Ozone from TROPOMI/S5P

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Outlook

– TROPOMI/S5P – Operational L2 Products

– Total Ozone
  – NRT DOAS
  – OFL GODFIT

– Tropospheric Ozone

– New Retrieval Algorithms

– Summary
## TROPOMI/S5P – Operational L2 Products

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Data Product</th>
<th>Vertical Resolution</th>
<th>Accuracy</th>
<th>Precision</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ozone</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ozone Profile</td>
<td>6 km</td>
<td>10-30%</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td><strong>Total Ozone (NRT, OFL)</strong></td>
<td>total column</td>
<td>3.5-5%</td>
<td>1.6-2.5%</td>
</tr>
<tr>
<td></td>
<td><strong>Tropospheric Ozone</strong></td>
<td>trop column</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>NO₂</strong></td>
<td>Stratospheric NO₂</td>
<td>strat column</td>
<td>&lt; 10%</td>
<td>0.5e15</td>
</tr>
<tr>
<td></td>
<td>Tropospheric NO₂</td>
<td>trop column</td>
<td>25-50%</td>
<td>0.7e15</td>
</tr>
<tr>
<td><strong>SO₂</strong></td>
<td>SO₂ enhanced</td>
<td>total column</td>
<td>30%</td>
<td>0.15-0.3 DU</td>
</tr>
<tr>
<td></td>
<td>Total SO₂</td>
<td>total column</td>
<td>30-50%</td>
<td>1-3 DU</td>
</tr>
<tr>
<td><strong>Formaldehyde</strong></td>
<td>Total HCHO</td>
<td>total column</td>
<td>40-80%</td>
<td>1.2e16</td>
</tr>
<tr>
<td><strong>CO</strong></td>
<td>Total CO</td>
<td>total column</td>
<td>15%</td>
<td>&lt; 10%</td>
</tr>
<tr>
<td><strong>Methane</strong></td>
<td>Total CH₄ (offline)</td>
<td>total column</td>
<td>1.5%</td>
<td>1%</td>
</tr>
<tr>
<td><strong>Cloud</strong></td>
<td><strong>Cloud Fraction</strong></td>
<td>total column</td>
<td>&lt; 20%</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td><strong>Optical Thickness (albedo)</strong></td>
<td>total column</td>
<td>&lt; 20%</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td><strong>Cloud Height (Pressure)</strong></td>
<td>total column</td>
<td>&lt; 20%</td>
<td>&lt; 0.5 km (&lt; 30hPa)</td>
</tr>
<tr>
<td></td>
<td>SNPP VIIRS Cloud @ SSP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Aerosol</strong></td>
<td>Aerosol Layer Height</td>
<td>total column</td>
<td>&lt; 100hPa</td>
<td>&lt; 50hPa</td>
</tr>
<tr>
<td></td>
<td>Aerosol Type</td>
<td>total column</td>
<td>~1 AAI</td>
<td>&lt; 0.1 AAI</td>
</tr>
</tbody>
</table>
TROPOMI/S5P – Total Ozone Algorithms Heritage

**NRT: DOAS (GDP 4.x)**
- DOAS fitting in the Huggins bands (325 to 335 nm)
  - $O_3$ slant column and effective temperature
- Iterative AMF at 325.5 nm
- Lambertian cloud model (CRB)
- GOME/SCIAMACHY/GOME-2A/GOME-2B
  - EUMETSAT AC-SAF GOME-2 products

**OFL: GODFIT (v 4)**
- Direct fitting in the Huggins bands (325 to 335 nm)
  - $O_3$ total column, effective temperature and albedo
- Effective scene located between ground and cloud
- GOME/SCIAMACHY/OMI/GOME-2A/GOME-2B
  - ESA CCI and Copernicus C3S
TROPOMI/S5P – Total Ozone

- **NRT (GDP_CAL 5.0)**
  - *Polarization* correction for AMF calculation
  - Very important for large VZA
  - Improved *a priori* ozone profile *climatology*
    - Total O₃-classified (Labow et al., 2015) and tropo. OMI/MLS (Ziemke et al., 2011)
  - Optimal wavelength selection for AMF calculation
    - Change from 325.5 nm to **328.125 nm**
  - Cloud as layer (*CAL*) model
    - S5P OCRA/ROCINN cloud parameters (Loyola et al., 2018)
    - No need of ghost-column and intra-cloud corrections (Loyola et al., 2011)

- **OFL (GODFIT 4.0)**
  - Use the latest version developed in the framework of ESA CCI (Lerot et al., 2014)
  - Two versions implemented:
    - On-the-fly LIDORT RTM
    - LUT version for speed
TROPOMI/S5P Total Ozone OFL – Continuation of GTO-ECV Dataset

- GOME-Type Total Ozone (GTO) ECV: 23 years of homogenized and merged data record from GOME, SCIAMACHY, OMI, GOME-2A, and GOME-2B

- GTO-ECV was developed in the framework of ESA Climate Change Initiative (CCI) and it is being updated in the EU Copernicus Climate Change Service (C3S)

- GTO-ECV used in quadrennial WMO Ozone Assessment, yearly AMS Bulletin, and a number of scientific publications

- Very good agreement between GTO-ECV, SBUV and ground based ozone

Weber et al., 2018
TROPOMI/S5P – Total Ozone GDP_CAL (NRT)

Loyola et al., 2011
Koukouli et al., 2012
Hao et al., 2014
TROPOMI/S5P – Total Ozone GODFIT (OFL)

ozone_total_vertical_column
SSP TROPOMI, 2017-11-25

CAMS Total column ozone
2017-11-26

Courtesy Antje Inness
TROPOMI/S5P – Tropical Tropospheric Ozone Column

– CCD algorithm developed for TOMS

– Successfully adapted to GOME, SCIAMACHY, GOME-2A/B (Valks et al., 2014; Heue et al., 2016)

– Comparison with SCIAMACHY (limb-nadir matching)
  – Negative offset ~2 DU

– Comparison with sondes
  – Positive offset ~2 DU
  – Good agreement with annual cycle

– Adapted to TROPOMI (Heue et al., 2016)
TROPOMI/S5P – Tropical Tropospheric Ozone Column

DLR/ESA

AC-SAF/EUMETSAT
Ozone profile shape determination using machine learning

- Ozone profile algorithms from nadir UV satellites are based on Optimal Estimation
  - Iterative fitting of forward model simulations to the observations
  - Computational heavy

- Novel machine learning approach
  - Reformulate the ozone profile retrieval as a classification problem
  - Training using RTM simulations is very time consuming, but the application to satellite measurements is extremely fast.
FP-ILM for ozone profile shape retrieval

A Novel Ozone Profile Shape Retrieval Using Full-Physics Inverse Learning Machine (FP-ILM)

Jian Xu, Member, IEEE, Olena Schüssler, Diego Guillermo Loyola Rodriguez, Senior Member, IEEE, Fabian Romahn, and Adrian Doicu
TROPOMI/S5P – Public Dissemination of Ozone Products

- NRT Total Ozone
  - June 2018
- Tropical Tropospheric Column
  - August 2018
- OFL Total Ozone
  - October 2018
- Ozone Profiles
  - December 2018

Disclaimer: The presented work has been performed in the frame of the Sentinel-5 Precursor Validation Team (S5PVT) or Level 1/Level 2 Product Working Group activities. Results are based on preliminary (not fully calibrated/validated) Sentinel-5 Precursor data that will still change.

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