



sentinel-4



Sentinel-4 and Sentinel-5 Mission Status Update

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Acknowledgements: ESA Sentinel-4 and Sentinel-5 project teams,
industrial consortia lead by ADS, L2 consortia lead by DLR and S&T

Supplement to Agenda Item 2.08
AC-VC#17 virtual meeting, 7-11 June 2021

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European Space Agency

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



sentinel-4



- Built under the responsibility of ESA
 - Instruments and Level-1b prototype processor by a consortium led by ADS
 - L2 operational processor by a consortium led by DLR
- Will be operated by EUMETSAT
- Geostationary
- Two S4/UVN in sequence → mission lifetime of 15 years
- Embarked on Meteosat Third Generation-Sounder S1 and S2
- Synergy with FCI and LI on MTG-I, IRS on MTG-S
- Proto-Flight Model integration and testing
- L1bPP V2 expected mid-2021, L2OP acceptance ongoing
- On-ground calibration & characterization planning
- Launch expected 2023



PFM Optical system integrated and aligned into the Instrument Module; Airbus Courtesy



Sentinel-4 Image Gallery

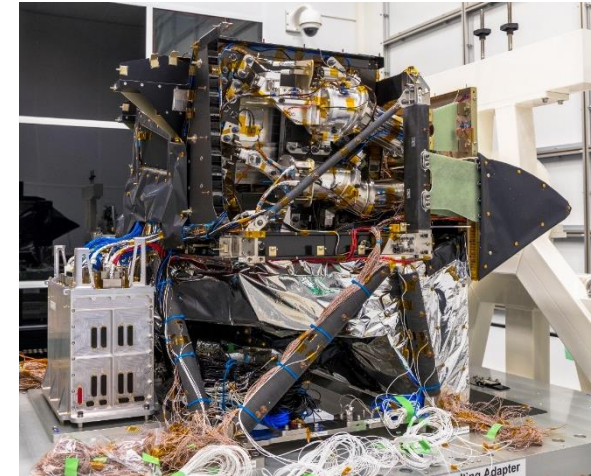


PFM Instrument Module integration almost completed (May 2021)



Calibration facility integration and testing progressing

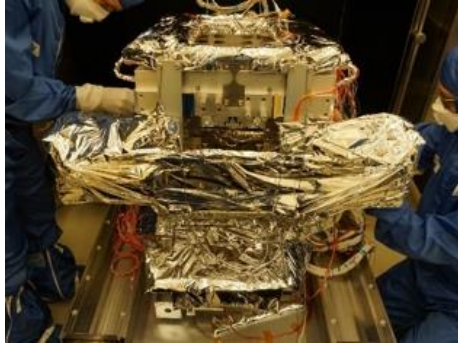
Copernicus Sentinel-5 UV-Vis-NIR-SWIR (UVNS) Imaging Spectrometer



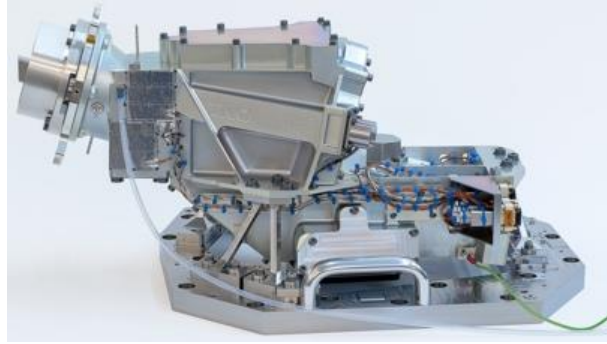
Structural Thermal Model; Airbus Courtesy

- Built under the responsibility of ESA
 - Instruments and L1b prototype processor by a consortium led by ADS
 - L2 prototype processor by a consortium led by S[&]T
- Will be operated by EUMETSAT
- Low Earth Orbit \sim 9h30 local solar time
- Three S5/UVNS in sequence \rightarrow mission lifetime 21 years
- Embarked on MetOp Second Generation A1, A3 and A3 satellites
- Synergy with MetImage, IASI-NG, and 3MI on MetOp-SG-A
- Proto-Flight Model integration and testing
- L1bPP v2 and L2PP acceptance reviews ongoing
- On-ground calibration & characterization planning
- Launch expected 2023

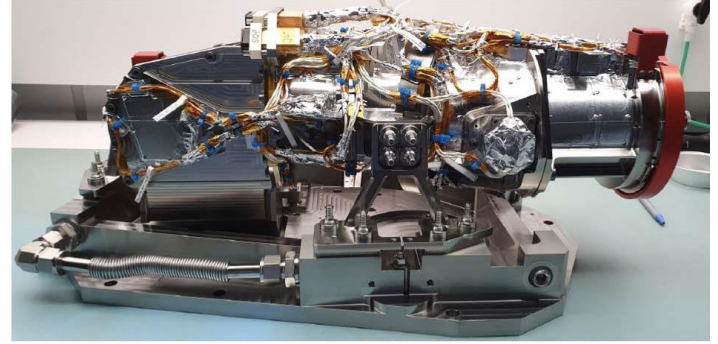
Sentinel-5 Image Gallery



Vis-NIR Telescope (TNO)



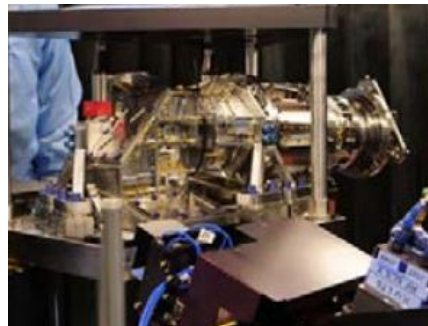
PFM UV1 Spectrometer (TNO)



PFM NIR Spectrometer, courtesy JOP



UV-SWIR Telescope (TNO)

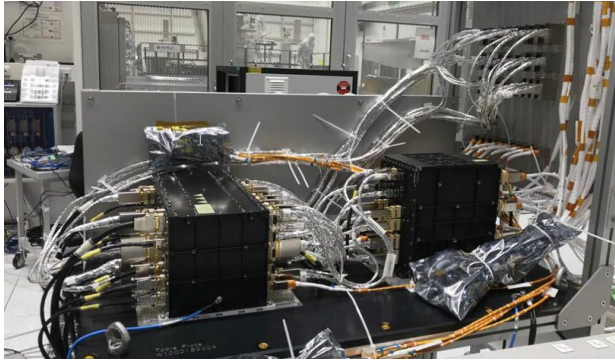


PFM UV2Vis Spectrometer (Sodern)

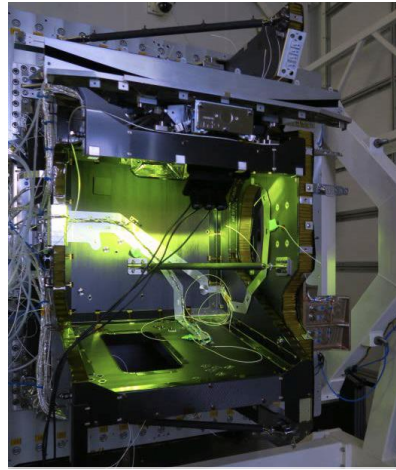


PFM SWIR Optics Integrated (Leonardo)

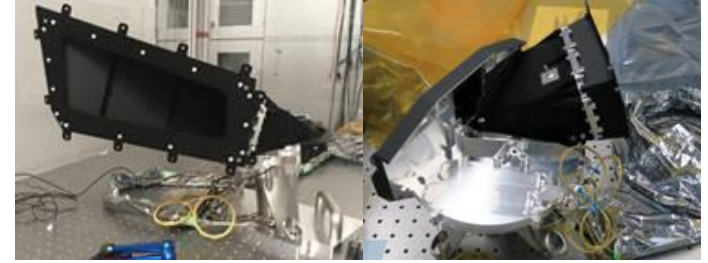
Sentinel-5 Image Gallery



PFM ICS (L) and DSE (R), courtesy Airbus/CRISA/TAS-E



PFM Instrument with first telescope integrated, Courtesy Airbus



The two PFM Calibration units (MICOS)

*FM2 Instrument
CFRP Structure
Courtesy Airbus/Almatech*

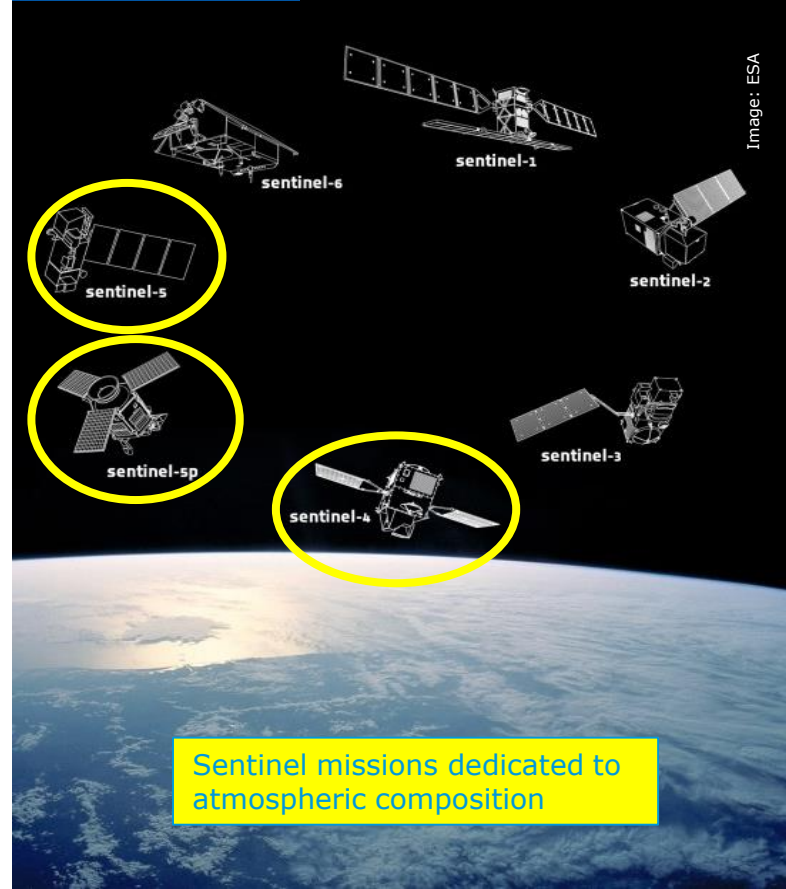


Intermediate Integration Model, courtesy Airbus



CnC facility with MGSE, courtesy RAL/APCO

- 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

Copernicus Missions for Atmospheric Composition



Sentinel-4
on MTG-S

Sentinel-5 Precursor
TROPOMI



Sentinel-5
on MetOp-SG A



Focus

Short lived species in troposphere

Driving Application

Air quality

Orbit

Geostationary

Coverage

Hourly over Europe + parts of Atlantic and North Africa

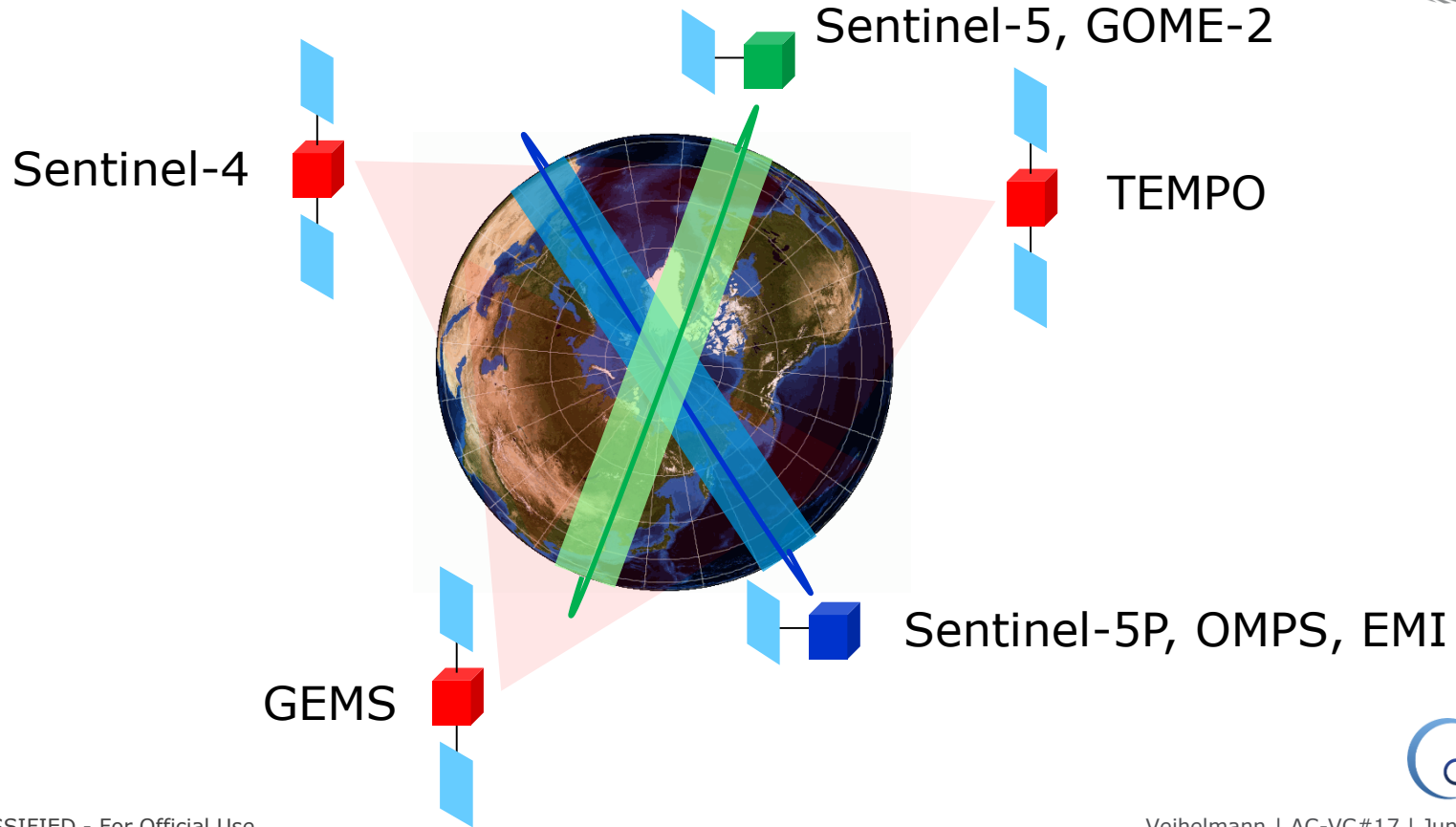
Short and long lived species in troposphere and stratosphere

Air quality, climate, ozone, ...

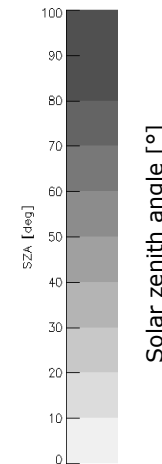
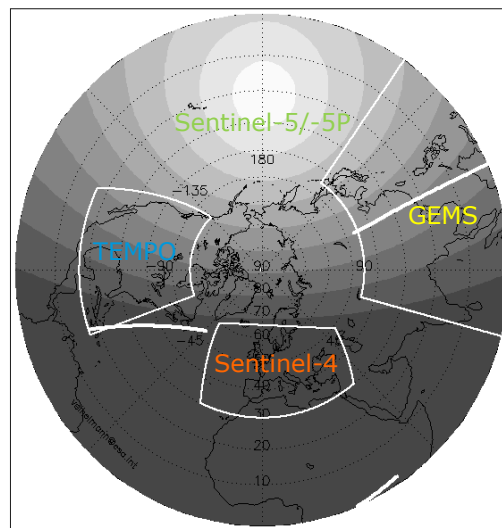
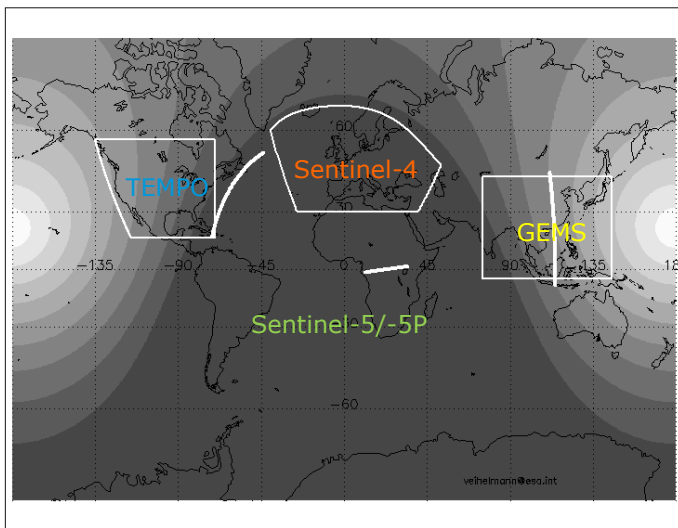
Low Earth orbit

Daily global

Global Atmospheric Composition Constellation

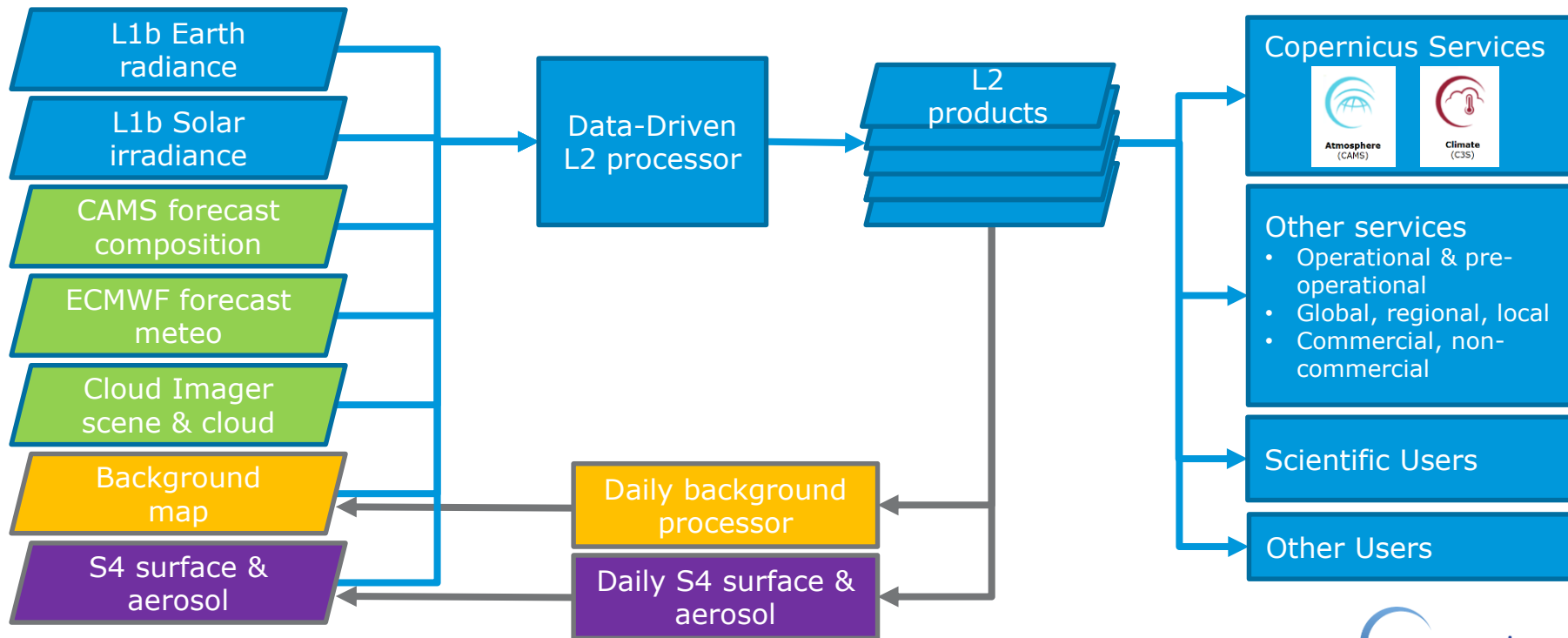


Geostationary Air Quality Constellation



	USA TEMPO	Europe Sentinel-4	Korea GEMS	Sentinel-5/-5P
Orbit	Geostationary	Geostationary	Geostationary	LEO
Domain	North America	Europe and surrounding	Asia-Pacific	global
Revisit [h]	1 hour	1 hour	1 hour	Daily, more @ higher lat
Spectral ranges	UV-Vis	UV-Vis-NIR	UV-Vis	UV-Vis-NIR-SWIR
Key products	O ₃ , NO ₂ , SO ₂ , HCHO, CHOCHO, aerosol	O ₃ , NO ₂ , SO ₂ , HCHO, CHOCHO, aerosol	O ₃ , NO ₂ , SO ₂ , HCHO, CHOCHO, aerosol	O ₃ , NO ₂ , SO ₂ , HCHO, CHOCHO, aerosol, CH ₄ , CO, ...
Spatial res. [km²]	9 x 5 at 35°N	8 x 8 at 40°N	8 x 7, 8 x 3.5 at 38°N	7 x 7 / 7 x 3.5 at nadir

Copernicus Sentinel-4/-5 Level-2 Processing



Copernicus Sentinel-4 and -5 Level-2 Products



Species	Relevance				Observed by	
	Air quality	Climate	Ozone/UV	Varia	S4	S5/5P
O₃	Toxic, irritates lung and soft tissue, regulated*	Greenhouse gas	Surface UV, stratosphere	Oxidising capacity of atmosphere, damages plants	Total & troposph.	Total & profile
NO₂	Toxic, nitrate aerosol, regulated*	Nitrate aerosol	O ₃ production	Acid rain	X	X
SO₂	Toxic, sulphate aerosol, regulated*	Sulphate aerosol		Acid rain, tracer for volcanic emissions	X	Total & layer height
HCHO	O ₃ and CO production	Tracer for VOC emissions	O ₃ production	Understanding VOC oxidation	X	X
CHOCHO	O ₃ and CO production	Tracer for non-methane VOC emissions	O ₃ production	Understanding VOC oxidation	X	X/TBC
Aerosol	Pulmonary & cardiovascular diseases, regulated*	Direct and indirect effect		Aviation control (volcanic ash), cloud formation	Layer height, index, AOD	Layer height, index, AOD
CH₄	O ₃ production	Greenhouse gas	O ₃ production	Source stratospheric H ₂ O		X
CO	Toxic, regulated*, O ₃ production	CO ₂ precursor	O ₃ production	Tracer for long-range transport of pollutants		X
Cloud				Auxiliary for other products	X	X
Surface				Auxiliary for other products	Hourly BRDF daily generated	LER climatology
Surface UV			Erythema & vitamin-D dose			Downwelling irradiance and dose rates

*) by European Standards: <http://ec.europa.eu/environment/air/quality/standards.htm>

	goal / threshold	SZA<60°, VZA<60°, cloud fraction < 0.2, unless specified otherwise
O₃ total column	3% / 4%	All cloud conditions
O₃ troposphere	25% / 40%	
NO₂ troposphere	1.5 × 10 ¹⁵ molec/cm ² or 30% / 50%	
SO₂	3 × 10 ¹⁶ molec/cm ² or 60% / 100%	Pollution cases
HCHO	1 × 10 ¹⁶ molec/cm ² or 50% / 100%	
CHOCHO	1.5 × 10 ¹⁵ molec/cm ² (random) 2.5 × 10 ¹⁴ molec/cm ² or 50% (systematic)	>5 × 10 ¹⁴ molec/cm ²
Aerosol Optical Depth	0.05 or 15%	Cloud free
Aerosol Layer Height	1 km	>1.5 km, cloud free, AOD ₇₆₀ >0.3
UV Aerosol Index	0.3 / 0.5	All cloud conditions
Surface	first BRF parameter k: 0.02 (k≤0.03) 0.01 or 5% (k>0.03)	cloud-free, homogeneous

Sentinel-5 Level-2 Performances



	goal / threshold, (stability/decade)	SZA<80°, VZA<66°, unless specified otherwise
O₃ total column	3%, (1%)	all cloud conditions
O₃ profile	Surface-300 hPa: 8% / 16%, (3%) 300- 50 hPa: 8% / 16%, (3%) 50-0.1hPa: 4% / 8%, (2%)	SZA<65°, effective cloud fractions < 0.1 for troposphere
NO₂ troposphere	1.3 × 10 ¹⁵ molec/cm ² or 20%, (2.6 × 10 ¹⁴ molec/cm ² or 4%)	SZA<77°, cloud radiance fraction < 0.5
SO₂	3 / 6 × 10 ¹⁶ molec/cm ² or 50%, (2.6 × 10 ¹⁴ molec/cm ² or 6%)	SZA<77°, cloud radiance fraction < 0.5
SO₂ Layer Height	1 / 2 km	SO ₂ >25 DU, cloud radiance fraction < 0.5
HCHO	1.2 × 10 ¹⁶ molec/cm ² (rand.), 5 × 10 ¹⁵ molecules.cm ⁻² or 50% (sys.), (2.6 × 10 ¹⁴ molec/cm ² or 6%)	SZA<70°, effective cloud fraction < 0.3
CHOCHO	1.5 × 10 ¹⁵ molec/cm ² (rand.), 2.5 × 10 ¹⁴ molec/cm ² or 50% (sys.), (2.6 × 10 ¹⁴ molec/cm ² or 6%)	SZA<70°, effective cloud fraction < 0.3
Aerosol Optical Depth	340-390 nm: 0.05/0.1 or 10%/25%, (0.016 or 2%) 390-500 nm: 0.02/0.1 or 10%/25%, (0.01 or 2%) 760 nm: 0.05/0.1 or 10%/25%, (0.01 or 2%)	cloud free
Aerosol Layer Height	0.5 / 1 km, (0.2 km)	AOD>0.5 (land), AOD>0.1 (ocean), cloud-free,
UV Aerosol Index	0.25, (0.05)	all cloud conditions
CH₄	10 / 18 ppbv or 0.5% / 1%, (0.25%)	SZA<70°, Clear sky
CO	4×10 ¹⁷ molec/cm ² or 5%, (8×10 ¹⁶ molec/cm ²)	SZA<70°, excluding high and optically thick cloud



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

