Anonymous Referee #1

Summary: In this study, the authors performed analyses on data collected during the MOSAiC campaign, focusing on the atmospheric boundary layer height (ABLH). The authors first identified the ABLH manually and then calibrated the critical bulk Richardson number in the bulk Richardson number method for computing ABLH based on the manually labeled ABLH. The relations between ABLH and surface variables were examined, and two cases were examined in detail to investigate the controlling factors of the ABLH variations during the campaign. My overall impression of the paper is that the motivation was justified, the methodology was sound, and the results made sense. I have a few comments on the bulk Richardson number method and also the language needs to be improved (beyond what I pointed out in my comments below).

Response: Thank you very much for your time and effort in reviewing our manuscript and for the constructive comments. We have revised the manuscript by addressing the referee comments, and our use of the English language has been carefully edited by all authors. The revisions in the manuscript and the reply to the comments are marked in blue.

Major comments:

1, the bulk Richardson number method for computing the ABLH.
1.1 Some studies also considered a friction velocity in the definition of bulk Richardson number (see e.g., Zhang et al. 2020). It might be worth discussing this.

Response: Thank you very much for your helpful advice. In our improved Ri algorithm, the friction velocity (u_*) is now considered. The Ri formula with u_* can significantly improve the ABLH estimation in cases of ABLs with relatively high wind speed. In addition, we also consider the cloud effect in the improved Ri algorithm to estimate ABLH better. For this comment, the corresponding changes are given in our revised manuscript as follows:

3.3 An improved Ri algorithm Considering the cloud effect

As a traditional Ri_b formula, Eq. (3) may break down in cases of ABLs with relatively high wind speed and upper-level stratification due to the overestimation of shear production (Kim and Mahrt, 1992). Vogelezang and Holtslag (1996) proposed the finite-difference Ri formula, which is expressed as:

$$Ri_F = \frac{(g/\theta_{vs})(\theta_{vh}-\theta_{vs})(h-z_s)}{(u_h-u_s)^2+(v_h-v_s)^2+bu_*^2}, (6)$$

where z_s is the lower boundary for the ABL, θ_{vs}, u_s, and v_s are the θ_v and wind components at the height z_s, respectively, b is an empirical coefficient, and u_* is the surface friction velocity. Ri_F is considered for a parcel located somewhat above the surface to avoid the above problem, and u_* is also taken into account to avoid underestimation in the situation of a uniform wind profile in the upper layer. Here, we use Ri_F for clear-sky profiles and take z_s and b values as 40 m and 100, respectively, according to Zhang et al. (2020).

As shown in Fig. 3, the estimations of cloudy ABLHs are sometimes quite poor, which motivates us to further improve the algorithm. Under cloudy conditions, the moist Richardson number (Ri_m) can be used to include cloud effects on the buoyancy term. Brooks et al. (2017) adopted the Ri_m formula expressed as:

$$Ri_m = \frac{\left(\frac{g}{T}\right)\left(\frac{dT}{\mathrm{dz}} + \Gamma_m\right)\left(1 + \frac{Lq_s}{RT}\right) - \frac{g}{1+q_w}\frac{dq_w}{\mathrm{dz}}}{\frac{du}{dz}^2 + \frac{dv}{dz}^2}, (7)$$

where T is air temperature, Γ_m is the moist adiabatic lapse rate, L is the latent heat of vaporization, q_s is the saturation mixing ratio, and q_w is the total water mixing ratio, i.e., $q_w = q_s + q_L$, where q_L is the liquid water mixing ratio and is obtained based on the condensed water content. However, Eq. (6) is a gradient Ri and is calculated based on local gradients of wind speed, temperature, and humidity. To be consistent with the Ri formula proposed by Vogelezang and Holtslag (1996), we rewrite the formula in a finite-difference form expressed as:

$$Ri_m = \frac{\left[(g/T_s)\left(\frac{T_h - T_s}{\mathrm{h} - z_s} + \Gamma_m\right)\left(1 + \frac{Lq_{sh}}{RT_h}\right) - \frac{g}{1+q_{wh}}\frac{q_{wh} - q_{ws}}{\mathrm{h} - z_s}\right](\mathrm{h} - z_s)^2}{(u_h - u_s)^2 + (v_h - v_s)^2 + bu_*^2}, (8)$$

where subscripts (h and s) of the variables denote the calculated height, similar to Eq. (6), but note that the s and z_s are adjusted to 130 m, given the cloud radar blind zone. Considering that Ri_m is only appropriate for the liquid-bearing cloud cases, we use the Ri_F for "clear" grid points and use Ri_m for "cloudy" grid cells. Using this improved approach, we evaluated the best value of Ri_c to minimize the errors compared to the reference data set, arriving at an optimal value of Ri_c=0.35. The comparison of ABLH estimates obtained through the improved Ri algorithm with the manually-labeled ABLHs demonstrates significant improvement relative to other algorithms, particularly for cloudy conditions (Fig. 4, Table 1).

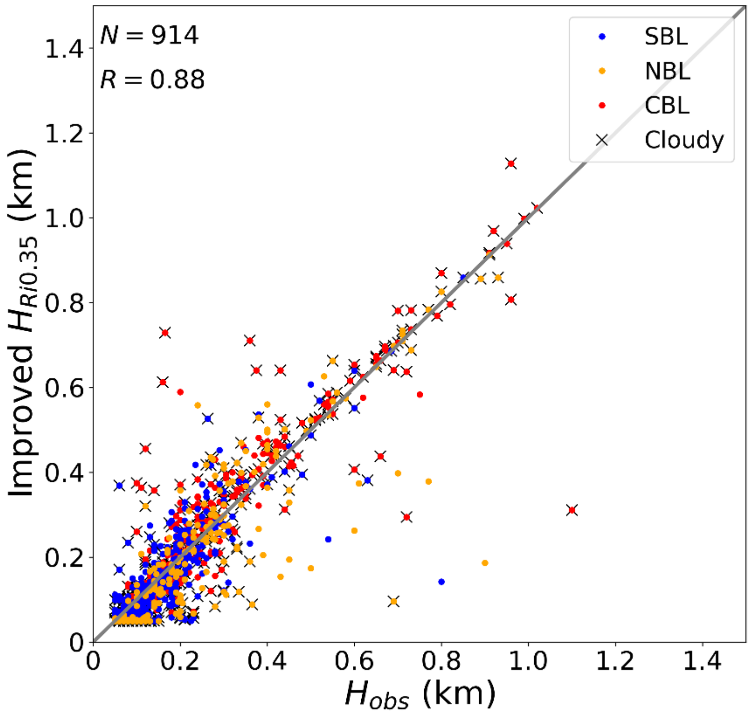

Figure 4 Similar to Fig. 3, but for the comparison of the ABLHs determined by the improved *Ri* algorithm with the observed ABLHs. The case number (*N*) and correlation coefficient (*R*) are given.

Table 1 The statistical measures (R, $Bias$, $MEAE$) for the four algorithms applied to the radiosonde dataset. All correlation coefficients are statistically significant ($p < 0.05$), except for SBL types in the Liu-Liang algorithm.

Algorithm	Regime type	***R***	Bias	MEAE (m)
The Ri_b algorithm with $Ri_{bc} = 0.25$	**ALL**	0.72	0.10	50
	SBL	0.81	0.16	34
	NBL	0.68	−0.04	62
	CBL	0.65	0.15	71
	Cloudy	0.69	0.08	51
The Ri_b algorithm with $Ri_{bc} = 0.5$	**ALL**	0.67	0.40	97
	SBL	0.73	0.50	88
	NBL	0.61	0.23	91
	CBL	0.60	0.39	120
	Cloudy	0.66	0.36	94
The Heffter algorithm	**ALL**	0.57	0.23	53
	SBL	0.46	0.17	33
	NBL	0.45	0.30	59
	CBL	0.66	0.28	74
	Cloudy	0.68	0.25	59
The Liu-Liang algorithm	**ALL**	0.47	0.04	82
	SBL	0.05	0.15	90
	NBL	0.44	−0.07	81
	CBL	0.56	−0.05	69
	Cloudy	0.52	−0.01	82
The improved *Ri* algorithm with $Ri_{bc} = 0.35$	**ALL**	0.85	−0.06	29
	SBL	0.79	−0.08	21
	NBL	0.79	−0.18	35
	CBL	0.87	0.05	36
	Cloudy	0.86	−0.03	30

1.2 it is not clear whether Eq. 2 is exactly the formula used in the VAP. If so, please state it.

Response: Thank you very much for pointing this out. The Eq. (2) is exactly the formula used in the PBLH VAP. The VAP technical report cites Sivaraman et al. (2013) as a reference for the algorithms. We have added relevant statement and the reference into our revised manuscript as follows:

These algorithms, including the Liu-Liang algorithm, the Heffter algorithm, and the bulk Richardson number algorithm, are all available in the PBLH VAP, as described in Sivaraman et al. (2013).

Ri_b is a dimensionless number that represents the ratio of thermally produced turbulence to that induced by mechanical shear. The Ri_b formula used in the PBLH VAP (Sørensen et al., 1998; Sivaraman et al., 2013) is expressed as:

$$Ri_b = \left(\frac{gz}{\theta_{v0}}\right)\left(\frac{\theta_{vz}-\theta_{v0}}{{u_z}^2+{v_z}^2}\right), (3)$$

1.3 the authors mentioned that their results are different from Jozef et al. (2022). It would help the readers understand this by discussing a bit more of how exactly the formulations differ. Which formula did Jozef et al. use?

Response: Thank you very much for your helpful suggestions. We have added the analysis and comparison of different Ri formulas and Ri_c values, and the Ri formula used in Jozef et al. (2022) is now also included. Jozef et al. (2022) calculates the Ri over a rolling 30 m altitude range, and uses the Ri_c value of 0.75. The method of calculating Ri over a rolling 30 m range causes dramatic variation within the ABL, as seen in Fig. 5. Thus, for this Ri definition, a large Ri_c value is required to avoid the noise. The corresponding changes are given in our revised manuscript as follows:

Since some other studies have proposed different Ri_c values for MOSAiC (e.g., Jozef et al., 2022; Barten et al., 2023; Akansu et al., 2023), we will discuss the difference in Ri_c values here. The first thing to make clear is that these studies use different formulas to obtain Ri profiles. Barten et al. (2023) and Akansu et al. (2023) both use the traditional Ri_b algorithm based on Eq. (3), while they used Ri_c values of 0.4 and 0.12, respectively. This difference was likely caused by the different methods to manually derive their reference ABLH data sets. Jozef et al. (2022) calculates the Ri over a rolling 30 m altitude range, labeled as Ri_r, and the criterion is modified to require four consecutive data points to be above the Ri_c of 0.75. In our study, we use Ri_F proposed by Vogelezang and Holtslag (1996) for clear-sky conditions, and Ri_m for cloudy conditions. Based on the results presented here, it is apparent that this more complex approach improves the error statistics relative to approaches based on Eq. (3), regardless of Ri_c. In addition, some of the differences may also related to authors using different data sets or time periods. For instance, Akansu et al. (2023) primarily used sounding data based on tether balloon for a specific sub-period of MOSAiC, and Jozef et al. (2022) used radiosondes from when they had concurrent UAV observations. The data used in our study are based on merged sounding-tower product, as mentioned above.

To further explore the differences among the four different Ri approaches, we examine one SBL and CBL case. For a clear-sky SBL case (Fig. 5 a, b), the approaches from Akansu et al., Jozef et al. (2022), and this study all agree closely with the manual ABLH, while the Barten et al. approach results in a significant overestimation. For a cloudy-sky CBL case (Fig. 5 c d), the approach from this study agrees with the manual ABLH, while the approach from Barten et al. overestimates the ABLH by about 30 m, and the approaches from Akansu et al. and Jozef et al. (2022) underestimate the ABLH by 130 m and 230 m, respectively. These results further demonstrate how Ri_c depends on the choice of Ri formula. Moreover, Ri_c is not analytically derived from basic physical principles (Zilitinkevich et al. 2007), and the concept of Ri_c is challenged by non-steady regimes (Zilitinkevich and Baklanov, 2002) and the hysteresis phenomenon (Banta et al., 2003; Tjernström et al., 2009). Therefore, an objective Ri_c does not exist. Rather, it is empirically used as an algorithmic parameter to simply derive the ABLH.

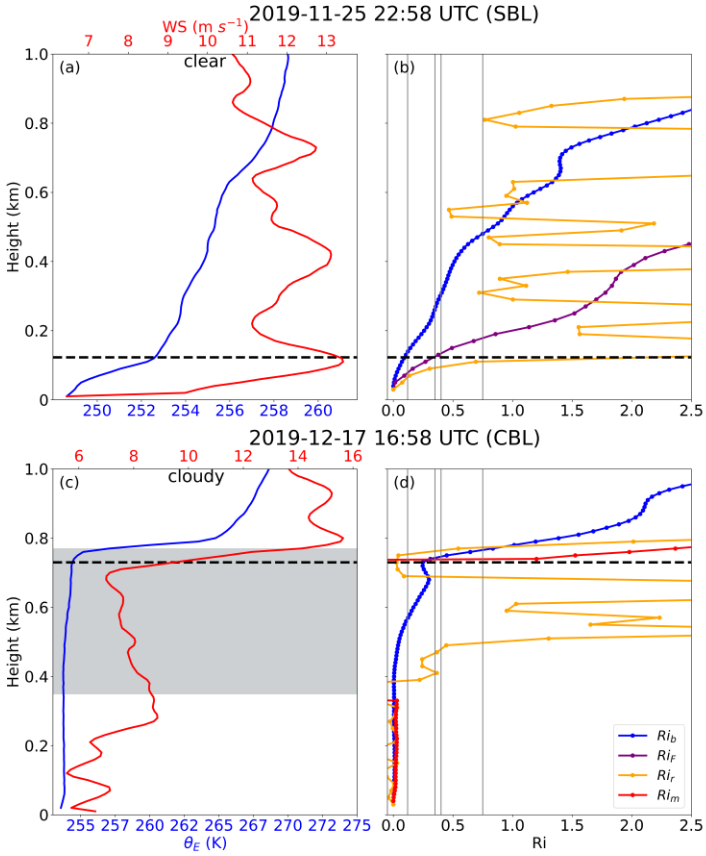

Figure 5 Vertical profiles of (left) θ_E and wind speed, and (right) Ri based on different formulas at (a–b) 25 November 2019, 22:58 UTC and (c–d) 17 December 2019, 16:58 UTC. Boundary layers at the two times represent a clear-sky SBL and a cloudy-sky CBL respectively. The black dashed horizontal lines denote the manually-identified ABLH, and the gray solid vertical lines denote the different Ri_c values, including 0.12, 0.35, 0.4, and 0.75. The gray shading in (c) denotes the cloud layer.

2, an automated algorithm

By looking at Figure 3, why not use an automated algorithm that is based on the bulk Richardson number method for SBL and the Heffter algorithm for CBL?

Response: Thank you very much for your helpful comment. The Heffter algorithm performs well in some CBL cases, but it also causes severe ABLH overestimation. As mentioned above, we have improved the Ri algorithm to better estimate ABLH in CBL cases. In addition, we realize that Fig. 3 is unclear. The data range of Fig. 3c in the original manuscript is from 0–3.5 km due to severe ABLH overestimation by the Heffter algorithm, and thus the axis range is different from that of other panels. Therefore, we unify the axis ranges of all panels to avoid misunderstanding, and add a subgraph in Fig. 3c to denote all data points. The error statistics for different ABL regime types are also calculated and listed in Table 1. For this comment, the corresponding changes are given in our revised manuscript as follows:

(1) Changes related to Figure 3

Figure 3 presents the comparisons of estimated ABLHs with the manually-labeled ABLHs, and the associated statistical measures are given in Table 1. The results show that the Ri_b algorithm with Ri_{bc} of 0.25 performs best overall, and particularly for SBL cases. The performance of the Ri_b algorithm with Ri_{bc} of 0.5 is poorer than that of the Ri_b algorithm with Ri_{bc} of 0.25, with overestimations of ABLHs in general, and larger errors with lower correlation coefficients for all types of ABLs. The Heffter algorithm performs well in cases of high ABLH and particularly for cloudy and CBL cases, but does significantly overestimate ABLH in a large number of cases as shown in the Fig. 3c subgraph. This is attributed to the determination criterion of the Heffter algorithm, i.e., ABLHs are determined by inversion layers, which means that large errors occur when the inversion layer is higher than the mixed layer. Additionally, while the Heffter performance in many of the ABL conditions is only marginally worse statistically than the Ri_b algorithm with Ri_{bc} of 0.25, its correlations are notably worse for SBL and NBL cases. The performance of the Liu-Liang algorithm is generally poorer than the other algorithms, particularly for correlation coefficient, which is probably due to the impact of noise in the lower ABLH profiles and unsuitable parameters in the algorithm. In summary, the Ri_b algorithm is reliable over the Arctic Ocean and performs better than other algorithms, and this result agrees with Jozef et al. (2022). Furthermore, we will explore ways to improve the Ri_b algorithm to make it more suitable for cloudy and convective conditions.

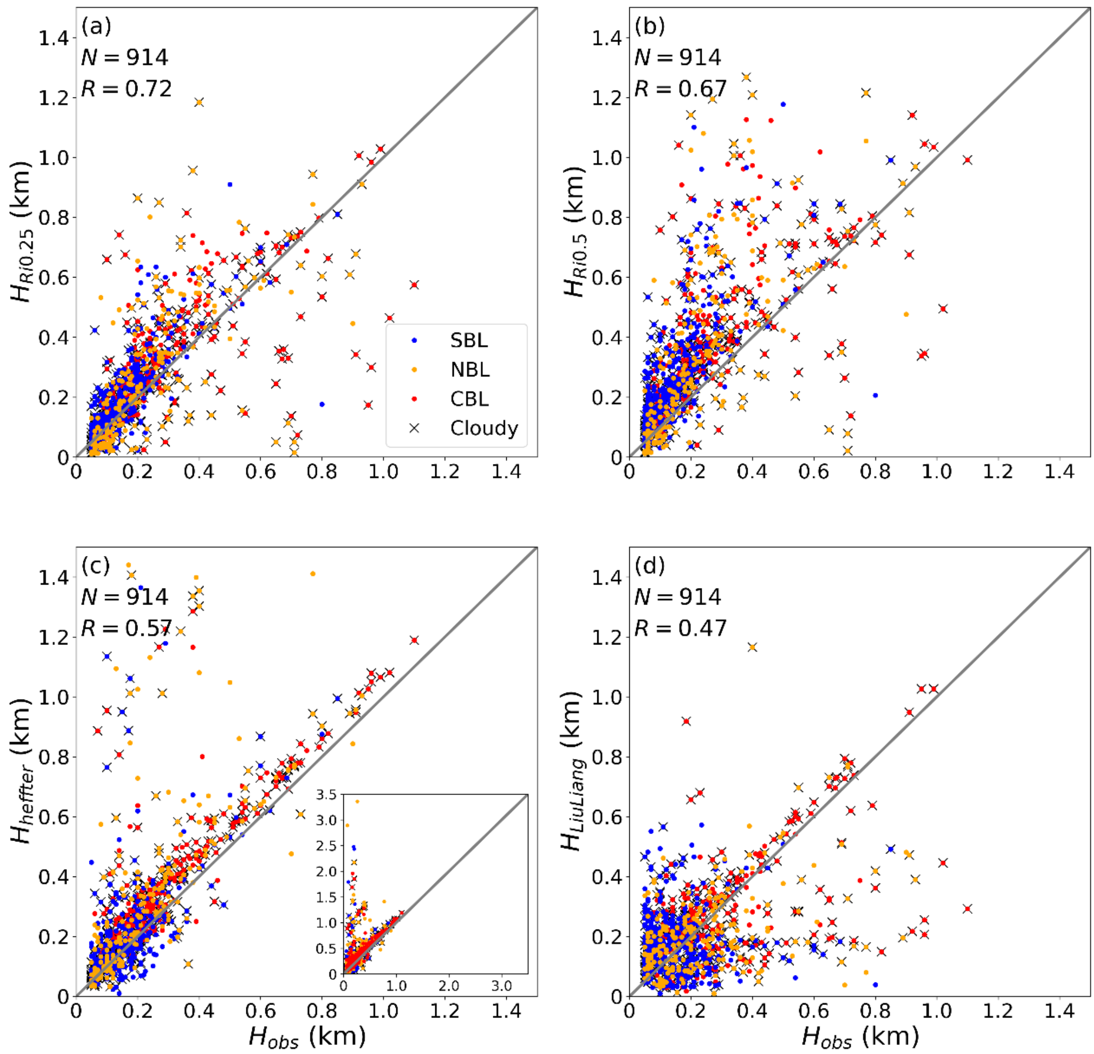

Figure 3 Comparisons of the ABLHs determined from radiosonde profiles using the bulk Richardson number (Ri_b) algorithm with the critical values (Ri_{bc}) of (a) 0.25 and (b) 0.5, (c) the Heffter algorithm, and (d) the Liu-Liang algorithm with the manually-identified "observed" ABLHs. The blue, yellow, and red colors indicate regime types of SBL, NBL, and CBL, respectively. The "x" signs indicate the Cloudy ABLs. The case numbers (N) and correlation coefficients (R) are given in each panel. The subgraph in (c) denotes all data points ranging from 0 to 3.5 km.

(2) Changes related to the improved Ri algorithm

3.3 An improved *Ri* algorithm Considering the cloud effect

As a traditional Ri_b formula, Eq. (3) may break down in cases of ABLs with relatively high wind speed and upper-level stratification due to the overestimation of shear production (Kim and Mahrt, 1992). Vogelezang and Holtslag (1996) proposed the finite-difference Ri formula, which is expressed as:

$$Ri_F = \frac{(g/\theta_{vs})(\theta_{vh} - \theta_{vs})(h - z_s)}{(u_h - u_s)^2 + (v_h - v_s)^2 + bu_*^2}, (6)$$

where z_s is the lower boundary for the ABL, θ_{vs}, u_s, and v_s are the θ_v and wind components at the height z_s, respectively, b is an empirical coefficient, and u_* is the surface friction velocity. Ri_F is considered for a parcel located somewhat above the surface to avoid the above problem, and u_* is also taken into account to avoid underestimation in the situation of a uniform wind profile in the upper layer. Here, we use Ri_F for clear-sky profiles and take z_s and b values as 40 m and 100, respectively, according to Zhang et al. (2020).

As shown in Fig. 3, the estimations of cloudy ABLHs are sometimes quite poor, which motivates us to further improve the algorithm. Under cloudy conditions, the moist Richardson number (Ri_m) can be used to include cloud effects on the buoyancy term. Brooks et al. (2017) adopted the Ri_m formula expressed as:

$$Ri_m = \frac{\left(\frac{g}{T}\right)\left(\frac{dT}{\mathrm{dz}} + \Gamma_m\right)\left(1 + \frac{Lq_s}{RT}\right) - \frac{g}{1+q_w}\frac{dq_w}{\mathrm{dz}}}{\frac{du}{dz}^2 + \frac{dv}{dz}^2}, (7)$$

where T is air temperature, Γ_m is the moist adiabatic lapse rate, L is the latent heat of vaporization, q_s is the saturation mixing ratio, and q_w is the total water mixing ratio, i.e., $q_w = q_s + q_L$, where q_L is the liquid water mixing ratio and is obtained based on the condensed water content. However, Eq. (6) is a gradient Ri and is calculated based on local gradients of wind speed, temperature, and humidity. To be consistent with the Ri formula proposed by Vogelezang and Holtslag (1996), we rewrite the formula in a finite-difference form expressed as:

$$Ri_m = \frac{\left[(g/T_s)\left(\frac{T_h - T_s}{\mathrm{h} - z_s} + \Gamma_m\right)\left(1 + \frac{Lq_{sh}}{RT_h}\right) - \frac{g}{1+q_{wh}}\frac{q_{wh} - q_{ws}}{\mathrm{h} - z_s}\right](\mathrm{h} - z_s)^2}{(u_h - u_s)^2 + (v_h - v_s)^2 + bu_*^2}, (8)$$

where subscripts (h and s) of the variables denote the calculated height, similar to Eq. (6), but note that the s and z_s are adjusted to 130 m, given the cloud radar blind zone. Considering that Ri_m is only appropriate for the liquid-bearing cloud cases, we use the Ri_F for "clear" grid points and use Ri_m for "cloudy" grid cells. Using this improved approach, we evaluated the best value of Ri_c to minimize the errors compared to the reference data set, arriving at an optimal value of Ri_c=0.35. The comparison of ABLH estimates obtained through the improved Ri algorithm with the manually-labeled ABLHs demonstrates significant improvement relative to other algorithms, particularly for cloudy conditions (Fig. 4, Table 1).

3, line 318:

If the manually labeled ABLH didn't include any data in transit, why did the authors think that the calibrated bulk Richardson number method using the manually labeled ABLH could be used to compute ABLH during transit?

Response: Thank you very much for your helpful comment. The data in transit contain soundings that are influenced by open ocean environment, particularly in early June. In our original manuscript, we have directly excluded the contaminated soundings from our analysis. Nonetheless, we still manually labeled the ABLHs in transit and added the relevant discussion about the in-transit period into our revised manuscript. First, we tested the performance of the traditional and improved Ri algorithms during transit periods. The results are presented in Fig. R1. It can be found that the traditional Ri algorithm performs well for selected ABL cases, but with an overall overestimation. The improved Ri algorithm solves this problem and shows better agreement with manually labeled ABLH. In addition, we also examined the impact of adding the manually labeled ABLH in transit into our analysis. We find that the difference in results would not affect our conclusions. Therefore, we have added the manually-labeled ABLH data during transit periods into our analysis and updated the results. The corresponding changes are given in our revised manuscript as follows:

(1) Changes related to in-transit information

The full-time series of ABLH during the MOSAiC expedition is presented in Fig. 7 and forms the bases for the remaining analyses. According to near surface conditions and the sea ice state, the whole MOSAiC observation period is divided into "freeze up", "winter", "transition", and "summer melt" periods (Shupe et al., 2022), roughly corresponding to the seasons of autumn, winter, spring, and summer, respectively. In Figure 7, the black solid lines indicate persistent low-level clouds that exist for more than 12 h; these occur most frequently in the late summer and autumn (the "freeze up" period), which agrees with Shupe et al. (2011). Note that the grey dots indicate that the ABL data were observed while the vessel was in transit, and the representativity of the ABLH data should be considered in this context. For the first such period, the vessel left the MOSAiC ice floe in mid-May and slowly progressed south through tightly consolidated sea ice, such that the data are generally representative of the sea ice pack in the region. Measurements from early June when the vessel was near or in open water close to Svalbard have been excluded entirely from the analysis. In the middle of June, as the vessel returned to the original MOSAiC ice floe, the sea ice was not as tightly consolidated and the vessel preferentially went through leads; the preferentially lower ice fraction along this transit could have impacted the thermal structure of the ABL. For the three weeks in early August, the vessel moved around in the Fram Strait area and then made its way north to another passive sea ice drifting position near the North Pole, again transiting through regions with lower sea ice fraction. Finally, at the very end of the expedition, the vessel took some time to exit the sea ice, stopping a few times to allow for work on the ice.

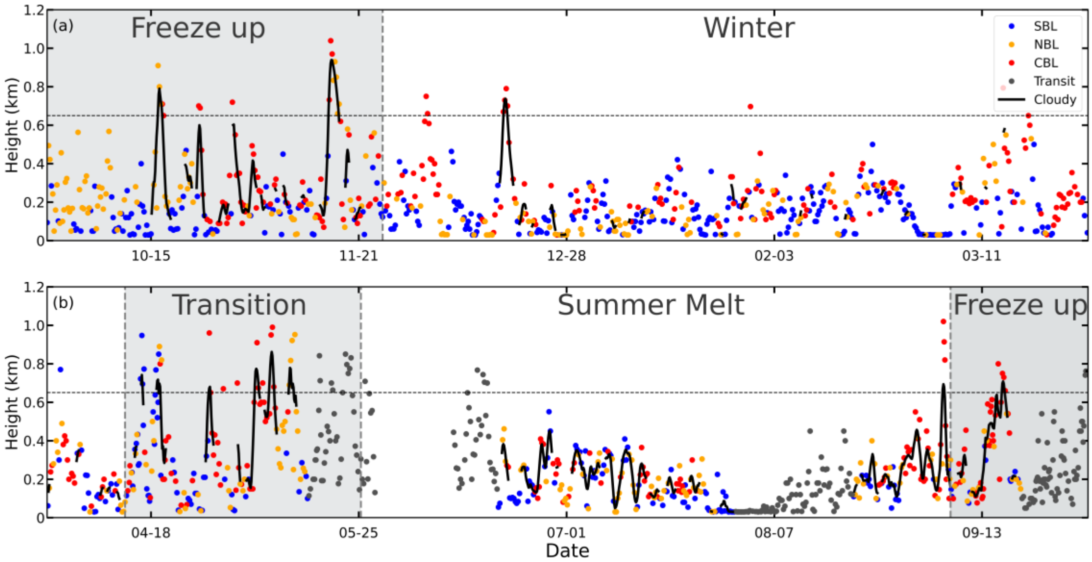

Figure 7 Time series of ABLHs throughout the MOSAiC year is divided into (a) and (b). The blue, yellow, and red dots indicate the heights of SBL, NBL, and CBL, respectively. The gray dots indicate ABL data observed while the vessel was in transit. The black solid lines indicate the heights of cloudy ABLs and persist for at least 12 hours. The gray dashed horizontal line denotes the 95th percentile of ABLH (650 m). The gray and white background shadings indicate the periods under different surface-melting states, i.e., "freeze up", "winter", "transition", and "summer melt" periods.

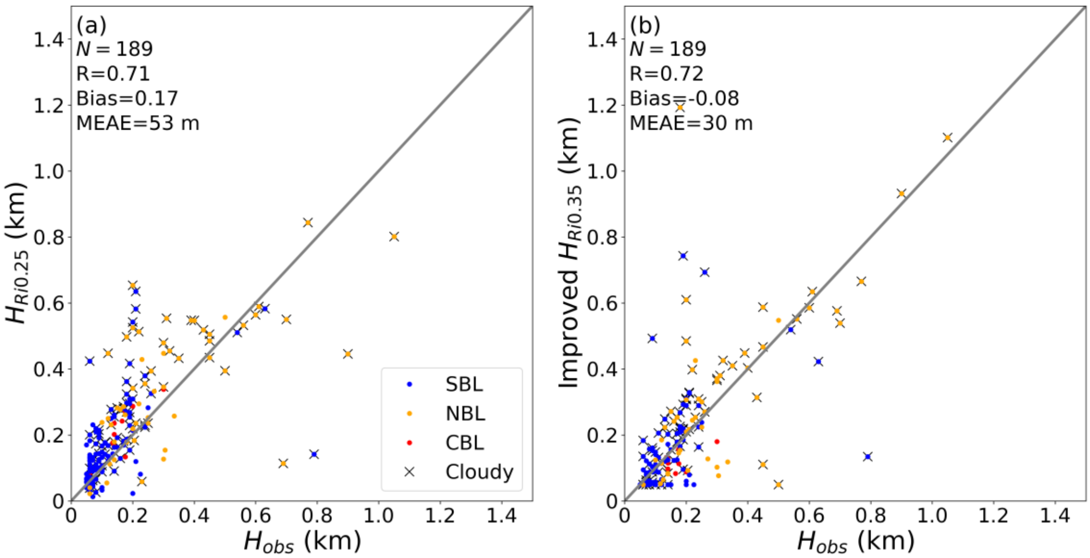

Figure R1 The Comparisons of the selected ABLHs determined by the (a) bulk Richardson number (Ri_b) algorithms with the critical values (Ri_{bc}) of 0.25 and (b) the improved Ri algorithm with observed ABLHs. The blue, yellow, and red dots indicate regime types of SBL, NBL, and CBL, respectively. The case number (*N*), correlation coefficient (*R*), *Bias*, and median of the absolute error (*MEAE*) are given in each panel.

(2) Changes related to data selection

The sentence "In total, we select 686 samples from 964 radiosonde profiles, and all data from observations while the vessel was in transit have been excluded" is fixed as "This VAP provides 964 ABLH estimates, and we select 914 samples from these to ensure that the estimates obtained by all algorithms are available", and is added into the radiosonde description section.

Minor comments:

1, line 32: "has" should be "have", and add "the" before "rapid changing"

Response: Revised as suggested.

2, line 37: "and the essential place for…" can be removed.

Response: Revised as suggested.

3, line 52: add "the" before "Atmospheric boundary layer height", "referred to…" should be removed.

Response: Revised as suggested.

4, line 56: replace "literature" with "studies"

Response: Revised as suggested.

5, line 60: replace "surface mixed layer" with "surface layer". Surface mixed layer is odd.

Response: Revised as suggested.

6, line 107: remove "special"

Response: Revised as suggested.

7, line 108: remove "fundamental"

Response: Revised as suggested.

8, line 211: I wouldn't call this "multiple methods". Maybe change it to "multiple profiles".

Response: Revised as suggested.

9, line 161/182/221/260: I would not call this “subjective ABLHs”. Maybe “manually-labeled ABLHs”.

Response: Revised as suggested.

10, line 223: replace “applied” with “available”

Response: Revised as suggested.

11, line 257: add “a” before “better performance”.

Response: Revised as suggested.

12, line 302: “the smallest” should be “the best”. R is not the smallest clearly.

Response: Revised as suggested.

13, line 324-327: these sentences need to be re-worded.

Response: Thank you very much for pointing this out. This statement aims to demonstrate that overall variation of the Arctic ABLH during the MOSAiC year is irregular, which is distinct from a ABL variation over land surface with diurnal cycle. We have revised these sentences as “The Arctic ABL is suppressed for most of the MOSAiC year, while for a few periods it intensively develops for several days at a time, most commonly when clouds and a CBL are present”

14, line 382: I would probably not call this “where the annual cycle began”. Please reword.

Response: Thank you very much for pointing this out. We have revised the sentence as “The whole process forms these general shifts over the annual cycle.”

15, line 392: how do you know a priori that it is the surface conditions that influence the ABLH, not the other way around? Please re-word.

Response: Thank you very much for pointing this out. We have revised the sentence as “To further explore the relations between surface conditions and the ABLH, we evaluate …”

16, line 397: I would not say this. The friction velocity and dissipation are affected by both shear and buoyancy.

Response: Thank you very much for pointing this out. We have revised the sentence as "Generally, the near-surface buoyancy and shear effects both modulate these variables."

17, line 408: turbulence intensity is different from turbulence kinetic energy. Do you mean turbulence intensity or turbulence kinetic energy?

Response: Thank you very much for pointing this out. We have revised it as "turbulence kinetic energy".

18, line 412: replace "accorded" with "proposed"

Response: Revised as suggested.

19, line 427: add "the" before "highest"

Response: Revised as suggested.

20, line 468: I wonder what features on the figure led the authors to conclude "the cloud-mixed layer aloft does not interact with the near-surface environment". The relative humidity is closer to saturation than figure 9 where the authors concluded "the near-saturated relative humidity indicates that the cloud-mixed layer couples with the surface-mixed layer, which facilitates the ABL development". This needs to be clarified.

Response: Thank you very much for pointing this out. We realize that this statement is unclear. Actually, as mentioned in Shupe and Intrieri (2004) and Brooks et al. (2017), the Arctic ABL structure is highly dependent on atmospheric moisture and liquid-bearing clouds. In most of the year (e.g., Fig. 9 in original manuscript), liquid-bearing clouds can create more downwelling longwave radiation and result in an ABL that is well-mixed from the surface up to the top of the saturated layer, which indicates that the cloud-mixed layer couples with the surface-mixed layer. In the Arctic summer (e.g., Fig. 10 in original manuscript), low-level stratiform clouds form as a result of ample moisture available (Tjernström et al., 2012), but the clouds cannot contribute to the ABL development due to a strong temperature inversion maintained near the surface, which is different from other seasons. For this comment, we have revised the sentence as:

"Despite that, the ABL is still stably stratified, and the ample moisture and clouds cannot contribute significantly to the ABL development, which is consistent with Shupe et al. (2013)."

21, line 556-558: it's unclear to me what the authors mean by "Coupling between the cloud mixed layer and surface mixed layer could also be recognized by the Rib algorithm". Does the Rib method can really distinguish this?

Response: Thank you very much for pointing this out. We realize that this statement is unclear. This statement aims to demonstrate that the Ri algorithm can estimate ABLH well in some cases of cloud-surface coupling, and the ABL development caused by the cloud effect can be captured by the Ri algorithm. In our improved Ri algorithm, the cloud effect is explicitly considered, which helps estimate ABLH better in the cloud coupling state. For this comment, we have revised the sentence as:

"The ABL development supported by cloud processes was captured by the improved *Ri* algorithm, which is similar to Brooks et al. (2017)."