

SENTINEL-4, -5, 5P GMES MISSIONS DEDICATED TO ATMOSPHERIC COMPOSITION

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Traceability of Requirements for ESA's Sentinel-4/-5



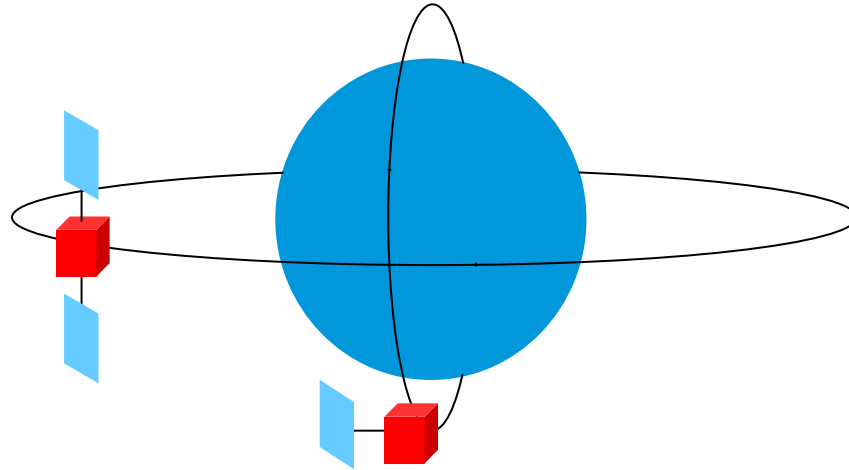
- **User requirements (Level-2)**

for the GMES Atmosphere Services (GAS) based on

- Precursor Service Developments (GEMS/EC, PROMOTE/ESA) with end-user involvement via Service Level Agreements
- CAPACITY study
- IGACO theme report
- GAS Implementation Group Final Report
- Driving policies
 - Montreal protocol monitoring (Ozone)
 - CLRTAP convention monitoring (Air Quality)
 - Kyoto protocol monitoring (GHGs)

- **Mission requirements (Level-1)** based on

- CAMELOT study
- other dedicated studies
- Advice from Sentinel-4/-5 Mission Advisory Group



GEOstationary (GEO)

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

→ Sentinel-4

Low Earth Orbit (LEO)

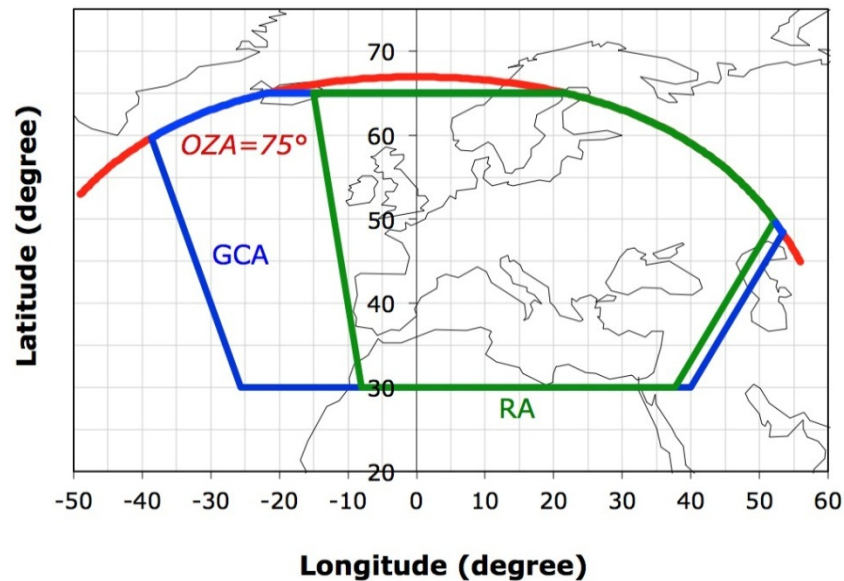
- Daily revisit time global coverage
- Climate, air quality, ozone & UV
- Tropospheric & stratospheric composition

→ Sentinel-5 / Sentinel-5 Precursor

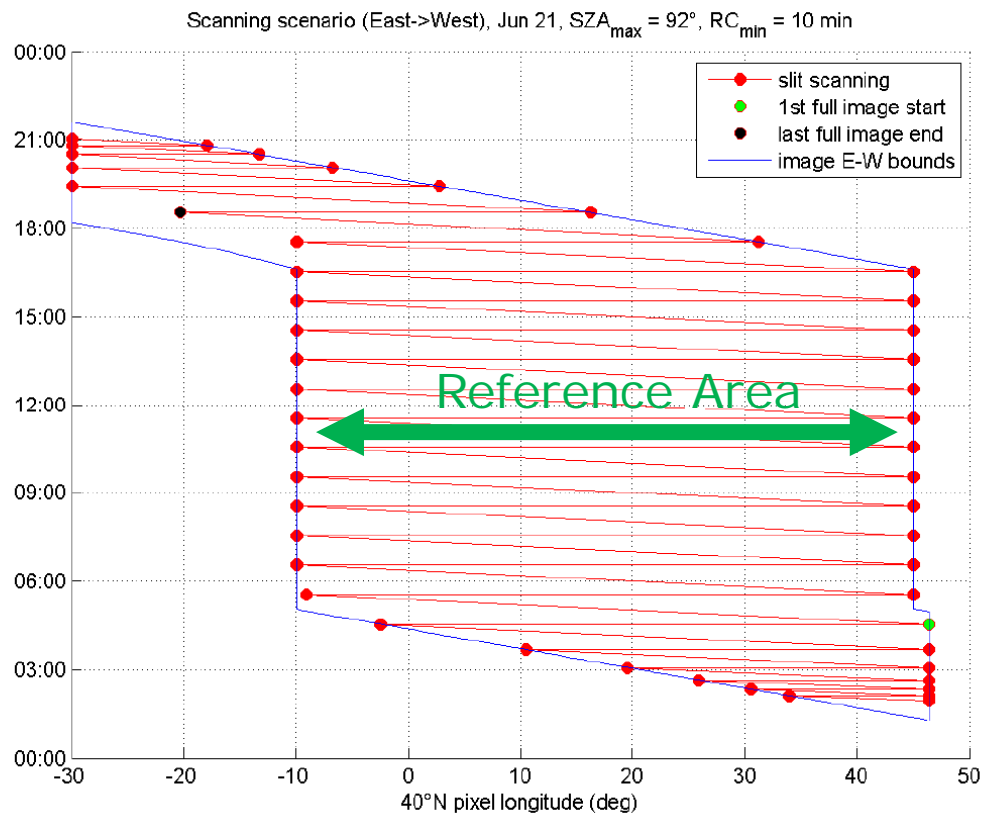
UVN = UV + Visible + Near infrared
UVNS = UVN + Short wave infrared

- **Sentinel-4**
 - UVN spectrometer on EUMETSAT's MTG-S platforms
 - utilisation of infrared data from IRS on MTG-S
 - utilisation of imager data from FCI on MTG-I
- **Sentinel-5**
 - planned as a UVNS spectrometer on EUMETSAT's EPS-SG platforms
 - atmospheric composition requirements in addition to NWP requirements for the IRS on EPS-SG
 - utilisation of imager data from VII on EPS-SG
 - utilisation of aerosol data from 3MI on EPS-SG
- **Sentinel-5 Precursor**
 - a UVNS spectrometer on a dedicated platform
 - utilisation of imager data from VIIRS on NPP

- Spatial resolution: 8 km at 45°N
- Geographical Coverage Area (GCA): Europe + part of Sahara
- Reference Area (RA): part of GCA
- Seasonal southward shift of GCA/RA (<math><10^\circ</math> latitude)



- Push-broom in E/W direction by scan mirror
- East-West scanning triggered by solar illumination conditions
- Revisit time 1h within Reference Area during the day



- Two grating spectrometers:
 - 0.5 nm spectral resolution in the UV-visible
 - 0.12 nm spectral resolution in the near infrared (NIR)
- Low sensitivity to polarization <1%
- Low level of spectral features 0.05%
- High radiometric accuracy < 3%

Band	Spectral	
	range [nm]	resolution [nm]
UV	305-400	0.5
VIS	400-500	0.5
NIR	750-775	0.12

Sentinel-4 Level-2 Products targeted by ESA



Product	Application			Comment
	Air Quality	Climate	Surface UV	
O₃ total & trop. column	X		X	
O₃ profile	X		X	Synergy with infrared data from IRS
NO₂ total & trop. column	X			
SO₂ total column	X			Also for volcanic eruptions
CHOCHO total column	X			By-product
CH₂O total column	X			
Aerosol extinction coeff. profile, column optical depth / type / index	X	X		Also for volcanic eruptions Also auxiliary for other S4 products Synergy with imager data from FCI
Cloud optical thickness, fraction, altitude			X	Mainly auxiliary for other S4 products Synergy with imager data from FCI
Surface reflectance daily map			X	Mainly auxiliary for other S4 products

IRS-alone products (eg O₃, CO) assumed to be developed by Eumetsat

- Phase B2/C/D activity with industry **by ESA**
 - Instrument & Level-1b Prototype processor
 - Preliminary Design Review in Summer **2012**
 - Launch **2019**
- Level-2 Prototype processor **by ESA**
 - Current preparatory activities dedicated to
 - Aerosol profile retrieval from O₂-A band
 - Surface reflectance product
- To be operated **by EUMETSAT**
- GMES Services **by the European Commission (EC)**
 - MACC and PASODOBLE pre-operational
- Future downstream services **by national providers**

Sentinel-5 Instrument Mission Requirements



- Spectral bands in the UVNS (UV-VISible-NIR-SWIR) (priority 1 bands only)
- Spectral bands in the thermal infrared (IRS) between 650 cm⁻¹ and 2900 cm⁻¹
 - in line with EUMETSAT's mission requirements

S5-UNVS Band	Spectral	
	range [nm]	resolution [nm]
UV-1	270-300	1.0
UV-2	300-310	0.5 (G) / 1.0 (T)
	310-370	0.5
VIS	370-500	0.5
NIR-1	685-750	0.2 (G) / 0.4 (T)
NIR-2	750-775	0.06 (G) / 0.4 (T)
SWIR-1	1590-1675	0.25
SWIR-3	2305-2385	0.25

Sentinel-5 Level-2 Products as specified in the MRD



Product	Application			Comment
	Air Quality	Climate	Surface UV	
O ₃ profile	X		X	
O₃ profile	X		X	Synergy with infrared data from IRS
NO₂ total & trop. column	X			
SO₂ total column	X			Also for volcanic eruptions
CHOCHO total column	X			
CH₂O total column	X			
CO total column	X	X		
CH₄ total column		X		
CO₂ total column		X		potential observational capability
Aerosol extinction coeff. profile, column optical depth / type / index	X	X		Also auxiliary for other S5 products Also for volcanic eruptions Synergy with VII and 3MI
Cloud optical thickness, fraction, altitude			X	Mainly auxiliary for other S5 products Synergy with VII and 3MI
H₂O, O₃, CO, CH₄, SO₂, HNO₃, NH₃, CH₃OH, HCOOH	X	X	X	From IRS alone

Sentinel-5p Level-2 Products



Product	Application			Comment
	Air Quality	Climate	Surface UV	
O ₃ profile	X		X	
O₃ profile	X		X	
NO ₂ total & trop. column	X			
SO ₂ total column	X			Also for volcanic eruptions
CHOCHO total column	X			
CH ₂ O total column	X			
CO total column	X	X		
CH ₄ total column		X		
CO ₂ total column		X		potential observational capability
Aerosol extinction coeff. profile, column optical depth / type / index	X	X		Also auxiliary for other S5 products Also for volcanic eruptions Synergy with VIIRS
Cloud optical thickness, fraction, altitude			X	Mainly auxiliary for other S5 products Synergy with VIIRS

Cloud data from Suomi-NPP (loose formation flying)

European Space Agency

- Sentinel-5 Precursor **by ESA and The Netherlands (TROPOMI)**
 - Phase-B2/CD
 - Preliminary Design Review (PDR) in summer 2012
 - Level-2 development activities about to start
 - Launch **2015**
- Sentinel-5 **by ESA**
 - Phase-A, two competitive studies
 - Preliminary Requirements Review (PRR) in spring 2012
 - Launch **≥2020**
 - To be operated **by EUMETSAT**
- GMES Services **by EC**
- downstream services **by national providers**

- Sentinels-4 and -5 will meet the urgent needs of the atmospheric composition community
- Continuity of existing capabilities shall be ensured by embarking Sentinel-4 on MTG-S and Sentinel-5 on EPS-SG
- To avoid observational data gap in LEO orbit after 2015, a Sentinel-5 precursor will be implemented