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Airborne measurements of spatial NO_2 distributions during AROMAT

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1. AROMAT campaign

- The AROMAT (**A**irborne **RO**manian **M**easurements of **A**erosols and **T**race Gases) campaign was held in September 2014
- Dedicated to comparison of multiple remote sensing and in-situ instruments for satellite data validation
- Many European research institutions involved
- Two target sites
  - City of Bucharest (Urban emissions from traffic and industry)
  - Jiu Valley (Two large power plants with high emissions and localized plumes)
- **Shown here:** are solely measurements in the Bucharest area

2. Instrumental setup and method

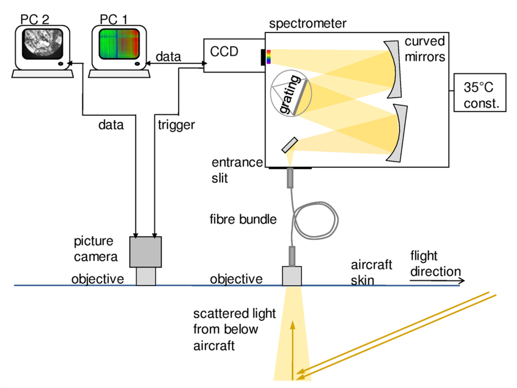


Fig. 1: Instrumental setup
Scattered sunlight from below the aircraft is collected and fed into an imaging spectrometer via an sorted fiber bundle (35 individual fibers), retaining the spatial information.

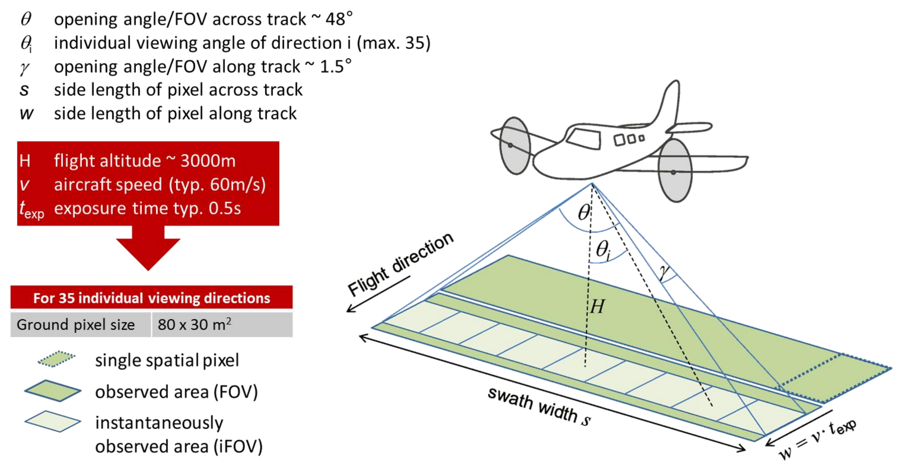


Fig. 2: The AirMAP viewing geometry
The swath of the pushbroom imager depends on flight altitude, groundspeed of the aircraft and exposure time. For typical values during AROMAT this results in a spatial resolution of 30 x 80 m^2.

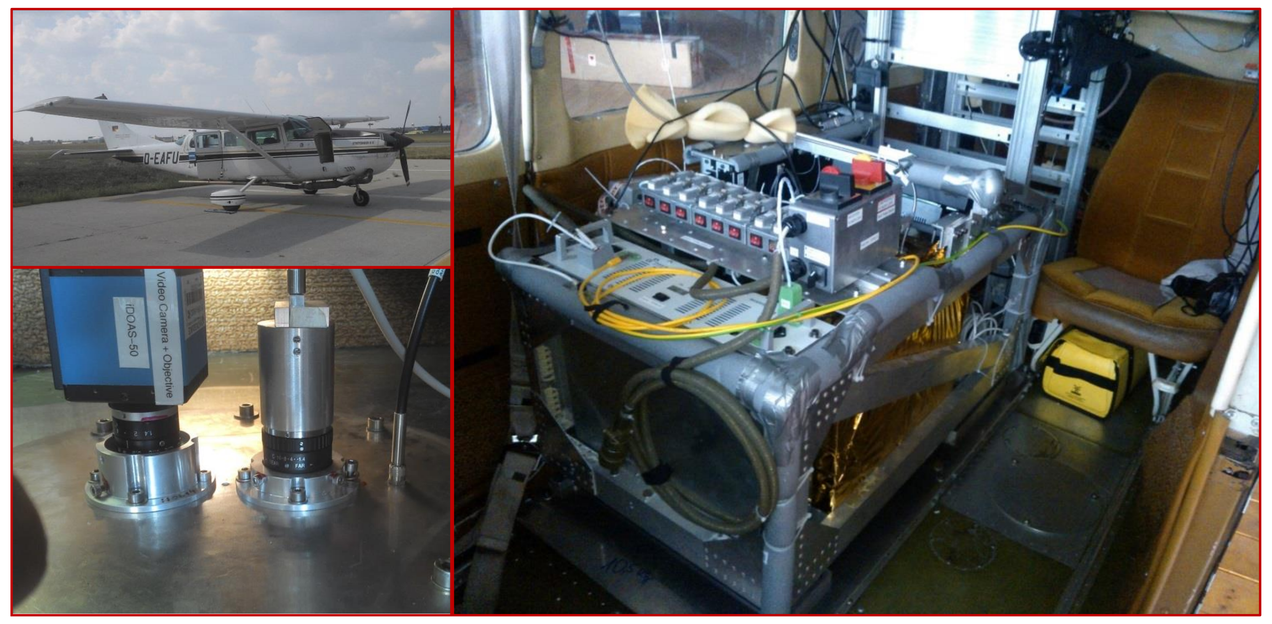


Fig. 3: Photographs of AirMAP & Aircraft :

Top left: Aircraft AirMAP was installed on (Cessna 207 Turbo); operated by FU Berlin.

Bottom left: Nadir ports of entrance optics and video camera

Right: Instrument rack carrying spectrometer, PCs, UPS etc.

- For the retrieval of trace gas distributions the recorded spectra are georeferenced and the DOAS method (**D**ifferential **O**ptical **A**bsorption **S**pectroscopy) is applied.
- The settings used are shown in the table to the right

Parameter	Value
Spectral calibration	Using Fraunhofer lines
Fitting window	425 – 450 nm
Trace gases	NO_2 (293K), O_3 (241K), O_4 (296K), H_2O (HITRAN2006)
Atmospheric Effects	Ring effect (SCIATRAN calculation), constant stray light
Polynomial	Quadratic
Reference spectrum I_0	Rural scene with low NO_2
Slit function	Individual per viewing direction
AMF	Const. albedo 5%, no aerosols

3. NO_2 maps of Bucharest

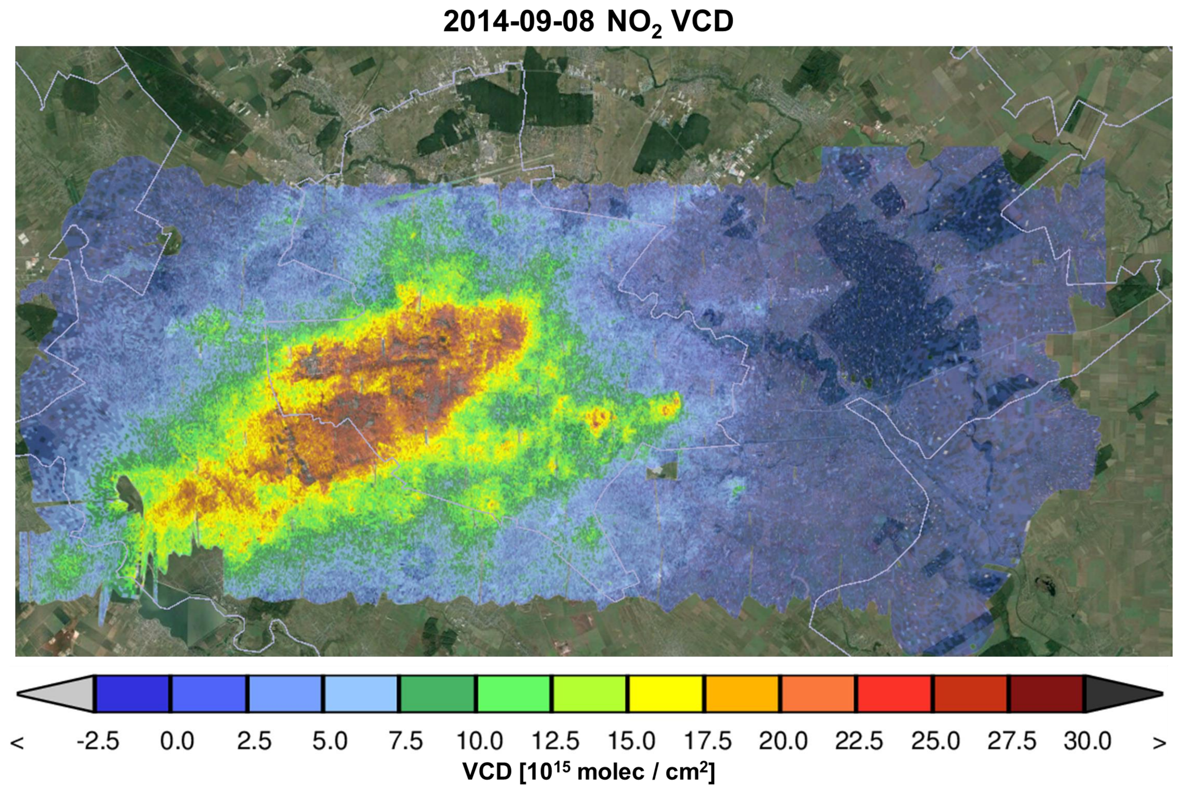
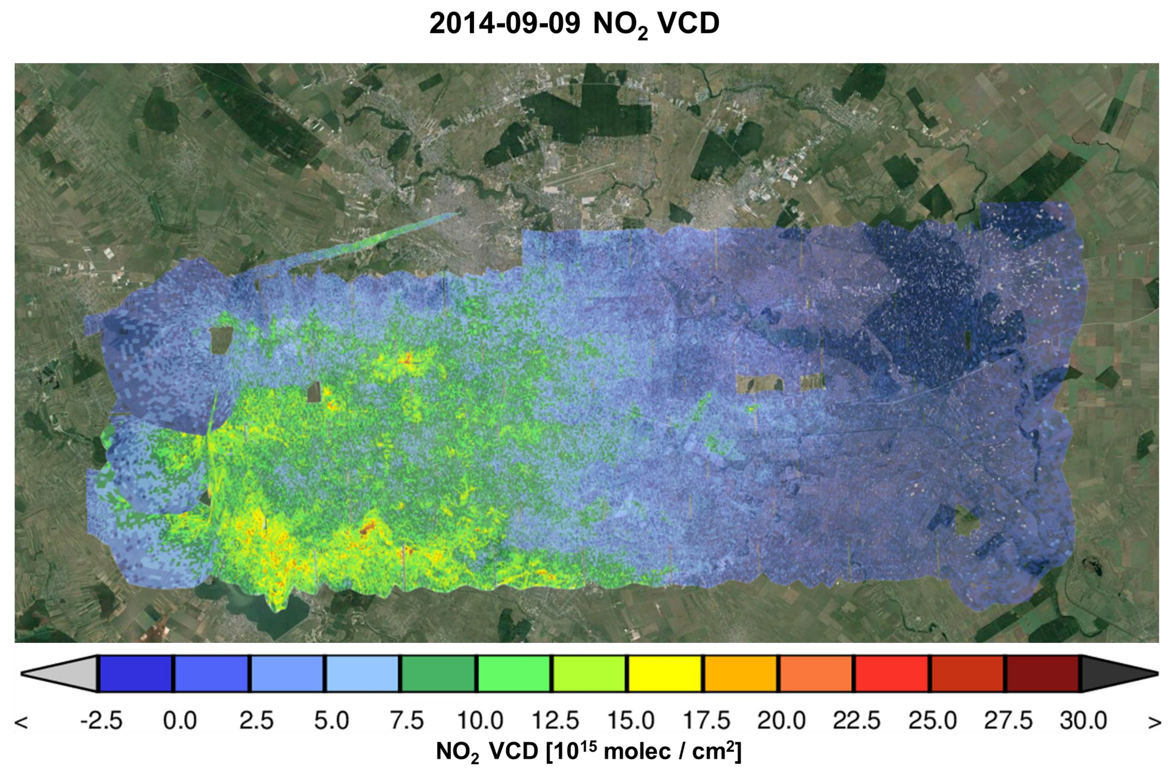


Fig. 4: Spatial distribution of NO_2 vertical columns over Bucharest:

Top figure: Pattern of NO_2 over the city of Bucharest retrieved from AirMAP spectra during a flight of 2.5 hours. Strong spatial gradients are observed. On this day with low wind speed of ~ 1m/s from northwesterly directions the highest NO_2 columns are found downwind of the city center. Easterly of the city center several hotspots are detected.

Bottom figure: Measurements on the subsequent day reveal much smaller NO_2 VCD. Showing the strong inter-day variability in the urban environment.



4. Comparison to mobile car-DOAS measurements

- On the day 2014-09-08 (Fig. 4 top) mobile car-DOAS measurements were performed in coordination with the AirMAP flights.
- Shown below is a comparison of the differential slant column densities (DSCDs) measured by a zenith looking mobile car-DOAS system operated by the University of Galati and BIRA to DSCDs from AirMAP
- For the comparison both datasets were gridded to 0.001° x 0.001° ≈ 100 m^2

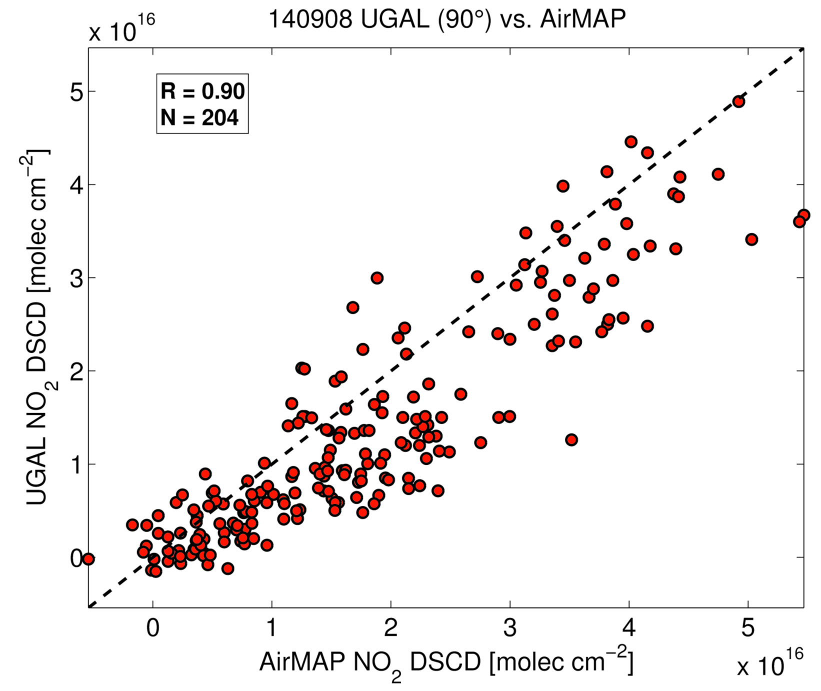


Fig 5a: Comparison between AirMAP and UGAL Car-DOAS NO_2 DSCDs:
Pixel-wise correlation plot of NO_2 DSCDs of co-located measurements of AirMAP pixels and car positions. The dashed line represents a 1:1 relationship.

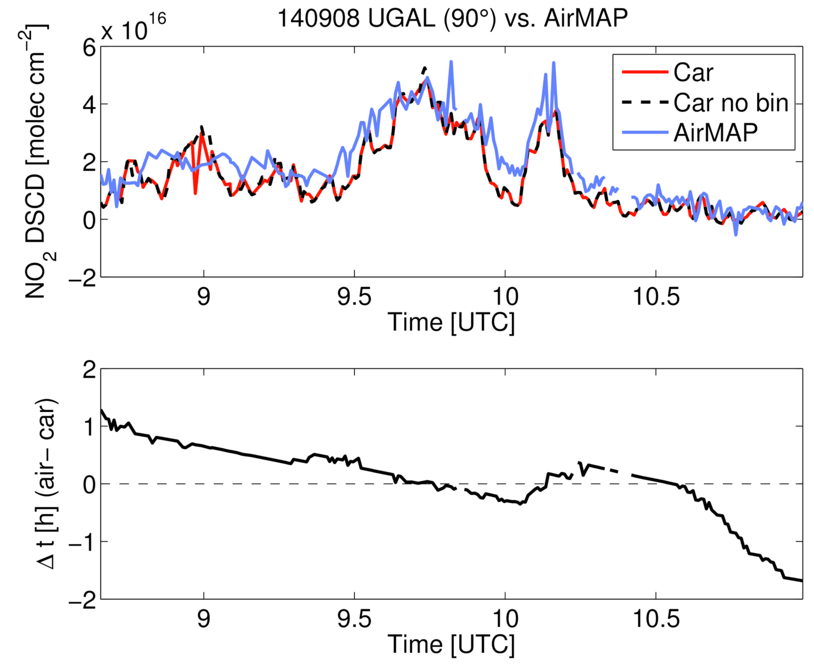


Fig 5b: Time series of the car-DOAS measurements: Additionally shown are the corresponding AirMAP measurements for the car locations. The plot at the bottom shows the time difference between the measurements.

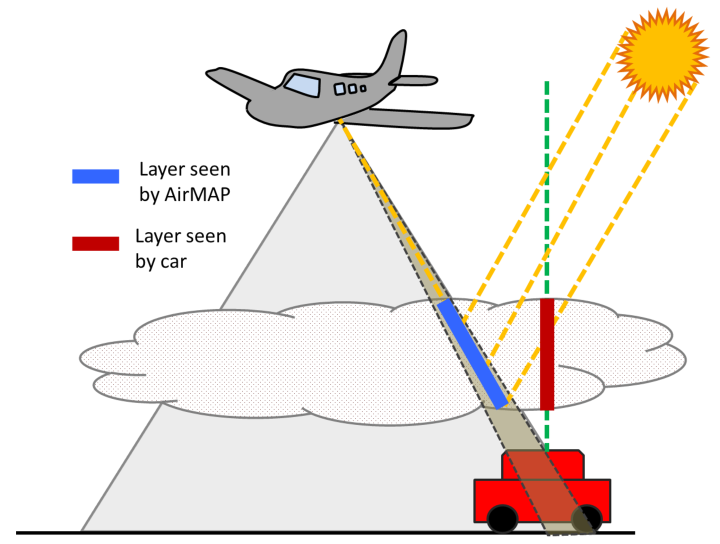


Fig 6: Sketch of the measurement geometries:
Although the measurements have the same ground location, slightly different air masses are observed. The car-DOAS instrument is looking in zenith direction, while the AirMAP measurements are deviating from nadir by the line of sight of the respective viewing direction.

5. Summary & Outlook

- AirMAP was successfully used during AROMAT to create high resolution NO_2 maps of Bucharest and in addition (not shown here) the Turceni power plant
- First inter-comparison with results from car DOAS instruments looks promising
- Deviations between instruments can partly be explained by geometric considerations of observed air masses, but further investigation is needed
- Improvement of instrumental setup to allow simultaneous retrieval of SO_2 and other trace gases in the UV spectral range

Acknowledgements

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