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Biogeosciences Discussions

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 the time you spent to read our manuscript. Your comments will indubitably help us to improve our work. Here below, you will find our answers to all your comments taken one by one (in italics).

General comment

The mesocosm experiment focused on the impact of the varying pCO2 on different Ehux cellular activities able to participate to an export of carbon, i.e. primary production, calcification and production of TEP. The main goal of our model is to represent conjointly all these three cellular processes as they occurred in confined environment conditions like mesocosms. Our paper concerns the first stage of our model development for which the representation of the bloom is restricted to present-day pCO2 conditions. That first stage should have given a mathematical tool taking into account the various specificities of mescosm affecting Ehux bloom. The structural formulations and the parameters set tested in mesocosms of present-day pCO2 treatment should constitute the best reference model able to study the impact of higher pCO2 treatments, avoiding side-steps imputable to mesocosm conditions. This is why the good matching between model results and observations had to be underlined in the conclusion. Indeed, the choice of the parameters values was motivated by the good matching.

Reviewer:”How the parameters are dependent up on the initial conditions? Do they have some generality which may be used in other modelling studied?”

This question is difficult to answer. Indeed, if you change the initial conditions, you change the framework of the experiment and thus, it is expected that experimental results will be different. It is therefore difficult to know whether the model will be able or not to reproduce the dynamics in this modified environment with our calibrated parameters set or whether a new calibration of model parameters will be necessary to reproduce the new experiment. What we can say is that our calibrated parameters remain in the range found in the literature models (e.g. Paasche, 2002; Tyrrell & Taylor, 2006); with these parameters, model results remain in the range of the three replicates. Microbial loop parameters (bacteria, labile and semi-labile DOC and DON) as well as POM (POC, PON) dynamics have been taken unchanged from the work of Anderson and Williams (1998) (see our bibliography). This parameters set have been found able to simulate the microbial loop dynamics in mesoscoms (e.g. Van Den Meersche et al. , 2004) and in real sites such as the Ligurian Sea (e.g. Raick et al., 2005) and the Black Sea (Gregoire et al., 2008). We essentially focused our calibration efforts on the parameters associated to the dynamics of Ehux. The calibrated parameters values are totally in the range proposed by Paasche (2002). Other parameters concern

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innovating formulations like the ones describing the enhanced mortality due to viral lysis. These parameters are calculated with the relevant data from the three replicates of present-day pCO2 mesocosms. However, in real oceanic case, the parameters set that we proposed for Ehux dynamics will have probably to be calibrated once again. The values we propose in this paper can be good initial starting values. The only way to know is to test the model in a real context. This is our aim in the Black Sea.

It must be recalled that one of the scopes of this paper was not only to provide parameters values but also to test mathematical formulations of processes such as calcification, extra-excretion, DOC aggregation. This mesocosm experiment offered a unique diversified data set to test these formulations. Indeed, in our knowledge, this is the first time that a dynamic model of coccolithophores disposes of such a diversified data set to be calibrated. For instance, alkalinity and DIC data allow the validation of the representation of the calcification process. Data on DOC, DIC and TEP allow the validation of the representation of the process of extra-excretion and TEP formation. Nitrate, Ammonium and phosphate data allow to test the formulation of DIN uptake by coccolithophores. Data on DIC, nutrients and chlorophyll allow assessing the uncoupling of carbon and nitrogen dynamics.

Reviewer: “An experiment without action of viruses would be useful to further explore the performance of the model.”

Your comment concerning the relevance of the viral action is pertinent. The mesocosm experiment offered data permitting to develop equations relative to viral multiplication which is quite new. Actually, viruses affected the bloom dynamics only at the end of the experiment. Prior to the development of these viruses, the formulations concerning only Ehux physiology could have been properly tested. The introduction of an enhanced cellular mortality due to viral lysis was imposed to minimise the impact of the enclosed experimental conditions on the conclusions given by the model concerning Ehux growth. Viral lysis had to be taken in consideration as the Ehux blooms seemed to be terminated by viral lysis in each mesocosms. As it was formulated, the complement of mortality induced by viral action is not a constant rate but is modulated by the density of viral agents and cellular hosts. This complement mortality (added to the constant natural mortality rate) acts thus as an interactive response to the promiscuity between Ehux cells and virus. Unfortunately, there was no replicate of present-day pCO2 mesocosms where virus were totally absent. This makes impossible to test the model in conditions without viruses as you suggested it.

Reviewer: “What are the simplifications that the model would support to remain realistic and to be implemented in real oceanic cases?”

We follow your suggestion concerning the necessity to include in the work a synthesis of the aspects strictly needed to represent Ehux in an extended ecological model. On one hand, the model indeed 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. On the other hand, 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.

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

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