Aerosol Vertical Structure as Assessed by the Micropulse Lidar upon Ascension Island during the LASIC Campaign

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LAYERED ATLANTIC SMOKE INTERACTIONS WITH CLOUDS LASIC 2016-2017

Introduction

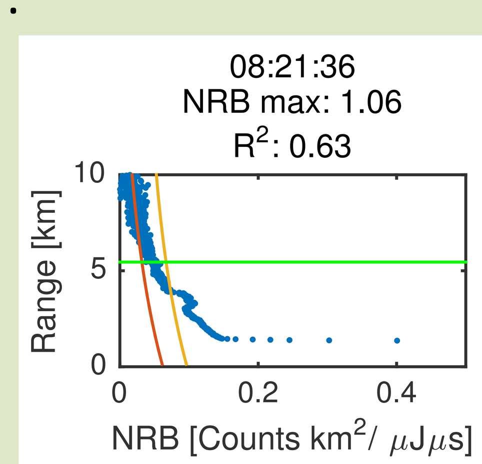
- Ascension Island (8S, 14W) is an ideal location to witness the long-range transport of smoke from African biomass burning and dust.
- The DOE micropulse lidar provides the only consistent indicator of vertical structure during the 17-month-long LASIC campaign.
- The lidar extinction profile is derived using an Fernald-based inversion algorithm developed at the University of Miami and is constrained by AERONET-derived aerosol optical depth.
- We compare our lidar inverted extinction profiles to the CLARIFY EXSCALABAR aircraft in-situ extinction profile.

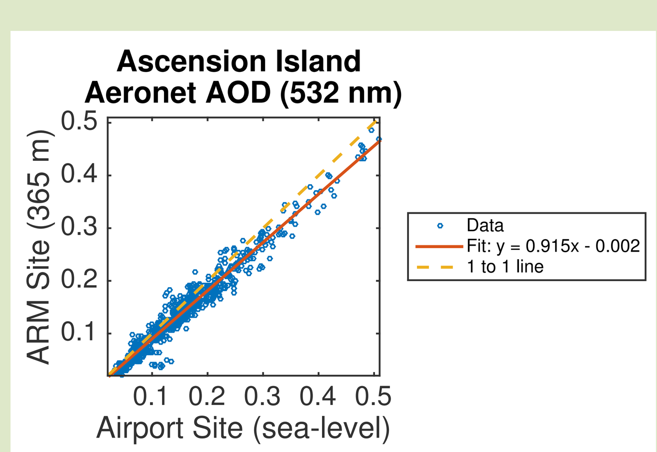
Aim

- Comparison between the DOE lidar and in-situ extinction values
- Observe aerosol structure evolution by month.
- Better understand how to obtain high quality extinction retrievals from micropulse lidar

Lidar Constant C Calibration

- Normalized Relative Backscatter signal is found by applying the afterpulse, deadtime, overlap, and range corrections to raw lidar signal: $S_{NRB}(z) = C(\beta_a(z) + \beta_m(z))e^{-2(\tau_a(z)+\tau_m(z))}$
- The molecular profiles rely on nearby radiosonde profiles.
- The column-averaged lidar constant C is found using a molecular fitting algorithm searching for the statistically best top of aerosol layer.





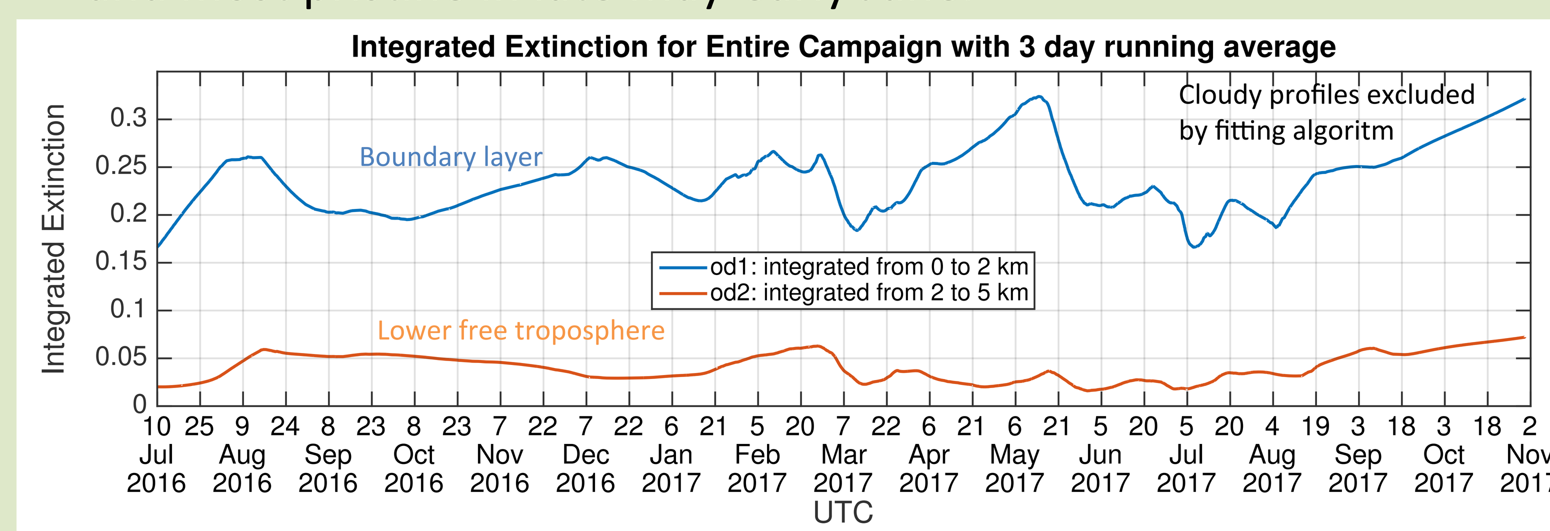
- Aeronet AOD : Airport Site (76 m alt.) and Mobile Site (341 m alt.)
- The airport site was cross-calibrated to the mobile site to increase the number of lidar C calibration data points.

Solving for Lidar Extinction

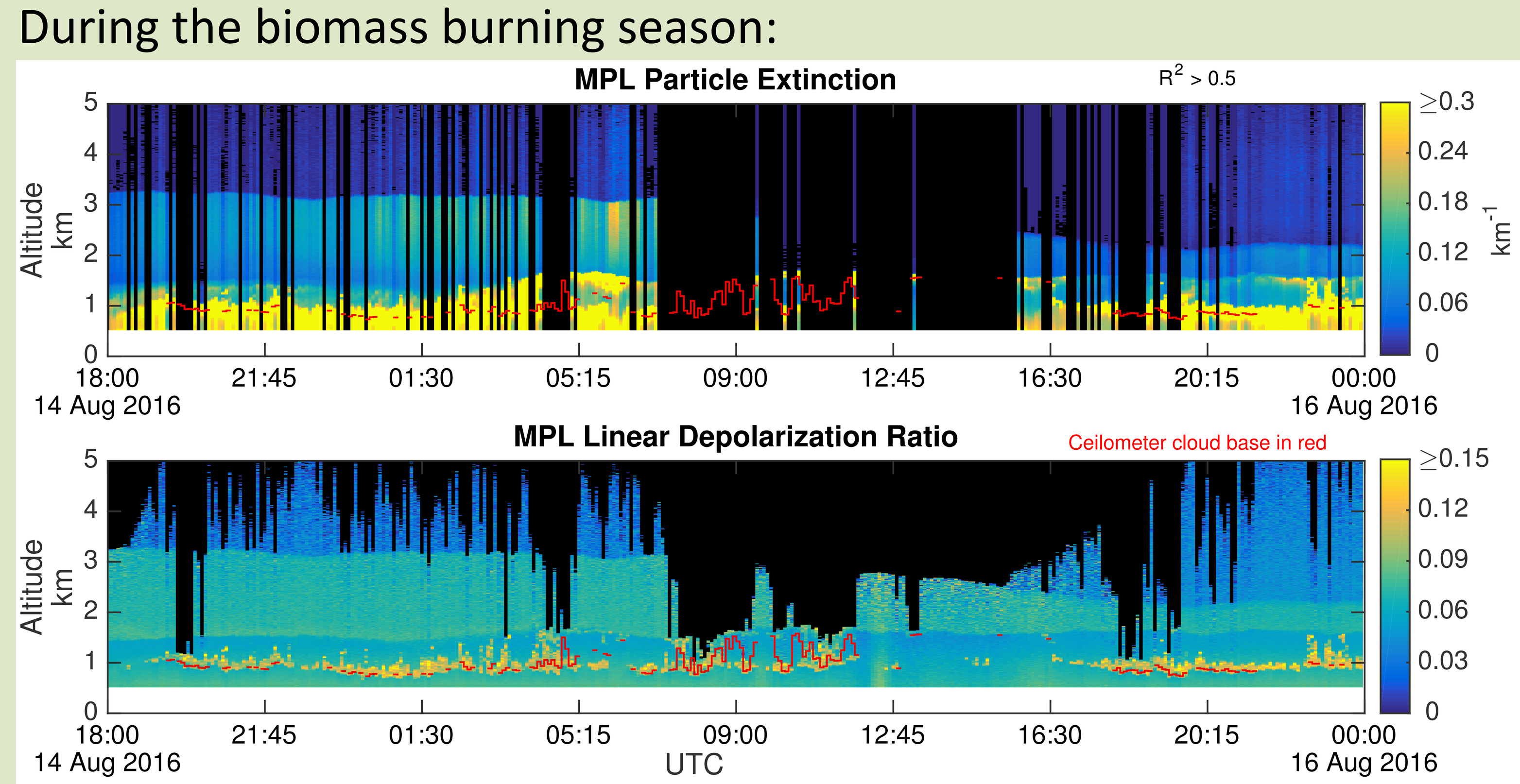
- A molecular fitting algorithm finds the top of the aerosol layer, which is combined with the previously found C solves for the column optical depth.
- The Fernald algorithm is then used to find the extinction profile.
- Since this inversion is dependent on the molecular fit, the coefficient of variation R^2 determines the quality of the data.
- Only $R^2 > 0.5$ data are considered.

Results

- The mountains of Ascension Island and proximity to the ocean encourage orographic lifting of moist air.
- Consequently, It is often cloudy at the lidar mobile site.
- Most of the optical depth stems from the cloudy boundary layer (0 to 2 km). The altitude range above the clouds (2 to 5 km) that can contain smoke and other aerosols was most polluted in Oct. 2017, and most pristine in late May-early June.

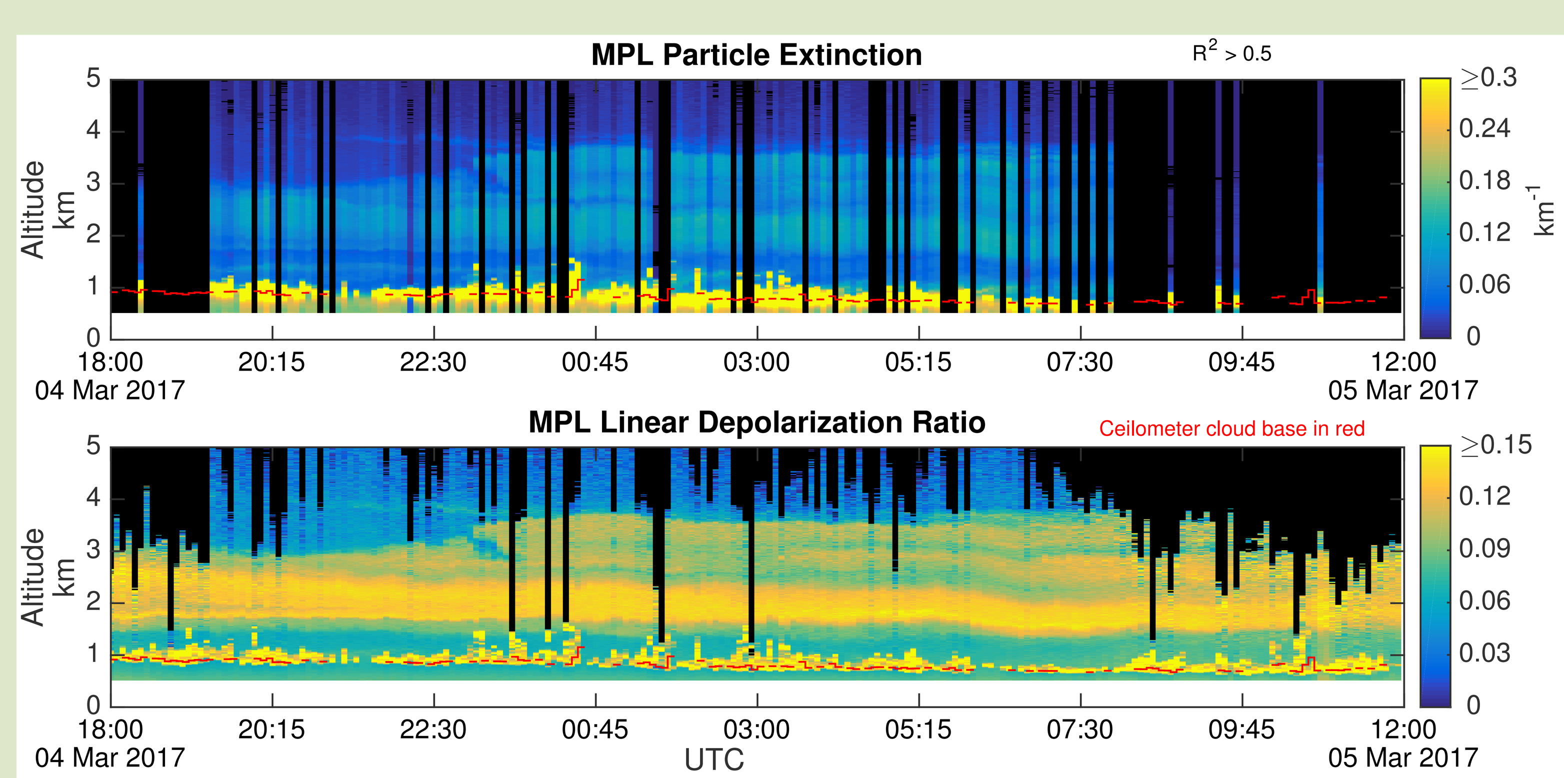


During the biomass burning season:



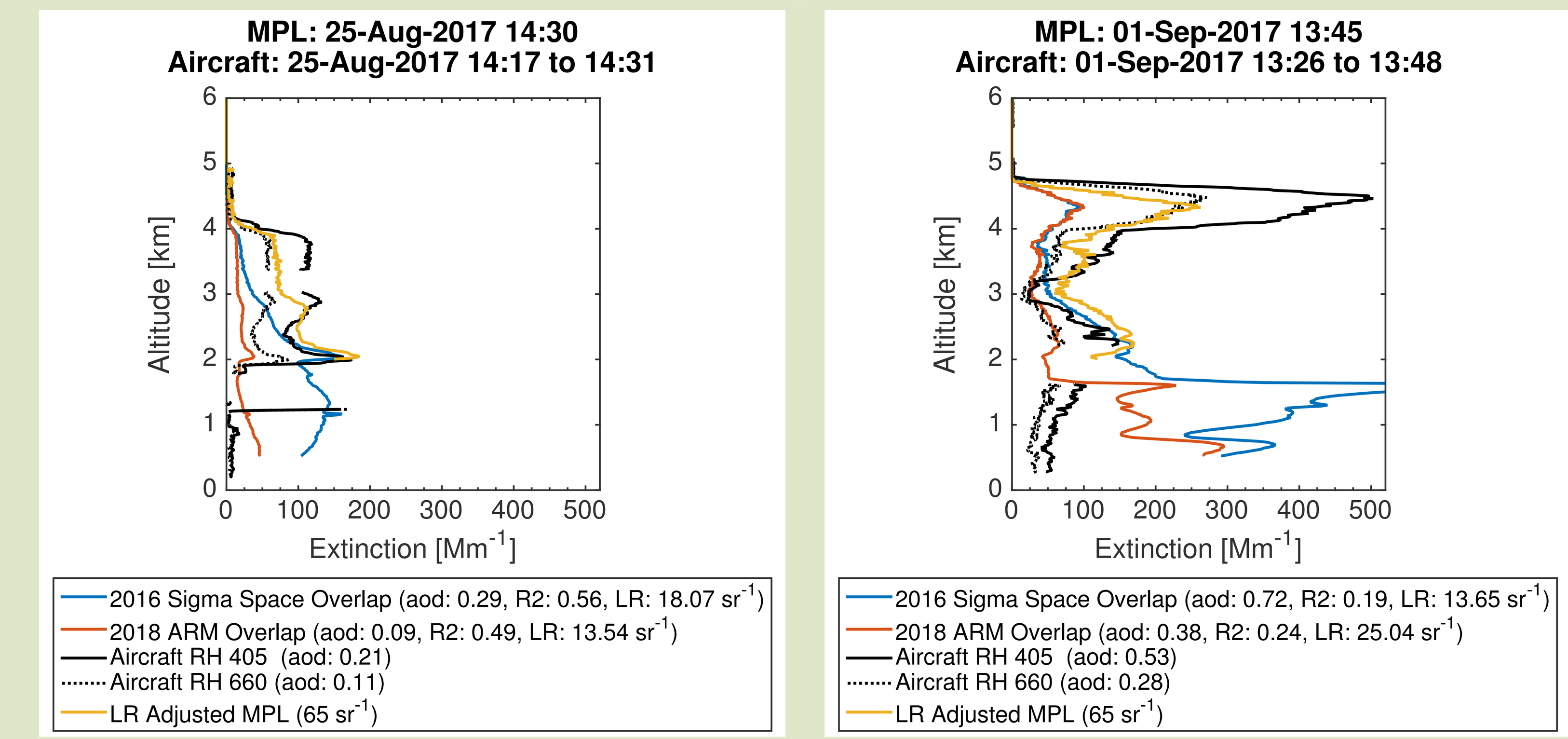
- The low depolarization ratio indicates that the aerosols are probably smoke.

Elevated aerosol layers also occur in Feb and March (example below). The higher depolarization ratios suggest this is dust not smoke



Comparison with CLARIFY In-situ Extinction (EXSCALABAR)

- MPL extinction for 15 min average of the raw lidar data:



- The post-deployment overlap calibration done by ARM at the SGP site differs substantially from the pre-deployment calibration done by the MPL manufacturer SigmaSpace. The new overlap places less weight within the boundary layer, reducing those extinctions.
- The new extinction profiles above 2km have vertical structures that agree with those from the aircraft.
- Correcting the derived column-averaged lidar ratio to be 65/sr, the mean lidar ratio of free-tropospheric smoke at 530 nm derived by the NASA High Spectral Resolution Lidar 2 during ORACLES Sept 2016, brings the MPL-retrieved values into approximate agreement with the in-situ extinction.

Conclusion

- Aerosols above clouds, between 2 to 5 km, are often present at Ascension
- A new finding is that these are more likely to be dust in late austral summer
- The ever-present clouds provided a significant challenge in identify good quality lidar data.
- Collaboration with the CLARIFY team, the NASA ORACLES lidar team and the new ARM overlap function has allowed us to improve our lidar extinction calculation and provide confidence in the results.

Acknowledgements

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