We thank Referee#1 for his/her positive and constructive feedback on our study. In the revised manuscript, we have addressed most or all of the comments raised and we think that the manuscript has been significantly improved since. Below, please find point-by-point response to each of Referee#1 comment. They are constructed as follows (1) original comments from the referee in **bold**, (2) our response in *italics*, and (3) description of changes applied in the revised manuscript in blue.

Referee#1: Throughout the text the authors refer to the gridded pCO2 dataset as "observations" (e.g. abstract line 2). This is technically not correct since the pCO2 dataset is derived from a statistical model. A more accurate description would be "observation-based".

Response: We agree with the referee#1 that "observation-based" is the correct term to used.

Revision: Throughout the text, we have replaced "observations" with "observation-based", specifically when the text refers to values not referring to direct observations.

Referee#1: In the introduction I am missing a link to some previous studies in the Southern Ocean. E.g. Le Quéré et al. 2007 argue for a saturation of the Southern Ocean carbon sink which is expected to continue throughout the century, whereas the authors show that CMIP models agree that the Southern Ocean continues to take up CO2.

Response: We follow referee#1 suggestion and have added some new references in the introduction section that review how the ocean carbon sinks in different regions vary due to different mechanisms. We do not however discuss how Le Quere et al.'s result differs from our finding because, initially, we did not intend to focus solely on the Southern Ocean.

Revision: At the end of paragraph 4 in the introduction section we have added the following: "This is necessary because the strength and variability of the ocean carbon sinks vary considerably from one region to another, which are attributed to different mechanisms. For instance, in the Equatorial Pacific, the long-term trend in CO_2 uptake is strongly influenced by the El-Nino variability (Feely et al., 2006). In other regions, such as the Southern Ocean, the variability is related to the Southern Annular Mode (e.g., Le Quere et al., 2007; Landschutzer et al., 2015)."

Referee#1: Introduction page 2647 lines 5-6: This is very minor, but there are more recent references by the Global Carbon Project reporting the fraction of the emitted CO2 taken up by the ocean.

Response: We concur.

Revision: We have replaced "Le Quere et al., 2009" with the latest Global Carbon Project estimate reference "Le Quere et al., 2015".

Referee#1: Introduction page 2647 lines 12-24: I believe you should add some references here.

Response: We agree.

Revision: In the revised manuscript, we have added two key studies that support our statements: "Volk and Hoffert, 1985" and "Sarmiento et al., 1998".

Referee#1: Introduction page 2648 lines 13-23: I believe this part should be in the results section.

Response: After careful consideration, we think that Fig. 1 and the respective texts (i.e., lines 13-23 in the previous version) actually would fit better in the introduction as it nicely shows the growing inter-model spread in the projection of future CO_2 carbon sinks, and hence it establishes a strong motivation of our scientific objective, which is to constrain these growing uncertainties.

Revision: We have kept the text discussing Figure 1 as is, but we add additional statement to highlight that the study is motivated by the growing uncertainties and the need to identify method to constrain these.

Referee#1: Methods page 2650 line 19: The co2sys software tool for matlab should be referenced as van Heuven et al. 2011.

Response: We follow the referee suggestion and have cited van Heuven et al., 2011 in the revised manuscript.

Revision: We have revised previously P2650, L19 from
"CO2SYS developed in Matlab (http://cdiac.ornl.gov/oceans/co2rprt.html)"
with
"CO2SYS developed in Matlab (van Heuven et al., 2011)"
and the new reference has been added into the reference list.

Referee#1: Methods page 2654 lines 11-12: "... both metrics, the CMIP5 models have linear relationships ..." - I don't believe you can argue for a linear relationship based on Figure 2a, whereas it is more clear for figure 2b.

Response: Referee#1 is correct in that the linear relationship is more evident from Fig. 2b. We have revised this and its subsequent sentences.

Revision: We have revised the sentences:
"It shows that for both metrics, the CMIP5 models have linear relationships between present and future CO_2 uptake rate. As expected, the relationships become more obvious for cumulative carbon sinks, as shown by R^{glb}_{cum} value of 0.77."
with
"Figure 2a shows that the models have positive correlation coefficient but weak linear relationships between the present and future CO_2 uptake rate. However, the linear relationships become more pronounced for cumulative carbon sinks (Fig. 2b), as shown by R^{glb}_{cum} value of 0.77."

Referee#1: Methods page 2654 lines 9-15: I believe this belongs to the results section.

Response: We follow the referee#1 suggestion and have moved this segment into the first paragraph of result section (subsection 3.1).

Revision: Previously lines 9-15 on page 2654 has been moved to the beginning of subsection 3.1 in the revised manuscript.

Referee#1: Methods page 2654 lines 18-20: "The regional distribution is defined according to the low-, mid- and high-latitudes, motivated by the large-scale difference in carbon uptake mechanisms occurring in these regions" - While I am not concerned by the regional division I do

disagree with the argument provided by the authors here. E.g the 45S line is actually cutting more or less exactly through one of the main CO2 uptake regions, hence processes a few degrees north and south of these lines are the same.

Response: The concern pertaining the 45°S separating the subtropical and the high latitude Southern Ocean is also raised by Referee#2. Initially, we followed the regional division from Mikaloff-Fletcher et al., (2007), who apply the 44°S latitude line in their study. Nevertheless, we understand both referees concern and have added new text explaining the limitation of our 45°S boundary and included new analysis where we use the model-dependent dynamic boundary separating the subtropical and the high latitude Southern Ocean.

Revision: The following new statements have been added in the end of subsection 2.6:
"We note that the selection of the 45°S as boundary between the mid- and high-latitude SO, could pose issues since the SO region has a sophisticate dynamics and, dependent on the models, the 45°S latitude could cut into regions of dominant carbon sources or sinks. To address this issue, we perform additional analysis where we use a dynamic boundary separating the mid- and high-latitude Southern Ocean applying a surface density of 26.5 kg m^{-3}. For instance, Séférian et al. (2012) apply this density line to separate the Subtropical Mode Water (TMW, region of weak increase in future CO_2 uptake) and the Subantarctic Model Water (MW, region of strong increase in future CO_2 uptake)."

In addition, we have also added a new Fig. 5 illustrating these dynamic boundaries as simulated by the models and the corresponding inter-model relationships when this boundary is used. The following paragraph has been added at the end of result section 3.1.
"As stated in subsection 2.6, we also compute the correlation coefficient metrics for the SO region using a dynamic boundary (instead of a fixed 45°S latitude). Figure 5c illustrate the model-dependent dynamic boundaries as simulated for August 2005. Figure 5a and b show that the linear inter-model relationships remain strong (correlation coefficient of at least 0.76) when the dynamic boundary is used, suggesting that the inter-model relationships in the SO is relatively robust."

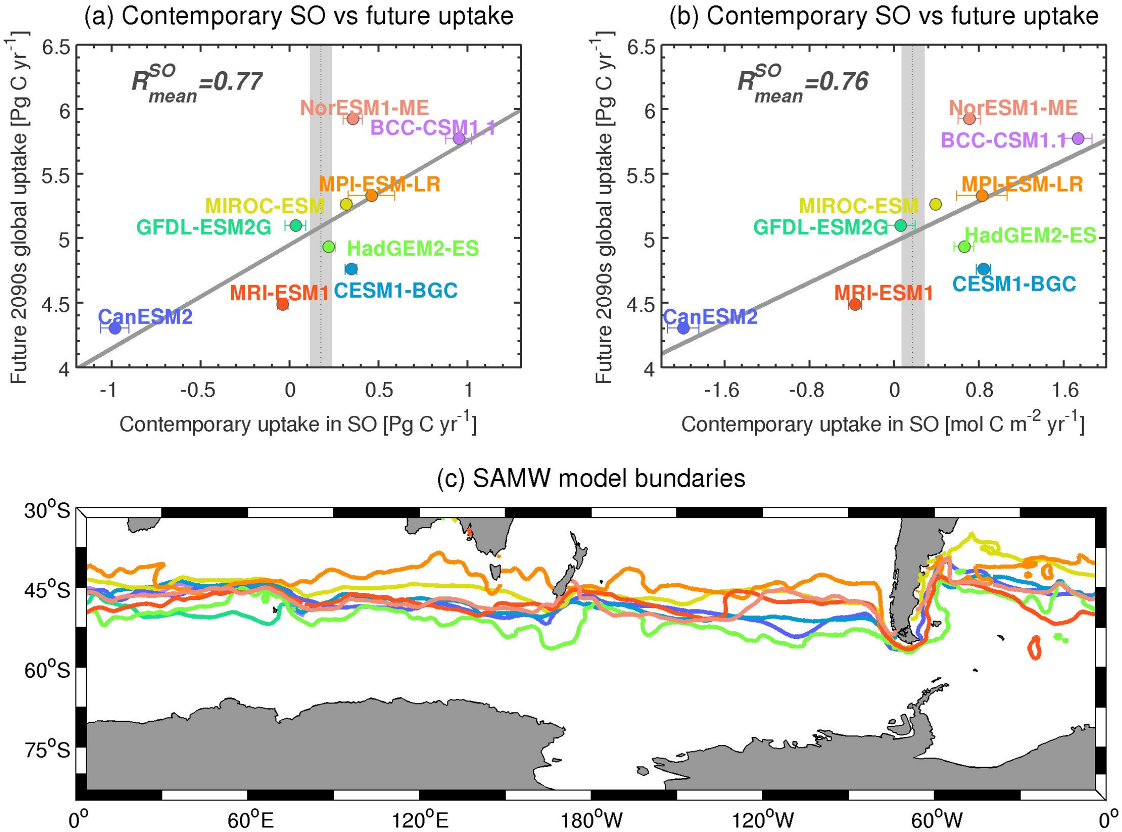

Figure 5. Annual contemporary carbon uptake vs. global uptake rate projected in the last decade of the 21st century by CMIP5 models. Here the SO is defined using dynamic boundary separated by the surface water density of 26.5 kg m^{-3}. Panels (a) and (b) show the contemporary SO carbon uptake on the x-axes in Pg C yr^{-1} and mol C m^{-2} yr^{-1} units, respectively. Panel (c) illustrates the 26.5 kg m^{-3} density lines that separate the MW from the TMW for the month of August 2005 as simulated by the different models (same color convention as in panels a and b).

Referee#1: Results page 2656 line 1: Lenton et al 2013 compare inversion estimates, model estimates and an observation-based estimate from Takahashi et al 2009. Please explain which estimate from Lenton et al. 2013 has been used for the comparison.

Response: The estimate in the paper is taken from the observation-based estimate from Takahashi et al., 2009.

Revision: We have revised the sentence:
"…two independent observational-based estimates of about 0.15±0.12 and 0.27±0.13 Pg C yr^{-1} (Landschützer et al., 2014; Lenton et al., 2013)."
with
"…two independent observational-based estimates of about 0.15±0.12 Pg C yr^{-1} (Landschützer et al., 2014) and 0.27±0.13 Pg C yr^{-1} (Lenton et al., 2013), the latter is derived from Takahashi et al. (2009) datasets."

The new reference to Takahashi et al., 2009 has been added accordingly.

Referee#1: Results page 2660 lines 15-19: the authors do not explicitly rank the G1 and G2 groups, but based on the comparison of the seasonal cycle in the text and the agreement with the mechanisms explained in Takahashi et al 2002, I am inclined to rank G1 models higher than G2 models. This could be a user recommendation for future research in the Southern Ocean.

Response: Also in accordance to referee#2 comments, it is not trivial to rank the model performance. Nevertheless, we think that in addition to projecting the correct amplitude of seasonal cycle of CO2 fluxes, it is also crucial to get the correct predominant mechanism, i.e., the non-thermal pCO2 seasonal cycle in the Southern Ocean (Landschützer et al., 2015).

Revision: We have added a new paragraph in section 4 (4th paragraph) and indicated that the GFDL model is likely to project the CO_2 fluxes in the Southern Ocean closer to the observations.

"Based on the linear inter-model relationship presented in this study, the GFDL-ESM2G, MIROC-ESM, and HadGEM2-ES models simulate contemporary CO_2 fluxes in the SO closest to the observational-based estimate (see also Fig. 6a), and therefore are likely to have more credibility in their future projections. Nevertheless, from our seasonal cycle analysis it is not clear if these models simulate the observed mechanisms governing the CO_2 fluxes. According to Landschutzer et al. (2015), the non-thermal component of the pCO_2 variation is an important driver for the long-term CO_2 fluxes in the SO. Figure 10 shows the seasonal anomaly of non-thermal pCO_2 seasonal cycle in the SO from models and observation-based estimate. The CanESM2 and GFDL-ESM2G simulate comparable amplitude and seasonal phase with the observation-based estimate, but the former model has anomalously high surface pCO_2 (i.e., it simulates a net source of CO_2 to the atmosphere in the SO). Taking this as an additional constrain, our analysis suggests that the GFDL-ESM2G performs best in capturing the observed CO_2 fluxes in the Southern Ocean."

Referee#1: Results, general: There is an inconsistency regarding the sign of the fluxes. Before the seasonal cycle analysis, the authors use positive numbers for ocean uptake fluxes (see figures 1-5), whereas for the seasonal cycles analysis (Figures 6-7 and text) outgassing fluxes are positive. Please adjust for consistency.

Response: We thank the referee for catching this inconsistency. We have revised Figures 6-7 (now Figures 7-8) accordingly.

Revision: Previously Figs. 6 and 7 have been revised to show the same signs for uptake/outgassing of CO_2 as in other figures and throughout the text.

Referee#1: Discussions page 2665 lines 26-29: the interannual variations in the air-sea flux do not necessary effect the seasonal cycle, unless the interannual variations are of seasonal nature. A good reference for this is Hauck et al 2013.

Response: We thank the referee for the new reference. We were indeed referring to the SAM-induced interannual variability, which is shown in Hauck et al. (2013) to influence the summer pCO_2 in the Southern Ocean.

Revision: we following the referee's comment, we have revised:
"In addition, the strong interannual variations in the air–sea CO_2 fluxes identified in this region (e.g.,Landschützer et al.,2015; Lovenduski et al., 2015) further emphasizes the potentially large uncertainty of the seasonal pCO2 cycle determined from the observations as presented in this study."

with
"In addition, the strong interannual variations in the air–sea CO_2 fluxes identified in this region due to the Southern Annular Model (Landschützer et al.,2015; Lovenduski et al., 2015) could also contribute to the discrepancies in the observed and model simulated pCO_2 seasonality presented in this study (see also Hauck et al., 2013)."

The new reference has been added as well.

Referee#1: Page 2663 line 11: "seasonality" change to seasonal

Response: Agree.

Revision: The text has been changed as suggested.

Referee#1: page 2663 lines 12 and 13: remove "compared to" and "total seasonal cycle"

Response: Agree.

Revision: The text has been changed as suggested.

Referee#1: page 2661 line 19: sectors of THE SO

Response: Agree.

Revision: "… SO…" has been replaced with "… the SO…" as suggested.

Referee#1: page 2665 line 24: change "... in the SO is non-negligible." to "…in the SO are non-negligible."

Response: Agree.

Revision: As suggested, the text has been revised accordingly.

Referee#1: Figure 8 caption: observations are represented by gray lines and markers, not black

Response: We thank again referee#1 for spotting this error.

Revision: The caption in the previously Fig. 8 has been updated as suggested.