Sentinel-5p (S5p) Mission Status and First Results on Methane

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Key input provided by J. Landgraf from SRON

May 2018 – University of Toronto

European response to global needs:

- to manage the environment,
- to mitigate the effects of climate change and
- to ensure civil security

European independence, contribution to global system (GEOSS)

Copernicus Space Component

Copernicus Services Component

Sentinel Launches

S1A/B: Radar Mission — 3 Apr 2014/25 Apr 2016

S2A/B: High Resolution Optical Mission — 23 June 2015/6 March 2017

S3A/B: Medium Resolution Imaging and Altimetry Missi Feb 2016/ r 2018

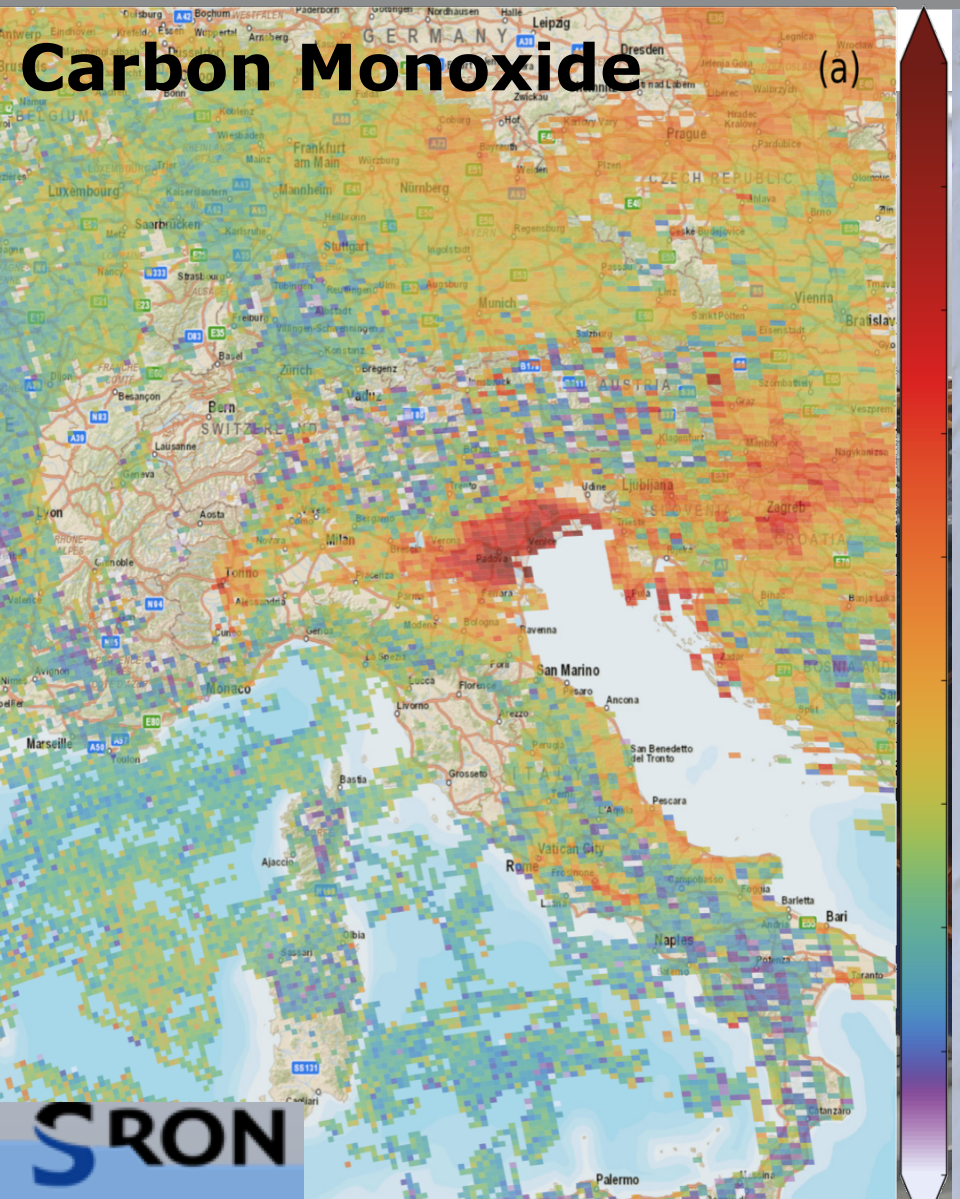
S4A/B: Geostationary Atmospheric Chemistry Mission — 2022

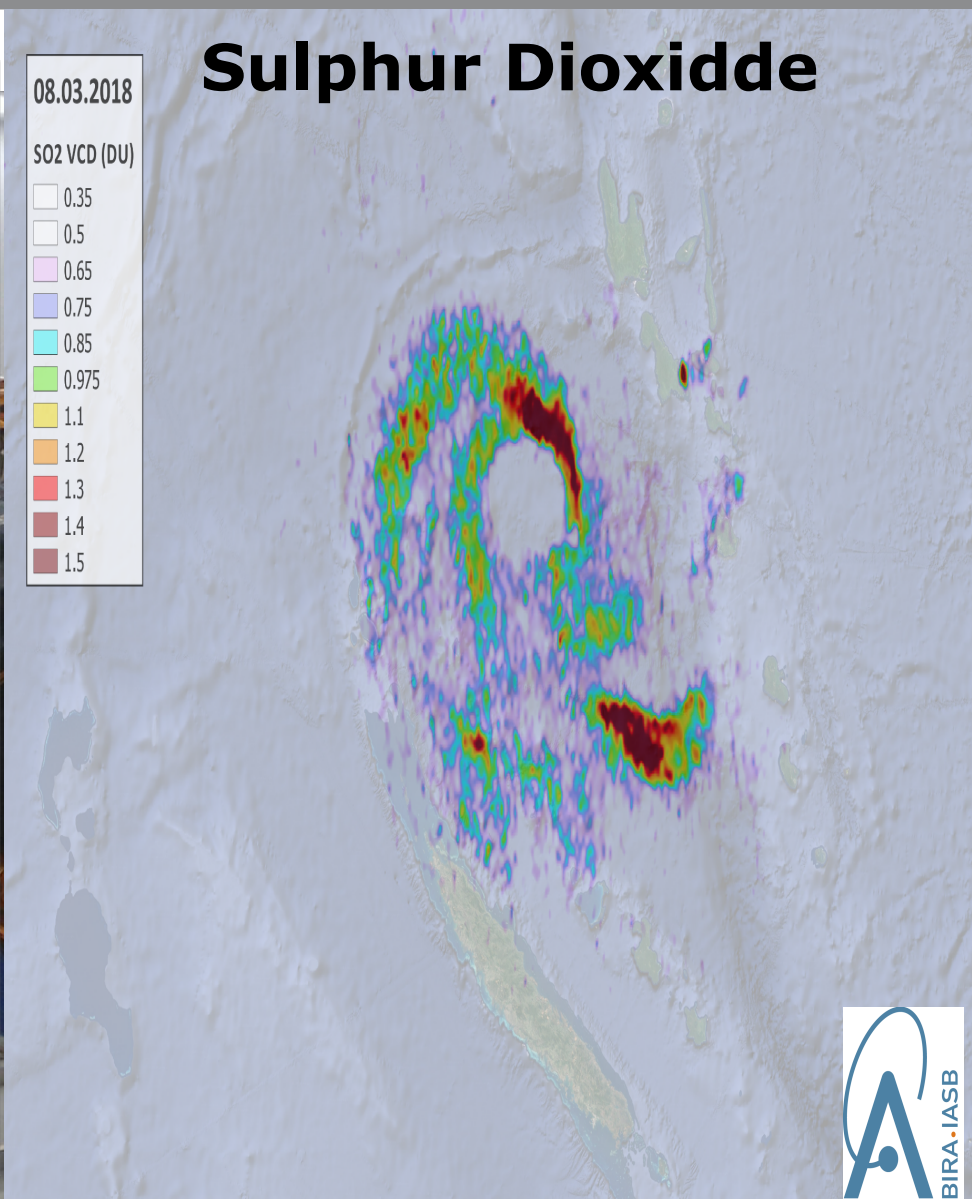
S5P: Low Earth Orbit Atmospheric Chemistry Mission — Oct. 2018

S5A/B/C: Low Earth Orbit Atmospheric Chemistry Mission — 2021

S6A/B: Altimetry Mission — 2020

Sentinel-5 Precursor 'PR Slogan'





Sentinel-5 Precursor

COPERNICUS ATMOSPHERE MISSION IN POLAR ORBIT

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.

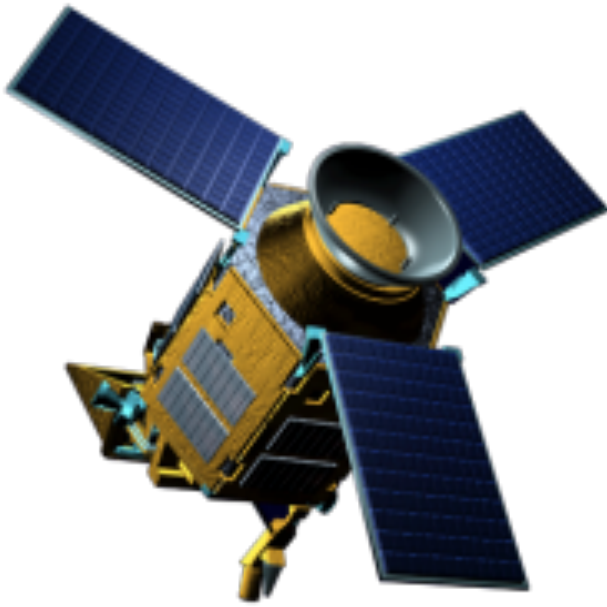
Launched on **Oct. 13 2017** with a **7 years** design lifetime.

Commissioning Phase finalised successfully on 24 April 2018.

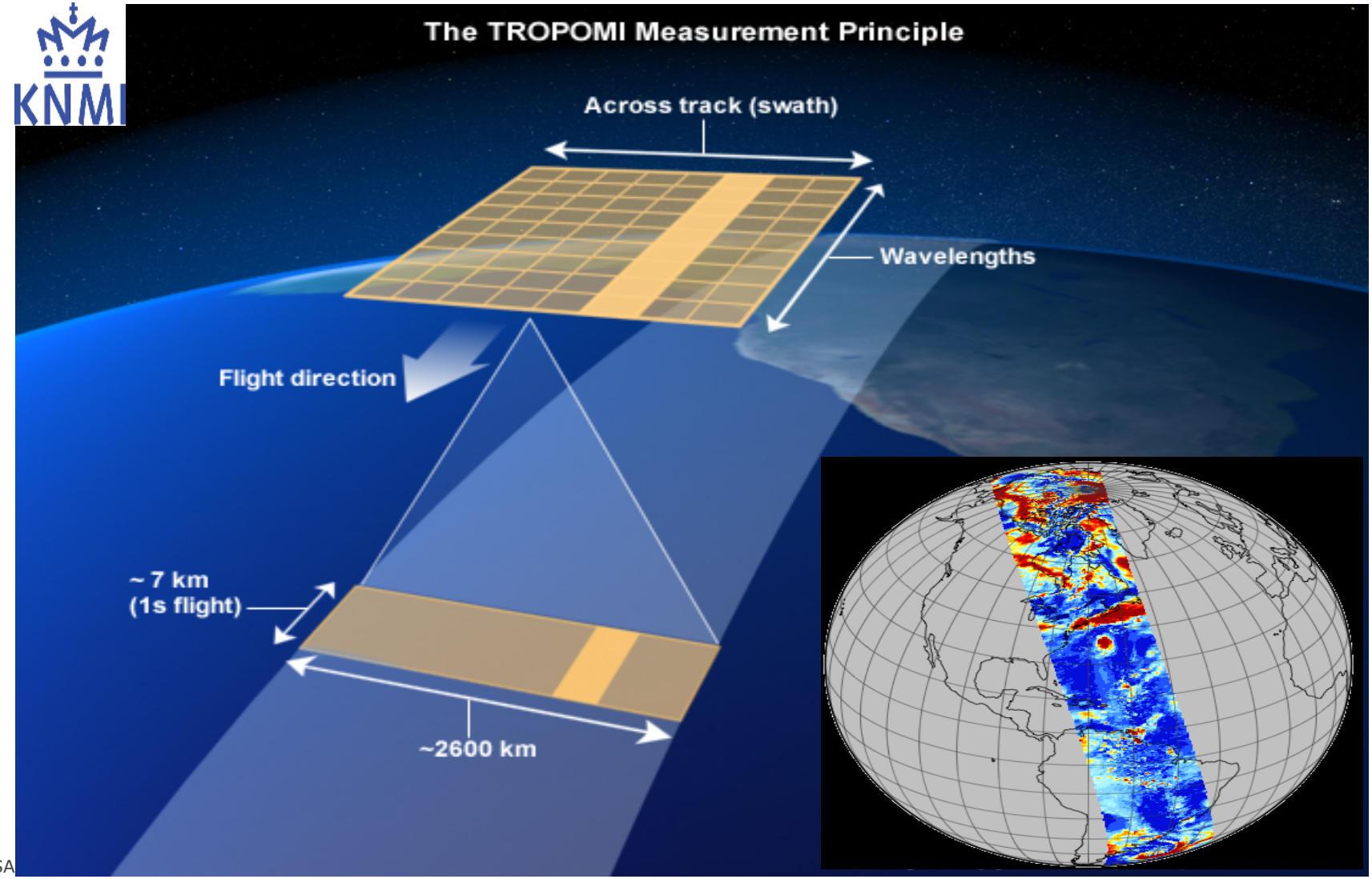
Ramp-up Phase started on April 25.

TROPOMI

- UV-VIS-NIR-SWIR nadir view grating spectrometer.
- Spectral range: 270-500, 675-775, 2305-2385 nm
- Spectral Resolution: 0.25-1.1 nm
- Spatial Resolution: 7x3.5km^2
- Global daily coverage at 13:30 local solar time.



TROPOMI Measurement Principle



Sentinel-5 Precursor Spectral Bands

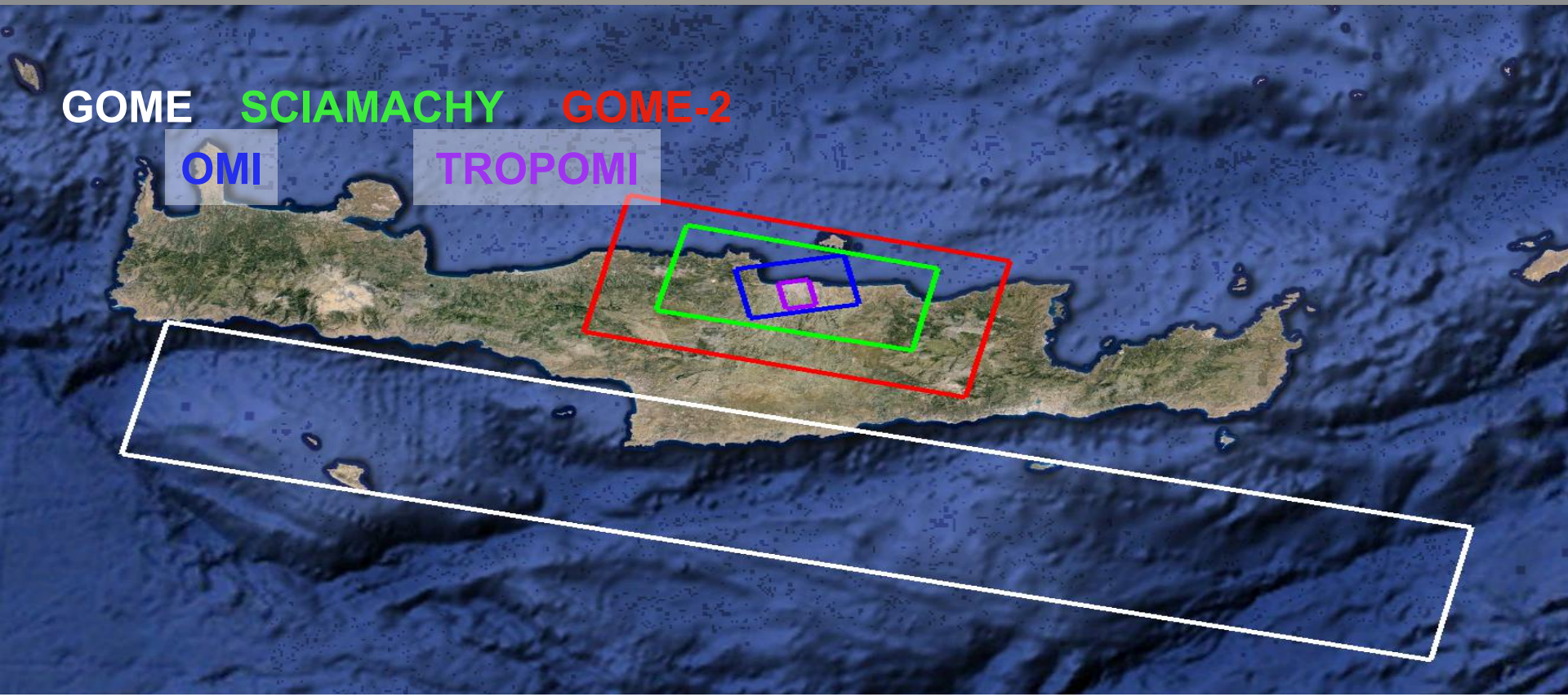
TROPOMI	UV		UVIS		NIR		SWIR	
Band	1	2	3	4	5	6	7	8
Spectral coverage [nm]	270 – 320		320 – 495		675 - 775		2305 – 2385	
Full spectral coverage [nm]	267 - 332		303 - 499		660 - 784		2299 - 2390	
Spectral resolution [nm]	0.49		0.54		0.38		0.25	
Spectral sampling ratio	6.7		2.5		2.8		2.5	
Spatial sampling [km^2]	7 x 28	7 x 3.5				7 x 3.5	7 x 7	

Sentinel-5 Precursor Level Products

Product	Spectrometer	Application
Ozone	UV, UVIS	Ozone layer monitoring, UV-index forecast, Climate monitoring
NO_2	UVIS	Air quality forecast and monitoring
CO	SWIR	Air quality forecast and monitoring
CH_2O	UVIS	Air quality forecast and monitoring
CH_4	SWIR	Climate monitoring
SO_2	UVIS	Air quality forecast and monitoring, Climate monitoring, Volcanic plume detection
Aerosol	UVIS, NIR	Air quality forecast and monitoring, Climate monitoring, Volcanic plume detection
Clouds	UVIS, NIR	Climate monitoring
UV-Index	UVIS	UV index forecast

- **Routine dissemination of global L1B & 2 products over design lifetime**
- **Near real time (NRT) service for most data products (NTC: L1B, CH4, Tropospheric Ozone)**

Improved Spatial Resolution



S-5P vs SCIAMACHY, GOME-2, OMI:

- Smaller pixels: 3.5x7 km^2
- Larger swath-width (2600 km) with daily global coverage

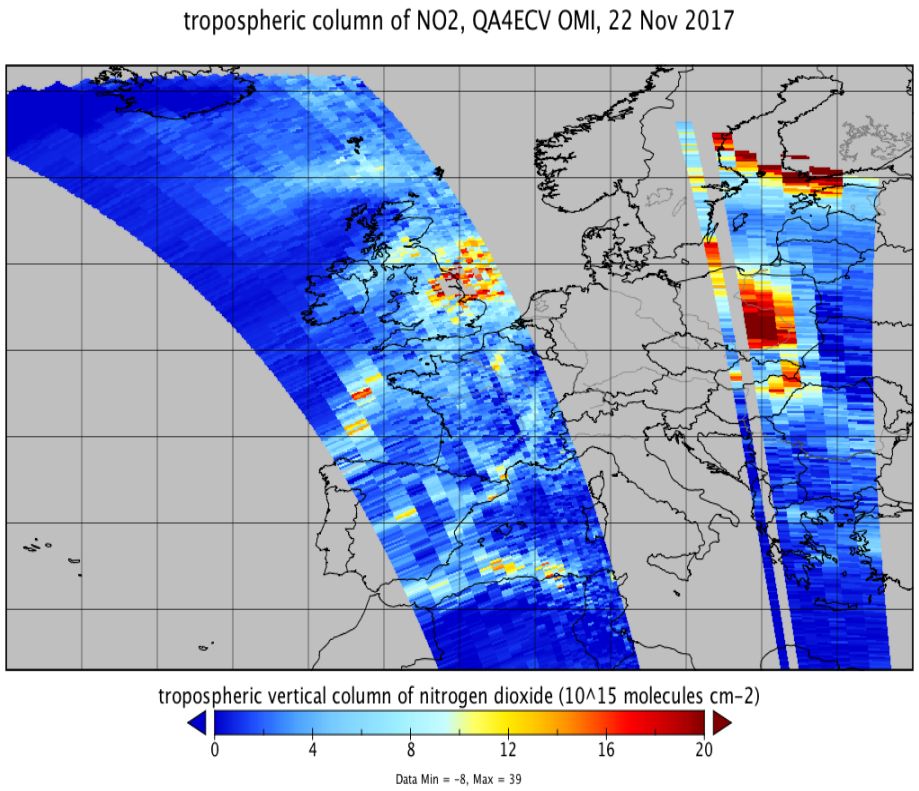
S-5P Data Volume:

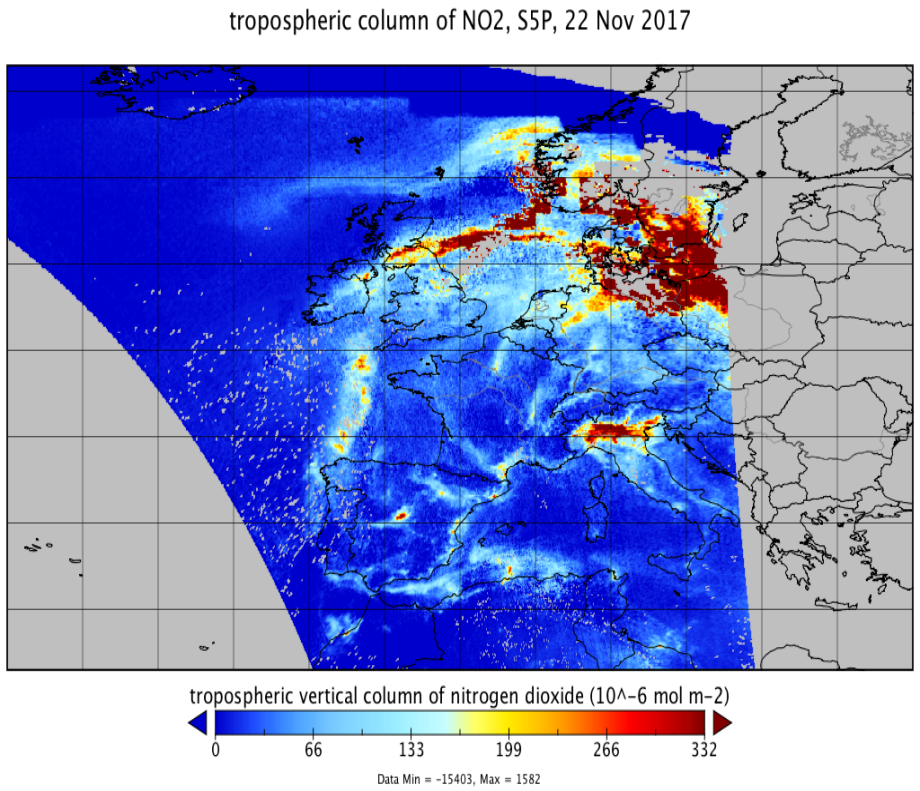
- ~1.5 million ground pixels/orbit
- L1: ~35 Gbyte/orbit
- L2: ~3.5 Gbyte/orbit
- Total: ~ 640 Gbyte/day

Improved Spatial Resolution

Comparison with the new QA4ECV NO_2 product of OMI, 22 Nov 2017

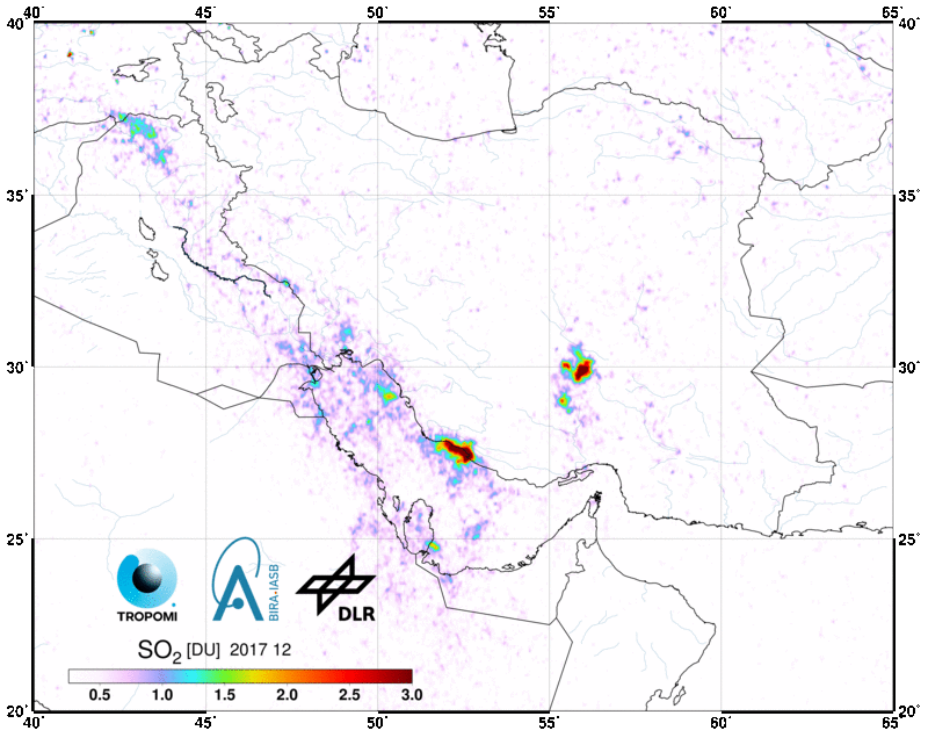
⇒ Same world, stripe amplitude TROPOMI very small, despite much higher resolution (Courtesy: KNMI)



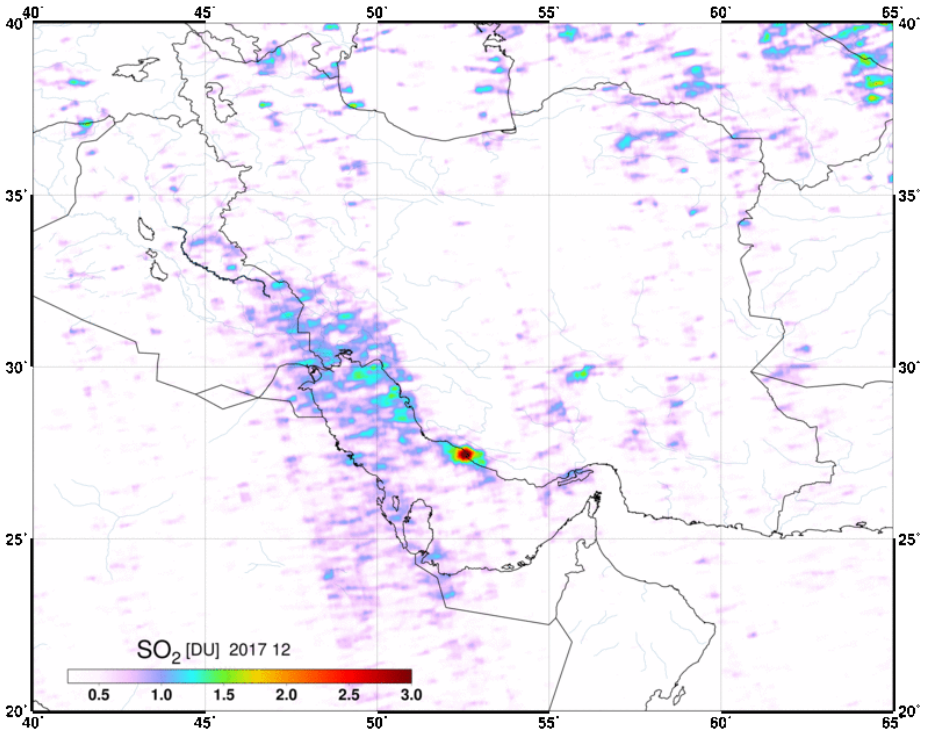


SO_2: Middle East

TROPOMI



OMI



S5p Commissioning Phase Outcome Ramp-up Phase

Algorithm Investigations for product quality improvement:

- Band 2/3 radiometric inconsistency (impact on O3 profiles)
- Verify the NIR stray-light correction based on the dedicated phase E1 (limb) measurements, verify sun diffuser reflectance characterisation
- Methane retrieval: test the inclusion of the NIR band in the retrieval, reduce delivery time (within 2 days as requested by the **Copernicus Atmospheric Monitoring Service (CAMS)** rather than 2 weeks)

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

On-board fuel for additional 13 years of operations (in theory).

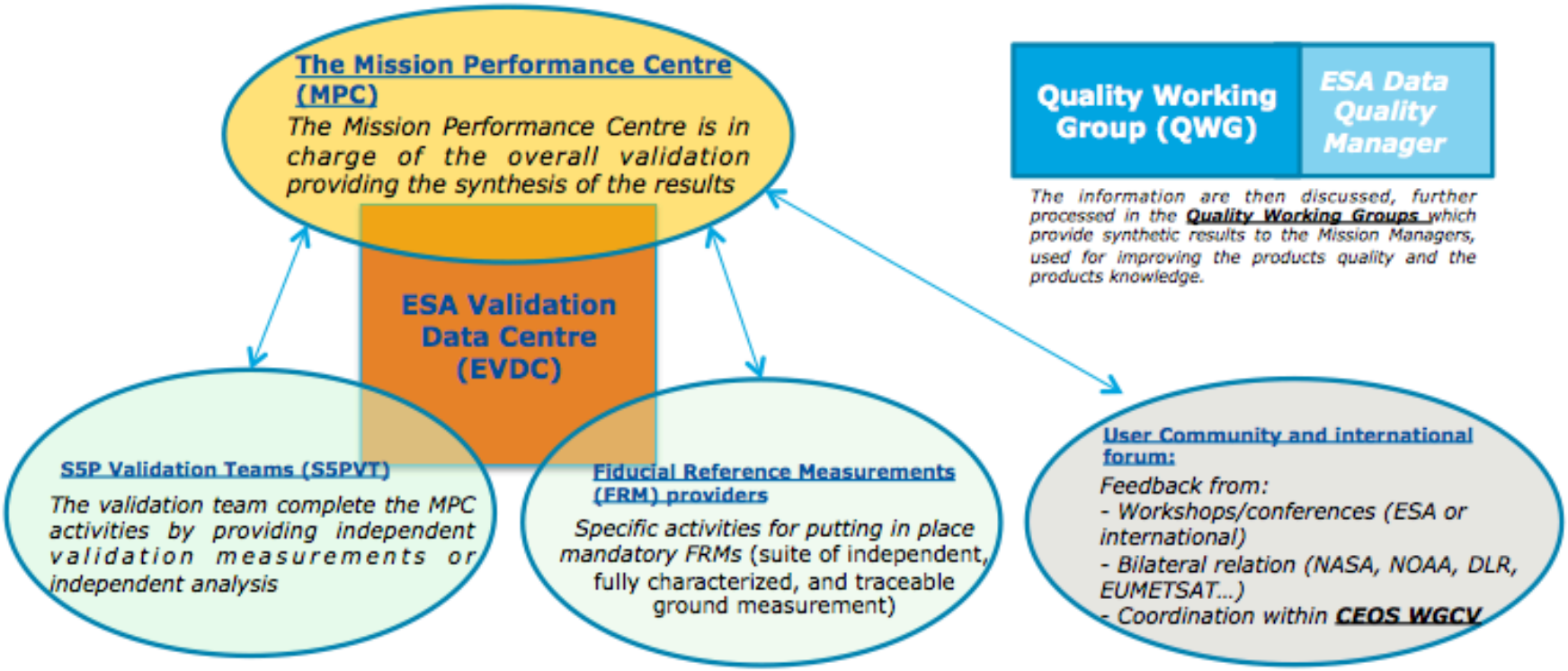
Ramp-up phase has started preparing a WS on the first S5p product release – **June 25/26 ESRIN** - Start full qualified operations after the Routine Operations Readiness Review (**RORR**) Meeting - **Dec. 2018**.

Sentinel-5 Precursor Product Releases

Product	Main Parameter	Staggered Product Releases to the Public
UV Aerosol Index	Aerosol index	**June 2018**
Cloud Properties	Fraction, optical depth, top height	
Nitrogen Dioxide (NO_2)	Total and tropospheric columns	
Total Ozone (O_3)	NRT total column	
Carbon Monoxide (CO)	NTC total column	
NPP_CLOUD	Cloud mask from VIIRS	
Sulphur Dioxide (SO2)	Total column	**August 2018**
Formaldehyde (HCHO)	Total column	
Tropospheric Ozone	Tropospheric column	
Methane (CH4)	Total column	**October 2018**
Carbon Monoxide (CO)	NRT total column	
Total Ozone (O_3)	NTC total column	
Aerosol Layer Height	Mid-level pressure	**December 2018**
Ozone Profiles	Total and tropospheric profiles	
UV	UV dose	

S5p Cal/Val Plan – First Product Release Workshop at ESRIN

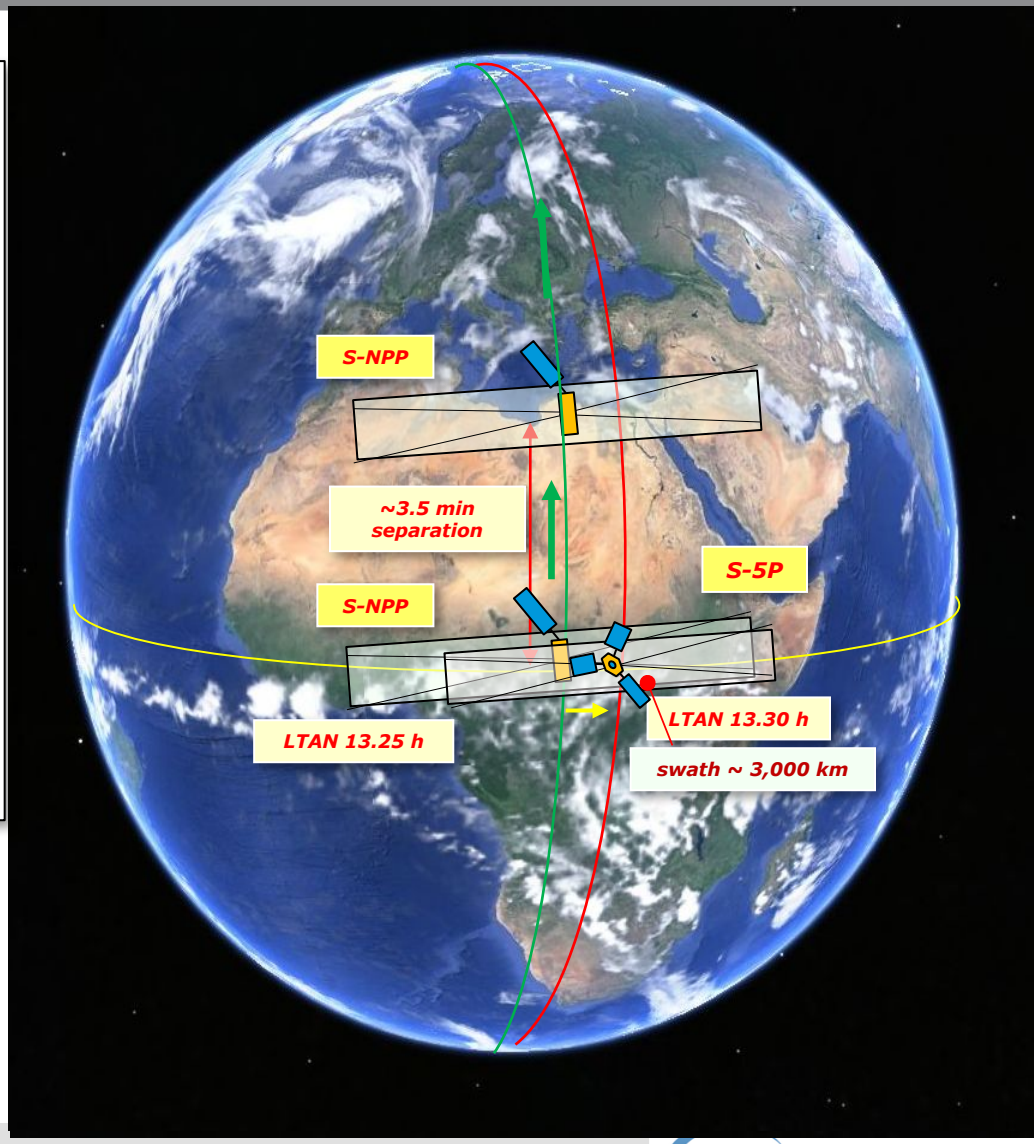
https://sentinel.esa.int/documents/247904/2474724/Sentinel-5P-Calibration-and-Validation-Plan.pdf



Workshop on the first release of S5p products – 25/26 June at ESRIN:
https://nikal.eventsair.com/sentinel-5p-first-product-release-workshop/sentinel-5p

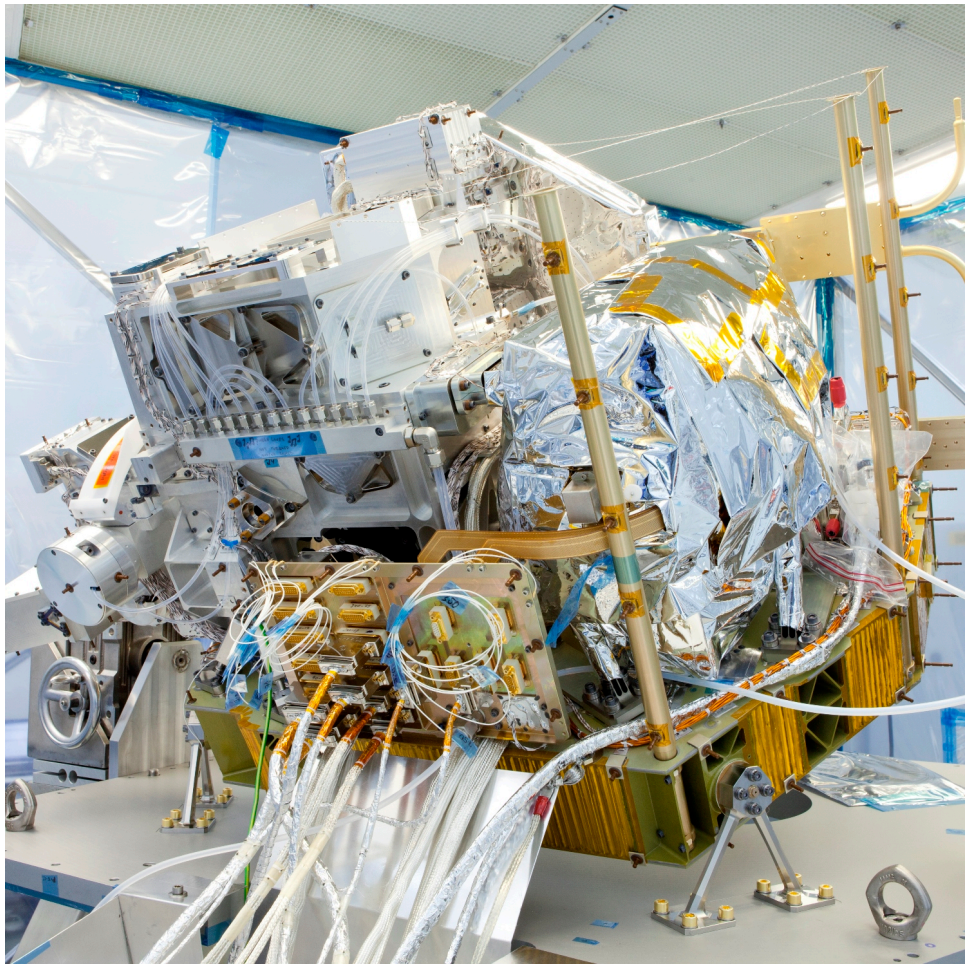
Joint Operation S-NPP + Sentinel 5P

- *CH_4 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



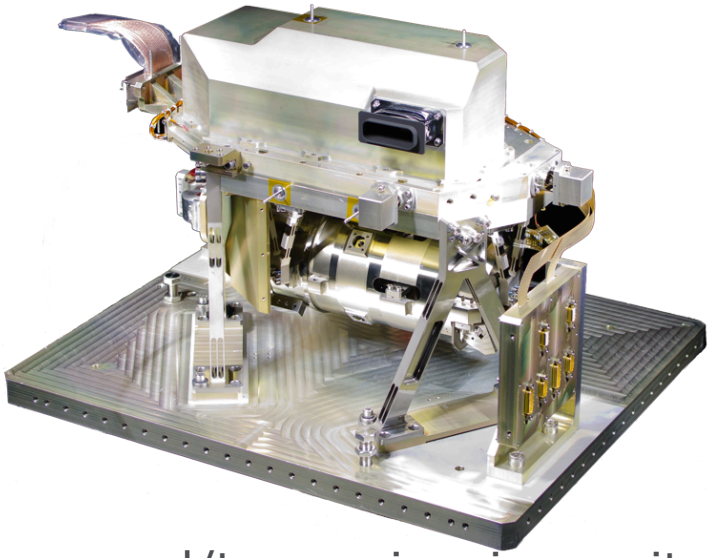
SWIR channel

band: 2305-2385 nm

resolution: 0.25 nm

sampling at sub-satellite point: 7x7 km^2

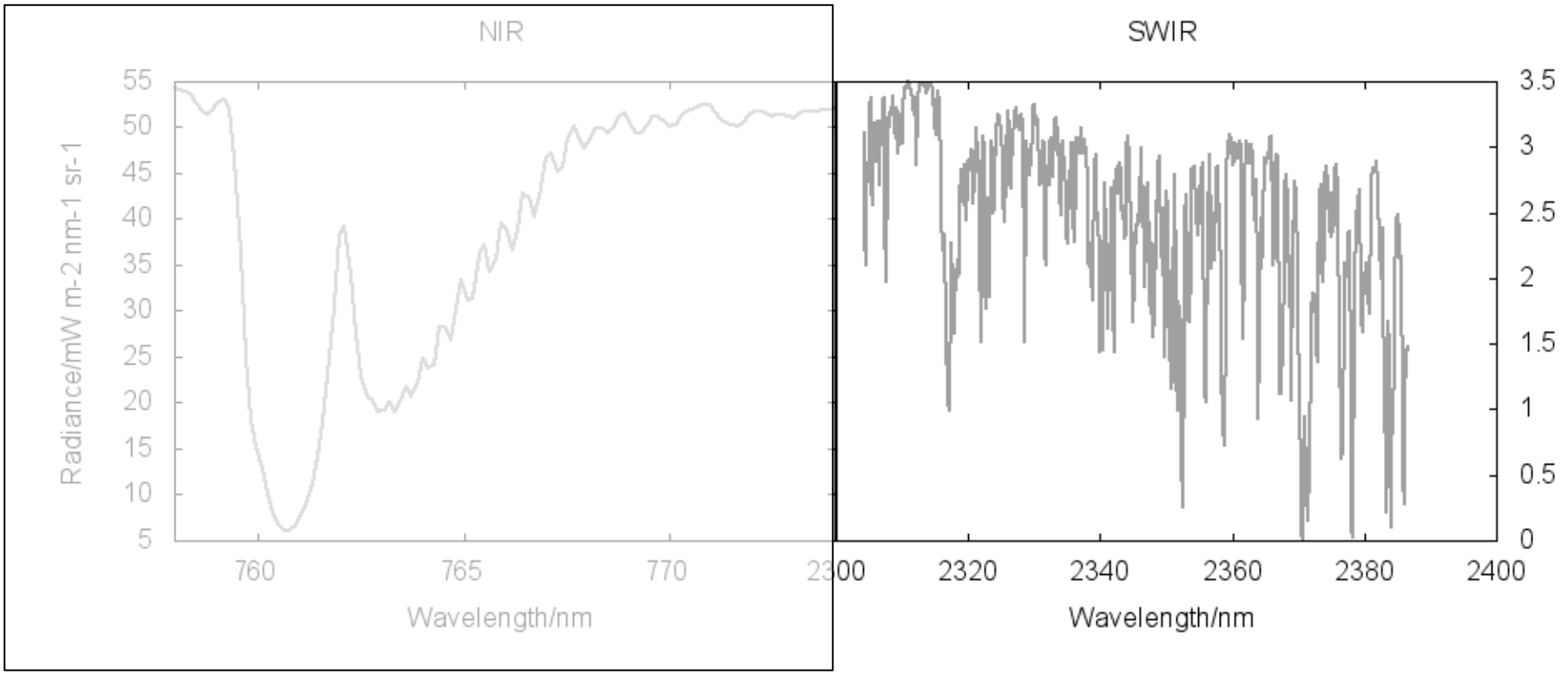
Very stable SWIR performance and instrument in excellent condition.



https://www.sron.nl/tropomi-swir-monitoring

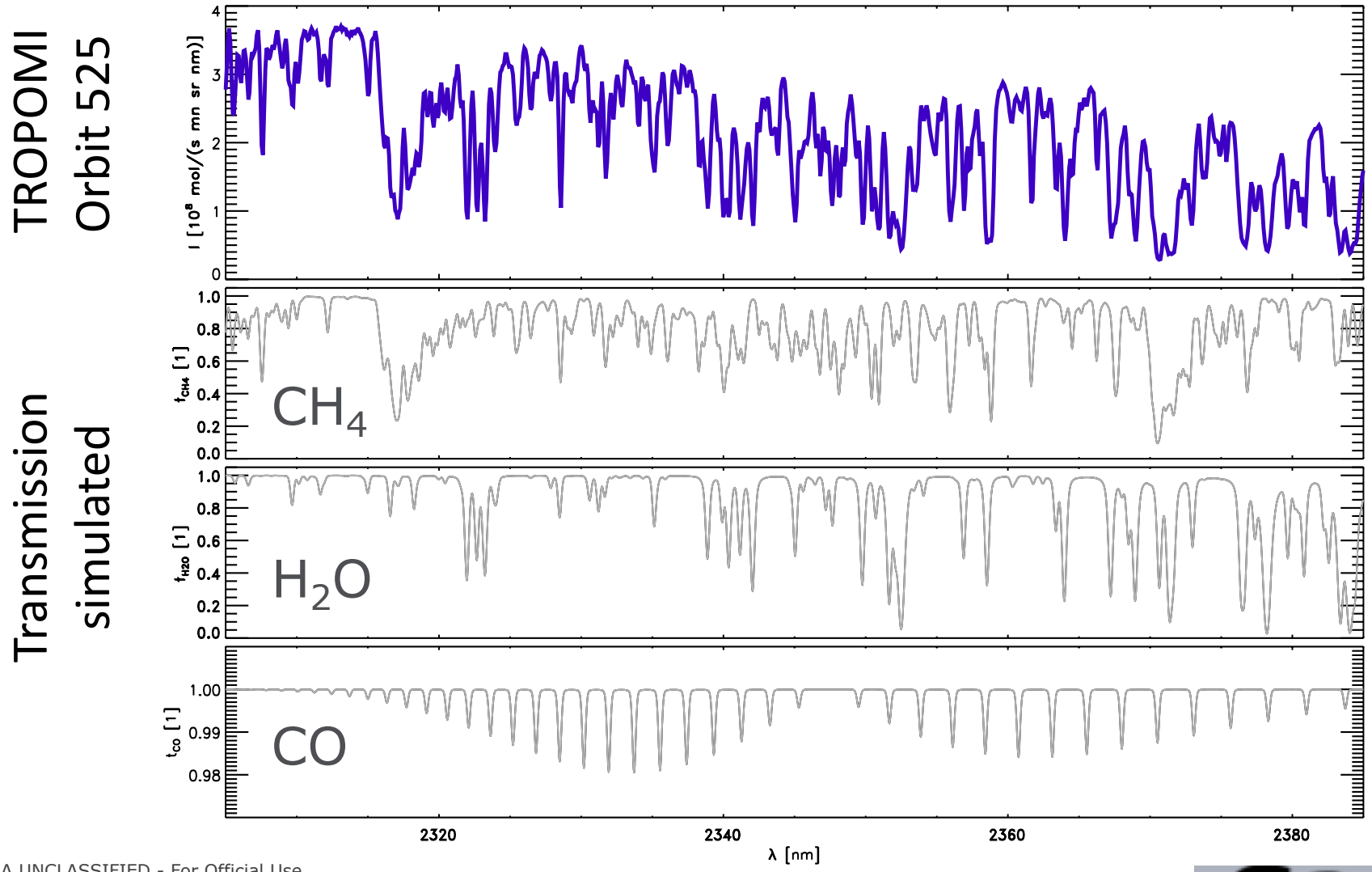
TROPOMI Methane

SWIR and SWIR+NIR processing options



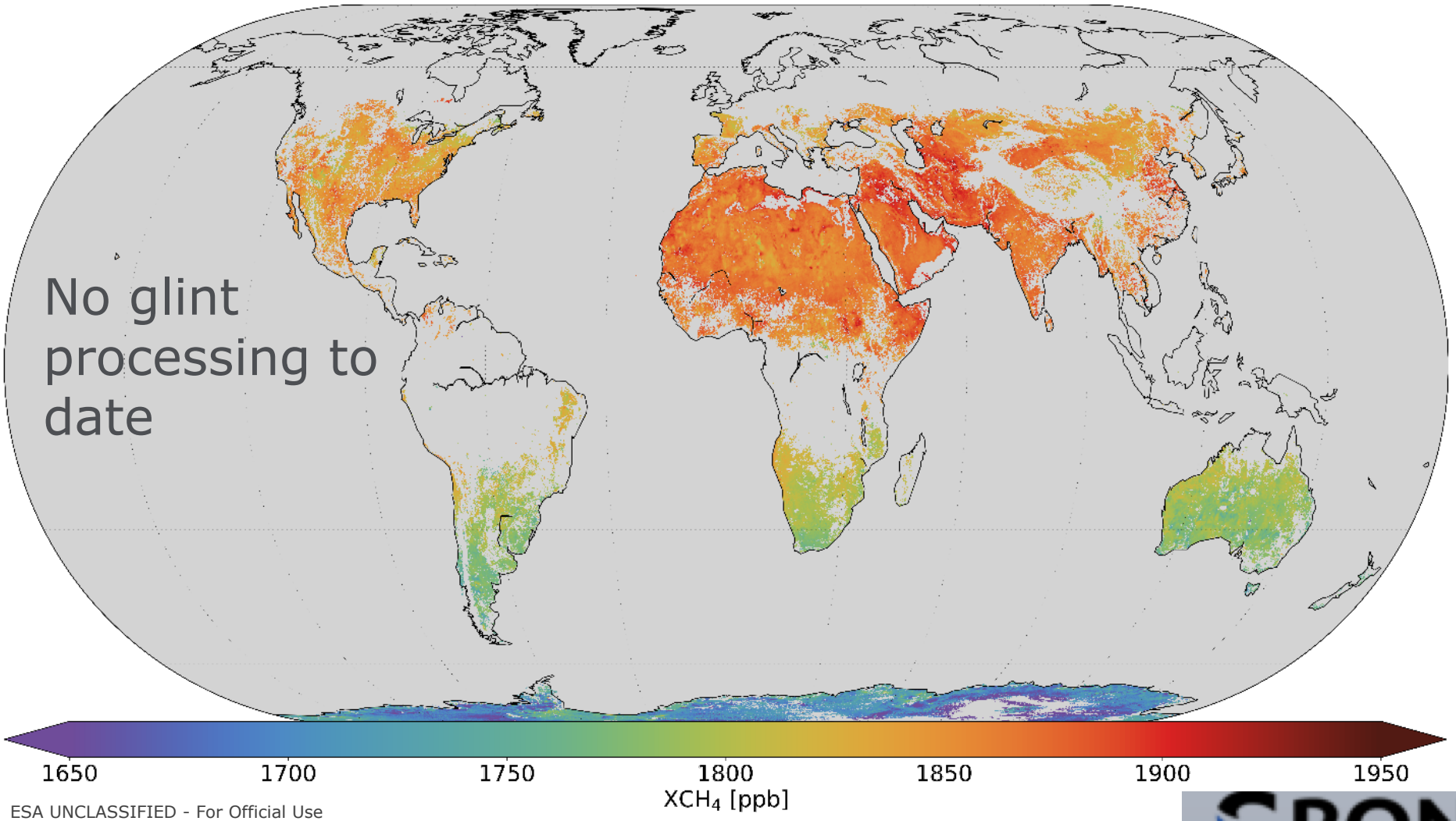
Currently, the NIR does not add significant information to the SWIR one-band retrieval. All presented results for one-band approach.

TROPOMI Methane



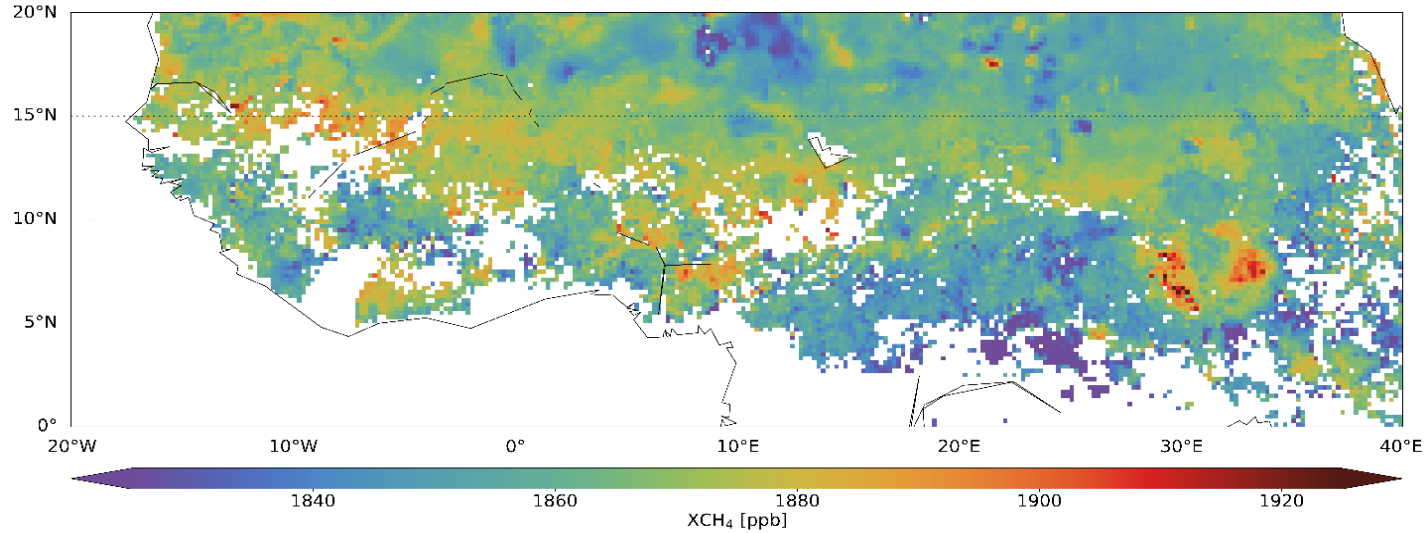
TROPOMI Methane – preliminary results

November 12th to December 30th, 2017

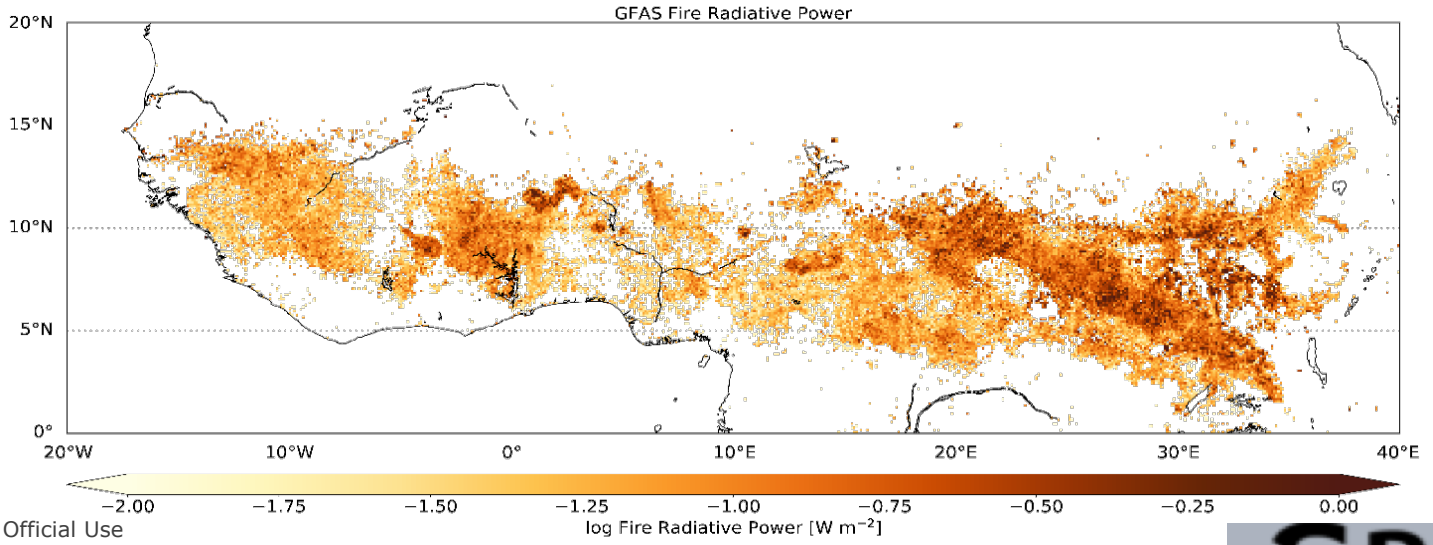


TROPOMI Methane – preliminary results

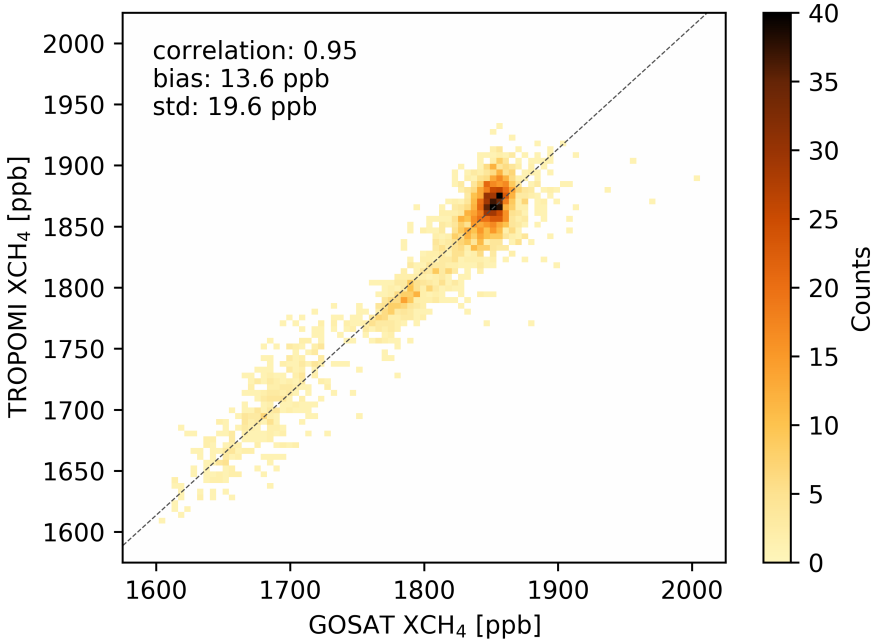
TROPOMI CH_4

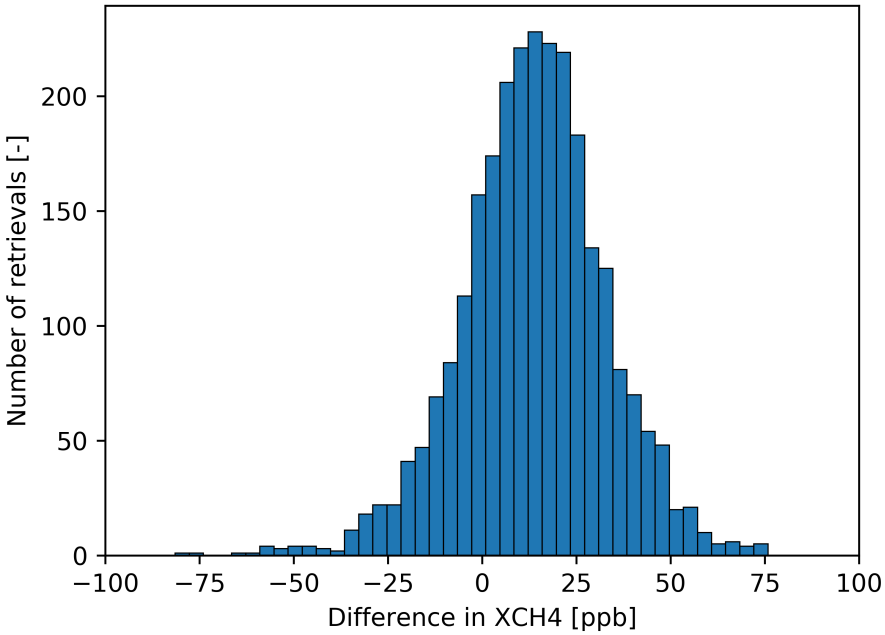


CAMS GFAS



TROPOMI Methane – preliminary validation results - GOSAT





- 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 CH_4 proxy product shows good agreement with a bias of 13.6 ppb, standard deviation of 19.6 ppb
- **TROPOMI Methane: Planned Release to the Public - October 2018**

Copernicus Data Policy/Access

Users shall have **free, full and open** access to Copernicus dedicated Sentinel data and Copernicus service information

Open Data Access Hub: scihub.copernicus.eu

- Simple self Registration (about 110.000 users so far)
- Currently all data generated since October 2014 is available online
- APIs provided for automatic downloads via scripts