

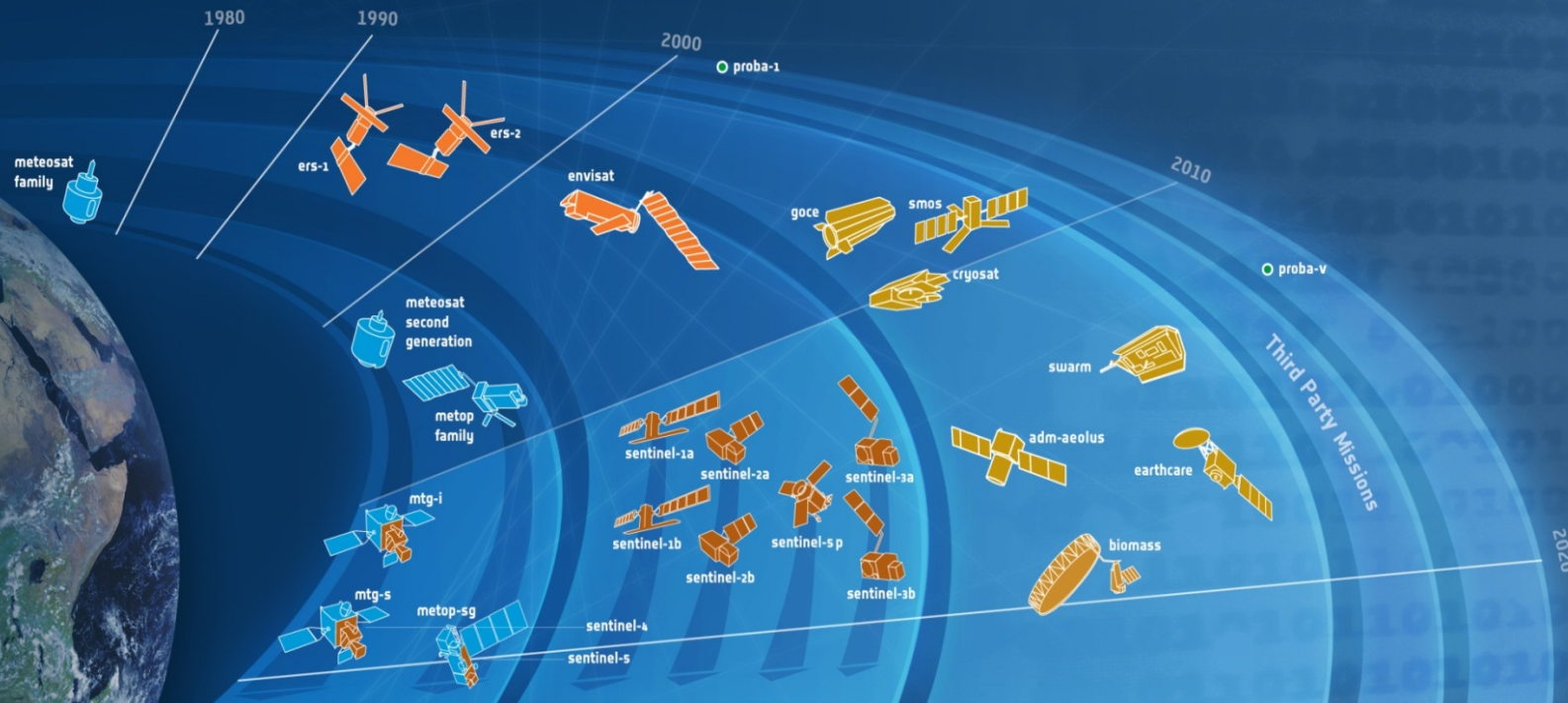
→ **ADVANCED ATMOSPHERIC TRAINING COURSE 2014**

ESA Atmospheric Missions/Data Access

Claus ZEHNER

27–31 October 2014 | Forschungszentrum Jülich | Germany

→ THE ESA EARTH OBSERVATION PROGRAMME



Meteorological Missions

driven mainly by Weather forecasting and Climate monitoring needs. These missions developed in partnership with EUMETSAT include the Meteorological Operational satellite programme (MetOp), forming the space segment of EUMETSAT's Polar System (EPS), and the new generation of Geostationary Meteorological satellites (MSG & MTG satellites).

Copernicus Sentinel Missions

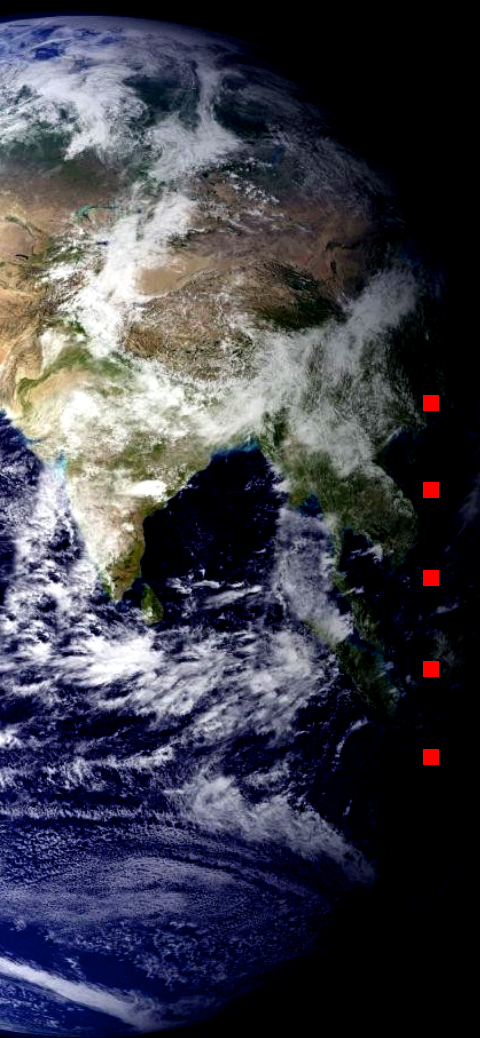
driven by Users needs to contribute to the European **Global Monitoring of Environment & Security (GMES)** initiative. These satellite missions developed in partnership with the EU include C-band imaging radar (Sentinel-1), high-resolution optical (Sentinel-2), optical and infrared radiometer (Sentinel-3) and atmospheric composition monitoring capability (Sentinel-4 & Sentinel-5 on board Met missions MTG and EPS-SG respectively).

Earth Explorer Missions

driven by Scientific needs to advance our understanding of how the ocean, atmosphere, hydrosphere, cryosphere and Earth's interior operate and interact as part of an interconnected system. These **Research** missions, exploiting Europe's excellence in technological innovation, pave the way towards new development of future EO applications.

Missions
With
Partners

ESA
Operated
Missions

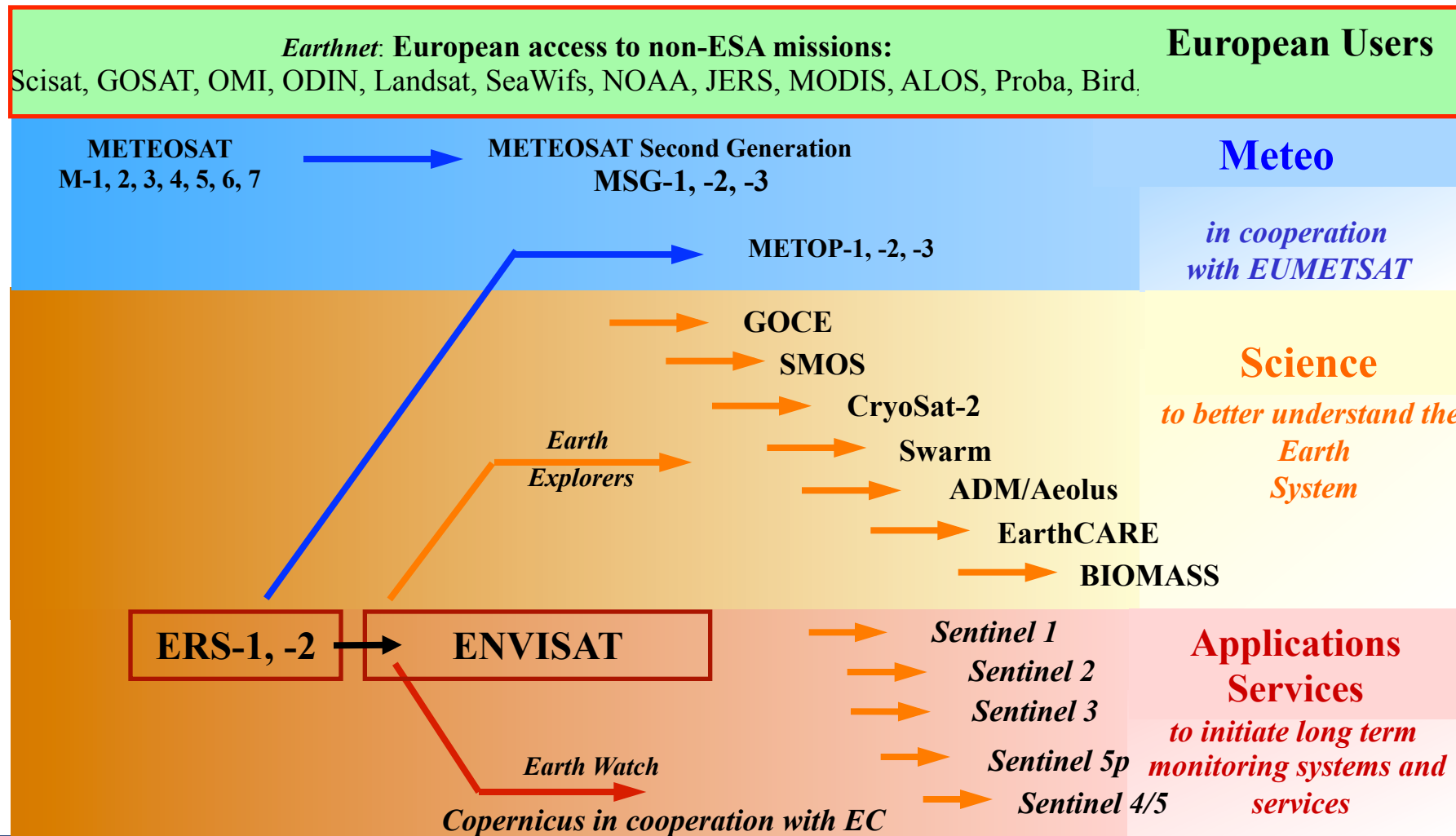
- 
- Four working satellites in orbit
 - Four types of missions
 - ~20 satellite missions planned in the next 10 years
 - ~21 years of data from ERS and ENVISAT Missions
 - ~30 Third Party Missions available to scientists

Since
1977

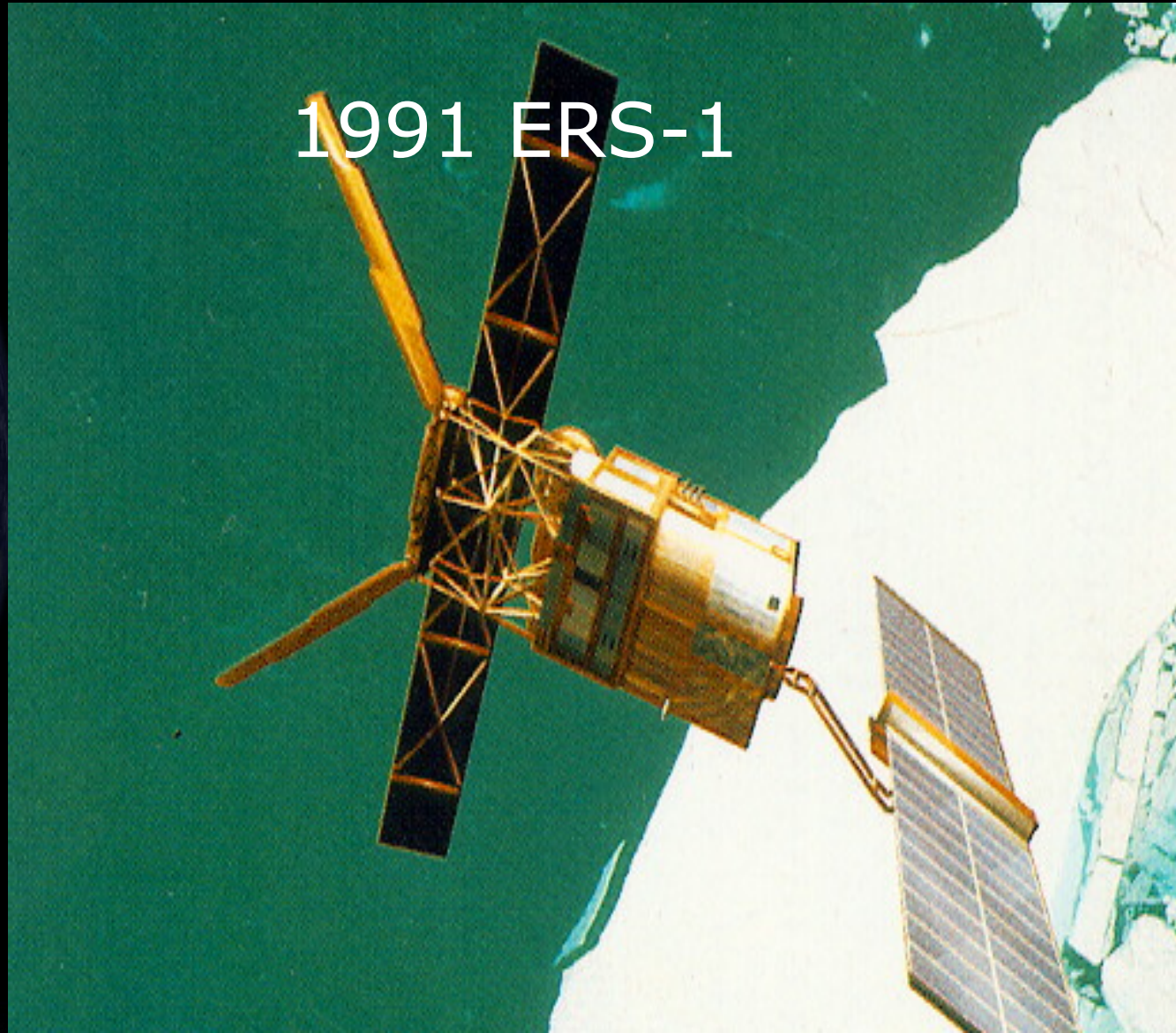
2000

2010

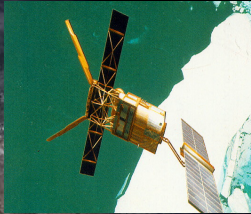
2030



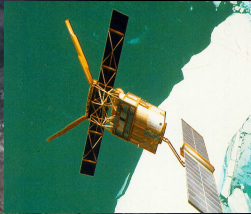




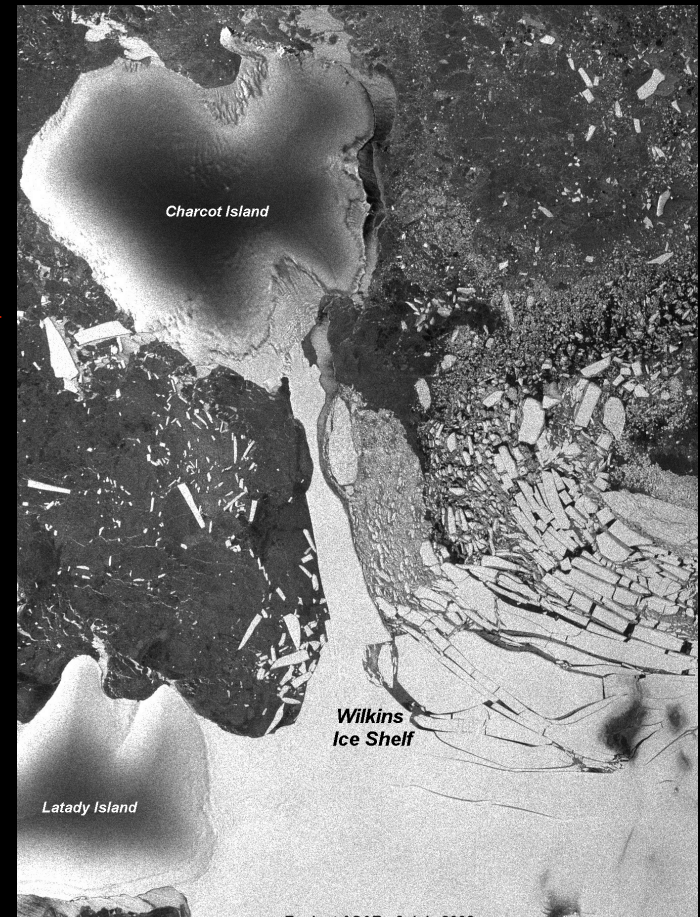
1991 ERS-1



1991



1991

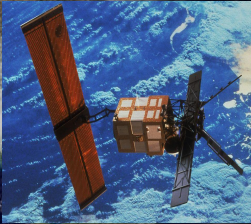


- Break-up event between 30/5 and 9/7 2008: ca. 1350 km² loss
- Occurrence during Southern hemispheric winter!

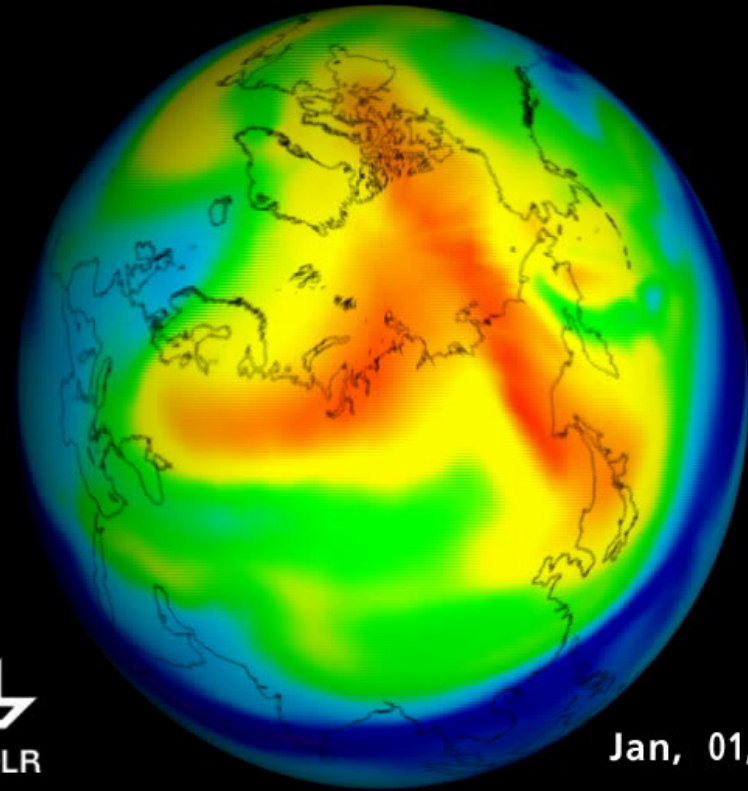
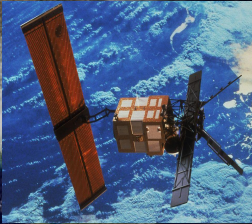
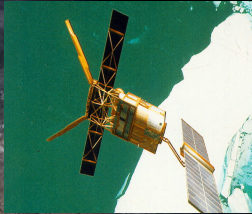




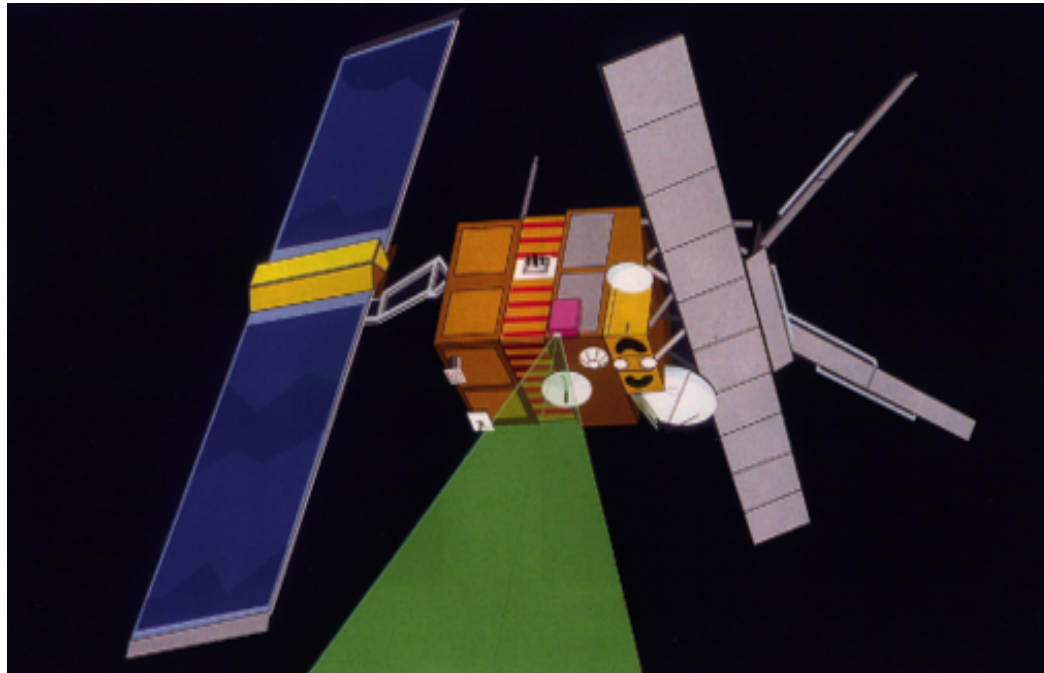
1991



1995



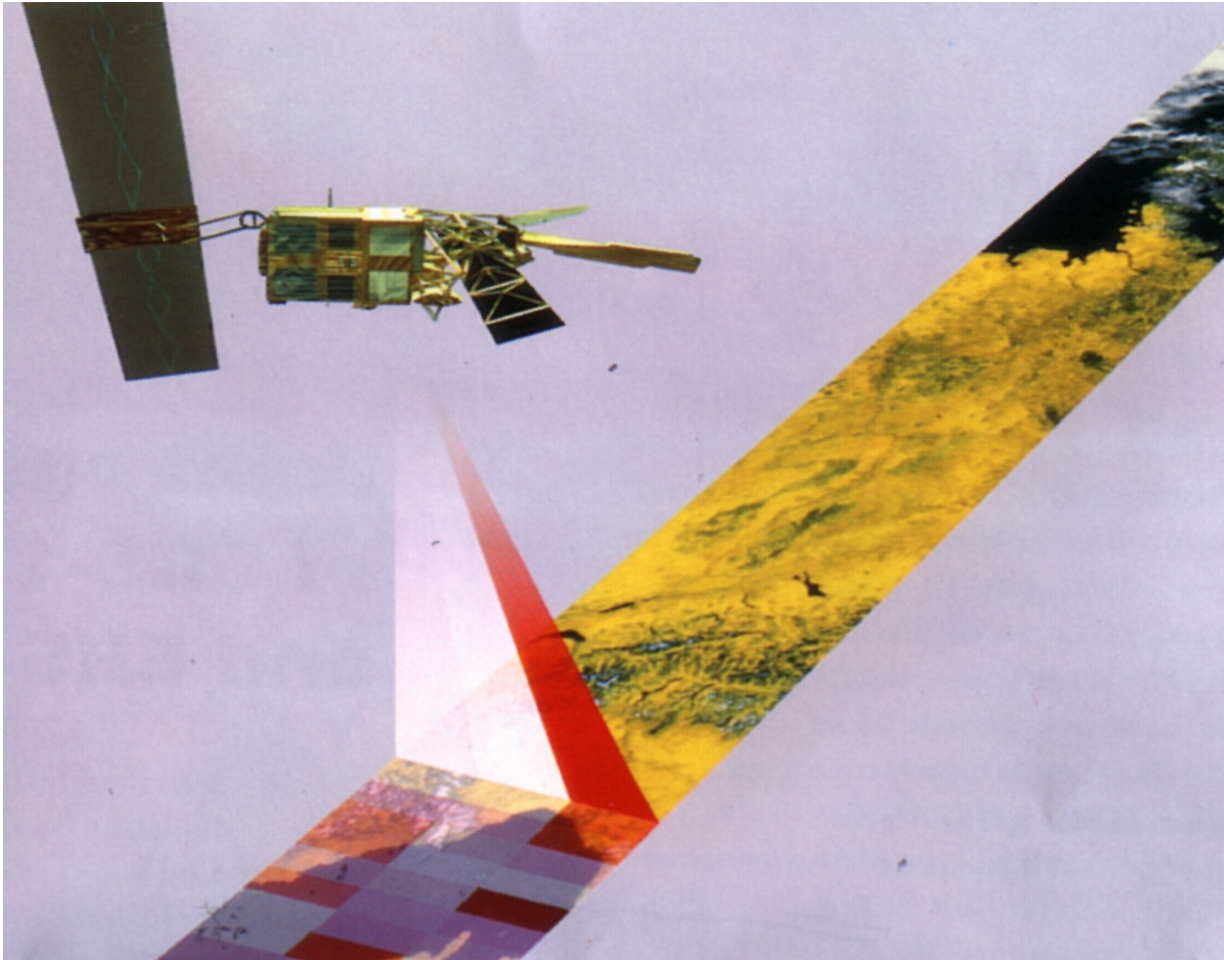
Global Ozone Monitoring Experiment (GOME)



Operational on ERS-2 since April 95 (predecessor of **GOME** follow on Instruments on the operational **METOP** Series, GOME is a small version of **SCIAMACHY** on **ENVISAT**)
GOME is a spectrometer which collects light arriving from the sun illuminated Earth's atmosphere/surface in nadir view.

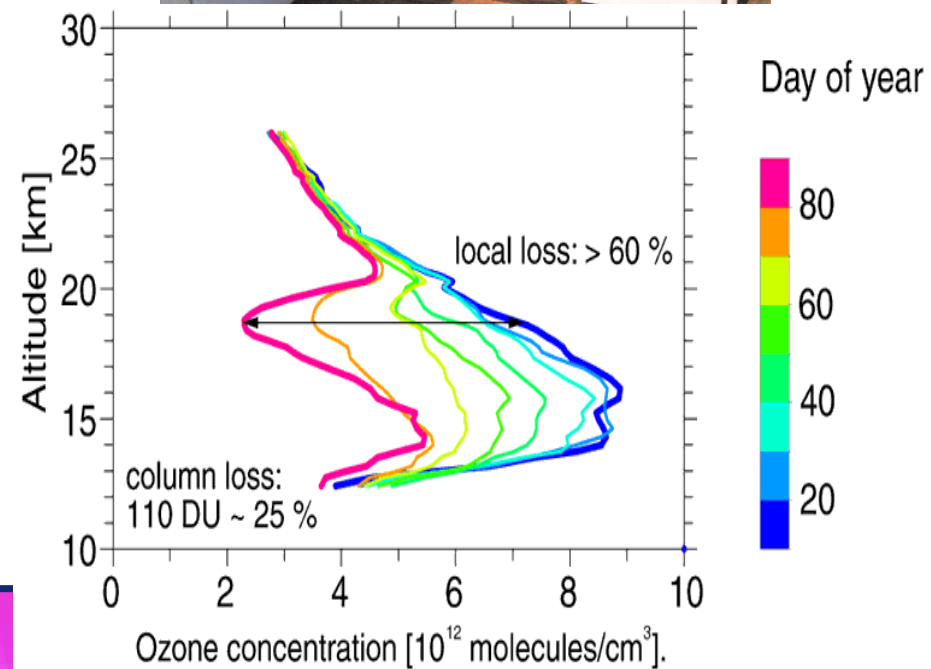
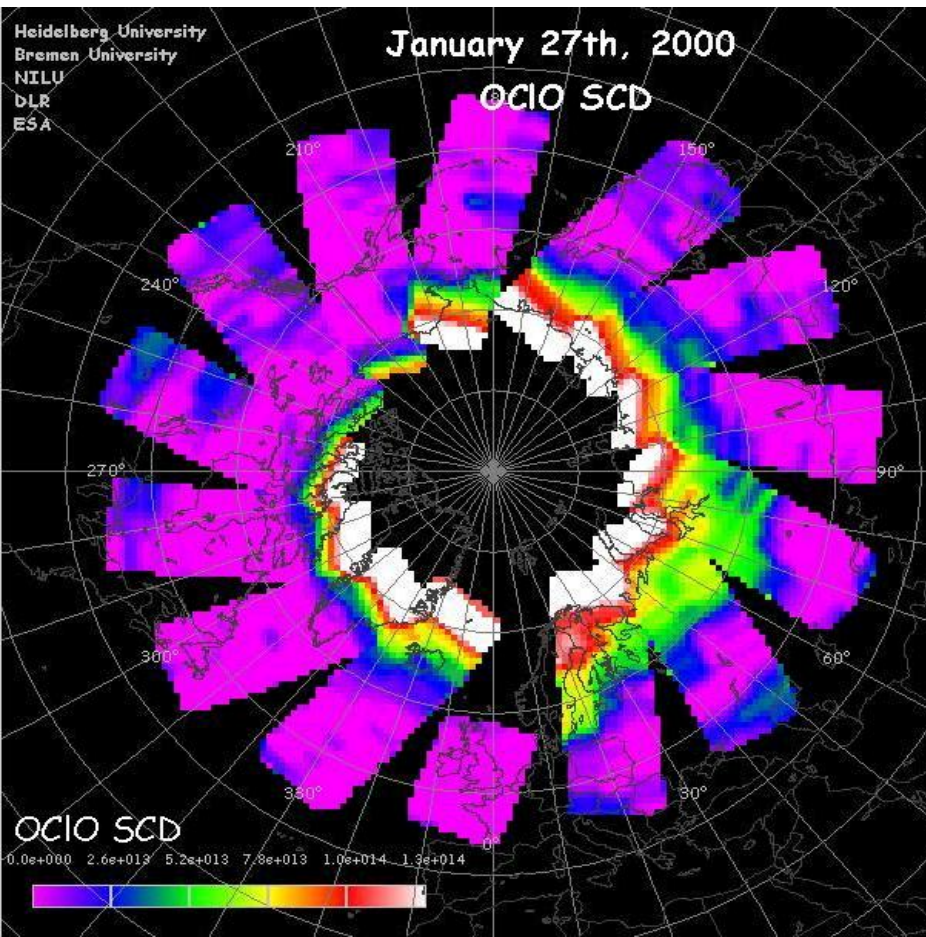
Spectral coverage: 240 - 790 nm with Spectral resolution: 0.2 - 0.4 nm

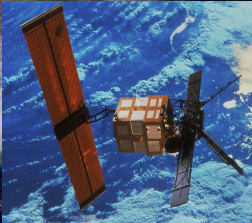
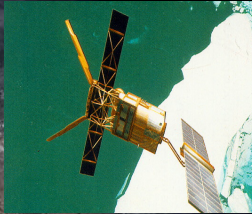
GOME Scan Pattern from ERS-2



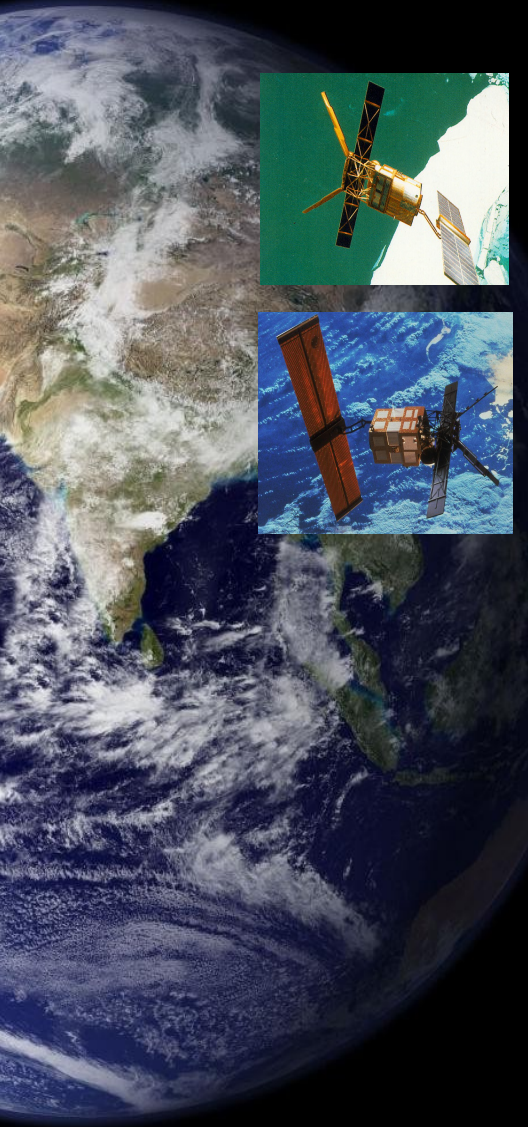
Instrument Stability/Sensitivity to measure minor
Trace Gases responsible for Ozone Depletion

Chlorine Dioxide





2002 ENVISAT



Michelson Interferometric Passive
Atmospheric Sounder
MIPAS

MERIS
Medium Resolution
Imaging Spectrometer

GOMOS
Global Ozone Monitoring
by Occultation of Stars

RA-2 Antenna
Radar Altimeter 2

LRR

AATSR Advanced Along Track Scanning Radiometer

SCIAMACHY Scanning Imaging Absorption Spectrometer
for Atmospheric Cartography

MWR Microwave Radiometer

Ka-band Antenna → to Data Relay Satellite Artemis

DORIS Doppler Orbitography and Radio-positioning
Integrated by Satellite

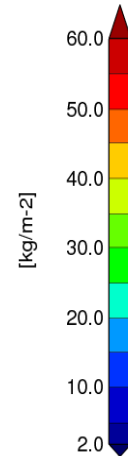
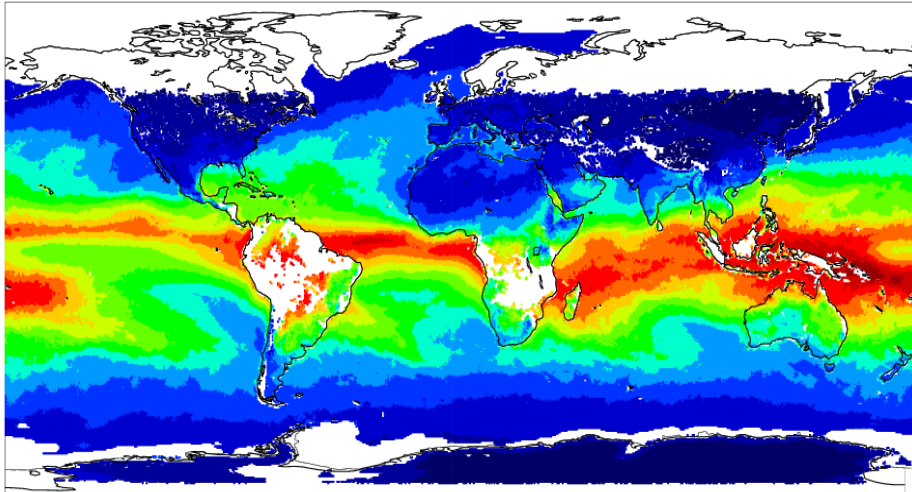
X-band Antenna → to Ground Stations

ASAR Advanced Synthetic Aperture Radar

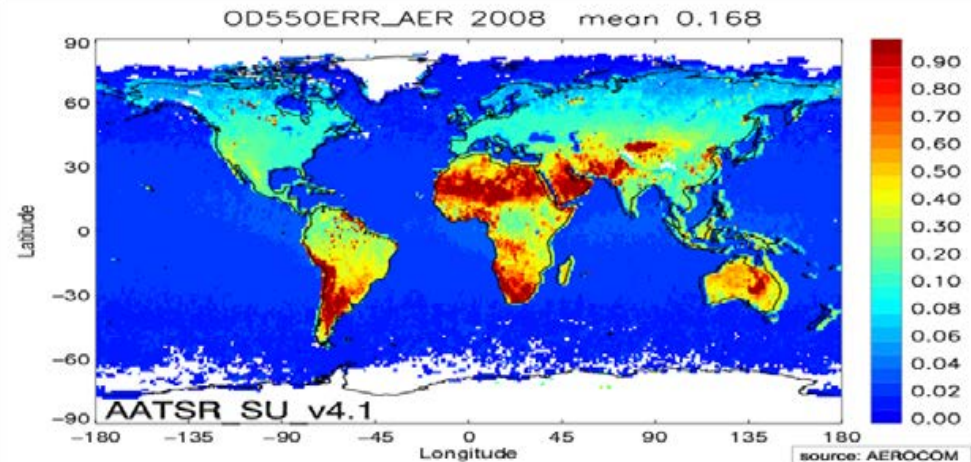
- **Launch**
1st March 2002
- **Orbit**
800 km, sun synchronous
10:00 am, i.e. 30 minutes before ERS-2

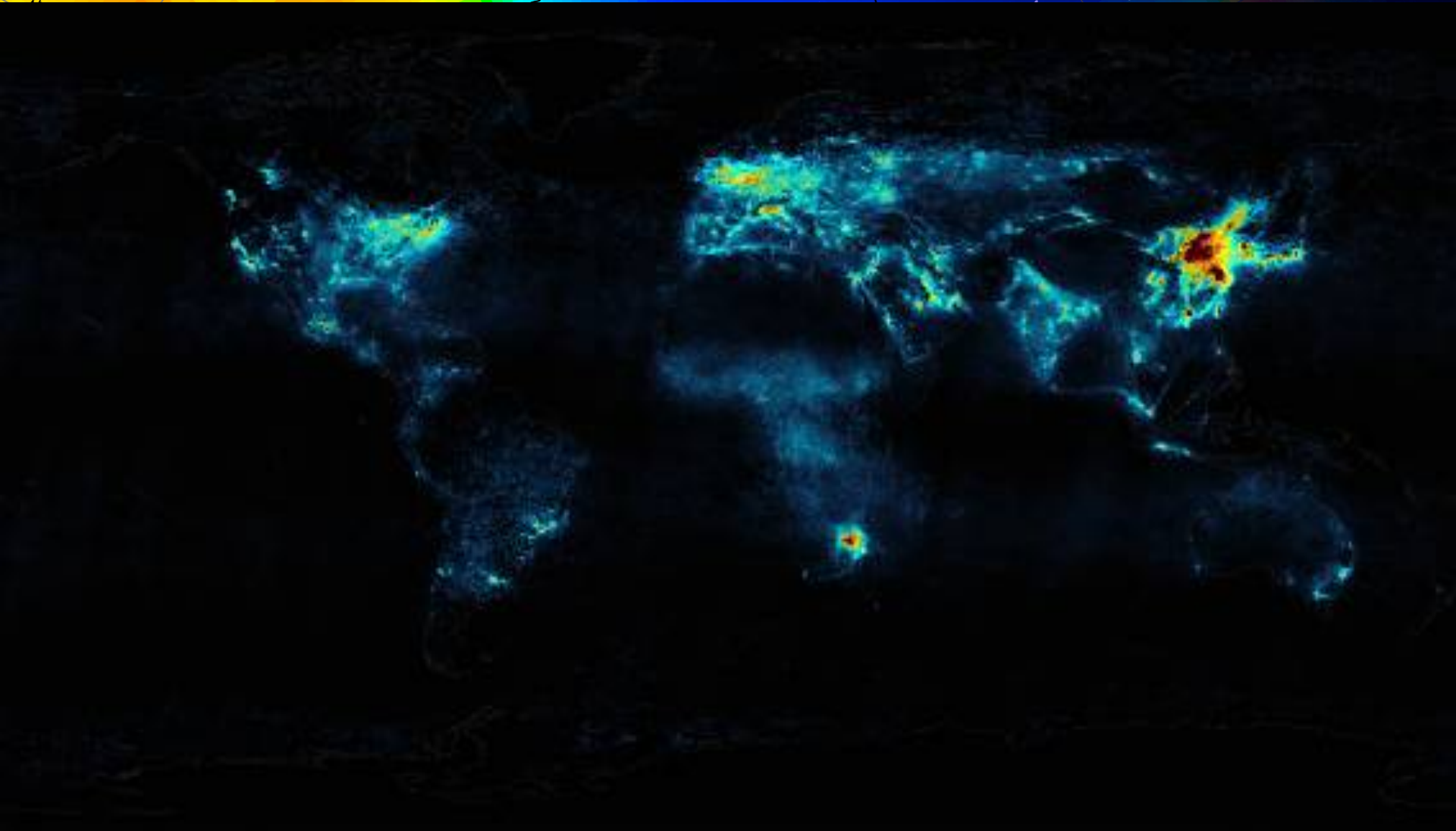
MERIS - Water Vapour

TCWV SSMI+MERIS Monthly Mean January 2008



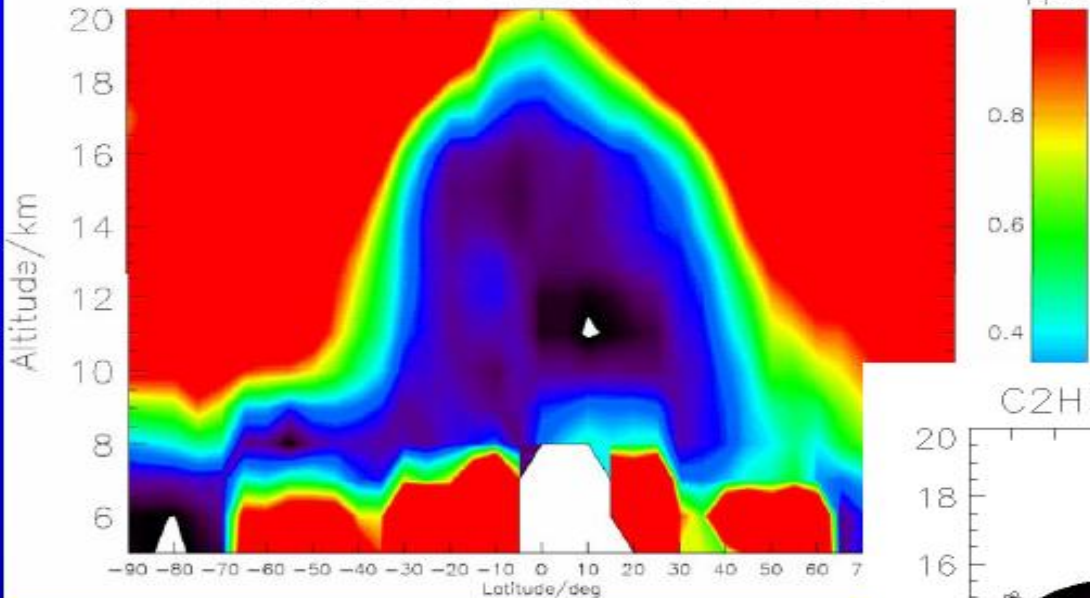
AATSR - Aerosol





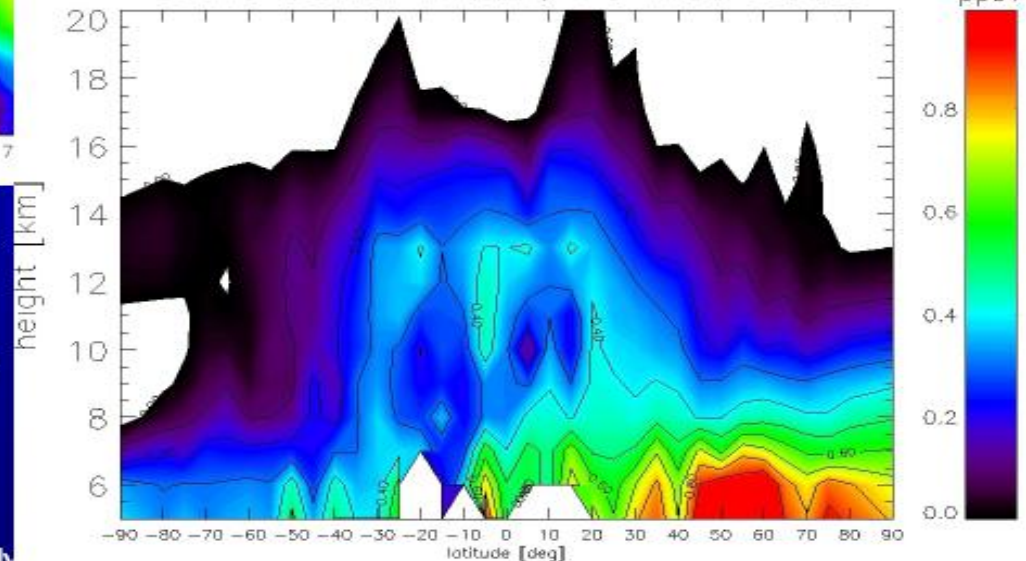
More Insight into Processes in the UT/LS as provided by MIPAS Measurements

HNO₃, zonal mean, SON 2003

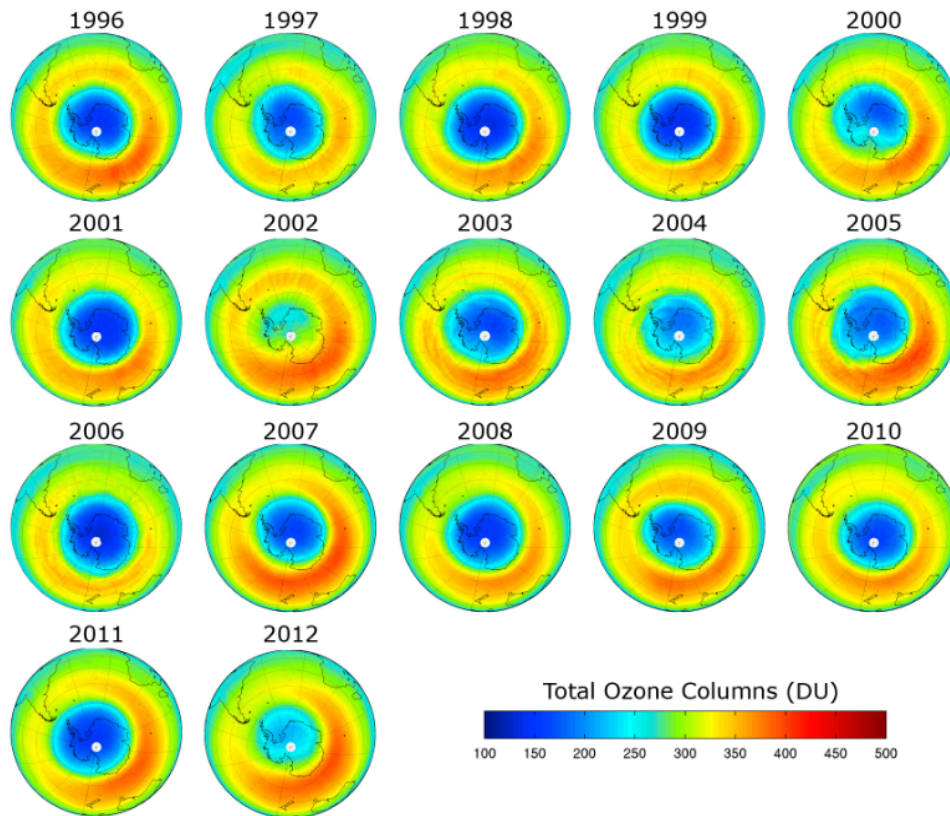


Zonal mean
distribution HNO₃,
Sep/Oct/Nov 2003

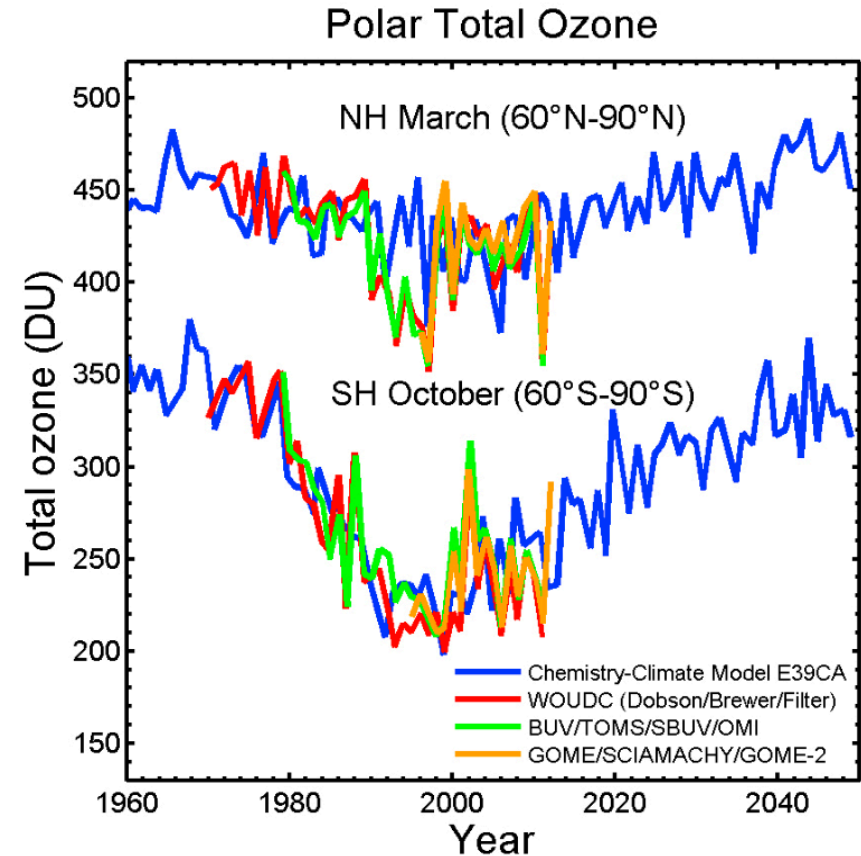
C₂H₆ zonal mean, 16 Nov 2002



Zonal mean distribution C₂H₆,
16 Nov 2003



Time-series (1996 to 2012) of total polar ozone mean values over the months of September, October and November as measured by GOME, SCIAMACHY and GOME-2 flown on ERS-2, Envisat and MetOp-A, respectively. Smaller ozone holes are evident during 2002 and 2012

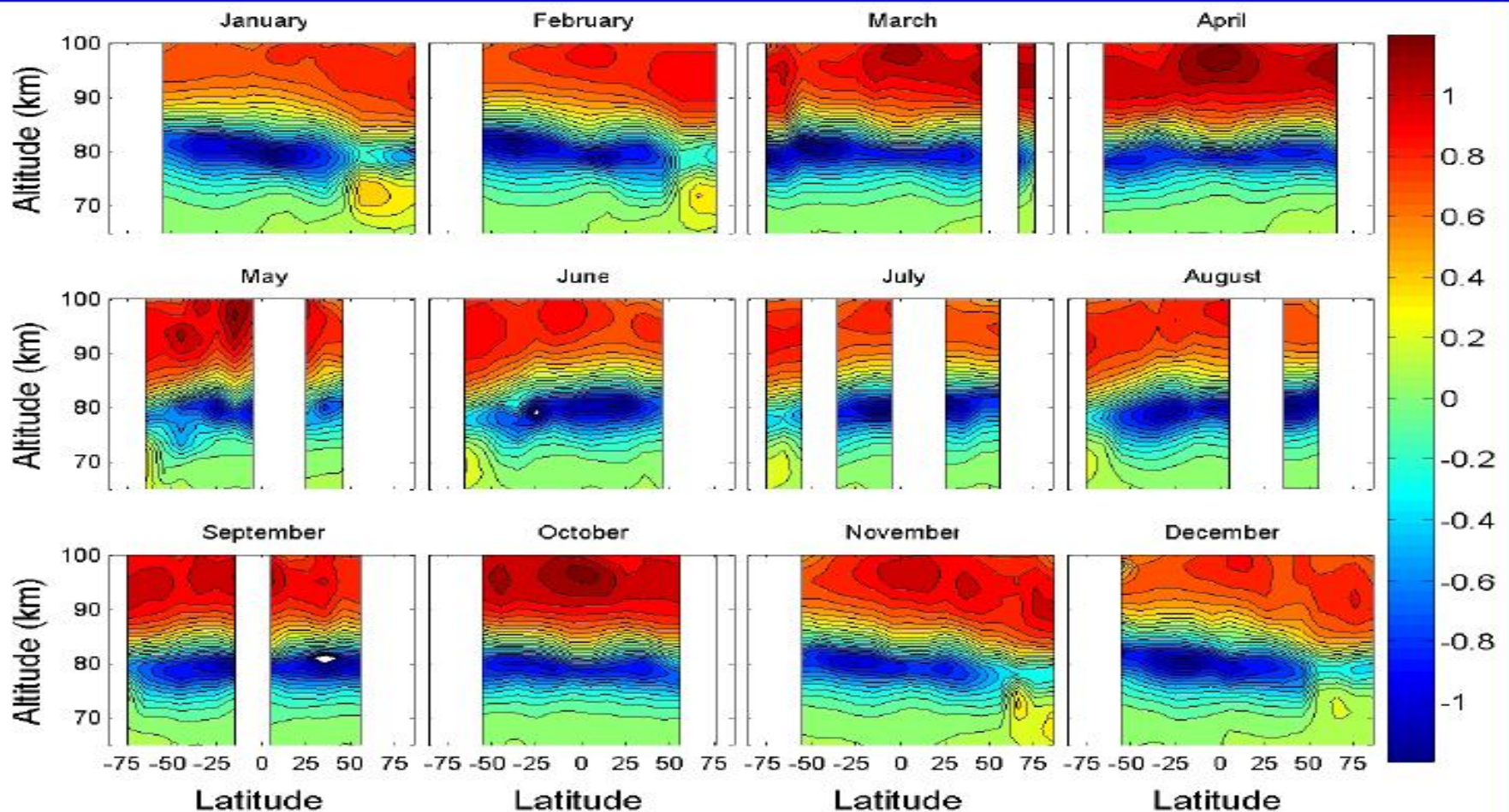


Total polar ozone in the northern and southern hemispheres as measured by various instruments, including GOME, SCIAMACHY and GOME-2 flown on ERS-2, Envisat and MetOp, respectively (in orange). The blue line depicts projections based on the Chemistry Climate Model E39CA. The total ozone reached its lowest levels in both hemispheres in the late 1990s, and it is expected to increase in the coming years.

http://www.esa.int/Our_Activities/Observing_the_Earth/Is_the_ozone_layer_on_the_road_to_recovery

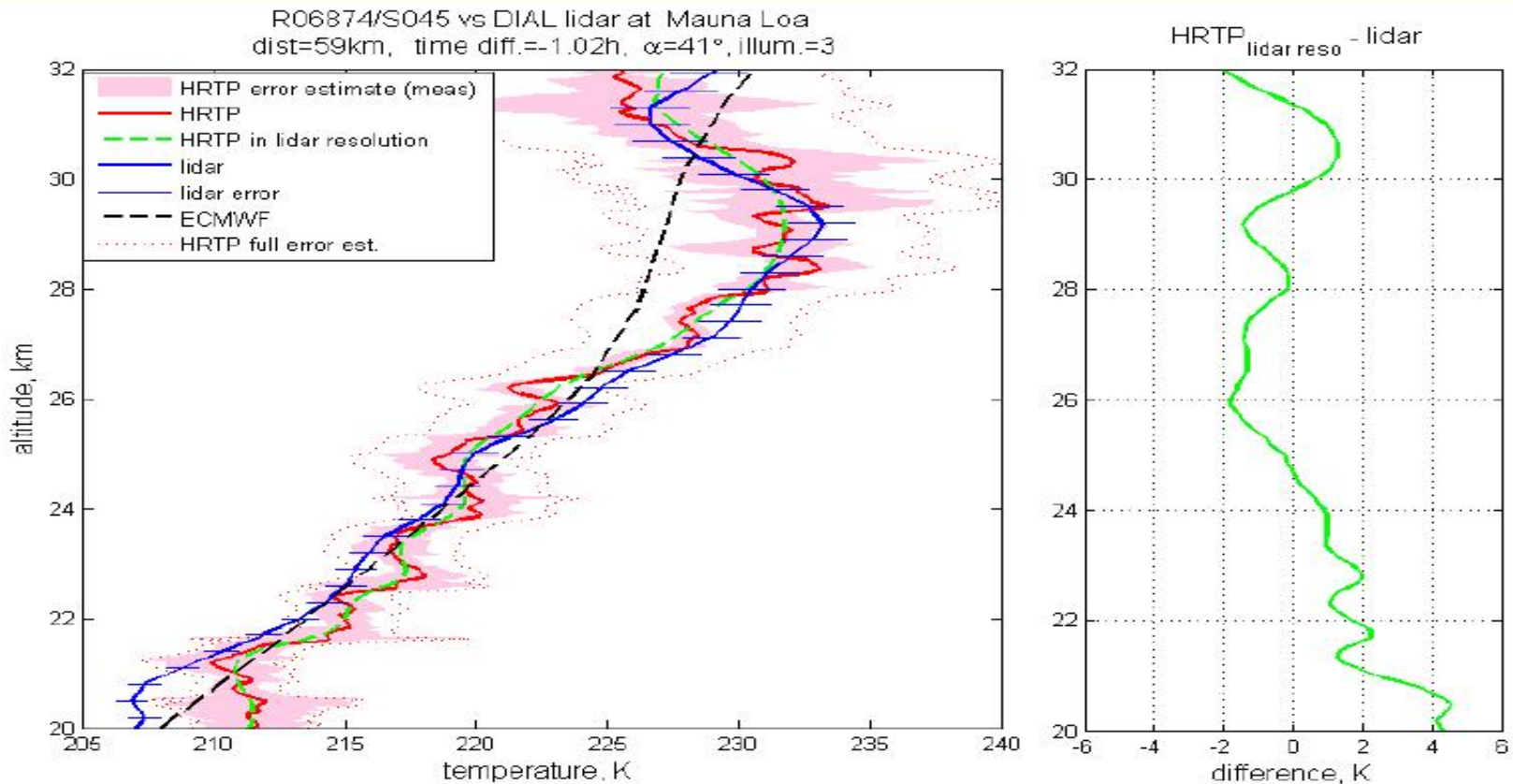
Measurements in the Mesosphere as provided by GOMOS

Mesosphere: \log_{10} O₃ mixing ratio in 2003



Measurements of High vertical Resolution Temperature Profiles as provided by GOMOS

GOMOS HRTP vs a lidar and ECMWF

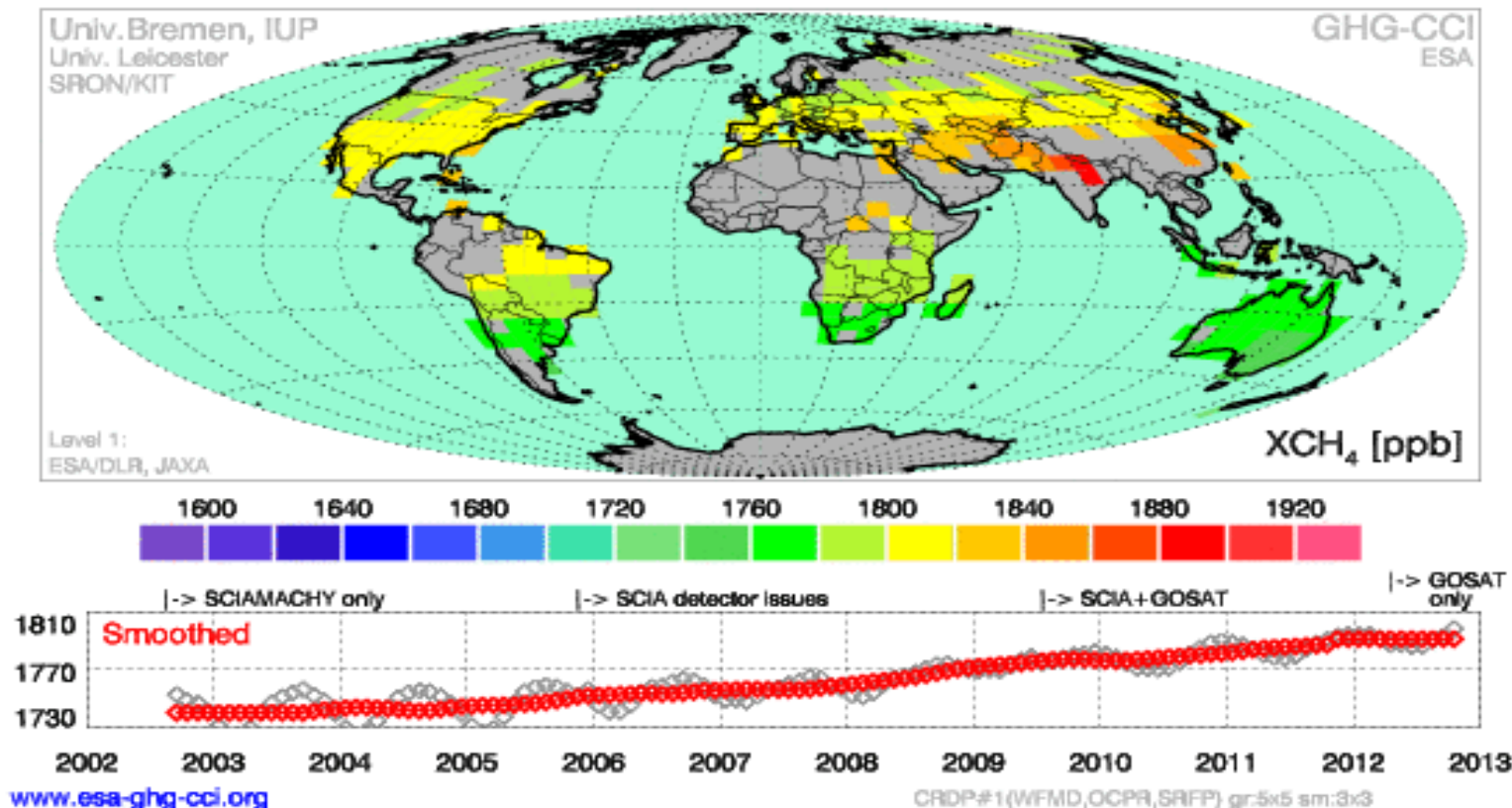


Retrieval of Greenhouse Gases from Space (University Bremen)

Methane

SCIAMACHY/ENVISAT+TANSO/GOSAT

2012 09



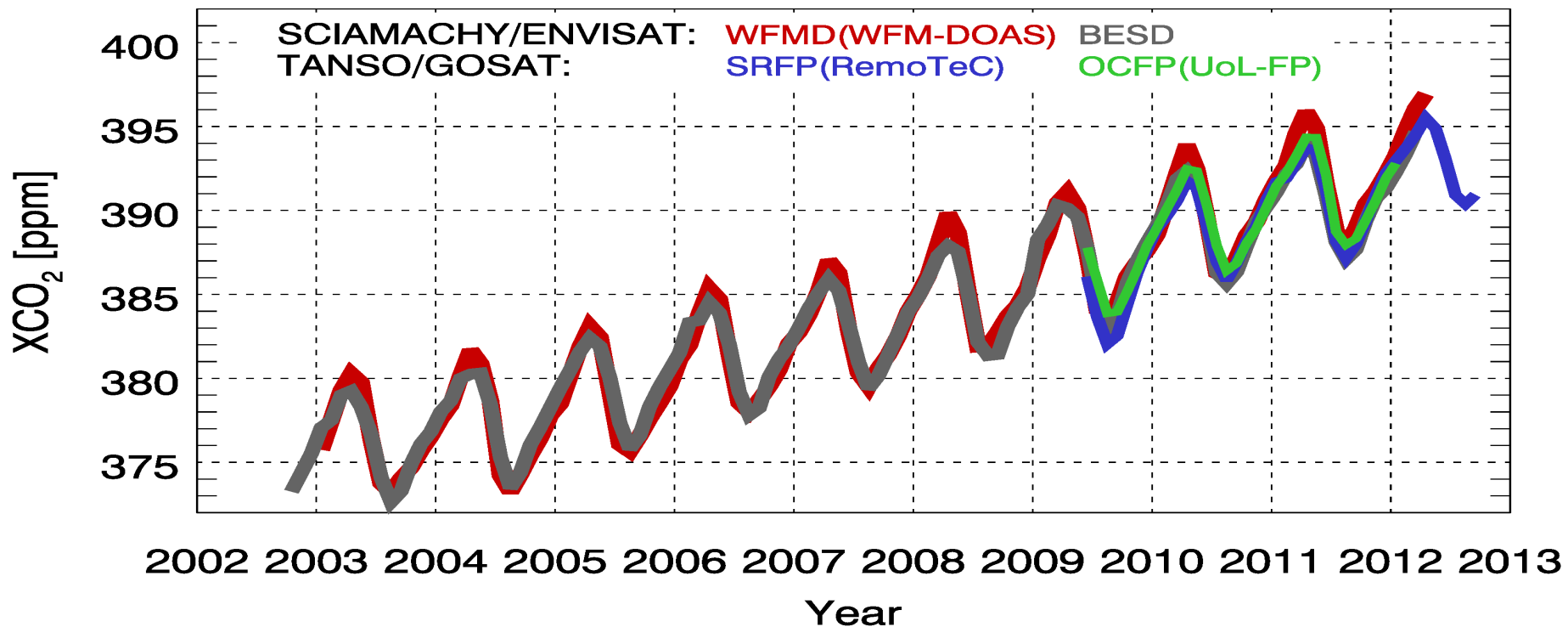
Atmospheric Methane from the SCIAMACHY instrument on Envisat (2002–12) and the TANSO instrument on Japan's GOSAT (2009–12)

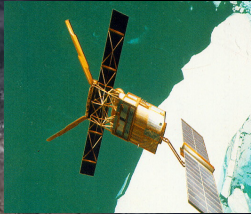
http://www.esa.int/Our_Activities/Observing_the_Earth/Space_for_our_climate/Our_living_planet_Earth_s_carbon_dioxide_breathing_seen_from_space

Retrieval of Greenhouse Gases from Space (University Bremen)

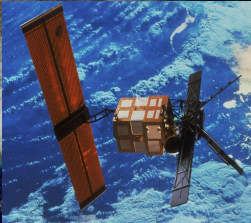
GHG-CCI CRDP#1

Carbon Dioxide (CO₂) - NH (0°-60°N)





1991



1995



2002





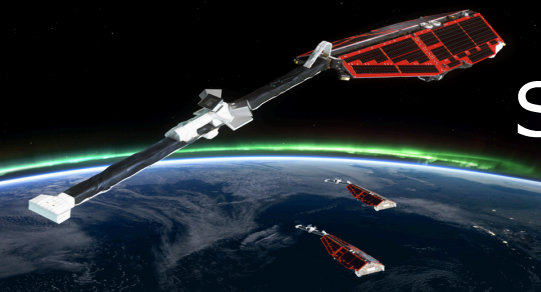
GOCE launched 18 March 2009
ended on 11 November 2013



SMOS launched 2 November 2009

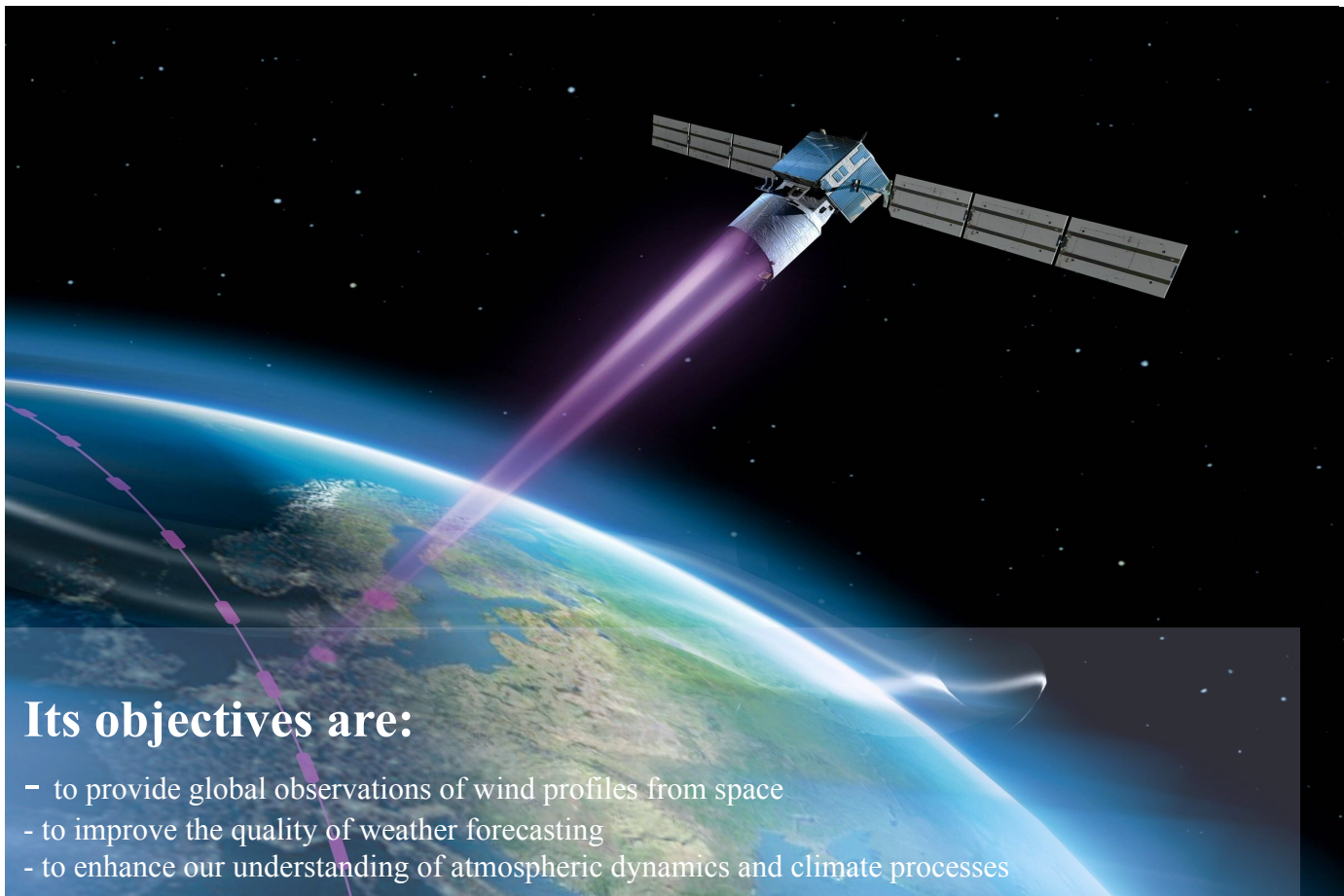


CryoSat launched 8 April 2010



Swarm launched 22 November 2013

ADM-Aeolus: Wind Mission



Its objectives are:

- to provide global observations of wind profiles from space
- to improve the quality of weather forecasting
- to enhance our understanding of atmospheric dynamics and climate processes



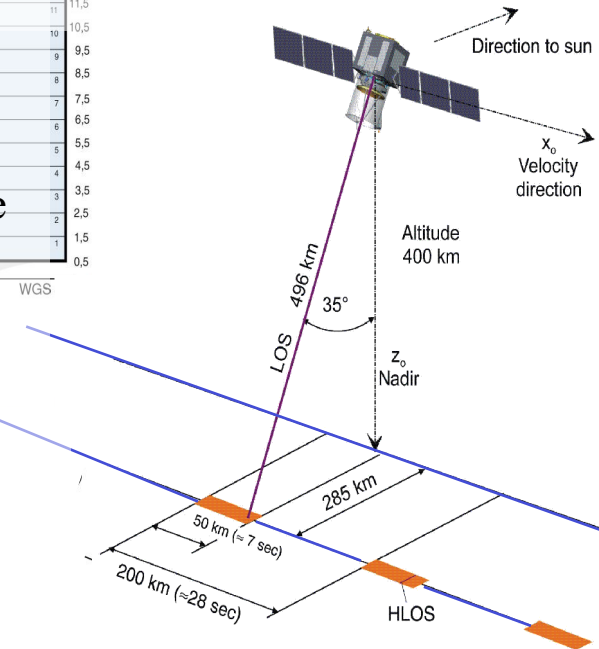
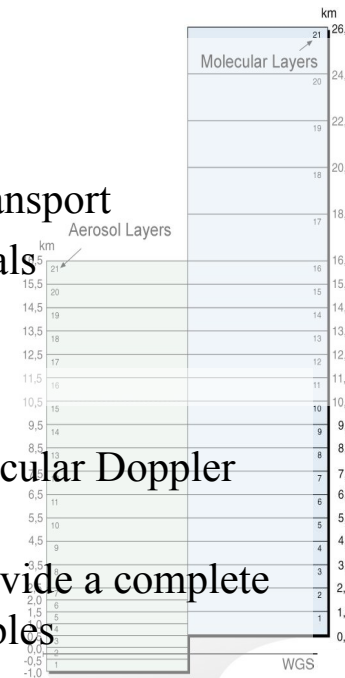
What are the scientific objectives?

Improve understanding of

- atmospheric dynamics and global atmospheric transport
- global cycling of energy, water, aerosols, chemicals

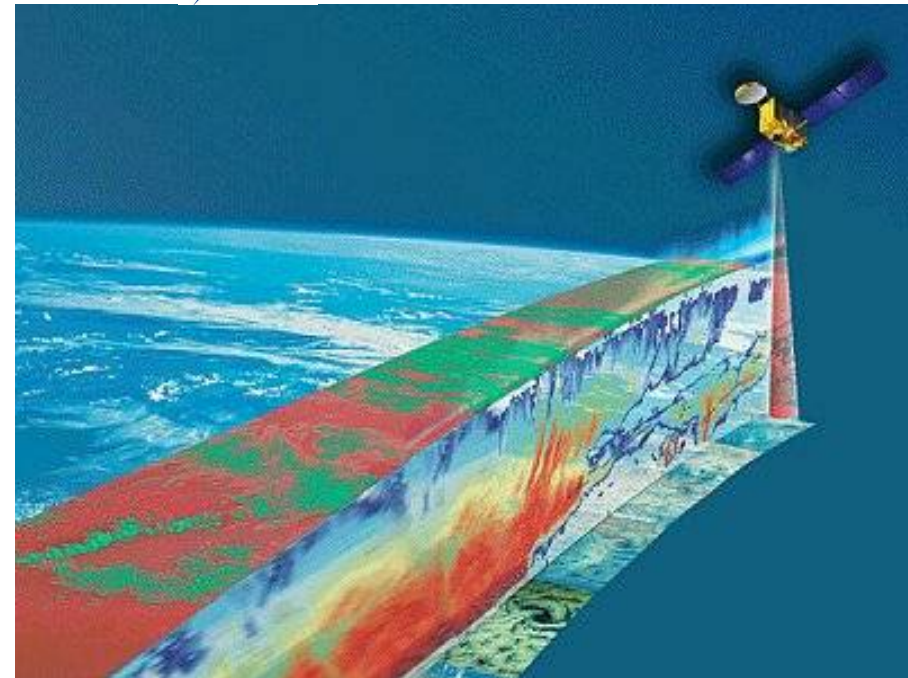
How are they achieved?

- line of sight winds are derived from aerosol/molecular Doppler shifts
- Improved analysis of the atmospheric state to provide a complete three-dimensional picture of the dynamical variables



What are the benefits?

- Improved parameterisation of atmospheric processes in models
- Advanced climate and atmospheric flow modelling
- Better initial conditions for weather forecasting



EarthCARE is a joint European - Japanese mission

Its objectives are:

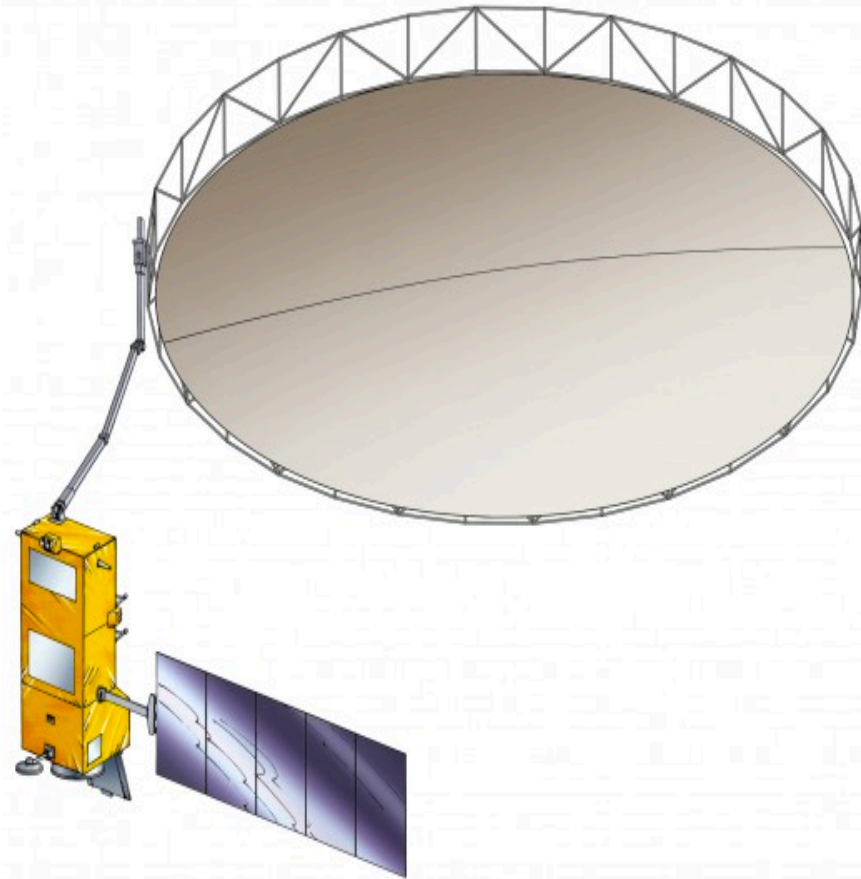
- to improve process understanding of cloud-aerosol-radiation interactions
- to measure parameters to be included in models
- to improve climate and weather model predictions



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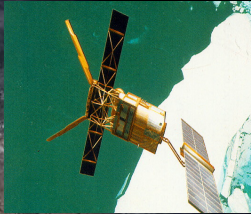
Earth Explorer 7:

BIOMASS: to be launched in 2020 - aimed to take measurements of forest biomass to assess terrestrial carbon stocks and fluxes.

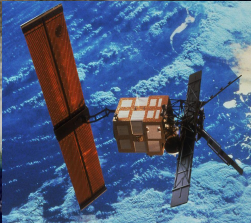


Earth Explorer 8:

- **CarbonSat:** aims to image and quantify the distribution of the two most important greenhouse gases in the atmosphere released through human activity: carbon dioxide (CO_2) and methane (CH_4)
- **FLEX:** the global monitoring of steady-state chlorophyll fluorescence in terrestrial vegetation
- **To be selected during autumn 2015**



1991



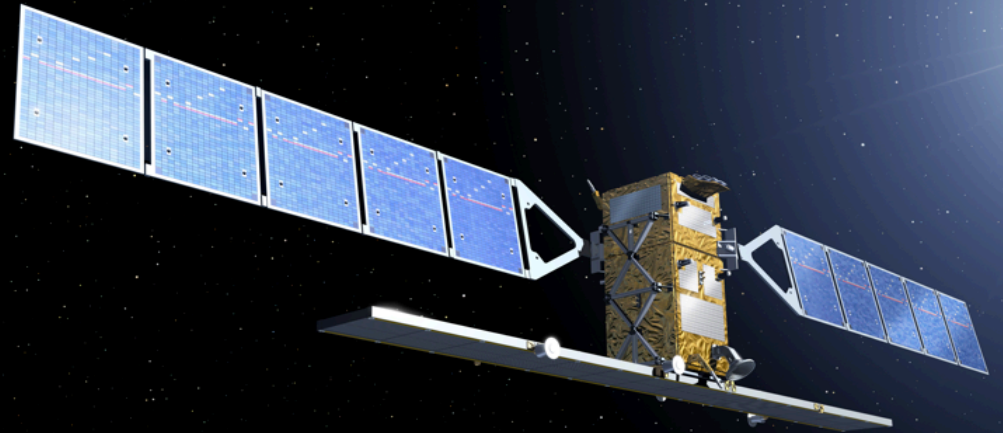
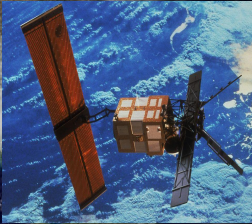
1995



2002



2009+



2014



1991 - 2000

1995 - 2011

2002 - 2012

2009+

2014+

Copernicus: an Earth Observation Programme for Global Monitoring for the Environment and Security.

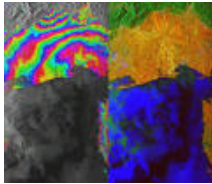
Led by the **European Commission** in partnership with **ESA** and the **European Environment Agency**.

ESA is responsible for implementing the space component, including developing the Sentinel satellite series.

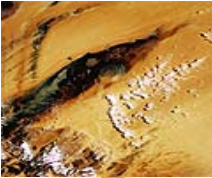
Sentinel 1A: launched on April 3 2014.

Sentinel-5 Precursor (2016), Sentinel-4 (2018), and Sentinel-5 (2020)
atmospheric missions

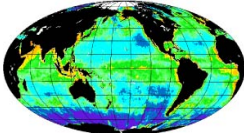




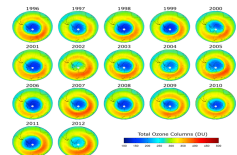
Sentinel 1 – SAR imaging – launched 2014 April 3
All weather, day/night applications, interferometry



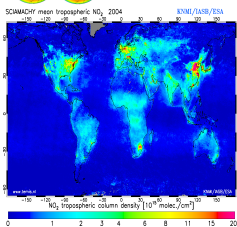
Sentinel 2 – Multispectral imaging
Land applications: continuity of Landsat, SPOT data



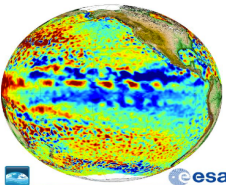
Sentinel 3 – Ocean and global land monitoring
Wide-swath ocean color, vegetation, sea/land surface temperature, altimetry



Sentinel 4 – Geostationary atmospheric
Atmospheric composition monitoring, air quality



Sentinel 5/P – Low-orbit atmospheric
Atmospheric composition monitoring, air quality



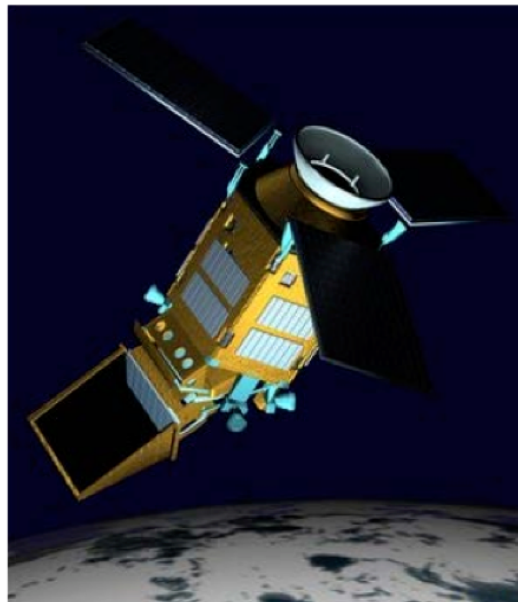
Sentinel 6 – Altimetry
high precision ocean altimetry following the Jason-3 satellite mission

Sentinel-5 Precursor

- Pre-operational mission focussing on global observations of the the atmospheric composition for air quality and climate for Copernicus
- The TROPOspheric Monitoring Instrument (**TROPOMI**) is the payload of the S5P mission and is jointly developed by The Netherlands and ESA
- Planned Launch: early 2016

TROPOMI

- ▶ UV-VIS-NIR-SWIR nadir view grating spectrometer.
- ▶ Spectral range: 270-500, 675-775, 2305-2385 nm
- ▶ Spectral Resolution: 0.25-1.1 nm
- ▶ Spatial Resolution: 7x7km²
- ▶ Global daily coverage at 13:30 local solar time.



- ▶ Total column
O₃, NO₂, CO, SO₂, CH₄,
CH₂O, H₂O, BrO
- ▶ Tropospheric column
O₃, NO₂
- ▶ O₃ profile
- ▶ Aerosol absorbing index,
type, optical depth

Sentinel-4: GEO atmospheric mission

Applications:

- monitoring changes in the atmospheric composition (e.g. ozone, NO₂, SO₂, BrO, CHOCHO, formaldehyde and aerosol) at high temporal resolution
- tropospheric variability

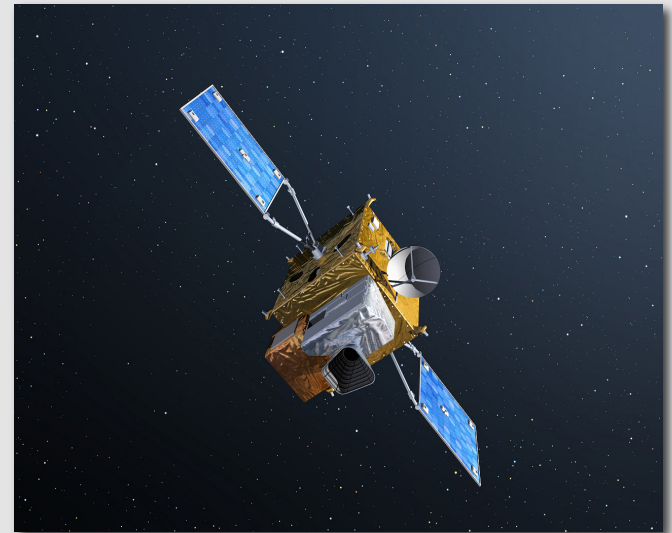
Narrow field spectrometer covering UV (305-400 nm), visible (400-500 nm) and near-IR (750-775 nm) bands

Spatial sampling 7 x 7 km² and spectral resolution between 0.12 nm (near-IR) and 0.5 nm (UV, visible)

Geostationary orbit, at 0° longitude

Embarked on MTG-Sounder Satellite and operated by EUMETSAT

Planned launch: 2018



Sentinel-5: LEO atmospheric mission

Applications:

- monitoring changes in the atmospheric composition (e.g. ozone, NO₂, SO₂, BrO, formaldehyde and aerosol) at high temporal (daily) resolution
- tropospheric variability

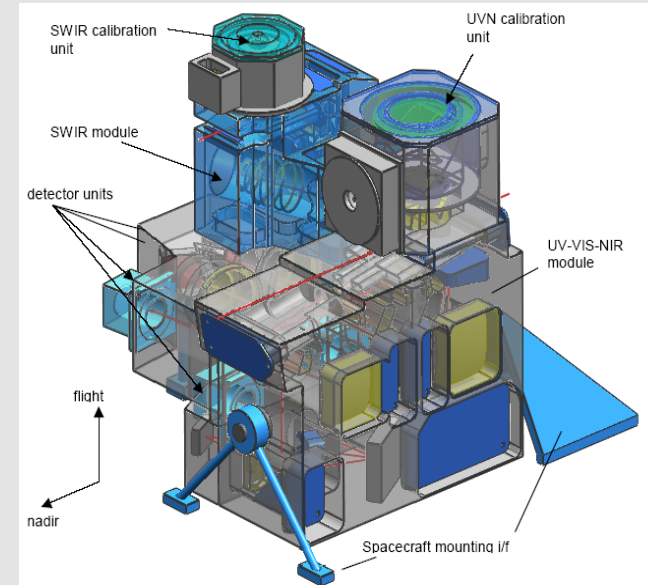
5 channels spectrometer covering UV (270-495 nm), visible (400-500 & 710-750 nm), NIR (710-775 nm) and SWIR (2314-2382 nm) bands.

spectral resolution between 0.25 nm and 1.1 nm

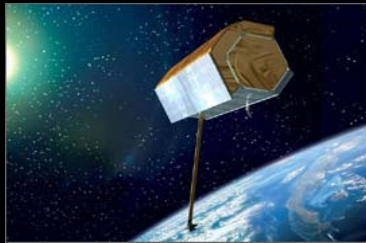
Low Earth orbit (reference altitude of about 824 km)

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

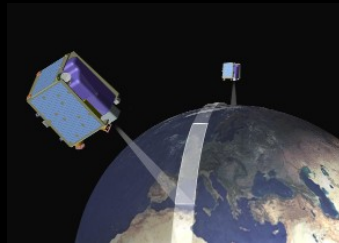
Planned launch: 2020



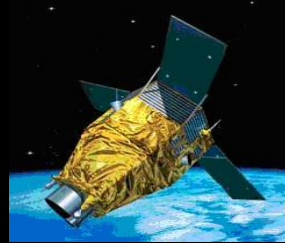
National, Eumetsat and Third Party Missions (excerpt)



Terrasar-X



Rapideye



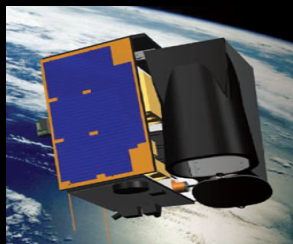
Pleiades



Jason-2



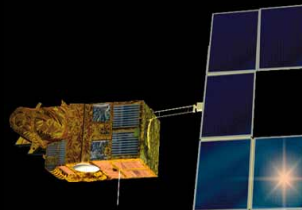
CosmoSkymed



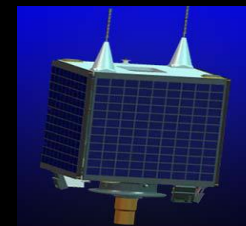
TopSat



Radarsat



SPOT

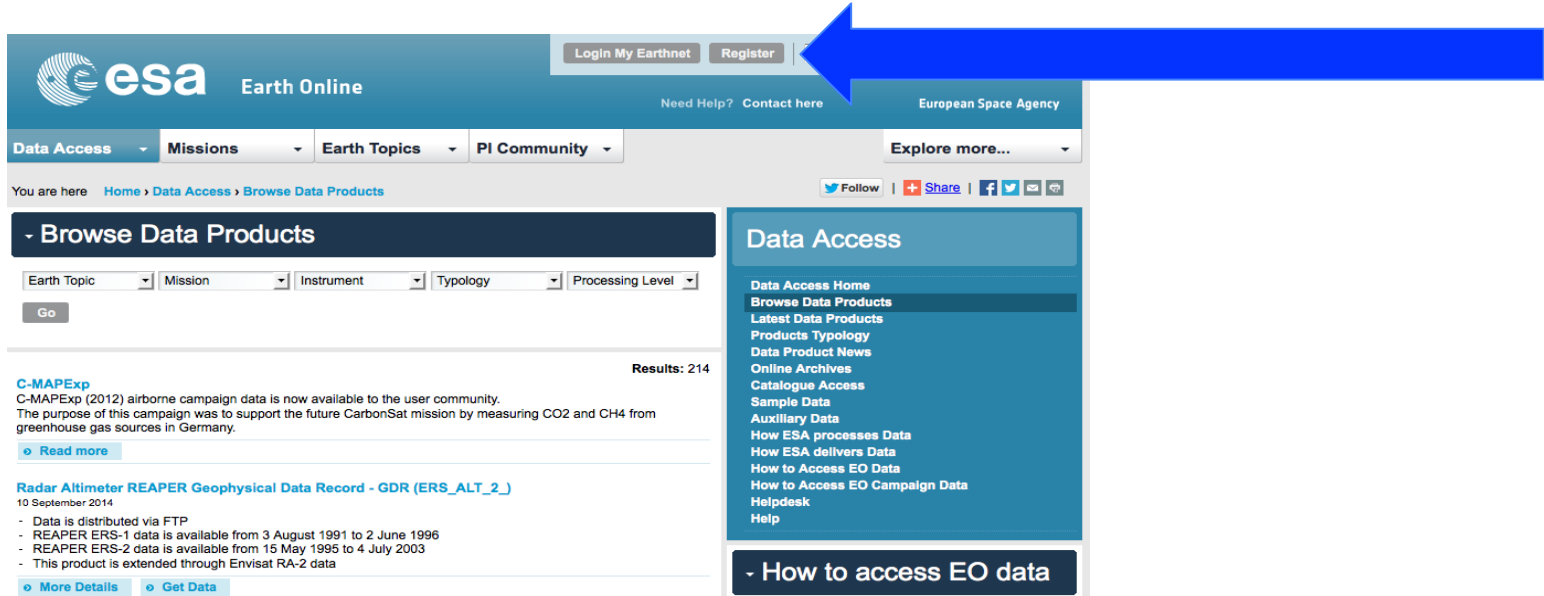


UK-DMC



METOP

- ❑ **Free Data Sets:** free of charge – online registration at earth.esa.int/web/guest/data-access/browse-data-products – valid for all atmospheric products



- ❑ **Restrained Data Sets:** e.g. ERS and Envisat SAR data (very large data volume, submission of a project proposal, quota, in principle free of charge – contribution in case of very large data sets)
- ❑ earth.esa.int/web/guest/data-access; eohelp@esa.int

