Study Finds 6°C Cooling on Land during the Last Glacial Maximum,
With Implications about Future Global Warming

Woods Hole, Mass. (May 12, 2021) -- Low-to-mid latitude land surfaces at low elevation cooled on average by 5.8 ± 0.6°C during the Last Glacial Maximum (LGM), based on an analysis of noble gases dissolved in groundwater, according to a new study published in *Nature*.

Temperature estimates in the study are substantially lower than indicated by some notable marine and low-elevation terrestrial studies that have relied on various proxies to reconstruct past temperatures during the LGM, a period about 20,000 years ago that represents the most recent extended period of globally stable climate that was substantially cooler than present.

"The real significance of our paper is that prior work has badly underestimated the cooling in the last glacial period, which has low-balled estimates of the Earth's climate sensitivity to greenhouse gases," said paper co-author Jeffrey Severinghaus, a professor of geosciences at Scripps Institution of Oceanography, University of California San Diego. "The main reason that prior work was flawed was that it relied heavily on species abundances in the past. But just like humans, species tend to migrate to where the climate suits them. Think, for instance, of snowbirds moving from Canada to Arizona in winter. So, species aren't very good thermometers."

The paper does broadly support a recent marine proxy study by Tierney et al. published last year that found substantially greater low-latitude cooling than previous efforts and, in turn, suggested greater climate sensitivity than prior studies. That earlier paper suggested the equilibrium response of Earth's global-mean surface temperature is 3.4°C per doubling of atmospheric carbon dioxide, in line with the consensus range of estimates from state-of-the-art climate models, but somewhat higher than the usual best estimate of 3.0 °C.

"The rather high climate sensitivity that our results suggest is not good news regarding future global warming, which may be stronger than expected using previous best estimates. In particular, our global review reinforces the finding of several single noble gas case studies that the tropics were substantially cooler during the last glacial maximum than at present. The unpleasant implication for the future is that the warmest regions of the world are not immune to further heating," commented co-author Werner Aeschbach, a professor at the Institute of Environmental Physics, Heidelberg University, Heidelberg, Germany.

The paper made use of a technique in which measurements of noble gases dissolved in ancient groundwater enable direct and quantitative determination of past surface temperature. Noble gases in the atmosphere are chemically and biologically inactive and have no appreciable sinks or sources over the 40,000-year timescales relevant to this study. They dissolve into groundwater, and their equilibrium concentrations depend strongly on temperature. The authors compiled four decades worth of groundwater noble gas data from every continent except Antarctica, along with previously unpublished measurements from some key tropical locations to produce a global record of noble gas-derived temperatures (NGTs) of the LGM.

"Noble gas paleo temperature records are so powerful because they are based on a physical principle and are not much influenced by life—which always complicates everything— and short term extreme events." said journal article co-author Martin Stute, a professor in the Environmental Science Department at Barnard College and an adjunct senior research scientist at the Lamont-Doherty Earth

Observatory. “They provide a temperature average over hundreds to thousands of years. It is remarkable, and rewarding for me, how consistent noble gas paleo temperature reconstructions are in low latitudes from the early studies that I led in the 1990s to the most recent ones.”

The study bolsters the method of analyzing noble gases to reconstruct paleo temperatures and provides more confidence in climate models, according to the authors.

“Another key goal of our study was to evaluate the overall accuracy of the so-called ‘noble gas paleo-thermometer’ for reconstructing temperatures on land during the last glacial period. Naturally, our ability to confidently use this tool to understand the past is related to how well it works in the present. By comparing modern temperature observations to independent estimates using noble gases in relatively young groundwater, we found that the noble gas thermometer is remarkably accurate over a wide temperature range from around 2 to 33 ^{o}C (36 to 91 ^{o}F). This adds a good deal of confidence to our estimates of cooling during the LGM,” said the paper’s lead author, Alan Seltzer, an assistant scientist in the Marine Chemistry and Geochemistry Department at the Woods Hole Oceanographic Institution.

Seltzer added that the new analysis is important because climate models “provide an important tool that policy makers can use to decide on how to prepare for future environmental changes. This study alleviates the concern that, based on LGM proxy data, models might over-predict the global mean temperature response to carbon dioxide. In fact, based on both our study and the recent marine-proxy compilation, it is becoming clear that paleoclimate proxies and models are in agreement.”

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