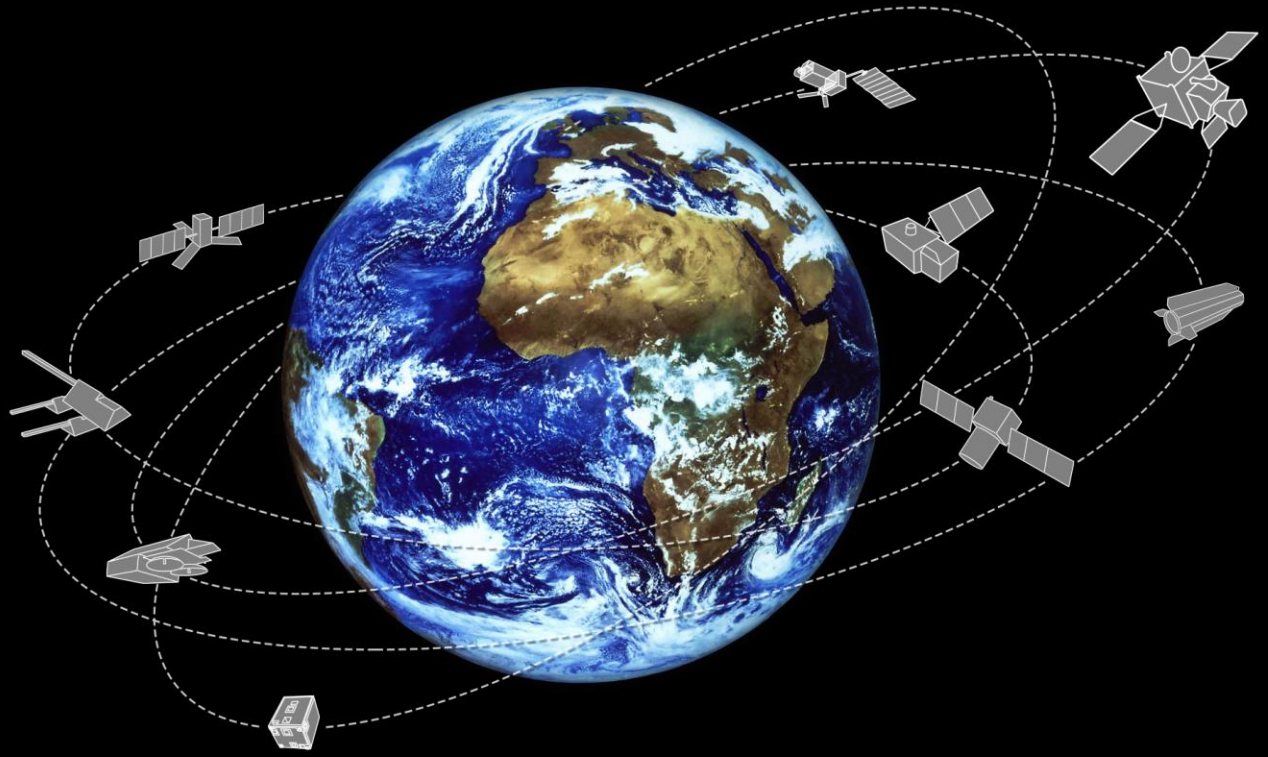


Observing Earth From Space:

Earth Observation Data Across the Copernicus Landscape


esa

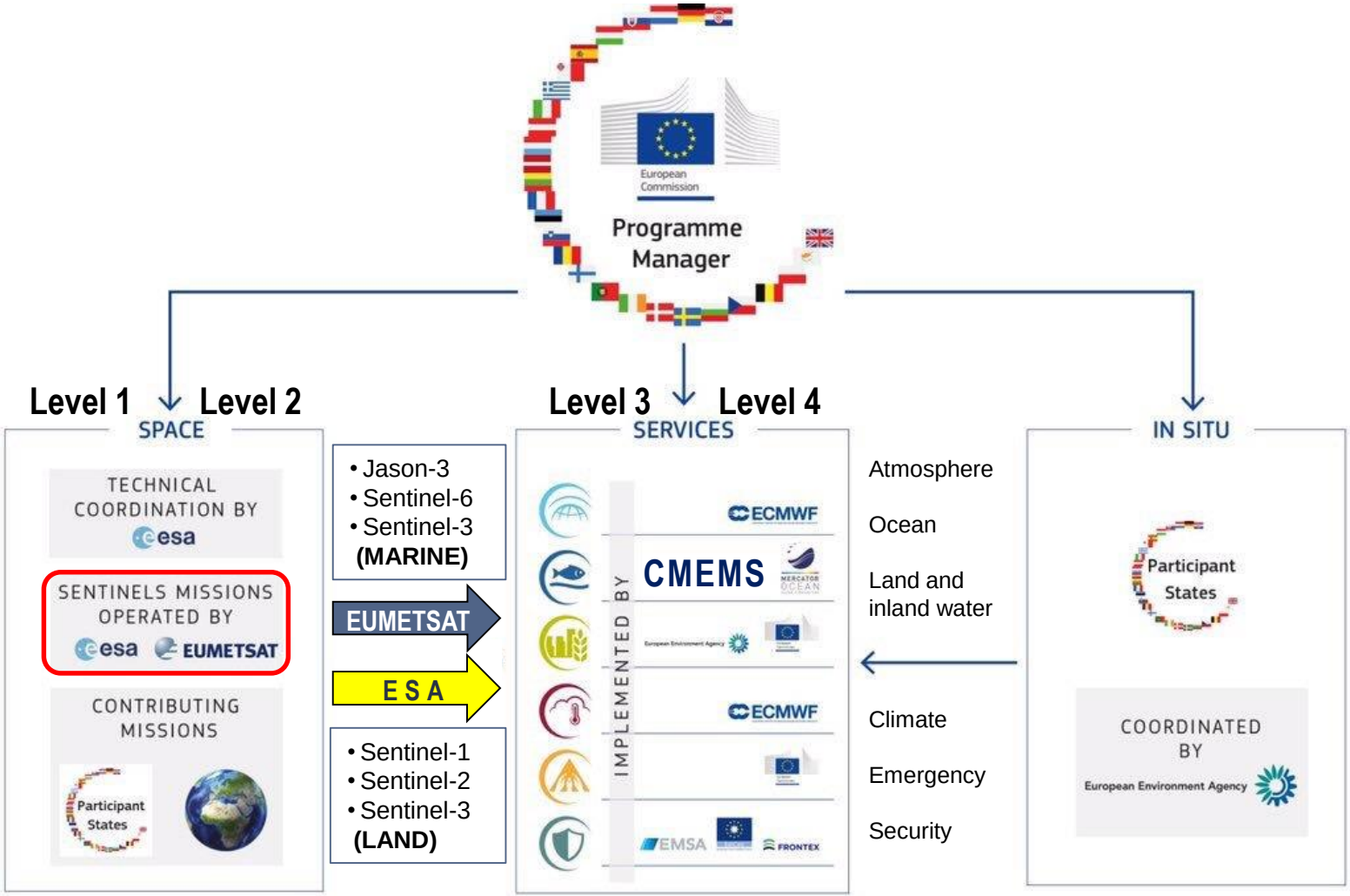
- Active sensor.
- Radar!
- Max ~10 m spatial resolution.
- Terrestrial mission with marine applications.
- Level 1 data, Level 2 products.

- Passive sensor.
- Optical!
- Max 10 m spatial resolution.
- Terrestrial mission with marine applications.
- Level 1C and Level 2 data.

- Mix of passive and active sensors.
- Optical, IR plus radar.
- Best 300 m spatial resolution.
- Primarily marine mission.
- Level 1 data and level 2 data and products.

Copernicus Programme:

- Copernicus is funded and managed by the **European Commission**.
- It has three segments shared by ESA & EUMETSAT:
    1. Space
    2. Services
    3. In situ


European Commission
Programme Manager
Level 1
Level 2
Level 3
Level 4
SPACE
TECHNICAL COORDINATION BY esa
SENTINELS MISSIONS OPERATED BY esa EUMETSAT
CONTRIBUTING MISSIONS
Participant States
• Jason-3
• Sentinel-6
• Sentinel-3
(MARINE)
EUMETSAT
E S A
• Sentinel-1
• Sentinel-2
• Sentinel-3
(LAND)
SERVICES
IMPLEMENTED BY
ECMWF
CMEMS
ECMWF
EMSA
FRONTEX
Atmosphere
Ocean
Land and inland water
Climate
Emergency
Security
IN SITU
Participant States
COORDINATED BY
European Environment Agency

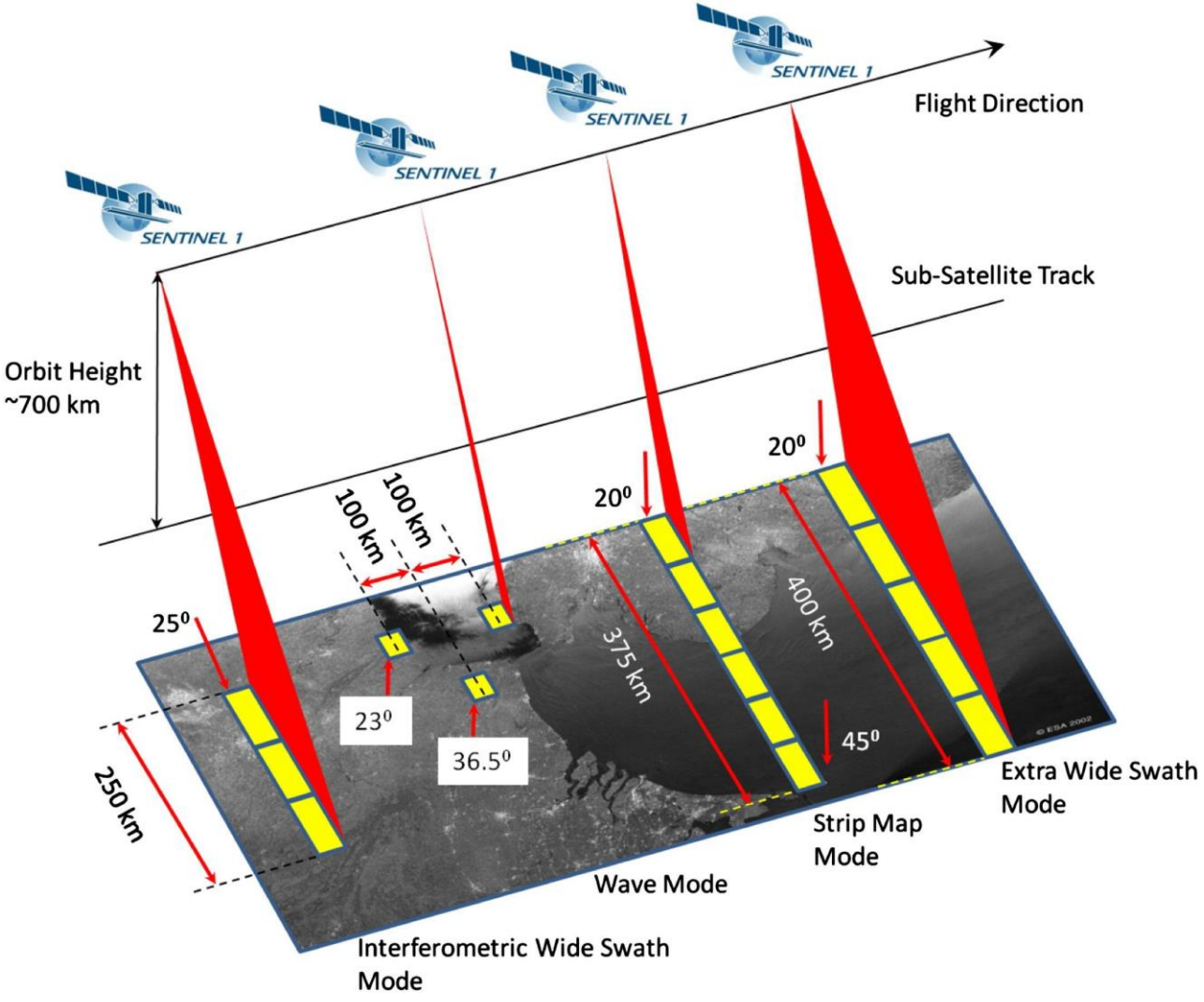

esa

- Sentinel-1A was launched on 3 April 2014, and Sentinel-1B was launched on 25 April 2016.
- Both carry a C-band synthetic-aperture radar instrument, which is an **active** sensor capable of collecting data in most weather, day or night – backscatter.


2011-Aug-31 23:31:02 UTC
Thu 1-Sep
Fri 2-Sep
Sat 3-Sep
Sun 4-Sep
2011-Aug-31 23:32:26
Lat :
Lon :
MLST :
SZA :
Range : 8650.5 km
Altitude : 9367.9 km
N
W
E
S
Sentinel-1A

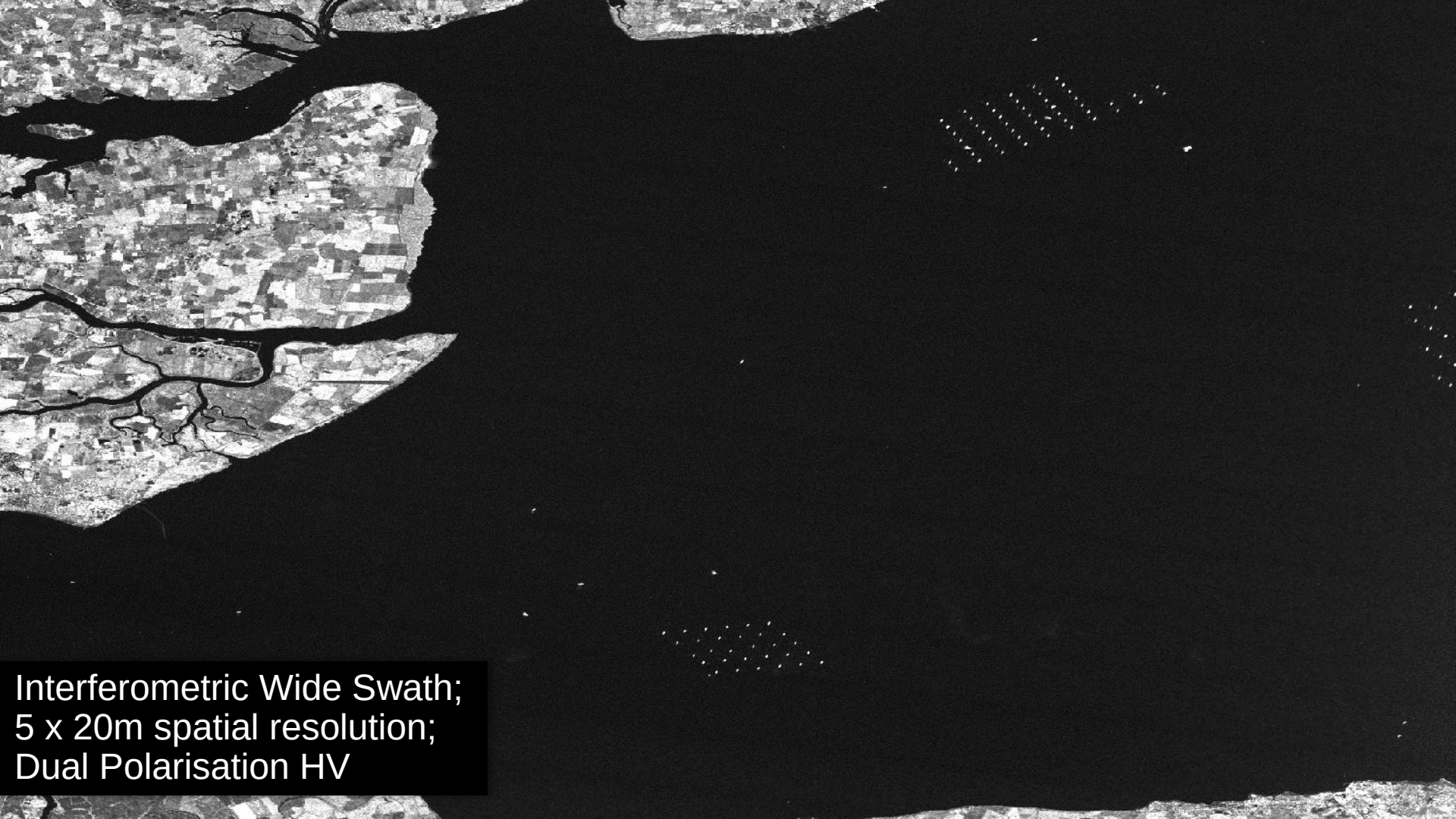
Sentinel-1 operates in four acquisition modes:

1. Stripmap (SM) mode acquires data with an 80 km swath at slightly better than 5 m x 5 m spatial resolution (single look) - used to image small islands and in exceptional cases only, to support emergency response.
2. Interferometric Wide swath (IW) mode acquires data with a 250 km swath at 5 m x 20 m spatial resolution (single look) - main acquisition over land.
3. Extra-Wide swath (EW) mode acquires data over a 400 km swath at 20 m x 40 m spatial resolution - primarily used over the poles to **measure ice**, but also over maritime zones for oil spill monitoring and security services.
4. Wave (WV) mode uses a 'leap-frog' acquisition pattern to acquire data in 20 km by 20 km 'vignettes', at 5 m by 5 m spatial resolution every 100 km along the orbit - default mode for acquiring data over the open ocean.

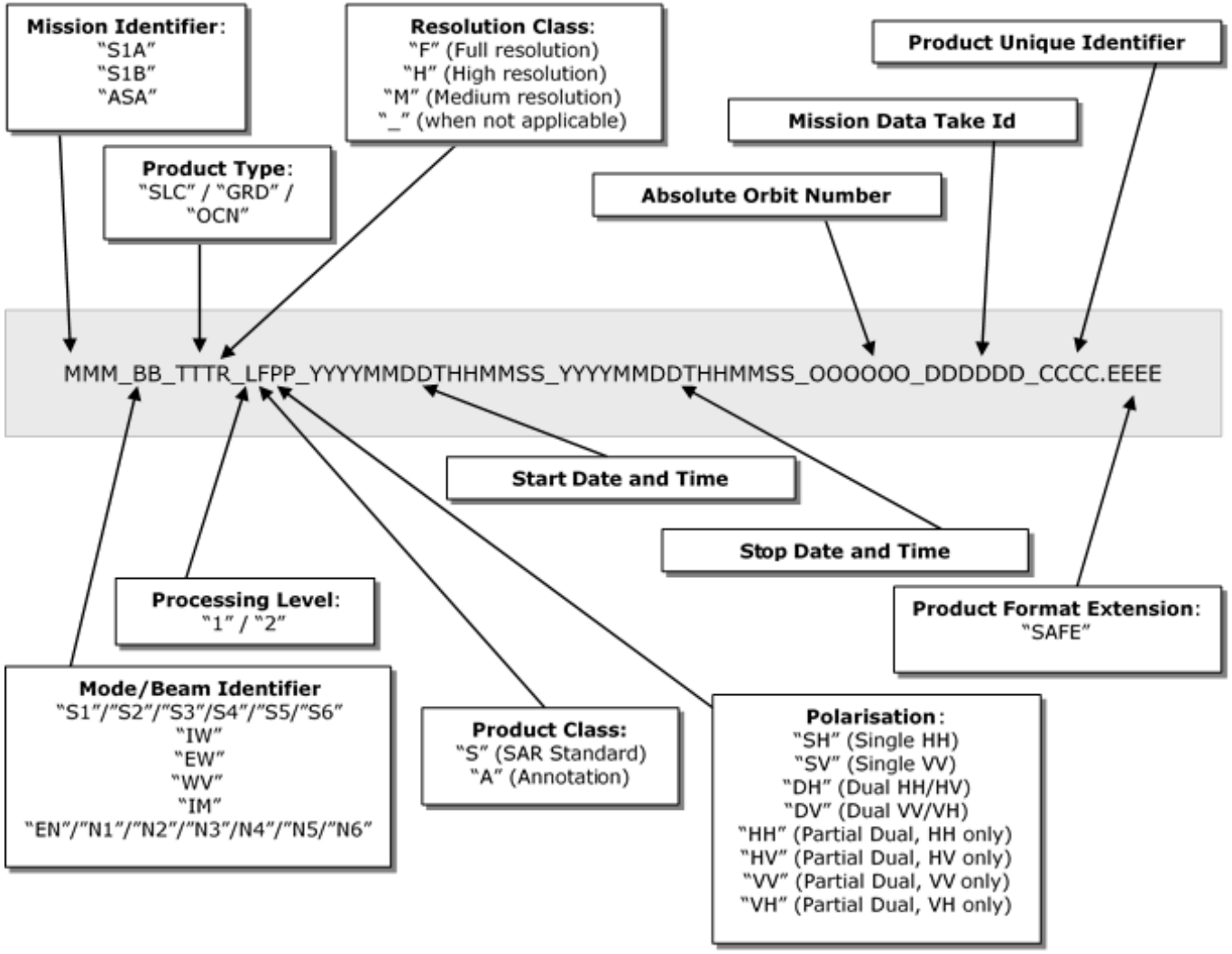

SENTINEL 1
SENTINEL 1
SENTINEL 1
SENTINEL 1
Flight Direction
Sub-Satellite Track
Orbit Height
~700 km
20⁰
20⁰
100 km
100 km
25⁰
23⁰
36.5⁰
375 km
400 km
45⁰
250 km
Extra Wide Swath
Mode
Strip Map
Mode
Wave Mode
Interferometric Wide Swath
Mode

Sentinel-1 for marine monitoring:

- Vessel detection and monitoring – objects including boats, rigs, and turbines are bright spots on a dark background.
- Oil spill detection and polluter identification – illegal discharges of oil are visible in SAR imagery.
- Wind / wave information – vital for maritime safety and rescue operations, measurements can be extracted directly from SAR surface roughness.
- Sea-ice and iceberg monitoring – covers safety of shipping / offshore operations, climate monitoring.


Interferometric Wide Swath;
5 x 20m spatial resolution;
Dual Polarisation HV


Interferometric Wide Swath;
5 x 20m spatial resolution;
Single Polarisation VV


Mission Identifier:
"S1A"
"S1B"
"ASA"
Resolution Class:
"F" (Full resolution)
"H" (High resolution)
"M" (Medium resolution)
"_" (when not applicable)
Product Unique Identifier
Mission Data Take Id
Product Type:
"SLC" / "GRD" /
"OCN"
Absolute Orbit Number
MMM_BB_TTTR_LFPP_YYYYMMDDTHHMMSS_YYYYMMDDTHHMMSS_OOOOOO_DDDDDD_CCCC.EEEE
Start Date and Time
Stop Date and Time
Processing Level:
"1" / "2"
Product Format Extension:
"SAFE"
Mode/Beam Identifier
"S1"/"S2"/"S3"/S4"/"S5/"S6"
"IW"
"EW"
"WV"
"IM"
"EN"/"N1"/"N2"/"N3"/N4"/"N5/"N6"
Product Class:
"S" (SAR Standard)
"A" (Annotation)
Polarisation:
"SH" (Single HH)
"SV" (Single VV)
"DH" (Dual HH/HV)
"DV" (Dual VV/VH)
"HH" (Partial Dual, HH only)
"HV" (Partial Dual, HV only)
"VV" (Partial Dual, VV only)
"VH" (Partial Dual, VH only)

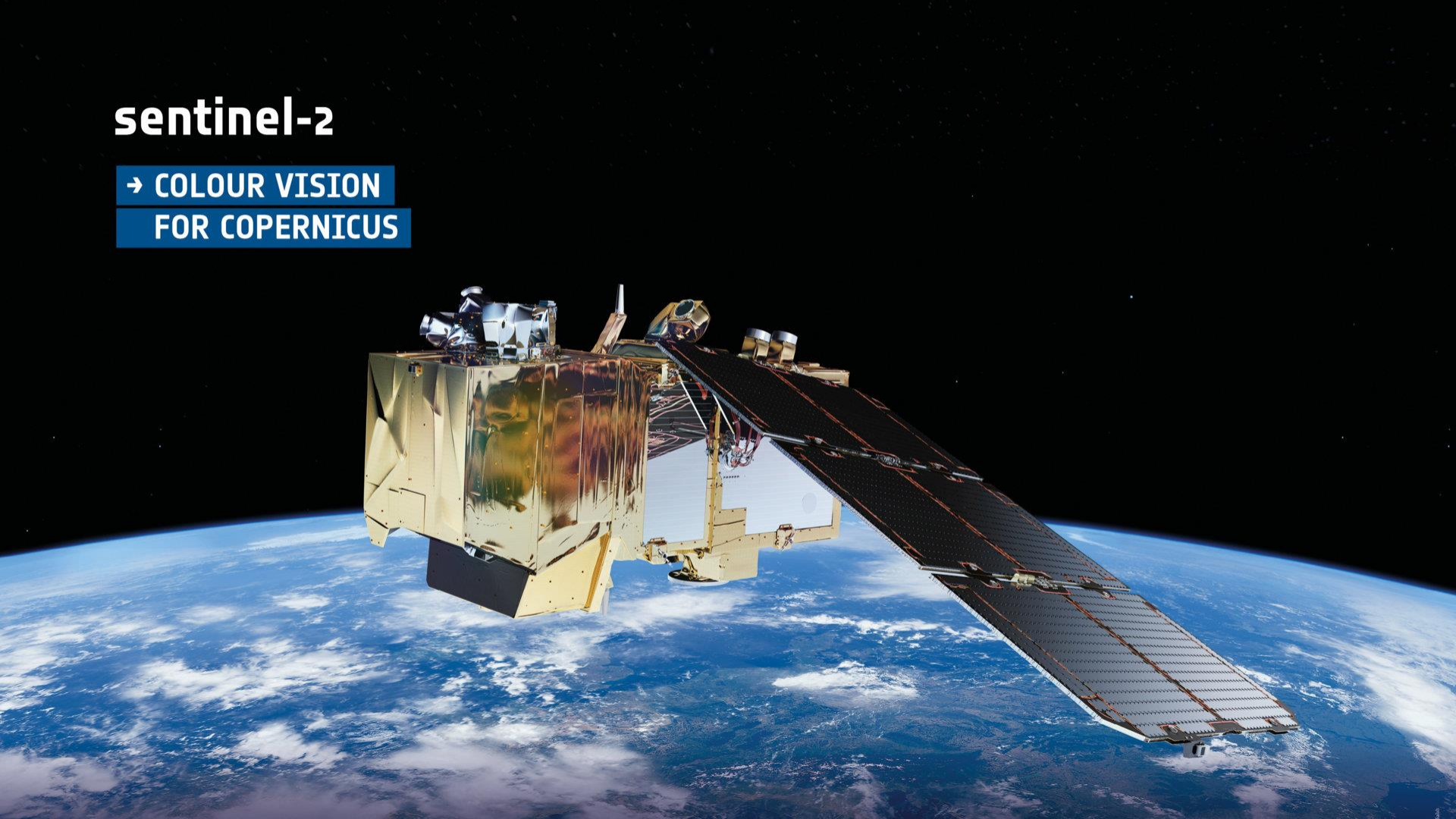
S1A_IW_GRDH_1SDV_20201013T131247_20201013T131312_034778_040D7A_8E39.SAFE

S1A_
IW_
GRDH_
1SDV_
20201013T131247_
20201013T131312_
034778_040D7A_8E39
.SAFE


Rafts of pumice
Late Island,
Tonga

sentinel-2

→ COLOUR VISION
FOR COPERNICUS



Sentinel-2 Multispectral Instrument (MSI)

- Unlike Sentinel-1, the Multi-Spectral Instrument (MSI) aboard Sentinel-2 is passive; exploiting sunlight reflected from the Earth's surface.
- Optical data is acquired along the orbital path at high spatial resolution (10 m, 20 m and 60 m) over land and adjoining coastal waters.
- The Sentinel-2 mission is also a constellation with two satellites (A and B) in orbit – same as Sentinel-1 and Sentinel-3.
- Why have Copernicus (ESA and EUM) taken this approach?

Sentinel-2 Multispectral Instrument (MSI)

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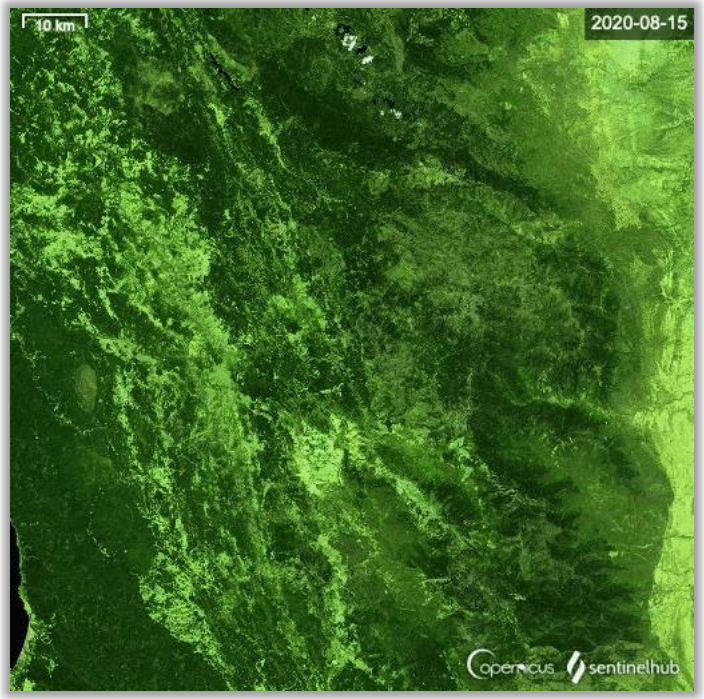
- Why have Copernicus (ESA and EUM) taken this approach?

Sentinel-2 MSI

- Sentinel-2 mostly a terrestrial focused mission with priorities around land monitoring, land cover classification, security and emergency management.
- The MSI is sensor not ideal for marine applications:
  - few, wide bands
  - low signal to noise ratio.

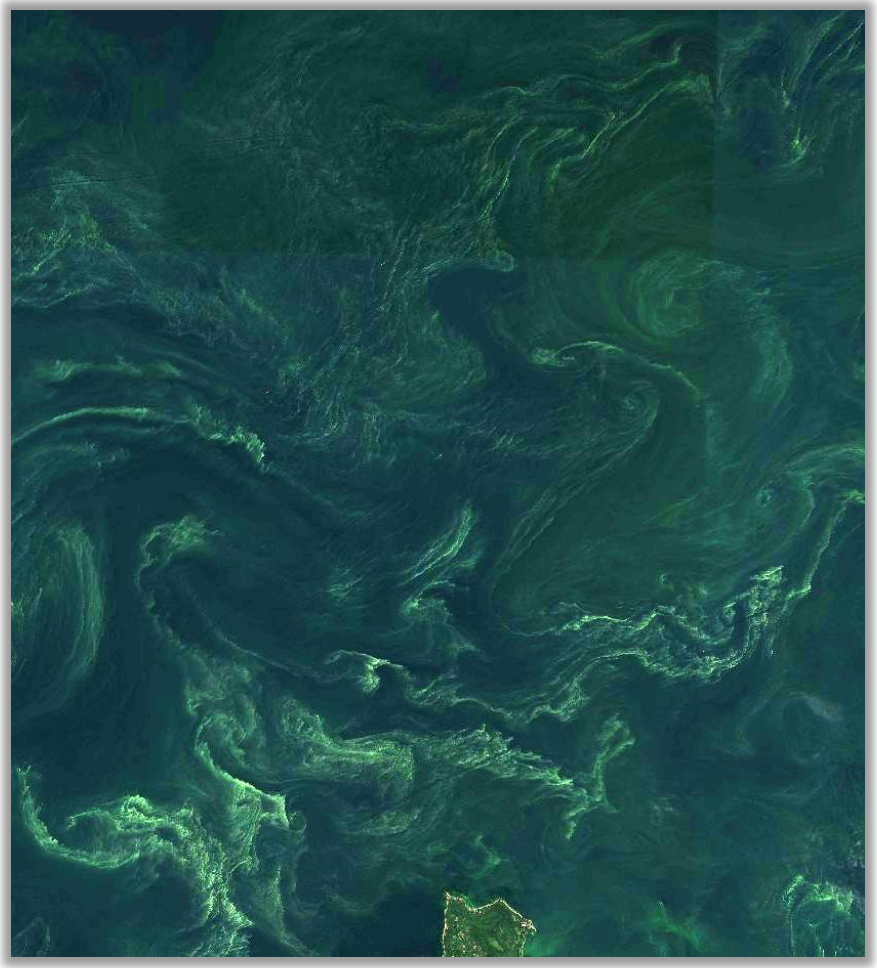


MSI False Colour: SWIR2, SWIR1, Red

Sentinel-2 MSI

Despite this, Sentinel-2 is useful for monitoring the coastal environment, including for:

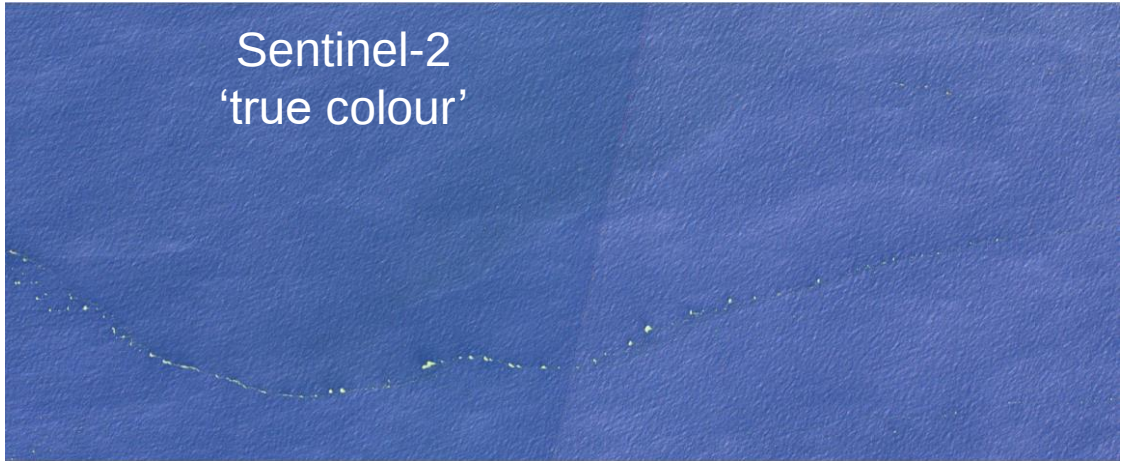
- Observing blooms
- Monitoring water quality
- Retrieving measures of turbidity
- Detecting floating debris

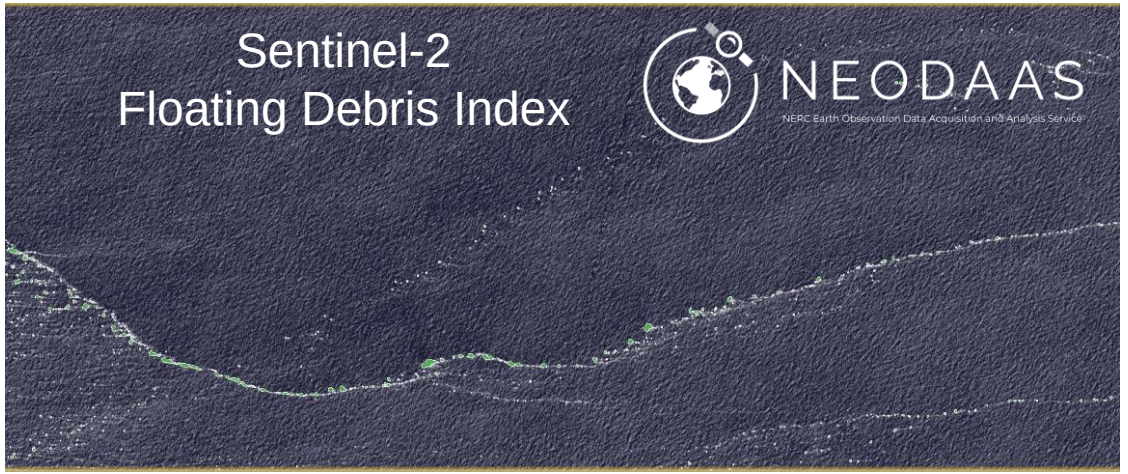



Cagnes-sur-Mer
Baie des Anges

Macroalgae

- Sargassum seaweed is increasingly widespread.
- Floating ‘rafts’ can be up to seven meters deep.





sentinel-3

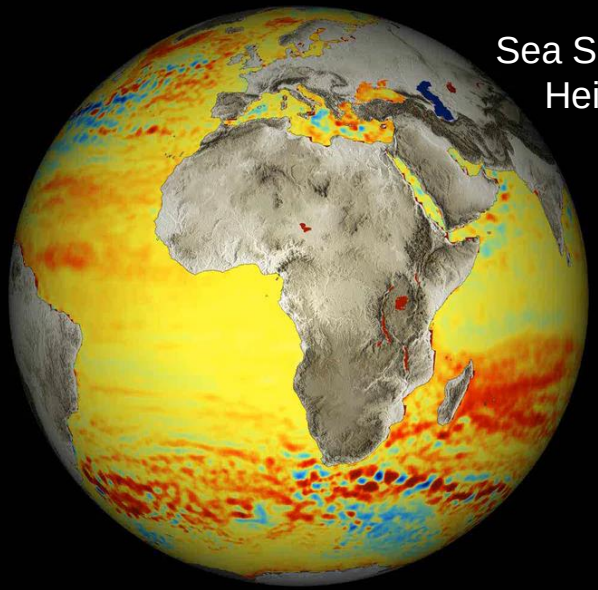
→ A BIGGER PICTURE FOR COPERNICUS

copernicus
Europe's eyes on Earth

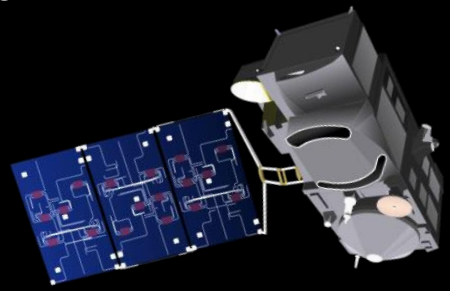
Sentinel-3: Marine

- Sentinel-3 is the **'Blue Sentinel'** thanks to its suite of ocean observing instruments.

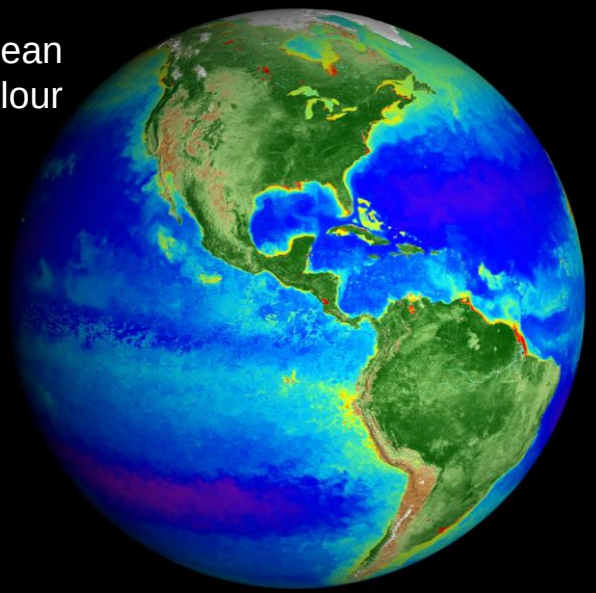
1. The mission's main objective is to deliver sea-surface topography, sea-surface temperature and ocean colour.
2. Two-day global coverage of optical data (constellation).



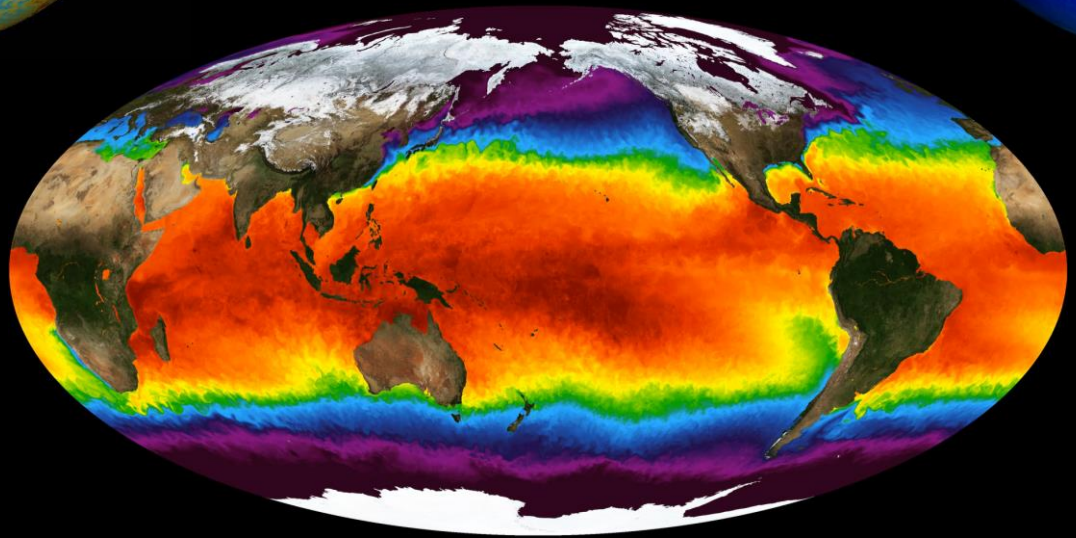
Sea Surface Height



Ocean Colour

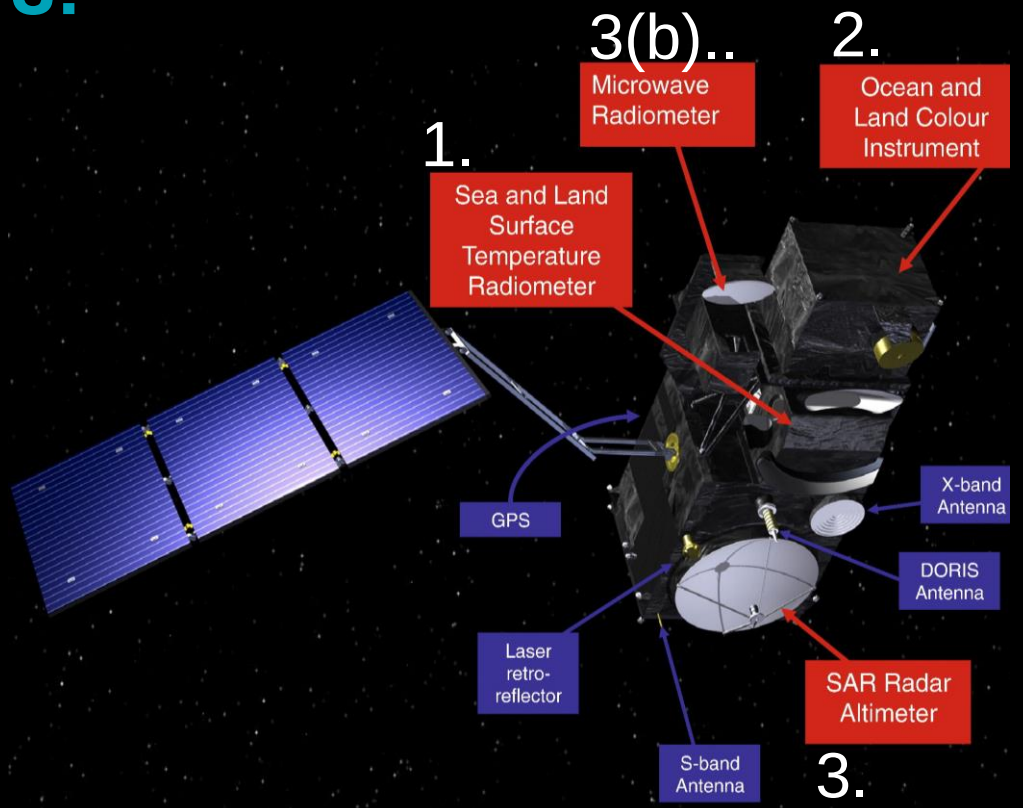


Sea Surface Temperature



EUMETSAT Sentinel-3:

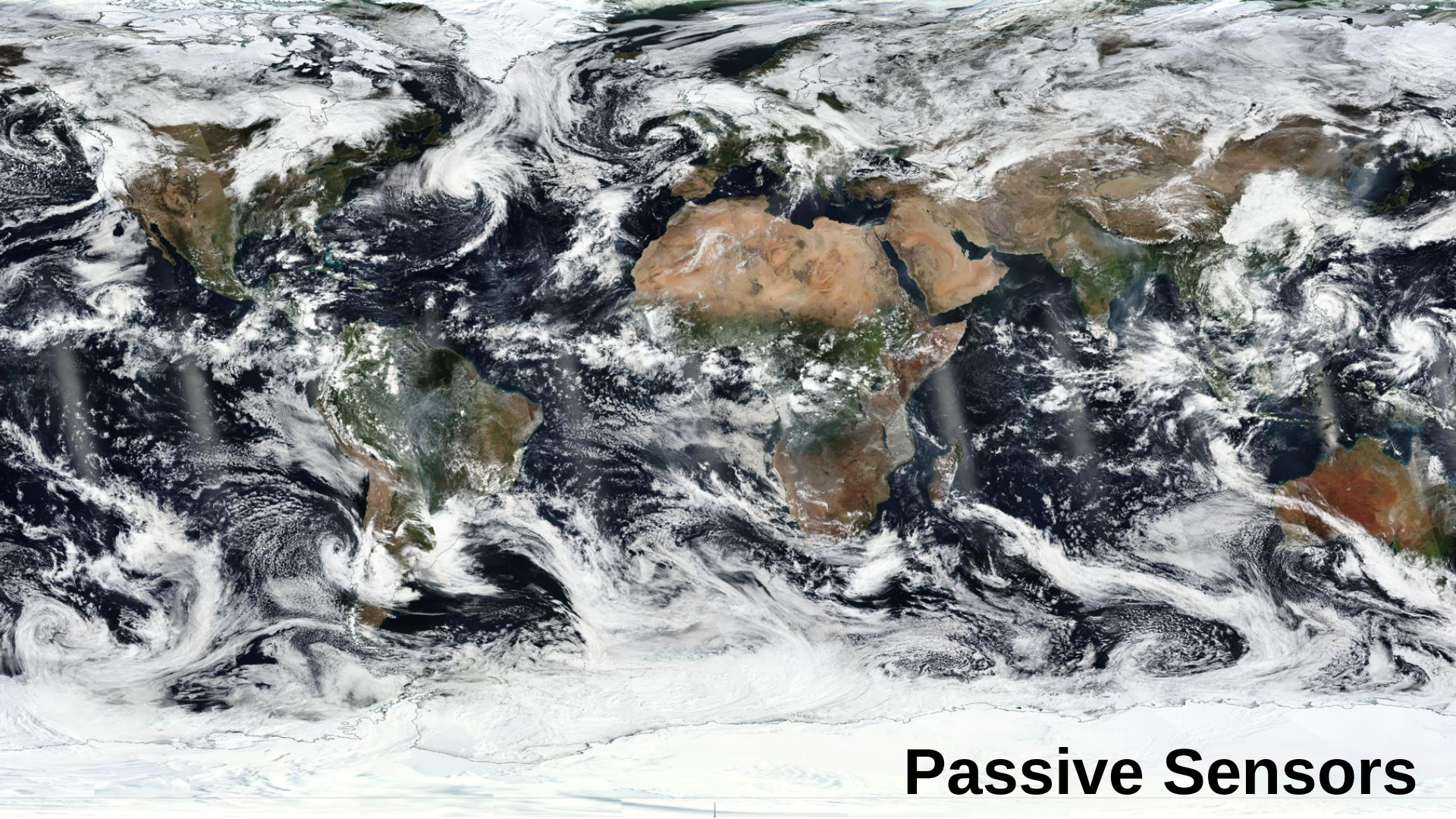
- Sentinel-3 has 3 EO data sensors:
  1. SLSTR (SST)
  2. OLCI (Ocean Colour)
  3. SRAL (Altimetry)
- Sentinel-3A launched Feb 2016 and Sentinel-3B launched April 2018.
- EUMETSAT Marine Centre operates Sentinel-3 satellites.
- Also conducts marine data processing and dissemination.



- Spectral resolution: 21 spectral bands from visible into SWIR.
- Good Signal to Noise Ratio (SNR) for ocean applications.
- Push-broom imaging spectrometer with 5 cameras.

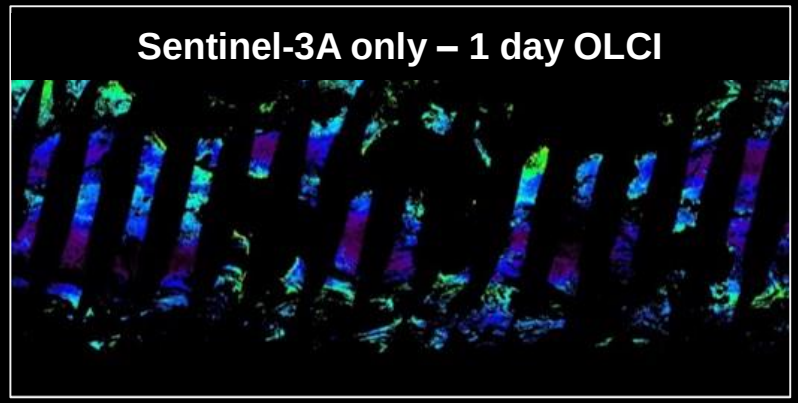
OLCI ocean colour Instrument:

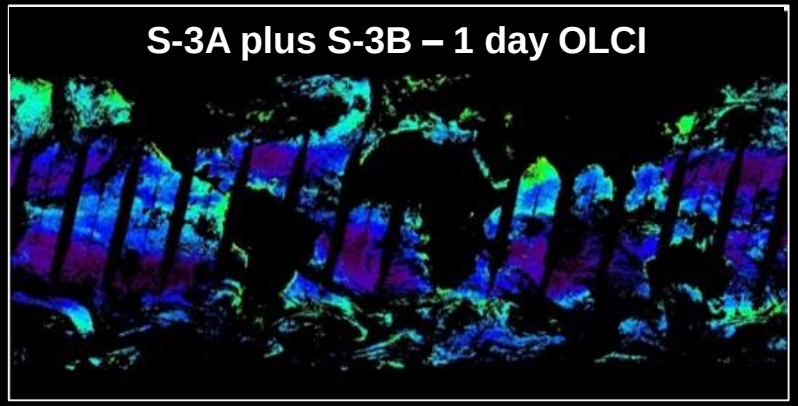
- Swath width: 1 270 km.
- Spatial resolution: 300m full resolution (FR) granules, 1km reduced resolution (RR).

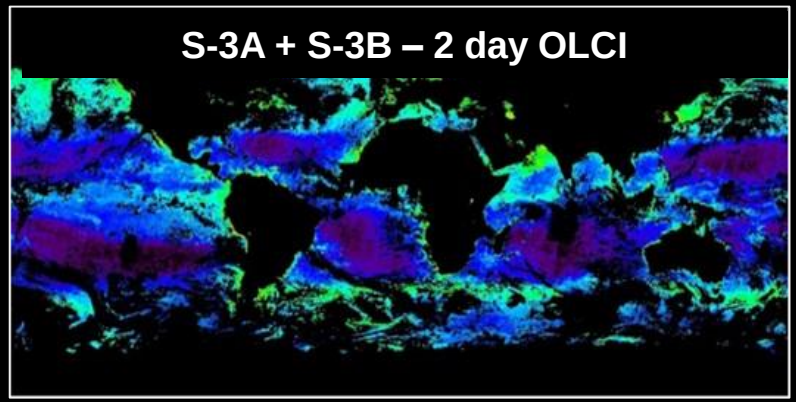


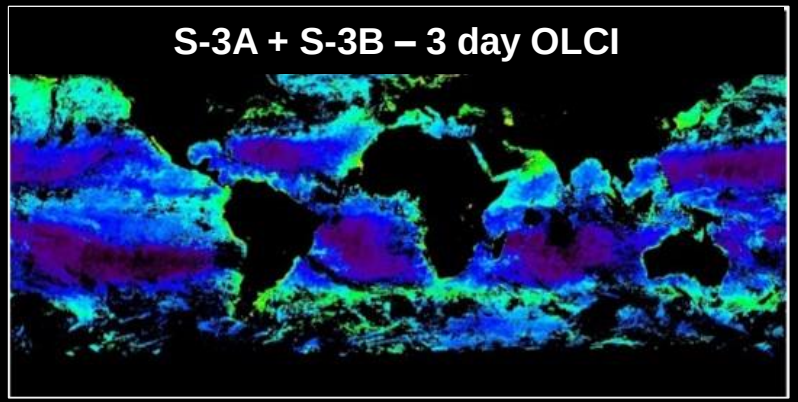
Passive Sensors

The Sentinel-3A & S-3B constellation:

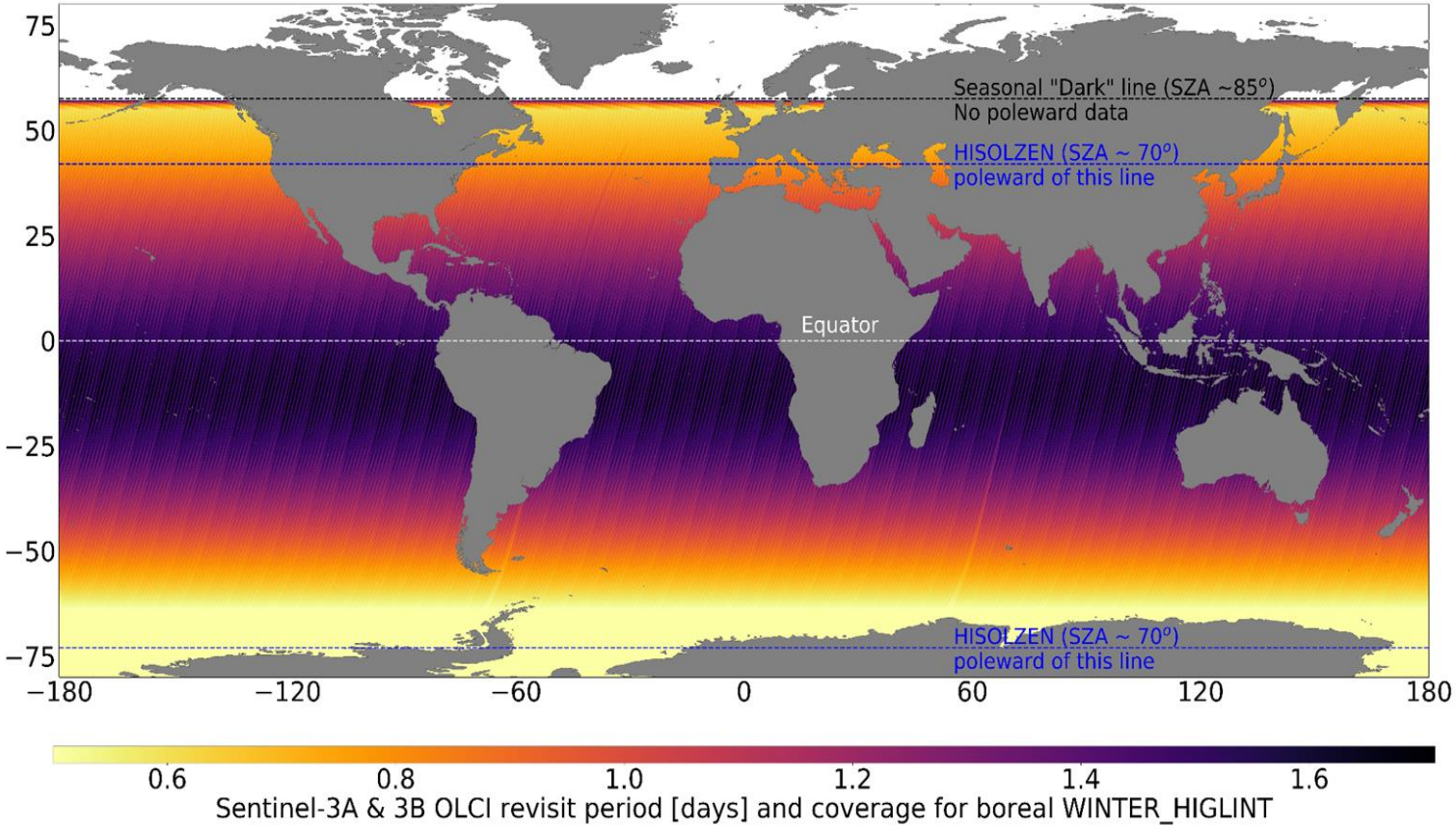








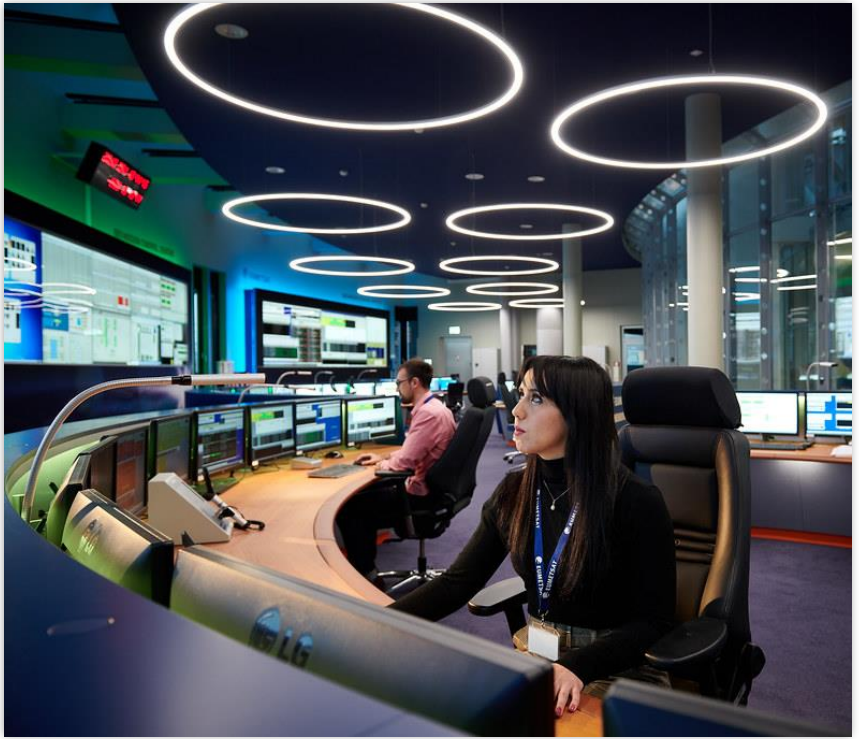
Coverage maps:
Ocean Colour Sentinel-3A and S-3B (NH winter)



EUMETSAT Copernicus Marine Data Service

Global Level 1 and Marine Level 2 data

- Daily, highest resolution (sensor specific, native)
- NRT/STC/NTC
- Level 1 allows for the user to implement custom processing
- Level 2 - geophysical products provided as standard

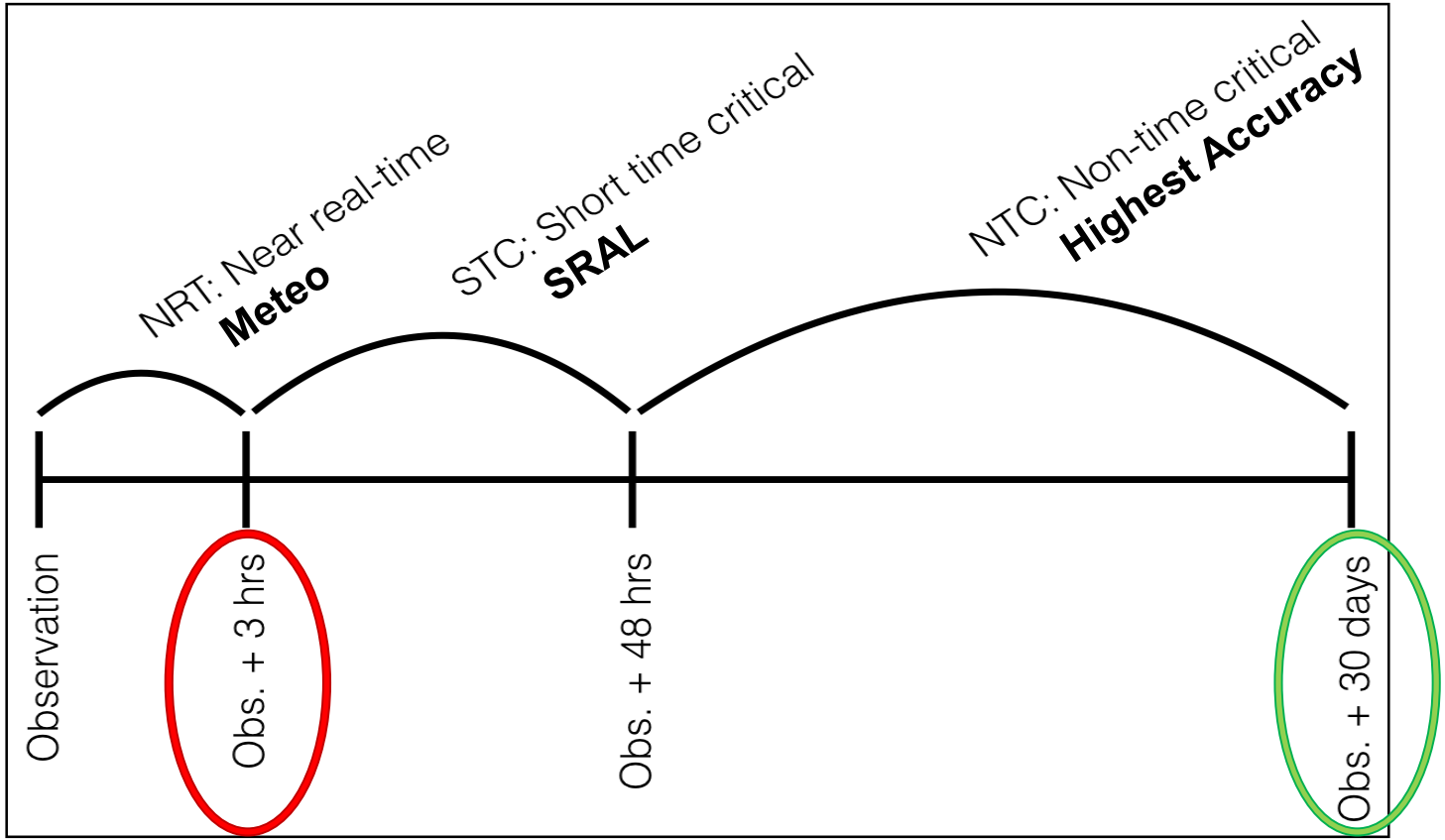


Processing Levels

Processing Level	Description
Level 0	Reconstructed, unprocessed instrument and payload data at full resolution, with communications artefacts removed.
Level 1	Reconstructed, unprocessed instrument data at full resolution, time-referenced, and annotated with ancillary information.
Level 2	Derived geophysical variables at the same resolution and location as Level 1 source data. Often involves atmospheric correction.
Level 3	Variables mapped on uniform space-time grid scales, usually with some completeness and consistency. Except topography (L4)
Level 4	Model output or results from analyses of lower-level data (e.g., variables derived from multiple measurements).

NOTE: There are differences in how parts of the remote sensing community define processing levels.

Timeliness


NRT: Near real-time
Meteo
STC: Short time critical
SRAL
NTC: Non-time critical
Highest Accuracy
Observation
Obs. + 3 hrs
Obs. + 48 hrs
Obs. + 30 days

File formats for EUMETSAT Copernicus marine data

SAFE Format: Folder with NetCDF data files and manifest

MMM_SS_L_TTTTTT_YYYYMMDDTHHMMSS_YYYYMMDDTHHMMSS__YYYYMMDDTHHMMSS_<instance ID>_GGG_<class id>.<extension>

MMM	Mission ID (e.g. S3A for Sentinel-3A)
SS	Data Source (e.g. OL/SL/SR for OLCI/SLSTR/SRAL)
L	Processing level (e.g. 0/1/2 or '_' if not applicable)
TTTTTT	Data type ID. -> OLCI, L1: EFR___ ERR___ L2: WFR__ WRR___ -> SLSTR, L1: RBT___, L2: WST___ -> SRAL: L1: SRA___, SRA_A_, SRA_BS, L2: WAT___
YYYYMMDDTHHMMSS	Sensing period start time
YYYYMMDDTHHMMSS	Sensing period stop time
YYYYMMDDTHHMMSS	Product creation date
<instance ID>	DDDD_CCC_LLL_FFFF_ where DDDD is the sensing time interval (in seconds) CCC is the cycle number and LLL is the relative orbit number, FFFF frame along-track coordinate (only for frames/granules) Product generating center (e.g. MAR for MARINE, EUMETSAT)
GGG	Indicates processing system. e.g. X_YY_NNN
<class id>	XX: software platform, O/F/D/R: operational/reference/dev/reprocessing) YY: timeliness (NR/NT/ST: for NRT, NTC and STC) NNN: baseline collection (001).
<extension>	.SEN3

Example:

S3A_OL_2_WFR____20191012T014724_20191012T015024_20191012T035326_0179_050_174_2340_MAR_O_NR_002.SEN3

S3A_OL_2_WFR____20191012T014724_20191012T015024_20191012T035326_0179_050_174_2340_MAR_O_NR_002.SEN3

S3A_
OL_
2_
WFR____
20191012T014724_
20191012T015024_
20191012T035326_
0179_050_174_2340_MAR_O_NR_002
.SEN3

Data Access:

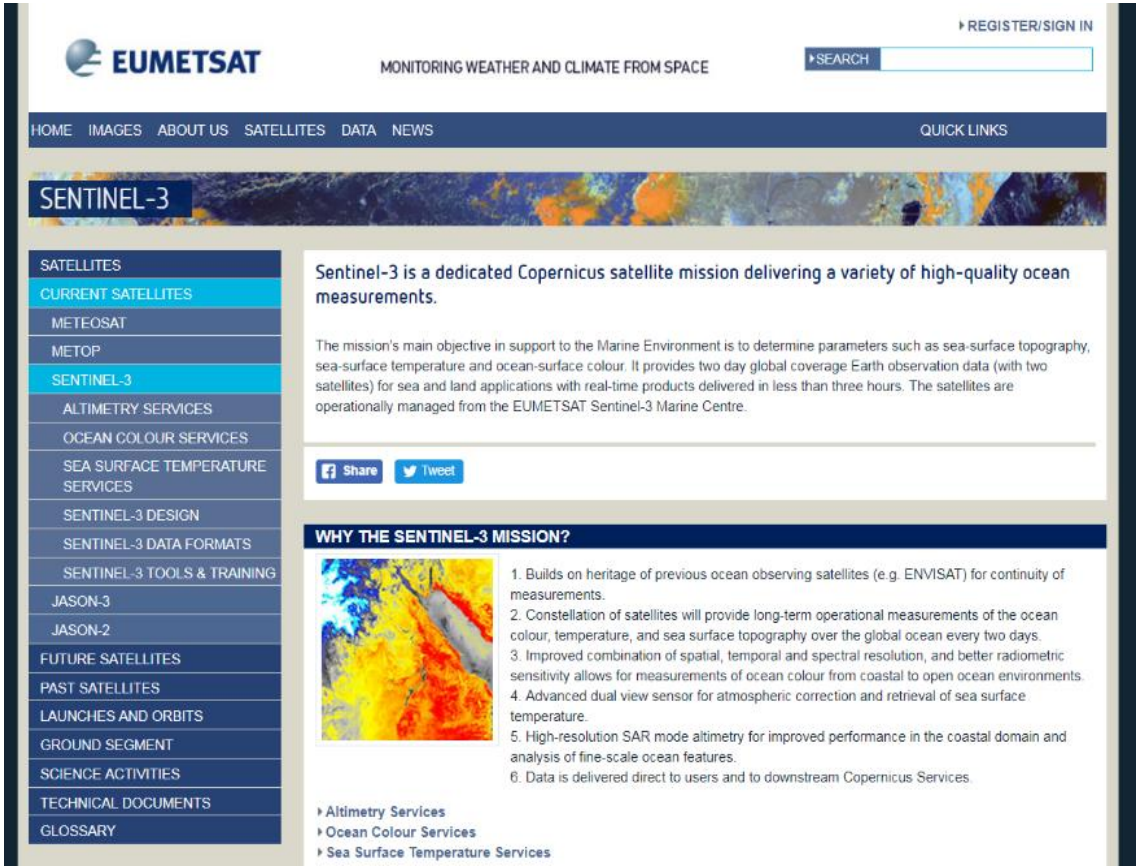
Single sign on registration for all online services at **https://eoportal.eumetsat.int**

	EUMETView eumetview.eumetsat.int	• Get a quick look at recent coverage from the Sentinel 3 instruments, download image files, and make animations.
	CODA coda.eumetsat.int	• Download service offers all the recently acquired Sentinel-3 marine and atmospheric products through a rolling dataset that (at a maximum) spans 12 months. • A separate instance of CODA exists for reprocessed data at codarep.eumetsat.int
	Data Centre Long-Term Archive archive.eumetsat.int	• Ordering application that enables users to browse and select products from EUMETSAT's long-term archive • Includes all the Copernicus Sentinel-3 marine and atmospheric products.
	EUMETCAST	• EUMETCast is a multi-service push dissemination system based on multicast technology. • The multicast stream is transported to the user via satellite or terrestrial networks.
	WEkEO	• WEkEO is one of the Copernicus Data Information and Access Services (DIAS), and is coordinated by EUMETSAT, ECMWF and Mercator Ocean. • It is currently open for beta testing here: https://www.wekeo.eu/

More information!

Detailed information is available through the EUMETSAT dedicated Sentinel-3 web pages:

- ✓ Product Handbooks
- ✓ Algorithm Theoretical Basis Documents
- ✓ Product notices



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Find all training | Apply for Courses | Go to Class | Register

Resources

MSG Interpretation Guide
SatManu
EUMeTrain Resources
EUMETSAT Training Library

Software: McIDAS-V

Learn at your own pace

EUMeTrain produces self-paced learning resources.

We work with the COMET program to produce self-paced, free to use learning resources. Register on the MetEd site.

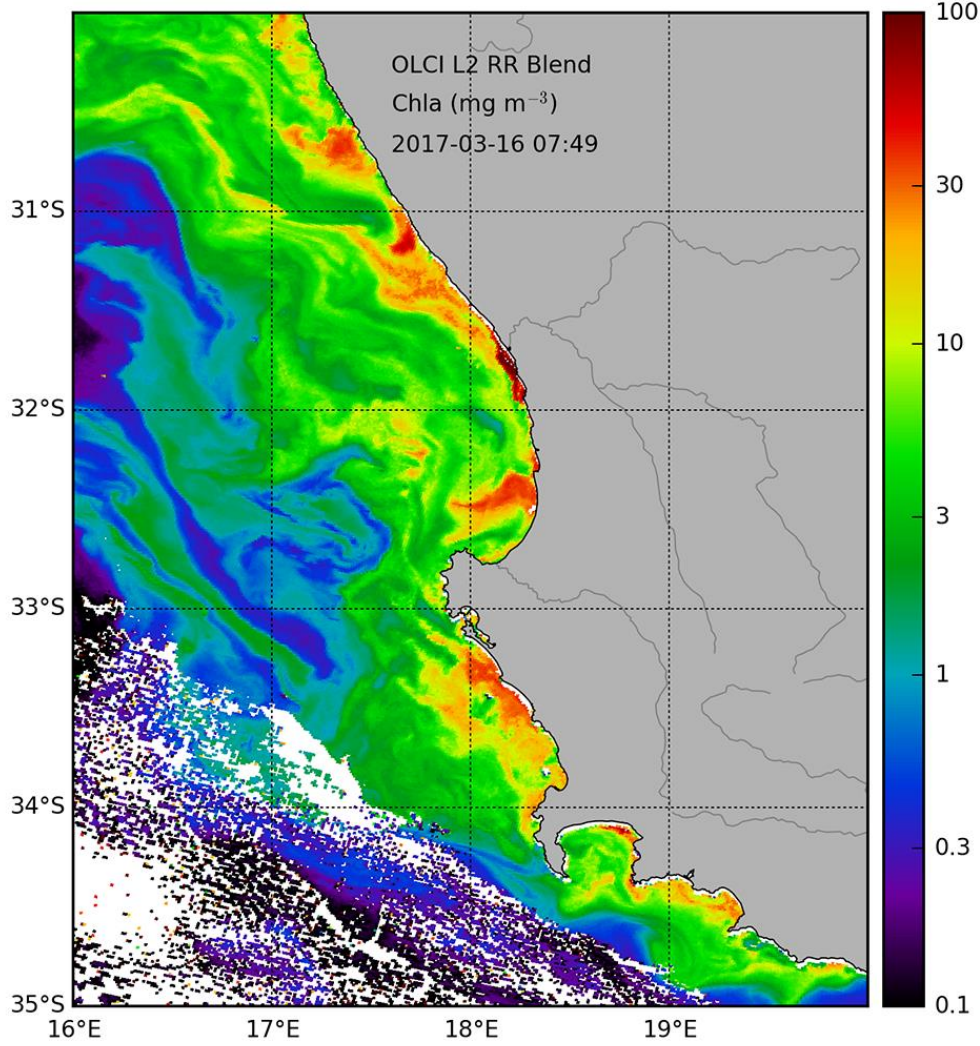
- APPLY FOR COURSES
- RESOURCES

EUMETSAT

Monitoring Harmful Algal Blooms (HABs)

OLCI [Chlorophyll-a]

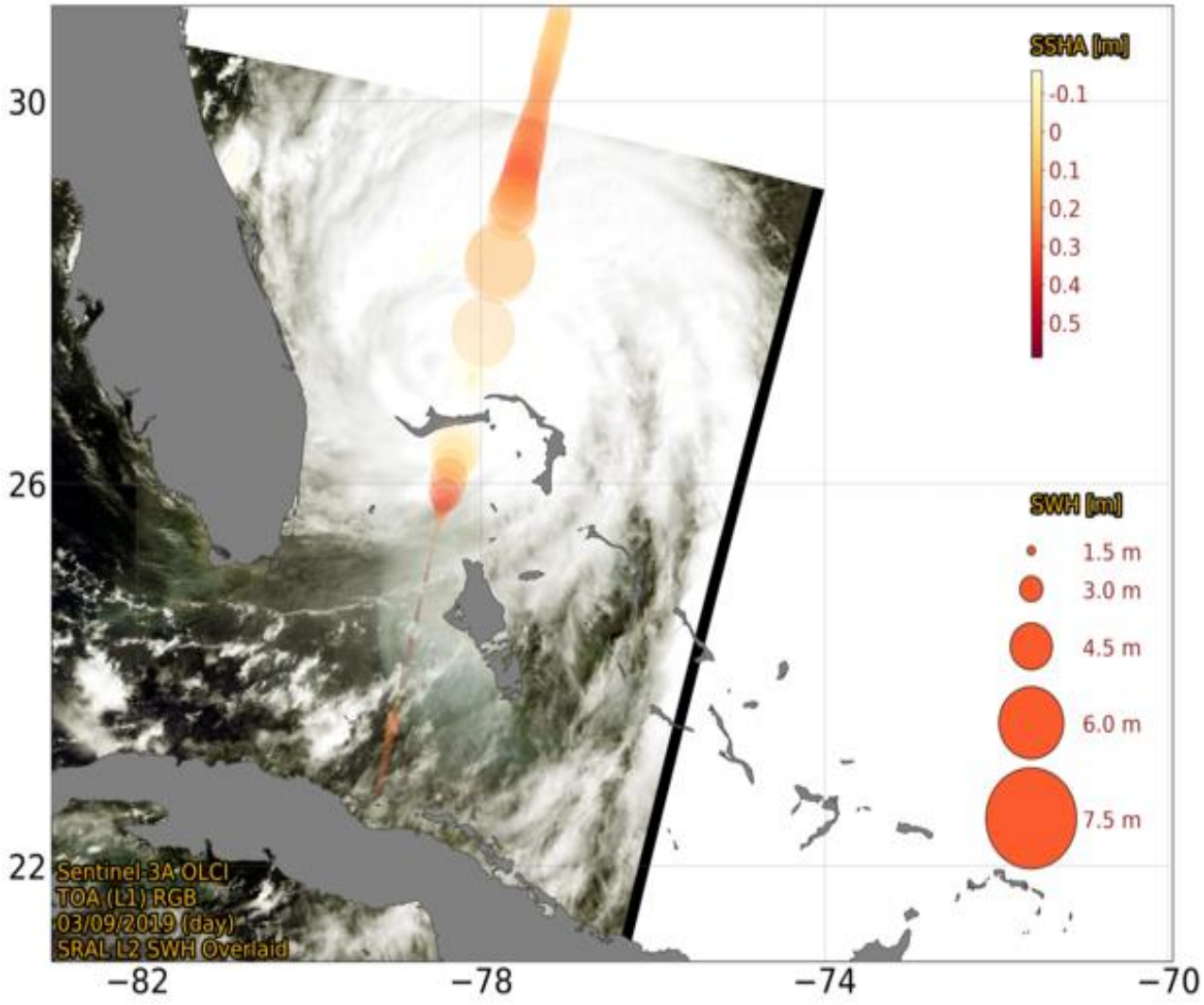
- Full resolution 300m granules, 1km reduced resolution (RR).
- 21 spectral bands
- Good Signal to Noise Ratio.
- About 2 day revisit time.
- Measures to 1 optical depth - determined by what is mixed in the surface waters.



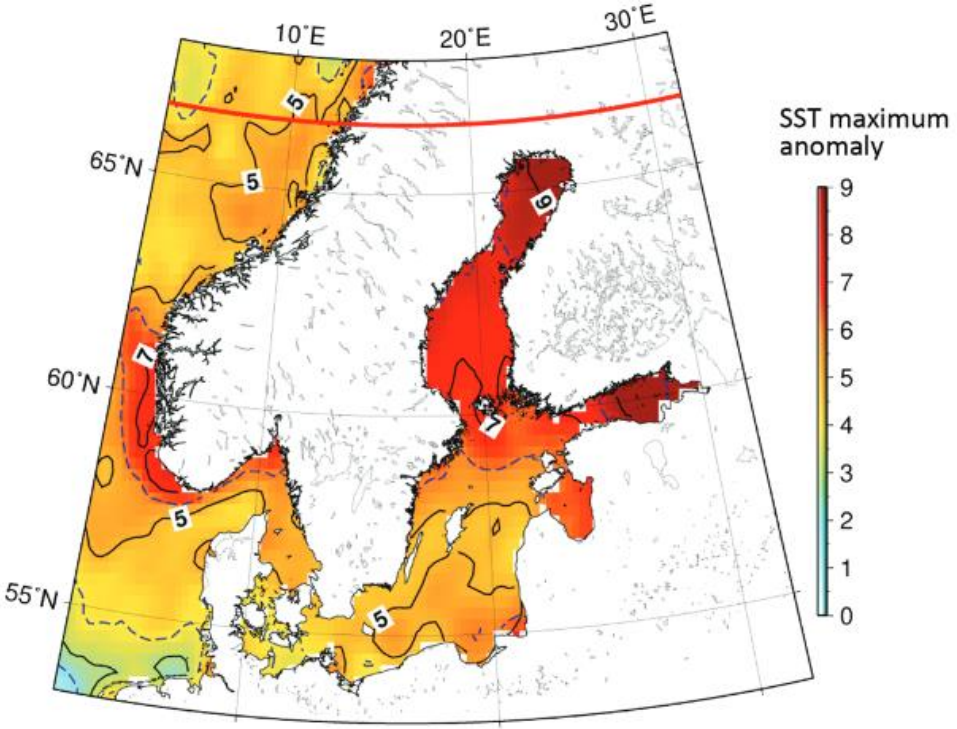
Tracking Storms…

SRAL sensor – Radar Altimetry

- Active sensor to see through cloud.
- Sea **Surface** Height Anomaly & Wave Height (m).



Tracking water-borne diseases like cholera:



SLSTR sea surface (skin) temperature

- Vibrio cholera likelihood linked to SST anomalies, as well as Chl-a and pH.
- Projected to increase globally under warming conditions.

Wrapping up:

- Within the limitations of the sensors themselves, there's no end to what can be done with satellite data in terms of applications.
- Especially true when different satellite datasets are combined to tackle problems that can't be solved through ordinary means.
- An example of this is the tracking of pelagic fish species, using:
  - SAR radar
  - AIS
  - Chlorophyll
  - SST
  - SSH

PML | Plymouth Marine Laboratory

Thank you

JNCC

Listen to the ocean

esa

NASA

opernicus

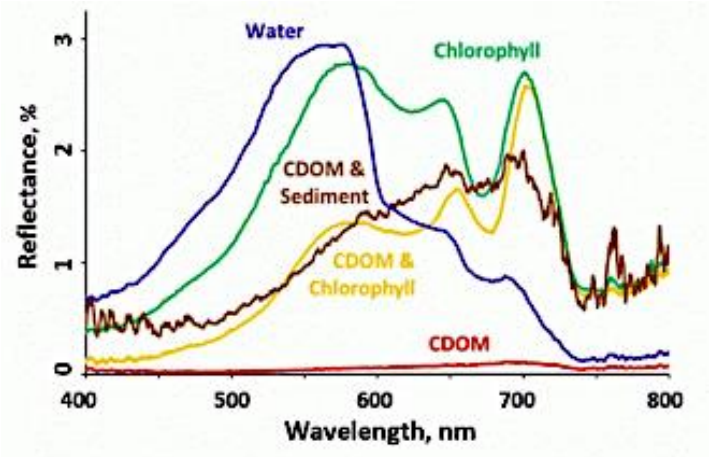
Europe's eyes on Earth

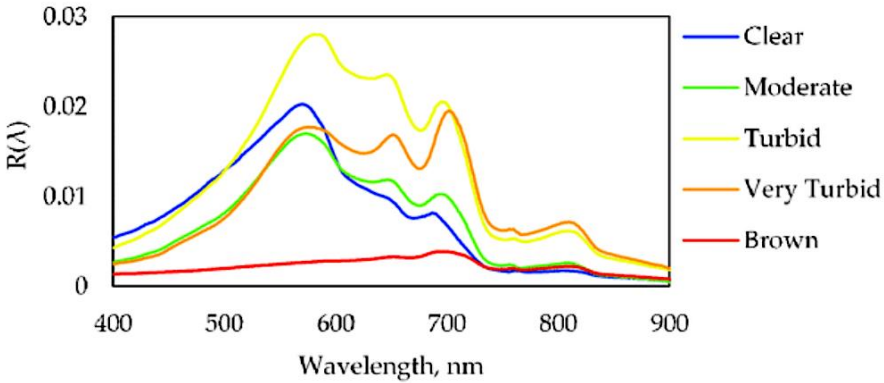
NOAA

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

U.S. DEPARTMENT OF COMMERCE

EUMETSAT


Water
Chlorophyll
CDOM & Sediment
CDOM & Chlorophyll
CDOM
Reflectance, %
0
1
2
3
400
500
600
700
800
Wavelength, nm


R(λ)
0.03
0.02
0.01
0
400
500
600
700
800
900
Wavelength, nm
Clear
Moderate
Turbid
Very Turbid
Brown


0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
490
521
551
582
613
643
674
704
High Chl-a
Med Chl-a
Low Chl-a
Seawater