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The evolution of the Antarctic ice sheet at the Eocene-Oligocene Transition.

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An increasing number of studies suggest that the Middle to Late Eocene has witnessed the waxing and waning of relatively small ephemeral ice sheets. These alternating episodes culminated in the Eocene-Oligocene transition (34 – 33.5 Ma) during which a sudden and massive glaciation occurred over Antarctica. Data studies have demonstrated that this glacial event is constituted of two 50 kyr-long steps, the first of modest (10 – 30 m of equivalent sea level) and the second of major (50 – 90 m esl) glacial amplitude, and separated by $\sim$ 200 kyrs. Since a decade, modeling studies have put forward the primary role of CO_2 in the initiation of this glaciation, in doing so marginalizing the original "gateway hypothesis". Here, we investigate the impacts of CO_2 and orbital parameters on the evolution of the ice sheet during the 500 kyrs of the EO transition using a tri-dimensional interpolation method. The latter allows precise orbital variations, CO_2 evolution and ice sheet feedbacks (including the albedo) to be accounted for. Our results show that orbital variations are instrumental in initiating the first step of the EO glaciation but that the primary driver of the major second step is the atmospheric pCO_2 crossing a modelled glacial threshold of $\sim$ 900 ppm. Although model-dependant, this higher glacial threshold makes a stronger case for ephemeral Middle-Late Eocene ice sheets. In addition, sensitivity tests demonstrate that the small first step only exists if the absolute pCO_2 value remains within $\sim$ 100 ppm higher than the glacial threshold during the first 250 kyrs of the transition. Thereby, the pCO_2 sufficiently counterbalances the strong insolation minima occurring at 33.9 and 33.8 Ma but is low enough to allow the ice sheet to nucleate. Nevertheless, questions remain as to what may cause this pCO_2 drop.