Biogeosciences Discuss., 6, C1174–C1180, 2009
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Biogeosciences Discussions

Interactive comment on "Skill assessment of the PELAGOS global ocean biogeochemistry model over the period 1980–2000" *by* M. Vichi and S. Masina

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Received and published: 14 July 2009

As requested by all referees, we have substantially revised the manuscript by adding a new section named "Discussion and applications" (new Sec. 4). The aim of this new section is to separate the part related to the objective assessment from the discussion on the subjective acceptability of performance indicators and the applications of the validated model to assist process understanding.

We thank the reviewer for appreciating the assessment effort. We agree with him/her that model evaluation is a necessary step to gain credibility for biogeochemical models and we also share the considerations that model assessment is ultimately a subjective

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process. However we would prefer to use the concept of "acceptable levels" of validity (e.g. Rykiel, 1996), which is still subjective, but requires the definition of objective thresholds. We have added these thoughts in the discussion.

In order to highlight the scientific results of the manuscript besides the definition of acceptability criteria and the pass-fail analysis, we have now discussed more thoroughly some of the outcomes as suggested by the reviewers.

The discussion section now includes the three points raised by the reviewer:

1. We added a new section 4.1 "Analysis of major bias" where we discuss and justify the major discrepancies presented in Sec. 2. In particular, we added the following experiment as suggested by the reviewer:
   A sensitivity analysis has been performed to demonstrate the linkage between primary production and biomass formation in the Southern Ocean and the seasonal cycle of the mixed layer. We thank the reviewer for suggesting the techniques to perform this analysis. The results are shown in Fig. 1 and 2 (this comment) and also included in the new Fig. 12 in the revised manuscript. The results indicate that simulated chlorophyll is substantially reduced by artificially increasing the minimum level of turbulent kinetic energy throughout the year in the Southern Ocean. This is however only a proof of concept and further work is needed both on the physical and biological components of the model. It is known that the Southern Ocean experiences local intense mixing events (Garabato et al., 2004) and that current MLD climatologies are inadequate to provide robust estimates of this region due to limitations in data availability (de Boyer Montégut et al., 2004). Recently, a new climatology derived from ARGO float data indicates that deeper mixed layers are located in the Subantarctic province, with maxima from June to October (Dong et al., 2008), similarly as obtained in Fig. 1 (this comment). This experiment demonstrates that mixed layer depth controls the annual evolution of phytoplankton in the Southern Ocean and reduces

the systematic bias.

2. The discussion on the importance of DOC measurements when comparing primary production models and incubation data is now more extended as also requested by Ref. #1. The following new subsection 4.2 has been added in the discussion section 4.
4.2 DOC and primary production
The usage of objective skill indicators allowed us to demonstrate that NPP scores improve when the model variable is diagnosed by estimating net particle production (NPP1) and not the more typical difference between gross production and respiration losses (NPP2, Sec . 3.3.2). In fact, the removal of a constant portion of the produced carbon that is directly released as DOC improves the comparison with the ClimPP data set (Table 1 and Fig. 7) and also at BATS (not shown). It is known that a considerable fraction of primary production may be lost directly as dissolved organic carbon in nutrient-stressed conditions (Ogawa and Tanoue, 2003). Recently, a paper comparing 8 different methods of measuring primary production highlighted the role of dissolved organic matter, which may lead to experimental underestimates of 14C NPP especially in the case of nutrient-stressed cells (Robinson et al., 2009). Our results indicate that considering this fraction when comparing with 14C in situ primary production estimates considerably improves the results. However, the choice of a constant fraction that fix the proportion between HMW and LMW DOC is still insufficient. In the more oligotrophic HOT data, the observations lie between the two NPP estimates (Fig. 10). If the amount of colloidal LMW DOC produced at Sta. ALOHA is higher than at BATS due to the more oligotrophic conditions, it is likely that a fraction higher than 50% (as estimated with the ClimPP dataset and used with BATS, cfr. Sec. 3.3.2) be retained by the filter. Concurrent comparisons of 14C NPP, DOC quality and oxygen production fluxes should help to clarify further this issue. Our experiments suggest that a dynamical parameterization of the quality

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of the exudate production may contribute to a more proper estimation of the observed production and export rates, since colloidal DOC may also increase the sinking velocity of organic matter through aggregation (e.g. Engel et al., 2004). It is important to remember that the different estimates of NPP presented in this work do not change the other variable results; it only implies a different way of comparing data with a model like PELAGOS that implements a more sophisticated parameterization of primary production. This occurs because our model of primary production simulates the different carbon pathways and the same methods may not be applicable with specific models built to quantify net (particulate) primary production. However, since most of the biogeochemical models aim at the estimation of net ecosystem production as a proxy to export production, by neglecting this fraction they may underestimate the flow of carbon through the food web.

3. To clarify the issue on the metabolic balance of the ocean, we now included the formerly separated section 5 as sub-section of the new Sec. 4 on discussions. Our results suggest that under current climate conditions the ocean is in slightly positive autotrophic balance as also evidenced by geochemical considerations and recent measurements. We also moved here the considerations on export production at BATS and HOT JGOFS stations that have been compared with estimates by Brix et al. (2006). This part was previously mixed with other results in Sec. 4.2 and not clearly focused.
   We also rewrote the part on the Atlantic transect to clarify the issues raised by the referee. We did not mean to generalize that the extrapolation of any local data may lead to heterotrophic biases when computing carbon flux balance. Indeed, we neglected to include the regional reference to the Atlantic basin in some of our statements. We report that computing the surface carbon flux balance in the Atlantic subtropical ocean using winter boreal period leads to a heterotrophic balance in the model. This balance becomes slightly autotrophic if we consider the

whole year, implying that there is a compensation between summer and winter in the carbon pathways. We hope to have now clarified this issue both in the discussion and in the conclusions

We finally agree with the reviewer that the issue on the metabolic balance of the ocean would require a dedicated study. Given the need to first objectively quantify the validity of the model, this part was not fully exploited in the previous manuscript. That part is now expanded with more details. For the same reason we removed former Sec. 4.3 on the variability of primary production in the equatorial Pacific since, as pointed out by other comments, it required a more thorough analysis of the driving processes and not just a brief paragraph. This topic and further studies on the carbon metabolism will be the subject of future specific investigations both with a coupled Earth System Model and with additional forced simulations.

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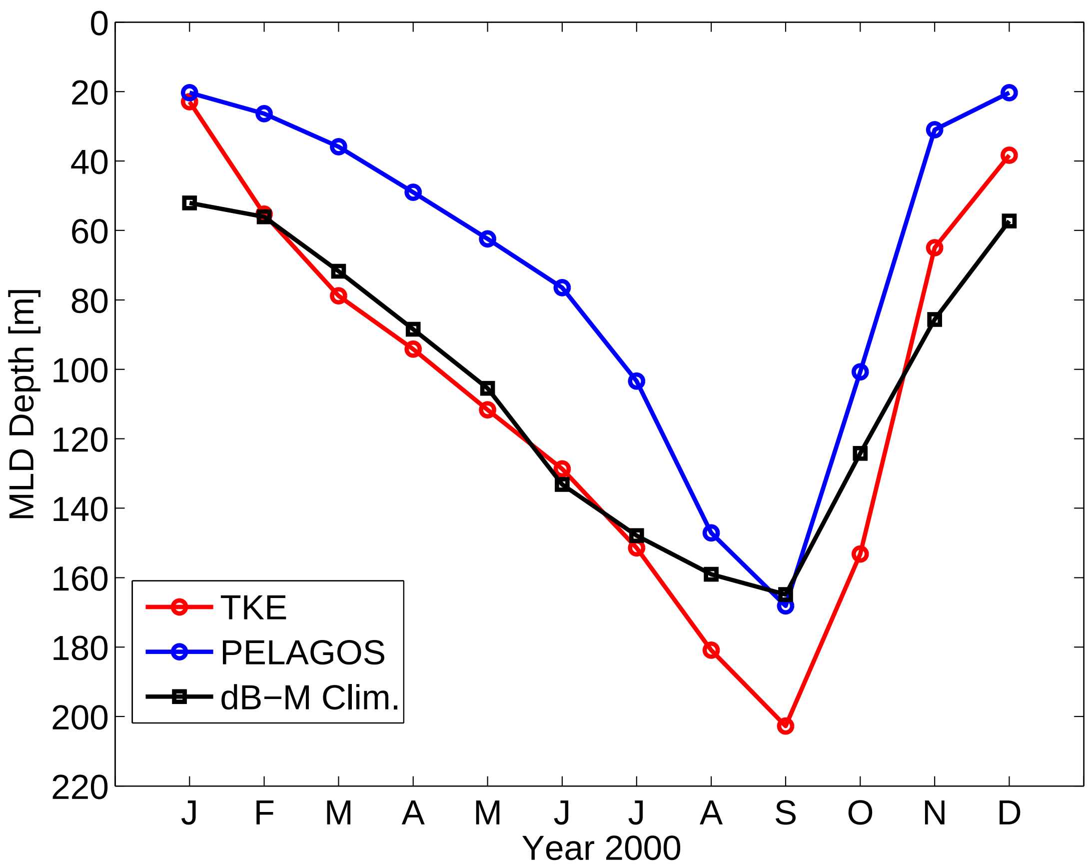

Fig. 1. Results of the sensitivity experiment on the artificial increase of TKE in the Southern Ocean (year 2000). Comparison of the seasonal cycle of mixed layer depths in the Subantarctic province

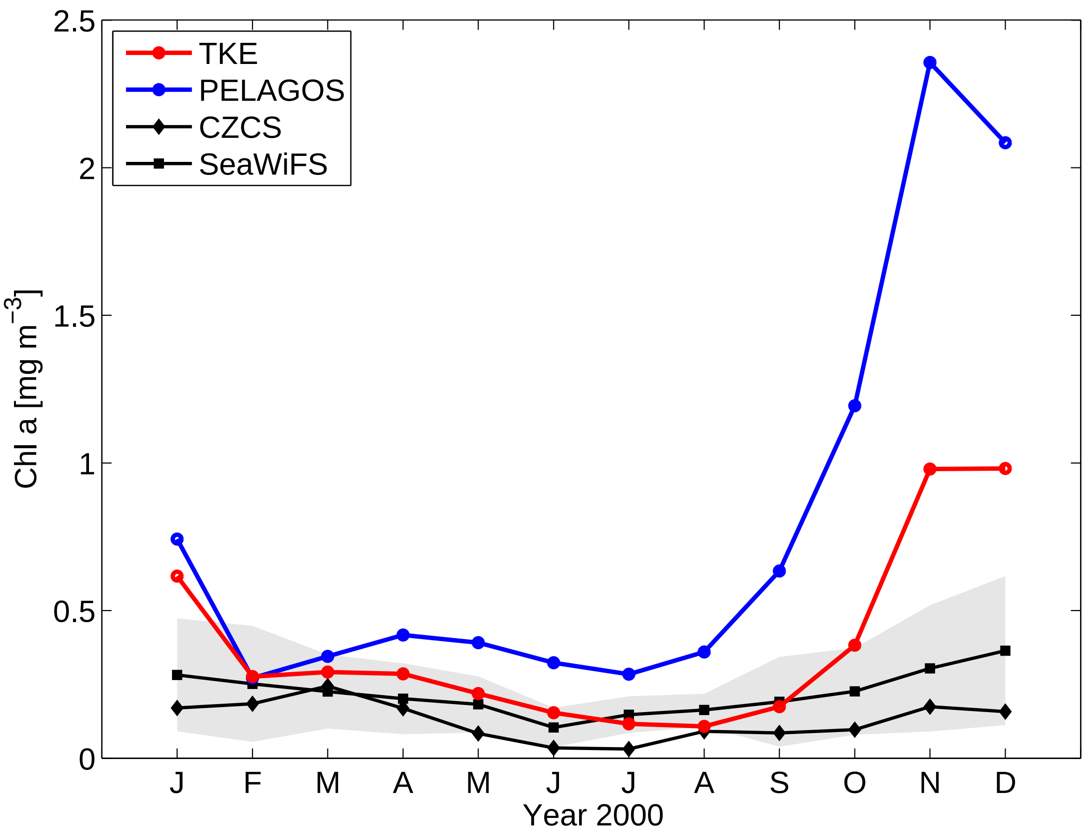

Fig. 2. Results of the sensitivity experiment on the artificial increase of TKE in the Southern Ocean (shown for year 2000). Resulting mean chlorophyll concentrations and comparison with SeaWiFS and CZCS data