Response to Editor and Reviewers

We thank the editor and both reviewers for their careful evaluation of our revised manuscript and for their constructive feedback. We appreciate the recognition of the improvements made in the previous revision. We have carefully considered all comments and revised the manuscript accordingly. In particular, following the editor's guidance and RC1's concerns, we have removed the eddy covariance (EC) CO_2 flux data from the manuscript. Our detailed responses are provided below.

Editor Comments:

Dear Authors,
many thanks for your efforts in addressing the issues raised during the process. Your manuscript has been evaluated by the same experts which reviewed the original version. While both referees acknowledge the improvements in the current version of the manuscript, they have additional concerns which should be revised before considering publication (please see their comments below).
In particular, I would like to bring your attention to the comments by Referee 1, who expressed serious concerns with the inclusion of your CO2 Eddy Covariance flux data in the revised version of the manuscript, even if in a qualitative manner. I concur with this assessment and encourage you to reconsider whether you would like to use these data in your manuscript. I would like to emphasize that keeping these data knowing that they are, unfortunately, flawed, is not adequate for publication, as this goes beyond acknowledging any methodological limitations. As I see it, both referees agree in that your work could be an important contribution, even without the flux data.

Response to Editor

We thank the editor for the clear guidance regarding the inclusion of the EC CO_2 flux data. We agree with this assessment. Accordingly, we have removed all EC CO_2 flux data from the manuscript and no longer use them to support our interpretations. The manuscript has been revised throughout, and our conclusions are now based solely on hydrographic and carbonate system observations.

RC1 Comments

I appreciate the authors' efforts to address my comments and revise the manuscript. Most of my minor concerns have been resolved.
However, my major critical point remains unaddressed adequately. The open-path eddy covariance CO2 data are still used to support some arguments, even if only qualitatively. The authors justify these data based on Landwehr et al. (2014), suggesting they may be reasonable when |latent heat flux| < 7 W m-2. Nevertheless, this 7 W m-2 threshold is not a universal criterion, which may different for different setup and enviroment. A key takeaway from Landwehr et al. (2014) is that significant correlation between EC CO2 fluxes and latent heat flux strongly indicates water vapor cross-

sensitivity bias. As shown in Fig. 8, such a clear correlation persists in the authors' dataset within the 7 W m-2 range.
Furthermore, a back-calculation approach, i.e., estimating fCO2w from EC fluxes, wind speed, and the K660 parameterization, would help validate plausibility. For the EC CO2 fluxes of 40–50 mmol m-2 day-2 in Fig. 8, paired with wind speeds of ~4–6 m s-1 (Fig. 3d), the implied fCO2w is unreasonably high.
Given that the open-path EC system fails to capture CO2 fluxes accurately in both magnitude and variability, I question whether these data are suitable for inclusion in a scientific paper, even for qualitative analysis.

Response to RC1

We thank RC1 for their continued careful and thorough evaluation of the manuscript. We agree that the observed correlation between EC CO_2 fluxes and latent heat flux indicates unresolved humidity cross-sensitivity, and that the back-calculation suggests physically implausible flux magnitudes. We also acknowledge that the previously applied threshold based on Landwehr et al. (2014) is not universally applicable and does not adequately resolve this issue for our dataset.

In light of these concerns, and following the editor's recommendation, we have removed all EC CO_2 flux data from the manuscript. These data are no longer used, even qualitatively, to support any arguments or interpretations.

The revised manuscript now focuses exclusively on the high-resolution vertical profiles of pCO_2, temperature, and salinity. The primary objective is to document pronounced near-surface stratification during sea ice melt and to assess how this vertical heterogeneity can lead to biased air-sea CO_2 flux estimations.

We retain only the heat flux data in the supplementary materials, as these do not experience the problematic CO_2 cross-sensitivity and are used solely to support the estimation of sea water skin temperatures. These data are not used to infer or discuss CO_2 exchange.

We appreciate the referee's insistence on this point, which has strengthened the overall robustness of the manuscript.

RC2 Comments

The revised manuscript has thoroughly addressed the comments raised during the previous review. The authors have clearly made substantial efforts to improve the quality of the manuscript.

Before publication, I have one minor suggestion.
Although the influence of tidal mixing on the observed surface-layer changes is likely limited, it would be helpful if the authors briefly comment on its possible role.

Even a short statement clarifying that its effect is considered small would further strengthen the interpretation of the surface variability presented in this study.

Response to RC2

We thank RC2 for their careful, constructive, and encouraging assessment of our manuscript and for recognizing the improvements made in the revision.

Following the recommendations of the editor and RC1, we have removed the EC CO_2 flux data from the manuscript. The main conclusions, namely that sea ice melt drives strong near-surface stratification with implications for estimating air-sea CO_2 exchange, remain robust and are supported by the hydrographic and carbonate system observations alone.

Regarding the potential influence of tidal mixing, we have added a brief discussion in the manuscript (Lines 143-144 and 256-258). We note that tidal mixing is expected to play a minor role during the observation period due to the relatively small tidal amplitude and the persistent stratification associated with continued freshwater input to the surface ocean.