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Perturbations of volcanic CO_2 emission to orbital paced climate-carbon cycle

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How the global carbon cycle and climate changes interact on orbital timescales under different boundary conditions remains elusive. Previous studies have found that changes in global ice-sheet volume and marine carbon cycle are synchronized at the eccentricity time scales with a slight lead of climate-cryosphere relative to carbon cycle throughout Oligo-Miocene (~34-6 Ma). Here, we analyze the evolutive phase relationship between benthic foraminiferal oxygen ($\delta^{18}O$) and carbon isotope ($\delta^{13}C$) to reveal an unnoticed phenomenon that variations of oceanic carbon cycle could lead those of global ice-sheet volume on 405-kyr cycle during Miocene Climate Optimum (MCO, ~17-14 Ma), which was a profound warming interval partly ascribed to the carbon emission from the eruption of the Columbia River Basalts Group (CRBG). Eccentricity sensitivity analysis indicate a relatively constant response of ice sheet to orbital forcing during MCO. Combined the results of box model, we propose that volcanic CO_2 input accelerates the response of marine carbon cycle to orbital forcing. The enhanced greenhouses effect probably had strengthened the low-latitude hydrological cycle and chemical weathering and ultimately generated the $\delta^{13}C$-lead-$\delta^{18}O$ scenario.