We would like to thank Anonymous Referee #1 for their thoughtful review and constructive suggestions. We agree that an important contribution of this work is highlighting the potentially overlooked contribution of OrgAlk within the sea ice carbonate system.

This paper examines the potential importance of organic alkalinity in antarctic sea ice brines. I can sum up its main outcome fairly concisely: a recent study (by other authors) showed the importance of organic alkalinity in Arctic sea ice, and reported a DOC:OrgAlk ratio; because Antarctic sea ice brine typically has higher DOC, it stands to reason that organic alkalinity might be even higher in Antarctic sea ice brine. That is essentially the premise, and the eventual conclusion of the paper.

I did not identify any major technical flaws in the study (although I have some comments about the final "sensitivity analysis"), and in fact it serves as a nice review of the issue of organic alkalinity, highlighting the specific case of sea ice. I think the challenge for the editor is simply to decide whether or not this simple, and fairly intuitive conclusion, is significant enough for publication in this particular journal.

Let me make the case for the strengths of this paper, and why it might warrant publication in The Cryosphere:

-The authors have put in the effort of compiling a dataset of DOC and TA measurements for Antarctic brine, and related seawater measurements. This does allow for us to understand the range of DOC in Antarctic brine, and the resulting OrgAlk range that may arise from applying different OrgAlk:DOC ratios. This certainly adds more value than a simple statement of "Antarctic ice has high DOC, therefore it probably has high OrgAlk" (see my summary above)

-The authors have also compiled a wide range of OrgAlk:DOC ratios from the literature, which allows them to do a very wide sensitivity analysis of what the OrgAlk contribution could be in Antarctic sea ice.

-The authors are very up front about limitations of their study, and thoroughly explain why the study is limited. Their review of carbonate system theory and its applications to sea ice is excellent, and is a strength of the paper.

-It does elevate the issue of OrgAlk in sea ice brine; it is important that the sea ice carbonate system community is aware of this issue, and in that way the paper could be impactful.

We thank the referee for recognizing these contributions of our study. We agree that bringing together existing datasets across multiple environments provides a useful basis for evaluating the potential range of OrgAlk contributions in Antarctic sea ice brines. We also particularly appreciate the referee's recognition of the relevance of this work to the sea ice carbonate community, which is the primary audience we hope to reach.

Here are the weaknesses of the paper, and why it may need work before publication:

-The core calculations that are performed with this carefully curated dataset are quite simplistic. They are really just multiplying their DOC data by a wide range of OrgAlk:DOC ratios, and reporting them in graph and table form.

We acknowledge that the calculation of OrgAlk from published OrgAlk:DOC ratios are relatively straightforward. We believe the value in this work lies in compiling and investigating the wide range of OrgAlk:DOC relationships across different environments where there are no direct measurements. We have added the following text to be upfront about this point in Sect. 2.2:

"Ultimately, these calculations provide simplified, parameterized OrgAlk estimates by multiplying the measured DOC concentration by a set of published OrgAlk:DOC ratios. Although OrgAlk quantification by overdetermination of the CO_2 system is precluded by the lack of reliable pH measurements in existing sea ice brine datasets (Sect. 4.2.2), this analysis evaluates the range of reported OrgAlk relationships and their potential implications for carbonate system calculations where direct measurements are unavailable."

-While overall the writing in this paper is strong, I found it at times to be redundant. Certain concepts are repeated at different points in the paper (sometimes separated by no more than a paragraph), and this affects the readability. Here are some examples of redundancy:

-Lines 115 - 120 provide significant detail on the range of OrgAlk:DOC ratios in literature, and the studies they arise from; Line 150 -154 repeat the same information.

The information repeated in lines 150-154 has been removed.

-Lines 354 - 356 describe constraints on the Antarctic dataset, and mention that a sensitivity analysis is the only thing possible. Lines 361-362 repeat this.

Lines 354-356 have been removed.

-Section 4.2.1 contains many redundancies, both internally and with other sections of the paper

In Sect. 4.2.1, we have removed redundancy by removing lines 249-251, 255-260, 273-276, and 284-289.

Basically, key concepts are introduced and then reiterated multiple times throughout the manuscript. Concepts that are prone to redundancy in this paper include: the published range of OrgAlk:DOC relationships (see above), the inability of existing Antarctic datasets to uniquely constrain OrgAlk, the uncertainty associated with transferring OrgAlk:DOC relationships between environments, and the statement that the present study provides sensitivity bounds rather than quantitative OrgAlk estimates

We thank the reviewer for identifying these instances of repetition, and we agree that several concepts were unnecessarily reiterated throughout the original manuscript. We have removed redundancy around these concepts throughout the paper by furthermore removing lines 240-241, 243-244, 313-314, 318-319, 349-350, 354-356, 362-364, 400, and 402. We have also removed repetition of the following words/concepts: sensitivity, constrain, transferability of OrgAlk:DOC relationships, and sensitivity bounds.

-I really thought the final sensitivity analysis (Section 4.3) could be improved. Here are my thoughts about that:

-Why not apply the full range of OrgAlk:DOC ratios to this analysis? One of the core purposes of the paper was to explain that the ratio was highly uncertain... Shouldn't the sensitivity analysis be applied to the full range of OrgAlk:DOC ratios that you think are feasible?

We thank the reviewer for this suggestion. We propose restructuring the discussion as described below to ground the sensitivity analysis choices. First, we have added a new section to the discussion where we explicitly identify and hypothesize the most feasible Antarctic sea ice brine OrgAlk:DOC ratios based on the full literature range. It was for these reasons below that the sensitivity analysis originally solely used the Arctic sea ice brine case. The added text follows Section 4.2.2 and reads:

"4.3 Assessing the feasibility of parameterized OrgAlk values and sensitivity calculations

Although the literature represents a broad range of ratios, not all of these are necessarily representative of Antarctic sea ice brines. For example, the upper end of the OrgAlk:DOC range (0.44) was reported in the lowest salinity estuarine waters of Song et al. (2023), where river freshwater was postulated to be a major source of organic acids to the estuaries. As discussed, this source of organic matter is unlikely to be important in Antarctic sea ice. We do believe a feasible OrgAlk:DOC ratio is that of the Arctic sea ice brines, but we hypothesize Antarctic sea ice brines to have slightly lower OrgAlk:DOC ratios than those observed in the Arctic. Arctic sea ice brines exhibited an average OrgAlk:DOC ratio of 0.13, with individual values ranging from 0.03 to 0.27. This variability reflects a span of DOM compositions from lower ratio proteins and lipids to marine fulvic acids, fragmented and photochemically oxidized fulvic acids, and potentially terrestrial humic acid rich DOM with higher ratios. We hypothesize that Antarctic sea ice brines are less likely to exhibit a strong humic-like signal characterized by densely clustered negative charges on the carbon skeleton (high OrgAlk:DOC ratio). Instead, their DOM is expected to contain a greater relative contribution from proteins and lipids, where negative charges are more dispersed along the carbon skeleton (lower OrgAlk:DOC ratio). Additionally, we expect a background marine fulvic acid contribution (OrgAlk:DOC ratios of ~0.07 to 0.16). We, therefore, hypothesize, that Antarctic sea ice brines will exhibit similar but lower overall OrgAlk:DOC ratios than Arctic brines, consistent with the predominance of autochthonous DOM. For these reasons, we consider the 0.06 and 0.13 ratios to represent the most likely OrgAlk:DOC ratios for Antarctic sea ice brines and, consequently, the most plausible range of calculated carbonate system parameters."

Regarding the sensitivity analysis overall, we propose a more robust approach below.

-I'm concerned that the effort to just proportionally scale the effect of OrgAlk on pCO2 calculations is unsupported. The authors just spent several sections (4.2.1, 4.2.2) explaining how complex the sea ice carbonate system becomes when you consider organic alkalinity and other factors (e.g. poorly constrained dissociation constants). I would not assume that the effect of organic alkalinity on pCO2 would just scale proportionally between Arctic and Antarctic sea ice. There could be many factors (many of which have been reported in this study!) that would preclude that... One would need to consider at the very least one other carbonate parameter (e.g. DIC or pH). Can the authors better justify this choice? Were additional carbonate parameters (pH, DIC) not available in their dataset? If they were available, why did they not actually do the sensitivity calculation in CO2SYS?

We agree that the proportional scaling is a simplification and does not fully account for the complexities of the carbonate system. It is for this reason that we intended the scaling exercise to illustrate the potential magnitude of the OrgAlk contribution rather than provide actual pCO_2 estimates. We thank the reviewer for prompting us to reconsider this aspect of analysis further, and we present what we believe would be the best option to more robustly evaluate carbonate system implications, though there are limitations. First, we have added the following text to the methods following Section 2.2 and updated the reference list accordingly:

"2.3 OrgAlk Sensitivity Analysis Calculations

To assess the impact of the calculated OrgAlk on derived carbonate parameters, including pCO_2, pH, and $CaCO_3$ mineral saturation states, differences were computed between values derived using measured A_T ($A_{T,meas}$) and calculated A_T ($A_{T,calc}$) for a subset of the dataset containing both A_T and C_T measurements. $A_{T,calc}$ was determined by subtracting parameterized OrgAlk, estimated from measured DOC concentrations using the selected OrgAlk:DOC ratios, from $A_{T,meas}$. In each case, C_T served as the complementary input parameter. For each parameter of interest, X, the difference, ΔX, was determined by subtracting the value derived with $A_{T,calc}$ from that derived with $A_{T,meas}$:

$$\Delta X = X\left(C_T, A_{T,meas}\right) - X\left(C_T, A_{T,calc}\right) \quad (1)$$

Calculations were performed in PyCO2SYS using the carbonic acid dissociation constants of Papadimitriou et al. (2018), the boron to salinity ratio of Lee et al. (2010), the bisulfate ion dissociation constant of Dickson (1990), and the fluoride dissociation constant of Dickson and Riley (1979). The measured concentrations of soluble reactive phosphorus (SRP) and silicate (silicic acid) were also included as inputs."

In original Section 4.3 (now Section 4.4), we have removed all material related to the proportional scaling of Arctic to Antarctic OrgAlk (lines 366-399 and Figures 5 and 6). We have rewritten section 4.3 as follows:

"Numerous studies have demonstrated that OrgAlk can influence carbonate system calculations when A_T is used as an input parameter. In systems with unaccounted OrgAlk, calculations using A_T and C_T will underestimate pCO_2 and overestimate pH. Calculations using A_T and pH as the input parameters can overestimate both pCO_2 and C_T. In Antarctic sea ice brine studies, A_T has frequently been employed as a carbonate parameter measurement in campaigns due to its quasi-conservative nature, compared to pH. It is, therefore, critical to ascertain the accuracy of calculated carbonate system variables by evaluating the potential influence of unaccounted OrgAlk.

An ideal sensitivity analysis would use the overdetermination approach, where pH and C_T would be used to independently calculate $A_{T,calc}$. The influence of OrgAlk on carbonate system parameters could subsequently be evaluated by comparing CO2SYS results calculated using $A_{T,meas}$ and $A_{T,calc}$, with C_T held constant. Although pH measurements were collected during both field campaigns, their quality is insufficient for robust carbonate system calculations. The available pH measurements were taken at the start of the open cell A_T titrations making them susceptible to CO_2 exchange. Because the brines were supersaturated with respect to atmospheric CO_2, degassing during sample processing would have resulted in an overestimation of the measured pH. Thus, the pH measurements cannot be considered reliable or support an overdetermination approach.

Nevertheless, both datasets contain C_T measurements of high analytical quality, which allows for an alternative sensitivity analysis whereby $A_{T,calc}$ was computed from $A_{T,meas}$ and the OrgAlk estimated as described in Section 2.3. The potential influence of OrgAlk on carbonate system parameters was then evaluated by comparing CO2SYS results calculated using $A_{T,meas}$ and $A_{T,calc}$, with C_T held constant. This analysis was repeated across the full published OrgAlk:DOC ratio range to assess the sensitivity of calculated

carbonate parameters to the assumed OrgAlk contribution. Importantly, this approach does not remain independent of the assumed OrgAlk:DOC relationship and cannot independently constrain OrgAlk carbonate system impacts.

Differences in pCO_2, pH, and $\Omega_{aragonite}$ were evaluated following Equation (1), where the Δ value represents the difference of including parameterized OrgAlk (Fig. 5; Table 4). At the low end of the published OrgAlk:DOC ratio range (0.06), ΔpCO_2, ΔpH, and $\Delta\Omega_{aragonite}$ in brines ranged from -1 to -765 µatm, 0.00 to 0.06, and 0.00 to 0.37, respectively. At the upper end of the OrgAlk:DOC range (0.44), the corresponding differences were -11 to -5880 µatm, 0.03 to 0.45, and 0.03 to 2.54. These results are comparable in magnitude to carbonate system responses reported in studies incorporating directly measured OrgAlk and associated pK_a values. Song et al. (2020) reported pCO_2 changes of 30 to 1600 µatm and pH changes of 0.03 to 0.26 at OrgAlk:DOC ratios of 0.07-0.28. Song et al. (2023) reported pH changes of 0.01 to 0.78 (OrgAlk:DOC ratios: 0.06-0.44), and Rush et al. (2026) reported pH changes of 0.01 to 0.08 (OrgAlk:DOC ratios: 0.03-0.27). As the OrgAlk:DOC ratio increases, the magnitude of the carbonate system response generally tends to increase as well; however, the largest literature responses and upper end cases here are unlikely to be representative of Antarctic sea ice brines. As discussed above, an OrgAlk:DOC ratio slightly below the Arctic brine average is more reasonable for these datasets. At the average Arctic OrgAlk:DOC ratio (0.13), ΔpCO_2, ΔpH, and $\Delta\Omega_{aragonite}$ in brines ranged from -3 to -1677 µatm, 0.01 to 0.13, and 0.01 to 0.79, respectively. These results solely demonstrate that uncharacterized OrgAlk effectively represents appreciable uncertainty in carbonate system parameter estimates derived from typical A_T-C_T input."

The new Fig. 5 and Table 4 are reproduced below:

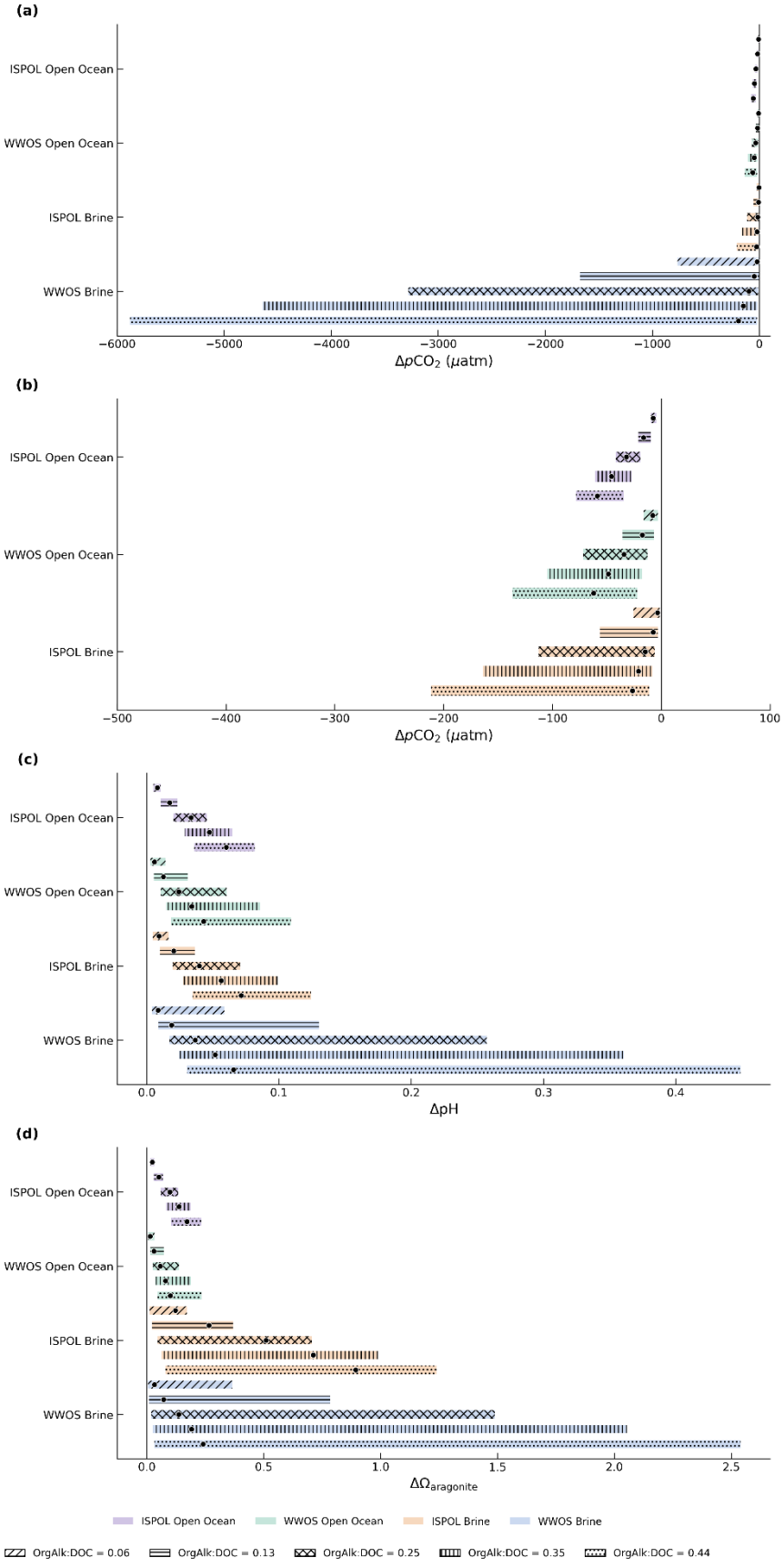


Figure 5. Potential ΔpCO_2, pH, and $\Omega_{aragonite}$ ranges across the OrgAlk:DOC ratio range reported in previous studies applied to sea ice brine and open ocean samples from the WWOS and ISPOL Antarctica field campaigns. Differences (Δ) between carbonate system parameters are calculated using measured total alkalinity and OrgAlk-adjusted total alkalinity. Panel (b) is a zoomed version of panel (a). Shading and hatching patterns indicate expedition sample type and OrgAlk:DOC ratio, respectively. The horizontal bars reflect the range of Δ values, and the black circles indicate the median Δ value.

Table 4. Sensitivity of calculated pCO_2, pH, and aragonite saturation state ($\Omega_{aragonite}$) to the inclusion of OrgAlk in Antarctic open ocean and sea ice brine samples from the WWOS and ISPOL field campaigns. OrgAlk-adjusted A_T was calculated by subtracting estimated OrgAlk, derived using previously reported OrgAlk:DOC ratios, from measured A_T. Differences (Δ) between carbonate system parameters calculated using measured total alkalinity and OrgAlk-adjusted total alkalinity are reported as mean ± standard deviation (minimum to maximum, median).

OrgAlk:DOC Ratio			**0.06**	**0.13**	**0.25**	**0.35**	**0.44**
Descriptor			**Low end of published range**	**Arctic sea ice brine (Rush et al., 2026)**	**Intermediate case within published range**	**Intermediate case within published range**	**High end of published range**
Campaign	**Sample Type**	**n**	**ΔpCO_2 (µatm)**				
WWOS	Brine from First- and Second-Year Ice	119	-40±80 (-765 to -3, *-22*)	-90±177 (-1677 to -6, *-50*)	-184±357 (-3277 to -12, *-99*)	-270±518 (-4639 to -16, *-149*)	-356±674 (-5880 to -21, *-196*)
	Open Ocean	8	-8±4 (-16 to -3, *-8*)	-18±9 (-36 to -6, *-17*)	-37±18 (-72 to -12, *-34*)	-52±26 (-105 to -18, *-49*)	-67±34 (-137 to -22, *-62*)
ISPOL	Brine from First- and Second- Year Ice	35	-4±4 (-25 to -1, *-3*)	-9±9 (-56 to -3, *-8*)	-17±18 (-113 to -6, *-15*)	-25±26 (-164 to -8, *-21*)	-32±34 (-212 to -11, *-27*)
	Open Ocean	12	-8±1 (-9 to -4, *-7*)	-17±3 (-21 to -10, *-16*)	-33±6 (-42 to -19, *-32*)	-48±9 (-61 to -27, *-46*)	-61±12 (-78 to -34, *-59*)
Campaign	**Sample Type**	**n**	**ΔpH**				
WWOS	Brine from First- and Second-Year Ice	119	0.01±0.01 (0.00 to 0.06, *0.01*)	0.03±0.02 (0.01 to 0.13, *0.02*)	0.05±0.04 (0.02 to 0.26, *0.04*)	0.07±0.06 (0.02 to 0.36, *0.05*)	0.09±0.08 (0.03 to 0.45, *0.07*)
	Open Ocean	8	0.01±0.00 (0.00 to 0.01, *0.01*)	0.01±0.01 (0.01 to 0.03, *0.01*)	0.03±0.01 (0.01 to 0.06, *0.02*)	0.04±0.02 (0.01 to 0.09, *0.03*)	0.05±0.03 (0.02 to 0.11, *0.04*)
ISPOL	Brine from First- and Second- Year Ice	35	0.01±0.00 (0.00 to 0.02, *0.01*)	0.02±0.01 (0.01 to 0.04, *0.02*)	0.04±0.01 (0.02 to 0.07, *0.04*)	0.06±0.02 (0.03 to 0.10, *0.06*)	0.07±0.02 (0.03 to 0.12, *0.07*)
	Open Ocean	12	0.01±0.00 (0.00 to 0.01, *0.01*)	0.02±0.00 (0.01 to 0.02, *0.02*)	0.03±0.01 (0.02 to 0.05, *0.03*)	0.05±0.01 (0.03 to 0.06, *0.05*)	0.06±0.01 (0.04 to 0.08, *0.06*)
Campaign	**Sample Type**	**n**	**$\Delta\Omega_{aragonite}$**				
WWOS	Brine from First- and Second-Year Ice	119	0.06±0.06 (0.00 to 0.37, *0.03*)	0.12±0.13 (0.01 to 0.79, *0.07*)	0.23±0.25 (0.02 to 1.49, *0.14*)	0.32±0.35 (0.03 to 2.05, *0.19*)	0.40±0.43 (0.03 to 2.54, *0.24*)
	Open Ocean	8	0.02±0.01 (0.01 to 0.03, *0.01*)	0.03±0.02 (0.01 to 0.07, *0.03*)	0.07±0.03 (0.03 to 0.14, *0.06*)	0.09±0.05 (0.04 to 0.19, *0.08*)	0.11±0.06 (0.05 to 0.24, *0.10*)
ISPOL	Brine from First- and Second- Year Ice	35	0.11±0.04 (0.01 to 0.17, *0.12*)	0.24±0.09 (0.02 to 0.37, *0.27*)	0.46±0.17 (0.05 to 0.71, 0.*51*)	0.65±0.24 (0.06 to 0.99, 0.*71*)	0.81±0.30 (0.08 to 1.24, *0.89*)
	Open Ocean	12	0.02±0.01 (0.01 to 0.03, *0.02*)	0.05±0.01 (0.03 to 0.07, *0.05*)	0.10±0.02 (0.06 to 0.13, *0.10*)	0.13±0.03 (0.08 to 0.19, *0.14*)	0.17±0.04 (0.10 to 0.23, *0.17*)

I think if the authors put some effort into reducing the redundancy of the paper, and were able to come up with a more robust final sensitivity analysis (impact of OrgAlk on pCO2 or other derived carbonate system variables), this paper could warrant publication in The Cryosphere.

Again, we sincerely thank the reviewer for their constructive assessment. We believe our revised sensitivity analysis more robustly evaluates the impact of OrgAlk on derived carbonate system variables.