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The Role of Carbon Dioxide during the Onset of Antarctic Glaciation

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Earth's modern climate, characterized by polar ice sheets and large equator-to-pole temperature gradients, is rooted to environmental conditions that led to the glaciation of Antarctica ∼34 million years ago. Rapid Antarctic glaciation reflects a "tipping point" in Earth's climate history and provides a target to investigate the contributing role of atmospheric carbon dioxide during climate change. For this study, we reconstruct CO2 trends using the alkenone-CO2 methodology, as well as changes in coccolithophore cell size, and show that CO2 declined just prior to-, and in association with, major Antarctic ice accumulation. We further show that CO2 estimates from Subantarctic and Antarctic sites do not reflect average atmospheric CO2 levels and yield spurious global CO2 trends if included in alkenone compilations. Substantial atmosphere-ocean CO2 disequilibrium evolved throughout the Southern Oceans, in conjunction with enhanced upwelling rates elsewhere, and potentially contributed to an apparent rise in atmospheric CO2 just prior to the CO2 decline associated with Antarctic glaciation. Our results imply high "Earth system" climate sensitivity to CO2, with sea-ice expansion and increased albedo playing an important role in enhancing global cooling.