

From MERIS to OLCI Ocean colour at ESA

Henri Laur et al.

Earth Observation Programmes
European Space Agency

International Ocean Colour Science, Darmstadt, 6 May 2013

- ✓ European expertise built initially on CZCS, SeaWiFS, MODIS (thanks USA !)
- ✓ ESA decision as early as 1992 to build ocean colour sensors
→ **MERIS launched on-board Envisat in 2002**
- ✓ Envisat MERIS observations lasted 10 years, until 2012
→ further expansion of the Ocean Colour community in Europe
- ✓ Strong support to MERIS data exploitation possible thanks to adequate funding at ESA (e.g. GlobColour, Climate Change Initiative) and at EC (e.g. GMES marine core services)
→ has fostered **strong user acceptance and high demand** for long-term Ocean Colour data for marine & coastal monitoring under environmental policies
- ✓ Sentinel-3 OLCI will provide continuity of MERIS class observations well into the future
- ✓ National missions in Europe, e.g. the German hyperspectral Enmap mission, are also relevant for the OC community



André Morel

→ **The present outlook for ocean colour in Europe is positive**



Envisat satellite: 10 years of good performances

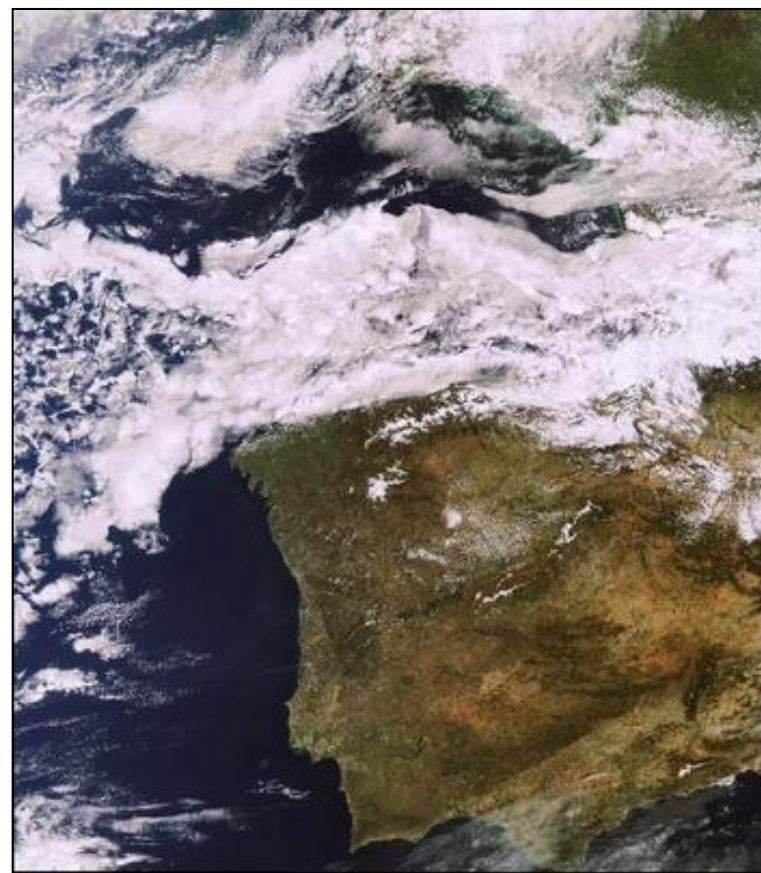


*First MERIS image
(22 March 2002)*



- ✓ Envisat satellite celebrated its **10th year** in orbit in March 2012
- ✓ Envisat satellite nominal lifetime was 5 years (orbit change in 2010)

- ✓ Overall good performances, with excellent performances of MERIS
- ✓ No symptoms of degradation in any Envisat module during the days/hours before the anomaly on 8th April 2012



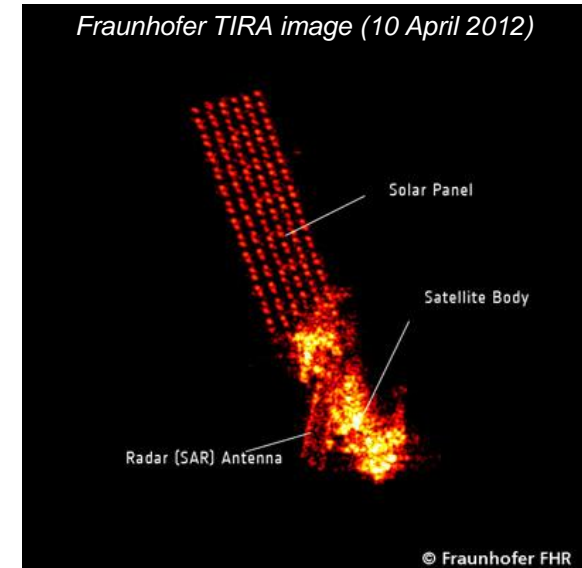
*Last MERIS image before anomaly
(8 April 2012, 11:05 UTC)*



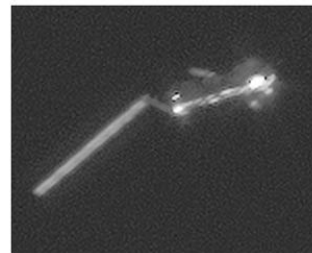
Envisat satellite failure on 8th April 2012



- Based on the anomaly events on 8th April and on the external observations since then, several failure scenarios were devised.
- Two failure scenarios were retained as most coherent with the observations:
 - ✓ Failure Scenario 1: Non-observable double failure in the Power Subsystem (e.g. a silent first failure could have happened in the past, then second failure on 8th April)
 - ✓ Failure Scenario 2: Failure in Central Communication Unit followed by a failure while the satellite was in transition towards Safe Mode



14:52:03



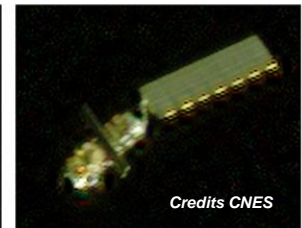
14:59:07



14:59:57



Pleiades images
(15 April 2012)



10 years of constant effort:

- to improve the quality of MERIS data
- to facilitate access to MERIS data
- to support and promote MERIS data exploitation

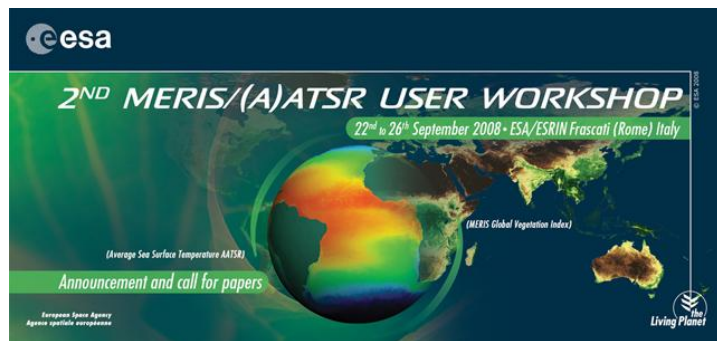
- ✓ **Large effort in improving quality of products (processing algorithms, validation) under the leadership of the MERIS Quality Working Group (QWG)**
 - several reprocessing (4th improvement loop starting)
- ✓ **ESA EO data policy (Envisat, ERS, Earth Explorers):**
 - **open and free of charge** (user registration requested)
- ✓ **Data access continuously improved:**
 - NRT rolling archives for recent data (when Envisat was in operations),
 - MERCI system for archived data access,
 - MIRAVI imagery for large public, ...
- ✓ **Development of alternative ways to provide data, e.g.**
 - processing on demand (G-POD)
 - processing forums (ODESA)
 - user toolboxes (BEAM)
 - *MERIS data redistribution through NASA*



Users involvement during operation phase



Lessons learned are captured by the user communities themselves



USER WORKSHOP

RECOMMENDATIONS



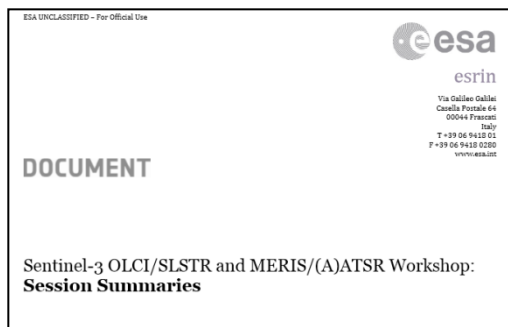
ACTIONS

REPORTING on PROGRESS



USER WORKSHOP

RECOMMENDATIONS



Some 2012 user community recommendations :

- Processing algorithms upgrade and subsequent data reprocessing
- Systematic processing of MERIS Full Resolution dataset (products are only available on demand until now)
- Maintenance of validation infrastructure for Sentinel-3 data validation
- Concept of science exploitation platforms/forums

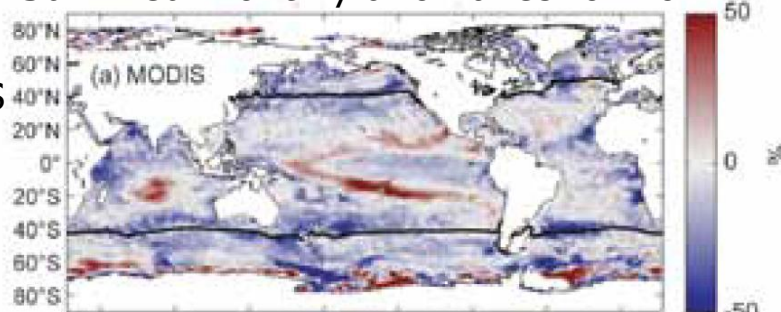


MERIS is part of the international fleet of ocean colour missions

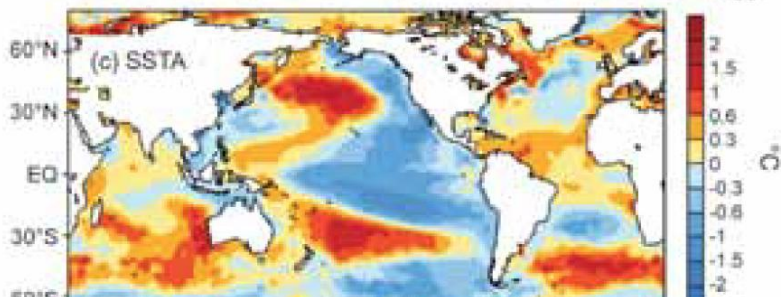
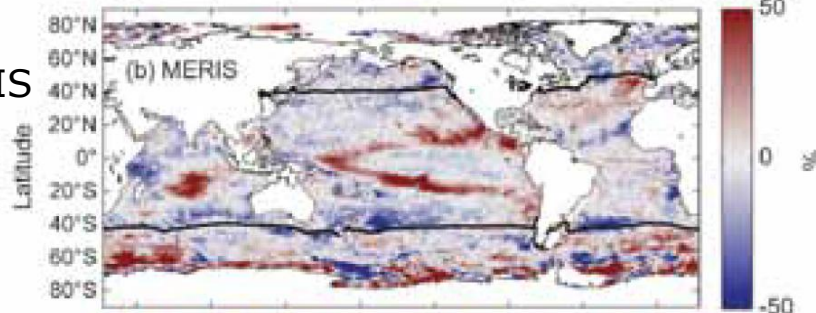


Summed monthly anomalies for 2011

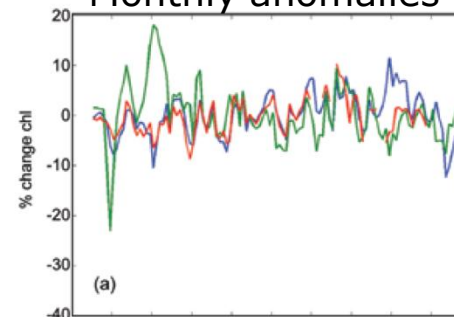
MODIS



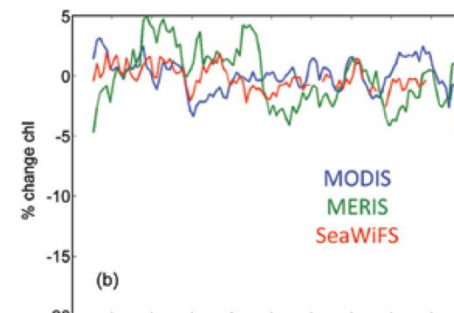
MERIS



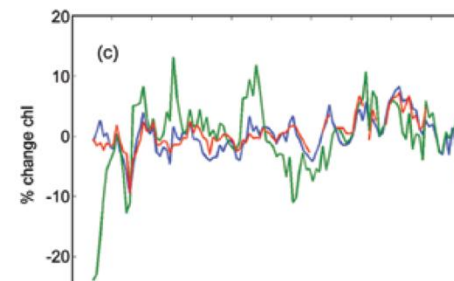
Monthly anomalies



Northern hemisphere,
where mean SST < 15°C



Warm, stratified, ocean
where mean SST > 15°C



Southern hemisphere,
where mean SST < 15°C

In: Siegel D.A., D. Antoine, M.J. Behrenfeld, O. H. Fanton d'Andon, E. Fields, B.A. Franz, P. Goryl, S. Maritorena, C.R. McClain, M. Wang and J.A. Yoder (2012),
State of Climate 2011 - Global Ocean Phytoplankton,
Bulletin of the American Meteorological Society, 93, S107-S110.



Support to MERIS data exploitation



COAST WATCH

MarCoast
a GMES Services Network

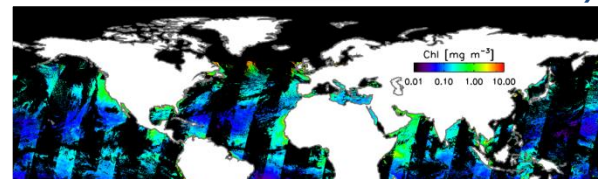
coastcolour

GLOBECOLOUR



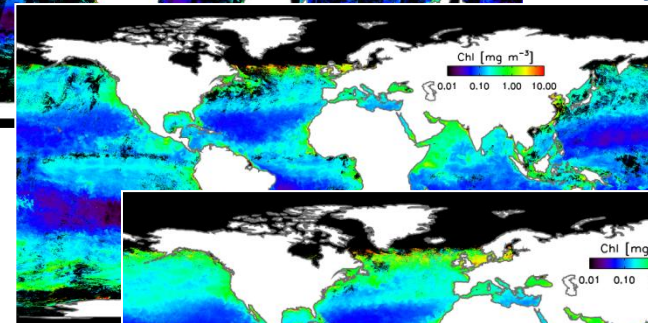
**ESA Climate Change
Initiative programme**

Daily

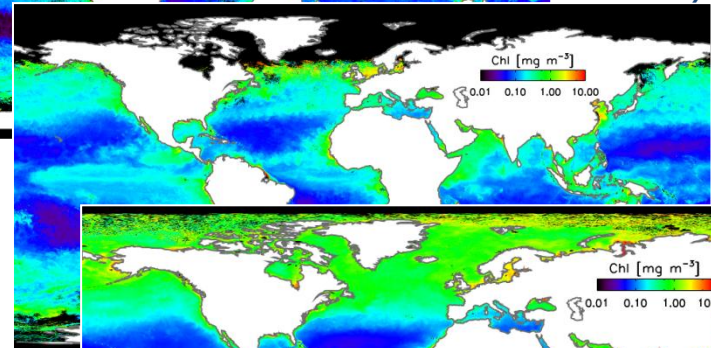


Improved spatial
coverage, even at
weekly scale

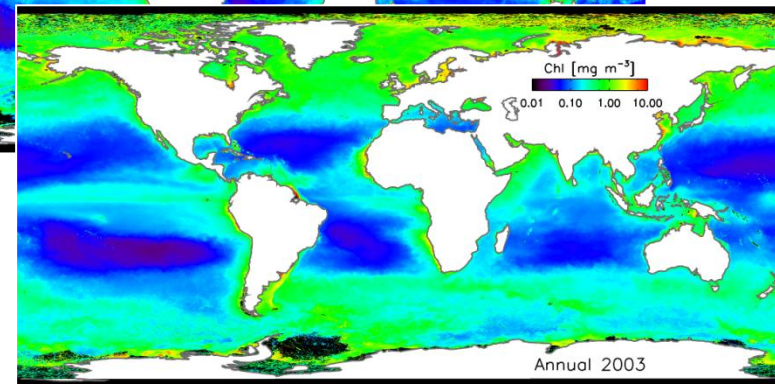
Weekly



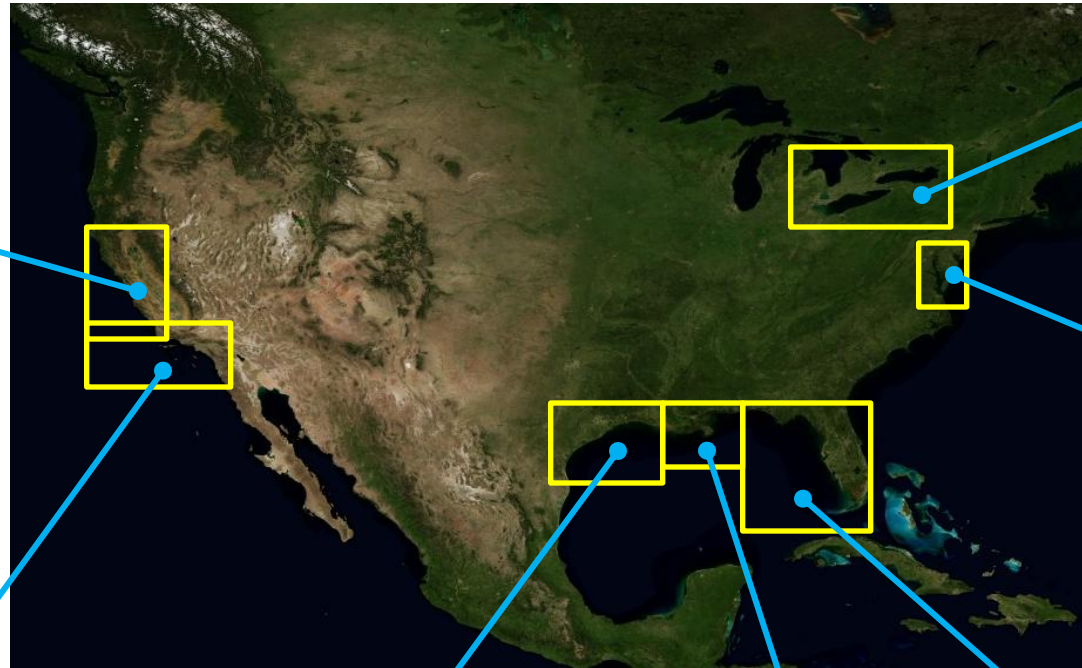
Monthly



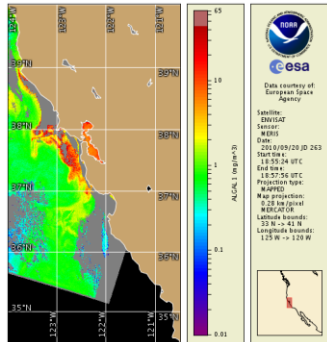
Annual



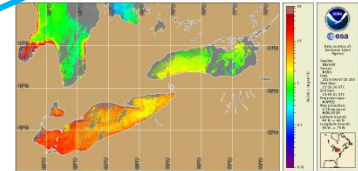
Full Resolution Ocean Color Data and Experimental Products by NOAA CoastWatch



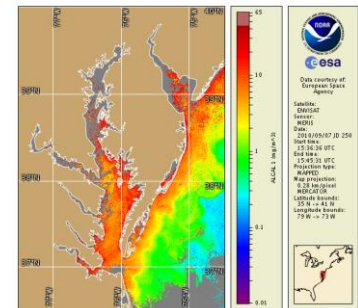
California Coast



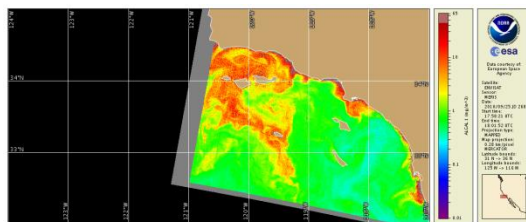
Lake Erie



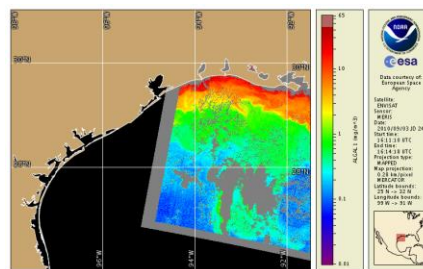
Chesapeake Bay



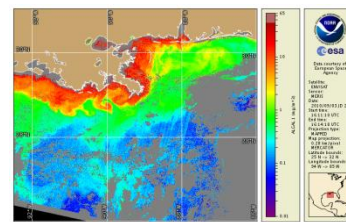
Southern California



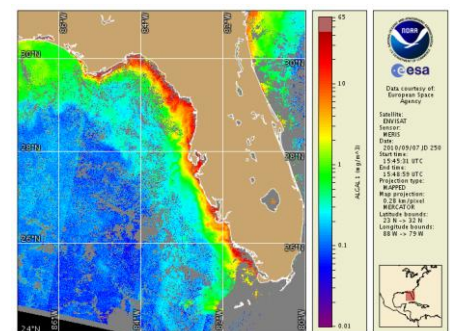
Texas Coast



Mississippi Delta



Florida





Weekly Lake Erie Bulletin, 500 subscribers, 4th year, 1st year without MERIS !



Experimental Lake Erie Harmful Algal Bloom Bulletin

2011-008

08 September 2011

National Ocean Service

Great Lakes Environmental Research Laboratory

Last bulletin: 22 July 2011

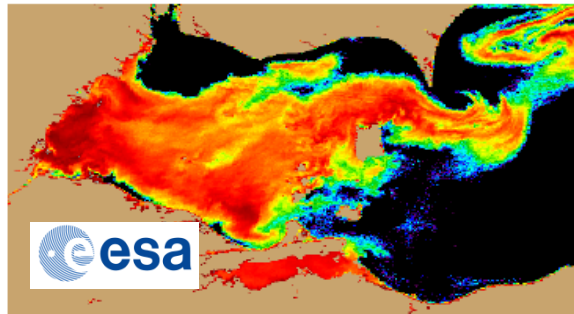


Figure 1. MERIS image from the European Space Agency. Imagery shows the spectral shape at 681 nm from September 03, where colored pixels indicate the likelihood of the last known position of the *Microcystis* spp. bloom (with red being the highest concentration). *Microcystis* spp. abundance data from shown as white squares (very high), circles (high), diamonds (medium), triangles (low), + (very low) and X (not present).

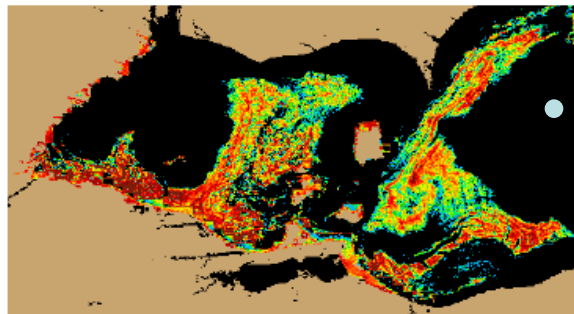
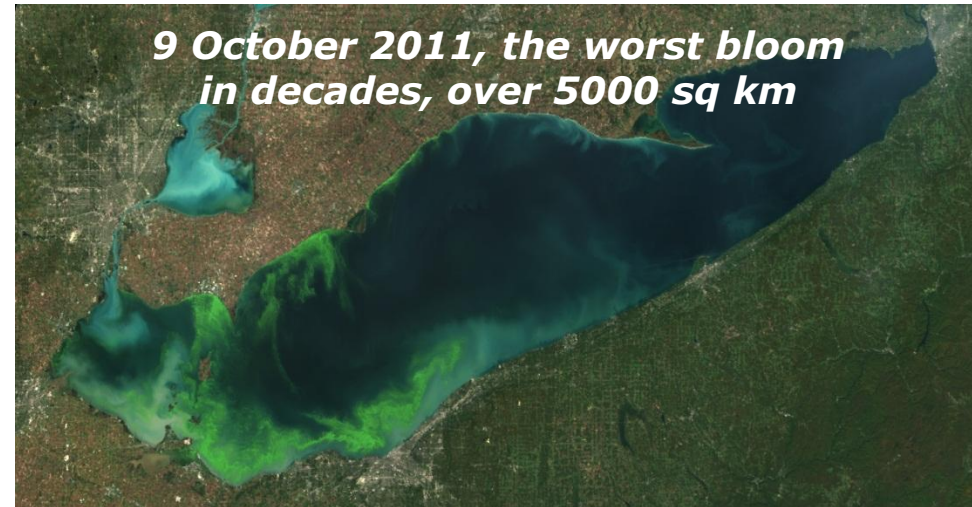


Figure 2. Nowcast position of *Microcystis* spp. bloom for September 08 using GLCFS modeled currents to move the bloom from the September 03 image.



Conditions: A massive *Microcystis* bloom persists throughout most of Lake Erie's Western Basin.

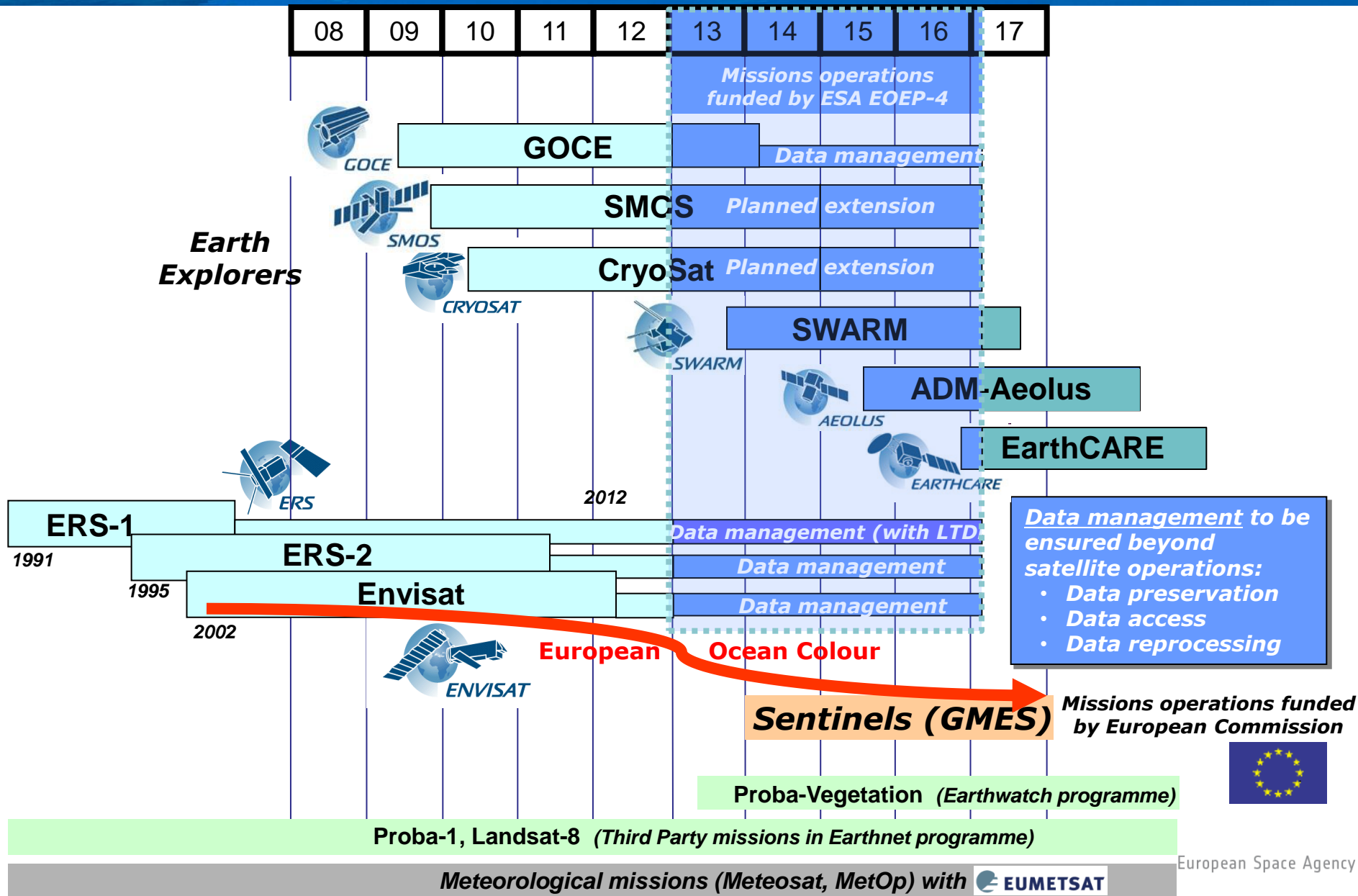
Analysis: As indicated in satellite imagery from Saturday (9/3/2011), an enormous *Microcystis* bloom was present in western Lake Erie. The southern extent of the bloom was remotely observed along the coast of Ohio from Maumee Bay to Catawba Island. The northern extent of the bloom was observed to be consistent along the Michigan coast from Northern Maumee Bay to the mouth of the Detroit River. The eastern-most portion of the bloom was observed past Point Pelee and to the northeast up in to Rondeau Provincial Park.

At the mouth of the Detroit River, a five day nowcast shows a southward suppression of the western-most portions of the bloom. However, the bloom is likely to still persist in much of the Western Basin. The nowcast also suggest the bloom has spread to the east of Sandusky and into the Cleveland area. (Note: Due to a lack of clear imagery the bloom has not been remotely observed in the Cleveland area.) A three day forecast also suggests that the bloom will persist to the north of Cleveland through the weekend. Water temperatures remain above 20 degrees Celsius and are forecast to decrease into the weekend; however, conditions remain favorable for bloom growth.

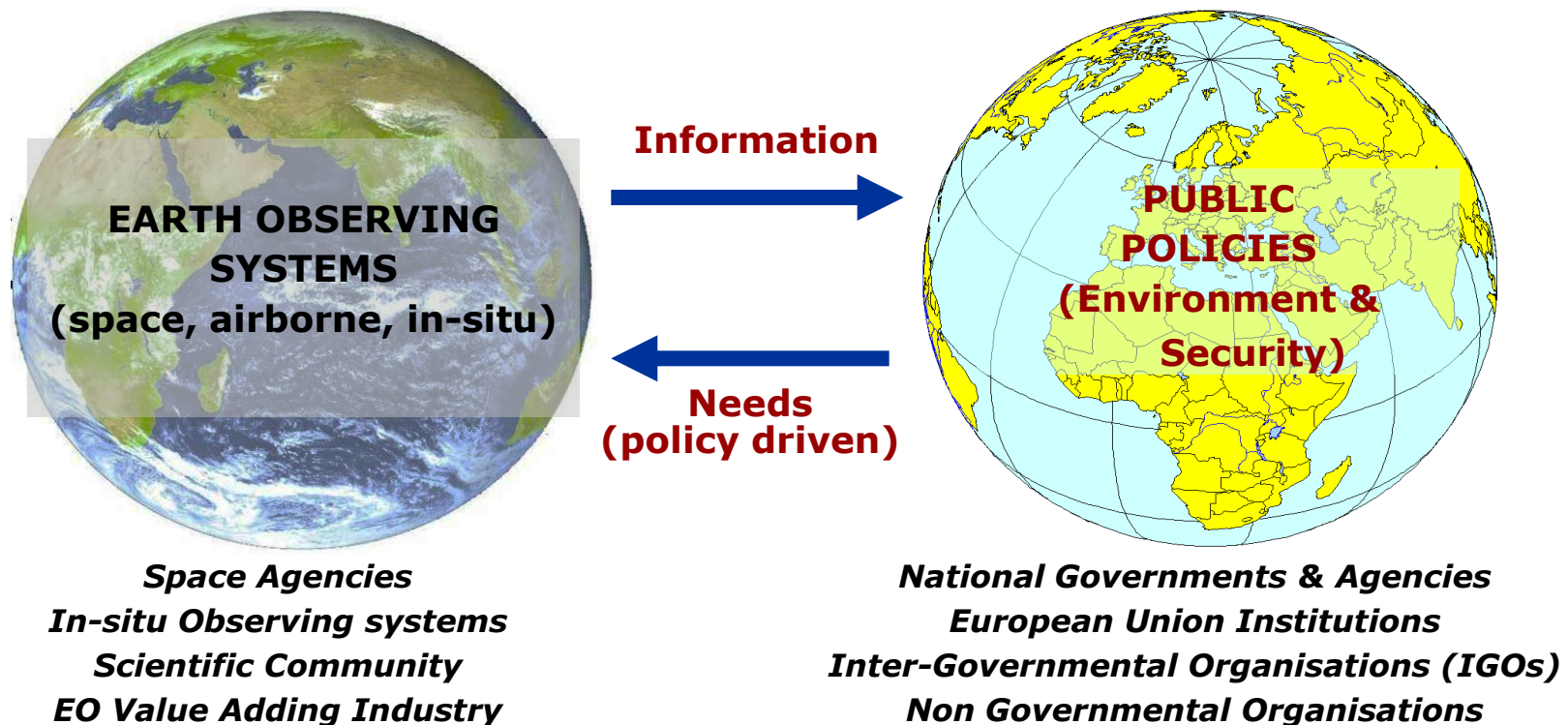
Briggs, Wynne

ESA Earth Observation programmes

- overview -



- GMES is an initiative led by the **European Union** (EU)
- The coordination and management of the GMES programme is ensured by the **European Commission** (EC)
- Aims at establishing a European capability for the provision and use of **operational monitoring information** for a wide range of environment and security applications
- Europe's response to the global need for environment & climate monitoring



GMES Components



Services Component – coordinated by the European Commission

- Produces information services in response to European policy priorities in environment & security
- Relies on data from in-situ and space component

In-situ Component – coordinated by the European Environment Agency

- Observations mostly within national responsibility, with coordination at European level

Space Component – coordinated by ESA

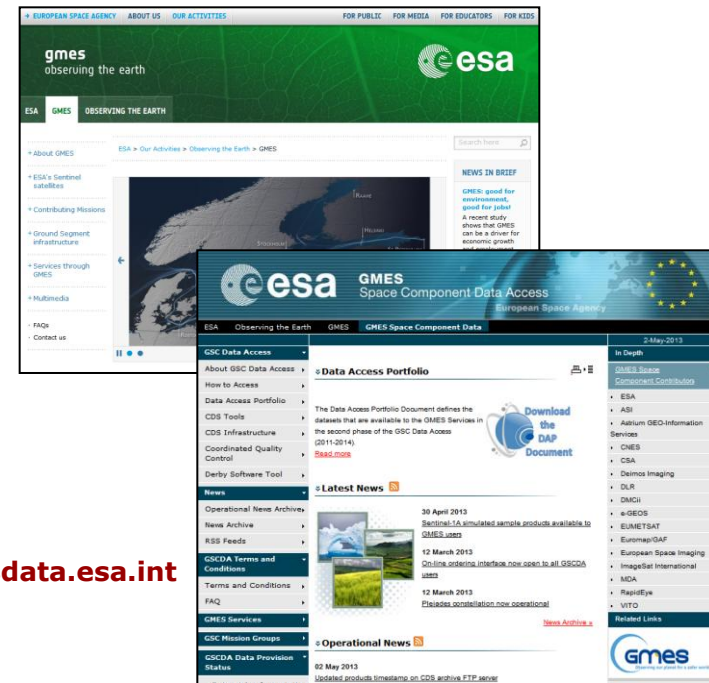
- Ensures data continuity
- ESA is procurement agency for the **Sentinels**: EO missions developed specifically for GMES
- ESA coordinates access to “**Contributing Missions**”: EO missions built for purposes other than GMES but offering part of their capacity to GMES (MSs, EUMETSAT, commercial, international)

www.esa.int/GMES

<http://gmesdata.esa.int>



<http://copernicus.eu>



GMES dedicated missions: Sentinels



SAR imaging

All weather, day/night applications, interferometry
Continuity of Envisat ASAR

Sentinel-1A
launch End 2013



Multi-spectral imaging

Land applications: urban, forest, agriculture,..
Continuity of Landsat, SPOT

Sentinel-2A
launch Sep 2014



Ocean and global land monitoring

Wide-swath ocean color, vegetation, sea/land
surface temperature, altimetry
Continuity of Envisat MERIS, AATSR, altimetry

Sentinel-3A
launch Nov 2014



Low-orbit atmospheric

Atmospheric composition monitoring
Continuity of Envisat

Sentinel-5 Precursor
launch 2015

Sentinel 4 – Geostationary atmospheric (on-board Meteosat Third Generation)

2019+

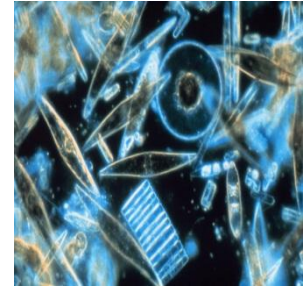
Sentinel 5 - Low-orbit atmospheric (on-board MetOp Second Generation)

Complementing existing/planned missions at national European level

Sentinel-3: ocean & global land mission



- ✓ Sentinel-3 is part of the GMES → **operational mission**
- ✓ High-inclination (98.65 deg.), Sun-synchronous Low Earth Orbit
27 days repeat cycle, equatorial crossing time 10:00 am
- ✓ Sentinel-3 implements 3 core missions to provide continuity to existing missions:
 - **Sea and land colour** (at least MERIS quality)
 - Sea and land surface temperature (at least AATSR quality)
 - Sea surface topography (at least Envisat Altimeter quality)
- ✓ Full performance achieved with **2 satellites in orbit**
- ✓ A series of satellites (A/B/C/D), each designed for a lifetime of 7 years, shall provide an operational service over 15 to 20 years
- ✓ 2 satellites (A and B units) are in development at the moment
- ✓ **Launch of the first Sentinel-3 (A unit) planned for Nov. 2014**
- ✓ **EUMETSAT** will be the operator of the marine part of Sentinel-3
- ✓ **ESA** will be the operator of the land part of Sentinel-3

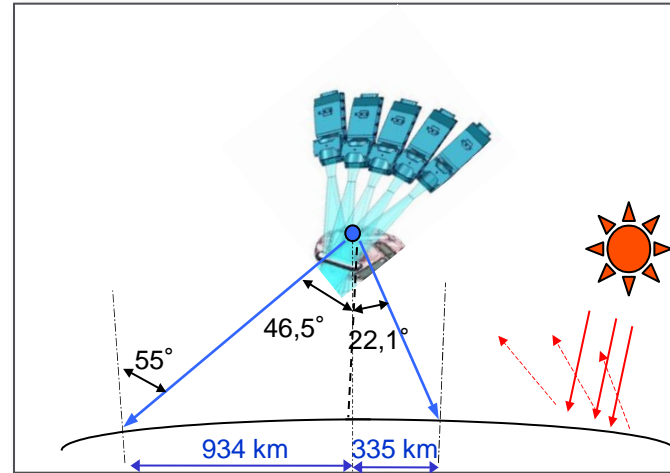


OLCI = Ocean & Land Color Instrument

strongly inherited from the flight-proven MERIS of Envisat (spectral bands and radiometric performances)

OLCI key improvements:

- ✓ 21 bands (MERIS + 6): 400-1020 nm
- ✓ slightly broader swath: 1270 km
- ✓ Sun glint free configuration by design: across-track tilt 12.20° in west direction
- ✓ Full Resolution (260m x 300m) acquired systematically over both land & ocean
- ✓ Reduced Resolution (1200m) over ocean, binned on ground (L1B)
- ✓ improved instrument characterisation, e.g. straylight
- ✓ short revisit times for optical payload:
 - at equator: 1 satellite < 4 days, 2 satellites < 2 days
- ✓ 100% overlap with SLSTR



MERIS bands

λ center	Width
412.5	10
442.5	10
490	10
510	10
560	10
620	10
665	10
681.25	7.5
708.75	10
753.75	7.5
761.25	2.5
778.75	15
865	20
885	10
900	10

New OLCI bands	λ center	Width
Aerosol correction	400	15
Fluorescence retrieval	673.75	7.5
Atmospheric correction	764.375	3.75
Cloud top pressure	767.5	2.5
Atmos./aerosol correction	940	20
Atmos./aerosol correction	1020	40

Recent main achievements

- Satellite AIT started following delivery to the Prime of the Sentinel-3A Platform Module

Current main criticalities

- SLSTR and OLCI Instrument delivery dates still critical, despite introduction of double shift work
- Unclear interpretation of US Department of State clarification note issued in Feb 2013 indicating applicability of ITAR rules retroactively on items originally classified as EAR, blocking delivery of a number of Sentinel-3 units

*Sentinel-3A spacecraft
master cubes sighting at
Thales Prime premises*



Sentinel-3 product size is substantial and hence data access/delivery to users needs to be appropriately sized.

	Level 1 GB/orbit	Level 2 Marine GB/orbit	Level 2 Land GB/orbit
OLCI	29.6	35.5	7.8
SLSTR	45.6	5.8	2.8
SYN (OLCI+SLSTR)			31.2

Comparison with similar Envisat instruments products:

AATSR L1 (GBTR) ~0.7 GB /orbit

MERIS L1 (RR+FR) ~10 GB/orbit

- **Joint Principles for a GMES Sentinel data policy:**
(2009 approved ESA document)
 - **Anybody can access** acquired Sentinel data; in particular no difference is made between public, commercial and scientific use and in between European or Non-European users
 - The licenses for the Sentinel data itself are **free of charge** (...)
- EC presently drafting a **GMES data and information policy**, based on the Joint Principles (see above) in the shape of a Delegated Regulation, to be approved in 2013.

... the **GMES Space Component (GSC) Operations Concept**, which will rely on a GSC Ground Segment consisting of a:

- 1. GSC Core Ground Segment** (GSC-funded), providing:
 - the **primary data access to Sentinel Missions**, and
 - the coordinating access functions to the **GMES Contributing Missions data**,
- 2. GSC Collaborative Ground Segment** (non GSC-funded) providing:
 - a **supplementary access** to Sentinel Missions data
i.e. either through specific data acquisition services (e.g. Quasi-Real-Time), or **specific data products** ..
 - the **frame for international cooperation**

- ✓ Access to data through collaborative agreements provides added value via the development of operational ground segment services complementing the GSC ground segment core services.
- ✓ **The collaboration provides a frame for specialised solutions to further enhance the Sentinels missions exploitation** in the area of:
 1. Sentinels data acquisition and (quasi-) Real Time production
 2. **Complementary collaborative data products and algorithms definition**
 3. **GSC data product dissemination and access (e.g. mirror sites)**
 4. **Development of innovative tools and applications**
- ✓ It is envisaged to use this scheme as a mechanism to formalise the participation to the Sentinel-3 cal & val teams:
 5. **External validation support**
- ✓ The collaboration will rely on the definition of formal agreements as well as the technical definition of dedicated operational interfaces.
- ✓ Discussions on collaborative ground segment are currently taking place with ESA/EC Member States.

- ✓ Europe has a ***strong satellite ocean colour programme***
- ✓ Effort will be maintained for MERIS data reprocessing
- ✓ Sentinel-3 launch is foreseen towards end 2014
- ✓ Present ESA data policy (MERIS) and future EC/ESA Sentinel data policy as well as the GMES Space Component Operations Concept open ***collaboration*** with International partners
- ✓ Europe has a particular need in accessing common reference ***in-situ infrastructures*** which are essential for sensor calibration and product validation

