Temperature-CO_2 Uncoupling and Terrestrial Carbon

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Because greenhouse gas concentrations and palaeotemperature reconstructions from ice cores generally indicate coupled climate and atmospheric CO_2 trends over the last four interglacial-glacial cycles, we may be falsely led to believe that changes in CO_2 and temperature have always been coupled through time. Mid-Cenozoic CO_2 minima reconstructed from stable carbon and boron isotopes, however, indicate that CO_2 levels may have been well below 360 µmol mol^{-1} (around 200 µmol mol^{-1}) at a time when regions of the earth are thought to have been up to 6°C warmer than today. The implications of temperature-CO_2 (un)coupling for terrestrial carbon are addressed using data from physiological and vegetation modelling sensitivity experiments. Different geological time-scales are investigated, including Eocene-Miocene temperature-CO_2 uncoupling (low CO_2, high temperature), Pleistocene coupling (low CO_2, low temperature) and late-Holocene uncoupling (i.e. Little Ice Age cooling, relatively stable CO_2). Temperature-CO_2 (un)coupling can alter terrestrial carbon storage because changes in atmospheric CO_2 and temperature independently and collectively influence leaf-carbon assimilation. Reduced terrestrial carbon uptake under conditions of high temperature and low CO_2 arise in part from increased photorespiration, the oxygenation of the primary carboxylating enzyme in C_3-plants. Spatial differences in the influence of (un)coupling on terrestrial carbon are expected, because low-latitude C_3-plants are more limited by photorespiratory processes than their mid- and high-latitude counterparts, such that global (un)coupling events could result in opposite trends in terrestrial-atmosphere carbon fluxes depending on region.