ESA Atmospheric Composition missions:
Status and plans

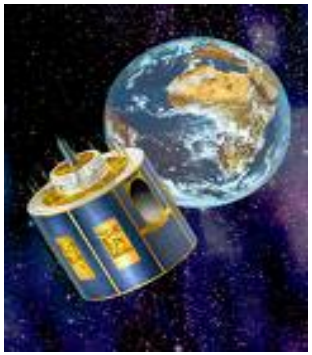
Dr S. Briggs

Europe's first mission dedicated to studying the Earth's ice was launched 8th April from Kazakhstan.

From its polar orbit, CryoSat-2 will send back data leading to new insights into how ice is responding to climate change and the role it plays in our 'Earth system'.

The CryoSat-2 satellite was launched at 15:57 CEST (13:57 UTC) on a Dnepr rocket provided by the International Space Company Kosmotras from the Baikonur Cosmodrome in Kazakhstan. The signal confirming that it had separated from the launcher came 17 minutes later from the Malindi ground station in Kenya.

Europe's expanding EO capability



Earth Explorers

Since 1978 — Meteosat → 1991 — ERS 1 → 1995 — ERS 2 → 2002 — ENVISAT

Sentinels / GMES

Geo-stationary meteorology missions

Oceans
Cryosphere
Land Surface
Climatology

+ Global Ozone
+ Land Surface

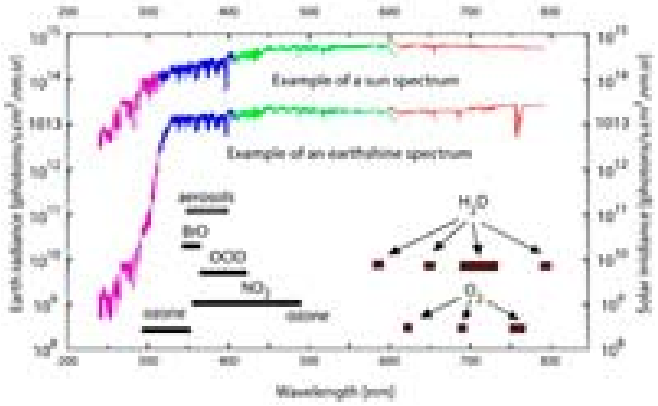
+ Ocean Colour
+ Atmospheric Constituents

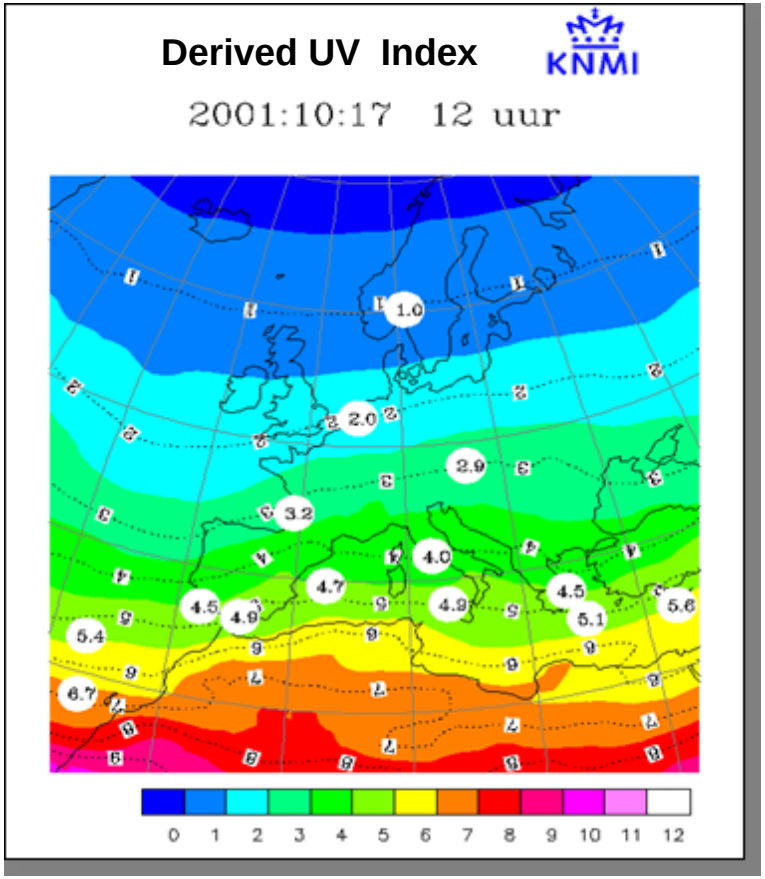
ERS-2

- Launched in 1995, ERS-2 embarked the GOME instrument, dedicated mainly to the retrieval of Ozone. ERS-2 is still in orbit, providing some coverage of data.

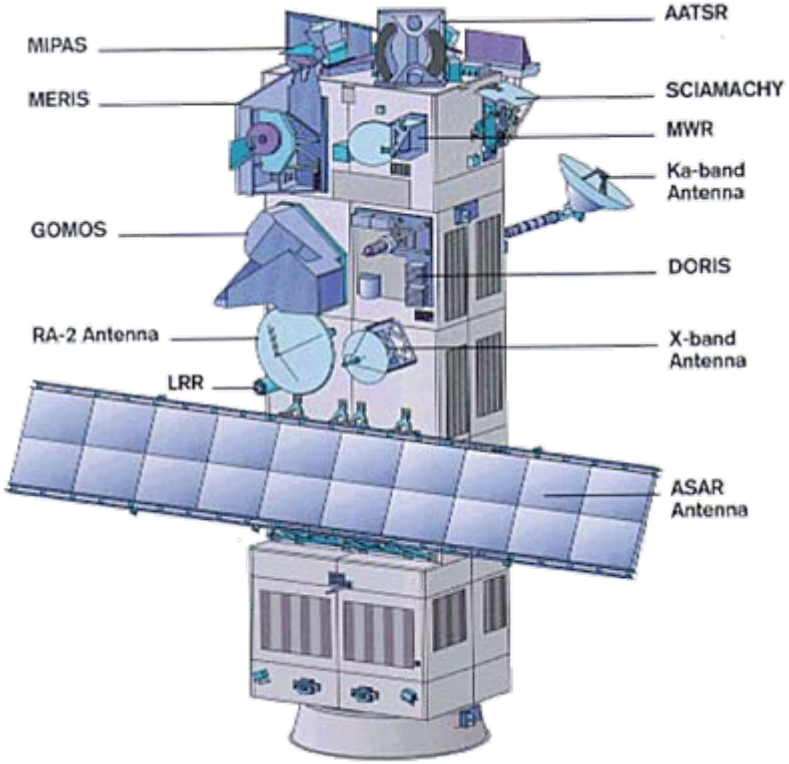
- An improved GOME-2 was embarked in the series of MetOp satellites. MetOp A was launched by EUMETSAT in 2006, providing continuity to these data.

GOME/GOME-2, is a spectrometer covering the UV and VIS 250-790 nm band in 4 channels. It is able to detect O3, NO2, BrO, SO2, clouds and aerosols.





Envisat was launched by ESA (European Space Agency) 1st March 2002 from Kourou (French Guiana). It is the most ambitious environmental satellite ever launched. Still working and operations assured for the next 3 years.



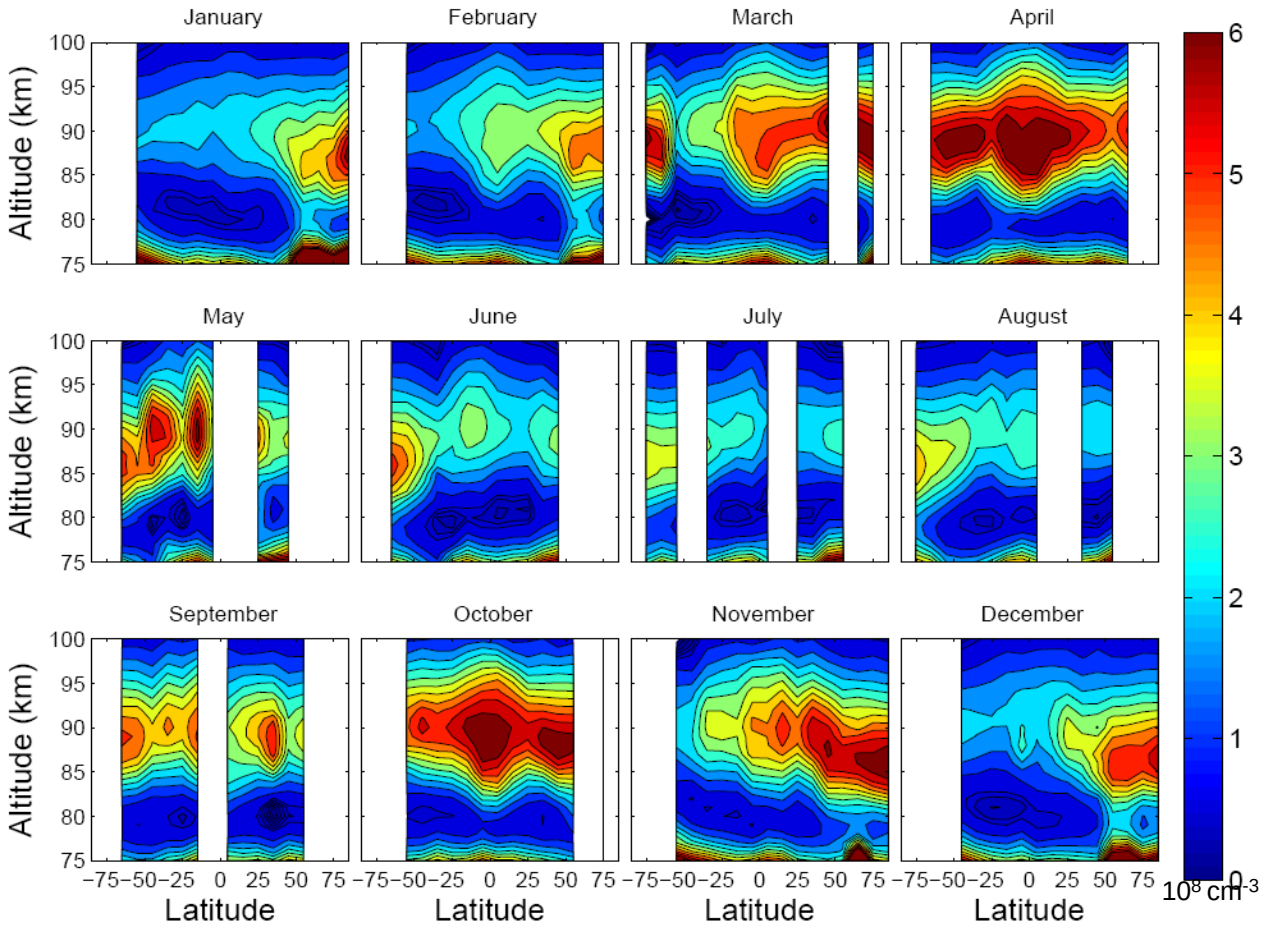
GOMOS, SCHIAMACHY,MIPAS

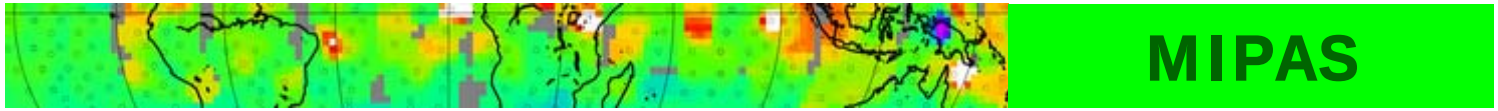
- GOMOS (Global Ozone Measurements by Stars Occultation) measures atmospheric constituents by spectral analysis of the spectral bands between 250 nm to 675 nm, 756 nm to 773 nm, and 926 nm to 952 nm. Additionally, two photometers operate in two spectral channels; between 470 nm to 520 nm and 650 nm to 700 nm, respectively.

- MIPAS: The Michelson Interferometer for Passive Atmospheric Sounding is a Fourier transform spectrometer for the measurement of high-resolution gaseous emission spectra at the Earth's limb. It operates in the near to mid infrared where many of the atmospheric trace-gases playing a major role in atmospheric chemistry have important emission features.

- SCIAMACHY is an imaging spectrometer whose primary mission objective is to perform global measurements of trace gases in the troposphere and in the stratosphere.

Night-time Ozone in the Mesosphere/Lower Thermosphere for 2003





Gas species

Altitude

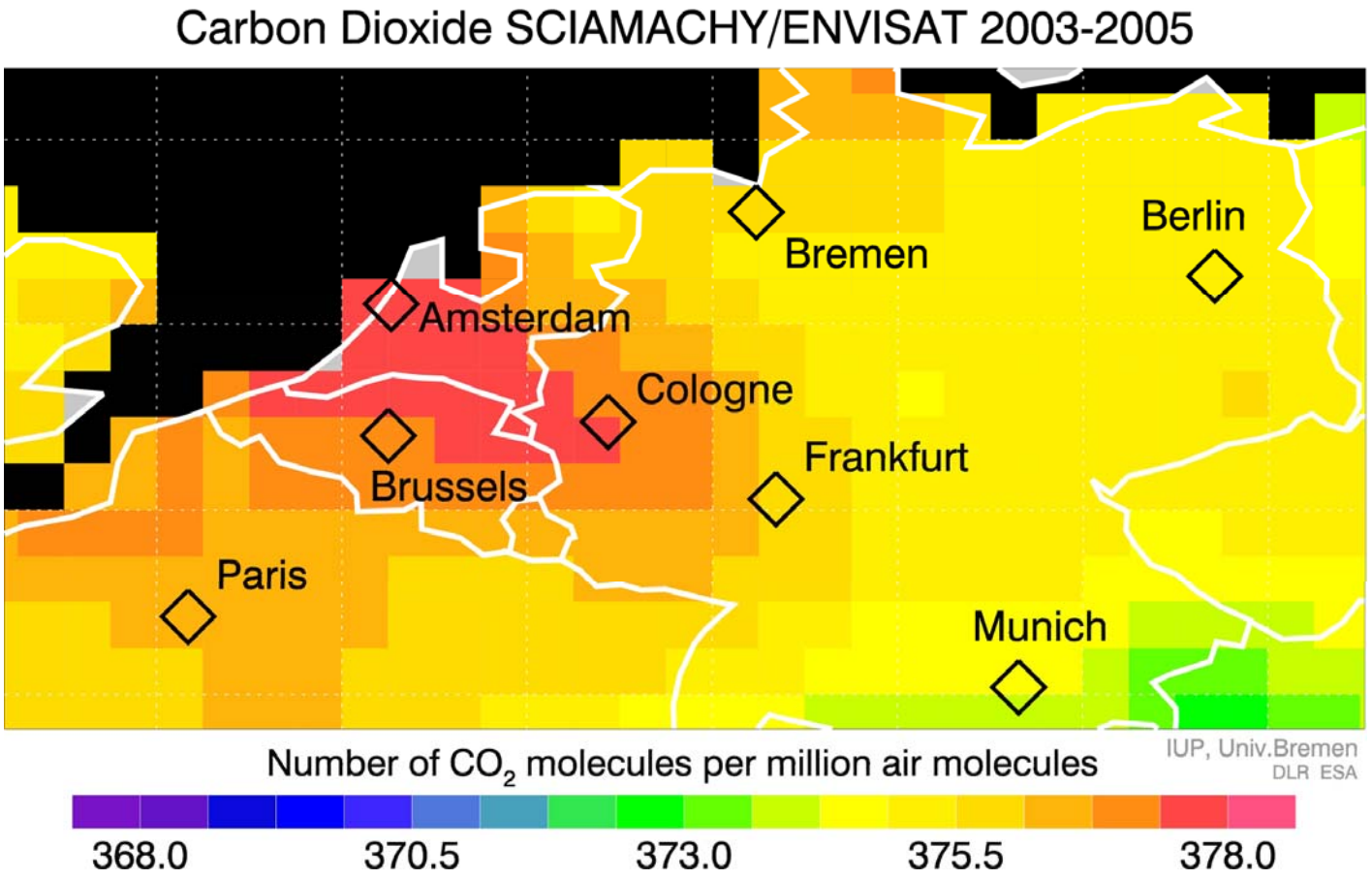
km T H2O O3 HNO3 CH4 N2O NO2night NO2day

42
39
36
33
30
27
24
21
18
15
12

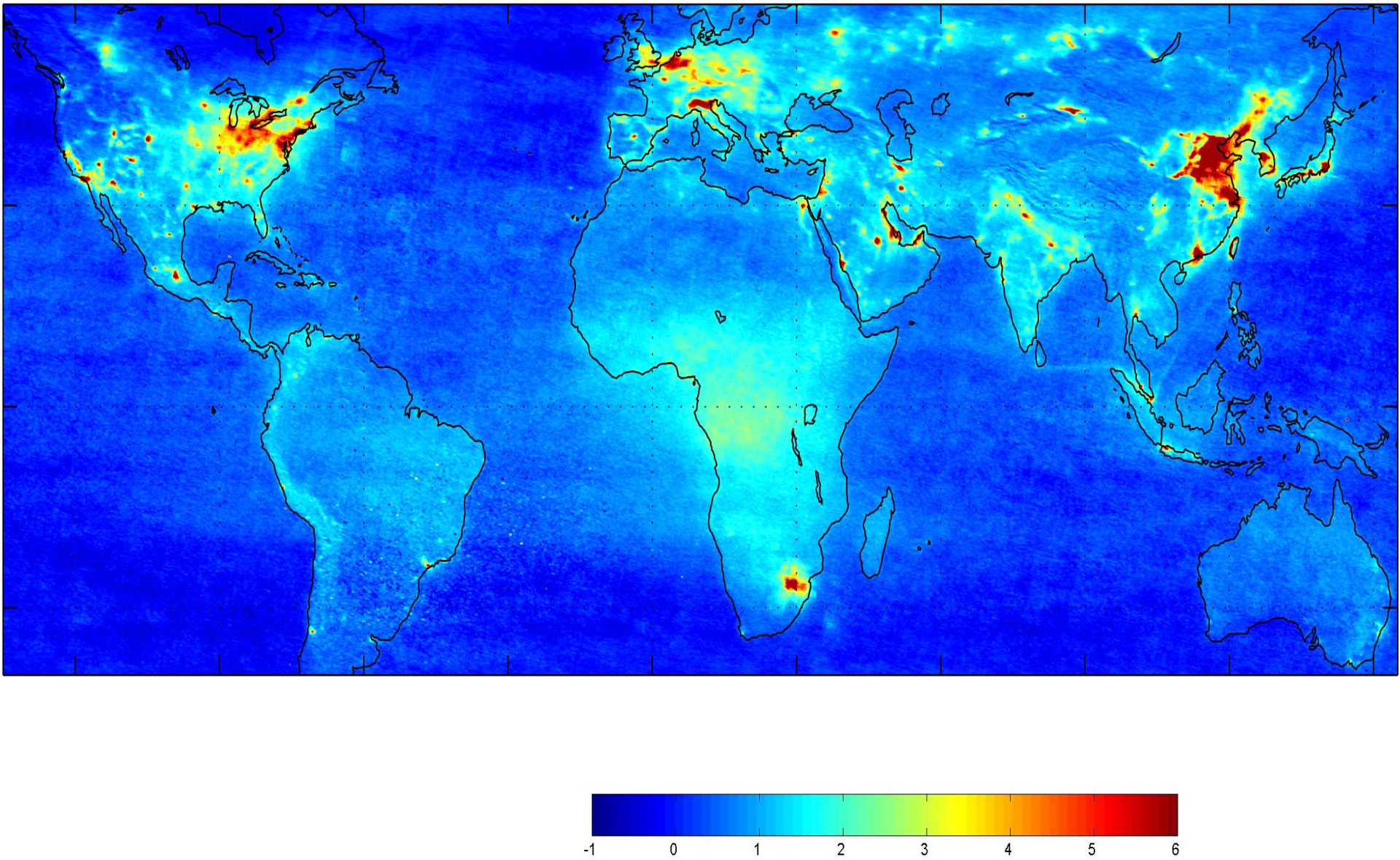
01 Oct 2003

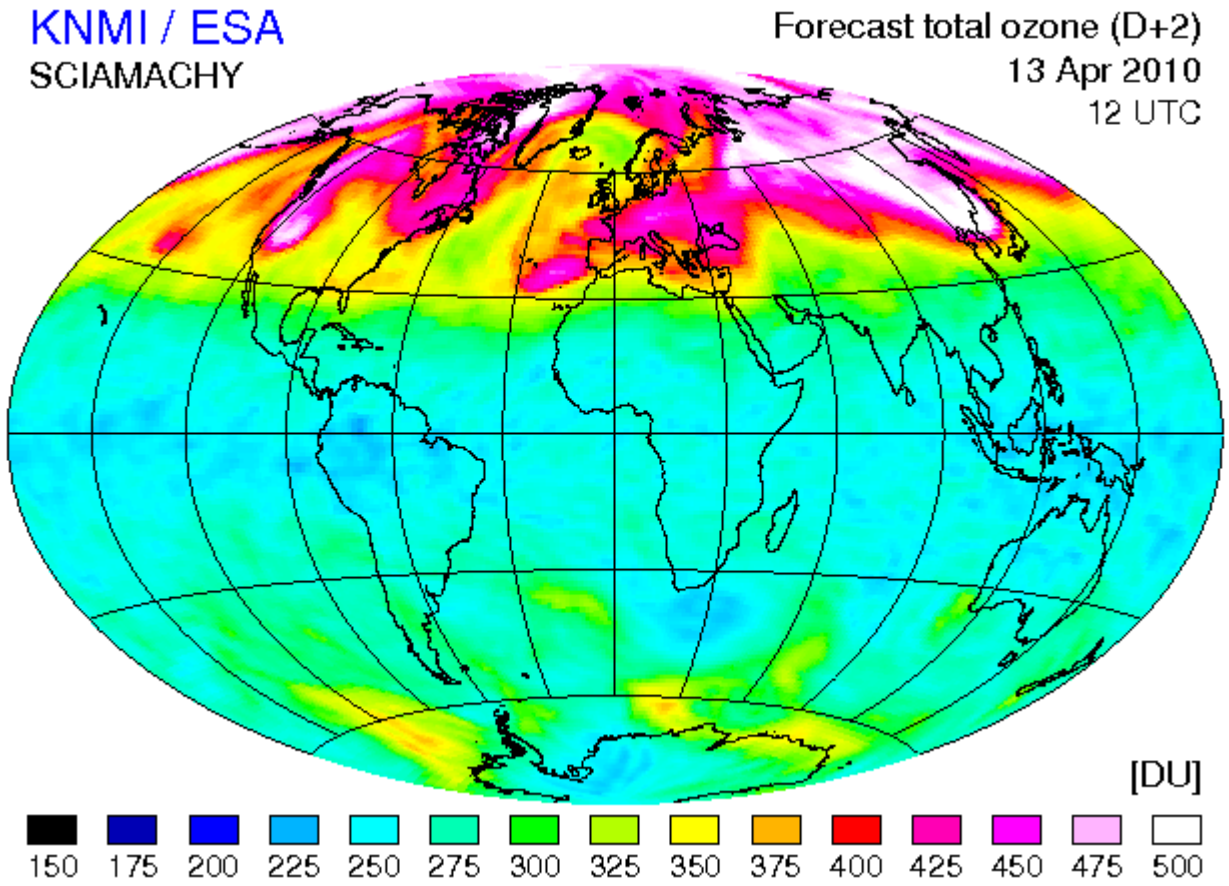
Courtesy of IFAC, CNR, Italy

Envisat makes first ever observation of regionally elevated CO2 from manmade emissions

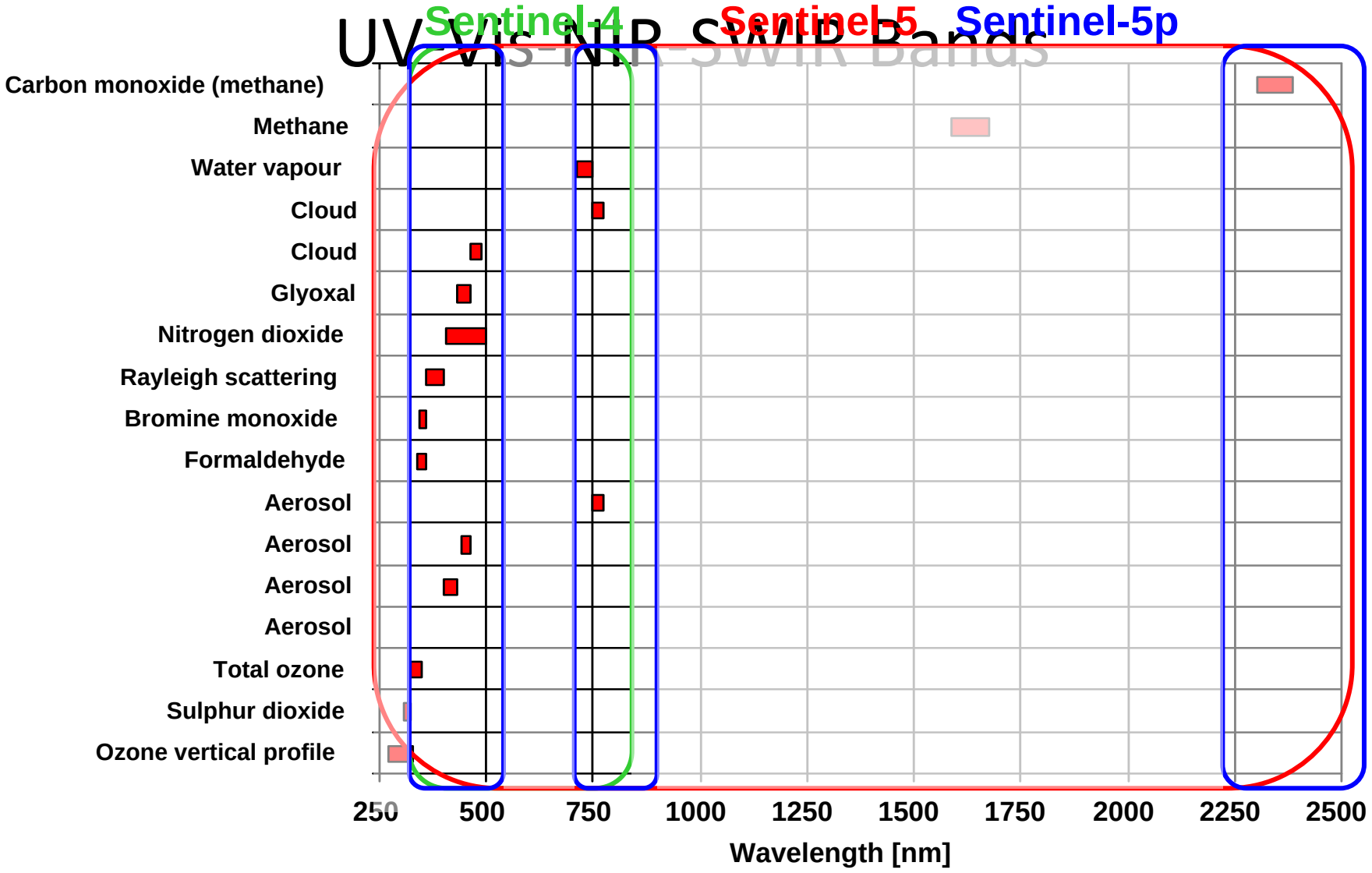


NO2 CONCENTRATION



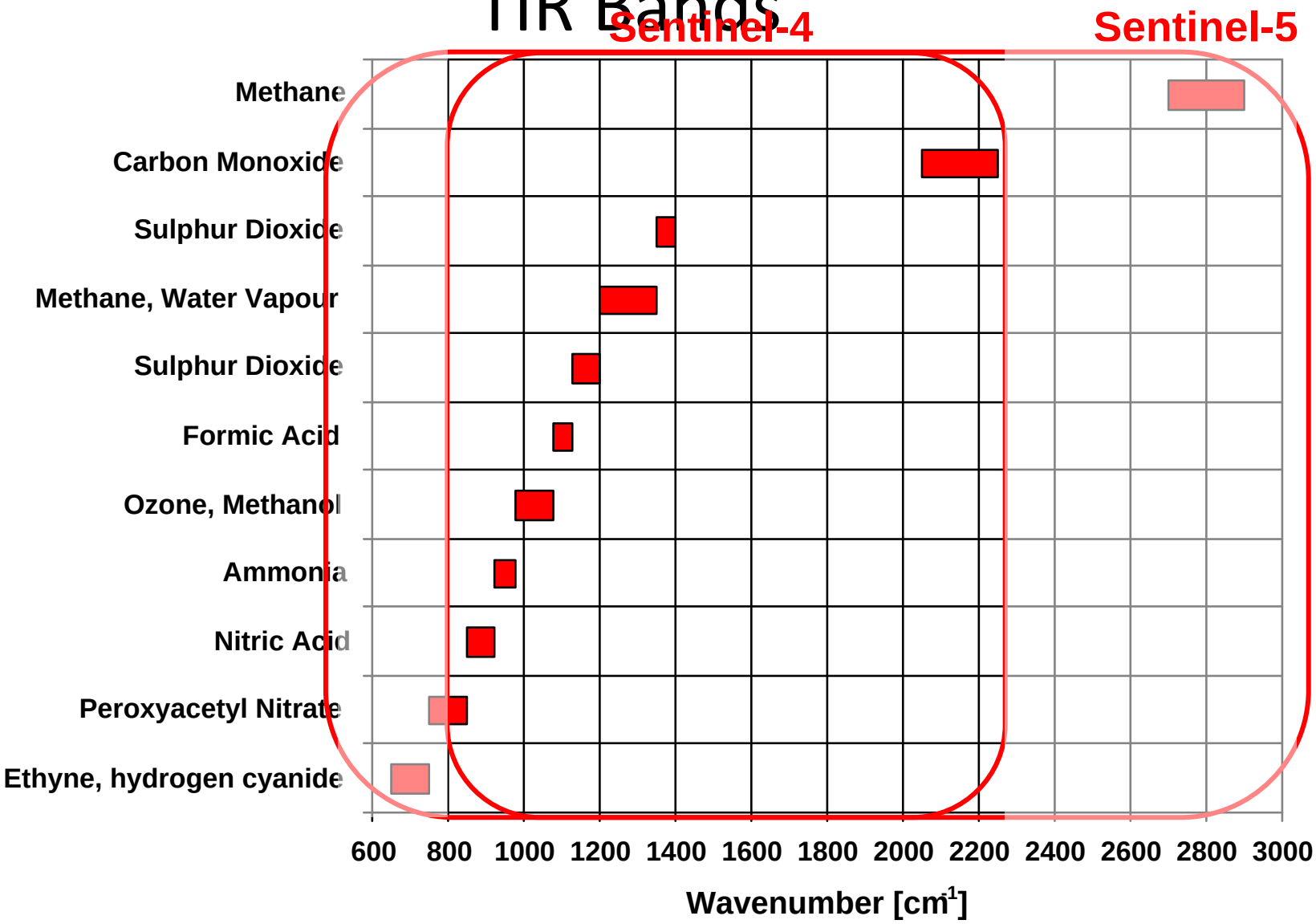

KNMI / ESA
SCIAMACHY
Forecast total ozone (D+2)
13 Apr 2010
12 UTC
[DU]
150 175 200 225 250 275 300 325 350 375 400 425 450 475 500

Summary of Observation Requirements



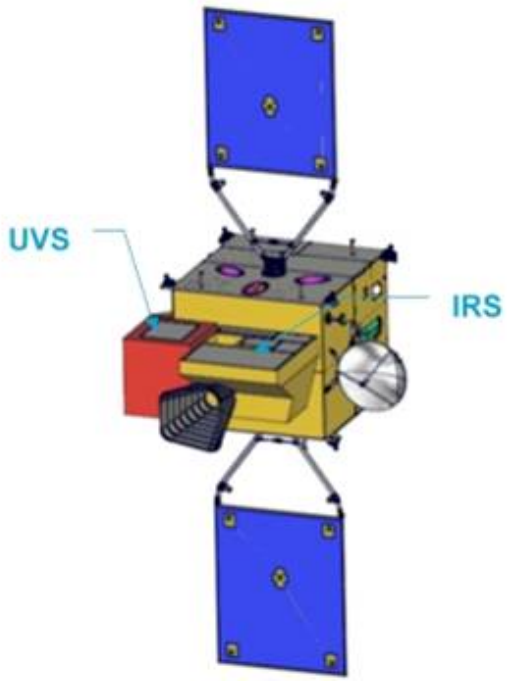
Summary of Observation Requirements TIR Bands

Using IRS



Sentinel-4

GEO atmospheric composition mission



Applications:

- monitoring changes in the atmospheric composition (e.g. ozone, NO_2, SO_2, BrO, formaldehyde and aerosol) at high temporal resolution (1 hour)
- troposphere variability

Narrow field spectrometer covering UV (305-400 nm), visible (400-500 nm) and near-IR (750-775 nm) bands

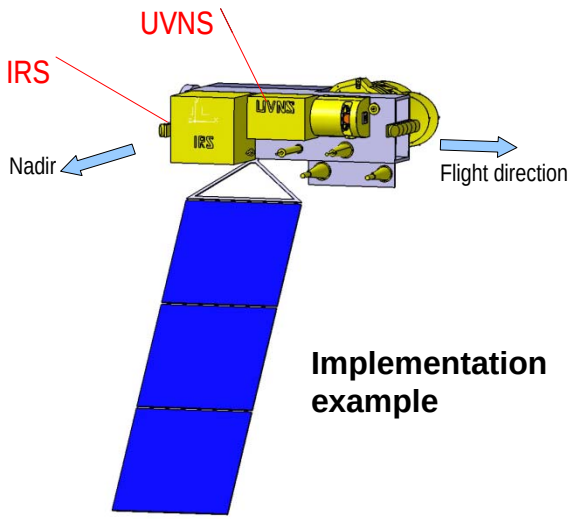
Spatial sampling 8 km (over Europe) and spectral resolution between 0.12 nm and 0.5 nm (depending on band)

Geostationary orbit, at 0^o longitude

Embarked on MTG-S and operated by EUMETSAT

Sentinel-5

LEO atmospheric composition mission



Implementation example

Applications:

- monitoring changes in the atmospheric composition (e.g. ozone, NO_2, SO_2, BrO, CO, CH_4 formaldehyde and aerosol) at high temporal (daily) resolution
- troposphere variability

LEO UVNS instrument with bands: UV1, UV2, VIS123 and SWIR-1 and SWIR-3. Option also to include SWIR 2 channel.

Spatial resolution

15 x 15 km^2 (UV1)

5 x 5 km^2 (UV2/VIS/NIR/SWIR)

Low Earth orbit (reference altitude of about 817 km)

Sentinel-5 embarked on post-EPS and operated by EUMETSAT

Sentinel 5 precursor

1. Continuity of data 2014 – 2020 (Envisat/Aura – Sentinel 5)

- spatial resolution
- CO and CH_4 with PBL sensitivity

2. Transition to operational scheme

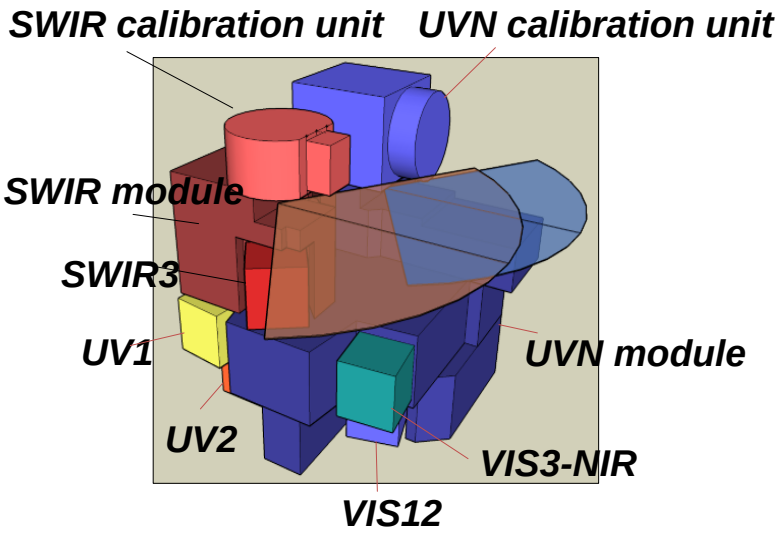
- Afternoon orbit required for AQ forecast (Metop: 9:30h).
- Use synergy S5 precursor – Metop to start into observation of diurnal variation, as needed for AQ monitoring. (*Will be picked up by S4 later*).
- improved radiometric sensitivity

3. Implementation

- UV-VIS-NIR-SWIR spectrometer on dedicated platform, flying in loose formation with NPP (13:30h)

Sentinel-5 Precursor

LEO atmospheric composition mission



Applications:

- monitoring changes in the atmospheric composition (e.g. ozone, NO_2, SO_2, BrO, CO, CH_4 formaldehyde and aerosol) at high temporal (daily) resolution
- tropospheric variability

LEO UVNS instrument with priority bands in the UV12, VIS123, NIR and SWIR.

Spatial resolution

21 x 28 km^2 (UV1)

7 x 7 km^2 (UV2/VIS/NIR/SWIR)

Low Earth orbit (reference altitude 828 km)

Sentinel-5 precursor shall fill data gap (2013-2019) in critical data streams between Envisat/Sciamachy, Aura/OMI and Sentinel-5 embarked on post-EPS

Implementation of S4&5 on Eumetsat platforms

- **Sentinel 4 will be a realised as**
  - addition of a UVN spectrometer on the MTG-S platforms;
  - utilisation of TIR data from the IR sounder onboard the same platforms; and
  - utilisation of imager data from the MTG-I platforms.
- **Sentinel 5 will consist of**
  - a UVNS spectrometer embarked on the post-EPS platforms;
  - utilisation of the EUMETSAT post-EPS IR sounder which addresses requirements for both meteorology and atmospheric chemistry (the latter consistent with the Sentinel 5 IR sounding requirements);
  - utilisation of post-EPS imager data;
  - utilisation of multi-directional polarisation imager if implemented.

ESA CCI Programme: Satellite-based ECVs

Atmosphere	**Surface** (0, 0, 6)	*Air Temperature; Precipitation ; Air pressure; Water vapour; Surface radiation budget; Wind Speed & direction;*
	Upper air (1, 1, 3)	***Cloud properties,*** ***Wind speed & direction*** *Earth radiation budget; Upper-air temperature; Water vapour;*
	Composition (3, 0, 0)	***Carbon dioxide Methane & other GHGs; Ozone; Aerosol properties***
Ocean	**Surface** (4, 2, 1)	***Sea-surface Temp; Sea-level; Sea-ice; Ocean colour;*** ***Sea state; Sea-surface salinity*** *Carbon dioxide partial pressure*
	Sub-surface (0, 0 , 7)	*Temperature; Salinity; Current; Nutrients; Carbon; Ocean tracers; Phytoplankton*
Terrestrial (3, 7, 4)	***Glaciers & ice caps; Land Cover; Fire disturbance*** ***Fraction of absorbed photo-synthetically active radiation; LAI , Albedo*** ***Biomass, Lake levels, Snow cover, Soil moisture*** *Water use, Ground water, River discharge Permafrost and seasonally-frozen ground*	

CCI First Steps (11 ECVs) : Later in CCI (10 ECVs) : Not in CCI (24 ECVs)