Demonstration of the 2D MAX-DOAS instrument: comparison with HSRL, MFRSR and in-situ aerosol optical properties during TCAP

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Introduction

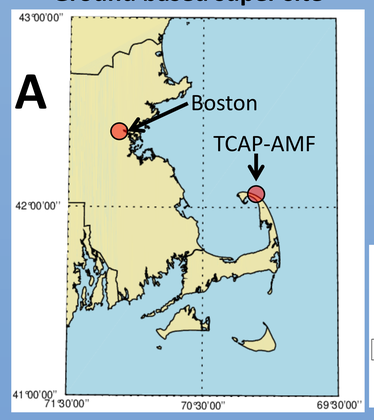
The two Column Aerosol Project (TCAP) investigated uncertainties in the aerosol direct effect in the northern hemisphere mid-latitudes. The DOE Atmospheric Radiation Measurement (ARM) Mobile Facility (AMF) and Mobile Aerosol Observing System (MAOS) provided opportunities for 1) atmospheric radiation closure studies, and 2) test retrievals of aerosol optical properties in the presence and absence of clouds.

The University of Colorado deployed an innovative instrument, the 2D scanning ground Multi AXis Differential Optical Absorption Spectroscopy (2D-GMAX-DOAS) instrument to access column and profile information about aerosol optical properties and trace gases in the lower atmosphere.

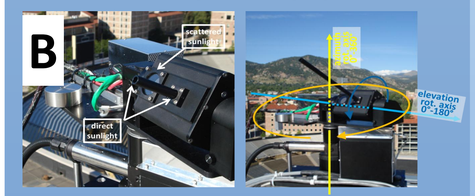
Ground based deployment

• The 2D-GMAX-DOAS (B) and Cavity Enhanced (CE-) DOAS (C) instruments were deployed at the AMF site (A) from 1 Jul – 13 Aug 2012.

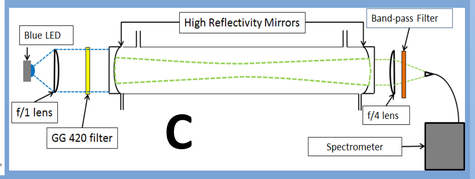
Ground based super site



2D-GMAX-DOAS



LED-CE-DOAS

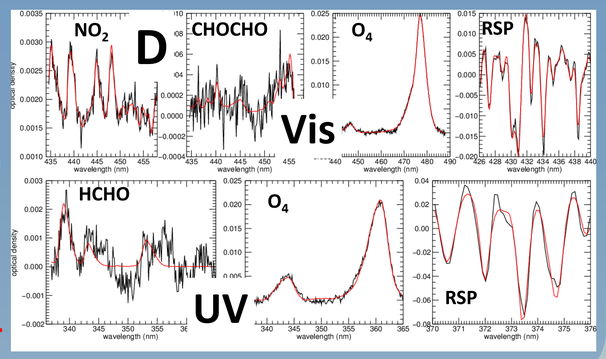


2D-GMAX-DOAS	CE-DOAS
EA: 1˚,3˚,6˚,10˚,20˚, 30˚, 45˚ and zenith **View:** North-South	In-situ technique
Azimuth: 5, 10, 15…180˚ (both sides)	
3 spectrometers, 300-631 nm, 0.4-0.6nm FWHM	Acton-PIXIS spectrometer, 390-490nm, 0.5nm FWHM
Species: NO_2, CHOCHO, O_4, HCHO, IO, Raman Scattering Probability (RSP)	**Species:** NO_2, CHOCHO, O_4

Data analysis

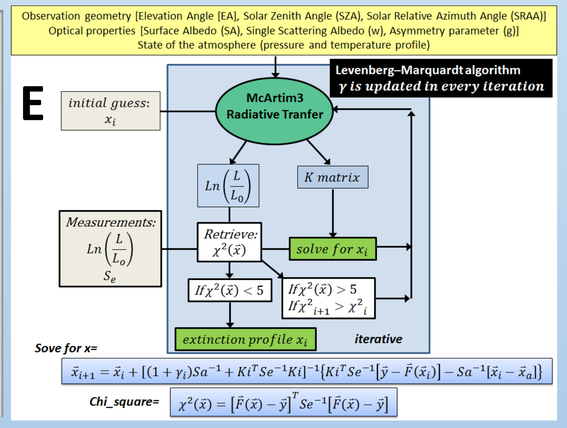
Spectra were analyzed with the DOAS method in order to obtain differential Slant Column Densities (dSCD) in the visible and UV (D) spectral region.

SCDs are column densities of an absorber along the path of the scattered light from the sun to the telescope; *differential* means with respect to a reference spectrum.

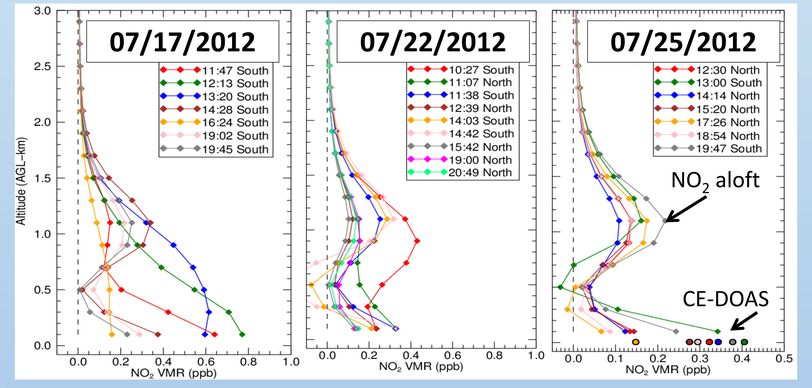


Aerosol extinction profile → NO_2 trace gas profile

Sun normalized radiances are modeled by a Monte Carlo Radiative Transfer Model (McArtim) and a Levenberg-Marquardt non-linear inversion is used to retrieve extinction profiles. (modified based on Prados Ramon et al., 2010, ACP)



Trace gas profile retrieved by a linear inversion using Optimal Estimation.

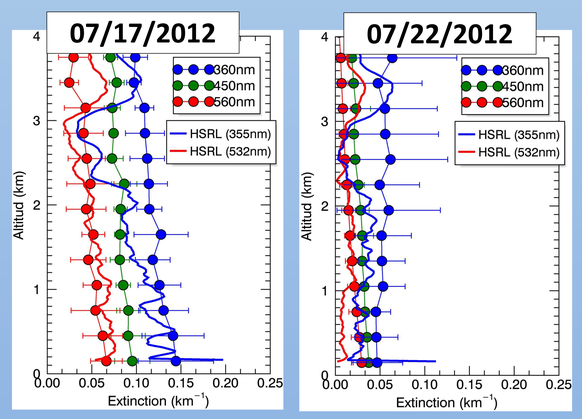


Extinction profiles: HSRL comparison

We compare retrievals of aerosol extinction profiles (360, 450, and 560 nm) with the High Spectra Resolution Lidar (HSRL, 355 and 532nm).

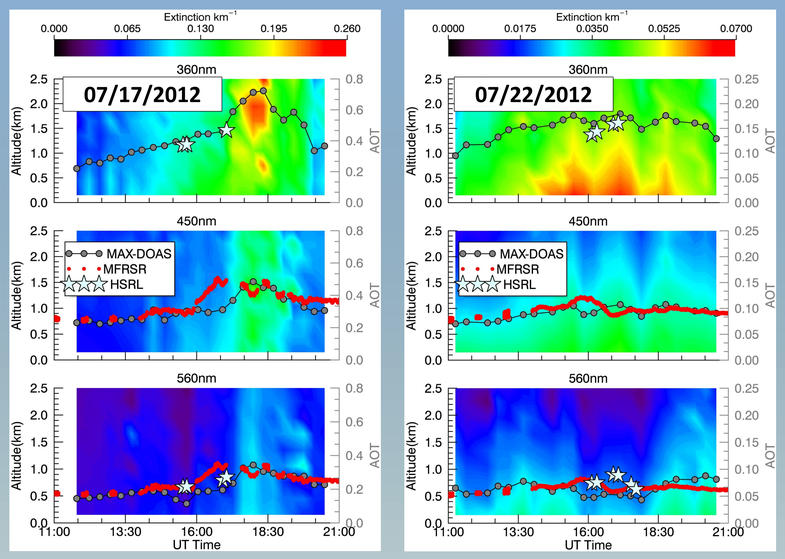
HSRL-NASA's King-Air

Aerosol extinction profiles represent the average obtained during HSRL overpasses within 5km. The error bars are the standard deviation.



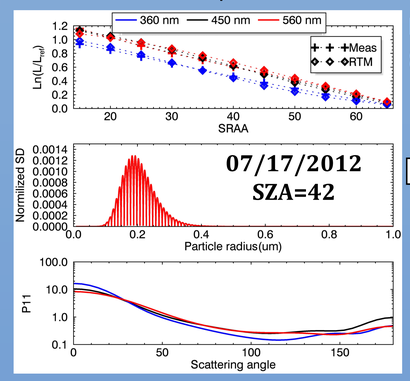
AOD: comparison with MFRSR and HSRL

The integrated extinction profile below 4km is compared with the AOD retrieved from the NOAA Multi Filter Rotating Shadowband Radiometer (MFRSR 450 and 560 nm) and HSRL (355 and 532nm).



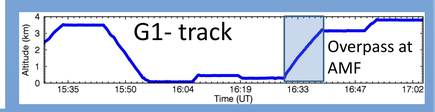
Aerosol Microphysical properties

Look up table of azimuth normalized radiance calculations (McArtim3 RTM) with different phase functions-SSA (Mie code); iterative comparison with measurements are performed until convergence is found.



Here: monomodal size distribution (Multi-modal SD is work in progress)

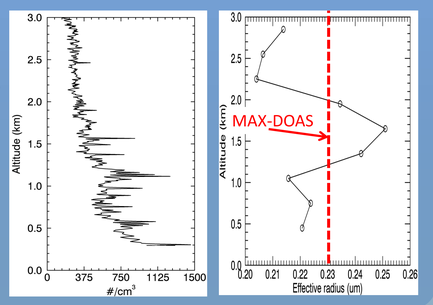
Effective radius = 0.23 um
Complex refractive index: m=1.68 + 0.005i (average-wavelength)



DoE-G1: Comparison with UHSAS

The column averaged effective radius (R_e) retrieved from MAX-DOAS agrees reasonably with in situ R_e from UHSAS.

G1-DoE



Conclusions and Outlook

- 2D-GMAX-DOAS provides effective means to measure profiles of trace gases and aerosol optical properties simultaneously (no need for radiance calibration.
- NO_2 layers aloft are observed to be often decoupled from the surface.
- Aerosol extinction profiles and AOD agree well with HSRL and MFRSR.
- The MAX-DOAS technique is extended to aerosol microphysical properties.
- 2D-GMAX-DOAS measurements facilitate a link between the ground-based ARM/MAOS dataset, the DoE-G1 and NASA King Air aircrafts, NASA's OMI satellite (i.e., NO_2 vertical column), and chemistry transport models.

Acknowledgments

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