# First retrievals of glyoxal tropospheric columns from TROPOMI onboard the Copernicus Sentinel-5 Precursor Mission

C. Lerot[1, ✉], I. De Smedt[1], N. Theys[1], H. Yu[1], J. Vlietinck[1], M. Van Roozendael[1], T. Stavrakou[1], J.-F. Müller[1]

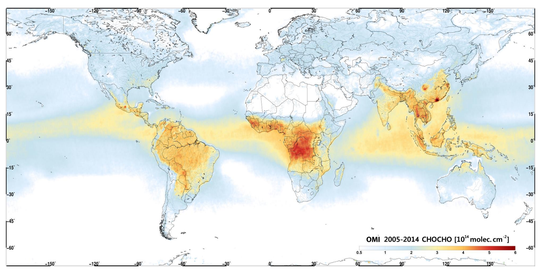
(1) BIRA-IASB; ✉: Christophe.Lerot@aeronomie.be

## Abstract

The TROPOspheric Monitoring Instrument (TROPOMI) has been launched on October 13, 2017, aboard the polar orbiting platform Sentinel-5 Precursor (S5p). TROPOMI measures the Earth's radiance in the ultraviolet, visible, near and short-wave infrared spectral ranges with an unprecedented spatial resolution of 7x3.5km², providing important information on natural and anthropogenic emissions of trace gases and aerosols.

Although currently not part of the suite of operational products, glyoxal tropospheric columns retrieved from TROPOMI are expected to provide important and complementary information on VOC emissions and their localization. In the past, we developed a scientific retrieval algorithm relying on the DOAS approach which has been successfully applied to the GOME-2A/B and OMI observations in the visible spectral region. In this work, we present first results of its application to TROPOMI spectra.

Based on comparisons with OMI retrievals, we illustrate the benefit of the excellent TROPOMI spatial resolution and signal-to-noise ratio to better identify and characterize the sources of this challenging tropospheric trace gas.




## Baseline DOAS Retrieval algorithm

1. **Glyoxal slant column retrieval**
   - *Reference*: Daily mean earthshine radiance spectrum taken in the Pacific sector. (GOME-2/OMI) or irradiance spectrum (S5p - orbit 991). One reference spectrum per row; wavelength grid further optimized with a cross-correlation procedure based on a high-resolution sun spectrum.
   - *2-step DOAS fits:* liquid water optical depth fitted in the window 405-490 nm is fixed for the glyoxal SCD fit in the interval 435-460 nm.
   - *Slit function:* High-resolution cross-sections are convolved with either (1) Row-dependent key data slit functions (OMI) or (2) Fitted function as part of wavelength calibration (GOME-2, S5p).
2. **AMF computed combining:**
   - Weighting functions calculated with the RT model LIDORT at 448 nm.
   - A priori glyoxal profile shapes provided by the Chemical-Transport model IMAGES V3 over lands. Over oceans, a fixed profile, measured with an Airborne MAX-DOAS during the TORERO campaign (Volkamer et al., AMT, 2015), is used.
   - No cloud correction applied: pixels with a cloud fraction larger than 20% are filtered out.
3. **Normalization/destriping procedure:**
   - A constant value is added to all SCDs, this value being daily determined to ensure a mean glyoxal VCD in the Pacific sector of $1x10^{14}$ molec/cm2.
   - For imager-type of instruments, normalization values are determined separately for each row to limit as much as possible stripes intrinsic to imager-type instruments.

| Absorption cross-sections | Reference |
|---|---|
| Glyoxal | Volkamer et al. (2005) |
| Ozone | Serdyuchenko et al. (2013), 243K |
| $H_2O$ (vapor) | Rothman al. (2010) |
| $NO_2$ | Vandaele et al. (1998), 220 + 296 K |
| $O_4$ ($O_2$-$O_2$) | Thalman et al., (2013), 293K |
| $H_2O$ (liquid) | Pope et al. (1997) (Fixed) |
| **Ring effect** | Pseudo-absorber (Chance and Spurr, 1997). |
| **Polynomial** | 2nd order |
| **Intensity offset correction** | 1st-order offset (additional cross-section taken as the invert of the reference spectrum) |
| **Earthshine wavelength Doppler-shift** | 1st-order shift |

**Illustration of fitted S5p glyoxal optical depth and associated residuals**

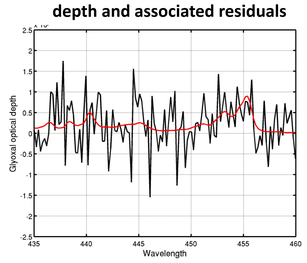
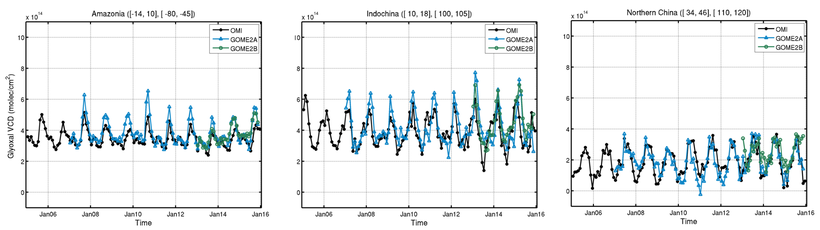


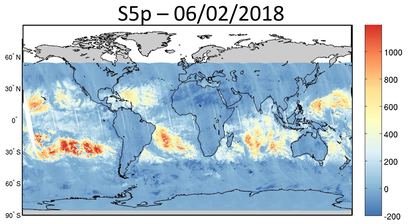

**Illustration of GOME2-A/B/OMI time series**



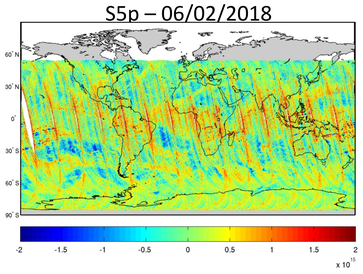

## TROPOMI DOAS fits

**Inverted Slant Column Densities**

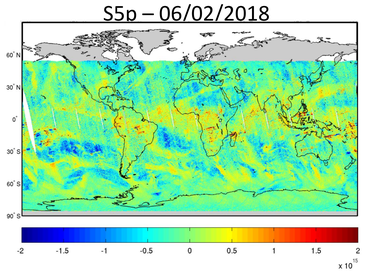
Step 1: Liquid water optical depth fit
S5p – 06/02/2018



Step 2: Glyoxal SCDs fit
S5p – 06/02/2018

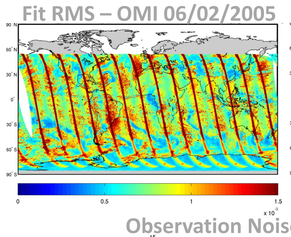


Step 3: Normalization of SCDs
S5p – 06/02/2018

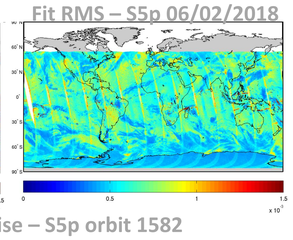


**Impact of signal-to-noise ratio**

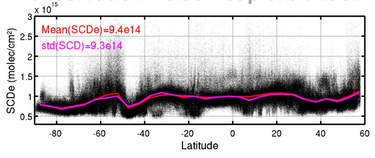
Fit RMS – OMI 06/02/2005



Fit RMS – S5p 06/02/2018



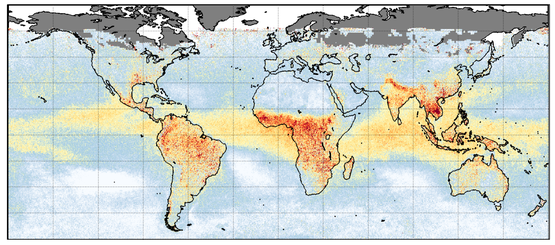
Observation Noise – S5p orbit 1582



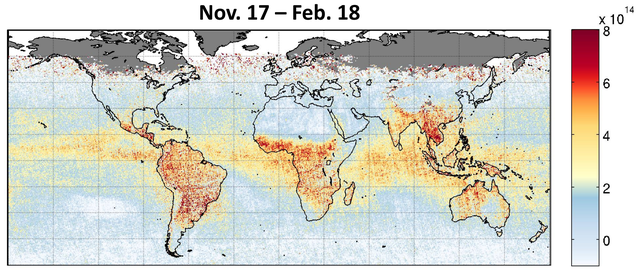

- The DOAS retrieval settings have been applied to S5p observations and lead to reasonable glyoxal SCD fields.
- Using an irradiance spectrum as the DOAS reference leads to significant row-dependent variations in the inverted SCDs. The row-dependent background correction efficiently removes those variations.
- Compared to OMI, the fit residuals RMS are significantly lower and the observation noise is 30-40% lower.
- Like for the other sensors, an increase of the glyoxal SCDs is observed over bright surfaces (e.g. clouds). Also, saturation and blooming effects impact sometimes the retrievals for cloudy pixels and their neighbors. Appropriate filters are therefore needed to remove such pixels.

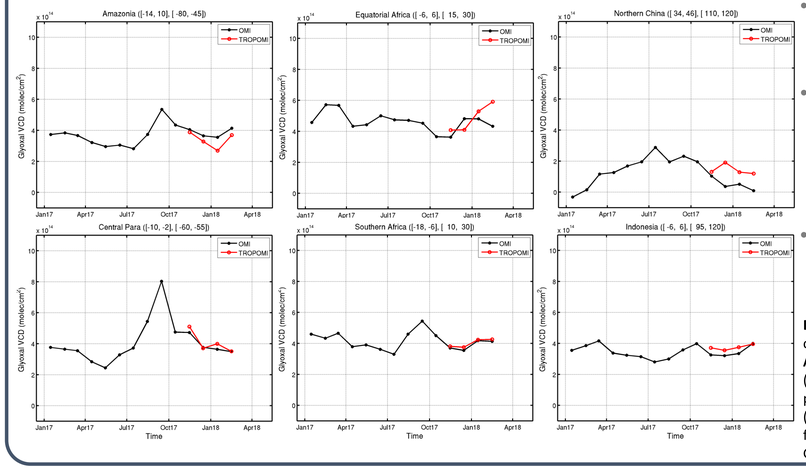
## TROPOMI Glyoxal Vertical Columns – Comparison with OMI

**TROPOMI/S5p Glyoxal VCDs (molec/cm²)**
**Nov. 17 – Feb. 18**



**OMI/AURA Glyoxal VCDs (molec/cm²)**
**Nov. 17 – Feb. 18**






- The BIRA-IASB glyoxal DOAS algorithm has been applied to S5p observations and lead to results very similar to OMI.
- First comparisons in specific regions of the world indicate good consistency between S5p and OMI both in terms of absolute values and seasonal variations, although longer time series are obviously necessary to confirm this.
- The better SNR, spatial resolution and large amount of observations of S5p will allow to better identify and distinguish VOCs sources.

**Disclaimer:** 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