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δ13C from diatoms record a CO_2 decline since the late Miocene

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Since the partial pressure of atmospheric carbon dioxide (pCO_2) is a key climate regulator, accurate climate modelling producing scenarios comparable to proxy evidence requires reliable and accurate CO_2 reconstructions as input parameters. The carbon isotopic fractionation by phytoplankton (εp), specifically measured from coccolith calcite, has been widely used to estimate past CO_2 variations. Over the last $\sim$14 Ma, CO_2 records calculated from coccolith δ13C suggest a decoupling of greenhouse gas forcing and sea surface temperature (SST) variations, which in the extratropics show a decrease of up to 17 ºC, while CO_2 concentrations estimated by coccolith εp remain rather constant.

Phytoplankton εp does not only depend on the carbon availability in seawater and therefore on CO_2 concentrations, but also on the cellular carbon demand, which is in part controlled by the diffusive supply rate of CO_2 to the cell (i.e. cell size and geometry). Since the cell size of coccolithophores changed significantly over the last $\sim$13 Ma, it is likely that the stable CO_2 concentrations previously reconstructed by coccolith εp where no size corrections were conducted, are rather inaccurate. In contrast, uncertainties due to the cell size variation effect can be eliminated from εp records calculated from δ13C measurements of the organic matter trapped inside diatom frustules, as diatoms with restricted cell size and geometries can be produced by careful frustule separation techniques (i.e. microfiltration and settling).

Here we reconstruct εp from pennate diatoms <10 μm from the Eastern Equatorial Pacific Ocean at Ocean Drilling Program Site 846 over the last $\sim$13 Ma. Various productivity indicators (i.e. opal content, alkenone concentration and coccolith Sr/Ca) were used to estimate the potential effects of growth rate variation in our samples. Our pennate diatom εp record shows a decline of $\sim$5.2 ‰ during the past $\sim$11 Ma, which implies a pCO_2 decline from 454 (+/-41) to 250 (+/-15) ppmv between $\sim$11 and 6 Ma. This magnitude of CO_2 change is likely to be a minimum estimate, as it does not consider potential increases in the active carbon uptake by diatoms.

As opposed to previous coccolith-based εp CO_2 records, our record suggest a decreasing greenhouse forcing related to the cooling observed during this time period, giving new insights of climate sensitivity and carbon cycle feedbacks during the last $\sim$13 Ma, which should be included into numerical models to produce more accurate reconstructions of past climate and better approximations to future climate variations.