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# *Interactive comment on* "Biogeochemical variations at the Porcupine Abyssal Plain Sustained Observatory (PAP-SO) in the northeast Atlantic Ocean, from weekly to inter-annual time scales" *by* S. E. Hartman et al.

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Responses to Reviewer 2 Comments

Hartman et al., Biogeochemical variations at the Porcupine Abyssal Plain sustained observatory (PAP-SO) in the northeast Atlantic Ocean

We would like to thank the reviewer and for the positive and constructive review of our manuscript. Here we address each comment, and list additional changes/updates that were made to the manuscript. References used within the responses have been



listed at the end of this document. The changes outlined in the document are further highlighted in the accompanying word document.

Re: Reviewer specific comments

1) Some information necessary to assess the quality of the dataset are missing. In general uncertainty estimates for measured and calculated data, especially when used for TA & flux.

As with our reply to reviewer 1 we have put precision and uncertainty estimates for each measurements and calculated variables into the method section. Specifically: For nitate data: "Nitrate concentration measurements were initially made using wet chemical NAS Nitrate Analysers (EnviroTech LLC, USA) precision 0.2 $\mu$mol l-1, as described in Hydes et al. (2000) with twice daily sampling frequency and internal calibration as described by Hartman et al. (2010). From 2010 additional higher frequency inorganic nitrate measurements were made using UV detection methods (ISUS, Satlantic), precision 1 $\mu$mol l-1."

For Chl data: "The quoted precision for the fluorometers is 0.04% and the text has been changed. We have also noted that the fluorescence output can only provide an approximation of chlorophyll a. The fluorescence/chlorophyll a calibration ratio changes throughout the year, due to variations in the phytoplankton species composition."

For pCO2 data: "Although measured by different instruments, the two p(CO2) data sets were calibrated in a similar way to make them comparable: the sensor outputs were calibrated against p(CO2) values calculated from dissolved inorganic carbon (DIC) and total alkalinity (TA) from discrte samples taken at the mooring site during deployment/recovery cruises; and plausibility check were made with underway p(CO2) measurements around the PAP site (see below). The 2003-2005 data were previously published (see Körtzinger et al., 2008 for details) with a precision of 1 $\mu$atm and an accuracy estimated as 6-10 $\mu$atm. The 2010-2012 data have a similar precision (1 $\mu$atm) and accuracy (6 $\mu$atm). "

For calculated TA: "The TA was calculated from Argo temperature and salinity (30 m), following the relationship for the North Atlantic developed by Lee et al. (2006) with a uncertainty of $\pm$ 6.4 $\mu$mol kg-1 (Lee et al., 2006)."

For calcualted DIC: "Using TA and p(CO2) to calculate DIC introduces an error in the order of 6 $\mu$mol kg-1.".

2) The dataset could have been used to calculate budgets

We acknowledge that this is a strength of the dataset and will be done in further work but it was not our intention to address this in the paper.

3) An estimate of advection could be given

Hartman et al 2010 showed the importance of advection at the site but we have not calculated the extent of this. It is important to acknowledge this in the discussion of results and we have strengthened the discussion to reflect this.

4) Be consistent with affiliations

We have added a city when there are multiple sites (eg: Southampton version of NOC to distinguish it from Liverpool). Where the site is unambiguous we have not mentioned the city (eg: University of Exeter or UEA). The citation list has been further modified to put the affiliations in the correct numerical order.

5) Remove mention of Gas tension device if not used.

Thank you we have now removed reference to this device.

6) There is no quantitative comparison with Kortzinger 2008 data.

The early data was reproduced here - we had previously reported it in Kortzinger 2008 so the whole paper is a comparison of that early time period with more recent data. For most variables such as temperature, MLD, DIC and wind speed, our 2010-2012 data show similar seasonality when compared with the Kortzinger 2008 data (as shown in



Fig. 2, 3, 5). However, when we are discussing inter-annual variability, we not only qualitatively compare the seasonal trends but also quantitatively comapare the winter maximum nitrate concentration, air-sea CO2 flux, annual mean wind speed and pCO2 values (See Discussion section).

7) Concerns with using factory calibrations especially with respect to IR instrument drift and temperature dependence

We have clarified this in the methodology. "For each instrument the manufacturer's calibration was checked at the start of each deployment and instrument drift was corrected using a second calibration check on recovery of the instruments". For pCO2 measurment:."Twice daily p(CO2) measurements, from 2010 to 2012, were made using a membrane-based PRO-CO2 sensor (Pro-Oceanus, Canada), which uses an infrared detector and is internally calibrated through an auto-zero calibration function (Jiang et al., 2014). Note that measurement error of early version of PRO-CO2 sensor during the deployment, induced by the fluturation of detector cell temperature, was identified and corrected (see Jiang et al., 2014 for further details).". "The sensor outputs were calibrated against p(CO2) values calculated from dissolved inorganic carbon (DIC) and total alkalinity (TA) from discrte samples taken at the mooring site during deployment/recovery cruises; and plausibility check were made with underway p(CO2) measurements around the PAP site".

8) Show how ARGO and microcat compare, especially as the box contains shelf and open ocean water

I am not sure how to clarify this further as we stated in the text that the shelf edge data were excluded: 'To obtain a continuous seasonal description, a large region was selected (45âÛę N to 52âÛę N and 26.08âÛę W to 8.92âÛę W, excluding the shelf area)'. Also stated in the text was the results of the ARGO comparison with in situ 30 m microcat data and our decision not to show this. 'n=112, comparison not shown'. We don't think a plot of this comparison (supplementary figure a) adds to the interpretation.

9) Why didn't the authors use SOCAT?

When we looked at SOCAT data for the region the only data set that showed (for the time periods covered here) was the UEA SOO data. As we are also involved in collecting salinity and nutrient data on this line we didn't include further data from SOCAT as it would not add to the comparison.

10) Use parenthesis for pCO2sea and pCO2air

Thank you we have amended this.

11) Delete line 21 'the partial pressure of carbon dioxide' as already introduced Thank you we have amended this

12) How good is the agreement between VOS and PAP-SO pCO2 data?

As the VOS (SOO) data were not collected at the same frequency with the PAP-SO measurements and there are rarely times when the data points coincide, we didn't directly compare the agreement between VOS and PAP-SO pCO2 data. Instead, the VOS data is used as a plausibility check for the calibrated sensor outputs and it fill the gap where the PAP-SO data are not available.

13) Add parenthesis to 2010 citation l.13

Thank you we have amended this

14) Use PAP-SO instead of 'sustained observatory..'

Likewise, we have amended this

15) Add uncertainty estimates p. 12425.l.10

Uncertainty estimates have been added by looking at the change of ratio between max & min lines of best fit.

16) Correct DIC for air-sea flux



We have now corrected the DIC for air-sea flux.

17) P12428, l.11 the NAO was already introduced

This is not a reintroduction of the NAO and has been left unamended. The initial introduction was to Hurell dataset, in the discussion we point out the importance of the winter index to the MLD.

18) Try to estimate advection p.12429, l.3-5

As in comment 3 Hartman et al 2010 showed the importance of advection at the site but we have not calculated the extent of this for later data as it was not the focus of the paper (this will be investigated in a further paper by H.Frigstad). However, it is important to acknowledge advection in the discussion of results and we have strengthened the discussion to reflect this.

19) Correct page numbers on l.16, p.12432 to 264-280

Thank you, we have amended this

20) Add a contour line for the shelf break

Please see response to reviewer 1 who had a similar comment. Figure 1 has been amended to show the shelf break. We hope that this is satisfactory for the reviewer as an improvement on the previous Fig. 1?

21) Fig.2 labels are hard to read. Keep legend consistent (no legend in panel a) Thank you we have amended this by going up one font size.

22) Fig 3 add Microcat temperature and rephrase the last part of the figure caption

The microcat data have not been added. As you can see from supplementary figure b they are in agreement with Argo data and as stated in comment 8 above we decided to use ARGO data (away from the shelf) in preference as the dataset was more complete. We have rephrased the caption as follows: 'Figure 3. Data from 2003–2005 (blue

circles) and 2010–2012 (red diamonds) with vertical lines to represent the start of each year showing: (a) Argo temperature data from 30 m depth around the PAP-SO; (b) monthly mixed layer depth (MLD) data; (c) calculations of weekly dissolved inorganic carbon (DIC) concentrations.' Fig.4 increase font size. Typo in caption (concentration). Add 'of' before 6.6 in last line. Make Redfield dashed line more visible. Figure 4 has been amended to reflect all of the above and the DIC (corrected for air-sea flux has been used).

23) Fig. 5. Increase font size. Keep legend consistent with no repetition in caption.

Figure 5 has been amended to reflect all of the above.

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Interactive comment on Biogeosciences Discuss., 11, 12415, 2014.



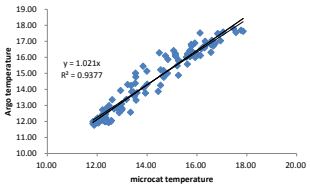


**Fig. 1.** BG-345 figa

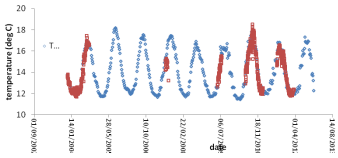


**Fig. 2.** BG-345 figb