Aerosol Measurements Over Mauna Loa Observatory

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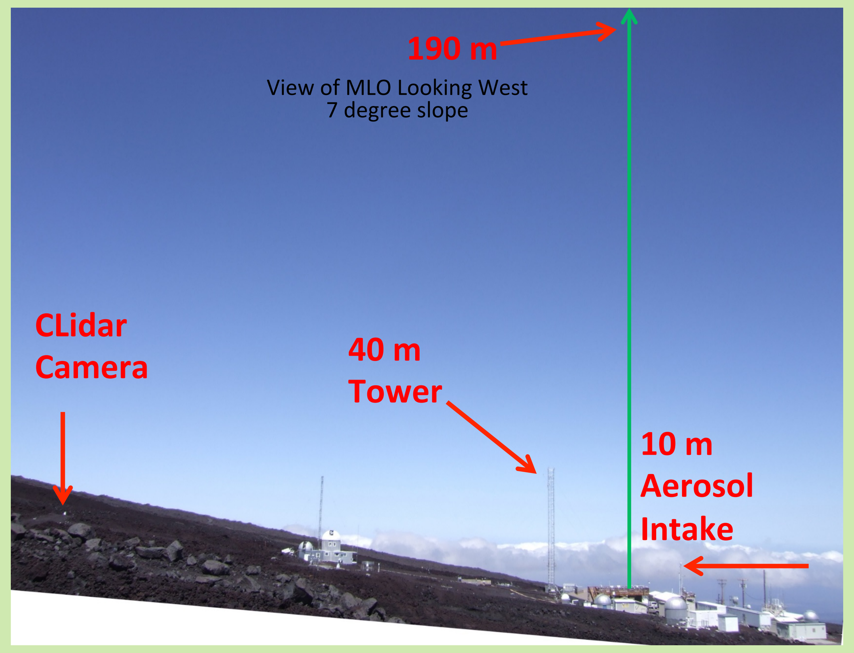
Abstract

Aerosol measurements were conducted for several years over Mauna Loa Observatory (MLO), an atmospheric baseline observatory using the CCD Camera Lidar (CLidar) System. The system transmits 532 nm laser pulses vertically into the atmosphere and the side scattered light is imaged unto a CCD camera with wide angle optics and laser line filter. The altitudes of atmospheric constituents scattering laser-light were determined by the bistatic lidar system's geometry. Pixel intensities combined with a molecular scattering model and Aerosol Robotic Network (AERONET) retrieved phase functions were used to derive aerosol extinction at 4-10 km above sea level.

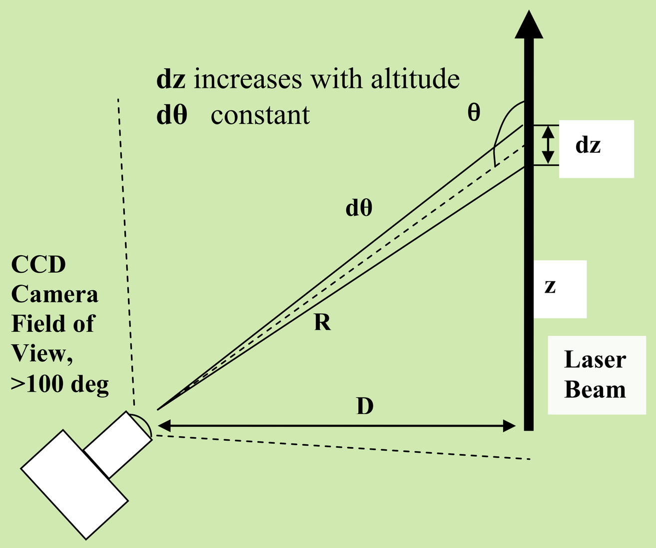
MLO and Hilo Hawaii Instrumentation

- CCD Camera Lidar– measures atmospheric side scatter as a function of altitude. Best altitude resolution near ground (3400 m.a.s.l.). Night data only.
- Stratospheric lidar– measures backscatter as a function of altitude at constant altitude resolution. Also measures water vapor. Night data only.
- •TSI Nephelometer– measures total scatter from intake stack at 10 m above ground level.
- •AERONET sun photometer measures solar irradiance to derive column average aerosol scattering phase functions. Day data only.
- Hilo, Hawaii (64 km from MLO) Radiosondes measure wind speed and direction



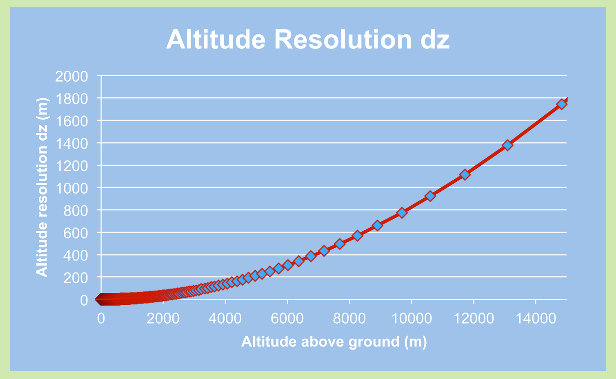
Mauna Loa Observatory – Elevation 3400m

Mauna Loa Observatory CLidar

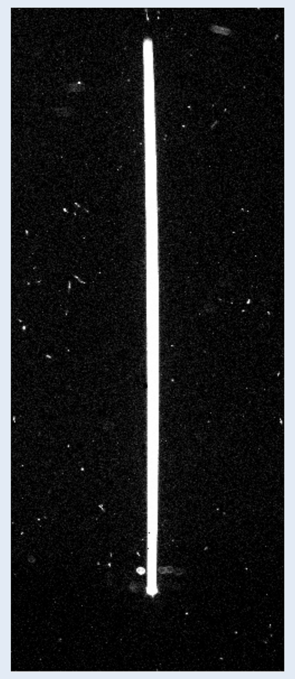


- Nd:YAG GCR-6 laser, 330 mJ per pulse, 30 Hz, 532 nm stratospheric lidar laser
- 10 nm FWHM laser line filter
- Cooled CCD Camera Santa Barbara Instruments Group ST-237, 139 m from laser .
- Wide angle lens images entire beam at once.

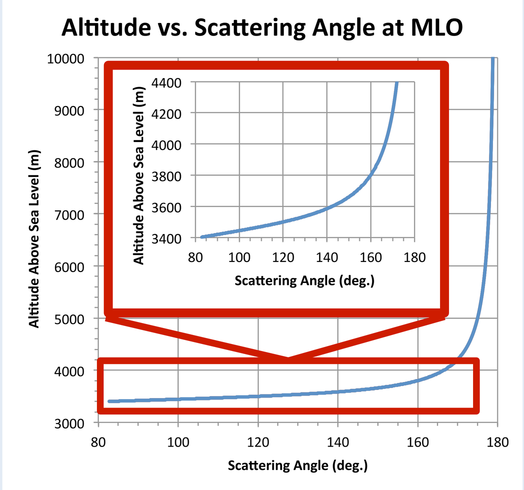
Altitude resolution at ground ≈ 20 cm, at 3km above ground ≈ 80 m, at 6km ≈ 300m, at 7 km ≈ 400 m for experimental conditions in this study.



CLidar Experiments and Extinction Analysis


Raw MLO ClidarData file.

- CLidar data were measured at MLO in 332 second exposures commencing shortly after sunset and lasting for a few hours over a period of several years.
- Data were normalized to a molecular scattering model in the altitude range of 10.7 to 14.9 km.
- Unlike backscatter lidar, CLidar scattering angle varies with altitude as shown below. Scattering angle changes rapidly near the ground and swiftly approaches 180° at higher altitudes.



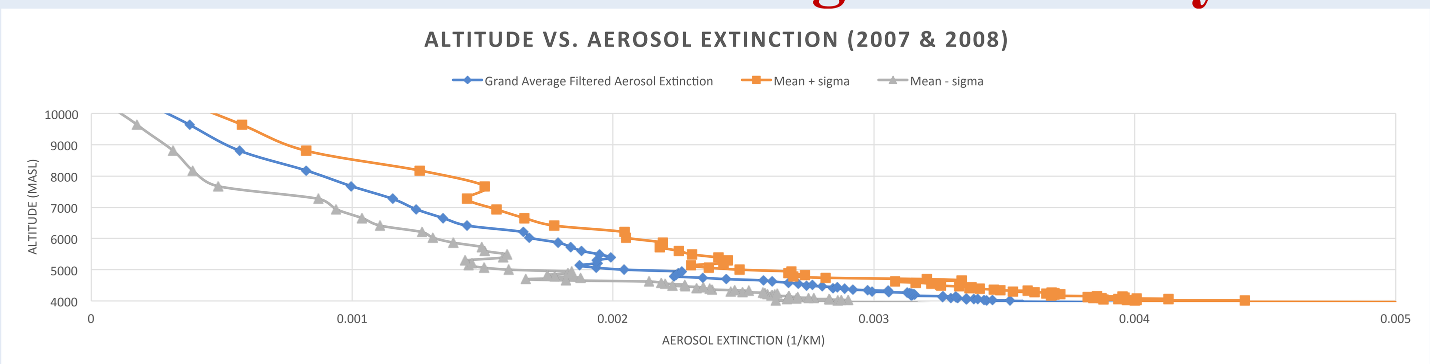
- Aerosol scattering phase functions employed were derived from co-located AERONET data from the daytime prior to the CLidar night observations.

•Transmission was corrected iteratively.

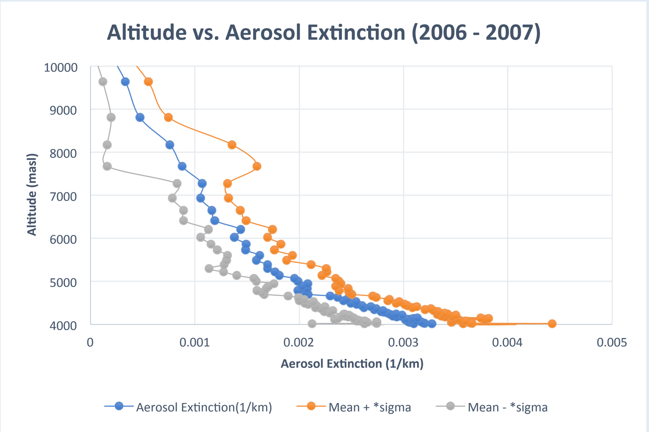
•The aerosol phase function along with an assumed single scattering albedo of 0.9 were then employed to derive aerosol extinction as a function of altitude.

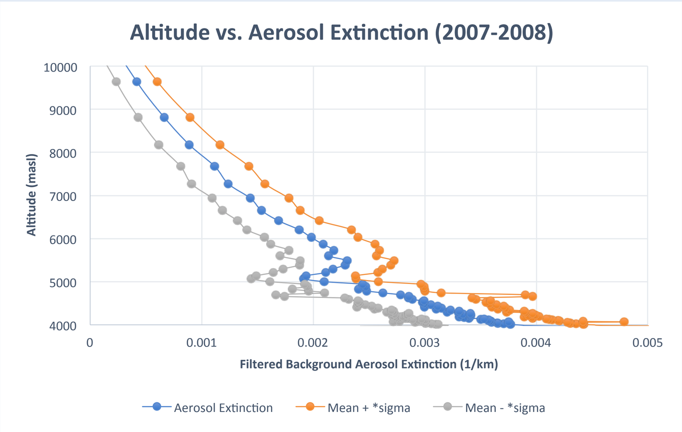
•Extinction in the 4000-10000 m.a.s.l. altitude range (since near ground flows are complex and highly variable) were computed for 29 dates in 2006-2007 and 2007-2008.

Results: Grand Average and Yearly

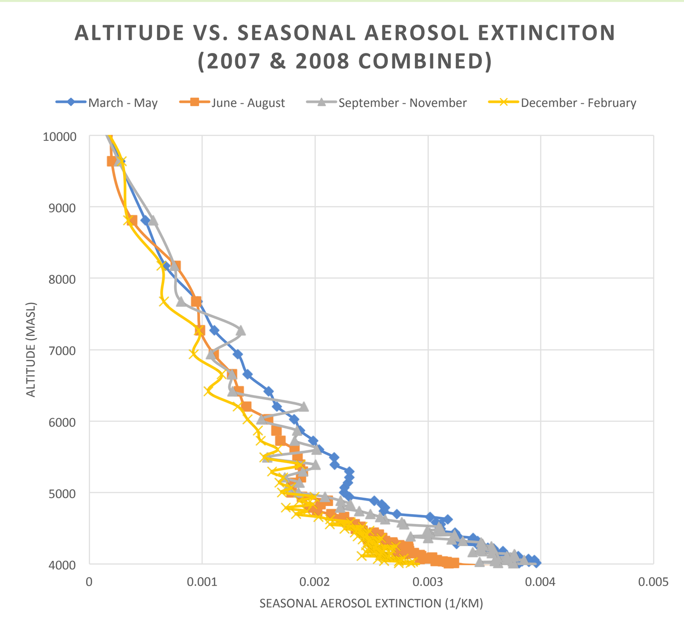


- Average aerosol extinction from 4 to 10 km ranged from 0.0035 km^{-1} with a standard deviation of 0.0007 km^{-1} at 4 km to 0.00037 km^{-1} with a standard deviation of 0.0002 km^{-1} at 9.7 km.
- Yearly average aerosol extinction between 4-10 km was approximately 20% higher in 2007-2008 than in 2006-2007.
- For reference, avg. AOD for Hawaii in 2001 was ~ 0.1. Stratospheric aerosol contributes ~ 0.005 and the integrated CLidar AOD from 4 km to 10 km is ~ 0.01, leaving AOD below 4 km at 0.085.





Results: Seasonal



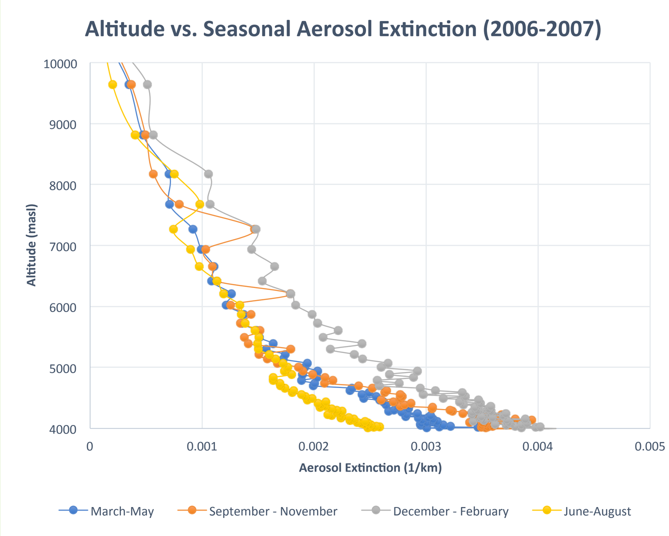
•Number of data sets per season is limited.

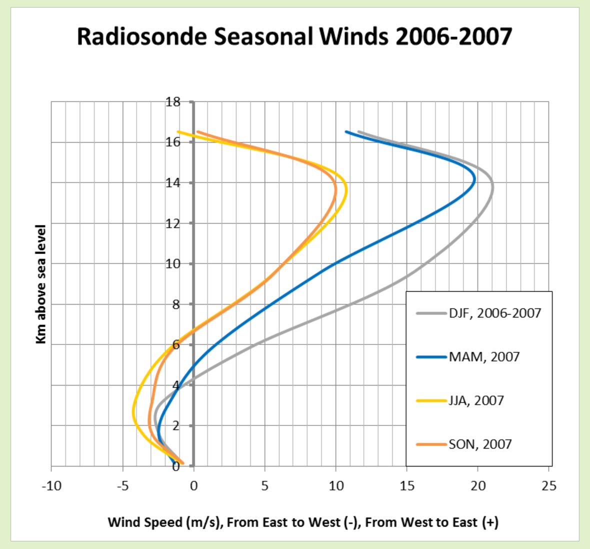
•Year to year, season averages varied substantially, though some of this difference may be due to AERONET phase functions.

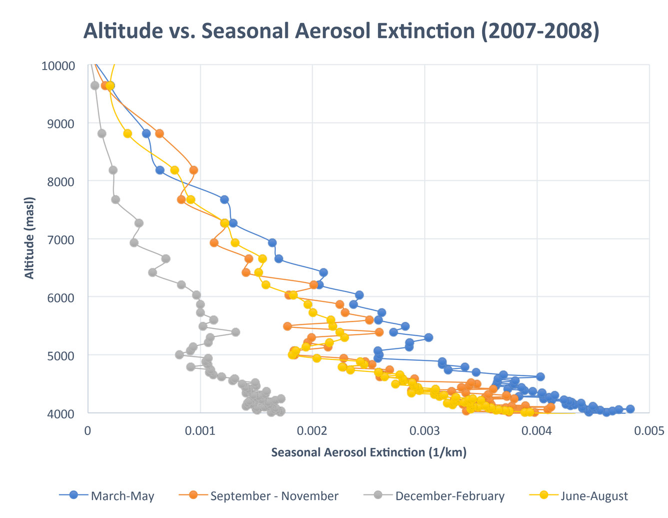
•In 2006-2007 winter data showed high aerosol extinction, with values over two times those of winter 2007-2008.

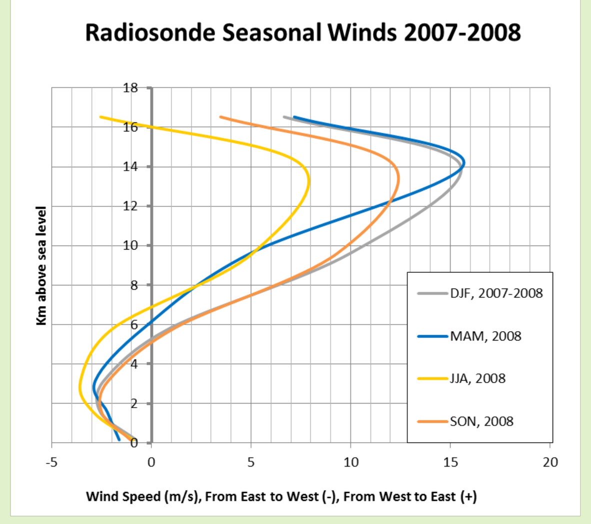
•Autumn of each year were roughly comparable in extinction magnitude.

•2006-2007 spring and summer aerosol extinctions were substantially lower than in 2007-2008.









•A transition between near ground easterly trade winds and higher altitude westerly winds occurs between 4200-6800 m.a.s.l. as detected by Hilo radiosondes.

• Potential for different source regions for background aerosol above and below transition.

•A fairly consistent aerosol layer appears between approximately 5000 m.a.s.l. and 6200 m.a.s.l., especially in 2007-2008.

•Aerosol appears to clean out near 5000 m just below this layer.

Future Work

- Increase number of data sets to include data from several more years.
- Evaluate extinction at higher altitudes with data from MLO stratospheric lidar.
- Investigate seasonal variations in phase functions derived from AERONET.

References and Acknowledgements

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•We thank AERONET and their staff for establishing and maintaining the MLO site used in this investigation.