Geosci. Model Dev. Discuss.,
doi:10.5194/gmd-2017-40-AC2, 2017

Geoscientific Model Development Discussions

Interactive comment on "Neodymium isotopes in the ocean model of the Community Earth System Model (CESM1.3)" *by* Sifan Gu et al.

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Received and published: 21 April 2017

First of all, we thank the reviewer for his/her time for constructing the comments. We should have emphasized that the main objective of this paper is to document the details of Neodymium isotopes in the CESM. Indeed, it is a follow-up of Jahn et al. 2015, which describes carbon isotope implementation in the CESM. We are still working on implementing more different isotopes in the CESM for the purpose of a capability of a direct model-data comparison, which will help us to better understand past climate changes in terms of better interpretations of different proxy records as well as model validation. Since CESM is a community model and Nd module will be included in the next release of CESM, which will be used by many users, we feel it is necessary to document Nd implementation in the CESM. This is a technical paper, which describes and documents a new feature of the CESM, therefore, we submit it to GMD. Improving

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Nd cycle is not the purpose of this paper, but probably will be done in the future work.

Although we have largely followed the method in Rempfer et al. 2011, there are several new features in our work. Firstly, we are using a more sophisticated model and it is not obvious that two totally different model will produce similar results. Therefore, it confirms the robustness of their method. Secondly, we are tuning parameters for the CESM using a more completed data, but it gives similar parameters as in Rempfer et al. 2011, which confirms the robustness of the overall magnitude of the parameters. Thirdly, we have eco_Nd, which is coupled with active marine ecosystem, as well as abio_Nd, which is similar as Rempfer et al. 2011. The small difference between eco_nd and abio_Nd is anticipated because the particle fields used in abiotic Nd module is the climatology of the particle fields in the marine ecosystem. Therefore, in principle, when equilibrium is reached, abiotic and biotic should produce the same climatological Nd fields (there are some seasonal variations, but the comparison showed in the paper are all decadal mean). However, if we use this module to do paleo simulation, in which both circulation and particle fields are changing, these two versions of Nd have the advantage that we can separate the two effects. But this kind of simulation is out of the scope of this study and we are working on some paleo simulations and will address this abiotic and biotic difference in our future work.

In the following, we have addressed all comments, with the original review text quoted. "(1) Way to optimize tuning parameters and evaluate simulation performance fboundary and [Nd]p/[Nd]d are optimized by cost function J (Figure 3). There is no information about spatial distribution of difference between observation and model simulation except for several selected profiles (Figures 9 and 10). Histograms (Figures 6 and 7) only present the trend in major oceanic basins for four depth layers. The size and spatial distribution of difference between observation and model will provide the information about under and/or over-estimation of source and sink terms. For instance, I would like to see the results of the tuning that is realised separately for different oceanic basins (Atlantic and IndoPacific separately and Southern Ocean as buffer zone to ensure the continuity, for example). The upper layers affected by dust and river water will be treated separately from and the lower layers. With higher spatial resolution and more observational data relative to the previous study, such treatment would be possible. Since lithology and distance from continental margins are different between Atlantic and IndoPacific, it is not surprising that different parameterization lead to better simulation of seawater Nd concentration and "Nd values. About the evaluation of simulation performance, the authors continued to use a track of vertical sections from Atlantic to Pacific (Figure 2a). Because of large gradient of Nd concentration and "Nd from Atlantic to Pacific, moderate amplitude of discrepancy is not visible with this presentation. Basin-scale transect is more appropriate for this study. About the criteria of good agreement (3 "-units) should be revised because this size is equivalent or larger than changes in glacial/interglacial intermediate/deepwater "Nd values."

In addition to the several selected profiles (Figure 9 and 10), histograms (Figure 6 and 7), the spatial distribution of difference between observation and model simulation can also be seen in Figure 5 (the transect from the North Atlantic to the North Pacific). Figure 8, the scatter diagram, is another more direct comparison. We are trying to show our model is able to capture the general features of both [Nd]d and εNd.

Thanks for suggesting tuning parameters in different regions. It is a very good idea. Indeed, we are planning to use an ensemble Kalman filter method to perform parameter estimation for this ocean model and it will be interesting to optimize the parameters in different regions (Liu et al., 2014) in the future.

We agree that for the transect, a basin scale plot is more appropriate. Please see this in the Figure attached (Fig.1 in this AC).

This +/- 3 εNd for validating is from Rempfer et al., 2011, we use their measurement as a benchmark, therefore we can compare with their results quantitatively.

"2) Assumption of homogeneous Nd flux from margins This assumption was already questioned in the study of Rempfer et al. (2011) by the authors themselves (“a globally uniform flux of fbs probably is not valid”). It will be really interesting to tackle this difficult issue because there are some new evidences. The first clue is the partial dissolution of river particle. This potential source had been considered independently from margins before the idea of the boundary source is generally accepted. A recent study on Amazon river mouth demonstrates the dissolution of detrital fraction and Nd release to the ocean (Rousseau et al., 2015). Since river runoff was simulated in CESM, river sediment flux could be quantitatively evaluated by assuming ratio(s) between dissolved and solid phases, a partial dissolution rate and a Nd concentration in solid phase. It is a similar treatment to dust Nd flux. This consideration will contribute to establishing weighted Nd flux from margins. The second clue is Nd release from poorly chemically weathered detrital fraction in relation to the dynamics of cryosphere (Howe et al., 2016). Howe et al. (2016) indicated detrital Nd contribution in the Labrador Sea due to Laurentide ice sheet retreat in the early Holocene. At present, glacier and ice sheet retreat at high latitudes during warm seasons could form Nd flux to the ocean by similar processes. Even if it will be difficult to quantitatively estimate such Nd flux, some sensitivity tests will provide new insight into Nd flux from this source."

Thanks for the references and suggestions. A more realistic boundary source will definitely improve model performance and also improve our understanding of Nd cycle. With more and more available observations, it is doable, for example, using the parameter estimation by data assimilation mentioned above to estimate the boundary source in different regions. But it is out the scope of our current work.

"Specific or minor comments Figures 9 and 10: What are the criteria of selection to show the profiles comparing Nd and "Nd values between observation and simulation?"

We pick these profiles as in Rempfer et al. 2011 to have a inter comparison.

"More recent compilation of seawater Nd and "Nd as well as Holocene "Nd values of sedimentary authigenic fraction and biogenic carbonate by Tachikawa et al. (in press) provides hydrography parameters (temperature, salinity, nutrients) that could be useful for data model comparison, for instance with Figure 11."

Thanks for pointing out this new compilation of data. More available observation is always good. The first version of this study is using the data by Lacan et al., 2012. After van de Flierdt et al., 2016 (which is about double the amount of Lacan et al. 2012) is available, we re-do all the parameter tuning and analysis using more complete data set. However, there is no significant improvement as shown in the table attached (Fig2 in this AC). CTRL_new is the optimal parameter using the new data (van de Flierdt et al., 2016). CTRL_old is the optimal parameter using the old data (Lacan et al., 2012). CTRL_R_new is using parameters in Rempfer et al. 2011 and the new observation data. CTRL_R* is results in Rempfer et al. 2011 (old data).

Interactive comment on Geosci. Model Dev. Discuss., doi:10.5194/gmd-2017-40, 2017.

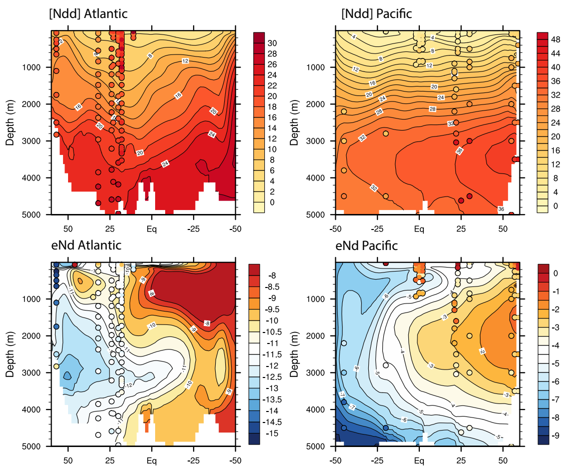

Fig. 1. [Nd]d and eNd track in the Atlantic and Pacific basin

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Exp	$\frac{[Nd]_p}{[Nd]_d}$	$f_{boundary}$ (g yr^{-1})	Inventory (g)	τ_{Nd} (yr)	$J_{[Nd]d}$ (pmol kg^{-1})	$J\varepsilon_{Nd}$	J_1 (%)	J_2 (%)
CTRL_new	0.0009	4×10^9	4.3×10^{12}	785	8.1	1.76	72	82
CTRL_old	0.0008	4×10^9	5.0×10^{12}	900	9.6	1.8	71	82
CTRL_R_new	0.001	5.5×10^9	5.1×10^{12}	720	9.3	1.78	64	83
CTRL_R*	0.001	5.5×10^9	4.2×10^{12}	700	9	1.66	70	83

Fig. 2. Parameters and general performance of different experiments

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