Response to Reviewer 3's comments for Assessing Carbon Dioxide Removal Through Global and Regional Ocean Alkalization under High and Low Emission Pathways by Lenton et al

Comments Reviewer 3

The Lenton et al., study investigates the impacts from adding artificial alkalinity to the oceans using the model CSIRO under 2 different emission pathways - RCP2.6 and RCP8.5. It was a really well done and interesting study to read technically, however my main comment is that the way the paper is currently structured makes it confusing to read. For example, each paragraph jumps back and forth between RCP26 and RCP85 making the story line hard to follow. I suggest setting up the story for one of the emissions pathways and then comparing to that one for the other pathway. It would also be useful to set up the chemistry in a little more detail or reiterate the paragraph in the intro. This would be useful when explaining why adding alk under a 2.6 scenario is more effective.

At this stage, we do not feel that major rewrite or reordering of the paper is warranted. It is clear from other studies is that AOA will reduce OA and global warming; what is more interesting is whether the response to the same amount of AOA differs between emissions scenarios. This is the main focus of the study hence it does not make sense to restructure the paper as suggested. Instead we have gone through the paper to ensure that it is clearer and easier to follow.

It would also be useful to set up the chemistry in a little more detail or reiterate the paragraph in the intro. This would be useful when explaining why adding alk under a 2.6 scenario is more effective.

Please see the response to Reviewer 2.

Lastly, section 3.1 was confusing (you may want to expand on the methods section to make this section clearer). For each run you added 0.25Pmol/yr of alkalinity but then I read in ln216 that the magnitude of the increase in alkalinity is dependent on where it was added. Is the 0.25Pmol/yr added to all the boxes? or is it divided up between the boxes for a total of 0.25Pmol/yr? Can you put everything in the same units to be constant?

We apologise for any ambiguity and have now clarified this section, it now states:

For each emissions scenario, we simulated four different AOA experiments, which all had the same 0.25 Pmol/yr of alkalinity added. In the case of the regional experiments the per surface values were larger than the case of global addition.

Minor comments: ln50: "including through coral bleaching" - not clear what this means

We have now removed this statement.

ln79-80: This sentence seems out of place.

We have now removed this sentence.

ln149: what do you mean by impact?

We have now been more explicit and the sentence now says:

In this work, we use a fully coupled ESM (CSIRO-Mk3L-COAL), which includes climate and carbon feedbacks, to investigate the impact of AOA on the carbon cycle, global surface warming (2m surface air temperature), and ocean acidification response to the global and regional AOA experiments under the high (RCP8.5) and low (RCP2.6) emissions scenarios.

ln158: extra period between feedbacks and references

Corrected

ln230: the first sentence does not make sense.

Rewritten it now states:

The large atmospheric CO_2 concentration at 2100 under RCP8.5 reflects the large projected increase in emissions during this century, while under RCP2.6 a similar atmospheric concentration of CO_2 is seen in 2100 as at the beginning of the simulation (2020) (Figure 2a).

ln250: why is there a difference in export?

The text now reads:

…Consistent with Keller et al. (2014) and Hauck et al. (2016) the simulated changes in ocean export production were very small (~0.2 PgC) under RCP8.5 and due to small changes in ocean state, e.g. stratification. Under RCP2.6, it was slightly larger at 1.2 PgC, but still less than 1% percent of the total ocean uptake increase simulated under AOA, due to small changes in ocean state in a more stratified ocean…

Section 3.1.2: I don't understand how soil-moisture feedbacks are influencing temperature in this case. Temperature is more variable on land than over the ocean, could it be simply that?

We apologise for the confusion we have removed this section and attribute these changes to the differences different in atmospheric CO2 growth rate.

The section now states:

…In the period 2081-2100 we see larger mean changes in SAT under RCP2.6 than RCP8.5 primarily due to differences in atmospheric CO_2 growth rate. Krasting et al. (2014) showed that the slower rate of emissions, the lower the radiative forcing response. This occurs in response to the timescales associated with the uptake of heat and carbon. Consequently, under RCP8.5 the atmospheric CO_2 growth rate is much faster than RCP2.6, leading to a strong radiative forcing response. This explains why, despite a larger reduction in atmospheric CO_2 concentration under RCP8.5, the biggest reduction in global mean SAT occur under RCP2.6…

Ref:

Krasting, J. P., Dunne, J. P., Shevliakova, E., and Stouffer, R. J.: Trajectory sensitivity of the transient climate response to cumulative carbon emissions, Geophys Res Lett, 41, 2520-2527, 10.1002/2013gl059141, 2014.

Table4: relative to what?

It now reads:

Table 2 The differences in surface value of aragonite saturation state and pH between the AOA experiments for each emission scenarios in 2100 relative to the emissions scenario with no AOA.

Figures: relative to what?

We have added text to each of the captions to clarify

Figures: There are a lot of figures which I'm not sure add much to main text. You could simply the story in the text and only look at a few and toss the rest into the supplement. Or could you combine the 2.6 and 8.5 figures into 1? Could you do a difference between them? That would visually show the reader where the differences between scenarios lie....

While this seems attractive, we think that there is value in keeping these figures. Furthermore, we do not see a simply way of combining these into 8 panel figures, nor does doing the differences make much sense, as differences of differences is quite confusing.

Section 3.2.5: I think the figures referenced are not the correct figures. Plus I think a description of figures 11 and 12 are missing.

Thank you for this – we have now ensured that the figures are referenced correctly, and switched the order to better reflect the order they are appear in the text.

I see that the previous reviewers picked up a bunch of typos

Corrected.