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
- Two target sites
  - City of Bucharest (Urban emissions from traffic and industry)
  - Jiu Valley (Two large power plants with high emissions and localized plumes)

2. Instrumental setup

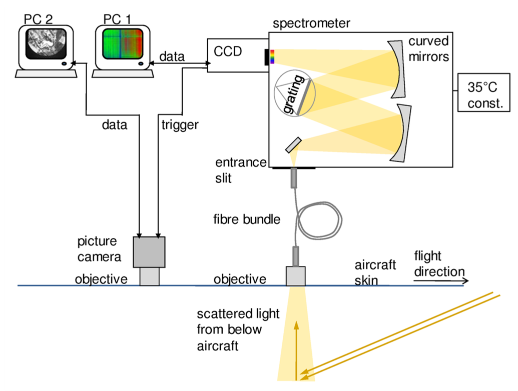

Fig. 1: Instrumental setup
Scattered sunlight from below the aircraft is collected and fed into an imaging spectrometer via an sorted fiber bundle (35 individual fibers), retaining the spatial information.

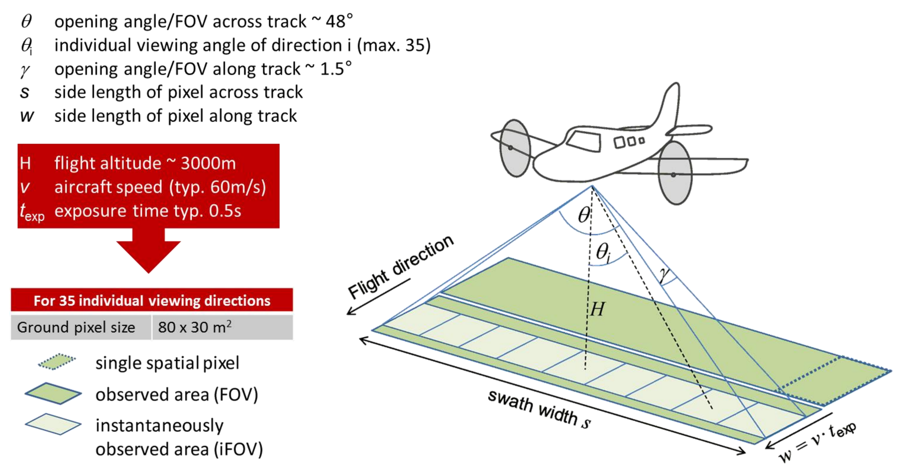

Fig. 2: The AirMAP viewing geometry
The swath of the pushbroom imager depends on flight altitude, groundspeed of the aircraft and exposure time. For typical values during AROMAT this results in a spatial resolution of 30 x 80 m^2.

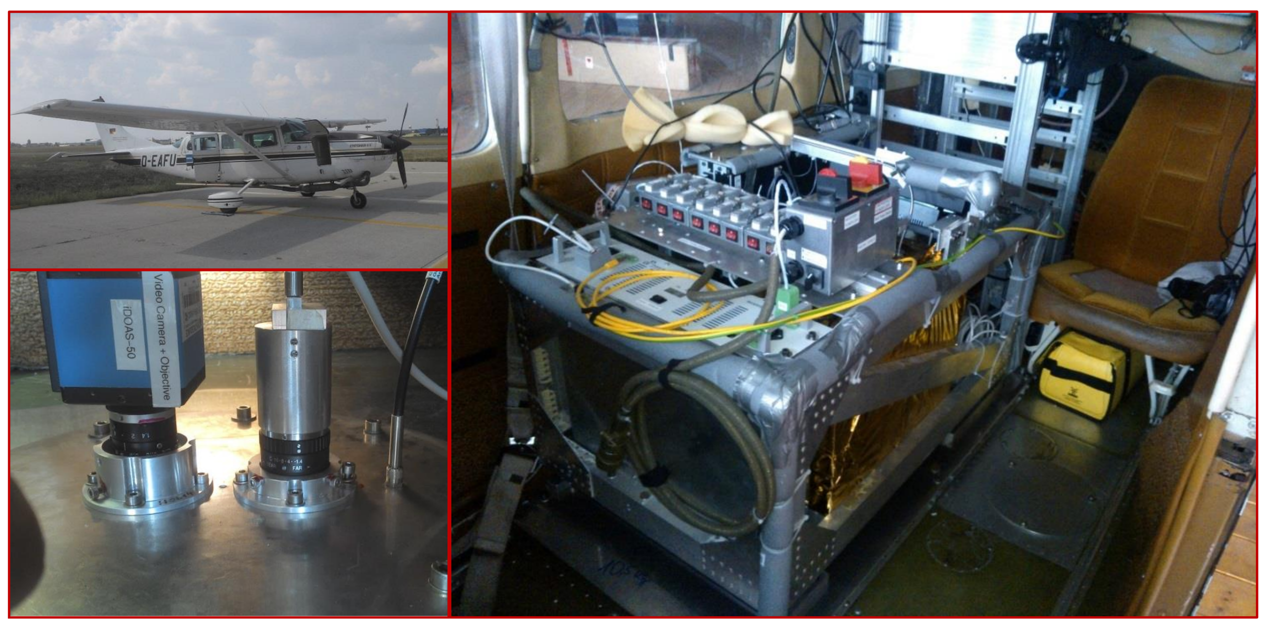

Fig. 3: Photographs of AirMAP & Aircraft :

Top left: Aircraft AirMAP was operated on (Cessna 207 Turbo)

Bottom left: Nadir ports of entrance optics and video camera

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

3. Method

- 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, no aerosols

4. Results of airborne imaging DOAS and comparison to mobile car-DOAS measurements

2014-09-08 NO_2 VCD

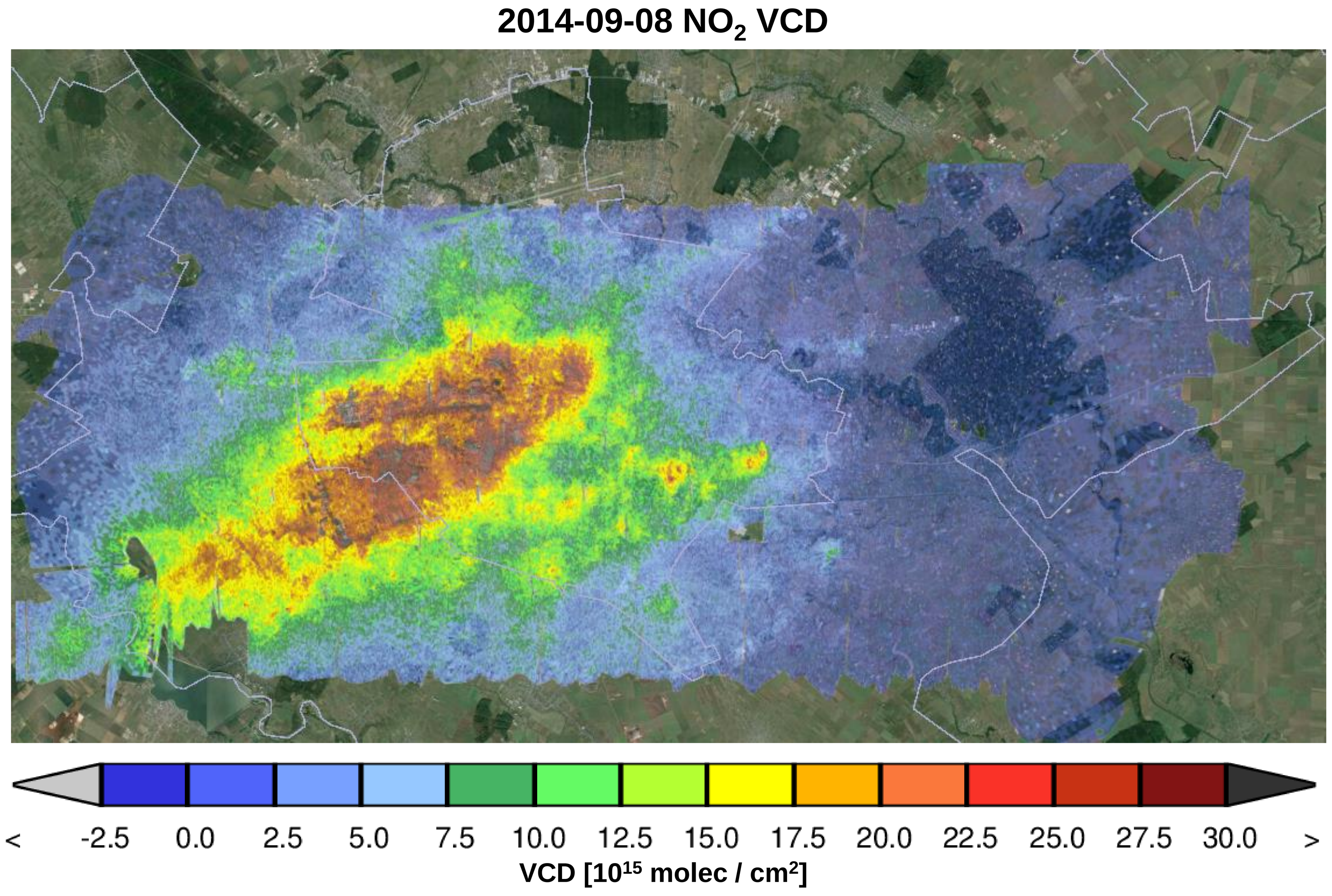

Fig. 4: Spatial distribution of NO_2 vertical columns over Bucharest:
This figure shows nicely the pattern of NO_2 over the city of Bucharest retrieved from AirMAP spectra during a flight of 2.5 hours. Strong spatial gradients are observed. On this day with low wind speed of ~ 1m/s from northwesterly directions the highest NO_2 columns are found downwind of the city center. Easterly of the city center several hotspots are detected, which can be attributed to industrial sources.

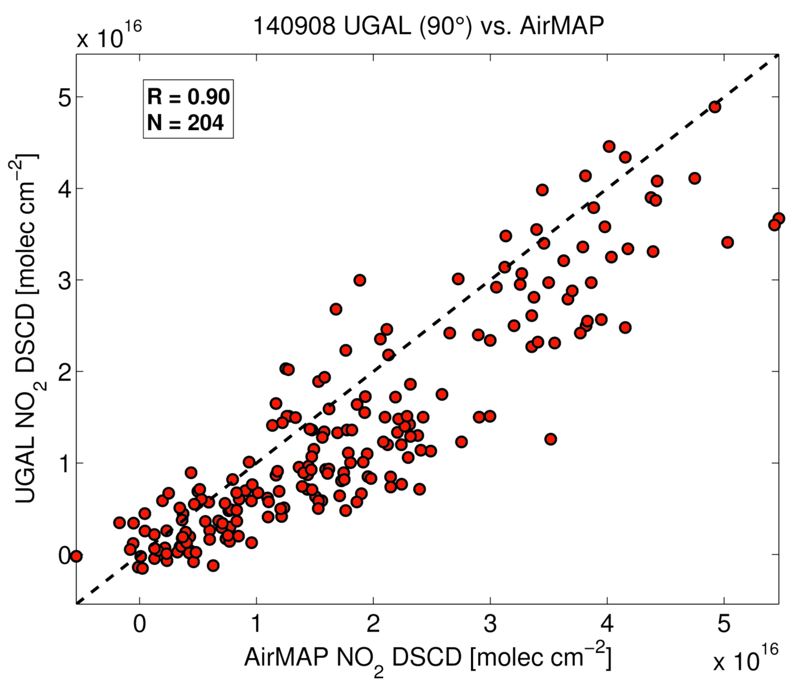

Fig 5a: Comparison between AirMAP and UGAL Car-DOAS NO_2 DSCDs:
Pixel-wise correlation plot of NO_2 differential slant column densities (DSCDs) of gridded datasets (0.001° x 0.001° ≈ 100 m^2) of co-located measurements of AirMAP pixels and car positions.

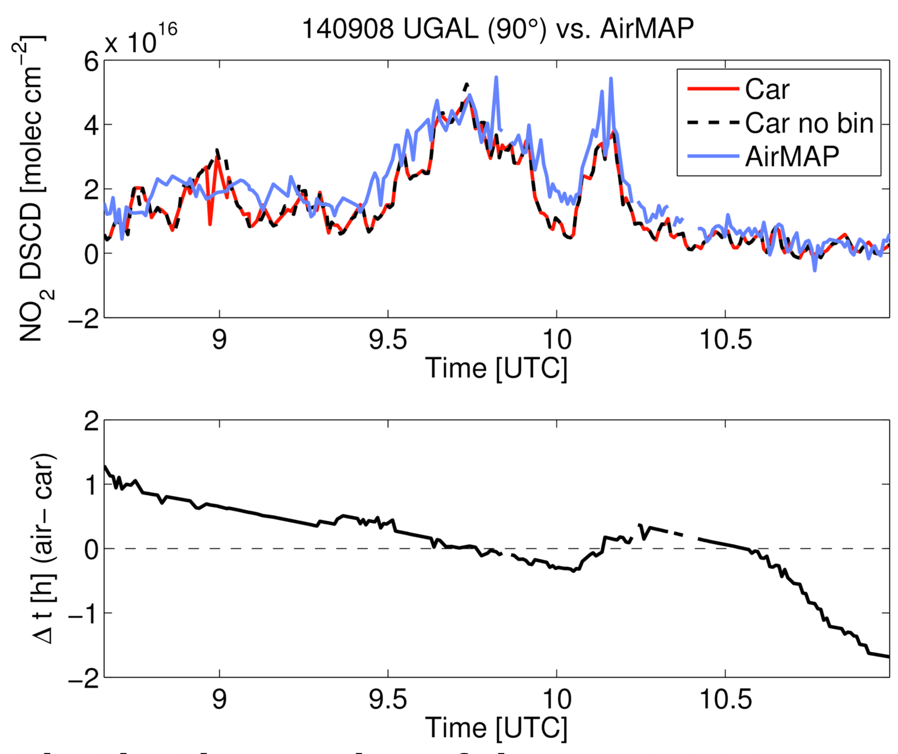

Fig 5b: Time series of the car-DOAS measurements. Additionally shown are the corresponding AirMAP measurements for the for car locations. The plot at the bottom shows the time difference between the measurements.

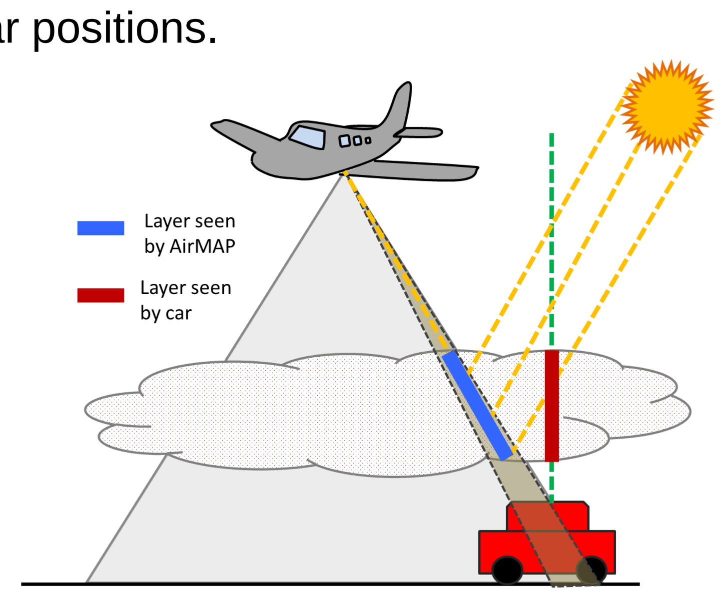

Fig 6: Sketch of the measurement geometries:
Although the measurements have the same ground location, slightly different air masses are observed. The car-DOAS instrument is looking in zenith direction, while the AirMAP measurements are deviating from nadir by the line of sight of the respective viewing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

Selected references

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- Heue et. al.: " Direct observation of two dimensional trace gas distributions with an airborne Imaging DOAS instrument". *Atmos. Chem. Phys* 8: 6707–17, 2008
- Berg, N. et.al.: " Ship emissions of SO_2 and NO_2: DOAS measurements from airborne platforms". *Atmospheric Measurement Techniques* 5 (5): 1085–98, 2012

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Acknowledgements

The authors gratefully acknowledge funding of the AROMAT campaign by ESA , and further financial support by the University of Bremen. Moreover we would like to thank the Romanian authorities for the approval of the research flights and all institutions that contributed to the successful course of the campaign.

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