Investigation of NO$_2$ vertical distribution from satellite data by using two NO$_2$ DOAS retrievals

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1 Motivation & Introduction

- NO$_2$ is one of the most important air pollutants
- Catalyses ozone production, causes summer smog, acid rain, and adds local radiative forcing
- NO$_2$ emission sources and their horizontal distribution are well known from satellite measurements
- Knowledge of the vertical NO$_2$ distribution is only limited

DOAS: Differential Optical Absorption Spectroscopy

- Based on Lambert-Beer’s law: $I/I_0 = \exp(-\alpha N l)$
  - $I$: wavelength; $\alpha$: amount of absorbers
  - $l$: light path

- May be used for ultra violet (UV) and visible (vis) light

- Amount of trace gases can be derived from the absorption
  - ==> slant columns (SCs) can be calculated

- Rayleigh scattering in the atmosphere depends on the wavelength
  - Larger wavelength: larger penetration depth than smaller wavelength

- Vertical sensitivity of NO$_2$ measurements
- NO$_2$ SCs derived from the visible are mostly higher than from the UV spectral range

- Vertical sensitivities, expressed as box air mass factors (BAMFs)
- Can be calculated with the radiative transfer model SCIAMACHY to investigate the differences between the UV and visible spectral ranges

- Above 9 km, the sensitivity is slightly higher in the UV, while below 9 km, the sensitivity is considerably higher in the visible spectral range

- To get additional knowledge about NO$_2$ vertical distribution:
  - Develop new NO$_2$ retrieval for UV spectral range based on satellite observations from GOME-2

2 The NO$_2$ retrievals and datasets

- Fit settings of NO$_2$ retrievals:
  - UV NO$_2$ fit
    - fitting window: 342 – 361.5 nm
    - polynomial degree: 3
    - cross sections:
      - $O_3$, NO$_2$, O$_3$, BrO, HCHO, Ring
    - instrumental function:
      - Zeta
  - vis NO$_2$ fit
    - fitting window: 425 – 450 nm
    - polynomial degree: 3
    - cross sections:
      - $O_3$, NO$_2$, O$_3$, HCHO, Ring
    - instrumental function:
      - Zeta

- The dataset is from 2007 to 2015
- UV NO$_2$ VCs have a larger spread (7.4 x 10$^{14}$ molec cm$^{-2}$) compared with vis NO$_2$ VCs (2.1 x 10$^{15}$ molec cm$^{-2}$)

3 Comparison of global NO$_2$ SCs

- Global distribution of monthly mean tropospheric NO$_2$ SCs for both spectral ranges and their ratio
- Differences are mostly located in areas with high anthropogenic air pollution
- We provide a NO$_2$ DOAS fit in the UV spectral range for GOME-2/MetOp-A satellite data

4 Comparison of time series of NO$_2$ SCs

- Time series from 2007 to 2015 for different regions. The upper three plots are for biomass burning regions and the lower plots are regions with high anthropogenic air pollution

5 Summary & Outlook

- We provide a NO$_2$ DOAS fit in the UV spectral range for GOME-2/MetOp-A satellite data

- The patterns of SCs derived from vis and UV spectral ranges agree well, however UV NO$_2$ values are smaller than vis NO$_2$ values
- NO$_2$ retrieval in the visible spectral range is more sensitive to the lower troposphere
- Possibility to assess vertical distribution of NO$_2$
- Large differences in NO$_2$ values in areas with high anthropogenic air pollution

- Next step: comparison of NO$_2$ VCs, we can get additional information about height dependency

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