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An estimate of Earth System Sensitivity from the Pliocene

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One of the cornerstones of future climate research has been the attempt to characterise the equilibrium global temperature response of the Earth to a doubling of atmospheric CO_2 concentration. However, due to insufficient understanding of key mechanisms and a lack of the necessary computational resource, studies have traditionally neglected possible changes to components of the system which act on long timescales, such as ice sheets and vegetation. Because there is evidence of past time periods when the whole Earth System was close to equilibrium with elevated CO_2, a combined palaeo data and modelling approach can be used to estimate the true long-term response of the Earth System to increased CO_2. The mid-Pliocene (about 3 million years ago) provides an ideal case study, as CO_2 was higher than modern, temperature elevated, and ice sheet and vegetation changes relatively well constrained by observations. Here, we show that the long-term response of the Earth System to elevated CO_2, including ice sheet and vegetation changes (the Earth System sensitivity), is about 60% greater than the more traditional short term response (the Charney sensitivity).