Developing a BrO product for S-5P

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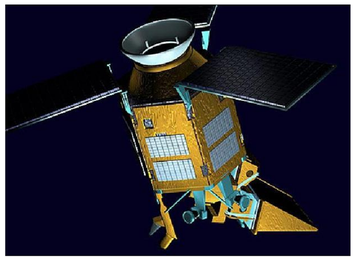
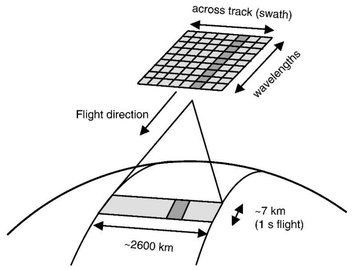
I. Sentinel-5 Precursor (S-5P)

The ESA (European Space Agency) Sentinel-5 Precursor (S-5 P) is a low Earth orbit polar satellite that was launched in October 2017 to provide daily global information on columns of trace gases and aerosols. The 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 O_3, NO_2, SO_2, CO, CH_4, HCHO, BrO and aerosol properties. TROPOMI has a wide swath of ~2600 km with a ground pixel area of 3.5 x 7 km^2.





[https://directory.eoportal.org/web/eoportal/satellite-missions/c-missions/copernicus-sentinel-5p]

II. BrO retrieval from TROPOMI

For the BrO retrieval, TROPOMI data are analysed using the Differential Optical Absorption Spectrometer (DOAS) technique.

$$I(\lambda, s) = I_0 exp(-\sigma(\lambda)\rho s)$$

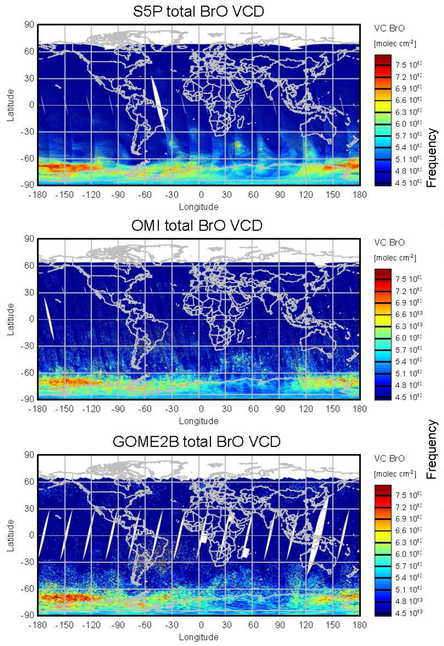
(the initial intensity: I_0, the length of light path: s,
the absorption cross-section: σ , the absorber number density: ρ)

Atmospheric absorbers (BrO) are separated using the characteristic differential structures of their absorption cross-sections determined from laboratory measurements. The retrieved quantity is the integrated BrO concentration along the mean optical light path referred to as the slant column density (SCD).

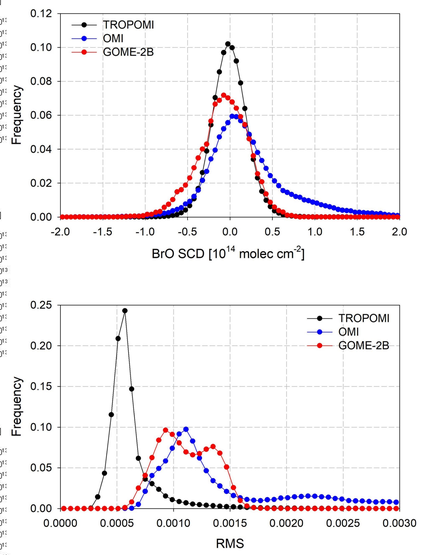
Table 1. BrO retrieval settings for S-5P

Parameter	S-5P BrO retrieval settings
Fitting window	332- 359 nm
Solar Reference Spectrum	Kurucz solar spectrum (Fraunhofer calibration)
Trace gases cross sections	BrO (Wilmouth et al., 1999; 228K) O_3 (Serdyuchenko et al., 2013; 223K, 243K) NO_2 (Vandaele et al., 1998; 220K) OClO (Kromminga et al., 2003; 213K) O_4 (Hermans et al., 298K) HCHO (MellerMoortgat et al., 2000 ;298K)
Ring cross sections	Cross-section calculated using SCIATRAN model
Slit function	Preflight Model, TROPOMI ISRF Calibration Key Data
Polynomial degree	5th order
Background	Daily Earthshine, Pacific (30°S-30°N, 150-240°E)
Offset correction	Slope (2 parameters)

III. Satellite BrO observations from various sources



Total BrO VCDs for TROPOMI, OMI and GOME-2B on 28-29 Nov, 2017



Distribution of BrO SCDs and RMS over a clean Pacific region (10 S–10 N, 150–260 E) for study period (28-29 Nov, 2017)

- Global daily distribution of TROPOMI BrO VCDs are generally consistent with OMI and GOME-2 observations.
- TROPOMI BrO SCD scatter shows a distribution around zero with the smallest FWMH.
- TROPOMI shows the best performance with the smallest mode of RMS distribution compared to OMI and GOME-2B.

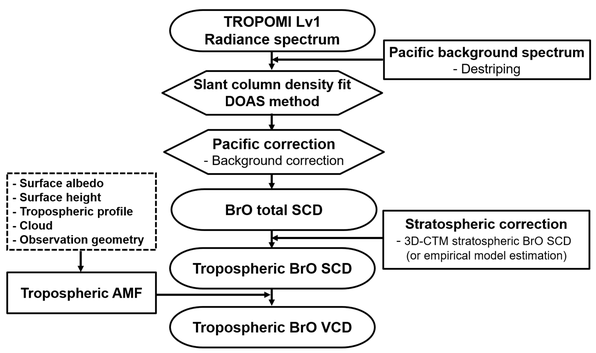
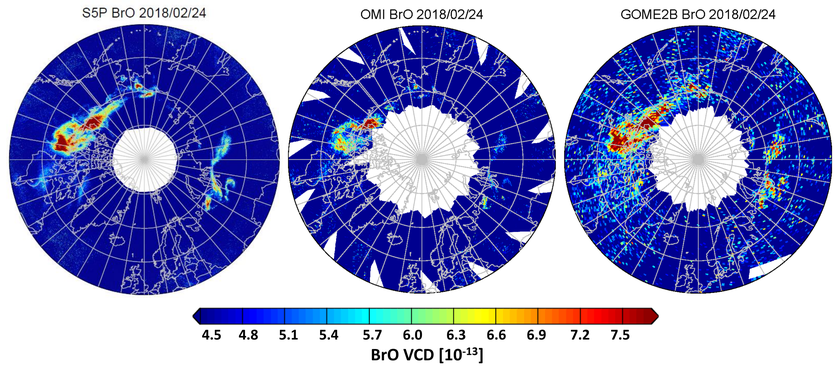
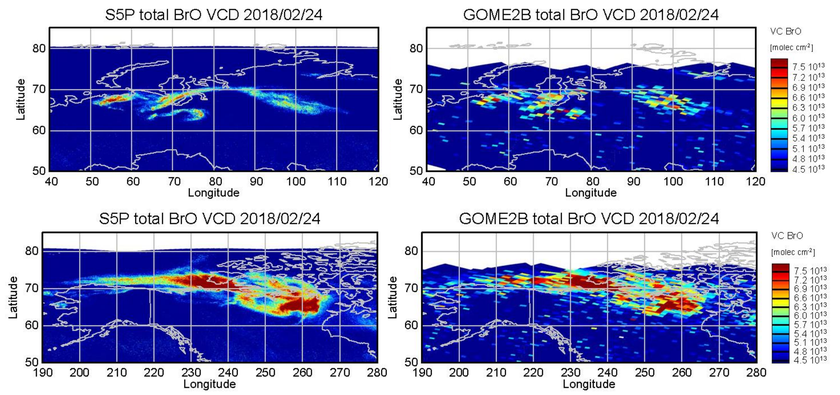


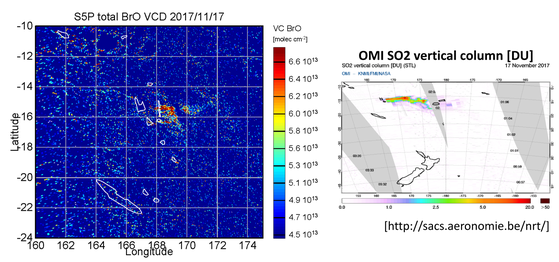
Fig 2. Overview of the tropospheric BrO retrieval algorithm

▪ Polar BrO observations



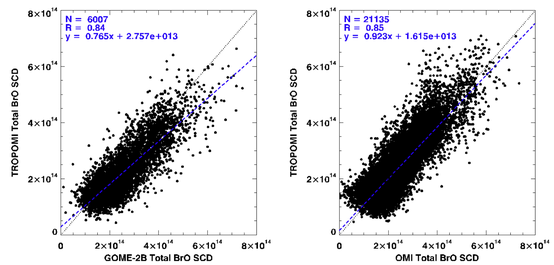


▪ Volcanic BrO observations



- Volcanic BrO was detected from S-5P data on 17 Nov 2017

▪ Intercomparison of BrO satellite retrievals



- Comparison of TROPOMI BrO SCDs with OMI and GOME-2B BrO SCDs (on Feb 24 2018; 50 - 85 N and 190 - 280 E)
- TROPOMI BrO shows good agreements with OMI and GOME-2B BrO

IV. Conclusions and Outlooks

- Based on previous algorithms for GOME-2 and OMI, a DOAS BrO retrieval algorithm has been developed for S-5P measurements.
- Due to its finer spatial resolution, S-5P BrO retrieval results can monitor transport and explosion events of BrO in more detail.
- TROPOMI BrO shows good agreements with GOME-2B and OMI BrO with a correlation of 0.84 and 0.85, respectively.
- BrO retrievals from S-5P are still challenging for inhomogeneous scenes such as fractional clouds and continental boundaries.

V. Selected references and Acknowledgements

Veefkind, J. P., et al. TROPOMI on the ESA Sentinel-5 Precursor: A GMES mission for global observations of the atmospheric composition for climate, air quality and ozone layer applications. *Remote Sensing of Environment*, 2012, 120: 70-83

Disclaimer : The presented work has been performed in the frame of the Sentinel-5 Precursor Validation Team (S5PVT) activities. Results are based on preliminary (not fully calibrated/validated) Sentinel-5 Precursor data that will still change.

Acknowledgement : Sentinel-5 Precursor is a European Space Agency (ESA) mission on behalf of the European Commission (EC). The TROPOMI payload is a joint development by ESA and the Netherlands Space Office (NSO). The Sentinel-5 Precursor ground-segment development has been funded by ESA and with national contributions from The Netherlands, Germany, and Belgium.

This work was funded by the University of Bremen and DLR Bonn under contract 50 EE 1618.

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