.1,000 to more than 2,000ppm) and mean global temperatures that reached a long-term maximum. Relative to the present day, meridional temperature gradients were unusually low, with slightly warmer equatorial regions but with much warmer subtropical Arctic and mid-latitude climates. Yet global climatic conditions during this pre-glacial interval have remained poorly constrained, as only a few temperature records are available portraying the Cenozoic climatic evolution of the high southern latitudes.

Here we present the first organic geochemistry results from IODP expedition 318, including molecular organic biomarker (tetraethers, alkenones and plant waxes) records extracted from bio- and magnetostratigraphically dated, late early to early middle Eocene sediments recovered at Site U1356. For the first time, we reconstruct terrestrial and marine temperatures and ecological conditions from the Eocene Greenhouse world in direct proximity to the Antarctic continent. Independent lines of evidence from biomarkers and palynology suggest an extremely warm early Eocene Antarctic climate.

These results further confirm that exceptionally warm polar regions are a feature common to reconstructed Greenhouse periods. However, a data-model mismatch problem persists, in which interpreted high-latitude temperatures are substantially higher than can be simulated by most models without assuming exceptionally high pCO2 levels. Resolution of this mismatch is crucial for more accurate constraints on the Earth's climate sensitivity to pCO2.