Biogeosciences Discuss., 12, C3388–C3393, 2015
www.biogeosciences-discuss.net/12/C3388/2015/

Biogeosciences
Discussions
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Interactive comment on "Historical reconstruction of ocean acidification in the Australian region" *by* A. Lenton et al.

Anonymous Referee #1

Received and published: 7 July 2015

Review of Lenton et al: Historical reconstruction of ocean acidification in the Australian region

Lenton et al compile available data for ocean pCO2, SST, SSS and atmospheric CO2 to estimate the evolution of pH and aragonite saturation state on a higher spatial and temporal resolution than available before. They provide this data set to be applied to ecological applications and gain new insights on the magnitude of changes over the last 140 years.

This study is a valid contribution to ocean acidification research, provides high resolution maps of pH and aragonite saturation state around Australia and gives estimates of their historical change. It will likely have many readers and be a very valuable reference for ecologists and physiologists working in this region.

I recommend this manuscript for publication in Biogeosciences, after clarifying the methodological approach and providing further estimates on the uncertainty of the bold simplifications that the authors make. Some of the results need more discussion, see specific comments. The manuscript would also profit from another careful reading by the authors, as a number of typos are apparent and a rework of the maps in the figures is needed (see specific comments).

Specific comments:

p. 8266 L 8-10: This sentence is unclear. My understanding from the text is that the authors use present day pCO2 from Sasse et al, together with constant (in time) salinity, the time-series of atmospheric CO2 and the time-series of sea surface temperature to calculate pH and aragonite saturation state as a 3D field (time-series of surface ocean around Australia). This 3D field can be used to look at the more recent part of it to produce the maps of present day pH/Omega and also to analyze the temporal evolution over the last 140 years. If this understanding is correct, it doesn't make any sense to say that "these predicted changes (are combined . . .) to reconstruct pH and Omega". It's one calculation for present and past together and it's not as the authors state here the case that the present is calculated first to predict the past. It's generally hard to understand from the abstract what the authors did. You should mention here which data goes into the calculation (not the specific data set, but time-series of SST, time-invariant salinity. . .)

p. 8268, l. 14-16: what about SOCAT data?

p. 8269, l. 17. As this is a crucial part of your method, you need to explain more about the method and the results of Sasse et al.

l. 20ff: If I understand correctly, the authors use Sasse et al ocean pCO2 and present day atm CO2 to calculate Delta pCO2. Then they use this Delta pCO2 together with the time-series of atmospheric pCO2 to calculate a time-series of ocean pCO2., i.e they assume that Delta pCO2 was constant over the last 140 years. This is a bold

simplification and I'm skeptical that it holds, e.g. the temperature effect on pCO2 is not accounted for and air and sea are assumed to be in the same relative equilibrium instantly and always. In other words, it means that the ocean CO2 uptake was constant in the last 140 years, which is not the case (see e.g. Sitch et al. 2015, doi:10.5194/bg-12-653-2015, Figure 9c for a decreasing CO2 uptake around Australia between 1990 and 2004). This needs to be addressed by the authors and estimates about the uncertainty of this assumption have to be made.

l. 25-26: there should have been some measurements of ALK after the GLODAP data set was assembled. Please use and refer to some newer cruises as well.

p. 8271, l. 2: please give more information on the method here. I checked in the Lenton et al 2012 paper and it's just one sentence, but makes it much easier to follow the paper if this is repeated here.

l. 4-6: refer to Hauck and Völker, 2015 (doi: 10.1002/2015GL063070) where this is shown and/or to some of the earlier studies that suggest that this might be the case (Egleston et al., 2010, doi:10.1029/2008GB003407, Riebesell et al., 2009, doi:10.1073/pnas.0813291106; Pätsch & Lorkowski, 2013, DOI 10.4319/lom.2013.10.41.

l. 7ff. This correction is hard to follow, please explain more or illustrate with a figure. Can you validate this method somehow?

p. 8272, l. 17-19: Yongala is mentioned as being well and badly represented at the same time.

p. 8273, l. 18: gradient from 8.1 to 8.14 does not seem to be strong to me. The latitudinal gradient in Omega appears stronger in Fig 5

l. 23ff: I'm confused by this small evaluation paragraph here by comparing to GLODAP which is not shown, whereas the Takahashi fields are shown and discussed later. Both parts of the evaluation should be placed in the same section.

l. 27/8: explain the different effect of temperature on pH and Omega more and give reference for that.

p. 8274: l. 7: "The low seasonal variability suggests Omega > 3.5 in winter". Why don't you just check your reconstructed fields whether Omega goes below 3.5 in winter?

p. 8275: l. 24-27: what's the difference between (i) and (ii): both refer to the spatial interpolation?

p. 8276, l. 17: 0.48 – is that the average number over all the area or the same at all locations. Describe how it was calculated.

l. 20-23: inconsistent, does the largest change occur "in northern Australian waters" or "in the Tasman sea and along the southern coast of Australia"? Don't you mean >0.6 (instead of <0.6)?

l. 25: there is no figure 10.

l. 25-26: show figure or describe gradient in Revelle factor, give numbers. Explain this sentence more.

l. 28: 0.09: – again, is that the average number over all the area or the same at all locations. Describe how it was calculated.

p. 8277, l. 5-6: does the gradient in temperature change, too? Else I would expect the temperature gradient to have an effect on pH but not necessarily on pH changes.

p. 8279, l. 6-7, not only no interannual variability, but more importantly this implies that there is no trend of Delta pCO2 with increasing atmospheric CO2, which the authors need to discuss! This should not only be discussed with regard to seasonal versus interannual variability, but also with regard to the overall quality of the reconstruction. Present day values were evaluated against measurements at stations, but the past values cannot be evaluated, so this uncertainty is very important.

l. 25-27: This effect needs to be discussed more. Can you give a rough estimate of the

impact on pCO2, pH, Omega estimates?

p. 8280, l. 11: climatology , do you refer to Takahashi or GLODAP (see comment above on putting these two evaluation bits in the same section)?

l. 19: “marginal conditions”: name Omega = 3.5

Table 1/Figure 1: Is it not possible to cover a larger part of the Australian Seas by data (I’m surprised there is not more cruise data available)? What about cruises going to the south, the region south of 40°S is only covered by the MAI station.

Figures 3+4: Increase fontsize of axes labels.

Figure 5+6+7+9: the figures are not readable, increase fontsize of all axes labels and tick marks. I’d recommend to use red for low pH and low Omega values. Use the same color scale for Figures 5 and 6. The regional differences between pH and Omega could be elaborated more in the text.

Figure 7: the overlain temperature is even harder to read. It would be much easier to grasp if another map would show temperature.

Figure 8: plot critical value (3.5) as dashed line.

Technical comments:

p. 8266, L. 24: delete “to”

p. 8267: l. 11 to greater → to be greater

l. 13: will persistent → will persist

l. 20 and 24: reef building coral → reef building corals

l. 26: stresses → stressors (?)

p. 8268, l. 9: delete “regional” once

p. 8274: l. 18: seasonality variability → seasonal variability

l. 24/5 change to “off Northern Australia”

p. 8275, l. 6: 8S → 8°S

l. 12: occur in off → occur off

p. 8277, l. 14: homogenous → homogeneous

l. 14-16 this is not a complete sentence.

p. 8278, l. 13: due changes → due to changes

p. 8279, l. 23: changes oceanic → changes in oceanic

l. 24: delete “likely”

p. 8280, l. 4: an new → a new

l. 23: of → in

l. 23: 1990-2009-1889-1870 → (1990-2009)-(1870-1889)

p. 8281, l. 9: delete “at”

l. 11: likely vary → likely to vary

Interactive comment on Biogeosciences Discuss., 12, 8265, 2015.