Geosci. Model Dev. Discuss., 7, C2817–C2819, 2014
www.geosci-model-dev-discuss.net/7/C2817/2014/

Geoscientific Model Development Discussions

Interactive comment on "Carbon isotopes in the ocean model of the Community Earth System Model (CESM1)" *by* A. Jahn et al.

Anonymous Referee #2

Received and published: 31 December 2014

The manuscript by Jahn et al. describes a new implementation of the carbon isotopes ^{14}C and ^{13}C into the ocean component of the Community Earth System Model (CESM1). ^{14}C and ^{13}C are tracers that are often used as paleoclimatological proxies, but that can also be used e.g. as proxies of anthropogenic carbon or to validate the ventilation of the deep ocean in circulation models. Two different implementations are described: One that models only ^{14}C and neglects biological uptake following the OCMIP-2 protocol, and one that models both ^{14}C and ^{13}C and that takes into account fractionation during biological formation of particulate carbon (both organic and calcium carbonate). After a detailed and useful description of the implementation in chapter 3, it demonstrates the use of the implemented carbon isotopes by comparing them to present-day ocean observations in chapter 4. One interesting aspect of the paper is that several formulations for the fractination during phytoplankton growth that have

been discussed in the biological literature are implemented here, so that one can see whether they result in very different distributions of δ^{13}C in the ocean. The effect is relatively minor, which is reassuring for people using carbon isotopes as proxies. What is lacking in the manuscript is a brief overview over where the implementation differs from that in other models, e.g. those cited on page 7463. This could easily be amended.

The description of the model implementation of the carbon isotopes, which is the main focus of the paper, is detailed and well-written, and it will become a useful reference for other groups that want to include isotopes into their ocean biogeochemical models. I would therefore recommend to accept the paper for publication after a few minor revisions.

I share the concern by the first reviewer that the model runs presented in the results section are not in equilibrium, especially the distribution of Δ^{14}C in the biotic run. Probably, in the meantime the model has run for a few thousand model years longer and I would suggest to replace the figures and numbers in the results section with ones from a later stage of the model experiments.

The authors use a constant fractionation of 2‰ for ^{13}C during formation of calcium carbonate, referring to Ziveri et al. (2003) (page 7474). Ziveri shows a range of about 5‰ for different species (from +3 to -2), and several other studies indicate a smaller fractionation around 1‰, see e.g. Zeebe and Wolf-Gladrow (2001), Figure 3.2.13. Although the effect on δ^{13}C in dissolved inorganic carbon is probably negligible, this may bias the interpretion of δ^{13}C values from marine carbonates. I would suggest that the authors describe briefly the range of fractionation factors found and add a few more citations.

Chapter 5 describes very briefly that the carbon isotopes have now also been implemented in CESM version 1.2, which includes a simple description of marine sediments. How this sediment model works, however, is not described in sufficient detail, and neither is how the carbon isotopes are represented in it. Early diagenesis can affect the

isotopic composition of DIC near the bottom of the ocean and of foraminifera recording it (Mackensen et al., 1993), and it would be useful to know whether these effects are represented in the model. I would therefore suggest that the authors add a little more model description here. Are the modeled distributions of carbon isotopes in the water column affected to some extent by the addition of a sediment module, e.g. by a burial loss with a $\delta^{13}C$ that differs from the average $\delta^{13}C$ of seawater?

Minor comments

Page 7478, line 18: 'differences . . . is': either use singular or plural

Page 7492, line 28: 'active uptake or' → 'active uptake of'

Page 7494, caption table 1: 'using' → 'used'

References

A. Mackensen, H. W. Hubberten, T. Bickert, G. Fischer, D. K. Fütterer, The 13C in benthic foraminiferal tests of Fontbotia wuellerstorfi (Schwager) relative to the 13C of dissolved inorganic carbon in sou- thern ocean deep water: implications for glacial ocean circulation models, Paleoceanography 1993, 8, 587-610.

R.E. Zeebe, D.A. Wolf-Gladrow, CO_2 in seawater: equilibrium, kinetics, isotopes. Elsevier Oceanography Series, 65, Elsevier, Amsterdam, 2001

Interactive comment on Geosci. Model Dev. Discuss., 7, 7461, 2014.