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Discussions

Interactive comment on "Controls on oxygen dynamics in a riverine salt-wedge estuary – a three-dimensional model of the Yarra River estuary, Australia" *by* L. C. Bruce et al.

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The authors would like to thank Anonymous Referee #2 for their constructive comments and suggestions made regarding our manuscript: "Controls on oxygen dynamics in a riverine salt-wedge estuary – a three-dimensional model of the Yarra River estuary, Australia" by L. C. Bruce et al.

In response to suggestions made by Anonymous Referee #2 and a HHG Savenije (Referee #1 the authors have re-analysed the results to clarify the findings and address the issues raised. The manuscript is to be revised with the following main improvements:

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1) Figure 1 to include boundary conditions, correct chainage, all sampling stations and the position of the points of inflection discussed in the results as well as the sill. 2) A comprehensive description of the Yarra River estuary study site to include classification based on morphometry, structure and function. 3) Clarification of the main research findings on the elucidation of the dominant physical driving factors leading to patterns of oxygen depletion in the study side. 4) An enriched discussion that seeks to better demonstrate the relevance of the findings and to place them in both a local and international context. We highlight that estuarine hypoxia is impacted upon by flow management. The authors have included new figures as supplementary material for consideration. A more detailed response to each comment within the review is given below.

Referee 2 (Anonymous Referee)

In this paper a complete dataset of the characteristics of the Yarra River estuary is presented. The authors focused into the oxygen and salinity dynamics associated with the saline wedge movement and river discharge. The methods applied included the modeling for a better understanding of the processes and particularities of this study area. Summarizing, it is a manuscript with valuable data and interesting results. Nevertheless despite of the interest of the research I found many aspects that can be improved to make the text more attractive for the international reader. Also the addition of some information and an enriched discussion of some of the results would be necessary.

We acknowledge some detail was lacking and the main concerns are addressed by expanding the discussion to highlight new insights gained from the analysis - in particular these changes aim to: 1) put the insights into context with the current literature to benefit the international reader; 2) provide additional information and explanation as described below; and 3) expand the discussion of the results.

Abstract The authors should highlight the benefits of this work at an international scale.

Example: Page 9800. Lines 7-10. "Coupled physical and biogeochemical models have been applied to study the interaction of physical processes and seasonal hypoxia, however, application to riverine estuaries with tight curvature and more sporadic periods of oxygen depletion is rare." If the authors consider this as a new viewpoint of this study they should detail which studies focused into these tight curvature estuaries and why is this remarkable.

A reference to Diez-Minguito et al (2013) has been included in the introduction to highlight a comparison study on an estuary with tight curvature.

Introduction The introduction is mostly a general review of investigations developed in estuaries but not adjusted to the objectives of this paper. There is a mix of general statements extracted from other authors with some new information about the study area, this is making difficult to 1) have a good knowledge of the local conditions (the authors should presented them clearly) 2) Have a good overview of the connection between literature review and the objectives of this paper. The authors should try to make a better contextualization of the research challenges in these environments and connect them with the Yarra River case.

The revised manuscript will include a re-structure of the introduction along the lines suggested above. In particular the background will relate directly to the stated objectives at the end of the introduction. A description of the Yarra River estuary in context with these objectives will be included and a more comprehensive description included in the Methods section.

There is a lack of connection between sentences a few times. Examples: Lines 4-10, lines 11-17.

A thorough final edit of the manuscript will be undertaken before submission to ensure connection between sentences.

Page 9801. Line 3. Health

Corrected as noted.

Page 9802. Line 4-6. The sentence needs to be reviewed.

This sentence now reads: "Monthly measurements of oxygen have recorded regions of anoxia propagating the length of the estuary during periods of low flow and a complete absence of anoxia in response to peaks in fresh water inflow (Roberts et al., 2012)."

Study site. Where is GardinerâĂšs Creek? I donâĂšt see it in the Figure 1. It is commented some aspects about its properties but it never was shown in the results its impact over the model. If it is not relevant, what is the reason for the detailed description that is made?

Gardiner's Creek is now clearly marked in Figure 1 (refer to supplementary material). The revised manuscript will seek to include a reference to the impact of GC on the distribution of both the salt wedge and anoxia in the estuary.

Page 9805. Line 4. In the text is commented that the temperature ranges from 4-47 C but in the Figure 2 the maximum reached is 43 C.

Corrected to read 4-43oC.

Page 9807. AHD should be defined.

Added the following definition: "Australian Height Datum (AHD) defined as the mean sea level for thirty tide gauges around the coast of the Australian continent."

After reading the methods section I suggest the addition of the river channel morphology description. In later sections it is commented the effect of changes in the shape, increases/decreases of the depth and even the presence of an island. Also the results indicate that it has a high impact over the model results but this was never explained. The authors should describe this question and also consider what are the implications over the modeling to ensure that the obtained results are including all the elements that affect them.

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We have added a figure that plots depth and area as a function of chainage for the model domain (see supplementary material). We will include a description of the estuarine morphology in the study site description in the Methods section including the context of mixing and salt wedge intrusion.

In the text the authors commented that they have 160 sections of the river, on the light of this information, are the simplifications that they assumed for the modeling (interpolation and smoothing) acceptable from a scientific perspective?

Determination of model bathymetry came from interpolation based on both the 160 sections and the more comprehensive study involving 3 soundings per metre run in the main section of the river. The implications of discretising these data into 397 grid cells have been discussed in the context of model fit performance leading to suggestions of model improvement.

Some assumptions for the model setup are not discussed even if they are strong simplifications. Examples: "salinity and oxygen were linearly interpolated from weekly sampling", ". . .and found to have strong correlation.". The authors should consider the implications that this has over the model and also be more specific about the correlation of the methods.

The authors will seek to explain the implications of each simplification in the Methods and refer back to these implications in the discussion of model fit performance.

Model evaluation Where is Johnson Street?

Reference to Johnson Street has been replaced by Dight's Falls.

One of the main problems of this manuscript is the way of localizing the measuring stations/morphology of the river/processes. The use of very local references as bridge, college and roads makes very difficult to follow the explanations without checking the map. I would recommend the use of a less arbitrary system as naming the places with increasing/decreasing numbers of alphabetical letters that will be easier. Also it would

help to have a rough idea of the distance to the sea. In general the authors should include any geographical reference mentioned in the text into the Figure 1.

All stations mentioned in the text have now been included in Figure 1. An additional table has been added that includes chainage for all monitoring stations used in the study. Refer to supplementary material for both revised Figure 1 & Table 3.

Page 9808. Line 25. ". . .because different methods of model evaluation tell us different things about model performance". Can the authors be more specific about this sentence. Model evaluation. The different calculations of model fit. The purposes that the authors consider for the use of the different methods are not directly applied in this manuscript and they did not include it as an objective itself in the aims description.

Whilst considering the inclusion of model fit analysis an important component of the study outcomes, so as not to distract from main purposes of the paper, in the revised version it will be placed as an Appendix.

Page 9811. Line 1. Is Burrnley Station the same that Burnley Depot?

Yes all references now refer only to Burnley Depot

The authors make reference to the horseshoe bends, can they show them in the map to know which one is the first or the second? In general any description of the river channel as the sill or threshold should be show in the map to avoid misunderstandings.

All points of inflection as well as the sill is now included in Figures 1 & 2 (refer to supplementary material).

Page 9811. Lines 1-4. "Model skill scores were all reasonably high and NMAE reasonably low with the exception of Burnley Station." Can the authors define reasonably high and low?

P9811L1-4 now reads: "Model skill scores were all reasonably high (>0.8) and NMAE reasonably low (<0.3) with the exception of Burnley Depot."

After reading the explanation about the model results with the different methods to do it and Table 3, what is the benefit of having so many different methods to quantify the quality of it?. I think this could be an interesting question for many model users.

This question in the context of model users will be answered in more depth in the Appendix section on the evaluation of model fit performance.

Page 9812. Line 7. "These correspond to the regions from 5–10 km upstream and 12–17km upstream of Spencer Street Bridge." I donâĂšt see these distances in the figure. I would say that is located at 5-9 km and I donâĂšt know how the authors consider that at 12 km there is a change, I donâĂšt detect it in figure 7. Also how can they assure that is until 17 km if the maximum distance represented is 15 km?

The chainage has been recalculated as the distance upstream of Port Philip Bay and the text changed to reflect the altered chainage. The text now reflects the observations made from Figure 7.

Page 9812. Line 26. The distances of horseshoe bends are not evident for me in figure 1. Maybe 6500 and 9700 can be possible but the one at 15800 is a 90 degrees angle. Anyway for avoiding imprecisions the best would be to mark in the figure the horseshoe bends.

Figure 1 now includes the points of inflection as correct chainage and as located on regions of tight curvature (please refer to supplementary material).

Page 9813. Line 1, It is stated that the "salinity measurements were interpolated from monthly profiles". Why not run the model until the date when you have collected the data?

The model was run for the duration of the monthly sampling regime. The interpolation referred to here is along the thalweg, the text has been changed to avoid any confusion.

I think figure references are wrong from figure 9 that is actually 10 and the same for figure 10 that is 11.

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All figure references have been checked and corrected where necessary.

The discussion about the evaluation of the model is not representing an advanced in the state of the art. If the authors consider that this section is necessary they should discuss with broader perspective and not only to remark the quality of the model. A bit of this is observed at the end of section 4.1. but the rest of the discussion is more appropriated for a local journal.

As mentioned the main discussion of model evaluation will be moved to the Appendix so as not to distract from the main purpose of the study.

Page 9818. Line 22-23. Review this sentence

P9818L22-23 now reads: "In this study the model results illustrated that patterns of salt-wedge intrusion in the Yarra River estuary were dominated by both bottom topography and the effect of channel curvature."

Page 9820. Line 6-7. "..and found a strong linear relationship (Fig. 12)." I donâǍšt see this strong linear relationship that the authors consider.

To our knowledge there is no analytical solution for the extent of anoxia in estuaries in response to changes in flow or other boundary conditions. We therefore attempted numerous approaches to develop a simplified relationship from the numerical model. Most attempts led to a poor relationship highlighting the multiple interacting factors that ultimately combine to manifest in low oxygen conditions.

The purpose of Fig. 12 is to demonstrate the effect of antecedent conditions on the response of anoxia to temperature. When the salt wedge toe is sitting in zone 4, the relationship is strongest, however under high flow levels when L2 is sitting in zone 1 there is no linear relationship apparent. We will endeavor to provide greater explanation in the text to explain the purpose and interpretation of this figure.

Page 9820. Lines 12-20. This discussion is more adequated for the introduction.

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These lines have been moved to the introduction and linked to a fourth study objective to explore how anoxia in the Yarra River estuary may respond to predicted patterns of climate change.

Conclusions. The first part of the conclusions is only describing general facts that are not very relevant. The conclusions can be improved showing the most outstanding results and quantitative results more that general statements.

The conclusions will be revised to link to the specific objectives of the study as outlined in the revised Introduction.

Figure 1. What is the meaning of field stations? Some of them were used in this work but others no. Please just add the stations necessarias for the explanations. What is the meaning of bottom depth? Would be more correct bottom depth elevation? I added in the previous comments many suggestions for this figure. The fonts are very small and difficult to read.

The Figure 1 has been improved and included in the supplementary material. Only the field stations mentioned in the text have been labelled and the figure caption now reads: "bottom depth elevation". Font sizes have been increased for ease of read.

Figure 2. I donâĂšt see very well the differences between grey and black but it seems that there is a different T and rainfall in Gardiners Creek. How far are the climate stations? How affect this to the results? If Gardiners creek is not use in the rest of the manuscript, why is so carefully explained here?

Figure 2 has been re-done in colour. The temperature and rainfall for Gardiner's Creek are the same as the Yarra. The distance to the met stations has been listed in the methods section and a brief explanation as to the error induced added. Gardiner's creek will be mentioned in the manuscript as justified by the inclusion in the model set up.

Figure 3. This figure is good but I donâĂšt think that is connected with the objectives

of the work. It is not discussed. Remove it.

This figure is for the purpose of describing the physical model as the main tool used in this study as well as being of interest to numerical modellers. It can be moved to the Appendix.

Figure 4. I donâĂšt see well the dots. I donâĂšt think that the adjustment is as good as the statistical indicators showed.

We acknowledge that there is a lot of scatter in the data and that we are using a simplified SOD model. The purpose of this plot is to illustrate that the parameters that we are using will give rates of oxygen flux across the sediment water interface that are in order of that measured experimentally.

Figure 5. The font is very small.

We think here you refer to Figure 6 which we will supply with larger font sizes.

Figure 6. I donâĂšt see the arrows.

We think here you refer to the figure caption for Figure 7 which has been corrected to read: Figure 7 – Predicted a) strength of stratification (bottom cell – top cell, psu) and b) bottom oxygen concentration (mmol/m3). Right panel average daily flow rate (m3/s).

Figure 12. The correlation is not showing the linear trend suggested. Zones 1 and 2 are not acceptable; Zones 3 and 4 demand a better discussion.

As explained above the purpose of this figure is to show both zones with no linear trend and zones with high linear trend. The accompanying discussion in the text will be adjusted to avoid any confusion.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 10, 9799, 2013.