Earth Syst. Sci. Data Discuss.,
https://doi.org/10.5194/essd-2018-114-AC1, 2019

Earth System Science Data Discussions

Interactive comment on "Autonomous seawater pCO_2 and pH time series from 40 surface buoys and the emergence of anthropogenic trends" *by* Adrienne J. Sutton et al.

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Received and published: 15 February 2019

We thank all referees for their thoughtful and constructive comments and suggestions on our manuscript "Autonomous seawater pCO2 and pH time series from 40 surface buoys and the emergence of anthropogenic trends." The revised manuscript will be much improved as a result of the careful critiques. Below we discuss the comments from Referee #1 point by point including original referee comments and our responses bulleted (–) underneath.

Sutton et al. release a comprehensive data product for pCO2 and pH (among other variables) from 40 surface ocean buoys around the globe. Further, this paper briefly

analyzes the time series data to compute Time of Emergence (ToE) of the anthropogenic emissions signal. They propose conservative estimates of ToE, since their relatively short time series do no capture the influence of decadal variability. The data product is extremely accessible and the website is well put together. One can acquire plots of near real-time pH and pCO2 via the web server as well as select a buoy of interest from a map to retrieve well-labeled and quality-controlled data. I suggest that this manuscript be published in ESSD following minor revisions. I only have a few very minor comments/clarifications.

2 Major Comments

1. I appreciate the attention to detail on limitations to ToE with such short time series (i.e., taking an estimate of decadal variability on the TAO buoys and applying that to all other stations). However, I'd be curious to see what the influence of the differing IAV estimates does to the ToE estimate. I.e., what is the difference in the ToE when using the detrended vs. not detrended estimate of anomalies in Equation 1? I imagine that the 12% change in IAV from this tactic might propagate a decent bit of uncertainty into ToE (that is separate from the decadal variability uncertainty).

– We find that ToE estimates are on average 55% shorter using detrended monthly anomalies compared to ToE estimated using not detrended monthly anomalies (page 9 line 21). This is different from the detrending applied to the WHOTS example for IAV. IAV is typically calculated on data with the long-term trend removed; however, we did not do this, as the long-term trend is unknown at most sites and the time series are relatively short (<12 years). The 12% change was presented here to highlight the uncertainty in the IAV estimates, which are separate from the ToE calculation.

3 Minor Comments

2. Lines 31–33 (pg. 3): ". . . magnification of the seasonal amplitude of pCO2 due to warming, . . . resulting in increased detection time." You could cite Kwiatkowski and Orr (2018) and Landschützer et al. (2018) here, which cover this topic.

– Good suggestion. Those references have been added.

3. Lines 1–3 (pg. 6): Perhaps expand here on what future efforts will be done to improve IAV estimates. What can be done other than waiting for longer time series to develop?

– Good point. We have added the following to that section: “Future efforts to improve these IAV estimates can rely on future assessment of longer time series (moored or observations from other platforms) and regional models that better characterize all modes of temporal variability.”

4. Lines 10–11 (pg. 9): “Since ToE is dependent on the variability . . . tend to have longer ToE estimates." I would suggest more clear wording for this sentence. In the case of this application, ToE is mainly variability-induced, since all stations share a commonly imposed trend of 2 μatm yr-1. However, in many cases, long ToE estimates can be also driven by a weak signal, and short ToE estimates by a very strong signal, etc.

– We agree it was confusing to mention the imposed long term trend here and have modified the sentence to focus on the correlation between variability and ToE: “In this application ToE is dependent on the variability in the data, resulting in the pattern where sites that exhibit larger seasonal to interannual variability (Figs. 1 and 2) tend to have longer ToE estimates (Fig. 5).” We also suspect that our use of the term “emergence” may add confusion. Multi-ensemble modeling assessments of emergence of a forced trend over model variability typically also use the emergence terminology. This manuscript addresses a slightly different approach in assessing the time period of observations required to detect a long-term trend above natural variability. As such, throughout the manuscript we have added more description of this observation-based trend detection time approach of the method.

5. Figures 1 and 2: When using a discrete color bar, it is generally advised that the tick marks align with discrete color boundaries. In their current format, both color bars have

tick marks placed arbitrarily within color bounds, which makes these color divisions useless. E.g., in Figure 1, setting 10 color boundaries with colorbrewer would align the ticks/color boundaries in 25 μatm increments.

– Thank you for catching that. Color bar modified to align ticks/color boundaries.

6. Figure 3: I suggest changing the color scheme for (b) and (c) to be mindful of those that are red-green color blind.

– Again, thank for you catching that. Color scheme modified.

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