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Geoscientific Model Development Discussions

Interactive comment on "A global scavenging and circulation ocean model of thorium-230 and protactinium-231 with realistic particle dynamics (NEMO–ProThorP 0.1)" *by* Marco van Hulten et al.

Anonymous Referee #2

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Review of "A global scavenging and circulation ocean model of thorium-230 and protactinium-231 with realistic particle dynamics (NEMO–ProThorP 0.1)". Here the already existing GCM NEMO-PISCES has been improved by implementing the ocean circulation proxies 231Pa and 230Th. Before going into detail I want to make a general statement: It is remarkable that within 2017 alone three papers on implementing and applying 231Pa and 230Th isotopes into models have been presented ((Gu et al., 2017; Rempfer et al., 2017) and the here submitted manuscript). This points to the high interest of the community into these isotopes as well as to the fact that sufficiently well measured observational data is available now, which was probably not the case almost a decade ago (Burke et al., 2011; Siddall et al., 2007). However, now in 2017

the models obviously have catch up with the grown observational data base. So, the models should be tested not only against observations but also inter-calibrated in order to identify and quantify fields and processes where models still have problems (as done by the experimental geochemists (Anderson et al., 2012)). Such an approach may also help to identify weaknesses of the individual model, but more important it will strengthen each conclusion made from the models when main features are reproduced by all of them. This is not part of the review, of course. I just want to encourage the authors to get into contact with the modellers working on CESM1.3 and Bern3D and others and may think about starting such an inter-calibration project.

Detailed comments:

General: It seems like the submission of this manuscript felt into the time range of the publication of the Guo and Liu paper. Although it was under open discussion since April, the authors may have missed it. Anyway, they definitely should incorporate the findings of Guo and Liu. As well they could provide a short summary (maybe as a table) on all of these recent model papers and what is different with their approaches, how particle fields are generated, how circulation, the range of adsorption/desorption coefficients etc.

page 1: title: I'm not sure about using the term "realistic particle dynamics" in the title. It slightly implies that previous studies have applied unrealistic particle dynamics, which might true for a few only. What about "new" or "refined" instead of realistic?

page1, line 17: I welcome very much that the source code of the model is available.

p2, l133: I think Siddall07 is based on Bern3D.

p3,l1: what is much too low? Please give numbers/factors.

l23-26: these sentences seem redundant from p2 and 1

general: please make sure to introduce all used abbreviations. E.g. table 1: OPA?

table 1: large or big ? Called "big" before.

Fig1 and 3: I'm very sorry but my copy of the manuscript does not show the whole contents of these figures. According to the caption I miss a considerable part of the concept. I tried on a Windows and Linux system.

p5, l11: Hauglustaine04 is a model approach. Why not using a satellite based particle flux?

Fig2: why are dust depositions explicitly shown, but not other fluxes? Whats the transfer function between fig 2 and fig 5d

Table 2: I may have missed it, but why are the factors of the partition coefficients between small and big 5 for POC and 10 for lithogenics?

p9, l14: as mentioned before it might be helpful to give the range of the reported values.

p9, l18: when it comes to particles sizes I consider (Kretschmer et al., 2008) as an appropriate reference.

table 3: here I have a major concern. The model is compared to an arbitrary core top data set. The Oxford data has a global coverage, but the data is quite old and has been measured by alpha- and beta- counting which comprises large uncertanties. I know that there is little new data from the Pacific and the Southern Ocean, but when it comes to the Atlantic or the Arctic Ocean it would be recommendable to compare the model not only to the two Burckel studies. E.g.:(Bradtmiller et al., 2014; Christl et al., 2010; Hall et al., 2006; Hoffmann et al., 2013; Jonkers et al., 2015; Lippold et al., 2016; Luo et al., 2015; Negre et al., 2010; Roberts et al., 2014) (Rutgers van der Loeff et al., 2016; Voigt et al., 2017). In general it is not clear to me, how the goodness of the model versus observations is assessed (e.g. later on page 14). Wouldn't it be helpful to give some statistics?

p11,fig.4: later in the text we learn that the model gives too high 231Pa/230Th values (e.g. Fig. 8d). But given that the circulation scheme of Fig. 4 is not realistic (too

shallow northern overturning) this is not surprising. What parameters are responsible for creating such a shallow overturning, which reminds me rather of a glacial circulation scheme?

p11, l 10: "...has a strong overturning..." relative to what?

Fig. 5: What are the observations shown here based on? Please give references in the caption. I'm sure there are more observations available than shown here. The color codes seem to be scaled by arbitrarily increasing numbers. However, more important, the model generates impressively realistic particle fields, but what about this high production region off Argentina?

p12, l 9-11: I don't understand this sentence.

Fig. 8: I appreciate the overall good agreement with observations. But, as mentioned before, the deep could be much better with a realistic overturning scheme.

Fig. 10: caption: "Concentrations.." of what? Please provide units.

Table 4/p 16, l 3-4: Maybe more explanation needed here on the difference between "stock" and "particle flx". What creates the huge difference for both between bSiO2 and Litho.?

Fig. 11 and Fig. 13: Please use same scale for both plots (0.0 to 0.30 at max. Higher values are unrealistic). As mentioned before, please use an up-to-date data base for the Atlantic. Further it would be helpful to show the Atlantic model and observations in a 231Pa/230Th vs. depth plot like done by (Gherardi et al., 2009) (their figure 5).

p20: something wrong with the line numbering here. I want to suggest that the data mentioned in the "second line 7" (hydrothermal) could be indicated by different symbols in Fig. 12. This would enable to see where the model fails and where not.

chapter 6.1: the "weaker" affinity of Pa to opal is a very interesting finding. In order to strengthen this point it could be helpful to provide an overview of all the values proposed by the different studies, in particular by describing if it was a lab-experiment, in situ observation (where) or the best fit for the model.

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