

## ***Interactive comment on “CO<sub>2</sub> and CH<sub>4</sub> in sea ice from a subarctic fjord” by O. Crabeck et al.***

### **Anonymous Referee #2**

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General Comments: The authors describe a series of four ice stations over the course of one week during which they measured  $^{18}\text{O}$  in water,  $\text{CH}_4$ ,  $\text{CO}_2$  and other ice properties. This study found persistent  $\text{CO}_2$  under-saturation (with respect to atmospheric equilibrium) and  $\text{CH}_4$  over-saturation in first-year sea-ice, indicating that the latter is a sink for atmospheric  $\text{CO}_2$  and source of  $\text{CH}_4$ , once the ice melts. Although the timeframe over which the study was conducted is limited (1 week), it provides a very thorough analysis and unique insight into  $\text{CO}_2$  and  $\text{CH}_4$  dynamics in sea-ice. Specifically, the comprehensive understanding of sea-ice dynamics inferred from  $^{18}\text{O}$  profiles, gas content,  $\text{N}_2$ , Ar etc. allows a thorough discussion of the distribution of  $\text{CO}_2$  and  $\text{CH}_4$ . I have some specific comments which probably amount to minor revision, but have no hesitation in recommending a revised manuscript for publication in BG.

Specific Comments: 1) p.4049, line 7: Spelling "areas"

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- 2) p.4052, line 23: Please define "b" in "b/bulk ice volume"
- 3) p. 4053, line 3: Please define "hi" in equation 1.
- 4) p.4054,line 17: "1013 atm" - Please correct the units or insert decimal point. I'm pretty sure this should be micro-atm, not atm.
- 5) p. 4056, line 16: Please define "Sice". This is obviously sea-ice salinity, but has not been defined previously. Also, in Figure 2&6 this is marked as Si. It may be better to use "Sice" everywhere. Also, salinity is unities (Figure 2&6).
- 6) p.4063, line 17: Spelling "Weisenburg"
- 7) p.4064,line 5: Spelling "rises"
- 8) p.4064, lines 4-10: The authors seem to attribute CH<sub>4</sub> accumulation just below the sea-ice to advected sedimentary sources. They go on to mention riverine inputs, but the emphasis appears to be on the former. I would say that riverine inputs are more likely to be the dominant factor here for two reasons: a) The study area is fairly enclosed. Advective processes may therefore be limited to tidal exchange. What was the tidal range over the study period? This might give at least a relative indication of exchange. b) Fluvial inputs are much closer (geographically) and the CH<sub>4</sub> maxima in the overlying sea-ice also coincide with salinity minima which have been attributed to freshwater input (section 5.2).
- 9) p.4066, lines 17-21: The authors suggest that CH<sub>4</sub> bubbles may have been trapped in the growing sea-ice following their release from the seafloor. This may also explain why they are near the top of the sea-ice. I would expect the maximum methanogenesis to occur in the autumn, following the maximum POC flux from the surface to the seafloor. As sea-ice begins to grow in the autumn, the effluxing CH<sub>4</sub> bubbles would be captured near the top of the ice (since it grows from below). On the other hand, if the seasonal sediment source is so strong in autumn, I would expect at least some CH<sub>4</sub> to still be coming out in Spring. This doesn't seem to be the case (Figure 2; albeit

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depth-profiles only reach 9 m and the seafloor is at 45 m). Shakhova et al. did show CH<sub>4</sub> bubble trapping in sea-ice, but they also measured 2000+ nmol/L CH<sub>4</sub> in the water column, not 17, as here! I think it's much more likely that CH<sub>4</sub> concentration in the forming sea-ice led to the formation of CH<sub>4</sub> bubbles as the authors explain earlier and that CH<sub>4</sub> came from the riverine source.

10) Figure 7: The color/symbols for 13 Mar and 15 Mar. are mixed up. Please swap the color or symbols to match legend.

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**BGD**

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