

Climate-carbon cycle interactions from the Pliocene to the deep future

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Atmospheric CO₂ influences climate mainly through its greenhouse effect, and climate in turn affects many carbon cycle processes, primarily through their temperature dependence. Different carbon cycle processes in the Earth system operate on very different time scales ranging from seasonal/annual to >100,000 years, resulting in climate-carbon cycle interactions across a wide range of time scales.

Here we use the CLIMBER family of fast Earth system models to explore and better understand the climate carbon-cycle interactions from the Pliocene to 200,000 years into the future. We show that small imbalances in the carbon cycle result in long-term trends of atmospheric CO₂ that influence climate leading to the Pliocene-Pleistocene transition and to glacial inception in the future. During glacial-interglacial cycles of the Pleistocene carbon cycle dynamics amplified the climate and ice sheet response to orbital forcing. We finally show that atmospheric CO₂ concentration exerts a strong control on the appearance of millennial-scale climate variability, both in the past and in the future, and propose an explanation for the different CO₂ response to Dansgaard-Oeschger and Heinrich events.