GloboLakes

Global Observatory of Lake Responses to Environmental Change

NATURAL ENVIRONMENT RESEARCH COUNCIL

HABS & EO in Italian Lakes and Curonian Lagoon

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CNR-IREA, Italy

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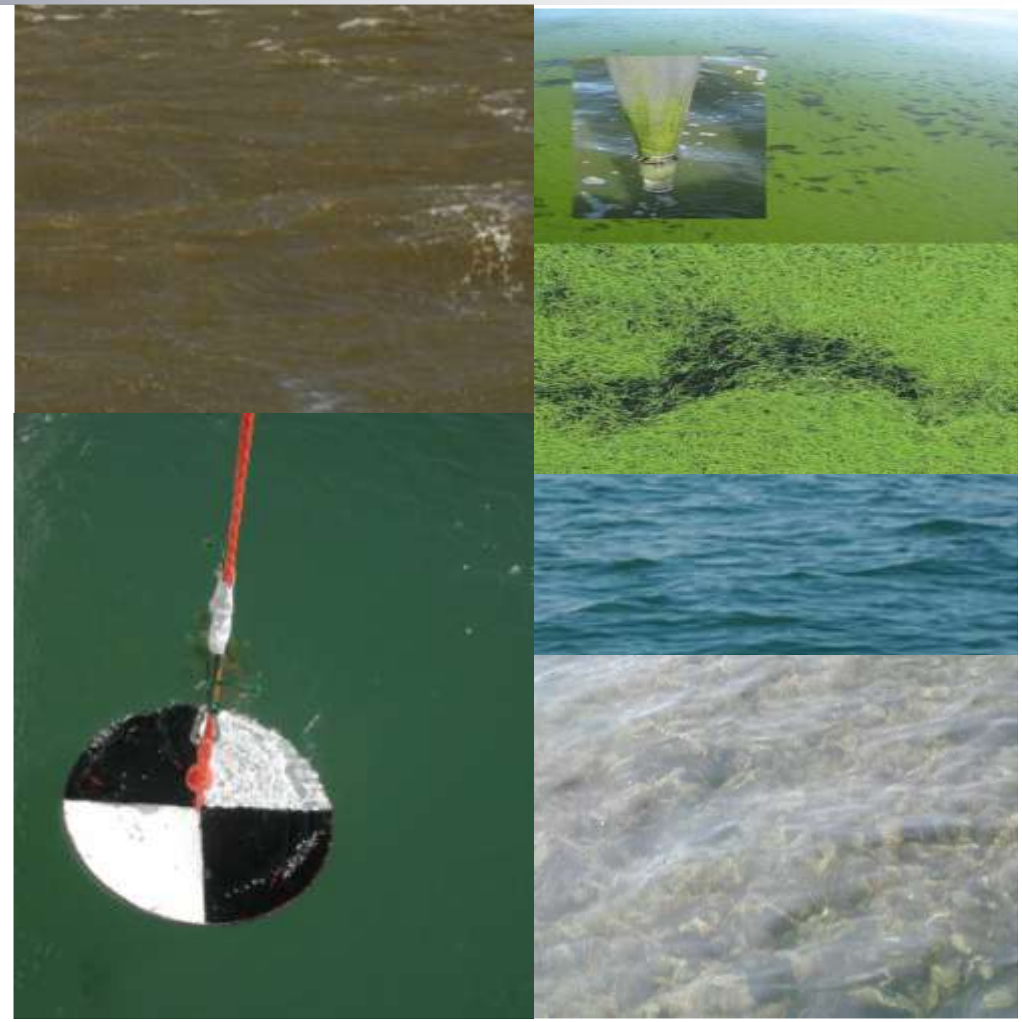


The products obtained from satellite images are key data that can be integrated with products/data derived from other disciplines, meteorological and morphological data for a proper management of the aquatic environment.

Research framework (1/2)

Our research activities are carried out in the framework of a consolidated research experience grown in the context of numerous research projects and the long term collaboration with research institutes and national end-users.

ARPA umbria – agenzia regionale per la protezione ambientale
C.R.A. Sirmione – Centro Rilevamento Ambientale
progetti e ambiente
APPA Trento
Istituto Superiore di Sanità
Parco del Mincio
Comunità del Garda
ARPA – Agenzia Regionale per la Protezione dell'Ambiente della Lombardia

- **SALMON**: Satellite Remote Sensing for Lake Monitoring
  EU-FP4, **1996-99**
- **HySens**: Evaluation of airborne imaging spectrometers in mapping algal blooming and macrophyte distribution in lakes
  EU-FP5, 2000-2001
- **Ninfa**: An integrated remote sensing system experiment for lake water monitoring
  ASI, **2004-2006**
- **MELINOS**: Monitoring European lakes by means of an integrated earth observation system
  ESA 2003-on-going

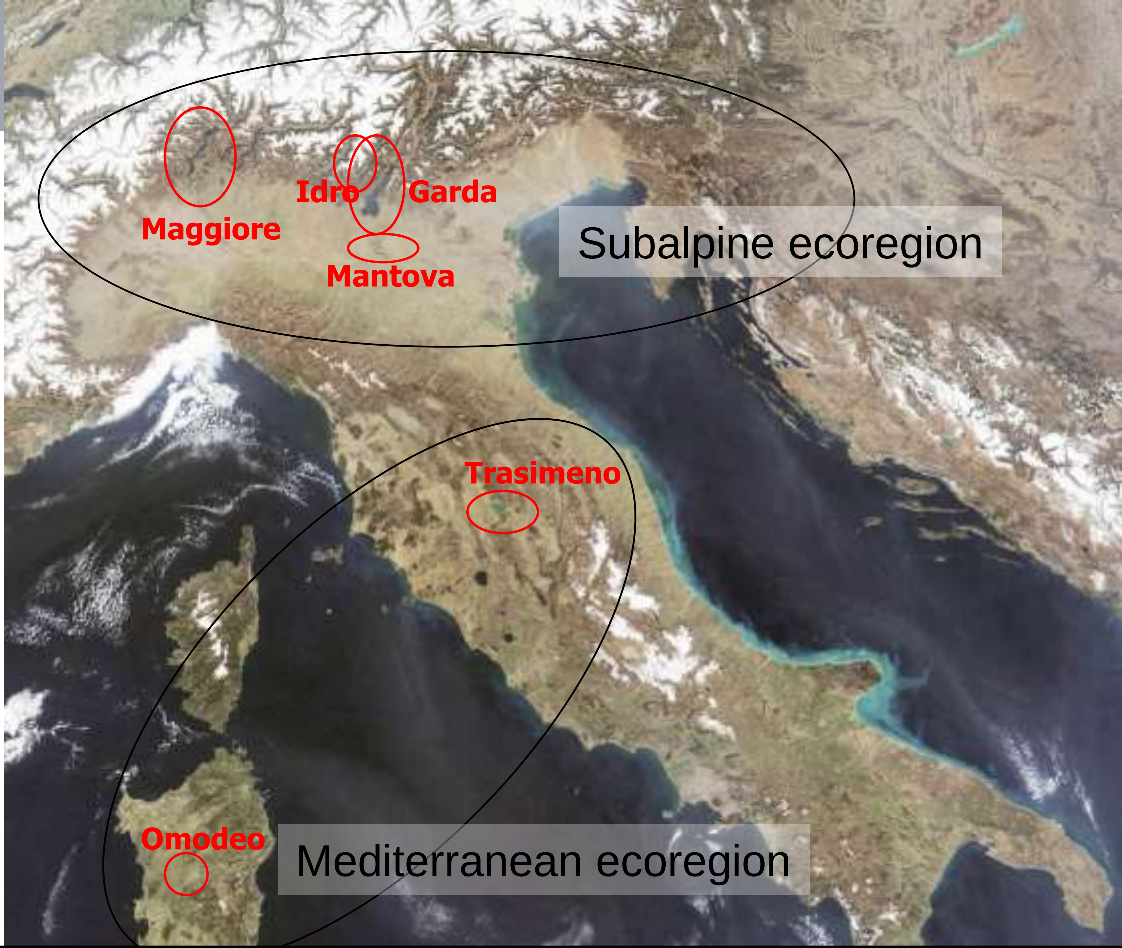
Coastal Research and Planning Institute
GEO – GROUP ON EARTH OBSERVATIONS
CSIRO
I.S.E.
ISMAR

Research framework (2/2)

At the present time the on going research project are:

Projects	Times	Funds
Cyanobacteria assessment in Italian and Swedish waters from space (CYAN-is-WAS)	2010-13	MIUR
Spectral characterization of Harmful Algal Blooms in Mantua Lakes (Italy) (HABs)	2011-12	EUFAR
Coasts and Lake Assessment and Monitoring by PRISMA HYperspectral Mission (CLAM-PHYM)	2010-2014	Italian Space Agency
European Lakes Under Environmental Stressors (EULAKES)	2010-2013	Central-Europe Programme
Monitoring European Lakes by means of an Integrated Earth Observation System (MELINOS)	2003-on going	ESA cat-1 (AO553)
La Ricerca ITaliana per il MARE (RITMARE)	2012-2016	CNR-Italy
Global Lakes and Land Sentinel Studies (GLaSS)	2013-2016	FP7

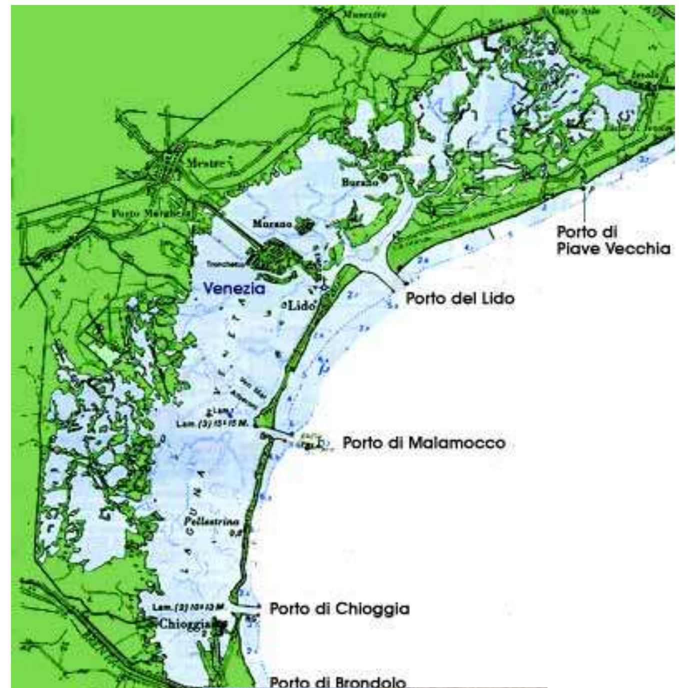
Italian Lakes



Lake	Surface (km²)	Average/max depth (m²)	Trophic status	Cyanobacteria	Aquatic plants
Garda	370	136/346	Oligo-mesotrophic	Sporadic	Submerged macrophytes
Maggiore	213	177/372	Oligotrophic	Sporadic	Submerged macrophytes
Idro	11	77/122	Mesotrophic	Sporardic	Submerged macrophytes
Mantova	6	3.3/5	Hyper/Distrophic	Persistent from Jun.-Sep.	Submerged macrophytes, emergent macrophytes; Floating-leaved macrophytes
Trasimeno	124	4.5/6	Eutrophic	Persistent from Jun.-Sep.	Submerged macrophytes, emergent macrophytes;
Omodeo	30	12/60	Hyper/Eutrophic	Persistent from May.-Sep.	Submerged macrophytes, emergent macrophytes;

Curonian Lagoon and Venice Lagoon

Lagoon	Surface (km^2)	Average/max depth (m^2)	Trophic status	Cyanobacteria	Aquatic plants
Curonian	1584	3.7/5	Hyper/Eutrophic	Persistent from Jun.-Sep.	
Venice	550	1	Eutrophic	Benthic cyanobacteria	Submerged fanerogames, emergent plants.



In situ data (1/3)

Fluorometer Cyclops-7

Spectrophotometer

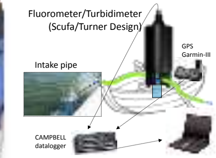
Multiplexer Radiometer Irradiometer

GF/C filter

WISP-3

Laboratory

Fluorometer SCUFA



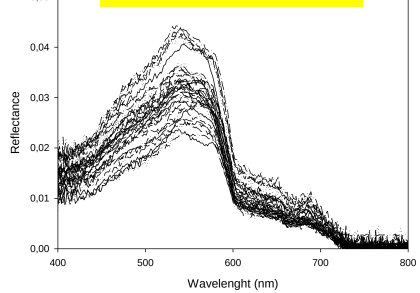
Secchi disk

Hydroscat-6

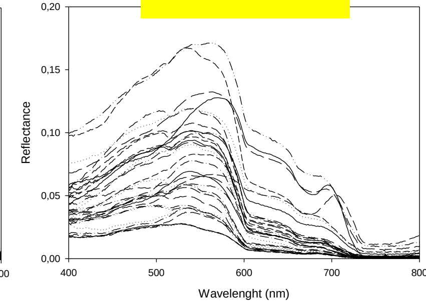
HPLC

SunPhotometr EKO

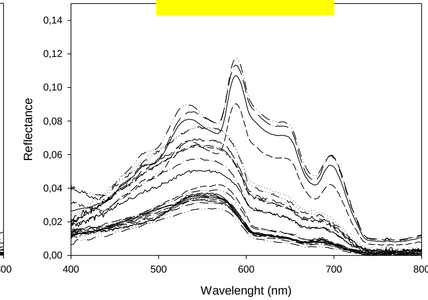
Lake Maggiore



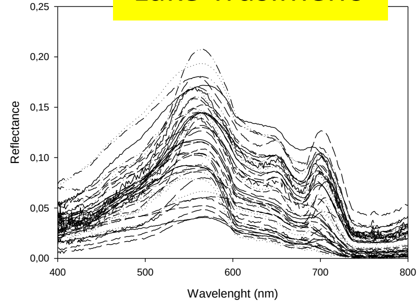
Lake Garda



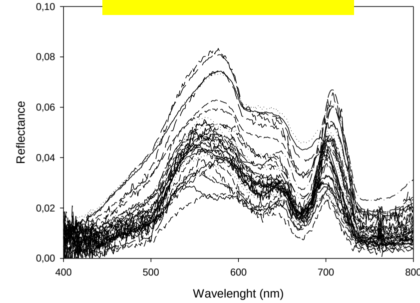
Lake Idro



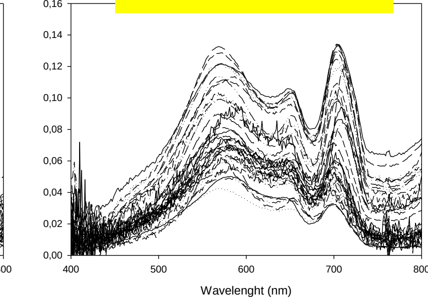
Lake Trasimeno



Lakes Mantua



Curonia Lagoon



CTD-Rosette Sampler

Ramses-Trios

ASD-HandHeld

GF/F filter

FieldSpec ASD-FR

Spectrascan

Ac-9

In situ data (2/3)

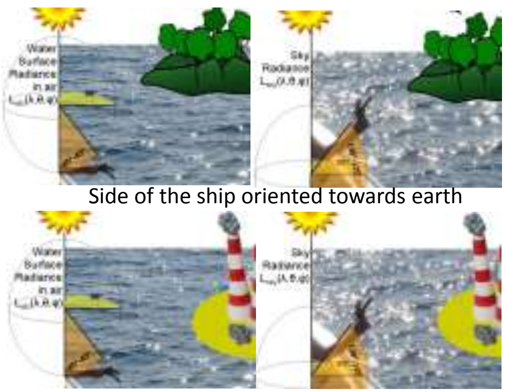
Some key rules for the correct and proper collection of field are:

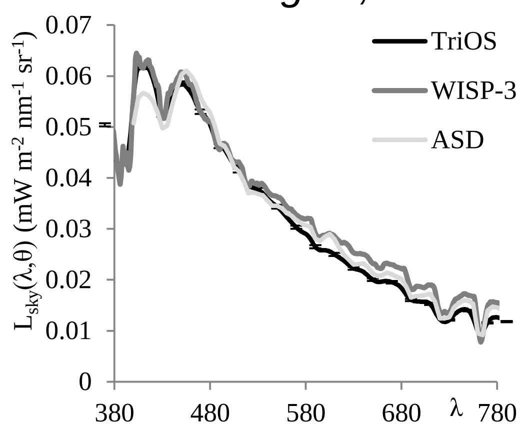
Simultaneous measurement of AOP-IOP and physic-chemical and biological parameters

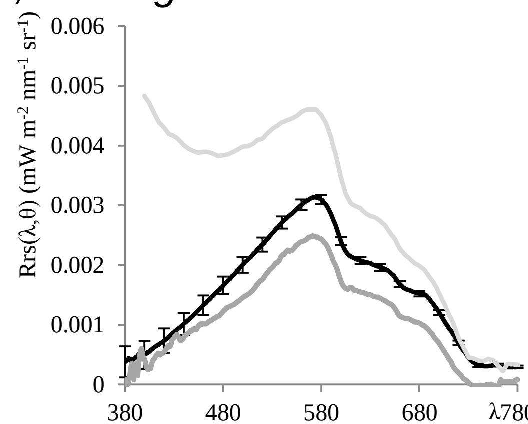
The presence of clouds, such as cirrus clouds, and the high variability of phytoplankton (e.g. buoyancy) as well as changes due to plumes from rivers might change quickly AOP and IOP values and therefore affect the empirical correlations we are working on.

Applications of correct measurement methodologies

For example, collecting AOP with noise due to glint, shadows, and high values of tilt



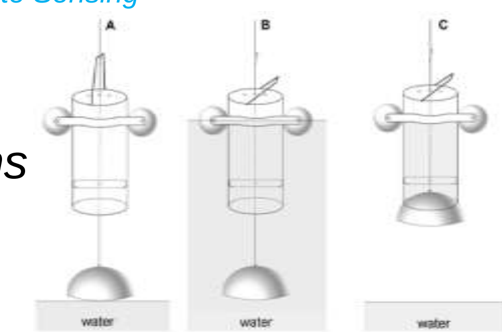




Hommerson et al., IN PRESS. *Journal of Applied Remote Sensing*

Adequate sampling methodology

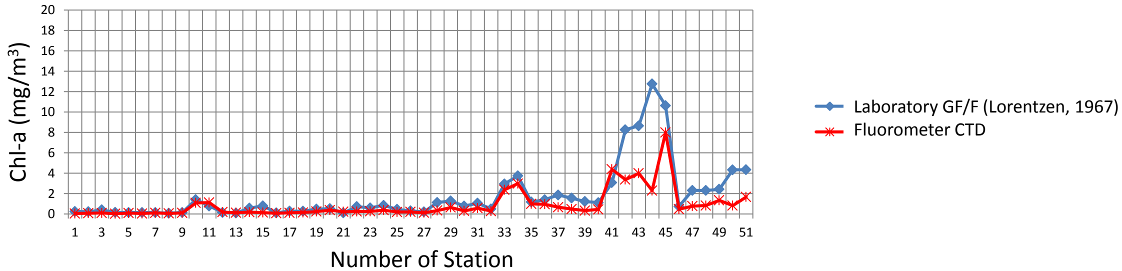
For example, standardization of protocols for sampling scums

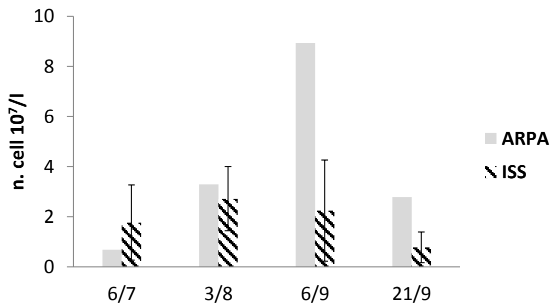


In situ data (3/3)

Application of correct methods and instruments of sampling

different sampling protocols and methods (fluor. probes, HPLC, spectrophot.) does not help the validation





Implementation of appropriate laboratory measurements

For example different extraction methods may provide mismatching chl-a concentrations (the divergence is function of phytoplankton composition)

	MG/C	MG/F	GF/C	PVDF
st.1	16.02 (0.46)	12.36 (0.42)	19.45 (0.67)	10.97 (0.59)
st.2	5.59 (0.18)	2.67 (0.37)	7.49 (0.22)	2.22 (0.16)

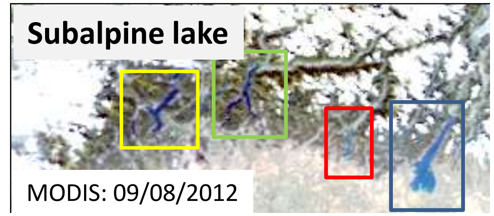
Appropriate number of replicates

Adequate spatial distribution of variables

EO data (1/2)

APEX: 21/09/2011

MERIS: 23/07/2009



MODIS: 09/08/2012

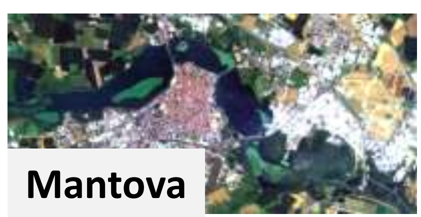
LANDSAT: 18/07/2009

ALOS-AVNIR2: 21/06/2007

	MERIS/ MODIS	Satellite Multispectral	Satellite Hyperspectral	Airborne Hyperspectral	SAR
Subalpine lakes (Garda, Maggiore, Idro)	> 500	~ 40 (Landsat-TM, Oceansat-2, ALI, ALOS, ASTER)	~ 10 (Chris-Proba, Hyperion, HICO)	~ 10 (MIVIS, AISA)	~ 15
Mantua Lakes		~ 10 (Landsat-TM)	3 (Chris-Proba)	3 (MIVIS, APEX)	
Mediterranean lakes (Trasimeno, Omodeo)	>500	15 (Landsat-TM, Oceansat-2, ALI, ALOS,	3 (Chris-Proba)	1 (MIVIS)	
Curonian Lagoon	> 100	10 (Landsat-TM)	2 (Chris-Proba)		30
Venice Lagoon	>100	~ 40 (Landsat-TM, Oceansat-2, ALI, ALOS, ASTER)	~ 20 (Chris-Proba, Hyperion, HICO)	3 (MIVIS-CASI)	>50

AISA: 30/04/2010

MIVIS: 02/12/2009



CHRIS-PROBA: 29/06/2008

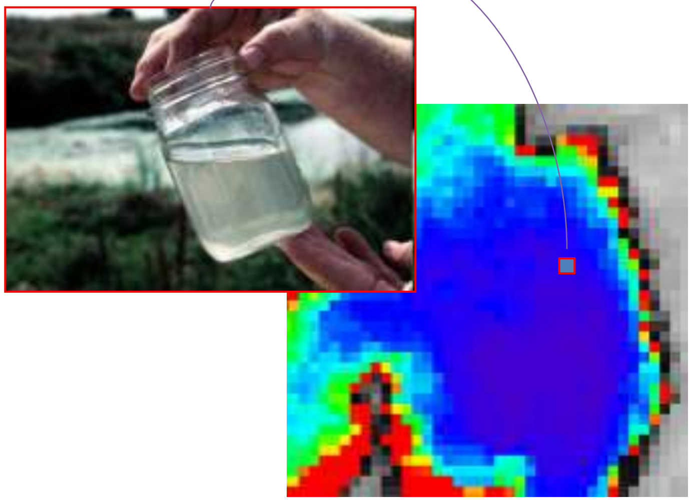
ALI: 13/07/2008

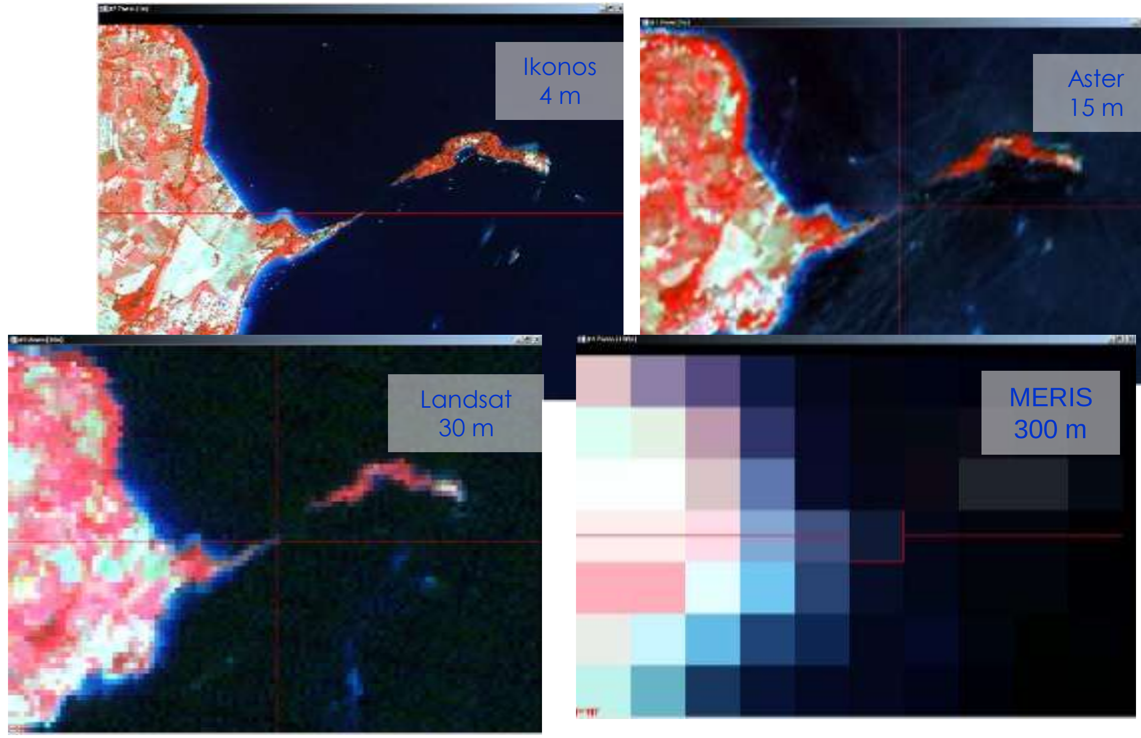
SAR: 04/08/2011

Hyperion:22/07/2003

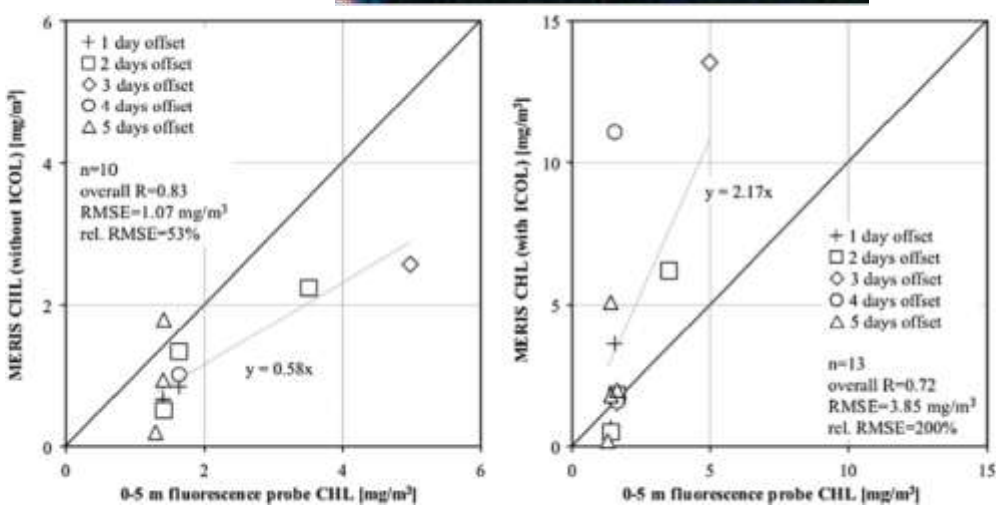
In situ vs Eo-data

Scale: point vs. pixel



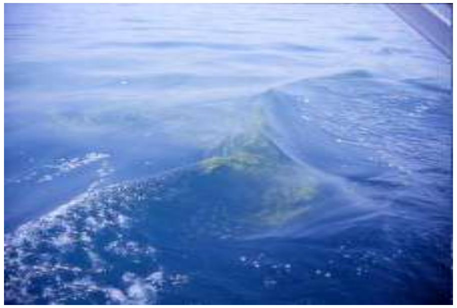


Time:



Odermatt et al., 2010. Remote Sensing of Environment

Type of blooms



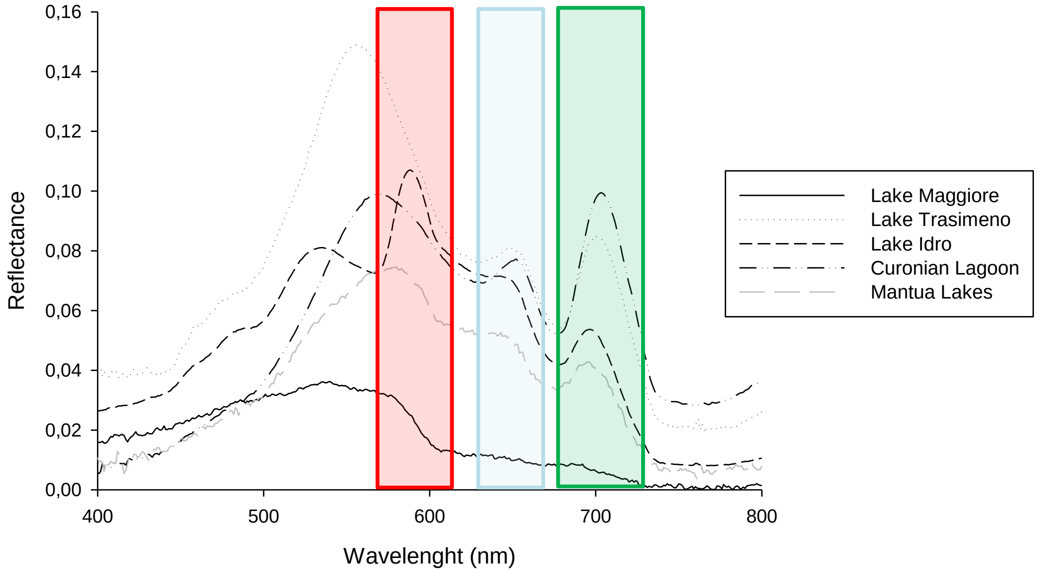
Sporadic homogeneous blooms with high vertical migration in oligo-meso trophic lakes

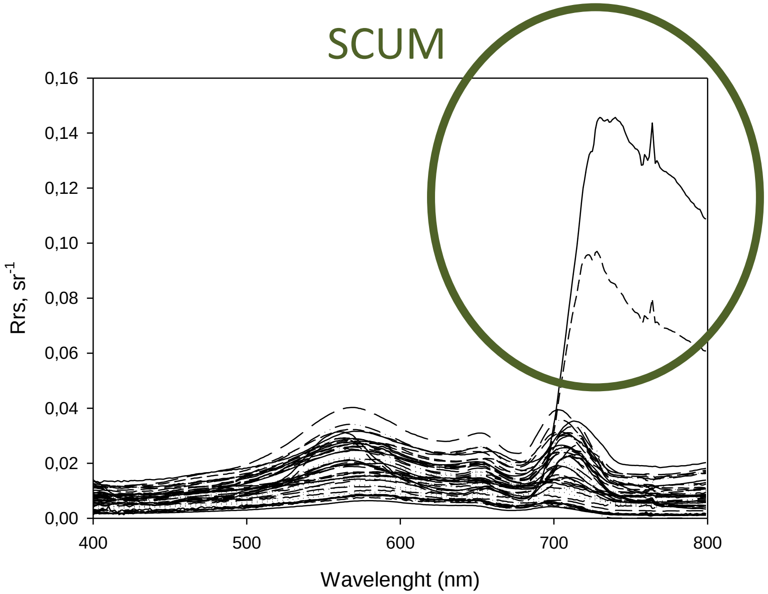
Frequent and intense heterogeneous blooms in hypertrophic lakes

Frequent and intense homogeneous blooms in hypertrophic lakes with scums

Frequent homogeneous blooms in meso-eutrophic lakes without scums

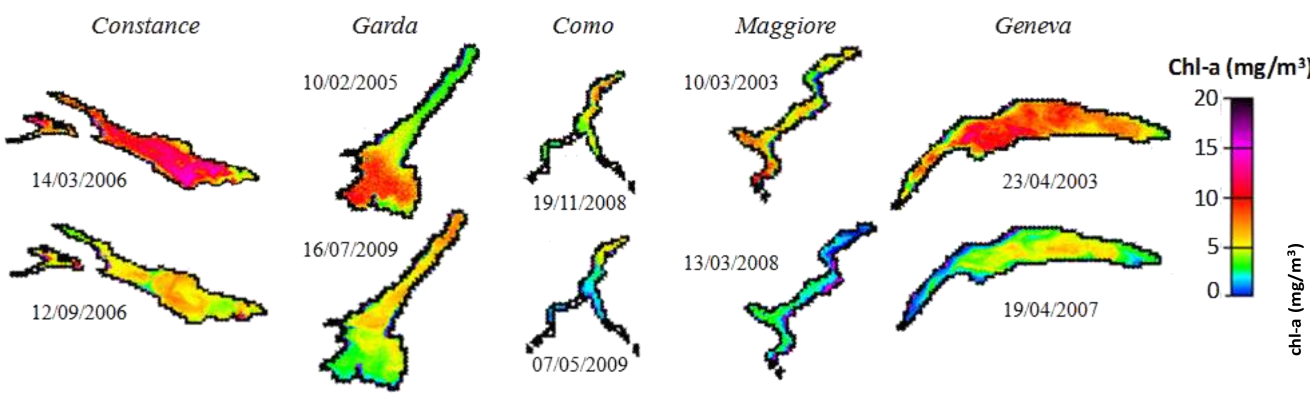
These types of blooms are composed of different phytoplankton groups (in particular cyanobacteria), that are in turn characterized by different photosynthetic pigments with different spectral signatures.

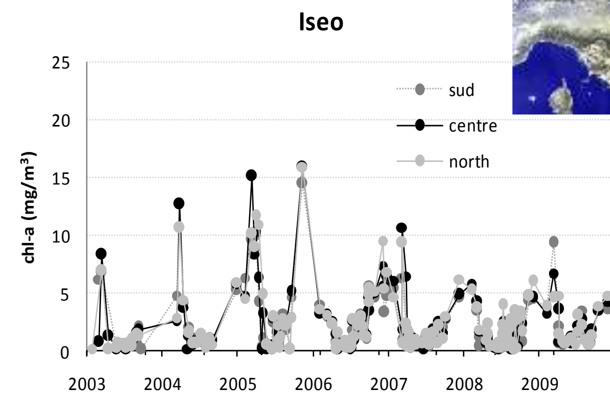


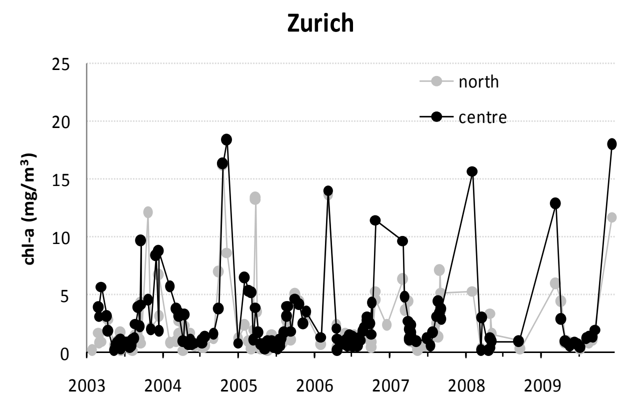


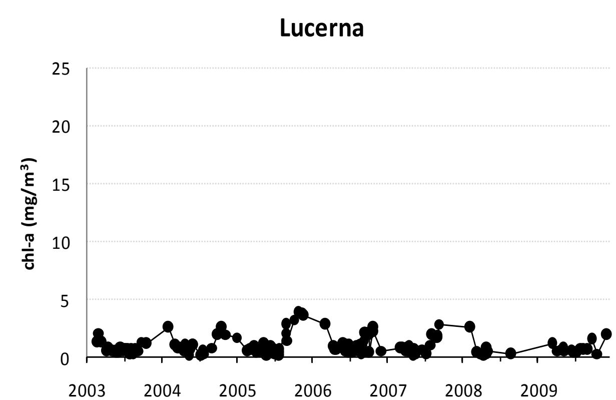
Chl-a monitoring Water quality

Monitoring water quality parameters in **cost effective** way with respect to traditional sampling





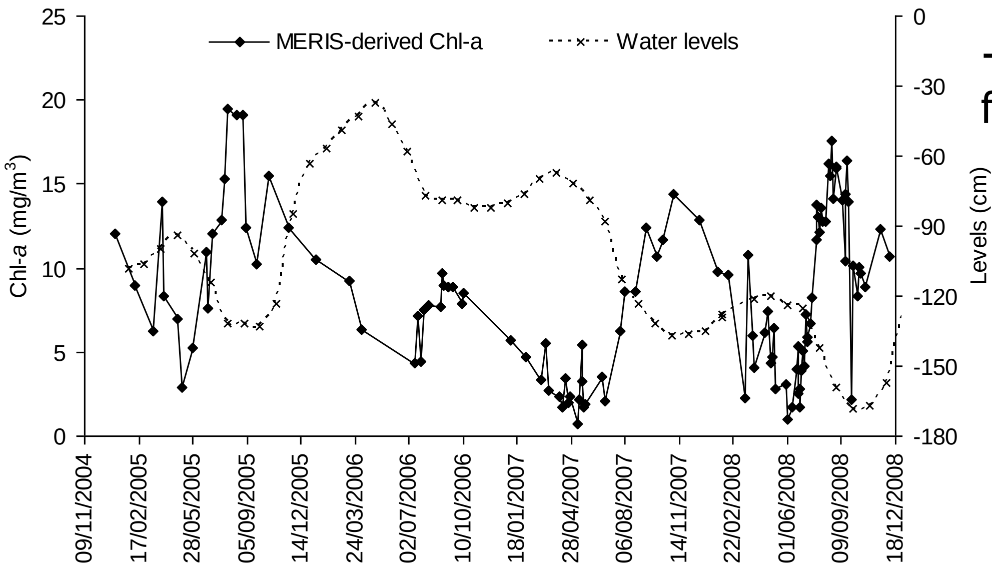




Bresciani et al., 2011. Science of Total Environment

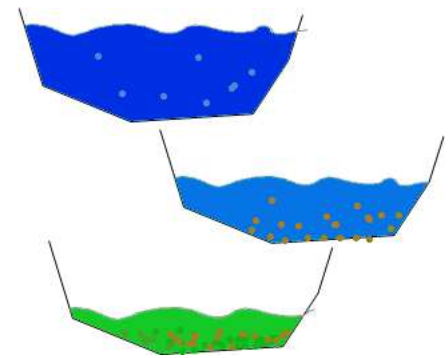
Chl-a vs Temperature and water level

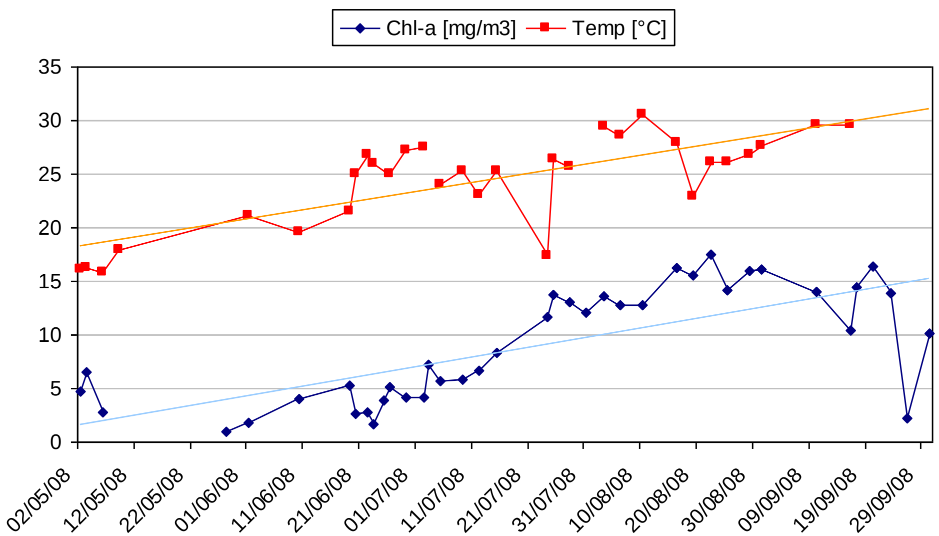
Providing some info to explain the **dynamics** of **natural phenomena**



Giardino et al., 2010. Water Resources Management

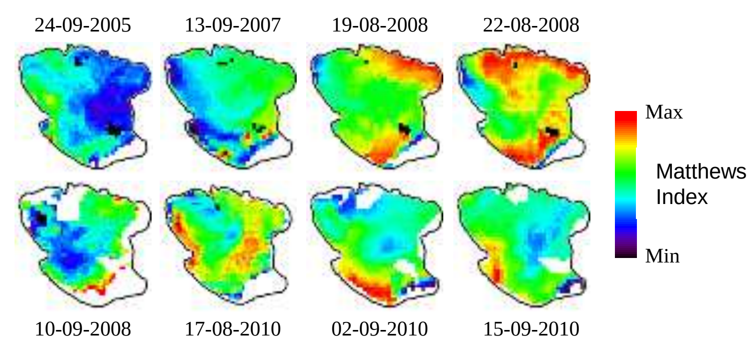
→ Increase of chlorophyll-a concentration for diminishing water levels





Bresciani et al., 2011. Italian Journal of Remote Sensing

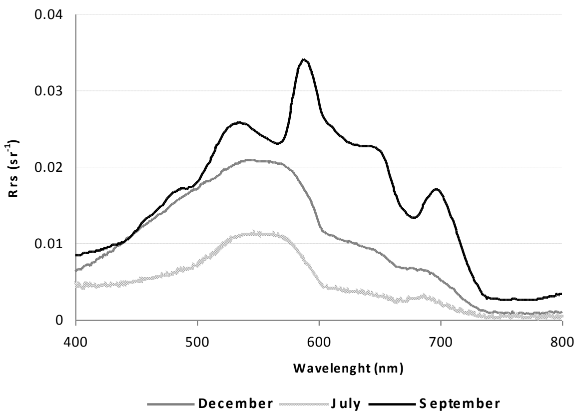
→ Increase of chlorophyll-a concentration with water temperature

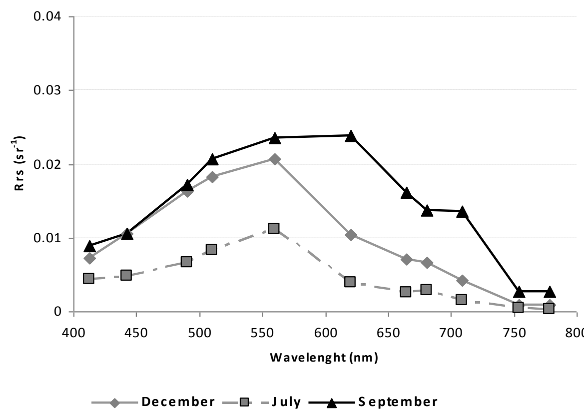


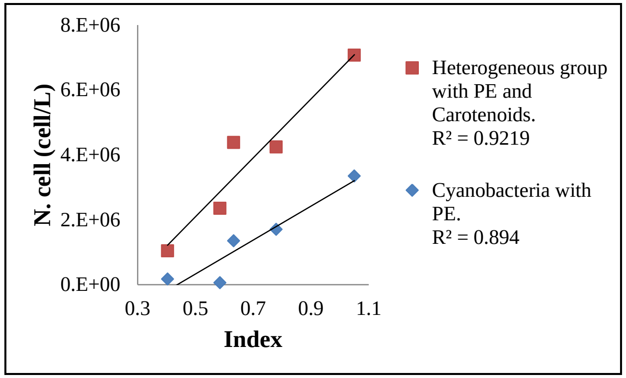
Cyano blooms with phycoerithrin (1/2)

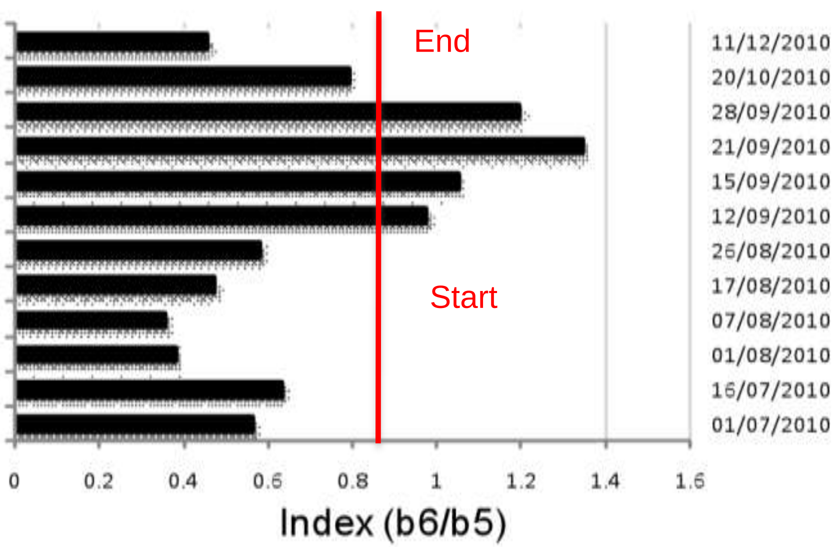
Detection of **starting/ending** phase of **algal bloom**

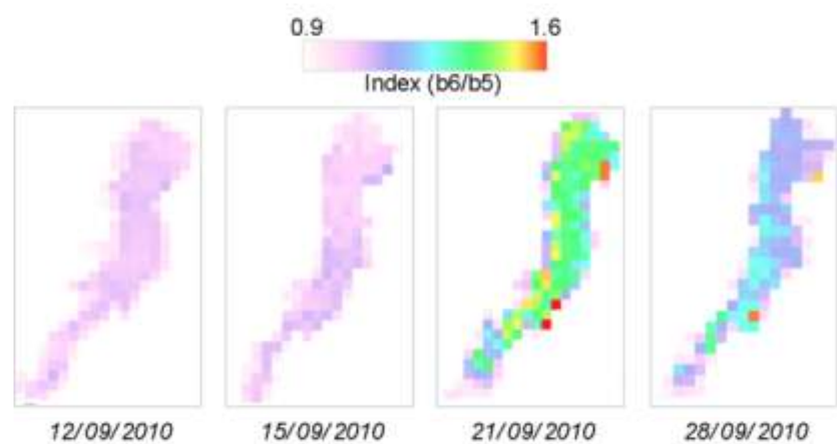
Lake Idro has been poorly studied and monitored







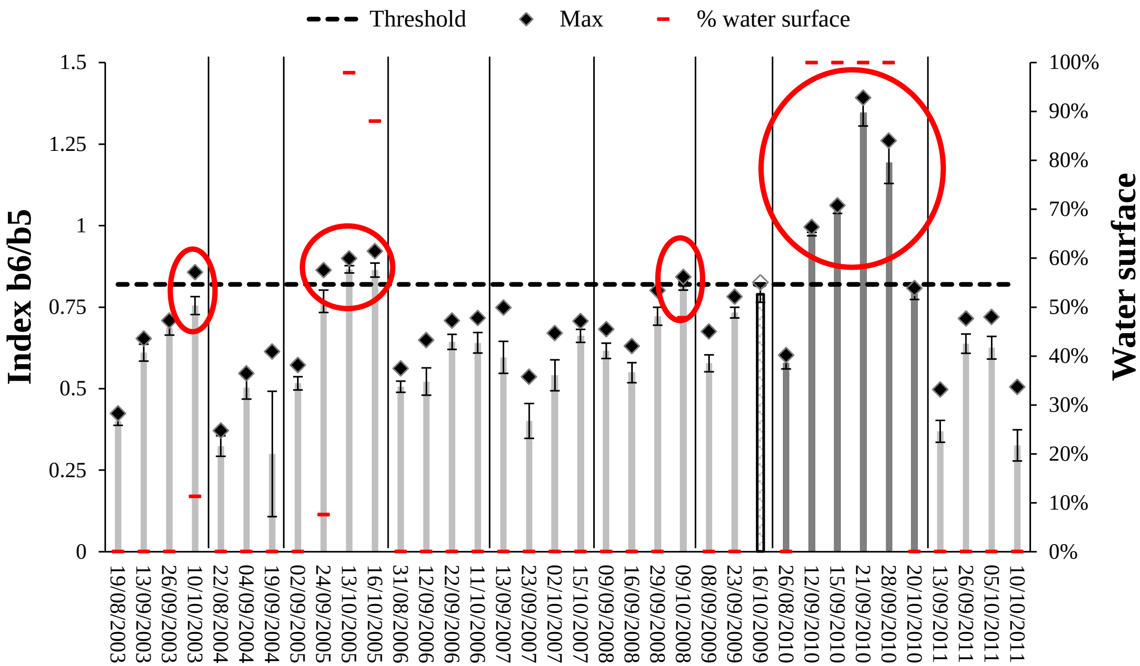




Bresciani et al., 2011. Journal of Applied Remote Sensing

Cyano blooms with phycoerythrin (2/2)

We applied the same methodology to a multi-temporal data-set (2003-2011) and found that algal blooms also occurred in 2003, 2005 and 2008.



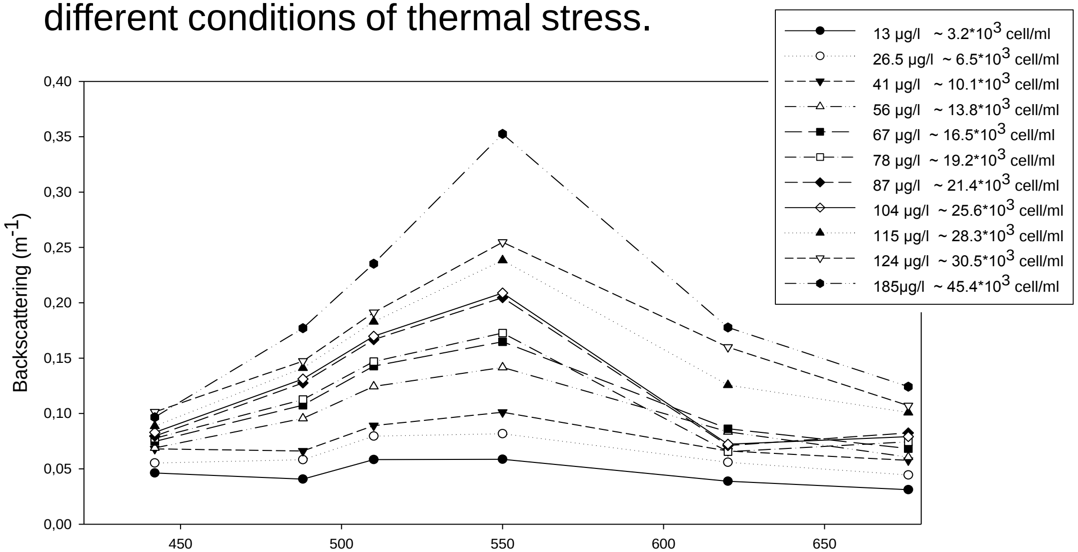
Relation with the meteorological parameters showed that the cyanobacteria with high phycoerythrin have been positively affected by periods of high cloud cover and high temperatures.

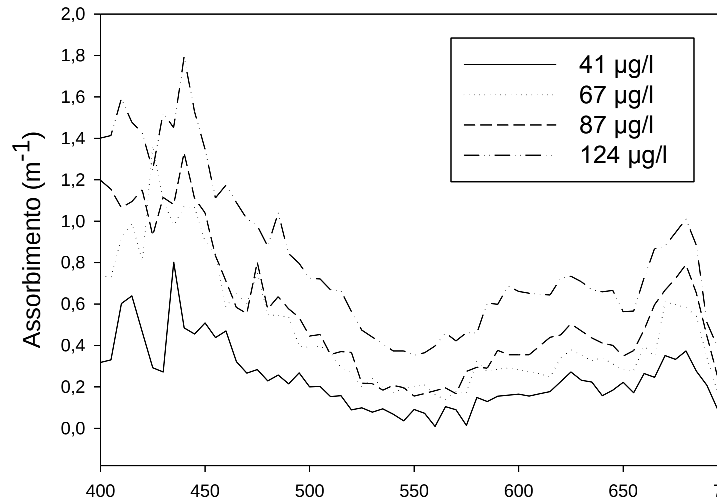
Bresciani et al., 2013. European Journal of Remote Sensing

Cyano blooms with phycocyanin (1/3)

Laboratory measurements of IOP of water with cyanobacteria

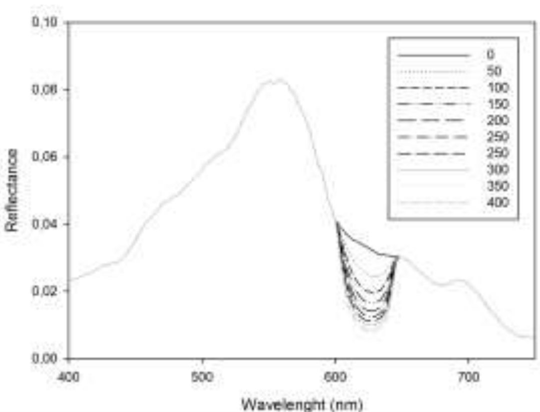
Microcystis colonies assayed in different phenological stages. Toxic and nontoxic colonies. Colonies at different conditions of thermal stress.

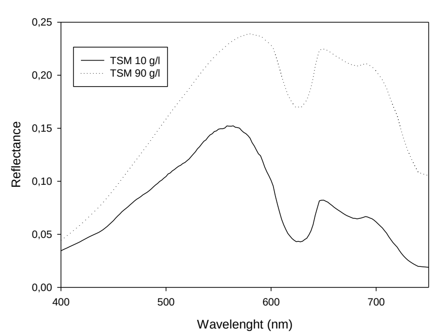


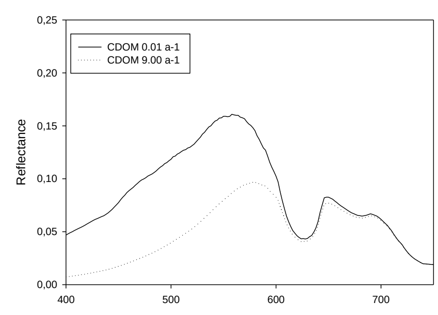


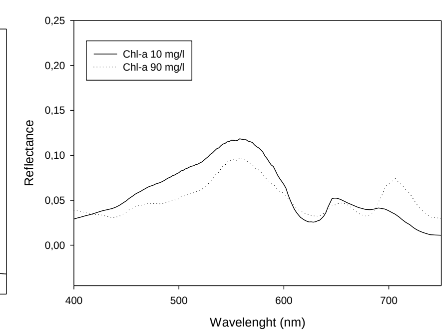
Simulations with Hydrolight

to assess (i) the variability that has then been compared to AOP measured in laboratory and (ii) to assess the disturbance due to the presence of other optically active components



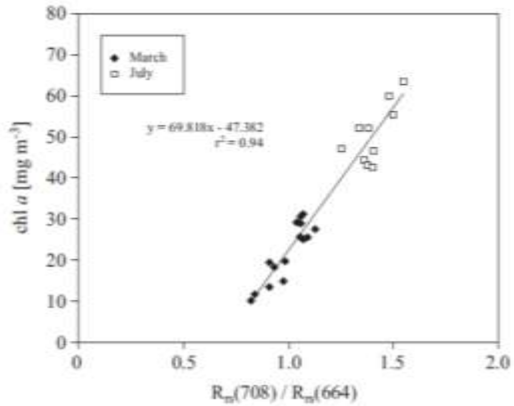


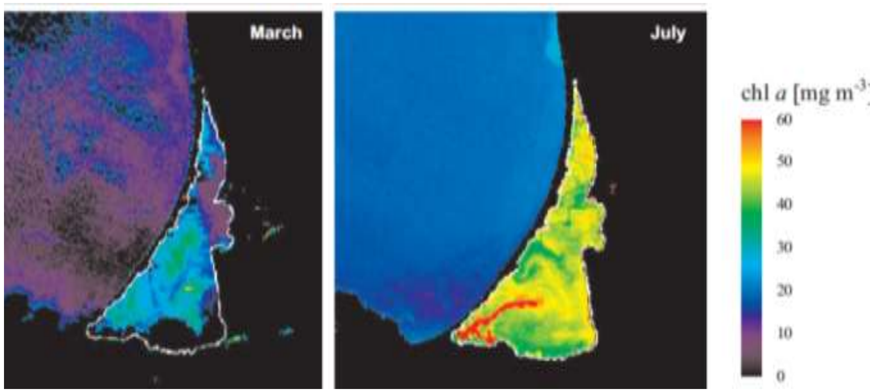




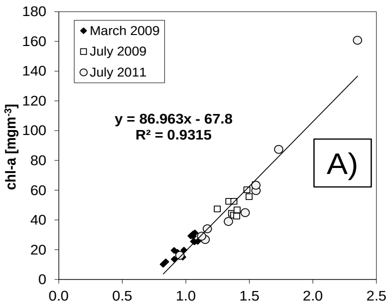
Cyano blooms with phycocyanin (2/3)

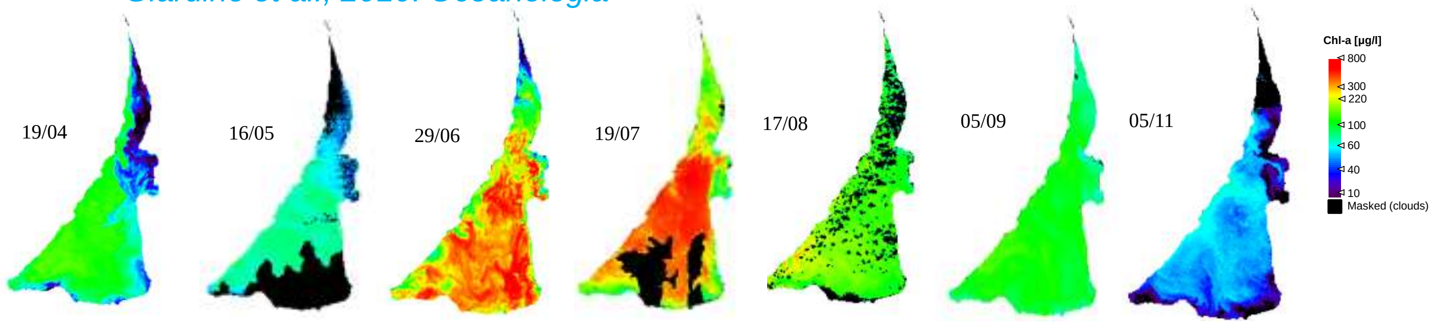

Semi-empirical algorithm

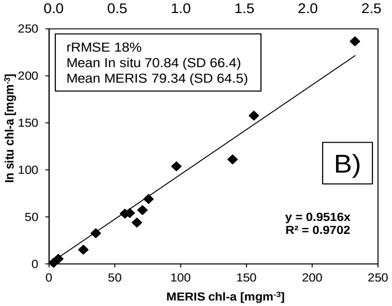


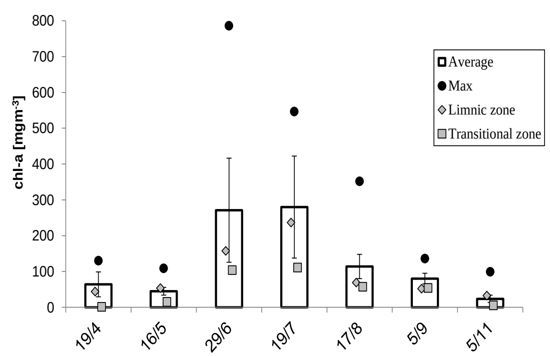


Giardino et al., 2010. Oceanologia





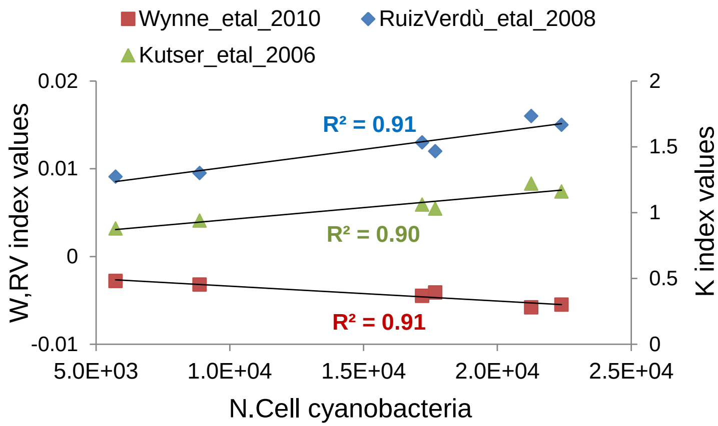


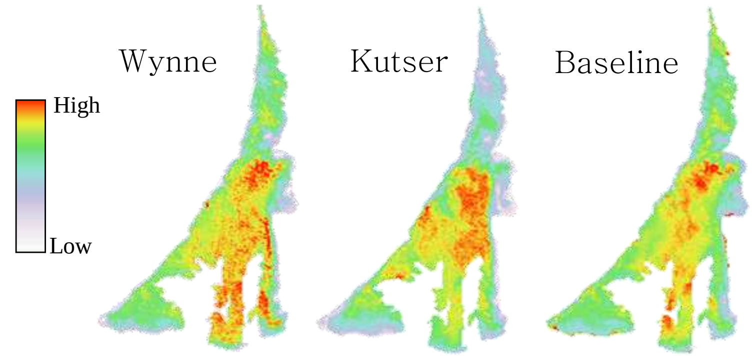


Bresciani et al., 2012. Journal of Coastal Conservation

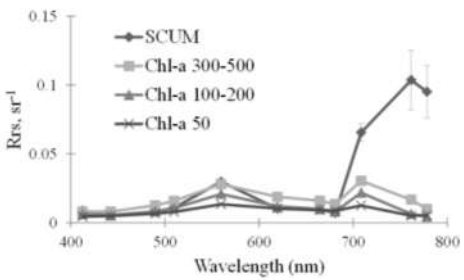
Cyano blooms with phycocyanin (3/3)

specifically algorithms developed for mapping phycocyanin

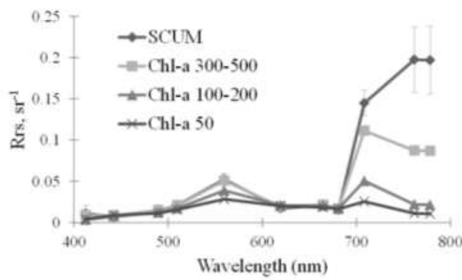


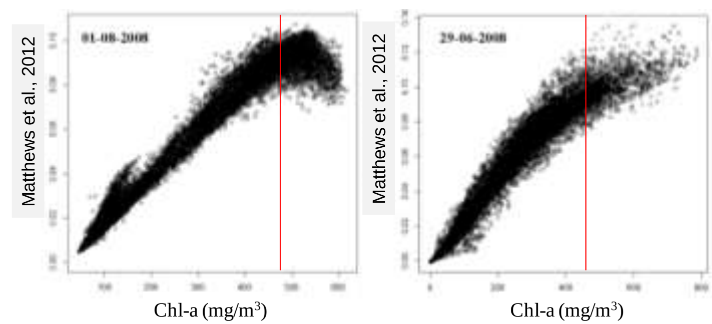


In situ

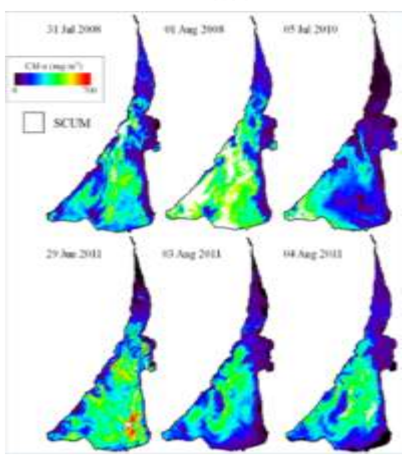


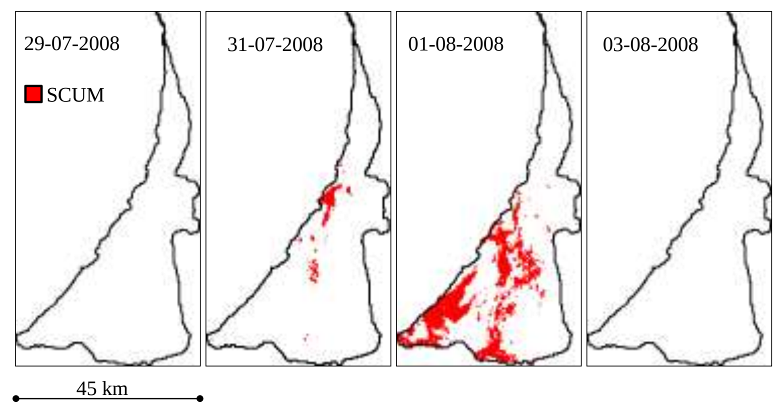
MERIS





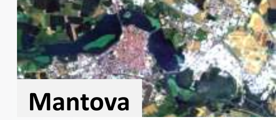
$$\text{Scum}=\frac{Rrs(\lambda_{753})}{Rrs(\lambda_{709})}$$



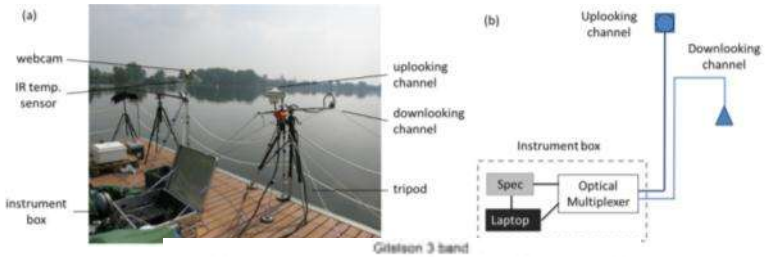


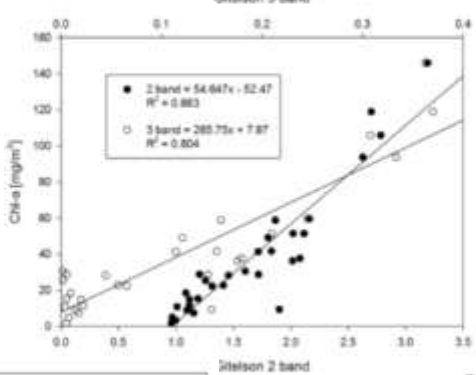
Bresciani et al., 2012. IN REVISION, Remote Sensing of Environment

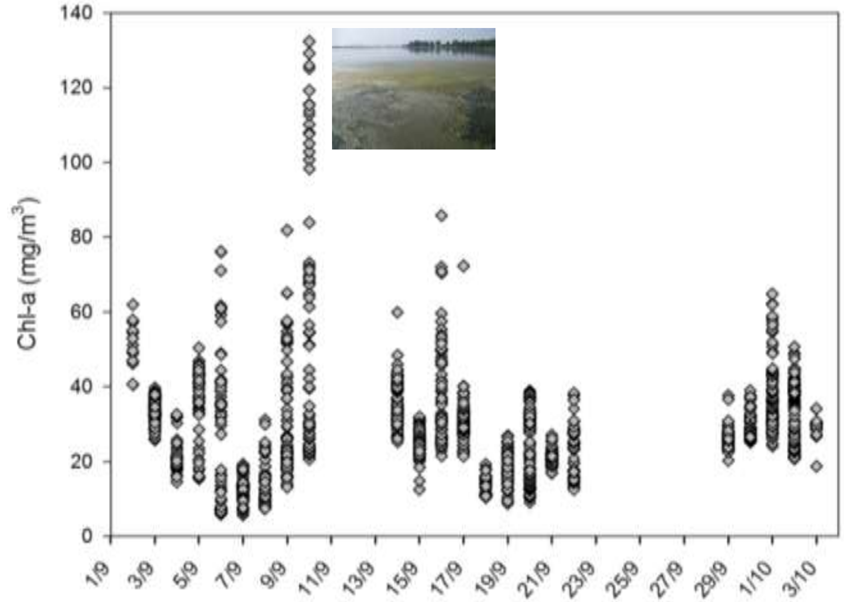
Heterogeneous blooms (1/2)

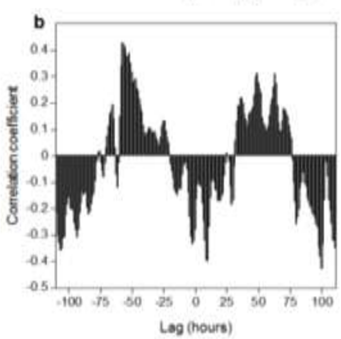


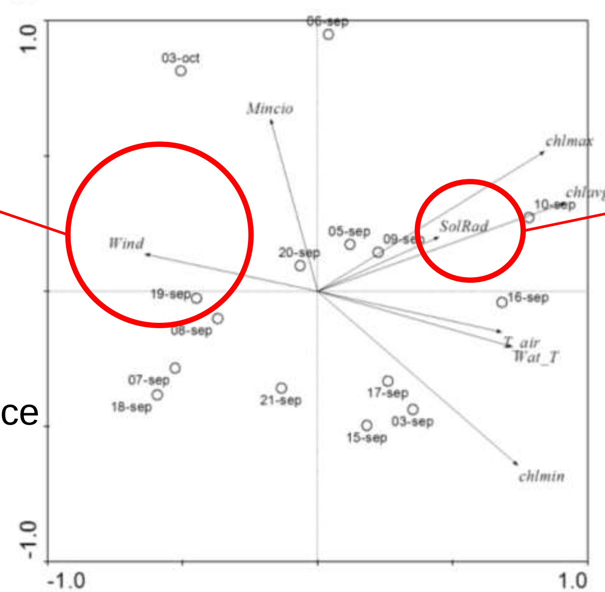
Daily dinamics

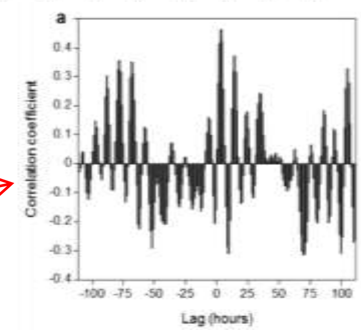












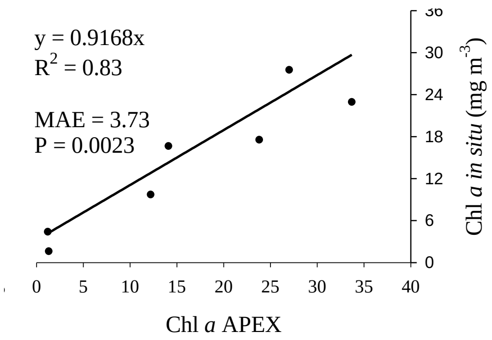
After 8-9 hours, decreasing values of Chl-a were registered as a consequence of an increasing wind force; a positive relation was found after 48 hours.

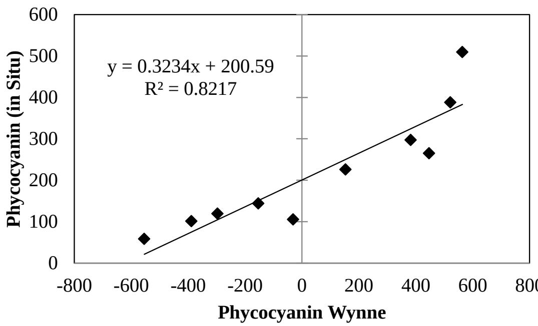
Chl-a increase appeared 3 hours later with respect to the rise of the solar radiation. Negative correlation with 8-9 hours delay.

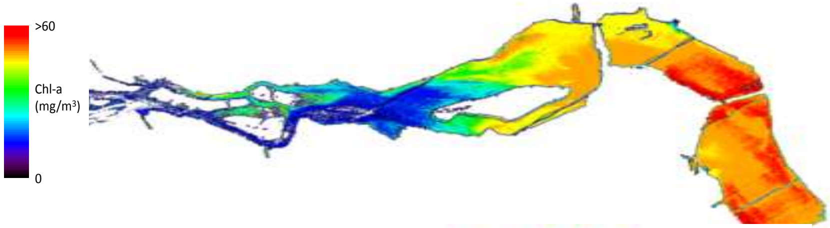
Bresciani et al., IN REVISION. Marine and Freshwater Research

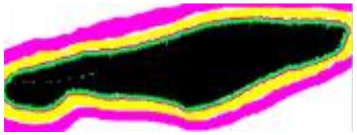
Heterogeneous blooms vs Macrophyte

APEX data 21/09/2011
h 16:30

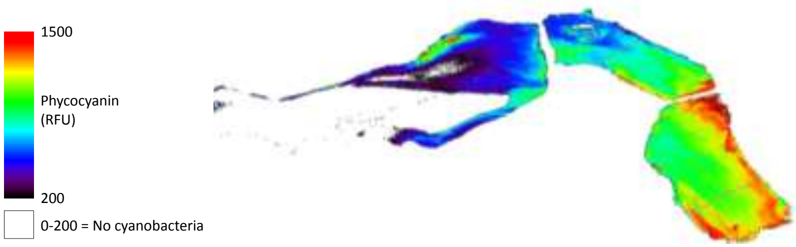


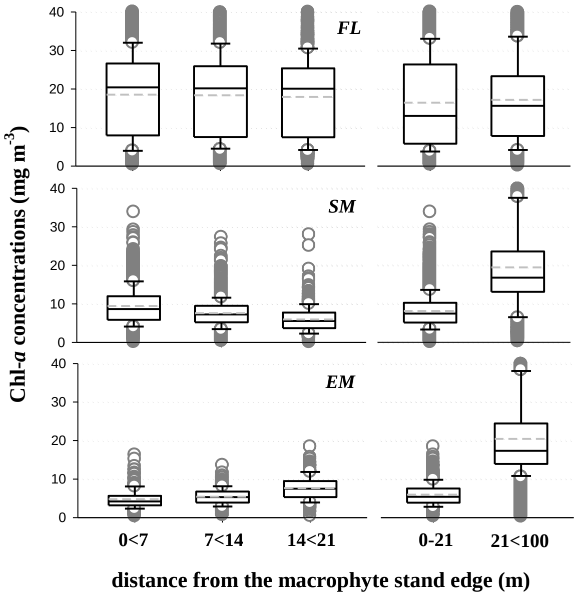


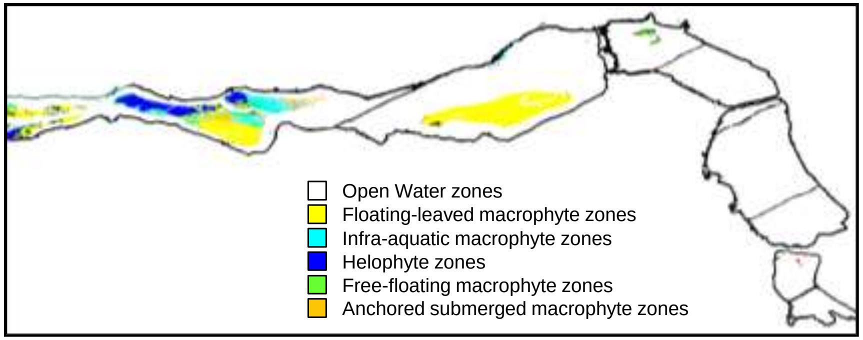




Buffer with difference distance of macrophyte







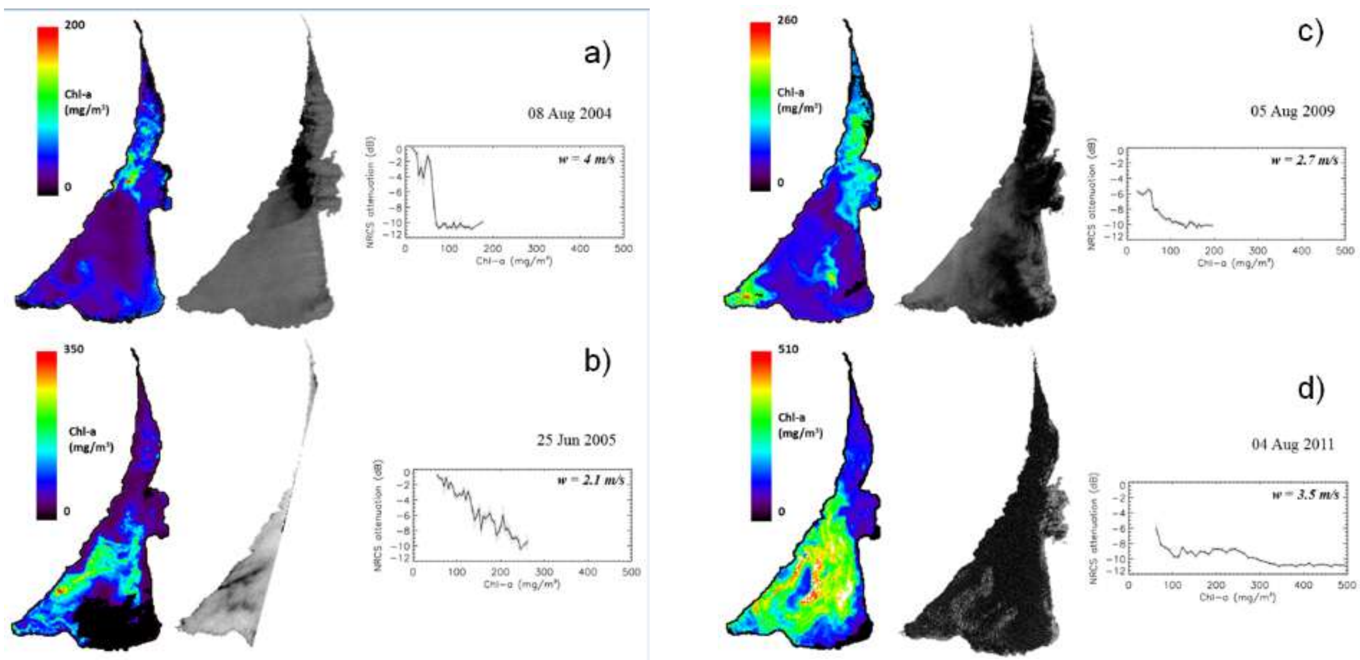
Bolpagni et al., IN REVISION. Hydrobiologia

Integration Passive and Active sensors

Integration of optical-radar images

e.g. **MERIS** and **SAR** images (**cyanobacteria** blooms and scum are related to the **wind action**)

e.g. **Airborne imaging spectrometry** and **LiDAR** images (**macrophytes** detection)



The analysis of the radar data have shown that in specific wind conditions the radar cross section is influenced by bloom

Bresciani et al., 2012. IN REVISION, Remote Sensing of Environment

Conclusion

Cost-effective methods, **time-series** data and **synoptic observations** are more and more requested by "lakes-users" (i.e., **water authorities** as well as **researchers** working on lake's ecology/climate)

The optical variability of phytoplankton found **within the lake** and **among lakes** make it **difficult** to **generalise bio-optical models** even if a "**regionalisation**" of algorithms may help

The knowledge about **in situ optical properties** and **water quality concentrations**, which is needed to perform a full calibration of bio-optical models and semi-empirical algorithm, also provide useful data to know if existing methods can be successfully applied

Research activities on **validation** are still an **important issue**

Thank you for attention!

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