

Interactive comment on “CO₂ and CH₄ in sea ice from a subarctic fjord” by O. Crabeck et al.

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Received and published: 9 September 2014

Dear Editor

Below are our comments and responses to the questions and suggestions by the reviewers. In addition, we have attached a revised version of our manuscript. As you will see we have addressed all reviewer's comments and followed most of their suggestions and revised accordingly. We have provided our answers below in blue text. We would like to thank you for constructive comments and suggestions that improved our manuscript.

On behalf of all authors Odile Crabeck Anonymous Referee #2 Received and published: 12 August 2014

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

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2) p.4052, line 23: Please define "b" in "b/bulk ice volume" b is defined as brine volume line 132: The brine volume (b) was calculated according to Cox and Weeks (1983) for ice temperatures < -2°C and Leppäranta and Manninen (1988) for ice temperatures ≥ -2°C. Brine salinity (S_b) was calculated from the measured sea ice temperatures and the freezing point of seawater (Unesco, 1978). The brine volume fraction (V_b) was calculated as b/bulk sea ice volume (%).

3) p. 4053, line 3: Please define "hi" in equation 1. The equation 1 has been revised line: $Ra = (g(h-z) \beta_w [\sigma(z) - S_w] \pi(e_{min})) / (K(i) \eta)$ (1) where g is the gravity acceleration $g = 9.81 \text{ m s}^{-2}$, h-z is the distance (m) between the ice-ocean interface at depth h (m) and the level z (m) in the ice,...

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. Thanks, this was a typo. Corrected in our revised version.

5) p. 4056, line 16: Please define "S_{ice}". 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 "S_{ice}" everywhere. Also, salinity is unites (Figure 2&6). Thanks, however Si is the international abbreviation for silicate, in the sea ice field Si is the common abbreviation for bulk ice salinity. In our revised manuscript, Si is spell out line 106: Bulk ice salinity (Si) was measured with a conductivity meter (Orion Star Series Meter WP-84TP, Beverly, USA) which had a precision of ±0.1 for deduced salinity. To stay in line with the literature, we choose to use Si everywhere in our revised manuscript.

6) p.4063, line 17: Spelling "Weisenburg" Revised

7) p.4064, line 5: Spelling "rises" Revised

8) p.4064, lines 4-10: The authors seem to attribute CH₄ 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

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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 CH₄ maxima in the overlying sea-ice also coincide with salinity minima which have been attributed to freshwater input (section 5.2). Thanks for this and to clarify this point we revised the manuscript according to your comment by adding at the end of the section line 430-431 : Like CH₄ maxima in the overlying sea-ice also coincide with salinity minima, the Kapisillit river is most likely the major sources of CH₄ into the fjord system.

9) p.4066, lines 17-21: The authors suggest that CH₄ 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 CH₄ 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 CH₄ to still be coming out in Spring. This doesn't seem to be the case (Figure 2; albeit depth-profiles only reach 9 m and the seafloor is at 45 m). Shakhova et al. did show CH₄ bubble trapping in sea-ice, but they also measured 2000+ nmol/L CH₄ in the water column, not 17, as here! I think it's much more likely that CH₄ concentration in the forming sea-ice led to the formation of CH₄ bubbles as the authors explain earlier and that CH₄ came from the riverine source. Thanks for this useful comment and we agree. Moreover in this subarctic fjord, the sea ice start to grow later in the winter, so its most unlikely that the CH₄ bubbles come from ebullitive phenomena from the sea floor. According to your comment, we deleted the third point about potential ebullition phenomena from the sea floor.

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

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Interactive comment on Biogeosciences Discuss., 11, 4047, 2014.

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