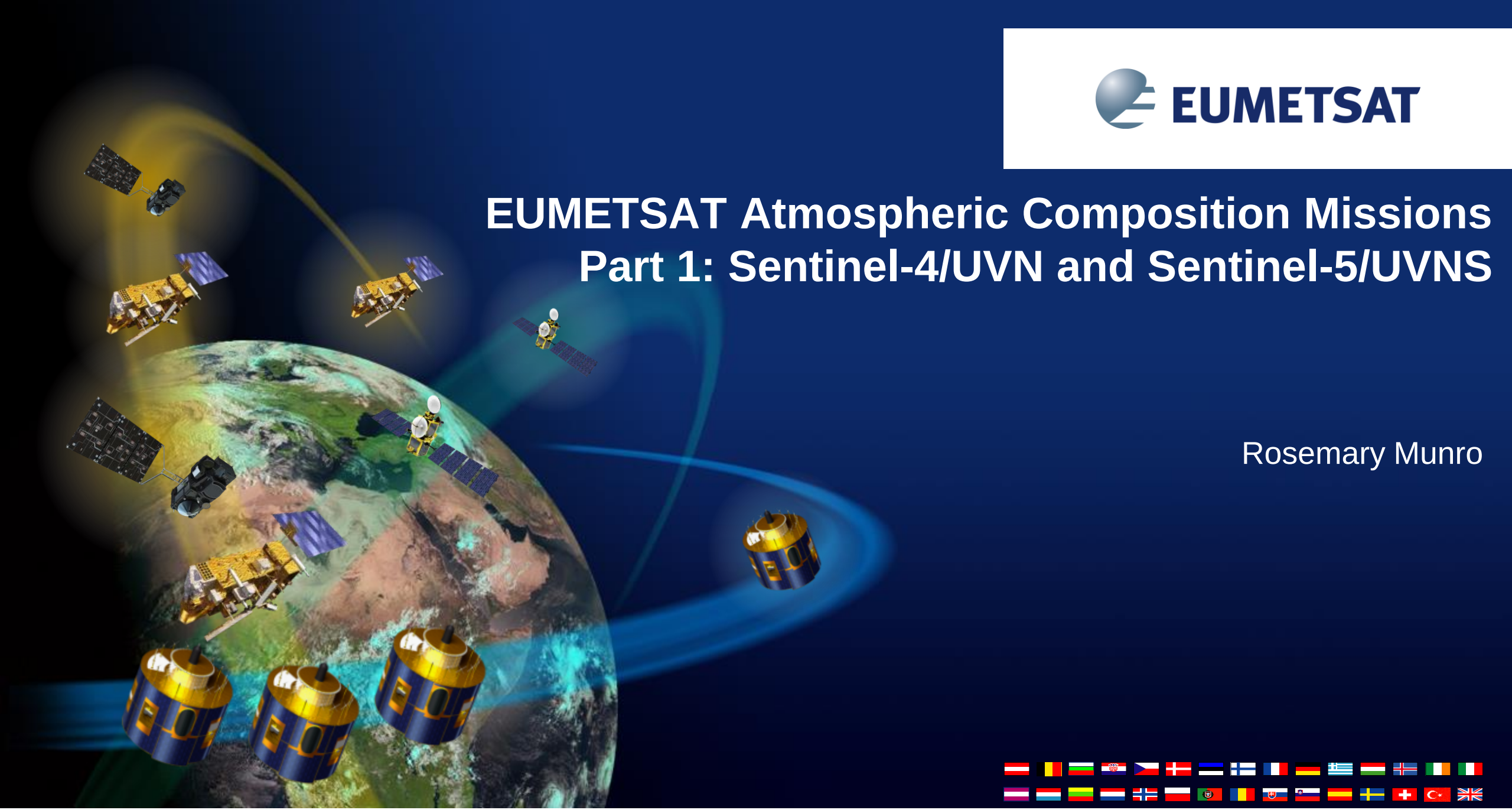
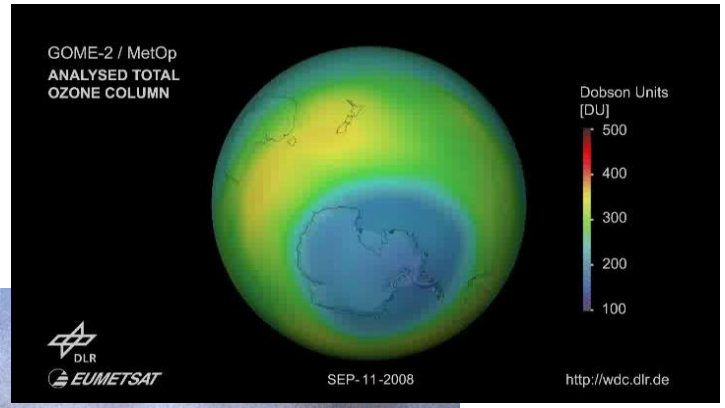


EUMETSAT Atmospheric Composition Missions
Part 1: Sentinel-4/UVN and Sentinel-5/UVNS

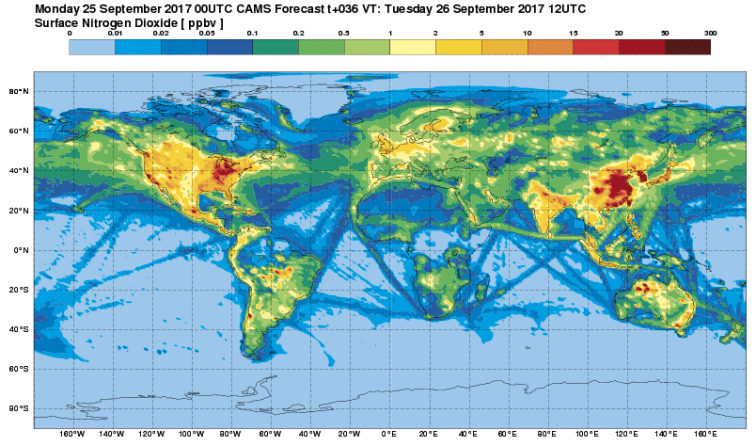
Rosemary Munro

Recalling the Main Application Areas

Stratospheric Ozone Monitoring

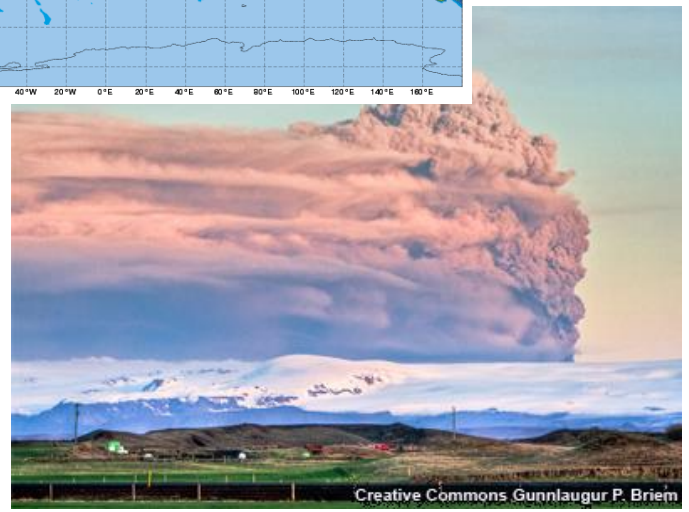


Air Quality Monitoring & Forecasting



Emissions Monitoring

GHG Monitoring

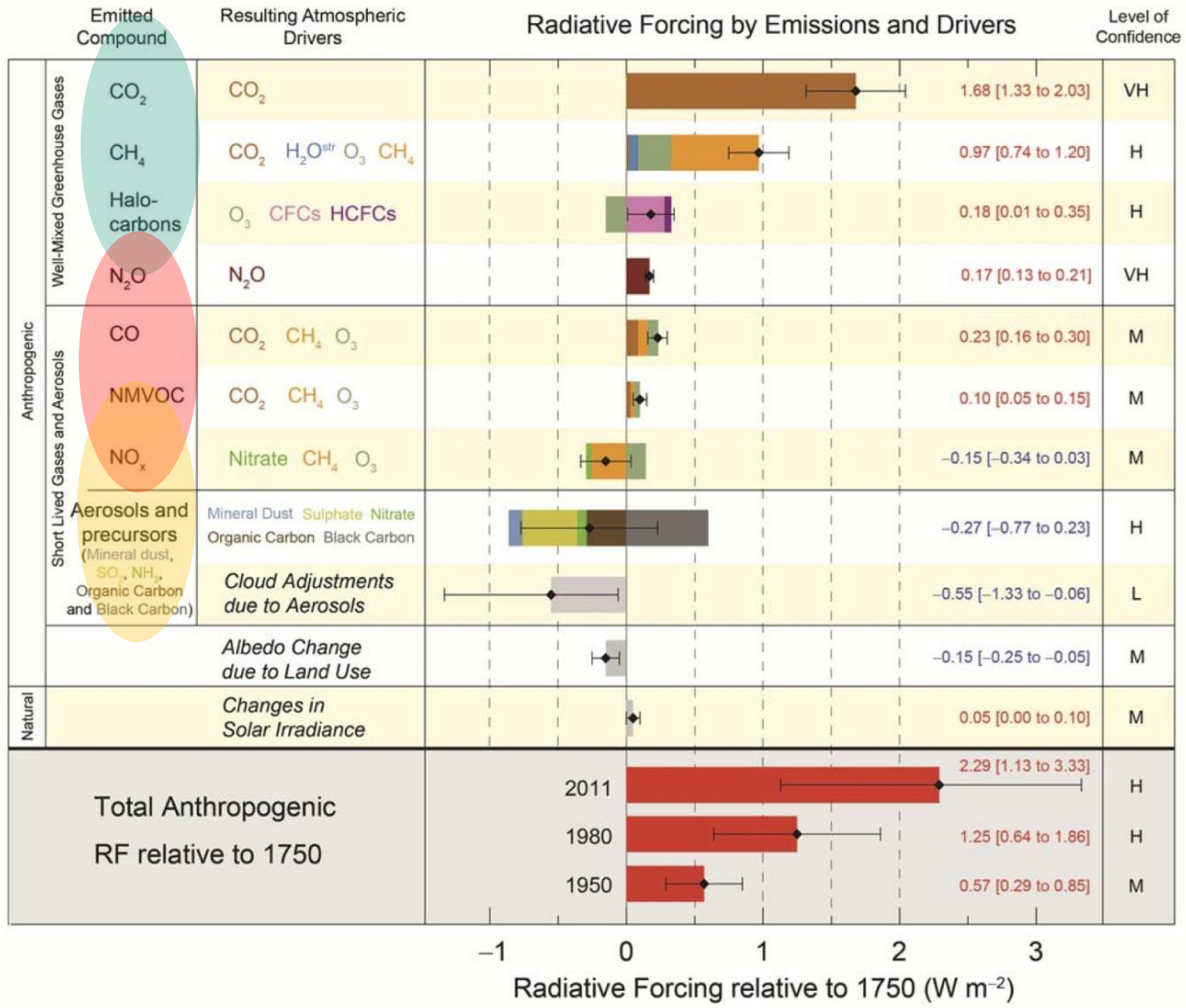


Natural Hazards Monitoring
Dust and Volcanic Ash

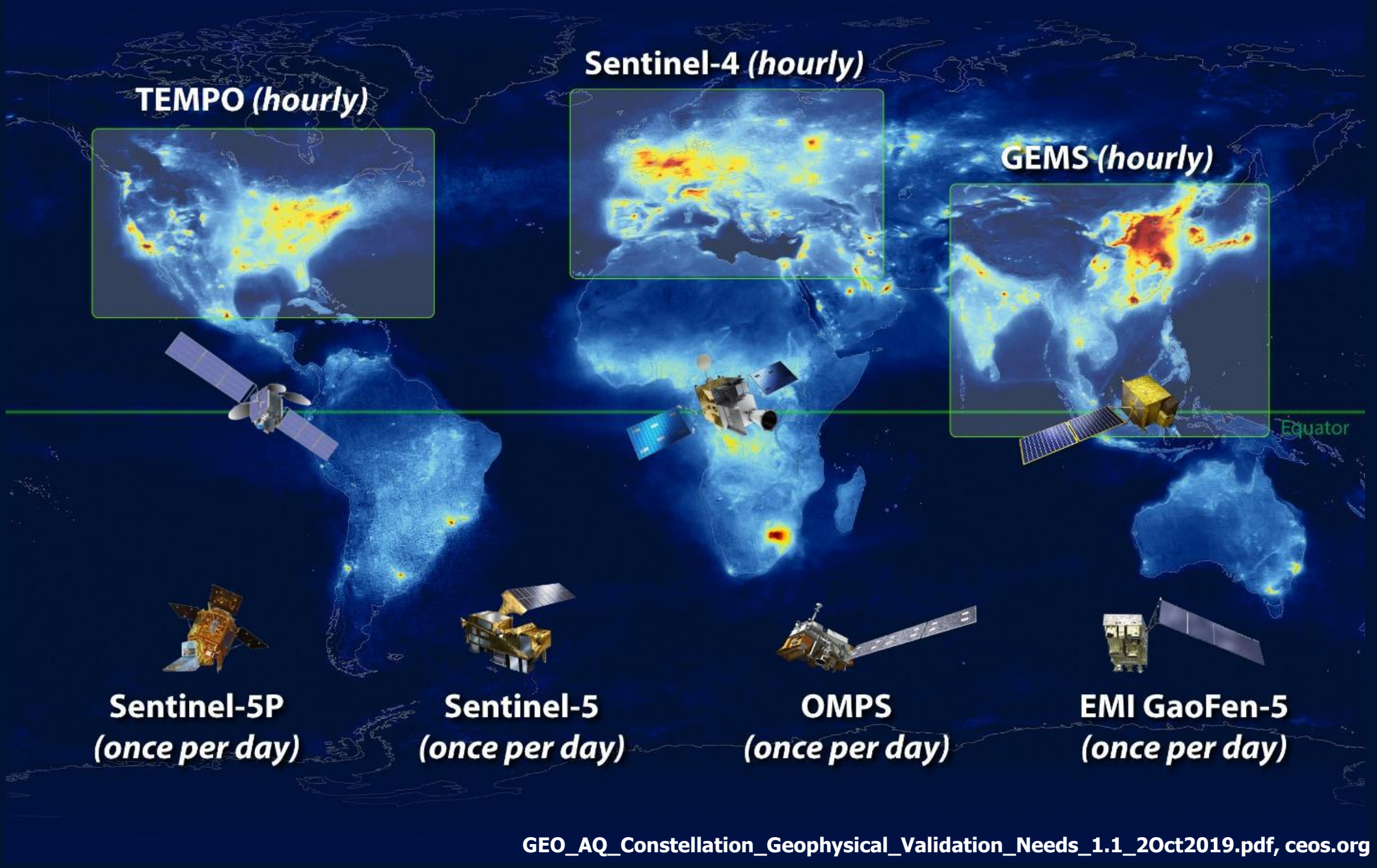
and … Atmospheric Composition - Climate Interaction

Primary emissions that are responsible for anthropogenic climate change are:

- **Greenhouse Gases (CO2, CH4, Halocarbons, N2O)**
- **Short lived reactive gases (CO NMVOC, NOx)**
- **Aerosols**



IPCC 2013



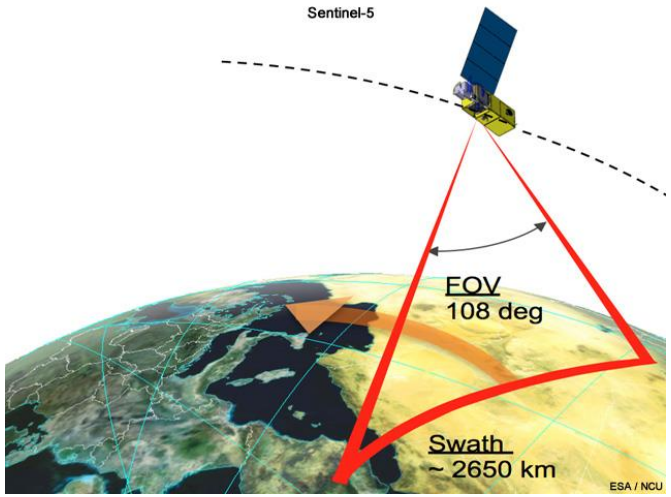
GEO_AQ_Constellation_Geophysical_Validation_Needs_1.1_2Oct2019.pdf, ceos.org

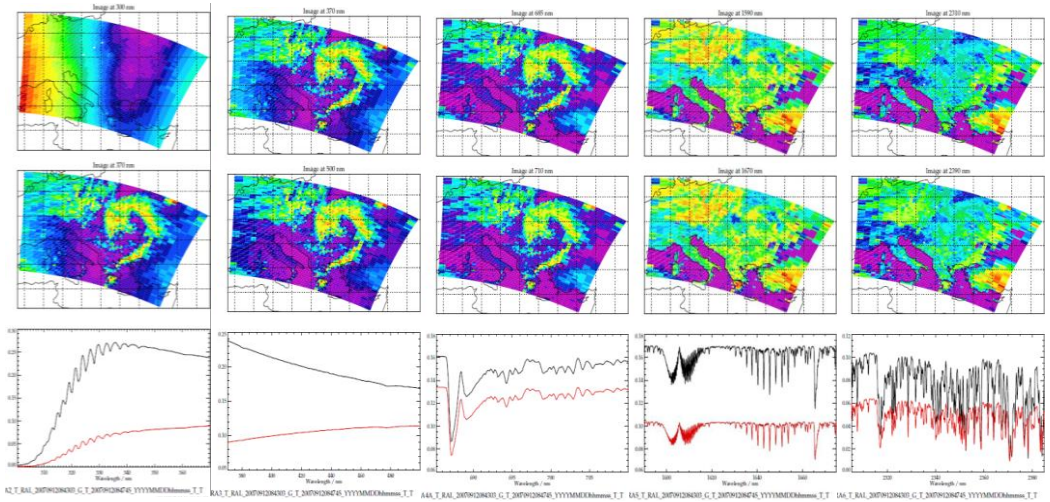
EUMETSAT Polar System – Second Generation A (EPS-SG A): Sounding and Imagery Mission

1. **IASI-NG**
   Infrared Atmospheric Sounding
2. **MWS**
   Microwave Sounding
3. **METImage**
   Visible-Infrared Imaging
4. **RO**
   Radio Occultation
5. **3MI**
   Multi-viewing, -channel, -polarisation Imaging
6. **Copernicus Sentinel-5**
   UN/VIS/NIR/SWIR Sounding

EPS-SG Sentinel-5/UVNS: UV-Vis-NIR-SWIR Spectrometer

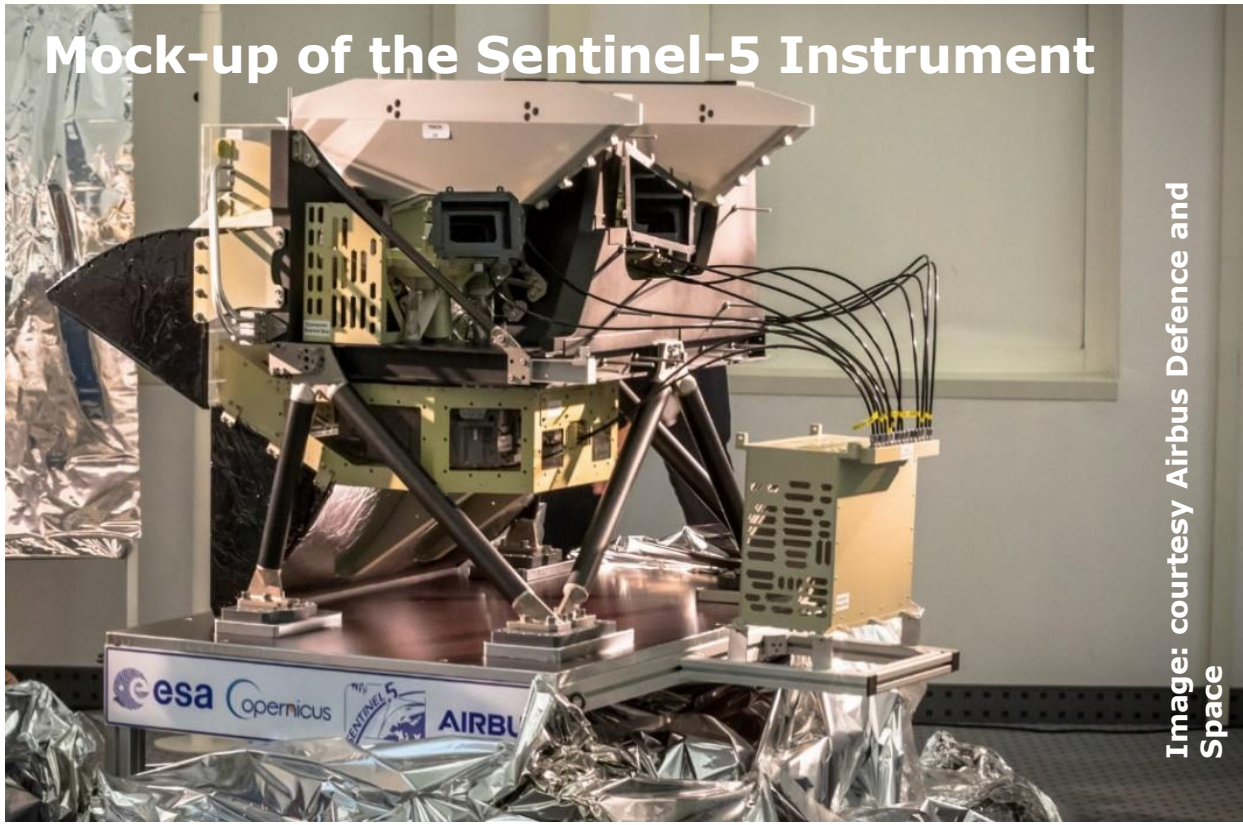
- Copernicus Sentinel-5/UVNS will build on the heritage from, and provide continuity with the GOME/SCIAMACHY/GOME-2 /OMI/Sentinel-5P series of instruments
- The spatial resolution will be significantly improved at ~7 x 7 km at SSP, which is important to support development of air quality applications
- Sentinel-5/UVNS level 1 and 2 products will be produced operationally by EUMETSAT
- Products: O_3, NO_2, SO_2, HCHO, CH_4, CO, CHOCHO, UV, AAI, AOD, ALH, CLD, HSC, SUR





Sentinel-5/UVNS Specifications

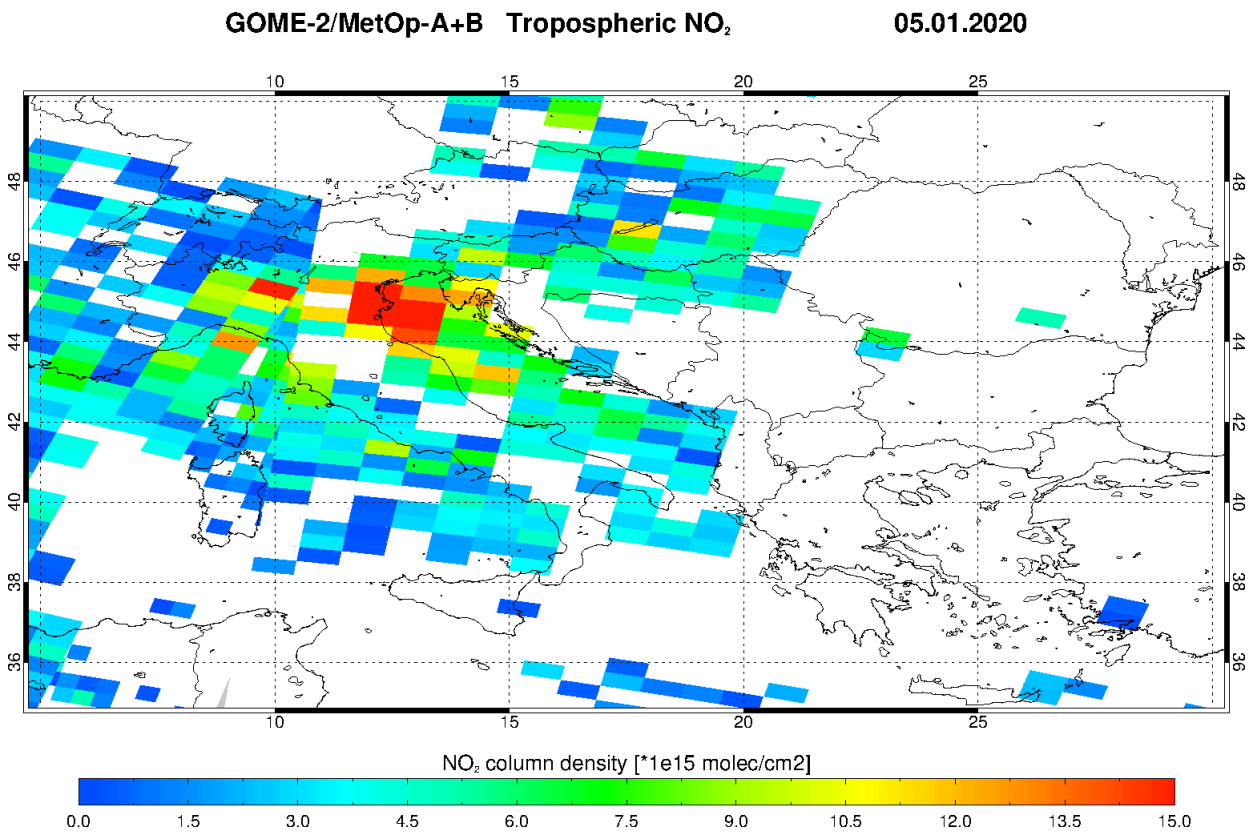
Spectral Ranges [nm]	270 - 310	300 – 400	685 - 710	755 – 773	1595 - 1675	2305 - 2385
Resolution [nm]	1	0.5	0.4	0.4	0.25	0.25
Oversampling	3	3	3	3	2.5	2.5
Signal to Noise of radiance (SZA=75/70°, alb=0.02/0.05 in UVN/SWIR)	100 @ 270 nm	1500 @ 420 nm	500 @ 710 nm	500 @ 755 nm	~220 (cont.)	~100 (cont.)
Radiometric Accuracy	3%	3%	3%	3%	6%	3.5%
Polarisation Sensitivity	0.5%	0.5%	0.5%	0.5 / 0.7%	20%	20%
Spectral Features	0.25% and constrained by L2 impact					

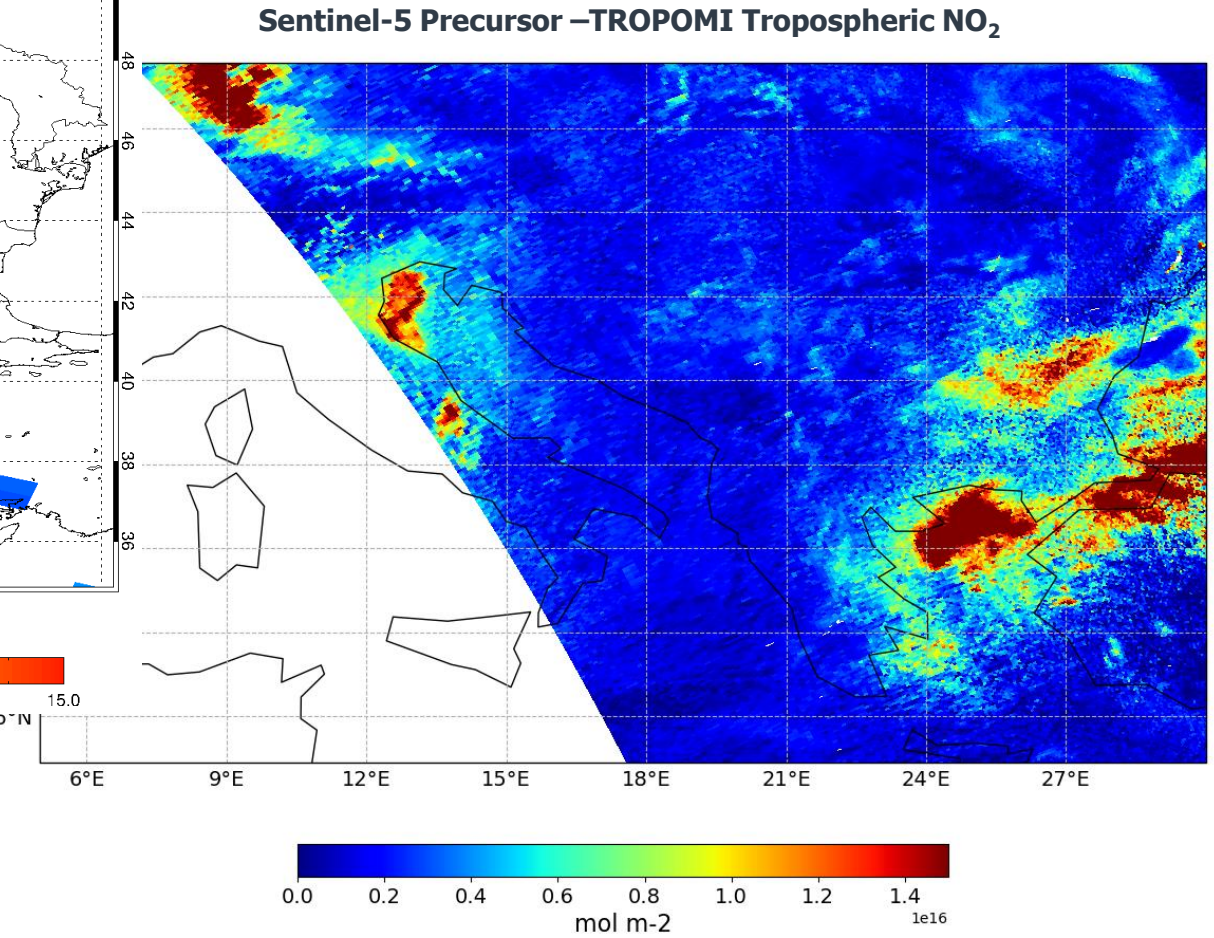


Revisit time	Coverage	Spatial Sampling	Mass	Power (Obs.)	Data Rate
Daily (more often at higher latitudes)	global	7.5 km @ nadir	295 kg	300 W (average)	≈ 20 Mb/s (average)

Slide provided courtesy of Ben Veihelmann, ESA/ESTEC

Advances for Atmospheric Composition Applications





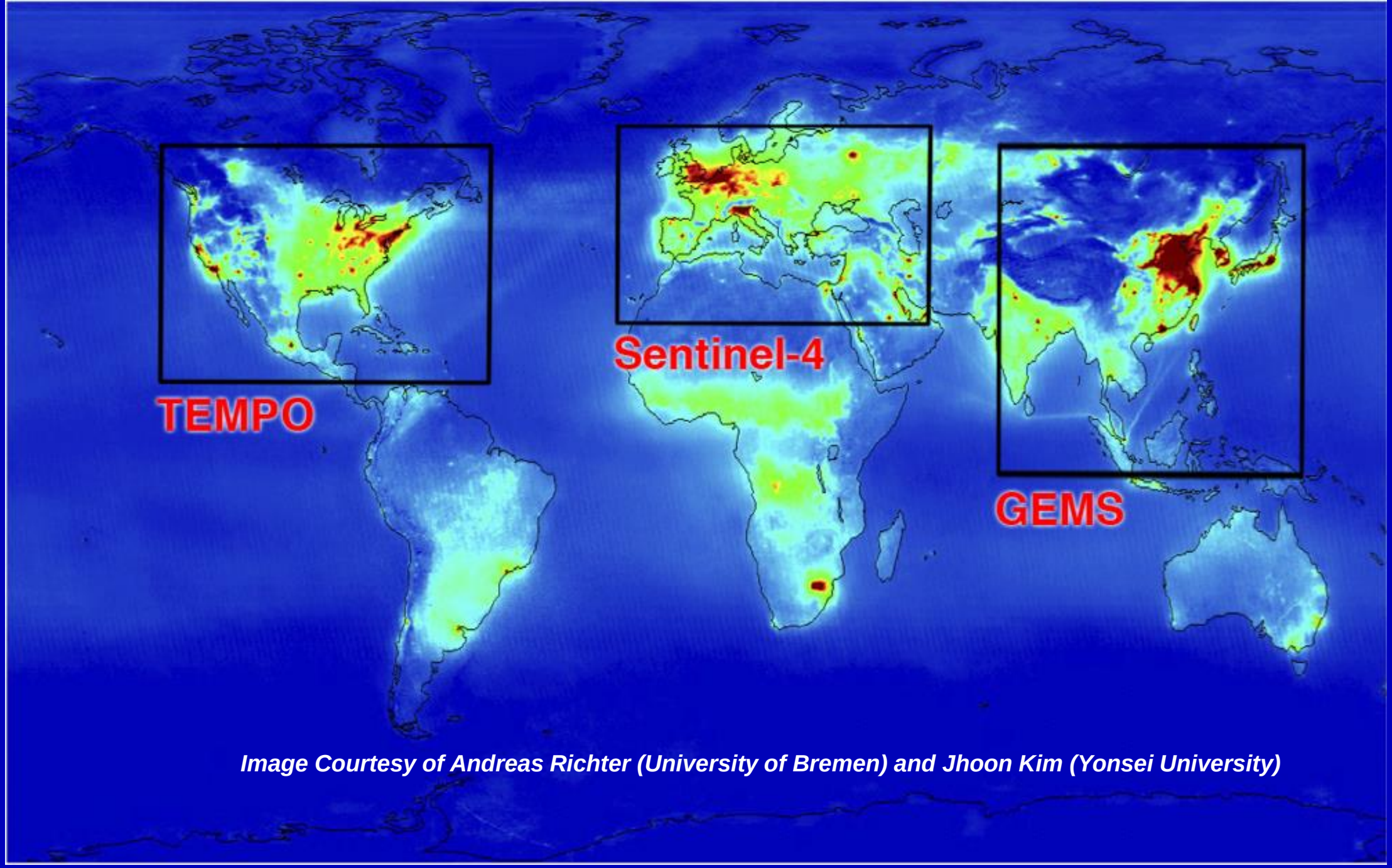


Image Courtesy of Andreas Richter (University of Bremen) and Jhoon Kim (Yonsei University)

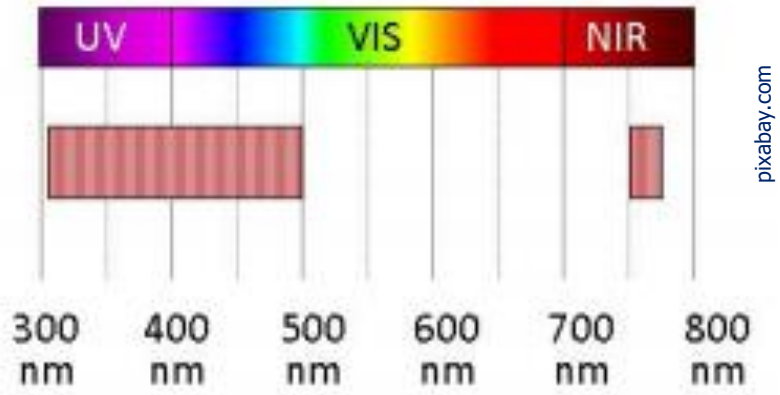
Meteosat Third Generation Sounding mission (MTG-S)

- Hyperspectral infrared sounding mission
- 4D weather cube: temperature, water vapour, O_3, every 30 minutes over Europe
- Air quality monitoring and atmospheric chemistry in synergy with Copernicus Sentinel-4/UVN instrument

- **Start of operations in 2024**
- **Operational exploitation: 2024-2043**

MTG-S: Sentinel-4/UVN

- Ultraviolet Visible Near-infrared (UVN) spectrometer – *Copernicus Sentinel-4/UVN*
- Continuous monitoring of atmospheric composition / chemistry.
- **Focus on air quality with the main data products being O_3, NO_2, SO_2, HCHO, AOD (simultaneously retrieved with surface parameters), ALH, AAI, CLD.**
- Spatial sampling at 45° North: 8 x 8 km²
- Temporal resolution: 60 min.



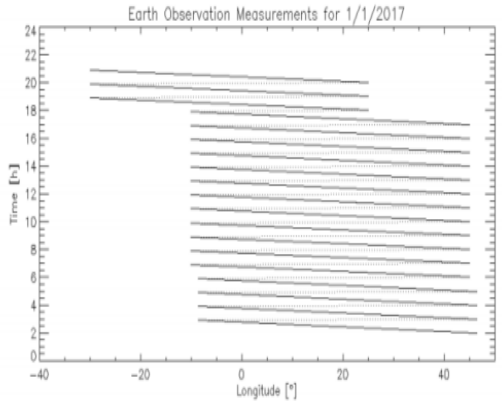
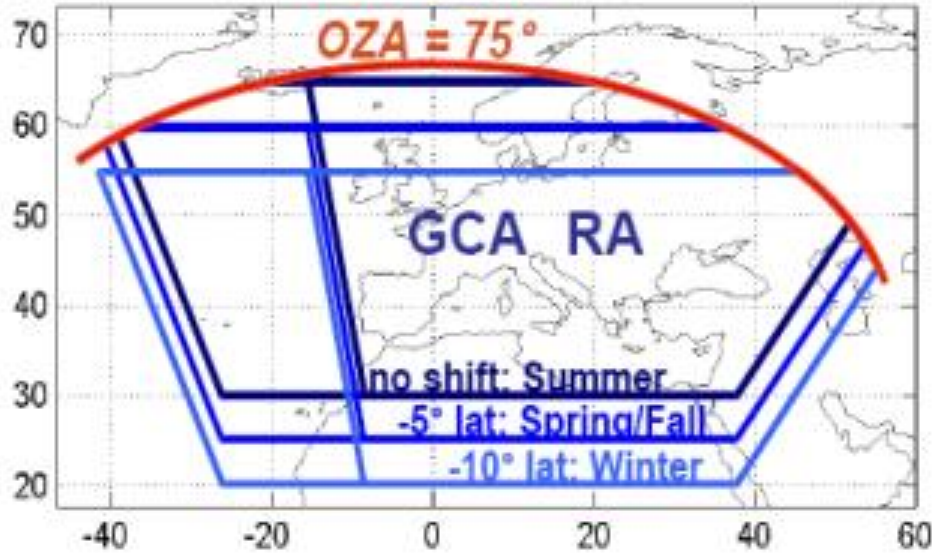


Figure 9-2: Possible UVN scanning scheme

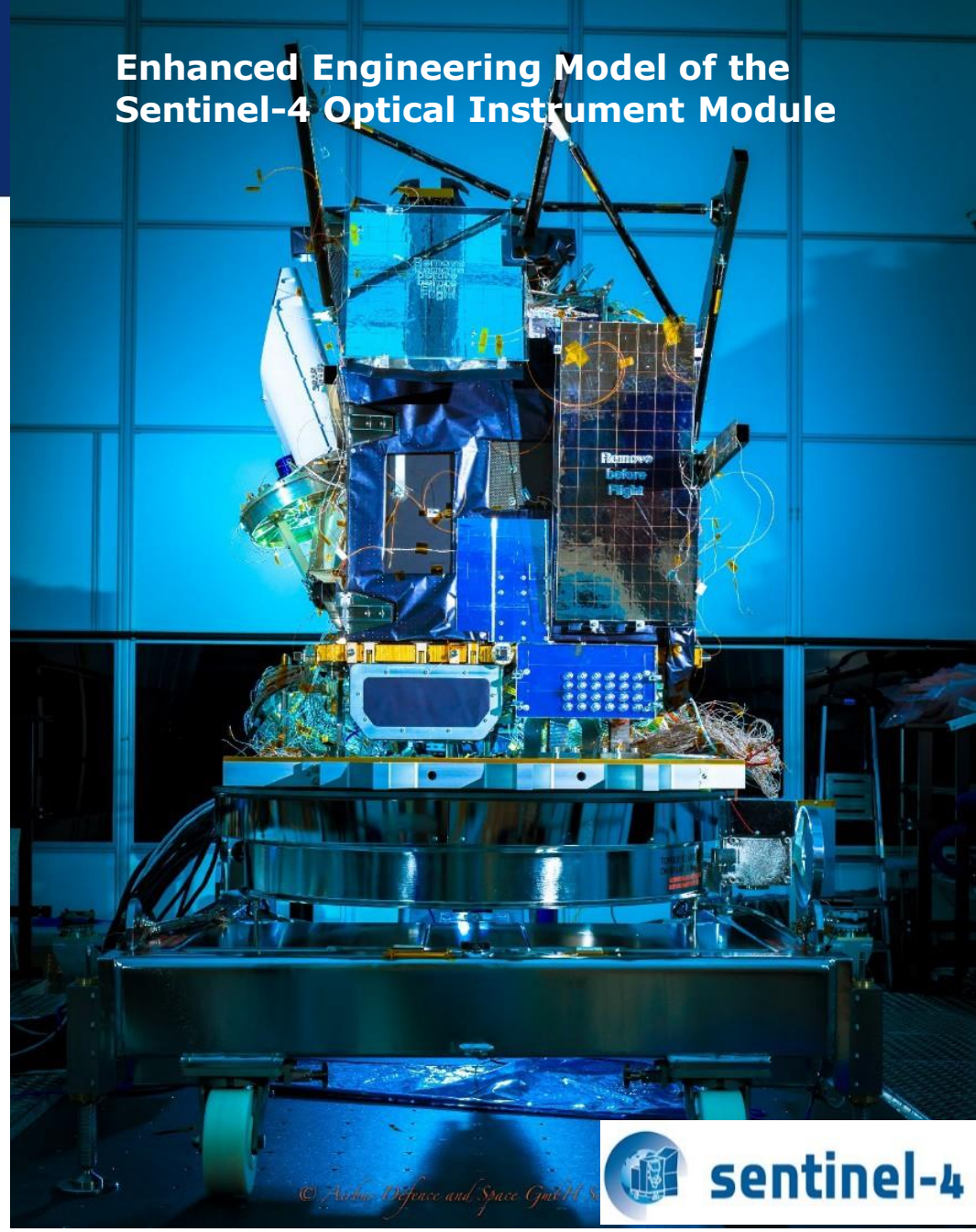


Sentinel-4/UVN Specifications

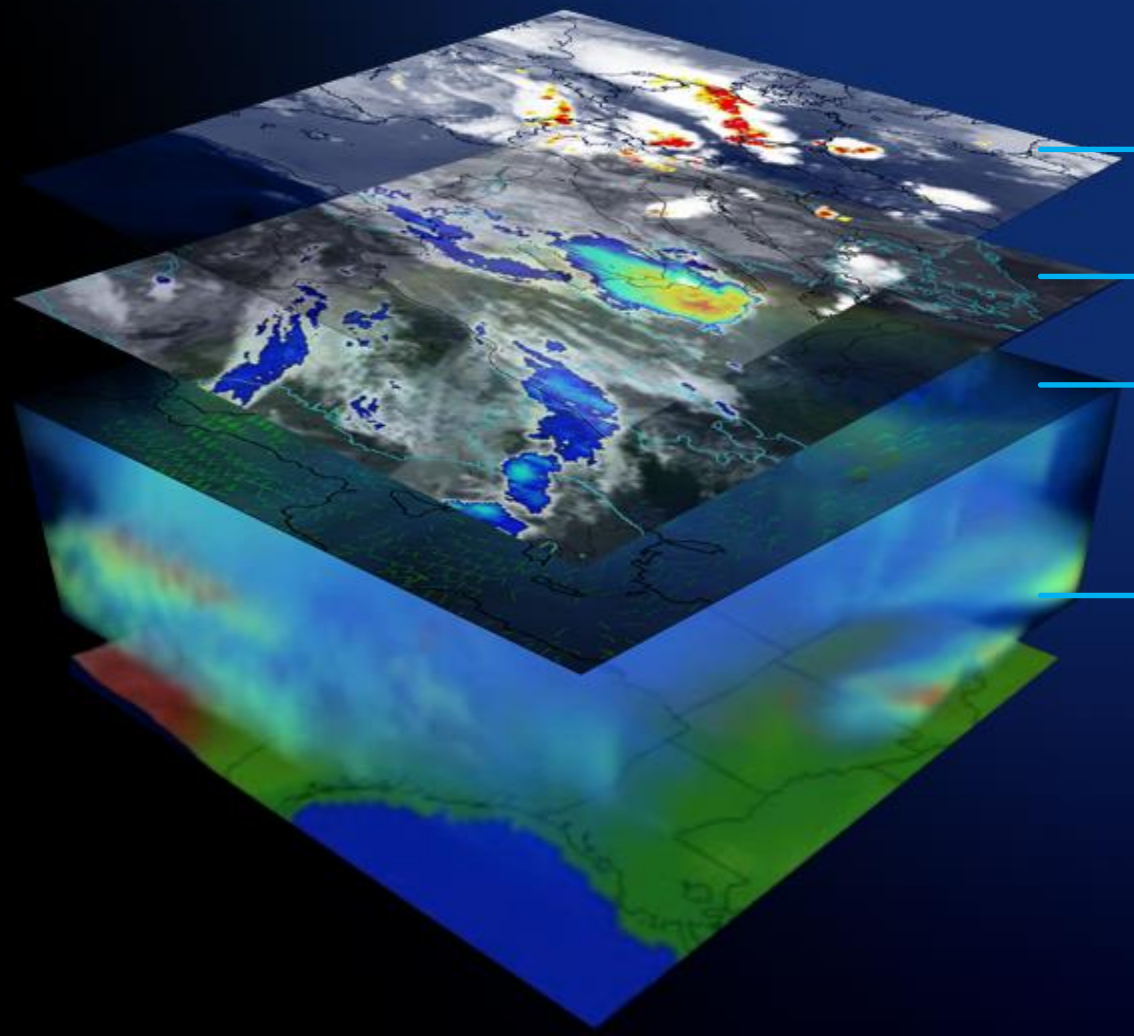
Spectral Ranges [nm]	305-400	400-500	750 – 775
Resolution [nm]	0.5	0.5	0.12
oversampling	3	3	3
Signal to Noise of radiance (SZA ~65°, albedo= 0.05/0.05/0.15)	300 @ 310 nm	1800 @ 450 nm	600 (continuum)
Radiometric Accuracy	2-3%	2-3%	2-3%
Polarisation Sensitivity	1%	1%	1%
Spectral Features	0.05%	0.05%	0.05%

Revisit Time	Coverage Area	Spatial Sampling Distance
hourly	Europe + part of Sahara and Atlantic	8 km @ 40°N
Mass	**Power (Obs.)**	**Data Rate**
≈ 200 kg	≈ 180 W (average)	≈ 30 Mb/s (average)

Slide provided courtesy of Ben Veihelmann, ESA/ESTEC



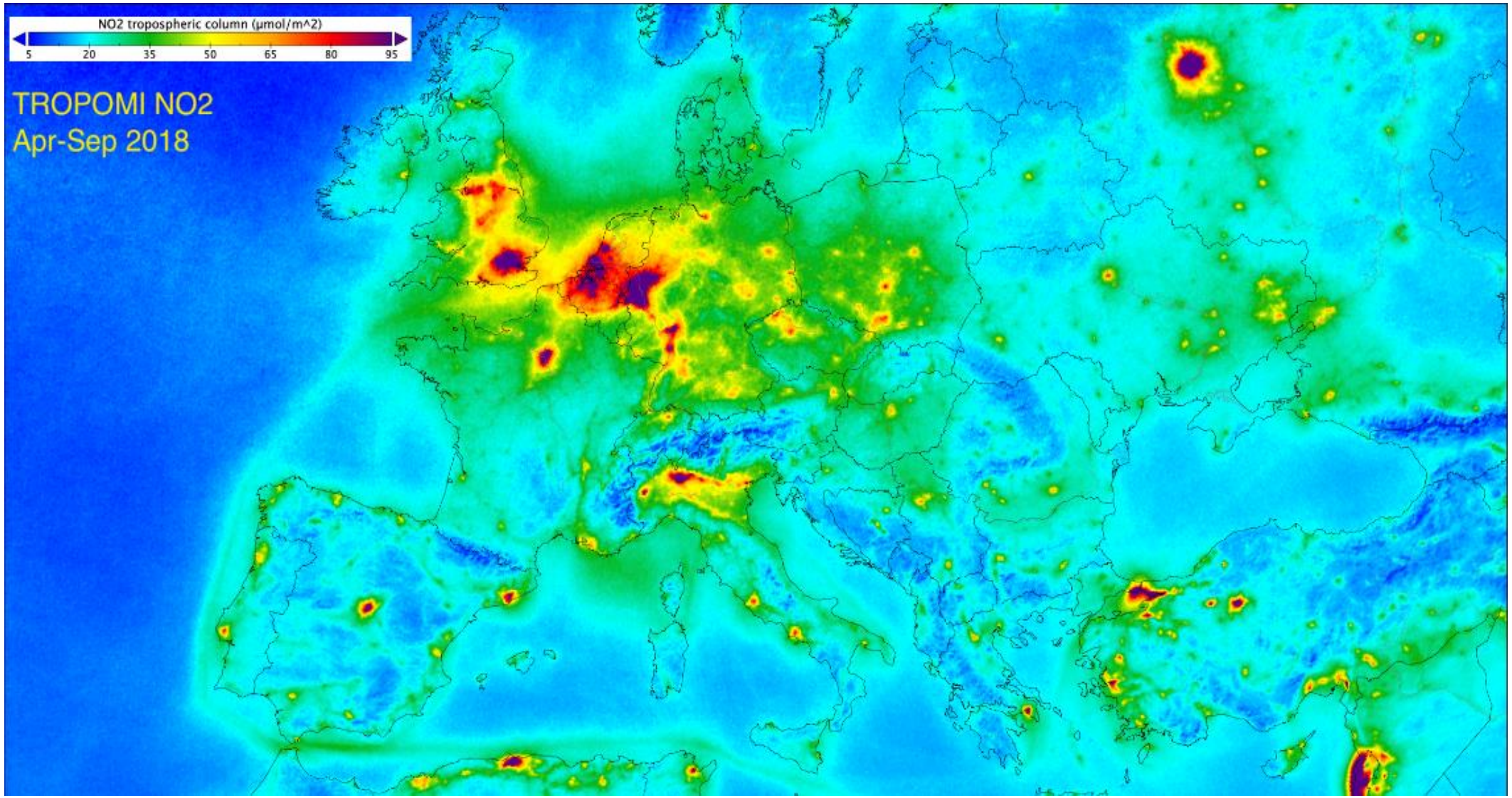
MTG Summary: 4D Weather Cube



- Lightning
- Convection
- Winds
- Atmosphere

Every 30 min over Europe

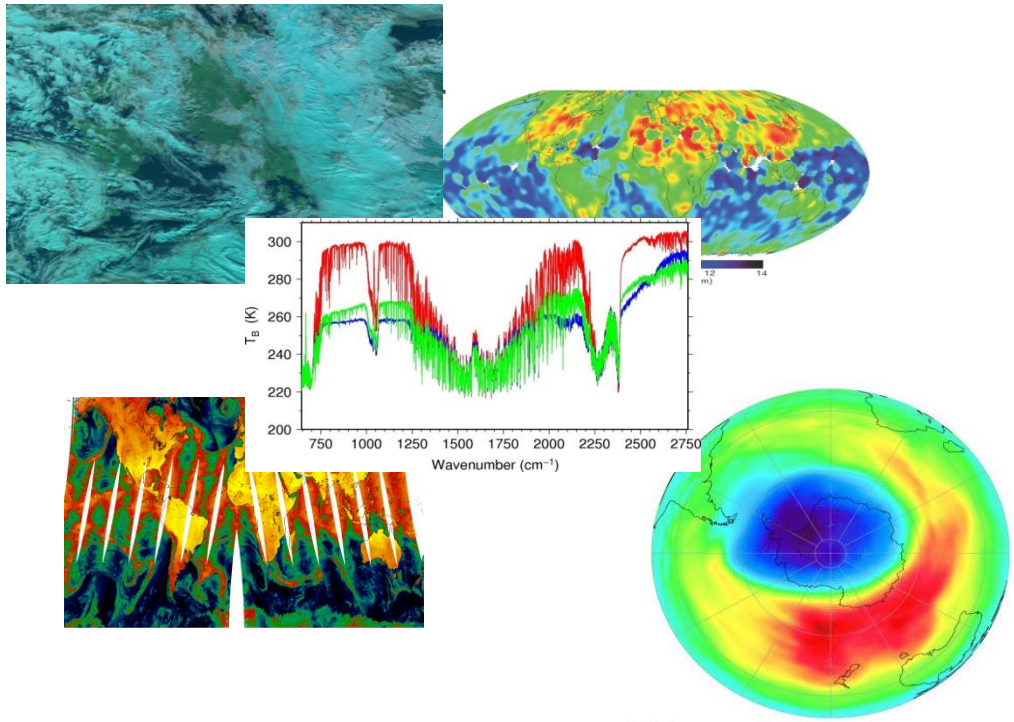
Sentinel-4/UVN on MTG: Monitoring Air Quality Hourly



EPS-SG: Synergy of Observation Missions

Observation missions are highly complementary

- Co-registration of measurements will allow to optimise the information extraction
- Synergy has been considered in payload distribution of a dual satellite configuration

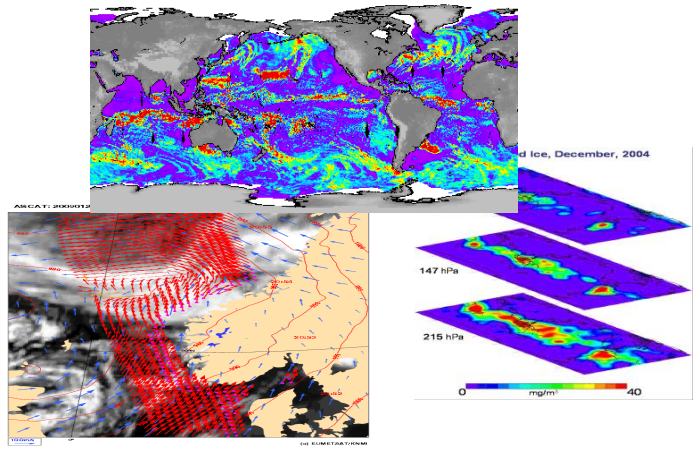


Essential co-registrations

- IASI-NG – METimage – S5/UVNS
- MWI - ICI

Desired co-registrations

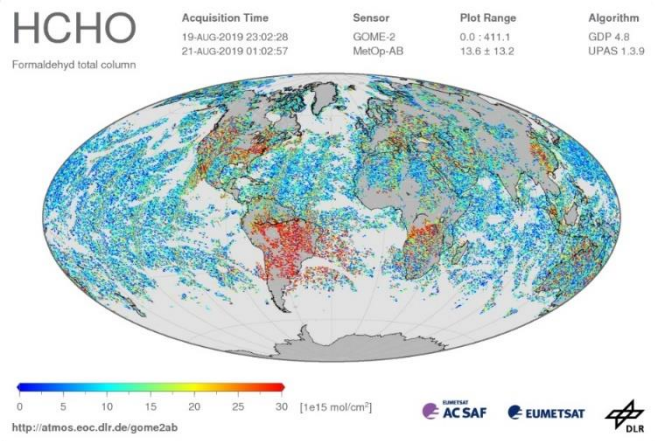
- IASI-NG – MWS
- METimage – 3MI
- IASI-NG – S5/UVNS – 3MI
- MWI – SCA – METimage

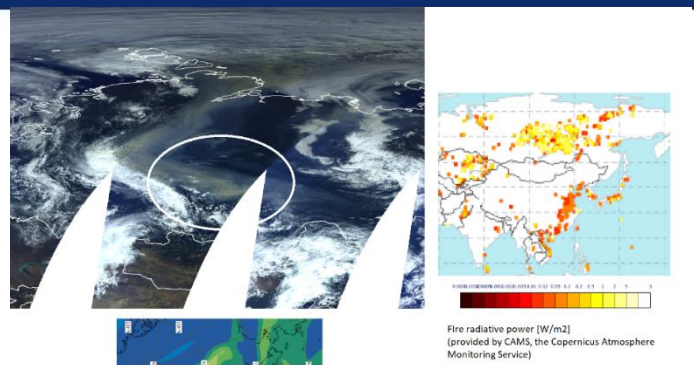


MTG: Synergy of Observation Missions

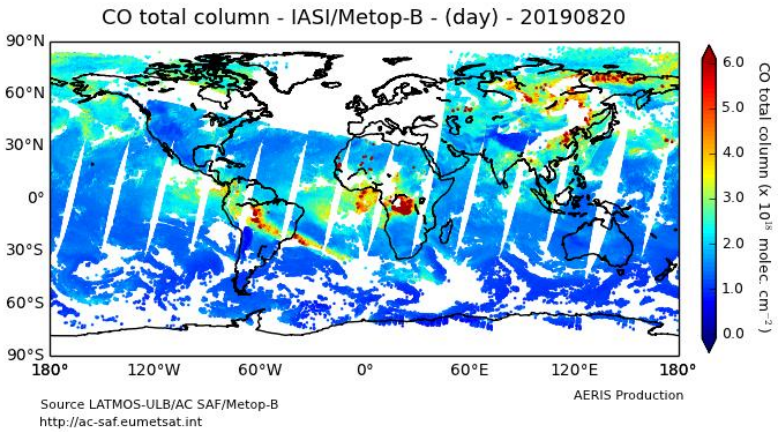
- Primary mission: support nowcasting/ Short Range Forecasting of high impact weather
  - Continuity and enhancement of MSG imagery
  - Addition of a new lightning imaging capability
  - New, innovative infrared hyper-spectral sounding
- Secondary mission: air quality monitoring over Europe
  - Synergy between Sentinel-4, IRS and imagery

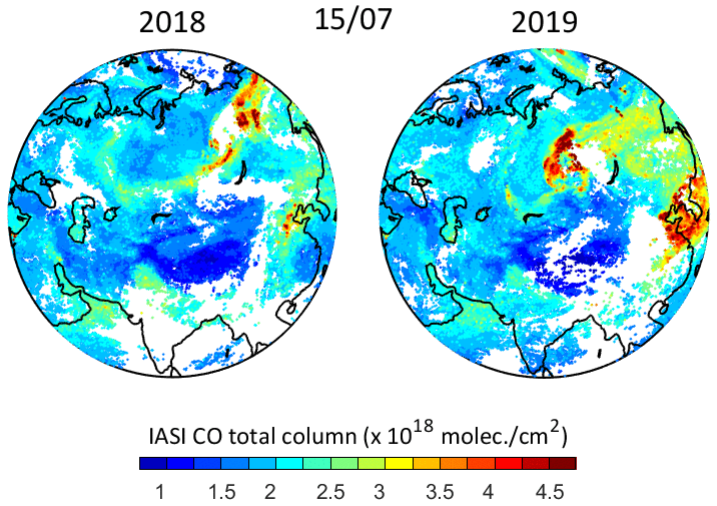
Synergy of Observation Missions: 2019 Stories on Fires





IASI CO and GOME-2 Formaldehyde – Amazon data





LATMOS - ULB

Cal/Val & End User Products

Product (Cal/Val & Trace Gas)	Metop GOME-2	MTG-S S4/UVN	EPS-SG S5/UVNS	Copernicus CO_2 M
Radiance	√	√	√	√
Irradiance	√	√	√	√
O_3 total column	√	√	√	
O_3 profile (incl. troposphere)	√		√	
O_3 tropospheric column	√	√		
NO_2 total column	√	√	√	√
NO_2 tropospheric column	√	√	√	√
SO_2	√	√	√	
SO_2 Layer Height			√	
HCHO	√	√	√	
CHOCHO	√	√	√	
BrO	√		√	
OClO			√	
CO			√	
CH_4			√	√
SIF	√		√	√
CO_2				√
H_2O	√	√	√	
UV Products	√	√	√	
Surface Reflectance	√	√	√	

Cells coloured:

blue indicate products to be produced at EUMETSAT, green indicate products to be produced by the AC SAF or via external scientific cooperation, orange indicate products not yet committed but possible.
Grey indicate "Not Applicable"

Summary

- The future Sentinel-4/UVN and Sentinel-5/UVNS missions offer a significant advance for atmospheric composition applications.

- Synergistic use of the data in combination with other missions on EPS-SG and MTG offers users further new opportunities.