1. Introduction

- Bromine monoxide (BrO) plays an important role in atmospheric chemistry as a catalytic element in ozone depletion processes.
- Satellite observations from instruments such as GOME, SCIAMACHY, GOME-2 and OMI have been used for monitoring of BrO distributions on regional to global scales for more than two decades.
- To continue and improve daily global trace gas observations with an unprecedented spatial resolution, the TROPOspheric Monitoring Instrument (TROPOMI) was launched onboard the Copernicus Sentinel-5 Precursor platform in October 2017 (Veefkind et al., 2012).
- In this study, we performed sensitivity tests to find an optimal TROPOMI DOAS setting of BrO under various measurement conditions.
- As a consistency test, TROPOMI BrO columns were compared with OMI and GOME-2 BrO columns on both global and regional scale.

2. Sentinel-5 Precursor (S-5P)/TROPOMI

- Low earth orbit polar satellite that was launched in October 2017
- Daily global information on columns of trace gases and aerosols
- TROPOspheric Monitoring Instrument (TROPOMI) is a spectrometer on board of the S-5P satellite platform with spectral bands in the UV, VIS, NIR and SWIR. This wavelength range can measure key atmospheric constituents including O₃, NO₂, SO₂, CO, CH₄, HCHO, BrO and aerosol properties.
- Large swath of 2600 km with high spatial resolution of currently 3.5x7 km² at nadir
- Compared to previous satellites, TROPOMI has prominent advantages in extended spectral band range and higher spatial resolution.

3. BrO retrieval from TROPOMI

- **DOAS retrieval**
  - The retrieval algorithm for BrO uses the Differential Optical Absorption Spectroscopy (DOAS) technique. The absorber concentration integrated along the light path, the slant column density (SCD), is determined assuming the Beer-Lambert’s law is applicable.
  \[ I(\lambda, s) = I_0 \exp(-\sigma(\lambda) ps) \]
  (the initial intensity: I₀, the length of light path: s, the absorption cross-section: \( \sigma \), the absorber number density: \( n \)).

- **Sensitivity test of retrieval fitting intervals**
  - Selection of the retrieval fitting window is one of the most important things in the DOAS retrieval process.
  - Sensitivity tests of the wavelength interval on DOAS BrO retrievals were performed by evaluating the BrO SCDs and fitting RMS values in many different wavelength ranges.
  - Wavelength interval step: 0.2 nm.
  - Polynomial of order 4
    - BrO, O₃, NO₂, HCHO, CO, O₂, and Ring cross sections

- **DOAS settings used for the BrO retrievals**

- **Parameter** | **Description**
  - Fitting window | 303.5–367 nm
  - Solar Reference Spectrum | Kurucz solar spectrum (Fraunhofer calibration)
  - Trace gases cross sections | NO₂ (Valkenbroek et al., 1999-2000), O₃ (Sentanuchens et al., 2013, 222K, 243K), NO (Valkenbroek et al., 1999-2000), OCO (Kromer et al., 2002, 213K), O₂ (Hamma et al., 2012), HCHO (Meller/Mougenot et al., 2000, 208K)
  - Ring cross sections | Ring cross section calculated by SCIATRAN model

- **BrO retrievals over the polar sea ice region**
  - Negative BrO SCDs with relatively high fitting RMS values at shorter wavelengths < 327 nm → O₃ interference

- **BrO retrievals over a salt marsh**
  - Positive BrO SCDs with high fitting RMS values at shorter wavelengths < 327 nm → SO₂ interference
  - Relatively high fitting RMS values at wavelengths >565 nm due to the Ring effect from high aerosol loads or cloud interference.

4. Comparison with OMI and GOME-2 retrievals

- **Fig 6. Global distribution of monthly mean BrO VCD.** Distribution of BrO SCDs and fitting RMS values over a clean equatorial Pacific region (10°S-10°N, 150°W-150°E) for April 2018
- TROPOMI shows the best performance with narrow SCD distribution close to the detection limit and the smallest mode of fitting RMS distributions

5. BrO observations in various source regions

- **BrO plumes over Arctic sea ice**
  - Elevated BrO columns are associated with polar low pressure system

- **Volcanic BrO plumes**
  - NO eruption event occurred in conjunction with wind-driven blowing snow events (high surface wind speeds)

6. Conclusions / Outlook

- **Conclusion**
  - In this study, we present retrievals of BrO column amounts from TROPOMI observations using an optimized and adapted DOAS retrieval algorithm.
  - TROPOMI shows excellent performances with much smaller fitting RMS values and lower random scatter of BrO columns than OMI and GOME-2B.
  - TROPOMI BrO retrievals show good agreements with OMI and GOME-2B BrO columns.
  - More small-scale hotspots can be identified in greater detail by TROPOMI with its improved signal-to-noise ratio and the excellent spatial resolution of 3.5x7 km².

- **Outlook**
  - Stratospheric correction schemes and more sophisticated air mass factor calculations accounting for factors such as presence of clouds, varying surface albedo, and surface altitude are needed to obtain accurate tropospheric BrO columns.
  - Validation with ground-based measurements should be performed for more detailed assessment of the quality of TROPOMI BrO columns.

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### References

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