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Interactive comment on “Interhemispheric gradient of atmospheric radiocarbon reveals natural variability of Southern Ocean winds” by K. B. Rodgers et al.

Anonymous Referee #2

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The authors investigate the change to the interhemispheric gradient of atmospheric radiocarbon in MOM3 and an offline atmospheric transport model when the Southern Ocean wind forcing are changed to scalar multiplication of NCEP winds. The goal is to test the hypothesis that the integrated strength of the winds over the Southern Ocean may have caused the interhemispheric gradient of atmospheric radiocarbon, as recorded in tree ring record and to understand the processes that drive such a change. The model (MOM3) the authors applied has a representation of $\Delta^{14}\text{C}$. They find that simulated interhemispheric radiocarbon gradient is dominated by wind-driven changes over the Southern Ocean, a result primarily through gas exchange (wind speed experiments in the manuscript) in the surface ocean. Based on their simulated results, the

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authors then imply that a weakening of the winds over the Southern Ocean might have been the cause for observed tree ring $\Delta^{14}\text{C}$ and therefore the climate transition from the Medieval Warm Period to the Little Ice Age.

This is an interesting model study that explores the cause of interhemispheric $\Delta^{14}\text{C}$ gradient. The physical process that responsible for such variation is an important one in understanding global carbon cycle and in testing our ability to model it.

My major concern is the gas exchange parameterization they used in light of the conclusion the author arrived – that gas exchange has a profound influences on interhemispheric $\Delta^{14}\text{C}$ gradient. They state (p353, line 10-16) that the Wanninkhof (1992) parameterization overestimates gas exchange (by how much?) as a result they chose over quadratic Wanninkhof instead. While it's reasonable and common to choose the same parameterization in modeling studies, they do not report the sensitivity of gas exchange from the two different parameterizations and to what extent the choice of parameterization will change their conclusion and if this might be the reason that the simulated mean gradient is smaller than the observed data. Given that gas exchange is the dominate factor in driving interhemispheric $\Delta^{14}\text{C}$ gradient (from Fig. 5). A more detail justification of this choice is important, if they are to draw the conclusion they make. If the authors have access to one set of experiment with different parameterizations and the results are consistent with what's reported, it would strengthen the case here.

Related to the conclusion that the simulated interhemispheric $\Delta^{14}\text{C}$ gradient was achieved mainly by gas exchange process (which occurs at the ocean surface), are the author implying that carbon flux between ocean and atmosphere reservoirs at longer (e.g. glacial-interglacial) time scale might be driven by DIC diffusion in the ocean? One reason that previous studies invoke ocean circulation changes is that it brings up carbon rich deep water. In the case where gas exchange is more important than changing circulation (upwelling), DIC in the deep ocean would have to reach the surface ocean for gas exchange through diffusion. Can you comment?

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Minor comments

Sec 2 Model configuration: I find the description of how experiments were carried in MOM3 and ATM a little too terse. Given that it is an important and unique part of this paper; can the author give a bit more information? Specifically, are both MOM3 and ATM are forced by same looping NCEP1 wind? Why using looping wind as it might cause a discontinuation every six years (the end of every loop)? Are you using NCEP long term mean or six hour wind? Do you interpolate NCEP wind to each time step or blowing the same wind for certain period of time?

P354 line18. When include the disequilibrium sink due to the residence time of terrestrial biosphere based on CASA, does the number based on present day vegetation cover?

P361 line25. The author state that the atmospheric $\Delta^{14}\text{C}$ was viewed as a tracer of the global carbon cycle. Can you comment on how much atmosphere-ocean carbon flux for every permill change of $\Delta^{14}\text{C}$? This is of course without the consideration of the downstream effect by ocean biota but would be an interesting one to discuss.

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