Responses in Italic

First of all, the authors thank the reviewer very much for his thoughtful and constructive comments and advice.

The authors investigate the impacts of ocean carbon injection (and of direct carbon capture and storage with no leakage) on the carbon inventories of the atmosphere, the ocean, and the land biosphere using the UVIC model. This is a solid study that should be published after taking into account the following comments:

1) The authors evaluate the impact of climate change on the fraction retained by comparing their complete mitigation (CM) simulations without emission forcing after 2020 and the RCP8.5 simulations with continued emissions (WE) (Line 181). They conclude (line 182) that larger climate change in RCP8.5 leads to a higher fraction of injected carbon retained in the ocean (FR).

I doubt that the difference between the CM and RCP85-WE simulations is indicative of climate change. I suspect that the higher fraction retained in the CM compared to the WE simulation is largely the result of differences in the Revelle factor/carbonate chemistry. The higher carbon emissions under RCP8.5 lead to a higher atmospheric and oceanic CO_2 and a higher Revelle factor. In turn a smaller fraction of anthropogenic carbon ends up in the ocean in the RCP8.5 case compared to the zero emission CM case. As in the long run, both simulations with and without ocean injection tend to achieve the same carbon partitioning between the ocean and the atmosphere (when neglecting ocean-sediment and weathering fluxes as done here) this mechanisms also affects the fraction retained. More injected carbon remains in the ocean for the low than for the high emission case.

A proper evaluation of the climatic impacts would require RCP8.5 simulations with carbon emissions, but with radiative forcing from anthropogenic agents set to zero. Then, climate would remain at equilibrium while atm. CO2 and carbonate chemistry would still change.

(Alternatively, I may misunderstand the experimental protocol. This would then require a clarification in the method section.).

We thank the reviewer for this very important comment. The description of the diagnostic marker tracer in the experimental design section was insufficient, which led to the misunderstanding.

In lines 101 to 110 of the submitted manuscript, we describe how we deal with the injected carbon in the model. First, injected carbon is added to the total DIC pool of the model. Second, and in order to track the physical transport of injected CO_2 *and its transport pathways from the individual injection sites, injected carbon is added to seven site-specific diagnostic 'marker tracer'. At the sea surface, these tracers have an instantaneous gas exchange with the atmosphere, i.e. as soon as some of the injected carbon reaches an ocean surface grid box, the value of the marker tracer in this surface ocean grid box is set to zero. The fraction retained computed from this tracer approach thus provides a lower limit estimate of carbon stored to carbon injected.*

Hence, the Revelle Factor does not come into play with respect to the fraction retained. Differences in the fraction retained between the WE and CM simulations [section 3.3] cannot be explained by changes in the Revelle-Factor related to the invasion of anthropogenic CO_2 *into the ocean, but only by climate induced changes of ocean circulation and stratification.*

We apologize for the insufficient description of the diagnostic marker tracer in the original manuscript but improve this now in the experimental design section. Further, we add to the results and discussion section 3.3 that due to the assumed instantaneous gas exchange of the marker tracer, the fraction retained provides a lower limit estimate of carbon stored to carbon injected and that the Revelle Factor is not affecting the fraction retained.

In contrast to the fraction retained that counts only the injected carbon atoms (lines 125-129), the net fraction stored accounts for all potential feedbacks of carbon fluxes into and out of the ocean in response to the injection of CO_2 *into the ocean (lines 130-135) and thus considers changes in the Revelle Factor in the surface ocean grid box. Our comparison of the net fraction stored with a lower estimate fraction retained is hence somewhat biased. We have performed a first test run for I-800 with a realistic gas exchange of the injected carbon at the ocean surface. The gas exchange of each individual marker* *tracer is computed by scaling the difference of the gas exchange of model DIC (including injected carbon reaching the sea surface) and a hypothetical gas exchange value considering a DIC value diminished by the sum of marker tracers to the individual marker tracer concentration. Thus, this approach does consider effects on the fraction retained through changes in the Revelle Factor. By comparing the fraction retained of I-800 as given in section 3.3 (Table 1) with the one of the realistic gas exchange simulation, we find that the latter increases by about 5% at the end of the injection period (year 2120). Consequently, the difference of the fraction retained and the net fraction stored in I-800 (Fig. 4 a) would increase, when assuming a realistic gas exchange of the injected carbon in the ocean surface grid boxes.*

2) A caveat of this study is that ocean sediments and the effect of calcium carbonate dissolution (also known as calcium carbonate compensation) are not considered. This caveat should be addressed in the introduction and conclusion section. This mechanisms could be relatively important as ocean carbon injection may bring the excess carbon close to deposits of calcium carbonate and thus would permit carbonate dissolution to occur on much faster time scale than for emissions into the atmosphere.

Yes, we agree with the reviewer that this could be of importance. We will therefore clarify that we do not investigate the effect of calcium carbonate sediments feedbacks in our direct CO_2 injection experiments by running the model with and without a sediment sub-model. However, we feel that this issue should be discussed in the experimental design and conclusion sections.

3) The marker tracer used to compute the fraction retained should be explained in detail in the method section. As the fraction retained (FR) is a central metric in this study, it is not enough to refer to the literature.

We agree with the reviewer and, as mentioned above, we will add a complete and detailed description of the marker tracer in the experimental design section.

With respect to further comments

line 44: "reach a chemical equilibrium (mainly an equilibrium between the ocean and atmospheric carbon reservoirs)." This statement is not completely true as carbonate compensation and weathering feedbacks are important for time scales longer than 5000 years.

Thank you for your careful reading. Carbonate compensation and weathering feedbacks have to be mentioned in this context as well and will be added to the revised manuscript.

L 93: What about non-CO_2 forcings?

This is a very good point. Non-CO_2 greenhouse gases and anthropogenic aerosol forcing agents as well as emissions from land-use change are not considered in our simulations. We have to mention this in the experimental design section.

Line 127: could you please say a few more words about the diagnostic marker tracer. How is carbonate chemistry and air-sea and air-land flux computed for this tracer?

A detailed description of the marker tracer will be added in the revised manuscript.

Line 183: I doubt that the FR remains higher with than without climate change. I also doubt that this statement applies to all time scales (longer than the simulations).

As mentioned above, in our simulations the Revelle Factor is neglected with respect to the fraction retained. Hence, differences in the fraction retained between the WE and CM simulations can, in our case, only be explained by a decrease of the ocean circulation and an increase of the ocean stratification as climate change progresses [Jain and Cao, 2005]. Consequently, and in line with our results (Table1) the fraction retained has to remain higher in the WE simulations compared to the CM runs. Figure R1 below illustrates that the fraction retained stays constantly higher in the I-800 WE simulation compared to the I-800 CM run over an extended time period of 1000 years (year 4020). Furthermore, we conducted an additional simulation forced under the RCP 8.5 emission scenario, but this time the CO_2-related radiative forcing is kept constant at pre-industrial level (i.e., I-800 no radiative forcing, Fig. R1). Its fraction retained stays below the ones of the I-800 WE and CM simulations. Unfortunately, the I-800 no *radiative forcing simulation can only be compared until the year 3769. The results show clearly, that the I-800 CM and I-800 no radiative forcing runs converge with time as the hysteresis effect of climate change in the I-800 CM run keeps diminishing (Fig. R1).*

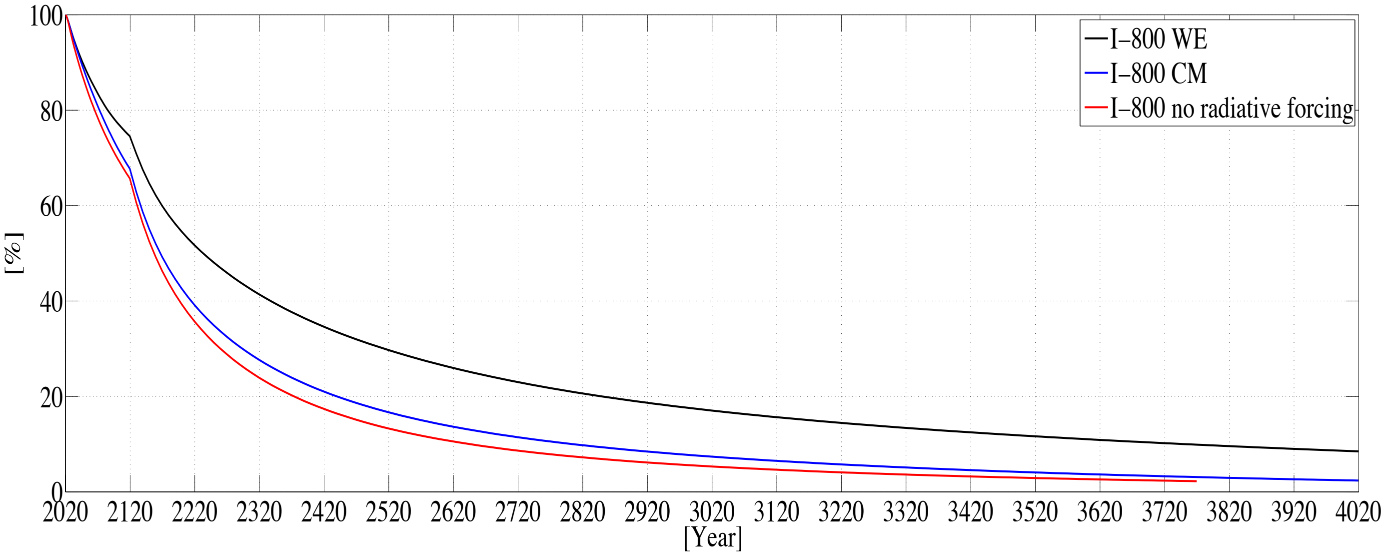

***Figure R1**: Fraction retained for I-800 of the WE simulations (I-800 WE, black line) and for I-800 of the CM simulations (I-800 CM, blue line) until the year 4020. The red line illustrates the fraction retained for I-800 with the CO_2-related radiative forcing being kept constant at pre-industrial level (I-800 no radiative forcing) until the year 3769.*

Reference:

Jain, A. K. and Cao, L.: Assessing the effectiveness of direct injection for ocean carbon sequestration under the influence of climate change, Geophys. Res. Lett., 32(9), L09609, 2005.