AMAXDOAS NO2 and HCHO measurements during the FORMAT Campaigns

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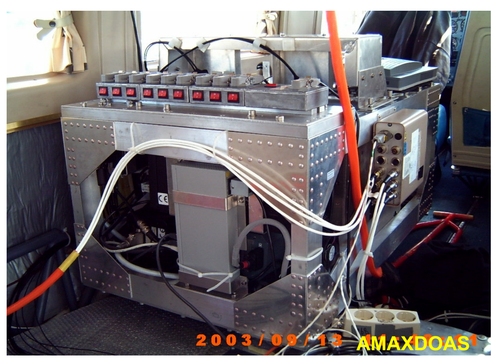
Introduction

The AMAX-DOAS (Airborne Multi-AXis Differential Optical Absorption Spectroscopy) instrument on board the Partenavia aircraft participated in two campaigns of the European FORMAT (Formaldehyde as a tracer of oxidation in the troposphere) campaign focused on measurements of HCHO pollution in the Po valley (Italy) the in August 2002 and September 2003. The AMAX instrument consists of two UV/visible grating spectrometers operated on a plane and observing scattered light from several directions simultaneously. Using the well known Differential Optical Absorption Spectroscopy (DOAS) technique, slant columns of several species that are relevant for tropospheric chemistry (O3, NO2, HCHO, SO2) can be retrieved. Using the radiative transfer model SCIATRAN, the results from the different viewing directions can be used to determine vertical columns above and below the aircraft, and to some extent also the vertical distribution.

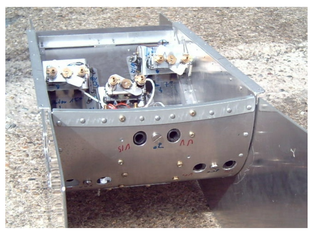
During the FORMAT campaign, the AMAX-DOAS measurements were focused on HCHO and NO2 in pollution plumes near Milano, Italy. The HCHO and NO2 results are interpreted based on the differences observed in the 10 viewing directions and during the well designed flight tracks.

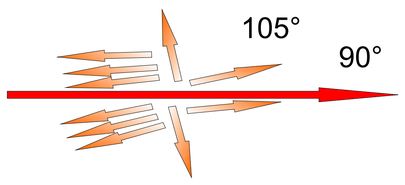
Measurements

- AMAXDOAS measures the scattered sunlight in 10 viewing directions simultaneously. The viewing directions are plotted below.
- It has two spectrometers, the wavelength ranges are 330 - 440 nm (UV spectrometer) and 440 - 570 nm (visible spectrometer).
- Light is detected by the CCD detectors cooled down to -30°C.
- The flgiht altitude is below 1500 m, in boundary layer.
- A GPS system is used to detect the altitude, position, pitch, roll and azimuth.
- The data are saved every 10 seconds (UV spectrometer) and 30s (visible spectrometer)

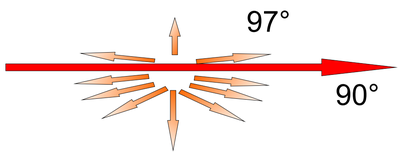


The telescopes used in the FORMAT campaign 2003





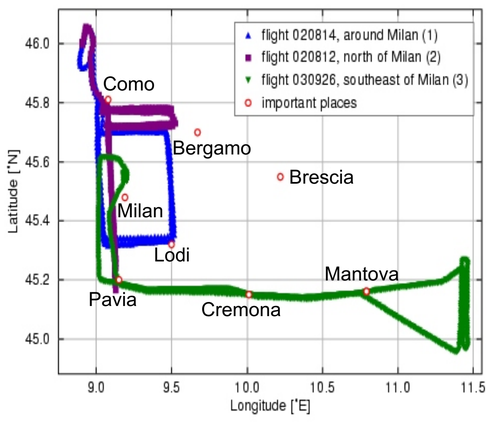
view direction in the FORMAT camapign 2002, flight direction is 90°. Viewing angles are 105°, 190°, 272°, 275°, 278°, 284°, 287°, 290°, 97°, 12° counterclockwise.



view direction in the FORMAT camapign 2003, flight direction is 90°. Viewing angles are 97°, 180°, 263°, 277°, 285°, 300°, 0°, 60°, 75°, 83° counterclockwise.

The flight tracks

Two FORMAT camapigns were performed in 2002 July-August and Sep. 2003.
There were about 20 flights, the flight routes can be divided to 3 types
1) flight around Milan city to study urban pollution,
2) flight at the north of Milan, in some relatively clean areas.
2) flight to the southeast of Milan, around some factories, to determine the pollution from the point sources.
The typical flight tracks are plotted in the right figure with some important places, large cites or factories.



Acknowledgements

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Avionik Straubing, Aerport Lugano and Milano Control (for being allowed to fly these Flight tracks in these altitudes).
Special thanks to our pilot Georg Vogl and all the others who helped us during the campaigns.

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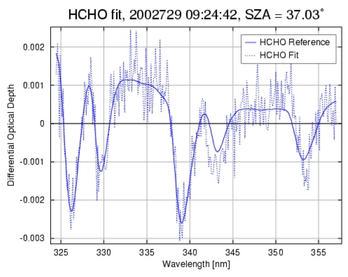
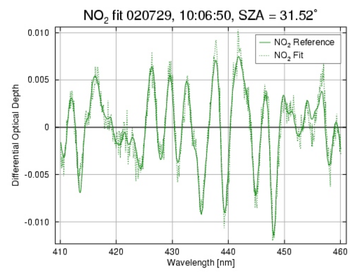
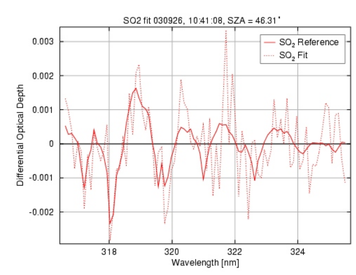
Results

Examples of the DOAS fit

The data analysis was performed using the DOAS method. During the campaign we detected the NO2, HCHO, SO2 and O3 absorption. Here are some typical fit results at the polluted area.

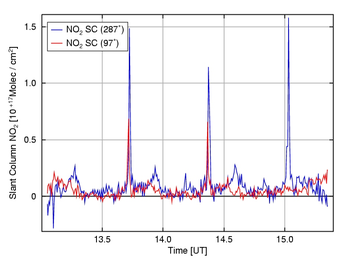


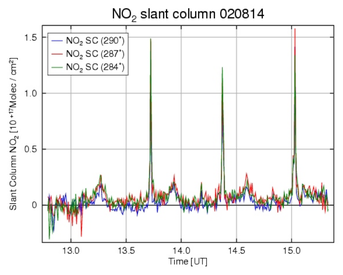




NO2 HCHO slant columns

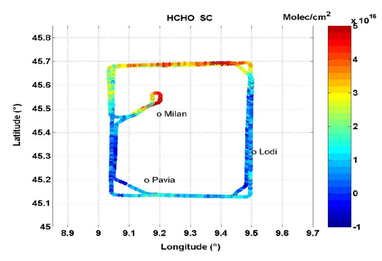
During the fligth on August 14th, 2002, AMAXDOAS measured NO2, HCHO in all the view directions. The flight altitude was 1400m on that day, the NO2 and HCHO were mainly below the aircraft. The slant column in viewing directions, 290°,287°, 284° were very similar on this day, which indicates that the pollutants are well mixed in the boundary layer.

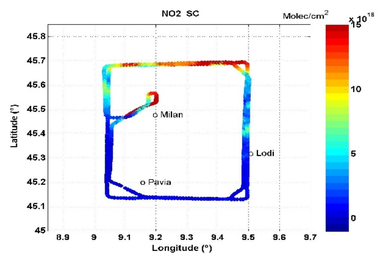


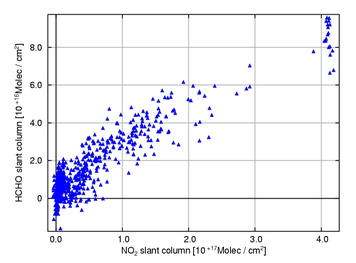


NO2 point source and polluted area are both detected during the same flight. The flight track was repeated three times so we see the NO2 peaks three times.

On Sep. 18th, the same flight route was taken as on Aug. 14th, 2002.
We detected NO2 and HCHO increases at the north part of the flight, which is similar as last year but no NO2 point source. The NO2 and HCHO slant columns are correlated.
The NO2 and HCHO slant column along the flight track are from the 97° viewing direction. The flight altitude was about 700 m, which is in the NO2 and HCHO plume.







Summary and Conclusions

- During the FORMAT campaign, the AMAXDOAS instrument has for the first time been used for measurements in the lower troposphere.
- NO2, HCHO, SO2 absorptions could clearly be identified in the measurements.
- The measurements are consistent with respect to spectral range (UV / vis), viewing directions (forward / backward and upward / downward) and repeated flights.
- Plumes of NO2 and HCHO in the boundary layer could be identified on many occasions.
- During the campaigns NO2 was measured both as point source and well-mixed pollution. No point source for HCHO was detected.
- The NO2 and HCHO vertical column can be derived from zenith and nadir viewing direction with a radiative transfer model. The NO2 vertical column will be compared with in-situ measurement because there are lots of in-situ NO2 measurement in Lombardy region.
- The point source maybe difficult to get the accurate concetration but it is a good case study for the tomograph.

Selected References

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see also: www.doas-bremen.de