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Interactive comment on "The fate of pelagic CaCO$_3$ production in a high CO$_2$ ocean: A model study" *by* M. Gehlen et al.

Anonymous Referee #2

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General Comments

This study addresses the change in pelagic calcium carbonate production and dissolution in response to rising atmospheric CO2. The parameterization of CaCO3 production includes a dependency on the saturation state of seawater with respect to calcite. It was derived from laboratory and mesocosm studies on particulate organic and inorganic carbon production in Emiliania huxleyi as a function of pCO2. The model predicts values of CaCO3 production and dissolution in line with recent estimates. The effect of rising pCO2 on CaCO3 production and dissolution was quantified by means of model simulations forced with atmospheric CO2 increasing at a rate of 1% per year from 286 ppm to 1144 ppm. The simulation predicts a decrease of CaCO3 production by 27%. The combined change in production and dissolution of CaCO3 yields an excess uptake

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of CO2 from the atmosphere by the ocean of 5.9 GtC. While this paper is potentially a useful contribution to the scientific literature, the authors leave out several important details and references that are vital for providing better clarity and understanding that is a necessary requisite for a successful scientific research article. I strongly recommend that they provide the requested information outlined in the specific recommendations below before the manuscript is accepted for publication.

Specific Recommendations

Page 534; line 15. Provide reference for this statement.

Page 534; line 22. Add Caldeira and Wickett, 2003.

Page 535; line 12. Please provide a reference for this statement.

Page 539; line 9. The authors need to be specific about which thermodynamic constants for the CO2 system in seawater were used in their model. The Lewis and Wallace (1998) program provides a variety of different constants to choose from.

Page 540; line 15. The Dissolution Rate Equation (4) should be

$R_{Diss} = k \times (1 - \Omega c)^n$.

where Ω is the saturation state of the $CaCO_3$ phase of interest). The parameters k and n are obtained by data-fitting and differ depending on the source. A variety of exponents (n) have been proposed for calcite: 4.5 (Keir, 1980), 2.86 (Walter and Morse, 1985), 1.0 (Arakaki and Mucci, 1995; Hales and Emerson, 1997; Hales, 2003 Furthermore, the rate constant (k) also varies significantly and it has been suggested that this is due to variations in either the reactive surface areas or size fractions being studied, or perhaps due to coatings on the minerals themselves. The authors need to provide appropriate references and a detailed explanation for their choice of k and n.

Page 541; line 20. Why was the model run with an atmospheric pCO2 increasing at a rate of 1% per year when the actual rate is approximately 0.5 per year?

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Page 542. The model should be depicting the calcite saturation state, not the lysocline as the authors suggest. Consequently, Figure 2 is not appropriate. What should be plotted is a map of the calcite saturation depth. This is an inappropriate use of the term lysocline, since the lysocline depth refers to the sediment depth where significant calcite dissolution is first observed. The calcite saturation depth is often shallower than the lysocline depth.

Page 542; line 25. The authors state that "model predicts a global dissolution flux of

0.5 PgC/yr and compares well to the Feely et al. (2004) estimate." Since the Feely (2004) estimates includes dissolution of both aragonite and high-magnesium calcite forms in addition to calcite, why should the model agree with the Feely et al. (2004) estimate? Moreover, on Page 543; line 6 the authors say that "Model derived dissolution rates are low compared to in situ dissolution rates summarized by Feely et al. (2004). Please explain how both statements can be true at the same time?

Page 543: line 17. The term lysocline is not appropriate here for the reasons stated above.

Table 2. Should include the Lee (2001) CaCO3 production rates.

Figure 2a is not easy to read.

Figure 2b. The authors should be plotting calcite saturation state, not lysocline depth.

Figure 3. Why is the Pacific dissolution rate above the saturation index?

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