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Interactive Comment

# *Interactive comment on* "Glacial meltwater and primary production as drivers for strong $CO_2$ uptake in fjord and coastal waters adjacent to the Greenland Ice Sheet" *by* L. Meire et al.

**Anonymous Referee #1**

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General comments: The authors investigate atmospheric CO2 uptake in fjord systems and shelf areas affected by glacial meltwater. They present and analyse a unique and extensive dataset from Godthåbsfjord, Greenland including monthly observations at three dedicated stations in the fjord, in addition to seasonal transects across the whole fjord and shelf system. Their main finding is that glacier meltwater input and net community production drive a year- round strong (when normalized to area) CO2 uptake in the fjord. The authors also construct and use a simplified biogeochemical model to resolve the importance of the different driving processes of the CO2 uptake in the fjord.

The paper is appropriately structured and well written and I recommend publication after a minor/moderate revision according my specific comments (below).

Specific comments: In section 4.2 the authors discuss the effect of glacial meltwater on the carbonate system variables. They suggest that in addition to a “negligible” direct effect on pCO2, glacial meltwater can also induce pCO2 undersaturation through a second mechanism which is due to the non-conservative behaviour of pCO2 during the mixing of fresh water and saline water. To illustrate this point they compute pCO2 for a mixture of glacial meltwater with a TA= 50 & DIC=81.2 and seawater with TA =2220 and DIC=2118 $\mu$molkg-1. The result is a pCO2 undersaturation that vary with salinity (or glacier water fraction) (Fig 11a) in a highly non-linear way. The authors argue that this nonlinearity is due to the non-linear effect of salinity on pCO2. I disagree with authors on this point! I believe the strong non-linearity depicted on Fig 11a is due to the fact that DIC of the glacial meltwater is higher than its TA value whereas in the saline water TA is higher than DIC. Thus, both DIC and TA mix conservatively, but the mixing lines have different slopes and they cross at some point. The crossing point is the point with highest pCO2 undersaturation. One simple way to confirm the above is to re-plot Fig.11a with glacier water TA and DIC values such that the mixing lines never cross. For instance, TA =50, and DIC=50 or TA=159 and DIC =60. Note, the latter values are those indicated by the linear regressions reported on page 17938, lines 7-9. I recommend this section to be revised accordingly.

I also find the TA values to be inconsistent within the manuscript and with Rysgård et al (2012). On page17938, lines 7-9: the TA vs. S relationship suggests a TA value of 159 $\mu$mol kg-1 for the glacial endmember i.e. with S=0. This is three times the measured value reported on page 17935, line 8). Furthermore, both the above values are different than that obtained from the TA vs. S relationship reported by Rysgård et al (2012) for the same area. The authors need to clarify on this point.

For the measurement of TA, the authors report that they used the Standard Operating Protocol 3b of Dickson et al. (2007) which is suitable oceanic levels of total alkalinity (2000-2500 umol/kg) (Dickson et al., 2007). Did the authors make any modifications to ensure applicability for the much lower TA values in the glacier meltwater? If not, they need to comment the effect this issue on the accuracy of TA values (see e.g. Bates et al 2014, their section 2.2.3).

What constants were used for the computation of pCO2?

On page 17940, lines 5-9: please be aware of that Fig 8C also compares the ASE flux from three cruises and it seems that highest flux occurs in May although the strongest CO2 undersaturation was observed in August. This is most probably due to the nonlinear effect of wind speed on ASE and need to be commented.

Technical comments: Figure 5: I would encourage the authors to use different symbols for the four curves so that these can be differentiated even on colourless printouts.

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Interactive comment on Biogeosciences Discuss., 11, 17925, 2014.