

Comments

Please make a sensitivity analysis of the computations using more recent (and possibly more adequate) constants such as Millero et al. (2006).

I still have the impression at such low temperatures and salinities the computations of the thermodynamics of CO₂ remain guess work, and a sensitivity analysis might reinforce the confidence on the computations presented in this paper.

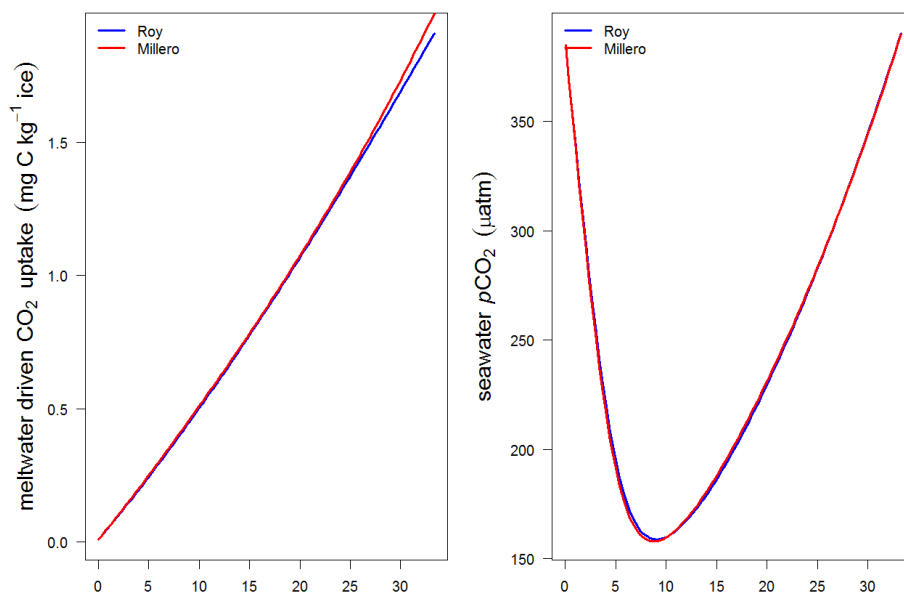
It might be useful to check if in the frame of large-scale projects such as EPOCA some sort of recommendations have been made regarding the choice constants.

As requested by the referee we have made a sensitivity analysis of the equilibrium constants K1 and K2 that are used in our CO₂ calculations.

Dickson et al. (2007), also through the EPOCA project, recommends the use of constants by Lueker et al. (2000) for K1 and K2 for ambient seawater conditions. However the constants by Lueker et al. (2000) are only valid in salinity range: 19-43 and T range 2-35 °C and consequently they cannot be used in this study. This leaves two alternative sets equilibrium constants.

- The constants of Roy et al. (1993) with the freshwater adaption for salinities below 5 by Millero et al. (1995), which are stated to be valid between salinity 0- 45 and T 0-45 °C.
- The relations by Millero et al. (2006), which are stated to be valid for a salinity range 0.1-50 and T 1-50°C.

We have now implemented both to calculate the CO₂ uptake per kg of melted ice (left panel) and the pCO₂ undersaturation during the mixing of meltwater and seawater (right panel). This analysis shows that our thermodynamic calculations of the CO₂ system are robust against changes in the choice of the carbonate equilibrium constants.



The text is adapted as follows:

We used the carbonate equilibrium constants by Roy et al. (1993) with the adaptation by Millero et al. (1995) for low salinities. Consequently the dissociation constants are valid over the salinity range of 0–45 and the temperature range 0–45°C. To test the sensitivity of our calculations we also implemented the equilibrium constants by Millero et al. (2006), which had a negligible impact, thus showing that our thermodynamic calculations of the CO₂ system are robust against the choice of the carbonate equilibrium constants.

Page 11 : "no to vary" => not to vary

This is now corrected in the manuscript.

Page 18 : We can compute from AT = 161 μM, DIC = 61 μM, temp = 5°C, S = 0, a pCO₂ of 0 μatm. How realistic is this ?

Calculation of pCO₂ using these AT and DIC values yields indeed a pCO₂ of ~ 0 μatm. The study from Rysgaard yields a value of 107 μatm. Due to the scarcity of data points at low salinities in both studies, the freshwater endmember values derived from these relations are not well constrained and should be interpreted with caution. They cannot be used to estimate pCO₂ reliably, as the reviewer points out correctly. Accordingly, we have decided to remove this statement.

Page 18 : "These relations are similar to those obtained by Rysgaard et al. (2012) (TA = 161 + 61*S and DIC = 169 + 55*S)" is an overstatement. DIC of 169 μM is not similar to 61 μM.

The reviewer is correct. We have adapted the text as follows:

*These relations are similar to those obtained by Rysgaard et al. (2012) (TA = 161 + 61*S and DIC = 169 + 55*S), apart from the DIC value of the fresh water endmember. However, it should be noted that the freshwater endmember values derived from these relations should be interpreted with caution, as confidence intervals widen near the end points of the range covered by linear regression, which is aggravated by the scarcity of data points at low salinities. As a result, a large uncertainty propagates into the estimated DIC and TA values of the freshwater endmember. Therefore, we use here in further calculations the DIC and TA values based on our measurements of meltwater from iceberg samples.*

Page 18 : "Both these sets of relations show that the freshwater endmember is undersaturated." They do not. You need to compute the pCO₂ which is not done in text.

Calculation of pCO₂ using the TA and DIC values does show that the freshwater endmember is undersaturated in both cases. However, as explained above, given the large uncertainty on the DIC and TA values of freshwater endmembers as estimated from salinity regressions, the pCO₂ cannot be estimated reliably. Accordingly, we have decided to remove this statement.

Page 19 : You might want to refer to some of the papers of the Delille group that have looked into salinity effects on the dynamics of brines and sea-ice underlying seawater such as Delille et al. 2009 although there might be more recent papers.

As indicated previously by the reviewer, the concept is not new but as yet, to our knowledge not used to explain the low $p\text{CO}_2$ in fjords affected by glacial meltwater. The paper by Delille et. 2009 shows more clearly the effect of salinity than Bates 2014, so the Delille reference is now used.

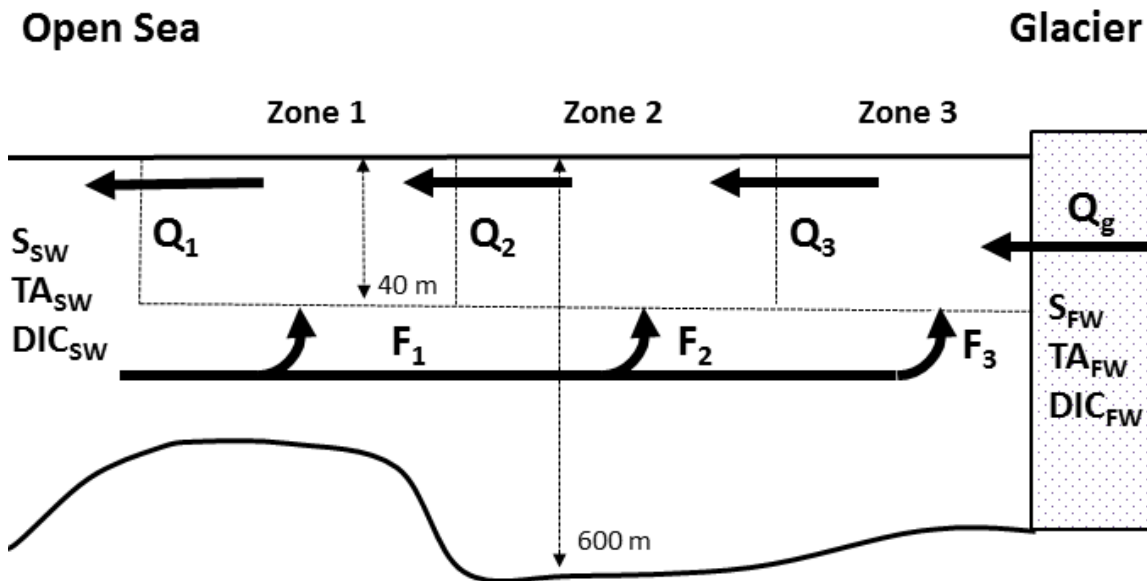
Page 19 : "The undersaturation in CO_2 that has been previously observed in other high latitude systems affected by glacier meltwater (Evans et al., 2014; Sejr et al., 2011; Torres et al., 2011) could possibly be explained by this same mechanism." Please discuss whether the salinity distributions in these studies show the effect of meltwater inputs. This would make this statement slightly less speculative.

This is a good point, we have now changed the text to:

The undersaturation in CO_2 that has been previously observed in other high latitude systems (Evans et al., 2014; Sejr et al., 2011; Torres et al., 2011) could possibly be explained by this same mechanism, since these systems also show the signature of a large input of glacial meltwater, leading to a strong reduction in salinity.

In Figure 2 it might be useful to indicate approximately the total depth profile.

This is now corrected in the manuscript



References

Delille B., B. Jourdain, A.V. Borges, J.-L. Tison & D. Delille (2007) Biogas (CO_2 , O_2 ,

dimethylsulfide) dynamics in Spring Antarctic fast ice, *Limnology and Oceanography*, 52(4), 1367-1379.

Millero, F. J., T. B. Graham, F. Huang, H. Bustos-Serrano, and D. Pierrot (2006), Dissociation constants of carbonic acid in seawater as a function of salinity and temperature, *Mar. Chem.*, 100(1–2), 80–94, doi:10.1016/j.marchem.2005.12.001