



Introducing Sentinel-3 marine products for NRT ocean monitoring

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Plymouth Marine Laboratory on
behalf of EUMETSAT



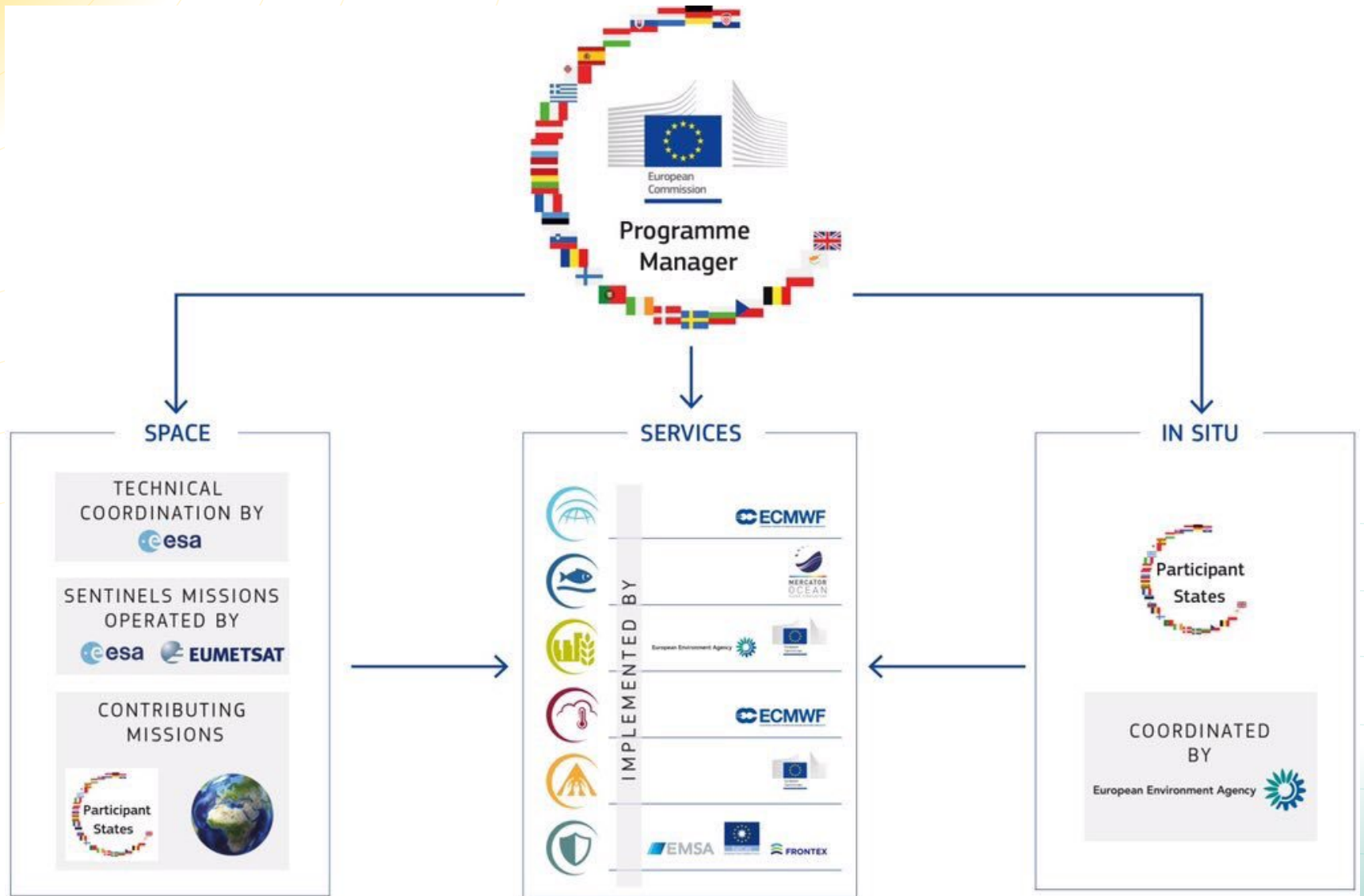
Intro

- Physical oceanographer
- Remote sensing scientist (OLCI/SLSTR/SRAL)
- Operational and research applications
- EUMETSAT contracted trainer and expert support

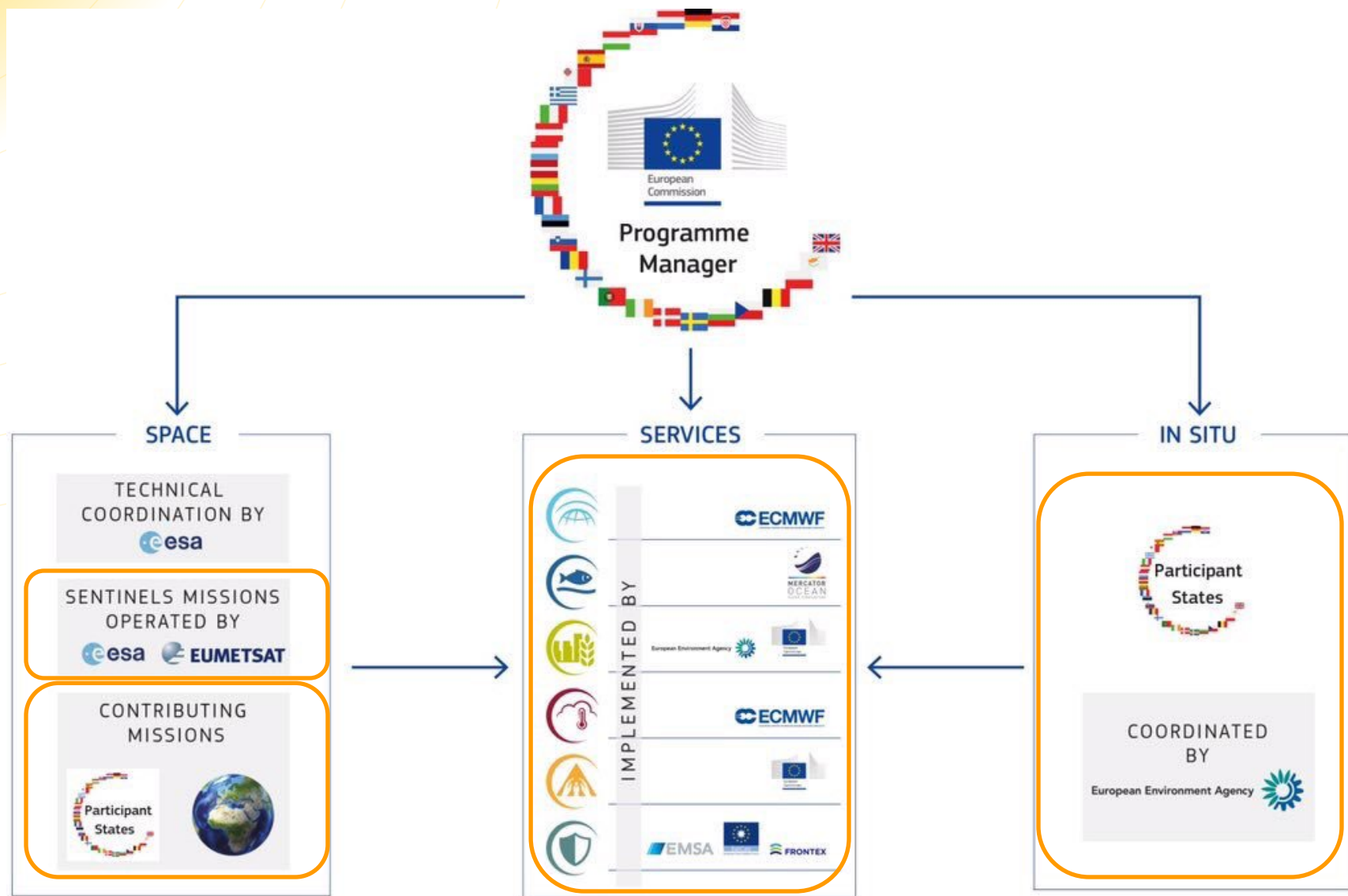


- Copernicus and the Copernicus Marine Data Stream
- Sentinel-3 instruments and data
- Deriving geophysical quantities from space
- SST theory
- SLSTR and thermal radiometry products
- Altimetry theory
- SRAL and altimetry products
- CMDS Data access points
- Monitoring product quality

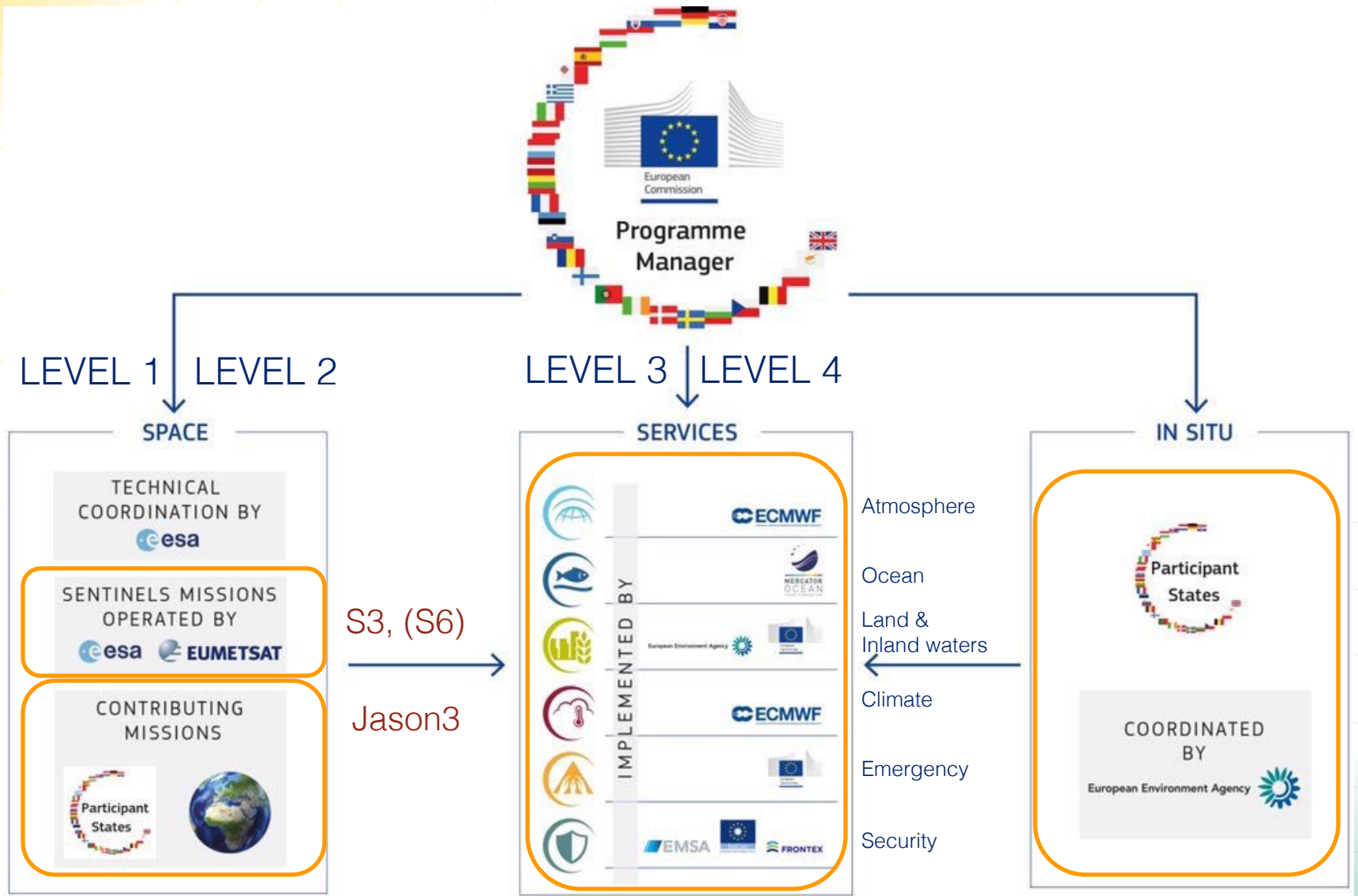
Copernicus



Where does marine data come in?



What marine data do we have?



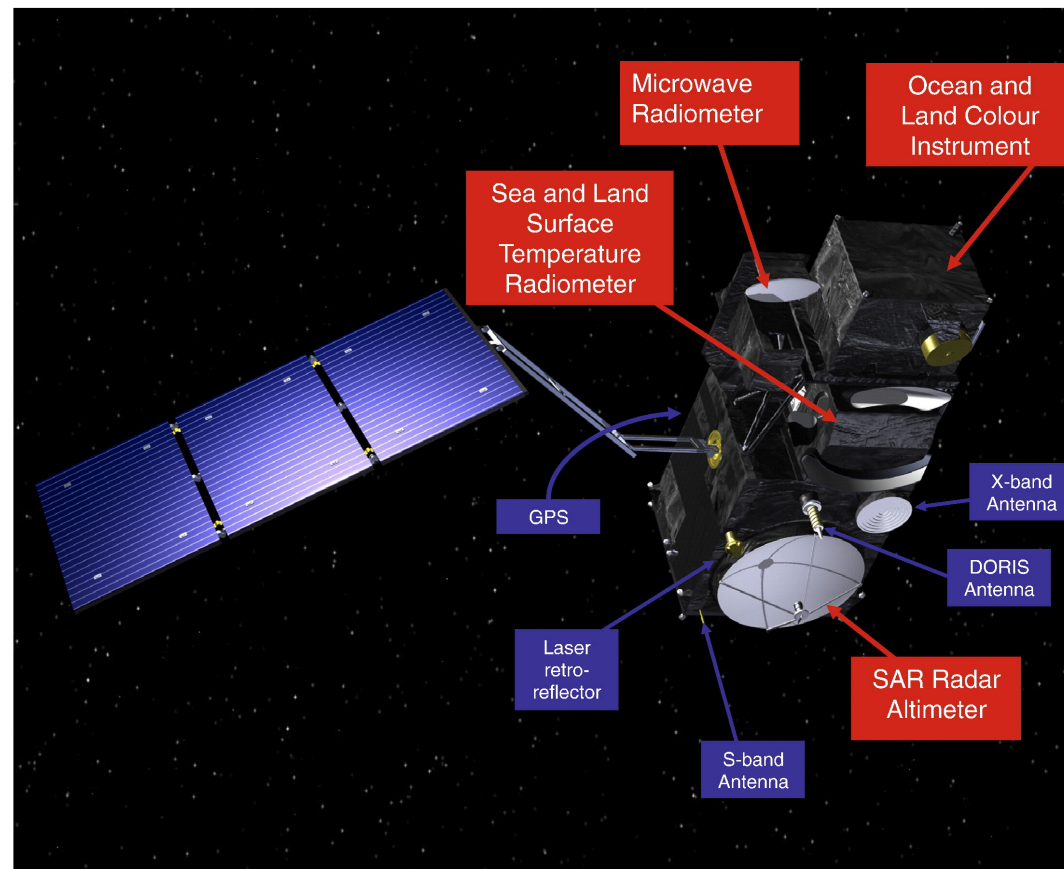
OceanSat2 (3)

MODELS



EUMETSAT Copernicus Data Services: Sentinel-3

- Sentinel 3
 - SRAL (Altimetry)
 - SLSTR (SST)
 - OLCI (Ocean Colour)
- Builds on heritage but with improved resolution and sensors.
- 3a (since Feb 2016),
- 3b (launched 25th April)
 - Currently in EUMETSAT managed drift phase
- Operated and marine data processed by EUMETSAT
- Many applications for ocean research and commercial operations.



Also operating Jason-3

Sentinel 3A and 3B

- Double the data – better revisit time.
- Redundancy, and operational continuity
- Opportunities for inter-calibration
 - Currently in drift phase
 - Test data available through S3VT

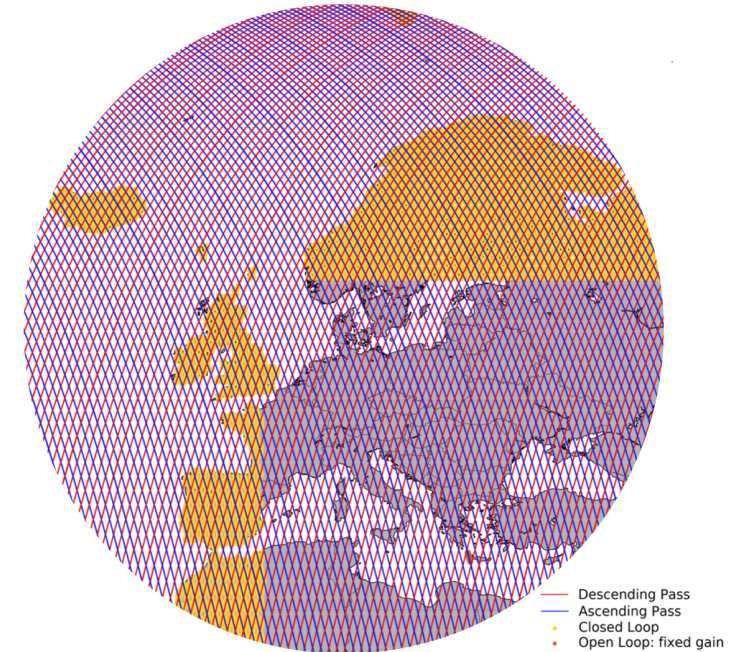
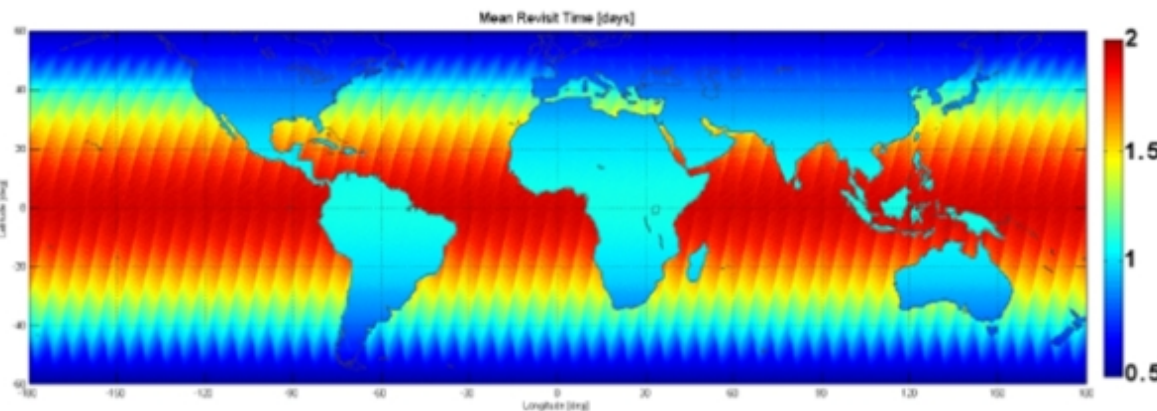
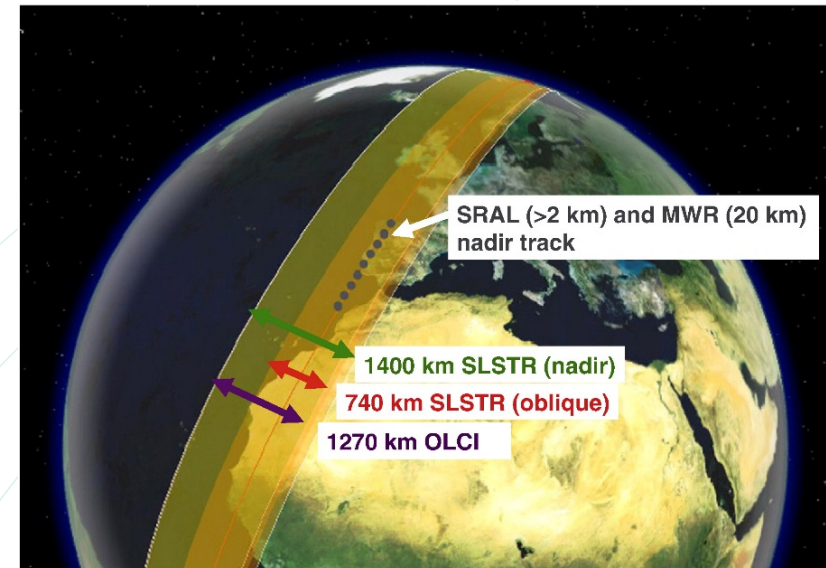


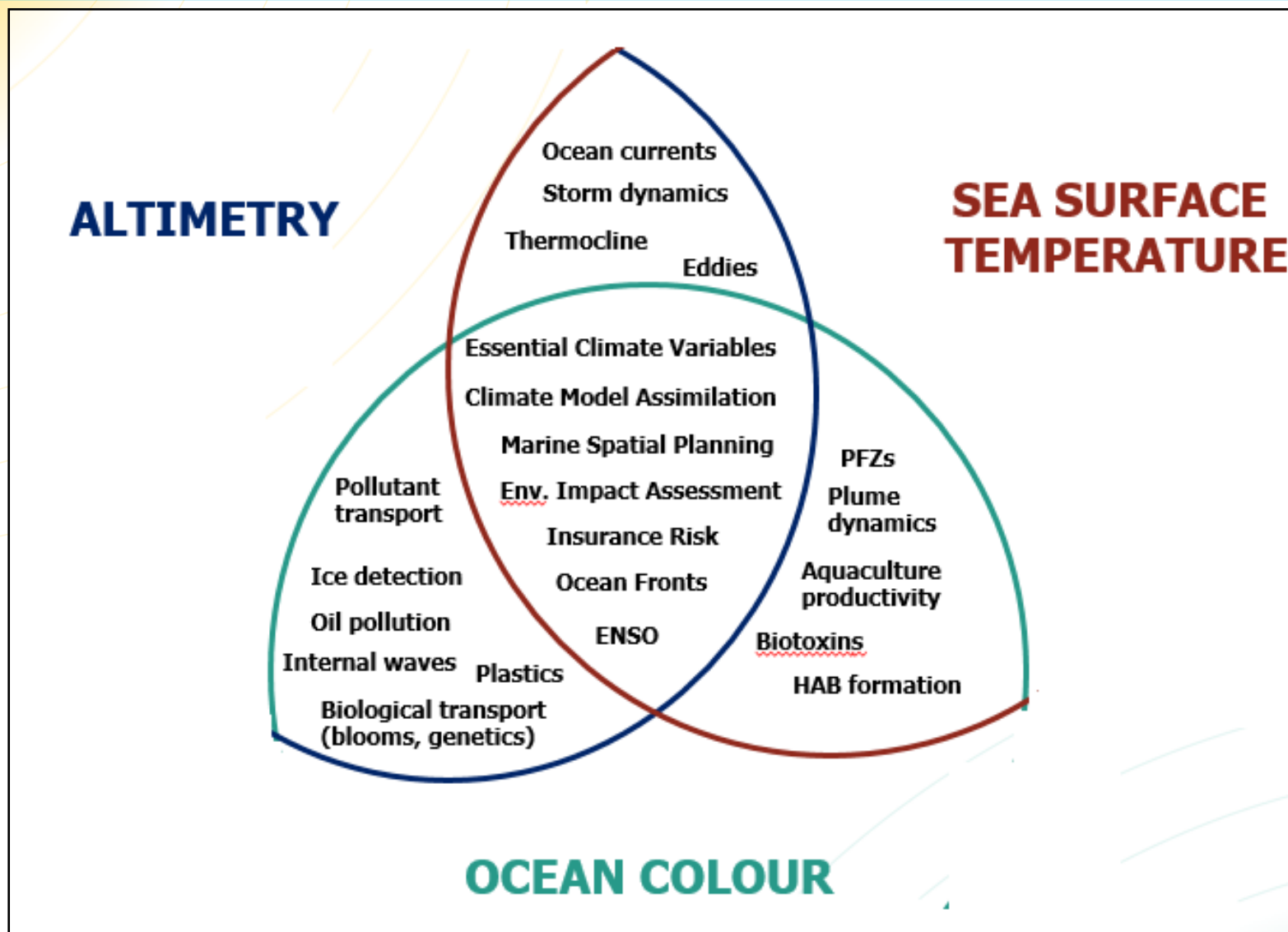
Figure 1: S3A SRAL track spacing and operating modes



<2 day revisit time with 2 satellites for OLCI/SLSTR



Sentinel-3 Synergy



Why are we interested in measuring physical ocean variables from space?

Temperature

Currents

Influence on weather and climate

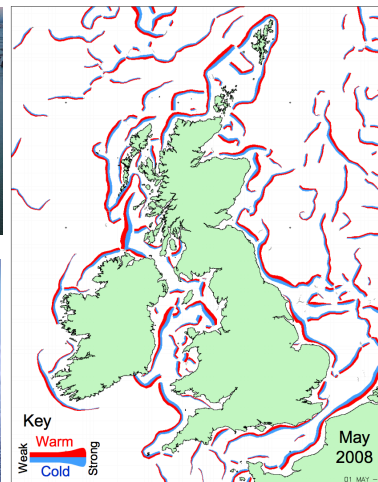
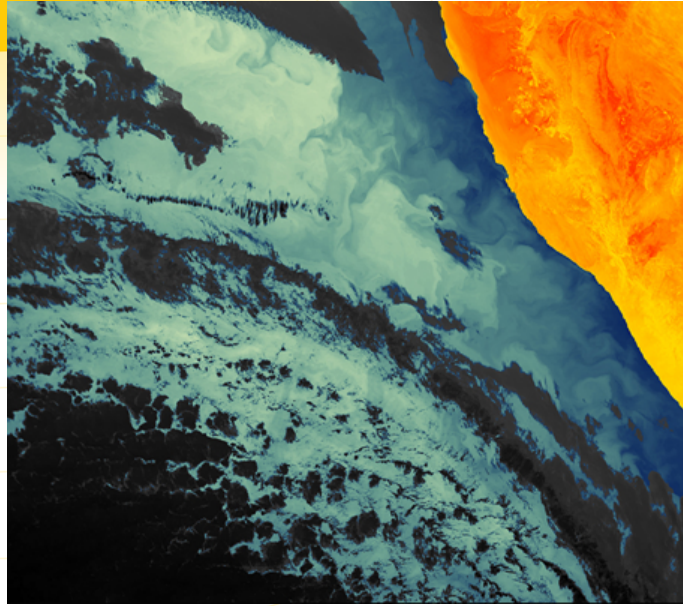
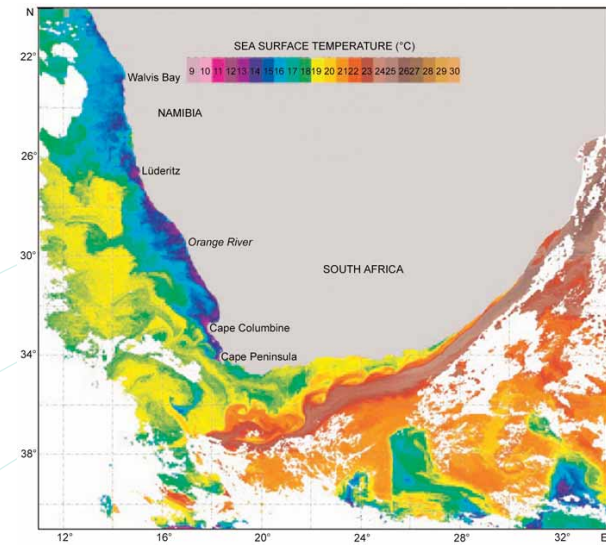
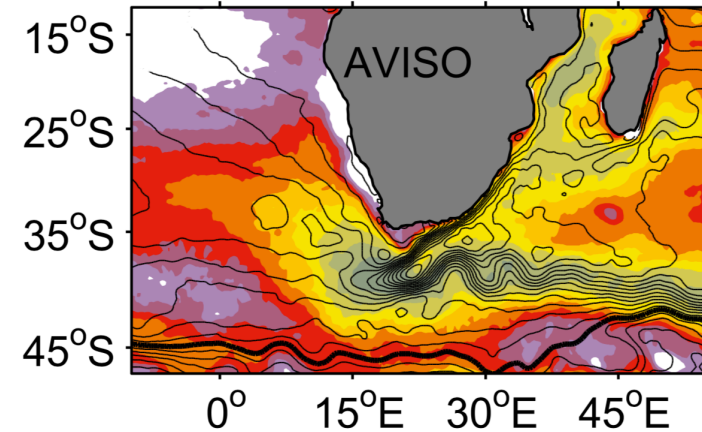
Sea level rise

Upwelling

Transport

Ocean fronts

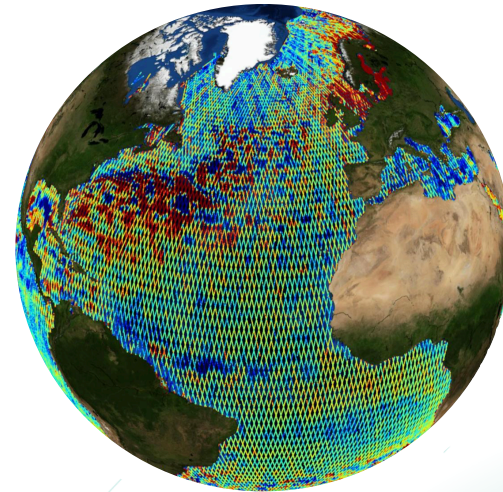
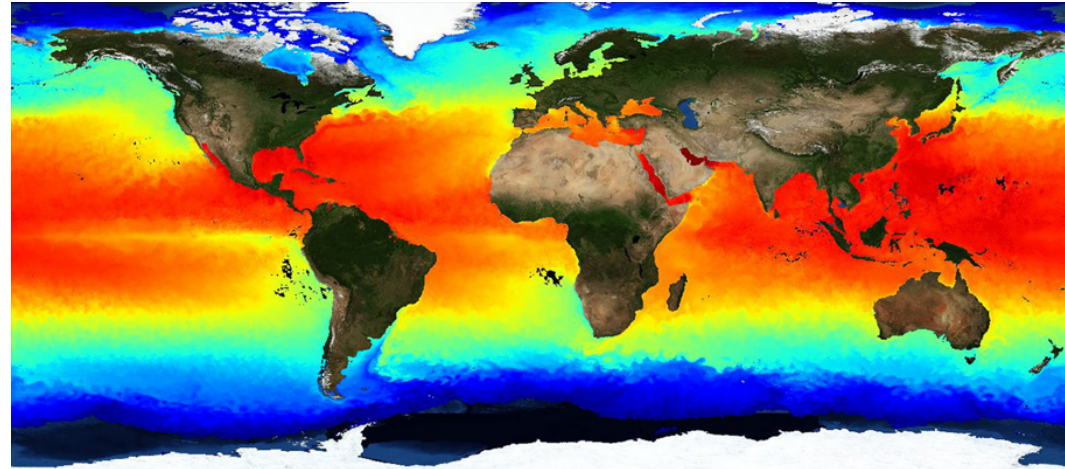
Extreme waves



Primary physical oceanographic variables available through CMDS

- SLSTR (Optical radiometry):
 - Sea surface Temperature

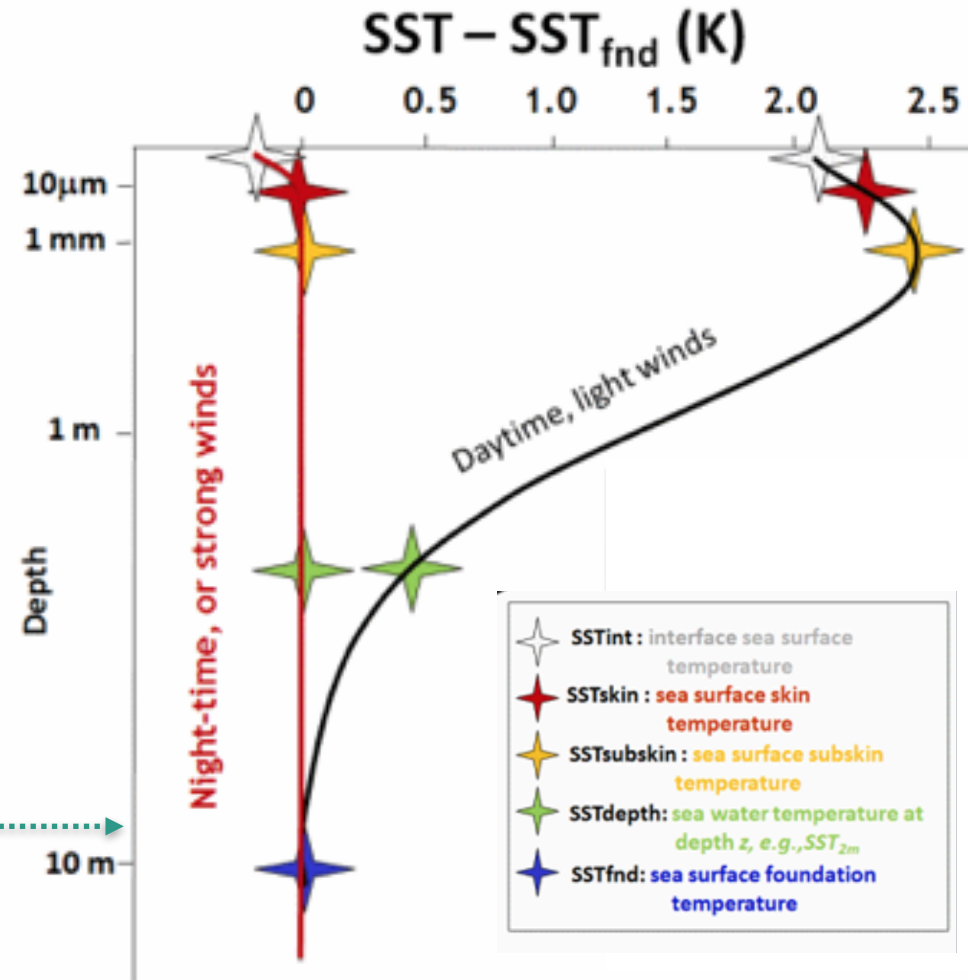
- SRAL* (SAR mode altimetry):
 - Sea surface height (L2)
 - Significant wave height (L2)
 - Wind speed (L2)
 - Anomalies (L2P)
 - Currents (L3, need multiple satellites)



***plus MWR and POD
(the unsung heroes!)**

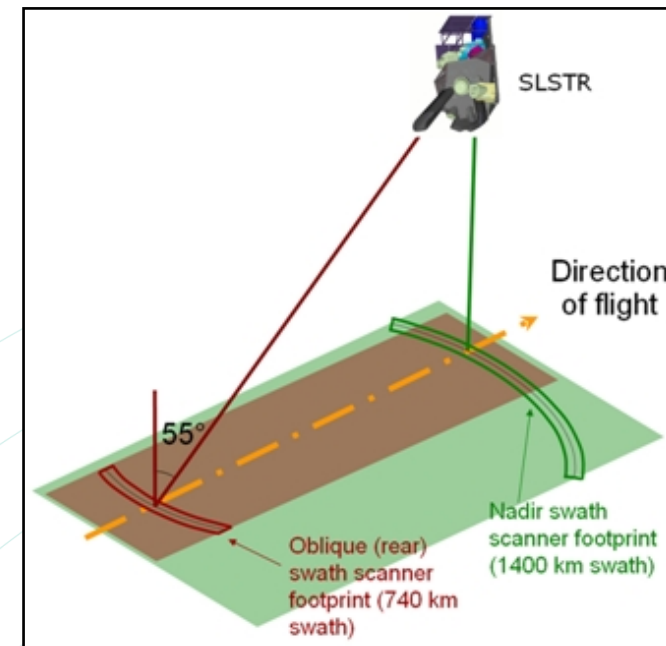
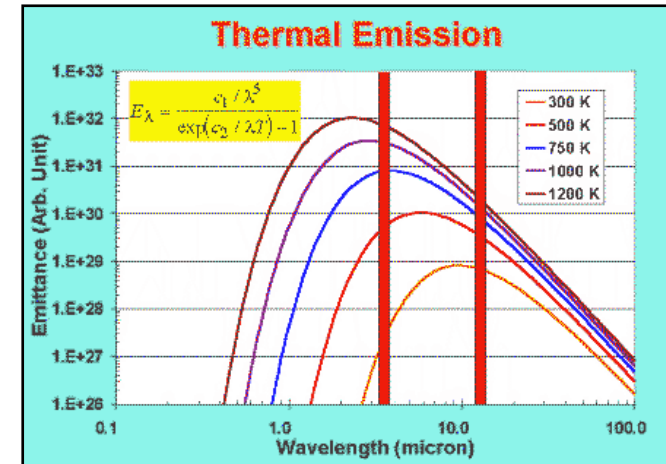
Measuring SST - Theory

- Measured by radiometers, as with ocean colour, but using infrared or microwave part of the spectrum.
- SST is a little tricky to define, and measured differently by different satellite and in situ sensors.
- IR Satellites (SLSTR/AVHRR etc.) measure **skin temperature**.
- GHRSSST for best community resources on SST:
www.ghrsst.org



Measuring SST - Theory

- Microwave – can see through cloud but lower resolution (convergence of black body curves).
- Signal at sensor (once calibrated)
 - top of atmosphere brightness temperature for IR channels (S7*-S9)
 - radiance for optical channels (S1-S6). (Used for land remote sensing and atmospheric correction).
- Must correct for atmosphere: newest sensors (e.g. SLSTR) use dual view approach



Measuring SST - Theory

Excellent intercomparison of two types of SST here:

<http://www2.hawaii.edu/~jmaurer/sst/>

Merged SST products also exist:

- **GHRSSST-PP**

- GHRSSST sets the SST community standard for L2P products and above.

- **NASA MUR**

- Seeks to get benefit of coverage/resolution/accuracy from multi-scale combination of global TIR and microwave signals (1 km).

- **REMS MWIR**

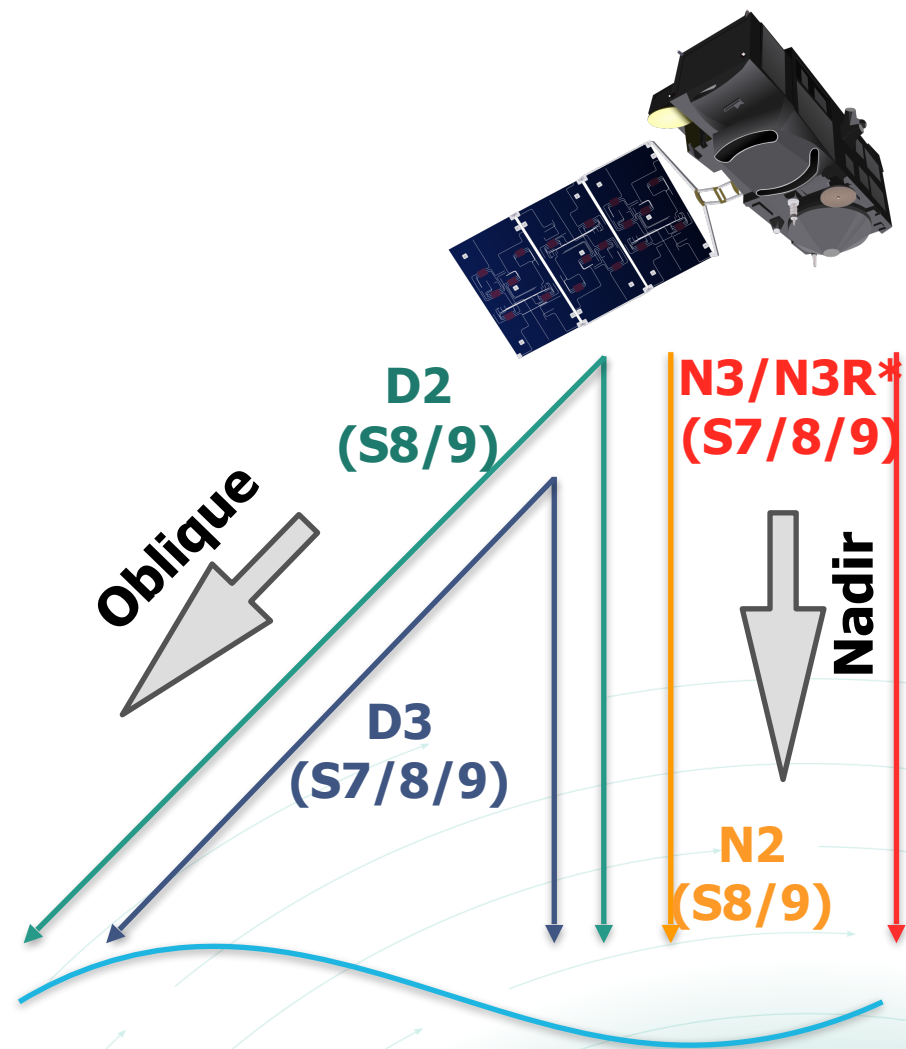
- Combines MW and TIR signals using optimal interpolation (9 km).

- **OSTIA**

- GHRSSST L4 merged product. AVHRR, AATSR, SEVIRI, AMSRE, TMI and in situ data. Optimally interpolated to 0.054o grid. Highly smoothed (v1).

Sea Surface Temperature from SLSTR

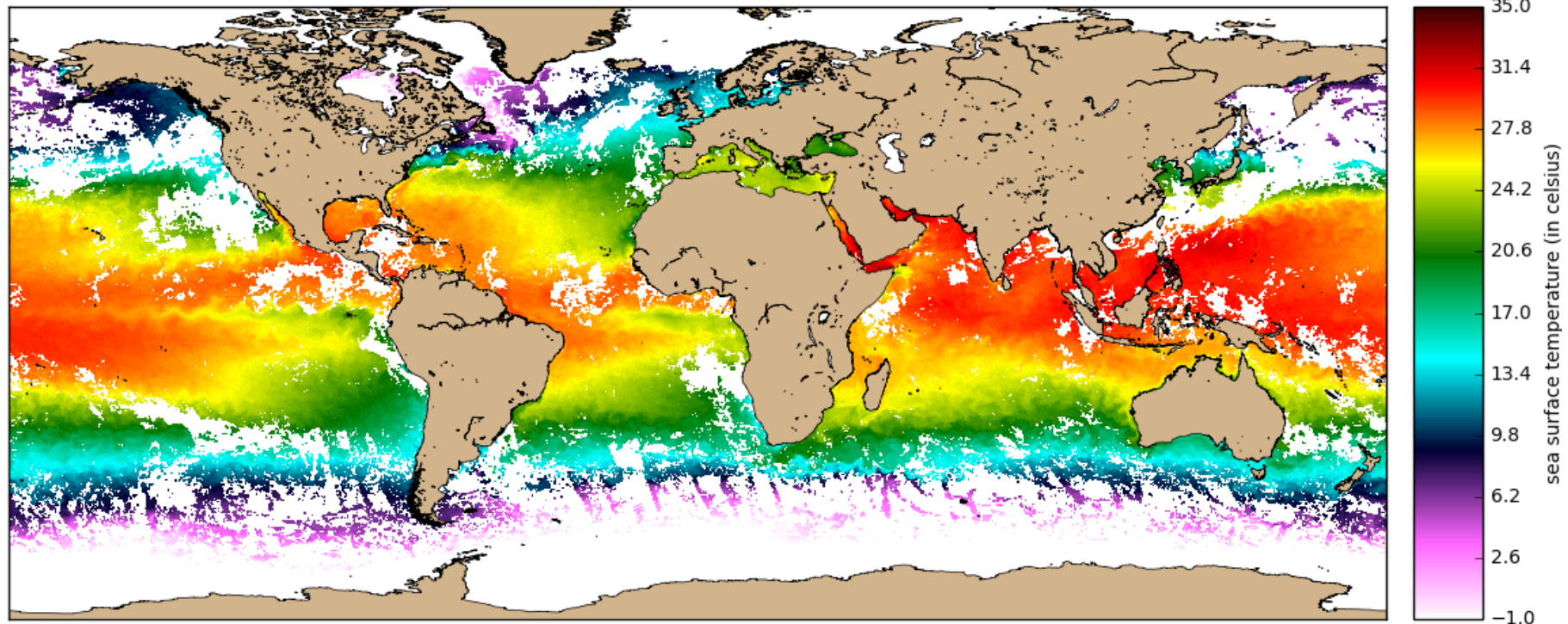
- SLSTR has 5 algorithm for SST retrieval
- “N” only algorithms use only the nadir looking view.
- “D” algorithms combine both nadir and oblique view to give a “dual” view.
- D & N algorithms have variants that use 2 (day) or 3 channels (at night).
- Dual view is better characterised, but has smaller swath.



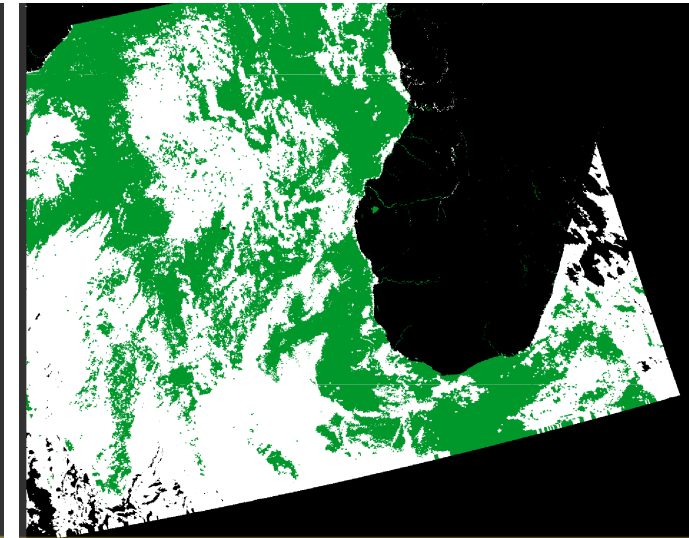
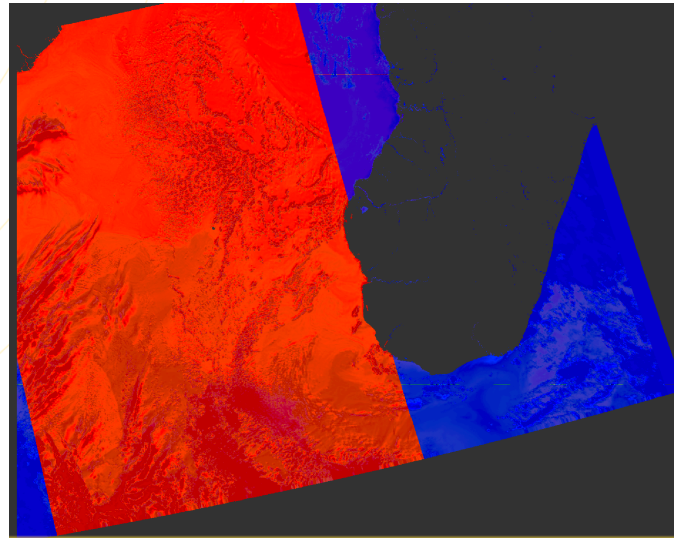
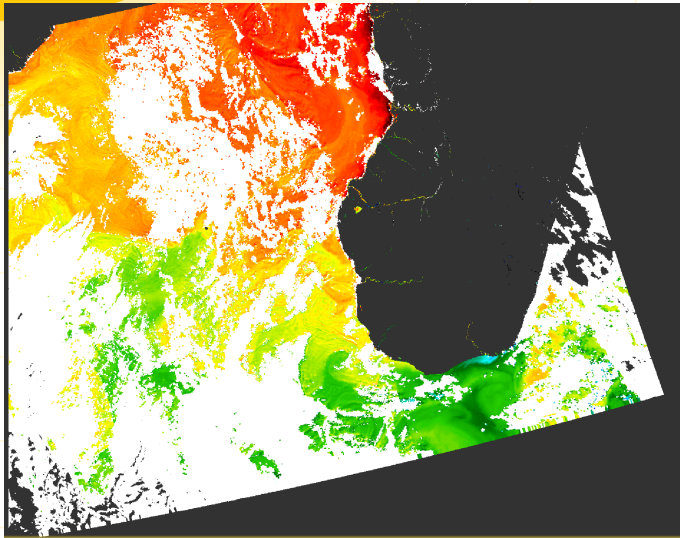
Sea Surface Temperature from SLSTR

- Level 1 – Radiances (S1-S6) and brightness temperatures (S7-S9), fire bands (F1 and F2).
- Level 2 – GHRSSST **L2P SST** and quality flags, meteorological parameters, single sensor error statistics, algorithm flags

sea surface skin temperature
15-19 Jun 2017 composite - Sentinel-3A / SLSTR WST NR [PB2.16]-
N = 1427346, min = -1.99 C, max = 36.71 C



SLSTR SST L2 flags and usage






“Best” SST







MUST be corrected for bias before use

Only use Q5 data for dual and, at your discretion Q4+ for Nadir only

Algorithm used

sst_algorithm_type_N3_retrie...	Maths	
sst_algorithm_type_D2_retrie...	Maths	
sst_algorithm_type_D3_retrie...	Maths	

Quality flag

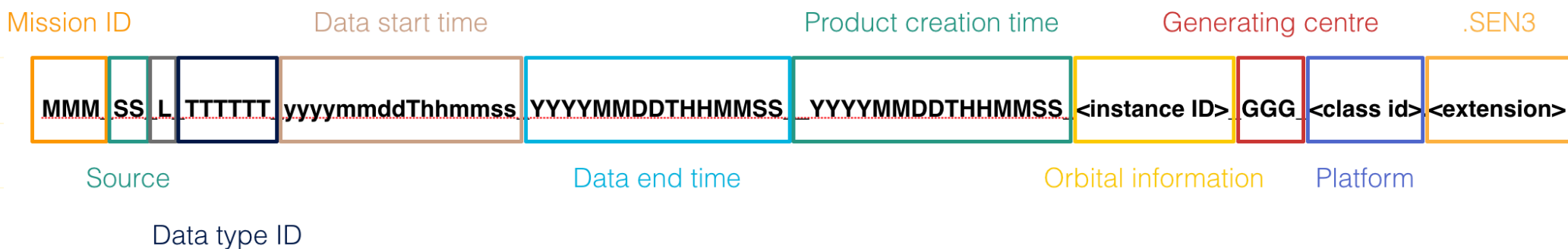
quality_level_no_data	Maths	
quality_level_cloud	Maths	
quality_level_worst_quality	Maths	
quality_level_low_quality	Maths	
quality_level_acceptable_qual...	Maths	
quality_level_best_quality	Maths	

Data Formats (SLSTR)

• SAFE Format:

- Folder with NetCDF data files and manifest
- Single netCDF file contains all variables at level-2

Processing level



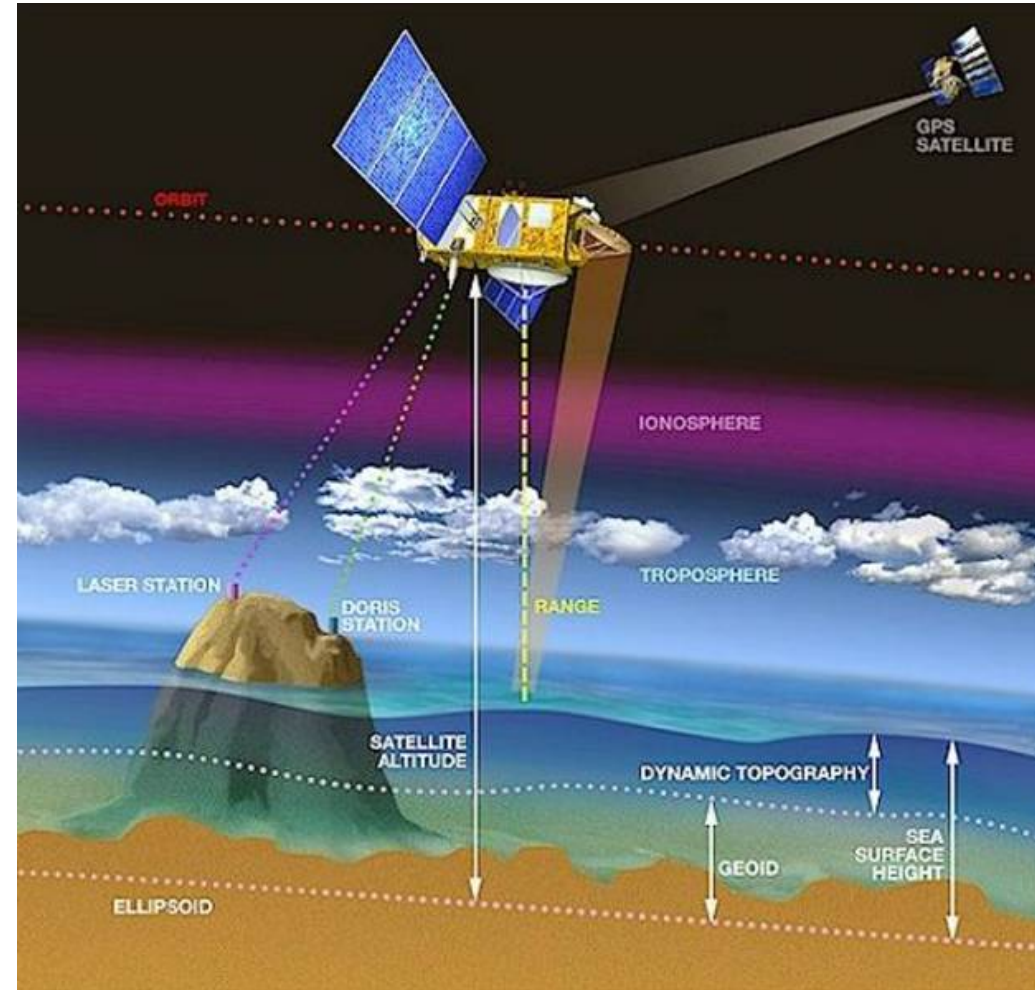
S3A_SL_1_RBT_____20171202T193449_20171202T193749_20171202T205935_0179_025_127_5579_MAR_O_NR_002.SEN3

Orbital information: duration, cycle number, relative orbit number, frame along track coordinate

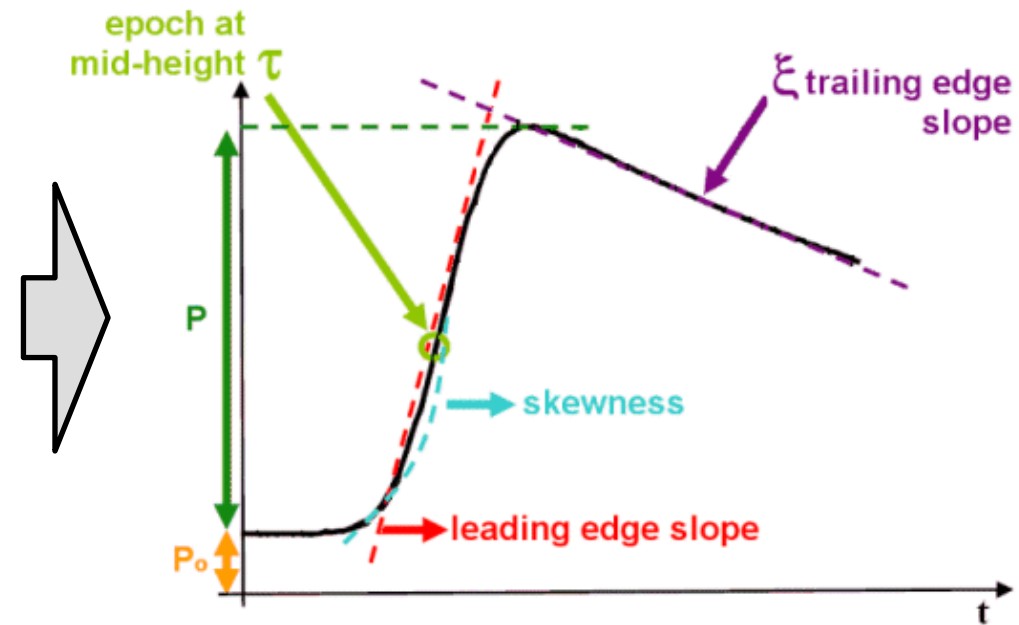
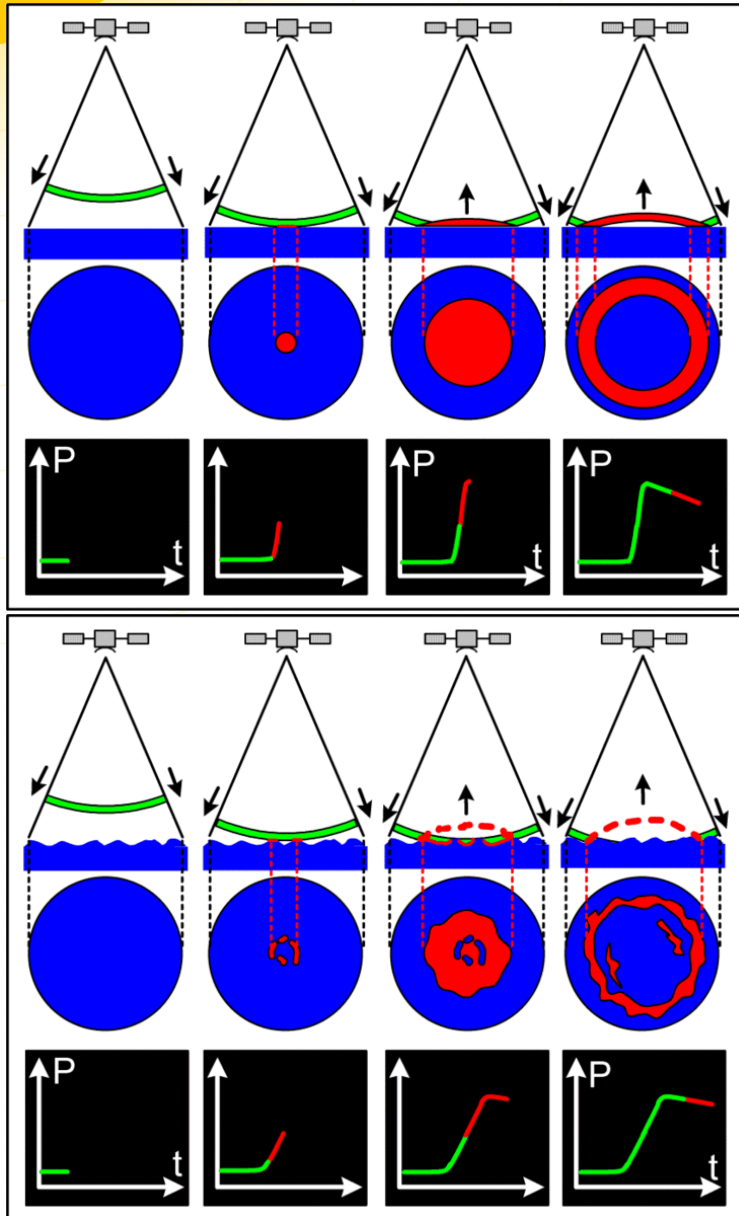
Platform: Processing system, timeliness, baseline correction

Theory - altimetry

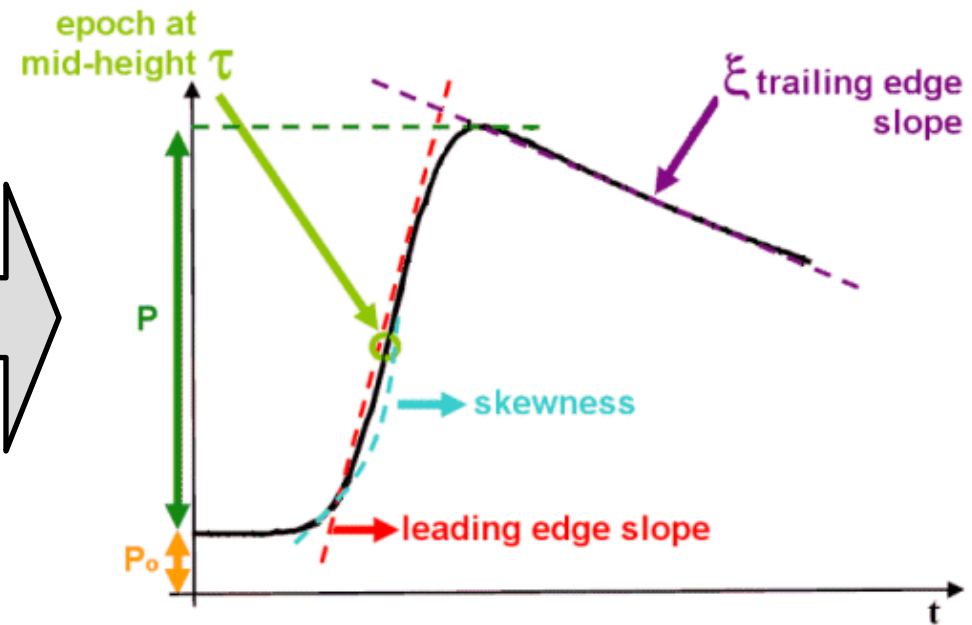
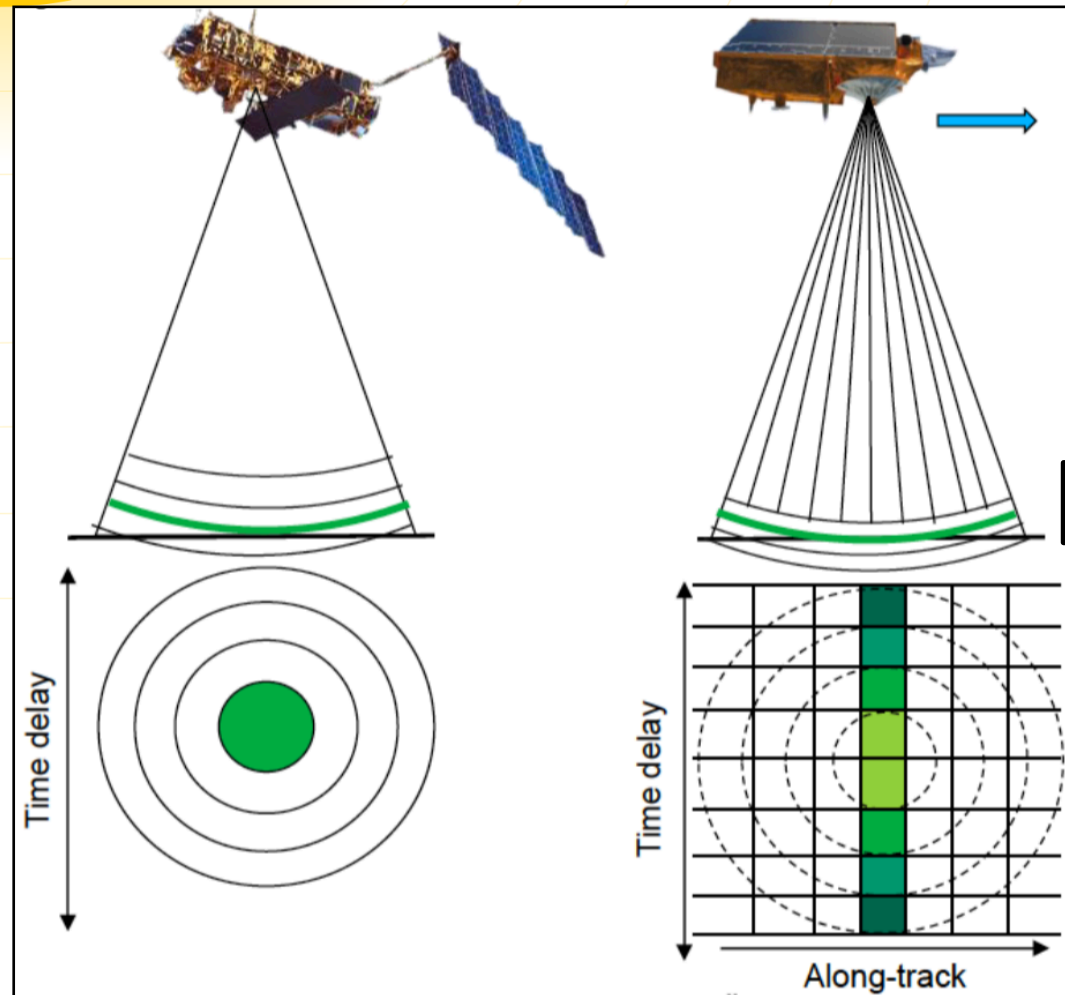
- Altimeters measure sea surface height
- Time it takes for a radar pulse emitted from sensor to travel to surface, reflect, and be received by satellite.
- Low Resolution Mode (LRM) or **delayed doppler (SAR) mode**.
- Corrections for wet troposphere, dry troposphere, & ionosphere.
- Errors due to retracking, tides (esp. on shelf) and fallible geoid characterisation.



Theory - altimetry



Theory - altimetry



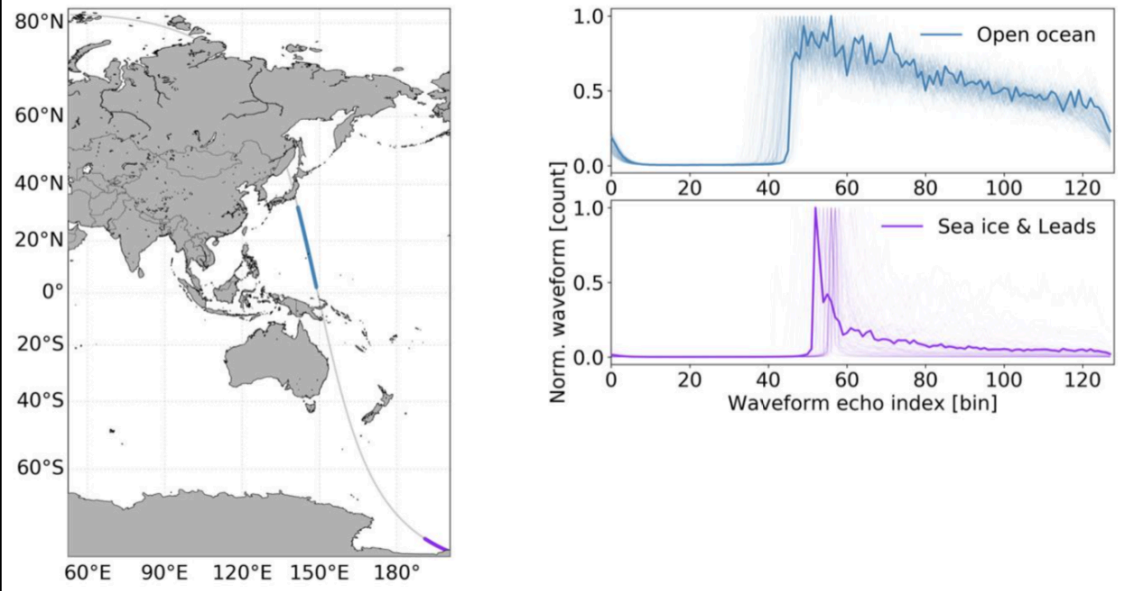
Much better along track resolution!

Altimetry products

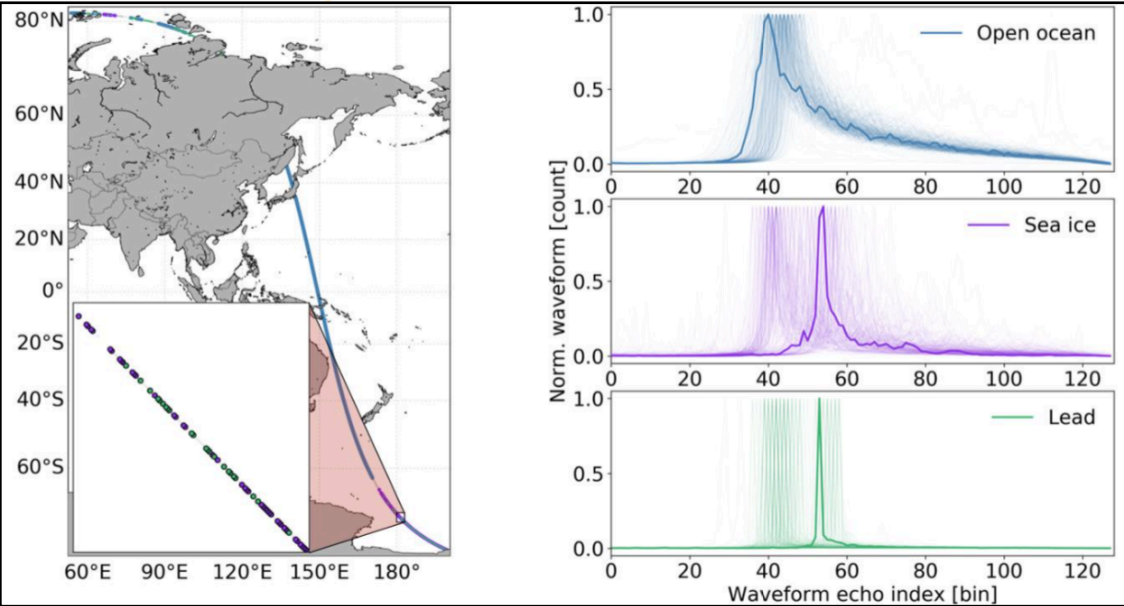
- **Products derived from the altimetry waveform:**

- Sea-surface height (SSH). Difference in distance between the range (R) and the satellite altitude (S), relative to a terrestrial reference frame.
 - Need precision location & reference ellipsoid.
 - Accurate retracking to get R based on multiple waveforms. Varies for ocean, coast, sea ice. (related to τ)
- Significant wave height: derived from leading edge slope of altimetry waveform
 - SWH = mean value of highest third of waves (related to LES)
- Wind speed (not direction) – wind affects the roughness which affects the backscatter of the radar pulse and the amplitude of the waveform. (related to P)

Effect of SAR mode on waveforms

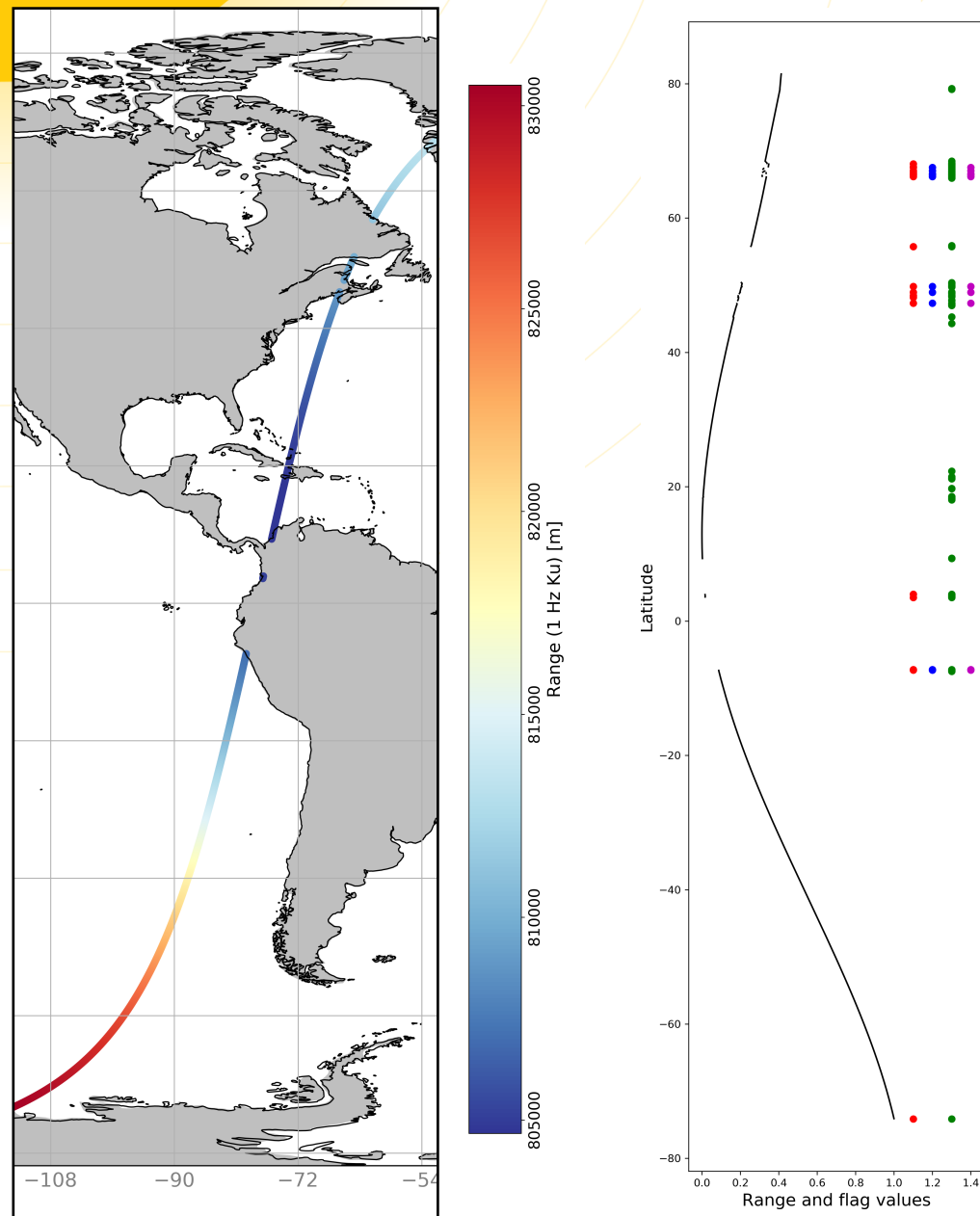


← PLRM



← SAR


SRAL Altimetry L2 flags and usage



- Level 2 products contain flags for quality values for **range**, **SWH**, **sig0** and **surface classification** at both 1 Hz and 20 Hz.
- Additional flags are available at 1 Hz and 20 Hz for proximity to land, ice presence, rain presence.
- 20 Hz data has yet further flags for identify outliers and 'goodness of fit'.

Data Formats (SRAL)

• **SAFE Format:**

- Same file naming convention as OLCI/SLSTR.
- Level 1 products available for retracking:
 - L1A - calibrated
 - L1B-S - calibrated, no multi-look
 - L1B - calibrated, multi-look combined, plus C band.
- Level 2 products: 
 - Three netCDF files contain different variables at level-2
 - REDUCED
 - STANDARD
 - ENHANCED

Measurement file type:

REDUCED

STANDARD

ENHANCED

1 Hz

1 Hz PLRM/SAR Ku data set
Sub-set of 1 Hz Ku band parameters from SAR-mode SRAL measurements, processed through the (P)LRM & SAR_Ku L2 chains.
0.52 Mb / orbit

1 Hz + 20 Hz

1 Hz PLRM/SAR Ku/C data set
1 Hz parameters from SAR-mode SRAL measurements, processed through the (P)LRM L2 (Ku & C band) & SAR_Ku (Ku band) chains.
20 Hz SAR C data set
20 Hz C band parameters from SAR-mode SRAL measurements processed through the (P)LRM L2 chain.
20 Hz PLRM/SAR Ku data set
20 Hz Ku band parameters from SAR-mode SRAL measurements processed through the (P)LRM and SAR_Ku chains.
32 Mb / orbit

1 Hz + 20 Hz + WF

1 Hz PLRM/SAR Ku/C data set
1 Hz parameters from SAR-mode SRAL measurements, processed through the (P)LRM L2 (Ku & C band) & SAR_Ku (Ku band) chains.
20 Hz SAR C data set
20 Hz C band parameters from SAR-mode SRAL measurements processed through the (P)LRM L2 chain.
20 Hz PLRM/SAR Ku data set
20 Hz Ku band parameters from SAR-mode SRAL measurements processed through the (P)LRM and SAR_Ku chains.
Waveforms
Waveforms and associated parameters to reprocess the data (at least in PLRM)
112 Mb / orbit

Copernicus Marine Data Stream: Data Archive



MONITORING WEATHER AND CLIMATE FROM SPACE

EUMETSAT WEBSITE

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KNOWN ISSUES

DATA CENTRE INFO

SELECT PRODUCT > FILTER > DATE/TIME > FORMAT > DELIVERY METHOD > CHECK OUT

SELECT PRODUCT

Search Term

Products Sentinel 3 DataSets

- OLCI L1 RR(1km) Arctic(NRT)
- OLCI L1 RR(1km) Black Sea(NRT)
- OLCI L1 RR(1km) Mediterranean(NRT)
- OLCI L1 RR(1km) North Atlantic(NRT)
- OLCI L2 FR Arctic(NRT)
- OLCI L2 FR Baltic(NRT)
- OLCI L2 FR Black Sea(NRT)
- OLCI L2 FR Mediterranean(NRT)
- OLCI L2 FR North Atlantic(NRT)
- OLCI L2 RR(1km) Arctic(NTC)
- OLCI L2 RR(1km) Black Sea(NTC)
- OLCI L2 RR(1km) Mediterranean(NTC)
- OLCI L2 RR(1km) North Atlantic(NTC)
- SST Arctic(NRT)
- SST Baltic(NRT)
- SST Black Sea(NRT)
- SST Global(NRT)
- SST Mediterranean(NRT)
- SST North Atlantic(NRT)

Thematic Filter

- Marine
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- Analysis
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- Fire
- Forecast
- Humidity
- Model
- Observation
- Ocean**
- Precipitation
- Pressure
- Radar Backscatter NRCS
- Radiation
- Soil Moisture Index
- Sea Ice
- Sea Surface Temperature
- Snow and Ice
- Temperature
- Vegetation
- Wave

CLEAR THEMATIC FILTER

benloveday

Selected Product

SST Global(NRT)



SST Global(NRT)

NEXT STEP

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LEGAL INFORMATION



<http://archive.eumetsat.int>



Monitoring SST data quality



MONITORING WEATHER AND CLIMATE FROM SPACE

METIS METIS-SST METIS-OC EUMETSAT WEBSITE

METIS SEA SURFACE TEMPERATURE

METIS-SST


Data Sources 3

Plots 5

Reference papers

Quickstart Guide

Partners & collaborators



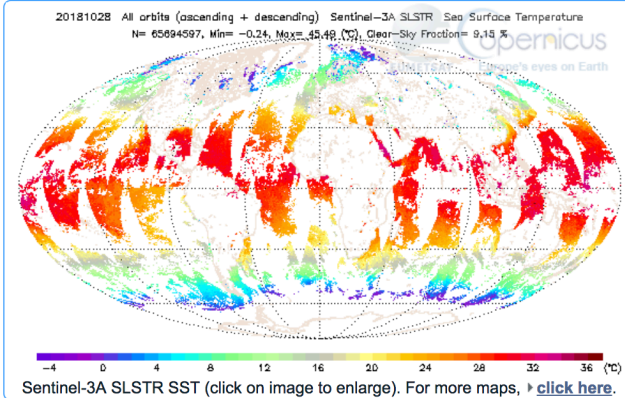
METIS-SST, the Sea Surface Temperature component of Monitoring & Evaluation of Thematic Information from Space (METIS), provides near-real time diagnostics of EUMETSAT operational level-2 (L2) satellite SSTs.

Current **Satellite SST Products** monitored in METIS-SST are from: Sentinel-3A SLSTR, Metop-B (M1) AVHRR and M1 IASI.

The satellite SSTs are monitored employing uniformly gridded Level-4 daily Canadian Meteorological Centre (CMC), daily UKMO OSTIA and monthly climatological OSTIA data as **Reference fields**. Validation against in situ SSTs will be performed as the Sentinel-3A products mature.

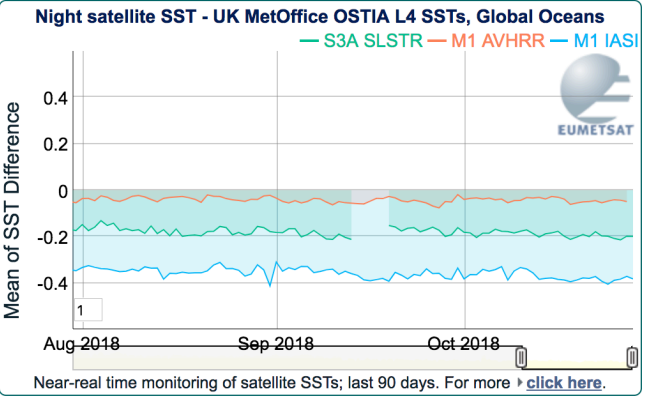
All analyses are performed Globally & for 15 selected **Regions of interest (ROIs)**.

Latest available Sentinel-3A SLSTR SST data:



20181028 All orbits (ascending + descending) Sentinel-3A SLSTR Sea Surface Temperature
N= 65694597, Min= -0.24, Max= 35.46 (°C), Clear-Sky Fraction= 9.15 %

Sentinel-3A SLSTR SST (click on image to enlarge). For more maps, [click here](#).




Night satellite SST - UK MetOffice OSTIA L4 SSTs, Global Oceans


— S3A SLSTR — M1 AVHRR — M1 IASI

Mean of SST Difference

Aug-2018 Sep-2018 Oct-2018

Near-real time monitoring of satellite SSTs; last 90 days. For more [click here](#).

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How to keep in touch!

- **Other training**

- Attend/send students – <http://training.eumetsat.int>
- Collaborate – we want to support other projects.
 - Contact copernicus.Training@eumetsat.int

- **Copernicus Marine User Forum**

- Questions
- Share results/papers/campaigns (case studies)
- <https://forums.eumetsat.int/forums/forum/copernicus-marine-calval/>

- **Helpdesk** – ops@eumetsat.int

- **Twitter** – @eumetsat_users

- **Copernicus Collaborative Exchange:**

- <https://www.eumetsat.int/website/home/TechnicalBulletins/Training/index.html>