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Interactive comment on "The global marine phosphorus cycle: sensitivity to oceanic circulation" *by* C. P. Slomp and P. Van Cappellen

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Comment 1

On page 1598, we write: "A slowing down of oceanic circulation is frequently invoked to explain the appearance of global scale anoxia in the geological past (e.g. Schlanger and Jenkyns, 1976, Hotinski et al., 2000, Erbacher et al., 2001). We do not write nor assume that a slowing down of ocean circulation will automatically lead to anoxia and that it is the only important factor. We considered the Hotinski et al. (2000) paper to be a good reference since it compares the response of deep ocean oxygen to reduced circulation - and other factors - when assuming different modes of this circulation and shows that decreased convective mixing can indeed drive the ocean to anoxia. To avoid misunderstanding, we have now rephrased the text:

"A slowing down of thermohaline circulation is frequently invoked to explain the appearance of global scale ocean anoxia in the geological past (e.g. Schlanger and Jenkyns, 1976; Erbacher et al., 2001; for a discussion of other possible causes see Hotinski et al., 2000), and is also considered to be a potential future consequence of anthropogenically-driven global warming (Broecker, 1997; IPCC, 2001)".

We did not include the modeled oxygen for the 4-box model since the results show essentially the same trend as those for the 1-box model in Figure 4. We have now added the plots for the degree of anoxia (DOA) for the 4-box and 1-box model in Figure 5. Note that for the 4-box model, DOA is directly calculated from the O2 concentration. We explain this in the legend. We have included a brief description of the results in the text:

"The 1- and 4-box models show a similar increase in the degree of anoxicity (DOA) but a very different response of the marine C and P cycles when the mixing parameters are decreased simultaneously (Fig. 5)." Addition to legend of Figure 5: DOA in the 4-box model is calculated directly from the deep ocean O2 concentrations as DOA = 1-[O2]t/[O2]t=o.

Given the size of the table required for the differential equations, we think it is better not to include it. With the information given in the paper, the model can be fully reconstructed. The model is also available from the first author upon request. This last statement is now included in the paper at the end of section 2.

Comment 2

Tyrrell (1999) shows that external phosphate inputs control longer-term primary production in the global ocean, with the last two sentences of the paper being: "Phosphorus, however, is predicted to be the ultimate limiting nutrient, whose rate of supply simultaneously regulates total ocean productivity. My model can thereby resolve the long-standing debate over the relative importance of nitrate and phosphate for ocean productivity".

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In our model, we assume that it is P availability that determines the rate of primary productivity, which is in line with the work of Tyrrell. Given the effects of redox-dependent enhanced preservation of organic carbon and reduced preservation of organic P as discussed in our paper, and by the reviewer, we believe it is not correct to state that P limits the burial of organic matter.

Comment 3

We used the Van Cappellen and Ingall (1994) model for the comparison. That is indicated in section 2.5 and in the caption of Table 5. The 1994 version does not include the P box referred to.

Comment 4

Our model predicts (Figure 8) that changes in open ocean vertical circulation largely determine primary production in both the coastal and surface ocean. This suggests that the response of the exchange with the shelves upon changes in thermohaline circulation is not so important. The conclusions drawn in this paper are based on the results of our model and we are not claiming that we are providing the final answer to all issues addressed. We have modified the first sentence of the conclusion section to make this more clear:

"Our model results suggest that a reduction in oceanic circulation results in a net transfer of soluble reactive phosphorus (SRP) from the open ocean to the coastal ocean, thereby increasing primary production and reactive P plus particulate organic C (POC) burial on the continental shelves."

Box modeling is a necessary, preliminary step before the implementation of biogeochemical processes in general circulation models. We are currently starting work with a 3D general circulation model, since it indeed is the logical next step.

Interactive comment on Biogeosciences Discuss., 3, 1587, 2006.