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Interactive comment on "Air–sea carbon flux from high-temporal-resolution data of in situ CO_2 measurements in the southern North Sea" *by* Steven Pint et al.

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We welcome the reviewer's constructive comments that especially refer to the fact that the data are temporally well-resolved, and that only this justifies its publication. Next to few minor comments, the referee mainly mentions the poor oceanographic description of the study area, the lack of detailed description of the correction factors, and despite the high resolution a short period of data (10 months).

We acknowledge that the term annual that we are using is not consistent with the time series, therefore we will rephrase our terminology, e.g. 2018 flux. We need to inform the reviewer that the station is still active, yet there are some gaps in the data coverage

that are associated with hardware failures, e.g. failure of the batteries and solar panels, that we are constantly addressing.

The reported correction of pCO2, sea measurements is based on a simple linear regression between in situ measurements and spot samples collected when the station was visited with our research vessel RV Simon Stevin. We have identified that the sensor values were closer to the spot samples from February 2018 until July 2018 and then there is a larger deviation from August 2018 until November 2018. This is because of increased biofouling after a prolonged deployment. Once this was identified and conditions allowed, we resolved this during our maintenance visits, by cleaning the sensor. The latter clearly improved the performance as can be seen in December 2018 (Fig. 1). In that respect, we have decided to use 2 linear regression periods. To make the corrections, we applied one regression curve for the period February 2018 – July 2018 and December 2018 (Fig. 2) and another regression curve for the period August 2018 – November 2018 (Fig. 3). We are also confident that the erroneous sensor values for the seawater CO2 are because of biofouling, pre and post deployment calibrations of the sensor's NDIR detector, performed by the manufacturer suggest minimum or no drift of the detector's signal. We will include the details of our corrections in the supplementary material of this paper.

We acknowledge that the oceanographic setting of the stations and the influence of the Scheldt/Rhine estuary on our observations are insufficiently described in our manuscript and we have taken this issue up in the study area part of the manuscript. The new paragraph now reads as: "The anti-clockwise rotation in the North Sea brings seawater from the English Channel towards the north (Fig. 6). Run-off from the Seine is brought to our area by this water flow. The Seine influences the salinity in our area the most (Lacroix et al., 2007). The influence of the Scheldt estuary near our observation station is relatively small. The Scheldt's influence on the salinity at our observation station is little as shown in Fig. 7 (Borges et al., 2008) and by (Fig. 13 in) Debrye et al. (2010). Freshwater flowing out of the Scheldt estuary is transported mainly southwards along and close to the Belgian coastline, i.e. away from our observation station. In case of nutrients, the Seine also plays a major role, except for the Scheldt estuary and northern part of the BCS. However, the distribution of nutrients could not be extracted from the water flow as nutrients are not conserved over seasons as a result of biological activity (Lacroix et al., 2007)."

Minor comments: Line 53: We are confident that the erroneous sensor values for the seawater CO2 are because of biofouling, pre and post deployment calibrations of the sensor's NDIR detector, performed by the manufacturer suggest minimum or no drift of the detector's signal. We will add a paragraph in materials and methods focused on the sensors, e.g. calibration.

Line 169: This will be omitted in the revised manuscript

Line 223: We are not using the term anthropogenic for our work as we are aware that we cannot do this with this type of measurements. This term is only used when referring to other work (e.g. Friedlingstein et al. 2019).

Line 235: In this study we use high-resolution robust CO2 observations, which allowed to identify significant variability in surface water pCO2; a variability that was also evident in the 2018 CO2 flux. Thanks to our unique set-up we were able to do this including pCO2, atm measured at sea close to the action zone (3 m). Unfortunately, we cannot provide a continued time-serie including 2019 and 2020 due to setbacks (mainly related to hardware failures, e.g. failure of the batteries and solar panels). The data collected in 2019 and 2020 is rather sporadic than continuously due to these setbacks.

As part of ICOS we are working with the ICOS Central Facilities (Ocean Thematic Centre and Carbon Portal) in order to make the data available in the ICOS Carbon Portal. This will be completed by the first quarter of 2021. We would also like to mention that data will be submitted to SOCAT v 2021.

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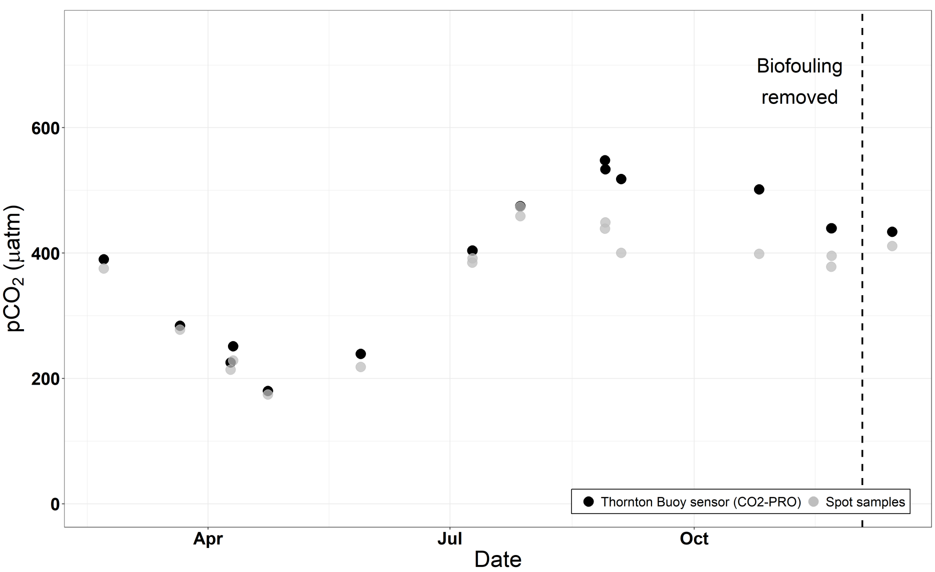

Fig. 1. pCO2 form the Thornton Buoy sensor and spot samples. The removal of biofouling on the buoy's sensor (CO2-PRO) is indicated with the vertical dashed line.

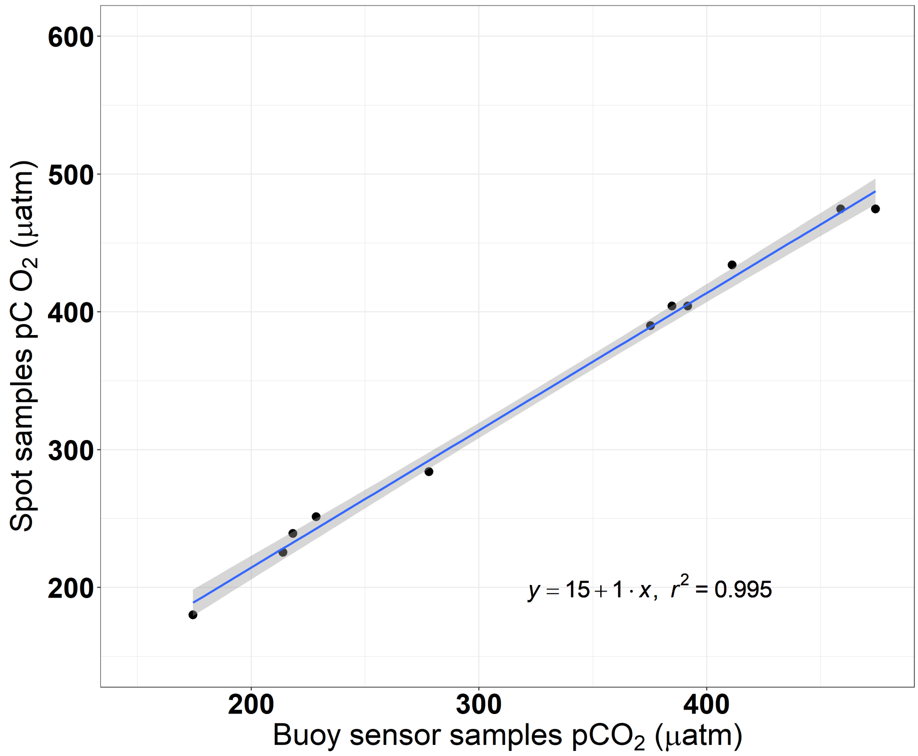

Fig. 2. Regression 1st period Feb-Jul 2018 and Dec 2018

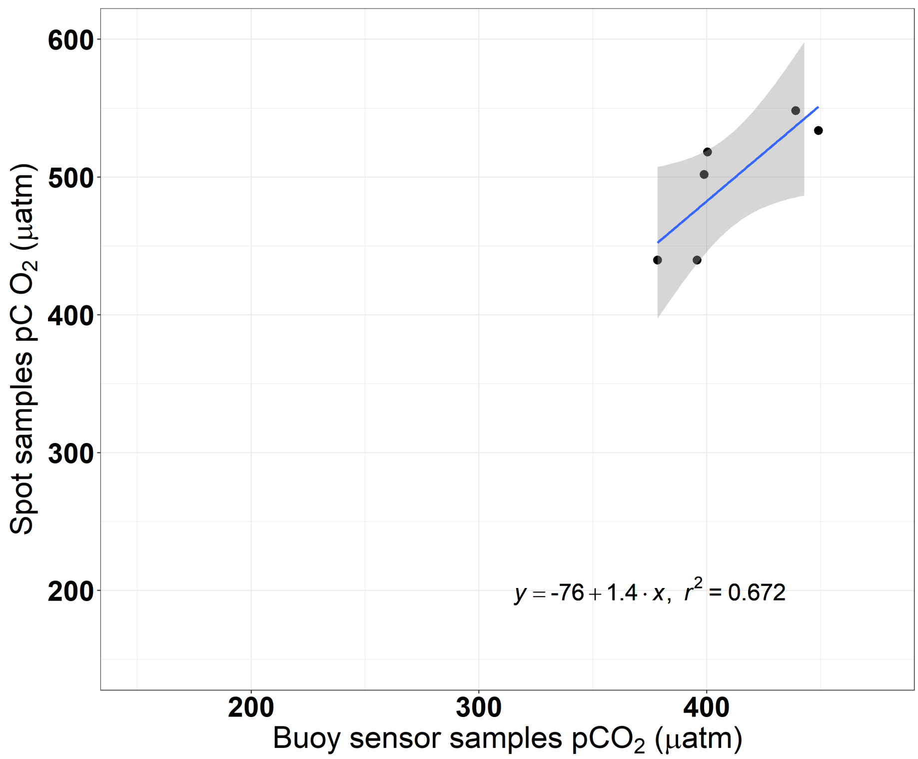

Fig. 3. Regression 2nd period Aug - Nov 2018

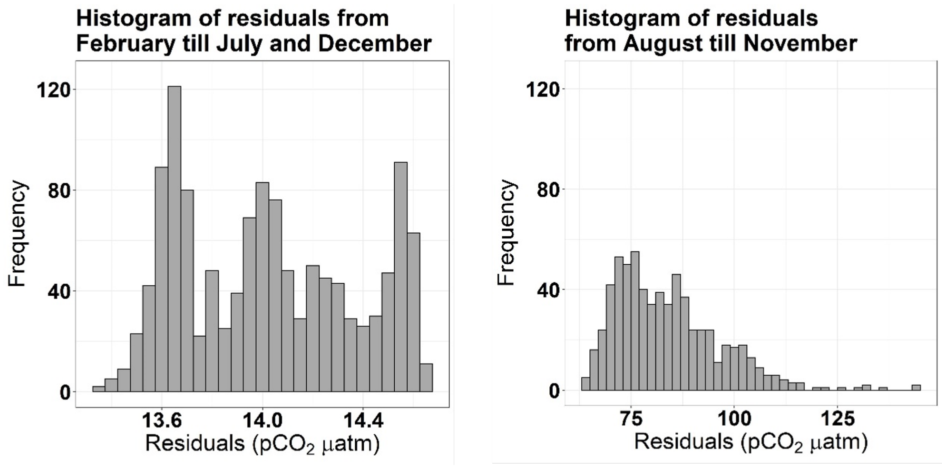

Fig. 4. Histogram of the absolute residuals for each period of correction

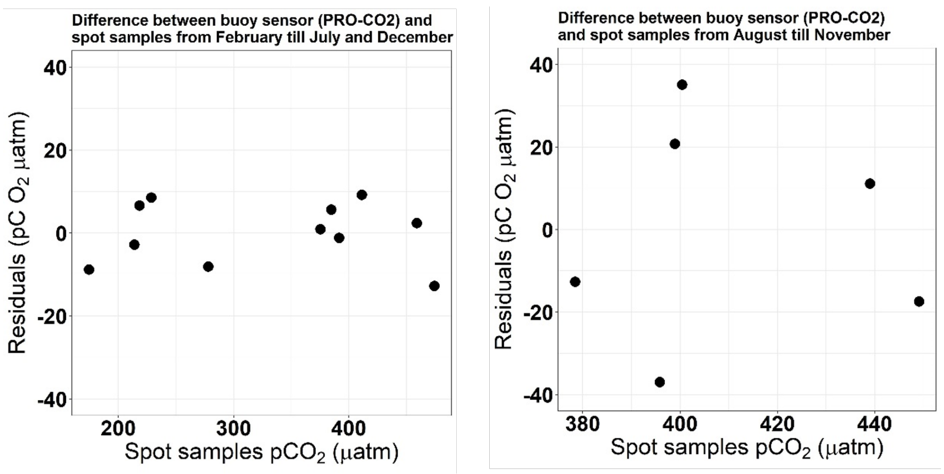

Fig. 5. The difference between the buoy's sensor and the spot samples. Negative values indicate a difference where the buoy's value is smaller than the spot sample value and vice versa

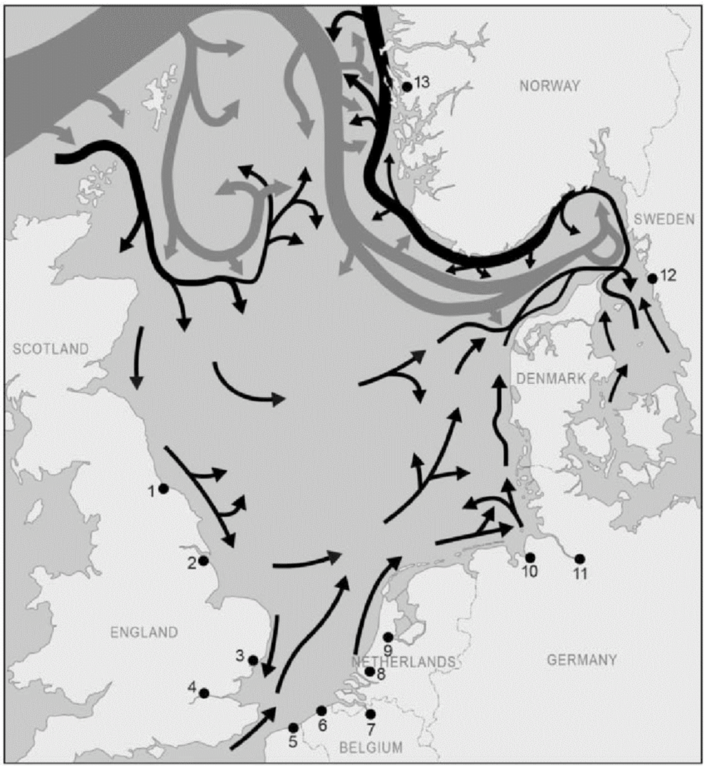

Fig. 6. The counterclockwise residual current in the North Sea (black) and the deep water flow from the Atlantic Ocean (gray) (Turrell 1992). Meer et al. (2016)

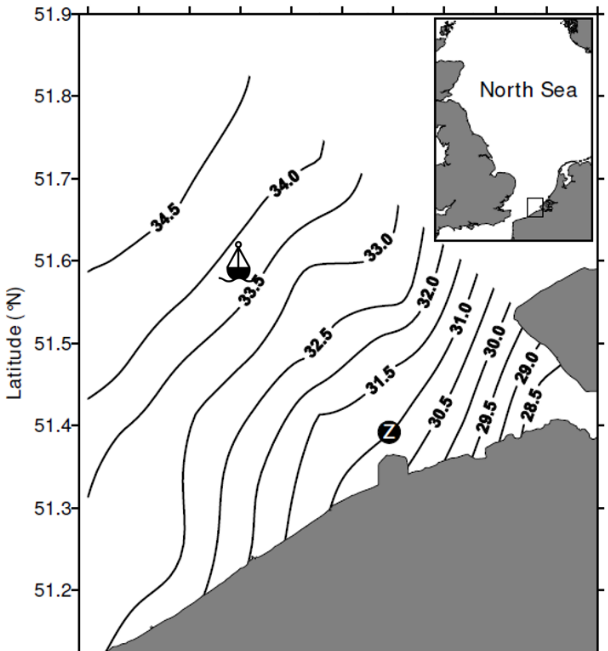

Fig. 7. Sea surface salinity isolines based on sampling from 1995 to 2004. The buoy symbol indicates the location of the Thornton buoy. The measuring station (Z) was used in Borges et al. (2008)