Response to Reviewer #2:

General Comments:

The manuscript studied the relationship between PBLH and PM2.5 concentration over different regions and seasons. Effects of aerosol, winds peed, topography etc. are also included in this study. Many data sources are included, multiple PBLH derived methods are compared, complex statistical relationships are revealed. Thus this study is comprehensive and valuable. While I do have some major revision suggestions since some part of the paper are confusing.

Response: We are very grateful to the reviewer for his/her helpful and constructive comments on our work. All of the comments and concerns raised by the referee have been carefully considered and incorporated into this revision. Our detailed responses to the reviewer's questions and comments are listed below.

Specific Comments:

1) Section 2 is very confusing. I understand that this part describes many observation datasets including ground based (routine and campaign) and satellite. Also includes multiple PBLH derivation methods. Please reorganize the section so that readers can have a very clear idea of the data sources and the purpose of the data. Two subsections of 2.1 Data and 2.2 PBLH derive method is good enough. For Data section, use a table to describe all the data used in this study. I included a sample table here. Current section 2.1 is a description of ground based observations, so CALIPSO related statements (line 126-130) are not fit in here. Please move the sentences to section 2.3 PBLH derived from CALIPSO.

Response: Thanks a lot for the guidance. Following your instruction, we added Table R1 to section 2 to describe the observations from multiple sources and platforms.

Table R1. Description of data.

Observations	Variables	Location	Temporal resolution	Time period
Environmental Stations	$PM_{2.5}$	~1600 sites*	Hourly	01/2012-06/2017
Meteorological Stations	WS/WD	~900 sites**	Hourly	01/2012-06/2017
MPL	PBLH, extinction	Beijing	15seconds	03/2016-12/2017
AERONET	AOD (550nm),	Beijing	~Hourly	01/2016-12/2017
MODIS	AOD	Whole China	Daily	01/2006-12/2017
CALIPSO	PBLH	Orbits in Figure 1d	Daily	06/2006-12/2017
MERRA	PBLH	Whole China	Hourly	01/2006-12/2017

* 224 sites over NCP; 105 sites over PRD; 215 sites over YRD; 159 sites over NEC

** 37 sites over NCP; 92 sites over PRD; 34 sites over YRD; 76 sites over NEC

In addition, we reorganized section 2, and kept two subsections describing the data and PBLH methodology, respectively. We also added a subsection to illustrate the statistical analysis methods. The CALIPSO-related statements in section 2.1 have been moved to the revised section 2.1.2.

2) PBLH is a fundamental variable in this study. Three observational dataset were used to derive PBL: ground MPL, space borne (CALIPSO), and radiosonde. CALIPSO-PBLH is verified by MPL-PBLH, MPL-PLBH is verified by radiosonde-PBLH. These three PBLH derivation methods have different theory bases which contributes discrepancies among them. Statistics as showed in Figure S1 are important, while please give examples of individual comparisons, e.g. one case of PBLH derivations from all the three observations/methods. Another suggestion is to include illustration figures for PBLH determination processes for both MPL and CALIPSO.

Response: Per your sound suggestion, we updated the statistical analysis for the PBLH comparisons. The RMSE and sample numbers (N) are given in each panel, the correlation coefficients (R) are already given in each panel, and R with asterisks indicates those correlations that are statistically significant above the 99% confidence level. As an example. Figure R1 (the

revised Figure S1) show the PBLH retrievals derived from CALIPSO, MPL, and RS on 7 June 2016 over Beijing. Based on aerosol backscatter, CALIPSO and MPL derive consistent PBLH retrievals in this case. Radiosonde also show reasonably good agreement with CALIPSO and MPL retrievals with a difference of ~0.1km.

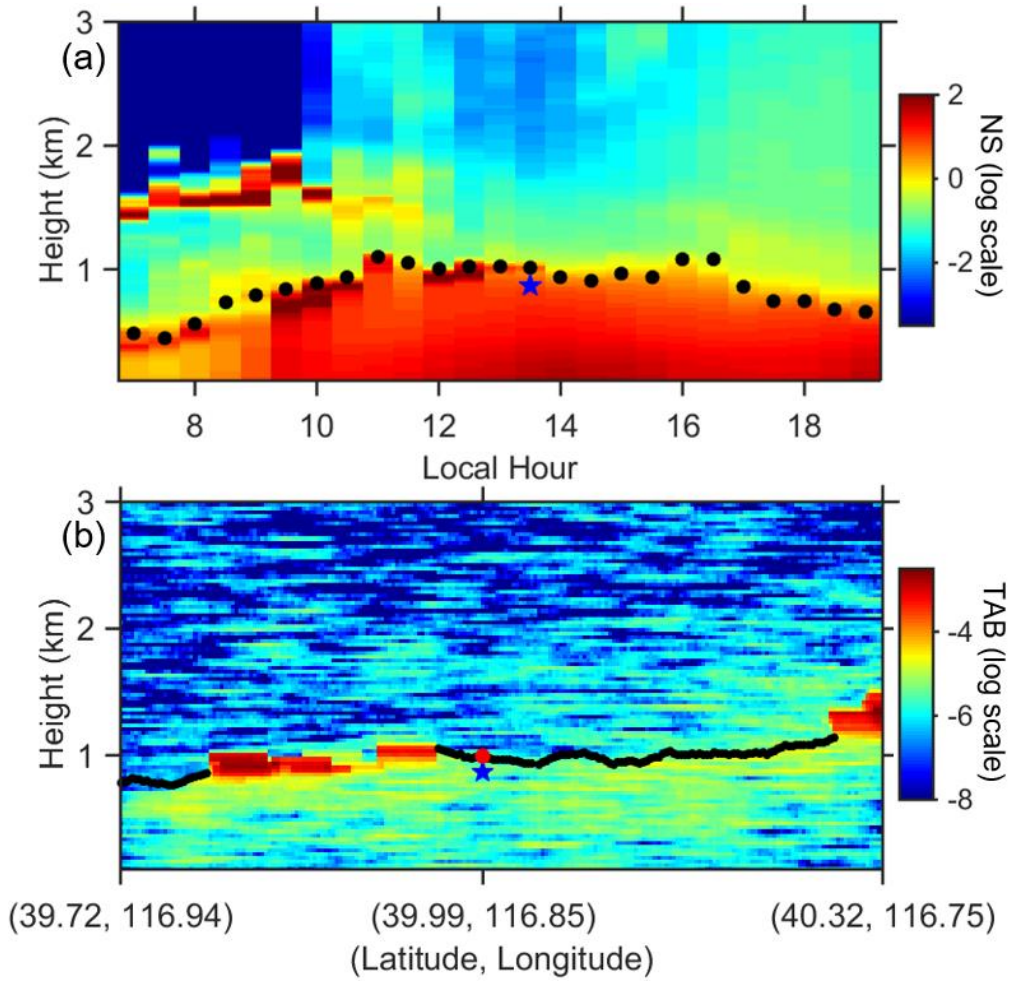

Figure R1. (a) Time evolution of the normalized signal (NS) plot from MPL on 7 June 2016 over Beijing. The black dots identify the PBLH derived from MPL, and the blue star indicates the PBLH derived from radiosonde. (b) Total attenuated backscatter (TAB) plot (log scale) from CALIPSO on 7 June 2016 over Beijing. The black line indicate the PBLH derived from CALIPSO. The red dot represents the corresponding PBLH derived from MPL, and the blue star indicates the PBLH derived from radiosonde.

As CALIPSO provides the primary measurements used in this study, we added a figure illustrating the CALIPSO PBLH determination processes (the revised Figure 2). For retrieving PBLH from MPL, we implement a well-established method, which was developed by Yang et al. (2013) and was adopted in multiple studies (e.g. Lin et al., 2016; Su et al., 2017). The principle is based on the traditional gradient method, and people can access the published paper (Yang et al., 2013) if they seek more details. We might save some space if we do not add the illustration figure for MPL.

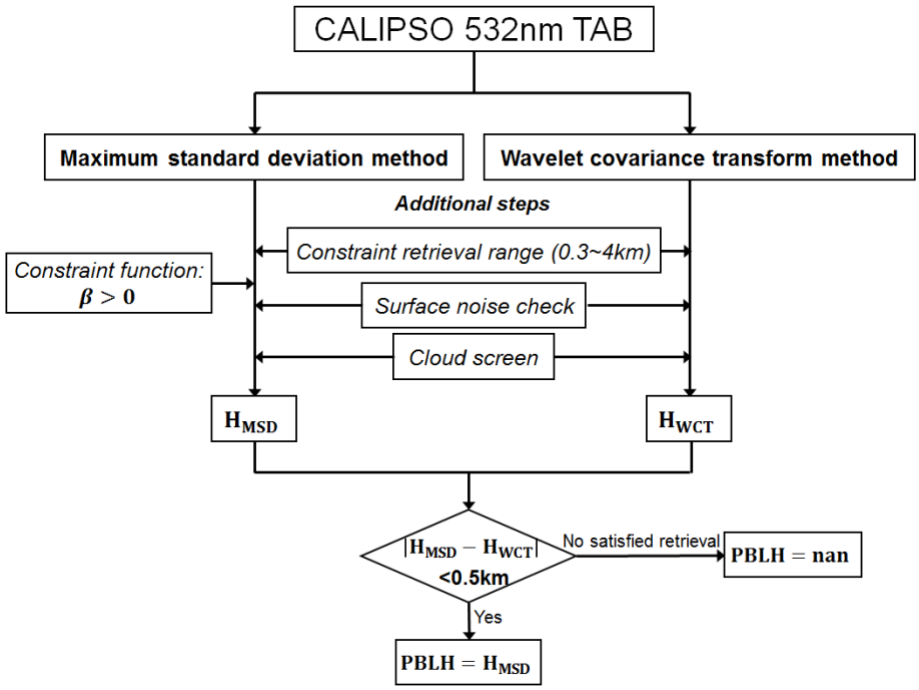

Figure R2. The schematic diagram of retrieving the PBLH from CALIPSO.

3) Section 2.4 MODIS AOD data is suddenly appeared and no explanation of how the data are going to be used and readers have to figure out after read the whole paper. Please add one or two sentences at the beginning to explain the usage.

Response: Thanks for pointing this out; we added the following statements to Section 2 to explain the use of MODIS AOD data:

"Note that aerosol loading is significantly different in different regions. To account for the background pollution level, we normalize the $PM_{2.5}$ with the MODIS AOD to qualitatively account for background or transported aerosol that is not concentrated in the PBL."

4) Line 206-210: please move the brief description of MERRA data to Section 2.

Response: According to your comment, we moved the description of the MERRA data to Section 2 as a new subsection (revised section 2.2.3).

5) Reorganize Figure 2 for easy comparison, suggestion: CALISPO at the left column, corresponding MERRA at the second column.

Response: Per your suggestion, we have revised this figure.

6) Table 1 is very hard to interpret. I suggest to put it in a figure with two y axes, left axis is for PBLH mean and std, right axis for PM2.5. x axis for four regions.

Response: Thanks for this valuable comment. The table is indeed very hard to interpret and conveys little scientific value, and is thus, deleted from the main text but keep as supporting information in case of anyone interested knowing the values of PBLH and $PM_{2.5}$ over different

ROIs. We revised Figure 3 and Figure 4 showing the climatological patterns of PBLH and $PM_{2.5}$ that are visually revealing. `

References:

Su, T., Li, J., Li, C., Xiang, P., Lau, A.K.H., Guo, J., Yang, D., and Miao, Y.: An inter-comparison of long-term planetary boundary layer heights retrieved from CALIPSO, ground-based lidar, and radiosonde measurements over Hong Kong. J. Geophys. Res., 122(7), pp.3929-3943, 2017.

Lin, C.Q., Li, C.C., Lau, A.K., Yuan, Z.B., Lu, X.C., Tse, K.T., Fung, J.C., Li, Y., Yao, T., Su, L. and Li, Z.Y.: Assessment of satellite-based aerosol optical depth using continuous lidar observation. Atmospheric environment, 140, pp.273-282, 2016.

Yang, D., Li, C., Lau, A. K. H., and Li, Y.: Long-term measurement of daytime atmospheric mixing layer height over Hong Kong. J. Geophys. Res., 118, 2,422–2,433. https://doi.org/10.1002/jgrd.50251, 2013.