Copernicus Sentinel (Ocean Colour) data - access and dissemination

Susanne Mecklenburg, ESA Sentinel-3 Mission Manager

Francois Montagner, EUMETSAT Marine Applications Manager

ESA and EUMETSAT Sentinel-3 operations teams

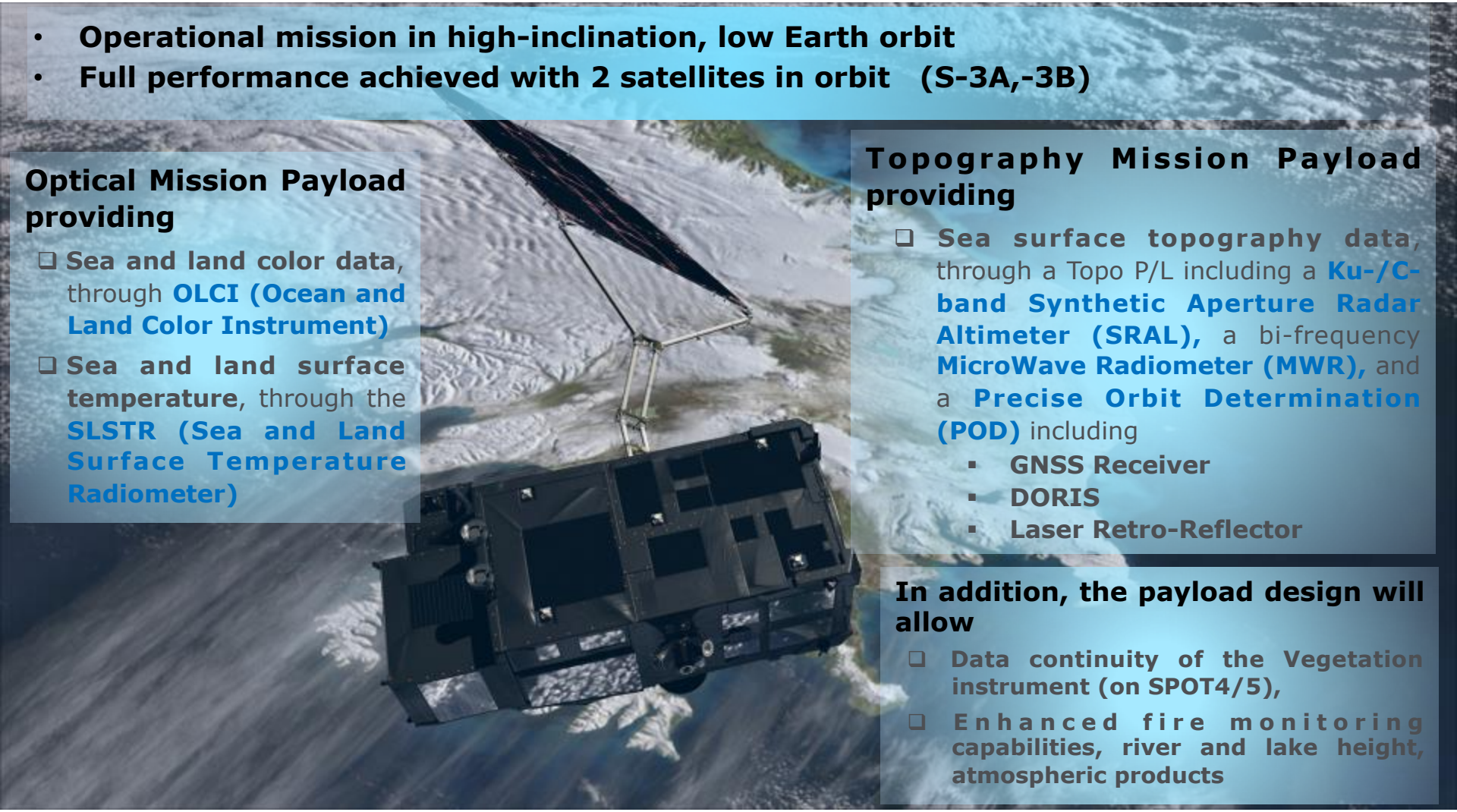
COPERNICUS SENTINEL MISSIONS - data products over OCEAN

Mission	Status	Data products over ocean
Sentinel-1: Radar Mission 	• **S1A** (launched 3/4/2014) in routine operations phase • **S1B** (launched 25/4/2016): core products distributed to all users since end September 2016; routine operations from May 2017+	**C-SAR instrument** • Level 1 Ground Range Detected (GRD) • Level 1 Single Look Complex (SLC) for wavemode planned for 2017 • Level 2 Ocean Swell spectra (OSW), Ocean Wind Fields (OWI), Surface Radial Velocities (RVL, not qualified yet)
Sentinel-2: High Resolution Optical Mission 	• **S2A** (launched 23/06/2015) in routine operations • **S2B** launched on 6 March 2017	**Multispectral instrument (MSI)** • Level 1C TOA reflectance • Level 2A BOA reflectance
Sentinel-3: Medium Resolution Imaging and Altimetry Mission 	• **S3A** (launched 16/2/2016) in ramp-up phase • **S3B** launch in Q4/2017	**Ocean/Land Colour Instrument (OLCI)** • Level 1 TOA radiances • Level 2 Ocean Colour **Sea / Land Surface Temperature Radiometer (SLSTR)** • Level 1 TOA radiances • Level 2 Sea Surface Temperature **S3 Ku/C Radar Altimeter (SRAL)** • Level 1A-1BS-1B (including waveform) • Level 2 over ocean and ice (surface height, wind speed, significant wave height over ocean, ice)
Sentinel-6 (Jason-CS): Altim[illegible] Mission 	• S6A launch in 2020 • S6B launch in 2025	**Ku/C Radar Altimeter, GNSS Radio Occultation** • Level 1A-1BS-1B (including waveform) • Level 2 over ocean (surface height, SWH, wind speed)

FOCUS ON OCEAN COLOUR

SENTINEL-3 MISSION OVERVIEW

- **Operational mission in high-inclination, low Earth orbit**
- **Full performance achieved with 2 satellites in orbit (S-3A,-3B)**



Optical Mission Payload providing

- **Sea and land color data**, through **OLCI (Ocean and Land Color Instrument)**
- **Sea and land surface temperature**, through the **SLSTR (Sea and Land Surface Temperature Radiometer)**

Topography Mission Payload providing

- **Sea surface topography data**, through a Topo P/L including a **Ku-/C-band Synthetic Aperture Radar Altimeter (SRAL),** a bi-frequency **MicroWave Radiometer (MWR),** and a **Precise Orbit Determination (POD)** including
  - **GNSS Receiver**
  - **DORIS**
  - **Laser Retro-Reflector**

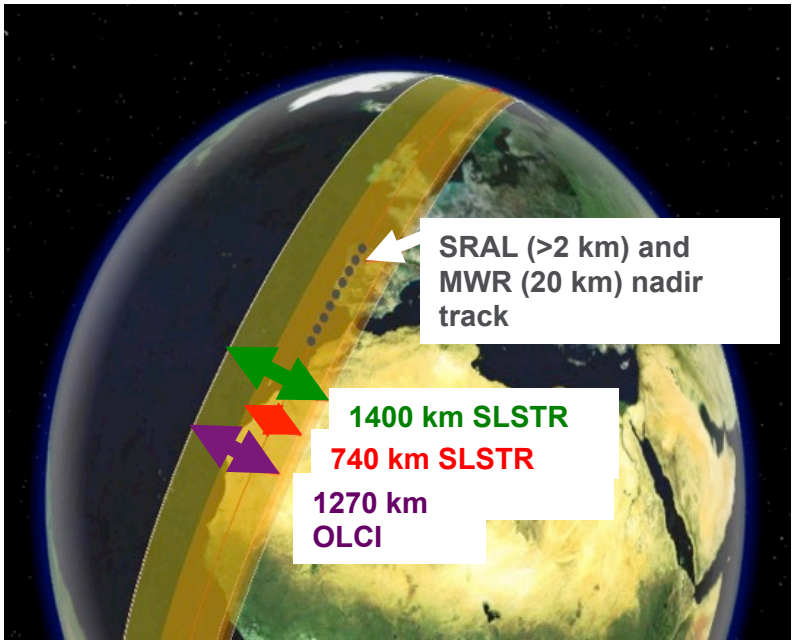
In addition, the payload design will allow

- **Data continuity of the Vegetation instrument (on SPOT4/5),**
- **Enhanced fire monitoring capabilities, river and lake height, atmospheric products**

NEW FEATURES - optical payload

- **100% overlap** between SLSTR and OLCI
- **Increased number of bands** compared to both AATSR and MERIS allowing
  - Synergy between OLCI and SLSTR measurements
  - Enhanced fire monitoring capabilities
  - Enhanced ocean colour products
- **Broader swath**
  - OLCI: from 1150 km to 1270 km
  - SLSTR: Nadir view 500km → 1400km, Oblique view: 500km → 740km
- Optical payload **< 2 days global coverage** (with 2 Satellites) in view of the substantially increased swath
- **Increased spatial resolution**:
  - OLCI: 300m for land and ocean
  - SLSTR: 500m for VIS-SWIR, 1km for IR-Fire
- **Mitigation of sun glint** by tilting cameras 12.5 deg in westerly direction
- **Near-Real Time** (< 3 hr) availability of L1 and L2 core products

Instrument Swath Patterns

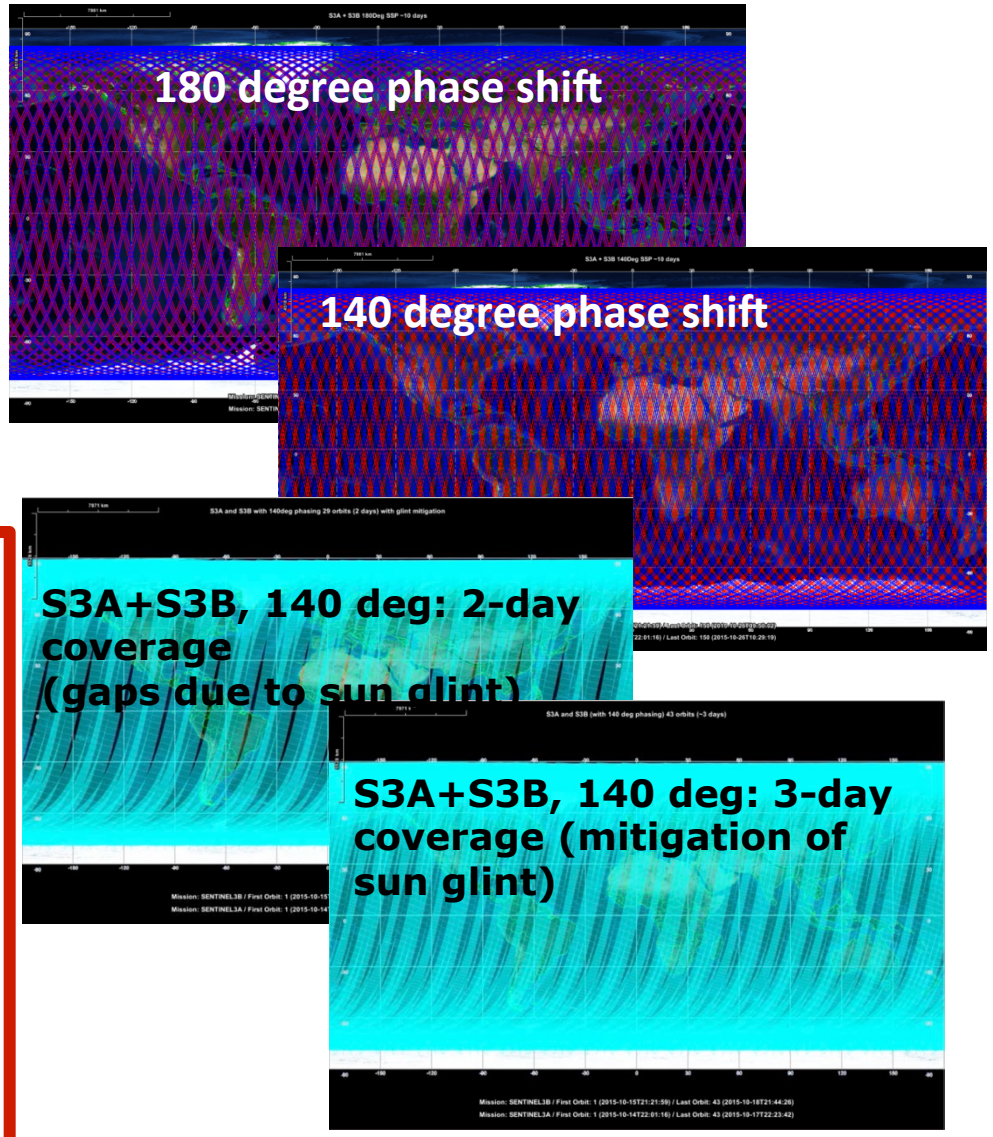


Orbit type	Repeating frozen SSO
Repeat cycle	27 days (14 + 7/27 orbits/day)
LTDN	10:00
Average altitude	815 km
Inclination	98.65 deg

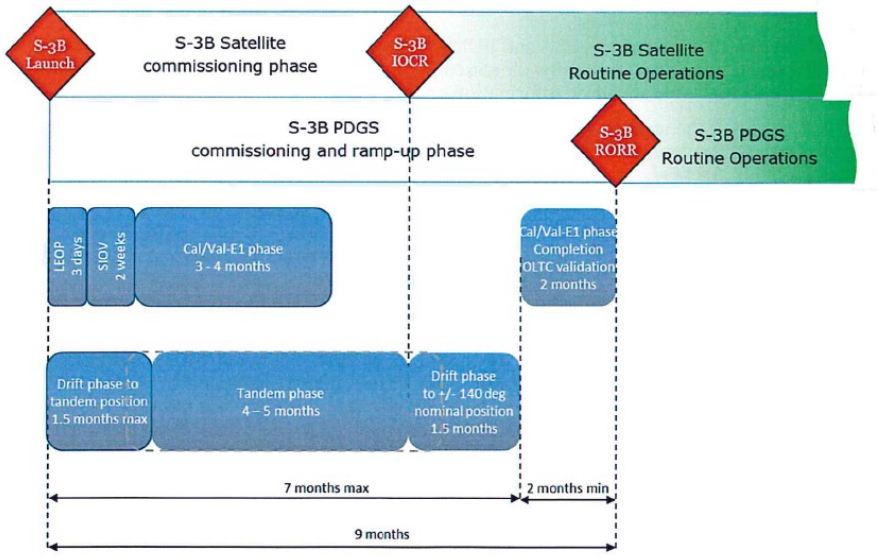
NEW: OPTIMISED ORBIT PHASING OF S3A/B AND C/D

- Copernicus Marine Environment Monitoring Service (CMEMS) asked for optimising orbit phase shift to **improve interleave between S3A and S3B for improved SRAL meso-scale sampling at 4-7 days**
- Solution of **140°** separation recommended by ESA, and confirmed by EUMETSAT assessment.
- EC has confirmed implementation for S3B

- **Minimal impact on optical mission**
  - **Over ocean**
    - OLCI: global coverage <2 days but parts of the swath will be impacted by sun-glint. Sun-glint free coverage by OLCI will be attained in ~3 days over the ocean.
    - SLSTR: coverage and revisit of the SLSTR remains compliant with requirements.
  - **Over land** (sun glint unproblematic, unless inland water) OLCI and SLSTR coverage is expected to remain compliant with requirements.



NEW: Sentinel-3A and -3B Tandem Phase



TECHNICAL PLANNING

- Operate S3A and S3B in Tandem for ~4-5 months at start of mission
- One satellite follows the other on the same ground track with a small 10-30 sec separation: minimum oceanographic and atmospheric variability reducing uncertainty in comparing measurements from both satellites
- Tandem and drift phase into final orbit separation of 140 degree between S3A/B separation completed by launch + 7 months
- Full operational capacity reached by launch + 9 months

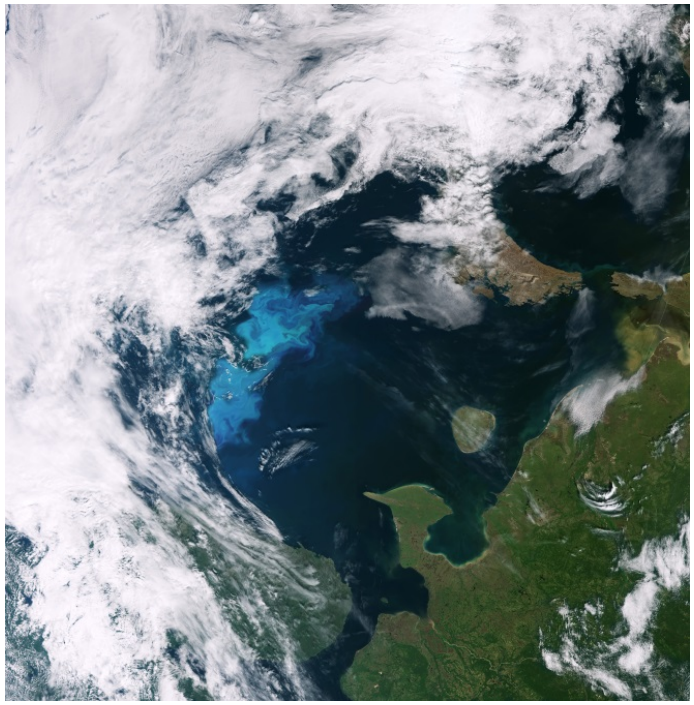
MOTIVATION

GCOS Climate Monitoring Principles (GCMP): need to fully understand biases between satellite missions

- *"Take steps to make radiance calibration, calibration-monitoring and satellite-to-satellite cross-calibration of the full operational constellation a part of the operational satellite system"*
- *"A suitable period of overlap for new and old satellite systems should be ensured for a period adequate to determine inter-satellite biases and maintain the homogeneity and consistency of time - series observations"*

Improved data quality for climate (CDR) and operational applications alike

SENTINEL-3 OLCI CORE DATA PRODUCTS
Level 1 TOA radiances



Switch on	**29 Feb 2016**
Sample L1/L2 data available	**May/June 2016**
L1 data release	**20 Oct 2016**
L2 data release	**Spring 2017**

- Ocean and Land Colour Instrument (OLCI) designed for observation with high absolute (relative) accuracy of 2 (1) % in reflectance, providing continuity for MERIS (Envisat)

- **Level 1 performance**

  - Radiometry: on-board radiometric calibration based; SNR is compliant with specification; calibration gains show some time variability but stability seems to improve with time; vicarious calibration shows spectrally/spatially/dynamically/X-track consistent results, however a ~+3% bias exists. Yaw steering manoeuvres have been performed for diffuser BRDF characterisation.
  - Spectrally: fully compliant; pre-flight characterisation confirmed for all cameras in-flight (<0.15nm); small temporal trends since beginning of the mission (comparable to MERIS)
  - Geometry: fully compliant (60m @ Nadir); bi-monthly check that thermo-elastic model is accounting for seasonal variations.

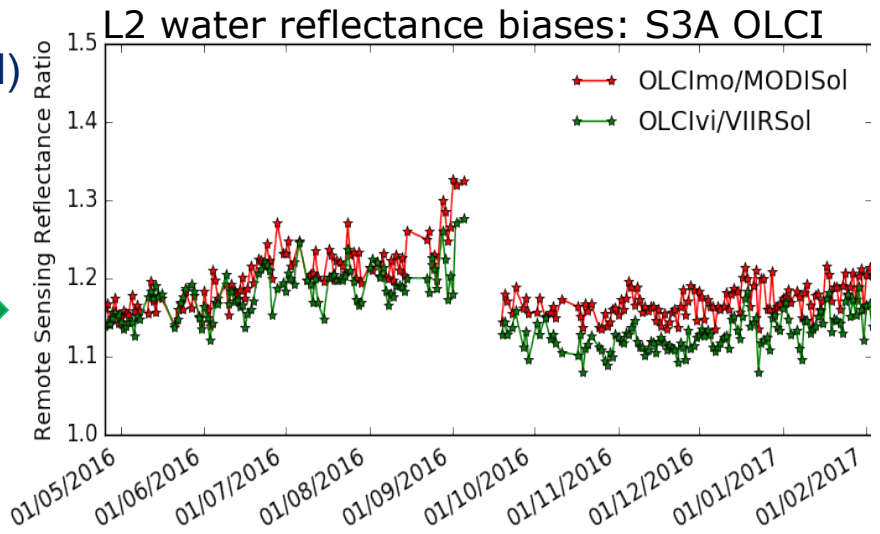
SENTINEL-3 OLCI CORE DATA PRODUCTS
Level 2 Ocean Colour

Status

- Available to the Sentinel-3 Validation Team
- Improved processing available in reprocessed data set (May-August 2016) and in NRT/ NTC since week 18/2017
- Calibration model update, further reprocessing and system vicarious adjustment ongoing

Issues

- Overestimation of water-leaving reflectance in VIS bands (blue > green > red)
- Noise in water-leaving reflectance well above proportion of noise at TOA
- Channel Oa21 (1020nm) quality
- Underestimation of Chl
- Many lesser issues *e.g.* “case 2” products

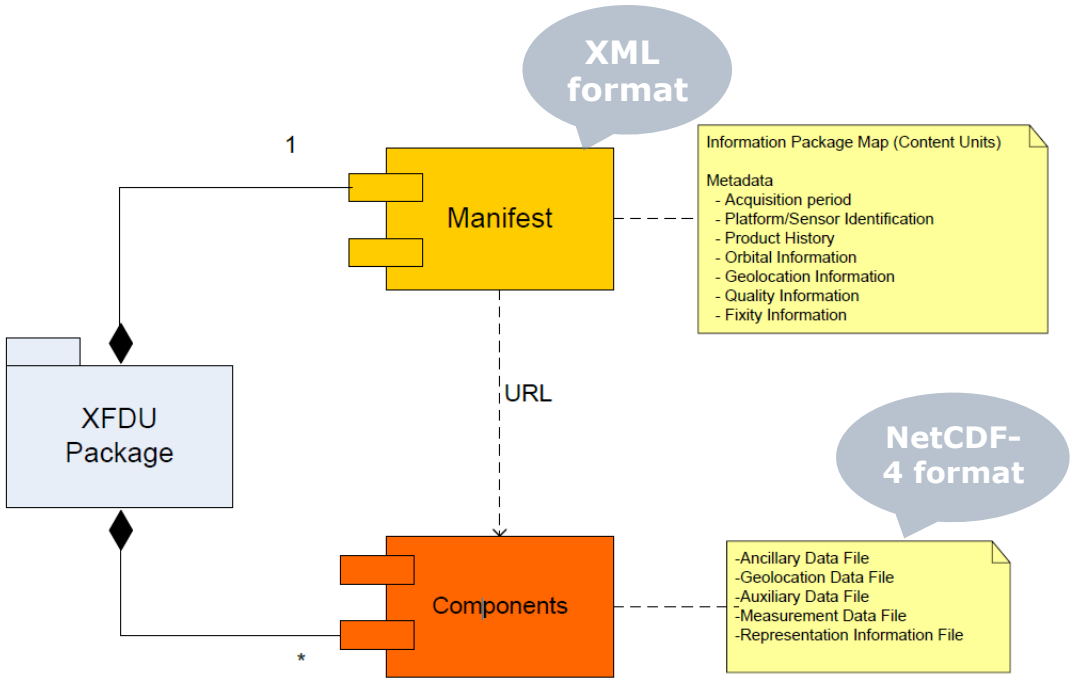


Outlook

- Application of updated calibration model and vicarious adjustment,
- **Release for operational use in 06/2017**

SENTINEL3 OCEAN COLOUR PRODUCTS ARE SAFE

- The Sentinel Products are organised in Standard Archive Format for Europe (SAFE) **packages**, using a restriction of the CCSDS XML Formatted Data Unit (XFDU).
- Delivery in **tar** format over EUMETCast or from EUMETSAT Data Centre



Example: OL_2_W product package contents:

- **xfdumanifest.xml**

Gridded data at measurement grid:

- **O*ann*_reflectance.nc**
- **chl_oc4me.nc**
- **chl_nn.nc**
- **iop_nn.nc**
- **tsm_nn.nc**
- **trsp.nc**
- **par.nc**
- **w_aer.nc**
- **iwv.nc**
- **time_coordinates.nc**
- **geo_coordinates.nc**
- **wqsf.nc**

Gridded data at tie point grid:

- **tie_geo_coordinates.nc**
- **tie_geometries.nc**
- **tie_meteo.nc**

Non-gridded data

- **instrument_data.nc**

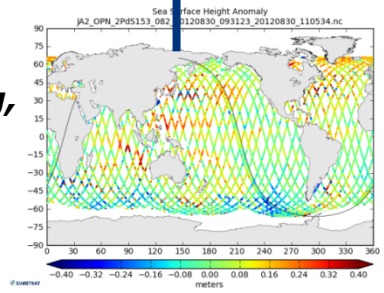
SENTINEL-3 PRODUCT TIMELINESS

sensing time

<3 h | <48 h | <30 d | ~1 y | time

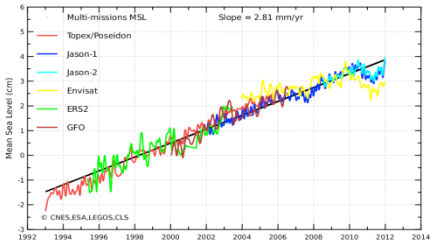
NRT products

Weather and ocean forecasting, sea state forecasting



STC products

Operational ocean monitoring and forecasting



NTC products

Climate monitoring

Oceanography

Climatology

Data exploitation for science

OLCI NTC Ocean Colour products are usually available within 2-3 days from sensing

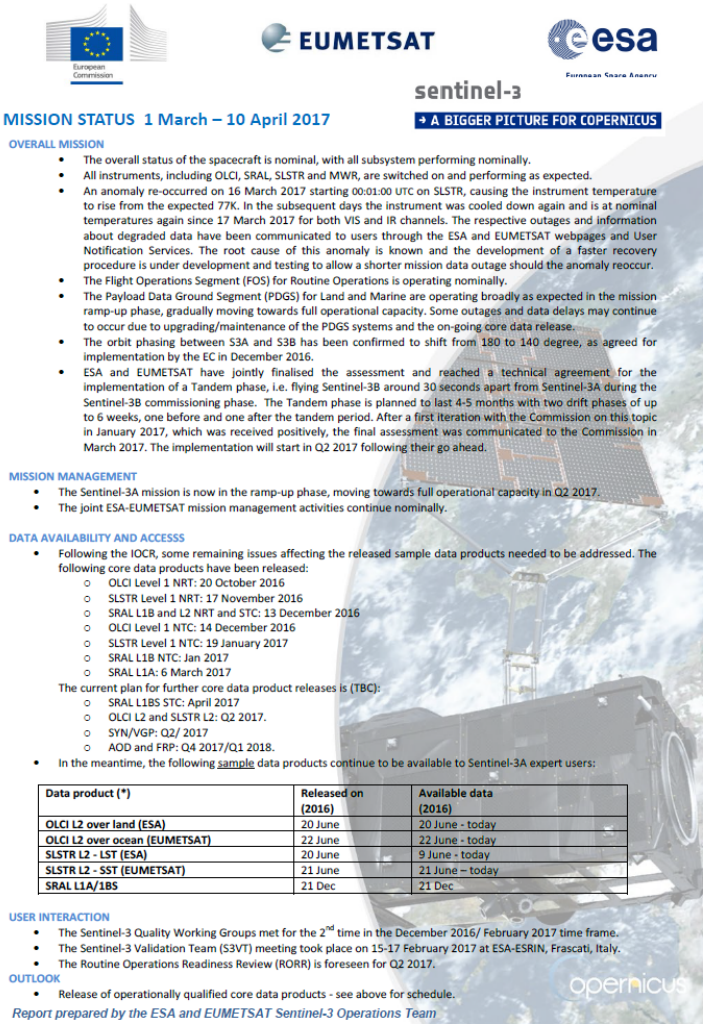
NRT: Near Real time

STC: Short Time Critical

NTC: Non time Critical

SENTINEL-3 CORE DATA PRODUCT RELEASE OVER OCEAN

- **All Level 1** have been released
- **Level 2**
  - SRAL over land and ocean released in Dec 2016
  - **OLCI and SLSTR sample data products are available to expert users, official release planned for June 2017**
- **Sample products** of not released core products available to expert users
- **Continuous improvement** of OC products
- **New OC products**
  - Inherent Optical Properties,
  - Fluorescence Line Height → in 2018
  - Considering: Phytoplankton, Functional Types, Carbon Products
- **Reprocessed data** sets for the Sentinel-3 Validation Team workshop released end of January 2017 available for following periods:
  - **OLCI 25/04/16-14/08/16**
  - SLSTR 12/07/16-15/11/16
  - SRAL 15/06/16- 15/11/16
- **Reprocessing of S3A full mission** data planned before end of 2017



EUMETSAT esa

sentinel-3

MISSION STATUS 1 March – 10 April 2017

→ A BIGGER PICTURE FOR COPERNICUS

OVERALL MISSION

- The overall status of the spacecraft is nominal, with all subsystem performing nominally.
- All instruments, including OLCI, SRAL, SLSTR and MWR, are switched on and performing as expected.
- An anomaly re-occurred on 16 March 2017 starting 00:01:00 UTC on SLSTR, causing the instrument temperature to rise from the expected 77K. In the subsequent days the instrument was cooled down again and is at nominal temperatures again since 17 March 2017 for both VIS and IR channels. The respective outages and information about degraded data have been communicated to users through the ESA and EUMETSAT webpages and User Notification Services. The root cause of this anomaly is known and the development of a faster recovery procedure is under development and testing to allow a shorter mission data outage should the anomaly reoccur.
- The Flight Operations Segment (FOS) for Routine Operations is operating nominally.
- The Payload Data Ground Segment (PDGS) for Land and Marine are operating broadly as expected in the mission ramp-up phase, gradually moving towards full operational capacity. Some outages and data delays may continue to occur due to upgrading/maintenance of the PDGS systems and the on-going core data release.
- The orbit phasing between S3A and S3B has been confirmed to shift from 180 to 140 degree, as agreed for implementation by the EC in December 2016.
- ESA and EUMETSAT have jointly finalised the assessment and reached a technical agreement for the implementation of a Tandem phase, i.e. flying Sentinel-3B around 30 seconds apart from Sentinel-3A during the Sentinel-3B commissioning phase. The Tandem phase is planned to last 4-5 months with two drift phases of up to 6 weeks, one before and one after the tandem period. After a first iteration with the Commission on this topic in January 2017, which was received positively, the final assessment was communicated to the Commission in March 2017. The implementation will start in Q2 2017 following their go ahead.

MISSION MANAGEMENT

- The Sentinel-3A mission is now in the ramp-up phase, moving towards full operational capacity in Q2 2017.
- The joint ESA-EUMETSAT mission management activities continue nominally.

DATA AVAILABILITY AND ACCESSS

- Following the IOCR, some remaining issues affecting the released sample data products needed to be addressed. The following core data products have been released:
  - OLCI Level 1 NRT: 20 October 2016
  - SLSTR Level 1 NRT: 17 November 2016
  - SRAL L1B and L2 NRT and STC: 13 December 2016
  - OLCI Level 1 NTC: 14 December 2016
  - SLSTR Level 1 NTC: 19 January 2017
  - SRAL L1B NTC: Jan 2017
  - SRAL L1A: 6 March 2017

  The current plan for further core data product releases is (TBC):
  - SRAL L1BS STC: April 2017
  - OLCI L2 and SLSTR L2: Q2 2017.
  - SYN/VGP: Q2/ 2017
  - AOD and FRP: Q4 2017/Q1 2018.
- In the meantime, the following sample data products continue to be available to Sentinel-3A expert users:

Data product (*)	Released on (2016)	Available data (2016)
OLCI L2 over land (ESA)	20 June	20 June - today
OLCI L2 over ocean (EUMETSAT)	22 June	22 June - today
SLSTR L2 - LST (ESA)	20 June	9 June - today
SLSTR L2 - SST (EUMETSAT)	21 June	21 June – today
SRAL L1A/1BS	21 Dec	21 Dec

USER INTERACTION

- The Sentinel-3 Quality Working Groups met for the 2nd time in the December 2016/ February 2017 time frame.
- The Sentinel-3 Validation Team (S3VT) meeting took place on 15-17 February 2017 at ESA-ESRIN, Frascati, Italy.
- The Routine Operations Readiness Review (RORR) is foreseen for Q2 2017.

OUTLOOK

- Release of operationally qualified core data products - see above for schedule.

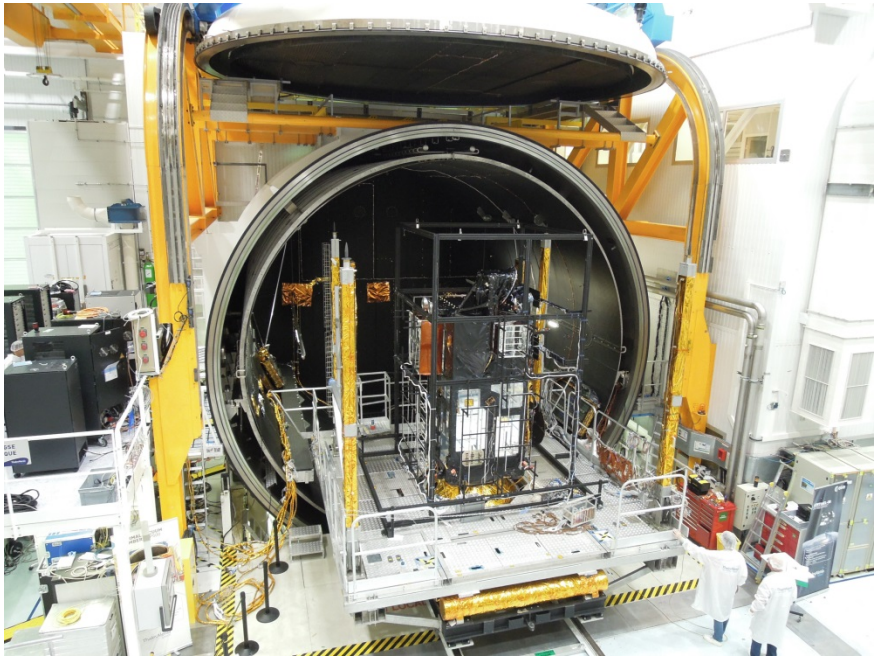
Report prepared by the ESA and EUMETSAT Sentinel-3 Operations Team

opernicus

Mission status reports on: https://sentinel.esa.int/web/sentinel/missions/sentinel-3/mission-status

UPDATE ON SENTINEL-3B

- **Sentinel-3B activities restarted in Q2 2016** after Sentinel-3A launch in Feb 2016
- Implementation of Return of Experience (REX) from S3A on-going
- Instrument status
  - **Topography** payload fully available and integrated, no open issues
  - **SLSTR** Proto-Flight Model assembly and testing progressing according to plan: Instrument calibration tests successfully completed in Feb in RAL and instrument currently at TAS-F for integration.
  - **OLCI-B** model experienced major anomaly (same as for A instrument) during instrument TVAC in July 2016; decision to refurbish all 5 cameras, which are now available and tested with good performance results; delivery of OLCI-B for S/L integration by mid June 2017 confirmed



- In view of late delivery of OLCI, Sentinel-3B S/L Integration and test activities reorganised to fit launch schedule
- Sentinel-3B Flight Acceptance Review planned for October 2017, launch date foreseen for end of 2017 (TBC)

SENTINEL-2 OVER OCEAN

WHAT IS AVAILABLE

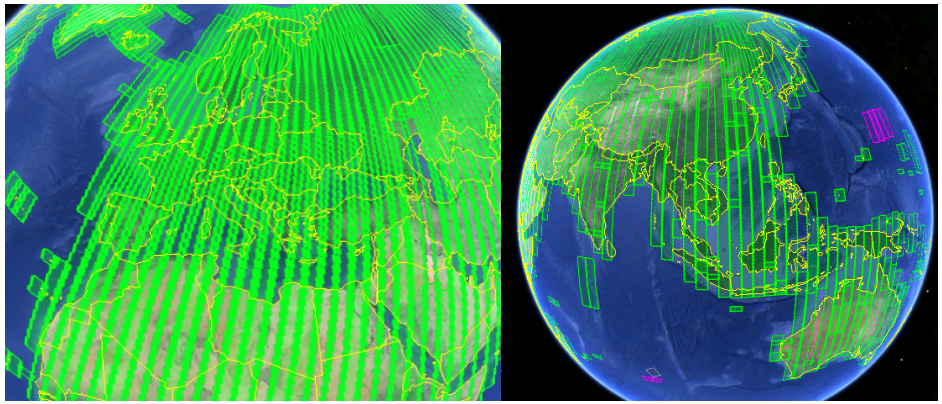
- Level 1C TOA reflectance
- Level 2A BOA reflectance – over Europe available now, global TBC
- In coastal areas (~20 km off coast), small enclosed seas (e.g. Med Sea, Baltic) , and island > 100km2
- Resolution: 10, 20, 60m
- Spectral range: VIS – SWIR

STATUS

- Sentinel-2A is in routine operations
- Sentinel-2B launched on 6 March 2017
- Reprocessing of data acquired during Sentinel-2A commissioning phase and entire Sentinel-2 archive into new tile format (100x100km)
- July 2017: Results of Level-2A (BOA reflectance, atmospherically corrected) feasibility study, objective to decide roadmap for systematic global Level -2A production
- Continued Sentinel-2B in-orbit commissioning, IOCR planned for mid June, followed by ramp-up (4 months)

DATA ACCESS

- ESA Sentinel Data Hubs: Level 1C
- ESA Copernicus Open Access Hub: Level-2A Europe



ESA and EUMETSAT DATA ACCESS

ESA SENTINEL DATA DISTRIBUTION - *CONFIGURATION*

spacedata.copernicus.eu

Copernicus Open Access Hub

- LATEST NEWS
- 78,112 Self registered Users
- 16,192,752 Products Downloaded
- 14.02 PB Volume Downloaded
- No Rolling Policy
- Sentinel-1 NTC
- Sentinel-2 L1C
- Sentinel-3 (preops)
- Max 2 concurrent Downloads

Collaborative Hub

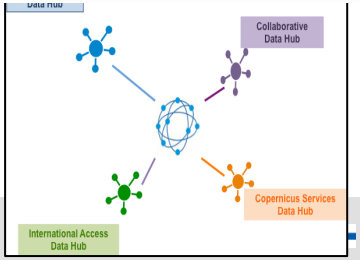
- LATEST NEWS
- 13 Collaborative GS
- 7 Data Hub Relays
- 6,810,570 Products Downloaded
- 6.84 PB Volume Downloaded
- Node1: 30 days
- Node2: 9 days
- Sentinel-1 NRT & NTC
- Sentinel-2 L1C
- Node1: Max 10 downloads
- Node2: No Limits

International Hub

- LATEST NEWS
- 4 International Agreements
- 2,284,381 Products Downloaded
- 2.07 PB Volume Downloaded
- 30 days
- Sentinel-1 NTC
- Sentinel-2 L1C
- Max 10 concurrent downloads

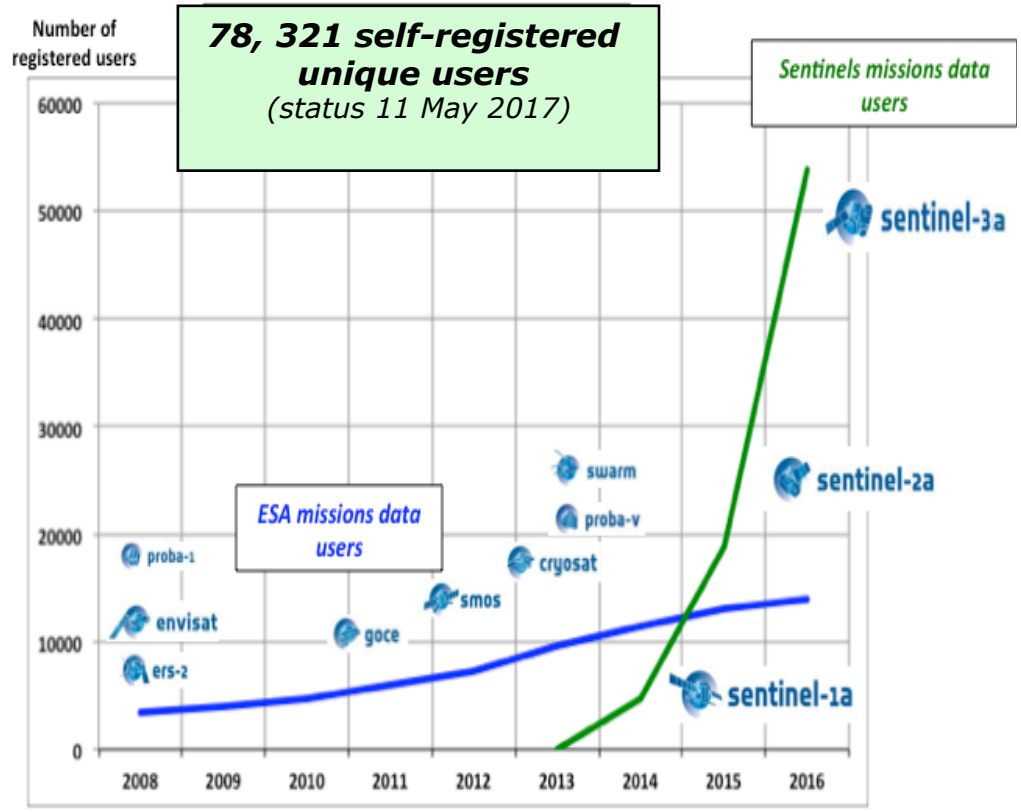
Copernicus Services Hub

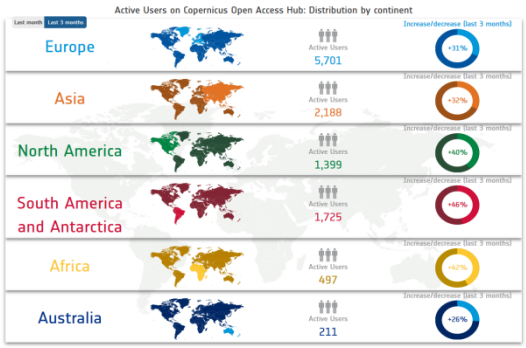
- LATEST NEWS
- 185 Registered Users
- 913,170 Products Downloaded
- 704.1 TB Volume Downloaded
- No Rolling Policy
- Sentinel-1 NTC
- Sentinel-2 L1C
- Max 10 concurrent downloads



Statistics: 11 May 2017

ESA SENTINEL DATA DISTRIBUTION – *USER REGISTRATION*

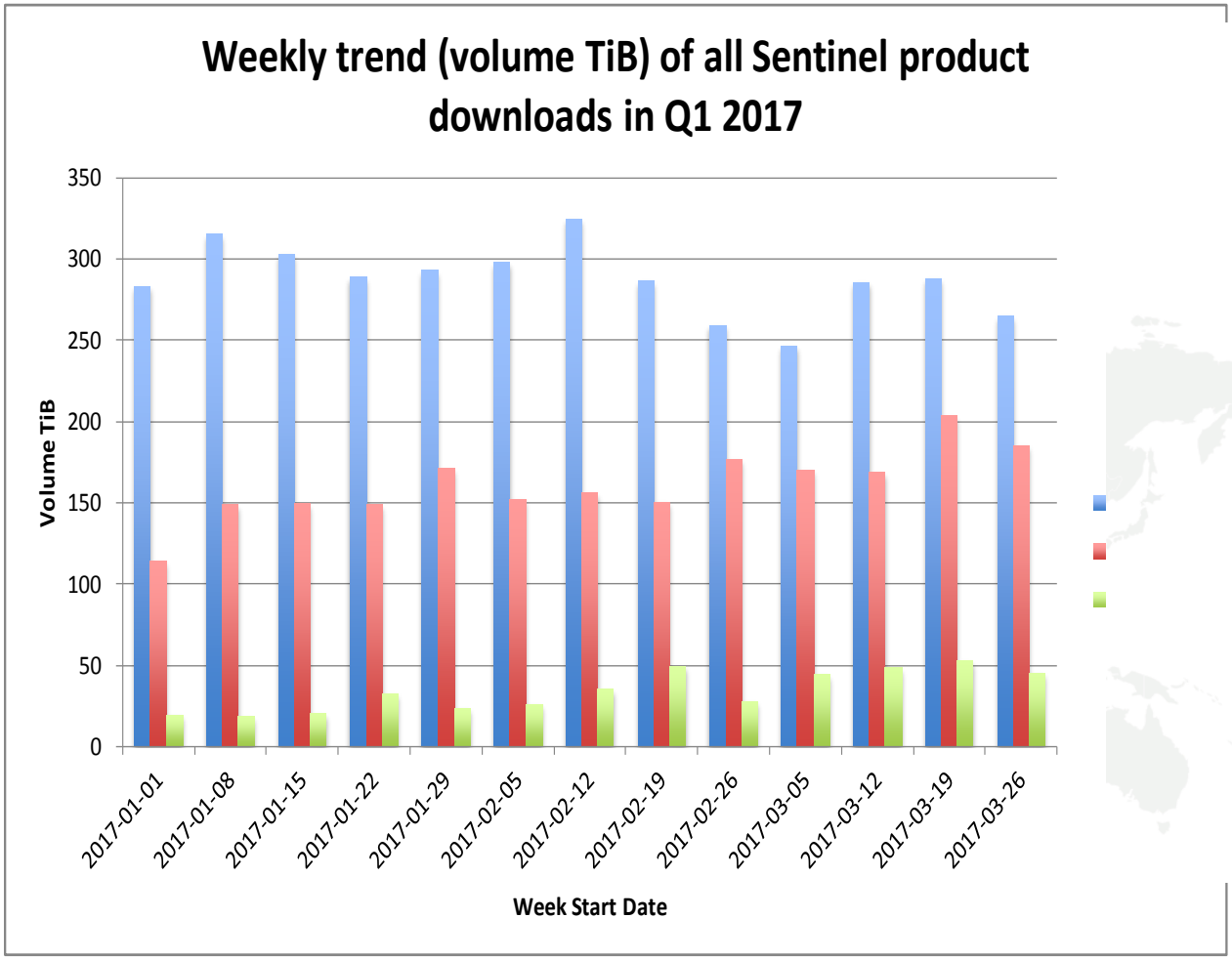


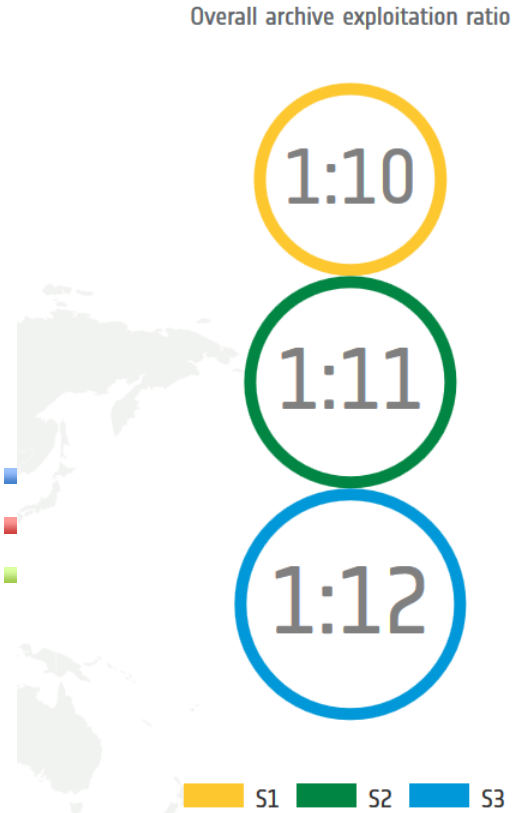


FACTS AND FIGURES 2016

- Produced in one year the equivalent of **50 years of ENVISAT mission data**
- **Increase of 250% in registered users** in last twelve months
- Reached **1.5 PB of data disseminated** to end users in a single month
- Served an average of more than 2 million user queries a day
- As of 2017, it is projected that approx. **1 million new products** will be generated quarterly

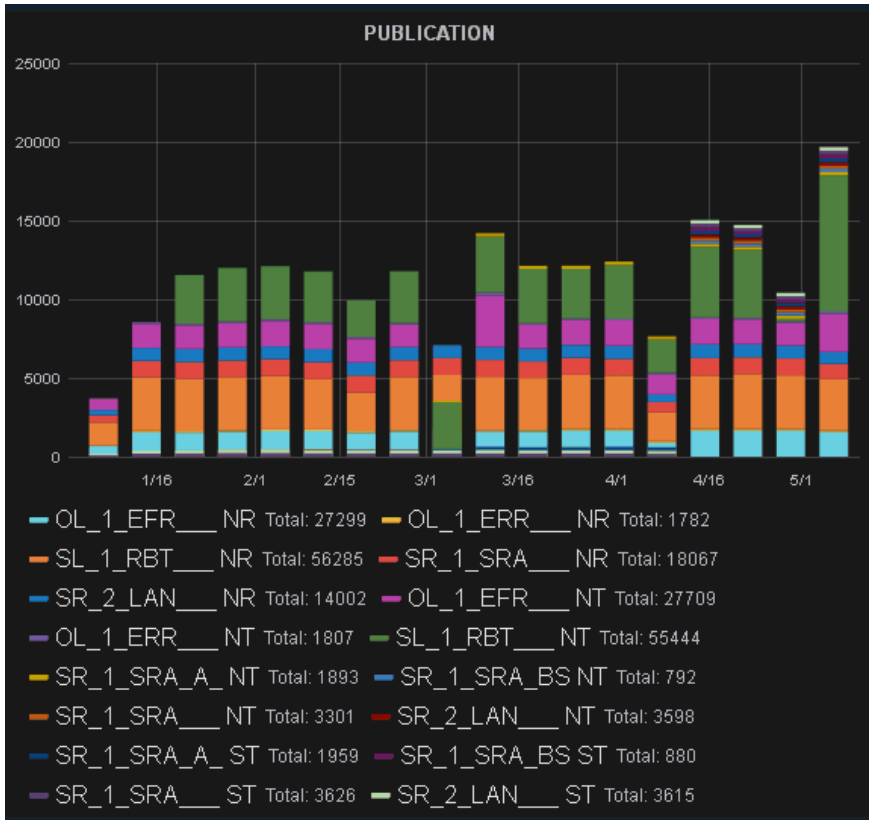
ESA SENTINEL DATA DISTRIBUTION – *STATISTICS*



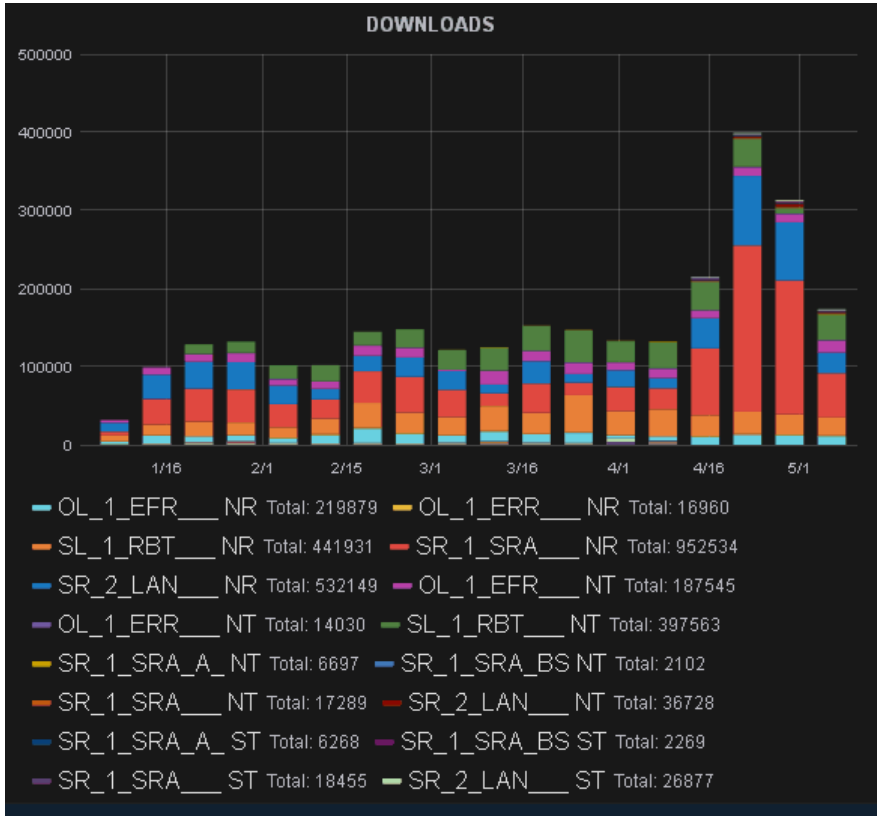


ESA SENTINEL-3 PRE-OPS HUB STATISTICS

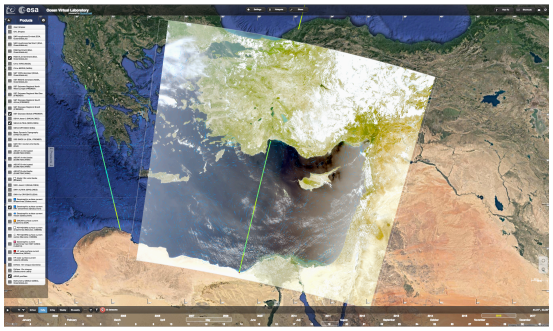
Publication of products (#) 1 Jan 2017 - now



Download of products (#) 1 Jan 2017 - now



ESA SENTINEL-3 TOOLS OVER OCEAN



- **S3-View:** allow Sentinel-3 users to efficiently discover Sentinel-3 data product content and assess their suitability for further application; uses Syntool software developed by the SEOM Ocean Virtual Laboratory (OVL) project http://ovl.oceandatalab.com/

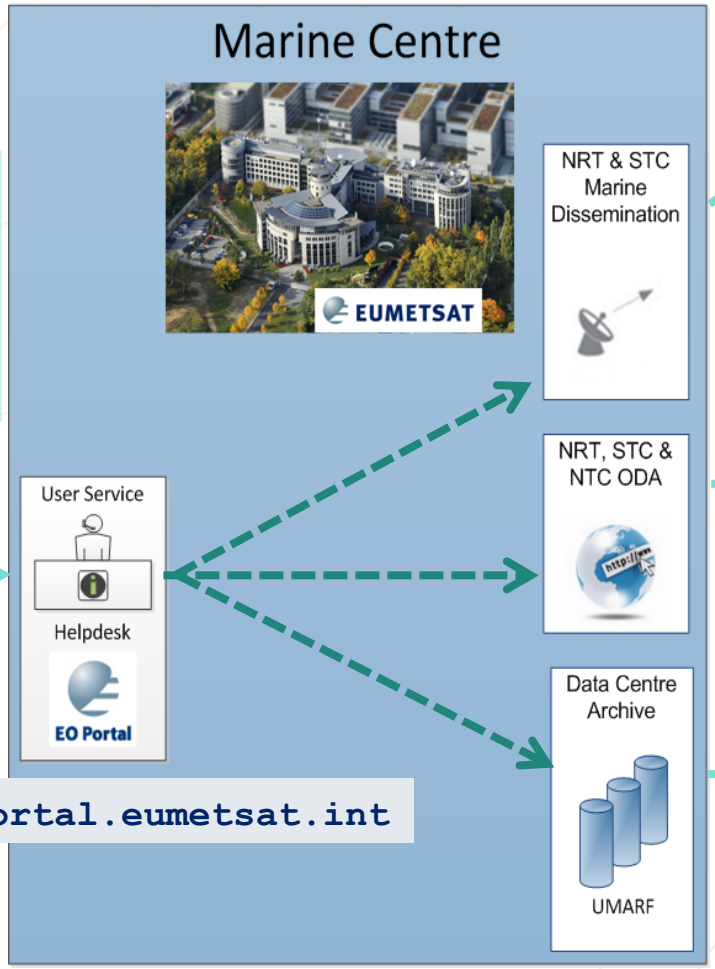
- **SNAP**: Visualisation & processing of Sentinel-3 OLCI and SLSTR data and other optical data; http://step.esa.int/

- **Delay-Doppler Altimetry Studio (DeDop)**: provide means to users to understand and use the low levels of Altimetry data and how these data are processed, by providing them with a Fully Adaptable and Configureable DDP and a friendly user interface. http://dedop.org/

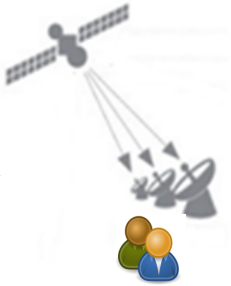
- **Broadview Radar Altimetry Toolbox (BRAT):** facilitates the processing of radar altimetry data; reads all previous and current altimetry missions' data; http://earth.esa.int/brat.

EUMETSAT S3 Marine Services & Data Access

User Support
User Registration & Support, Product Discovery Helpdesk, etc



http://eoportal.eumetsat.int



EUMETCast
EUMETSAT's data push service for NRT data. Can involve satellite and terrestrial methods.

Copernicus Online Data Access (CODA)
Rolling archive supporting http access

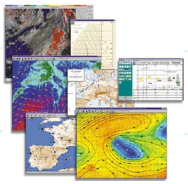
EUMETSAT Data Centre
Complete historical archive of all EUMETSAT data including S-3 marine data

EUMETCast Data Push Service

- EUMETCast is EUMETSAT's integrated dissemination system for the delivery of near real-time environmental data including S3 and later on S4 and S5;
- EUMETCast Satellite service has coverage over Europe, the Middle-East and Africa;

Key Features:

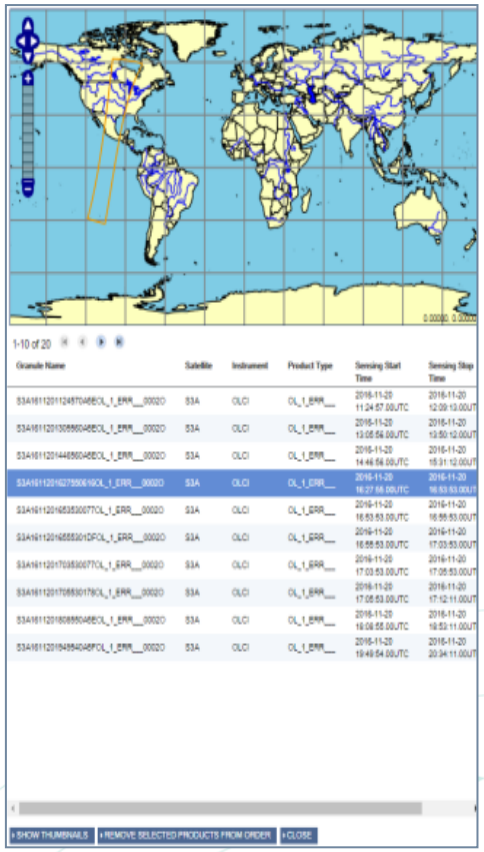
- Targets a large audience and delivers a wide range of earth observation data;
- Near real-time data stream includes Meteosat, Metop, **Jason-2 / -3, Sentinel-3** satellite data and wide range of third-party satellite data services;
- Service utilises low cost, user-friendly satellite receiving equipment similar to satellite TV;
- Secure delivery of data files to targeted audiences, with guaranteed service level.
- **EUMETCast Terrestrial** is a demonstration dissemination service:
    - The network used is the National Research and Education Network (NREN) and the GÉANT infrastructure.



European Commission Copernicus EUMETSAT

EUMETSAT's Archive Data Ordering Service

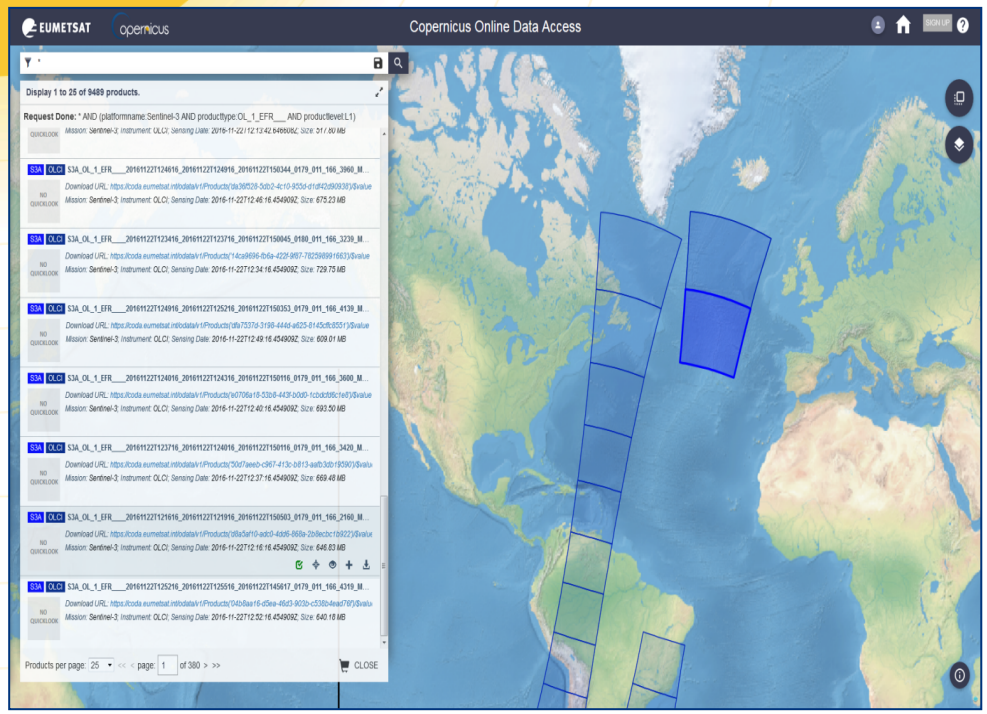
- The Data Centre provides access to the long-term archive of S3 and EUMETSAT mission data.

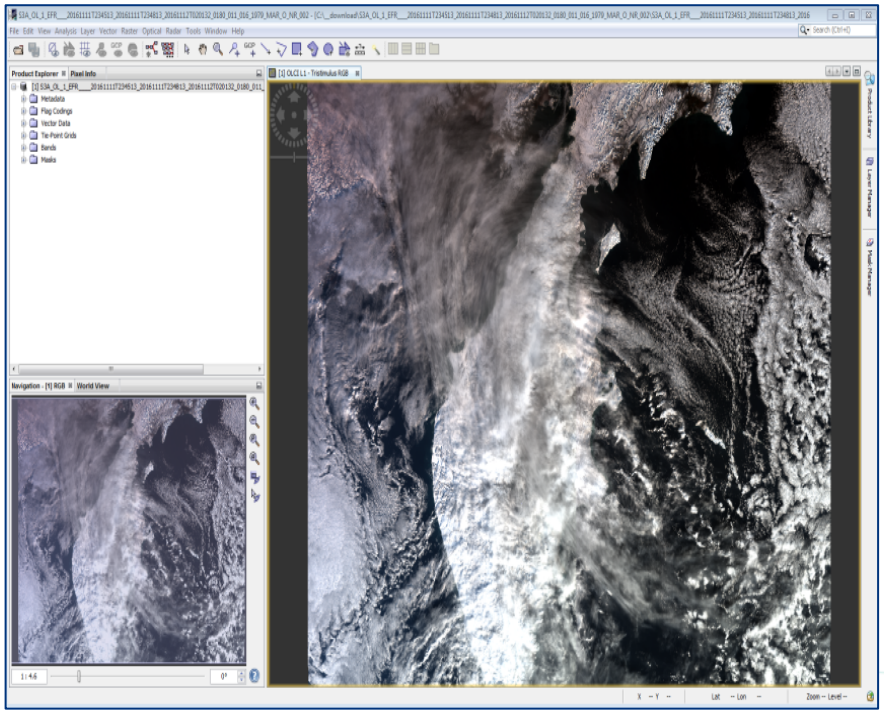


Key Features:

- Order options allow you to select your chosen format, spatial and spectral sub-setting and apply data compression;
- Orders are automatically processed and smaller orders are delivered within a few hours;
- Resulting data can be retrieved from an online server (http-download) or via offline media, depending on the volume of data requested;
- The Data Centre catalogue spans the whole satellite mission life. It guarantees the long-term preservation of these data which are critical for the generation of climate data records.

EUMETSAT's CODA Download Service





Key Features:

- CODA is an online rolling archive with http access. It provides access to Sentinel-3 data that has been declared operational;
- The user manual explains how to use the online tool, including how to download via an API (Open Data Protocol [Odata], Open Search [Solr])

S3 Marine Products Distribution

Product	EUMETCast		CODA	Data Centre	Timeliness	Size per orbit (GB)
	Sat.	Terr.				
OLCI L1 EFR	✓		✓	✓	NRT	21.5
			✓	✓	NTC	*idem*
OLCI L1 ERR	✓		✓	✓	NRT	1.4
			✓	✓	NTC	*idem*
OLCI L2 WFR		✓	✓	✓	NRT	14.2
			✓	✓	NTC	*idem*
OLCI L2 WRR	✓		✓	✓	NRT	0.95
			✓	✓	NTC	*idem*
SLSTR L1B			✓	✓	NRT, NTC	29.0
SLSTR L2 WST	✓		✓	✓	NRT	0.75
			✓	✓	NTC	Idem
SRAL L1B	✓		✓	✓	NRT, STC*	0.4
			✓	✓	NTC	idem
SRAL L2 WAT	✓		✓	✓	NRT, STC*	0.2
			✓	✓	NTC	idem

OLCI "mini-file" (Region Of Interest selected L1 and L2 products) available to S3VT members on Offline Data Access

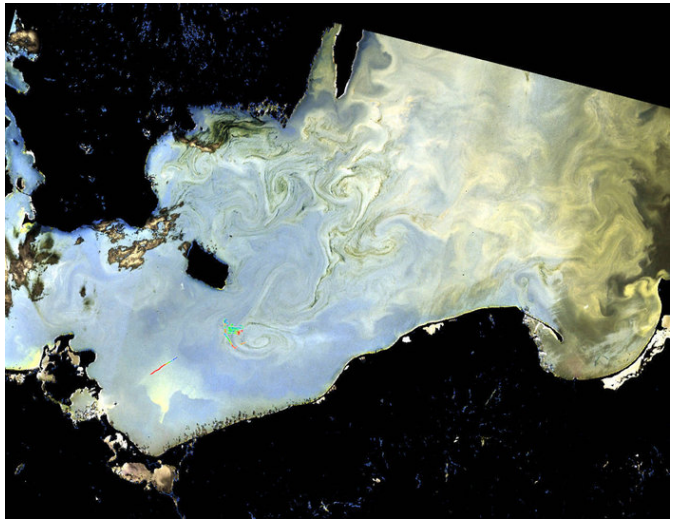
S3 OC Dissemination Status

	ODA/CODA			EUMETCast			Data Centre		
	NRT	STC	NTC	NRT	STC	NTC	NRT	STC	NTC
Level 0	√ (special users)						√ (special users)		
Level 1									
OLCI	√ (FR + RR)		√ (FR + RR)	√ (FR + RR)			√ (FR + RR)		√ (FR + RR)
SLSTR	√		√				√		√
SRAL	√	√	√	√	√		√	√	√
MWR	√		√	√			√	√	√
Level 2									
OLCI	√	-	√	√ (RR - Sat) (FR- Ter)			√		√
SLSTR	√	-	√	√			√		√
SRAL/ MWR	√	√	√	√	√		√	√	√

Green = dissemination activated / product operational
Pink = dissemination activated / product not operational (i.e. disseminated only to S3VT)
Orange = dissemination only for special users
Grey = not applicable

MAIN MESSAGES

- **Large variety of Sentinel data over ocean available through ESA's and EUMETSAT's data dissemination systems**
- Sentinel-3A in ramp-up phase with OLCI Level 2 ocean color data to be officially released in June 2017. Level 1 already available from ESA and EUMETSAT since October 2016.
- Sentinel-3B launch planned for end 2017
- Sentinel-2A Level 1C and Level 2 (Europe) available; Sentinel-2B data will be released summer 2017.



Baltic swirls; Credit: Contains modified Copernicus Sentinel data (2016)/HZG; Helmholtz-Zentrum Geesthacht's Clockwork Ocean project

Access to Sentinel data through

- ESA through the Sentinel Data Hub, Copernicus Services Hub, Collab Hub etc
- EUMETSAT Earth Observation Portal, CODA, Data Centre, EUMETCast
- Note variety of tools to visualise and process Sentinel-3 [marine] data

THANK YOU

Susanne Mecklenburg and Francois Montagner

Susanne.mecklenburg@esa.int and francois.montagner@eumetsat.int