Tower DOAS off-axis measurements of NO2 in Vienna

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Motivation

The VINDOBONA project:
- The main goal of the project is to improve our current knowledge of air pollution in large agglomerations caused by mankind
- The investigation of nitrogen dioxide (NO2) and aerosol amounts is based on spectral measurements from two MAX-DOAS instruments located at two different sites with ideal measurement conditions in Vienna, Austria

Aims of this study:
- Use an advanced miniature spectrometer and perform off-axis measurements from a rotating tower platform
- These measurements have the potential to provide averaged NO2 mixing ratios at 160 m altitude

DOAS data analysis

Fit settings:
- Fitting window: 425-497 nm
- Polynomial order: 2
- Single reference zenith-sky measurement
- Cross sections: O2 (223 K, Serduchko et al., 2014) NO2 (226 K, Vandaele et al., 1996)
- O2 (229 K, Thalmann and Vollmer, 2013) HCHO (229 K, Rothmann et al., 2010)
- Ring (SCIATRAN, Rozanov et al., 2014)

- Exemplary fit results of the DOAS analysis for a horizontal spectrum on 29 April 2016 (upper)
- NO2 cross section (green) as scaled for NO2 absorption
- NO2 absorption is probed by the instrument
- The residuals are shown in the lower plot

Time series of NO2 and O4 columns

Cloudless, but hazy conditions on 29 April 2016
- Reference zenith-sky measurement was taken afterwards (SZA = 63.4°)
- Almost: 4 rounds of measurements
- NO2 (green) and O4 (blue) columns show variation as a function of azimuth angle

Broken clouds (not in the field of view) on 10 May 2016
- Reference zenith-sky measurement was taken afterwards (SZA = 45.61°)
- 9 rounds of measurements
- NO2 (green) and O4 (blue) columns show less variation as a function of azimuth angle

Temporal evolution of NO2

22 April 2016 (Friday afternoon)
- Low wind speeds (5-10 km h⁻¹)
- Wind direction from north-westly directions
- NO2 amounts were highest towards South
- Only slightly changing with time
- 9 May 2016 (Monday morning)
- Relatively high wind speeds (15-25 km h⁻¹)
- Wind mainly from south-easterly directions
- Decreasing NO2 amounts throughout the morning hours (morning rush-hour traffic)

29 April (Friday morning)
- Very low wind speeds (less than 5 km h⁻¹)
- Wind direction from easterly directions
- NO2 maximum distribution centered towards southerly directions (factor of 2 when compared to other days)
- 10 May 2016 (Monday morning)
- Relatively high wind speeds (up to 20 km h⁻¹)
- Wind from south-easterly directions
- Lower NO2 amounts than the day before
- Large change of NO2 amounts throughout the day

References & Acknowledgements

- Financial support was provided by the University of Bremen and the Austrian Science Fund (FWF) I 2296-N29
- We thank Marius Meyer and the Donauturm staff for hosting us during our measurements

Set-up of tower DOAS measurements

- Determination of azimuth viewing directions:
  - Donauturm does not provide information on position
  - GPS mouse was unable to reliably determine position
  - DC Tower (220 m) comes into field of view once every rotation
  - Signal loss
  - Position of DC Tower from Donauturm is 167°

Geographical distribution of NO2

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Estimates of averaged NO2 mixing ratios

The mountain MAX-DOAS approach:
- Assumption that the signal for horizontal measurements (α = 0°) is dominated by the horizontal part of the light path after the last scattering event
- Added value of these observations will be important when having both MAX-DOAS instruments and Car DOAS measurements operating at the same time (VINDOBONA project)

- Measurements from Donauturm have potential to provide averaged NO2 mixing ratios at about 160 m altitude for all directions
- In this study, NO2 mixing ratios are obtained for two single rounds (close to the reference measurement) on a day with good visibility

Summary & Outlook

- Measurements went well and simple
- Donauturm personnel was very helpful
- Reference zenith-sky measurement was only taken once (outside) after off-axis measurements (inside)
- Long-term deployment of instrument was not yet discussed
- More reference zenith-sky measurements are needed for better quantification of NO2 amounts
- Added value of these observations will be important when having both MAX-DOAS instruments and Car DOAS measurements operating at the same time (VINDOBONA project)

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http://www.doas-vindobona.at/