

## General comments

The manuscript 'variation of Summer Oceanic  $p\text{CO}_2$  and Carbon Sink in the Prydz Bay Using SOM Analysis Approach' by Suqing Xu et al. presents their cruise data plus its analysis regarding oceanic and atmospheric  $p\text{CO}_2$  and the related air-sea  $p\text{CO}_2$  flux. The results can potentially be of interest to readers interested in the Southern Ocean carbon cycling, and its variability in time and space. It also provides an opportunity to the authors to show a practical example of the application of SOM in biogeochemistry. In order for the manuscript to be appreciated by the biogeochemical community, the authors should provide a better description of its relevance and importance for the greater Southern Ocean. As I am not an expert on SOM or neural networks, I cannot judge the methodology on that method in detail. I should however be able to understand what is presented in section 2.2. and I find this difficult at times. Several times mention is made of methods (like 'a linear method' or 'Linear regression extrapolation method') without further information on what is done: This makes reproducibility of the work without consulting the authors impossible. Besides that, I unfortunately often find the language to be confusing/imprecise, and therefore recommend professional English language checking before resubmitting. The language made it more difficult for me to judge the value of the manuscript, and I expect I can provide a more in-depth review after the language is improved. The manuscript would also improve if it were shortened as compared to the current version, as there is enough space to increase the information density in the manuscript in my opinion.

## Specific comments

### 1. The introduction

The introduction thoroughly describes the geographic setting of the Prydz Bay. I appreciate this, but it makes the introduction unbalanced as the questions 'why is this study of relevance' and 'what is new' are only covered by a few sentences. The authors describe the issue that the manuscript wants to address, namely the sparse spatiotemporal coverage of the Southern Ocean (SO) carbon cycle. They also tell the reader that they address the issue using the SOM approach. However, to what extent does research on the Prydz Bay support our understanding of the SO carbon cycle? On page 2, line 38-39 it is mentioned that the Prydz Bay is the third largest embayment in the Antarctic continent. No other reasons are given for the study of in specific this bay: What makes this bay (potentially) important for the SO carbon cycle even though it is small as compared to the total surface area of the SO? To what extent is this Bay representative for the SO as a whole (or just other parts of the SO), i.e. do the authors think their approach or data are useful for and representative of other areas in the SO? Why was the month February chosen to do the cruise?

**Response:** The Prydz Bay region is the third largest embayment in the Antarctic continent and one of the source regions of Antarctic Bottom water (AABW) as well as the Weddell Sea and the Ross Sea (Jacobs and Georgi, 1977; Yabuki et al., 2006). Studies have reported that Prydz Bay is a strong carbon sink in the austral summer (Gibson and Trull, 1999; Gao et al., 2008; Roden et al., 2013). It is important to study the carbon cycle in the Prydz Bay. We have revised this part and added the information. The Prydz bay is part of the SO. SOM has been applied to simulate oceanic  $p\text{CO}_2$  to overcome a complex relationship among the biogeochemical and physical conditions. We chose the beginning of February to early March because we had the in situ measurements during that time.

In the first sentence, it is mentioned that the SO is important for anthropogenic CO<sub>2</sub> uptake. The authors cannot distinguish between natural and anthropogenic carbon fluxes based on their measurements: Some sentences should be added to describe that the SO is a natural source of carbon to the atmosphere, but a sink for anthropogenic carbon – and that both are highly variable but creating a net sink for total carbon over the past decades. Here an argument could be made for their own study and cruise, which aims to reduce the spatiotemporal sparsity of the data and get a better understanding of the variability of the contemporary *p*CO<sub>2</sub> and its driving mechanisms. The authors call the Bay a sink at several instance (for example P3, L101 and P5, L125): Some numbers from previous studies should be given to support the statement that the Bay as a whole is a sink for carbon before presenting your own results.

**Response:** Sentences have been added to describe the SO on its role for carbon dioxide. About our study and cruise, we have added the argument. Recently studies have shown that there is a strong carbon sink in Prydz Bay especially in summer and we have added the references to support the statement.

In Figure1, an inset could be added to visualize the location of Fig.1 on the Antarctic continent.

**Response:**For Fig.1, we have added an inset to show the location of the Prydz Bay in the Antarctic continent.

P3,L64-66: How does a marine ecosystem interact with the physical environment to make it complicated to study *p*CO<sub>2</sub>? Clarify your statement, as it currently is imprecise.

**Response:** We have revised this sentence. Here we mean due to the special physical environment and complicated ecosystem, it is difficult to study the spatiotemporal variation of *p*CO<sub>2</sub>.

When describing the methods, clarify that in situ data from the cruise are combined with remotely sensed data to arrive at a gridded product.

**Response:** We have revised to clarify that in situ data from the cruise are combined with remotely sensed data.

## 2.1 In situ data

Here the authors present how they took their underway measurements and present them in Fig.2. The first time I read this section, I missed a good structure: The section starts with an explanation of the cruise and instruments used (until line 115). Then, the following paragraphs came to me as a bit of a surprise. One could help the reader find a better flow through the text by explaining that there are several processes/water characteristics that can influence the *p*CO<sub>2</sub> flux (which is the topic of this study). Then, the sea ice paragraph(lines 116-120), the information on the SSS and SST collection (lines 132-end of section) come more naturally. It is important to defend why specifically these proxies/data are used to do your study (create a gridded *p*CO<sub>2</sub> map). Don't forget to start the title with a capital letter i. It is unclear to me whether the results presented in Fig.2 are 4-week mean results or how they are calculated from the 4 cruise legs: Add more information to both the caption and the text.

**Response:** The results presented in Fig.2 are the data along the track cruise when R/V Xuelong sailed from east to west from the beginning of February to early March. It has been added in the caption and the text. We have added the information to explain some processes that can influence the  $p\text{CO}_2$  distribution in the text.

## 2.2 SOM method and input variables

This section is generally hard to follow, maybe partly because I am not familiar with SOM. It should be improved so that also people new to SOM are able to understand and appreciate what you have done. Which ‘environmental parameters’ and which ‘observational dataset’s (Fig.3) are used? Lines 205-220 (or even up to 228) could be moved up in order to introduce the reader earlier to the datasets. Then the authors can explain what they are used for and how.

**Response:** Thanks for the suggestion. We have reconstructed this section and make it more clear about the ‘environmental parameters’ and ‘observational datasets ’ in the text. We have also revised the sentence about SOM method to make it easier to be understood.

## 2.3 Validation of SOM derived oceanic $p\text{CO}_2$

This section raises a lot of questions from my side. To what extent is SOCAT comparable to your data? Are the data both summer data? Why do you talk about assimilating several years together, but then only take 2015 from SOCAT (line 239)? Could you maybe compare your data to a model estimate of  $p\text{CO}_2$  for this region? Lines 232-235: How is the equilibrium between atmospheric and surface ocean  $p\text{CO}_2$ , do you mean  $p\text{CO}_2$ -disequilibrium? Why do you describe this if you did not apply this method after all?

**Response:** We use dataset from SOCAT for the same period, which is February 2015. The dataset from SOCAT for validation as shown in Fig4-a. We prefer in situ measurements to model output to validate our results. We have removed line 232-238. Line 232-238 was a discussion and we think it didn’t relate to the text.

## 2.4 Carbon uptake in the Prydz Bay

This section is quite clear to me: You have combined wind speed data and your  $p\text{CO}_2$  measurements to arrive at a flux using Eq 2. However, you should clarify 1) where you used a ‘scaling factor’ (P10, L247-248) (in Eq. 2?), and 2) that that used your SOM-based  $p\text{CO}_2$  product to calculate  $p\text{CO}_2$  in Eq.2 (did you?). In addition, you write that the transfer velocity is a function of wind speed and temperature (Line 245) and then you write about a gas transfer rate (Line 248) (=transfer velocity?) which you apply a scaling factor to. I am left with the question which gas transfer rate or velocity you have used / how you calculated it.

**Response:** The original Eq.2 was a simplified equation considering the unit conversion factor. Now we have added the original sea-air  $\text{CO}_2$  flux equation in the text and we have revised this part and added some information.

## 3.1 the distribution of underway measurements

Here you present your underway measurements for three areas. On what basis did you divide the Prydz Bay in these subregions? You write the division is ‘robust’ (P11, L264): Did you test what effect the choice of your division has on your results? It would be helpful to the reader if you added a plot figure with the subdivision of the Prydz Bay into its three regions. Add units to all

numbers (especially salinity lacks the psu unit throughout this section). I assume you are describing the results that are visualized in Fig 2 in this section: you should make reference to it if this is the case. Throughout the text of this section, you should be more precise on whether the values are regional means, 4-week means, and how you calculated this (refer to the methods). When you say decrease or increase (like P12, L291), it is not always clear to me whether it decreases/increases in time or space or whether the mean is lower or higher than in the neighboring sub-region. This causes for example confusion when SST's 'vary sharply' (L293) but 'decreased slightly' just the sentence above (L291). The readability of this section may improve by summarizing your main results in a table. A sentence should be added either here on the methods where the relationship between chlorophyll-a (as remotely observed) and biological productivity is stated.

**Response:** Three regions are divided according to the distribution of oceanic  $p\text{CO}_2$  and depth of water. From the distribution of  $p\text{CO}_2$  as shown in Fig.2-a and Table.2 there are three ranges. One is from about  $300\mu\text{atm}$  to  $380\mu\text{atm}$ , the second is from  $200\mu\text{atm}$  to  $350\mu\text{atm}$  and the third is below  $250\mu\text{atm}$ . We roughly divided the study region according to the three ranges of  $p\text{CO}_2$  and the range of the depth of water in the Prydz Bay region. It was a mistake to use the word 'robustly'. We have made the change to the text.

We have added units to all numbers. We have added the subdivision lines on Figures. 5.

We have added the reference to Fig 2 in this section.

Section 3.1 was about the in-situ measurements and the average values we discussed were regional mean. We have added the information in the text to avoid the confusion about the numbers. A table was added to the text summarizing our main results. A sentence has been added here about the relationship between chlorophyll-a and biological productivity.

### 3.2 Quality and maps of SOM-derived oceanic $p\text{CO}_2$

You compare your results to SOCAT and calculate the RMSE. Could you also provide the  $R^2$  of the best-fit line (red line in Fig. 4b)? You say your RMSE is consistent but not as good as most of the neuron methods. Do you mean it is on the high side of the accuracies previously reported, or why is it not as good? Could you calculate/estimate how many extra data points you would need to gain an improved precision of your SOM approach? You could probably comment on the limited amount of data that retrieving more data is not realistic with the resources and time available. SOCAT is not perfect either: A comment on its limited overlap with your study area would be appropriate here. It is surprising that the SOM estimate is generally higher than the SOCAT one, as SOCAT does not cover the low-  $p\text{CO}_2$  area towards the south. Did you sample your SOM-derived  $p\text{CO}_2$  dataset on the SOCAT locations, or did you compare all SOCAT in the area to all your data points in Fig. 4b? The first would probably be a fairer comparison and provide a better outcome as well. Fig.4a could be plotted in the same way as Fig.2 to make it easier for the reader to compare the spatial coverage.

**Response:** Our RMSE is on the high side of the accuracies previously reported and the correlation coefficient has been added in the text. There are two reasons accounting for the precision. One is the limited spatial coverage of the in situ measurements to be labeled in SOM method. Increasing the spatial coverage of the labeling data will help to increase the precision of SOM derived oceanic  $p\text{CO}_2$ . The other one is the dataset from SOCAT is not sufficient neither for space overlap nor for time overlap. The best way to get an improved precision of the SOM approach is to have a

full coverage measurement in the study area. In our study, we selected the SOM derived oceanic  $p\text{CO}_2$  according to the location of the datasets from SOCAT for validation. As mentioned in the text, SOM derived  $p\text{CO}_2$  is generally lower than the SOCAT one. We have plotted Fig.4a as Fig.2.

### 3.3 Spatial and temporal distributions of SOM-derived $p\text{CO}_2$

Here I expect the presentation of your main result: the  $p\text{CO}_2$  maps of Figure 6. However, the text mostly describes the sea ice situation of the region: Why is this done here? Maybe a different title would be more appropriate? If sea ice is a main driving factor for  $p\text{CO}_2$ , this should be argued using the results. If the authors could add regional sub-division lines on the maps in Fig. 6, it might be easier to argue for the chosen sub-division (i.e. Shelf region, etc).

**Response:** We agreed with the reviewer and have revised this section. This section is mainly about the result of SOM derived  $p\text{CO}_2$ . We have presented the spatial and temporal distribution of SOM derived  $p\text{CO}_2$ . We have added regional sub-division lines on the maps.

### 3.4 Carbon uptake in Prydz Bay

This section is quite clear, although it would be good to clarify when mean values are reported, and whether they are regional means or temporal means, or both. From the figure on page 17 (which has no number?) it is hard to read the  $p\text{CO}_2$  changes: one could either present it as a table, or adjust the y-axis range. Please make sure the figure is suitable for the color blind (and check this throughout the manuscript): Use for example different shapes for the three different lines in the upper graph, and add shapes in the lower one.

**Response:** We have changed the figure to be a table and we have made the revised in the text.

### Supplementary information

The text at the start of the SI is already used in the main text, I do not see the need to provide it twice, and would recommend to remove it from the SI.

### Technical corrections

I made an effort to pick out the most important language issues. However, as recommended in the general comments, I would strongly advise the authors to revise their language throughout the manuscript and to have it checked before resubmitting.

1. Try to prevent the use of the word 'it' throughout the manuscript: replace by the actual subject of the sentence.

**Response:** We have made the changes in the text.

2. Caption of Fig.1: replace 'The circulations in the ' by 'The ocean circulation in the '. Replace sentence 'The weekly sea ice extents for our study periods were overlapped on the cruise.' By 'During the 4-week cruise, the sea ice extent varied as indicated by the contoured white areas:' and replace 'the white shadow' by a fourth contoured area.

**Response:** It has been replaced.

3. Check all figures on their suitability for color-blind people

**Response:** We have checked all the figures.

4. P2, L33: replace 'of reducing anthropogenic  $\text{CO}_2$  in the atmosphere' with 'in regulating

atmospheric carbon and acting as a net sink for anthropogenic carbon' or similar.

**Response:** It has been replaced.

5. P2, L35: replace 'this status derives' by 'This uncertainty comes'  
**Response:** It has been replaced.
6. P2,L36: replace 'for' with 'because of'  
**Response:** It has been replaced.
7. P2, L38: move 'lying in the Indian Ocean section' to the next sentence and replace 'lying' by 'situated'  
**Response:** It has been moved and replaced.
8. P2, L39-40: move 'With Cape Darnley ... to the east' to the end of the sentence or rephrase whole sentence, try to use the main verb as early as possible in a sentence  
**Response:** It has been moved and rephrased.
9. P2, L41: replace 'varies' by 'increases' (or does it go up and down?)  
**Response:** It has been replaced.
10. P3, L51-52: Add 'the': 'The Fram Bank and the Four Ladies Bank'  
**Response:** It has been added.
11. P3, L52: a spatial barrier for  
**Response:** It has been revised.
12. P3, L54: replace 'part of it' by 'partly'  
**Response:** It has been replaced.
13. P3, L63-64: rephrase sentence to clarify the sequence of events  
**Response:** It has been rephrased.
14. P2,L67: the importance for what? Replace 'carbon cycle' by 'carbon cycling'. This relates to comment 1 as well: how does studying the Prydz Bay relate to the SO carbon cycle?  
**Response:**We have added the importance of study carbon cycling in the Prydz Bay and added the information about the Prydz Bay related to the SO carbon cycle in the introduction section.
15. P3, L69: use present tense where possible: 'is'  
**Response:** It has been replaced.
16. P3, L72: remove first word 'the'  
**Response:** It has been removed.
17. P3,L77: Add 'A' before 'linear'. Clarify that it was not you doing this by adding 'In earlier studies, ...'  
**Response:** It has been revised.

18. P4, L78: What is a big scale? The entire Prydz Bay, the SO?  
**Response:** We have revised and made it clear to be ‘that alinear regression extrapolation method has been applied to expand the cruise data to study the carbon cycle in the Southern Ocean’.
19. P4, L79: Start a new sentence at ‘however’. Simplicity can be a good thing: why is calculating  $p\text{CO}_2$  based on SST and CHL insufficient? How do you know what controlling factors to select?  
**Response:** There are two opposing processes primarily govern  $\text{CO}_2$  chemistry in seawater: sinking of biological products from the photic zone to deep-ocean regimes (i.e., the biological pump), and upward transport by upwelling deep waters of  $\text{CO}_2$  and nutrients formed by the decomposition of biological debris (i.e., the physical pump). It is not sufficient to simulate oceanic  $p\text{CO}_2$  based on SST and CHL in previous studies, of which the RMSE tended to be high. From our previous researches and other studies we chose SST, CHL, MLD and SSS to be the controlling factors and we have added the information in the text.
20. P4, L83: remove ‘the’ before ‘February’  
**Response:** It has been removed.
21. P4, L84: Is NN a type of neural network? The acronym NN is not used anywhere else in the manuscript – so not need to define it. What makes it artificial?  
**Response:** NN is an abbreviation for neural network. Here artificial means artificial intelligence.
22. P4, L85: Remove ‘been’  
**Response:** It has been removed.
23. P4, L88: Add ‘and’ before ‘chlorophyll’  
**Response:** It has been added.
24. P4,L92: Remove ‘been’ and replace ‘a’ before spatial-temporal by ‘the’  
**Response:** It has been removed.
25. P4, L97: Add the word ‘cruise’ after ‘CHINARE’. Do the same on P4, L108.  
**Response:** They have been revised.
26. P4, L98: replace ‘to the early of March’ with ‘to early March’. Check general fluency of lines 97-99.  
**Response:** It has been replaced.
27. P4, L99: replace ‘is show’ by ‘are shown’  
**Response:** It has been replaced.

28. P4, L101: here the authors suddenly discuss carbon absorption: the readers have not learned before that this area is considered to be a sink for carbon, so it would be could to introduce the reader to that earlier in the introduction  
**Response:** It has been revised and we have added the information that the Prydz Bay is a carbon sink in the introduction.
29. P4,L102: Replace 'followed' by 'follows'  
**Response:** It has been replaced.
30. P4, L104: Add ', and' and remove '.'  
**Response:** It has been revised.
31. P4, L108: 'at the beginning of February 2015', did the cruise not extend into March? Why 'beginning'?'  
**Response:** It has been revised. The cruise was from the beginning of February to early March.
32. P5, L115: replace ' $p\text{CO}_2$  in atmosphere' by 'atmospheric  $p\text{CO}_2$ '. Check also that each time you use the word  $p\text{CO}_2$ , that you use an italicized letter p (also in captions, and axes titles)  
**Response:** It has been revised.
33. P5, L116/117: Replace 'in polar region' by 'in polar regions'  
**Response:** It has been replaced.
34. P5, L117: Move sentence 'Salinity records the physical processes' to later in the paragraph, because you first need to explain what salinity has to do with sea ice. It would also fit to explain to the reader why this is all relevant for a study of  $p\text{CO}_2$ .  
**Response:** It has been revised.
35. P5, L117-118: Replace 'During freezing, salt is excluded ... [] ... brine rejection' with 'During freezing, brine is rejected from ice, thereby increasing sea surface salinity'.  
**Response:** It has been revised.
36. P5, L119: replace 'to dilute' with 'thereby diluting'  
**Response:** It has been replaced.
37. P5, L125: Remove 'clearly'  
**Response:** It has been removed.
38. P5, L127-128: 'the active biological process': Do you mean photosynthesis?  
**Response:** Yes and we have added information about the relationship between chlorophyll-a and biological productivity in the text.
39. P5, L128-129: Explain the relationship between chlorophyll-a and biological productivity

before you directly connect them and the consecutive effect on  $p\text{CO}_2$  in this sentence.

Response:

40. P5, L129: Clarify that you used remote sensing data, and provide the reader with uncertainties associated with this method. Be consistent writing Modis either as Modis or MODIS.

**Response:** We have clarified that we used remote sensing data from MODIS. The uncertainty associated was mentioned in the last paragraph in section 2.2.

41. P5, L130: Replace link by appropriate reference.

**Response:** We prefer the link to show where the data comes from.

42. P5, L138-139: This sentence seems to repeat lines 121-122 on this page.

**Response:** It has been deleted.

43. P5/6, L139-141: Rephrase sentence to make clear to the reader that there are two main methods in use, and what the advantages are of the ‘difference criterion’ method in the SO.

**Response:** It has been rephrased.

44. P6, L141: Add ‘therefore’ between ‘we’ and ‘calculated’

**Response:** It has been added.

45. P6, L142: Replace ‘the’ with ‘on’

**Response:** It has been replaced.

46. P6, L142-143: ‘of with ...’ Do you mean ‘of which’? I do not understand this sentence, sorry.

**Response:** Yes, we mean ‘of which’.

47. P6, L143-144: Why where the data gridded? They were point data from the CTD taken along the track, so why where they not already on the right spatial and temporal ‘resolution’ (do you mean interval?)?

**Response:** Yes, we gridded the point data from the CTD taken along the track in interval and we have revised the sentence.

48. P6, L150-151: Start with a capital letter t. Some words have disappeared from the caption.

**Response:** It has been revised.

49. P7, L161: Replace ‘dimension’ by ‘dimensional’

**Response:** It has been replaced.

50. P7, L 163: ‘Input variables’, how do these relate to the boxes in Fig.3?’as a vector’ is more fluent than ‘in a vector form’

**Response:** The input variables related to the environmental parameters in Fig.3. We have made it clear the input variables and the environmental parameters. We have also changed to

be ‘as a vector’.

51. P8, L173: did not all your underway measurements include measurement of  $p\text{CO}_2$ ?

**Response:** The underway measurements included measurement of  $p\text{CO}_2$ . Here we mean: for the training process, the input environmental parameters are those from satellite and model data of 0.1 resolution. However, the measurement of  $p\text{CO}_2$  was along the cruise track and it has a spatiotemporal limitation compared to satellite data.

52. P8, L178: Why did you quantify skewness and what did you do with the results? Is taking the logarithm an accepted method to improve the N coverage? Why does the coverage increase when taking the log?

53. P8, L186: Why is this not done for SST and SSS?

**Response to No.52&53:** In table 1 all values are absolute values of the four proxies to show the value range. For the skewness and the N coverage percentage, the normalized data are shown in parenthesis. According to the change of skewness and N coverage percentage we found out only MLD and Chla data needed to be normalized for both the training and labeling dataset. Since we used Euclidean distance function to select the winner neuron and it depends on the data-value range of each proxy. The normalization for MLD and Chla dataset is to avoid weighting issue raised from the different magnitude among the variables.

In section 2.1 we have discussed the four proxies which will affect the distribution of  $p\text{CO}_2$  in the surface sea water. The dissolution of  $\text{CO}_2$  into water is mainly affected by temperature and pressure of water. The variation of salinity has little effect on the dissolution of  $\text{CO}_2$ . However the sea ice changed quickly in the study region and we chose salinity to be a proxy to simulate  $p\text{CO}_2$ . Moreover, in the region where local biology activities are active,  $p\text{CO}_2$  will be affected strongly by photosynthesis. The mixed layer depth will prevent the upward mixing of nutrients and limits the biological production therefore we chose MLD as another proxy to simulate  $p\text{CO}_2$ . Sea surface height and sea level pressure are not major factors to the distribution of oceanic  $p\text{CO}_2$ . Wind speed is vital for the sea-air gas exchange and it is included in the air-sea flux equation.

54. P9, L198: Add ‘part of the’ between ‘second’ and ‘process’. Also, it is either each neuron or all neurons (i.e. is it plural or singular here?)

**Response:** It has been added and corrected to be ‘neuron’.

55. P9,L213: What is meant with ‘8-d’? 8 dimensions, 8 days? If 8 days, why not 7 if used as weekly data?

**Response:** ‘8-d’ meant 8 days here. Our study period was from the beginning of February to March 4. When we used 8 days as weekly it was proper to cover the study period.

56. P10, L243: Replace ‘by two items’ with ‘using  $p\text{CO}_2$  and the transfer velocity across the air-sea interface’ or something similar.

**Response:** It has been replaced.

57. P10, L246: Replace ‘delta’ with ‘ $\Delta$ ’

**Response:** It has been replaced.

58. P10, L247: What scaling factor are you talking about here? Is it in  $Wq.2$ ?

**Response:** The scaling factor for the gas transfer rate is 0.251. It was not shown in Eq.2 because Eq.2 is a simplified equation taking into account the unit conversion factor. We have revised this part to make it clear.

59. P10, L251: Check that equation has one format/font and denote units in []-brackets.

**Response:** It has been revised.

60. P10, L252: Check superscripts of  $pCO_2$ -air and  $pCO_2$ \_sea, also add 'and' before  $pCO_2$ \_sea and end the sentence with 'respectively'

**Response:** It has been checked.

61. P10, L256: I am again confused by the use of the word regridding, your are working with sample data– why do you regrid? You mean you gridded the data from the point measurements you had of atmospheric  $pCO_2$ ? What linear method did you use?

**Response:** The atmospheric  $pCO_2$  was of the cruise track. When we got the SOM derived oceanic  $pCO_2$  it was of 0.1\*0.1 resolution. In order to calculate the air-sea flux we need to extrapolate the atmospheric  $pCO_2$  to be the same 0.1\*0.1 resolution. We used linear method.

62. P10, L258-259: Do you mean you integrated the gridded flux over the area of Prydz Bay, taking into account the ice-free area only? How did you take ice into account?

**Response:** We have added the information to the text. The sea-air flux was calculated according to the proportion of ice-free area.

63. P11, L267: No need to use the acronym AD if you only use it once

**Response:** It has been revised.

64. P12, L300: What is formed here? The subject of the sentence is the Shelf region, but a regions cannot be formed by modification of water.

**Response:** It was a mistake and we have changed the subject to be 'water inside the Shelf region'.

65. P12, L305-306: If the region was ice-free, Fig.5 cannot be correct?

**Response:** Fig.5 is correct and the ice shown in Fig.5 is permanent ice. We have revised the sentenced to be 'the most least ice-covered'.

66. P12, L314-315: When and where does the biological pump become the dominant factor setting the distribution of  $pCO_2$ ? How do you know this is the main contributor to the  $pCO_2$  variations?

**Response:** The low oceanic  $pCO_2$  was consistent with the high chlorophyll value in the Shelf region. For four weeks biological pump was the dominant factor setting the distribution of  $pCO_2$ . In the Shelf region other factors didn't show such pattern with oceanic  $pCO_2$ .

67. P16, L371: What indicators did you use to conclude that the stability of the water was weak?

**Response:** The original sentence is not proper here. We have removed this sentence.

68. P16, L377: flew? Please rewrite this sentence.

**Response:** It was a mistake. It should be 'flowing' and we have corrected it.

69. P18, L395:  $10^{12}$ gram=Tg

**Response:** It has been revised.

70. P18, L400: Please provide references to this statement and mention it earlier in the manuscript.

**Response:** The references have been added and we have added the information in the introduction.

71. P18, L408-410: So does the region take up more carbon than on average in the ocean? I.e., is it a relatively large sink as compared to its area?

**Response:** Yes, this region takes up more carbon than on average in the ocean. Though small area, it is a relatively large sink. Taking into account the Prydz Bay is one of the resources of AABW (Antarctic Bottom Water), large amount uptake of atmospheric CO<sub>2</sub> may have an effect on the ocean acidification in the long run.