Sentinel-5p (S5p) Methane Retrieval

Presented by C. Zehner
S5p, S4, and S5 Missions Manager – ESA

Key Input provided by J. Landgraf - SRON

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The Sentinel-5 Precursor (S-5P) is the first atmospheric Sentinel mission focusing on global observations of the atmospheric composition for air quality and climate.

The TROPOspheric Monitoring Instrument (TROPOMI) is the payload of the S-5P mission and was jointly developed by The Netherlands and ESA.

S-5P provides enhanced radiometric sensitivity & spatial resolution enabling sampling of small-scale variabilities specifically in the lower troposphere.

Launched on Oct. 13 2017 with a 7 years design lifetime.

**Commissioning Phase**

finalised successfully on 24 April 2018.

**Ramp-up Phase** started on April 25.
Sentinel-5 Precursor Level Products

<table>
<thead>
<tr>
<th>Product</th>
<th>Spectrometer</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ozone</td>
<td>UV, UVIS</td>
<td>Ozone layer monitoring, UV-index forecast, Climate monitoring</td>
</tr>
<tr>
<td>NO₂</td>
<td>UVIS</td>
<td>Air quality forecast and monitoring</td>
</tr>
<tr>
<td>CO</td>
<td>SWIR</td>
<td>Air quality forecast and monitoring</td>
</tr>
<tr>
<td>CH₂O</td>
<td>UVIS</td>
<td>Air quality forecast and monitoring</td>
</tr>
<tr>
<td>CH₄</td>
<td>SWIR</td>
<td>Climate monitoring</td>
</tr>
<tr>
<td>SO₂</td>
<td>UVIS</td>
<td>Air quality forecast and monitoring</td>
</tr>
<tr>
<td>Aerosol</td>
<td>UVIS, NIR</td>
<td>Air quality forecast and monitoring</td>
</tr>
<tr>
<td>Clouds</td>
<td>UVIS, NIR</td>
<td>Climate monitoring</td>
</tr>
<tr>
<td>UV-Index</td>
<td>UVIS</td>
<td>UV index forecast</td>
</tr>
</tbody>
</table>

- Routine dissemination of global L1B & 2 products over design lifetime
- Near real time (NRT) service for most data products (NTC: L1B, CH4, Tropospheric Ozone)
<table>
<thead>
<tr>
<th>Product</th>
<th>Main Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>UV Aerosol Index</td>
<td>Aerosol index</td>
</tr>
<tr>
<td>Cloud Properties</td>
<td>Fraction, optical depth, top height</td>
</tr>
<tr>
<td>Nitrogen Dioxide (NO₂)</td>
<td>Total and tropospheric columns</td>
</tr>
<tr>
<td>Total Ozone (O₃)</td>
<td>NRT total column</td>
</tr>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>NTC total column</td>
</tr>
<tr>
<td>NPP_CLOUD</td>
<td>Cloud mask from VIIRS</td>
</tr>
<tr>
<td>Sulphur Dioxide (SO₂)</td>
<td>Total column</td>
</tr>
<tr>
<td>Formaldehyde (HCHO)</td>
<td>Total column</td>
</tr>
<tr>
<td>Tropospheric Ozone</td>
<td>Tropospheric column</td>
</tr>
<tr>
<td>Methane (CH₄)</td>
<td>Total column</td>
</tr>
<tr>
<td>Carbon Monoxide (CO)</td>
<td>NRT total column</td>
</tr>
<tr>
<td>Total Ozone (O₃)</td>
<td>NTC total column</td>
</tr>
<tr>
<td>Aerosol Layer Height</td>
<td>Mid-level pressure</td>
</tr>
<tr>
<td>Ozone Profiles</td>
<td>Total and tropospheric profiles</td>
</tr>
<tr>
<td>UV</td>
<td>UV dose</td>
</tr>
</tbody>
</table>

**Staggered Product Releases to the Public**

- **June 2018**
  - Sentinel-5 Precursor Product Releases

- **August 2018**
  - Staggered Product Releases

- **October 2018**
  - Staggered Product Releases

- **December 2018**
  - Staggered Product Releases
Improved Spatial Resolution

S-5P vs SCIAMACHY, GOME-2, OMI:
- Smaller pixels: 3.5x7 km²
- Larger swath-width (2600 km) with daily global coverage

S-5P Data Volume:
- ~1.5 million ground pixels/orbit
- L1: ~35 Gbyte/orbit
- L2: ~3.5 Gbyte/orbit
- Total: ~ 640 Gbyte/day
Improved Spatial Resolution

Comparison with the new QA4ECV NO\textsubscript{2} product of OMI, 22 Nov 2017

⇒ Same world, stripe amplitude TROPOMI very small, despite much higher resolution (Courtesy: KNMI)

tropospheric column of NO\textsubscript{2}, QA4ECV OMI, 22 Nov 2017

tropospheric column of NO\textsubscript{2}, SSP, 22 Nov 2017
Joint Operation S-NPP + Sentinel 5P

- CH₄ challenging accuracy requirement (< 2 % TC) -> select only cloud-free pixels

- Use Suomi-NPP / VIIRS cloud mask data at high resolution covering TROPOMI SWIR & NIR pixels

- ‘loose’ formation S5P + S-NPP -> along track separation 3.5 … 5 min
TROPOMI Methane

Assembled TROPOMI instrument

SWIR channel
band: 2305-2385 nm
resolution: 0.25 nm
sampling at sub-satellite point: 7x7 km²

Very stable SWIR performance and instrument in excellent condition.

https://www.sron.nl/tropomi-swir-monitoring
Currently, the NIR does not add significant information to the SWIR one-band retrieval. All presented results for one-band approach.
TROPOMI Methane

Transmission simulated

TROPOMI Orbit 525

CH$_4$

H$_2$O

CO

$\lambda$ [nm]

$I_{\text{out}}$ [10$^8$ mol/(s mm sr nm)]

$\text{log}$ [I]

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TROPOMI Methane – preliminary results

No glint processing to date

November 12th to December 30th, 2017

XCH4 [ppb]
TROPOMI Methane – preliminary results

TROPOMI CH$_4$

CAMS GFAS

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• GOSAT dataset bias-corrected, remaining bias of -6.6 ppb and a standard deviation of 15.5 ppb with respect to TCCON
• A comparison with the GOSAT CH₄ proxy product shows good agreement with a bias of 13.6 ppb, standard deviation of 19.6 ppb
Sentinel-5 Precursor
COPERNICUS ATMOSPHERE MISSION IN POLAR ORBIT

Ramp-up Phase: already started with the beginning of phase E1 data reprocessing for Level 1B product generation to prepare for the first Cal/Val Workshop at ESRIN on 25/26 June 2018.

Duration of 8 months: staggered product releases until Dec. 2018.

Define (best) Reprocessing (Scenarios) for Routine Operations

Methane product: planned to release during October 2018.

TROPOMI Operations:
QWG/Experts to investigate possible impact of reduced along-track spatial resolution of 5.5 km on all Level 2 processors.

Spacecraft Operations:
QWG/Experts to investigate possible off-set S5p operations in order to fill the small gap over the equator on all processors.