



EGUsphere, author comment AC1
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Reply on RC1

Jing He and Michael D. Tyka

Author comment on "Limits and CO₂ equilibration of near-coast alkalinity enhancement"
by Jing He and Michael D. Tyka, EGU sphere,
<https://doi.org/10.5194/egusphere-2022-683-AC1>, 2022

Thank you for your in-depth review of our paper ! We've implemented all of the suggestions as detailed below:

- Line 7: " the steady-state OAE rate" is this referring to the rate at which OAE equilibrates with atmospheric CO₂? If so possibly consider "the rate at which OAE reaches a steady state..." as this was a difficult sentence to decipher.

Changed "steady-state OAE" to "sustainable OAE". This is the rate at which alkalinity can be added at a sustained rate while not exceeding the chosen deviation from background pH/Omega/etc.

- Line 9: "...currents allow the..." consider: "currents allow for the..."

Changed to "currents allow for the..."

- Line 10: "We found that within..." consider " We found that with..."

Changed to " We found that with..."

- Line 20-21: I found this to be a rather harsh concluding sentence, particularly for an abstract. Furthermore, there was no explanation of how much alkalinity is lost, particularly when in theory we should be able to avoid this loss through our selection of locations (I appreciate that you discuss this sufficiently in your manuscript, however for those readers who only read the abstract this may be misleading). I would recommend briefly expanding on this loss of alkalinity to the deep (e.g. potential for this to occur, the ability for us to avoid this etc.) and moving it up in the abstract so that it is not the concluding sentence.

Yes, we don't mean to give a gloomy conclusion. These bad locations are in the minority. I've changed the sentence to "Regions of significant downwelling (e.g. around Iceland) should be avoided by OAE deployments, as in such locations up to half of the OAE potential can be lost to bottom waters." I also moved the sentence up, so we end on a more positive note.

- Line 29: "On long geological timescales" this reads oddly and is stating the obvious, I

recommend deleting the adjective "long".

Deleted "long"

- Line 50: Although a relevant study please consider referencing (Guo et al., 2022) <https://doi.org/10.5194/bg-19-3683-2022> instead as this study directly looked at the effects of nickel on phytoplankton.

Referenced Guo et al.

- Line 51-52: This seems like an appropriate point to mention the energy costs associated with grinding and therefore benefits to coastal applications using coarser minerals.

Rephrased accordingly.

- Line 70: I think it is important to also state the subsequent drop in CO₂ associated with increasing pH as it is not currently clear which variable is impacting organisms (e.g. phytoplankton). Furthermore, although a relevant article, Bach et al. (2019) did not conduct any first-hand research into the ecological effects of OAE. I would recommend including the citation (Subhas et al., 2022) or another ecological study on the effects of OAE to bolster this statement.

Added Subhas et al. and added "and a decrease in pCO₂, all of which could potentially affect the local ecology" to emphasize the uncertainty in which variable is most relevant.

- Line 72: The manuscript by Moras et al., 2021 is now published and as such should be referenced as (Moras et al., 2022) <https://doi.org/10.5194/bg-19-3537-2022> . I would also recommend adding the citation Hartmann et al., 2022 as done in line 46. This could be said for other sections where Moras et al., 2022 is cited and the inclusion of Hartman et al., 2022 is appropriate.

Done throughout the text as suggested.

- Line 75: delete capital S in "Some"

I think instead there's a period missing before "Some". Fixed.

- Line 83: brackets around "2015" and full stop after et al. not "et al,"

Fixed.

- Line 84: "imagining the distribution of..." imagining is an odd word to have here, consider "simulating".

Changed to "simulating"

- Line 102: again, citing (Guo et al., 2022) <https://doi.org/10.5194/bg-19-3683-2022> would be beneficial.

Cited Guo et al.

- Line 104: I think it is important to distinguish the fact that an increase in alkalinity does not necessarily increase DIC. Increases in alkalinity increase the ability of the ocean to sequester CO₂ however whether DIC increases or not is dependent on the in-gassing of CO₂ from the atmosphere (or alternative method of CO₂ injection). I appreciate this is commonly inferred but I believe it is important to highlight this fact so that readers are not under any false impressions about OAE. I recommend deleting "(and subsequent increases in DIC)" or editing this sentence to reflect the above statement.

Emphasized the difference between OAE and CDR here and throughout the text.

- Line 117-118: "Finally, the effectiveness and timescale of CO₂ uptake due to an OAE deployment in a given region is of interest we can define the uptake efficiency η_{CO_2} as" this sentence is difficult to read. Consider something along the lines of: "Finally, to assess the effectiveness and timescale of CO₂ uptake due to an OAE deployment in a given region of interest we can define the uptake efficiency η_{CO_2} "

Changed as suggested.

- Line 213: I have one concern/question over the pulse injections of alkalinity. Did these consider the potential for alkalinity to precipitate out at depth? I understand the need to model the potential for high alkalinity/low CO₂ water parcels to return to the surface ocean. However, I am concerned that the modelling of such potentially long timescale processes may lead to over/underestimating the return of high alkalinity/low CO₂ water parcels to the surface ocean, as it is possible for alkalinity to be removed at depth through precipitation.

This is a very valid concern and is the subject of study in ongoing work. The carbonate/biology model used in this study is not sophisticated enough to account for such secondary effects on precipitation or secondary effects on biology (such as calcification rate). Given that most precipitation occurs at the surface where oversaturation is greatest and is largely biologically driven by calcifiers, I'm more concerned about the effect at the surface than at depth. On the other hand increased surface calcification could also increase sinking rates and thus transport of organic material to greater depths. These effects are very interesting, likely complex and underscore the need for better models and more experimental work.

- Results heading: The text under the heading "Results" appears to be more of a discussion which also includes the results. Consider changing the heading to "results/discussion" or "discussion" (depending on the journal requirements).

Changed to "Results and discussion"

- Figure 1 caption, line 3: "The variation of sustainable alkalinity flux in different parts of the coastal strip is apparent" I don't think this is necessary for the figure caption,

consider moving it to the main body of the text/ incorporating it into the discussion in lines 289-298.

Move to main text.

- Figure 1e and 1f: x-axis labels? Are they simply the number of grid points? I recommend adding at least one x-axis and labels (if both use the same x-axis) to assist the reader.

I assume this is referring to Y-axis labels ? Yes, they are simply counts of grid point count. I've added the label.

- Figure 1 caption: "...the total global total..." consider changing to "...the total global injection..."

Changed to "The total global injection"

- Figure 1 caption: "the addition rate and pH change stabilize after 5 years" Again I don't think this is necessary. I recommend moving this to the discussion.

Moved to discussion.

- Line 315: consider changing "...can both be found..." to "...can be found, both on the outside and inside of the injection strip"

Changed accordingly.

- DONE Figure 2 caption: again, I would recommend moving the descriptive parts of the figure caption into the main body of the text e.g. sentences "in general regions..." as well as "widening strips allow more...". Much of this is already in the text and is therefore repetitive.

Moved and merged with main text.

- DONE Figure 2B: the axis labels here are odd, consider editing it so that the y-axis labels line up with each other. E.g., 40 is on the same vertical line as 400 etc.

The left and right axes in 2B are different units (as given by the axis labels). The conversion factor between them happens to be close but not exactly 10 and thus they don't line up perfectly: 1mol of Alk absorbs approximated $0.8 \times 12\text{g/mol} = 9.6$ grams of carbon. The apparent near-coincidence is exacerbated by the log scale.

However, given that we've been using the unit tCO₂/yr instead of tC/yr throughout the rest of this paper I've amended this figure to use tCO₂/km²/yr and hopefully that will clear up the confusion.

- DONE Figure 2b caption: change "a large range of injection capacities is observed" to "a large range of injection capacities are observed"

Sentence deleted according to earlier comment (duplication with main text and

excessive figure legends)

- DONE Figure 3; figures seem to be mislabelled. Figure 3c should be 3b I believe. If not please change these around so they are in order (figure 3a, 3b then 3c).

Yes, thank you for catching that. Labelling was corrected.

- DONE Figure 3 caption: much of the caption is already present in the text, consider deleting the descriptive sections last 2-3 sentences).

Descriptive sentences merged with main text.

- DONE Figure 3: Consider labelling the figures as; "figure a.i" as done for figure 5.

Labeled figures as (a,b,c)(i,ii,iii)

- DONE Line 329: should this be "figure 2C", not "figure 3C", also note the text highlighting the locations could be included in the figure 2 caption and then referred to in the text simply as "...the regions depicted in figure 2c..." without the need to relist the countries.

Figure reference changed and countries list moved to caption.

- DONE Figure 5 caption: "...for the same 3 locations shown in A" should this be "...shown in i"?

Fixed.

- DONE Line 359-60: Is this in reference to a figure? If so please state the figure.

Figure reference added.

- DONE Line 381: "be" is repeated, delete

"Be" deleted.

- FIXED Line 392: it isn't clear why this is apparent, if it is based on the figure or from a reference, please clarify this in the sentence.

Clarified by changing to "Figure 7 shows that ship-wake dilution proceeds.."

Supplementary

- DONE figure caption s1, line4: "the total global total injection" change to "the total global injection rate..."

Changed to "the total global injection rate..."

- ACK figure s4 caption: consider including the general locations of these maps.

General locations added.

- DONE Figure s5: again, consider adding some general locations. Stating additional specific areas suggests that they have been chosen at random. Consider specifying if these areas were selected at random or why these areas were chosen.

Added: "The locations were chosen as examples, coarsely distributed along all major coastlines, in order to find and demonstrate the breadth of possible CO₂ uptake kinetics."