

Interactive comment on “Natural ocean carbon cycle sensitivity to parameterizations of the recycling in a climate model” by A. Romanou et al.

Anonymous Referee #2

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1 General comments

The paper by Romanou et al. addresses the relevant and topical issue of how differences in physical model parameterization compare to biological ones in terms of their effects on biogeochemical fluxes. While I think that the study presents a valid and adequate approach to address the question, the paper would in my opinion need a clearer presentation of the results. The paper does interpret results of the relevant compartments (detritus, nutrients, primary/export production, carbon cycle) in terms of both physical (circulation) and remineralization rate effects. However, the red thread sometimes gets lost in the amount of detail presented, partly because the underlying physical changes are not described or shown in this paper. This makes the explana-

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tions of the results hard to follow and to believe.

2 Specific comments

p11116, l7-p11117, l7 The model description provides a great amount of technical detail on physical model parameterizations. It lacks a description of how the differences between the physical models affects ocean circulation and relevant properties such as temperature, mixed layer depth etc. These differences are frequently referred to in the results section, and I believe they are explained in detail in Romanou et al., Ocean Modelling, 2013. For understanding the results described here, however, it is crucial to present at least the general picture of differences in physical properties between the models.

p11119, l14 you state that you explore remineralization rates from 0.01d^{-1} to 0.5d^{-1} - why not up to 0.8d^{-1} , if that's the highest literature estimate (l8)?

p11118, l2-4 so is there a large/relevant difference between the two methods?

p11119, l16 can you remind the reader how long it takes to reach equilibrium, and what is meant by the term "equilibrium"? Is the deep ocean also at equilibrium?

p11119, l25ff in the results section you are frequently referring to the subantarctic front (SAF) and the subtropical convergence zone (STCZ). It would greatly ease following the results, if you could indicate the position of these fronts at least in one of the global maps.

p11121, l1-4 "..., then at the surface (Fig. 2a, b) the remineralization term is lower in the tropical upwelling regions and in the polar regions where the surface waters are colder." - lower than what?

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p11121, 15-9 are these differences supposed to be visible in Fig. 2? If so, they're not. Maybe a difference plot instead of absolute values for one of the models helps.

p11121, 124 "the exponential 0.86" - I am guessing that you are referring to a parameter in the Martin curve, or is this number universally known?

p11122, 113 I'm a bit lost here: you say that in GISSEH detritus is near zero south of 60 S because temperatures are much lower in HYCOM in that region. My first thought is that low temperatures should lead to more detritus b/c of lower remineralization rates. Also, in I9 you say that HYCOM has shallower mixed layers due to higher SSTs south of 60 S - can you clarify? what do "higher" and "lower" relate to?

p11123, 119-21 if I understand correctly, you say that increasing the remineralization rate increases nitrate in GISSER, but decreases it in GISSEH, because GISSER is warmer at the surface than GISSEH and effective remineralization rate changes are larger. But doesn't effective remineralization still increase in GISSEH when you increase the remineralization rate? So how can that aspect alone give a positive nitrate change in one model, and a negative change in the other?

p11124, 124-p11125, 12 swapping the 2nd and 3rd sentence would make this paragraph easier to understand.

p11125, 127-29 absolute changes in carbon export are much more pronounced in GISSER than in GISSEH, but what about the relative changes?

p11126, 120-22 "there is a limit of nutrient remineralization increase, beyond which limitations of other nutrients start playing a role" - do you mean that different nutrients are remineralized at different rates in your model? If nutrient stoichiometry is fixed, as I thought it was in the model, how can the limiting nutrient change?

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p11128, 111 I guess small DIC increases as percentage of total DIC are not too surprising, given the large inventory of DIC compared to, for example, the relatively small amplitude of the seasonal signal.

p11128, 119-21 same confusion as in p11123, 119-21: how is the sign difference in changes related to one model being warmer than the other? isn't recycling still increasing in both cases?

p11128, 126/27 shouldn't a smaller vertical gradient reduce vertical mixing?

p11129, 116-p11130, 12 this section is hard to follow, since Fig. 12 apparently depicts just the air-sea CO₂ fluxes, but not their changes due to a change in remineralization rate. Also, the figure caption of Fig. 12 doesn't seem to fit the figure.

p11140, Table 1 what do you mean by "correlations" - correlation coefficients of some sort? Which observations do you use, and what do you mean by "regional"?

2.1 Figures

all global maps using tick labels -90 to 90 or 90 S to 90 N on y axes would make the maps a lot easier to use (check Fig. 12 for a particularly peculiar y axis). Same goes for larger font sizes in almost all figures.

Fig. 1 the colours in the colour scale don't seem to fit those in the plot. Also please avoid using the same colour for land and 0 - it makes the map hard to read. Use grey for the land, for example.

Fig. 2 missing labels for subplots a-f. can you use the same colour scale at least for the 500 m, 1000 m and 3000 m plots? Maybe differences between the model are easier depicted if GISSEH is shown as difference to GISSER, for example?

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Fig. 5 why is the land area around Antarctica different in subplots a compared to c and e?

Fig. 8 are the captions texts for subplots c and d swapped, or is it the plot titles? Also, in subplots a and b it looks like you've tested individual values of remineralization rate - would you indicating the fact by using symbols (possibly with connecting lines) rather than piecewise linear lines? Y axis labels with units would make the plots easier to read.

Fig. 10 I am not sure how this plot adds new information to the manuscript. The difference in DIC is already shown in Fig. 9.

Fig. 12 The figure caption doesn't seem to fit the figure: what/where is "06" and "08"?

Fig. 13 can you please identify which regions the acronyms stand for?

3 Technical corrections

p11112, l22 I would argue that the solubility and biological pump control DIC concentrations in the surface layers - the air-sea exchange of CO₂ is controlled by temperature, wind speed, carbon system properties etc.

p11113, l28 "... secondary effects on the solubility pump" - sounds like these effects are not as important as those on the biological pump; is that what you mean or is it rather direct vs. indirect effects?

p11114, l8 add dash in "... meso- to the bathypelagic ..."

p11115, l13 primary production here abbreviated "pp", later on "PP"

p11117, l9 typo: "diapycnal"

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p11117, l8 what is PPM?

p11118, l20/21 "Gregg and Casey (2007)"

p11120, l9/10 "Gregg and Casey (2007)"

p11121, l9 typo: "Subantarctic Front"

p11121, l26 typo: "... depths, however, ..."

p11122, l6-8 "However, in the GISSEH model, the region ... lies between the ... APF ... and the STCZ, a much narrower region than in GISSEH ..." - is this a typo, and one should be GISSER?

p11122, l10 typo: missing the in "Although at the surface ..."

p11122, l10 GISSEH instead of HYCOM?

p11125, l26/27 grammar?

p11126, l16 missing (in (Fig. 8a, b)

p11126, l21 no comma in "... beyond which, limitations ..."

p11129, l1 typo: "deepens"

p11129, l10 do you mean "changes in surface pCO₂ depend only on changes in DIC"?

p11129, l11 missing space in "T,S"

p11129, l22 missing "the" in "South of SAF"

p11131, l12 missing "in" in "of the SAF the Southern Ocean"

p11131, l13 and l17 missing "in" in "of the SAF the Southern Ocean"

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p11131, l22 no "the" in "the atmospheric CO₂"

p11131, l28 missing "the" in "along SAF"

p11131, l29 do you mean undersampled (too few samples) instead of subsampled?

p11132, l2 no () in "decreases of CO₂ of (about 6-10%)"

p11132, l18 Kwon et al. (2009)

p11133, l2 missing "of" in "the ratio carbon export to"

p11141 mg C m⁻³ instead of "milligrams C ..."

p11150 typos: "Units" and "mmol C m⁻³".

p11152 typos: missing space in molCO₂ m⁻² yr⁻¹, missing "ln" before "Unshaded"

p11153 typos: "mmol C m⁻² yr⁻¹" instead of "mmoles ...".

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