

Geosci. Model Dev. Discuss., referee comment RC1
<https://doi.org/10.5194/gmd-2021-5-RC1>, 2021
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Comment on Sasaki et al.

Anonymous Referee #1

Referee comment on "Global simulation of dissolved ^{231}Pa and ^{230}Th in the ocean and the sedimentary $^{231}\text{Pa}/^{230}\text{Th}$ ratios with the ocean general circulation model COCO ver4.0" by Yusuke Sasaki et al., Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2021-5-RC1>, 2021

Review of Sasaki et al., 2021 GMDD

The authors present an offline simulation of dissolved and particulate Pa and Th, and sedimentary Pa/Th. The effect of bottom scavenging and scavenging efficiency depending on particle concentration are discussed through sensitivity experiments. The description of the modeling results are in great detail and the authors state that the model reproduces the observations reasonably well. However, there are still many places of model-data discrepancy. I understand that it is impossible to perfectly reproduce the observation, but the mismatch should at least be discussed. In addition, this study lacks novelty. It seems that it is confirming previous other modeling results and provides limited new results for improving our understanding of marine Pa and Th cycle. Also, a critical comparison of this modeling results of sedimentary Pa/Th with other modeling studies is missing.

Detailed comments are listed below:

In the introduction, the authors reviewed previous modeling studies. From the methods part, I see this study is offline modeling, which is a big difference from other modeling studies and should be emphasized.

Line 100, why not using observations for calcite and opal? Why calcite and opal export productions are calculated using ratio and POC observation?

Line 154, sensitivity experiments in this study is using off-line model, it is not appropriate to call them "OGCM experiments", also later in the text.

What is the thickness of the nepheloid layer in the model?

Rempfer et al.,(2017) includes the bottom scavenging in their model, how this bottom scavenging implementation in this study differ from Rempfer et al., (2017)?

Line 170, C_total and C_ref, are they global average or values in each grid? Is C_total on each grid and C_ref a global mean?

Figure 3, although with bottom scavenging, the Pa_d concentration decreases below ~3,000m, from the vertical profile, the observation shows similar values below 3,000m with no decreasing trend with depth, but the model shows a clear decreasing trend (Figure 3d). How to explain this model-data discrepancy? It seems that the bottom scavenging is too strong.

Line 221, the authors pointed out the lower than observation Th_d, what could potentially cause this mismatch? Can it be improved in this model?

Line 250-251 "Similar features are also found for dissolved 230Th". For Pa_d, the maximum around 3,000 is more or less reproduced. But for Th, the maximum in the model is much deeper than the observation. Near 30W, the simulated mid-depth Th_d is much lower than the observation. Also in Figure S6.

Line 251-252, the authors state that the particulate Pa and Th are well reproduced. It is not obvious in Figure S5c and d due to the colormap scale. In Figure S5c, observations are all in dark blue (hard to tell the value from the color bar), but simulation has some green-yellow values. What processes in the model cause these high values in Pa_P? Also in Figure S5, Pa_P/Th_P should also be compared with observation.

Line 305, results about 1D_EXP. Sedimentary Pa/Th in the Atlantic is influenced by AMOC and particle flux effect in Siddall et al., (2005), probably AMOC is the first order factor (Gu & Liu, 2017). In this study, transport includes both of these effect. More experiments can be carried out to separate the effect of ocean currents and the diffusion caused by particle effects. In this off-line model, it is computationally achievable.

How is simulated sedimentary Pa/Th in CTRL and 3D_EXP compare with observation quantitatively? In Rempfer et al., (2017), the bottom scavenging is suggested to not affect Pa_P/Th_P to a small extent and also not affect the relationship between Pa_P/Th_P and AMOC. Does this study support the results in Rempfer et al., (2017)?

Also, how is the sedimentary Pa/Th in this study compare quantitatively with other previous models? This is important because sedimentary Pa/Th is an important paleo proxy.

Line 334-336 is confusing. Please rephrase to make it more clear.

Line 339-340, what is the "ocean transport" here mean? Southward transport by the lower limb of Atlantic Meridional Overturning Circulation or diffusion?

Line 340-342, "At the same time...; as a result..." I cannot follow the logic here.

Line 379: Residence time is calculated in CTRL_EXP and Siddall_EXP, with bottom scavenging the residence time is significantly decreased. However, the residence time in CTRL_EXP is similar to the residence time in (Gu & Liu, 2017) which does not include bottom scavenging. Does this mean the correct residence time does not necessarily need bottom scavenging?

Line 426 "Part of the error comes from the oceanic flow fields simulated in the ocean model". How is the oceanic flow simulated in this model? It can be verified against products such as ECCO (Fukumori et al., 2018). Since Atlantic sedimentary Pa_P/Th_P is greatly influenced by AMOC, what does AMOC in this model look like? This information should be provided in the manuscript.

Line 433-434, why not in this study? Results presented in this study are mostly confirmation of previous studies. With the efficiency of this off-line model, more things can be done for example test this particle fields effect on Pa and Th.

The summary is too verbose. Line 435-480 is repeating things in the previous section.

Line 486-489 simulated sedimentary Pa/Th under glacial times are also discussed in a 2-D model (Lippold et al., 2012) and recently in a 3-D model (Gu et al., 2020).

Quantitative model data agreement (Pa_D, Th_D, Pa_P, TH_P, and sedimentary Pa/Th) and also residence time can be summarized in a table for different experiments. In that way, the performance of different experiments can be clearly seen.

Minor issues:

Colorbars only have the highest and lowest values, it is not easy to tell the values in the middle.

Line 38, particulate organic carbon.

Line 47, Gu & Liu, (2017) also show AMOC change on sedimentary Pa/Th. Also, in Gu & Liu, (2017), the particle change due to freshwater and its impact on sedimentary Pa/Th is examined and should be cited in line 432.

Figure 6e, a lot of observations overlapped. It is hard to tell the color.

Figure 4 can be plotted in one figure as Figure 4 in Rempfer et al., (2017). In this way, the relative difference between different experiments is clearly shown.

References:

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