

# Implementation Status of ESA's Copernicus Atmospheric Service Sentinel-4/-5, and 5p

Presented by

Jacek W. Kaminski, EcoForecast Foundation

on behalf of Sentinel-4/-5 MAG

Sentinel-4/-5/-5p | P. Ingmann, B. Veihelmann, Y. Meijer, H. Nett | plus the Sentinel-4/-5 MAG | 19/09/2013 | Slide 1





## Services Component – led by EC

- Produces information services in response to European policy priorities in environment and security
- Relies on data from **in-situ** and **space component**

# In-situ Component – led by EEA

Observations mostly within national responsibility, with coordination at European level

## Space Component – led by ESA

• Sentinels - EO missions developed specifically for Copernicus

Plus Contributing Missions - EO missions built for purposes other than Copernicus but offering part of their capacity to Copernicus



## Copernicus – Space component ... 2/2



- 1. The Sentinels carry a range of technologies, such as radar and multi-spectral imaging instruments for land, ocean and atmospheric monitoring:
- 2. Sentinel-1 will provide all-weather, day and night radar imagery for land and ocean services,
- 3. Sentinel-2 will provide high-resolution optical imagery for land services,
- 4. Sentinel-3 will provide high-accuracy optical, radar and altimetry data for marine and land services,
- **5. Sentinel-4 and Sentinel-5** will provide data for atmospheric composition monitoring from geostationary orbit and polar orbit, respectively.
- 6. Sentinel-5 Precursor will bridge the gap between Envisat (Sciamachy data in particular) and Sentinel-5
- 7. The **Sentinel-4 and Sentinel-5** will be instruments carried on the next generation of Eumetsat meteorological satellites: Meteosat Third Generation (MTG) and MetOp Second Generation, also known as Post-EPS.



# Role of the Mission Advisory Group: advise on



- Fitness for purpose of Sentinel-4/-5 data for Copernicus Atmosphere Services
- Compatibility of system specifications with mission requirements
- Instrument calibration
- Specification of Level-1/-2 products, quality requirements, and quality indicators
- Study and campaign requirements, end-to-end product calibration/validation, retrieval algorithms and quality indicator verification and validation,
- Data quality requirements for the Level-1/Level-2 interface
- Data processing, archiving, retrieval and product delivery
- Promoting the missions



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# Background: Copernicus Space Component



2014

2014

2020 +

2020

2015



Sentinel-1: SAR imaging Land surface properties, sea-ice, all weather, day/night



Sentinel-2: Multispectral imaging Land applications: urban, forest, agriculture, etc.



Sentinel-3: Ocean and global land monitoring 2014 Ocean color, vegetation, sea/land surface temperature, altimetry

Sentinel-4: Geostationary imaging Atmospheric composition monitoring

Sentinel-5Precursor and -5: Low Earth orbit imaging Atmospheric composition monitoring



	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Sentinel-5p																
Sentinel-4 - 1																
Sentinel-5-1																
Sentinel-4 - 2																
Sentinel-5 - 2																
Sentinel-5 - 3																

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#### **Current International Plans for Geostationary Air Quality Missions**







# Identified Elements: LEO + GEO





#### Low Earth Orbit (LEO)

- Daily revisit time global coverage
- Climate, air quality, ozone & UV
- Tropospheric & stratospheric composition
- → Sentinel-5 Precursor (S5p)
- → Sentinel-5 (S5)

#### **GEOstationary (GEO)**

- Hourly revisit time over Europe
- Mainly air quality
- Diurnal cycle of tropospheric composition
- → Sentinel-4 (S4)



# **Observation techniques**

#### **Nadir-sounding**

- Near-surface layer seen
  between clouds but
- Little or no vertical resolution



#### **Limb-emission sounding**

- High res. vertical profiling
- Tenuous trace gases detectable
- Cold space background
- Dense coverage cf solar occultation

#### Implementation



Mission		Sentinel-4	Sentinel-5	Sentinel-5 Precursor		
Instrument		UVN: UV-Vis-Near infrared spectrometer on MTG-S	UVNS: UVN-Shortwave infrared spectrometer on MetOp-SG	TROPOMI: UVNS spectrometer on dedicated platform		
Utilisation of data	imager	FCI: Flexible Combined Imager on MTG-I	VII: Visible/Infrared Imager on MetOp-SG	VIIRS: Visible Infrared Imager Radiometer Suite on Suomi-NPP/JPSS		
	thermal infrared	IRS: InfraRed Sounder on MTG-S	IAS: Infrared Atmospheric Sounder on MetOp-SG	-		
	other	-	3MI: Multi-viewing, Multi-channel, Multi- polarisation Imager on MetOp-SG	-		

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UVN = Ultraviolet + Visible + Near infrared; UVNS = UVN + Short wave infrared



Mission Elements: Summary of Observation Requirements - UV-Vis-NIR-SWIR Bands





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# MTG – S4 Mission Architecture



#### Launch Segment



Launch Vehicle (A5, Soyuz, Proton)



#### Ground Segment





# Flight Operations Segment P/L Data Ground Segment Ground Station(s) Geostationary



<u>Sentinel-4 / UVN Mission Objective</u>: To monitoring continuosly the atmospheric composition and air quality of Europe (O<sub>3</sub>, NO<sub>2</sub>, SO<sub>2</sub>, HCHO and aerosol optical depth at a fast revisit time of ~1 hour.

# Mission Elements: Sentinel-4 GEO atmospheric mission



#### **Application:**

• Air quality

#### Instrumentation:

- UV-VIS-NIR spectrometer
- Use of thermal IR sounder (IRS) on MTG-S and of the imager (FCI) on MTG-I
- Vaw-flip/at equinox
- UV-VIS-NIR with spectral
  bands 305 500 nm and 750 775 nm
- Spatial sampling of 8 km at 45°N and spectral resolution between 0.12 nm and 0.5 nm
- Geostationary orbit, at about 0° longitude
- Embarked on MTG-Sounder Satellite and operated by EUMETSAT



## **Atmospheric Sentinel Flyers...**





Flyers on S5p and S4 can be found at http://www.esa.int/Our\_Activities/Observing\_the\_Earth/Copernicus/Sentinels\_-4\_-5\_and\_-5P

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# Next 7 years

- Selection of prime contractors
- Satellite building
- Instrument building
- Science studies
  - Model atmosphere chemical composition
  - Instrument characterization
  - Inversion algorithms
- Operational software and command control

# Geophysical data requirements



- Trace gas distribution in this key region are controlled by a complex interplay between different transport and mixing processes operating at fine scales
  - → Driving stringent observational requirements which substantially exceed capabilities of current and planned missions

# Ozone field – simulation at 15-km horizontal resolution

O3 (ppb) at 12.5 km asl



# Sentinel-4/UVN: Key Requirements



#### Instrument Spectral Coverage

Band ID	Wavelength range [nm]	Spectral resolution [nm]	Spectral sampling ratio
UV	305 - 400	0.5	3
VIS	400 - 500	0.5	3
NIR	750 - 775	0.12	3



Spatial Sampling: 8 km at 45°N

Coverage: Europe + Sahara

Repeat Cycle: 1 hour

- Low sensitivity to polarisation (1%)
- Low level of spectral features (0.05%)

High radiometric accuracy: 3% (target), 2% (goal)





#### Longitude (degree)

## Conclusion



- Sentinels-5p,-4 and -5 will meet the urgent needs of the atmospheric composition community
- S5p will help bridging the gap between OMI on Aura and S5
- S5p will embark a UVNS instrument (TROPOMI) an a dedicated satellite – launch in 2015
- S4 will be realised through embarking UVN instruments on the MTG-S series of satellites (2020)
- S5 will be realised through embarking UVNS instruments on the MetOp-SG series of satellites (2020+)

MTG and MetOp-SG are operational meteorological satellites operated by EUMETSAT

