LONG-TERM CARBON CYCLE TRENDS: FROM THE LATE PALEOCENE TO THE EARLY EOCENE CLIMATIC OPTIMUM

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Abstract

A prominent decrease of δ^{13}C as well as δ^{18}O over the late Paleocene and early Eocene ($\sim$57-52 Ma) has been observed in many sediment records. The δ^{18}O paleorecords indicate a long-term warming trend ($\sim$4°C) of the Earth system over this time interval, while planktic and benthic stable carbon isotope ratios appear to gradually drop by about 2‰, signifying a possible change in the carbon cycle. Concurrently, deep-sea carbonate records at several sites indicate a deepening of the calcite compensation depth (CCD). This study investigates possible causes (e.g. increased volcanic degassing and/or decreased organic carbon burial) for the observed climate shifts and unlike other studies, the evolution of the CCD is also considered in the model. The model employed here is a modified version of the GEOCARB III model, which uses more accurate input data (e.g. δ^{13}C of carbonate records), coupled to the LOSCAR model. Besides the CCD, the coupled model separately simulates surface and deep ocean δ^{13}C and it also includes full CO_2 seawater chemistry. Several different scenarios are investigated with the goal of achieving a consistent scenario with respect to the observed temperature increase, the CCD change and the surface to deep ocean δ^{13}C gradient. The results indicate that the most likely cause of the climate shift during the late Paleocene and early Eocene was mainly due to a decrease in net organic carbon burial, although an increase in metamorphic activity might have contributed to the overall trend. The model successfully recreates the temperature change, inferred from the δ^{18}O record, caused by the radiative forcing of atmospheric CO_2, as well as the drop in the CCD. At the moment, the model cannot recreate the surface to deep gradient in δ^{13}C, which according to data remained constant during the studied time interval; the deep δ^{13}C change predicted by the model is too small. The model also shows potential for explaining a 2 million year lag between the cessation of the carbon cycle perturbation ($\sim$52 Ma) and the onset of the cooling of the Earth system ($\sim$50 Ma) in the early Eocene.