Biogeosciences Discuss., 10, C7147–C7150, 2013
www.biogeosciences-discuss.net/10/C7147/2013/

Biogeosciences
Discussions
Open Access

Interactive comment on "Was the North Atlantic Ocean well-ventilated during Oceanic Anoxic Event 2 in the mid-Cretaceous?" *by* I. Ruvalcaba-Baroni et al.

I. Ruvalcaba-Baroni et al.

I.RuvalcabaBaroni@uu.nl

Received and published: 4 December 2013

We thank anonymous reviewer #2 for pertinent comments. We are very pleased to see that the reviewer has appreciated this manuscript and recommended it for publication. Below are our responses to specific comments made by the reviewer.

1) *I think the title is misleading. Asking the question about ventilation suggests that the study is devoted to the reconstruction of the dynamics of the Atlantic ocean. But it is not the case, since the biogeochemical model described in this contribution is driven by the output from a physical model coming from Topper et al. (2011). I would focus*

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper

more on the biogeochemistry in the title, rather than on the dynamics of the system.

Reply: We have modified the title to emphasize that we focus on the impact of changes in circulation on ocean biogeochemistry and the title now reads:

"Biogeochemistry of the North Atlantic during Oceanic Anoxic Event 2: role of changes in ocean circulation and phosphorus input"

2.1)*a critical constrain of the study is the choice of the NAB subdivisions in the model (the so-called boxes). It is said that the division is based on the location of upwelling and downwelling and the bathymetry during OAE2 (page 13240, line 2 and 3). Can you be a bit more explicit ? What is the dominant factor : upwelling/downwelling or bathymetry ?*

Reply: Both bathymetry and upwelling/downwelling are important and were used to constrain our choices for each box. We therefore included both the bathymetry (Fig. 1) and vertical velocities as calculated by the model of Topper et al. (2011) (Fig. 2a) in the manuscript so that the reader can see for his/herself what the boxes presented in Fig. 3 are based on.

We have modified the text in section 3.1 to clarify that both bathymetry and upwelling/downwelling are important:

"The proto-North Atlantic is divided into 7 boxes based on the location of upwelling and downwelling areas and the bathymetry during OAE2 (Fig. 3). We assume that the limit between the coastal and open ocean is 700 m, following the pronounced change of slope in the bathymetry (dark green areas in Fig. 1). We divide the coastal ocean into five boxes (W3, W4, W5, W6, and W7), according to the upwelling/downwelling areas defined in the model of Topper et al. (2011). These 5 boxes are further divided vertically into a surface water (0 to 100 m) and shallow bottom water (100 to 700 m) box. Two open ocean boxes (W1 and W2) are defined, according to their difference in upwelling/downwelling regime, and divided vertically into a surface (0 to 100 m),

BGD

10, C7147–C7150, 2013

intermediate (100 to 700 m) and deep bottom water (700 to 5000 m) box. This division is used for both pre-OAE2 and OAE2 settings. This subdivision is chosen in order to capture the major ocean circulation patterns calculated by the model of Topper et al., (2011)."

2.2) *Can you discuss in a few words the sensitivity of the model results to the geometry of the numerical model ? I guess it is not negligible.*

Reply: The configuration of the boxes in our model ("geometry") depends on the ocean circulation calculated by Topper et al., (2011). Considering another configuration would lead to changes in the water circulation and would indeed likely impact the biogeochemistry in the model. Increasing the resolution (implementing more boxes) would probably lead to better results, however, it would greatly complicate the calculations and the understanding of the results.

We now briefly touch on the role of the circulation pattern in the discussion (also see our reply to comment 10 of reviewer#1):

"Note, however, that both models do not contain an explicit representation of the coastal zone. Also, both models do not capture the regional circulation pattern in the proto-North Atlantic in the same detail as in our model."

3)*I think a brief discussion of the origin of riverine SRP during the OAE2 would be welcome. If the SRP is coming from continental rock weathering, increasing this flux by 10 or even 60 would require an increase in continental runoff by a similar factor. Such a tremendous increase cannot be sustained by the Earth system, simply because there is not enough incoming solar energy. Lehir et al. (2009, EPSL, 277, 453-463) have demonstrated that even if almost all the solar energy is converted into latent heat, global runoff can only increase by a factor of 2. The amount of energy coming from the sun is an absolute limit to the runoff increase. This was calculated for the specific case of the snowball super greenhouse aftermath, but there is little doubt that the* *runoff cannot increase by a factor of 10 or more globally. Are you thinking of regional changes, or other hypotheses ? The increase in P delivery to the ocean is often invoked to explain OAE, but it is time now to propose some scenarios.*

Reply: The purpose of Experiment 1, where increased riverine SRP is implemented, is to detect if local riverine P supply alone could have driven the bottom waters of the proto-North Atlantic to anoxia.

We demonstrate that a 60 times increase in SRP is what is needed if rivers were the only factor supplying SRP. This is indeed unrealistic. As mentioned in lines 20-22, page 13238, Blättler et al. (2011) suggested that the continental weathering may have increased from pre-OAE2 to OAE2 by a factor of 3. Therefore, we specified on page 13247, lines 2-3 and page 13251, lines 10-15, that a factor of 60 is unlikely: "This P supply is much larger than what can be explained by weathering alone."

In Experiments 6 and 7, where we attempt at realistic values for all forcings, we consider a much lower weathering P supply. This value is based on the results of Blättler et al. (2011). Note that we do not increase the water flux of rivers, instead we increase the concentration of P in the water of the river.

We have now modified the text to make this clear (also see our reply to comment 19 of reviewer #1):

"In experiment E6, such a combination of factors is assessed in an attempt to define a real scenario for OAE2. In this experiment, we assume a 3-fold increase in P input from rivers and increased erosive input of P, together amounting to 0.031 Tmol y^{-1}, and elevated SRP and lower oxygen concentrations in Pacific bottom waters (at 2.9 and 130 μmol L^{-1}, respectively; Table 3 and section 3.4). In these conditions, the southern open ocean..."

Interactive comment on Biogeosciences Discuss., 10, 13231, 2013.