Coccolithophorid bloom observed from space

Delayed and reduced coccolithophorid calcification under elevated PCO_2

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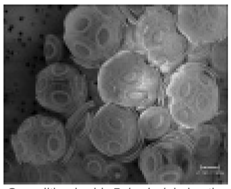
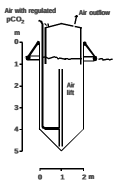
In the context of raising atmospheric CO_2 concentration, the biogeochemical significance of elevated pCO_2 on the future global carbon cycle with regards to **calcifying organisms and communities** remains uncertain. Numerous experiments to date have demonstrated that elevated PCO_2 is detrimental to biogenic calcification rates. This is the case for the **coccolithophorid *Emiliania huxleyi*** which is a major contributor to **pelagic biogenic formation of $CaCO_3$**.

However, most of these experiments have been realized in **batch or continuous cultures** and give little information on the **dynamics of calcification in natural conditions**.
We followed the **development and decay** of a nutrient-induced bloom of natural assemblages of coccolithophorid *Emiliania huxleyi* in large seawater enclosures submitted to in situ conditions (light, temperature…) and placed under various atmospheric CO_2.



Coccolithophorids *E. huxleyi* during the experiment

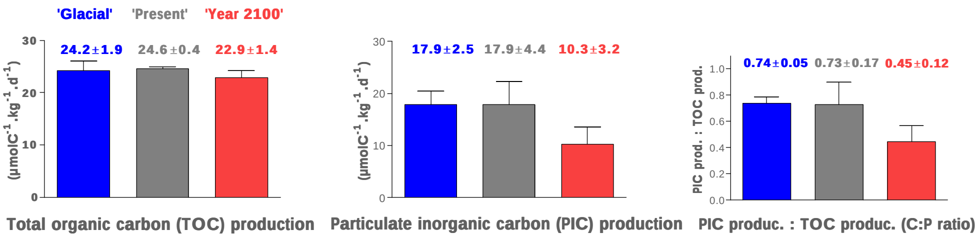
Experimental set up



The response of primary production and calcification of the coccolithophorid Emiliania huxleyi to different partial pressures of CO_2 (pCO_2) were investigated during a mesocosm bloom experiment in a Norwegian fjord.
In 9 **large sea-water enclosures** (volume of 11 m³) filled with unfiltrated nutrient poor (post-spring) water pumped from the fjord, pCO_2 in tents covering the surface was regulated to achieve 3 different levels with 3 replicates each, namely 180, 370 and 700 ppmV corresponding to glacial, present and future (year 2100, assuming IPCC's "business as usual" scenario IS92a) atmospheric CO_2 levels. The bloom of *E. huxleyi* was initiated by adding nitrates and phosphate in the mesocosms.

Net community calcification was computed from total alkalinity (TAlk), while **net community production** was assessed from dissolved inorganic carbon (DIC).

C:P ratio



From the integration of the net community production (NCP) and net community calcification (NCC) over time, we computed the changes of standing stocks of **total organic carbon** (TOC) and **particulate inorganic carbon** (PIC) associated to the bloom of *E.huxleyi* . No conspicuous changes of total organic carbon production with pCO_2 were observed under elevated PCO_2 during this experiment. In contrast, the production rate of inorganic carbon appeared to be **lowered by 40%** in the next century PCO_2 conditions, while the calcification to photosynthesis ratio (C:P) decreases concomitantly from **0.75** ('glacial' conditions) to **0.45** ('year 2100' conditions).

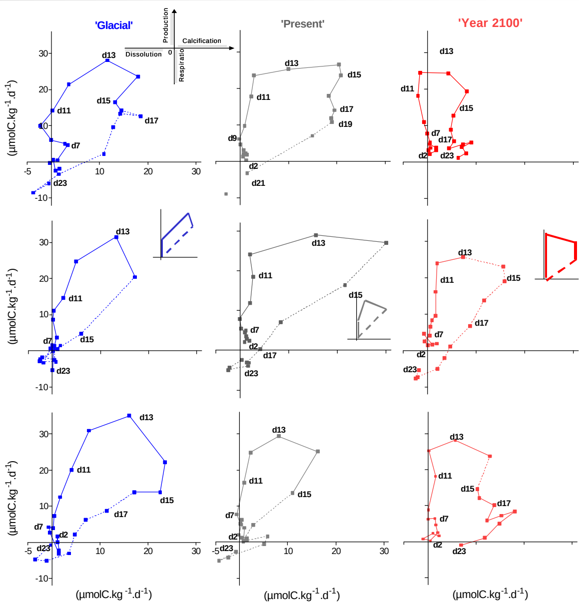
Dynamics of the bloom

Daily net community production (NCP) and calcification (NCC) as a function of time are plotted here. Each point corresponds to a daily measurement so that connecting day to day specifics provides an overview of the temporal evolution of net community production relative to calcification.

In 'glacial' conditions, NCC started at the beginning of the peak of the bloom (d_{10}-d_{11}) increases steadily in parallel to the NCP increase, to lead to almost simultaneous maximum (only one day lag). In contrast, in the 'year 2100' conditions (meso.1, meso.2 and meso.3), NCC started later (d_{12}~d_{13}) and suddenly when NCP has already reached its maximum, and increased very rapidly while organic carbon production was diminishing. The 'present' conditions exhibit an intermediate behaviour between 'year 2100' and 'glacial' conditions: the maximum level of primary production is reached when the rate of calcification is significant but lower than its maximal value.

Thus, if the overall pattern of organic carbon production prior to viral lysis is similar for all the conditions, the onset of calcification is **delayed by 24~48h in the 'year 2100' condition** compared to the the 'glacial' and 'present' conditions. Furthermore, in the 'glacial' conditions NCC **increases steadily** at the very beginning of the peak of the bloom in parallel to the exponential increase of primary production, while in the 'year 2100' NCC **occurs suddenly** at the maximum of organic carbon production.

We surmise that such delaying of the onset of calcification in the 'year 2100' conditions would act to **reduce the overall production of $CaCO_3$** in the course of a natural bloom.



Conclusions

Production of inorganic carbon appeared **to be affected in two ways**. Firstly, the production rate of inorganic carbon appeared to be **lowered by 40%** in the next century PCO_2 conditions, decreasing concomitantly the calcification to photosynthesis ratio from 0.75 (glacial conditions) to 0.45 (next century conditions).

Secondly, the onset of calcification was **delayed by 24~48h** under elevated PCO_2 conditions reducing the overall length of calcification in the course of the bloom. These two effects would act to reduce the amount of precipitated $CaCO_3$ by coccolithophorids *E. huxleyi* in a High CO_2 world

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