Report #1:

1. What is 2-minute wind?

Respond:

The 2-minute wind we referred to in the manuscript actually signifies the average wind speed and direction measured over a two-minute period. To ensure precision in terminology, we will modify it to "2-minute average wind speed" and "2-minute average wind direction". We appreciate your careful review, which will help improve the accuracy and clarity of the manuscript.

The following is the modification we made in Section 3.3:

"Moreover, the 2-minute average wind direction at Zhongshan Station mainly comes from the southeast, with the diurnal variation of the 2-minute average wind speeds ranging from 2 to 9 m s^{-1}."

"Figure 7 Diurnal variations of 2-minute average wind direction, 2-minute average speed, and $AOD_{500\ nm}$ in summer at Zhongshan Station."

2. Are there any studies in the Arctic or other pristine sites with similar absorption and concentration of aerosols where they didn't find aerosol boundary layer positive feedback?

Respond:

We acknowledge that there is currently a relative lack of studies on the positive feedback between low-concentration aerosols and the boundary layer in the Arctic or other pristine sites. This is because significant aerosol-boundary layer feedback typically occurs in heavily polluted urban areas where the concentration of absorbing aerosols is high. Although some studies have observed higher concentrations of absorbing aerosols in the upper troposphere during the Arctic summer, there has been insufficient discussion regarding their feedback with the boundary layer (Igel et al., 2017; Ansmann et al., 2023). Additionally, due to the limited sources of absorbing aerosols and the lower aerosol concentrations in the Antarctic region, there may be a lack of studies that can serve as references.

The references are:

Ansmann, A., Ohneiser, K., Engelmann, R., Radenz, M., Griesche, H., Hofer, J., Althausen, D., Creamean, J. M., Boyer, M. C., Knopf, D. A., Dahlke, S., Maturilli, M., Gebauer, H., Bühl, J.,

Jimenez, C., Seifert, P., and Wandinger, U.: Annual cycle of aerosol properties over the central Arctic during MOSAiC 2019–2020 – light-extinction, CCN, and INP levels from the boundary layer to the tropopause, Atmospheric Chemistry and Physics, 23, 12821–12849, https://doi.org/10.5194/acp-23-12821-2023, 2023.

Igel, A. L., Ekman, A. M. L., Leck, C., Tjernström, M., Savre, J., and Sedlar, J.: The free troposphere as a potential source of arctic boundary layer aerosol particles, Geophysical Research Letters, 44, 7053–7060, https://doi.org/10.1002/2017GL073808, 2017.

3. Line 266: $AOD_{500\ nm}$ exhibits a decline (increase) concurrent with decreasing (increasing) wind speeds. Shouldn't AOD decrease with increasing wind speed?

Respond:

Thank you for pointing out the error in our manuscript. We sincerely apologize for this mistake and have corrected it to: "$AOD_{500\ nm}$ exhibits a decline (increase) concurrent with increasing (decreasing) wind speeds."

4. How does the boundary layer vary with temperature? Doesn't convection have any impact on boundary layer in Antarctica?

Respond:

From Figure 1, it is evident that the diurnal variation characteristics of boundary layer height and temperature at Zhongshan Station are similar. Generally, the boundary layer height is primarily influenced by the diurnal cycle of energy budgets for both the Earth's surface and atmosphere, which typically leads to peak boundary layer heights occurring in the afternoon. However, we observe a slight decrease in boundary layer height during the period from 13:00 to 14:00. This suggests that there may be other factors affecting boundary layer height beyond solar radiation. We guess this phenomenon may be related to enhanced convective activity and lower wind speeds around noon, which facilitate the generation and accumulation of surface particles, thus resulting in a decrease in boundary layer height.

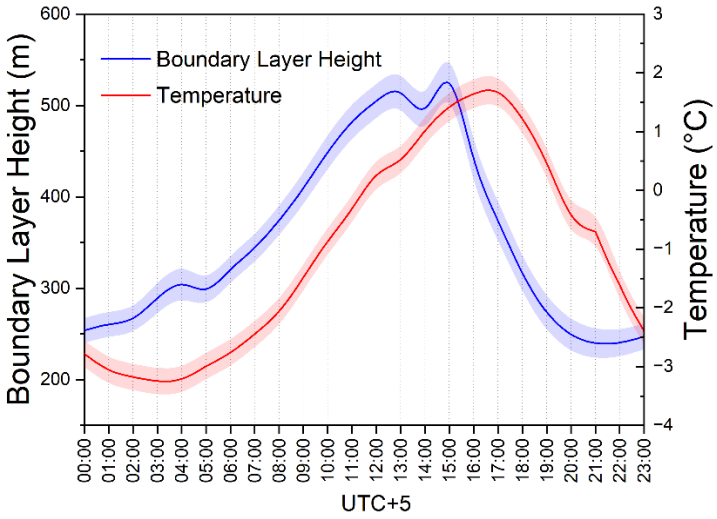

Figure 1 the relationship between boundary layer height and temperature at Zhongshan Station.

5. Can you also check precipitation along with high rh? This might explain scavenging effect which reduces AOD in summer?

Respond:

Thank you very much for your insightful suggestion. We agree that precipitation along with high relative humidity could be a significant process for aerosol scavenging during summer. However, since the CE318-T ceases observations during overcast or precipitation events, it is challenging for us to accurately assess the changes in AOD during these periods. Perhaps utilizing satellite AOD products could provide better insights into the impact of precipitation on aerosol scavenging. We will consider this approach for further investigation.

6. Can you include a figure of the backward trajectories season wise? It would be interesting to learn if you are considering only natural/background aerosols or long-range transport aerosols too in the AOD study. It would be nice if you divided the data into local vs long range transport and see how AOD behaves.

Respond:

Thank you for your valuable suggestions. we calculated the 168h backward trajectory once every 24h from January 2020 to December 2022, with the starting height of 500m and the starting time of 18:00 (13:00 local time at Zhongshan), and clustered by season (Figure 2). As you pointed out, the clustering results clearly indicate that the red and blue clusters are likely associated with local aerosol sources, while the yellow and green clusters are related to long-range aerosol sources.

We found that the contribution of local aerosols dominates throughout the year, while the influence of long-range transport aerosols is more pronounced in the autumn compared to other seasons. This suggests that the seasonal differences in AOD and AE at Zhongshan Station are largely driven by variations in the types and concentrations of local aerosols.

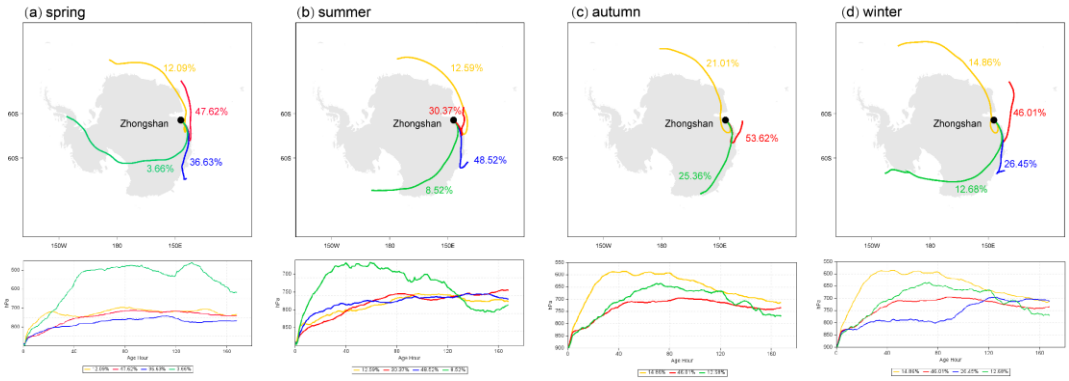

Figure 2 Clusters of air mass backward trajectories in (a) spring, (b) summer, (c) autumn and (d) winter at Zhongshan Station from 2020 to2022.

The following is the modification we made in Section 3.2:

To investigate the seasonal differences in AOD and AE, it is essential to understand the sources of air masses influencing aerosols at Zhongshan Station. Therefore, we calculate the 168h backward trajectory once every 24h from January 2020 to December 2022, with the starting height of 500 m and the starting time of 18:00 (13:00 local time at Zhongshan Station), and clustered by season (Fig. 3). We observed that the proportion of air masses originating from the surrounding waters (red clusters) and the ice edge margin of ice sheet (blue clusters) ranges from 50% to 80%, dominating throughout the year. These air masses are likely the primary sources of local or natural aerosols in Antarctica. In contrast, the proportion of distant origin (yellow and green clusters) is approximately 20%, but it significantly increases in autumn, reaching around 45%. These air masses are associated with long-range transported aerosols. Therefore, the seasonal differences in AOD and AE at Zhongshan Station are largely attributed to variations in the types and concentrations of local aerosols.

7. Can you extend the correlation with meteorological factors to other seasons? why particularly summer?

Respond:

Thank you for your comments. The main reasons we focus on summer are the following:

1) Data quantity consideration: During the summer, we obtained more AOD observations data (with over 1000 measurements per hour from 5:00 to 20:00), which enhances the reliability of the data. However, during other seasons, particularly winter, the amount of effective data after quality control is relatively low, we consider that these data may lack seasonal representativeness, which would introduce considerable uncertainty in the subsequent analysis of the correlation between AOD and meteorological factors.
2) Time range of the observation: The lower solar zenith angle in summer allows for a wider time range for studying diurnal variation of AOD.
3) Further study: We believe that the ultimate goal of studying the optical properties of aerosols in Antarctica is to understand their radiative characteristics. Since summer offers enough solar radiation while winter lacks solar radiation, we opted to focus on the summer period for our research.