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Climate of the Past Discussions

Interactive comment on "Deep ocean ventilation, carbon isotopes, marine sedimentation and the deglacial CO₂ rise" *by* T. Tschumi et al.

Anonymous Referee #1

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Tobias Tschumi and colleagues present a time-dependent, multi-proxy analysis investigating the marine carbon cycle across the last glacial termination. Their study considers 13C and 14C-cycling explicitly in the fully-coupled Bern3D+C model with sedimentation of all particulate species. The authors explore the sensitivity of atmospheric CO2 and marine biogeochemical cycles to changes in the ventilation state of the subsurface ocean and the ocean carbon pumps and sediment formation.

Given that my expertise is mostly in paleoceanography, I have concentrated myself to comment on the interpretation and analysis of paleoceanographic observations. I have thus assumed that the model architecture was fully suited for the study presented here.

The results presented in this manuscript are quite remarkable. The analysis is detailed and well balanced. Strengths and weaknesses of their model outputs are recognized and discussed objectively. The manuscript is richly illustrated and the figures are crucial to logically convey the authors' main arguments. In particular, I really appreciated the new hypothesis presented to possibly explain ambiguous aspects of certain paleoceanographic records (e.g. p.1923-1924).

The authors will find my comments below. They should be pretty straightforward to address.

I have a major comment/suggestion, though – I was wondering if the authors would be able to differentiate between preformed- and regenerated nutrients in their model, possibly using δ13C and AOU? Recent studies (e.g. Sigman & Haug, 03, Ito & Follows, 05, Marinov et al., 06; Sigman et al., 10) have suggested that the efficiency of the biological pump was scaling with the fraction of the global nutrient pool that is respired vs preformed. Given that the authors briefly discuss model outputs regarding relative changes in nutrient utilization in the Antarctic Zone of the Southern Ocean (p.1917, first §), these observations could be used to derive changes in the preformed nutrient fraction injected into the ocean interior and its impact on atmospheric pCO2.

Minor comments:

- p. 1898, l. 2 – by initial driver you mean internal forcing feedbacks? - p. 1898, l. 29 – there has been recent evidence for increased sequestration of remineralised C into the deep Pacific during the LGM (e.g. Bradtmiller et al., 10; Jaccard et al., 09), further refining the nutrient deepening hypothesis (Boyle, 88). - p. 1898, l. 27-29 could also be due to slower sinking organic matter degradation under colder water temperatures (Matsumoto, 07, Kwon et al., 09) - p. 1899, l. 27 – p. 1900, l. 2. Recent observations have shown that changes in the ventilation at intermediate depths, particularly in the Indo-Pacific had major influence on the glacial nutrient inventory. A decreased volumetric extent of oxygen minimum zones likely reduced both the marine

sinks for NO3 (e.g. Deutsch et al., 04) and PO4 (e.g. Wallmann, 10), observations that would not necessarily be linked to sea-level fluctuations. - p. 1900, l. 9. - The Marchitto et al., manuscript you are referring to has been published in 2005 (and not 2004 as stated). - p. 1901, l. 11 - Keep in mind that a 30% increase in the glacial nutrient inventory is likely an upper limit (see e.g. Deutsch et al., 04 and Wallmann, 10). - p. 1910, l. 8. The parameter that is really significant for the biological pump is the export production and not the biological productivity. - p. 1910, l. 9 - A glacial increase in export production inferred for the Northern Pacific is at odds with paleoproductivity reconstructions (see e.g. Crusius et al., 04, Kohfeld et al., 05, Galbraith et al., 07 or Jaccard et al., 09). Export production is considered to be limited by iron and light availability, similarly to the Southern Ocean. Can this be explained by the fact that upwelling/vertical mixing in the North Pacific is overestimated in the model? - p. 1910, l. 10 – please specify if you consider both Subantarctic- and Antarctic zones in the term Southern Ocean. - p. 1913, l. 28 – please add references - p. 1917, l. 1-5 – Schmittner et al., 07 proposed a similar conclusion. Could you please elaborate and confront your observations with theirs? As well, I am not too sure where the nutrient utilization observations – that could be useful for the respired/preformed nutrient discussion (see above) – are derived from. - p. 1917, l. 14-15 – somewhat obscure, please consider revising "i.e. the alteration. . ." - p. 1922, l. 22 – concluding (typo) - p.1925, l.3-10 - consistent with deglacial CaCO3 and OM flux reconstructions from the North Pacific (e.g. Jaccard et al., 05; Galbraith et al., 07) as well as CO32- reconstructions based on benthic foraminifera Zn/Ca (Marchitto et al., 05) measured in the deep eq. Pacific.

Interactive comment on Clim. Past Discuss., 6, 1895, 2010.