Bremian **A**dvanced **M**AX-DOAS Retrieval Algorithm

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BREAM

during CINDI

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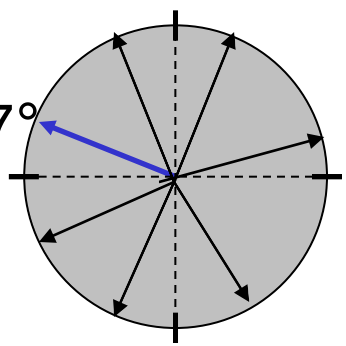
Outline

- Bremian MAX-DOAS during CINDI
- The algorithm BREAM
- Results
- Summary and Outlook

iup Bremen – MAX-DOAS during CINDI

Several azimuthal viewing directions:



16 (20) Lines of sight:

- **0°, 1°, 2°, 3°, 4°, 5°, 6°, 8°, 10°, 15°, 30°, ZS**
  30° (and 4°) in 5 (6) azimuth angles
- Integration time: 40 to 120 s
- **Full scan duration: 15 min or 4 scans per hour (on July 2 test with fast scans)**

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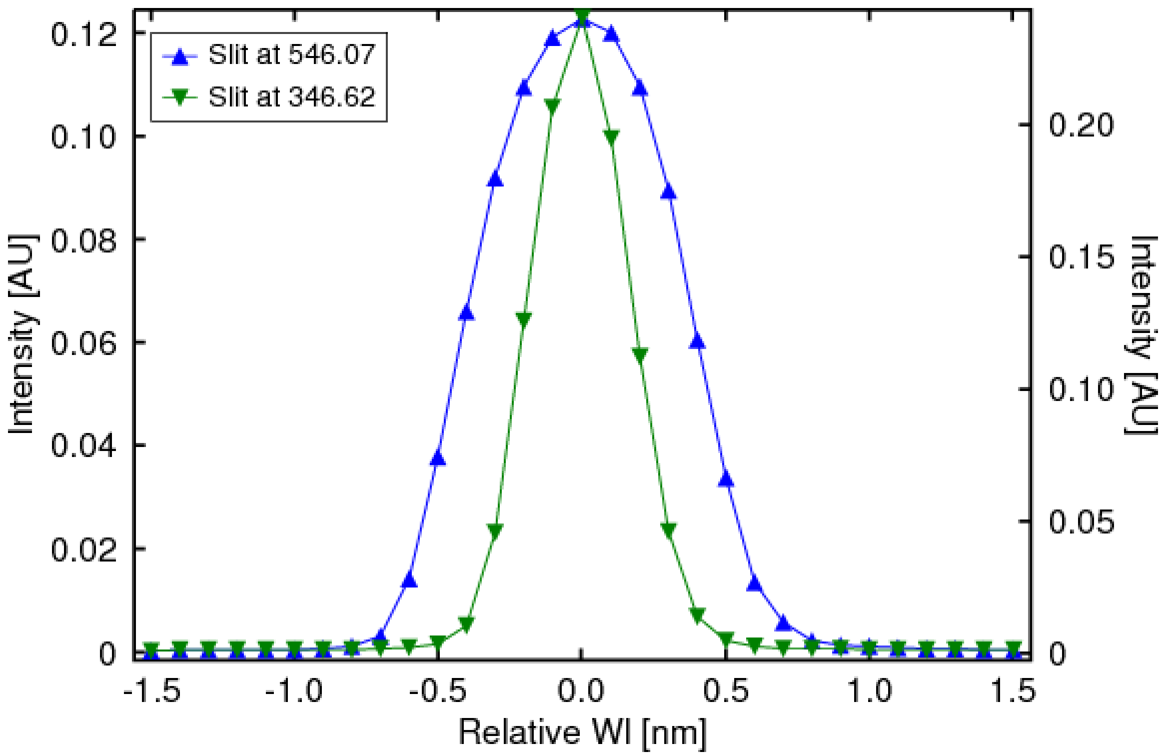
Basic spectral parameters:

- No slit! Direct fibre output ~150 µm
- FOV ~ 1°
- UV:
  - **315 – 384 nm**
  - 0.034 nm/pixel
  - FWHM 0.37nm
  - Oversampling 11
- Visible:
  - **400 – 573 nm**
  - 0.129 nmpixel
  - FWHM 0.8 nm
  - Oversampling 6.3



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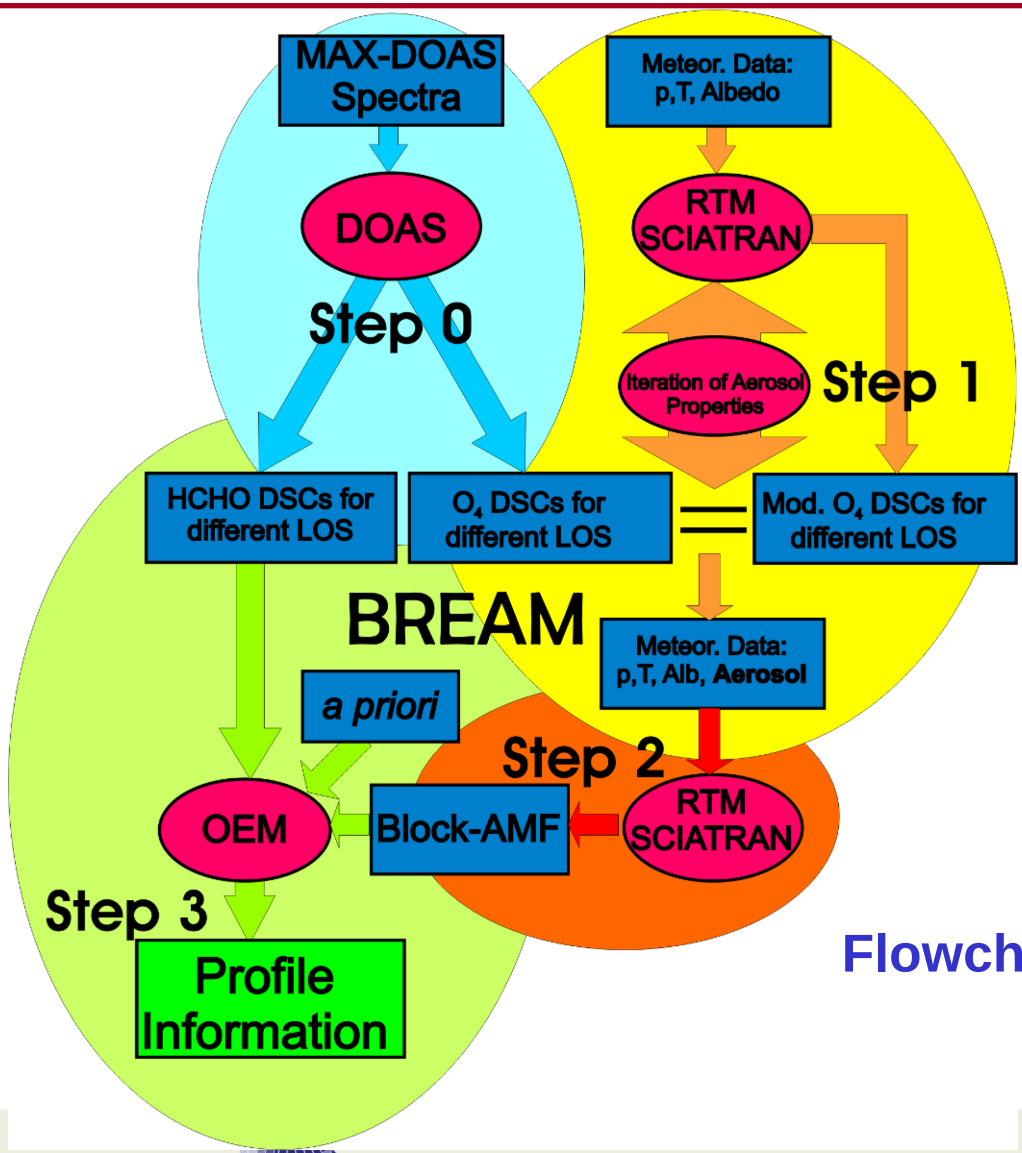
Data sets available:

- measurements from afternoon June 11 to July 21 in UV and visible, off-axis up to 92° SZA, zenith sky up to 95°
  - small data gaps on June 13 am, June 23 late pm, July 3 am – all less than 2 hours
  - big data gap from July 11 to 16!
- small pointing error (about 0.3°, due to wooden foundation?) corrected on June 28
- NO_2, O_4, intensities for UV and visible, HCHO, CHOCHO uploaded on cindi-share (all available days until July 21), BrO in preparation

Bremian Advanced MAX-DOAS Retrieval Algorithm - BREAM



Flowchart for BREAM

Optimal Estimation Method

- Optimal Estimation (Rodgers 1976, 1990, 2000)

$$y = K \bullet x$$

$$x = x_a + (K^T \cdot S_\varepsilon^{-1} K + S_a^{-1})^{-1} K^T S_\varepsilon (y - K x_a)$$

y measurement

x_a apriori profile

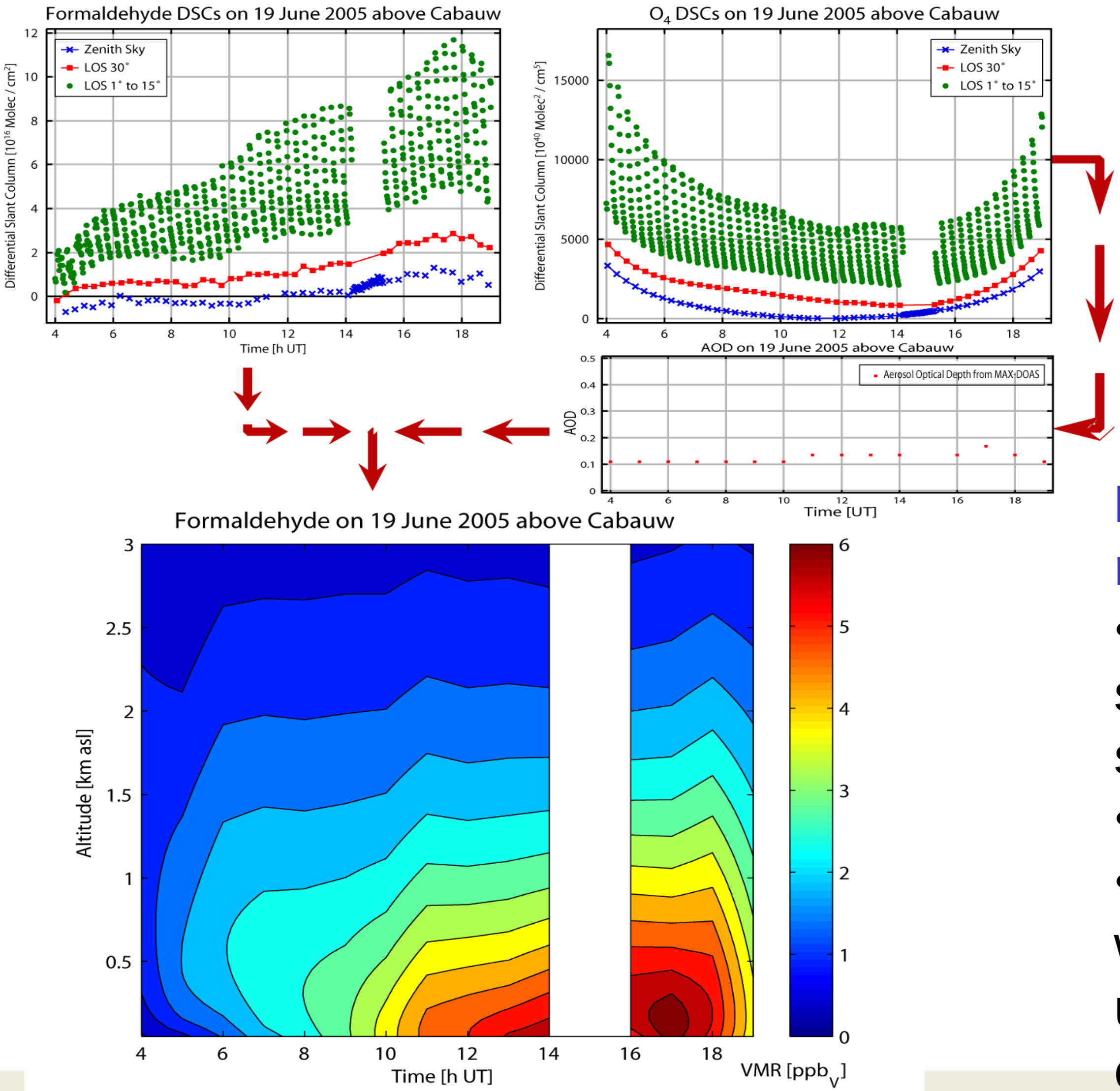
S_ε and S_a uncertainty covariance matrices

K Weighting functions

$$K(i,j) = \frac{BDAMF(i,j) \cdot p(j) \cdot R \cdot N_A}{T(j)} \cdot \Delta h$$

extra diagonal values on S_a to account for correlations between trace gas values on different altitude levels (Barret et al., 2002, Hendrick et al., 2004)

Bremian Advanced MAX-DOAS Retrieval Algorithm - BREAM



Example of input data and results for BREAM

- usually one hour temporal steps comprising 3 to 5 scans
- retrieval grid 50 m
- for NO_2 and aerosol two wavelength regions are used to benefit from different effective light paths

Retrieval settings

Forward Model SCIATRAN

- calculates O4 DSCs and NO2 BAMF for given wavelengths and viewing geometries
- P,T, O_3 : MPI monthly climatology
- surface albedo: lambertian = 0.05

- Fixed aerosol type (mixture of six different aerosol types)

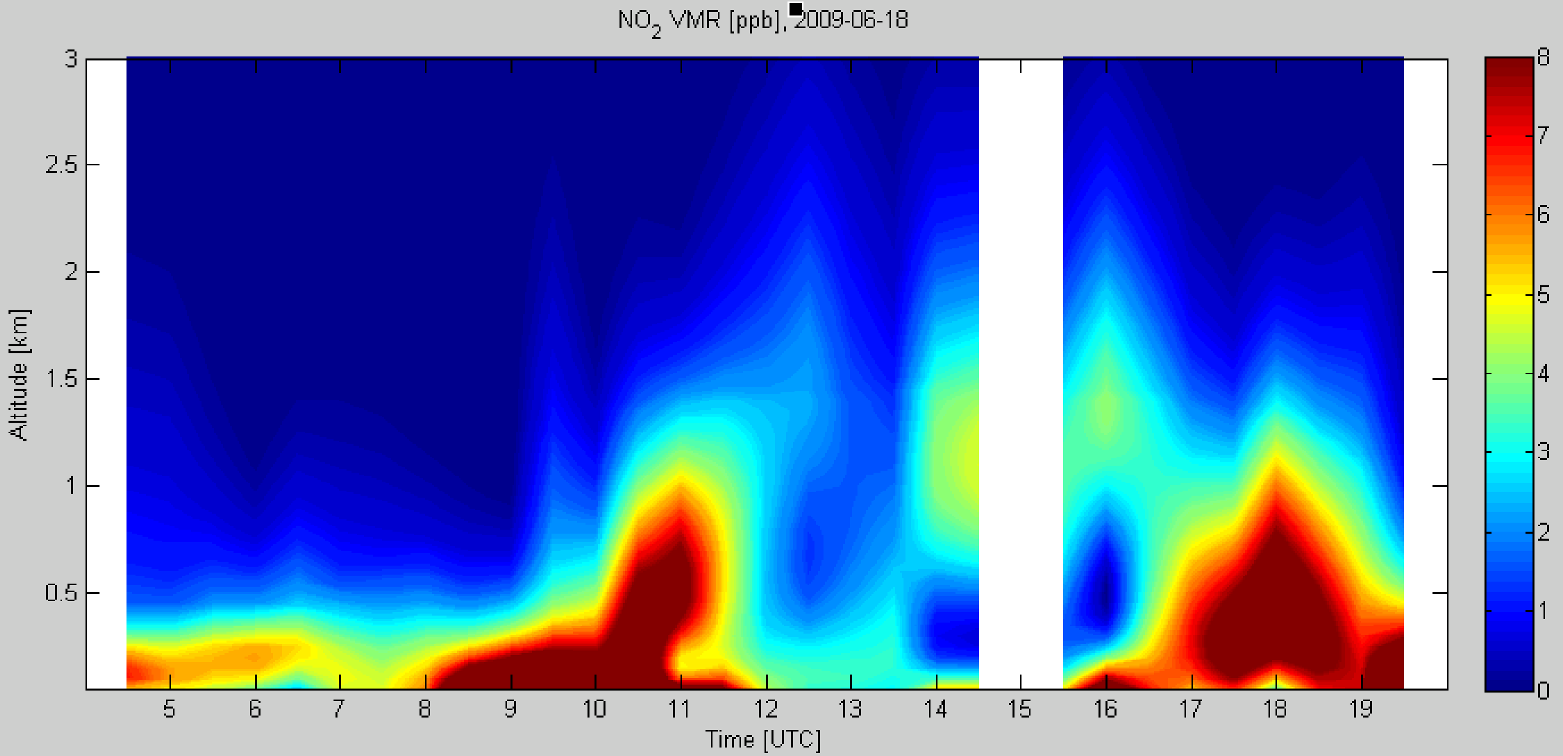
Calculation of O_4 DSCs for least squares fit

- aerosol extinction profile: constant in boundary layer, exponential decrease above
- constant value (0.1 1/km) is scaled with factors between $1/1.25^4$ and 1.25^4
- Boundary layer height varies with time according to climatology

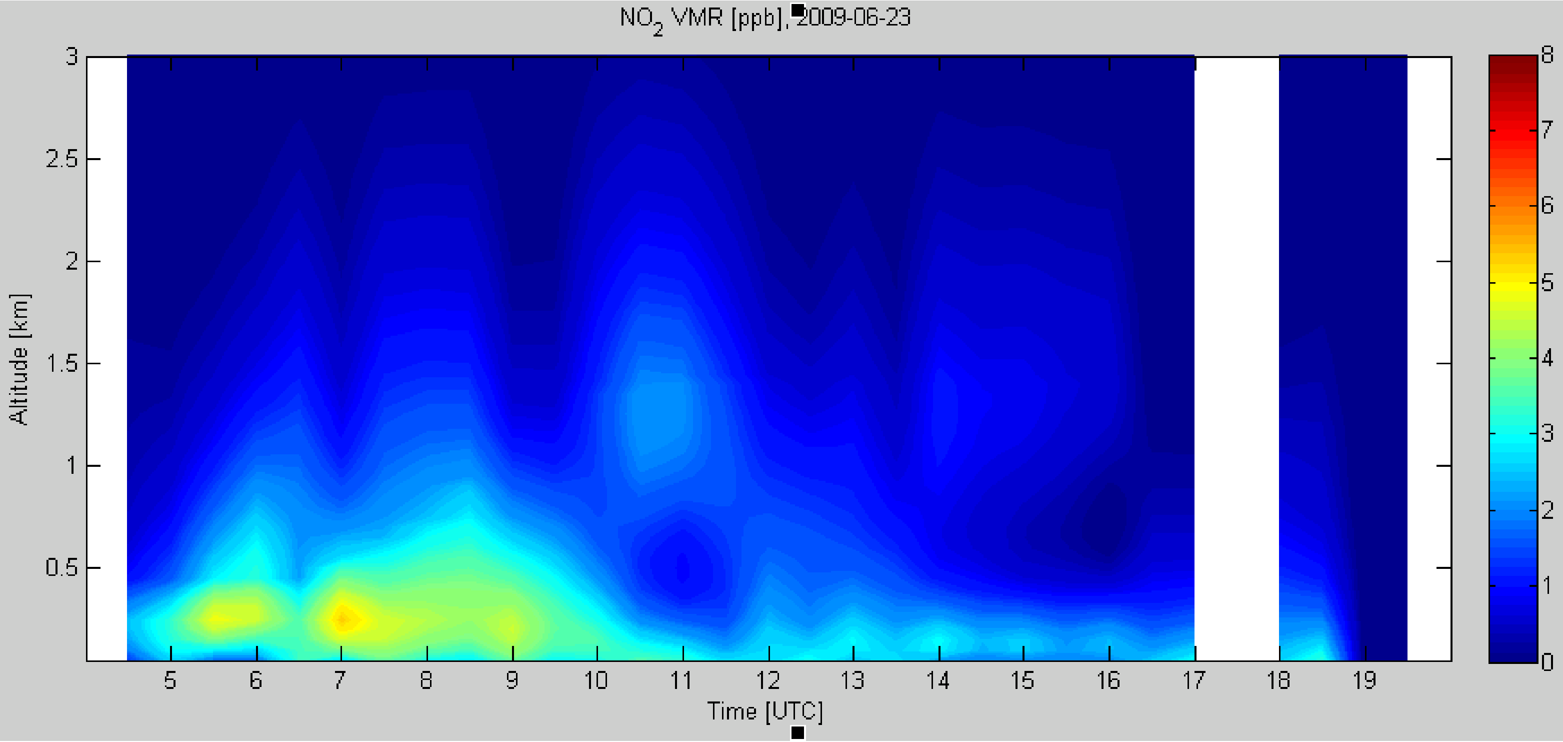
Optimal Estimation for trace gas

- 0.3 ppb in the lowest layer, 0.01 at 4 km, linear decrease between
- S_ε: diagonal, (DSCD error)^2
- S_a: 0.7, 0.0125 km correlation length
- grid step 50m, range 0-4 km.
- linear equation for OE
- standard retrieval for visible only, no azimuth scans included

CINDI results



CINDI results



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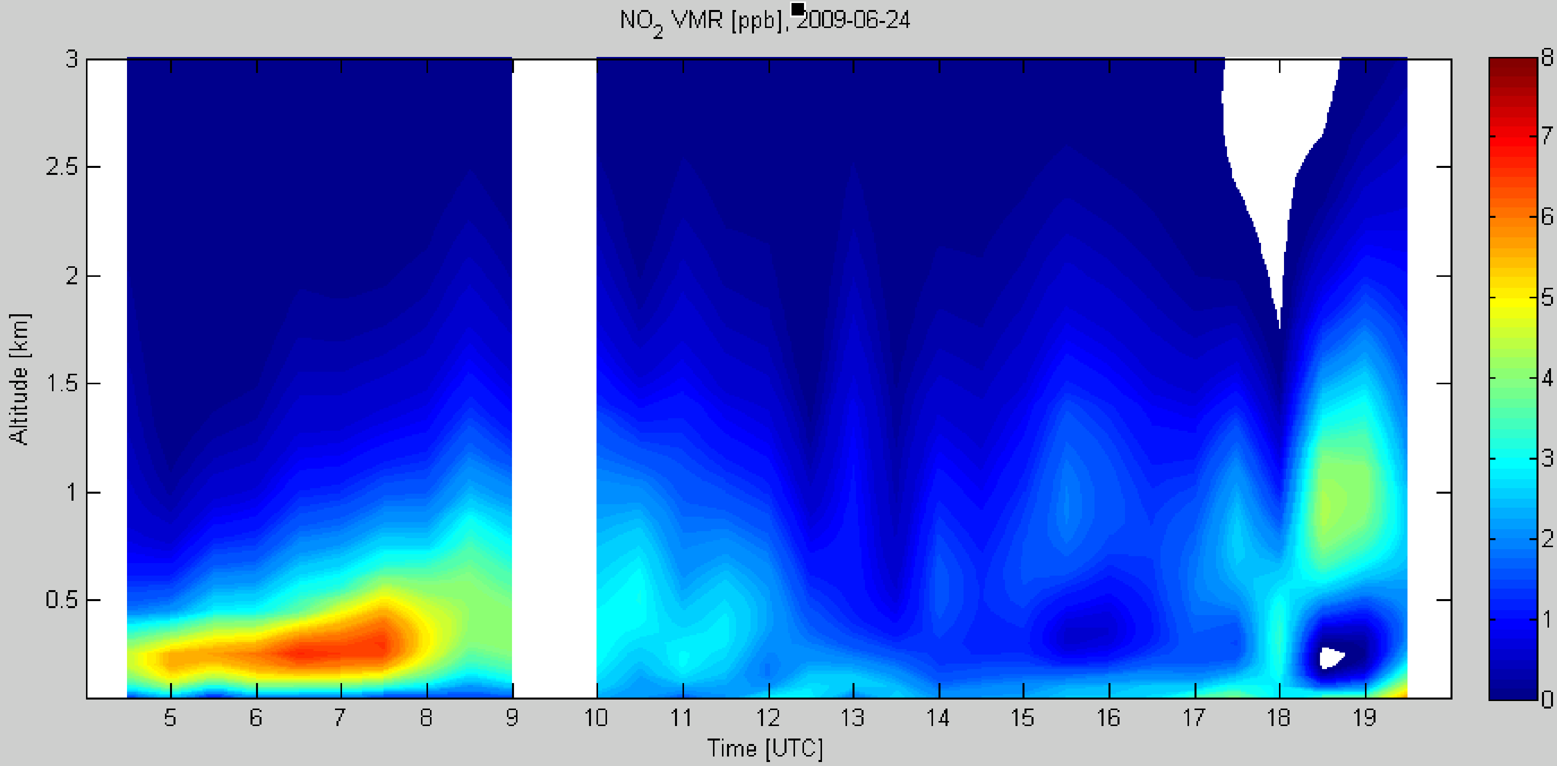
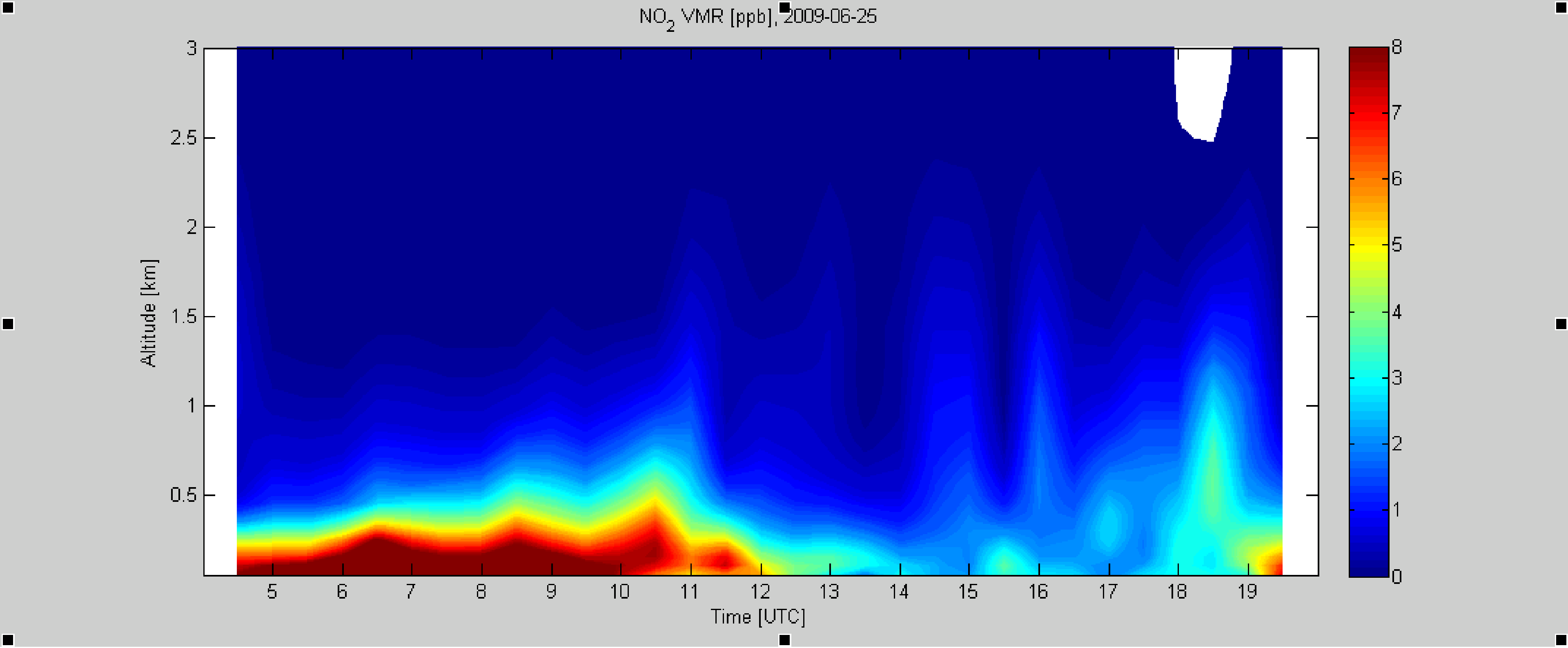


CINDI results



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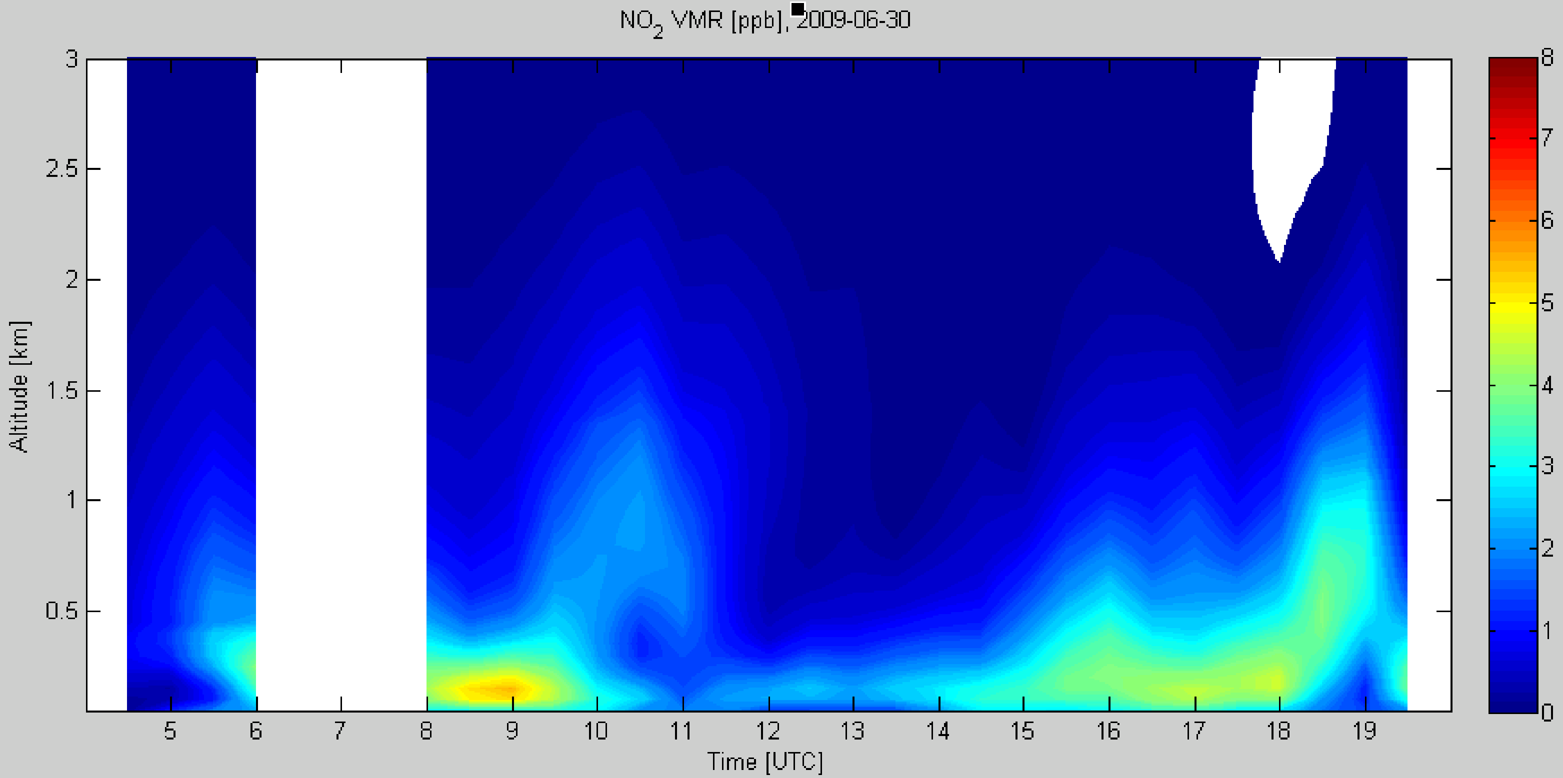

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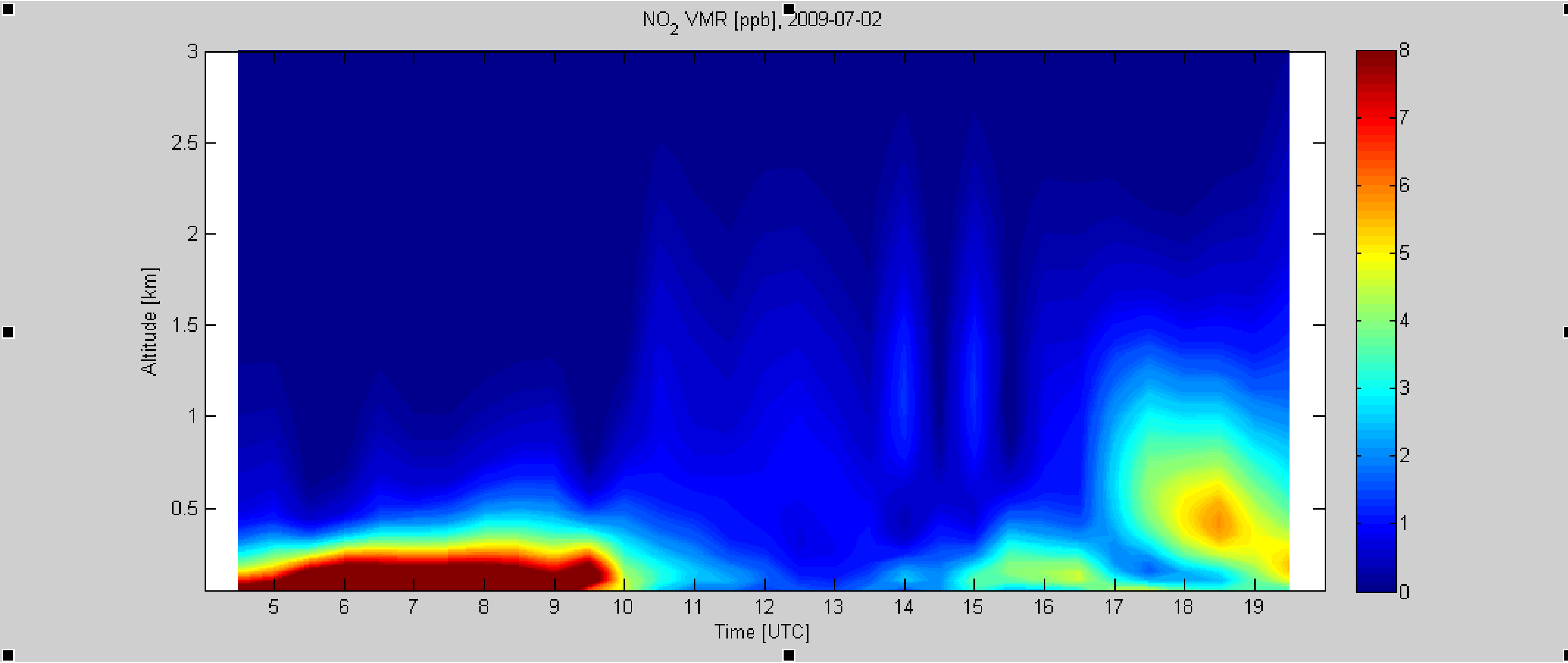

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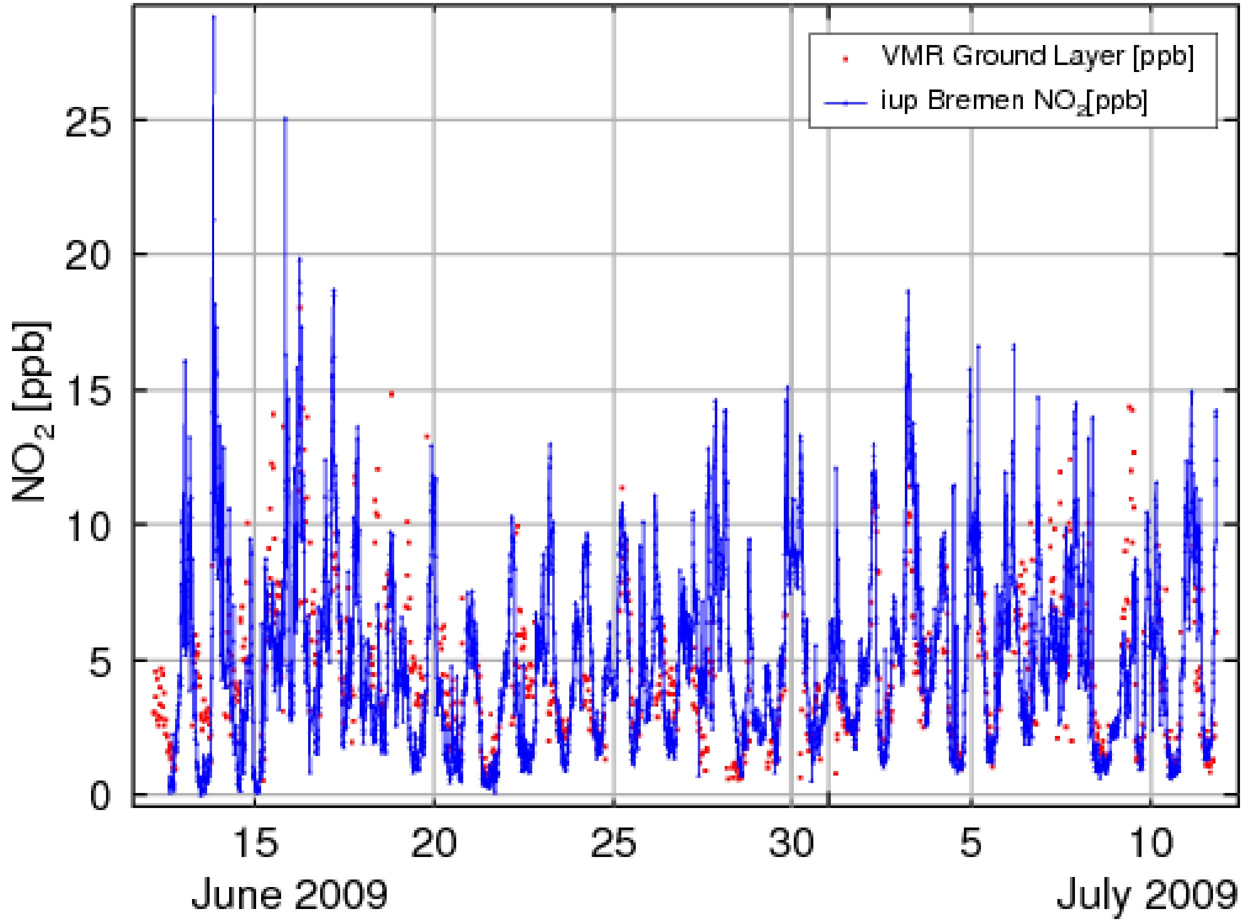

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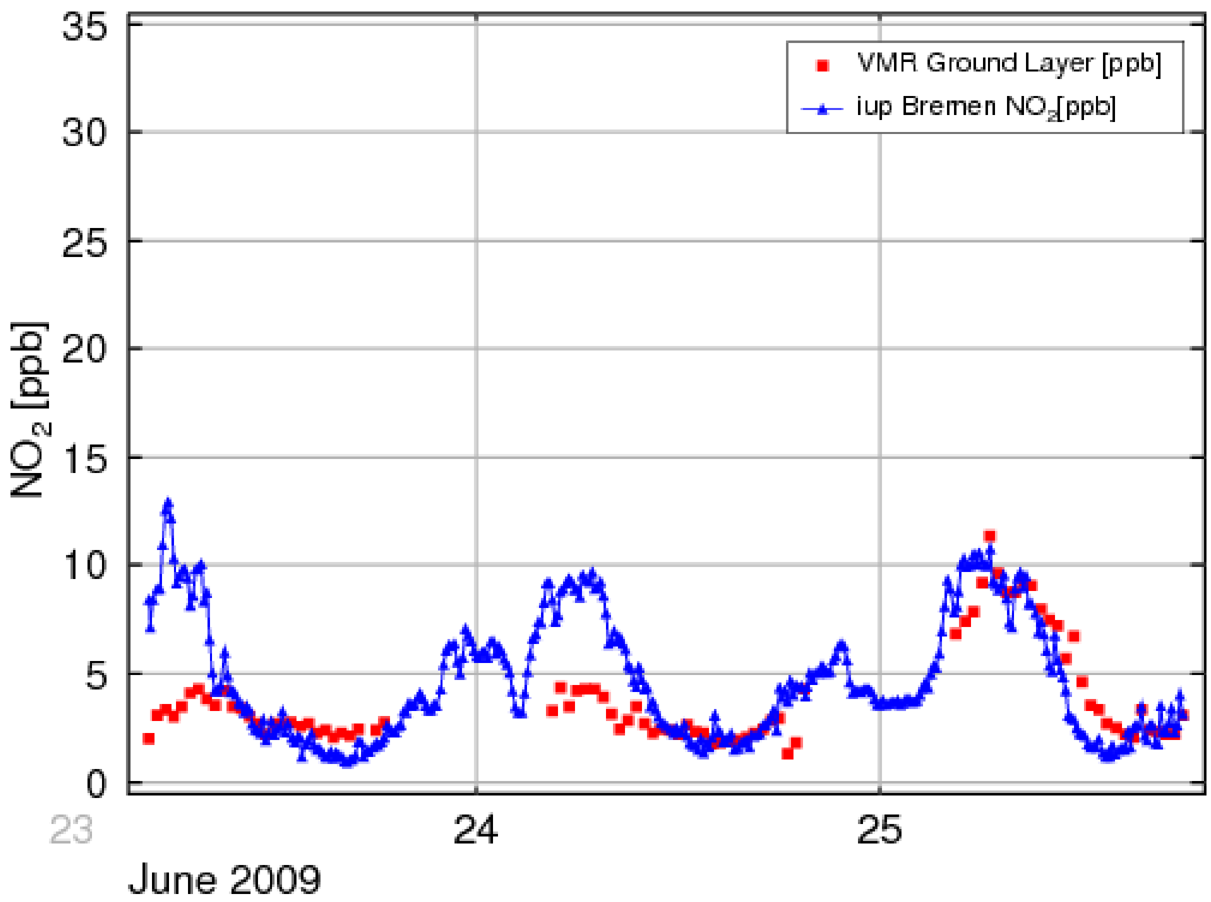

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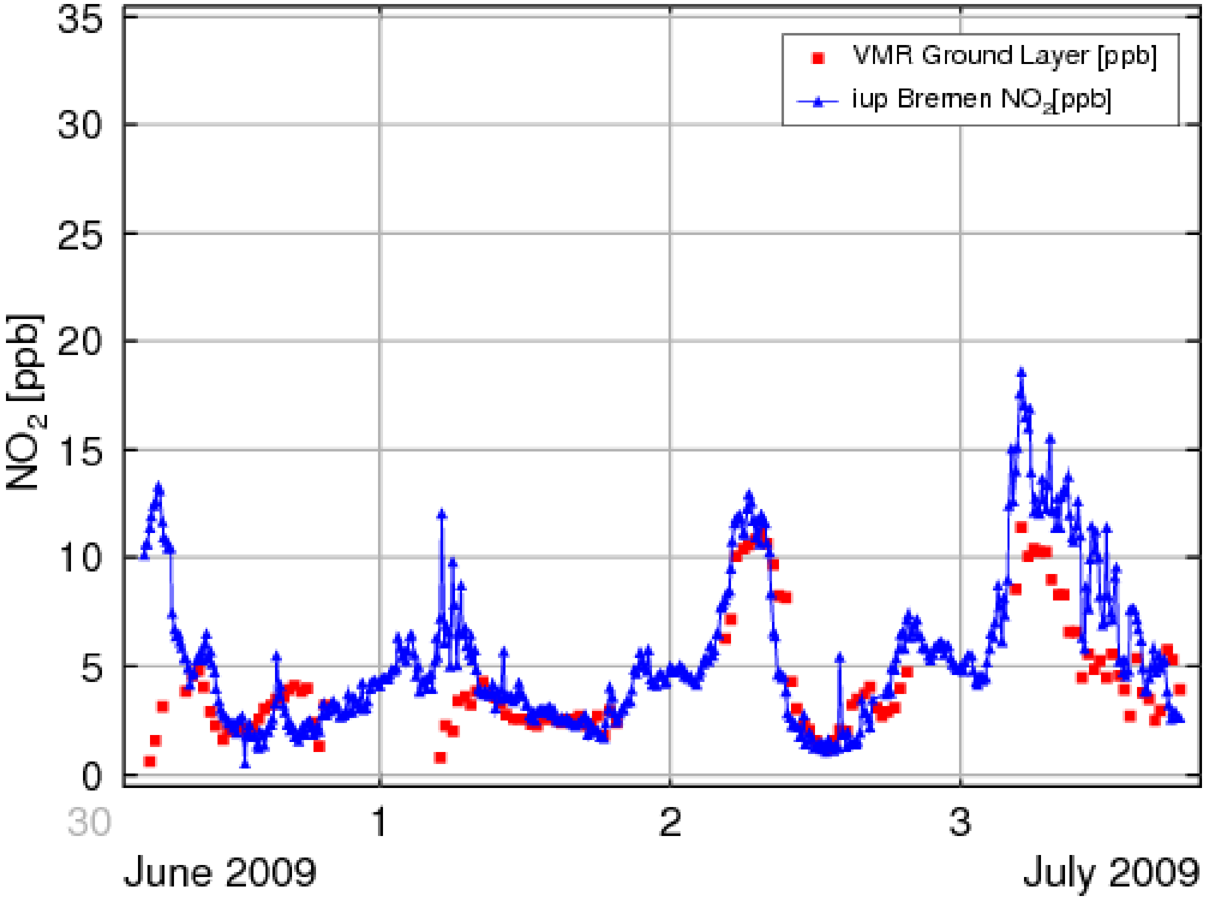

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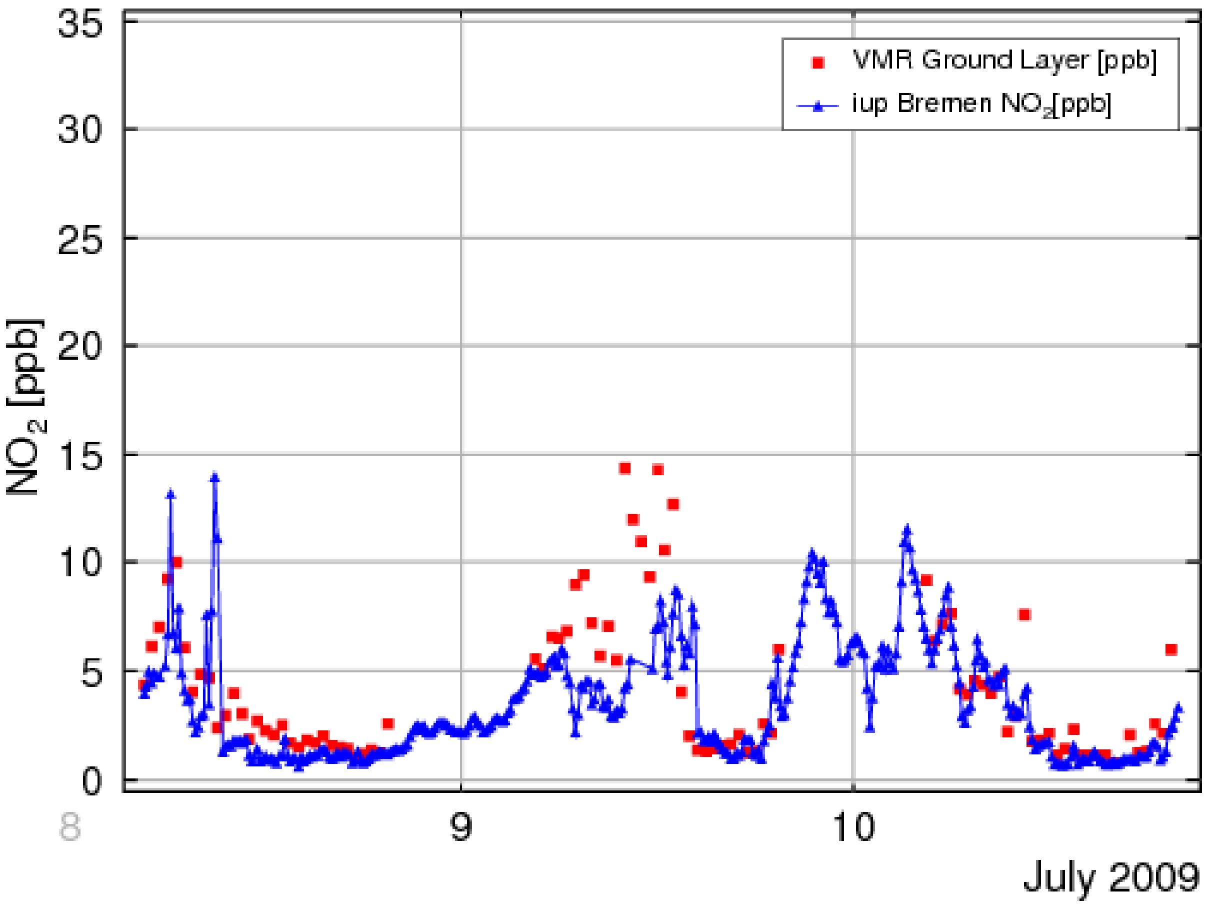

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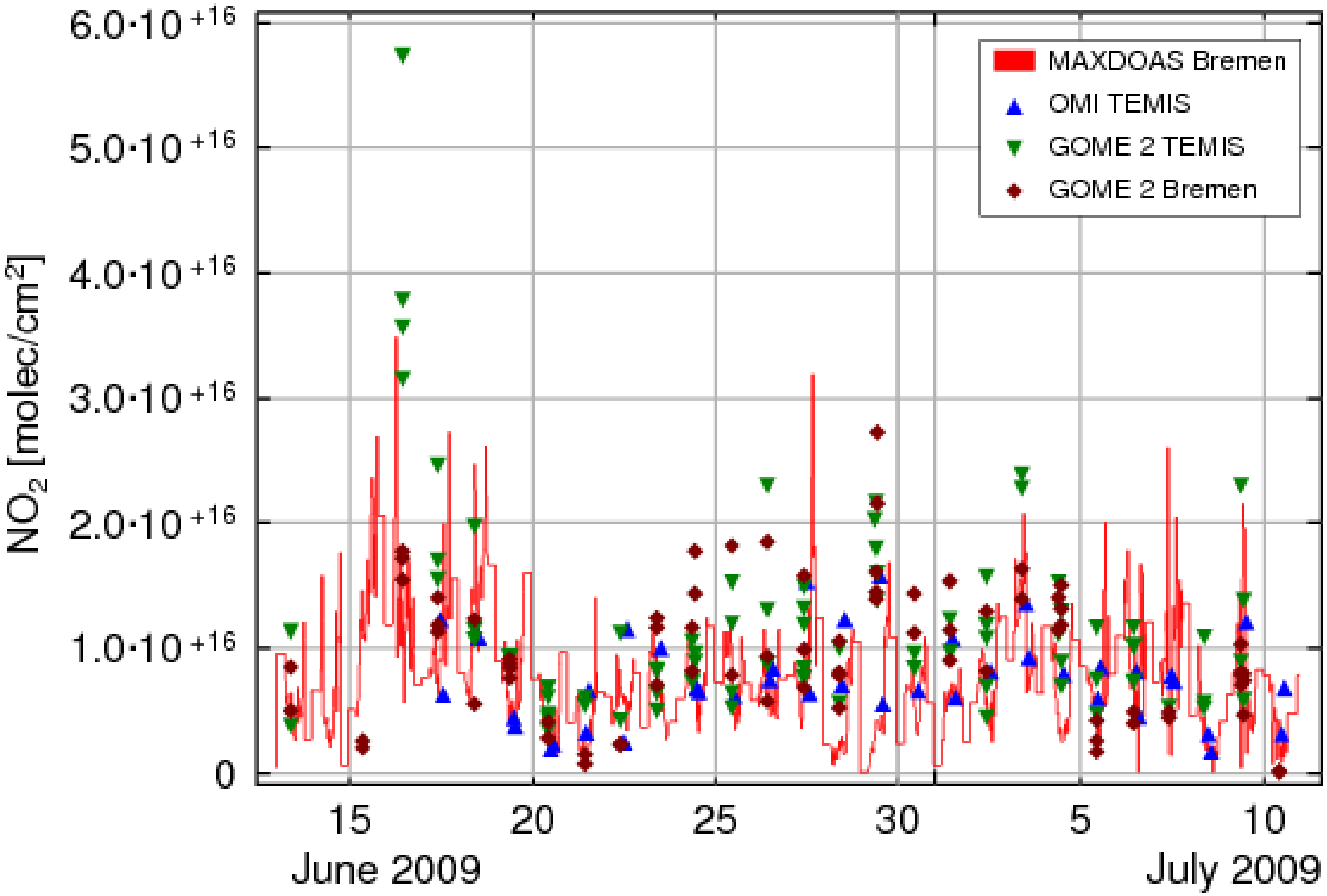

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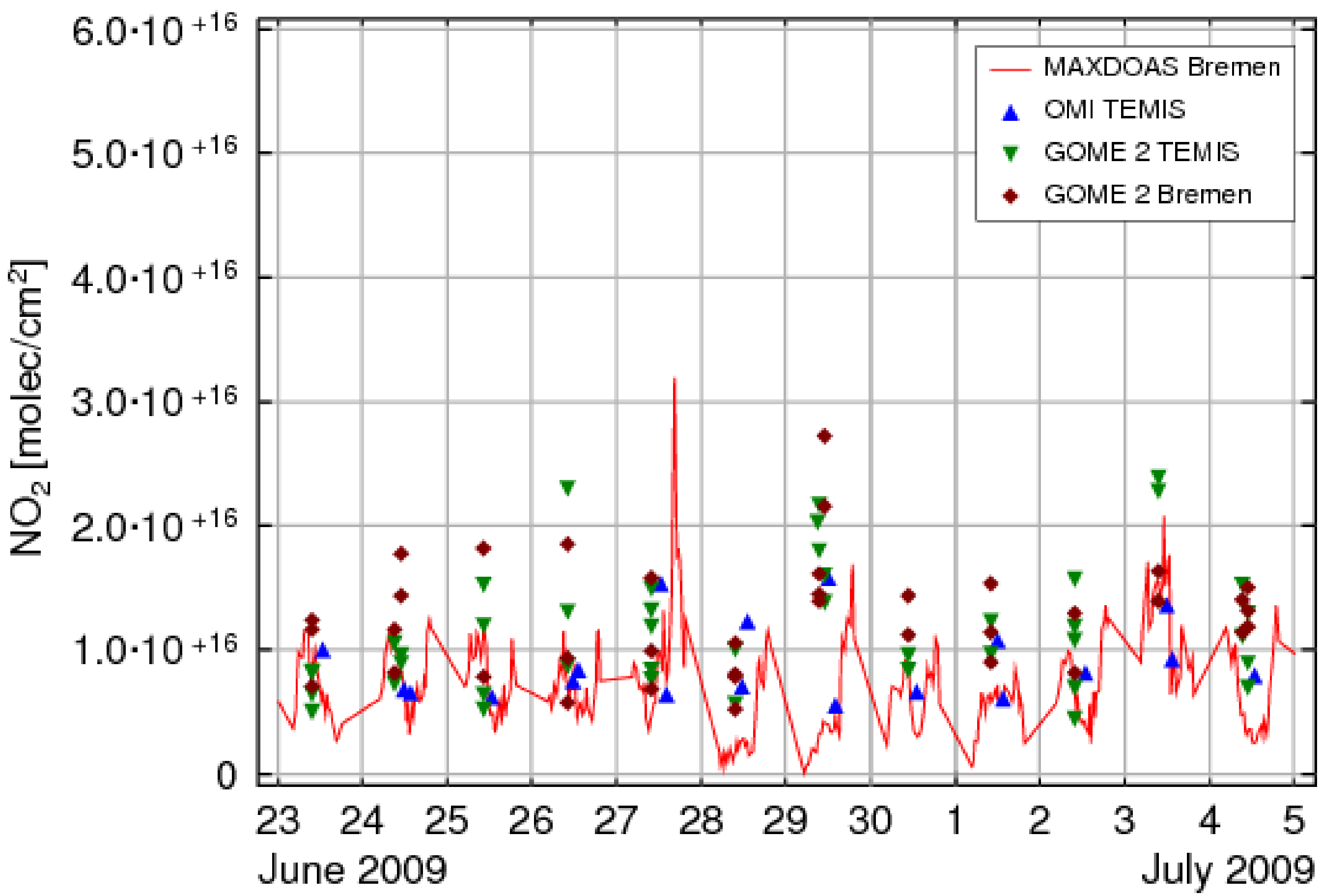

Conclusions

- NO_2 profile data set from June 12 to July 21 with a gap from July 11 to 16
- reasonable agreement between BREAM results and other instruments
- on several days underestimation of the NO_2 in the lowest layer during morning hours by more than a factor of 2, e.g. June 23, 24, 30 -> the reason for this is not clear