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Interactive
Comment

Interactive comment on "Modeling variations of marine reservoir ages during the last 45 000 years" *by* J. Franke et al.

J. Franke et al.

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Specific comments

... It would have also been instructive to see how well the model surface ocean responded to the nuclear weapons testing spike in atmospheric ^{14}C compared to existing coral records. This would add a degree of confidence in dealing with past rapid changes in atmospheric ^{14}C concentration.

A plot of surface ocean model response in comparison with coral Delta^{14}C reconstructions and corresponding text have been added.

A brief discussion of how well the University of Victoria Earth System Climate Model

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compares to other models ...

An assessment of the overall model behavior is clearly beyond the scope of our manuscript and has been done elsewhere (Meissner et al. 2003, Ewen et al. 2004). It is important that your model successfully simulates a Delta^{14}C distribution that is in agreement with the GLODAP data set and that atmospheric and marine data during and after the testing of nuclear weapons can be simulated properly. In this sense we added a comparison of the UVic ESCM with other models in the OCMIP-2 project (Orr et al. 2002).

An estimate of model reservoir age uncertainty would be extremely valuable especially in potential applications to ^{14}C calibrations. Particularly in Figure 6 it would be very useful if there were error ranges on the temporal variations for at least one of the regions.

In principle we fully agree with the referee that it would be desirable to have an estimate of the uncertainty. However, as outlined below, estimating uncertainties is at the moment computationally unfeasible because a single experiment takes about 6 months to complete and many additional experiments would be needed to estimate uncertainties.

Generally, one has to distinguish three different sources of uncertainties:

1. Forcing – the forcing includes uncertainties caused by using a constant reservoir age between 12.4 and 50 kyr BP, measurement/laboratory uncertainties, smoothed marine data instead of atmospheric reconstructions, changes in the carbon cycle and especially the ocean circulation. Theoretically at least two extra simulations with forcing $\pm$ max error would be needed to estimate an error due to the forcing = 1 year computation time. The only feasible way to assess uncertainties would be to derive the response to various atmospheric forcings by using the impulse-response function at each grid point. However, such an approach is beyond the scope of the current manuscript and will be considered in a forthcoming study.

2. Circulation – large-scale ocean circulation (specifically the rate of NADW formation) is only poorly constrained for the past 45 kyr. One could set up a best guess-type circulation by switching between off (Heinrich Event), intermediate (DO stadials and LGM) and strong (PD and DO interstadials) strength of NADW formation. However, such a forcing would be rather arbitrary and could be easily questioned. In any case it would require at least 6 month computation time.

3. Mixing in the model – experiment with different mixing schemes and diffusion coefficients (especially vertical mixing) would also require many additional experiments. A control run with a new model version that includes a new mixing scheme "tidal mix" indicates only minor changes due to the new mixing scheme.

Monte Carlo experiments are also not possible due to long time period needed for any simulation.

Thus, it appears currently impossible to give an error estimate, at least without running the model for many months or even years!

Technical corrections

p.87 Section 3.4 Line 10. Although on p. 91 the authors note that the ^{14}*C data used for the atmospheric forcing in the model comes from coral and foraminifera measurements with constant reservoir ages applied, it might be good to alert the reader at this stage.*

The suggested alert has been added.

line 15. "...through all the reconstructed data". Perhaps this should read "through the selected reconstructed data" since only the Hughen et al. 2006 and Fairbanks et al. 2005 were used for 25 to 50 kyr BP.

Changed following the suggestion.

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Line 16. It might also be noted that due to the size of the marine surface ocean reservoir, variations in the marine records are generally attenuated, which together with the spline used to construct the atmospheric ^{14}C forcing, are likely to have somewhat smoothed the ^{14}C production variations such as that due to the "Laschamp" event.

Done

Line 19. "As $\Delta^{14}C_{atm}$ reconstructions do not exist prior to 50 kyr BP...". A number of ^{14}C records do extend beyond 50 kyr BP but the data is very scarce and variable (e.g. Hughen et al., 2006; van Kreveld et al., 2000; Voelker et al., 2000)

Done

p.93 Line 7 "Reservoir ages of more than 2000 years were reconstructed in the northern North Atlantic" The maximum raw reservoir age from data in one of the papers referenced here (Bard et al. 1994) was 1600 years but when corrected for bioturbation the reservoir age average 700-800 years at the time of the Vedde Ash layer deposition.

Done

p. 94 Section 5.4 It might be noted here that the reconstructions of Bondevik et al 2006 and Cao et al. 2007 prior to 12.4 kyr BP are based on comparison to the floating tree-ring ^{14}C series of Kromer et al. 2004. A new positioning of the tree-ring data has recently been suggested (Muscheler et al. 2008) which would decrease the reservoir age in the early portion of Younger Dryas in these reconstructions.

Done

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