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Ocean Science Discussions

Interactive comment on "Seasonal and interannual variability of water column properties along the Rottnest continental shelf, south-west Australia" *by* Miaoju Chen et al.

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Response to reviewers: os-2018-115 (Submitted to Ocean Science)

Seasonal and inter-annual variability of water column properties along the Rottnest continental shelf, south-west Australia by Miaoju Chen, Charitha Pattiaratchi, Anas Ghadouani and Christine Hanson.

We would like to thank and acknowledge both reviewers and the editor for their careful reading and constructive comments on the manuscript. There were no public comments. We believe that we have addressed the issues raised by reviewers and the

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proposed changes to the manuscript are detailed in this document. We trust that the reviewers and the editor will find that the suggested changes will make the manuscript to be suitable for publication.

Reviewer #2

(1) Abstract Sentences 2 and 3 needs integration. They can be mix together integrating the information to report.

As suggested also by Referee#1 – the abstract has been revised and shortened. Sentences 2 and 3 have been integrated.

(2) Introduction Line 2. I would prefer to start the sentence like. “Among phytoplankton pigments, chlorophyll.„”There are other pigments in phytoplankton. I think that the is chlorophyll a that was used as indicator of phytoplankton biomass or you use the total amount of chlorophyll? Depending of your answer change the sentence accordingly.

Chlorophyll a was used as indicator of phytoplankton biomass. The ocean glider measures chlorophyll fluorescence. We have revised the text as follows:

Among the phytoplankton pigments, chlorophyll a (denoted as chlorophyll in the following description), is an important biological indicator of phytoplankton biomass in the water column.

(3) On paragraph 25 and 30, the sentence starting by “It is major is a mechanism. . .” I think this is a typing error remove the second “is” and “a”.

We agree: the second “is” has been deleted.

(4) Page 5 paragraph 10. Please remove “highly” from the sentence Thus the RCA is a highly nutrient”. . .

We agree: the word “highly” has been deleted.

(5) Page 5 paragraph 20. “. . .are not weather limited.” The gliders were able to fly

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even during bad weather conditions and strong winds? If so why you mentioned that in some seasons data were not present and the graphs have gaps?

It is true that gliders are capable of collecting data in harsh weather conditions and strong winds when ship sampling is not feasible, making them ideal platforms for sustained ocean surveys. However, due to funding limitations and operation reasons (i.e. gliders were not deployed over the Christmas/New Year holidays). The sampling was started with an ambitious goal of having at least one glider operating along the sampling line at all times. This was a quite a challenge and then with decreasing funding the deployments reduced to bi-monthly and then quarterly.

The gaps present in the graphs is due to the sampling nature of the gliders that travel in a saw-tooth pattern. In shallow water the down-cast and up-casts are close together whist in deeper waters the spacing is larger resulting in missing data.

(6) Methods Page 6. Paragraph 10. Of course, this methodology is a huge advance that regular measurements performed but I was also wondering if two or three days took to complete the transect was not too much time. In very dynamic areas, like upwelling areas, you might have complete different conditions within the 3 days for adjacent areas.

We agree with the review that in very dynamic areas, water properties may change within the 3 days, which we have submitted a paper to JGR (oceans) indicating that ocean gliders are capable of capturing diurnal upwelling.

However, in this study, we are addressing the seasonal and inter-annual variability, which will not be affected by these shorter term dynamic processes. In contrast, the ocean gliders provide high spatial resolution data ($\sim$1-2 km intervals).

In addition, we have compared glider transect with satellite data (for both temperature and chlorophyll), and the surface features were consistent.

(7) Page 6 paraph 20. Did you performed any inter- calibration exercise between

the data collected from the chlorophyll fluorescence recorded and the quantification of chlorophyll (mg/m3). Again total chlorophyll or chlorophyll a only.

As part of the IMOS ocean glider program we have undertaken many inter-calibration exercises. Here, we attached a glider to a rosette sampler and collected concurrent data from the glider and niskin bottles at surface, mid-depth and bottom of the water column in 100m depth. The water samples were subjected to HPLC analyses to determine the Chlorophyll a concentrations. The comparison between ocean glider derived fluorescence and the HPLC Chlorophyll a concentrations was very good with r2 > 0.75 (n > 100) in the range 0.17 to 0.21 (mg m-3) (see Thomson et al., 2015).

A recent study by Beck (2016) found that, through inter-comparison of chlorophyll a and Wetlabs ECOPUCK derived fluorescence on ocean gliders, the original manufacturer's recommendation for the estimation of chlorophyll a from fluorescence provided the best estimate.

See also response to Reviewer#1 (point 5)

(8) Page 6. Last paragraph is very confusing. I don't understand if you reach the conclusion that the data was anormal by subtracting to the seasonal mean. You say previously that you perform quality control on data. Why you don't exclude the anormal data there. . ..so you won't have to deal with them again later. I think that you should try to rephrase and clarify that paragraph.

We believe that the reviewer meant page 7 (and not page 6) about the calculation of the anomalies. We do not discuss 'anormal' but 'anomalies' (def: something that deviates from the mean). We decided to present the data as anomalies as the seasonal variation in properties obscured the variability. A detailed explanation is also included as the response to Reviewer#1 and we have included a Table of the mean values (see above). To avoid confusion and for completeness we have included the distribution of absolute values as supplementary material.

We have rephrased and re-written the paragraph – we believe that inclusion of Table 1 and the absolute values as supplementary material will remove this confusion.

(9) Results Page 8. 3.3 Methods section; first line. This information must be in Methods section and justified why there are no mean for the season for that months, if you claim that gathering of data using gliders are not weather limited.

We have moved the sentence to the methods section.

Glider data were not available mainly due to operational reasons (e.g. funding, holiday season etc) rather than limited by weather – see also response above (point 5).

(10) Page 9 Paragraph 25 Typing error. Replace 6a by 7a.

We agree: have replaced 6a by 7a.

Page 10. The 3.5 section of results were very difficult to follow because the figure 9 were not understandable and I advise rebuilding it in clearer manner. Probably because I was confused with the figure I think that the paragraph 20 description was not correct. You have a higher chlorophyll concentration than 0.81 mg/m3 mentioned for 2009, between 10 and 20 m depth with chlorophyll concentration ranging 1.8mg/m3.

We have added additional text to make the figure clearer. The figure shows the depth mean values of temperature, salinity and fluorescence with time for all of the ocean glider transects. Figure 9 shows the same information as Figure 10 which the Reviewer stated to be very good as good evidence as different patterns between El Niño e La Niña (point 11 below). The difference is that Figure 9 shows the variation across the whole continental shelf whilst Figure 10 is the same data but at a particular distance (10 km). We have explained the relationship between the two figures in the text. As such we propose to retain this figure in the revised manuscript.

(11) Figure 10 was very good evidencing the different pattern between El Niño e La Niña.

Thank you – and we of course agree with the reviewer. No change required needed.

(12) Discussion Page 12. Line 14 (I think) Typing error : repeated.

We agree: have revised the typing error as follows:

The chlorophyll variability was related to the changes in the temperature, salinity distribution, which was linked to changes in the physical forcing: (1) the local wind field; (2) the Leeuwin current system; and, (3) air–sea fluxes, especially in terms of surface cooling and evaporation.

(13) Paragraph 20 to 25 must be in introduction.

We agree: have moved to the Introduction

(14) Paragraph 35 to 40 was already described in introduction.

We have deleted the paragraph

(15) Paragraph 25 and 35 must integrated with the obtained data by proving examples of the physical processes I think that your discussion must be improved by comparing your data with another data from upwelling coastal areas also impacted by El Niño and La Niña and compared the impact results in terms of chlorophyll and consequently in productivity between areas or with former events. It is very important to bring awareness of climate change and the huge effects they have in coastal dynamics and phytoplankton biomass and overall productivity giving relevant to studies like the ones you developed.

Please also see the response to Reviewer#1 – Point 7.

One of the unique features of the study region is that it does not follow well established processes and seasonality in other regions globally. Although the study region is located in an eastern ocean basin – it is not a major upwelling region (similar say to off Peru/Chile or South Africa). This is mainly because of the presence of the Leeuwin Current which flows southwards against the prevailing upwelling favourable winds that

promotes downwelling. During the summer there is shallow upwelling that results in elevated chlorophyll but is not able to sustain a large fishery. Also, maximum chlorophyll presented here are factor 10 lower than those observed off South Africa. In addition to this the maximum chlorophyll levels are observed during late autumn/early winter and thus not during the period upwelling favorable southerly winds are present. In summer the most persistent feature was the sub-surface chlorophyll maximum. Autumn is characterised by low wind speeds and winter has not prevailing wind (see Figure 2 and 3). Although other upwelling regions such as off Peru and South Africa does respond to ENSO events- mainly due to changes in the wind field, here the response is mainly due to changes in the strength of the Leeuwin Current that determines changes in the chlorophyll rather than upwelling. We have included this in the discussion.

We agree with the reviewer that climate change and the huge effects they have in coastal dynamics and phytoplankton biomass are very important and we have also included an additional paragraph to highlight that understanding inter-annual variability provides a good indication of what we may expect from climate change.

References: Beck M. (2016), Defining a multi-parameter optics-based approach for estimating Chlorophyll a concentration using ocean gliders. Unpubl. MSc Thesis, Dalhousie University, Canada. Kämpf, J., and A. Kavi (2017), On the “hidden” phytoplankton blooms on Australia’s southern shelves, Geophys. Res. Lett., 44, 1466–1473, doi: 10.1002/2016GL072096. Rossi, V., M. Feng, C. Pattiaratchi, M. Roughan, and A. M. Waite (2013), On the factors influencing the development of sporadic upwelling in the Leeuwin Current system, J. Geophys. Res. Oceans, 118, 3608–3621, doi:10.1002/jgrc.20242. Thomson, P.G., Mantovanelli, A., Wright, S.W., Pattiaratchi, C.B. (2015). In situ comparisons of glider bio-optical measurements to CTD water properties. Australian Marine Sciences Conference, Geelong, Victoria, July 5th – 9th 2015.

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