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Interactive Comment

Interactive comment on "A mathematical modelling of bloom of the coccolithophore *Emiliania huxleyi* in a mesocosm experiment" by P. Joassin et al.

P. Joassin et al.

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Dear reviewer,

We do thank you for your comments which will indubitably help us to improve this work. Taking into consideration all your suggestions, please consider the following actions regarding the model itself or the discussion relative to its application.

Reviewer: "Modelling is about using simulation to help provide insight into the dynamics of systems, not merely reproducing observations"

We would first like to recall that this model has been developed in the framework of the Bergen mesocosm experiment which aim was the impact of varying pCO2 on sev-



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eral cellular Ehux processes able to contribute to an export of carbon, i.e. the primary production, the production of TEP and the production of calcite. The experimental approach especially focused on these processes, providing a large set of relative measures. The model was not developed to bring new findings on each specific process, but rather to take advantages from the diversified available data set in order to test various parameterizations concerning these three processes. Doing so, the model intended to study the interactions between these processes as well as their specific response against changes of pCO2. Considering this challenge, we think it is justified to underline the fact that model succeeds to represent correctly all the available observations, reflecting the whole experimental approach. Actually, the model permitted to verify those formulations conventionally used to represent calcification, primary production and TEP production. The good matching of the model results with the interconnected observations provided all by the same experience constitutes a positive appreciation of the adequacy of the formulations used to represent the mentioned processes. This demonstrated also the coherence of the experimental data set. The model also innovates; experimenting for a first time the representation of particular processes such the enhancing of cellular mortality due to viral lysis in confined environment. Till now, there was no investigation about the necessity to include such process in order to correctly represent an experimentally induced bloom. Concerning this aspect, the model gives a solid conclusion, demonstrating that the enhanced mortality due to viral lysis should not be ignored in confined environment. Beside this viral aspect, the model does bring clarification to the global dynamics of coccolithophores by demonstrating that an unbalanced growth in carbon and nitrogen is duly needed to reproduce the temporal decoupling between DIC and DIN uptakes. This learning is actually one of the most important elements of the conclusion and so far, all the model of coccolithiophores use balanced growth model only representing nitrogen cycling (e.g; Tyrell and Taylor, 1996). In this study we have quantified (by estimating the Ehux extra-excretion) the importance of the unbalancing between carbon and nitrogen. We will clarify these points in the paper by adding a paragraph in the introduction, highlighting more clearly

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model objectives.

For summary, to our opinion the major outputs of our work are: - The model learns about certain simplifications of Ehux mathematical representation. One of them concerns indubitably the state variables of free calcite and attached calcite. Following model results, it was observed that the molar calcite to organic carbon ratio of an Ehux cell remains quasi unchanged between values of 0,55 to 0,57. Regarding that fact, and within the condition that the model is applied in environmental conditions where there cannot occur any dissolution of calcite, the model economises both state variables of free and attached calcite. - The model demonstrates that the unbalanced growth model is duly requested to represent Ehux. The decoupling between DIC and DIN uptakes is certainly requested if the model aims to represent the TEP production, which is basically driven by the evolution of the cellular C:N molar ratio. - As said before, mathematical representation of important processes affecting coccolithophores were thoroughly validated with the diversified data set.

In future applications, we will use results of this study to represent the dynamics of coccolithphores in the Black Sea. We will represent this group by two boxes: carbon biomass and nitrogen biomass assuming that the Ca:C ratio is constant. All the mathematical formulations of processes will be kept unchanged as well as the parameters set. Then, we will assess whether a re-calibration of the model is necessary using available data (that are unfortunately very scarce: only a few DIC, alkalinity profiles and some punctual measurements of coccolithophores biomass).

Reviewer: "Did the authors try a formulation based on biomass for the calcification, and show that this does not work? "

Concerning the representation of calcification, the text of the manuscript explicitly declares that a comparative approach has been realised, testing both formulations: a first one based on Ehux carbon biomass, and a second based on the Ehux primary production and biomass. Even if this last option (which gave the best results) reveals to

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be not novel, it offers anyway a new confirmation to modellers that calcification has to be considered as a fraction of primary production. In any case, we have clarified in the text why we consider that the representation of calcification as a function of primary production is a kind of innovation in this model.

Reviewer: "The model includes only a single phytoplankton state variable and no state variables for grazers"

In order to avoid an excessive complexity, the model had to deal with several simplifications. Indeed, the model does not offer a direct representation for grazers. Experimentalists affirm that the development of grazers was not sufficient enough to sustain a significant action on Ehux mortality and to affect the phytoplankton growth. Actually, the possible part of Ehux mortality which could be imputable to grazing is included in the constant mortality rate. We have added a subsection in order to better clarify this option.

Reviewer: "The model will ignore the reproduction of groups other than Emiliania huxleyi"

Another simplification resided in the fact that the model does not take into consideration the presence of Micromonas. This phytoplankton specie indeed realises a bloom in the beginning of the experiment, which was observed and measured through the Micromonas enumeration. However, the impact on nutrients stocks due to this Micromonas bloom is not significant. The nitrates consumption imputable to Micromonas does not give a remarkable signal on the nitrates time-series. That last is almost flat at the time of Micromonas bloom. The chlorophyll time-series does manifest a slight increase during the Micromonas bloom, but it reaches a value 10 times lesser than the chlorophyll peak caused by the Ehux bloom. Changing the initial conditions was not a solution to avoid the eventual side-step due to the bloom of Micromonas. If the model started at day 10, the time given to the simulation is not enough to leave the coccolithophores blooming in phase with the observations. Indeed, it should be noted BGD

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that we are using an unbalanced growth model in carbon and nitrogen and thus, time is needed for the C/N ratio adapt to allow Ehux to bloom.

Reviewer: "Why is there no comparison of modelled primary production with data"

As you have suggested it, the modelled primary production could have appeared in the results. Actually, we preferred to validate the model estimated primary production using oxygen data due to the fact that it is always difficult to determine whether it was the net or gross production that was measured. The validation of the gross primary production has been satisfactorily realised with the oxygen concentration measurements.

We finally regret that the level of the English language imposed an effort for the comprehension of this work. Various corrections have been brought to the manuscript, and we follow your suggestion concerning the title. BGD

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