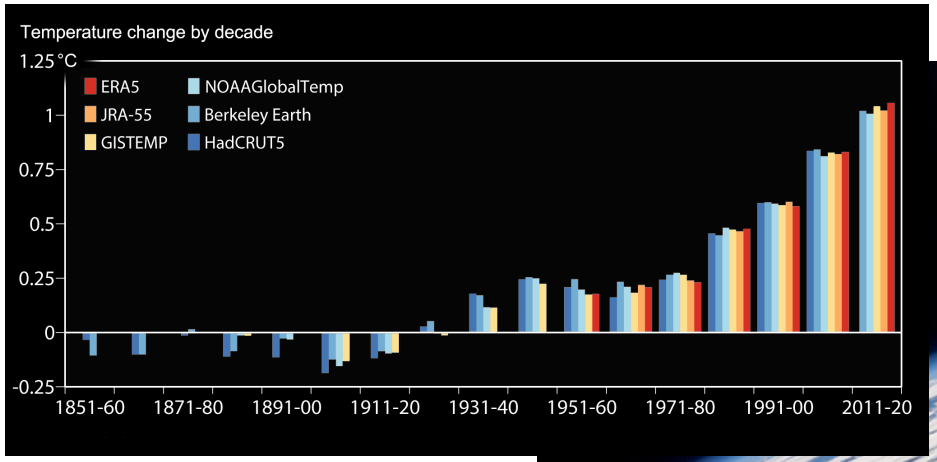
Handling crisis, from pandemics to climate change.

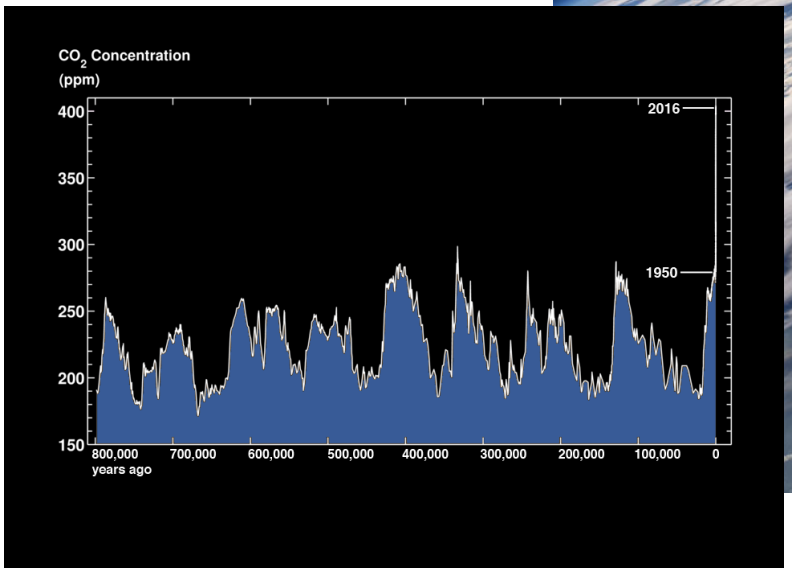
Scientific instruments on board EO missions

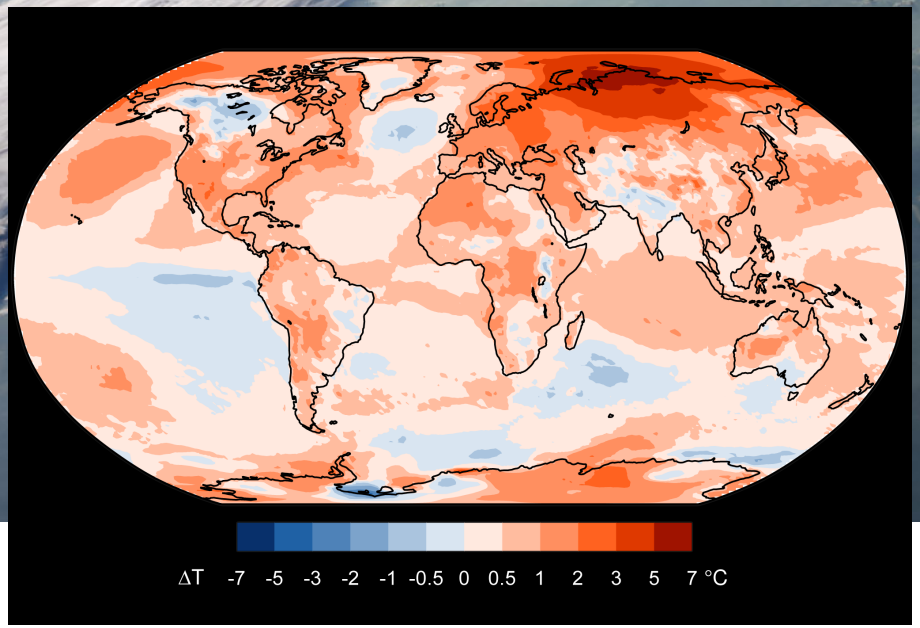
Michael Francois

10/06/2021

Earth Climate

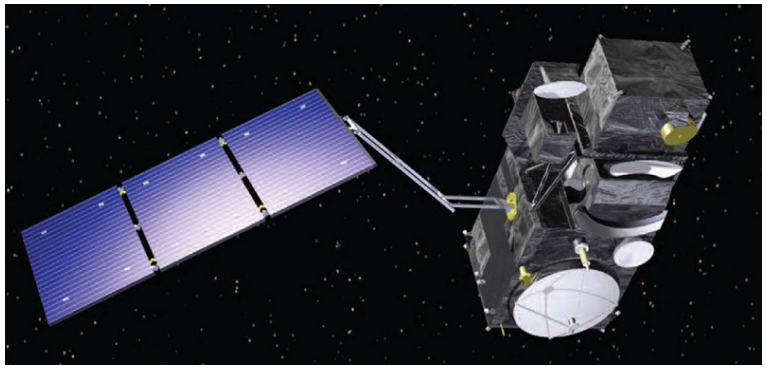


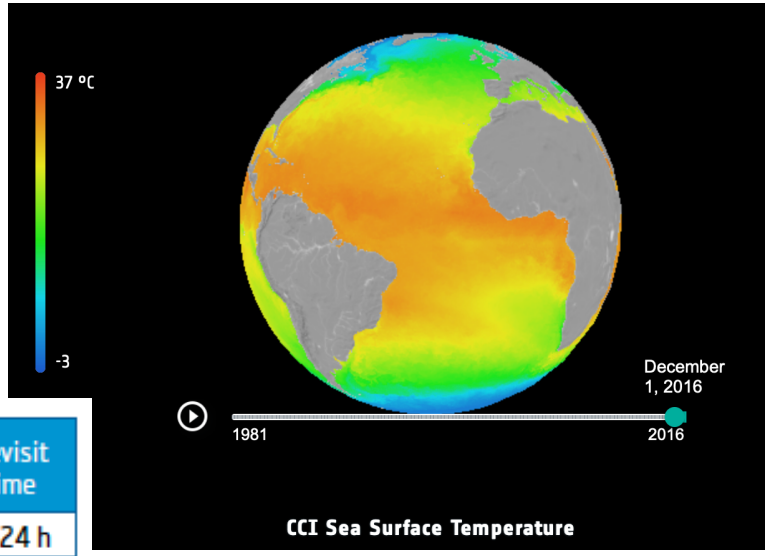




Tracking Climate Change from Space

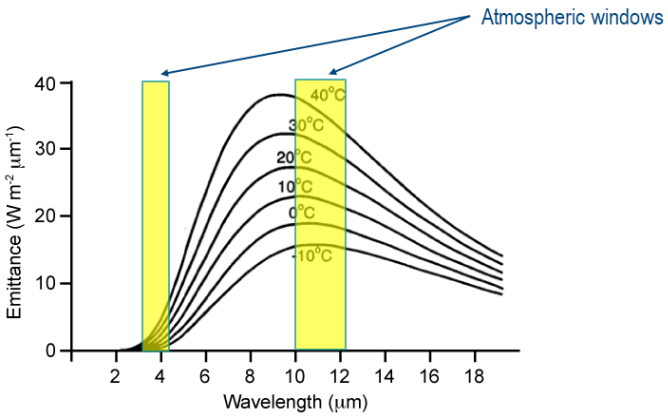
The Copernicus Sea Land Surface Temperature Radiometer

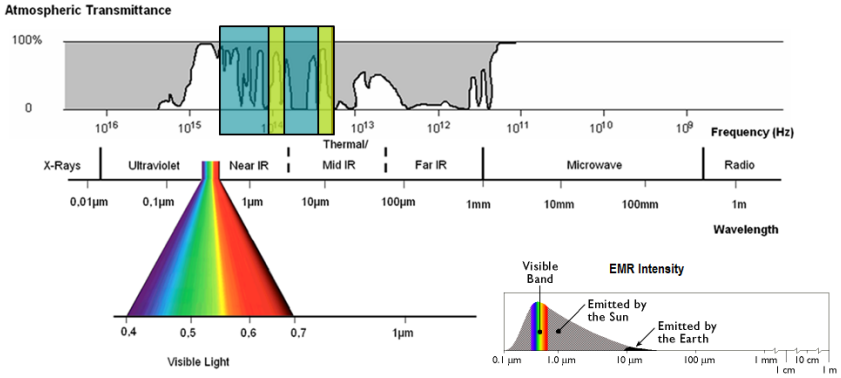




Application	Temperature accuracy (K)	Spatial resolution (km)	Revisit time
Numerical Weather Prediction	0.2–0.5K	1–50	6–24 h
Climate monitoring, climate stability	0.1K <0.1K/decade (goal)	10–50	8 days
Numerical Ocean Prediction	0.2K	1–10	6–24 h
Coastal/local applications	0.5K	<0.5	1 day
Land surface temperatures	<1K @ 1 km resolution	1 km	Daily
Ice surface temperatures	1K (10%)	<5 km (1 km goal)	Daily
Active fire detection	<3K	0.5–1 km	Daily
Fire monitoring (Fire burned area)	<3K	0.5–1 km	Daily
Lake water surface temperatures	<1K (10%)	<1 km	Daily

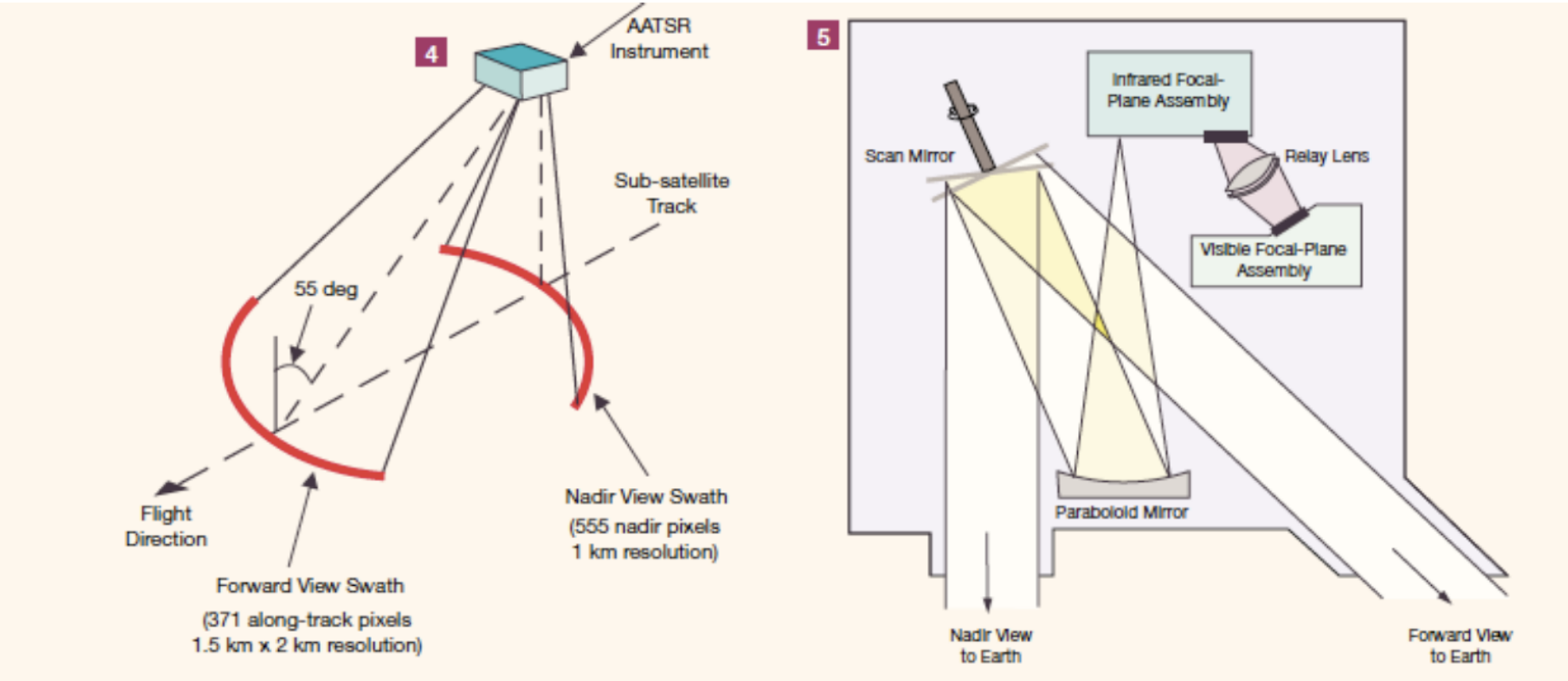
Along Track Scanning Radiometers since ERS-1

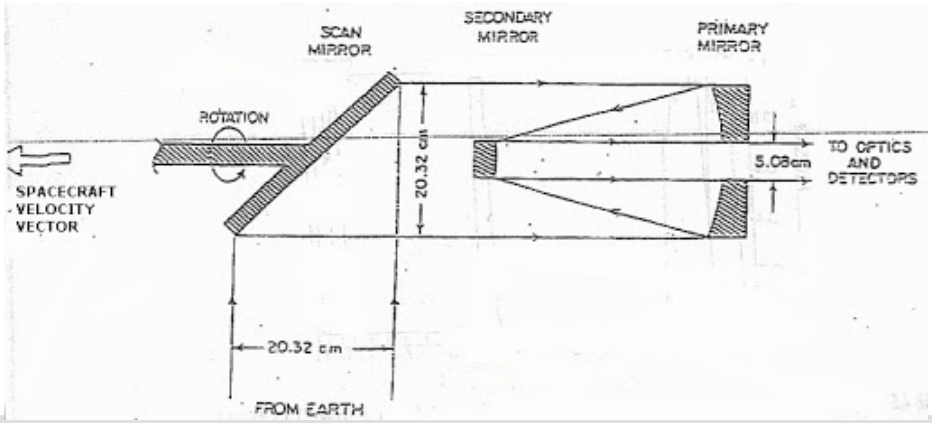




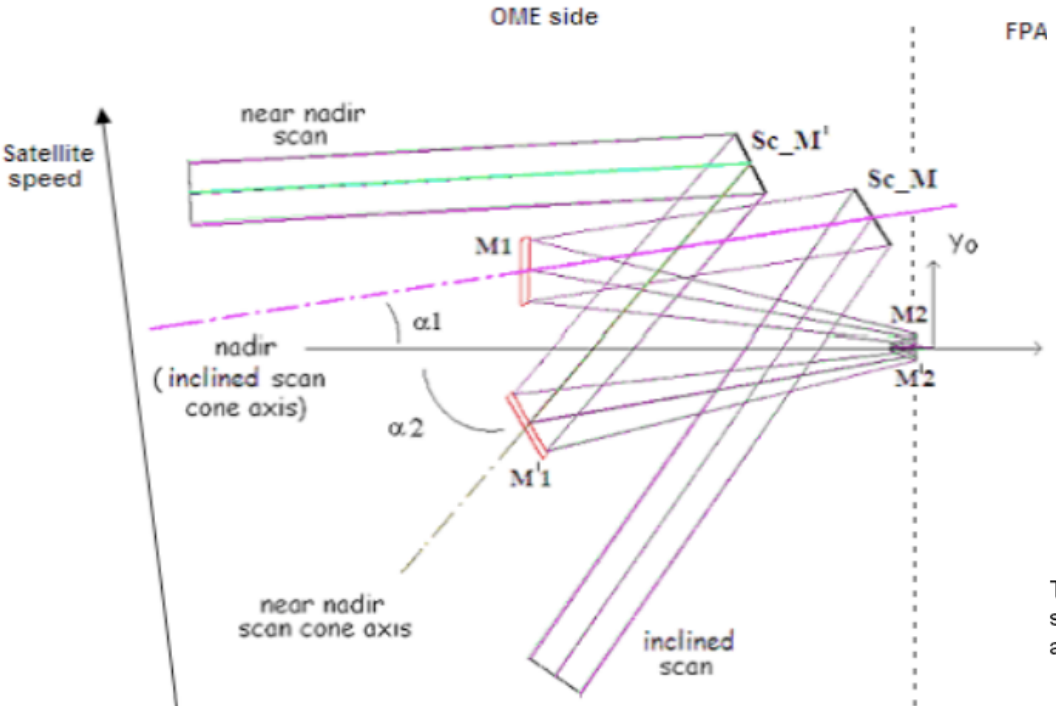
		ATSR-1	ATSR-2	AATSR	SLSTR
		ERS-1	ERS-2	ENVISAT	Sentinel3
Swath [km]	Nadir oblique	500 500	500 500	500 500	1400 740
SSI [km] VIS/SWIR	Resolution at sub sat point	1	1	1	0.5
SSI [km] IR		1	1	1	1
Band 1[12]	Chlorophyll	-	0.555	0.555	0.555
Band 2	Veg. Index	-	0.659	0.659	0.659
Band 3	Veg. Index	-	0.865	0.865	0.865
Band 4	Cloud clearing	-	-	-	1.375
Band 5	Cloud clearing	1.610	1.610	1.610	1.610
Band 6	Cloud clearing	-	-	-	2.250
Band 7	SST	3.740	3.740	3.740	3.740
Band 7 F	Fire	-	-	-	3.740
Band 8	SST	10.850	10.850	10.850	10.850
Band 8 F	Fire	-	-	-	10.850
Band 9	SST	12.000	12.000	12.000	12.000
Life time [years]	As designed As flown	3 1991-2000	3 1995-2008	5 2002 2012	7.5

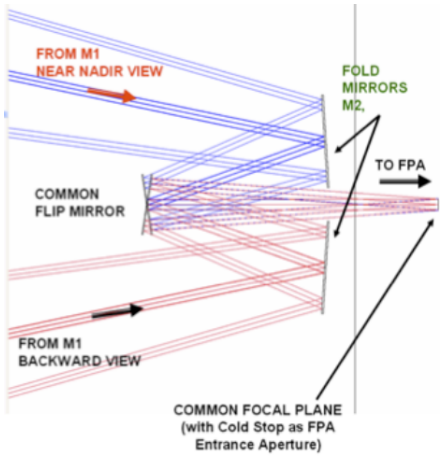
Along track scanning principle

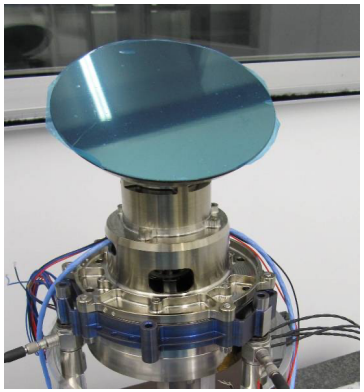


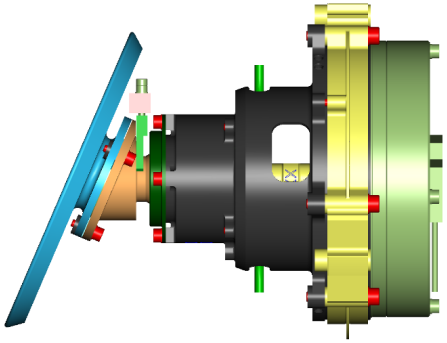


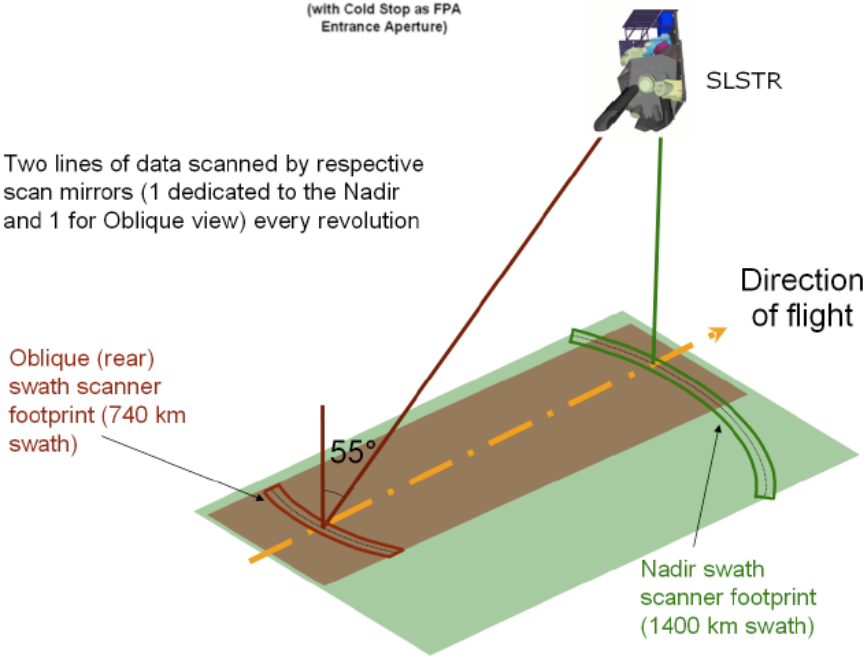
The SLSTR observation and telescope principle



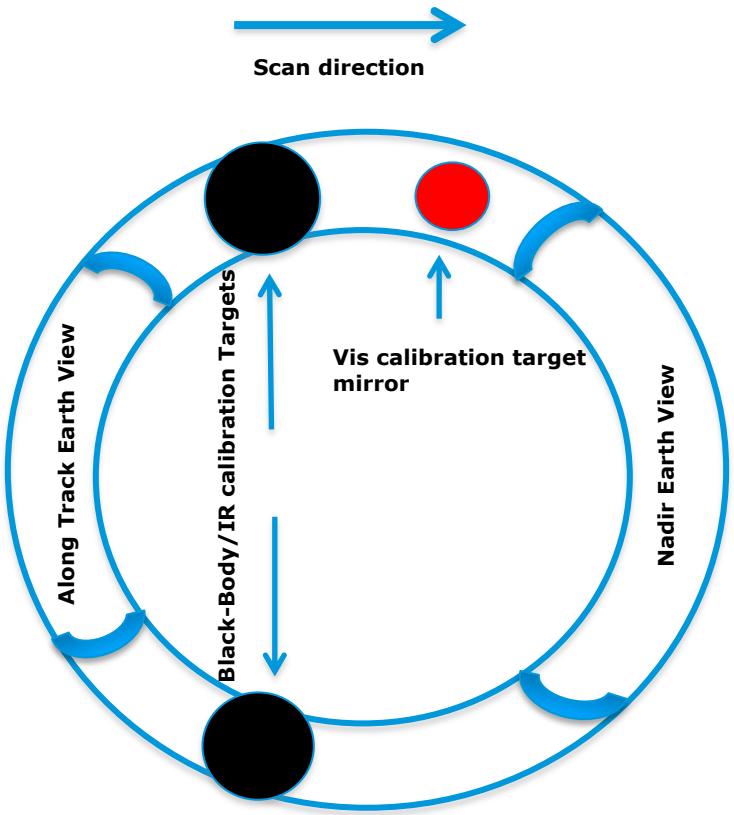




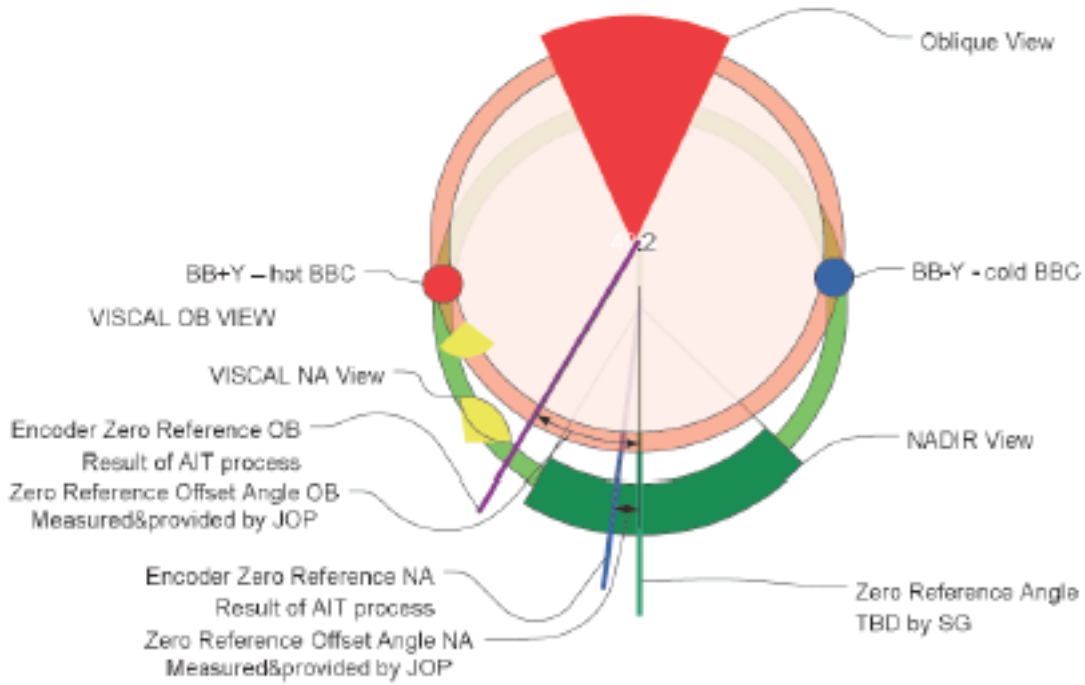




Scan cycle

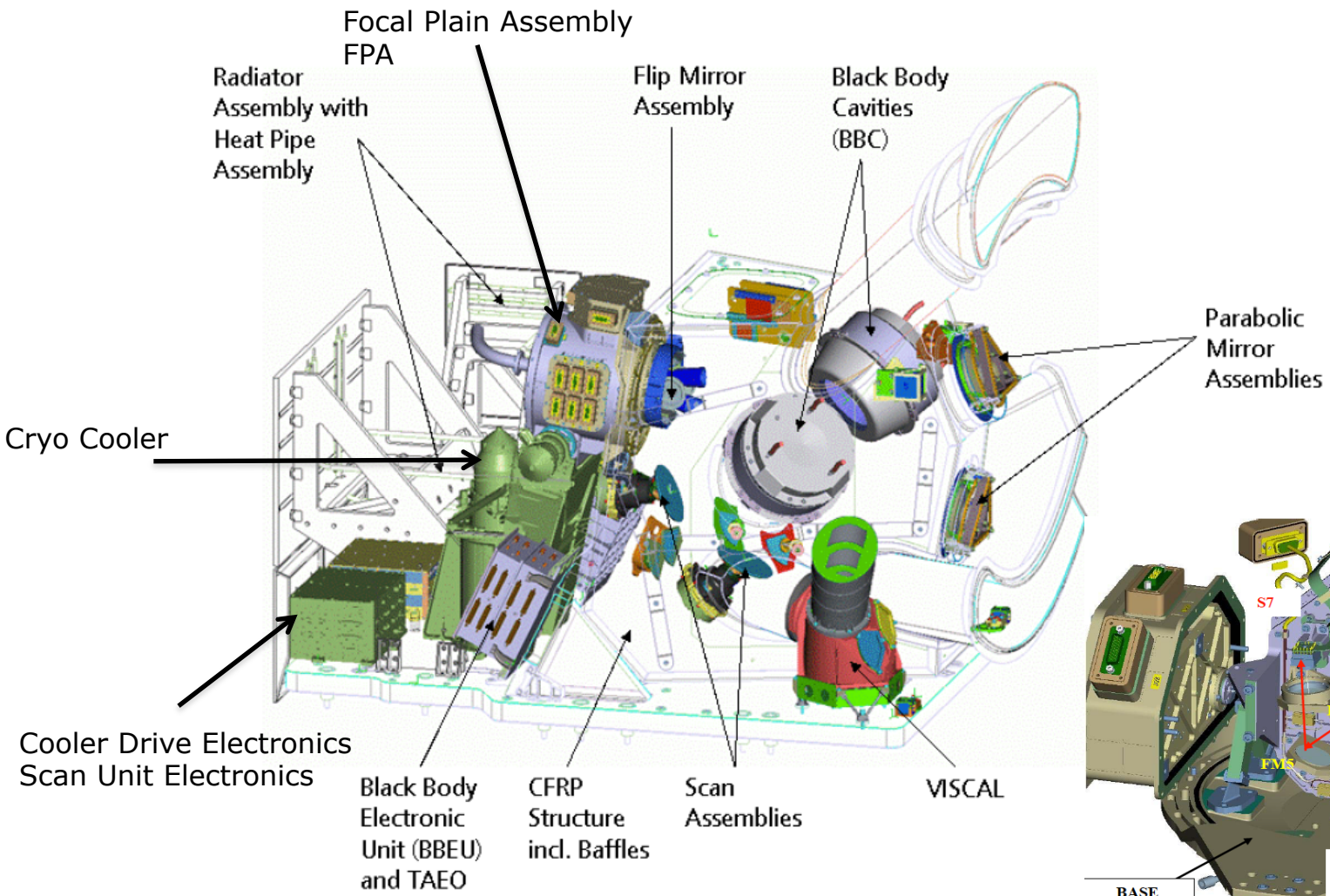


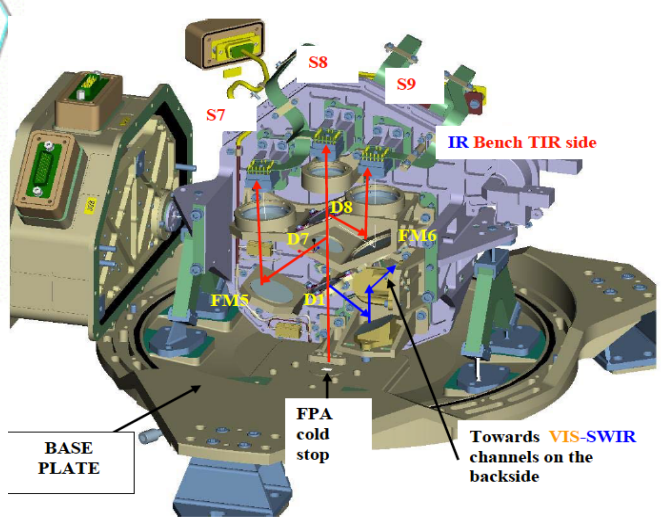
ATSR Scan cycle



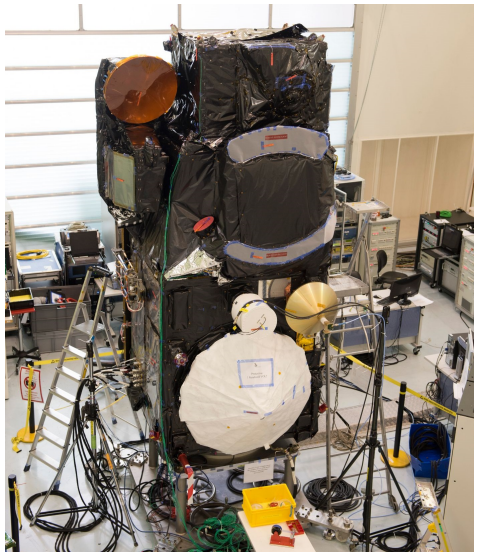
SLSTR Scan cycle

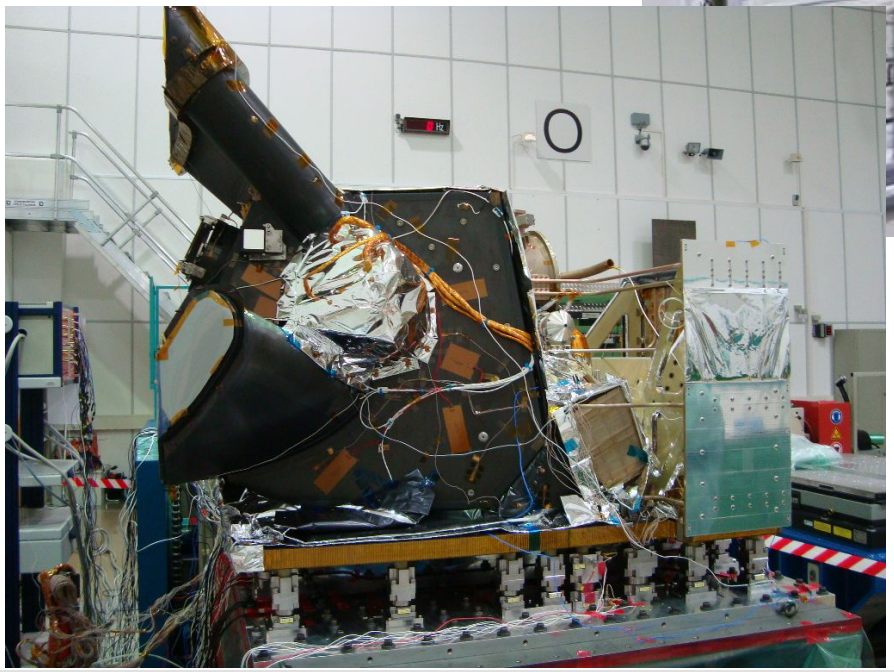
SLSTR Instrument Layout



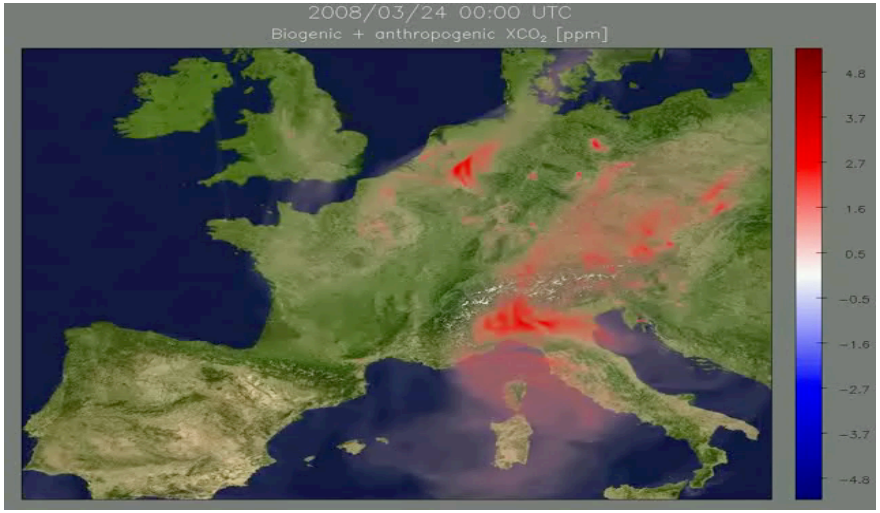


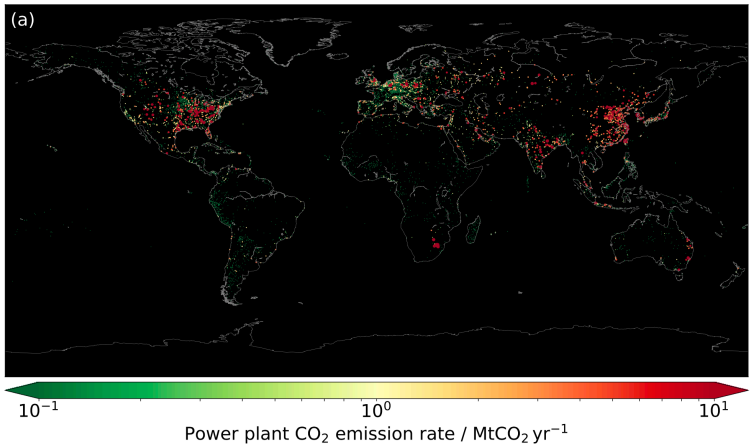
SLSTR and sentinel 3 Layout

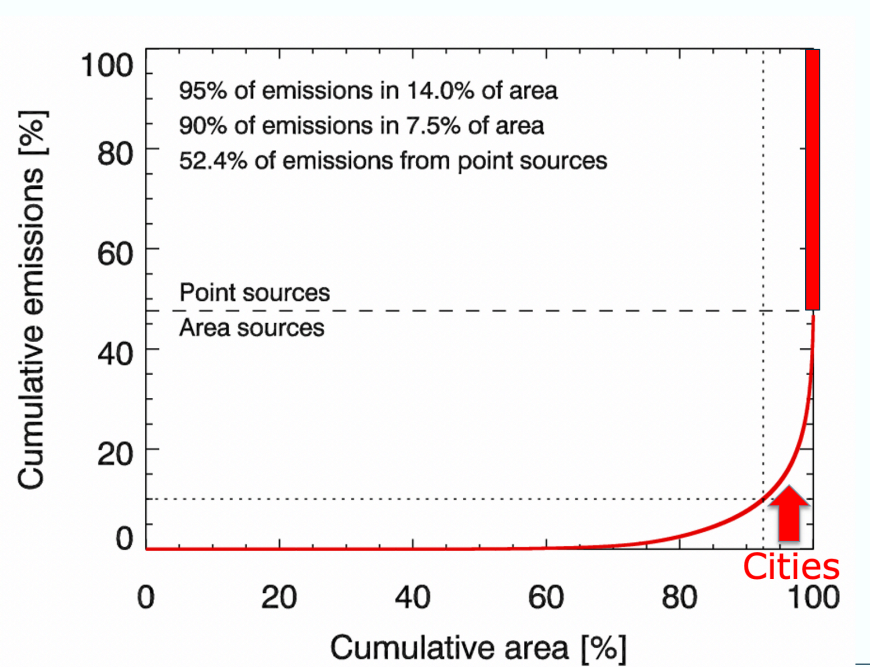




The Copernicus CO2M mission for monitoring anthropogenic carbon dioxide emissions







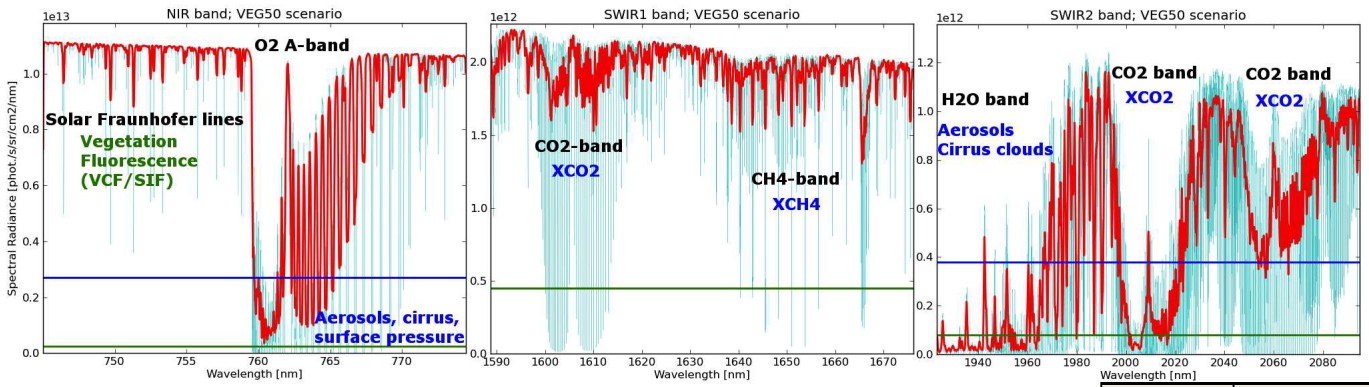
Cities account for ~70% of global CO_2 emissions

.... and have large reduction potential

CO_2 emissions are concentrated:

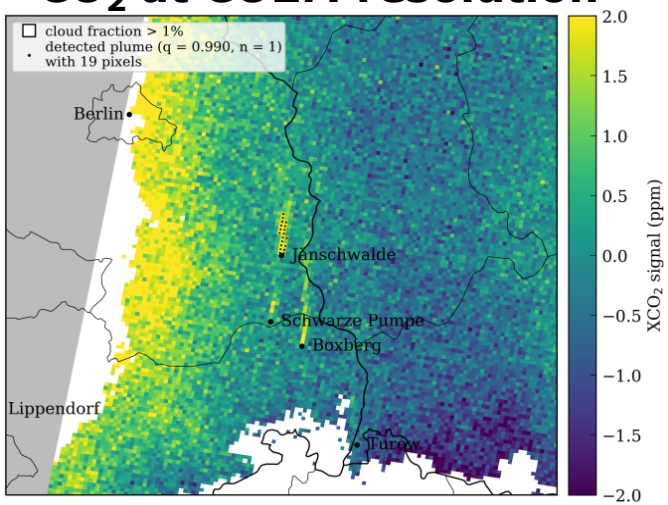
- 90% emitted over less than 8% of area of Europe
- 52% from point sources, primarily power plants

Observation principle of CO2 Imager

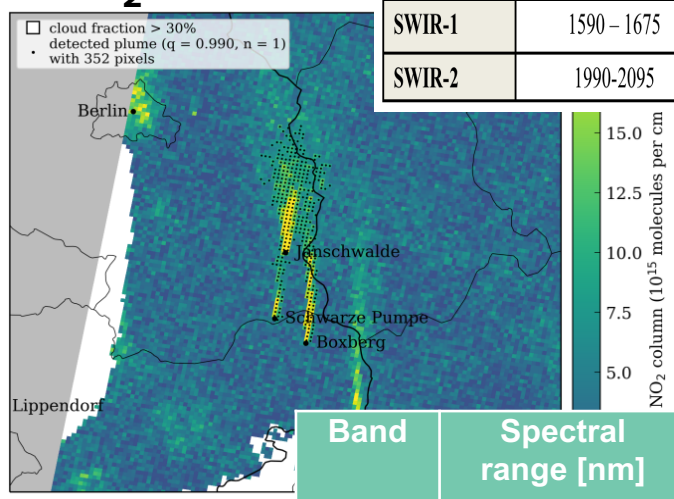


Spectral Band ID	Spectral Range [nm]	Spectral Resolution Δλ [nm]	Spectral Sampling Ratio
NIR	747 – 773	0.12	3.0
SWIR-1	1590 – 1675	0.30	3.0
SWIR-2	1990-2095	0.35	3.0

CO_2 at CO2M resolution

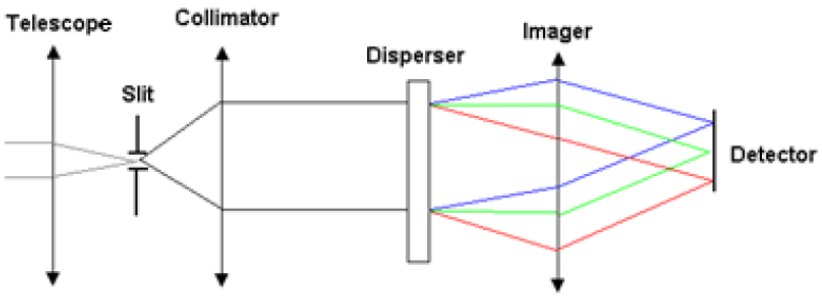


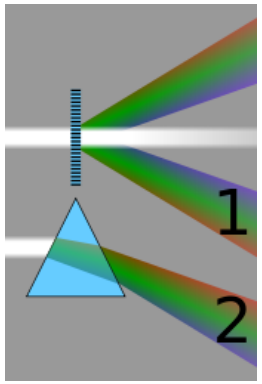
NO_2 at CO2M

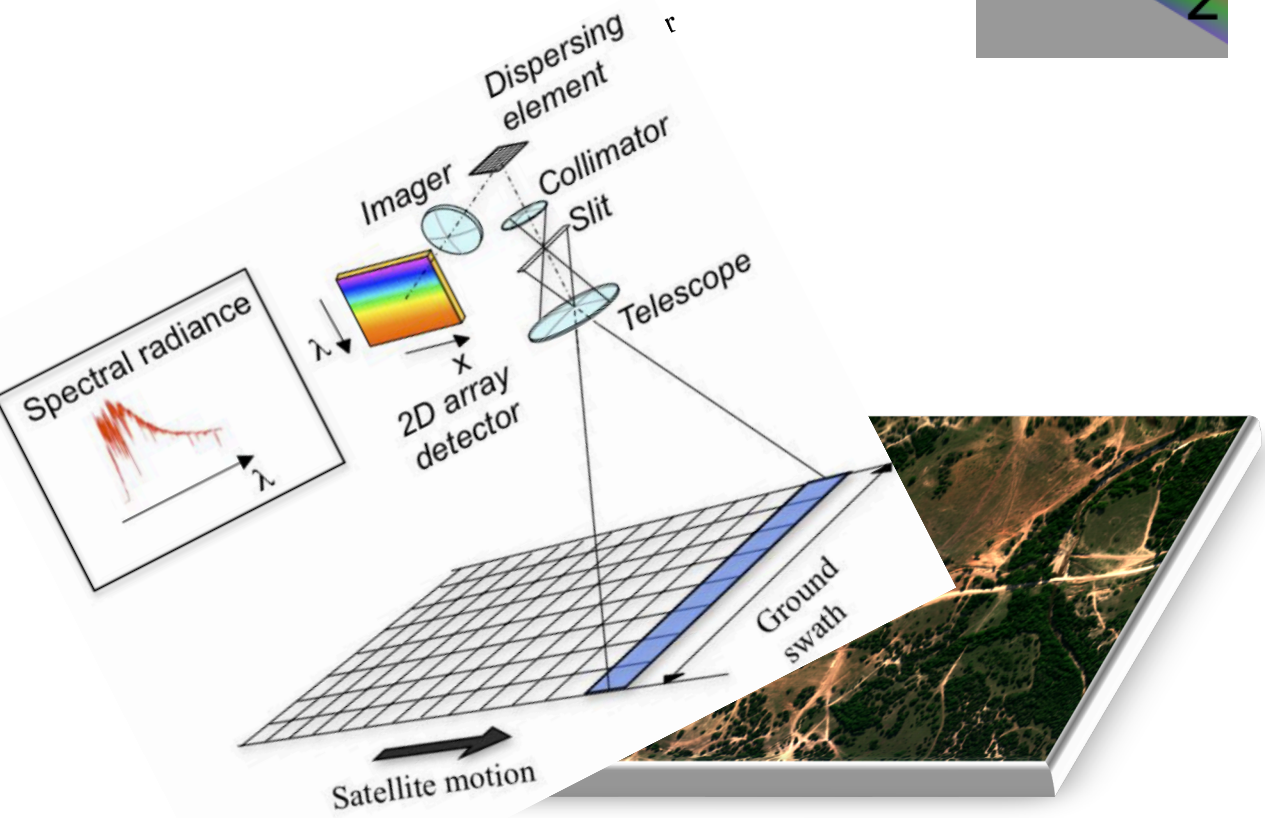


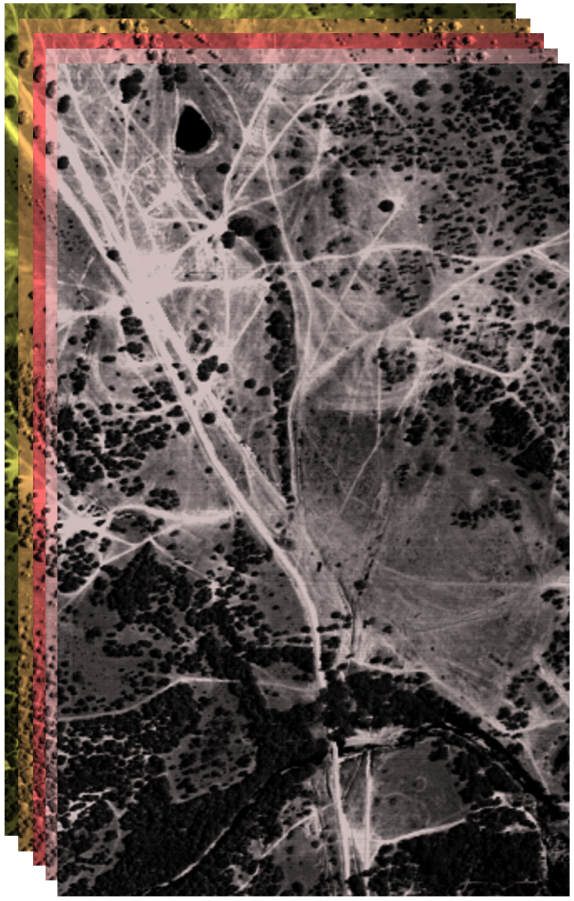
Band	Spectral range [nm]	Spectral resolution	SNR at reference radiance
VIS	405–490	0.6 nm	500

General principle of Push-broom imaging spectrometer

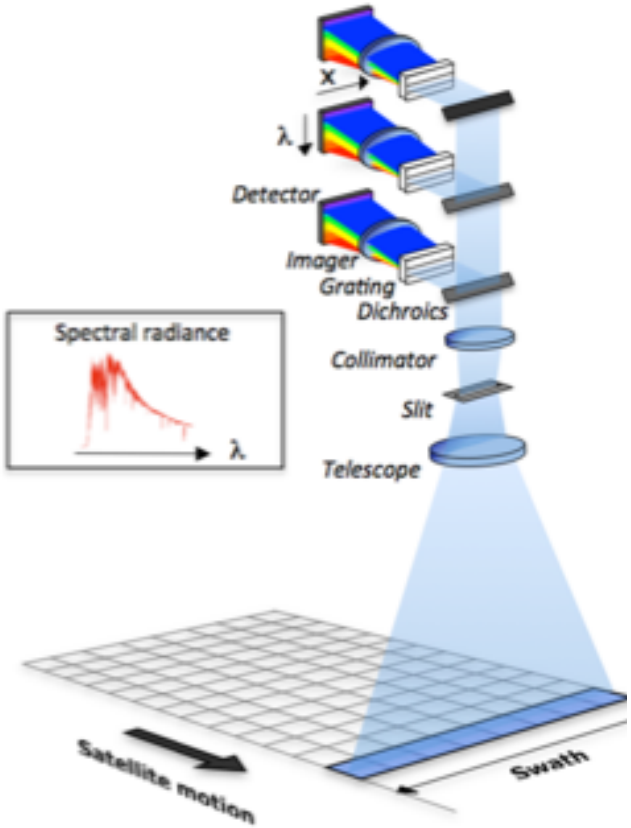




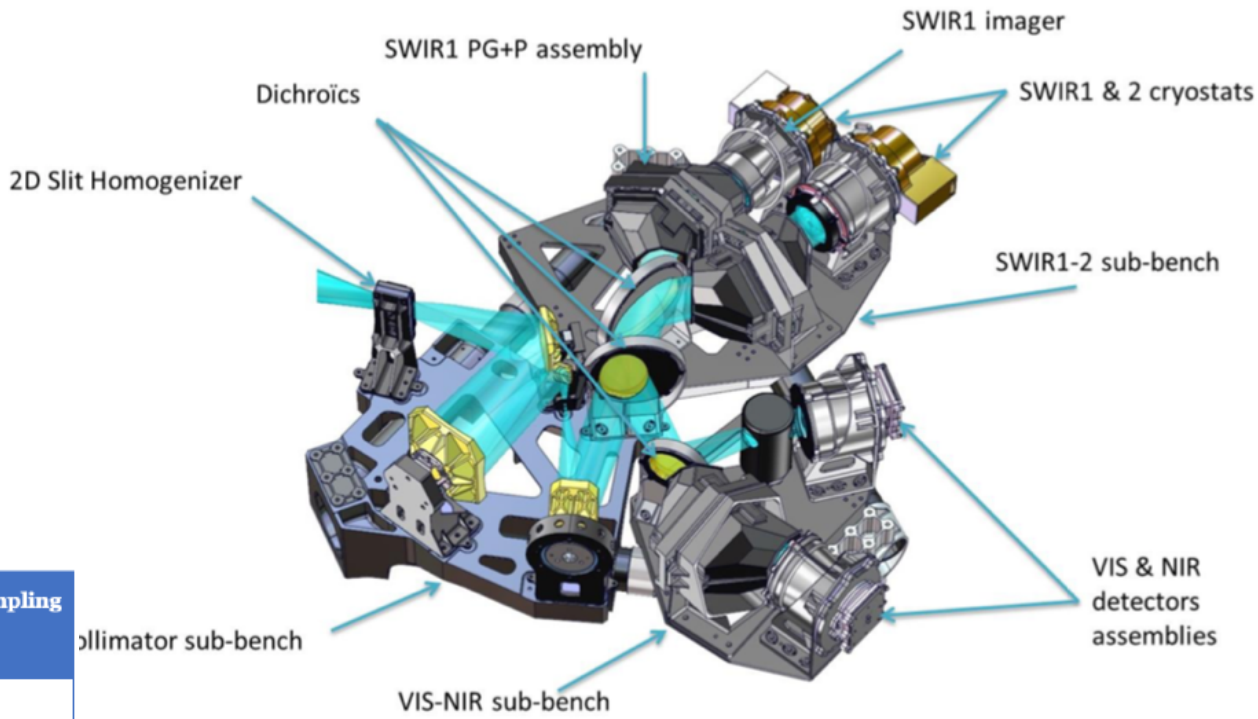




Concept and design of CO2I/NO2I

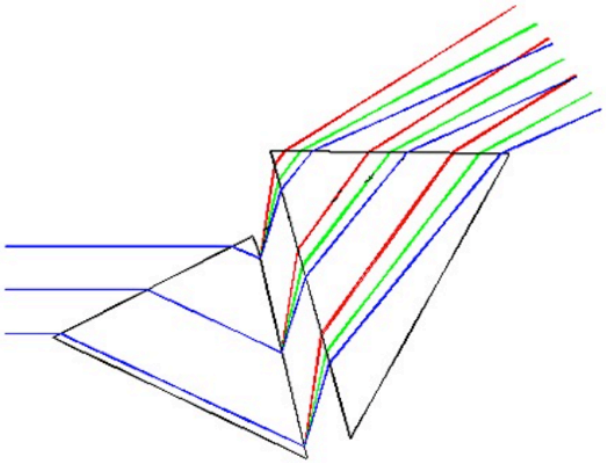


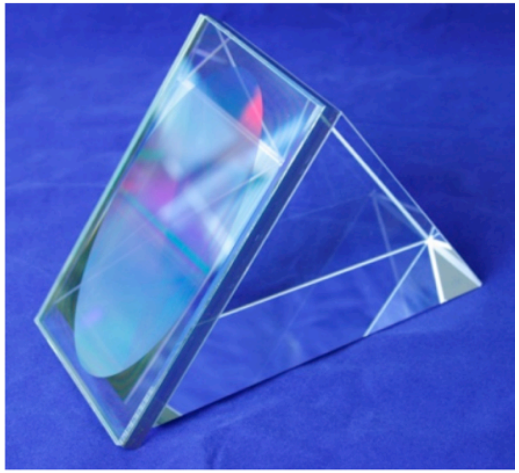
Spectral Band ID	Spectral Range (nm)	Spectral Resolution Δλ (nm)	Spectral Sampling Ratio
VIS	405-490	0.6	3
NIR	747-773	0.12	3
SWIR-1	1590-1675	0.30	3
SWIR-2	1990-2095	0.35	3

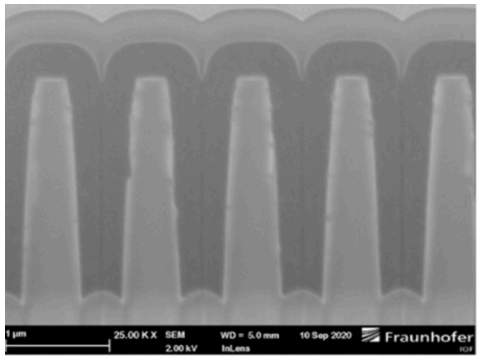


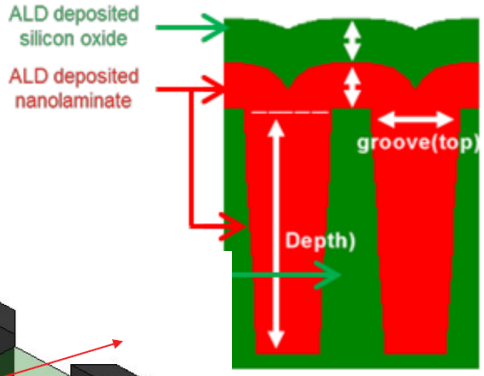
Key technolgies

Diffraction gratings

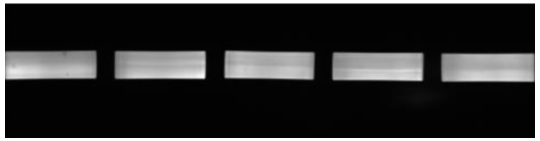


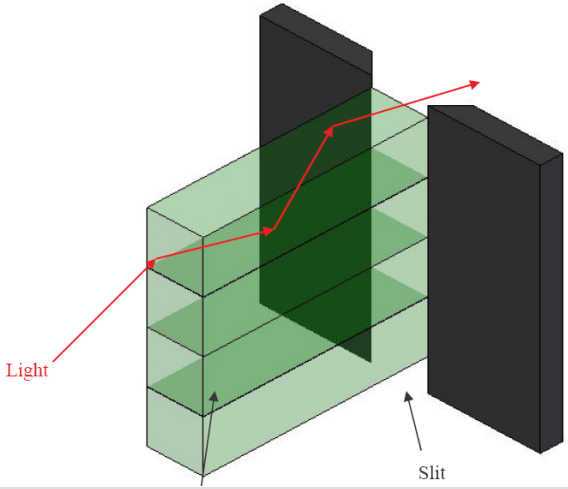






Slit Homogeniser





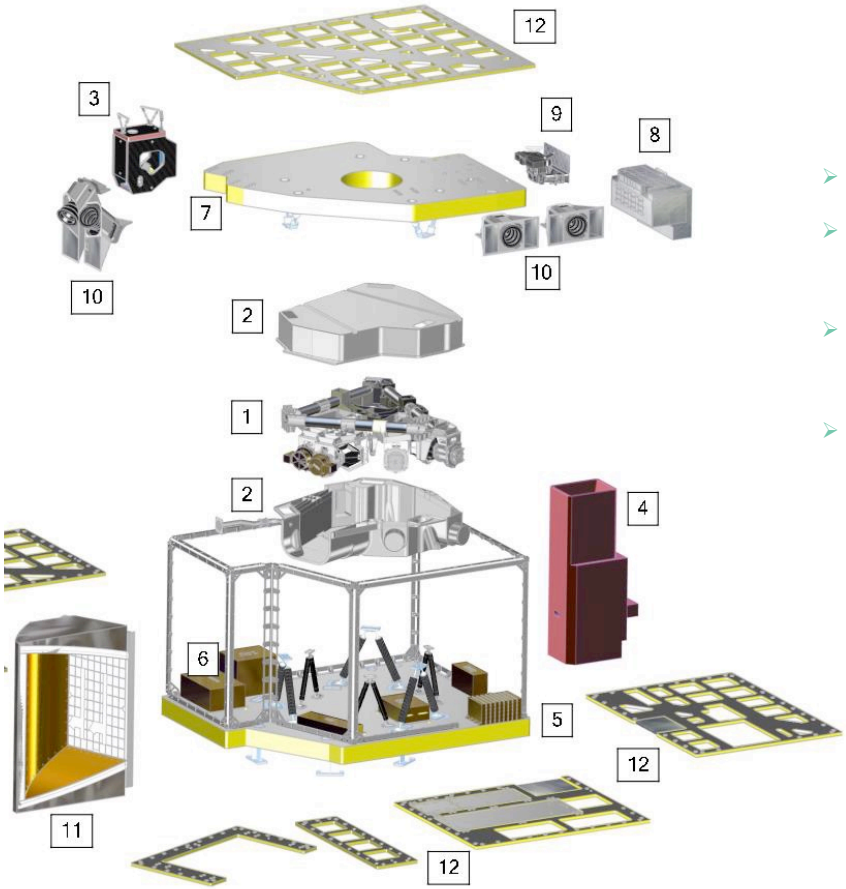
CO2M: Payload design

1) Si3N4 ceramic structure
2) Thermal guard
3) Telescope
4) Flight Calibration Unit

5) Instrument Support Panel
6) Dissipative electronics

7) Ultra Stable Interface Bench
8) MAP
9) CLIM
10) Star trackers

11) Cryogenic passive radiator
12) External housing panels overlayed with MLI



- Triple bench concept
- Thermally stabilised CO2I & MAP instruments & USIB
- CO2I SWIR FPA passively cooled
- Detectors:
  - CO2I VIS & NIR: 2x CIS120 (Te2v)
  - CO2I SWIR: 2x NGP (Lynred)
  - MAP: 4x CIS120 (Te2v)
  - CLIM VNIR: AT71547 (Te2v)
  - CLIM SWIR: Xlin-1.7-3000 (Xenics)

Thank you

Copernicus
Europe's eyes on Earth