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1 Motivation & Introduction

- NO₂ is one of the most important air pollutants
- catalyses ozone production, causes summer smog, acid rain, and adds local radiative forcing
- NO_x emission sources and their horizontal distribution are well known from satellite measurements
- knowledge of the vertical NO₂ distribution is only limited

- DOAS: Differential Optical Absorption Spectroscopy
 - based on Lambert Beer's law: $I(\lambda, s) = I_0 \exp(-\sigma(\lambda) \rho s)$
 - λ : wavelength; σ : absorption cross-section; ρ : amount of absorbers
 - method to calculate the absorption of light travelling through the atmosphere
 - can 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 NO₂ measurements
- NO₂ 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 SCIATRAN to investigate the differences between the UV and visible spectral ranges
 - above 9km, the sensitivity is slightly higher in the UV, while below 9km, the sensitivity is considerably higher in the vis

=> to get additional knowledge about NO₂ vertical distribution: develop new NO₂ retrieval for UV spectral range based on satellite observations from GOME-2 on board of EUMETSAT's MetOp-A

2 The NO₂ DOAS retrievals and datasets

- fit settings of NO₂ retrievals:

	UV NO ₂ fit	vis NO ₂ fit
fitting window	342 – 361.5nm	425 – 450nm
polynomial degree	5	3
cross sections	O ₃ , NO ₂ , O ₄ , BrO, HCHO, Ring	O ₃ , NO ₂ , O ₄ , H ₂ O, Ring
instrumental function	Zeta	–

- the dataset is from 2007 to 2015
- UV NO₂ VCs have a larger spread (7.4×10^{14} molec cm⁻²) compared with vis NO₂ VCs (2.1×10^{14} molec cm⁻²)

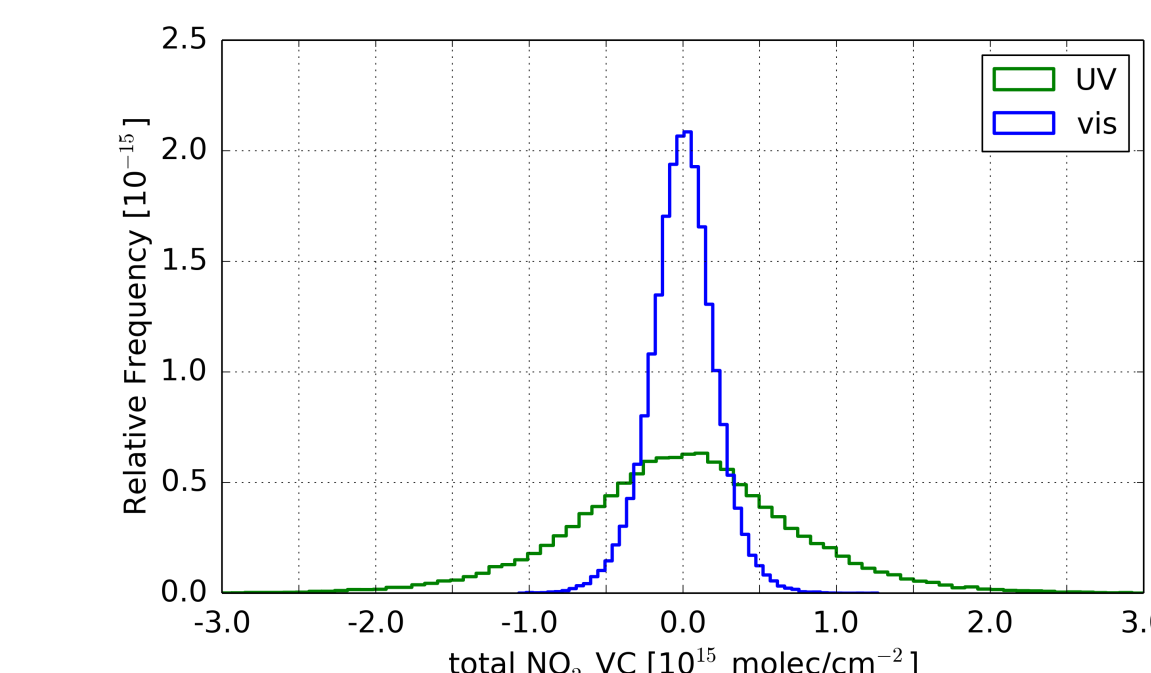


Figure 4: Scatter of NO₂ retrievals

Distribution of NO₂ VCs (January 2008) over a clean area (located over the Pacific: 5°S – 5°N, 150° – 210°E). It is assumed that there is no NO₂ in the troposphere. Therefore, a stratospheric AMF was applied to calculate NO₂ VCs. The curves are normalised and centred on zero.

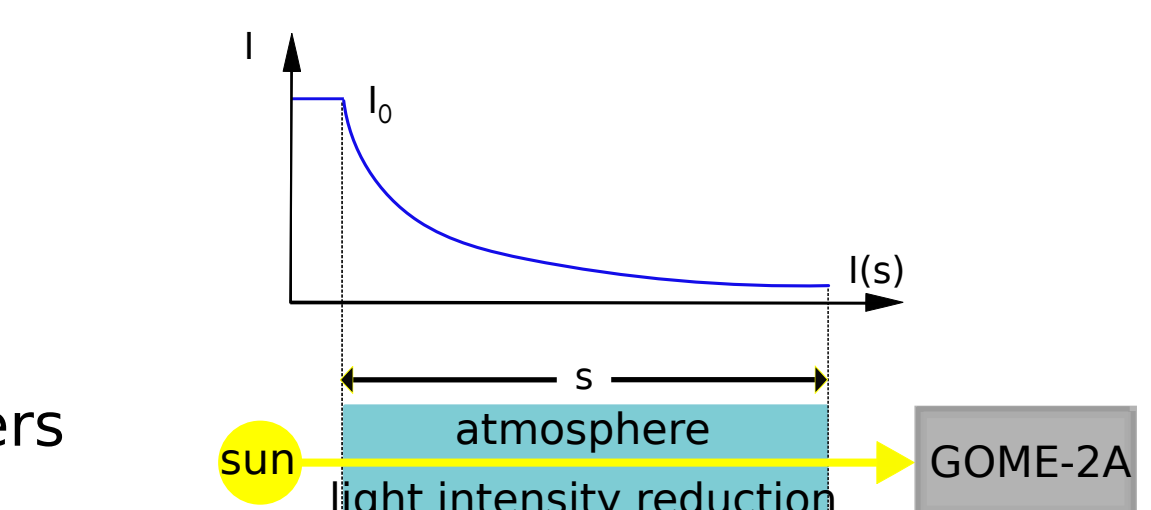


Figure 1: Illustration of the DOAS method

I : intensity at the detector
 I_0 : intensity of the light directly from the sun
 s : light path

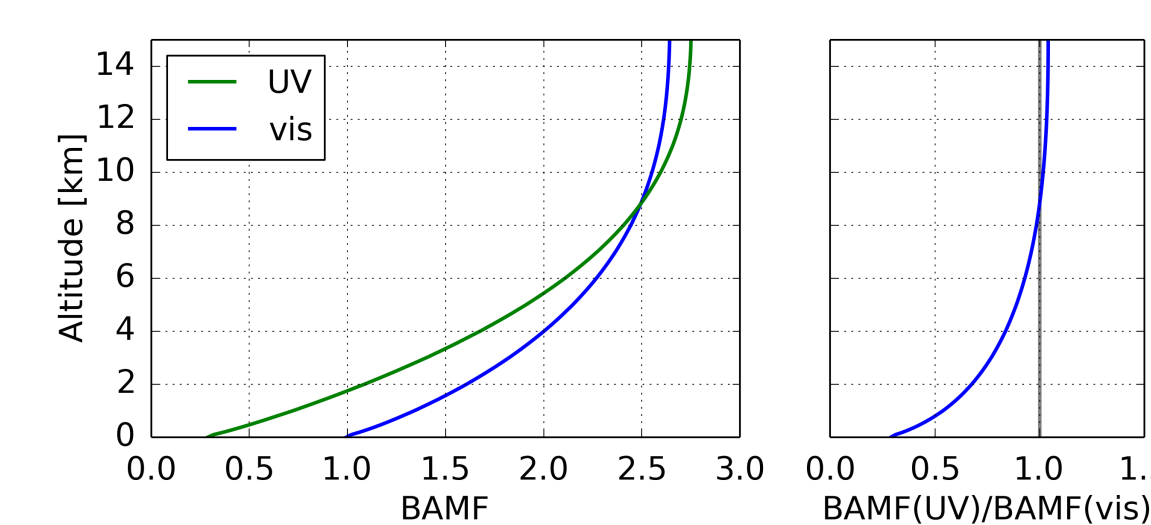


Figure 2: BAMF for both spectral ranges

BAMF for 352 nm (UV) and 438 nm (vis) with a solar zenith angle of 50°, a surface spectral reflectance of 0.04 (UV) and 0.06 (vis) and a US standard atmosphere profile.

3 Comparison of global NO₂ SCs

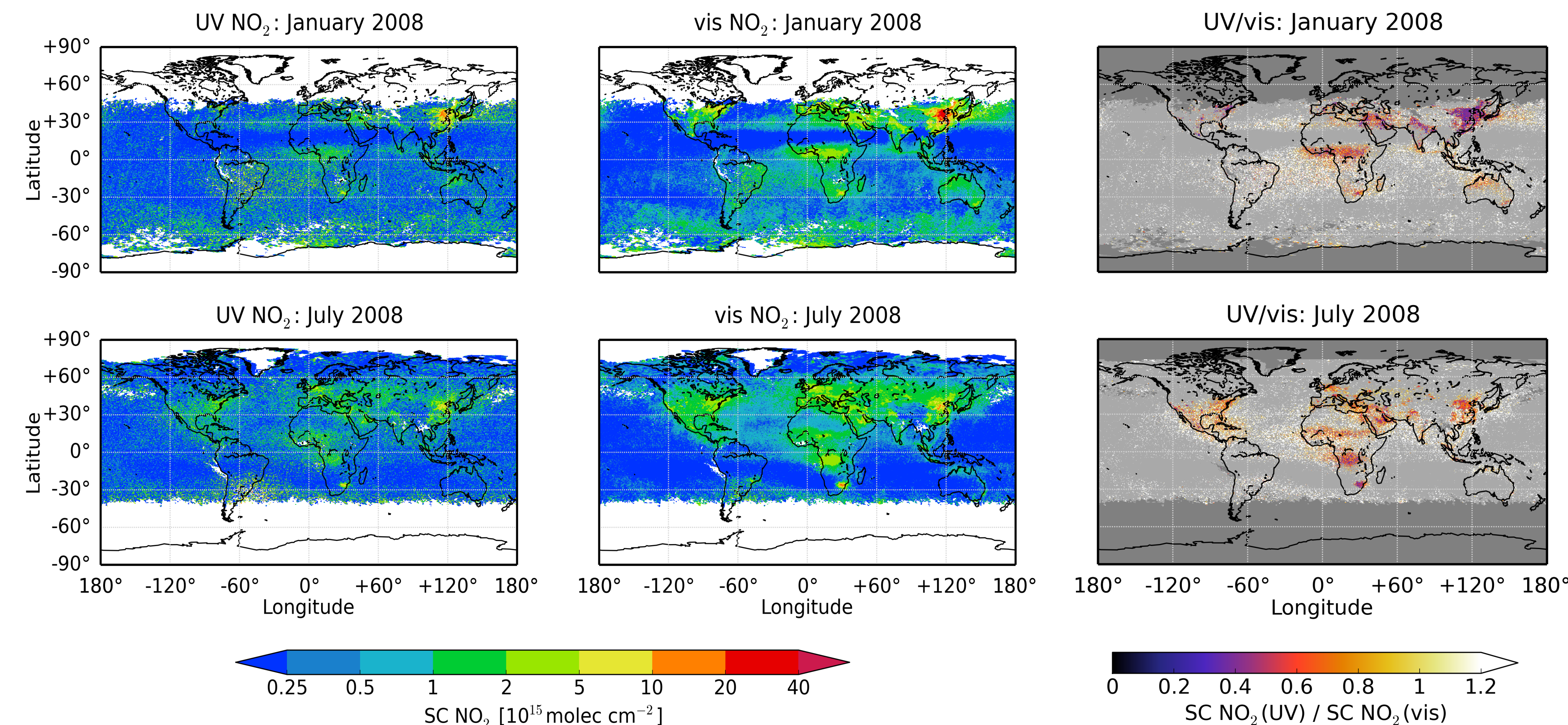


Figure 5: Global distribution of monthly mean tropospheric NO₂ SCs for both spectral ranges and their ratio

SCs (left and center columns): Similar patterns in UV and visible spectral ranges can be found. Also in the UV spectral range, well known NO₂ signals above highly polluted areas can be observed. Ratio (right column): Dark gray shaded areas indicate that there are no NO₂ values available. Lighter gray shaded areas indicate that the NO₂ values are below one standard deviation of a smoothed latitude-dependent threshold over the reference sector.

4 Comparison of time series of NO₂ SCs

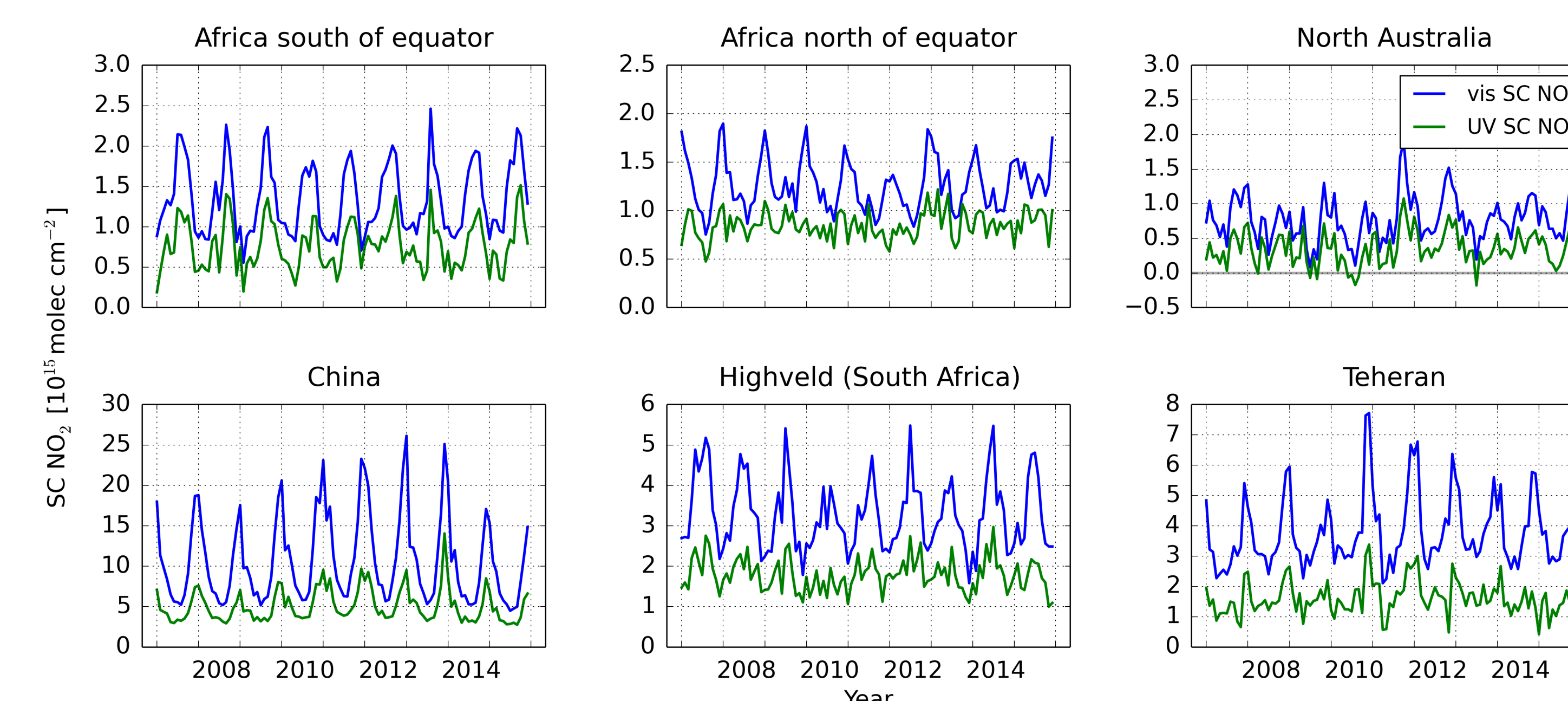


Figure 7: Time series of tropospheric NO₂ SCs for the visible (blue) and UV (green) spectral ranges

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. Note the different y-axes of the individual subplots.

5 Summary & Outlook

- we provide a NO₂ 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 NO₂ values are smaller than vis NO₂ values
- NO₂ retrieval in the visible spectral range is more sensitive to the lower troposphere => possibility to assess vertical distribution of NO₂
- large differences are mostly located in areas with high anthropogenic air pollution
- next step: comparison of NO₂ VCs, we can get additional information about height dependency => if the a priori model simulates the air pollution profile with correct height dependency, there should be no differences in NO₂ vertical columns for the two wavelength ranges

References & Acknowledgement

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