The manuscript entitled “Sea ice melt drives vertical pCO2 variability modulating air-sea gas exchange” presents a study on the physical and chemical stratification of Arctic fjord waters during sea ice melt. The study delivers an important and timely message: near-surface stratification during the transition period can generate strong vertical pCO2 heterogeneity within the upper meters, which can substantially bias bulk air–sea CO2 flux estimates when sampled at a single depth.

The high-resolution vertical profiles presented are chemically plausible and provide a compelling explanation for how freshwater dilution and reduced buffering capacity can elevate pCO2 in the surface layer. This finding alone makes the study a valuable contribution to Arctic carbon budgeting.

However, there are significant concerns regarding the quantitative robustness of the Eddy Covariance (EC) fluxes presented. As noted by the community and other reviewers, the reliance on an open-path CO2 analyzer in a marine environment introduces susceptibility to water-vapor cross-sensitivity. The strong correlation between CO2 flux and latent heat flux suggests that measurement artifacts may be influencing the reported efflux magnitudes. Despite this, the study offers critical insights into the limitations of bulk parameterizations.

Therefore, I recommend publication pending revision, provided the authors explicitly acknowledge the open-path EC limitations by reframing EC fluxes as qualitative support (not definitive quantification) and keeping the focus on the robust vertical $pCO_2$ stratification findings, as this manuscript will be a strong reference for high-latitude air–sea exchange.

**Specific Comments:**

Line 34: The statement "The bulk approach assumes homogeneous surface conditions" should be clarified. It implies no vertical gradients within the water column, but strictly speaking, bulk models assume a linear gradient across the diffusive sublayer. Please revise to clarify that the assumption is a lack of vertical gradients below the interface.

Lines 167~ & 404~ : The manuscript attributes the persistent offset between calculated (TA-DIC) and measured pCO2 to "disequilibrium." However, carbonate system calculations in cold, low-salinity water carry substantial uncertainty regarding equilibrium constants. Before claiming physical disequilibrium, please expand the sensitivity analyses to determine if this offset is a physical phenomenon or simply a methodological artifact inherent to the constants used.

Lines 206~ & 495~ : There is a valid concern that the reported upward CO2 fluxes are biased by water-vapor cross-sensitivity, a known issue with open-path NDIR sensors in marine environments. The strong correlation between CO2 fluxes and latent heat fluxes (Fig. S7) is a typical indicator of this artifact, and the flux magnitudes (up to 100 mmol $m^{-2}$ $d^{-1}$) are difficult to reconcile with the surface pCO2 profiles without invoking extreme, unmeasured surface gradients. I strongly suggest reframing the EC data as qualitative evidence supporting the potential for outgassing rather than as definitive quantitative constraints, while explicitly acknowledging in the text that open-path cross-sensitivity likely inflates the reported flux magnitude.

Lines 450~ : The authors apply a skin temperature correction to the bulk flux calculations. Since the cool skin effect is typically small (< 0.2 K) and may not significantly alter the bulk flux direction compared to the observed large chemical gradients, if possible, please provide the derived skin temperature values in the text. This is necessary to justify whether this correction is a primary driver of the flux reversal or if the salinity/chemical gradient remains the dominant factor.

Figure S7: This figure is critical for assessing the quality of the EC data. Please ensure it is referenced in the main text when discussing the reliability of the fluxes.