First application of a newly developed algorithm for the retrieval of aerosol optical properties in the lower troposphere from MAX-DOAS measurements

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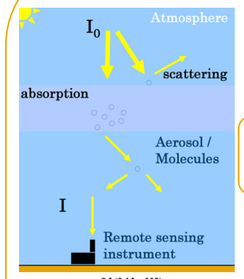
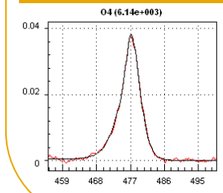
DOAS

Differential Optical Absorption Spectroscopy





- Solar radiation is attenuated when traveling through the atmosphere, following the Beer-Lambert law:

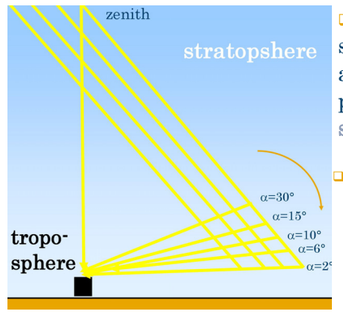
$$I(\lambda)=I_0(\lambda)\exp[\sum SCD_i.\sigma_i(\lambda)-\tau_{diffusion}(\lambda)]$$

σ_i: molecular absorption cross-section
SCD_i: slant column density
$\tau_{diffusion}$: Rayleigh and Mie scattering

- Use high frequency absorption structures to identify absorbers
- Quantify abundance based on measure of the differential absorption (i.e. difference between strongly and weakly absorbing wavelengths)

Multi-AXis

zenith + scan of multiple elevation angles down to horizon



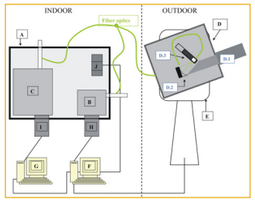
- Increased sensitivity towards atmospheric absorbers present close to the surface
- $DSCD=SCD_{zenith}-SCD_{off\text{-}axis}$ → elimination stratospheric contribution
- Provides information on the vertical distribution of gases and aerosol in the troposphere.

Instrument

Main parts:
- optical head
- sun tracker
- 2 spectrometers
- 2 low-noise CCDs
- 2 computers (synchronized)

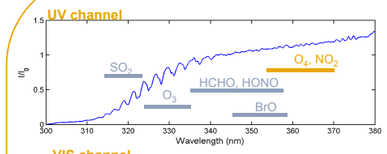
2 Channels:
- UV = 300 - 390 nm
- VIS = 400 - 720 nm

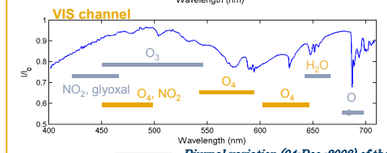
Measurement modes:
- MAXDOAS scan
- Almucantar scan
- Direct sun-measurement



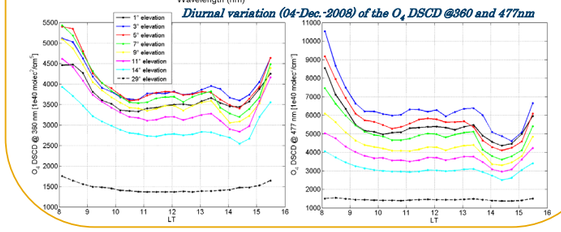
A. Thermo-regulated box
B. UV spectrometer (300-390 nm)
C. VIS spectrometer (400-720 nm)
D. Optical head (telescope, filterwheel, off-axis parabolic mirror)
E. Suntracker
F. & G. Computers for data aqcuisition

Measurements





- Location: Beijing (N 39° 58'; E 116° 23')
- Analyzed period: Nov. 2008- Mar. 2009

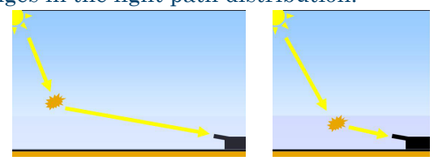


Principle

$$SCD=\int_0^L \rho(s)ds$$

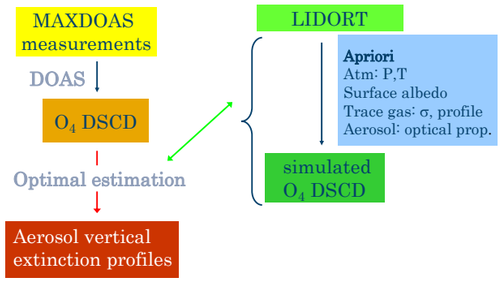
Derive aerosol properties from O_4 DSCD

- $\rho(z)$ of O_4 is well-known and nearly constant (it varies with the square of the O_2 monomer)
- Changes in the observed O_4 DSCD are due to changes in the light path distribution.



→ The length of the light path through the atmosphere and thus the observed SCD of a trace gas will depend on the vertical distribution and optical properties of the aerosol present in the atmosphere

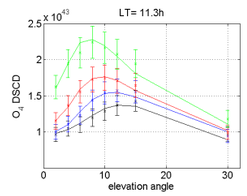
Algorithm

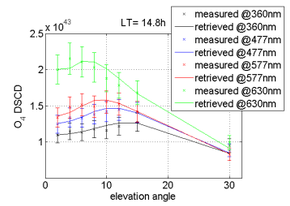


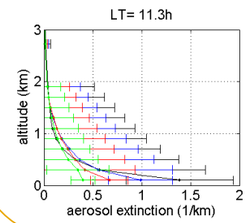
- Forward model: Radiative transfer code LIDORT *[LIDORT v3.3; Spurr, 2007]*; analytic calculation of weighting function.
- Inversion method: Optimal estimation *[Rodgers, 2000]*
- Aerosol single scattering albedo and phase function input from CIMEL sunphotometer measurements *[http://aeronet.gsfc.nasa.gov]*

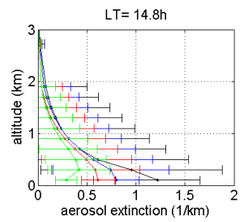
Beijing results

04-Dec.-2008



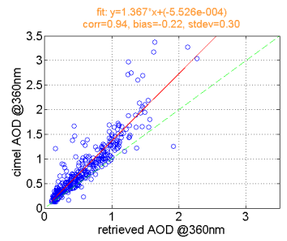


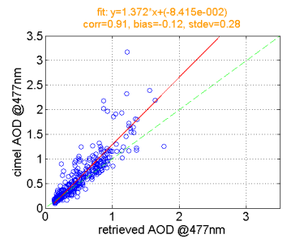




Nov. 2008- Mar. 2009

Selection: % RMS of the measured vs. the simulated O_4 DSCD < 10%





- Good correlation with CIMEL aerosol optical depth (AOD)
- Systematic underestimation: apriori too small (AOD~0.1) + low sensitivity over 800 m.

Future outlook

- Make appropriate choice of apriori profiles
- Use direct sun measurements for total AOD retrievals
- Combine the O_4 DSCD @ different wavelengths for the profile retrieval
- aerosol properties: single scattering albedo and phase function
  - Linearized Mie code (size distribution and refractive index)
  - almucantar measurements

Acknowledgements

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