

Polar ice sheets during the warm Cretaceous? Insights from coupled numerical modelling

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Most proxy estimates of Cretaceous climates reveal oceanic and terrestrial temperatures substantially warmer than modern's. Fossils of crocodylian species and remains of what is now low-latitude flora have been unearthed in polar locations. On top of that, direct evidence of polar ice sheets have yet to be found. The Cretaceous has thus historically been considered as a long and stable period of supergreenhouse with elevated CO₂ levels. For a couple of decades however, studies have suggested that dynamical climatic variations affect the Cretaceous greenhouse, in particular with the episodic growth of ephemeral polar ice sheets, for which indirect evidence have been argued for. In addition, new estimates of CO₂ levels suggest more modest values (400–1500 ppm), potentially in the range of those in place during Cenozoic glaciations. Here, we use a suite of models of climate and ice sheets to investigate the impact of the changing palaeogeography during the Middle-Late Cretaceous (120–70 Ma) on the development of ice sheets on polar latitudes. We show that palaeogeography alone, through a series of complex feedbacks, has the potential to significantly alter the CO₂ threshold for the onset of ice sheets, nucleating in particular at higher CO₂ concentrations in the Aptian (~115 Ma) and the Maastrichtian (~70 Ma) than in the Cenomanian–Turonian (~95 Ma). Our simulations demonstrate notably that part of the Cenomanian–Turonian climatic optimum can be explained by its specific palaeogeography and support the vision of an ice-free Earth during this stage. In addition, our numerical work derives Aptian and Maastrichtian glacial CO₂ threshold that are in the range of latest data compilations, thus adding to the growing body of evidence suggesting that ice sheets were once present during these stages.