The Copernicus Sentinel-4 Mission

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Level-2 consortium: D. Loyola (DLR), R. Siddans (RAL), T. Wagner (MPIC), ...
Industrial consortium: lead by Airbus Defence and Space

AC-VC-15, hosted by JAXA, 10-13 June 2019, Nakano, Tokyo, Japan

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Copernicus
Europe's eyes on Earth

- European system for monitoring
  land, marine, atmosphere, climate change, emergency management, security
- Observations from
  satellites, ground-based, air-borne sensors
- Information service for
  policymakers, public authorities, …, citizens
- Space Component:
  Sentinel missions by European Space Agency

Copernicus Atmosphere Monitoring Services


Air Quality and Atmospheric Composition


Climate Forcing


Ozone Layer & UV


Solar Radiation


Emissions and Surface Fluxes

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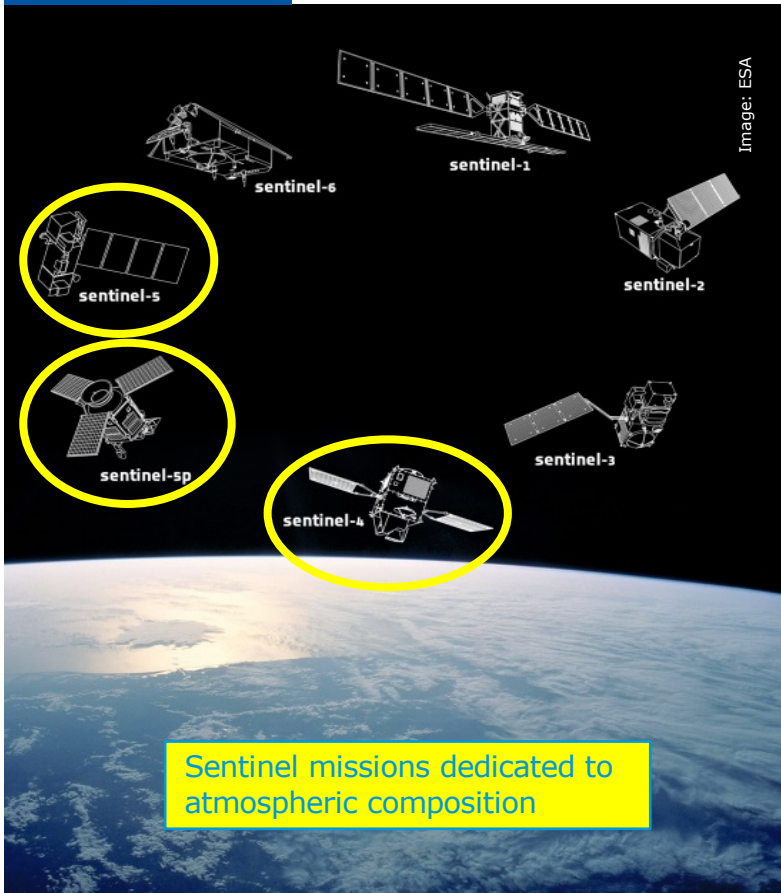


Sentinel missions dedicated to atmospheric composition

Copernicus Missions for Atmospheric Composition

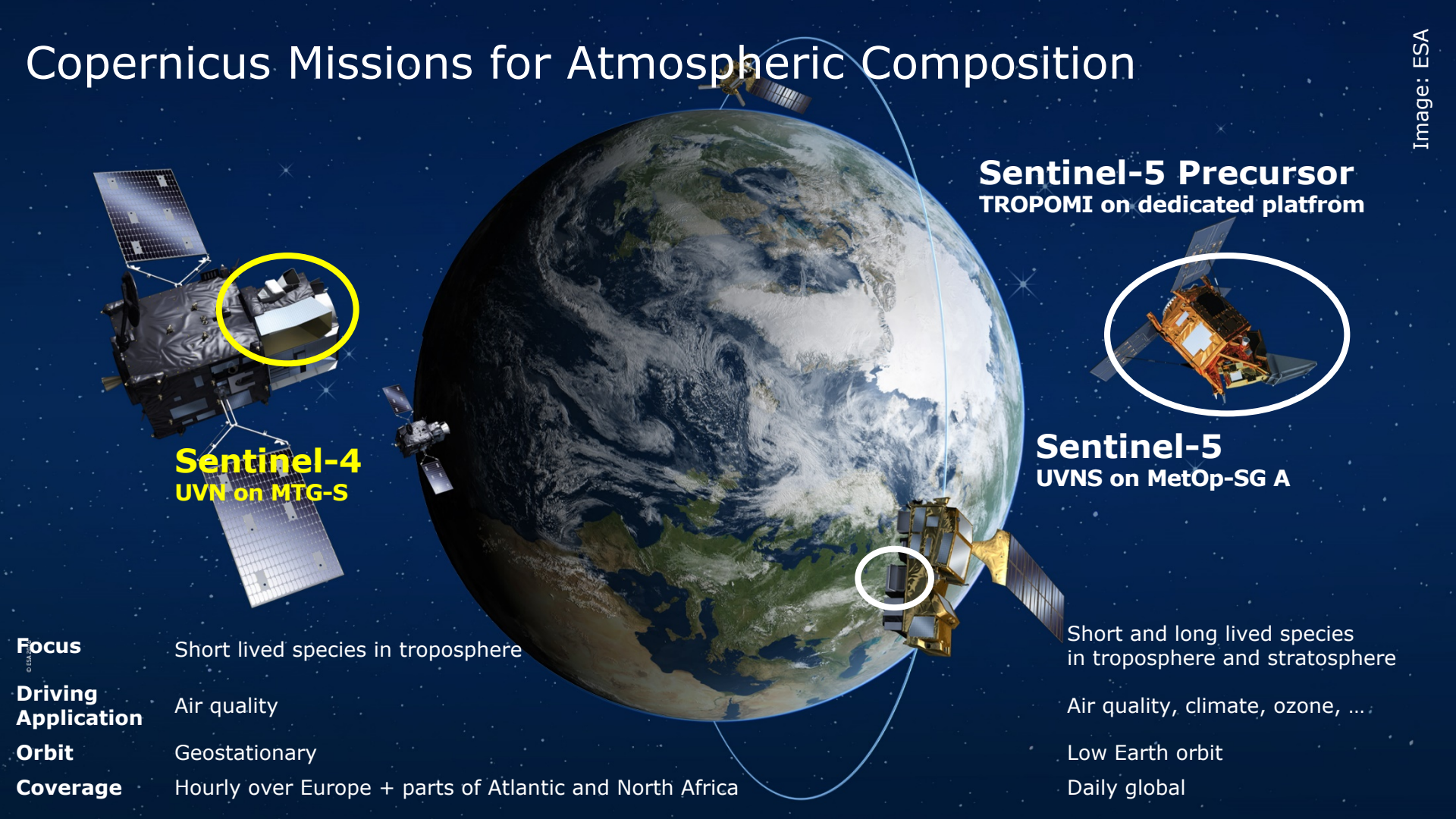


Image: ESA

	Sentinel-4	Sentinel-5 Precursor	Sentinel-5
Focus	Short lived species in troposphere		Short and long lived species in troposphere and stratosphere
Driving Application	Air quality		Air quality, climate, ozone, …
Orbit	Geostationary		Low Earth orbit
Coverage	Hourly over Europe + parts of Atlantic and North Africa		Daily global

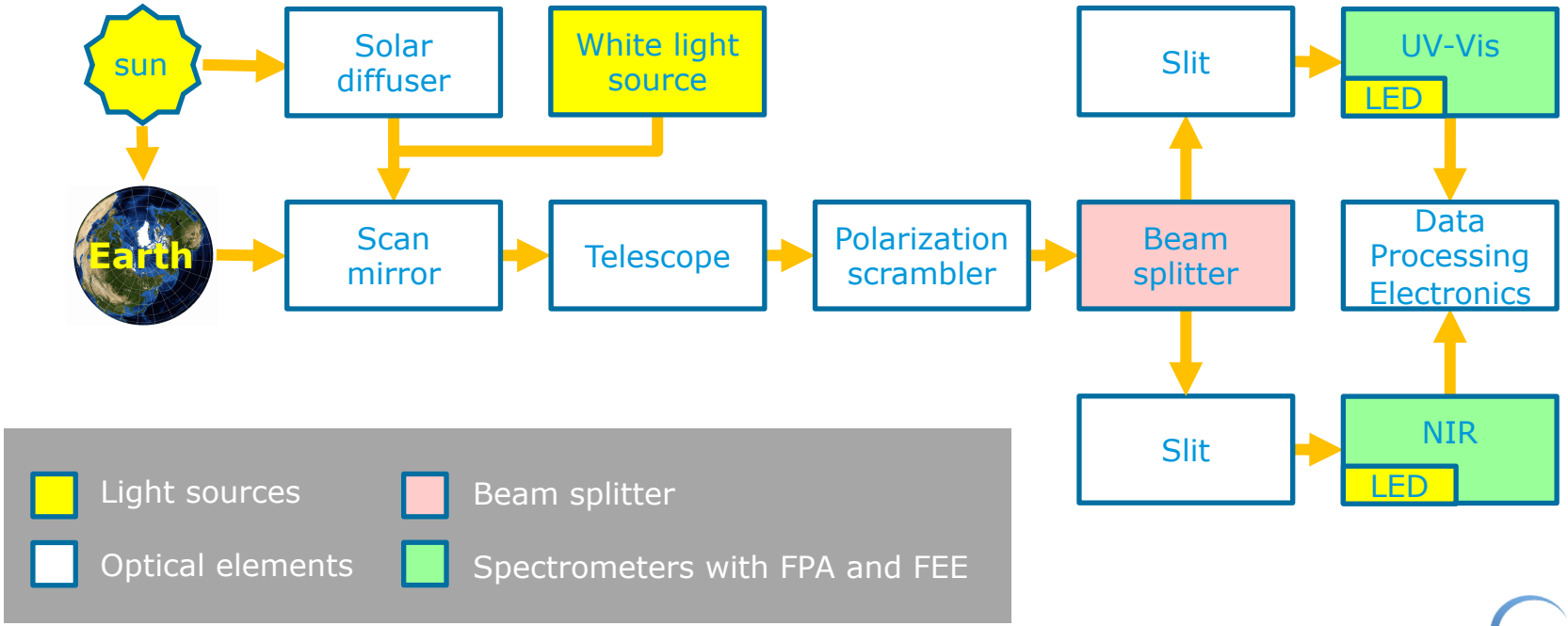
Copernicus Sentinel-4 Mission

- Built under the responsibility of ESA
  - Instruments and Level-1b prototype processor by a consortium led by ADS
  - Level-2 operational processor by a consortium led by DLR
- Will be operated by EUMETSAT
- Geostationary
- Embarked on Meteosat Third Generation-Sounder (MTG-S)
- Synergy with FCI and LI on MTG-I, IRS on MTG-S
- Two S4/UVN in sequence → mission lifetime of 15 years
- Flight Acceptance Review planned 2022 (MTG-S1)
- Launch expected 2023

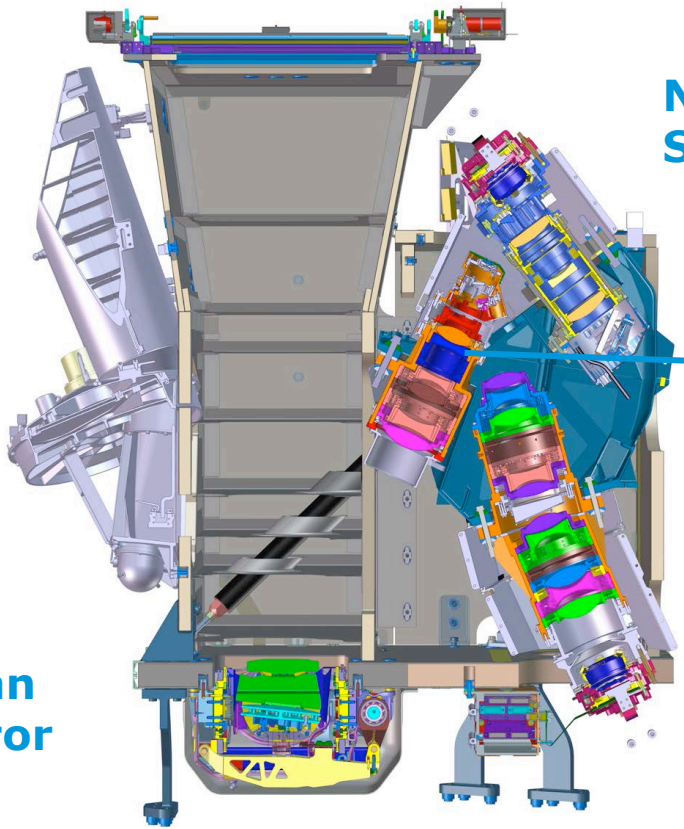
Copernicus Sentinel-4
UV-Vis-NIR (UVN) Imaging Spectrometer

Spectral Range [nm]	305-400	400-500	750 – 775
Spectral Resolution [nm]	0.5	0.5	0.12
Spectral Oversampling	3	3	3
Signal to Noise Ratio of radiance (SZA~65°, albedo=0.05/0.05/0.15)	300 @ 310 nm	1800 @ 450 nm	600 (continuum)
Radiometric Accuracy	2-3%	2-3%	2-3%
Polarisation Sensitivity	1%	1%	1%
Spectral Features	0.05%	0.05%	0.05%
Revisit Time	hourly		
Coverage	Europe + part of Sahara and Atlantic		
Spatial Sampling / Resolution [km^2]	8×8 / 8.9×11.7 (N/S×E/W @ 45°N)		

Sentinel-4/UVN Instrument Concept



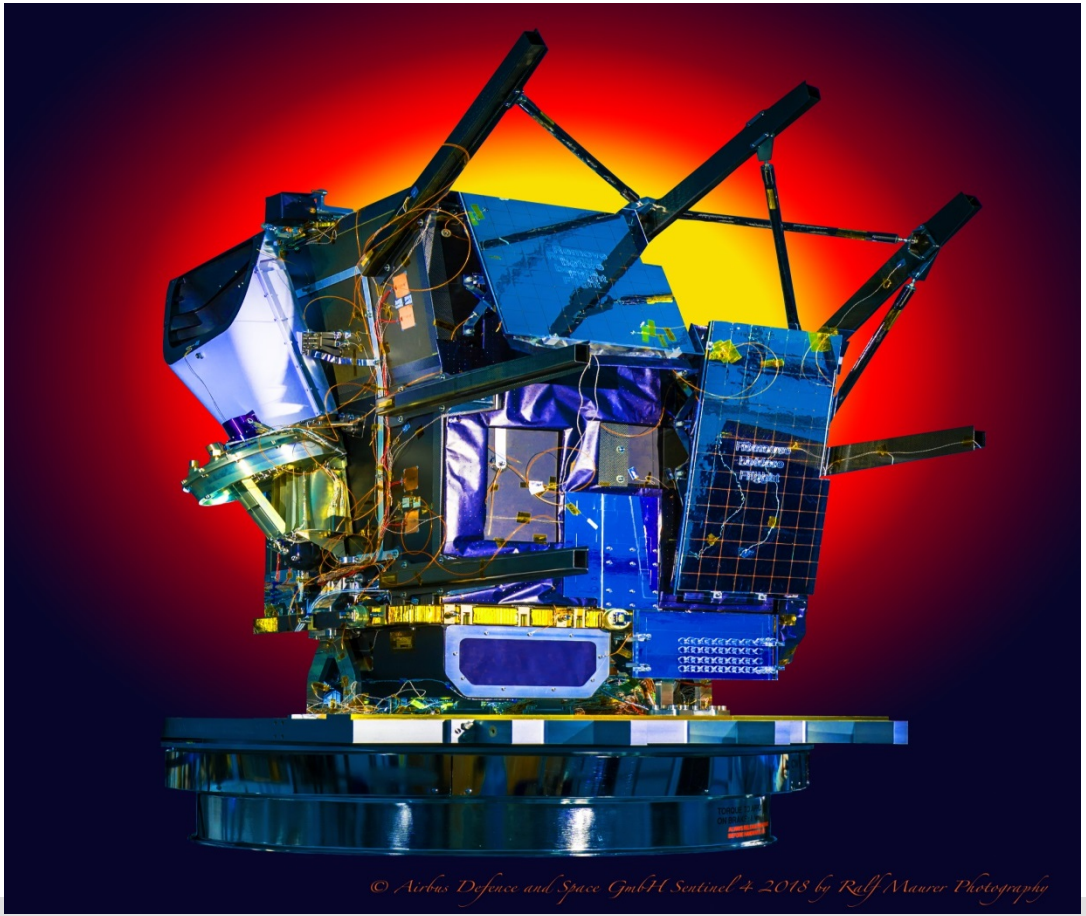
Sentinel-4/UVN Schematic View



Sentinel-4/UVN Structural Thermal Model (STM)

- Environmental testing successfully completed
- Delivered to MTG early 2017

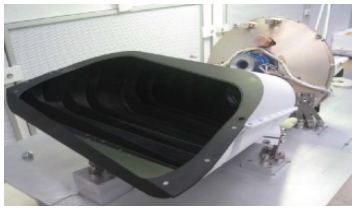
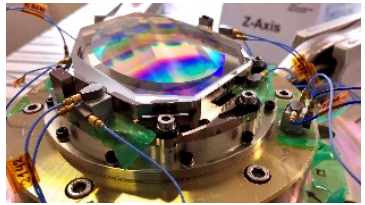
Sentinel-4/UVN Enhanced Engineering Model (e-EM)

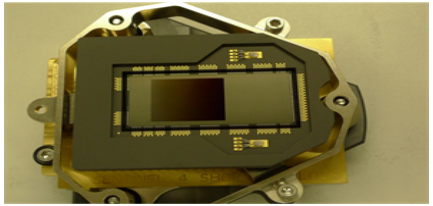
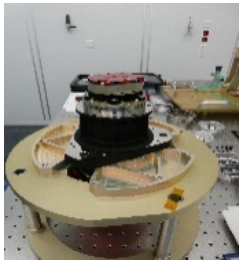
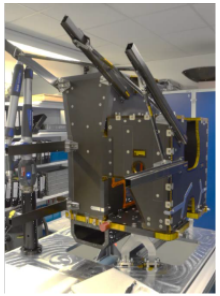


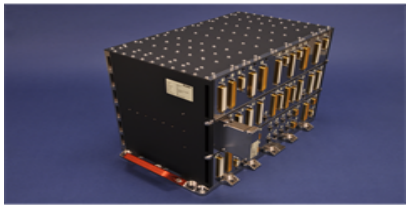
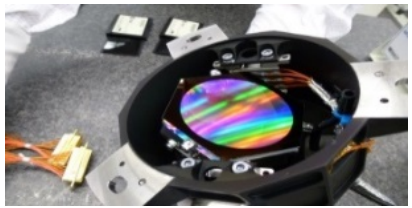
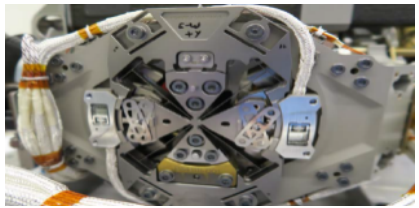
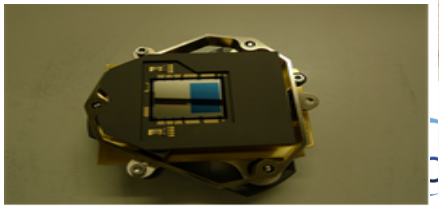
- Microvibration and EMC Tests successfully completed mid 2018
- TB/TV & pre-calibration test completed early 2019

Sentinel-4/UVN Flight Model Status

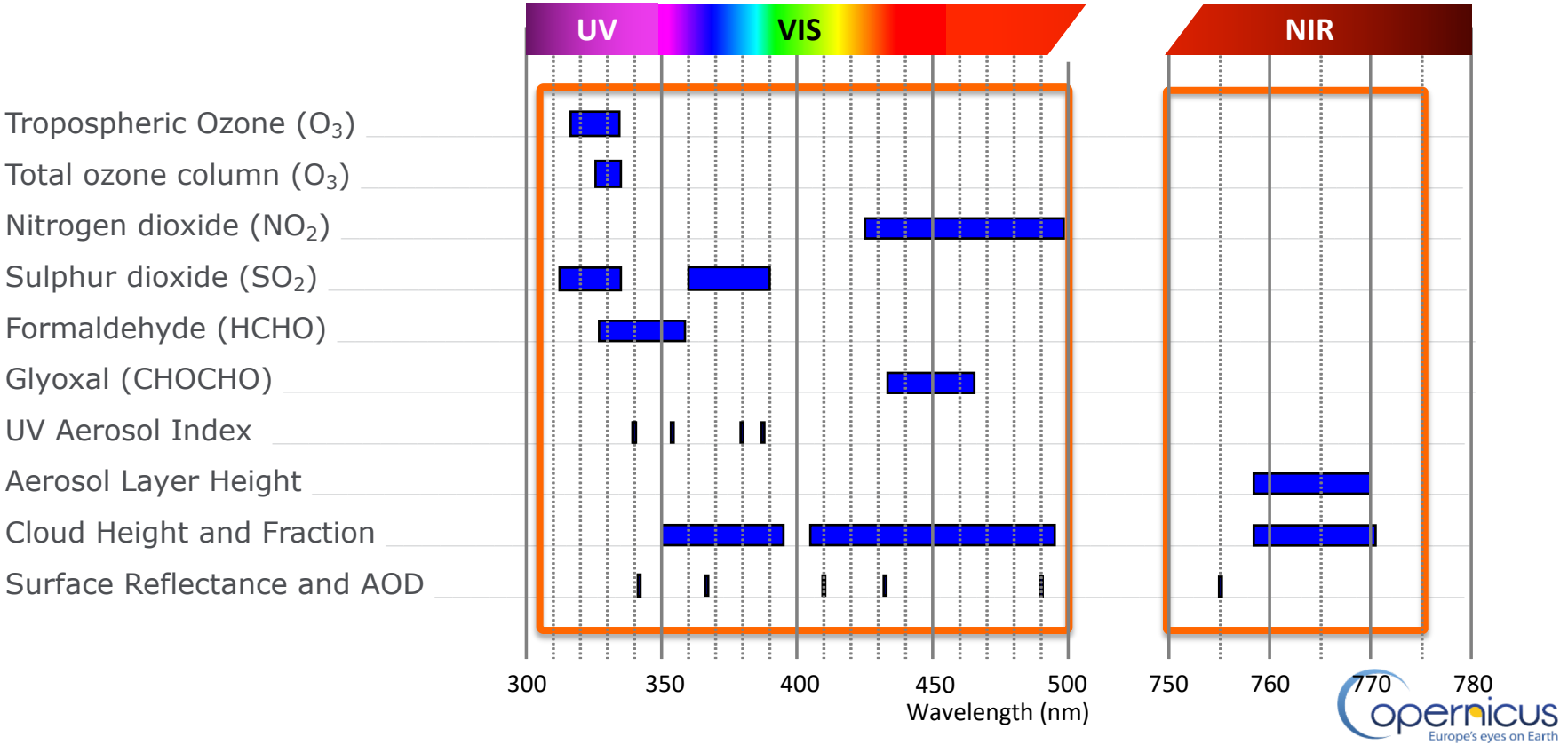
- Delivered: telescope, collimator, structure, harness,
  calibration assembly mechanism, aperture cover mechanisms
- Telescope-beamsplitter-scrambler assembly and spectrometers mid 2019
- Proto Flight Model (PFM) and FM2 planned 2021 and 2022

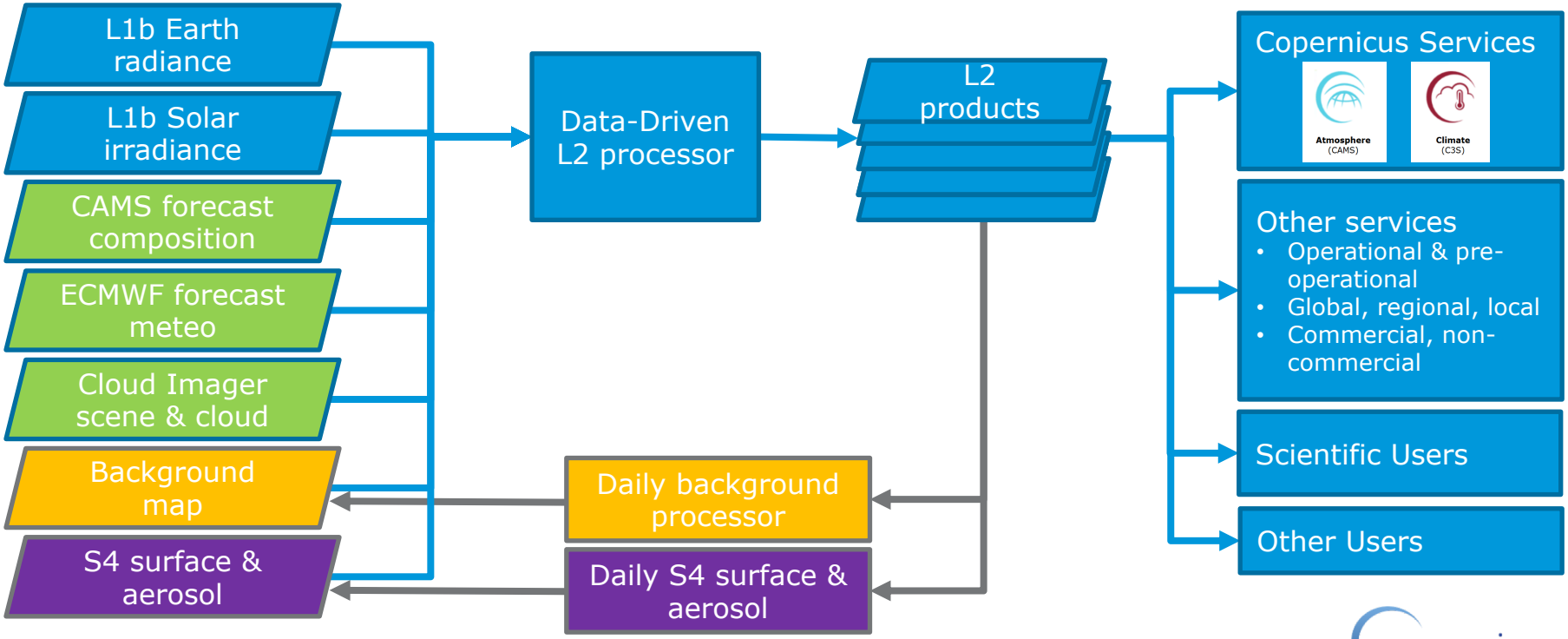
Copernicus Sentinel-4 Spectral Bands and Fit Windows



Copernicus Sentinel-4 Level-2 Performances

	Current Performance Estimate	Target Up to SZA<60°, VZA<60°	GeoAQ Consistency Target
O_3 total	1.6% random, 3.5% systematic	3%	1%
O_3 tropospheric	0-6 km 40% random	25%	20%
NO_2 tropospheric	0.5-1.5×10^{15} molec/cm^2, AMF: 42% (poll.), 31% (unpoll.)	1.5×10^{15} molec/cm^2 or 30%	1×10^{15} molec/cm^2
SO_2 total	40% random, 60% systematic (polluted, SZA&VZA=30°)	3×10^{16} molec/cm^2 or 60%	1×10^{16} molec/cm^2
HCHO total	70% random, 30% systematic (1×10^{16} molec/cm^2)	1×10^{16} molec/cm^2 or 80%	1×10^{16} molec/cm^2
CHOCHO total	TBD	7×10^{14} molec/cm^2 or 50%	4×10^{14} molec/cm^2
Aerosol Optical Depth	Target met for homogeneous cases	0.05	0.05 @ 440 nm
Aerosol Layer Height	0.5 km (ocean), 1.5 km (land)	1 km (>1.5 km, AOD_{760}>0.3)	-
UV Aerosol Index	0.3 to 0.5	0.3	-
Surface	Target met for homogeneous cases	First BRF parameter 0.01	-

Copernicus Sentinel-4 Level-2 Processing



Copernicus Sentinel-4 and Sentinel-5 Data

- **Free, full, and open access**
  - Copernicus Sentinel Data Policy & EU Regulations
- Processed up to L2 in EUMETSAT's MTG and EPS-SG ground segments
- Dissemination of L2 products in NRT via **EumetCast**
- Access to L1b and L2 via **EUMETSAT Data Centre**
  - L1b and L2 via rolling archive (limited time horizon and bandwidth)
  - L1b and L2 via archive
- Cloud-based access to data and processing tools
  - **DIAS**: Copernicus Data and Information Access Services, funded by EC
  - Enable users to build applications and process large datasets easily
- Copernicus Services benefitting from the atmospheric Sentinels
  - **CAMS**: Copernicus Atmosphere Monitoring Service
  - **C3S**: Copernicus Climate Change Service

Copernicus Sentinel-4 Mission Implementation Status

- Instruments and Level-1b prototype processor
  - Critical Design Review completed
  - STM and e-EM and tests completed
  - On-ground C&C planned for 2021
  - PFM delivery to MTG planned for 2021
  - Flight Acceptance Review planned 2022 (MTG-S1)
- Level-2 operational processor by a consortium led by DLR
  - Algorithm breadboarding
  - Independent Verification
  - Critical Design Review completed
  - Deliveries v1 end 2019, v2 after C&C, v3 after launch
- Launch expected 2023

Thank you

Copernicus Atmosphere Monitoring Service (CAMS)

Provides

- Air pollution over Europe monitoring and forecast: near-surface NO_2, SO_2, O_3, PM
- Atmospheric composition global analyses, forecasts, re-analyses
- Emission inventories for SO_2, NO_x, VOC, NMVOC, PM2.5, CH_4
- Essential Climate Variables monitoring of CH_4, O_3, aerosol, precursors
- Radiative forcing estimates
- Constrain atmospheric oxidizing capacity, improve process understanding and models
- Volcanic emission events monitoring
- Stratospheric ozone monitoring
- Down-welling irradiance and erythemal dose rates

- Implemented by ECMWF
- https://atmosphere.copernicus.eu

Copernicus Climate Change Service (C3S)

Provides

- Authoritative climate information to enable mitigation and adaptation strategies by policy makers and businesses
- Essential Climate Variable records via Climate Data Store (CDS)
- Tools and expert guidance to transform data into visual products
- Essential Climate Variable assessment reports

- Implemented by ECMWF
- https://climate.copernicus.eu

Air Quality Constellation