Environmental control on coccolithophore morphology: Do modern species yield information that is transferable to the geological past?

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It is generally assumed that calcareous nannofossils conserve palaeoenvironmental information from the time of their formation. Changes in coccolith morphology can result from physiological responses to environmental drivers. Temperature, salinity, nutrient concentration, light and carbonate chemistry are among the environmental drivers that impact extant coccolithophores and may alter coccolith size, as well as coccosphere size and morphology. Many palaeoreconstruction studies have assessed the biological responses of living coccolithophore species to environmental drivers with the expectation that it is possible to use this information for calibrating the biomineralisation responses of ancient coccolithophores. However, there is a large uncertainty concerning whether the morphological responses of living coccolithophores to environmental changes are similar to the morphological responses of fossil species, when you consider the fact that millions of years of evolutionary adaptation lie between the extant species and their fossilised ancestors. In order to test this caveat, we examined four extant species (*Emiliania huxleyi, Gephyrocapsa oceanica*, *Coccolithus pelagicus* subsp. *braarudii* and *Pleurochrysis carterae*), which have been evolutionarily distinct for millions of years. We cultured them under changing environmental conditions in order to evaluate any changes in coccolith morphology. Our underlying hypothesis was that if the species showed a uniform reaction to any of the tested environmental drivers, then this would suggests that the same response may well occur over geological timescales, and that coccolith morphological changes could serve as a palaeo-proxy for that particular driver. Our experiments demonstrated that the four species had no common response to changing light intensity, Mg/Ca, nutrient content or temperature with respect to coccolith size. These results revealed the difficulties in using coccolith size as a proxy for environmental drivers. One exception was an increase in malformations when coccolithophores were grown under excess CO_2, and these data provided evidence that this response variable can be used as a palaeo-proxy for episodes of acute carbonate chemistry perturbations.