Response letter #1 for the manuscript titled "Anthropogenic carbon dynamics in the changing ocean" (os-2010-14)

The authors thank Referee#1 for the constructive feedbacks. The manuscript is now revised to include all of the Referees' suggestions and comments. Below are more detailed point-by-point responses to Referee#1 comments:

Ref1.: The main major comment I have addresses a key finding of the study, i.e the future evolution of the Southern Ocean air-sea fluxes. These fluxes strongly depend on the retreat of sea-ice. A proper modeling of these processes is therefore very important to make any assessment on the future behavior of air-sea gas exchange. I think it is necessary to show how the model performs on present day Southern Ocean sea-ice cover and compare it to other modeling studies. How are the reported changes in Southern Ocean temperature, resp. solubility in the BCM-C compared to other models?

Response: We agree that this information is important to further support the results of our study. In the revised manuscript, we have included the following statements at the end of model validation section:

"We note that the carbon fluxes in the Southern Ocean also depends strongly on the ability of the model in simulating the sea-ice extend, temperature, as well as changes in solubility of CO_2 gas in sea water. Generally, the model slightly underestimate the sea-ice extend in the Ross Sea, especially during the winter period as compared to the observation (shown in Supplemental Fig 1). This discrepancy is mainly due to the stronger mixing in this region as described in Tjiputra et al. (2010). As a potential consequence, a recent multi-models study by Roy et al. (submitted to Journal of Climate) shows that, in the polar Southern Ocean, the BCM-C simulates stronger warming than the other models. For the 2010-2100 simulation period, they show that the BCM-C simulates changes in SST and CO_2 solubility of 1.88degreeC and -0.003 mol/kg ppm as compare to the multi-model average of 0.89 \pm 0.67 and 0.0017 \pm 0.0009, respectively in the region south of 58degreeS."

If the referee would like to get access to the Roy et al. study, we kindly suggest contacting her directly (Tilla.Roy@lsce.ipsl.fr).

Ref1.: It is not clear how EXP1 is conducted. Is the atmospheric CO_2 concentration fixed throughout the simulation, or just the radiative forcing? In EXP3, what is prescribed? Is the terrestrial biosphere also forced with the climate from EXP2? Did you include land-use changes?

Response:
In EXP1, the CO_2 forcings are held at preindustrial level (PRE, i.e., constant 284.7 ppmv value is used for both the carbon fluxes and radiative forcing computations).
In EXP3, we prescribe atmospheric CO_2 concentrations from EXP2 for the radiative forcing computation but a preindustrial CO_2 concentration is used for the terrestrial and oceanic carbon fluxes computation.
The LPJ model currently does not account for land use change in our version.

In addition to the above information, we have further included additional paragraph in the experimental design section to further clarify the different experiment setups.

"Here, EXP1 represent the control climate simulation with atmospheric CO2 concentration reference from the year 1850. Therefore, EXP1 simulates only the natural carbon variability between different reservoirs under preindustrial climate condition. The EXP2 represents the fully coupled simulation, which include all feedbacks including biological, physical, and chemical with the increasing atmospheric CO2 concentration. Both the natural and anthropogenic carbon variabilities are simulated together in EXP2. Similar to EXP1, EXP3 only represents the variability of natural carbon fluxes for both the terrestrial and ocean but under the climate change condition."

Ref1.: How is anthropogenic carbon calculated? Are the two simulations averaged over a certain time period to smooth out variability?

Response:
As described above, the EXP2 represents evolution of both natural and anthropogenic carbon in the earth system, whereas the EXP3 represents the evolution of only the natural carbon variability. Therefore the difference between EXP2 and EXP3 give an estimate of only the anthropogenic variations in the system.

"... the difference between EXP2 and EXP3 represents the response of anthropogenic carbon (Cant) under the projected future climate change."

Ref1.: p.394 line 5-10: It would be convenient to have the references for the different model components.

Response: The references for each model components used in the BCM-C are now included in the revised manuscript.

Ref1.: p395 line 17 and line 25: What represents the error in the anthropogenic and contemporary carbon uptake rates?

Response: Here, the model error range estimates represent the standard deviation of the residuals between the model simulated annual variability and the respected model smoothed (five-year running) mean. This information is now included in the first paragraph of the model validation section.

Ref1.: p396 line 5: What represents the error in the time integrated uptake rate?

Response: The error in the time-integrated values quoted in this study is simply the time-integrated standard deviation for the associated period.

Ref1.: p396 line 19: The simulated variability "is realistic in a statistical sense". Could you clarify?

Response: The model generates well the spatial and temporal variability of climate metrics such as temperature, salinity, sea level pressure, and precipitation as compared to the observation estimates (Tjiputra et al., 2010). As a result, while the model is capable of simulating the internal climate variability such as the El Nino-Southern Oscillation or the North Atlantic Oscillation, the timing and strength may disagree with the observation.
The above statements are now included in the revised manuscript.

Ref1.:

p398 line 13: Typo in the word "understand".

p398 line 23: "The early anthropocene period", add years.

p401 line 8: Typo in the word "inventor y".

p411 Figure1 d): Is this the change in annual mean sea-ice cover? Shouldn't the units read: kmˆ2/deg?

Response: We have fixed the above errors and typos.