

Interactive comment on “Insights into oxygen transport and net community production in sea ice from oxygen, nitrogen and argon concentrations”

by J. Zhou et al.

Anonymous Referee #1

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General comments

The authors present seasonal biogeochemical depth profiles in discrete ice cores from land-fast sea ice, treated as a time series. From their data set, they determine the biological and physical contributions to O₂ dynamics in bulk sea ice from late winter to early summer, and compute net community production in the form molecular oxygen changes using inert gases to account for physical changes in the gas composition of bulk sea ice. The data set is of good quality, and the topic will be much appreciated in the sea ice scientific community. The main issue with this manuscript is clarity, which is lacking in places, especially in the Discussion, and its lack compounds proper appreciation and evaluation of their data analysis. I recommend it for publication after

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moderate revision to edit, to clarify, and to sharpen several parts of the Discussion.

Specific comments

1. P2050, L12-13: Explain what reproducibility means in the context of this study and provide details of how it was assessed using standard gases.
2. P2052, L6-8: Dissolved gas evasion into gas bubbles forming in the brine of permeable sea ice should not affect the bulk sea ice O₂/Ar. In other words, bulk sea ice gas ratios could not provide information about phase change within sea ice, if I understand this correctly, unless the gas bubbles escape sea ice. I suggest the use of this term, “bulk sea ice gas (e.g., O₂/Ar, O₂/N₂) ratio”, throughout the manuscript for clarity when discussing the measurements in the context of gaseous and dissolved gas phases in sea ice. I also suggest use of the latter two terms for clarity too.
3. P2052, L17-18: Given that O₂ could be undersaturated when respiration dominates in sea ice, I suggest replacing ‘supersaturation’ with ‘O₂ concentration change in sea ice’.
4. P2055, L16 (and throughout the text): Explain what ‘sensitive’ means in this context and to what the gas ratios are compared to deduce ‘sensitivity’.
5. P2056, L17-19: Explain how warming may, or may not, have contributed to the sharp decrease in total gas supersaturation.
6. P2057, L4: Replace ‘0%’ with ‘saturation’ and ‘negative’ with ‘undersaturation’. In L10, clarify whether it is total gas content or the gaseous gas component. The text in L11-14 is unclear and, in the manner written, implies that (i) gases are incorporated in sea ice brine as a result of a temperature gradient of unspecified location in the air-ice-seawater system, and (ii) the decrease in gas solubility (where?) is a consequence of an unspecified agent. In L14, specify which component of the total gas it is that gases preferentially accumulate and in L15 replace ‘in comparison to’ with ‘in contrast to’ following degassing of supersaturated brines. In L19-20, I understand that the ‘accumulation of gas’ refers to ‘accumulation of gas in the gas phase of sea ice’ and the ‘low gas solubility’ refers to the low gas solubility in brine’, while the ‘induced high O₂ supersaturations’ could do better if it were replaced by ‘can account for the high total O₂ supersaturations observed in the impermeable (coldest) upper sea ice layers’.

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The whole of this paragraph calls for heavy editing along these lines and requires a good, careful re-write and is one of many similar muddled paragraphs throughout the Discussion. In L21, in the next paragraph, specify that the extent of saturation discussed here refers to the 'total' gas content. I suggest careful combing of the whole manuscript to insert this type of identifiers; left as it is, the discussion is confusing. 7. P2057, L23-25: Could the undersaturation be the result of warming and freshening of the internal brines in the upper ice layers? Equally, how much of the drop in the extent of saturation can be explained by these physical processes? Explain the causality allude to here between the enlargement of the brine channels (increase in brine volume fraction) and bubble escape to the atmosphere. 8. P2058, L1-4 & L5-14: The point of these statements was unclear to me. 9. P2058, L22: Clarify which gas component of the measured total gas standing stock was exchanged upon warming and permeability increase. Written as is, it alludes to either gaseous or dissolved gas exchange or both, and, therefore, two different mechanisms. 10. Title of Section 4.2 & 4.2.2: Clarify 'sensitivity'. 11. P2061, L13 & L19-28 & P2062, L1-11: Clarify and justify the validity of applying the calculations discussed here to the results of this study. Gas partitioning between the gaseous and aqueous phase of sea ice should not affect the total (bulk sea ice) gas content measured here and, therefore, the gas ratios, unless the gas bubbles are lost from sea ice. Further, in the statement in L13-17, it is unclear how the diffusivity difference amongst the investigated gases affects the 'sensitivity' of the two total gas ratios to record biologically-driven changes in the total O₂ content of sea ice. 12. P2063, L29: State how you calculate NCP-O₂ in mmol m⁻² d⁻¹ from the oxygen volumetric concentration units in eq. 4. 13. P2064, L15-16: Clarify 'obvious', 'O₂ exchanges', and 'retrieving'. 14. P2064, L22-23: Explain 'physical O₂ supersaturation' and why it should be negligible. 15. P2065, L6: Based on eq. 4, another, implicit, assumption in eq. 5 is that Ar/Ar_{req} = 1. 16. P2065, L24: Explain how you calculate the NCP in carbon units. 17. P2065, L26: How discernible from zero (no biological activity) are the calculated NCP values with depth in the ice in BRW10? In other words, what is the uncertainty in the calculations? 18. P2066, L23-24: Clarify

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where and when (season) the Nomura et al. (2010) rate was observed. In L25-27, explain why an additional source of dissolved inorganic carbon (DIC) is required in the under-ice seawater for photosynthetic production in the bottom sea ice when there is DIC in the brine of the biologically active sea ice layers; also, add 'primary production' or 'photosynthetic production' or something along these lines for clarity at the end of L27.

Technical comments

1. P2050, L15: Replace 'determined' with 'computed', as no experiments were performed in this study to determine the solubility of the investigated gases.
2. Figure 5 is unreadable in print. It needs substantial enlargement.
3. P2055, L20: Replace 'showed the atmospheric values' with 'were close to their respective the atmospheric values'.
4. P2052, L26, P2053, L1-3: This is irrelevant information and I suggest removing it.
5. P2058, L17: Replace 'remove' with 'alleviate'.
6. P2059, L16: Replace 'mismatched' with 'did not coincide' and in L22, insert 'diffusive' before 'transport'.
7. P2060, L13: Replace 'bacteria activities' with 'bacterial activity'. In L20, replace 'from' with 'to'.
8. P2064, L7: Replace 'witness' with, for example, 'suggest'.
9. P2065, L11-13: This is a fragment of a sentence and does not make sense.
10. Caption of Fig. 6: I suggest replacing 'assuming equilibrium between the diffusion and NCP' with 'assuming a (transient) steady state depth distribution of bulk sea ice O₂ (gaseous + dissolved) content'.