

Response to the Editor

We would like to thank the Editor for his guidance and further constructive comments. We incorporated his suggestions into the manuscript. We have also looked into the suggestion whether salinity S could be used to improve the CO₂ optode calibration further.

To recapitulate, we calibrated the CO₂ optode output, $p_c(\text{CO}_2)$, against the CO₂ concentrations measurements derived from discrete water samples, $c_{\text{ws}}(\text{CO}_2)$, using a quadratic parameterisation in terms of temperature θ :

$$c_{\text{reg2}}(\text{CO}_2)/(\mu\text{mol kg}^{-1}) = (0.12 \pm 0.14)\theta/^\circ\text{C} - (0.071 \pm 0.011)(\theta/^\circ\text{C})^2 + (0.0094 \pm 0.0048)p_c(\text{CO}_2)/\mu\text{atm} + 16 \pm 4$$

This regression gave a mean residual of $0.8 \mu\text{mol kg}^{-1}$.

As per the Editor's suggestion, we attempted a third regression, adding a quadratic parameterisation in terms of salinity. This gave the following fit:

$$c_{\text{reg3}}(\text{CO}_2)/(\mu\text{mol kg}^{-1}) = (0.10 \pm 0.11)\theta/^\circ\text{C} - (0.088 \pm 0.009)(\theta/^\circ\text{C})^2 + (4.2 \pm 1.0)(S-35) + (6.2 \pm 1.3)(S-35)^2 + (0.0084 \pm 0.0034)p_c(\text{CO}_2)/\mu\text{atm} + 17 \pm 3$$

This regression gave a reduced mean residual of $0.6 \mu\text{mol kg}^{-1}$.

However, as Figure A below shows, our parameterisation is not well constrained in terms of salinity (S) outside the range of the salinities of the discrete water samples. Only one discrete sample had $S < 35$. For such values of S , $c_{\text{reg3}}(\text{CO}_2)$ shows unrealistic spikes in the region influenced by the Norwegian Atlantic Current (NwAC) and even higher unrealistic values in the region of Norwegian Coastal Current (NCC) encountered in June/July (when $S < 35$).

Perhaps most importantly, due to their measurement principle, the raw optode phase measurements are not sensitive to salinity. The luminophor in the sensing foil primarily responds to pH changes caused by CO₂ fluctuations.

The apparent salinity dependence of $c_{\text{reg3}}(\text{CO}_2)$ is therefore likely due to overfitting the data in terms of environmental variability in the $c_{\text{ws}}(\text{CO}_2)$ values of the discrete samples, rather than an actual effect on the sensor.

Since there is neither a causal link nor a robust improvement of the (empirical) parameterisation, we have refrained from incorporating salinity into the fit and left the optode calibration in terms of $c_{\text{reg2}}(\text{CO}_2)$.

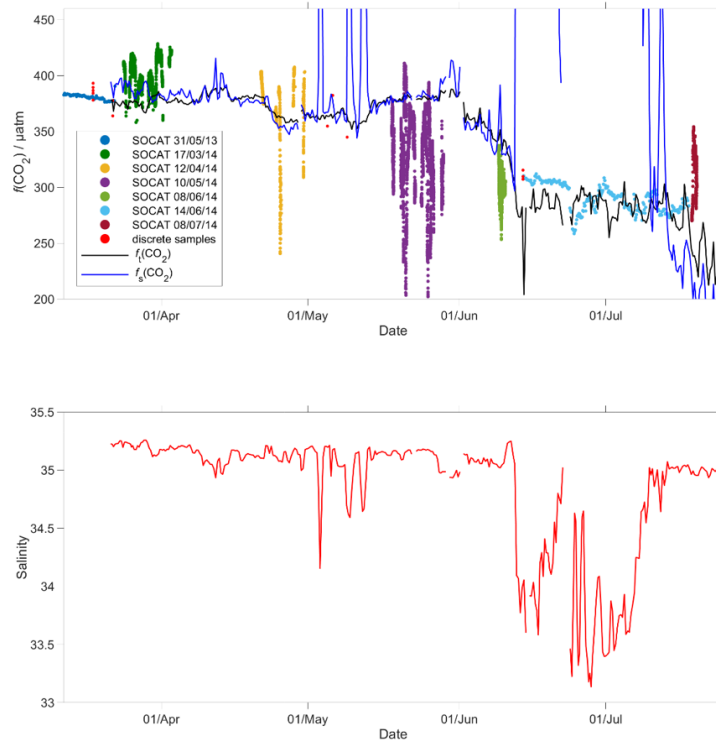


Figure A: Comparison between surface $f(\text{CO}_2)$ from 2014 SOCAT and CO₂ optode on the glider. Top panel: $f_1(\text{CO}_2)$ corresponds to $c_{\text{reg2}}(\text{CO}_2)$; and $f_2(\text{CO}_2)$ to $c_{\text{reg3}}(\text{CO}_2)$, which includes salinity in the parameterisation. Bottom panel: Glider surface salinity.