MERIS Cal/Val organization
Towards Sentinel 3

Philippe.Goryl@esa.int
<table>
<thead>
<tr>
<th>Plan</th>
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<tr>
<td>1. ENVISAT/MERIS – SENTINEL3/OLCI</td>
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<tr>
<td>2. Calibration principles reminder, Vicarious calibration verification</td>
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<td>3. Validation organization</td>
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<td>4. Mermaid</td>
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<td>5. ODESA</td>
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<td>6. Conclusion</td>
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</table>
ENVISAT launch: March 2002

Envisat satellite is in good health
→ MERIS instrument is in excellent shape.

Efficient consumption of on-board hydrazine allow to operate nominally Envisat until 2010. But most of hydrazine will be consumed in 2010.

→ ESA has elaborated a technical solution to further extend mission by 3 years, i.e. until 2013, based on a decrease of orbit altitude.

→ the solution allows to carry on with the current Envisat applications, including MERIS applications.
The new orbital parameters allow:

1. to keep current nominal mission until October 2010,
2. to extend the mission until end 2013,
3. to allow operations of all instruments with small or no degradation of their measurements, and minor impact on data quality, except for SAR interferometry
4. to commit with the satellite disposal rules.
Sentinel-3 is one element of the GMES system.

Sentinel-3 is an operational mission for oceanography & global land applications.

Provides continuity of existing missions, delivering:
- Sea/Land colour data (at least MERIS quality)
- Sea/Land surface temperature (at least AATSR quality)
- Sea surface topography data (at least Envisat RA quality)

A series of satellites, each designed for a lifetime of 7 years, shall provide an operational service over 15 to 20 years
- Only 1 satellite is in development at this moment

Launch planned for 2013
Sentinel-3 instruments

Instruments:

• **Ocean and Land Colour Instrument (OLCI)** with 5 cameras, 21 spectral bands
  • Spatial sampling: 300m @ SSP
  → **MERIS follow-on**

• **Sea and Land Surface Temperature (SLST)** with 9 spectral bands, 0.5 (VIS, SWIR) to 1 km res (MWIR, TIR). Swath: 180rpm dual view scan, nadir & backwards
  → **ATSR follow-on**

• **Radar Altimeter package**
  SRAL Ku-C altimeter (LRM and SAR measurement modes), MWR, POD (with Laser Retro Reflector and DORIS)
OLCI instrument

- Heritage from MERIS
- 5 cameras, 21 programmable spectral bands (incl. channels for MERIS & VGT legacy products)
- Sun Glint free configuration by design
- Across-track tilt = 12.20°
- Low polarisation < 1%
- Swath covered by SLST for atmospheric correction
### Sentinel-3 mission orbit

**Type:** Sun-synchronous low earth orbit  
**Repeat cycle:** 27 days (14 + 7/27 orbits per day)  
**Average altitude:** 814.5 km over geoid  
**Mean solar time:** 10:00 at descending node  
**Inclination:** 98.65°

<table>
<thead>
<tr>
<th></th>
<th>Revisit at Equator</th>
<th>Revisit for latitude &gt;30°</th>
<th>Specification</th>
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</thead>
<tbody>
<tr>
<td><strong>Ocean Colour</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Sun-glint free)</td>
<td>1 Satellite</td>
<td>&lt; 3.8 days</td>
<td>&lt; 2.8 days</td>
</tr>
<tr>
<td></td>
<td>2 Satellite</td>
<td>&lt; 1.9 days</td>
<td>&lt; 1.4 days</td>
</tr>
<tr>
<td><strong>Land Colour</strong></td>
<td>1 Satellite</td>
<td>&lt; 2.2 days</td>
<td>&lt; 1.8 days</td>
</tr>
<tr>
<td></td>
<td>2 Satellite</td>
<td>&lt; 1.1 day</td>
<td>&lt; 0.9 day</td>
</tr>
<tr>
<td><strong>SLST dual view</strong></td>
<td>1 Satellite</td>
<td>&lt; 1.8 days</td>
<td>&lt; 1.5 days</td>
</tr>
<tr>
<td></td>
<td>2 Satellite</td>
<td>&lt; 0.9 day</td>
<td>&lt; 0.8 day</td>
</tr>
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</table>
**Level 1 radiometric calibration**

Like MERIS, OLCI performs on board radiometric calibration:
- Every 2 weeks routine with 1st diffuser
- Every 3 months with 2nd diffuser for ageing

Maximum degradation of 4% after more than 8 years in space

Space environment implies **aging** of Diffuser and Optics
2nd diffuser to monitor diffuser-1 BRDF ageing

=> **Diffuser Aging model**

frequent calibration to monitor Instrument degradation

=> **instrument degradation model**

\[ G(t) = G(0) \cdot \left( 1 - \beta \left( 1 - \gamma \cdot e^{-\delta t} \right) \right) \]

Degradation Model based on the SeaWifs model (Barnes et al.)
We have gained confidence in the absolute accuracy of the MERIS L1b radiometric calibration. However, radiometric vicarious calibration is used to verify that:

1. The absolute radiometric level of L1b data is within the error bars of the methodologies.
2. No temporal trend is detected with these methodologies.

Methodologies:
- Rayleigh, Glint, Desert
- Snow, Dark target

Instrumented site:
- Campaign, LANDNET
- CEOS/IVOS framework
- CNES: SADE
- Rayleigh, Glint, Desert
- Dave Smith, RAL
- Desert and snow
- DIMITRI: M. Bouvet, ESTEC
- Intercomparison
- Dark target, LISE
Spectral calibration: Erbium Doped Diffuser

Acquisitions scenario:
Orbit n = Diffuser-1 Cal (Band setting j)
Orbit n+1 = Diffuser-Er (Band setting j)

“Pink” Diffuser Measurements

<table>
<thead>
<tr>
<th>centre</th>
<th>width (nm)</th>
<th>centre</th>
<th>width (nm)</th>
</tr>
</thead>
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<td>400.625</td>
<td>1.25</td>
<td>514.375</td>
<td>1.25</td>
</tr>
<tr>
<td>401.875</td>
<td>1.25</td>
<td>515.625</td>
<td>1.25</td>
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<tr>
<td>403.125</td>
<td>1.25</td>
<td>516.875</td>
<td>1.25</td>
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<tr>
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<td>1.25</td>
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<td>520.625</td>
<td>1.25</td>
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<tr>
<td>408.125</td>
<td>1.25</td>
<td>521.875</td>
<td>1.25</td>
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<td>409.375</td>
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<td>410.625</td>
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<td>524.375</td>
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<tr>
<td>413.125</td>
<td>1.25</td>
<td>526.875</td>
<td>1.25</td>
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<td>414.375</td>
<td>1.25</td>
<td>528.125</td>
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<tr>
<td>415.625</td>
<td>1.25</td>
<td>529.375</td>
<td>1.25</td>
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<tr>
<td>416.875</td>
<td>1.25</td>
<td>530.625</td>
<td>1.25</td>
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<tr>
<td>418.125</td>
<td>1.25</td>
<td>531.875</td>
<td>1.25</td>
</tr>
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Erbium absorption spectrum
Spectral calibration: Fraunhofer Lines

Examples of Fraunhofer absorption spectrum With MERIS spectral response overlay

White diffuser-1 measurement

Band settings (3 configurations)
For three orbits every six months, MERIS is configured to observe in detail the O2A absorption features.

Oxygen O2A absorption spectrum MERIS spectral response overlay

<table>
<thead>
<tr>
<th>name</th>
<th>centre</th>
<th>width (nm)</th>
</tr>
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<tr>
<td>blue-2</td>
<td>442.5</td>
<td>10</td>
</tr>
<tr>
<td>red-1</td>
<td>665</td>
<td>10</td>
</tr>
<tr>
<td>ref-1</td>
<td>753.125</td>
<td>6.25</td>
</tr>
<tr>
<td>O2-0</td>
<td>758.125</td>
<td>1.25</td>
</tr>
<tr>
<td>O2-1</td>
<td>759.375</td>
<td>1.25</td>
</tr>
<tr>
<td>O2-2</td>
<td>760.625</td>
<td>1.25</td>
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<tr>
<td>O2-3</td>
<td>761.875</td>
<td>1.25</td>
</tr>
<tr>
<td>O2-4</td>
<td>763.125</td>
<td>1.25</td>
</tr>
<tr>
<td>O2-5</td>
<td>764.375</td>
<td>1.25</td>
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<tr>
<td>O2-6</td>
<td>765.625</td>
<td>1.25</td>
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<td>O2-7</td>
<td>766.875</td>
<td>1.25</td>
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<tr>
<td>O2-8</td>
<td>768.125</td>
<td>1.25</td>
</tr>
<tr>
<td>O2-9</td>
<td>769.375</td>
<td>1.25</td>
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<tr>
<td>ref-2</td>
<td>778.75</td>
<td>7.5</td>
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<tr>
<td>IR-1</td>
<td>865</td>
<td>10</td>
</tr>
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</table>

O2A Campaign Band setting
Database for NIR gain computation

NIR investigation carried out on two oligotrophic areas of the world ocean:
South Pacific Gyre
South Indian Ocean.

Database generated from 2003 to 2009
Procedure allow us to both improve the number and the quality of the matchups:
data are extracted on the clearest pixels within a 10°x10° window over SIO and SPG
1794 matchups for SIO
1679 matchups for SPG  (about 2 days out of 3)

Selection criteria: 5x5 macro-pixel are selected if the surrounding 15x15 macro pixel present none of the following flags: cloud, ice haze or glint.
solar zenith angle <60°
wind speed <9m/s.

→ around 1500 matchups for gain computation

Further pixel constraints for gain computation reject pcd_1_13, pcd_19, case2_s, no maritime aerosols, chl > 0.2mg/m3
Adjustment in the visible

BOUSSOLE / MOBY used for:

→ adjustment in the visible

→ Validation
In-situ Sites

**Swedish Aeronet:**

SMHI, Norrköping 2007. It is one of the few high latitude AERONET stations.

CIMEL is converted into an AERONET-OC and deployed at Lake Vänern (spring 2008).

**PI:** Susanne Kratzer, Univ. Stockholm

Anu Reinart, Tartu Observatory, Estonia

TriOS- RAMSES hyperspectral spectroradiometers Vänern and in immerfjärden.
Portugal Water:

hyperspectral radiometer with a pitch and roll sensor and a compass

sun photometer

PI: John Icely – Sagremarisco, Algarve
In-situ Sites

AAOT: Venice Tower

SeaPrism

PI: Giuseppe Zibordi - JRC
Ramses Trios – on ferries – Norway NIVA (Kai Sorensen)

Simbada (D.Ramon, P-Y Deschamps)

+ International cruise
  - NATO – Ligurain Sea
  - Bencala cruise
  - BIOSOPE (pacific)
  - Aopex (west Med.)
Level 3 products

- MERIS level 3 demonstration products
- MODIS & SeaWIFS level 3 products
- GlobColour merged level 3 products

Quality control methodology

- Ratios
- Input data
- Parameters
- Zones
- Quality control items
  - Visual inspection
  - Time series
  - Histograms
  - Scatter plots
  - Anomalies

MERIS level 3 products analysis

- MERIS time series
- MERIS CHL 1 Histograms
- MERIS chlorophyll anomaly images
- MERIS Google-Earth images

MERIS versus other sensors

- MERIS-MODIS/SeaWIFS CHL 1 scatter plots
- MERIS-MODIS/SeaWIFS time series
- MERIS-MODIS/SeaWIFS CHL 1 histograms

Followed by the MERIS Science Advisory Group recommendation, ESA started the generation of some MERIS level 3 demonstration products, using the M1L3 tool developed by ACR-EST. The M1L3 tool is implemented on the GRID on Demand Processing chain at ESA and the MERIS level 3 products are generated routinely and are available on the web.

Although the validation of level 3 data cannot replace the validation of level 2 data, it may contribute to the estimation of the measurement quality by providing information where in-situ data does not exist, at a global scale almost every day, at daily, monthly, seasonal and annual temporal scales almost everywhere, on the long-term instrument stability and on instrument ageing.

The statistical analysis of the spatial variations of the level 3 data combined with oceanographic knowledge can lead us to a certain level of validation or invalidation of the products. Of course, the huge number of available points in the level 3 products increases the quality of the statistics.

Comparisons of level 3 products between sensors can be also of great interest to evaluate the coherence between the sensors’ instrumental processing as well as to characterize some possible inter-calibration between the products, for example before any merging attempt.

The analysis has been applied to the MERIS monthly level 3 products available on the ESA web site (1/12° sinusoidal grid) and the MODIS and SeaWIFS level 3 products available on the NASA Ocean Colour web site (both at 3 km on a Plate-Carrée grid). The MERIS products have been reprojected on the same 9km Plate-Carrée grid before any computation (using the Sutherland-Hodgeman area clipping and flux-conserving algorithms).

The following marine parameters are covered by the quality control tasks:

- chlorophyll-a, case 1 water
- normalized water leaving radiances (nW/L) at 412, 443, 480, 510 and 550 nm
- aerosol optical thickness over water at 385 nm
- Angstrom coefficient over water at 385 nm

The statistical analysis has been performed at global level and on a set of dedicated zones. MERIS L3 QC is performed by ACR-EST.
MERIS level 3 - Quality Control
MERIS time series

Last update of the service: 18/04/2008

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MERMAID

- A centralised database of concurrent MERIS acquisitions and in-situ optical measurements (protected by a standard data policy)

- Available to Ocean Colour researchers working within the MERIS mission: MERIS QWG, MVT and any collaborating PI

- Accessible on the web with a simple interface and standard data format
G. Zibordi: Abu Al Bukhoosh (53), Gustav Dalen Tower (99), Helsinki Lighthouse (89).
J. Icely: Algarve (16)
M. Ondrusek: Moby updated (472)
S. Kratzer: NW Baltic Sea (39), Palgrunden (28)
A. Hommersom: Wadden Sea (3)
D. MacKee: Bristol-Irish Sea (29)
G. Zibordi: new MERIS band-shifted matchups at AAOT (224 furnished after QC of 5064 potential measurements and less than 2 hours difference)
D. Antoine: new Boussole data recently provided (566)
J. Werdell: NOMADv2 instead of NOMAD (420 instead of 140)
D. Vandemark: MVCO (192)
→ 14 sites/missions with also SIMBADA (327).
Optical Data processor of ESA
Goal: provide a “run and test” platform to MERIS user community

- ODESA L2/L3 code distribution
- ODESA on-line L2/L3 processing
- ODESA forum
- ODESA validation & qualification
- Integrates BEAM as analysis tool

ODESA current web site [http://earth.eo.esa.int/odesa/](http://earth.eo.esa.int/odesa/)
The source code is delivered within a Graphical User Interface dedicated to the management of configurations of simulations.

- Draft version: currently available to QWG members
- 1st version (available to the public when the MERIS reprocessed data set is available):
  - MERIS processor (L1 to L2)
- 2nd version
  - GLOBCOLOUR processor (L2 to L3)
  - Processing of MERMAID matchups
ODESA - Results Analysis

Output Analysis

BEAM
You must log in first
email: 
Password: 
Submit
Register
Password lost

Meris Online processing

Select an area on map or enter coordinates

North 90°N
West 180°W 180°E East
90°S South

Level

Select

○ a period From 22/06/2010 to 25/06/2010
○ an orbit range (*)

Version MEGS_8.0b1

Currently under testing and validation by the MERIS QWG. This version is not available for any other purpose. Known issues are described in the quick start guide.

(*) Date format must be dd/mm/yyyy
Orbit range: the value of the first and last absolute orbit
Available period: 01/03/2002 to 25/06/2010
Available orbits: 1 to 43414

NB: the total size of generated products is limited to 50 GB
Calibration: on board calibration, vicarious technique for monitoring

Validation network for MERIS in place based on:
- Buoys case 1 – Moby Boussole
- Aeronet Ocean Colour Network + permanent instrumented sites
- Cruises
- Satellite Comparison

MERMAID – Central Tool for validation
ODESA – Environment for validation

Ideally MERIS program, methodologies, tools and infrastructure would need to be continued for OLCI:

BUT the set up is different:
- Sentinel operation is funded by European Commission
- Funding for the Sentinel exploitation phase is not yet established
- Eumetsat is in charged of the operation of OLCI marine part

Key issue and objective: continuity MERIS / OLCI