Clim. Past Discuss.,
https://doi.org/10.5194/cp-2019-45-RC1, 2019

Climate of the Past Discussions

Interactive comment on "Carbon isotopes and Pa / Th response to forced circulation changes: a model perspective" *by* Lise Missiaen et al.

Anonymous Referee #1

Received and published: 8 July 2019

The authors implement Pa/Th in the intermediate complexity model LOVECLIM. With the carbon isotopes, which are already in the model, the authors evaluate the responses of different proxies to the freshwater fluxes in the North Atlantic in a classical hosing experiment. They find that the Pa/Th leads the carbon isotopes by a few hundred years in the deep Atlantic. Pa/Th has been implemented in different GCMS and the authors follow the approach in Rempfer et al. (2017). Also, modeled Pa/Th response to fresh water fluxes added to the North Atlantic is carried out in previous studies (Gu and Liu, 2017; Rempfer et al., 2017). However, the comparison between Pa/Th and carbon isotopes helps to distinguish this study with previous modeling studies. Revisions are needed before this could be acceptable for publication.

Major Comments: 1. I find the separation of the single response and the dual response

quite confusing. First, is it really to identify the responses this way? It seems that for the dual response, the first response is associated with the AMOC reduction and the second response is associated with the AMOC overshoot (as pointed out in page 6 line 30). I think it is easier for people to follow if you state this as a response to decreased AMOC or increased AMOC instead of first or late response. Secondly, why some grids (for example 40S, 4000m, Figure 3 a, d and g) show both single response and dual response?

2. Responses of Pa/Th and carbon isotopes in the Atlantic in a hosing experiment are not new and have been examined in other studies already. Since this paper focuses on Pa/Th, their modeled Pa/Th response should be compared to previous studies (Gu and Liu, 2017; Rempfer et al., 2017). Spatial and temporal similarities and differences with these previous studies should be compared and discussed.

3. At the end of the introduction, three questions are raised. The first two questions are discussed in section 3 and 4, but the third question "How can the modelled multi-proxy response help to interpret the paleoproxy records" is not clearly answered. The implication for interpreting the paleoproxy records is not clearly state. This is a very important question for modeling proxies in GGMS. Authors need to add some discussion about this kind of implications in the discussion.

4. More differences between Pa/Th and carbon isotopes in reconstructing past AMOC could be discussed and highlighted. As mentioned above, the novelty of this paper is studying the Pa/Th together with carbon isotopes since the Pa/Th and carbon isotopes in a hosing experiment have been presented in previous studies. However, I feel this multi-proxy comparison is not fully developed in the current manuscript. A more in-depth comparison between Pa/Th and carbon isotopes and their implications for paleoceanography (back to comment 3) are needed.

5. Pa/Th leads carbon isotopes, but lead by how many years? From Figure 5 a and c, it seems that the 300 years hosing is too short for carbon isotopes to fully adjust to

the reduction of AMOC. If hosing is kept longer than 300 years, carbon isotopes may lag Pa/Th response even longer. Therefore, from this 300-years hosing experiment, we cannot determine the exact lead time. This should be pointed out.

6. The modeled Pa/Th is compared to observations in Dutay et al., 2009 and Henderson et al., 1999 (Page 5, line 14). However, in recent years, many new observations are now available. GEOTRACES offers a lot of relevant new data (also used in Rempfer et al., 2017). More core top Pa/Th are also available. A more complete compilation of the observations should be used to tune the model parameters. Also, if comparing to the same compilation of observations as in previous studies (Gu and Liu, 2017; Rempfer et al., 2017; Van Hulten et al., 2018), model performance in simulating Pa/Th can be estimated quantitatively.

Minor Comments: 1. Page 3, Line 27, Gu et al. (2017) simulating Pa/Th in CESM should be mentioned here (higher resolution then Rempfer et al. (2017) and longer integration than van Hulten et al. (2018)). Gu, S., Liu, Z., 2017. 231Pa and 230Th in the ocean model of the Community Earth System Model (CESM1.3). Geosci. Model Dev. 10, 4723–4742. https://doi.org/10.5194/gmd-10-4723-2017

2. Page 4, Authors follow Rempfer et al. (2017) to implement Pa/Th. One advance in Rempfer et al. (2017) in simulating Pa/Th is that bottom scavenging and boundary scavenging are included, which improves the simulation of water column Pa and Th activity. In page 8, line 37, authors state that the bottom and boundary scavenging are not modeled in LOVECLIM. This should be mentioned earlier in section 2.1 (model description and developments). Also, the modeling scheme (similarities and differences) comparing with previous modeling efforts should be discussed explicitly in section 2.1.

3. Page 5, Line 20 Details about the PI forcing should be provided. From Figure 5, there is interannual variability. Is the PI forcing looping in the first 300 years?

4. Section 3.1 Vertical structures of Pa/Th could also be provided and compared to observations (GEOTRACES transects), such as Figure 2 and Figure 3 in Rempfer et

al. 2017. Figure S1 only have particulate and dissolved Pa and Th.

5. Page 6, section 3.2, first paragraph, Figure 5 can be referred here. Then people can see exactly how the fresh water is added and how the AMOC evolves.

6. Page 6, line 14-16, this sentence can be rewritten for easier understanding.

7. Page 7, line 15, Any explanations for the 14C response time difference between the eastern and western basin?

8. Figure 2 gives two examples of the single response and dual response. What is the proxy exactly? Pa/Th? 13C? or 14C? And where is the grid, location and depth? Also, it would be good to add AMOC in this plot for people to follow.

9. Authors use fixed particle fluxes in their hosing experiment. After adding fresh water to the North Atlantic, the particle fluxes will change. Will this particle flux change affect the results of this paper should be discussed.

10. The conclusions and perspectives can be improved to highlight the major findings. Currently, it is too broad and descriptive.

Interactive comment on Clim. Past Discuss., https://doi.org/10.5194/cp-2019-45, 2019.