European Space Agency

Ocean Colour Activities at ESA

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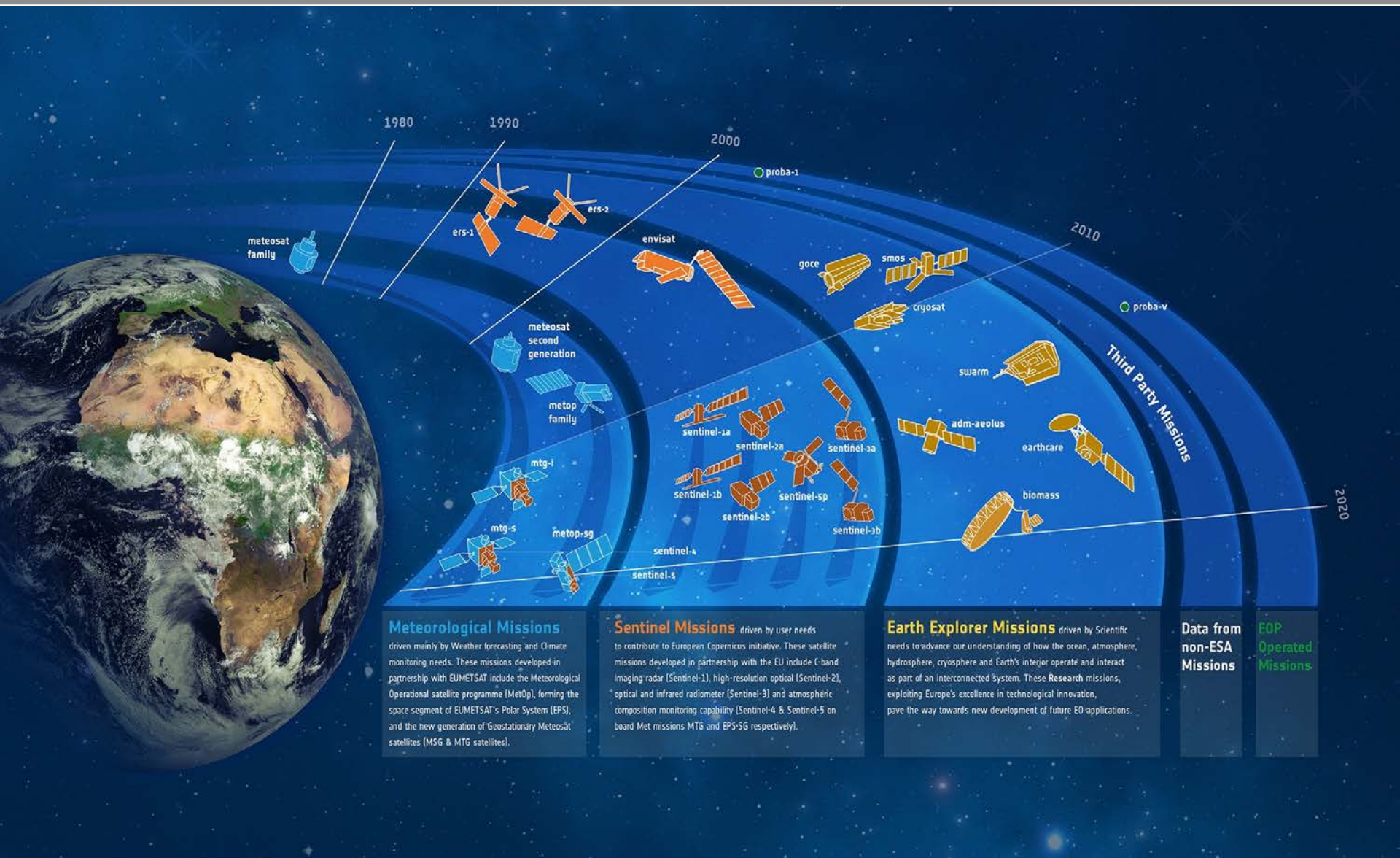
Assets in orbit



Outline

- MERIS 4th reprocessing
- Sentinel-3: OLCI status and plan
- Sentinel-2 for OC ?
- CCI Program – Ocean Colour
- FRM4OC
- SEOM program
- Conclusion

MERIS 4° reprocessing

- ENVISAT : March 2002 – April 2012 → 10 years of data
- MERIS is composed of five cameras disposed side by side, each equipped with a pushbroom spectrometer. These spectrometers use two-dimensional CCDs

→ 15 wavelengths (from 412.5 nm to 900 m), swath 1150 km

→ two spatial resolutions: Reduced Resolution (RR) 1 km, Full Resolution (FR) 300 m

→ systematic acquisition, processing in RR, Regional acquisition (land and coast) in FR

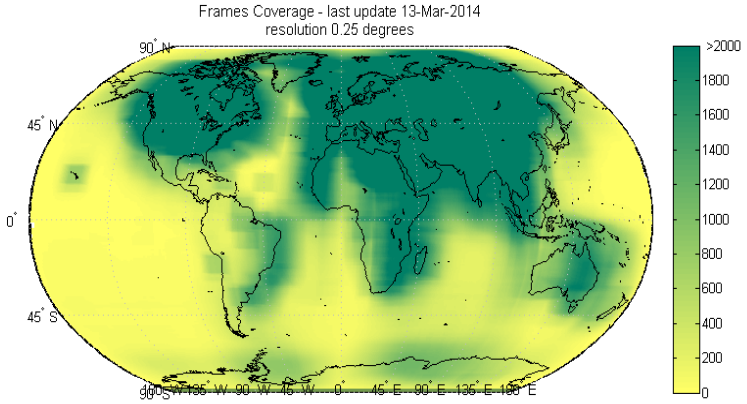
- 3 onboard calibration devices
- 3 reprocessing campaigns (RR) were done during the mission lifetime
- Data (RR and FR) free available at:

https://earth.esa.int/web/guest/data-access/online-archives

- Documentation (inc. ATBD, DPM, validation) available at:

https://earth.esa.int/web/sppa/mission-performance/esa-missions/envisat/meris/products-and-algorithms/products-information

- 4th reprocessing in preparation. Global reprocessing L1 and L2, RR and FR



MERIS 4° reprocessing

Sentinel-3 format: XML + Netcdf

Level 1B : Calibration update, ortho-geolocation

Level 2:

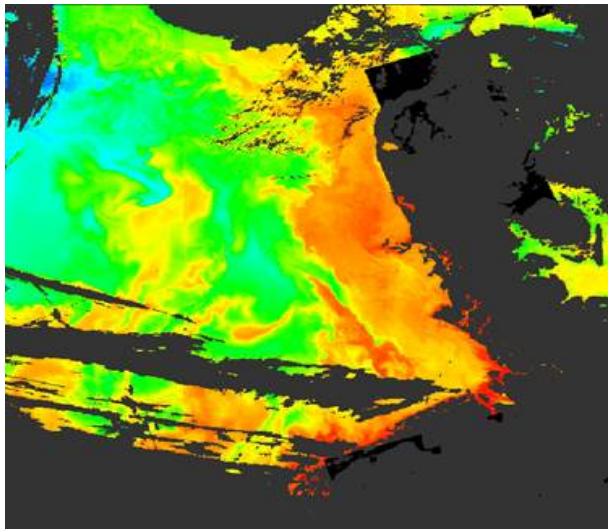
- Better classification
- Better BPAC
- Aerosol Model aligned with NASA – GSCF
- Better Water vapour product
- Pressure adjustment
- Aerosol over land
- Products provided with uncertainties per pixel

Reprocessing will start early 2016 – Data will be available by spring 2016.

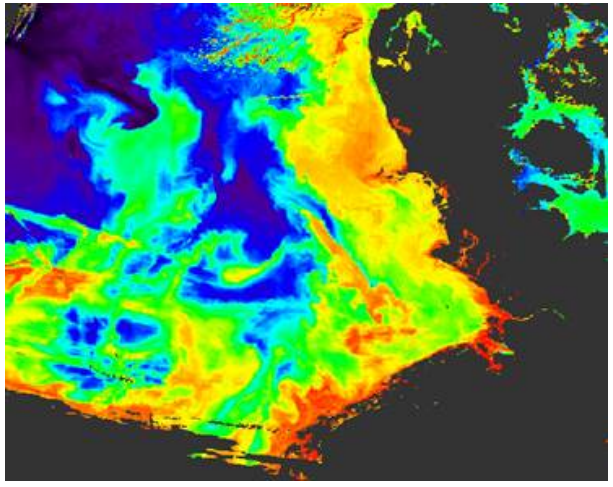
Documentation and validation report will be available at:

https://earth.esa.int/web/sppa/mission-performance/esa-missions/envisat/

Chl 4th reprocessing – better cloud masking



Chl 3rd reprocessing – cloud masking issue



MERIS 4° reprocessing

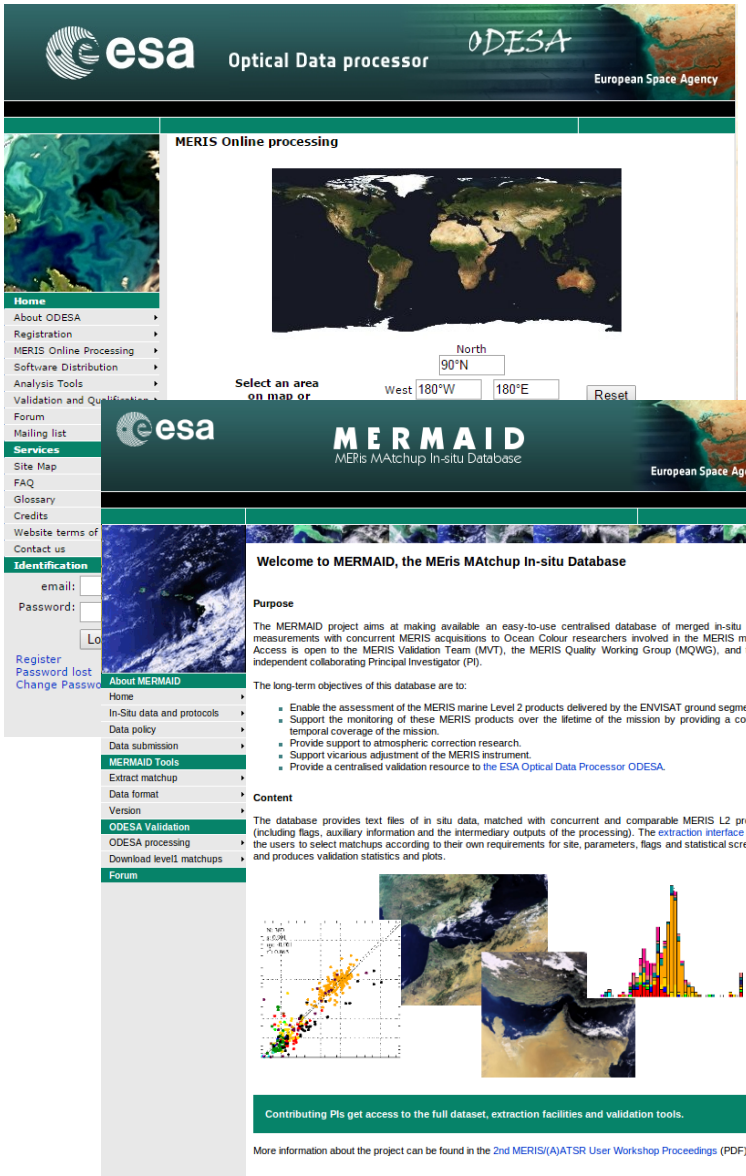
ODESA and MERMAID will be updated

- The ODESA system provides the users with a complete level 2 processing environment for the MERIS instrument (as well as for the future ESA optical sensors on board Sentinel 3.)

- Source code, embedded in an efficient framework for testing and for validation activities

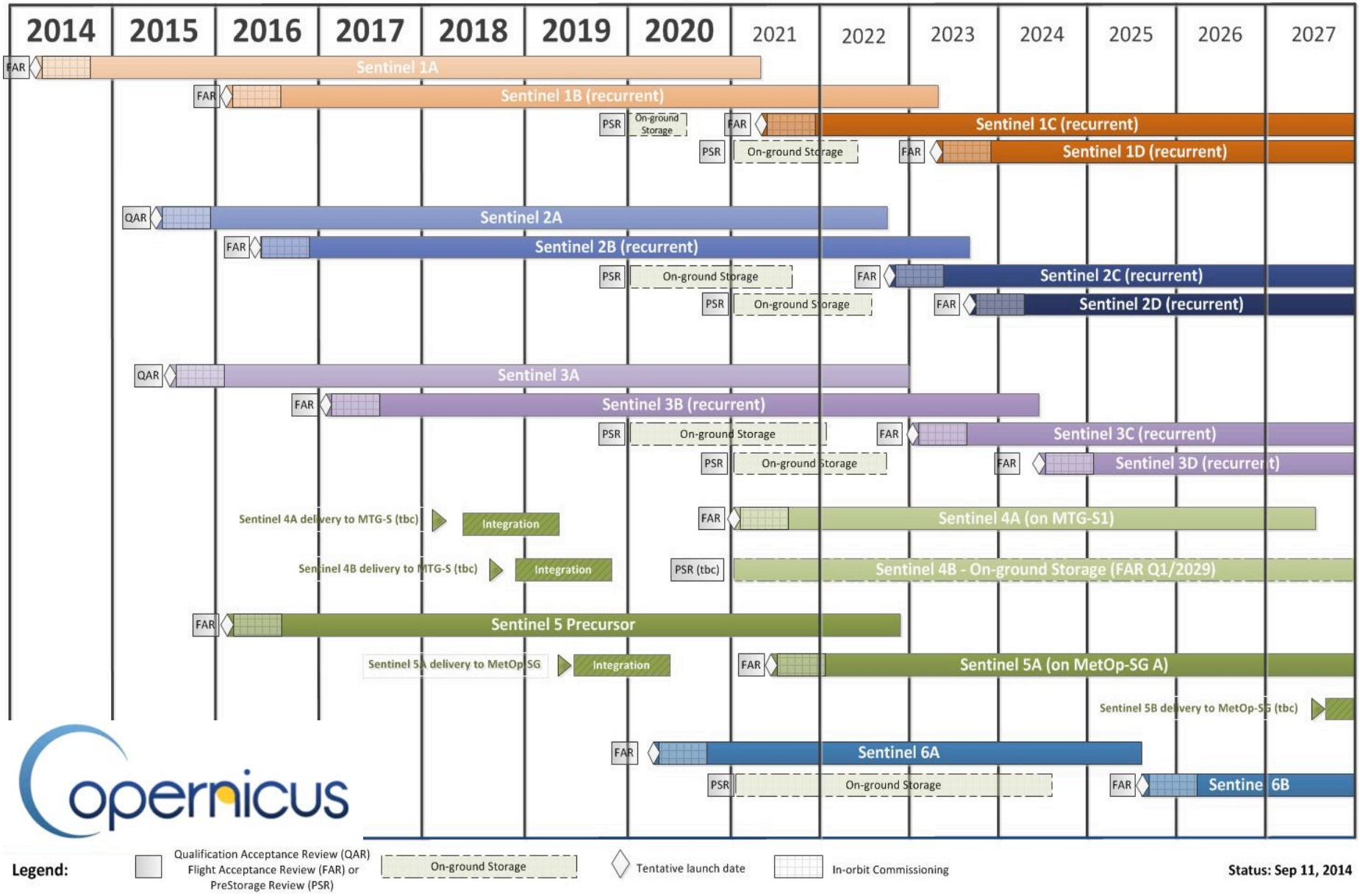
- Validation facilities including match-up processing & analysis, data set selection & analysis

http://www.odesa-info.eu/



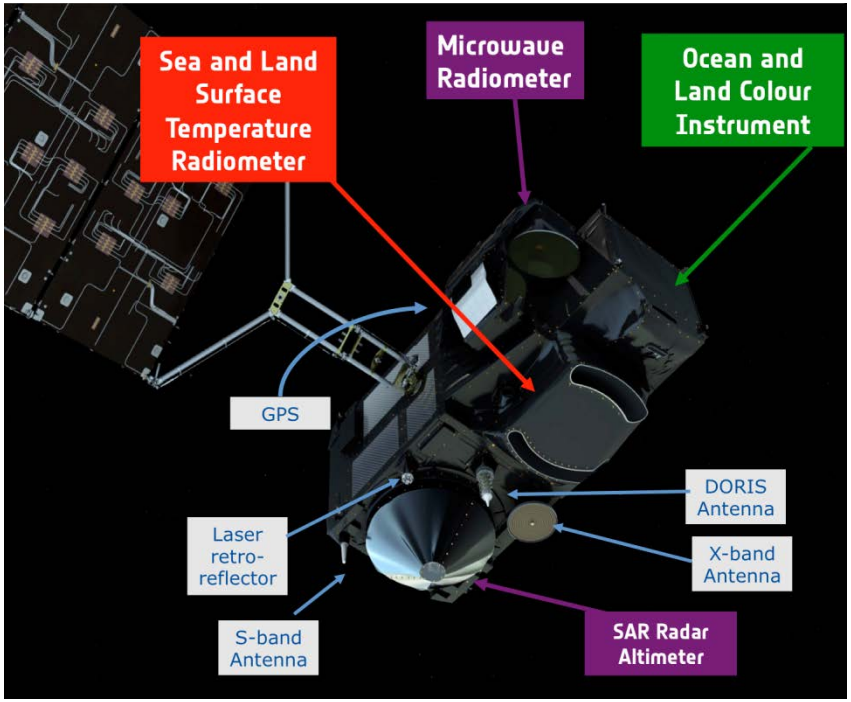
Sentinel-3 (and Sentinel-2) for OC

Sentinels provide decade-long observations



Sentinel-3 : Ocean and Land Colour Imager (OLCI)

- The Sentinel-3 Mission, being part of Copernicus Space Component, is an operational mission in high-inclination, low Earth orbit.
- Full performance achieved with 2 satellites in orbit (S-3A,-3B)
- Sentinel-3 implements 3 core missions to deliver continuity to
  - **Sea and land color data**, through **OLCI (Ocean and Land Color Instrument)** at least at the level of quality of the Medium Resolution Imaging Spectrometer (MERIS) instrument
  - **Sea and land surface temperature**, through the **SLSTR (Sea and Land Surface Temperature Radiometer)** at least at the level of quality of the Advanced Along-Track Scanning Radiometer (AATSR) instrument
  - **Sea surface topography data**, through a Topo P/L including a **Ku-/C-band Synthetic Aperture Radar Altimeter (SRAL)** and a bi-frequency **MicroWave Radiometer (MWR),** at least at the level of quality of the Envisat Radar Altimeter (RA-2) system
- In addition, the payload design will allow
  - Data continuity of the Vegetation instrument (on SPOT4/5),
  - Enhanced fire monitoring capabilities,
  - Along-track SAR for coastal zones, in-land water and sea-ice topography



Main satellite characteristics

- 1250 kg maximal mass
- Volume in 3.89 m x 2.202 m x 2.207 m
- 7.5 years lifetime (fuel for 5 add. years)

Observation Data Management

- *1 contact per orbit with Svalbard Ground Station*
- *3h delivery timeliness (from satellite sensing)*

Sentinel-3 : OLCI

→ **Current launch window: End October 2015**
(shipping to launch 20th Sept. 2015)

- Export licenses for S3A launch from Russia granted

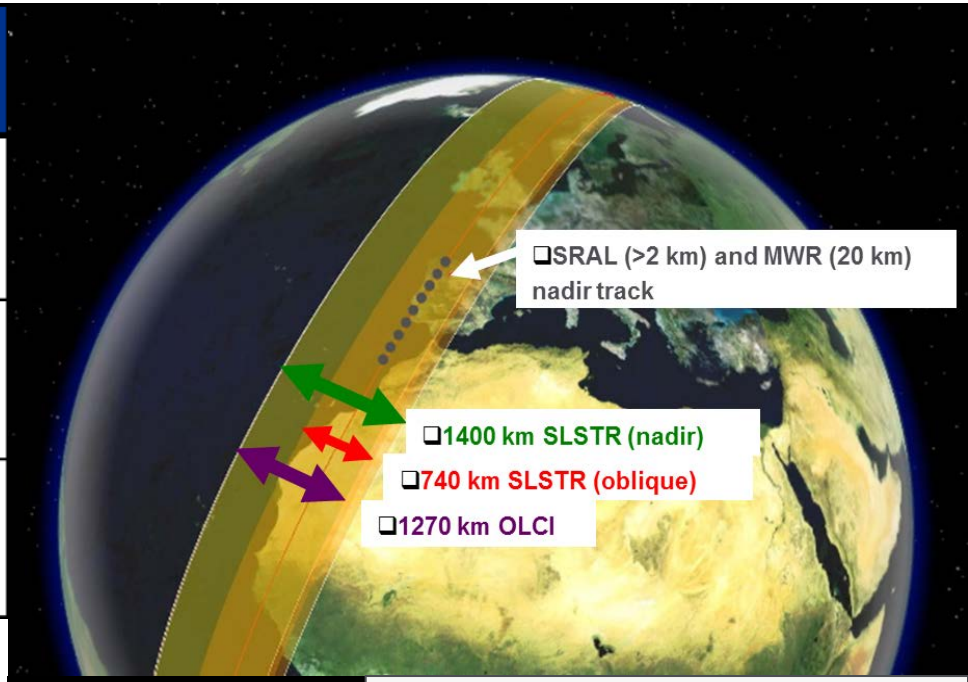
Readiness

- Sentinel-3A AIT progressing: Full satellite (including OLCI) integrated since early July 2014
- Mechanical Test Campaign successfully completed by end 2014
- **SLSTR-FM2** most tests completed: electrical, mechanical, functional as well as VIS radiometric calibration; radiometric calibration on SWIR and TIR concluded;
- **OLCI** defective camera detected in Oct 2014 and replaced in Nov; root cause found; replacement of all OLCI-A cameras with those produced for OLCI-B scheduled in July
- **Sentinel-3B** Assembly, Integration and Test on-going (***launch Spring 2017 – 18 months after S3A***)

Sentinel-3A in TAS test facilities
In April 2015

Sentinel-3 : OLCI

		Revisit at Equator	Revisit for latitude > 30°	Spec.
Ocean Colour (Sun-glint free, day only)	1 Satellite	< 3.8 days	< 2.8 days	< 2 days
	2 Satellites	< 1.9 days	< 1.4 days	
Land Colour (day only)	1 Satellite	< 2.2 days	< 1.8 days	< 2 days
	2 Satellites	< 1.1 day	< 0.9 day	
SLSTR dual view (day and night)	1 Satellite	< 1.9 days	< 1.5 days	< 4 days
	2 Satellites	< 0.9 day	< 0.8 day	



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

- ❑ **Constellation of 2 Sentinel-3 Satellites in the same orbital plane with an offset of 180° required for satisfying revisit and coverage requirements**
- ❑ **Furthermore, 2 satellites in-orbit increases robustness of operational service**
  - ❑ **No interruption of operational services in case of one satellite failure**

Sentinel-3 : OLCI

OLCI Pushbroom Imaging Spectrometer – Similar to MERIS with key Improvements:

- more spectral bands (from 15 to 21) between 400-1020 nm
- broader swath: 1270 km
- reduced sun glint by camera tilt in west direction (12.20˚)
- Absolute (relative) accuracy of 2 (0.5) %
- Full res. 300m acquired over land and ocean
- Reduced res. 1200m binned on ground (L1B)
- improved characterization, e.g. straylight, camera boundary characterization
- improved coverage Ocean < 4 days, with 2 satellites < 2 days
- Timeliness: 3 hours NRT Level 1 and level 2 products
- 100% overlap with SLSTR

⇒**L1 Products TOA radiance ortho-geolocated**

⇒**L2 OC products: surface reflectance, Chlorophyll (2 algorithms), TSM, KD490, Colour Dissolved Matter Absorption 443 nm, PAR, AOD, Angstrom, WV**

⇒**Uncertainties per pixel provided**

⇒**EUMETSAT is doing Marine Production**

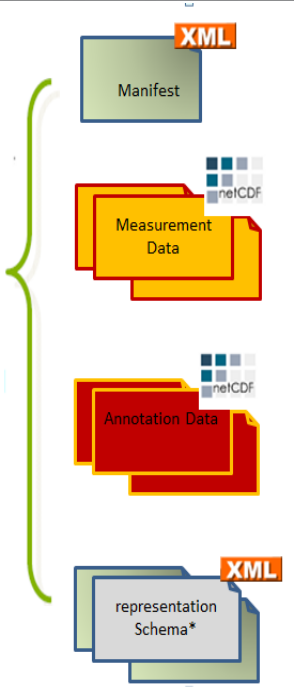
⇒**ESA is doing Land Production**

⇒**L1B is common to ESA and EUMETSAT**

Channel	Centre Wavelength (nm)	Approx. Band (nm)	Band-width (nm)	Signal to Noise Ratio*	Application
O1	400	392.5-407.5	15	2180	Aerosol correction, improved water constituent retrieval
O2	412.5	408-418	10	2050	Yellow substance and detrital pigments (Turbidity).
O3	442.5	437.5-447.5	10	1810	Chl absorption max., Biogeochemistry, Vegetation
O4	490	485-495	10	1540	High Chl, Other pigments
O5	510	505-515	10	1490	Chl, Sediment, Turbidity, Red tide.
O6	560	555-565	10	1280	Chlorophyll reference (Chl minimum)
O7	620	615-625	10	1000	Sediment Loading
O8	665	660-670	10	880	Chl (2nd Chl abs. max.), Sediment, Yellow Substance / Vegetation
O9	673.75	670.5-678	7.5	705	For improved Fluorescence retrieval and to better account for Smile together with the bands 665 and 680nm
O10	681.25	677.5-685	7.5	750	Chl fluorescence peak, red edge
O11	708.75	703.75-713.75	10	790	Chl fluorescence baseline, red edge transition.
O12	753.75	750-757.5	7.5	600	O2 absorption /Clouds, vegetation
O13	761.25	760-762.5	2.5	230	O2 absorption band/Aerosol corr.
O14	764.375	762.5-766.25	3.75	300	Atmospheric correction
O15	767.5	766.25 – 768.75	2.5	330	O2A used for cloud top pressure, fluorescence over land.
O16	778.75	771.25-786.25	15	810	Atmos. Corr. / Aerosol corr.
O17	865	855-875	20	680	Atmos. Corr. / Aerosol corr., Clouds, Pixel co-registration.
O18	885	880-890	10	400	Water vapour absorption reference band. Common reference band with SLST instrument. Vegetation monitoring.
O19	900	895-905	10	300	Water vapour absorption / Vegetation monitoring (max. reflectance)
O20	940	930-950	20	205	Water vapour absorption, Atmos. / Aerosol corr.
O21	1020	1000-1040	40	150	Atmos. / Aerosol corr.

Sentinel-3 : OLCI

- Sentinel-3 products are provided in SENTINEL SAFE = xml + netcdf-4
- Full Resolution Product unit is 3 mn frame – Reduced Resolution Product Unit is orbit
- **Documentation (technical guide, algorithm, product specification)**
  → **https://sentinel.esa.int/web/sentinel/home**
- **User Tool**
  → **https://sentinel.esa.int/web/sentinel/toolboxes/sentinel-3**



DATA POLICY:

EU Copernicus Regulation approved (applicable from 25 April 2014) establishes principle of a full, open and free data policy

The Copernicus Space Component Ground Segment data access is ensuring that all Sentinels core products are accessible to all users online

Access to Sentinel products is made available via dedicated data hubs. In addition, access to full Sentinels long-term archive will be made available to all users online

Sentinel-2

- **Systematic acquisition of:**
- ✓ All land surfaces (-56° and +84° latitude);
- ✓ Coastal/inland waters, Mediterranean Sea and all closed seas;

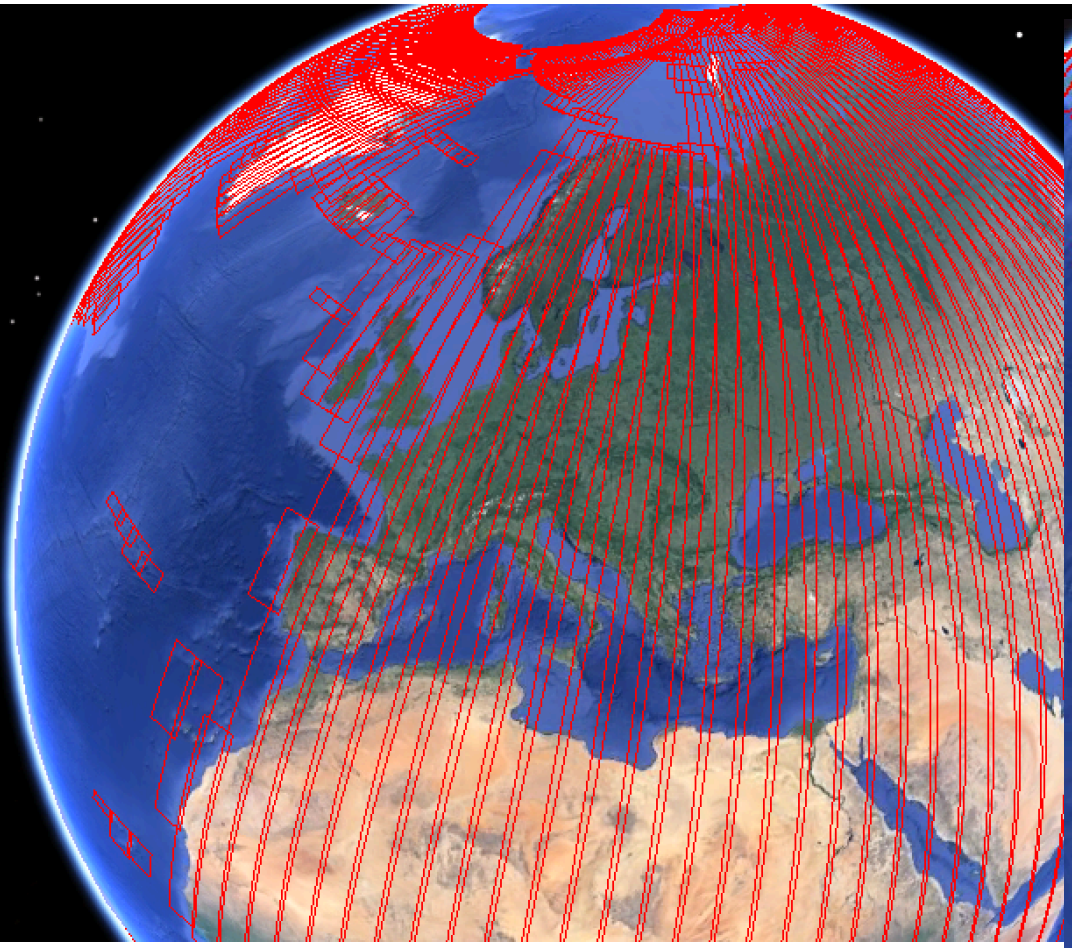
Band	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13
Center λ nm	443	490	560	665	705	740	783	842	865	945	1375	1610	2190
Spectral Width Δλ nm	20	65	35	30	15	15	20	115	20	20	30	90	180

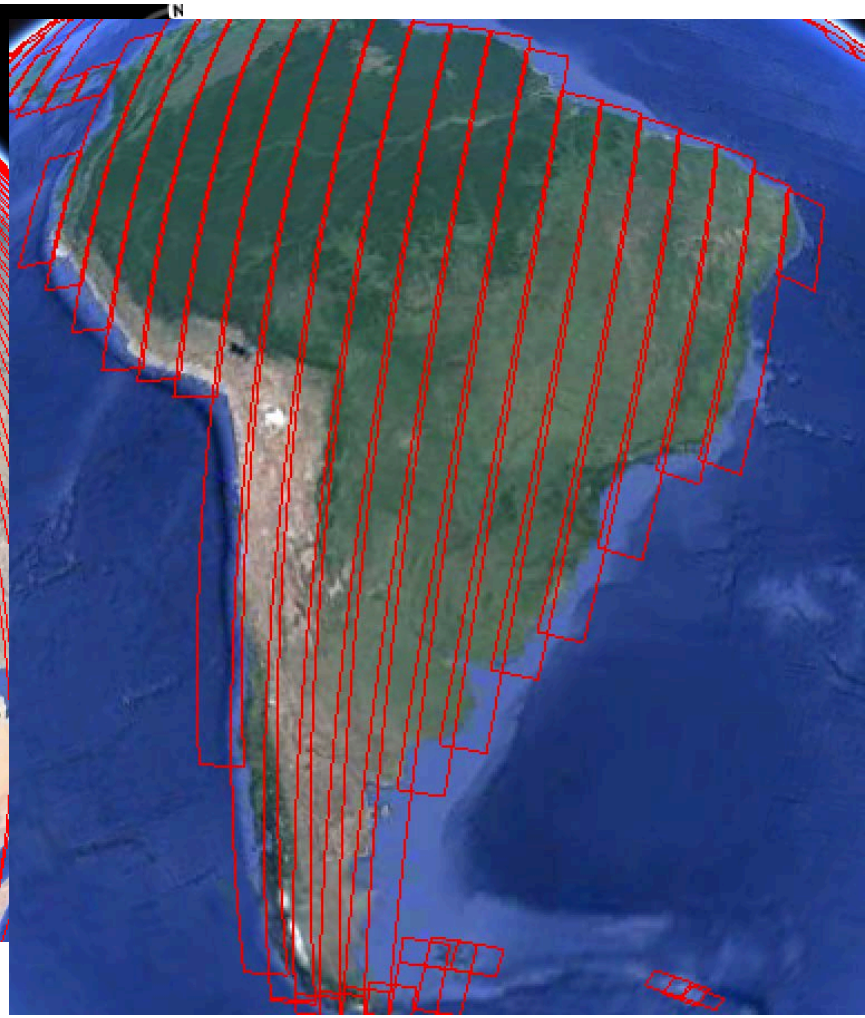
→ Highlighted Sentinel-2 capabilities for water quality monitoring in inland and coastal waters:

• Sentinel-2 will allow the mapping of small lakes;
• 10 m resolution is a suitable compromise for intertidal and supra-tidal vegetation mapping;
• Sentinel-2 is expected to be one of the most suitable system for a systematic monitoring of coral reefs for the next decades;
• The combined used of Sentinel-2 spatial resolution and Sentinel 3 spectral resolution will offer unprecedented water quality observing capabilities for coastal and inland waters.

Feature	Description
Spacecrafts	2 operating in twin configuration
Instrument	MSI (Multi-Spectral Instrument) operating in pushbroom principle (filter based optical system)
Spectral bands	13 (VIS–NIR–SWIR)
Spatial Resolution	10m / 20m / 60m
Swath	290 km
Orbit	Sun-synchronous at 786 km (14+3/10 revs per day), with LTDN 10:30 AM
Revisit Periodicity	10-day with 1 satellite 5 day with 2 satellites
Lifetime	7.25 years, extendable to 12 years
Launch	**22 June 2015 – VEGA, Kourou**

S2 Level-1C tiling grid, seasonal observation (SZA 82deg current baseline): Jun vs Dec and assumption on coastal acquisitions





Sentinel-2 encapsulated on the VEGA launcher in Kourou ready for launch 23rd June 01:52 GMT

Ocean Colour Component of ESA Climate Change Initiative

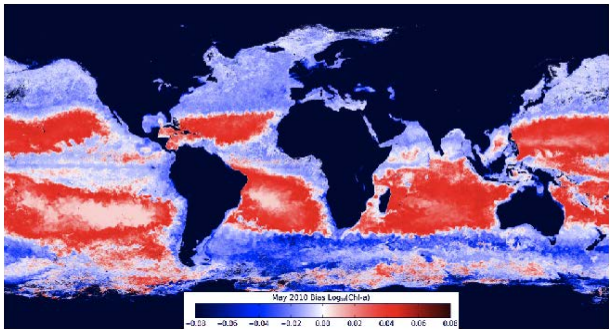
Objective: produce an uncertainty-characterised, inter-sensor bias-corrected, merged time series of ocean-colour products for climate research, and engage with users

V2 of the merged time series (SeaWiFS, MERIS and MODIS-A) released in March 2015.

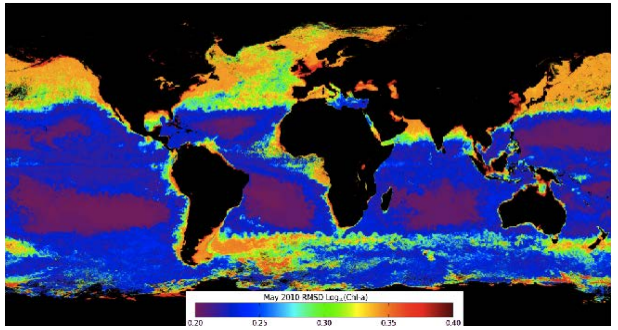
Specific aims of this version 2.0 release:

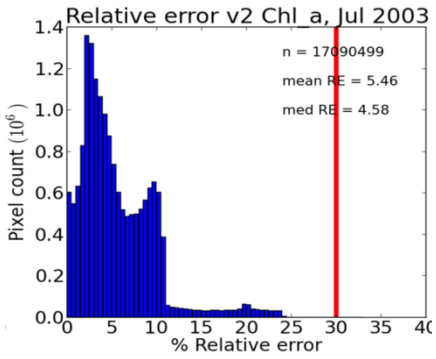
- improves the in situ database used for uncertainty characterisation
- optimizes the uncertainty generation for the CCI data
- improves consistency in many areas, including unifying the binning/mapping processing
- improves bias correction, able to respond to temporal variation (primarily seasonal)
- incorporates an improved cloud mask for MERIS
- benefits from a more automated quality assurance process
- extends the time series to the end of 2013
- refreshes the input datasets to the latest versions

May 2010 bias, log_10 Chl



May 2010 RMSD, log_10 Chl



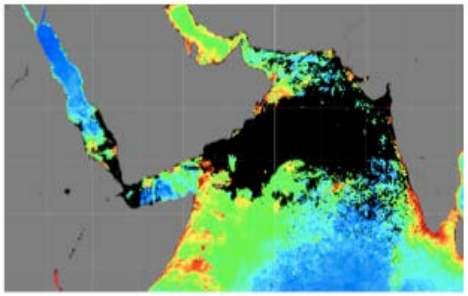


Relative error in V2 Chl based on bias.

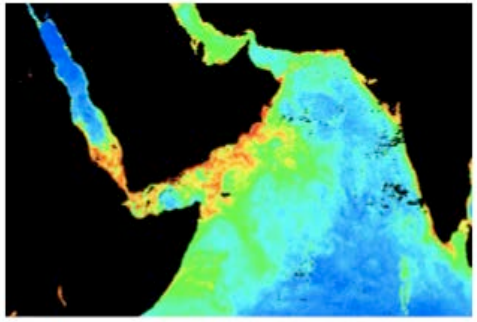
Red vertical line: GCOS requirement for accuracy

Ocean Colour Component of ESA Climate Change Initiative

OC-CCI: Improved coverage in many under-sampled regions

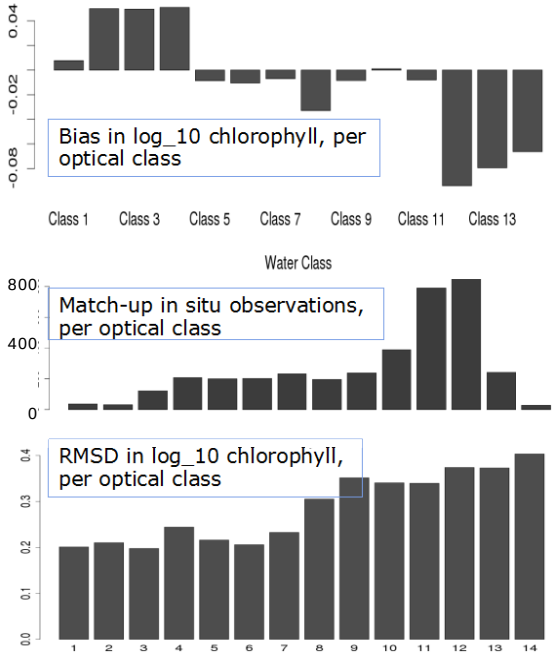


SeaWiFS July Climatology from NASA



OC-CCI July 2003

OC-CCI: Improved uncertainty characterisation in V2 compared with V1



OC-CCI:Future Plans

- Incorporate VIIRS into the time series
- Extend time series to 2015
- Prepare for Sentinel-3
- Improve Case-2 products

Acknowledgements

ESA and OC-CCI thank the many members of the ocean-colour community who helped in many ways: validation data, participation in user consultation; feedback on products.

A special thanks to NASA for their continued help and support.

SEOM

SEOM → ESA Program for Scientific Exploitation of Operational Mission

→ Framework for R&D, Algorithm Development, User forum, Tools development

On Ocean Colour a number of activities started in the last months:

Extreme Case 2:

- Water Quality parameters (Chlorophyll concentration, suspended matter, turbidity, …) fairly well addressed in open ocean ("Case 1") and moderate turbid coastal waters ("Case 2")
- Reliable consensus algorithms not available for extremely turbid and absorbing waters (e.g. river estuaries, Baltic Sea, Arctic Sea)
- Sentinel 3 offers new capabilities: new bands, including SLSTR SWIR bands, operational frequency

Pools Of Carbon in the Ocean:

- Explore the potential of remote sensing for detecting particulate carbon pools in the ocean, Compare with models, Focus on climate studies

Daily PAR:

- Develop an innovative daily PAR product from ENVISAT/MERIS & S3/OLCI and compare to existing in situ data and Level 3 daily, weekly and monthly equivalent products (from SeaWiFS, MODIS Aqua/Terra, VIIRS, and GOCI

FRM4SOC: Fiducial Reference Measurements for Satellite Ocean Colour

Establish and maintain SI traceability of Fiducial Reference Measurements (FRM) for satellite ocean colour.

Implement some of the CEOS OC-VC INSITU-OCR White paper recommendations

1. Development and implement an instrument laboratory and field inter-comparison experiment for FRM radiometers (round robin) with mandatory participation of National Metrology Institution(s)
2. Foster and enhance international Ocean Colour validation activities.
3. Study What is required in terms of infrastructure for vicarious calibration and validation for Europe for the next 20 years? **leading to firm recommendations on the way forward for the next generation of European Ocean Colour vicarious calibration/verification infrastructure.**

The output of #3 will be written up in the form of an IOGGC Monograph and, subject to IOCCG agreement could form an Official monograph (TBC by IOCCG).

The activity will start early 2016

Please Contact Craig Donlon at the IOCS if you would like to be involved!!

frm4soc

Conclusion

- **MERIS 4th reprocessing** FR and RR in progress

  → Sentinel format alignment + improvement

- **Copernicus:** Continuity and Long term OC program (more than 20 years)

  → Sentinel-3A (with OLCI) ready for launch end 2015.

  → OLCI + SLSTR gives:

  - 1 virtual instrument
  - Spectral range upto 12um (incl. 1.3, 1.6 and 2.2um in IR)
  - "Absolute" dual-view atmospheric correction over 750 km central swath

  → Sentinel-2 potentiality for OC in coastal and inland water

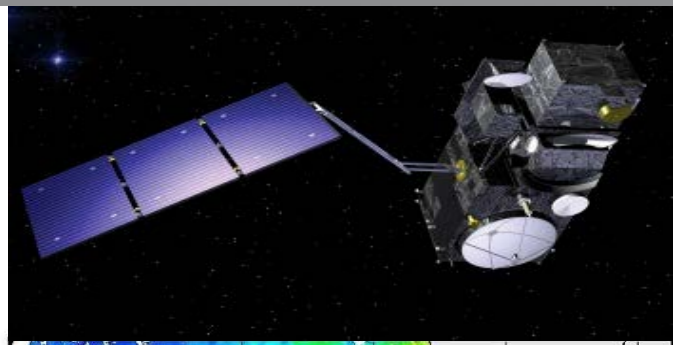
  → **Data Policy Free for all users**

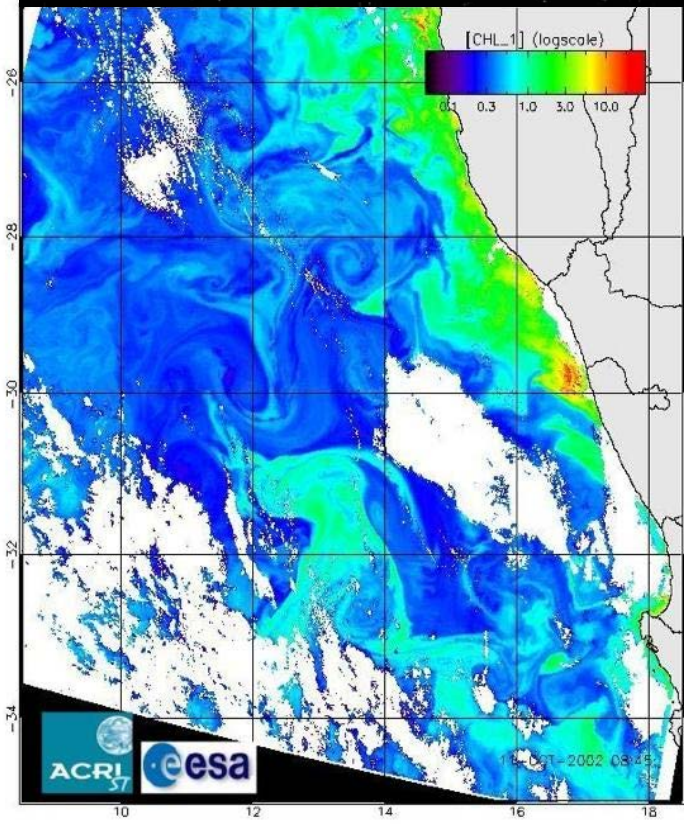
- **ESA shall continue to deliver R&D** that pioneers new satellite technologies, geophysical algorithms, products and applications of ocean colour working in partnership with the EC, EUMETSAT and the other international community

  → CCI Program

  → SEOM

  → FRM4SOC





PRAGUE 09-13 MAY 2016

living planet symposium | PRAGUE 09-13 May 2016

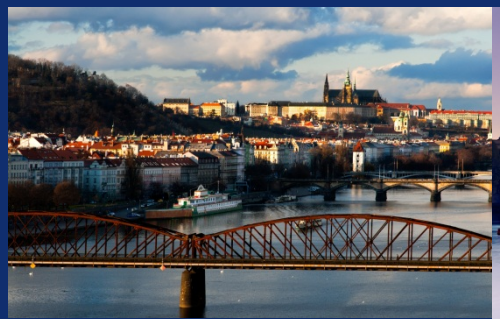
Main Objective:
Presentation of Exploitation Results based on ESA Earth Observation Measurements

Important Dates:

Deadline for abstract submission	16 October 2015
Notification of Acceptances	End January 2016
Issue of Preliminary Programme	February 2016
Opening of Registration to the Symposium	February 2016
Release of the Final Programme	at the symposium
Submission of Full Papers	at the symposium

Themes:
Atmosphere, Oceanography, Cryosphere, Land, Hazards, Climate and Meteorology, Solid Earth/Geodesy, Near-Earth Environment, Methodologies and Products, Open Science 2.0

http://lps16.esa.int



Thank you for your attention

For more information
http://www.esa.int
http://sentinel.esa.int

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