

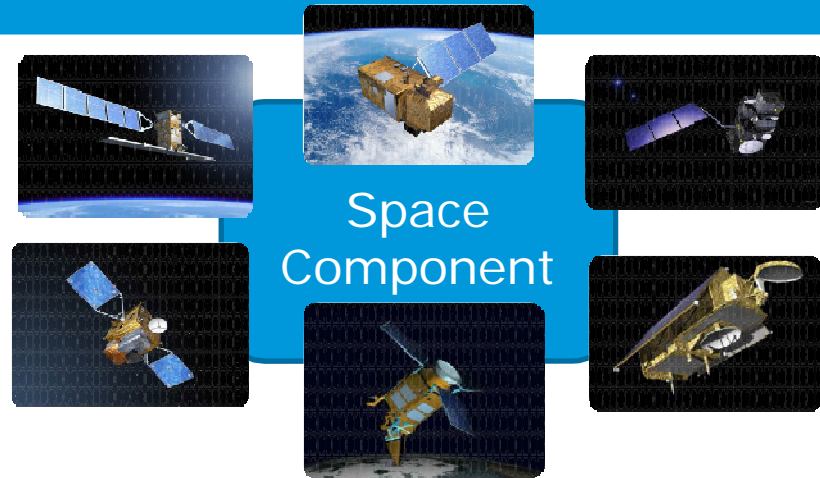
Sentinel-5 Precursor - Mission Overview



Thorsten Fehr, EOP-GMQ
on behalf of the Sentinel-5 Precursor Project team

European **independence** & contribution to **global observing system**

Global, timely and easily accessible information



Services monitoring Earth systems



Land Monitoring



Marine Monitoring



Atmosphere Monitoring

Horizontal services



Emergency Management



Security



Climate Change



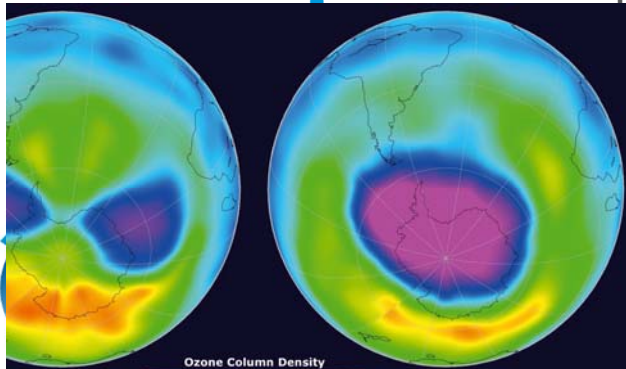
Copernicus Requirements



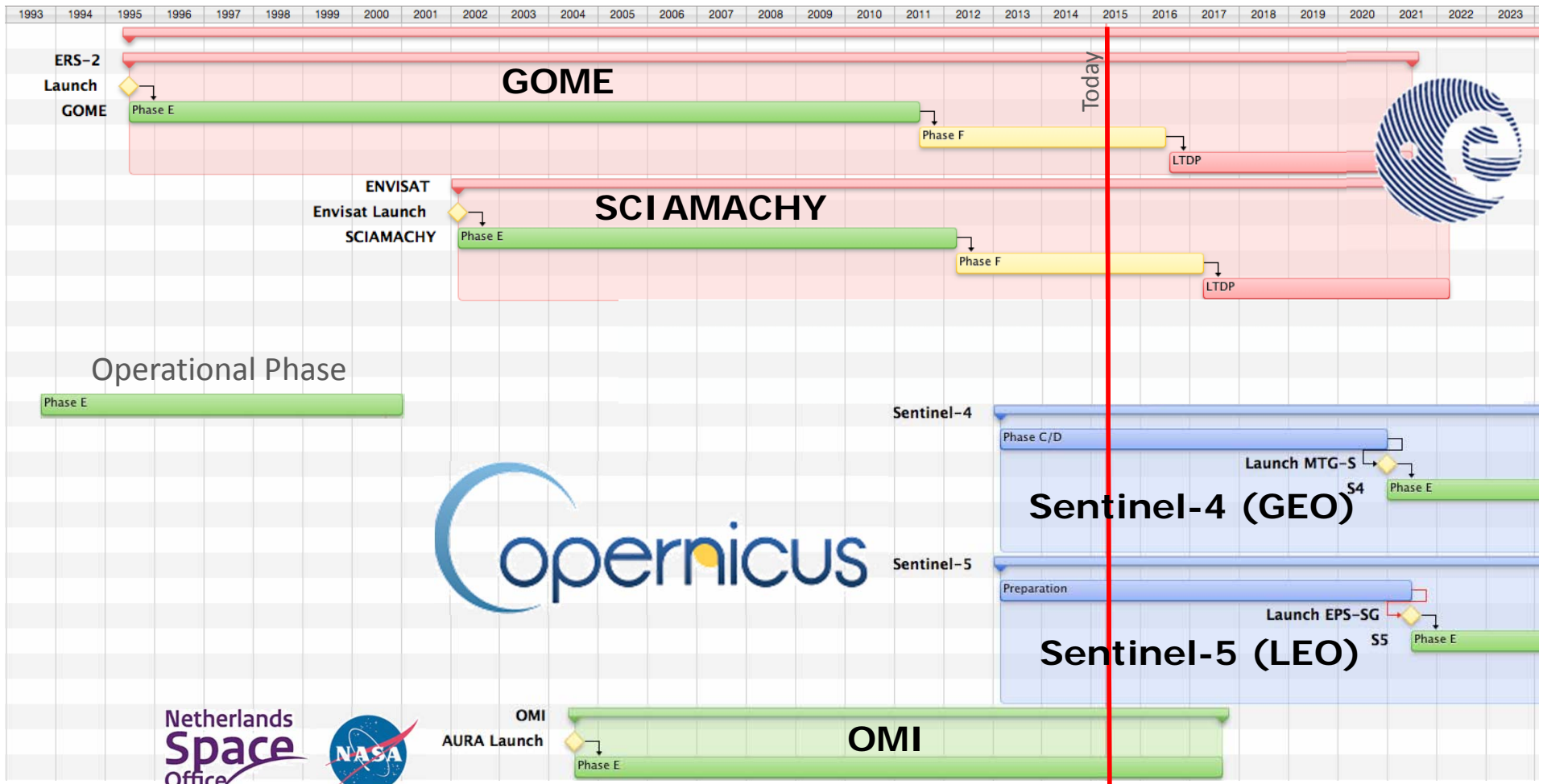
- Drivers for operational space-borne atmospheric composition observations:
 - Facilitation and improvement of operational applications and services related to atmospheric composition
 - Provision of information on treaty verification and protocol monitoring
 - Contribution to scientific understanding for environmental assessments to support policies (e.g., IPCC, LRTAP)
- Support Copernicus Atmospheric Core and Downstream services



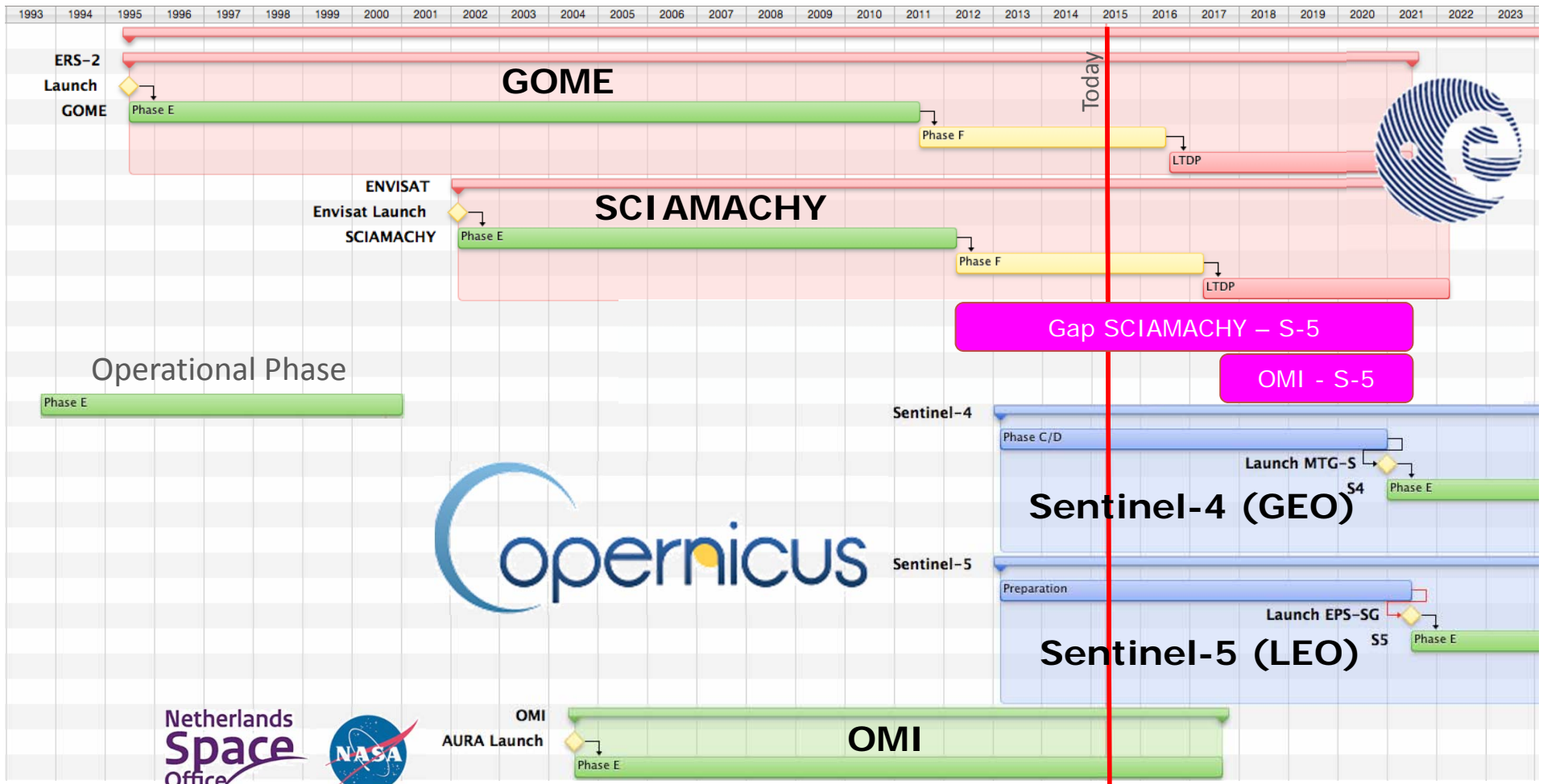
• Copernicus Atmospheric Core and Downstream services
• ULL, CAMS, C3S (all led by ECMWF)



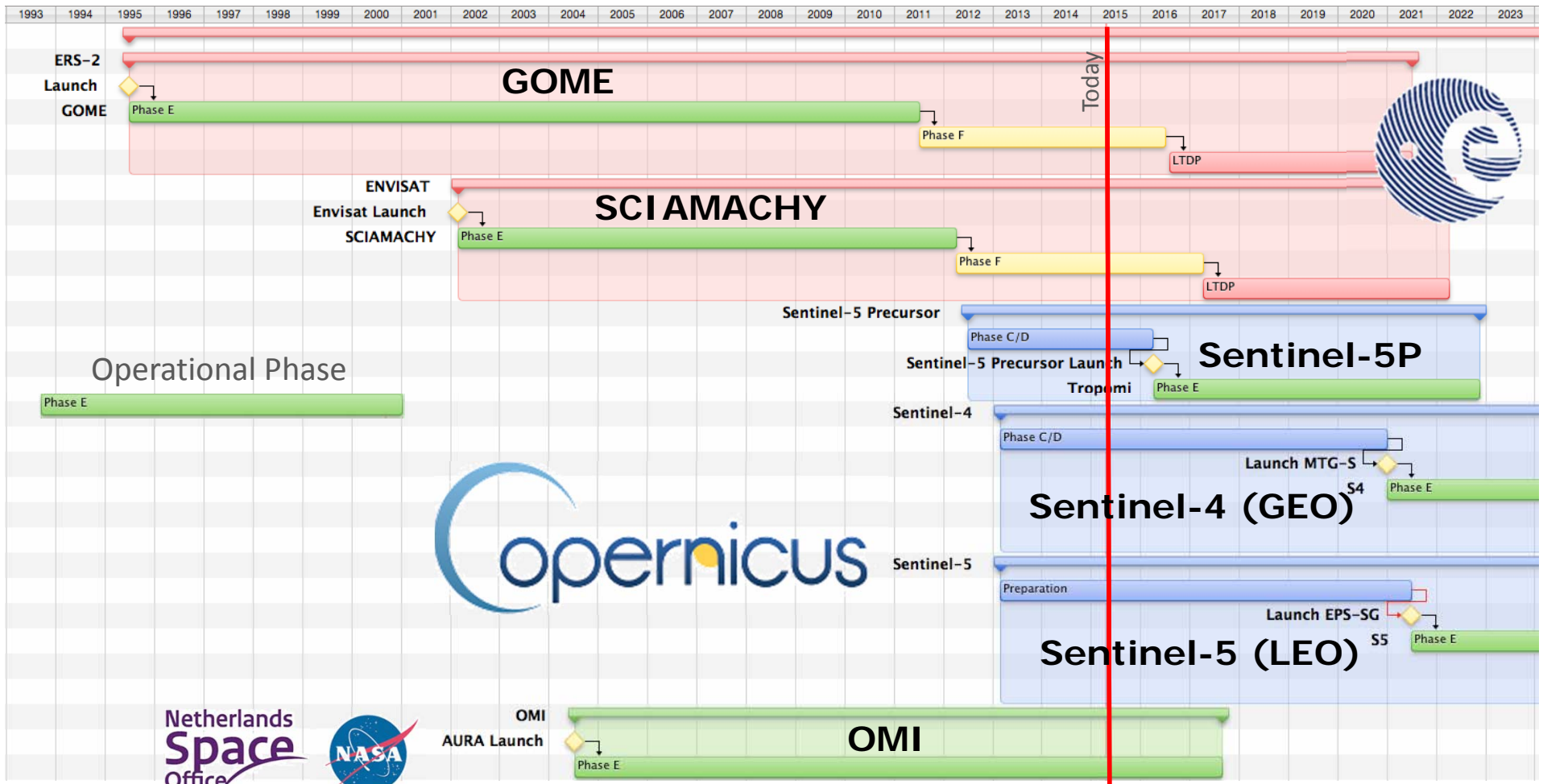
Sentinel-5 "Precursor" ?



Sentinel-5 "Precursor" ?



Sentinel-5 "Precursor" ?



OMI AURA Launch

OMI



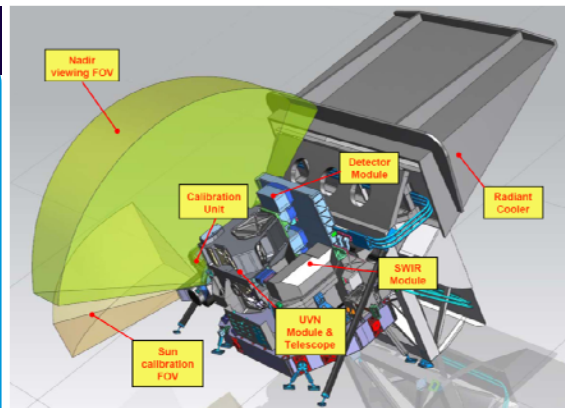


Sentinel-5 Precursor

- The ESA Sentinel-5 Precursor (S5P) is a pre-operational mission focussing 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 S5P is Q2/2016 with 7 year design lifetime.
- Background mission with global daily coverage.

Mission Profile

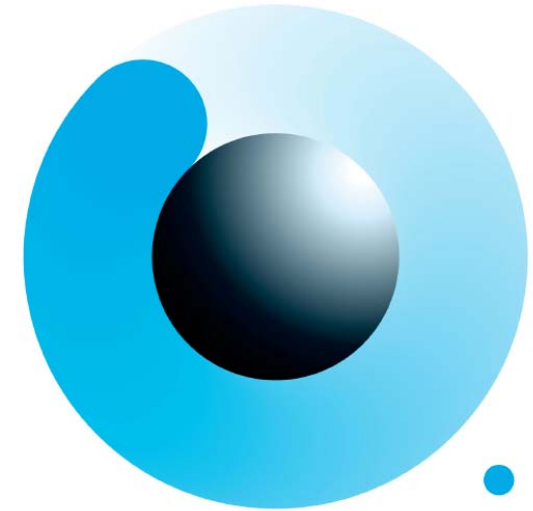
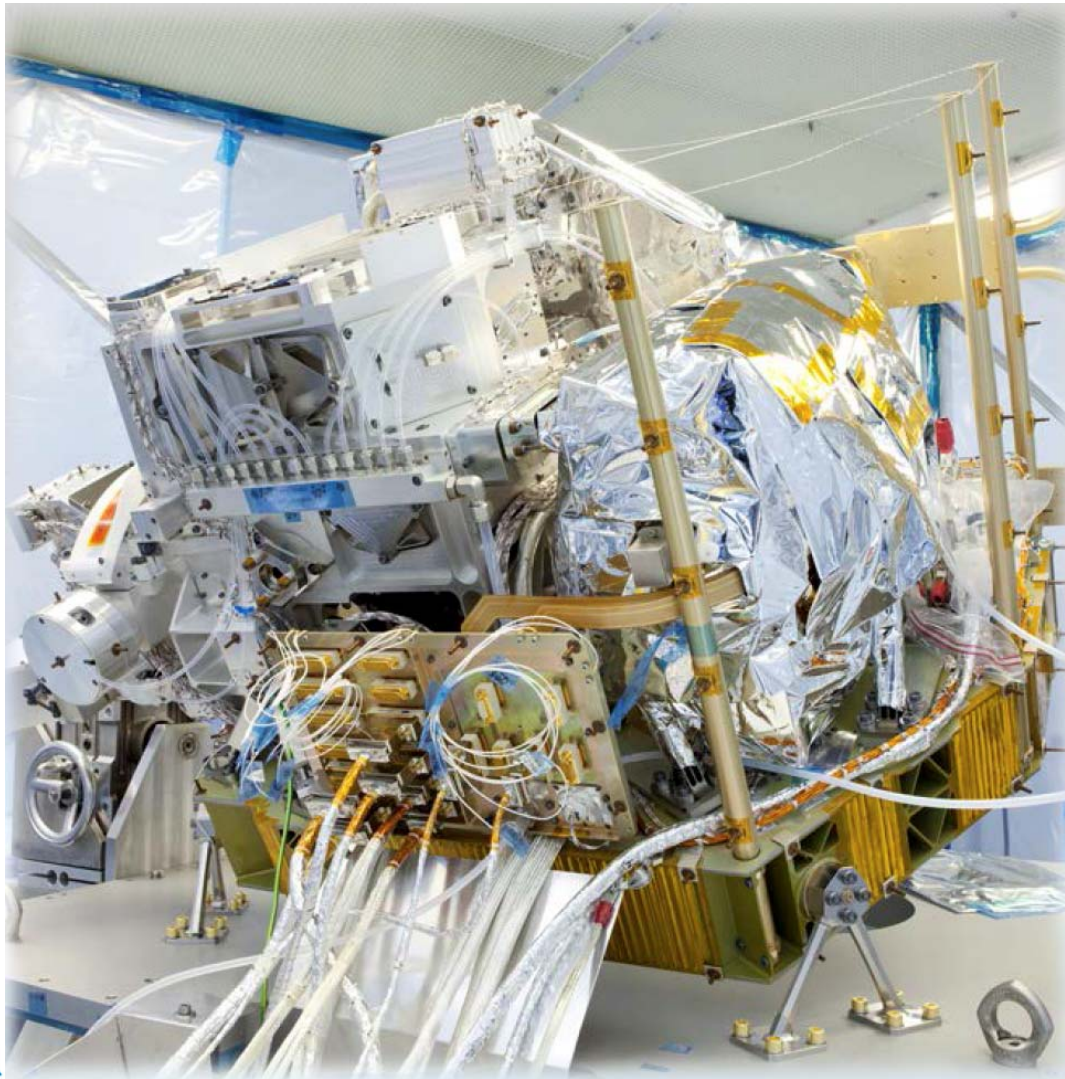
- ▶ 7 years lifetime
- ▶ Sun-Synchronous orbit at 824 km
- ▶ Mean Local Solar Time: 13:30
- ▶ Inclination: 98.742 deg
- ▶ Repeat cycle: 17-days
- ▶ Operative Autonomy: 72 hrs
- ▶ Spacecraft: Astrobus L 250 M from ASTRIUM
- ▶ Launcher: ROCKOT (VEGA)



TROPOMI

- ▶ UV-VIS-NIR-SSWIR push-broom grating spectrometer
- ▶ Spectral range: 270-500 nm, 675-775 nm, 2305-2385 nm
- ▶ Spectral Resolution: 0.25-1.1 nm
- ▶ Observation Mode: Nadir, global daily coverage, ground pixel 7x7km² at nadir

TROPOMI



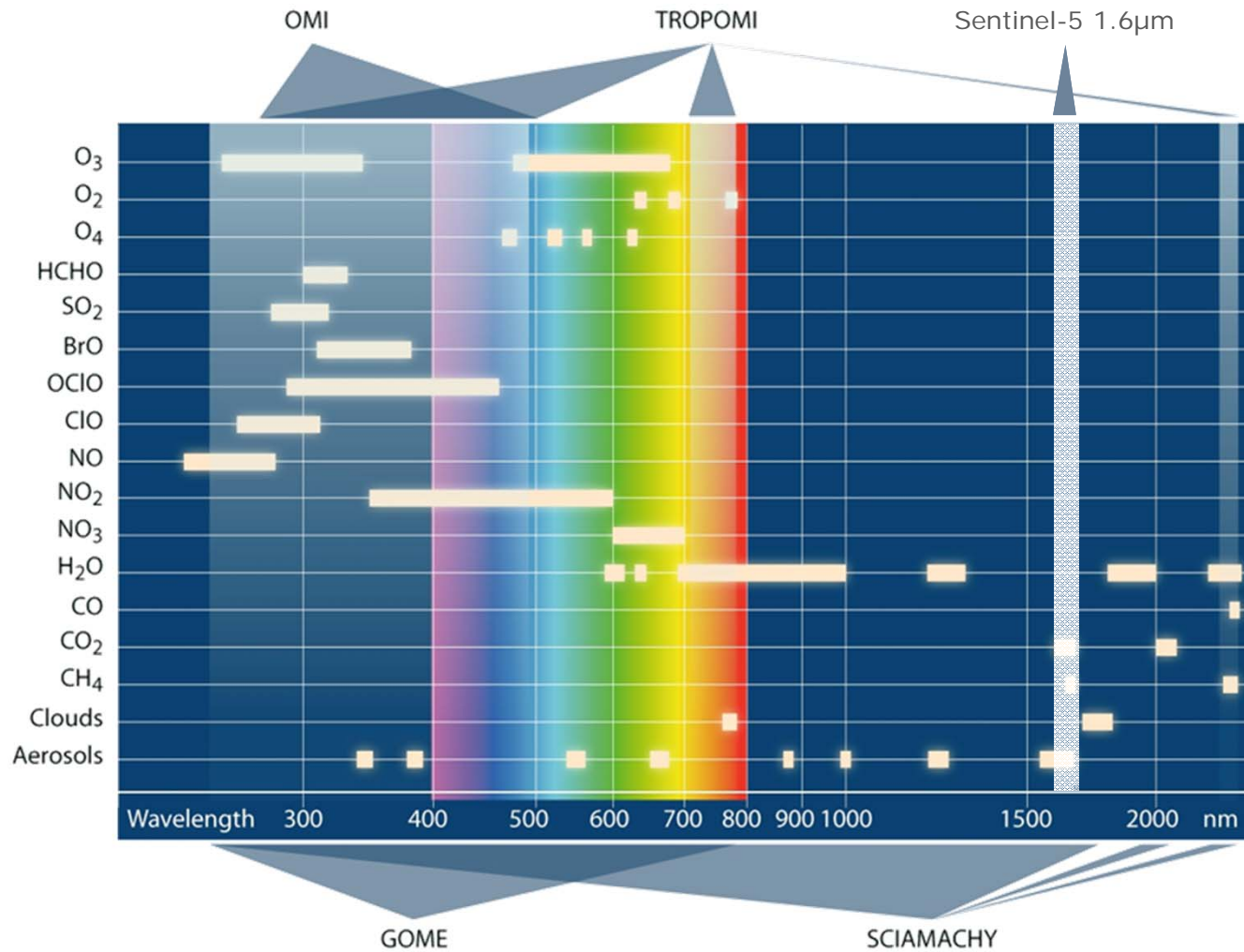
On TROPOMI see
presentation by
Pepijn Veeffkind, KNMI



Sentinel-5 Precursor, ACC-11, ESA/ESRIN, 29 April 2015



Spectral Range Comparison



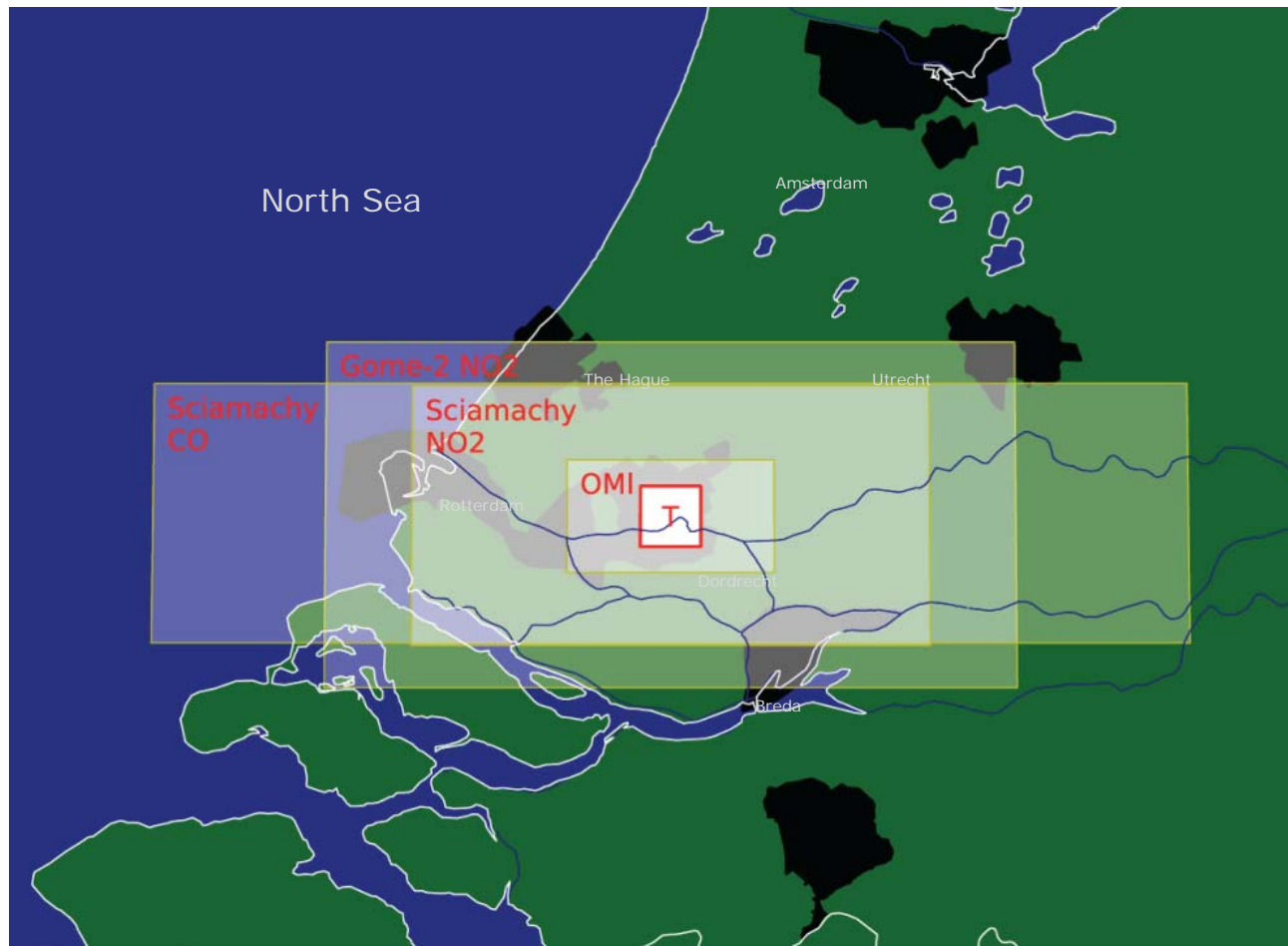
Source: <http://www.tropomi.eu>



Sentinel-5 Precursor, ACC-11, ESA/ESRIN, 29 April 2015



Spatial Resolution Comparison



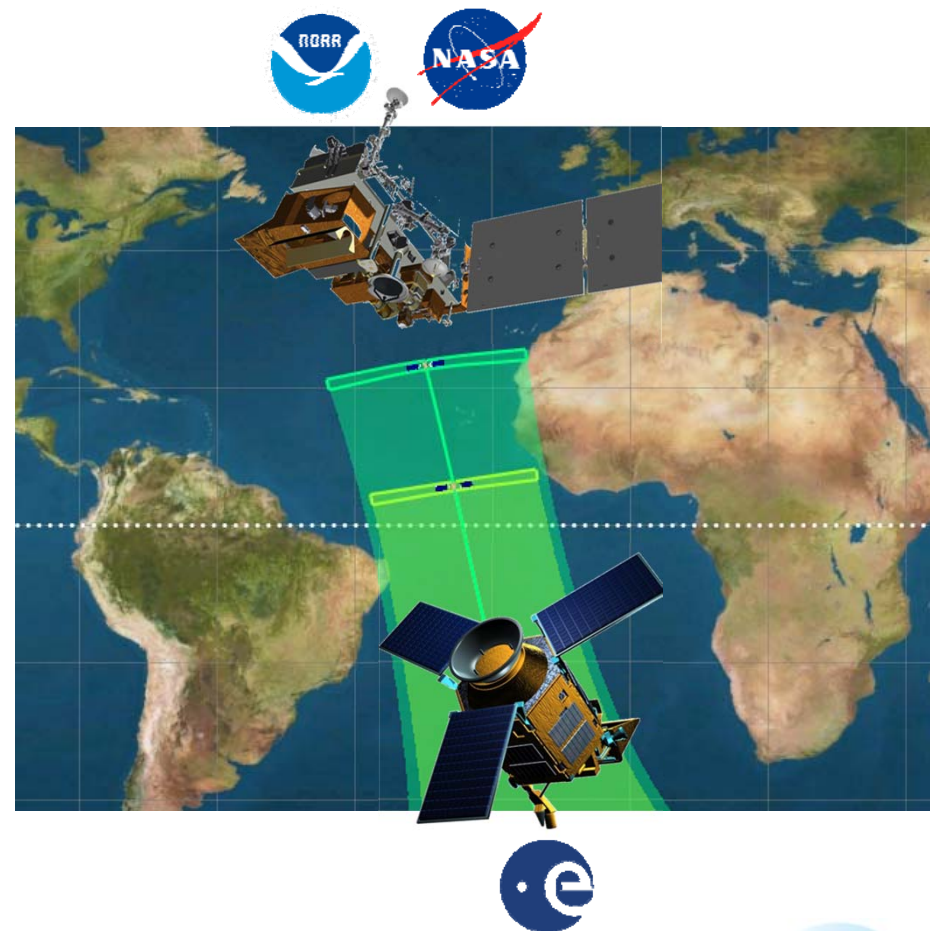
Source: KNMI



S-5p and S-NPP Loose Formation Flight











- In particular Methane requires a very reliable cloud clearing of optically thin layers (e.g. cirrus)
- “Loose formation” with separation 5 min +/- 5 min
- Close cooperation between ESA and NOAA/NASA on technical level
- Tailored VIIRS cloud products for S5P
- Synergistic use SNPP & S-5p products improve the S5P only cloud information



Level 2 Products and the L2 WG



Parameter	Data Product	Vertical Resolution	Accuracy	Precision
Ozone 	Ozone Profile	6 km	10-30%	10%
	Total Ozone	total column	3.5-5%	1.6-2.5%
	Tropospheric Ozone	trop column		
NO ₂ 	Stratospheric NO ₂	strat column	<10%	0.5e15
	Tropospheric NO ₂	trop column	25-50%	0.7e15
SO ₂ 	SO ₂ enhanced	total column	30%	0.15-0.3 (0.06-0.12) DU
	Total SO ₂	total column	30-50%	1-3 (0.4-1.2) DU
Formaldehyde 	Total HCHO	total column	40-80%	1.2e16 (4e15)
CO 	Total CO	total column	15%	<10%
Methane 	Total CH ₄	total column	1.5%	1%
Cloud 	Cloud Fraction	total column	<20%	0.05
	Albedo (Optical Thickness)	total column	<20%	0.05 (10)
	Cloud Height (Pressure)	total column	<20%	<0.5 km (<30hPa)
	SNPP VIIRS Cloud data			
Aerosol 	Aerosol Layer Height	total column	<100hPa	<50hPa
	Aerosol Type	total column	~1 AAI	<0.1 AAI

Source: S5P Level 2 Working Group

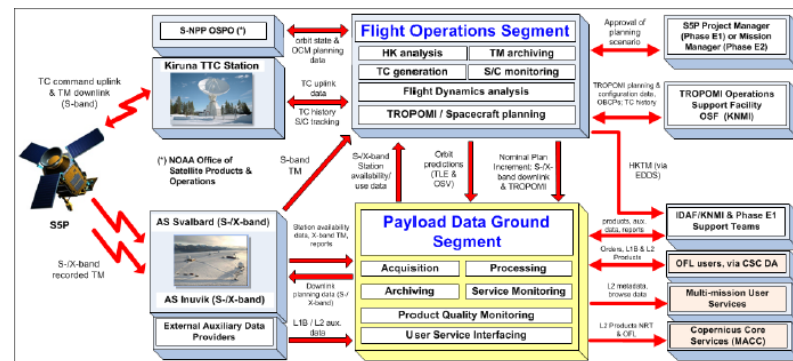
All ATBDs (L1 and L2) will be made available to the science community



Ground Segment Status



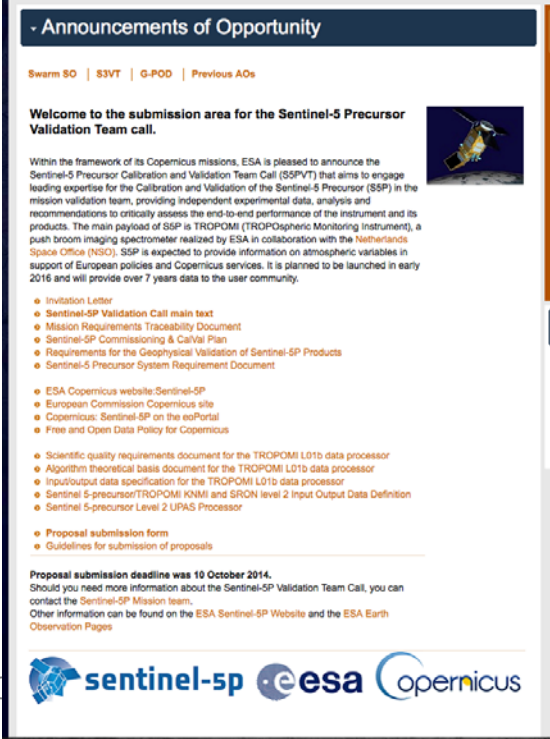
- Ground Segment (PDGS and FOS) Critical Design Review successfully completed in June '14
- Mission Control System delivery in April 2015
- Level 1b and Level 2 Processor Version 0.9 delivery in November 2015 for Phase E1
- Ground Segment Validation activities started
- S5P Mission Performance Centre ITT under preparation



Validation Preparation



- Validation based on existing experience gained on heritage or operational missions
 - Excellent experience and existing infrastructure for stratospheric products, in particular Ozone, and GHG
 - S5P requires focus on validation of Air Quality parameters
- Sentinel-5 Precursor Validation Team
 - Validation using satellite, airborne or ground-based experiments providing independent measurements
 - Experiments to assess accuracy, resolution, and stability TROPOMI
 - Assessment and validation of the S5P retrieval and processing
 - AO Call issued in September 2014



- Announcements of Opportunity

Swarm SO | S3VT | G-POD | Previous AOs

Welcome to the submission area for the Sentinel-5 Precursor Validation Team call.

Within the framework of its Copernicus missions, ESA is pleased to announce the Sentinel-5 Precursor Calibration and Validation Team Call (S5PVT) that aims to engage leading expertise for the Calibration and Validation of the Sentinel-5 Precursor (S5P) in the mission validation team, providing independent experimental data, analysis and recommendations to critically assess the end-to-end performance of the instrument and its products. The main payload of S5P is TROPOMI (TROPOspheric Monitoring Instrument), a push broom imaging spectrometer realized by ESA in collaboration with the Netherlands Space Office (NSO). S5P is expected to provide information on atmospheric variables in support of European policies and Copernicus services. It is planned to be launched in early 2016 and will provide over 7 years data to the user community.




- Invitation Letter
- Sentinel-5P Validation Call main text
- Mission Requirements Traceability Document
- Sentinel-5P Commissioning & CalVal Plan
- Requirements for the Geophysical Validation of Sentinel-5P Products
- Sentinel-5 Precursor System Requirement Document

- ESA Copernicus website: Sentinel-5P
- European Commission Copernicus site
- Copernicus: Sentinel-5P on the eoPortal
- Free and Open Data Policy for Copernicus

- Scientific quality requirements document for the TROPOMI L01b data processor
- Algorithm theoretical basis document for the TROPOMI L01b data processor
- Input/output data specification for the TROPOMI L01b data processor
- Sentinel 5-precursor/TROPOMI KNMI and SRON level 2 Input Output Data Definition
- Sentinel 5-precursor Level 2 UFAS Processor

- Proposal submission form
- Guidelines for submission of proposals

Proposal submission deadline was 10 October 2014.
Should you need more information about the Sentinel-5P Validation Team Call, you can contact the Sentinel-5P Mission team.
Other information can be found on the ESA Sentinel-5P Website and the ESA Earth Observation Pages

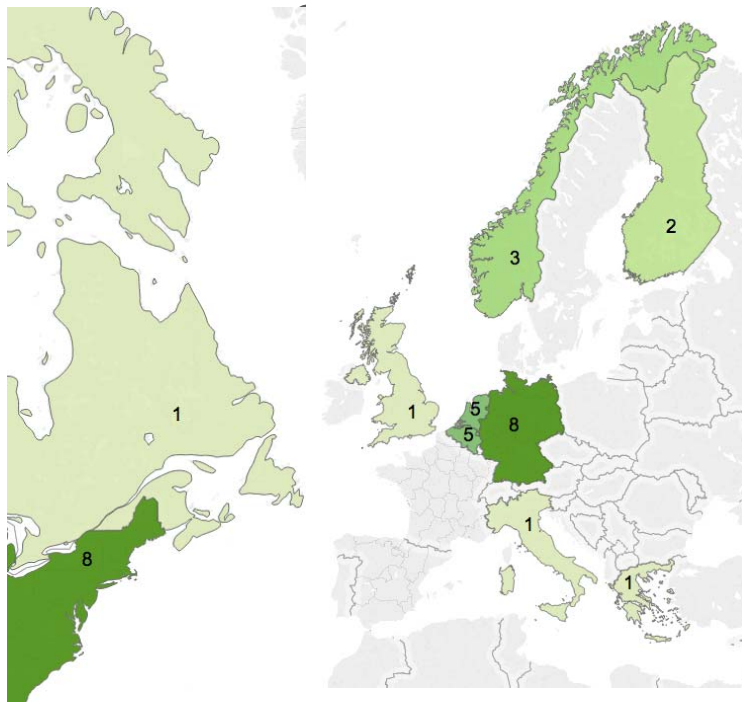
 **sentinel-sp**  **esa** 

Validation AO – Some Results

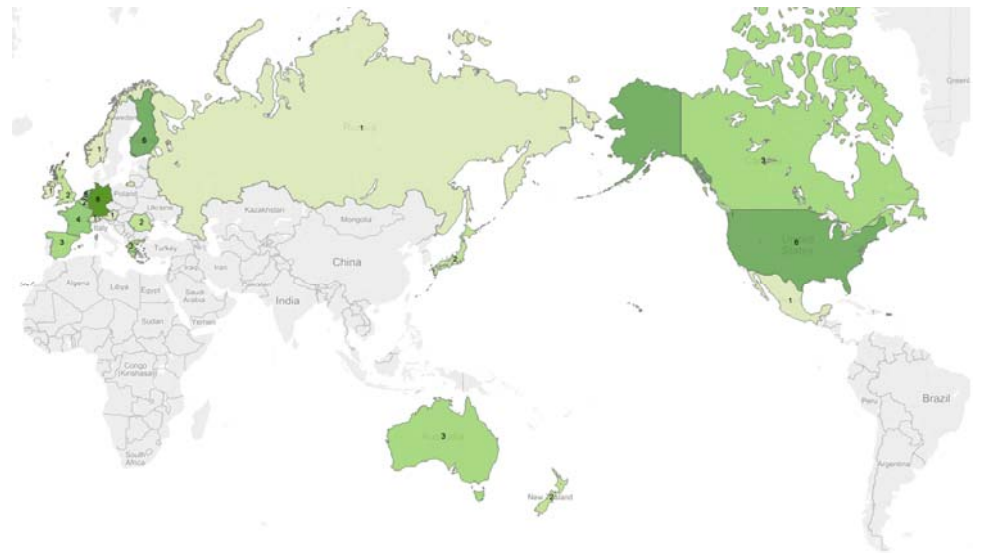


35 proposals received covering all products with different reference systems

PIs by Country



Co-PIs



Sentinel-5 Precursor Validation Team



Sentinel-5 Precursor Validation Team Workshop

ESTEC, The Netherlands

29 September – 01 October 2015

Targets

- Consolidation of information required
- Gap analysis needs to be performed
- Fiducial Reference Measurements Concept
- Coordination between S5PVT

esa sentinel-5 precursor validation team (S5PVT) workshop
29 september - 1 oktober 2015
European Space Agency

Introduction
Objectives
Themes and Format
Abstract Submission
Author Instructions
Registration
Committee
Calendar of Events
Venue
Contact

Sentinel-5 Precursor Validation Team (S5PVT) Workshop
ESA-ESTEC, Noordwijk, NL
29 September until 01 October 2015



- Campaigns
 - Several airborne campaign opportunities have been identified in the Validation Call
 - Preparatory and Cal/Val campaigns
 - AROMAT Campaign summer 2014, Romania
 - AROMAT-II Campaign summer 2015, Romania
 - [TBC] Ground based intercalibration campaign (“CINDI”-like), 2016, The Netherlands
 - [TBC] Sentinel-5 Precursor Validation Campaign, 2017, Romania



Sentinel-5 Precursor, ACC-11, ESA/ESRIN, 29 April 2015



- Science User Access:
 - Open and free to any users via self registration
 - Rolling Access to Latest Data via Sentinel Data Hub
 - Level 1b Off-Line; Level 2 NRT and Off-line
 - First Data release planned following the Commissioning Phase (Launch+6 Months)
- Near-Realtime (NRT) Processing: 3 hours after sensing
- Off-line Processing for Consolidated Products:
 - Typically after three days after sensing
 - Additional Level 2 Products (CH₄, tropospheric ozone)

Data Distribution



- Data Volume:

Product type	GB per Orbit	GB per day
Level 2 NRT	4.27	60.6
Level 1b Radiance OFL	35.6	504
Level 1b Irradiances OFL	0.03	0.42
Level 2 OFL	5.24	74.3
Total	45.1	639

- Data Organisation

- Level 1b radiance is provided as separate files for each of the 4 bands
 - UV-UVIS-NIR and SWIR solar irradiance product
- Each geophysical Level 2 parameter is provided in a dedicated product
- Data format is netCDF-4 using Climate and Forecasting Metadata Standards
- Data format harmonisation with heritage and future Sentinels

S5P: Overall Project Status



- S5P platform is in hibernation since December 2014
- Ground Segment development on track, including processors, with Overall Ground Segment Validation to started in April
- Preparation for Flight Acceptance Review in February 2016
 - Launch window in Q2/2016 confirmed

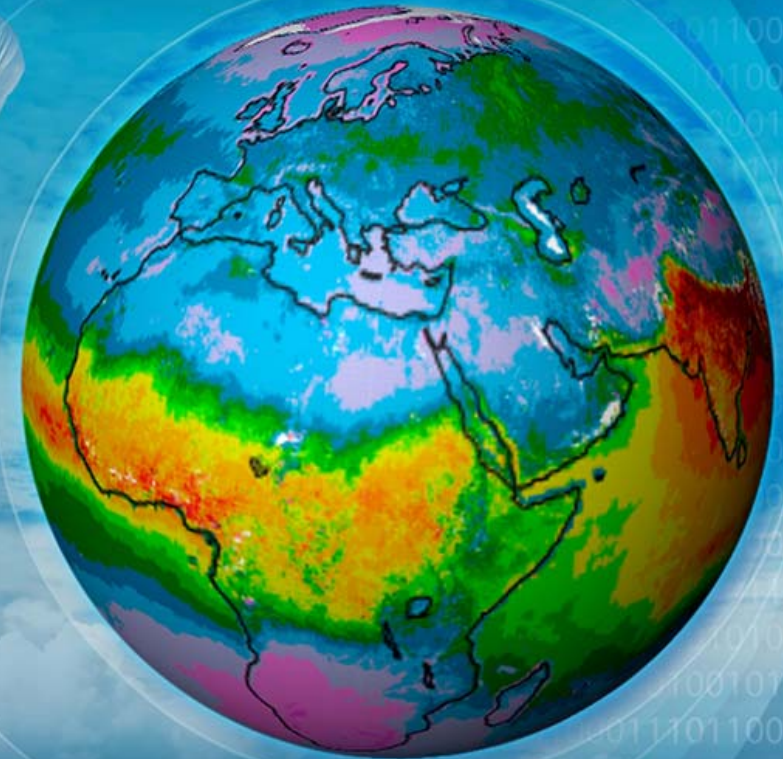
- TROPOMI instrument environmental testing completed in 2014
- Instrument calibration ongoing since December 2014
- Delivery foreseen in May 2015

- Calibration Validation preparation ongoing with S5PVT Meeting end September 2015



Thank you for your
attention!

© ESA 2013



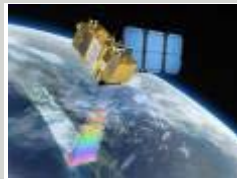
Sentinel Information: <https://sentinel.esa.int/>
S5P Validation Team: <https://earth.esa.int/aos/S5PVT>
Copernicus: <http://www.copernicus.eu/>



The Sentinel Family



Sentinel-1 (A/B/C/D) – SAR imaging
All weather, day/night applications, interferometry



Sentinel-2 (A/B/C/D) – Multi-spectral imaging
Land applications: urban, forest, agriculture,...
Continuity of Landsat, SPOT



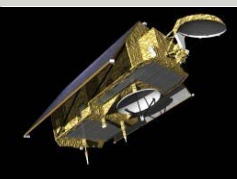
Sentinel-3 (A/B/C/D) – Ocean and global land monitoring
Wide-swath ocean color, vegetation, sea/land
surface temperature, altimetry



Sentinel-4 (A/B) – Geostationary atmospheric (on MTG)
Atmospheric composition monitoring, trans-boundary pollution



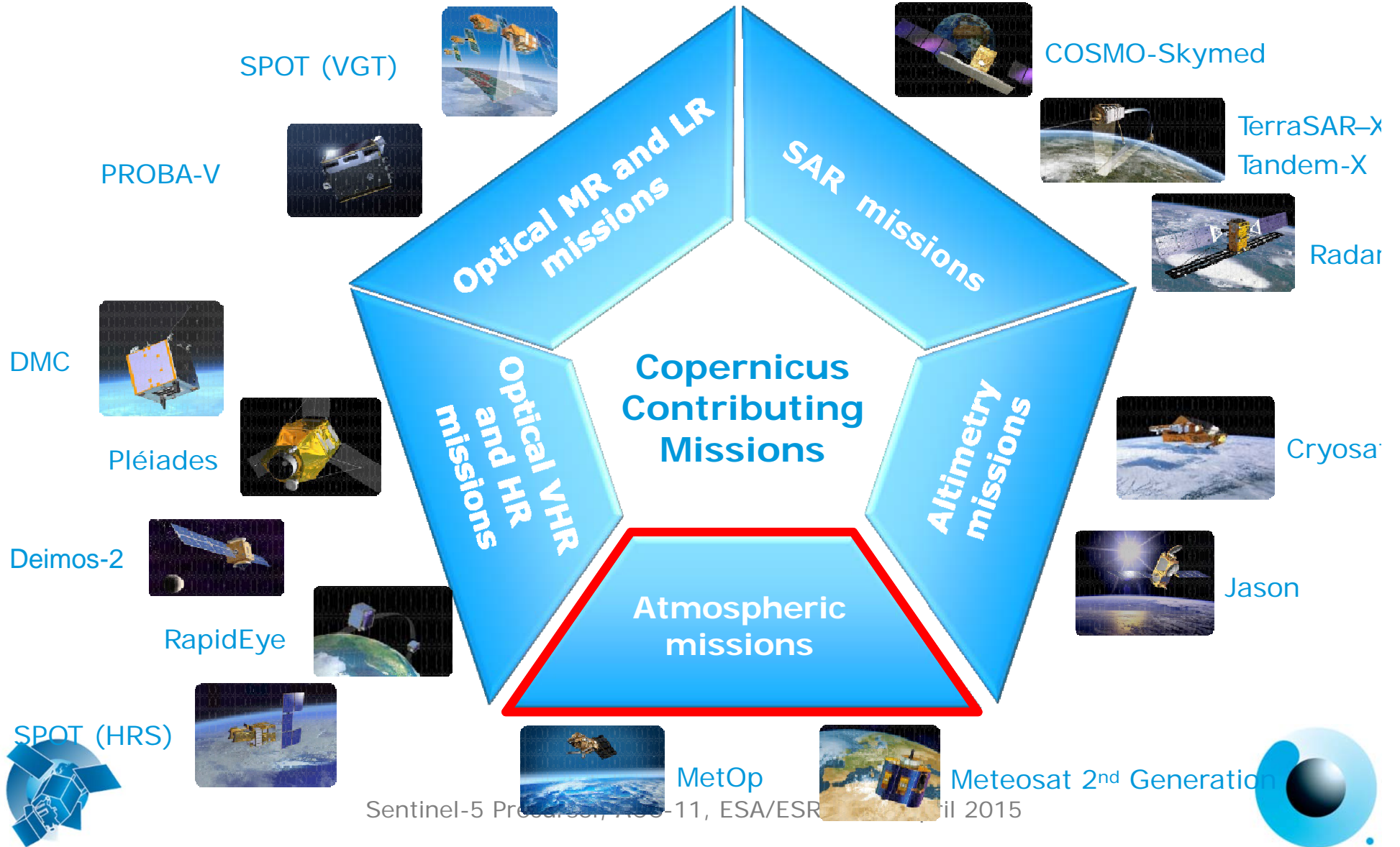
**Sentinel-5 Precursor/ Sentinel-5 (A/B/C) – Low-orbit
atmospheric (on MetOp-SG Series A)**
Atmospheric composition monitoring



Sentinel-6 [Jason-CS] (A/B) – Low inclination altimetry
Sea-level, wave height and marine wind speed



... and Contributing Missions



Sentinel-5 Precursor Copernicus Requirements (*cont.*)



- User requirements (Level-2) based on the IGACO theme report (2004), the CAPACITY study (2005), and the GAS-IG Final Report (2009)
- Mission requirements (Level-1) based on CAMELOT (2009)



GMES Sentinels 4 and 5 Mission Requirements Traceability Document



Low Earth Orbit (LEO)

- Daily revisit time global coverage
- Air quality, climate, ozone & UV
- Tropospheric & stratospheric composition

→ Sentinel-5



GEOstationary Orbit (GEO)

- Hourly revisit time over Europe
- Mainly air quality
- Diurnal cycle of tropospheric composition

→ Sentinel-4 (S4)



Tropomi: Performance Parameters



Spectrometer	UV		UVVIS		NIR		SWIR	
Band ID	1	2	3	4	5	6	7	8
Full Range [nm]	270-320		310-495		675-775		2305-2385	
Performance Range [nm]	270-300	300-320	320-405	405-495	675-725	725-775	2305-2345	2345-2385
Spectral Resolution FWHM [nm]	0.48	0.49	0.54	0.54	0.38	0.38	0.25	0.25
Spectral Sampling [nm]	0.071	0.073	0.22	0.22	0.14	0.14	0.1	0.1
Sampling Ratio	6.8	6.7	2.5	2.5	2.8	2.8	2.5	2.5
Slit Width [μm]	560	560	280	280	280	280	560	560
Spectral magnification	0.327	0.319	0.231	0.231	0.263	0.263	TBD	TBD
Spatial Sampling at nadir [km^2]	28x7	7x7	7x7		7x7	3.5x7	7x7	
Required Signal-to-noise	100-800	90-700	800-1000		100-500		100-120	

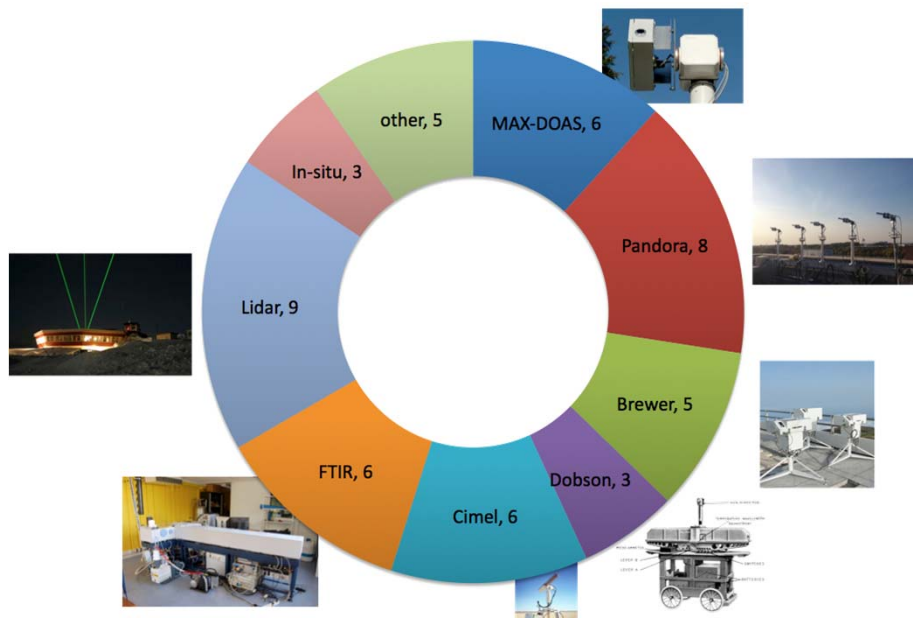
Source: S5P JPT, KNMI



Validation AO – Some Results



Proposed Observation System



Proposed Networks

