The UV Aerosol Extinction Coefficients Retrieval Using the Ground-based Ozone Lidar

Liqiao Lei[1,2], Timothy A. Berkoff[1], and Guillaume P. Gronoff[1,3], William Carrion[1,3]

[1]NASA Langley Research Center

[2]Universities Space Research Association

[3]Science Systems and Applications, Inc.

Background:

Air quality exceedance caused by urban pollution and transported wildfire emission requires the ability of simultaneously detect O_3 and aerosol spatiotemporal variations, which could be provided by ground-based lidar. This will greatly improve the ability of O_3 DIAL to contribute to the air quality monitoring. In this presentation, we describe a new UV aerosol retrieval from the Langley Mobile Ozone Lidar (LMOL) that will contribute to our understanding of the aerosol optical properties at UV wavelengths.

(a) (b)

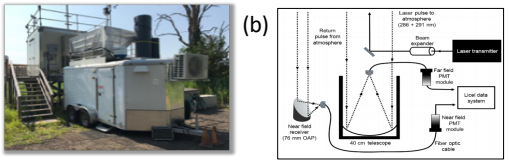


Figure 1. (a) LMOL in Westport during LISTOS campaign (Berkoff et al., 2018) (b) Schematic of the LMOL lidar system (Farris et al., 2019)

Methodology:

- **Instrument and data :**

LMOL: Ozone lidar, λ_{off} : 292 nm , λ_{on} : 287 nm

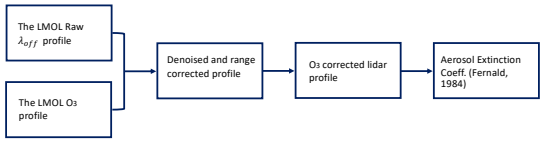
HALO: HSRL aerosol lidar, 532nm extinction and lidar ratio, and 532 nm backscatter data

CCNY: Aerosol Lidar, 532 nm aerosol extinction profile

Ceilometer: CL51, 910 nm backscatter profile

AERONET: Yale_coastal site data, multi-wavelength AOD

- **Aerosol Retrieval method:**



- **Lidar ratio and Angstrom Exponent selection method:**

Step1. Retrieving LMOL aerosol extinction with varied $S_1(i)$

Step2. Calculating LMOL 292 nm partial AOD, noted as $PAOD_{LMOL,S_1(i)}$

Step3. Calculating HALO 292 nm partial AOD with varied Angstrom Exponent (AE), noted as $PAOD_{HALO,\,AE(j)}$

Step4. Calculating partial AOD difference as following equation:

$$\Delta PAOD(i,j) = PAOD_{LMOL,S_1(i)} - PAOD_{HALO,\,AE(j)}$$

Step5. Finding $S_1(i_c)$ and $AE(j_c)$ with minimum $\Delta PAOD(i,j)$ for LMOL aerosol retrieval and HALO aerosol extinction conversion.

$S_1(i)$:10-90 sr, with step 5 sr
AE (j): 0.5-2.0, with step 0.1

Results:

- **Lidar extinction-to-backscatter ratio selection**

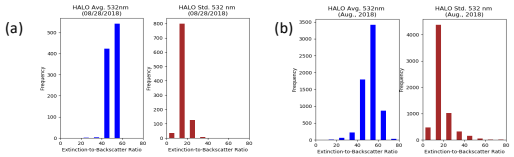


Figure 2. The HALO average of lidar extinction-to backscatter ratio profile and its standard deviation (a) for August 28, 2018 (b) for all available August PM data (including August 5, 6, 16, 24, 28, and 29)

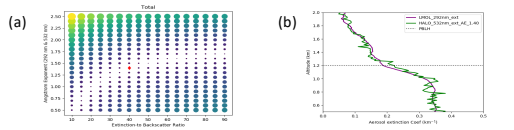


Figure 3. (a) The partial AOD difference and the Lidar ratio and AE selection (noted as red diamond, selected lidar ratio is 40 sr and AE 1.4). (b) Comparison of the LMOL retrieved aerosol profile and HALO aerosol extinction profile (converted to 292 nm)

- **LMOL Aerosol extinction Comparison**

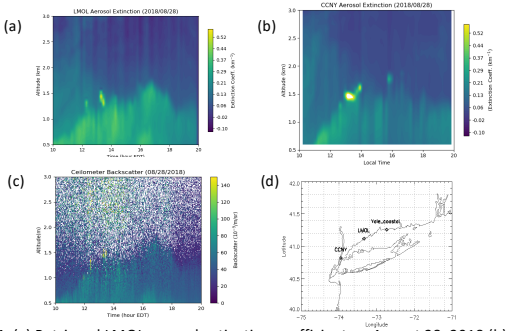


Figure 4. (a) Retrieved LMOL aerosol extinction coefficient on August 28, 2018 (b) Same day CCNY lidar aerosol extinction coefficient. (c) Same day Ceilometer (same location as LMOL) backscatter (d) Location of the LMOL lidar, CCNY lidar, and AERONET Yale_Coastal site

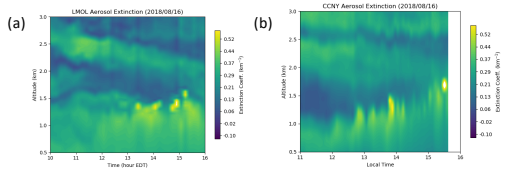


Figure 5 (a) LMOL aerosol extinction curtain plot on August 16, 2018 (b) the CCNY lidar aerosol extinction coefficient curtain plot.

Results:

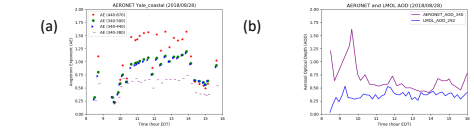


Figure 6 AERONET AE, AOD at Yale_coastal site and LMOL partial AOD on August 28, 2018 (a) AERONET AE for different wavelength pair (b) AERONET AOD at 340 nm and LMOL partial AOD (0.5-2 km) at 292 nm. LMOL AOD has smaller value because it is the partial AOD and because the LMOL system are 53 km away from AERONET Yale_coastal site.

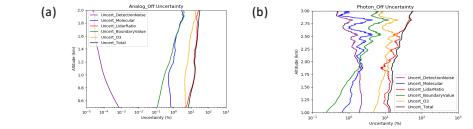


Figure 7. Uncertainty of the aerosol extinction retrieval caused by several factors for LMOL analog and photon channel. (a) for analog channel (b) for photon channel. The molecular uncertainty take as 1%, Lidar ratio uncertainty take as 40%, Boundary value uncertainty take as 1000% (Kuang et al., 2020).

Conclusion:

The aerosol extinction coefficient profile was retrieved for the Langley ground-based ozone lidar at wavelength 292 nm. The Fernald method was used for this retrieval and the result was compared with HSRL measurement from the airborne HALO system during the LISTOS campaign in New York city region during summer 2018. The retrieved aerosol extinction also was compared with the aerosol extinction measured by the CCNY (73.949W, 40.821N) aerosol lidar (converted to 292 nm) and aerosol backscatter measured by ceilometer which qualitatively agree with LMOL result. The method related to partial AOD was used to find the lidar extinction-to-backscatter ratio at 292nm and the Angstrom Exponent between 532nm and 292 nm which also could be used to show the optical properties of UV aerosol. Further cases will be studied to evaluate this new LMOL data product and the aerosol extinction on the on wavelength 287 will also be retrieved in the future.

Acknowledgement:

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Reference:

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