Geophysical Research Abstracts
Vol. 21, EGU2019-13692, 2019
EGU General Assembly 2019

Core-top calibration and first application of the dinoflagellate cyst based pCO_2 barometer

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Coupled reconstructions of past temperature and pCO_2 are needed to investigate paleoclimate sensitivity and thereby help to refine future projections of climate change. Although many methods exist for reconstructing past temperatures, unfortunately, most existing proxies for past pCO_2 are lacking the accuracy and precision needed for robust reconstructions. Therefore we develop and test a novel pCO_2 proxy based on carbonate system dependent carbon isotope fractionation (εp) between sea water DIC and dinoflagellate cysts (dinocysts). In culture experiments the carbonate speciation of εp in various autotrophic dinoflagellates was shown, including two species that build the ubiquitous, geologically long-ranging, dinocysts Operculodinium centrocarpum and Spiniferites ramosus (Hoins et al., 2015). A specially developed laser-ablation nano-combustion gas chromatography isotope ratio mass spectrometry (LA-nC-GC-IRMS) method (van Roij et al., 2017) allows accurate analyses of the carbon isotope composition of single dinocysts (δ13Cdinocyst).
Using newly acquired LA-nC-GC-IRMS data, we constructed the first environmental calibration datasets based on δ13C of O. centrocarpum cysts from North Atlantic and Mediterranean core-top sediments. We explore the influence of environmental parameters such as temperature, salinity and carbonate speciation on εp in the calibration dataset. Importantly, we observe that through carbonate speciation surface water pCO_2 is recorded in the carbon isotopic signatures of dinoflagellates in their cysts and therefore that εp of dinocysts can potentially be used as a pCO_2-proxy. Based on this we present the first tentative application of this approach and calibration to reconstruct sea surface pCO_2 and hence ocean-atmosphere pCO_2 disequilibrium, which in turn varies as a function of North-Atlantic Current strength. This reconstruction shows major perturbations in current strength during the latest Glacial and Holocene based on a sedimentary record recovered offshore northwest Ireland.