Validation and Verification of S5P NO_2 using ground-based, airborne and satellite data (VVS5P)

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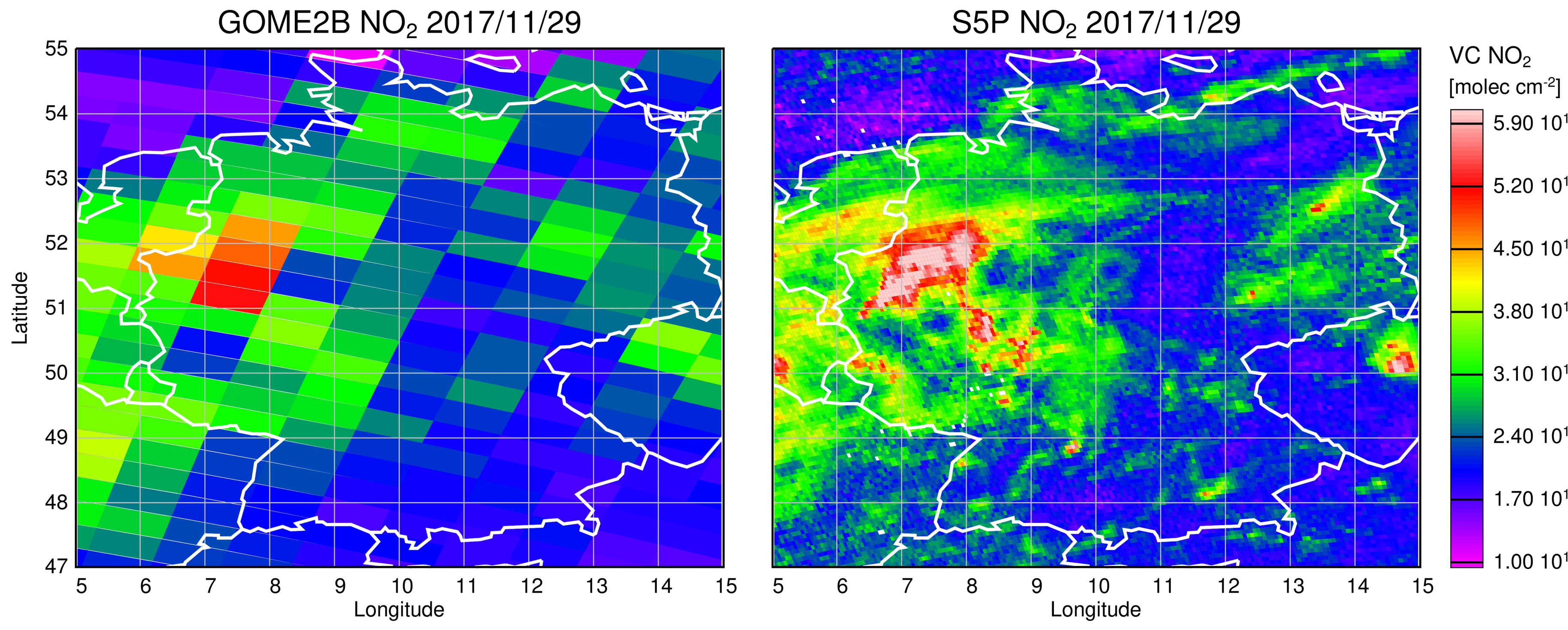


First IUP S5P NO_2 retrievals (stratospheric AMF, no cluod screening)

- good qualitative agreement with GOME2B retrievals
- very large improvement in spatial resolution, very good noise level

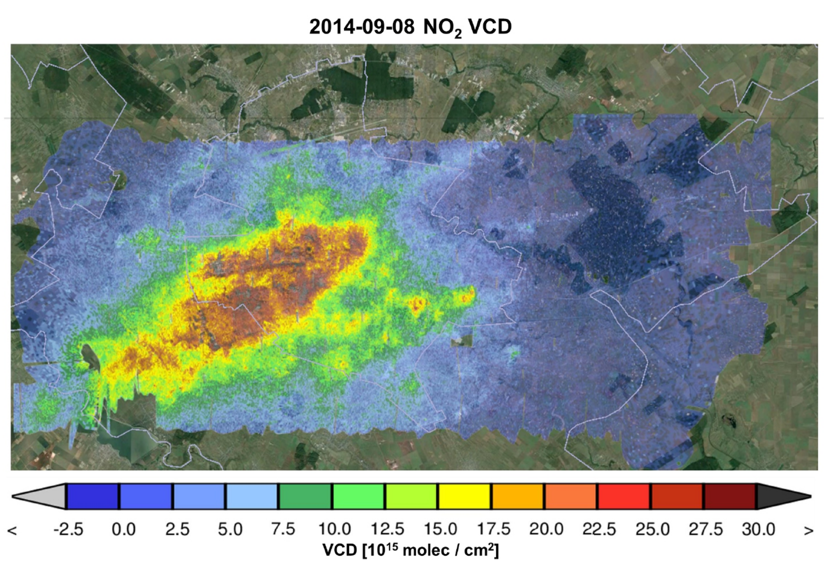
Introduction

- TROPOMI on Sentinel-5P will continue the time series of GOME / SCIAMACHY / OMI / GOME-2 nadir UV/vis observations
- it provides both tropospheric and stratospheric NO_2 columns
- spatial resolution will be much improved compared to current sensors

Challenges for S5P NO_2 validation

- are S5P columns consistent with those from other sensors?
- are S5P columns accurate and precise without temporal drift?
- is random noise in S5P NO_2 data as low as predicted?
- are spatial details in S5P tropospheric NO_2 columns reliable or are they limited by uncertainties in the a priori assumptions (NO_2 profile, surface spectral reflectance, aerosols, ...)?
- are there any calibration / retrieval related artefacts in the data (stripes, offsets, saturation, ...)?

Airborne Validation with AirMap



Typical measurements

- NO_2 map over Bucharest September 8, 2014
- part of ESA funded AROMAT campaign low wind speeds => pollution build-up
- flight time approx. 2.5 hours
- large spatial gradients over size of one S5P pixel
- individual hotspots and larger city plume
- large variability from day to day

Benefit for S5P validation

- only method able to spatially average over a full S5P pixel in a short time
- tropospheric column measured is very close to S5P product
- important information on sub-pixel variability in NO_2 (SO_2 / HCHO)
- verification of spectral surface reflectance assumptions
- ideal link between network of ground-based or car-borne DOAS observations

Plans for S5P validation

- if funded: participation in S5P validation campaign
- if funded: targeted flights over regions with large NO_2 gradients
- if funded: targeted flights over ares with variable surface reflectance

Summary

- S5P tropospheric and stratospheric NO_2 columns will be validated using three approaches:
  - validation with ground-based MAX-DOAS
  - validation with airborne mapping observations
  - comparison with IUP-UB retrievals on GOME-2, OMI and S5P spectra
- a special focus will be on spatial variability and the role of a priori assumptions

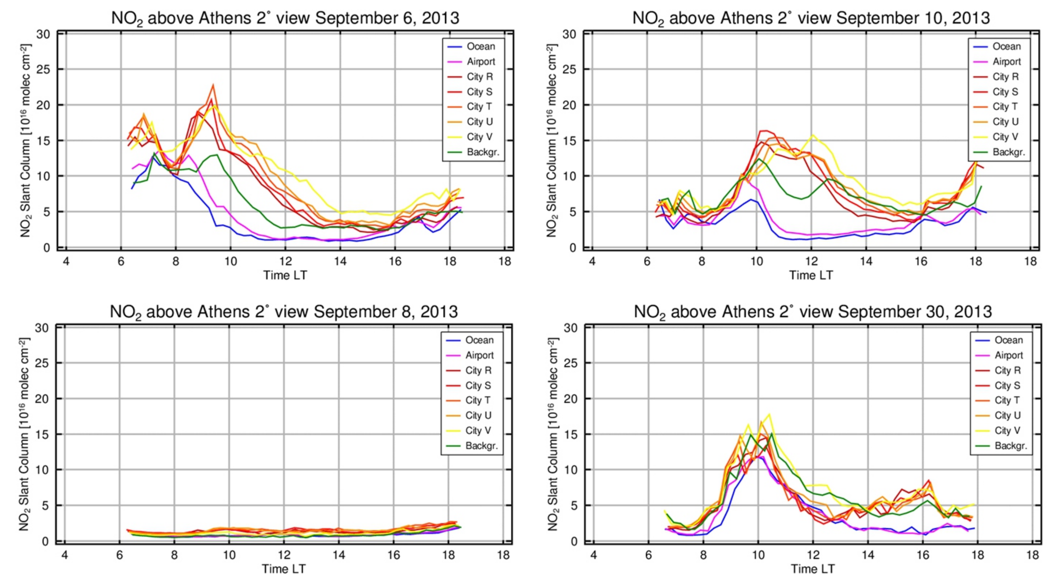
Funding for ground-based validation through DLR project MAXGRAD (50 EE 1709 A)
Funding for airborne validation not yet secured

Universität Bremen

Groundbased MAX-DOAS Validation

Approach

- ground-based MAX-DOAS observations of the BREDOM network
- Multi-Axis observations for vertical profiles, several azimuthal directions for horizontal variability
- stations in Ny-Ålesund, Bremen, Athens, and Vienna
- comparison of stratospheric NO_2 columns (interpolated from twilight measurements), tropospheric columns (from horizon observations)
- evaluation of tropospheric profiles used as S5P a priori

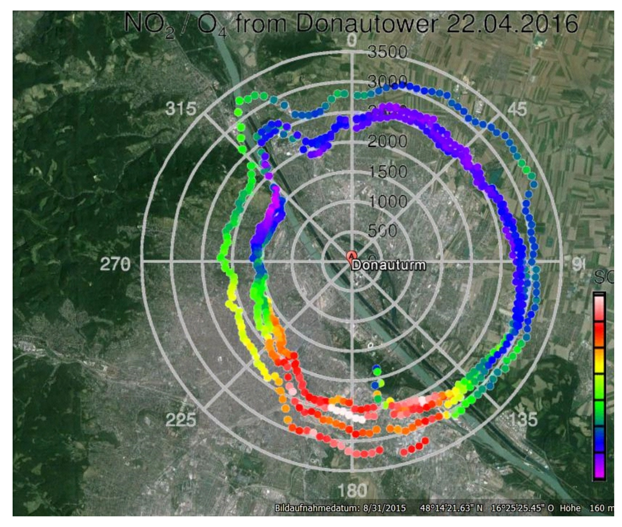


Example

- MAX-DOAS measurements in Athens on different days in 8 azimuthal directions
- large spatial and temporal variability is captured

Benefit for S5P validation

- continuous validation data set covering latitudes from 40°N to 80°N
- stratospheric and tropospheric columns of NO_2 (O_3, HCHO)
- lower tropospheric vertical profiles of NO_2 => relevant for check of S5P a priori profiles
- information on spatial gradients within one S5P pixel



Plans for S5P validation

- continuous operation of stations in Bremen, Ny-Alesund, Athens, and Vienna
- intensive validation campaigns in Vienna including car-DOAS and measurements from Donau Tower
- validation of S5P stratospheric and tropospheric NO_2 using all ground based observations
- statistical validation analysis following the approach taken for SCIAMACHY and GOME-2
- particular focus on spatial gradients
- contribution to community validation projects

Example

- DOAS measurements from the Donau Tower in Vienna on April 22, 2016
- horizontal light path in 160 m altitude
- radius is proportional to O_4 column, colour code is NO_2 / O_4
- large spatial gradient with much higher NO_2 values in the city centre
- some variability in time

Satellite-Satellite Comparison

Approach

- use of IUP-UB processor to analyse GOME-2, OMI and S5P spectra for NO_2
- comparison of large dataset with respect to absolute values, drifts, and systematic differences
- advantage is large number of coincidences and consistency in quantity compared
- disadvantage is similarity in approach => not an independent validation

Benefit for S5P validation

- large number of matching points
- full coverage of parameter space (latitude, season, SZA, VZA, pollution levels, surface properties etc.)
- relevant for use of S5P data in long-term trend analysis
- relevant for verification and algorithm refinements

Plans for S5P validation

- comparison of tropospheric and stratospheric NO_2 columns with IUP-UB OMI product
- comparison of tropospheric and stratospheric NO_2 columns with IUP-UB S5P analysis when available
- comparison with GOME2 IUP-UB product (correction for overpass time necessary)
- statistical analysis for latitude, season, SZA, VZA, cloud fraction and altitude, ...
- if deemed useful: stepwise variation in IUP-UB analysis settings to identify S5P lv2 problems

Selected References

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see also: www.iup.uni-bremen.de/doas