Developments in Earth observations for Lake Garda in the H2020 programme

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Presentation outline

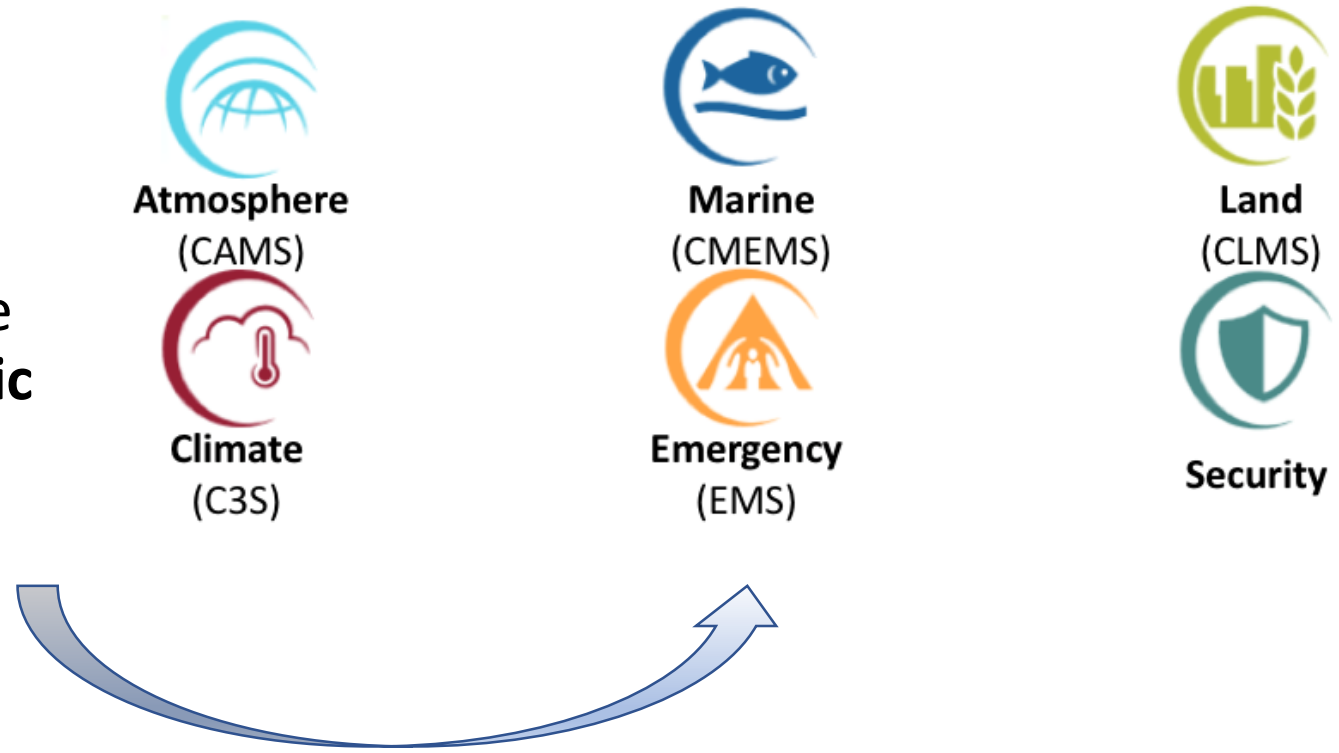
- Introduction
  - Copernicus programme
  - Overview on Sentinels
- Research projects on Lake Garda in H2020
  - EOMORES
  - SPACE-O
  - HYPERNETS
- Conclusions
- Future outlook

The Copernicus programme

- ***Copernicus*** is the European Union Programme aimed at developing European information services based on **satellite Earth Observation and in situ (non-space) data**.
- The Programme is coordinated and managed by the **European Commission**. It is implemented in partnership with the Member States, and EU Agencies (ESA, EUMETSAT, ECMWF and Mercator Océan).
- The **main users of Copernicus services** are policymakers and public authorities who need the information to **develop environmental legislation and policies** or to **take critical decisions in the event of an emergency**, such as a natural disaster or a humanitarian crisis.
- The information services provided are **freely and openly** accessible to users.

The Copernicus programme

- The Copernicus Services transform this wealth of satellite and in situ data into value-added information by processing and analysing the data
- **Datasets stretching back for years and decades** are made comparable and searchable, ensuring the **monitoring of changes**
- These value-adding activities are streamlined through **six thematic streams of Copernicus services**



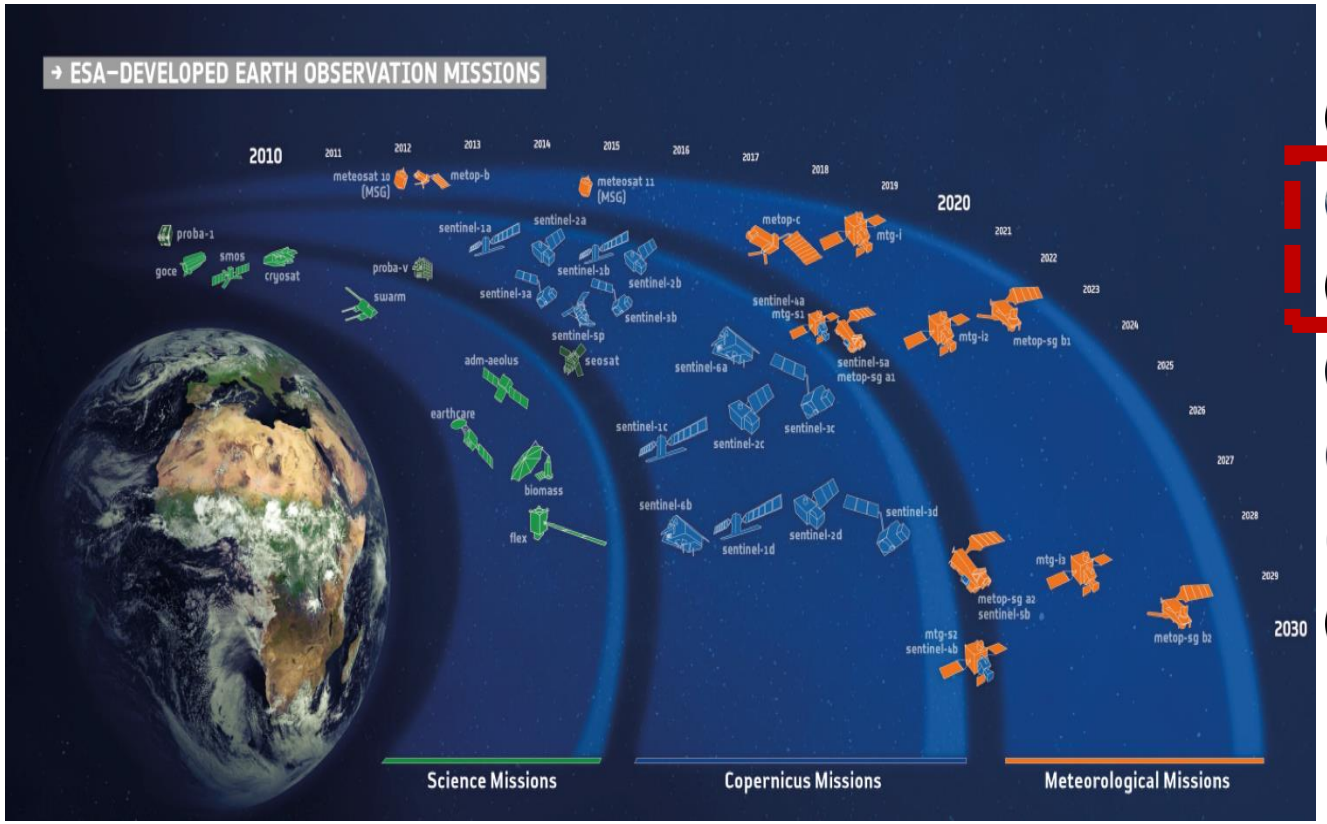
The Copernicus programme

Earth Observation

- The provision of Copernicus services is based on the processing of environmental data collected from Earth observation satellites and in situ sensors.

- The Earth observation satellites which provide the data exploited by the Copernicus services are split into two groups of missions:
  - The **Sentinel Satellites** are developed for the specific needs of the Copernicus programme. They provide a unique set of observations for Copernicus
  - Contributing Missions are missions from ESA, their Member States, Eumetsat and other European and international third party mission operators (NASA, NOAA, …) that make some of their data available for Copernicus.

EO Missions Overview - Sentinels

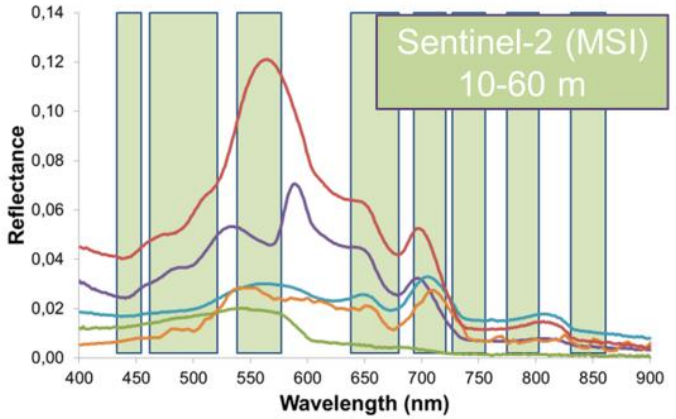


S1A/B: Radar Mission	3 Apr 2014/25 Apr 2016
S2A/B: High Resolution Optical Mission	23 June 2015/7 March 2017
S3A/B: Medium Resolution Imaging and Altimetry Mission	16 Feb 2016/2017
S4A/B: Geostationary Atmospheric Chemistry Mission	2021/2027
S5P: Low Earth Orbit Atmospheric Chemistry Mission	2017
S5A/B/C: Low Earth Orbit Atmospheric Chemistry Mission	2021/2027
S6A/B: Altimetry Mission	2020/2025

S3/B
25 April 2018

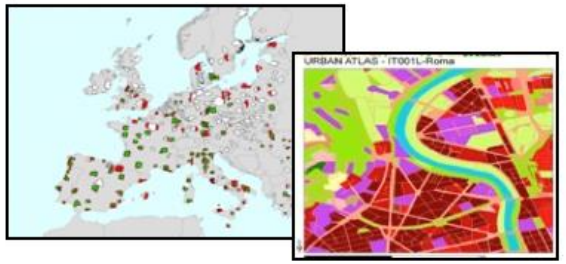
- Copernicus Space Component: the dedicated Sentinels …

Sentinel-2
MSI-optical, 10-60 m, 5 days



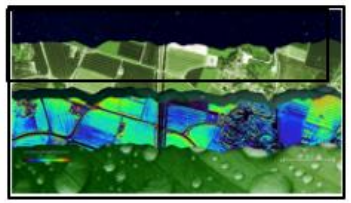
Forests & Carbon, Vegetation monitoring

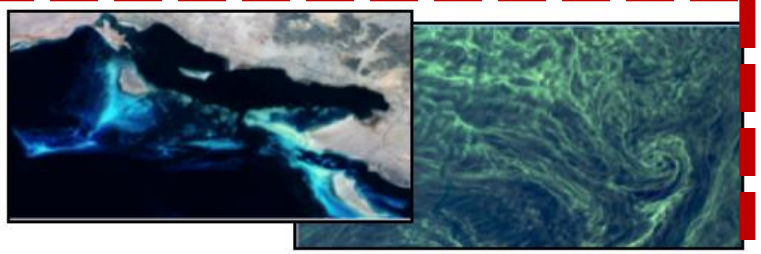
European land cover, human impact, high resolution layers



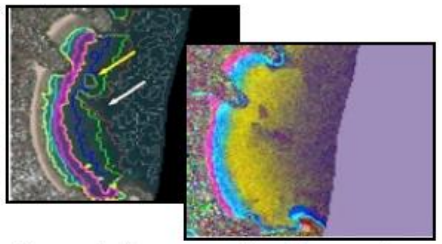
Regional to Urban Applications

Agriculture, fluorescence & biophysical parameters



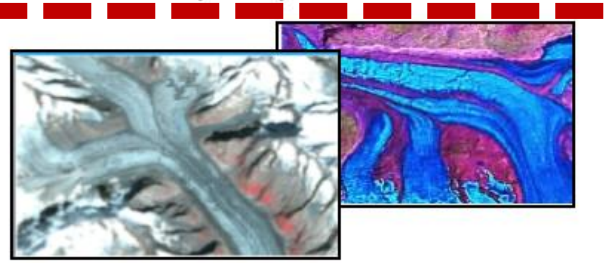


Water quality, Wetlands

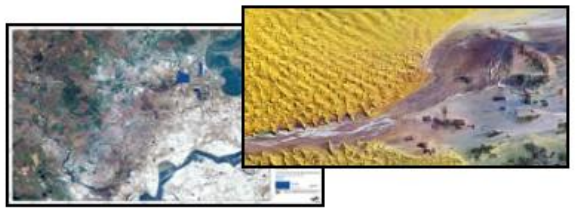


Coastal zones/bathymetry

Emergency management

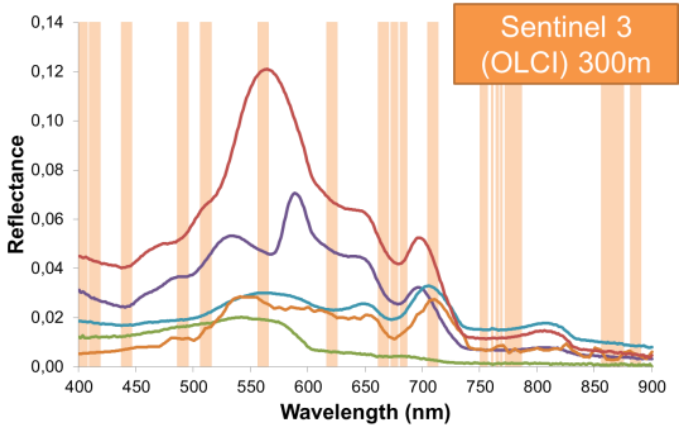


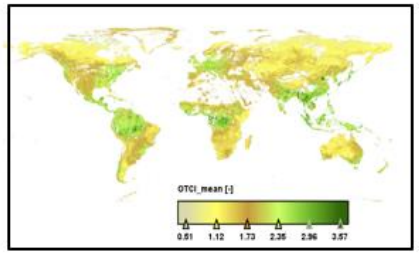
Glaciers & ice



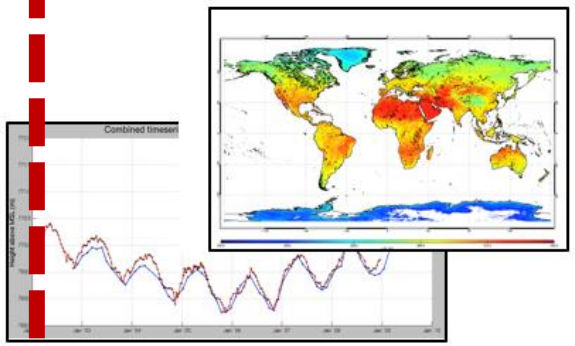
Geology & geomorphology

Sentinel-3
OLCI-optical, 300 m, 1-2 days
SLSTR-thermal, 1 km, 1-2 days

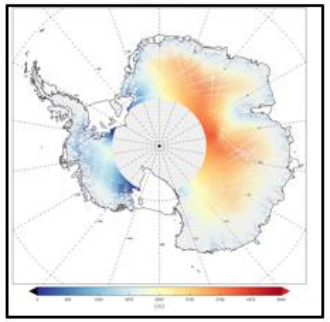




Agriculture, vegetation monitoring

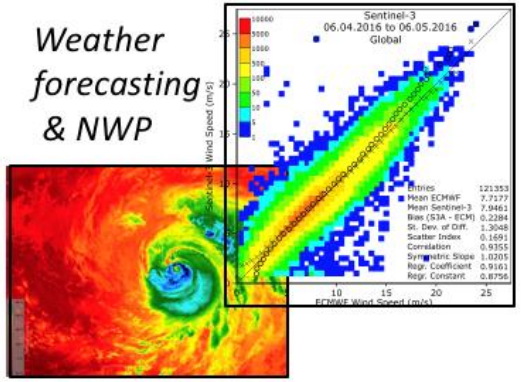


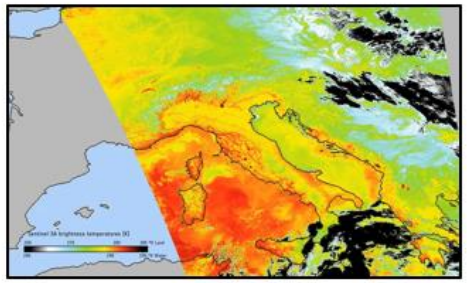
Water resource management



Climate research

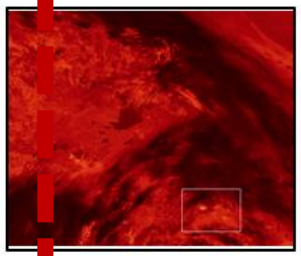
Weather forecasting & NWP





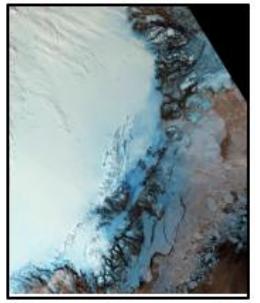
Climate monitoring, numerical modelling and mesoscale analysis

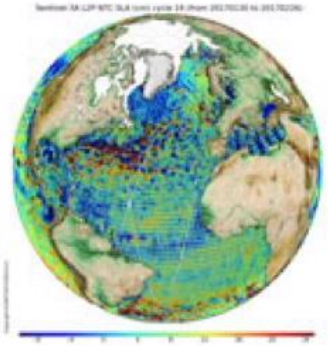
Inland water quality



Fire monitoring

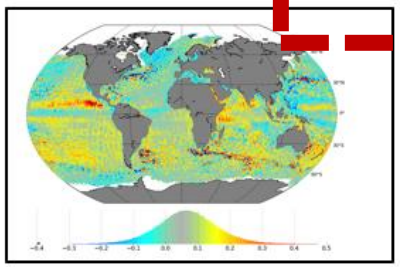
Snow and Ice





Mesoscale ocean circulation, currents, tides

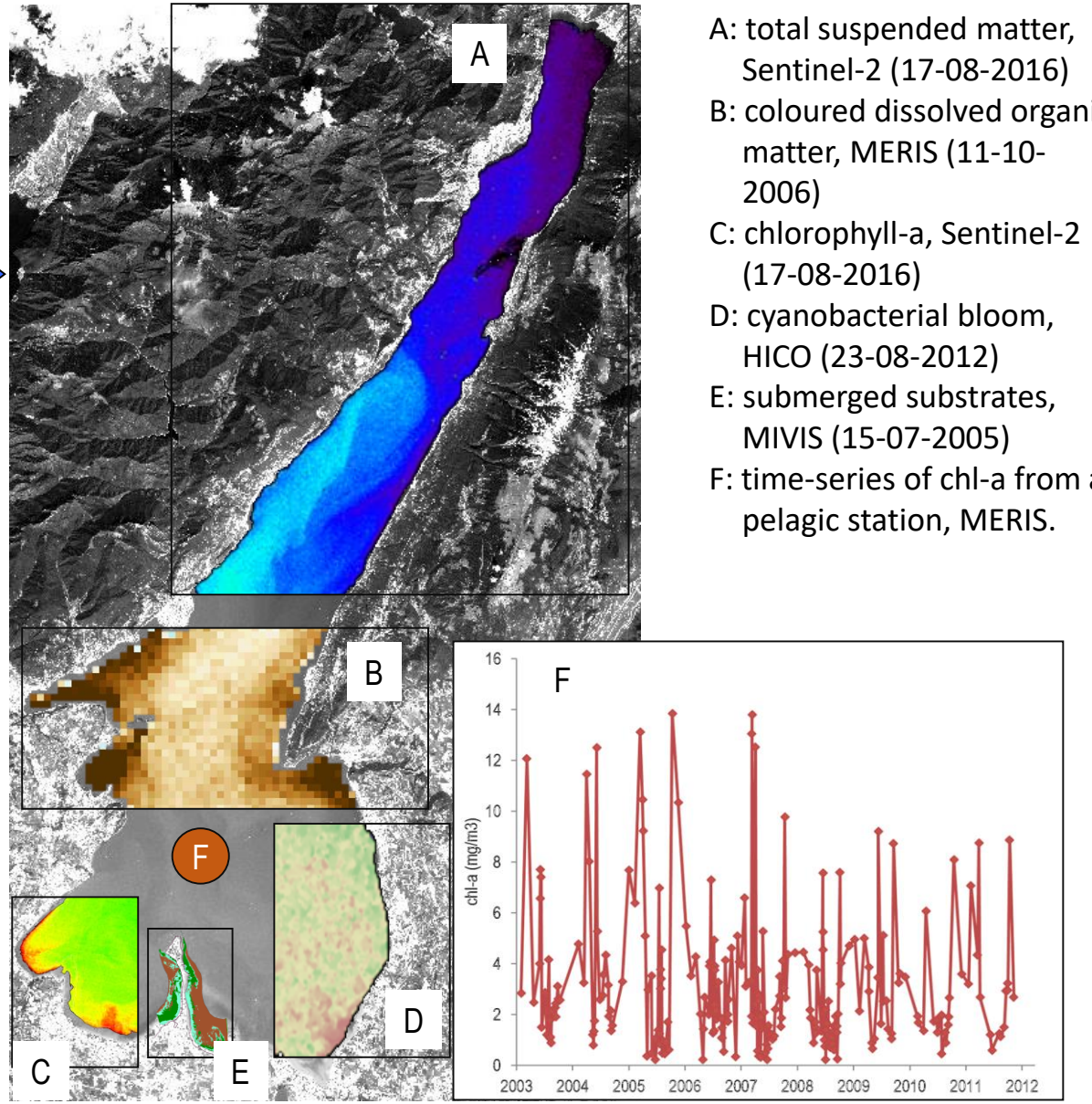
Ship routing: maritime safety



Fisheries: Harmful algal bloom/marine biology/global ocean primary production

Earth Observation of Lake Garda

Data → Products/ Indicators → Information



A: total suspended matter, Sentinel-2 (17-08-2016)
B: coloured dissolved organic matter, MERIS (11-10-2006)
C: chlorophyll-a, Sentinel-2 (17-08-2016)
D: cyanobacterial bloom, HICO (23-08-2012)
E: submerged substrates, MIVIS (15-07-2005)
F: time-series of chl-a from a pelagic station, MERIS.

Research projects on Lake Garda in H2020

space-O

Greece

2016-18
Integrates **state-of-the-art Earth observations** and **in-situ** monitoring with advanced **hydrological** and **water quality models** and ICT tools, into a powerful **decision support system** for drinking **water reservoirs**

EOMORES

Netherlands

2016-19
Develops fully-automated commercial, reliable and **sustainable services** based on the integration of **Earth observation** (Sentinels), **in situ** monitoring and **ecological modelling**

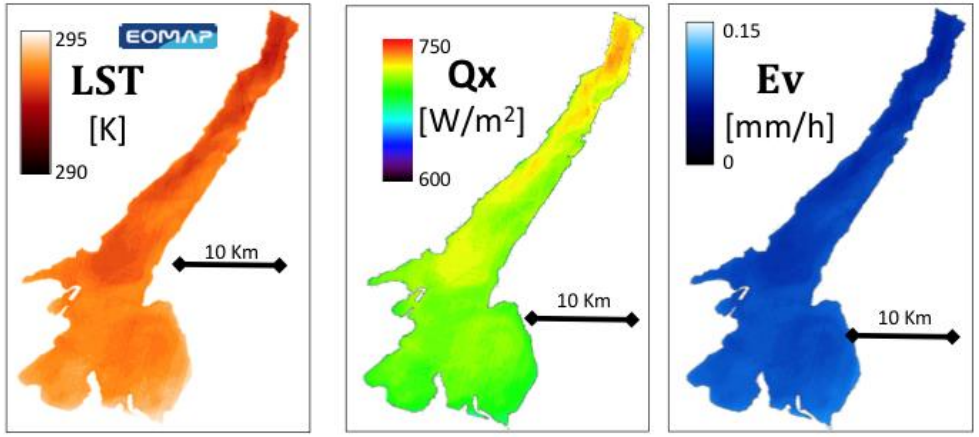
HYPERNETS

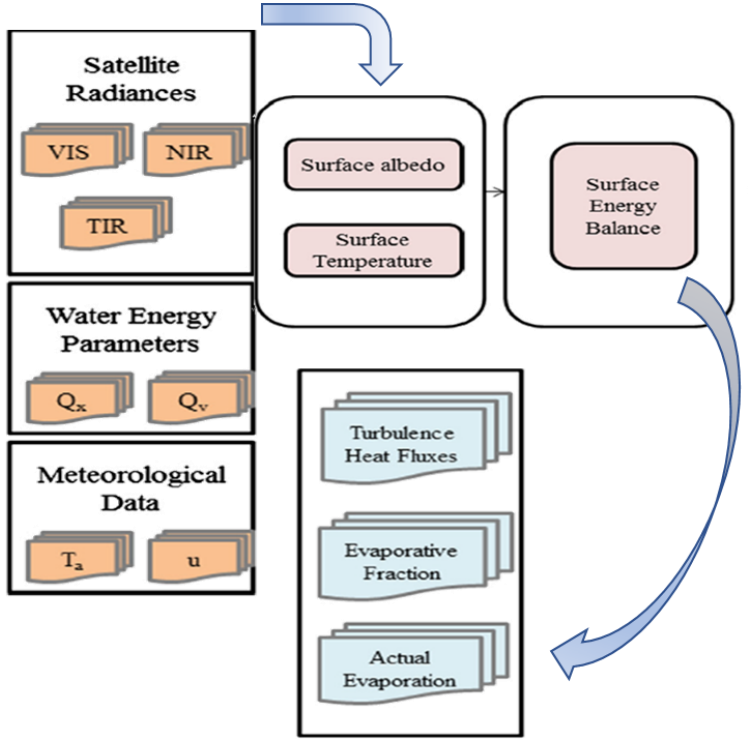
Belgium

2017-21
Design a new "low cost" **hyperspectral radiometer** for use in federated **networks** of water and land sites for multi-mission **satellite validation**

SPACE-O 2016-2018

- Space Assisted Water Quality Forecasting Platform for Optimized Decision Making in Water Supply Services
  - Although SPACE-O mainly focuses on DSS for artificial water reservoirs in Sardinia and Greece, two scientific experiments are are conducted for Umealven River catchment (Sweden) and **Lake Garda** (Italy)
  - For Lake Garda the assessment of **evaporation rates** are estimated from EO and used as inputs into hydrological modelling



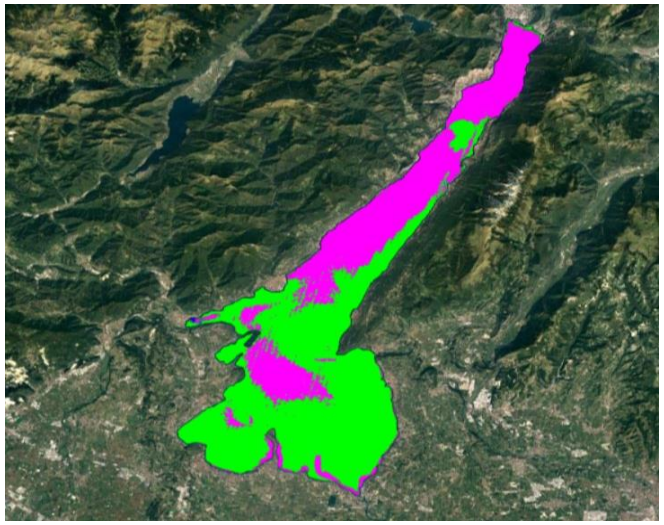


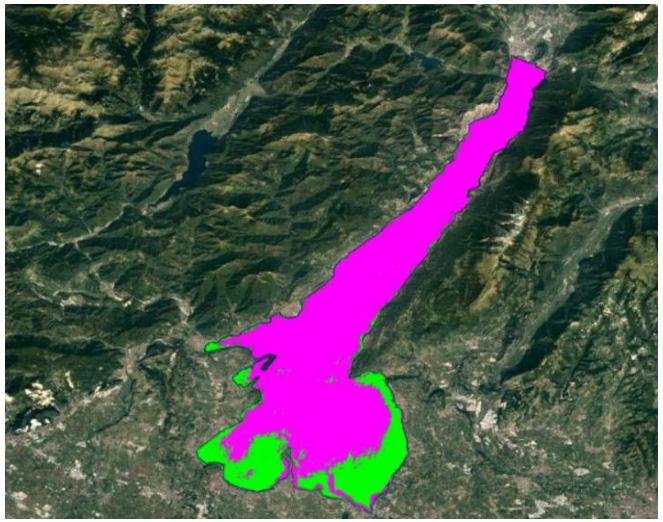
SPACE-O products

- Evaporation is an important component of the water and energy balance of lakes and reservoirs
- In-situ (e.g. meteo data) and Earth Observation data might support the hydrological modelling
- Improved radiometry of L8 OLI/TIRS (MODIS/S3) allows to investigate other physical parameters (heat fluxes and evaporation)

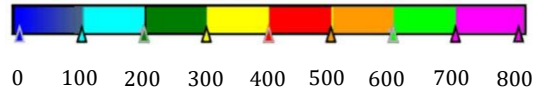
Spring

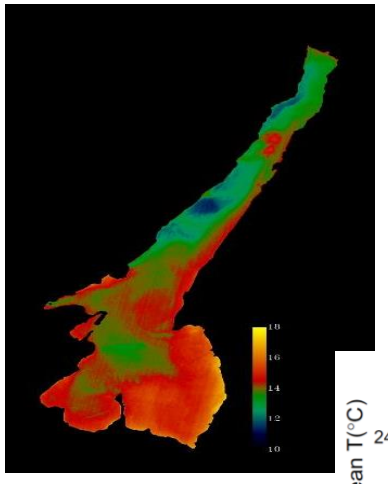
Summer





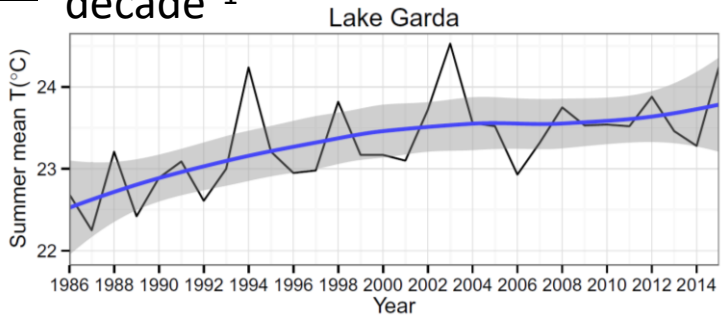
Qx [W/m²]



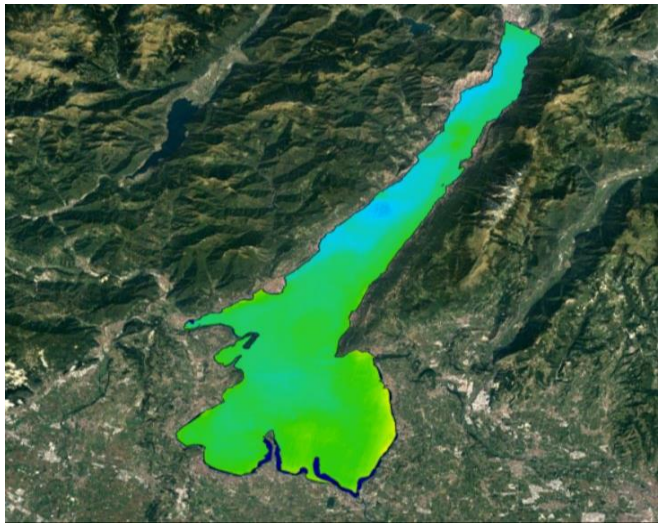


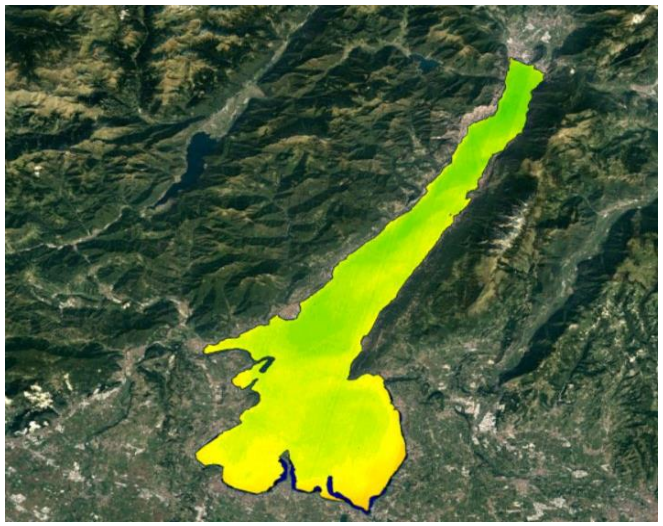
Lakes surface temperature is responding to climate change with a global warming trend of 0.34°C decade^{-1}

- In Subalpine lakes the summer warming trend is of 0.32 °C decade^{-1}



Pareeth et al., 2017





Evaporation rate [mm/h]

EOMORES 2016-2019

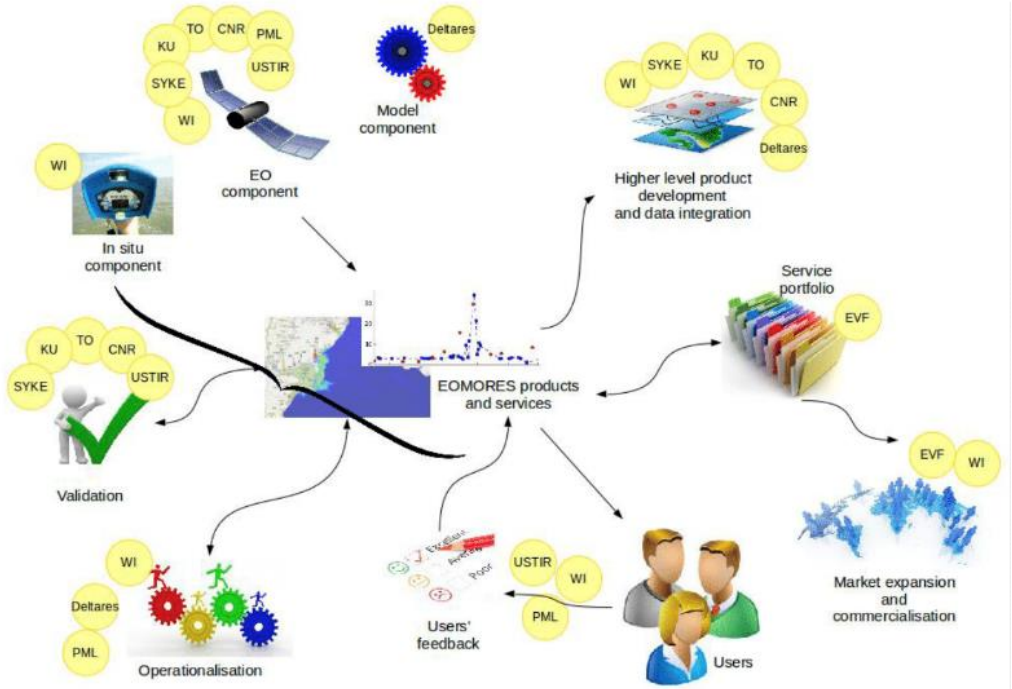
- Earth Observation based services for Monitoring and Reporting of Ecological Status

Combine EO, in situ and model data

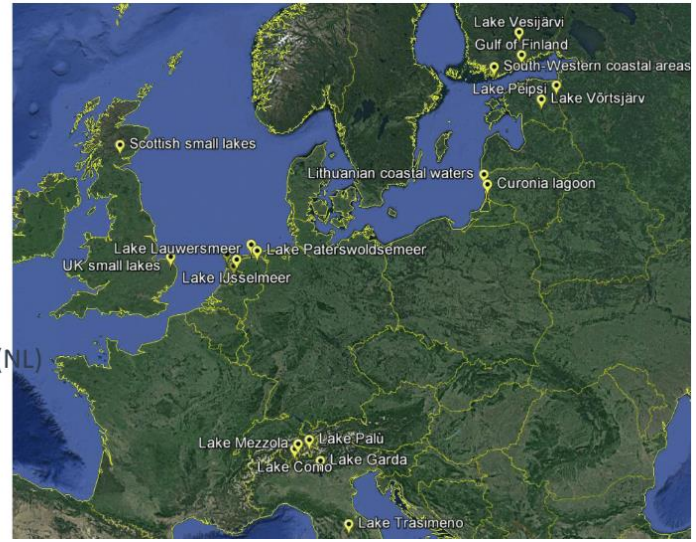
Develop higher level/integrated products and validate them

Operationalisation, commercialization

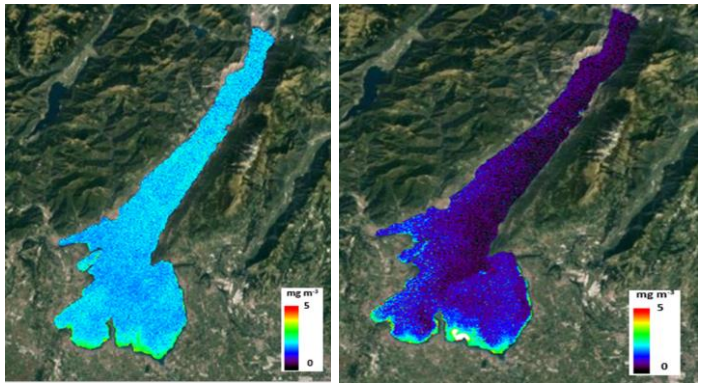
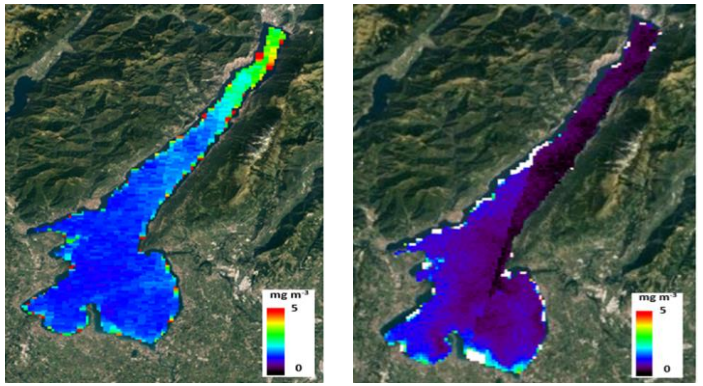
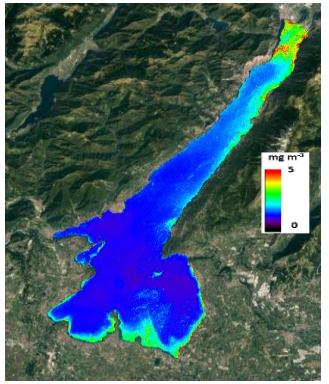
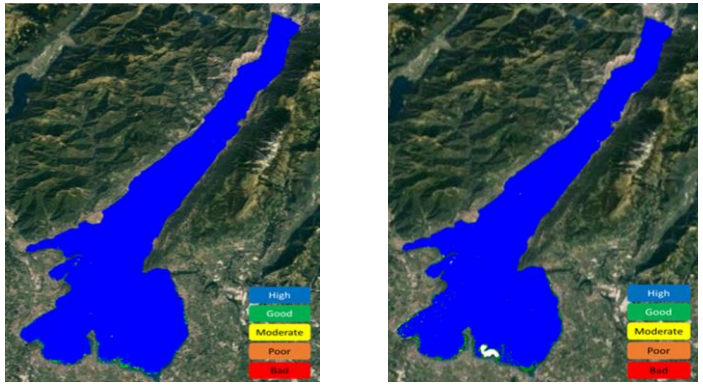
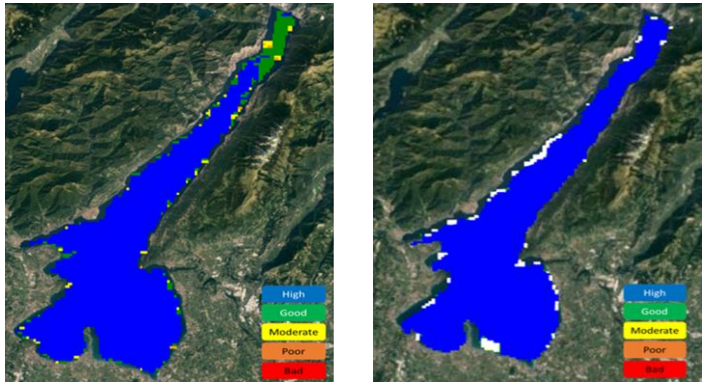
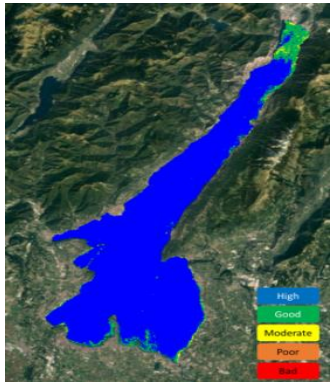
Several loops with users



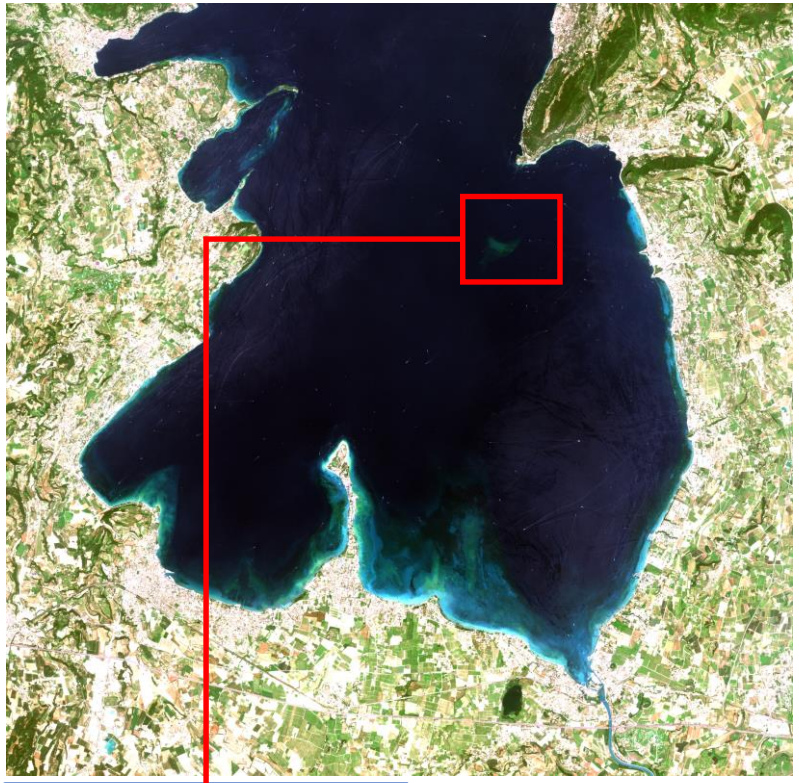
1. Monitor 2020 (Finland)
2. Finnish Environmental Institute (Finland)
3. ARPA Umbria (Italy)
4. ARPA Lombardia (Italy)
5. Environmental Protection Agency (Lithuania)
6. Nature Research Center (Lithuania)
7. HaskoningDHV (Netherlands)
8. Water Authority Noorderzijlvest (NL)
9. Water Authority HH Hollands Noorderkwartier (NL)
10. Rijkswaterstaat (NL)
11. Centre of Limnology (Estonia)
12. UK Environment Agency
13. Scottish Environment Protection Agency

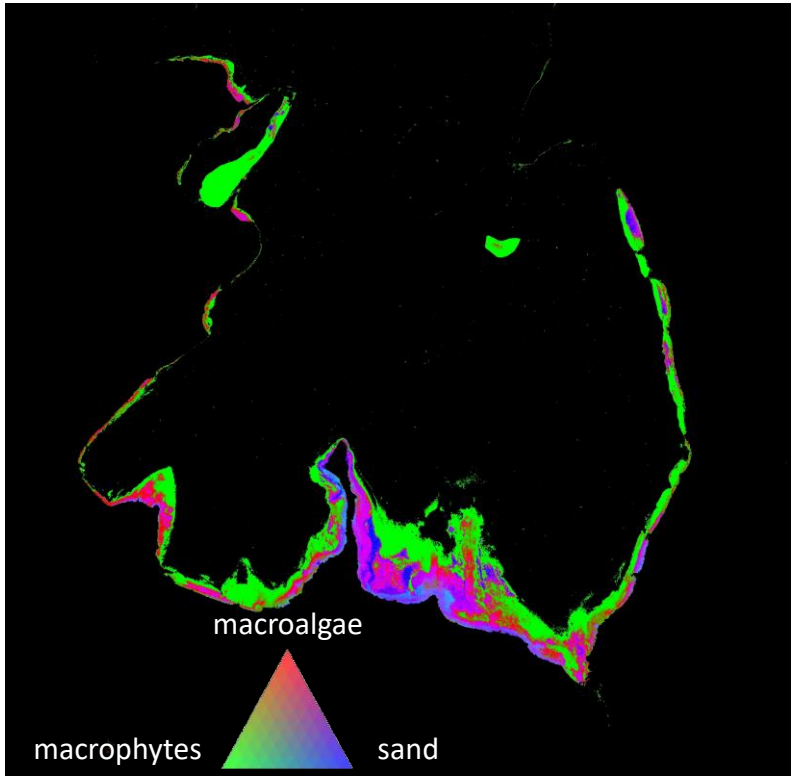


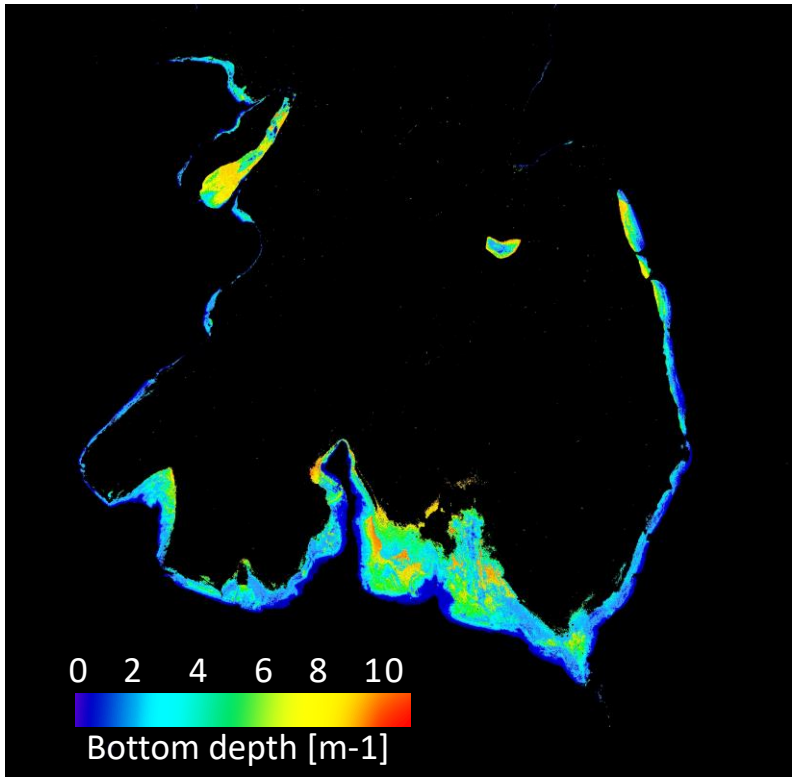
EOMORES Products

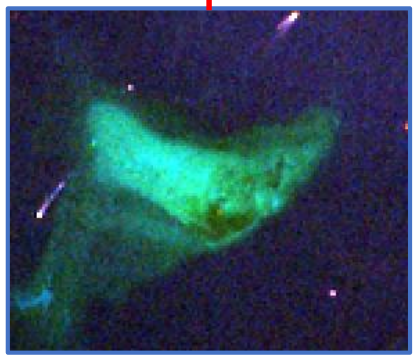
	Sentinel-2	Sentinel-3	Landsat-8
Chl-a			
WFD			

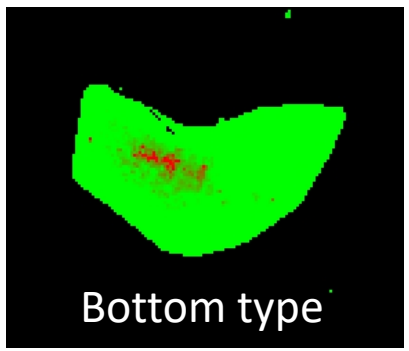
EOMORES shallow water

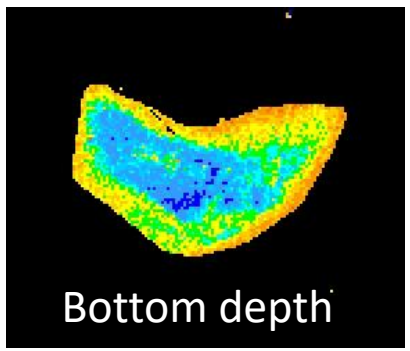






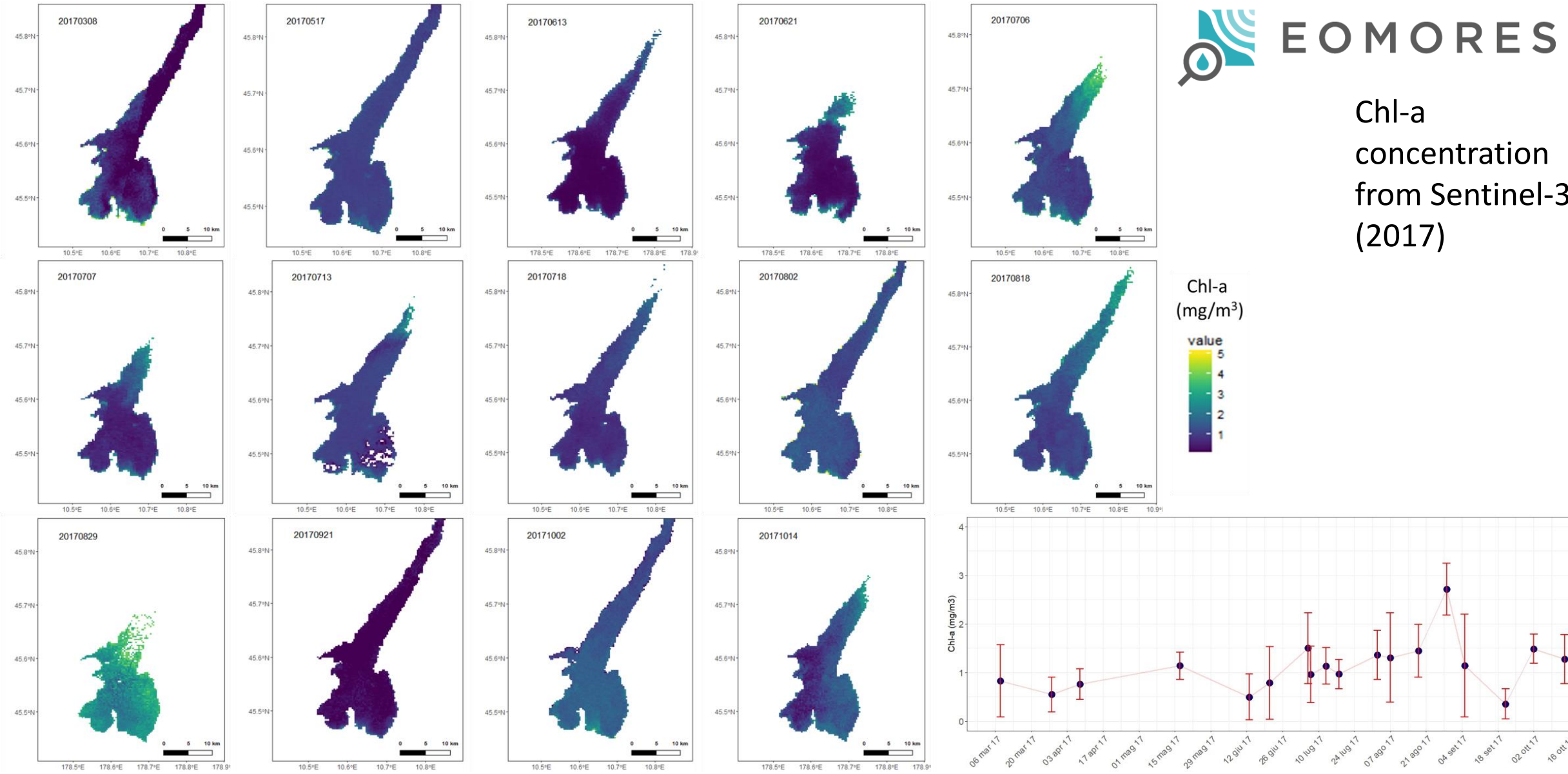






Bottom properties (depth and cover) in shallow water areas of Southern part of Lake Garda from Sentinel-2 (June 2017)

Zoom in Secca del Vo'



EOMORES

Chl-a concentration from Sentinel-3 (2017)

HYPERNETS 2017-2021

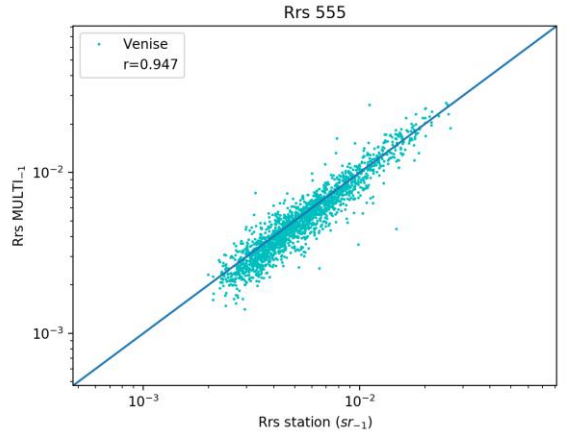
HYPERNETS

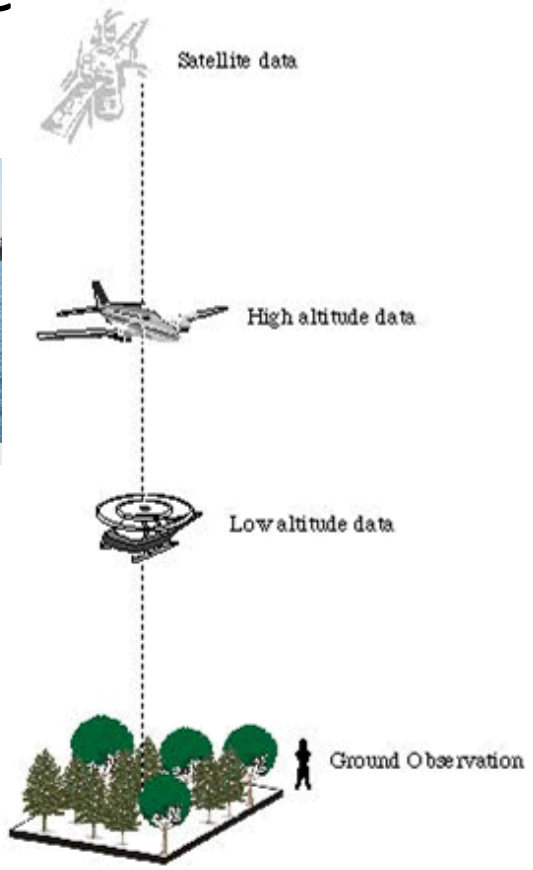
- A new hyperspectral radiometer integrated in automated networks of water and land bidirectional reflectance measurements for satellite validation

HYPERNETS land validation network phase 1

HYPERNETS water validation network phase 1

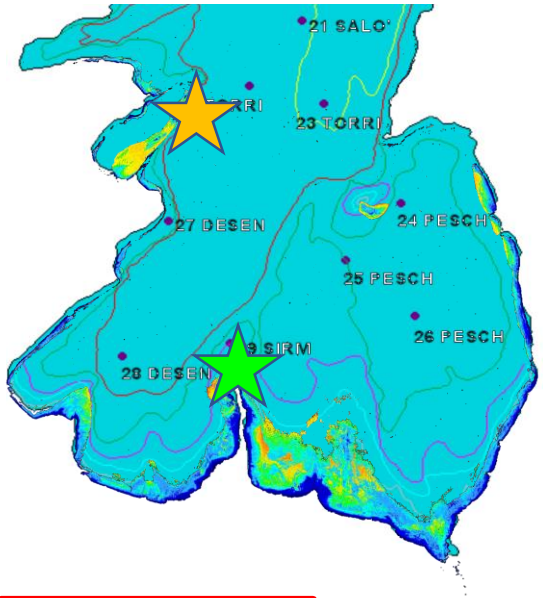
Water (Italy)
1. Venice Acqua Alta, 2. Lampedusa, 3. Lake Garda





HYPERNETS Infrastructures

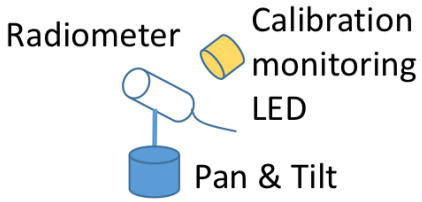
HYPERNETS

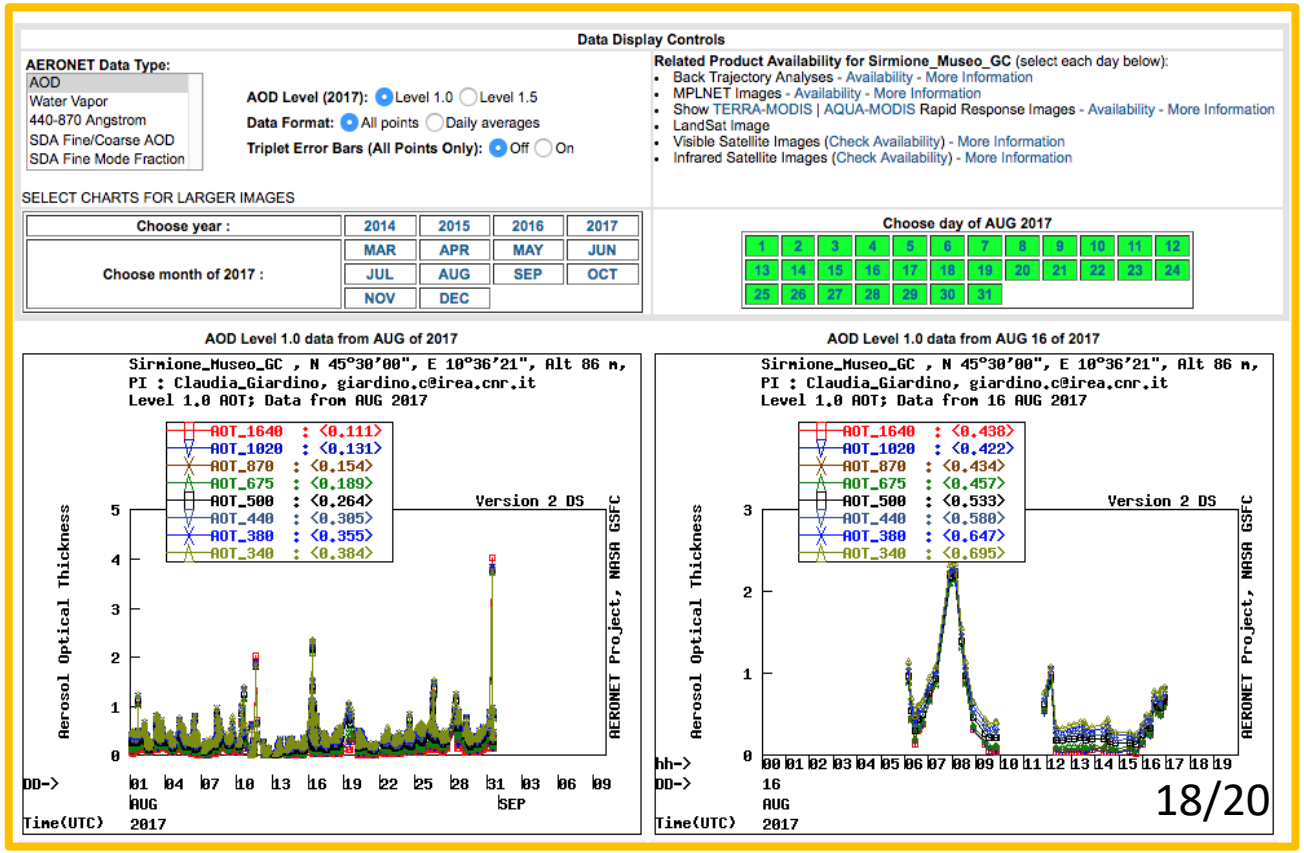


AERONET Sun-photometer
Sirmione 2014

HYPERNET Spectroradiometers

HYPERNETS
Autonomous
System





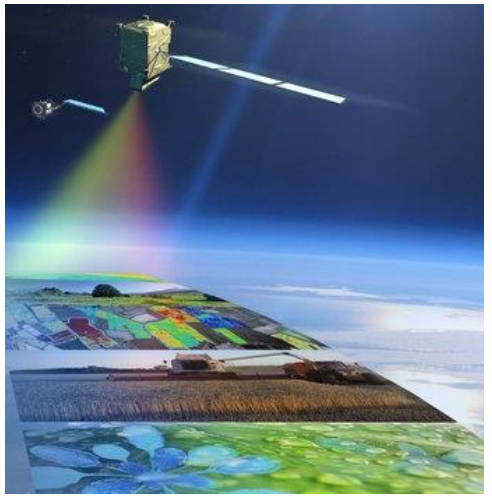
Conclusions

- The Sentinel-2 and 3 data are providing detailed information to observe changings in water quality conditions in lake Garda

- The applications developed with Sentinels sensors are even growing and interdisciplinary coupling EO with e.g. hydrodynamical model studies are emerging (e.g. Iseo and Mantova, see *Pilotti et al.* 2018 and *Pinardi et al*. 2015)

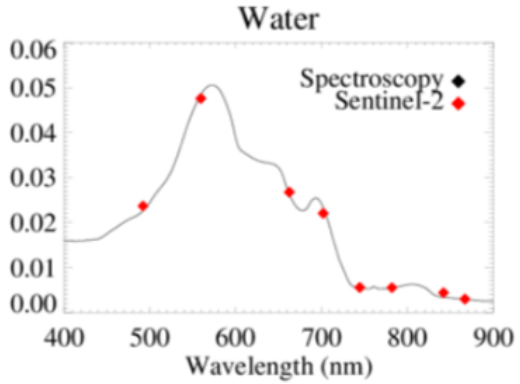
- Three H2020 projects with different aims are currently ongoing on Lake Garda for responding to multiple needs
  - Water quality assessment (EOMORES)
  - Development of value-added products (SPACE-O)
  - Provide validation data to latest generation of EO sensors (Hypernets)

Outlook



- We are looking forward to the next satellite missions in particular:
  - The ESA Earth Explorer - Fluorescence Explorer (FLEX, 2021) mission to map land vegetation fluorescence to quantify photosynthetic activity
    → We will look at the sun-induced chlorophyll fluorescence signal

  - **ASI-PRISMA** (2019), **DLR-EnMAP** (2020): two future satellite hyperspectral sensors to increase the accuracy of variables currently observed by multispectral sensors (e.g. Sentinel-2), as well as to facilitate detection of new variables of interest (e.g. types of pigments) for multiple applications.



- We are looking foreword to Cluster Garda as a scientific framework in which EO data support the Lake Garda studies (on e.g. climate change impacts), inter-comparison exercises (on e.g. in situ vs. EO bathymetry)

Thank You !