

# Sentinels-2 and -3 & ESA Development and Exploitation Programmes

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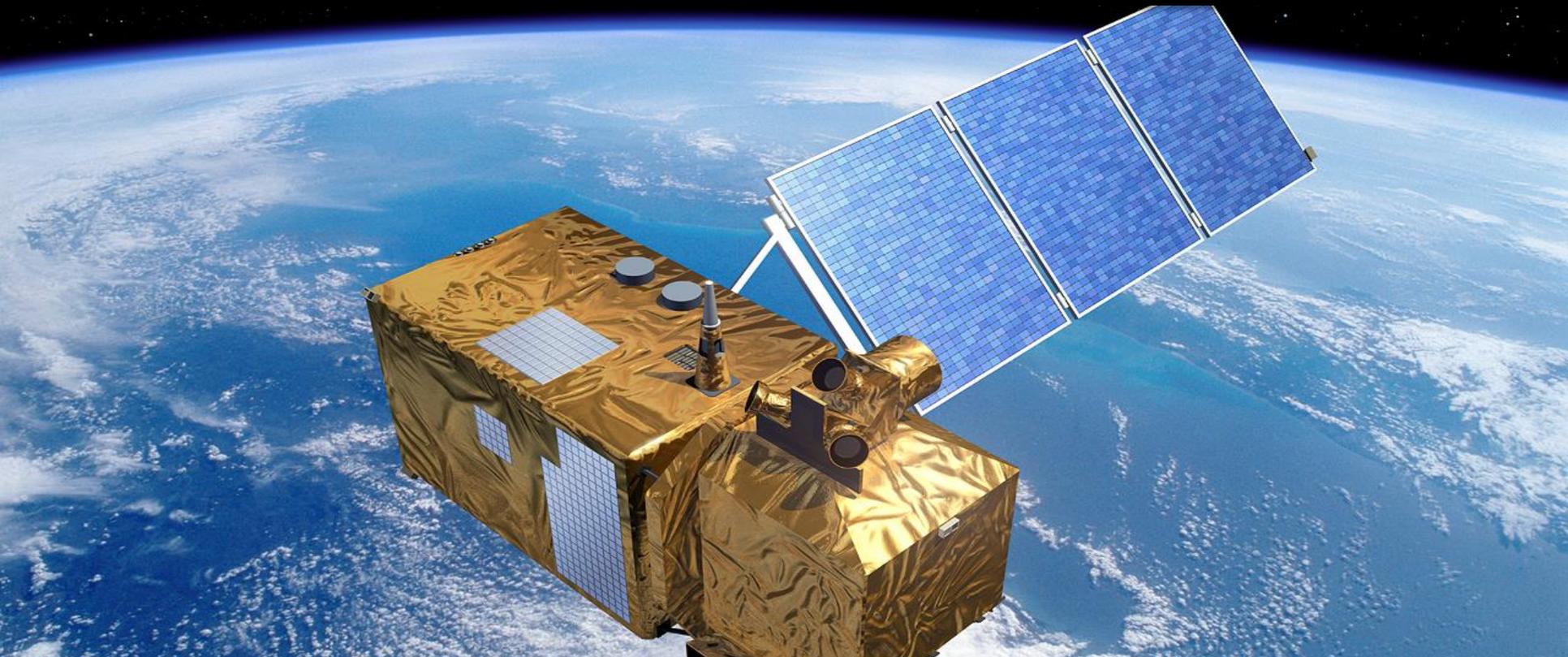


# GMES Sentinel-2

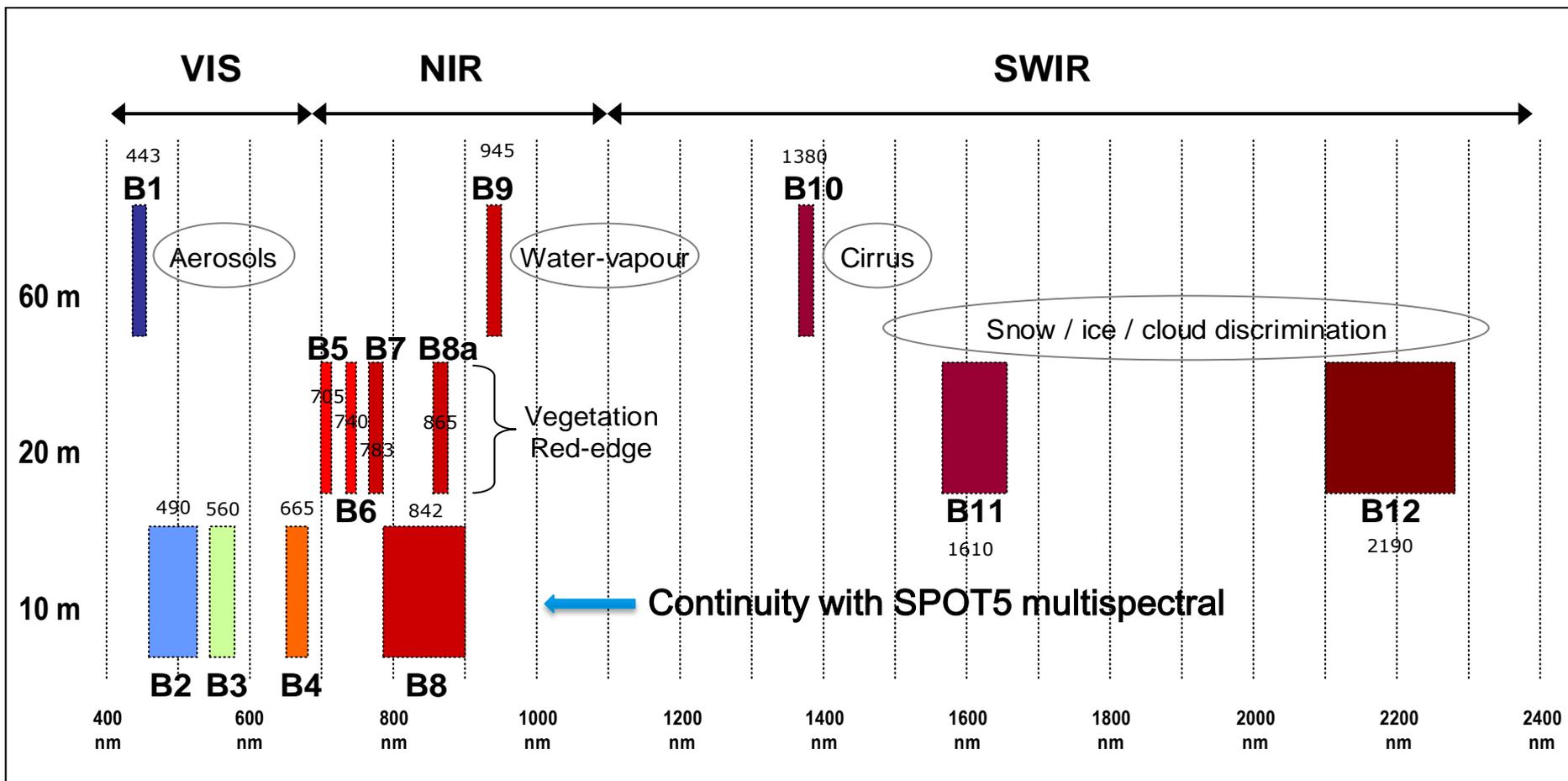


## Multispectral High Resolution Optical Imager

- Launch: Sep 2014, 2015, ...
- 13 bands (VIS, NIR & SWIR)
- 290 km swath at 10, 20 and 60 m
- Systematic acq. of all land and coasts
- 5 days repeat cycle with 2 satellites
- 7 years design lifetime (max. 12 yrs)



# Sentinel-2 Spectral Bands



## Level-1C

- Top-of-atmosphere (TOA) reflectances in cartographic geometry (UTM/WGS84).
- Image radiometry key features:
  - ✓ Radiometrically corrected data.
  - ✓ Product includes all necessary parameters required to convert the provided reflectances into radiances.
  - ✓ Reflectances coded in 12 bits.
- Image geometry key features:
  - ✓ Sub-pixel multi-temporal registration between images.
  - ✓ Resampling uses an SRTM-based DEM improved.
- Products also include:
  - ✓ Land/Water, Dense Cloud and Cirrus Cloud masks.
  - ✓ ECMWF data (ozone, water vapour and mean sea level pressure).

## Level-2+

- Generated on user-side with Sentinels Toolbox (Atm Corr, ...)

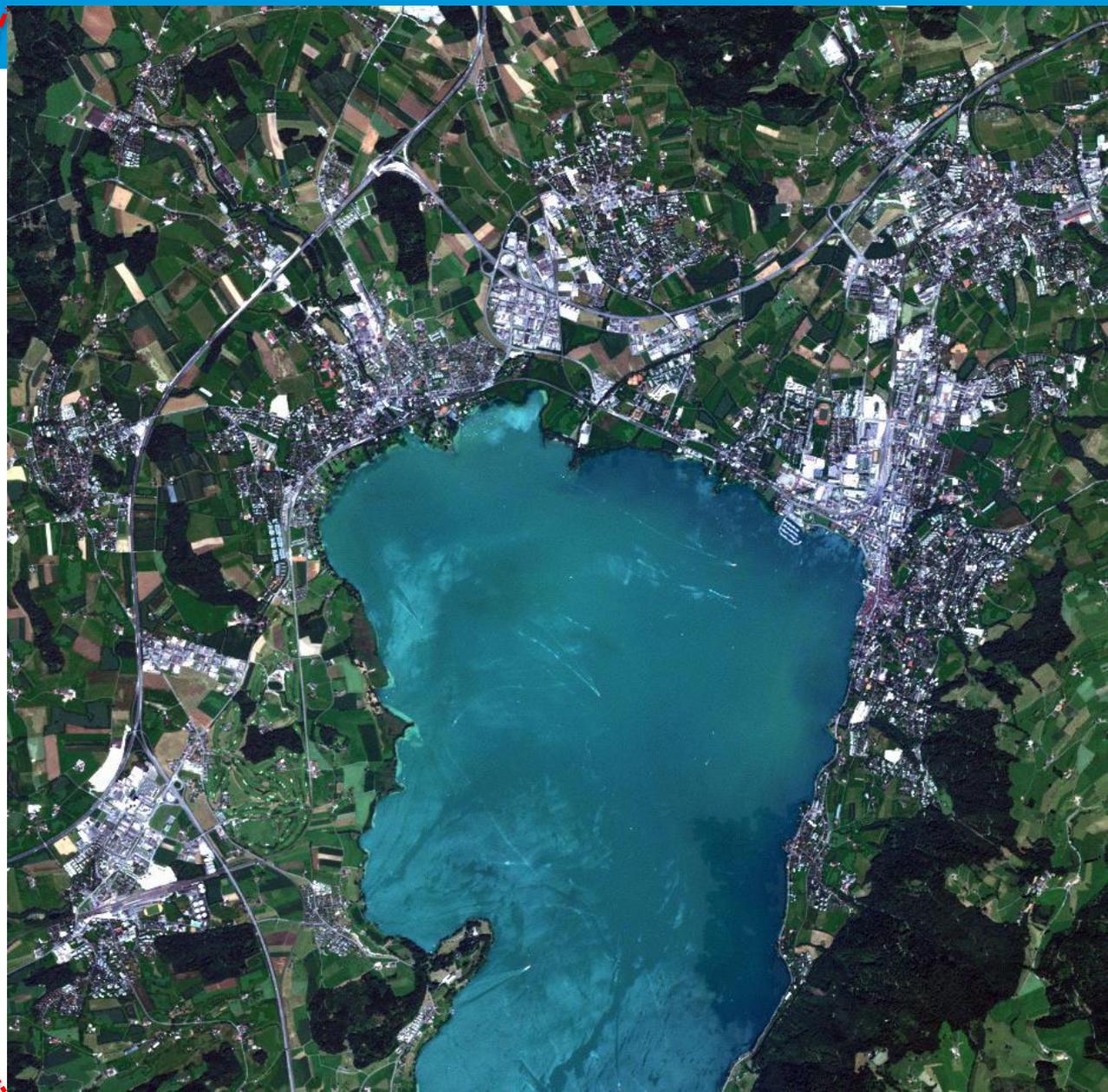
# Sentinel-2 Level 1C Product Tile (UTM)



100 km

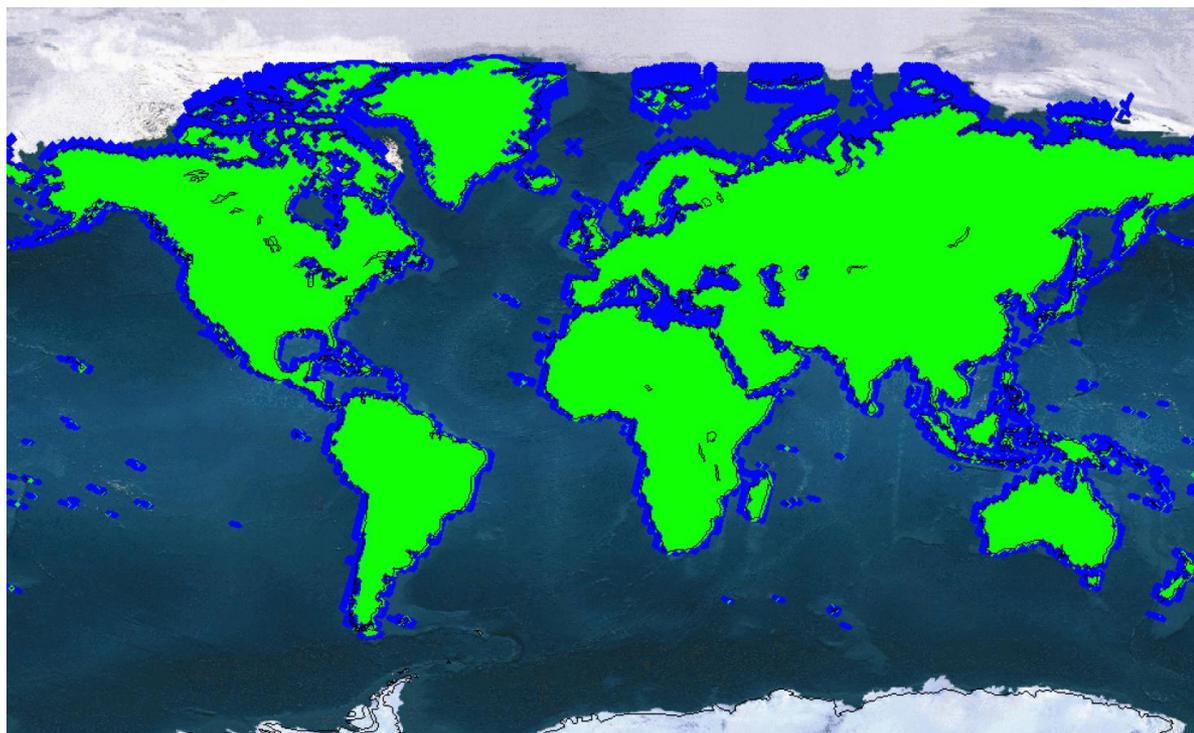


RGB composite  
of a Level-1C Tile  
Size ~ 500Mb



## Systematic coverage of:

- ✓ All land surfaces between 56deg South latitude and 84deg North latitude;
- ✓ All coastal waters up to 20km from the shore
- ✓ Major islands (greater than 100 km<sup>2</sup> size)
- ✓ All EU islands
- ✓ Mediterranean Sea
- ✓ All (e.g. Caspian Sea)
- ✓ Specific campaigns as required.

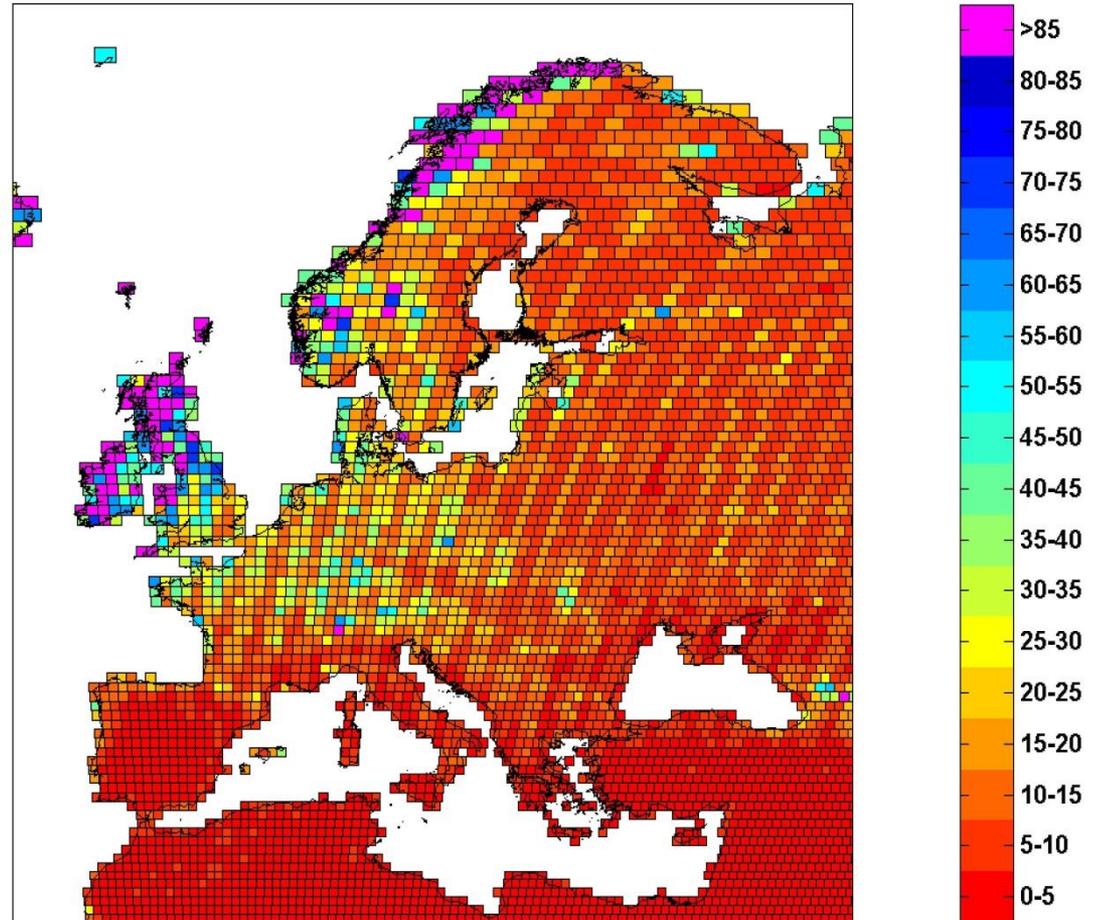


Maximum effective coverage time for SC1 & SC2 (days) (<15% cloud cover; 68% confidence)

Temporal sampling simulation:

Two satellites, summer time

About one or two cloud free observations per month over most of Europe.



<b>Radiometric Quality</b>	
Absolute radiometric uncertainty	3 % (goal) , 5 % (threshold)
Inter-band relative radiometric uncertainty	3%
Linearity knowledge accuracy	1%
Modulation Transfer Function (MTF)	0.15 to 0.3 (for 10m bands) <0.45 (for 20 & 60m bands)
<b>Geometric Quality</b>	
Absolute geolocation uncertainty	20m $2\sigma$ (threshold) 12.5m $2\sigma$ (goal) with GCPs
Multi-temporal registration	0.3 pixel $2\sigma$ (goal) with GCPs
Multi-spectral registration (for any couple of spectral bands)	0.3 pixel $3\sigma$

# Example #1: Sentinel-2 for Wetlands

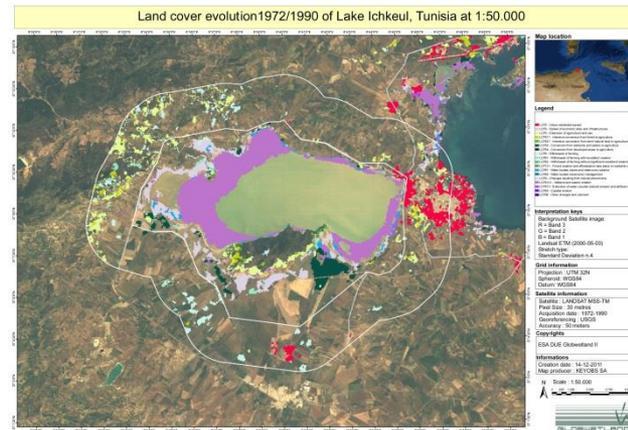


Sentinel 2, an observation asset of the future Global Wetlands Observation System (GWOS) for the inventory, assessment and monitoring of wetlands, worldwide.

Water Cycle Regime (WCR) of Merja Zerga, Morocco at 1:50,000 in 2005

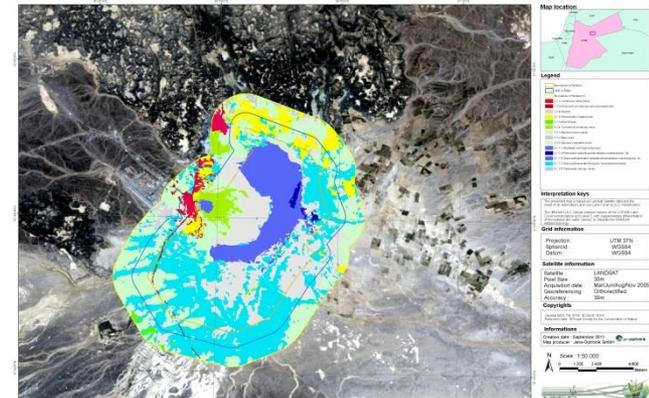


*Water Cycle Regimes i.e. what is permanent water, what is not. (needs freq repeat obs)*



*Land Use  
Land Cover  
maps*

GlobWetland II Land Use and Land Cover (LULC) map Azraq (Jordan) 2005



*Change  
Detection maps*

# Example #2: Sentinel-2 for Coral Reefs

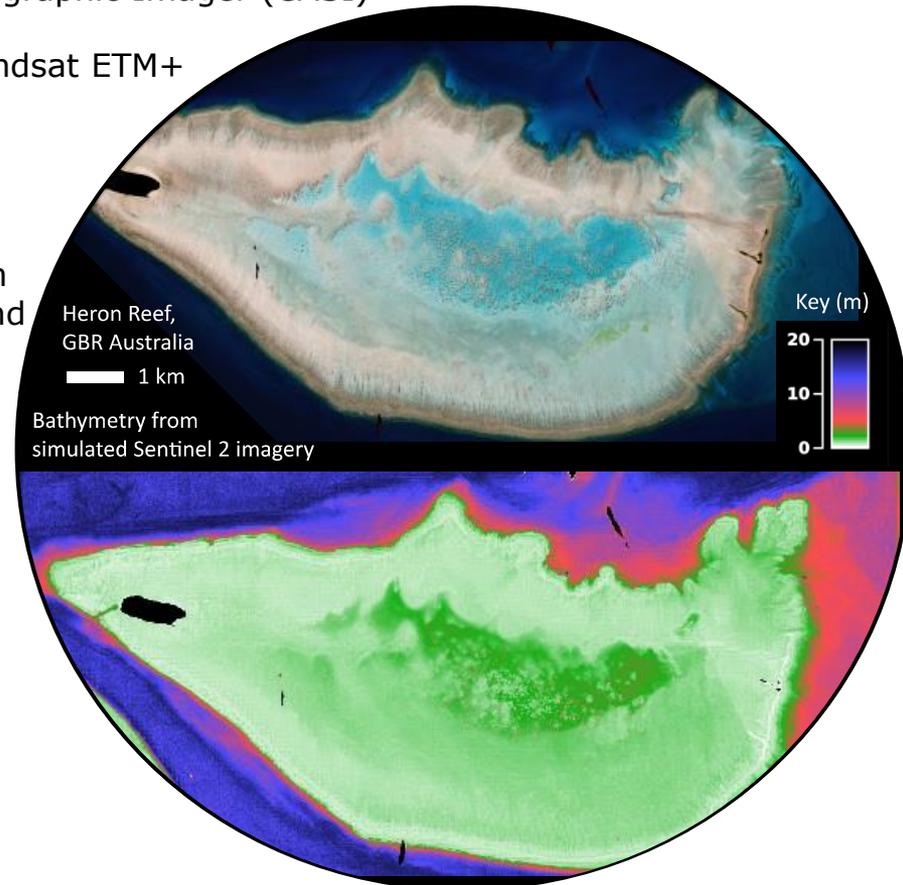
Capability of the Sentinel 2 mission for tropical coral reef mapping and coral bleaching detection.  
Hedley JD, C. Roelfsema, B. Koetz, S. Phinn, *Remote Sensing of Environment*, 120, p145, 2012

Simulated Sentinel-2 data from Compact Airborne Spectrographic Imager (CASI)

Comparison of the capabilities of Sen-2 vs SPOT-4 and Landsat ETM+

## Conclusions:

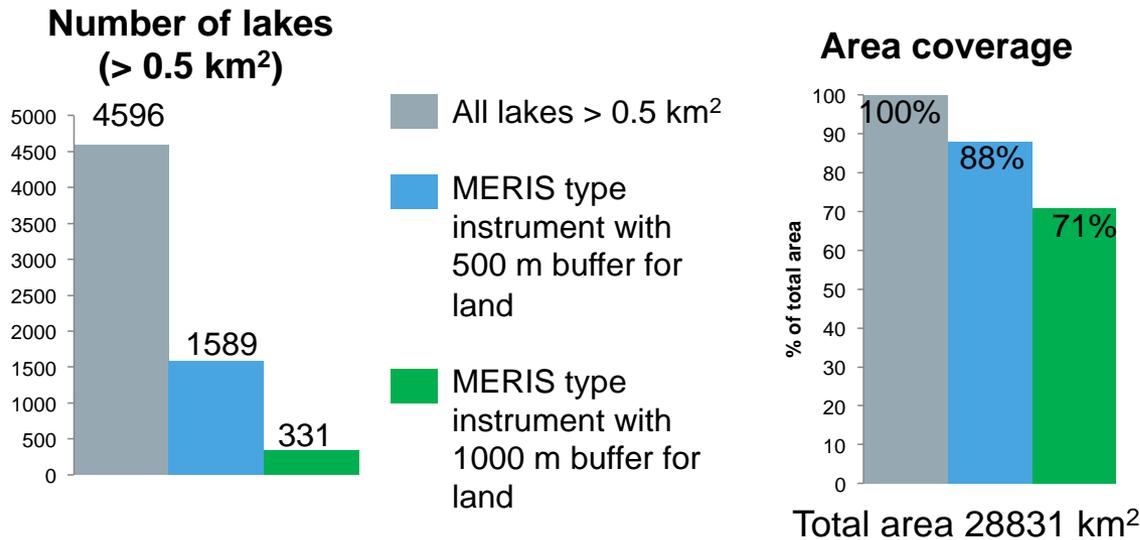
- Narrow bands, good spatial resolution and extra 443 nm band make Sen-2 perform better than Landsat ETM+ and SPOT-4 for coral reef habitat mapping (i.e. depth, bottom cover, water optical properties).
- Frequent Sen-2 overpass suggests possibility for coral bleaching detection, although only in shallowest and clearest water (i.e. less than 5m depth)
- Analysis of time series should be effective in reducing product uncertainties



# Example #3: Sentinel-2 for Lakes

DATA AND INFORMATION CENTRE

## WFD monitoring of Finnish lakes with MERIS and Sentinel-2 – **Effect of spatial resolution**



With Sentinel 2: All WFD lakes and much more

# Sentinel-2 Symposium

## Coastal and Inland Water Session



### 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 systems for a systematic monitoring of coral reefs for the next decades;
- The combined use of Sentinel-2 spatial resolution and Sentinel 3 spectral resolution will offer unprecedented water quality observing capabilities for coastal and inland waters.

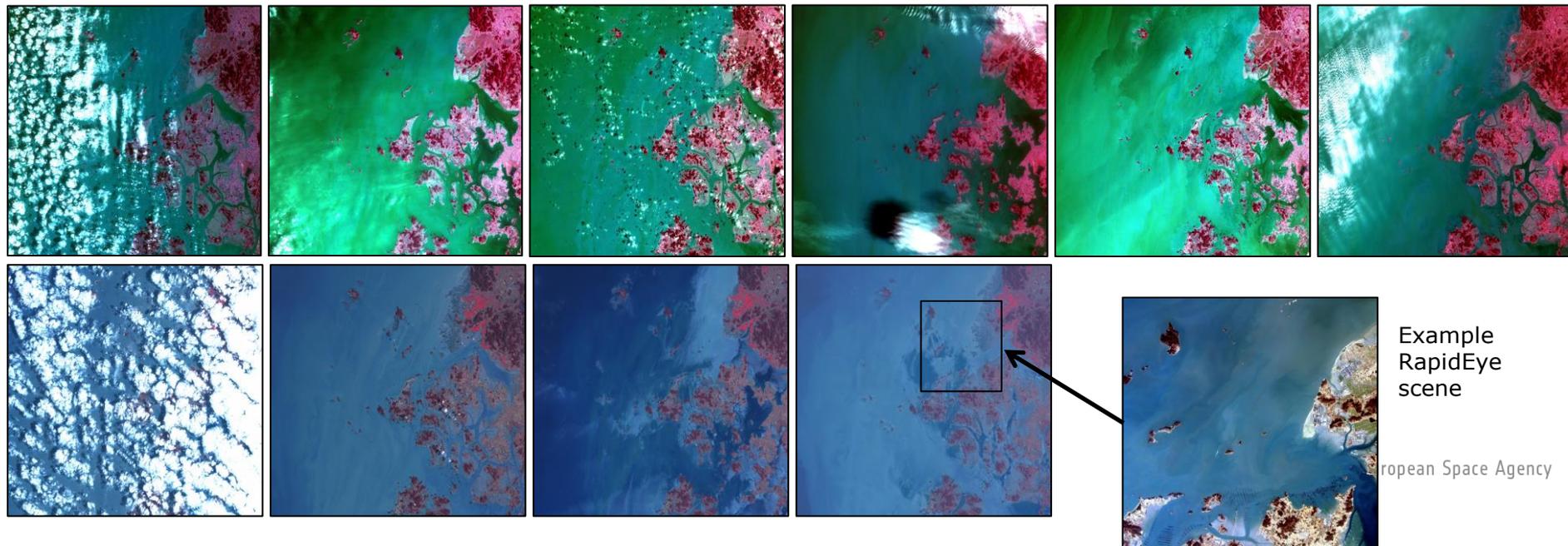
### Identified a broad range of potential applications of Sentinel-2 data:

- implementation of **water quality regulations** derived from the EU directives: the Water Framework Directive (WFD), the Marine Strategy Framework Directive (MSFD), the Bathing Water Directive & the Birds/Habitats Directive.
- **extended mapping opportunities** such as topography and bathymetry, aquatic habitats & benthic classification, coral reefs, intertidal flats and estuarine areas, and inland waters, in particular for nature conservation, civil engineering, aquaculture, algal blooms.
- **support to modelling** (physical and biological)

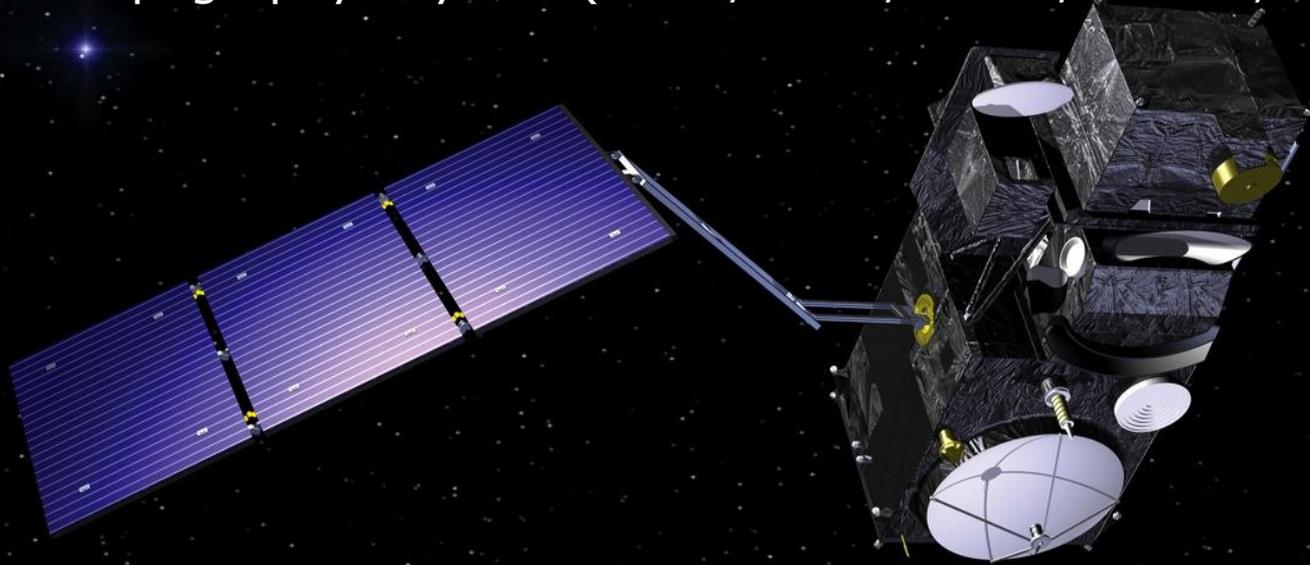


Simulation of Sentinel-2 5-day repeat cycle as part of SPOT-4 end of life de-orbiting

- 42 sites imaged every 5 days
- Feb-May 2013
- L1C and L2A data will be available at end June 2013 from CESBIO  
Pôle Thématique Surfaces Continentales (PTSC)
- Two sites for CoastColour: Chesapeake Bay and Korea, but others sites also contain lakes/coast
- ESA adding RapidEye and (hopefully) some Landsat-8 (both with blue spectral channels)
- E.g. Quicklooks of SPOT-4 data over Korean site acquired so far (Feb-April):



1. Ocean and Land Colour Instrument (OLCI) – an improved MERIS
2. Sea and Land Surface Temperature Radiometer (SLSTR) – an improved ATSR
3. Sea & Ice Topography Payload (SRAL, MWR, GNSS, DORIS, LRR)



- Launch: S3A in Nov 2014, S3B in 2015
- Revisit at equator = 2 days (or daily with 2 satellites)
- 7 year lifetime (max. 12 yrs)
- Operated jointly by ESA and Eumetsat

Expect Sentinel-3 to allow continued delivery of the sort of ocean-colour science and services developed and demonstrated using Envisat MERIS, but in a sustained, operational way, e.g.

- GlobColour
- Diversity
- MarCoast
- CoastColour
- Climate Change Initiative Ocean-Colour CCI
- EC FP7 projects
- National projects
- ...etc...



- ✓ **The Sentinel data policy will be jointly decided by ESA and EC**
- ✓ **ESA Member States and EC have prepared joint principles of a Sentinel data policy in Sep 2009, which focus on:**
  - ➔ **Access to Sentinel data by anybody (European and non-European users) and for any use (“full and open”)**
  - ➔ **Free of charge data licenses (“free”)**
  - ➔ **Some restrictions may be required (e.g. security, technical constraints, etc.)**
- ✓ **EC has been mandated by its Member States and the European Parliament to define the overall GMES data and information policy → Sentinel data policy is part of it**
- ✓ **The Sentinel data policy is still being finalized...**

## 1. A Core Ground Segment (GSC-funded), providing:

- the primary data access to Sentinel Missions, and
- the coordinating access functions to Contributing Missions data,

## 2. A 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 ..

**NB:**...discussions with **National** = ESA Member States are on-going in 2013, this may create additional data access points and products for YOU

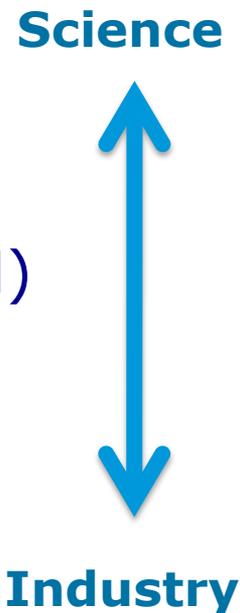
**NB:**...**International** co-operation and projects: possibility for collaborative agreements e.g. discussions started with USGS, NASA and NOAA, GA-Australia, China

*Related agreements will be prepared throughout 2013/14*

## Four Exploitation elements in EOEP-4

- Support to Science (STSE)
- Scientific Exploitation of Operational Missions (SEOM)
- Data User Element (DUE)
- Value Adding Element (VAE)

Total budget ~ 2-3 Meuro per year per element

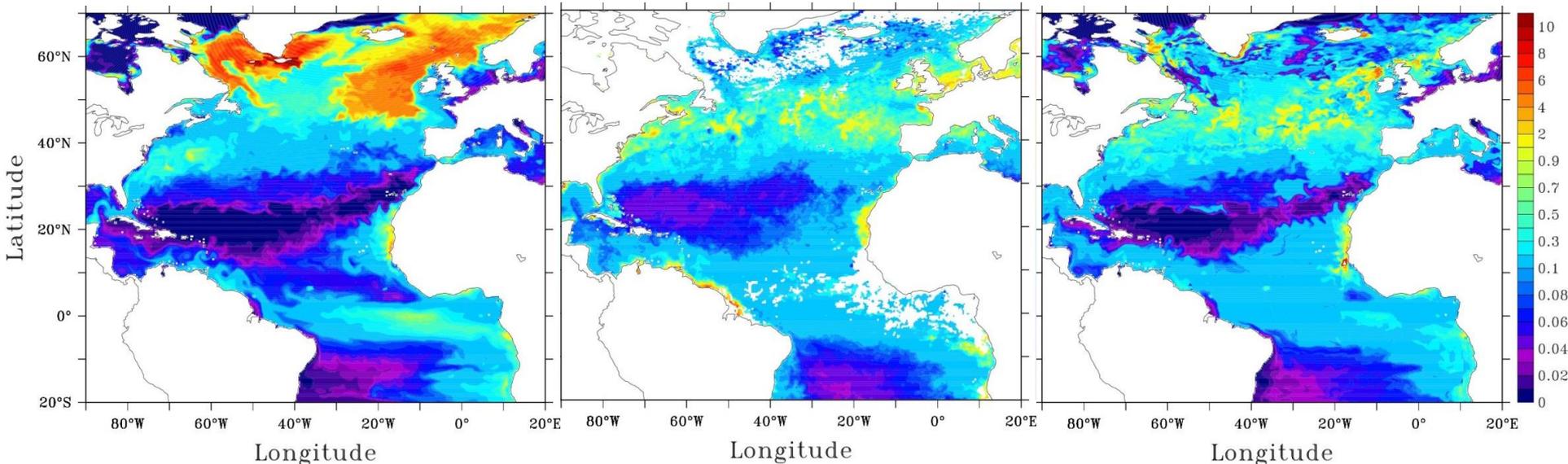




## ASSOCO - ASSimilation of Ocean COlour satellite data to monitor the biogeochemical state of oceans and estimate its variability, M. Doron, LEGI, Grenoble, France

- To take advantage of both coupled physical-biogeochemical models and satellite observations to get a deeper knowledge of the modelling of phytoplankton cycles.
- To develop a Data Assimilation system, using surface phytoplankton as observations.

**Maps of Chlorophyll-A obtained from a simulation with the coupled physical-biogeochemical model (left), from the GlobColour dataset (middle) and from the assimilation experiment (right)**



## RESEARCH and DEVELOPMENT STUDIES

Stimulating the development and validation of advanced EO methods

- **S3-ACWATER:** to develop atmospheric correction for S-3 over complex waters

## SCIENTIFIC TOOLBOXES DEVELOPMENT

Developing, validating and maintaining open-source, multi-mission, scientific software toolboxes, e.g. in 2013: Sen-1, Sen-2, Sen-3, Sen-3 Alt, Sen-5P.

## SCIENCE USER CONSULTATIONS

- **POLINSAR:** – ESA-ESRIN January 2013
- **S3ALT-COASTALWorkshop** – 2013
- **Living Planet Symposium** -- Edinburgh UK, 9 -13 Sep 2013

## TRAINING EVENTS

- **Radar Polarimetry** training at ESRIN, Frascati, Italy 21-25 January 2013.
- **Land Remote Sensing** training Harokopio Univ. of Athens Greece 1-5 July 2013
- **Ocean Remote Sensing** training at University of Cork, Ireland TBD 2013
- **Sentinel-3 new SAR mode exploitation** training at TBD in 2013

## PROMOTING SCIENCE DATA USE AND RESULTS

# Data User Element

Fostering the development and validation of EO applications with and for user communities



## GlobCurrent

Develop high-resolution ocean surface current information services for a wide variety of applications including search and rescue, wave forecasting, ship routing, maritime security, marine accidents, ocean pollution, offshore operations, aquaculture, offshore renewable energy.

**user consultation:** Ifremer, March 2012

## GlobTemperature

Improve the uptake of global-scale satellite land surface temperatures (LST) in Earth modelling and environmental monitoring.

**user consultation:** Edinburgh, June 2012

## GlobBiomass

Characterise the distribution and changes, and an improved quantification of regional and global biomass to help reducing uncertainties in calculations of carbon stocks and fluxes in the terrestrial biosphere.

**user consultation:** Jena, October 2012

## Sentinel2 Agriculture

Prepare for S-2 exploitation in agricultural monitoring (food security, national reporting, crop management, rural development) at national to regional and global scales

**user consultation:** ESRIN, April 2012

# Value Adding Element (ex. EOMD)

To strengthen the competitive position of the European & Candian Value-Adding sector, both small companies and institutional suppliers of marketable EO services.



Development of commercial EO services for:

- **International Development Banks** (WB, UN-IFAD, EIB, ADB)
- **EU Agencies** (EMSA, FRONTEX, EEA)
- **Law Enforcement outside Europe** (Border monitoring, illegal mining, trafficking, supporting NGOs, post-conflict services)
- **Market Expansion**  
e.g. Expanding customer base for existing services
- **Innovation and Development**  
e.g. Assess commercial impact of new satellite data and techniques
- **Growth**  
e.g. Support industry to develop export markets outside Europe.

# Monitoring of Inter-Tidal Flats Tagus Estuary, Portugal



INCB, ARHTEjo, MARETEC, Univ Lisbon,  
LNEC, IMAR

Six local users from Monitoring & Controlling,  
Agencies, Marine Laboratory, and Academic Research

## Main Objectives :

- Validation of Inter-tidal flats for Tagus estuary with methodologies developed for German Wadden Sea,
- Of Ecological and economic importance,

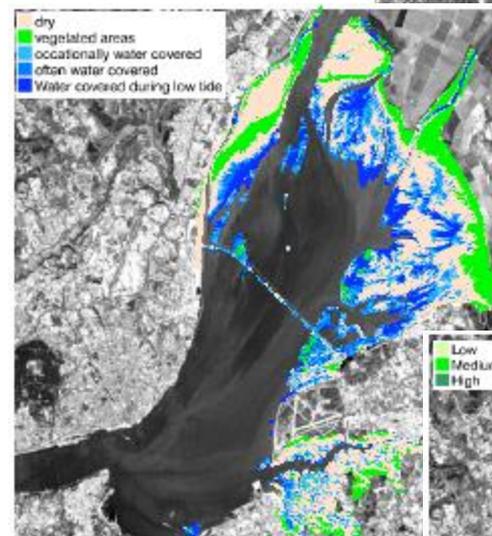
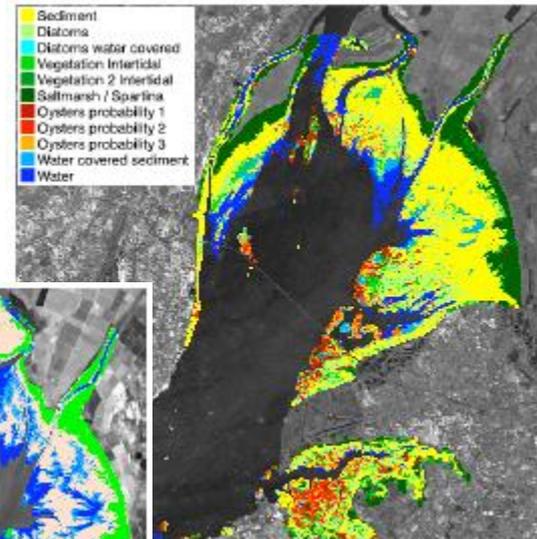
## EO Services :

- VHR Optical for surface types (sand, mud, oyster beds, mussels, sea-grass, algae)
- VHR radar for surface roughness,
- In-situ data critical.

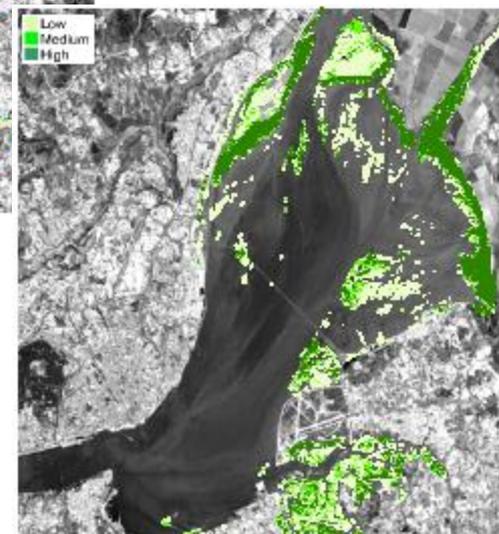
## Main Achievements :

- Classification successfully validated,
- Sediment in Tagus estuary is challenging,
- Salt marshes appear stable,
- Improved monitoring practices for Users.

Classification of oyster  
beds and vegetation



Water coverage map



Frequency of  
vegetation coverage



- Organized every 3 years
- Over 1700 abstracts received by deadline (mid February)

<http://www.esa.int/LivingPlanet2013>

# Thanks for your attention



Thanks also to some ESA colleagues:

- Ferran Gascon – S2 Products and Algorithms
- Marc Paganini – GlobWetlands and Diversity
- Ben Koetz – Coral Reef
- Biana Hoersch – Sentinel-2 Mission
- Diego Fernandez – STSE
- Stephern Coulson – VAE
- Yves Louis Desnos – SEOM