

Interactive comment on “Simulating natural carbon sequestration in the Southern Ocean: on uncertainties associated with eddy parameterizations and iron deposition” by Heiner Dietze et al.

Anonymous Referee #2

Received and published: 2 January 2017

GENERAL COMMENTS:

This manuscript describes differences in Southern Ocean (south of 40S) carbon uptake for several coarse resolution (3 degree) model simulations with different eddy parameterizations and a simulation with increased bioavailable iron. In all simulations, winds are increased by approximately 15% over 50 years following spin-up. The major result is that the decrease in Southern Ocean carbon uptake due to increased winds is not significantly different in the three simulations with very different eddy parameterizations. In contrast, the simulation with increased bioavailable iron shows

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a markedly smaller decrease in carbon uptake over 50 years relative to the case with constant bioavailable iron. Other recent studies have suggested that uncertainties in ocean biogeochemistry are of lesser importance with respect to future Southern Ocean carbon uptake compared to uncertainties related to eddy-parameterizations.

This manuscript is concise and focused with an important conclusion and should be published after minor revisions.

SPECIFIC COMMENTS:

Pg. 2, Lines 5-7: I would cite more recent studies here and include recent analyses of observations. Up to the mid 2000s there is evidence from models (e.g., Le Quéré et al., 2007; Lovenduski et al., 2007) and observations (please cite Landschützer et al., 2015) that Southern Ocean carbon uptake may have slowed relative to the expected increase due to the increase in atmospheric CO₂. More recent observational studies (please cite Landschützer et al., 2015; Munro et al., 2015; and Xue et al., 2015) suggest that the sink may have strengthened over the last decade.

Pg. 2, Line 8: I would say something more general like the “the link between variability in surface winds and Southern Ocean carbon uptake remains inconclusive”

Pg. 2, Lines 16-22: I would also mention current observational/model studies that have examined carbon uptake associated with mesoscale eddies within the Southern Ocean (please cite Song et al., 2016). This paper includes an analysis of the Drake Passage Time-series which represents the densest dataset of pCO₂ observations within the ACC. Observations are compared to results from a high-resolution (approximately 0.1 degree) simulation of the Southern Ocean region surrounding the Drake Passage. Both observations and model output indicate how a shifting balance of physical and biogeochemical processes drive air-sea carbon flux during different seasons and gives important context to the complexity of the topic presented here.

Figures: Fig. 7 is the most important in the paper particularly Fig. 7c. I think it would

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be helpful to include a Table summarizing these results with the linear rate of decrease in C uptake with uncertainty over the 50 years of increased winds. Alternatively, you could present the difference in C uptake with uncertainty between the last twenty years of spin-up and the last five or ten years of increase winds (i.e., years 46-50 or 41-50).

Figs. 8-11 might be more appropriate in a supplemental information section if allowed so that the reader focuses on the figures most important to the overall story.

TECHNICAL COMMENTS:

Pg. 2, Line 2: Replace “as regards their” with “with regards to their”

Pg. 3, Line 11: Replace “subsections 2.2.1 and 2.2.1” with “subsections 2.1.2 and 2.2.2”

Pg. 4, Line 3: Replace “following sub-section” with “following subsections”

Pg. 6, Line 32: Replace “were” with “where”

Pg. 7, Line 2: Replace “ratio” with “rational”

Pg. 9, Line 2: Delete “.” Replace “After all” with “since”

Pg. 9, Line 8: Delete “.”

Pg. 9, Line 8: Don't capitalize “T” in first word within parenthesis or remove parenthesis

Pg. 9, Line 10: Replace “is” with “are”

Pg. 9, Line 15: Replace “such as e.g.” with “e.g., as”

Pg. 9, Line 19: Replace “towards the choice of” with “with respect to”

Pg. 11, Line 14: Replace “to” with “with”

Pg. 11, Line 17: Replace “indicative for” with “indicative of”

Pg. 11, Line 25: Replace “Indic” with “Indian Ocean”

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Pg. 12, Line 8: Replace “compute” with “computer”

REFERENCES:

Landschützer, P., et al. (2015), The reinvigoration of the Southern Ocean carbon sink, *Science* 349(6253), 1221 – 1224, doi:10.1126/science.aab2620.

Munro, D.R., N.S. Lovenduski, T. Takahashi, B.B. Stephens, T. Newberger, and C. Sweeney (2015), Recent evidence for a strengthening CO₂ sink in the Southern Ocean from carbonate system measurements in the Drake Passage (2002–2015), *Geophys. Res. Lett.* 42(18), 7623 – 7630, doi:10.1002/2015GL065194.

Song, H., J. Marshall, D.R. Munro, S. Dutkiewicz, C. Sweeney, D.J. McGillicuddy Jr., and U. Hausmann (2016), Mesoscale modulation of air-sea CO₂ flux in Drake Passage, *J. Geophys. Res.* 121(8), 6635, doi:10.1002/2016JC011714.

Xue, L., L. Gao, W.-J. Cai, W. Yu, and M. Wei, 2015. Response of sea surface fugacity of CO₂ to the SAM shift south of Tasmania: Regional differences, *Geophys. Res. Lett.* 42, 3973 – 3979, doi:10.1002/2015GL063926.

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