

Status of Copernicus CO2M mission development

Anthropogenic greenhouse gas monitoring from space

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CO₂ Monitoring (CO2M) Mission

1. **Detection of emitting hot spots**
2. **Monitoring the hot spot emissions**
3. **Assessing emission changes against local reduction targets**
4. **Assessing the national emissions and changes**



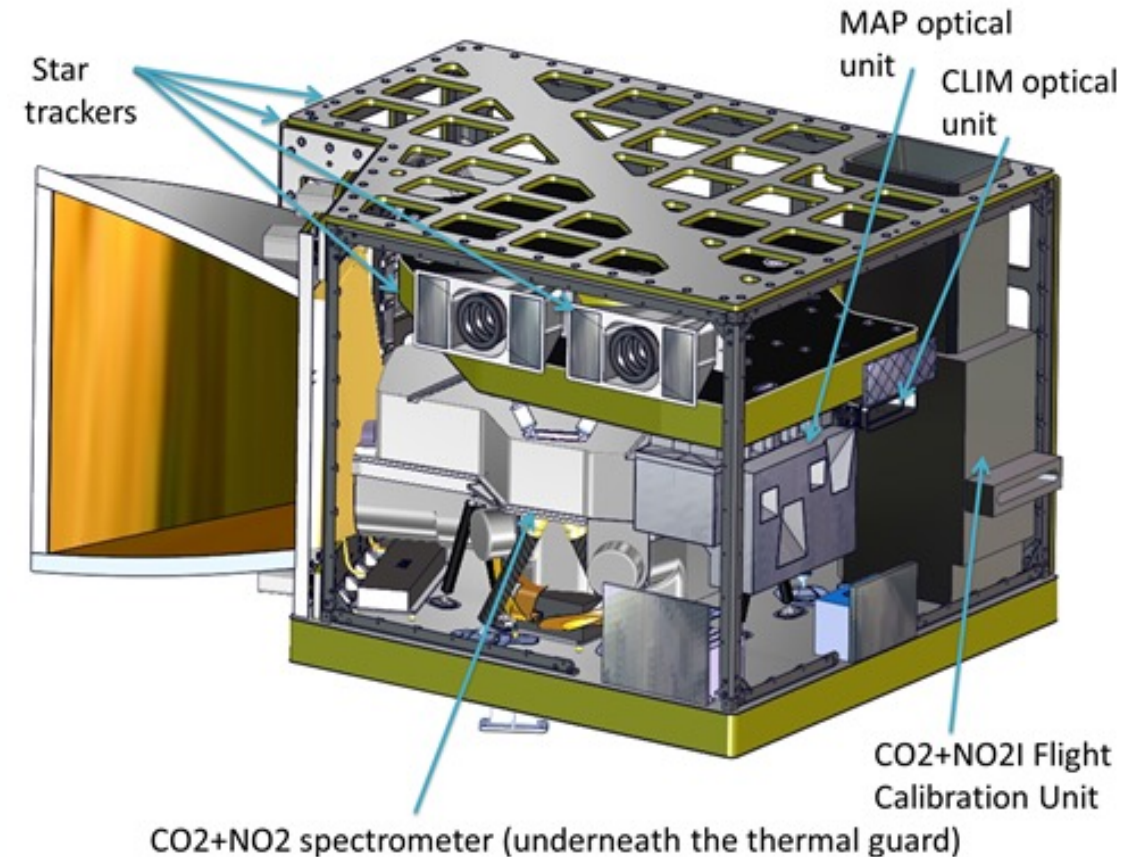
System requirements → Mission Requirements → Implementation → Performance

NB mission requirements need to be met 3-sigma & anywhere in the swath

Today implementation status & performance be will presented

Payload Components

- **CO2 Imager (CO2I)**: 3 band (1 NIR, 2 SWIR) co-located push-broom imaging spectrometer
- **NO2 Imager (NO2I)**: VIS band implemented as fourth band in CO2I instrument
- **Multi-Angle Polarimeter (MAP)** for aerosol observations
- **CLoud IMager (CLIM)** for low cloud & cirrus detection



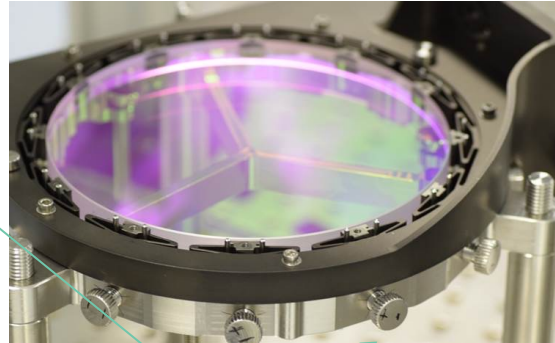
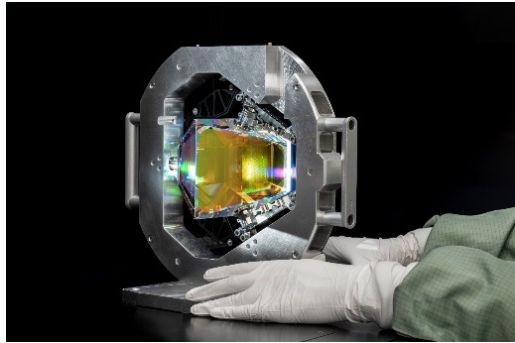
Credits: TASI F

Push-broom multi-band imaging spectrometer

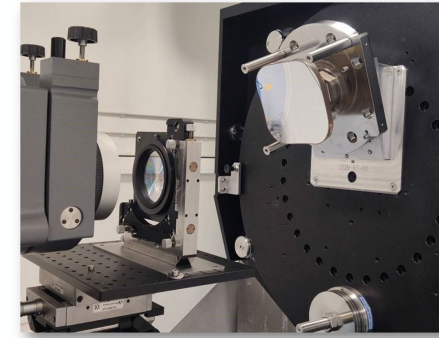
Credits: IOF



Credits: LYNRED

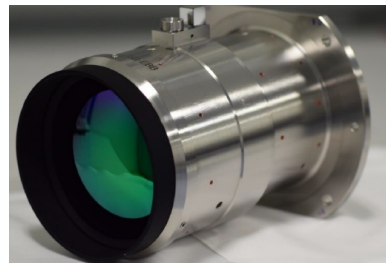


Credits: TASiF / TSESO

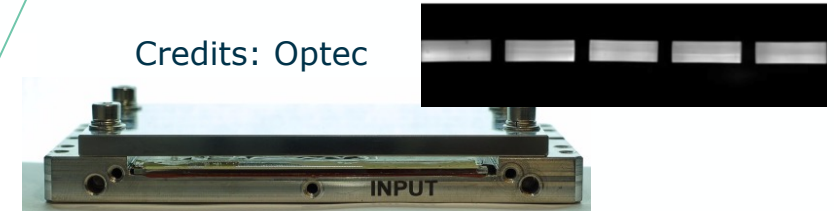
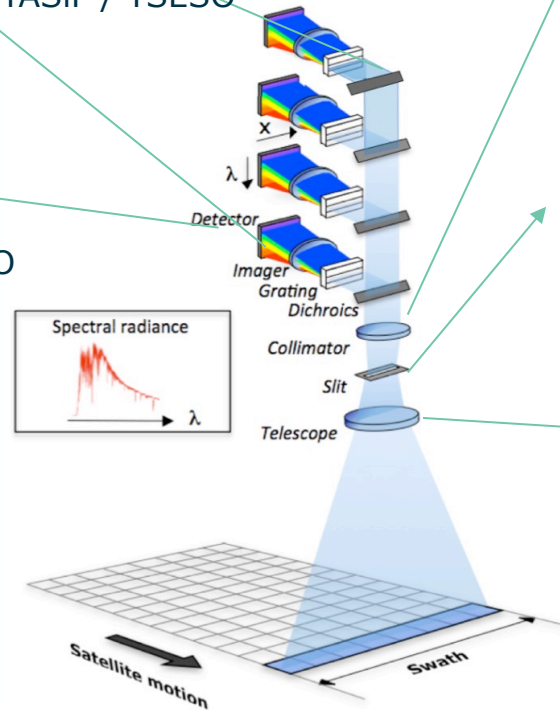


Credits: TASiF

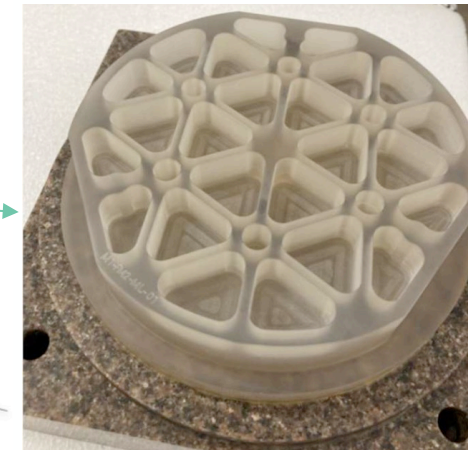
Band	Spectral range
VIS	405–490 nm
NIR	747–773 nm
SWIR-1	1590–1675 nm
SWIR-2	1990–2095 nm



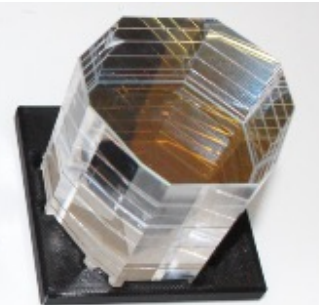
Credits: TSESO



Credits: Optec



Credits: Media Lario



Credits: Bernhard Halle

Telescope	Common telescope with polarisation scrambler
Slit	110 Fibres are used to homogenise the scene; one per sample
Collimator	One reflective collimator, common for all bands
Band separation	3 Dichroic plates used in collimated beam
Diffraction grating	4 Prism-Grating-Prism assemblies
Imagers	Glass (VIS/NIR) and silicon (SWIR-1/SWIR-2); band-pass filters
Detectors	MCT CMOS detectors in SWIR; Si CMOS in VIS/NIR

Critical design review (**CDR**) is nearly passed & integration has started

Performances are met with some minor points, but also with good exceptions:

- Swath width **266–276 km** (orbit variation)
- Spatial co-registration bands **+++**
- Spectral ch. position variation **very low**
- ISRF shape **well-known**
- Polarisation sensitivity **very low**
- Absolute radiometric accuracy **+++**
- Residual offset **very low**

CDR 

MAP Band	Wavelength
VNIR-1	410 nm
VNIR-2	443 nm
VNIR-3	490 nm
VNIR-4	555 nm
VNIR-5	670 nm
VNIR-6*	753 nm
VNIR-7	865 nm

Multi-angle polarimeter (MAP) implementation:

Compact push broom imager:

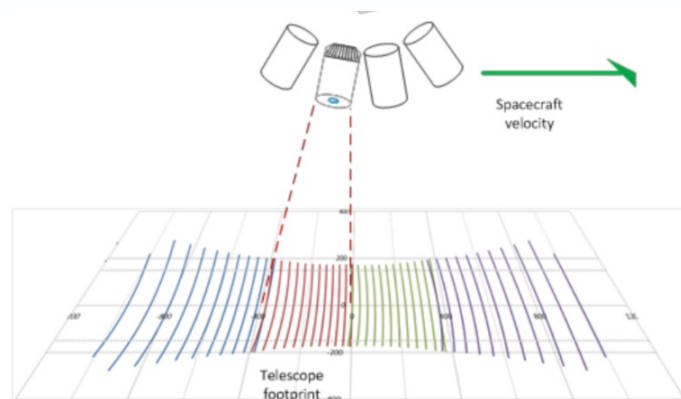
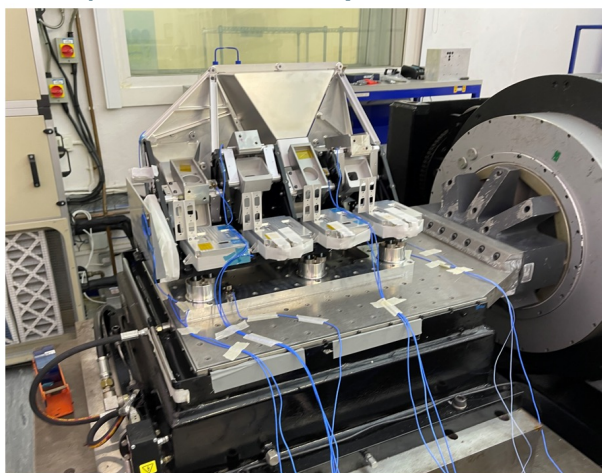
- 40 viewing angles (+/- 60°), plus 8 more @larger angles
- Spatial resolution: 4x4 km² and sampling < 1x1 km²

CDR



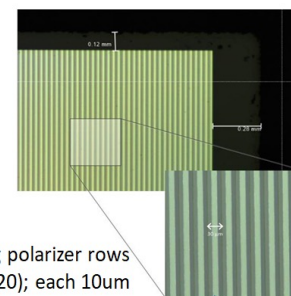
One focal plane assembly combining polarization & spectral filtering

- 6 spectral bands in VIS and NIR (+1 for co-reg with CO2I)
- 3 polarisations (0°, 60°, 120°) sampled by μ -polarizers at detector pixel-level

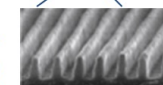


Credit © TAS-UK

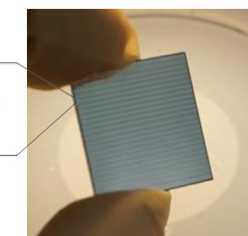
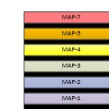
Alternating polarizer rows (0/60/120); each 10 μ m



SEM image of wire grid polarizer (Credit : Moxtek)

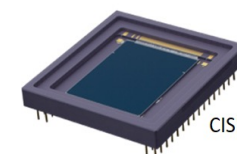
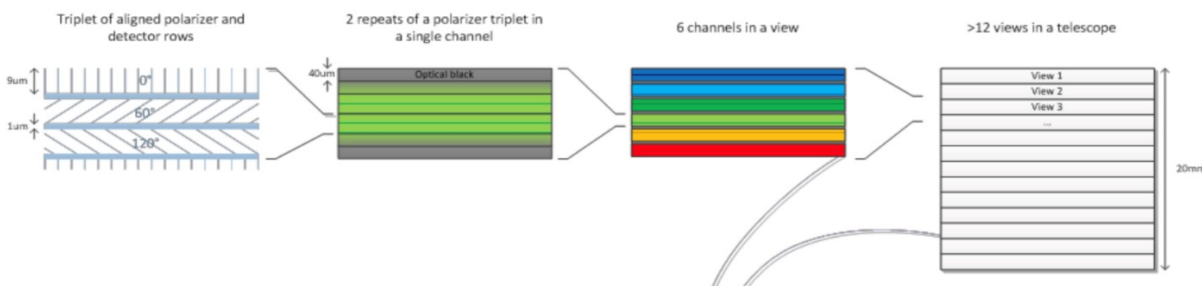


1 view = 6 spectral channels

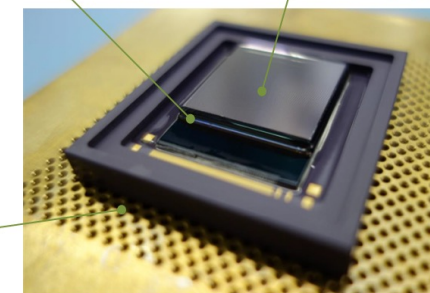


Multispectral filter with ~24 views (Credit : Optics Balzers)

MAP OU STM in mechanical testing



CIS120 detector



MAP Focal Plane Assembly

Credits:
TAS-UK

Cloud Imager based on Proba-V

- Binning on-ground, specs @400m
- Three mirror telescope with Aluminium mirrors
- InGaAs Xenics (CLIM-3) & Si CCD Teledyne E2V (CLIM-1 & CLIM-2)

Band	Band center	Band width	Native sampling (ALTxACT)
CLIM-1	670 nm	20 nm	94m x 87m
CLIM-2	753 nm	9 nm	94m x 87m
CLIM-3	1378 nm	15 nm	376m x 163m

SSRD	Required	Compliance status
SNR @Lref	SNR>200	CLIM-1 >542 (3sigma) CLIM-2 >533 (3sigma) CLIM-3 >240 (3sigma)

CDR

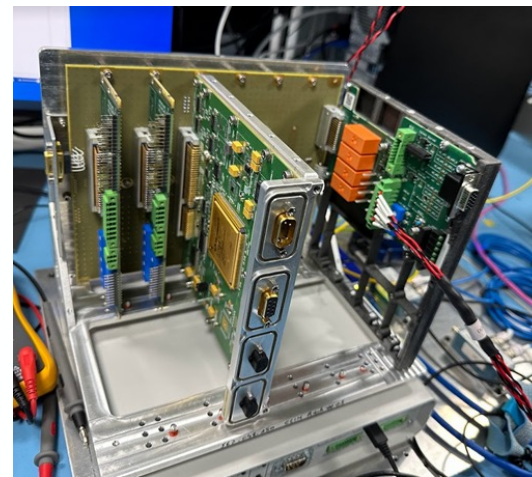
Credits: OIP

Credits: AMOS

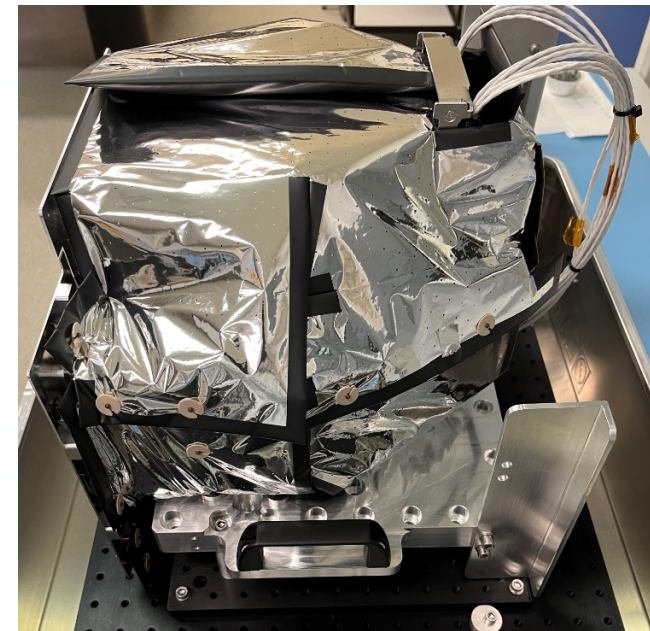


CLIM OU PFM Telescope

Credits: OIP



CLIM EU EM1 boards Testing



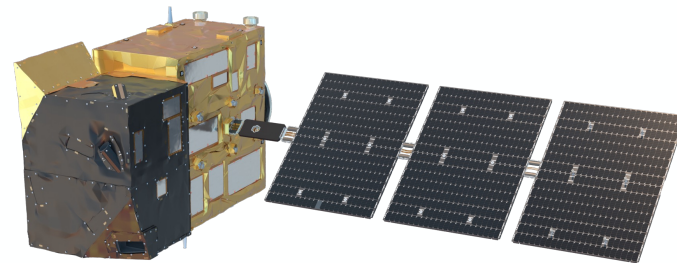
CLIM OU wrapped in MLI for thermal test

Project status:

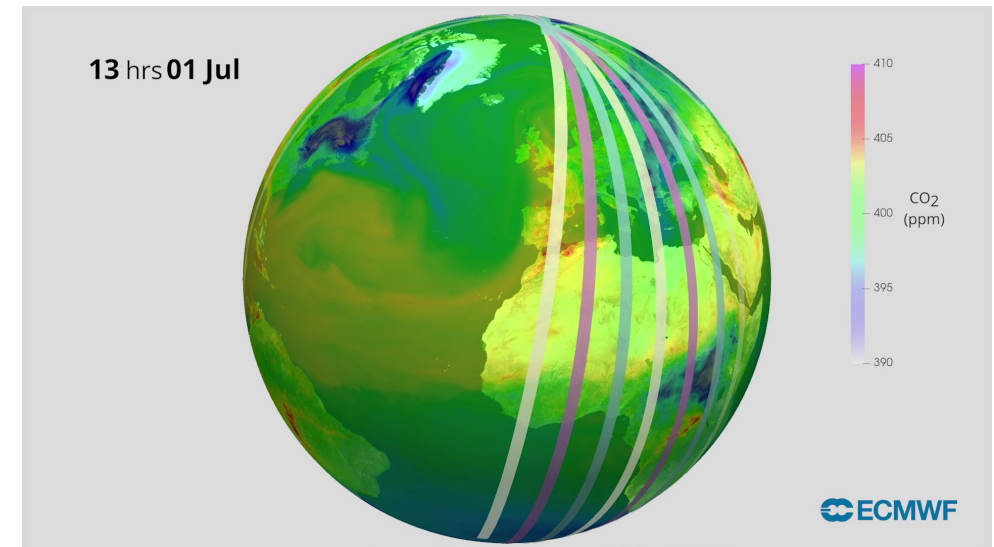
- **Constellation** of satellites
- Each satellite **>266 km swath**
- First and second satellite will have their Flight Acceptance expected **mid 2026**
- **Third satellite → APPROVED!!**

Copernicus data is made freely available to any person and organisation around the world

EUMETSAT performs operational data processing



Product	Spatial	Precision
CO ₂	4 km ²	0.7 ppm
CH ₄	4 km ²	10 ppb
NO ₂	4 km ²	1.5 10 ¹⁵ molecules cm ⁻²
Vegetation SIF	4 km ²	0.7 mW m ⁻² sr ⁻¹ nm ⁻¹
Aerosol params	16 km ²	0.05 AOD, 500 m LH
Cloud fraction	1%	Water clouds & cirrus



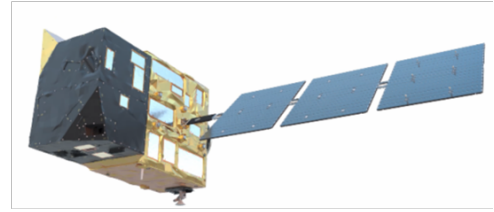
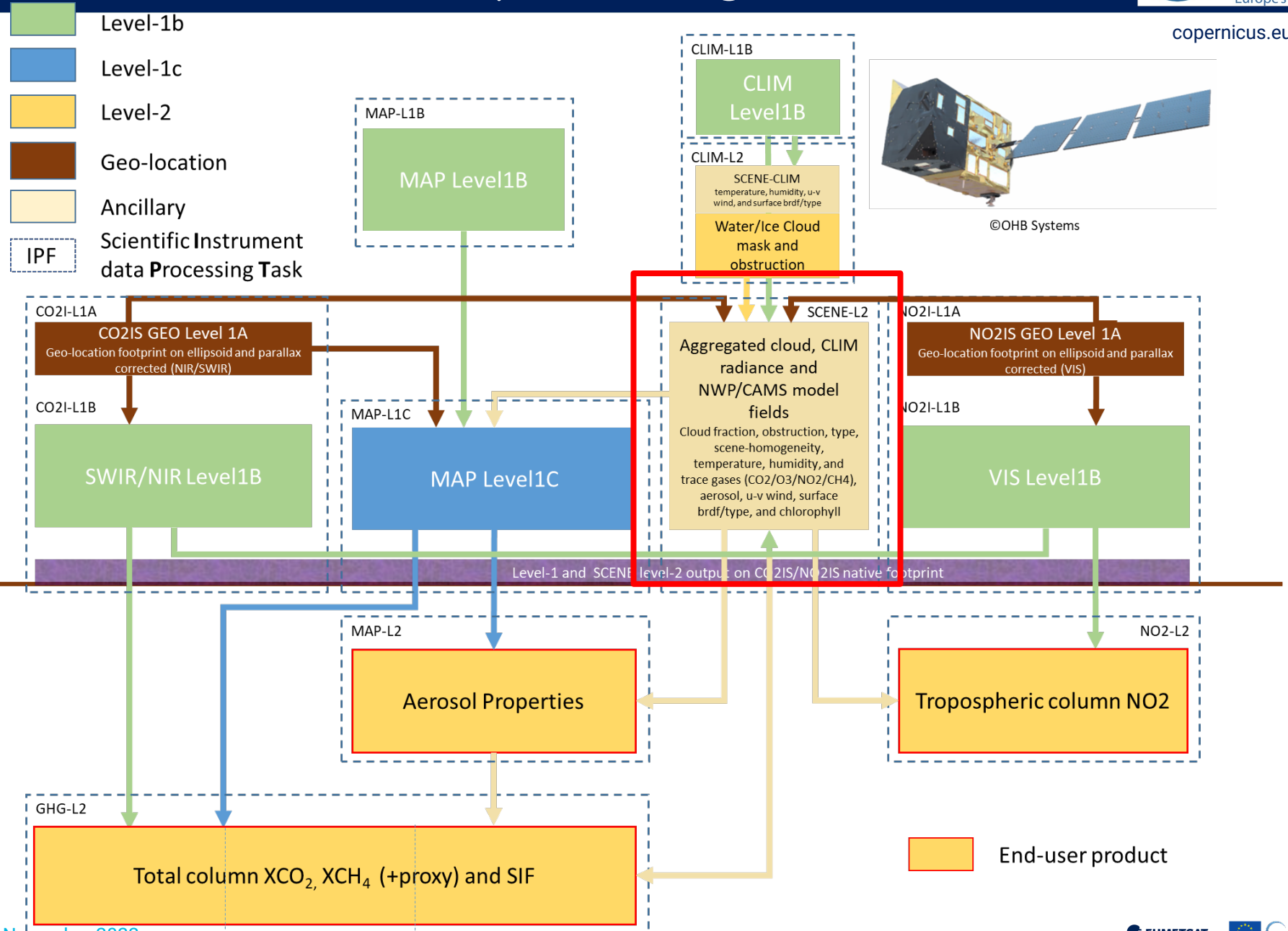
Credits: EMPA



EUMETSAT CO2M MDPS scientific processing tasks

CO2M
Mission Data
Processing System

Make one
"hyper-GHG/NO2-
instrument"
out of three!



©OHB Systems



Early results from synthetic data (GHG level-2 XCO2)

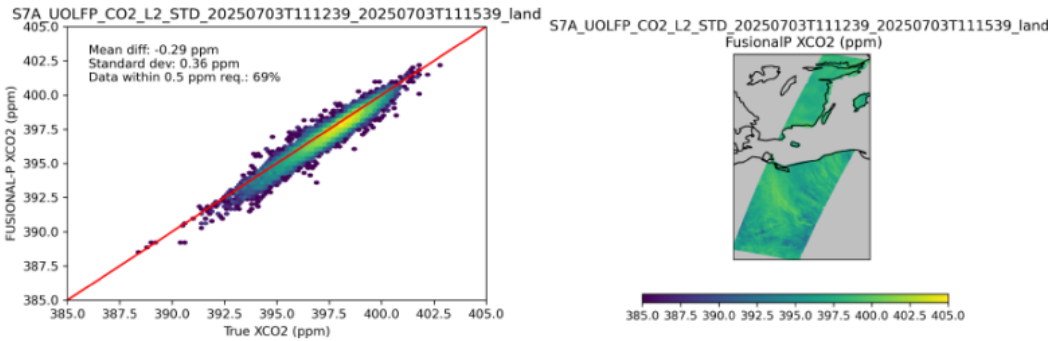
Three GHG algorithms for CO2M

FOCAL



Processing step	GHG L2 Input		
		RemoTAP	UoL-FP-FUSIONAL-P
Pre	SCENE-L2	SCENE-L2	SCENE-L2
Main	CO2I L1B+MAP-L1C	CO2I L1B+MAP-L2	CO2I L1B
Post			MAP-L1C/L2+CLIM L2

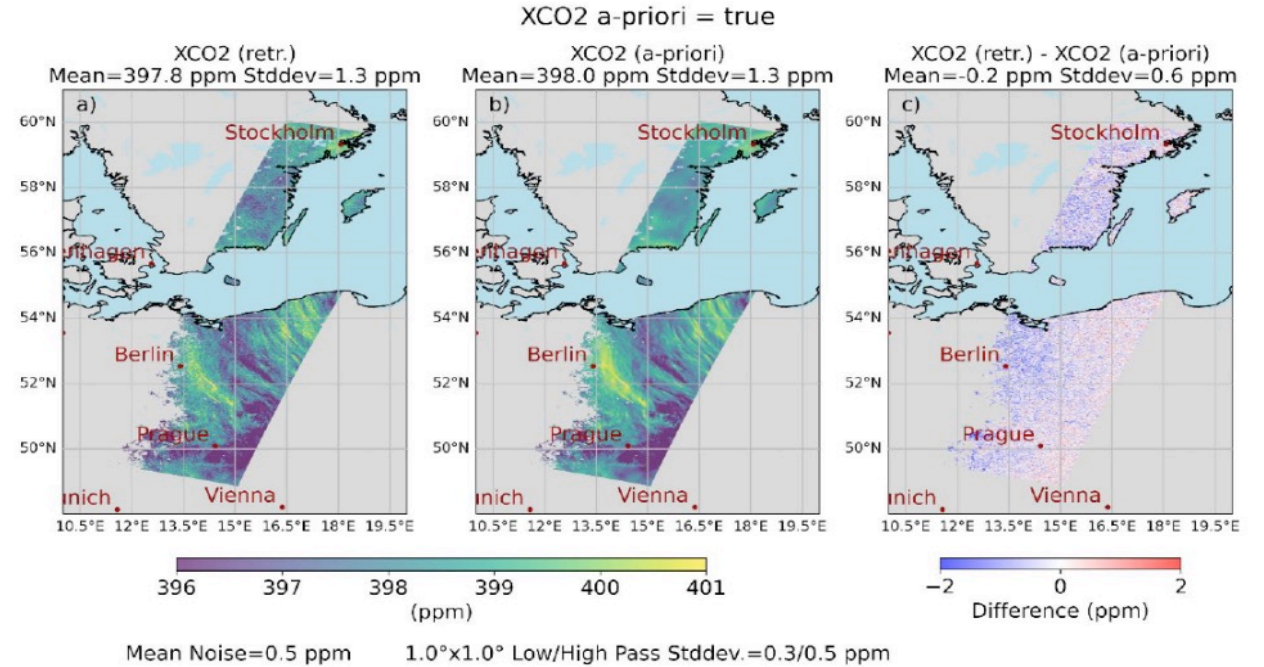
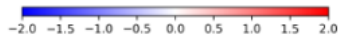
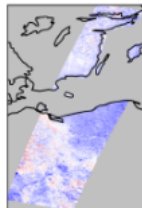
ATBDs v2L, 2024



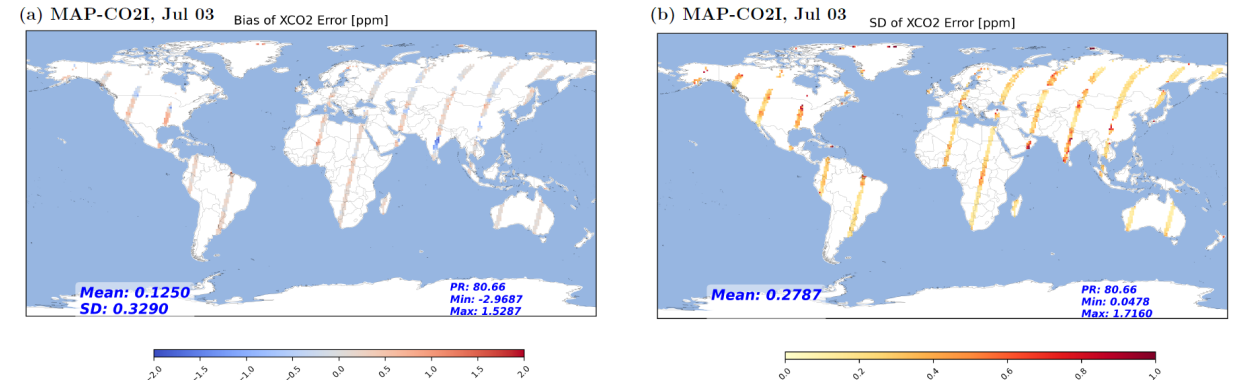
FUSIONAL-P



id 57A_UOLFP_CO2_L2_STD_20250703T111239_20250703T111539_land FUSIONAL-P - True XCO2 difference



RemoTAP SRON



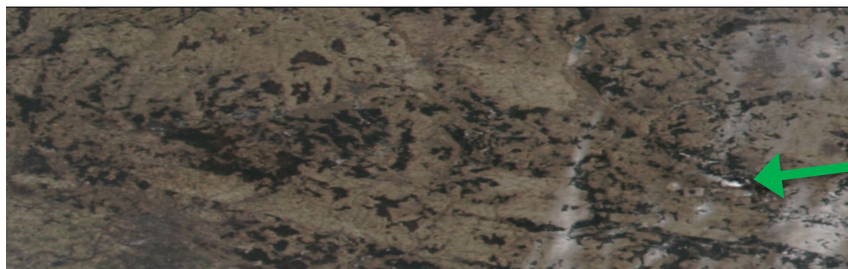


Early results from synthetic data (NO2 level-2)

NO2 algorithms or CO2M

Betchatów coal power plant

Albedo effects, ATBD 2024



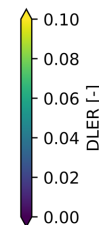
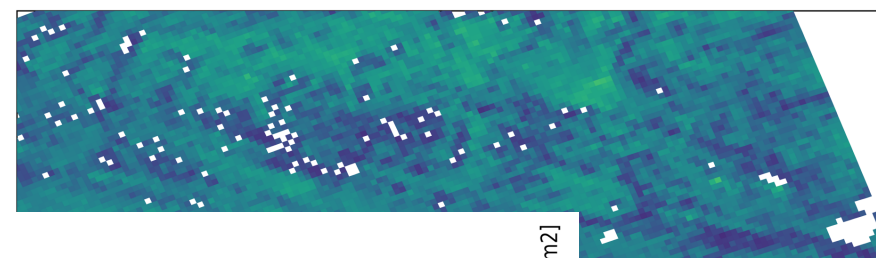
eumetsat.int

Source: Wikipedia

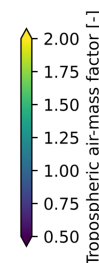
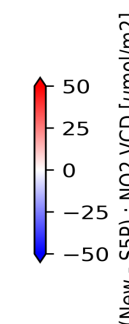
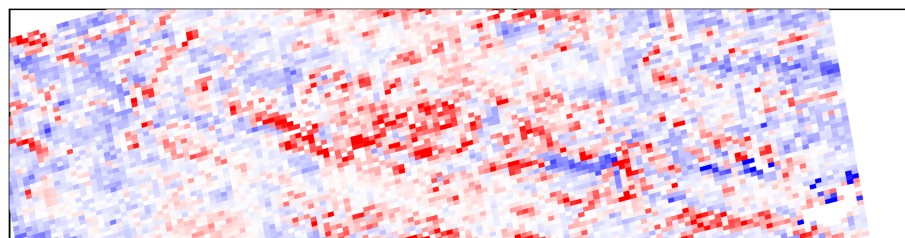
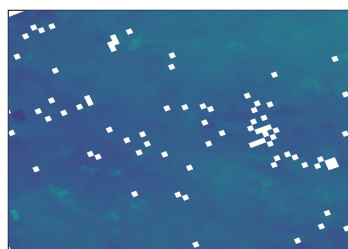
S5P algorithm

CO2M algorithm

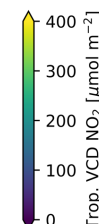
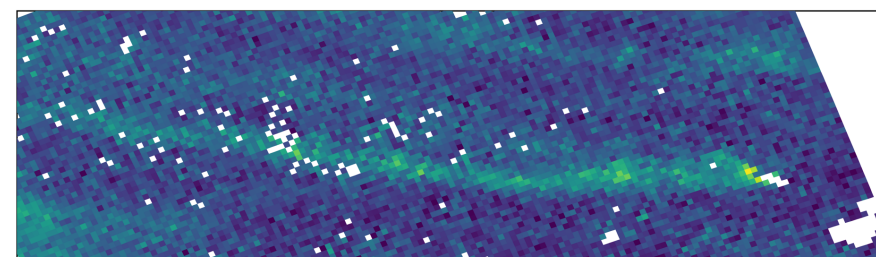
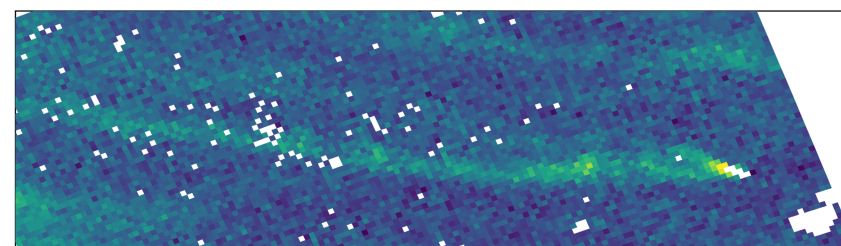
Surface reflectance (DLER)



Tropospheric air-mass factor



Tropospheric NO₂ vertical column



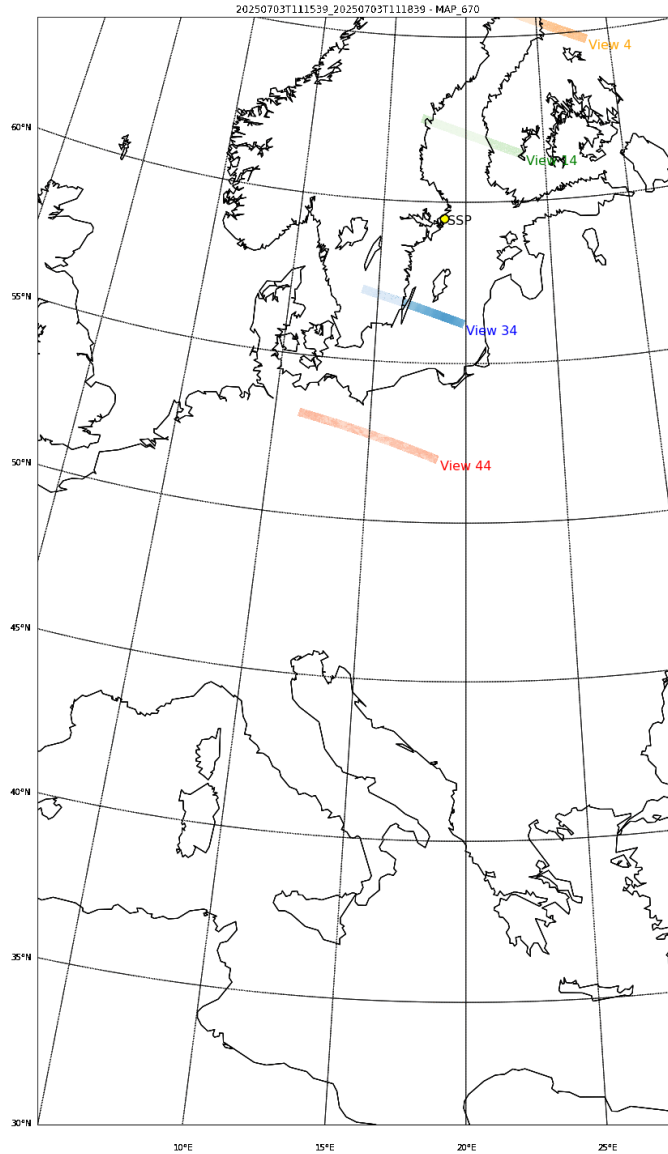


The CO2M MAP L1B product

2 granules (total 6 minutes)

Nadir pointing

4 views out of 48 are shown

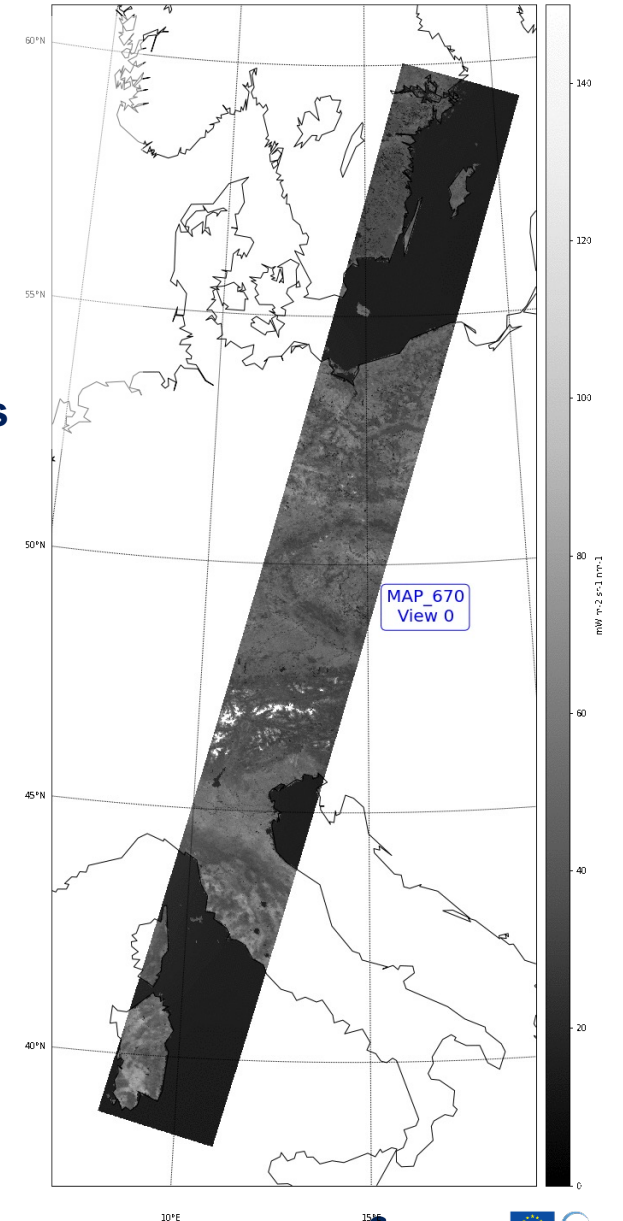


The CO2M MAP L1C

2 granules (total 6 minutes)

Nadir pointing

45 Co-registered views

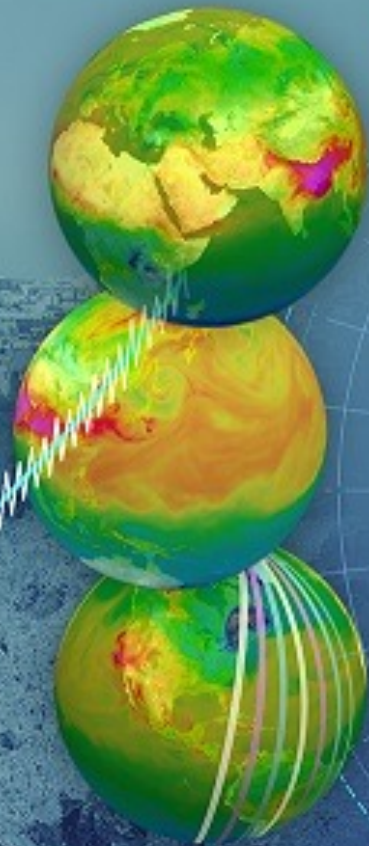
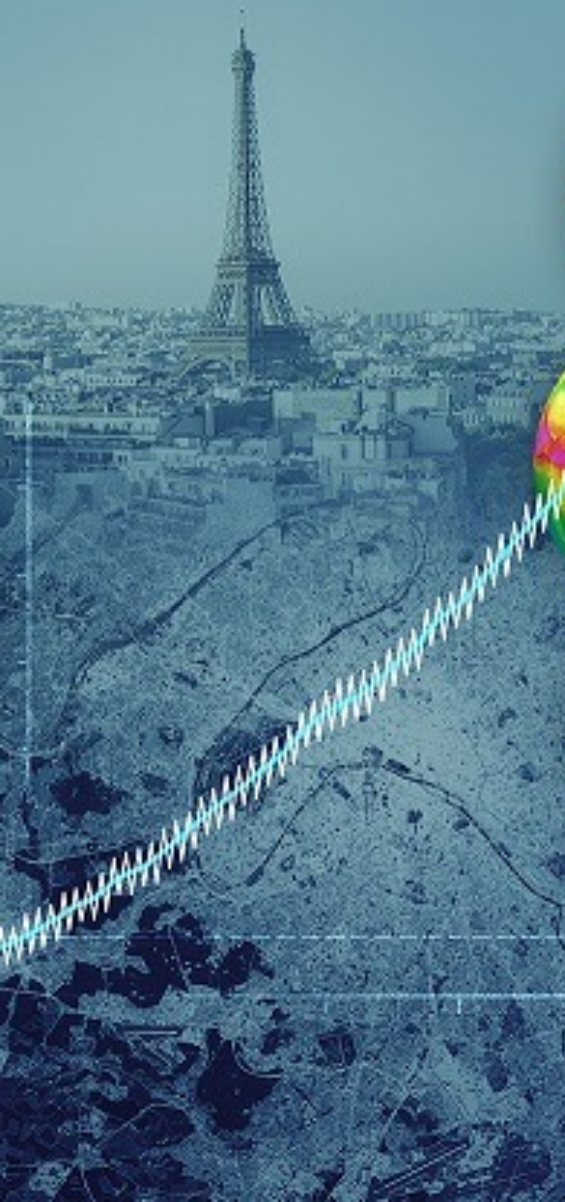




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Carbon Dioxide Monitoring

THANK YOU

