

ASSESSMENT OF EZ LIDAR AND ARM/SGP MPL LIDAR PERFORMANCES FOR QUALITATIVE AND QUANTITATIVE MEASUREMENTS OF AEROSOL AND CLOUDS

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ABSTRACT

The objective of this work is to assess the performances of EZ LIDAR™ (EZ) instrument with regard to those of a Micro Pulse Lidar (MPL) type 4, deployed at the ARM site in South Great Plains, Oklahoma, in October 2006. Results show that EZ lidar measurements performances are equivalent to those of ARM site MPL Lidar. A quantitative assessment of EZ aerosol extinction coefficient retrieval is also provided. This demonstrates the potential use of EZ LIDARS for autonomous monitoring lidar networks.

1. INTRODUCTION

In order to assess for the data quality of the EZLIDAR™ ALS450, manufactured by LEOSPHERE, a compact and rugged eye safe UV lidar, we conducted an intercomparison measurement campaign on the 23rd and 24th October 2006 at Southern Great Plains, situated in Oklahoma, United States. SGP Central Facility, located N36° 37' W97° 30' at altitude of 320 meters ASL, is providing a large number of sensors for atmospheric monitoring, among them a Micro Pulse LIDARs (MPL) type 4 from SigmaSpace and a Raman lidar at 355nm (Table 1). Data measurements from the Raman lidar (RL) were available on 24th October and have been used for a quantitative evaluation of the extinction retrieval from EZLIDAR data.

Raw data from MPL and EZLIDAR show for the first day clear atmosphere conditions, while on 24th October cirrus clouds between 10 and 12km, alto stratus and cumulus are present during the day.

	λ (nm)	Pulse Freq. (Hz)	Pulse En (mJ)	Resol. (m)	Tel. (cm)	Diam. Detection type
EZ	355	20	16	30	15	Analog
MPL	527	2500	0.008	30	17.8	Ph. Count
RL	355	30	400	39	13	Ph.Count

2. ASSESSMENT RESULTS

Range corrected signal comparison

In order to compare directly the instruments, the measurement time run from 5pm to 0am (UTC) on both days. Due to the different atmospheric conditions, it is possible to compare both systems in different features. The following plots show the range corrected signal [1] as function of the time for EZ, MPL and RL.

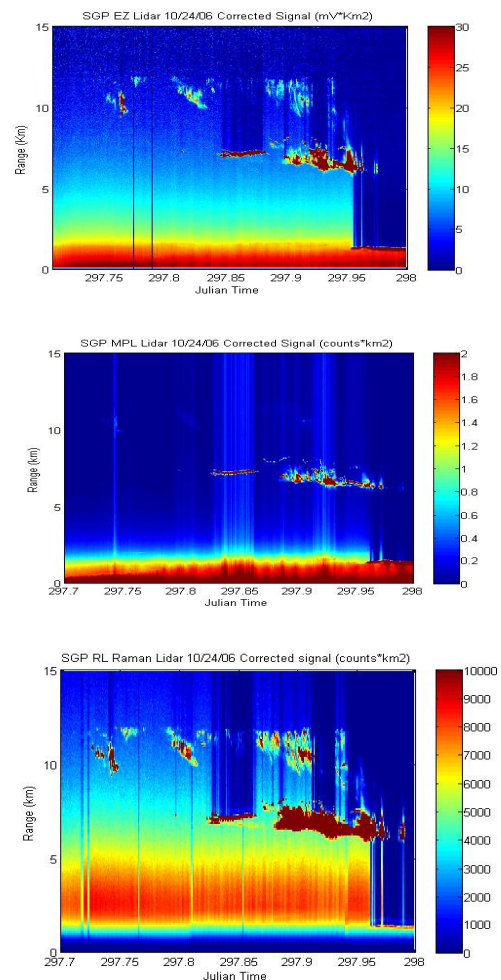


Figure 1 Range corrected signal for EZ lidar (top), MPL lidar (middle) and RL Raman Lidar (bottom) on 24th October 2006. Reference time is in UTC.

Direct comparisons of MPL and EZ Lidar systems

MPL data, not separated into polarized components, should be corrected with the recovered overlap function; also EZ data should be corrected by the overlap function. Both instrument overlap functions are plotted in Figure 2.

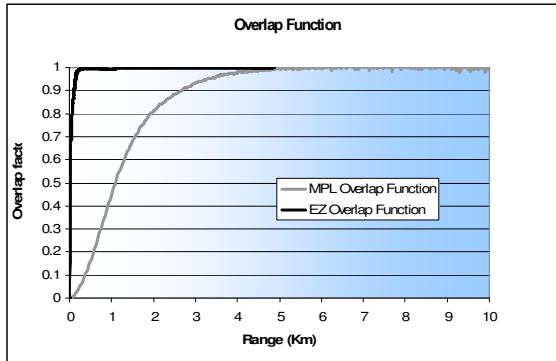


Figure 2: EZ and MPL overlap function

It can be noticed that, due to the extremely narrow MPL Lidar field of view, complete overlap is reached around 5 km, while EZ lidar reaches it at 320 m (and 98% overlapping at 170m). A narrow field of view permits to reduce unwanted solar background and effects due to the multiple scattering, but presents less accuracy in the recovering region. Intercomparison parameters are showed in Table 2:

	23 October 2006	24 October 2006
Accumulation Time	30 s	30 s
Spatial Resolution	30 m	30 m
Chosen Profiles	10.56.02pm (UTC)	10.30.56(UTC) ; 11.18.03(UTC)

Table 2 Chosen intercomparison parameters

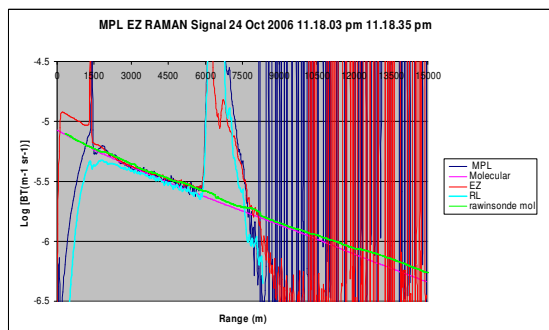


Figure 3 EZ, MPL and RL normalized range corrected signals and molecular rawinsonde profile

The Signal-To-Noise Ratio (SNR) is a parameter to assess lidar performances. For a given lidar signal, being the received number of photons small enough to approximate the detected signal by a Poisson distribution, SNR can be retrieved using the following equation [1]:

$$SNR(r) = \frac{NP(r)}{\sqrt{P(r)N + NP_{bkg}}} \quad (1)$$

Where N is the number of accumulated shots in 30s, P(r) is the received signal from range r and P_{bkg} is the received power due to the solar background.

It is now possible to compare SNR profiles for EZ, MPL and RL instruments, as plotted in figure 4.

.For each period of Table 2, it is possible to find an aerosol free region where the backscattered lidar signal of EZ and MPL lidars can be normalized to the molecular signal. In both measurement days, rawinsonde profiles are available. It is then possible to calculate the effective molecular signal versus altitude from pressure and temperature profiles and then calculate the instrumental constants.

Figure 3 shows the normalized range corrected signals for EZ, MPL and RL and molecular signal for 24th October at 11.18pm (UTC).

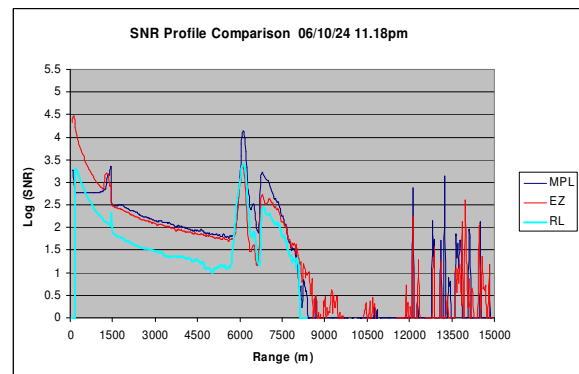


Figure 4 EZ, MPL, RL SNR profiles on 24th Oct, 11.18pm (UTC)

It is interesting to notice that EZ SNR is better in the first 1.5 km and it is comparable further. This is a consequence of a lower EZ full overlap, as showed in Figure 2.

The results are schematically reported in Table 3, where the Lidar range is defined as the range at

which SNR=1. Bias indicates the percentage divergence between the measured molecular signal and the normalized range corrected lidar signal:

10/24/06 11.18pm	Lidar Range	SNR 10	Overlap	Bias @ 6km
EZ	~9000 m	~8500m	~320m	< 20 %
MPL	~8800 m	~8500 m	~5000m	< 15%
RL	~8000 m	~5000 m	n/a	<5%

Table 3 Comparison result for 24th Oct, 11.18pm (UTC)

In the same way, the intercomparison results for clear sky on 23rd October at 10.56pm (UTC) are showed in Table 4:

10/23/06 10.56pm	Lidar Range	SNR 10	Overlap	Bias @ 6km
EZ	~12300 m	~6600 m	~320m	< 5 %
MPL	~9800m	~5700 m	~5000m	< 10%
RL	n/a	n/a	n/a	n/a

Table 4 Comparison result for 23rd Oct, 10.56pm (UTC)

The analysis of the obtained results shows that EZ lidar data quality is comparable with MPL data during daytime and under multi layered cloud conditions, and present a better maximum range under clear sky conditions. In these calculations, MPL data are referred to parallel polarization, while EZ data contain both.

EZ aerosol and backscattering coefficient retrievals

The EZ real time algorithm that retrieves aerosol backscattering and extinction coefficients is based on Klett backward inversion method [3], which makes some important assumptions, as the knowledge of the Lidar Ratio[3]. This parameter may be measured with the Raman Lidar [4]. In EZ LIDAR software, it is defined among 20 possible kind of potential aerosols. Another assumption is the theoretical molecular backscattering signal, calculated from a large climatological database and local ground pressure and temperature, and used in the normalization process as plotted in Figure 3. If EZ lidar data are reprocessed using as input the measured Lidar Ratio and the rawinsonde molecular signal, it is possible to assess the error of the retrieving method. At 9.59pm (UTC) of 24th October, the retrieved particle extinction from RL [4] and EZ lidar is plotted in figure 5:

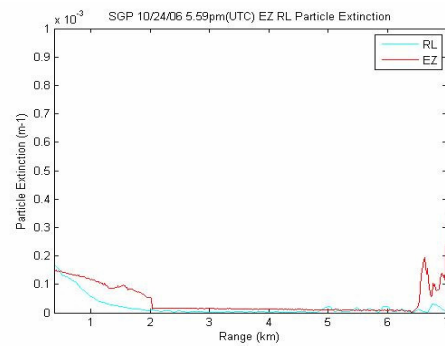


Figure 5 RL and EZ Particle Extinction coefficients at 9.59pm (UTC). The differences in retrieval the coefficient is less than 10% before the cirrus

Now it is possible to improve retrieving algorithms substituting the calculated theoretical molecular corrected signal with that one measured by rawinsonde; the differences between the retrieved extinction coefficients is plotted in Figure 6:

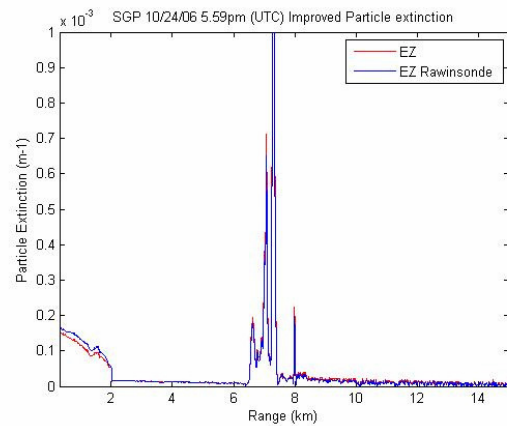


Figure 6 Original Extinction coefficient and retrieved Extinction coefficient with improved molecular rawinsonde profile.

Relative error varies from 3% to 14% over the profile before the cloud.

If we now improve the algorithm with the value of the measured Lidar Ratio by RL, we have:

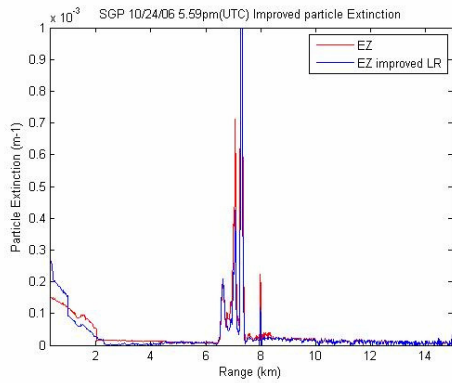


Figure 6 Improved Extinction coefficient with Lidar ratio measured by Raman lidar

In this case the retrieved extinction coefficient using the new lidar ratio is higher, as figure 24 shows; the difference ranges from 8% to 27% before the cloud.

Improving the algorithm with both molecular rawinsonde profile and measured lidar ratio, we have:

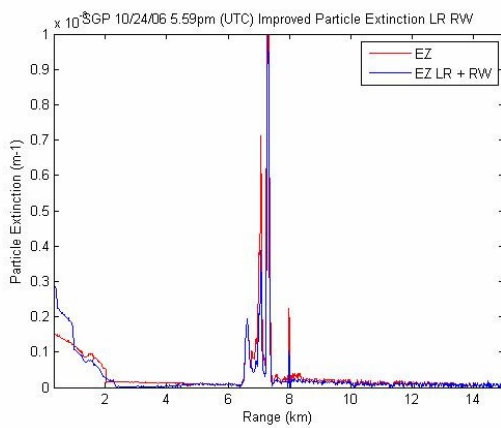


Figure 7 Improved Extinction coefficient with molecular rawinsonde profile and Lidar Ratio from Raman Lidar

In this case we have a certain compensation of both effects leading to a range difference that goes from 6% to 25%.

The worse case analysis is resumed in table 9 .

10/24/06 09 59pm	EZ
EZ RW	14%
EZ LR	27%
EZ RW+LR	25%

Table 9 Percentage differences between retrieved particle extinction coefficient improving Lidar ratio

(measured with RL) and molecular extinction (measured by rawinsonde).

In retrieving particle backscattering coefficient, the same schema can be applied with same results.

The measured Lidar Ratio by Raman Lidar has some incertitude due to the Ångström coefficient as input in the retrieving algorithm [2].

3. CONCLUSION

The results of the ARM/SGP campaign bring the evidence that EZ retrieved data are comparable with those of RL and MPL lidar instruments. Outdoor and unattended use capabilities of the EZLIDAR added to its measurements performances define then this instrument as a good candidate for deployment into growing global aerosol and cloud monitoring networks.

4. REFERENCES

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