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Geoscientific Instrumentation Methods and Data Systems
Discussions

Interactive comment on "A new mobile and portable scanning lidar for profiling lower troposphere" *by* C.-W. Chiang et al.

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Comment: Reviewer #1: General Comments This manuscript provides a description of a new instrument for profiling the lower troposhere. The instrument choice and methodology employed is of interest to the wider scientific community and worthy of publication. There are some specific issues to address, namely the understanding of the physical processes in the boundary layer that are being measured. There is no discussion of the potential impact of multiple scattering with a laser divergence of 0.5 mrad. What is the telescope FOV? Additional information is also required on the data processing, as this system is not identical to the system referred to in previous papers by the authors. For example, deriving extinction profiles from non-vertical scans are

subject to additional assumptions.

Response: We would like to sincerely thank anonymous referees for their critical examination and constructive comments/suggestions on the manuscript. We went through all the referee comments and suggestions, and implemented the same in the revised manuscript. Point-to-point clarifications for referee's comments and how we have addressed each recommendation are given below. We agree with the reviewer that the boundary layer processes are important in understanding the turbulent mixing, vertical diffusion, convective transport, cloud formation etc. The lidar remote sensing technique can be used to investigate the boundary layer height and mixing layer height and understand the boundary layer processes. Some of boundary layer studies have been reported in our previous work, e.g., Chiang et al., 2007, 2008, and 2012. The relative text and references has been added in the revised manuscript. Thanks for your suggestion. The effect of multiple scattering can be important under large optical thickness (τ>1) or large FOV (Eloranta, 1998). However, based on our past measurements and data analysis, it has been reported that the optical depth of the clouds and aerosols are usually less than 1 (Chen et al., 2002; Chiang et al., 2007, 2008; Nee et al., 2007; and Das et al., 2009) and thus the effect of multiple scattering is negligible. In the developed scanning lidar, the receiver telescope FOV is 0.5 mrad. In the telescope we have installed an iris (shown as below photo) to adjust the size of FOV, which further reduces the effect of multiple scattering.

We apologize reviewer to not have a discussion on the lidar data processing. Fernald (1984) backward integration method was applied to derive the lidar equation solution. The method to derive backscattering coefficient of particulate matters (aerosols + clouds) is similar as we do in a vertical pointing lidar (refer Chiang et al., 2007, 2008, 2012; Das et al., 2009). When we operate the lidar in a plan-position indicator (PPI) or section scan mode, it is assumed that the horizontal distribution of particulate matter is not homogenous. The signal-to-noise ratio (SNR) is used to determine the lidar data quality. If SNR is more than 20 and it is continuous for at least 5 more range gates then the lidar data for analysis. We used constant extinction-to-backscatter ratio (Chiang et al., 2007, 2008) to determine the extinction coefficient. The relative sentence has been added in the revised manuscript.

Comment: The manuscript would be improved with editing from a native English speaker, but is otherwise written in a clear and logical style.

Response: We have put our best effort to correct English in the revised manuscript.

Comment: Page 168, line 20: Here it is stated that the laser repetition rate is 10 Hz, but Table 1 states 20 Hz.

Response: The laser repetition rate is adjustable from 10 to 20 Hz. We set up 10 Hz for our experiment. The inconsistency has been corrected in the revised manuscript.

Comment: Page 172, section 3.3 The SNR of the system depends on the amount of signal.

Response: Yes, the SNR of the system depends on the amount of signal. The error of backscatter ratio caused by SNR in our cases does not exceed 0.5 % (Nee et al., 2007).

Comment: Page 173, Equation 5: This method of calculating the overlap function should contain a reference to Sasano et al. (Campbell et al.)

Response: Thanks. The references "Sasano et al., 1979" and "Campbell et al. 2002" has been added in the revised manuscript.

Comment: Section 4.2: State briefly how you calculate the aerosol extinction coefficient at 532 nm from this particular instrument. What is the impact when performing these calculations at nonvertical elevations?

Response: Fernald (1984) backward integration method was applied to derive the lidar equation solution. The method to derive backscattering coefficient of particulate matters (aerosols + clouds) is similar as we do in a vertical pointing lidar (refer Chiang et

al., 2007, 2008, 2012; Das et al., 2009). When we operate the lidar in a plan-position indicator (PPI) or section scan mode, it is assumed that the horizontal distribution of particulate matter is not homogenous. The signal-to-noise ratio (SNR) is used to determine the lidar data quality. If SNR is more than 20 and it is continuous for at least 5 more range gates then the lidar data for analysis. We used constant extinction-to-backscatter ratio (Chiang et al., 2007, 2008) to determine the extinction coefficient. The relative sentence has been added in the revised manuscript.

Comment: Section 4.3: It seems from the figure (Fig 4.) that you plot range-corrected signal intensity. Is this the case? Has the data been corrected for the overlap function? Why not normalize the data with respect to the molecular signal since you have this at 532 nm.

Response: Yes, Figure 4 indicates the range corrected signal and the data been corrected for the overlap function. In our analysis we used raw photon counts and plotted the range square corrected signal. In Figure 4 we want to show the intensity of the measured signal.

Comment: Turbulence does not necessarily increase when the land/sea breeze strengthens. Humid air from over the sea may contain its own aerosol (salt for instance). It is aerosol hygroscopic growth that causes the signal to increase as the aerosol particles grow. Although the amount of growth is dependent on the hygroscopicity factor, it is the growth itself that is important.

Response: We agree with the reviewer's argument. The relative sentence has been added in the revised manuscript.

Comment: When is sunrise for the morning case (Fig. 5)? In general, convection is the mechanism by which the boundary layer grows, but here, it seems as though it is the sea breeze (cooler, denser air) which is flowing in from the sea underneath the land boundary layer.

Response: The sunrise was at about 06:12 AM. In the absence of land-sea breeze, the convection plays an important role in the plume growth. In this case, both sea breeze and convection is playing a major role in the plume growth process. The relative sentence has been added in the revised manuscript.

Comment: Section 4.4: State where the CEMS instrument is located. If the lidar beam is at 5 degree elevation, how high is it above the in-situ site?

Response: CEMS is located at the periphery of Chimney outlet. The measurement site is about 570 m form the lidar location. If the lidar scan the measurement site at 5o elevation, then the lidar get the backscatter signal from $\sim$50 m height from the site.

Comment: Technical comments âĂŤâĂŤâĂŤâĂŤâĂŤâĂŤ Title: Suggest 'A new mobile and portable scanning lidar for profiling the lower troposphere'

Response: Thanks. The title has been corrected as suggested.

Comment: Abstract - lines 6-7: Suggest '..measurement of atmospheric pollutants with a temporal resolution of 1 minute.'

Response: Thanks. The sentence has been re-written as suggested.

Comment: Abstract - lines 10-13: Need to rewrite this sentence. I'm not aware of damage to detectors due to merely extended measurement duration.

Response: Now the sentence has been rewritten as "This versatile lidar system has also overcome the drawbacks which are popular in the other scanning lidar system such as complicated operation; overlap height between laser beam and telescope field of view; and reduces optical damage by using an integral coaxial transmitter and receiver".

Comment: Introduction Page 166, line 20: Modify 'alters' to 'alter'.

Response: Thanks. The "alter" is corrected in the revised manuscript.

Comment: Page 167, line 25: How about sensitivity?

Response: During night time the the quality of the lidar signal is good up to 15 km by using the SNR threshold. However in the day the lidar signal is limited upto 5 km due to the solar insolation.

Comment: Page 173, line 7: Start sentence with 'The ..'

Response: Thanks. Start sentence with 'The' has been added.

Comment: Page 176, line 5: Replace 'refer' with 'infer'.

Response: Thanks for this comment, the "refer" is corrected in the revised manuscript.

Comment: Page 176, line 18: What do you mean by 'fugitive emission'?

Response: Fugitive emission is the suspended particle/gases in the air caused by wind action and human activities.

Comment: Figure 3: Add location and start date-end date of PM measurements to figure caption.

Response: The location and start date-end date of PM measurements had been added in the revised figure caption.

Comment: Figure 4-5: Add location, date and time to figure caption. I know these are in the figure title. What are these figures displaying, and at what wavelength? Is it range-corrected signal (equivalent to uncalibrated attenuated backscatter)? Has the data been overlapcorrected? State whether the times are local time or UTC.

Response: The location and measurement date and time has been added in the revised figure caption. These figures are the signals (photo counts) from the lidar backscatter at 532 nm wavelength. Yes these are the range corrected signal. Yes, the data been corrected for the overlap function. Times are in Local time.

Comment: Figure 5: Annotation for top-left panel should state 'Clean air penetrating..'

Response: Thanks. The “Clean” has been corrected in the figure.

Comment: Figure 6: Can you not also show the retrieved SO2 concentrations as a function of range?

Response: Thanks for the suggestion. The SO2 concentration is shown in Figure 6b.

Comment: Figure 7: Why are there NaNs on the time axis? State location of measurement in the caption.

Response: NaNs on the time axis mean that non-observation of lidar. In the revised manuscript we have re-plotted the figure and rewritten the caption also.

Comment: Figure 8: What lidar measurement is being plotted here? Is it range-corrected signal? At what wavelength? What is the color scale? Add location and date of measurement to caption.

Response: Yes, it is normalized range-corrected signal at 532 nm wavelength, the color scale, location and date of measurement has been added in the revised manuscript.

References:

(1) CW Chiang, WN Chen, WA Liang, SK Das and JB Nee (2007), Optical properties of tropospheric aerosols based on measurements of lidar, sun-photometer, and visibility at Chung-Li (25 N, 121 E), Atmospheric Environment 41 (19), 4128-4137.

(2) CW Chiang, SK Das and JB Nee (2008), An iterative calculation to derive extinction-to-backscatter ratio based on lidar measurements, Journal of Quantitative Spectroscopy and Radiative Transfer 109 (7), 1187-1195.

(3) CW Chiang, S Kumar Das, CY Lin, JB Nee, SH Sun, HW Chiang, MJ Yu and ST Zhang (2012), Multi-year investigations of aerosol layer using lidar measurements at Chung-Li, Taiwan, Journal of Atmospheric and Solar-Terrestrial Physics 89, 40-47.

(4) WN Chen, CW Chiang, and JB Nee (2002), Lidar ratio and depolarization ratio for

cirrus clouds, Applied Optics 41 (30), 6470-6476.

(5) JB Nee, CW Chiang, H Hu, S Hu and JY Yu (2007), Lidar measurements of Asian dust storms and dust cloud interactions, Journal of Geophysical Research: Atmospheres (1984–2012) 112 (D15). (6) SK Das, CW Chiang and JB Nee (2009), Characteristics of cirrus clouds and its radiative properties based on lidar observation over Chung-Li, Taiwan, Atmospheric Research 93 (4), 723-735.

(7) FG Fernald (1984), Analysis of atmospheric lidar observations: some comments, Applied Optics 23, 652–653.

Interactive comment on Geosci. Instrum. Method. Data Syst. Discuss., 4, 165, 2014.

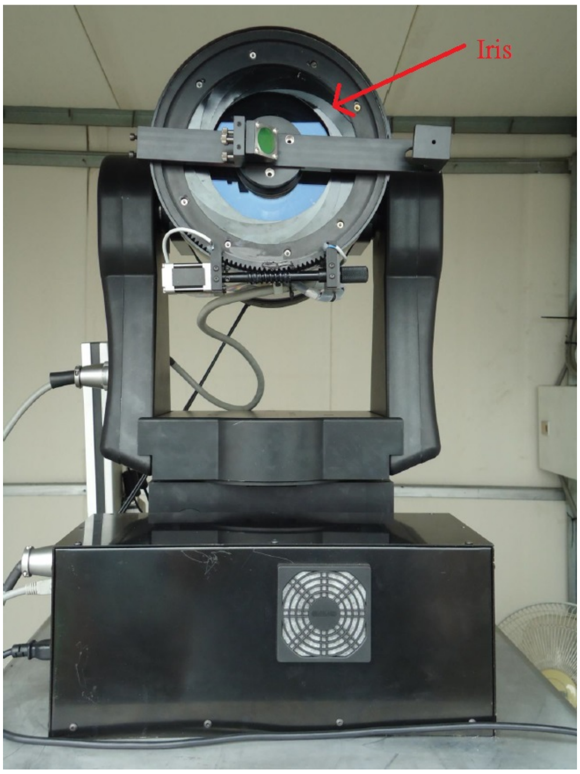

Fig. 1.