

General comments:

In this study, the authors assess future changes in the seasonal cycle of surface ocean pCO₂ using simulations from 7 different CMIP5 Earth system models subjected to RCP8.5 forcing. A Taylor series decomposition approach is used to identify the important drivers of pCO₂ seasonality and its future changes. The authors find that the pCO₂ seasonal amplitude will increase by a factor of 1.5 to 3 by the end of the current century. The primary cause of this increase is the increase in ocean mean pCO₂ (a response to increasing anthropogenic emissions), which enhances the pCO₂ seasonal variation occurring in response to seasonal variations in temperature (T) and dissolved inorganic carbon (DIC). Changes in T and DIC seasonality at high latitudes are also relevant for understanding the model-simulated changes in pCO₂ seasonality.

This is a nice study that complements some recent work (e.g., McNeil and Sasse, 2016; Landschützer et al., 2018; Kwiatkowski and Orr, 2018) examining the changing seasonality of ocean carbonate chemistry variables over recent decades and in the future. The paper is generally clear, well written and logically organized, and the scientific methods are sound. However, I do strongly agree with Referee #1's assessment that the authors should do a better job of placing their results in the context of previous work. While this is done to some extent already – and, in all fairness, the authors certainly cite the relevant literature – it tends to get a bit lost in the discussion and it's often a little unclear which results are novel and which simply confirm previous findings. It could be helpful to add a separate Discussion section before the Summary and Conclusions in which results from the current study are compared and contrasted with those from previous studies. In addition to this, I've included several specific comments and technical corrections below for the authors to consider. I feel that a suitably revised version of the manuscript – addressing the points raised here – should be publishable in Biogeosciences.

Specific comments:

- 1) p. 5, lines 19-20: “McNeil et al. (2016) using a data-based approach” – It would be good to clarify what you mean here by a “data-based approach”.
- 2) p. 5, lines 23-25: “Using observations Landschützer et al. (2018) found...” – I have two issues with this sentence. First, it's unclear to me where the “mean 20 µatm increase by the end of the century” comes from; the values given earlier in this paragraph (see also Fig. 1) are significantly larger than this (e.g., 41 µatm increase between 40°S-40°N). Second, I wouldn't expect the rate of change of pCO₂ seasonality in observations to match that in the CMIP5 models in the RCP8.5 simulations, since many of the important drivers of pCO₂ variability (e.g., atmospheric CO₂) are changing at much faster rates in the latter than they are in the former.
- 3) Fig. 3/Fig. S1: These figures show (among other things) that the Taylor expansion generally does a good job in reproducing the actual $\delta p\text{CO}_2$ calculated from model output. However, there seems to be an inconsistency between the two figures. Specifically, Fig.

3 suggests that the Taylor expansion slightly overestimates the seasonal amplitude of pCO₂ (this is most evident for the 40°S-70°S latitude band), while Fig. S1 suggests exactly the opposite: an underestimation of the seasonal amplitude.

4) p. 7, line 15: “decrease in the future to a global mean value of 0.035” – This number seems to be too small looking at Fig. 4c (middle column).

5) p. 7, line 26: “with lower temperatures in winter and higher in summer” – It might be good to clarify here that you do not mean lower temperatures in an absolute sense (i.e., winter temperatures are certainly projected to be higher at the end of century under RCP8.5 than they are at present).

6) p. 8, lines 26-27: “we decomposed the DIC_s and T contributions...” – I only see the seasonal cycle and mean pCO₂ components in Fig. 6b, not the sensitivity component.

Technical corrections:

1) p. 1, line 2: Should be “a rate of 2-3 μatm per decade”.

2) p. 3, line 5: “Methodology” misspelled.

3) p. 3, line 14: Should be “scarce”.

4) p. 7, line 11: Should probably remove the word “change” here, since the annual cycle amplitude change is actually 168 μatm minus 96 μatm (i.e., 72 μatm).

5) p. 7, line 15: Should be “row (c)”.