

Message to the authors

Please see my attached comments below. This research is interesting, and I do believe that this is meaningful science to the research community. However, given the current state of the manuscript, I believe that major revisions are necessary to be suitable for publication. I recommend that the authors carefully address the comments and suggestions, and then resubmit the manuscript as a new submission.

General Comments

Most of my comments pertain to the language presented in the manuscript. I understand that English is not everyone's first language, and I apologize in advance if my remarks come across as insensitive in any way. I strongly recommend that the authors have this manuscript proofread by someone proficient in English. Doing so will help elucidate some of the language used and improve the overall quality of the manuscript. Please note that some aspects of the research presented here are outside my area of expertise, so I apologize in advance if any of my comments seem basic.

Data and Methods: I believe this section needs substantial revision, particularly with regard to:

- Site and instrumentation description
- Data utilization and quality control, in particular:
 - o Validation of deployed instrument measurements to ground based instruments
 - o Quality control techniques
- Analysis techniques in sections detailing:
 - o K-means cluster analysis
 - o Utilization of turbulence parameters

Results:

- In the manuscript, some figures are referenced with variables that do not appear in the figures themselves. For example, the manuscript mentions a height reference to Figure S1, but the figure does not contain any height dimension.

- I believe that some figures in the supplement should be included in the manuscript itself. For example, Figure S1 is referenced frequently in alongside Figure 3. It makes it easier to read and understand when both figures are present in the manuscript rather than having to reference the supplement section for figures.

While these points are discussed in greater detail in the sections below, they highlight a few overarching points that I think should be addressed to the authors of the manuscript.

Major comments

Abstract (Lines 32 - 50): Abstract needs to be rewritten, the language makes it a bit hard to follow. There are grammatical and sentence structure issues that I believe after resolving, can really improve the flow of the abstract and elucidate the content for the reader.

All Figures in manuscript: Text on the figures are too small and hard to look at initially for information. For example: Figures 4, 5, S4, and S5 have embedded text that is critical for interpreting the figures, but the small text makes this difficult. I recommend enlarging the text in all figures for better clarity.

Lines 134 - 135: *“The first field campaign of Boundary Layer Meteorology and Pollution at SiChuan Basin (BLMP-SCB) was conducted at a rural site (Sanbacun, 103°40'38" E, 30°54'59" N) of eastern foothills of Tibetan Plateau in winter of 2018, lasting about 40 days (Fig. 1).”* - Please include elevation for those not familiar with the region.

Lines 146 - 147: *“The performances of the sensors were verified by comparing with on-ground reference instruments (Pang et al., 2021) ...”* - What instruments specifically? Can you provide some statistics describing these differences? (For example: R^2)?

Lines 168 - 170: *“The radiosonde has been widely used and validated (Haman et al., 2012), and there is a very slight difference with the other radiosondes such as 170 Vaisala RS92 (Trapp et al., 2016).”* – Validated how? Again, I think providing quantitative statistics that describe the difference would be beneficial.

Lines 217 – 219: *“Clustering analysis was used to divide the UVPM profiles during the campaign into three groups with comparable vertical structure of*

UVPM within groups.” – What are the groups? Explain in greater detail what each group signifies. How did you decide that three clusters were appropriate for this analysis? I suggest providing some sort of clustering validation to determine the correct number of clusters, such as “The Elbow Method” or even “Silhouette score” could be beneficial. I recommend the authors look into this and provide context, you do not necessarily need to provide plots, but I think a simple reference would suffice.

Lines 231 – 233: *“The ONA algorithm results in significant noise reductions and much more reasonable temporal changes in mass concentrations of carbonaceous particles (Cheng and Lin 2013; Park et al., 2010).”* – What exactly is the “ONA algorithm”? I think a more in-depth description into the mechanics and procedures of this algorithm is necessary. What percentage of data required the ONA technique? I think including this is also necessary to include in the manuscript for context.

Line 237: The authors mention $UVPM_{pri}$, but do not reference what it is or what it means? I assume this means organic carbon from primary sources, but this is not directly stated in the prior sections.

Lines 252 – 254: At this stage in the manuscript, the distinction between $UVPM_{pri}$ and $UVPM_{sec}$ in Equations 1 and 2 is not clear to me. In Eq. 2 $UVPM$ is referenced, but the manuscript does not specify how $UVPM$ differs from $UVPM_{pri}$ and $UVPM_{sec}$.

Section 2.5 Calculation of mechanical turbulence and wind shear: It seems like the authors want to isolate shear as a main contributor to atmospheric exchange and transport. However, it is not clear to me how this is directly achieved. The authors mention the TKE equation and shear terms, but I recommend the authors look into the TKE Budget equation, if possible, given the instrumentation deployed and measurements available. The TKE budget equation provides more detailed insight into the generation, transport, and dissipation of turbulence across a specific transect.

Lines 310 – 312: *“In order to better understand the mechanisms of the more uniform profiles of $UVPM_{sec}$ as compared to those of BC and $UVPM_{pri}$, we firstly analyzed the relationships between $UVPM_{sec}$ or $UVPM_{pri}$ and BC (Figs. 3 and S1).”* - This requires a bit of rephrasing to understand. The authors reference Figures 3 and S1 frequently in this section. I suggest moving Figure S1 into the

main text. This just makes it easier to reference especially in a section of the results where both figures are needed together to clarify the interpretation.

Lines 323 – 326: *“Specifically, the differences between BC and UVPMpri are getting smaller and smaller with the increasing altitudes at 02:00–11:00 and 23:00, while those are independent on altitudes with the low COD values (0.039–0.098) at 14:00–20:00 (Fig. S1).”* – Authors mention altitude, but altitude is not on Figure S1.

Lines 329 – 330: *“During the daytime, UVPMsec firstly increased with BC concentrations and then decreased gradually as the increased BC.”* – Rephrase, this is a bit confusing for the reader to understand.

Lines 493 – 496: *“. Furthermore, the UVPMsec peaks well correspond to the strong descending motion and wind shear, and thus the UVPMsec peaks at the upper air on 7 January 2019 are mainly modulated by dynamic processes instead of thermodynamic processes.”* – Not sure what “peak” is referenced here, not clear by looking at the figure(s).

Lines 502 – 503: *“As the surface is heated up and PBL developed during the daytime...”* – I would suggest adding a plot that shows a time series of PBL development with height either from the Lidar or other remote sensing instruments (if possible). This helps visualize how deep and fast the PBL grows throughout the day.

Minor Comments:

All figures: Figures that reference time (For example: Fig 3), are these all in local time? UTC?

Line 130: *“... understanding the change in air pollutants and then taking targeted measures.”* – What do you mean by “taking targeted measures”?

Lines 173 – 174: *“The uncertainty of temperature and RH measurements was ± 0.3 °C and $\pm 5\%$ given by the manufacturer.”* – Provide citation of manufacturer

Line 183: *“The DBS mode was used in this campaign.”* – What is “DBS mode”? I suggest the authors describe this in greater detail. Provide citations.

Lines 189 – 191: What instruments were on the tower? Can you provide model #'s, also basic statistics on comparison between Lidar and sonic wind anemometer values?

Lines 298 – 300: “*Unlike UVPMpri profiles, the vertical distributions of secondary UVPM (UVPMsec) were more uniform, and the differences among the profiles were more significant than UVPMpri profiles.*” – This is a bit unclear and should be rephrased for clarity.

Lines 346 – 348: “*Fig. S3 showed the relationships between UVPMsec/UVPM ratio and UVPMpri or UVPMsec concentrations at the varying altitude ranges at the different times of the day.*” – Rephrase for clarity. What do you mean by “UVPMpri or UVPMsec”? Do you mean: “Figure S3 showed the relationships between the UVPMsec/UVPM ratio and UVPMpri, as well as between the UVPMsec/UVPM ratio and UVPMsec.”?