CU Airborne MAX-DOAS measurements over California during CalNex field campaign

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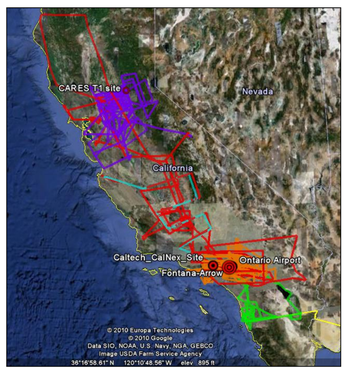
Introduction

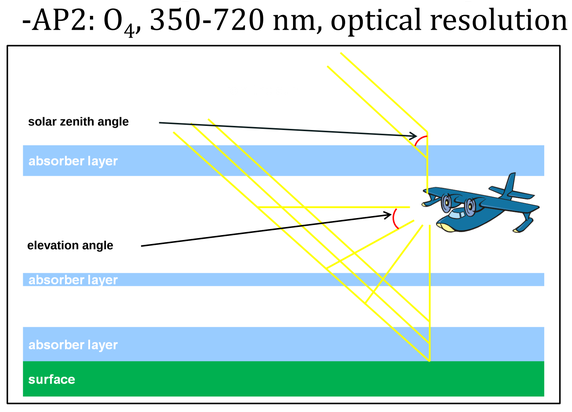
The University of Colorado Airborne Multi-Axis Differential Optical Absorption Spectroscopy (CU AMAX-DOAS) instrument was deployed aboard the NOAA Optical Remote Sensing Twin Otter Research Aircraft during the CalNex 2010 and CARES field campaigns.

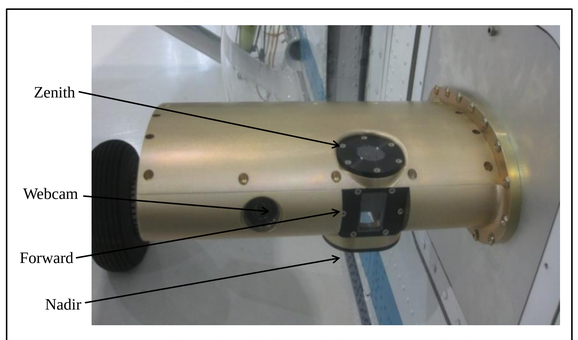
- Total of 52 flights of up to 4.5 hours between May 19 and July 19, 2010.
- Map out horizontal and vertical distributions of trace gases like NO_2, CHOCHO, and HCHO.
- Other instruments on board: NOAA TOPAZ O_3/aerosol lidar (see Senff et al., Langford et al.), U. of Leeds HALO Doppler lidar, NOAA in-situ O_3 monitor, CU albedo sensors



Instrumentation and Method

- The CU AMAX-DOAS instrument collects scattered sunlight with a telescope pylon mounted on the outside of the aircraft. The collected sunlight is transferred to two spectrometers /CCD detectors by a custom optical fiber assembly.
- The telescope has a rotating prism (360°) and the viewing geometry of the prism is actively controlled to correct for aircraft movements and vibrations using a real time motion compensation system.
- The two spectrometers (ACTON SP2150i) and CCD detectors (PIXIS400B) are characterized as follows:
  -AP1: trace gases, 330-470 nm, optical resolution 0.7 nm (FWHM)
  -AP2: O_4, 350-720 nm, optical resolution 2.5 nm (FWHM)





CU AMAX-DOAS Telescope Pylon

Fig. 1: Schematic of AMAX-DOAS observation geometry.

• The primary quantity measured by the AMAX-DOAS is a slant column density (SCD), which is the integrated concentration, (c) along the light path length, (s): SCD = $\int c(s)ds$
• Measured spectra are analyzed with the DOAS-method yielding a differential SCD (dSCD), differential with respect to the absorber amount in the reference spectrum.
• The obtained quantity, dSCD is related to the vertical column density (VCD) by a quantity called the differential Air Mass Factor (dAMF).

$$\mathrm{dAMF} = \frac{\mathrm{dSCD}}{\mathrm{VCD}}$$

Results

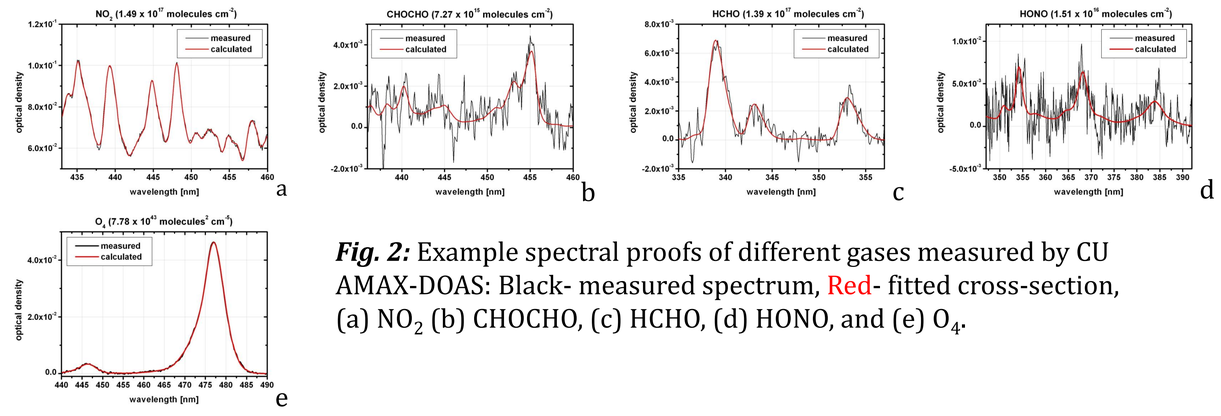
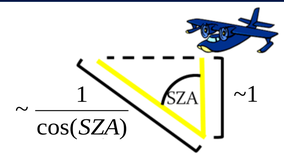


Fig. 2: Example spectral proofs of different gases measured by CU AMAX-DOAS: Black- measured spectrum, Red- fitted cross-section, (a) NO_2 (b) CHOCHO, (c) HCHO, (d) HONO, and (e) O_4.

I. NO_2 Vertical Columns

- dSCDs of NO_2 from 90 degrees elevation angle (nadir) of the CU AMAX-DOAS instrument were converted to vertical columns below the aircraft using the geometric AMF approximation.



Geometric Approximation

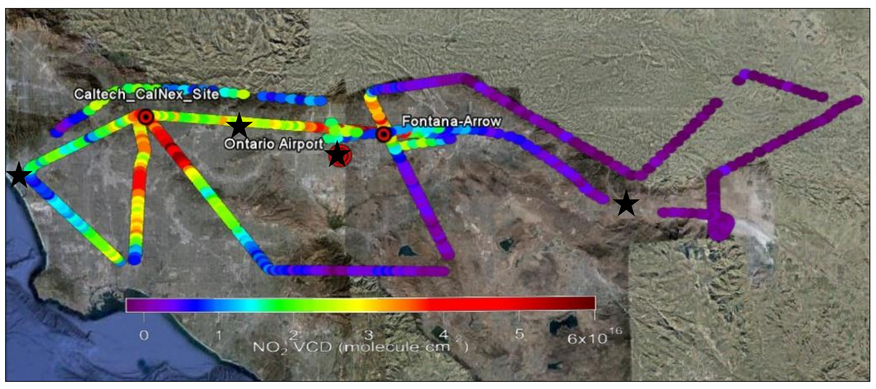


Fig. 3: Horizontal distributions of NO_2 vertical columns below the aircraft from a flight on July 16, 2010 (10:30-14:10 PDT) in the Los Angels basin. Stars represent locations of vertical profiles in **Fig. 6**.

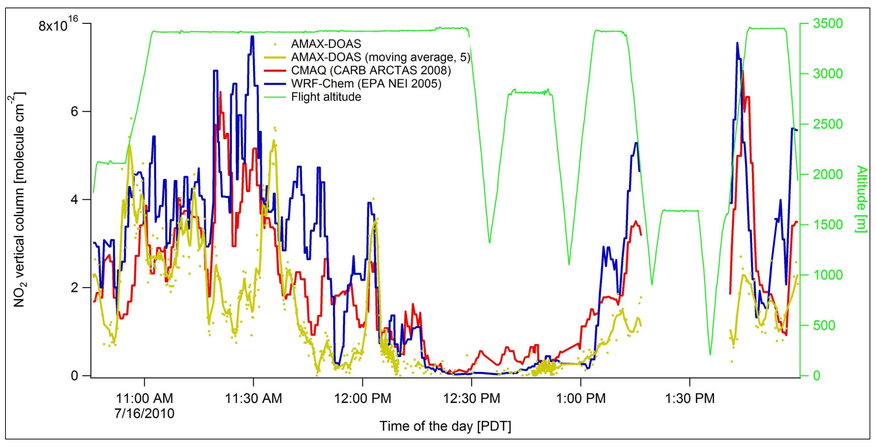


Fig. 4: Time series plot comparing observed NO_2 vertical columns with the model results: Gold- observations, Red- CMAQ model, Blue- WRF-Chem model. Green line represents the flight altitude above sea level. CARB ARCTAS 2008 and EPA NEI 2005 emission inventories were used for the CMAQ and WRF-Chem model simulations, respectively.

	NO_x (mol/km^2 /hr)	CO (mol/km^2 /hr)
EPA NEI 2005	100	1197
Millstein & Harley ES&T 2005	61	450
CARB ARCTAS 2008	73	447
Scaled 2010*	34	

*Millstein/Harley projected emissions for 2010; projection based on 9%/year decrease in NO_x emissions (Russell et al., 2010)

Table 1: Summary of different emission inventories

II. Vertical Profiles

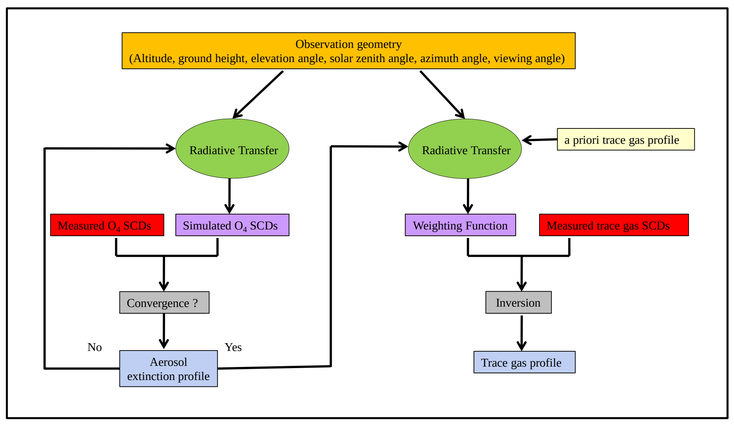


Fig. 5: Flowchart illustrating aerosol extinction and trace gas profile retrieval process using CU AMAX-DOAS measurements.

- Monte Carlo atmospheric radiative transfer inversion model (McArtim) was used for this work. The inversion is based on optimal estimation by Rodgers (2000).

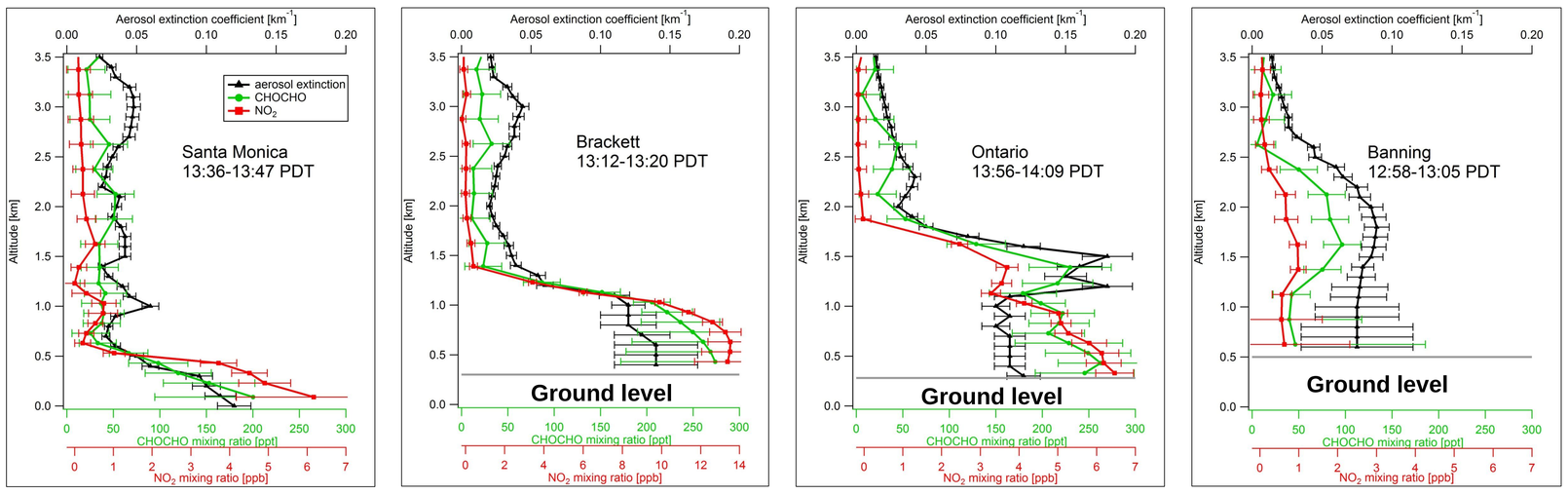


Fig. 6: Examples of vertical profiles retrieved from the CU AMAX-DOAS measurements from the July 16, 2010 morning flight: Red - NO_2, Green- CHOCHO, Black- aerosol extinction, (a) Santa Monica, (b) Brackett (*different scale for NO_2), (c) Ontario, (d) Banning. Stars in **Fig. 3** indicate the locations of the profiles.

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