OBSERVING
OUR FUTURE

TROPOMI

TROPOMI on the Copernicus Sentinel 5 Precursor:
Ready for Launch

Pepijn Veefkind. TROPOMI Principal Investigator

Netherlands Space Office | esa | AIRBUS DEFENCE & SPACE | TNO innovation for life | SRON Netherlands Institute for Space Research | Koninklijk Nederlands Meteorologisch Instituut Ministerie van Infrastructuur en Milieu

Sentinel 5 precursor

COPERNICUS ATMOSPHERE MISSION IN POLAR ORBIT

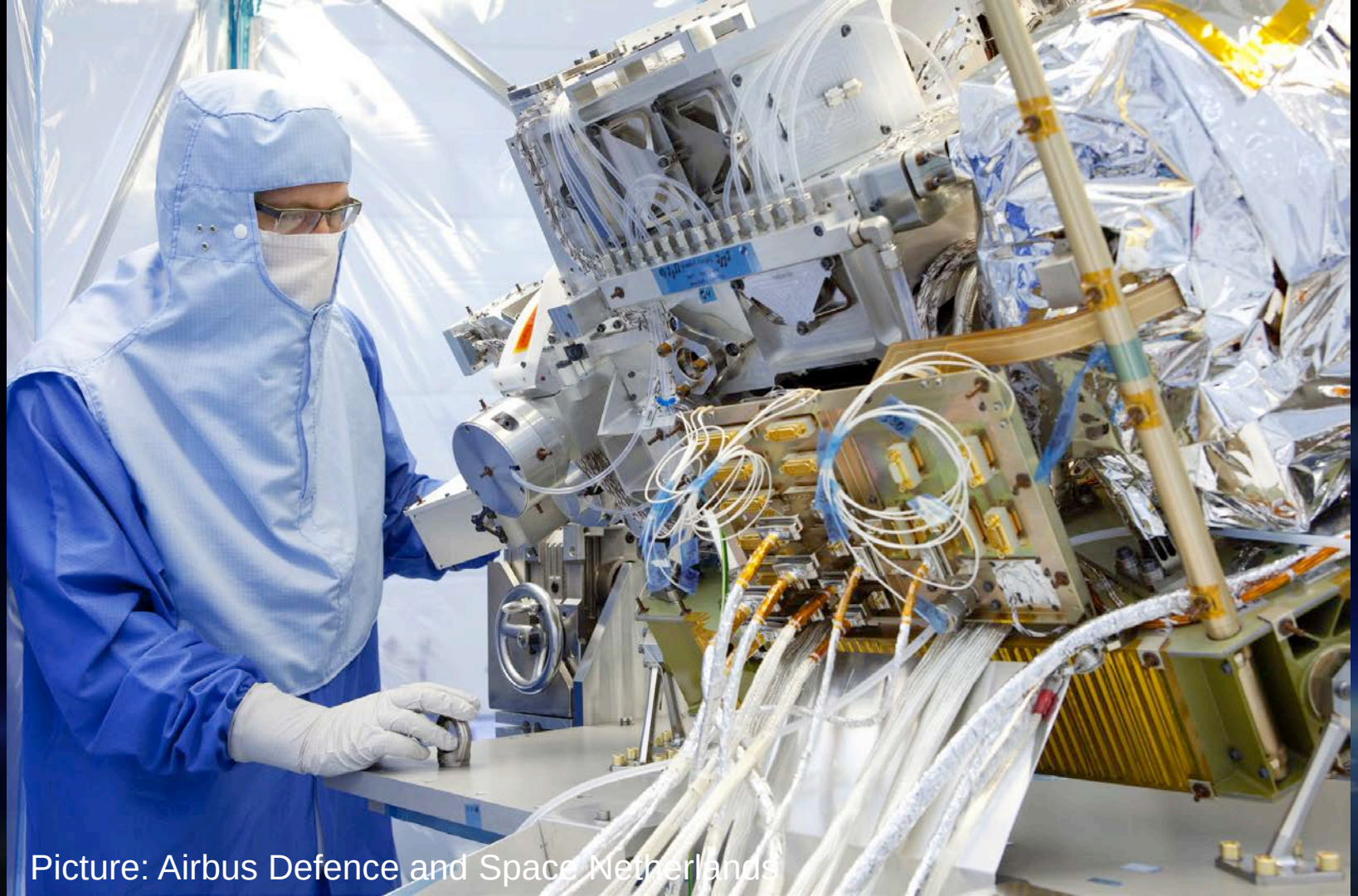
- The ESA Sentinel-5 Precursor (S-5P) is a pre-operational mission focusing on global observations of the atmospheric composition for air quality and climate.
- The TROPOspheric Monitoring Instrument (**TROPOMI**) is the payload of the S-5P mission and is jointly developed by The Netherlands and ESA.
- The planned launch date for S-5P is 2017 with a 7 year design lifetime.

TROPOMI

- UV-VIS-NIR-SWIR nadir view grating spectrometer.
- Spectral range: 270-500, 675-775, 2305-2385 nm
- Spectral Resolution: 0.25-0.5 nm
- Spatial Resolution: 7x7km2
- Global daily coverage at 13:30 local solar time.

Contribution to Copernicus

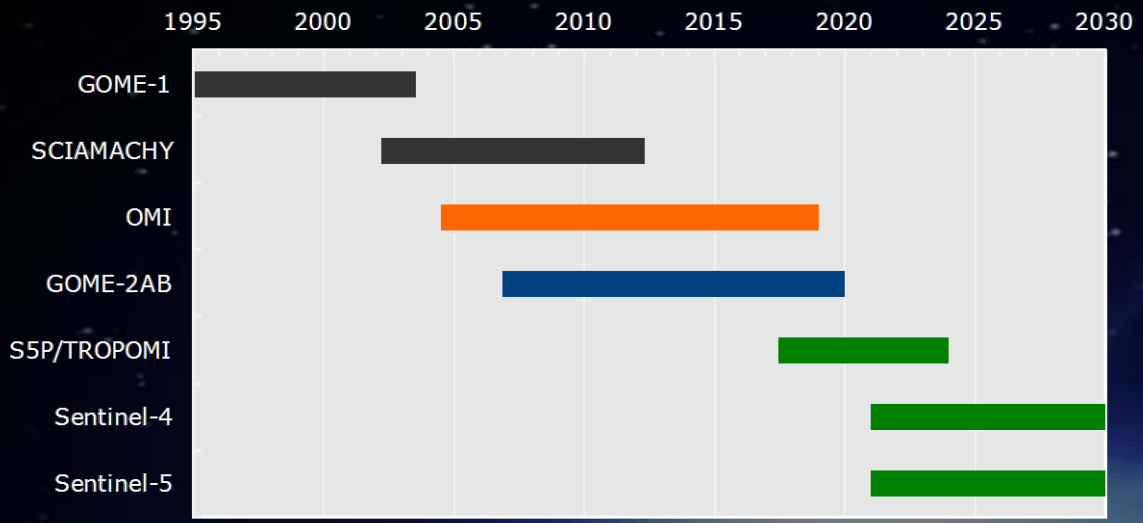
- Total column O_3, NO_2, CO, SO_2,CH_4, HCHO
- Tropospheric column O_3, NO_2
- O_3 profile
- UV Aerosol Index & Aerosol layer height
- Clouds

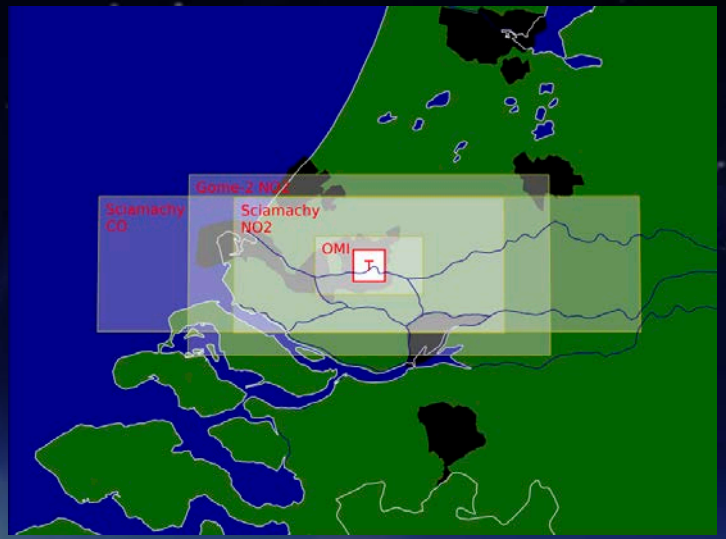


Picture: Airbus Defence and Space Netherlands

TROPOMI

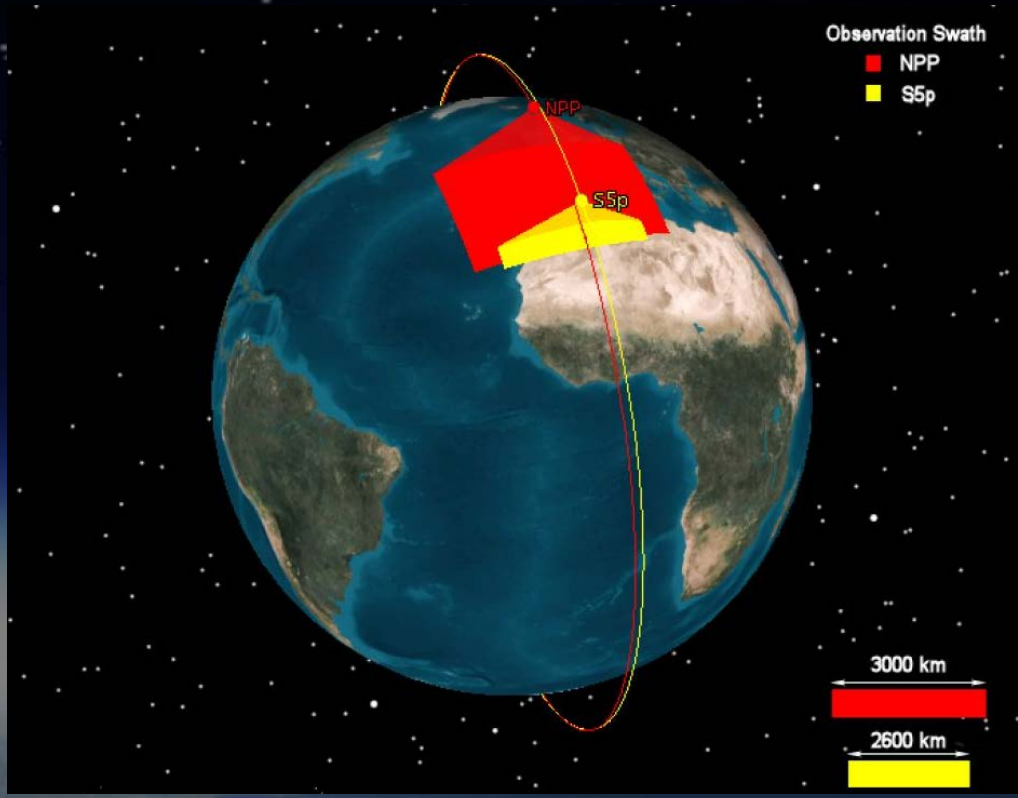
Atmospheric Composition Monitoring





International Co-operation

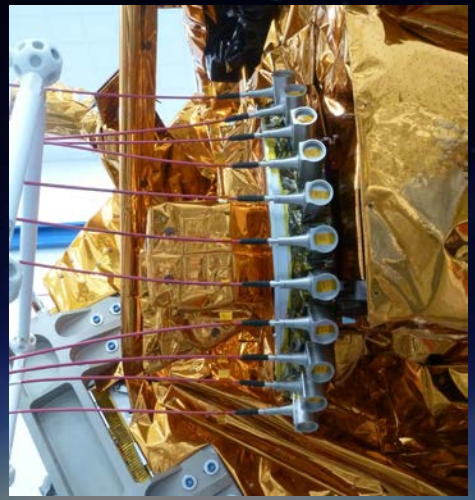
- TROPOMI/S5P is part of the CEOS AQ Constellation
  - TROPOMI provides the global coverage
  - Act as a “travelling standard” between the GEOs
- S5P will fly in loose formation with Suomi NPP
  - Primary objective is to use the VIIRS data for cloud clearing
  - Synergy with OMPS, VIIRS and CRIS

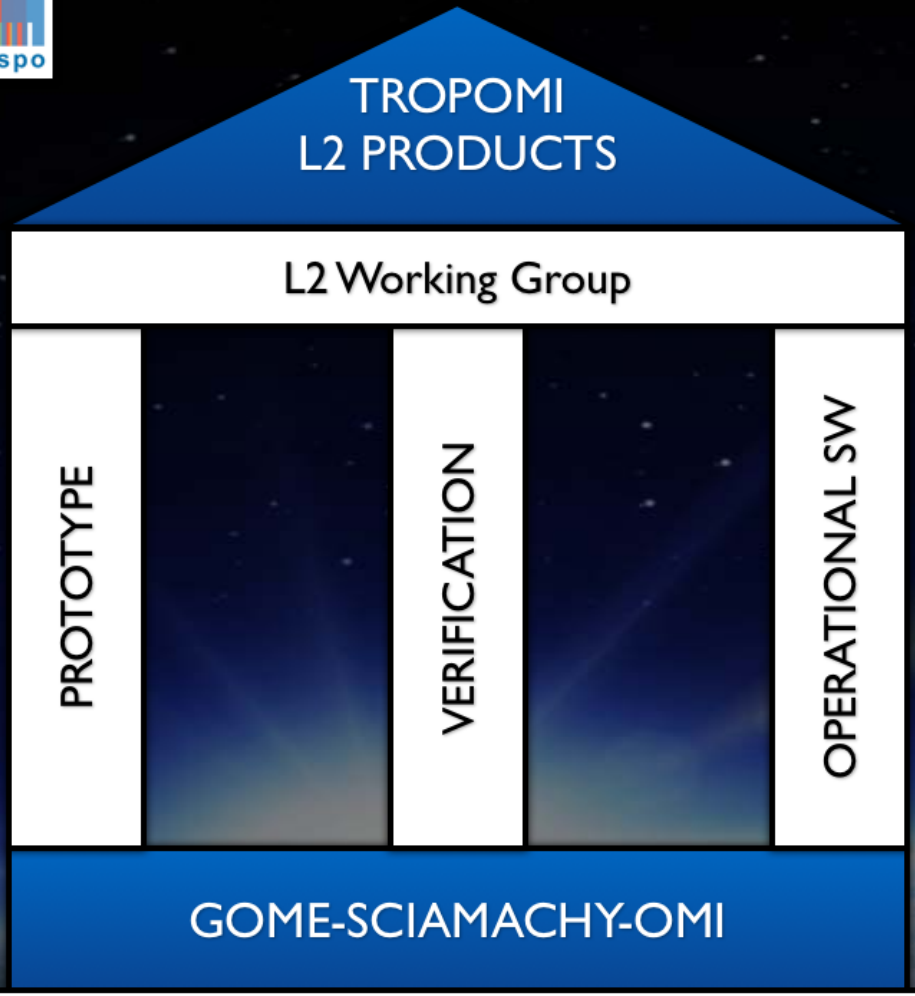


	UV		UVIS		NIR		SWIR	
Band	1	2	3	4	5	6	7	8
Spectral coverage [nm]	270 – 320		320 – 495		675 - 775		2305 – 2385	
Full spectral coverage [nm]	267 - 332		303 - 499		660 - 784		2299 - 2390	
Spectral resolution [nm]	0.49		0.54		0.38		0.25	
Spectral sampling ratio	6.7		2.5		2.8		2.5	
Spatial sampling [km^2]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

Calibration Campaigns

- Main on-ground calibration period – 2015
- NIR stray light calibration campaign – Jan. 2017
- In-flight calibration azimuth dependence of solar diffusors – Phase E1
- *The Level 0-1 processor was an essential part of all the calibration campaigns*





KNMI | DLR | IUP-Bremen | BIRA | SRON | MPIC | RAL | FMI

Level2 Data Products

TROPOMI

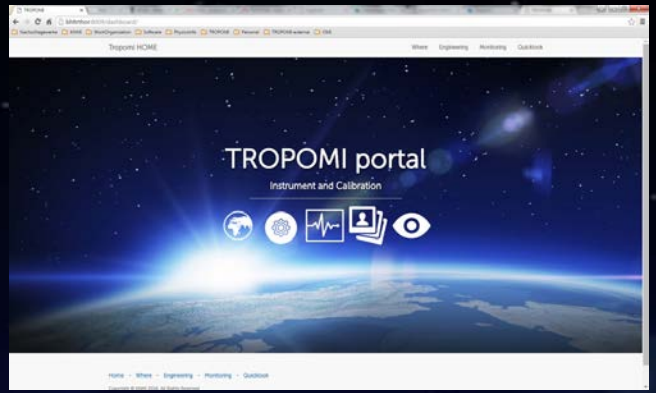
Product	Application
Ozone column	Ozone layer monitoring
Ozone profile, incl. troposphere	Ozone layer, Climate and Air quality monitoring
Nitrogen Dioxide	Air quality forecast / Emission monitoring
Formaldehyde	Air quality forecast / Emission monitoring
Sulphur Dioxide	Volcanic plume warnings / Emission monitoring
Methane	Climate and Air quality monitoring / Emission monitoring
Aerosol	Volcanic ash warnings / Climate monitoring
Carbon Monoxide	Air quality forecast / Emission monitoring
Cloud	Climate Monitoring
Surface UV index	UV Forecast
Solar irradiance	Climate monitoring

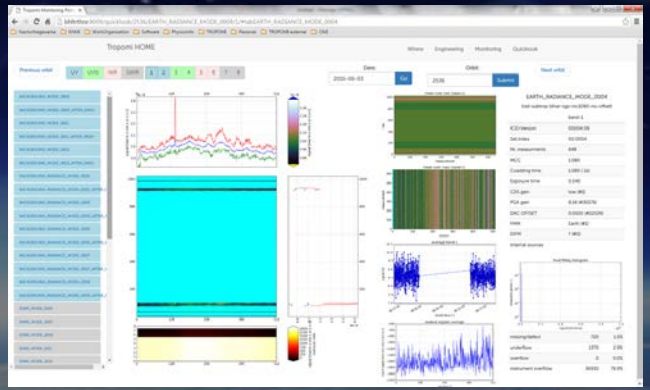
Phase E1 Measurement Schedule

Earth_week	Earth_day	Start_date	Phase	Subphase	Orbit_start	Num_orbits	Earth_day_start	Earth_day_end
1	1	16-Aug-17						
2	8	23-Aug-17						
3	15	30-Aug-17						
4	22	06-Sep-17						
5	29	13-Sep-17						
6	36	20-Sep-17	Phase E1-4	First light	526	30	37	39
7	43	27-Sep-17	Phase E1-6	Second light	661	30	47	49
8	50	04-Oct-17						
9	57	11-Oct-17	Phase E1-9 - Phase E1-17	Temperature dependency test - nominal 1	826	360	59	84
10	64	18-Oct-17						
11	71	25-Oct-17						
12	78	01-Nov-17						
13	85	08-Nov-17						
14	92	15-Nov-17						
15	99	22-Nov-17	Phase E1-19	Sun port QVD1 calibration, geolocation validation, high resolution science	1411	405	100	128
16	106	29-Nov-17						
17	113	06-Dec-17						
18	120	13-Dec-17						
19	127	20-Dec-17						
20	134	27-Dec-17						
21	141	03-Jan-18	Phase E1-22	Nominal operations baseline testing - 1	2011	75	142	147
22	148	10-Jan-18	Phase E1-23	Sun port QVD2 calibration, geolocation validation, high resolution science	2086	405	147	175
23	155	17-Jan-18						
24	162	24-Jan-18						
25	169	31-Jan-18						
26	176	07-Feb-18	Phase E1-24	Nominal operations baseline testing - 2	2491	75	176	181
27	183	14-Feb-18						

S5P Mission Performance Centre

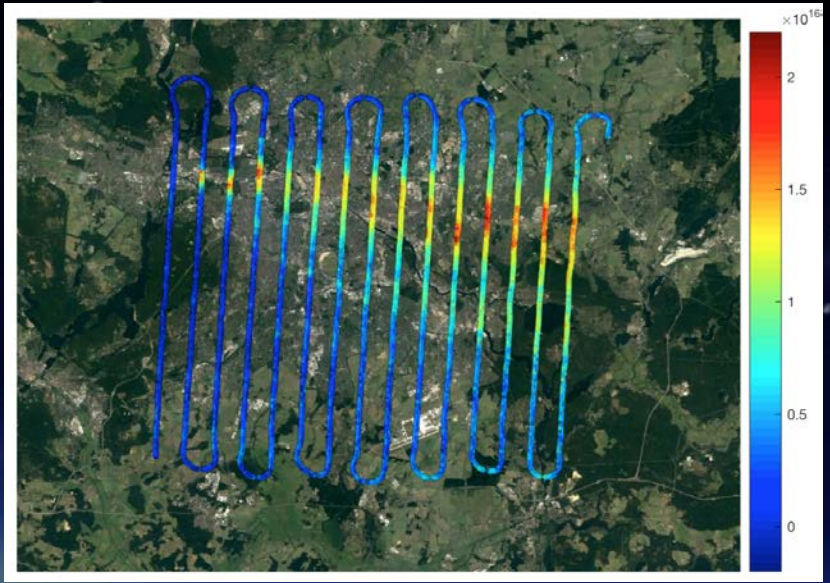
- Quality control of L1B and L2 data products
- In-orbit calibration of L1B data
- Routine validation against operational networks
- Algorithm evolutions and processor maintenance
- User support, including web site with product pages





Validation Organisation

- Pre-flight Campaigns
  - *AROMAT 1&2*
  - *AROMAPEX*
  - *CINDI-2*
- MPC Routine validation
  - *automated system based on Fiducial Reference Measurements (FRMs)*
  - *goal to provide up to date validation information*
- Dedicated S5P/TROPOMI Campaigns 2018 or 2019
  - *AROMAT-type campaign*
  - *KNMI ground based campaign*
- S5PVT
  - *campaigns and contributed validation activities through AO.* [https://earth.esa.int/aos/S5PVT]



TROPOLITE observations, AROMAPEX, TNO, TUD

Royal Netherlands Meteorological Institute
Ministry of Infrastructure and the Environment

CINDI-2

- The pre-launch CINDI-2 campaign organized in Cabauw, The Netherlands in September 2016, was very successful.
- More than 40 instruments operated by 30 groups participate to this field campaign. They include MAX-DOAS instruments as well as in situ systems (CAPS, NO_2 analyzers, NO_2 and O_3 sondes, lidar measurements, sun photometers and ceilometers)

FOS [ESOC]
Flight operations

Mission Man.
[ESA/NSO]

PDGS [DLR]
data acquisition &
processing

OSF [KNMI]
TROPOMI
measurement
planning

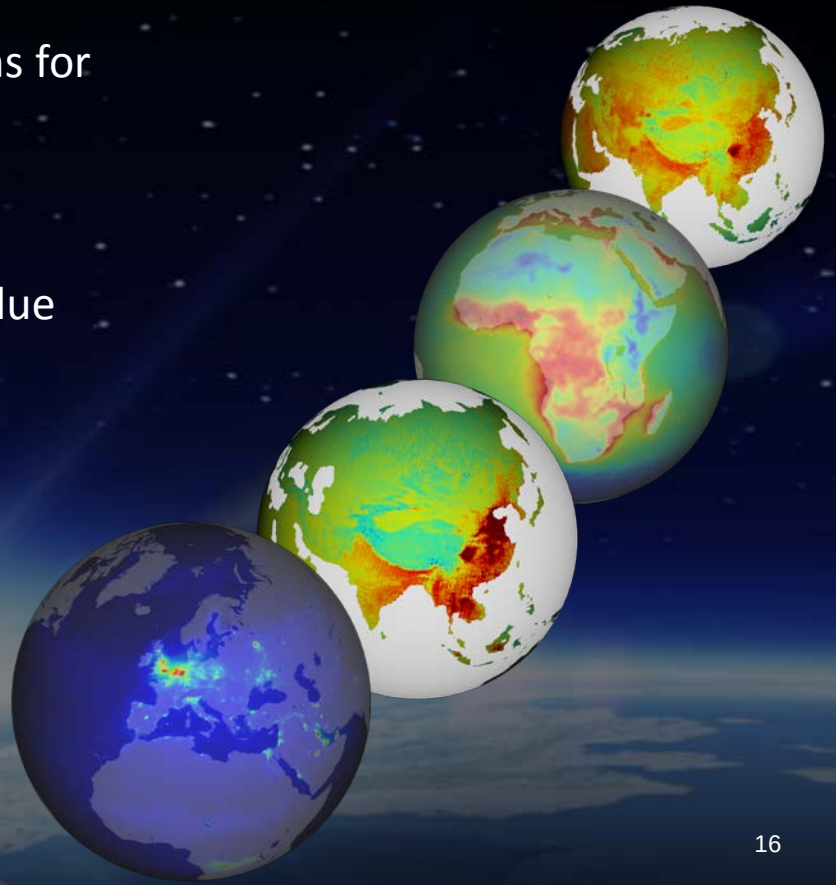
MPC [KNMI ..]
QC/CAL/VAL
Proc. Maintenance
Communication

ESA
data dissemination
User support

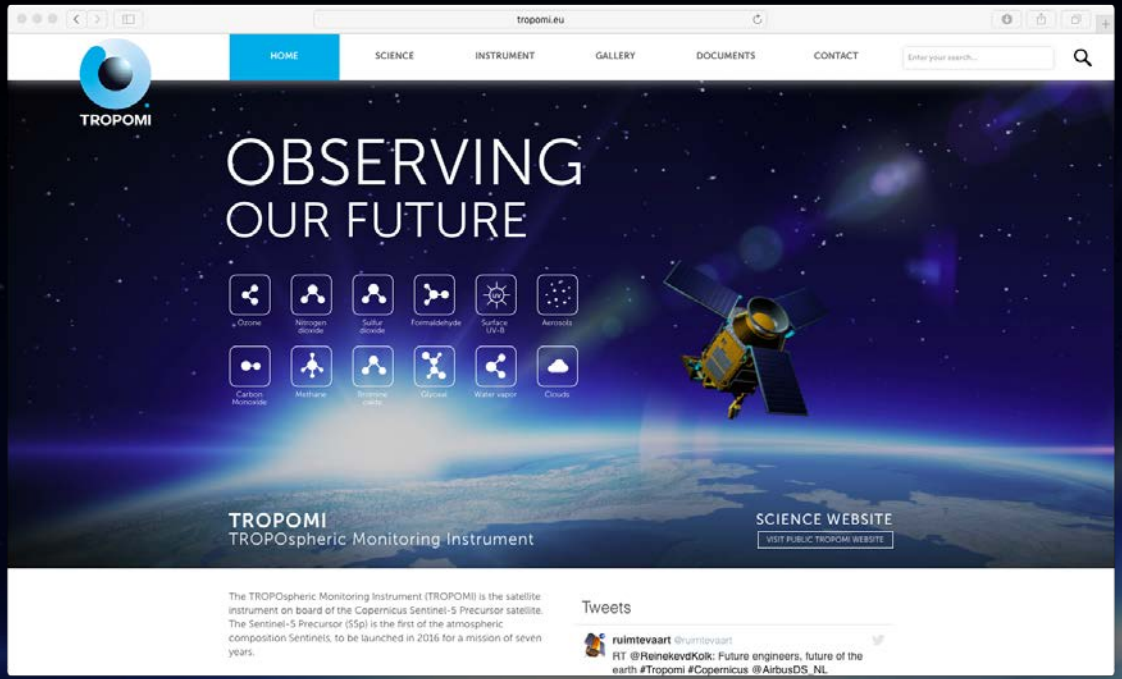
TROPOMI

Summary & Conclusion

- TROPOMI data will contribute to applications for societal challenges on climate change, air quality and the ozone layer.
- TROPOMI will be a major step forward for atmospheric composition observations due to improved spatial resolution & sensitivity.
- Validation of the Level 2 data requires contributions from the international user community.
- *We are counting down for a launch in 2017!*



More information



veefkind@knmi.nl

www.tropomi.nl

www.tropomi.eu

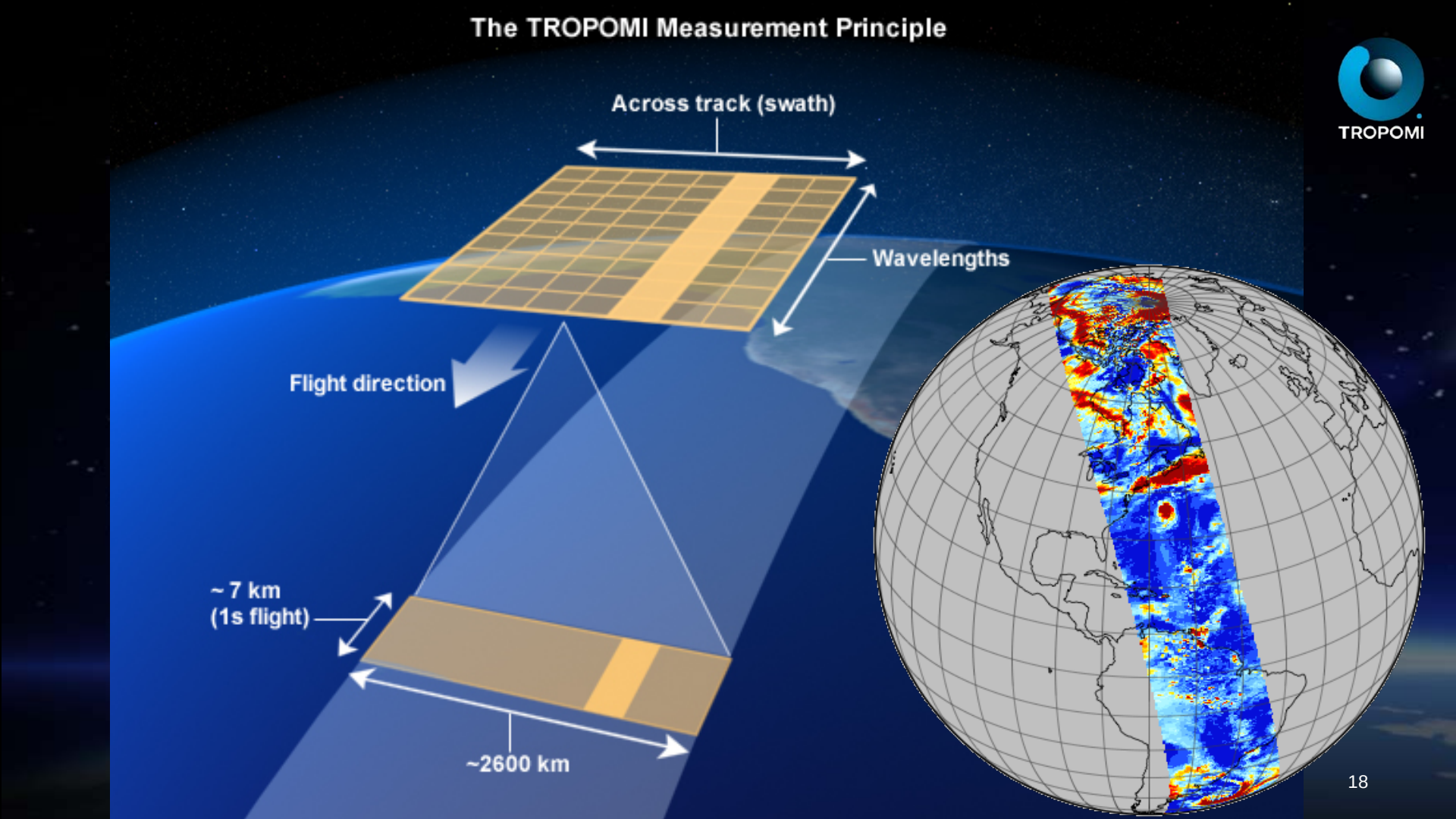
www.temis.nl

www.knmi.nl/omi

sentinel.esa.int/s5p

#tropomi_science

The TROPOMI Measurement Principle



TROPOMI

KNMI Activities

Instrument development support	On-ground calibration	In-flight calibration	Instrument operations
Level 0-1B Processor	Level 1-2 Processors	Data Processing	Geophysical validation

Principal Investigator KNMI/SRON

Functional Diagram