





5, S785–S791, 2008

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.

Received and published: 10 June 2008

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: "I do however have serious reservations about the work, most importantly: (1) Modelling is about using simulation to help provide insight into the dynamics of systems, not merely reproducing observations; this study leans too much toward the latter."



Printer-friendly Version

Interactive Discussion



The referee is right when saying that a big part of the manuscript is devoted to the comparison of model results with the observations. We found indeed this validation exercise crucial and obligatory before applying the model to other pCO2 conditions or to other environments. Indeed, the diversified data set collected in the frame of this mesocosm experiment really gives a unique opportunity to test mathematical formulations, usually used or not, to represent key processes characterizing Emiliania huxleyi dynamics: calcification, primary production, extra-excretion, TEP formation… The good matching of model results with interconnected observations provided all by the same experience constitutes a positive appreciation of the adequacy of these formulations used to represent the mentioned processes. This demonstrated also the coherence of the experimental data set. A lot of mathematical formulations presented in the manuscript are new and thus need to be tested before using the model to understand for instance the impact of changes pCO2 on Emiliania huxleyi dynamics. For instance, the model proposes for a first time the representation of particular processes such the enhancing of cellular mortality due to viral lysis in confined environments. 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 environments. 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 models 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 Emiliania huxlevi 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 model objectives.

In addition, the manuscript does not only describe model data comparison, the model

#### BGD

5, S785–S791, 2008

Interactive Comment

Full Screen / Esc

**Printer-friendly Version** 

Interactive Discussion



has been indeed used to derive carbon and nitrogen budgets during the different phases of the bloom. These flows have not been measured. Thus, the model helped us to identify different structures of the carbon and nitrogen flows. This section is in the discussion.

Reviewer: "The last two concluding sentences of the abstract exemplify this: "The model represented carbon, nitrogen, and phosphorus fluxes observed in the mesocosms. Modelled profiles of algal biomass and final concentrations of DIC are in agreement with experimental observations." So what? Readers will want to learn about biogeochemistry, rather than simply being told that a model matches observations. The main text of the manuscript is largely in the same vein."

We agree that reading the abstract it seems that the paper only deals with the comparison of model outputs with observations. We modify the abstract adding a description of the carbon and nitrogen budget derived from the model. For summary, to our opinion the major outputs of our work are: - Well tested mathematical formulations of important processes associated to Emiliania huxleyi dynamics. - We provide state variables that need to be included to accurately represent Emiliania huxleyi dynamics. - The model provides an understanding of the biogeochemical cycling during the experiment identifying four different phases.

It has been found necessary to describe Emiliania huxleyi both in carbon and nitrogen (2 variables which was not the case in past models of coccolithophores (e.g. Merico and Tyrell, 2004). The fact to use an unbalanced growth model is not a well known feature. Beside, as you know, 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. We found also that the Ca:C ratio is almost constant during the experiment and thus it is not necessary to add a description of attached and detached coccoliths unless coccolithophores grow in an environment where calcite can dissolve. We clarify model outputs in the discussion and conclusions.

## BGD

5, S785-S791, 2008

Interactive Comment



Printer-friendly Version

Interactive Discussion



Reviewer: "Of course, just because an apparently good fit with data was achieved, this does not in itself justify the chosen model structure. Many model parameters were tuned, and I would have been surprised if a reasonable fit had not been achieved."

As in each model, biogeochemical parameters have to be tuned. Unfortunately, it does not exist a well accepted unique value for these parameters but only ranges are available. The most important is that the proposed set of parameters is entirely in the range of values found in the literature.

It must also be recalled that this mesocosm experiment had offered a unique diversified data set to test conjointly several formulations about cellular processes and to derive associated parameters. In our knowledge, this is the first time that a dynamic model of coccolithophores disposes of such a diversified data set to be calibrated. Indeed, alkalinity and DIC data allow for instance the validation of the representation of the calcification process. Data on DOC, DIC and TEP allow the validation of the representation of DOC extra-excretion and TEP formation. Nitrate, Ammonium and phosphate data allow testing the formulation of inorganic nutrients uptakes by coccolithophores. Data on DIC, nutrients and chlorophyll allow assessing the uncoupling of carbon and nitrogen dynamics. All these mathematical formulations were revealed to be consistent with the whole set of observations. This global approach singularises our model as far as the validation of existing models of coccolithophores dynamics may be quite crude. Indeed, the validation of many models including coccolithophores resides only in satellite-derived concentrations in chlorophyll or phytoplankton abundances. In those cases, the absence of data for alkalinity, DIC, PIC and DOC does not allow testing formulations used in these models concerning calcification or TEP production.

We added a paragraph in the discussion where we explain why we consider that the model of Emiliania huxleyi developed in this study is different from existing coccolithophores models. This is because to our knowledge this is really the first time that a model disposes of a so large set of diversified data allowing validating most of the

#### BGD

5, S785–S791, 2008

Interactive Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



representation of biogeochemical processes and estimating their parameters.

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 Emiliania huxleyi carbon biomass, and a second based on the Emiliania huxleyi primary production and biomass. Even if this last option (which gave the best results) reveals to be not novel, it offers anyway a new confirmation to modellers that calcification has to be considered as a fraction of primary production. Indeed, so far, most models of coccolithophores represent the calcification as a function of biomass and not primary production. This is maybe trivial for the reviewer but it is not a well accepted feature in the modelling community. 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. Figure 7 exemplifies the comparison

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

Giving the fact that experimentalists affirm that the rapid end of the Emiliania huxleyi bloom in the mesocosm was due to viral attack and that the grazing was not a significant mortality cause, the model will not go through an explicit representation of grazers. Also, the mortality term related to the mortality of Emiliania huxleyi not due to viral action is a lumped representation of natural lyses and grazing. We have clarified this point in the manuscript where the model structure is described.

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

The development of phytoplankton groups other than Emiliania huxleyi occurred in the beginning of the experiment in some mesocosms. These groups are Micromonas

5, S785–S791, 2008

Interactive Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion



and Synechococcus. The most important bloom is the one of Micromonas. This last realised a bloom which was observed and measured through the Micromonas enumeration. However, available data of phosphate and nitrate showed that the impact of this bloom on nutrients stocks is not significant (these data are presented in section 3). For instance, the nitrate profile remains quasi flat at the time of the Micromonas bloom. The chlorophyll time-series only manifest a slight increase during the Micromonas bloom, reaching values 10 times lower than the chlorophyll peak caused by the Emiliania hux-leyi bloom.

It should be noted that initializing the model after these two early blooms was not a solution to avoid the eventual side-step due to these blooms. 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 that we are using an unbalanced growth model in carbon and nitrogen and thus, time is needed for the C/N ratio to adapt leading Emiliania huxleyi to bloom. This delay is totally in agreement with the observations. We have clarified why we did not explicitly model the other phytoplankton groups bloom in the manuscript in the section devoted to the description of model structure.

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. Figure 5 shows the comparison between the modelled and observed oxygen data.

Reviewer: "The grammar is highly variable, being generally poor throughout (and exceptionally poor in the early sections). Even the title is grammatically incorrect,

## BGD

5, S785-S791, 2008

Interactive Comment



Printer-friendly Version

Interactive Discussion



e.g. it should be something like: "Mathematical modelling of a bloom of the coccolithophore Ehux huxleyi in a mesocosm experiment"."

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 the title has been changed. Sorry, but we are not native speakers.

# BGD

5, S785–S791, 2008

Interactive Comment

Full Screen / Esc

**Printer-friendly Version** 

Interactive Discussion



Interactive comment on Biogeosciences Discuss., 5, 787, 2008.