EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

QA4EO
A QUALITY ASSURANCE FRAMEWORK FOR EARTH OBSERVATION

Joint Research Centre

Test Sites and Post-Launch Cal/Val Activities: the Ocean Color Case

Giuseppe Zibordi

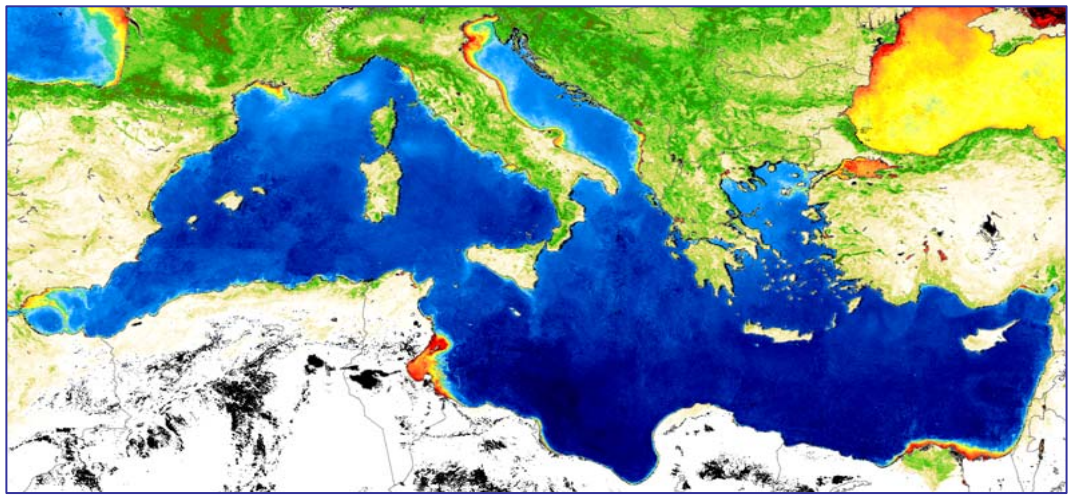
Joint Research Centre, European Commission, Ispra, Italy

QA4EO Workshop for Facilitating Implementation
Antalya - September 30, 2009

Ocean Color: What is it?

The term Ocean Color is generally used to indicate remote sensing of the sea in the visible and near infrared with the primary objective of determining *the radiance emerging from the sea* from the top-of-atmosphere radiometric signal.

The radiance emerging from the sea is afterward utilized to generate the higher level products (e.g. maps of chlorophyll-*a concentration*).



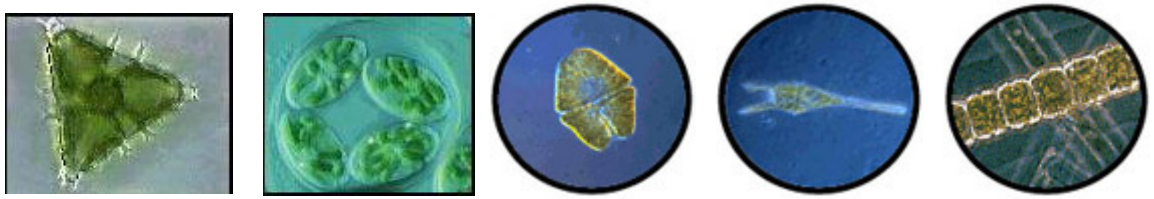
Why chlorophyll-*a* from space ?

Phytoplankton is composed of microscopic unicellular marine plants which contain chlorophyll. This pigment is essential for photosynthesis: sunlight is absorbed and utilized to fuse water molecules and carbon dioxide into carbohydrates.

When phytoplankton dies, its detritus component sinks to the sea bottom. Although phytoplankton account for approximately 50% of the photosynthesis on the Earth, over 99% of all the carbon dioxide that has been incorporated into living things over geologic time is buried in marine sediments.

Therefore, the larger the world's phytoplankton population, the more carbon dioxide gets pulled from the atmosphere.

Then, chlorophyll concentration utilized as a proxy for phytoplankton biomass, is an essential variable to comprehensively investigate Earth's climate change.

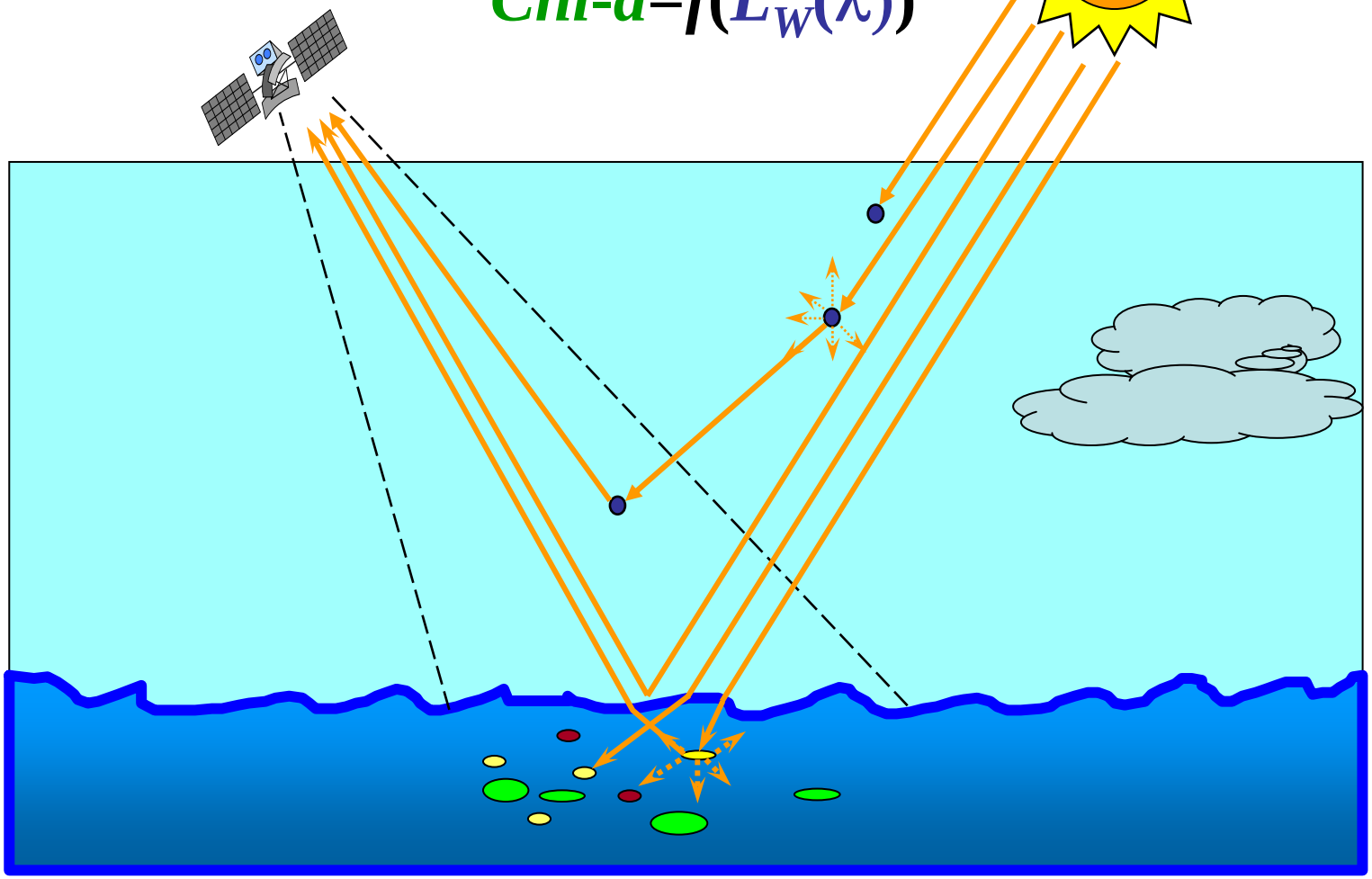


EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Ocean Color: the concept

$$L_{toa}(\lambda) = L_{atm}(\lambda) + t_d \cdot L_w(\lambda) + t \cdot L_g(\lambda)$$

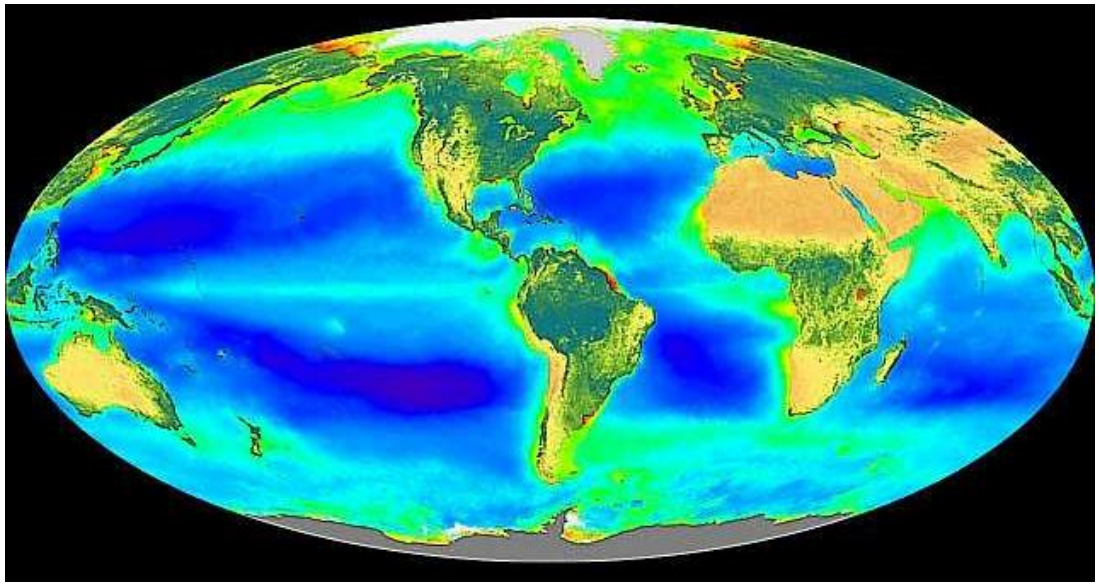
$$Chl\text{-}a = f(L_W(\lambda))$$



L_W is the desired quantity which carries information on the materials suspended and dissolved in the sea water (L_W is approximately 5-10% of L_{toa})

Remote Sensing and Data Quality

Data Quality provides the capability to combine or use data from different sources in a meaningful way.

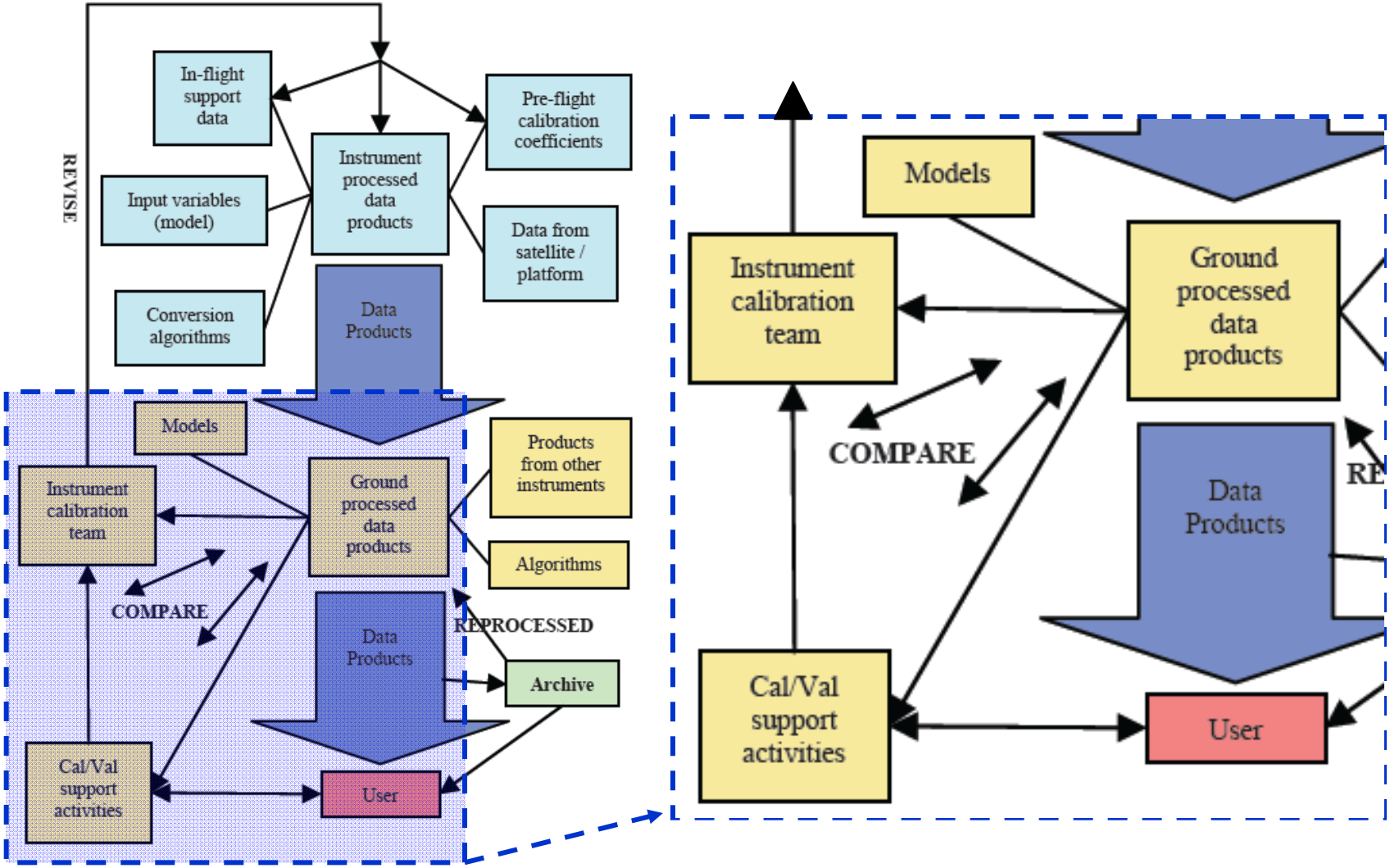


Data and Derived Products must have associated a Quality Indicator (QI) based on documented quantitative assessment of its traceability to Reference Standards.

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Schematic representation of a data process chain for a satellite sensor

Joint Research Centre

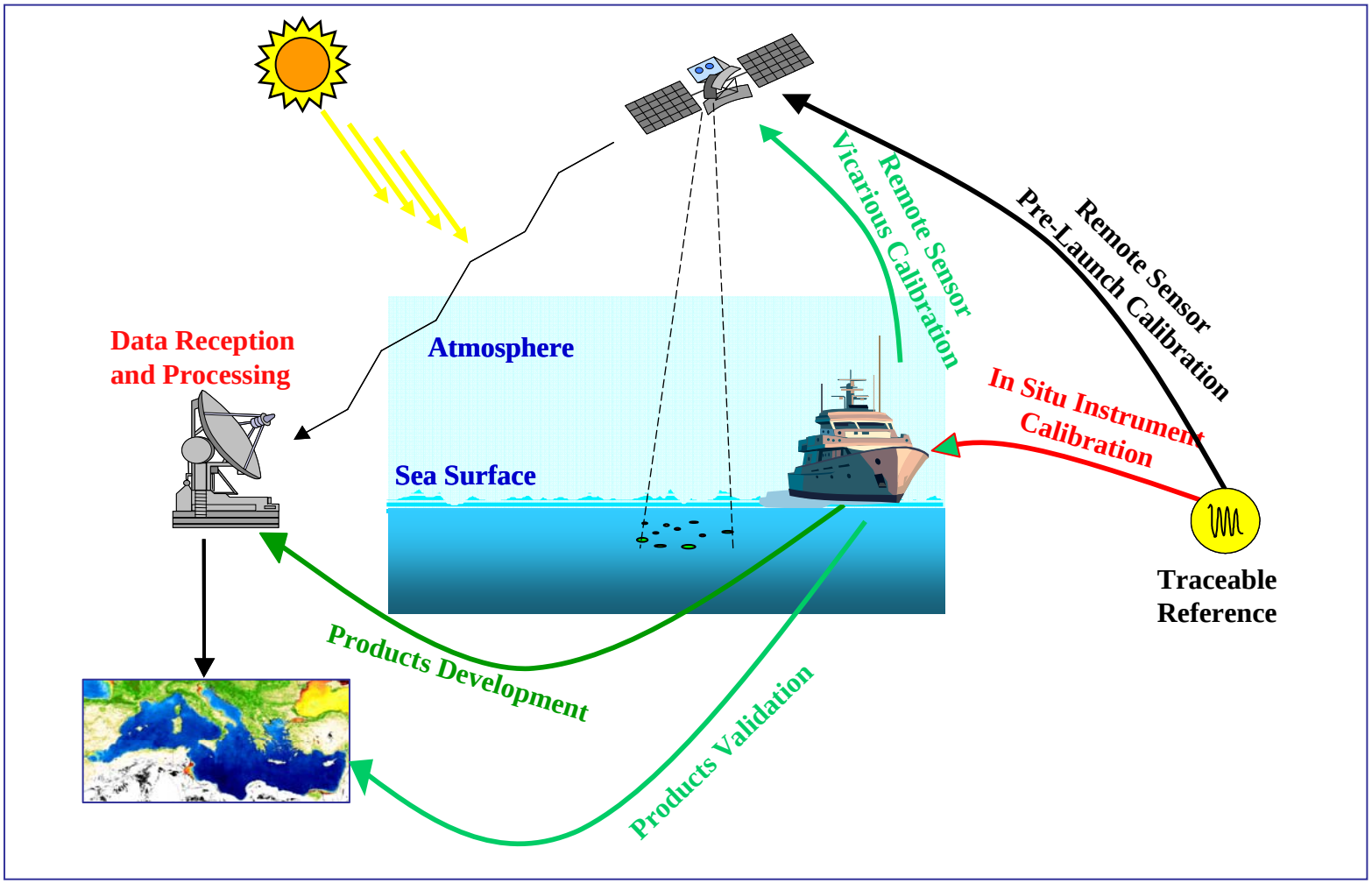


QA4EO
A QUALITY ASSURANCE FRAMEWORK FOR EARTH OBSERVATION

Steps in Ocean Color *Cal/Val*

- *Pre-Launch Absolute Calibration*
- Assessment of *Sensitivity Change* with time (using stable targets like the moon surface or onboard systems or Earth's surfaces or …).
- *Vicarious Calibration* (using suitable and highly accurate *in situ* data together with the mission specific atmospheric correction code).
- *Validation* of primary remote sensing products (i.e., L_{WN}).
- *Assessment* of the uncertainties of high level remote sensing products (i.e., *Chla, TSM, a*, b_b, …).

In Situ Data and the Cal/Val Paradigm



EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

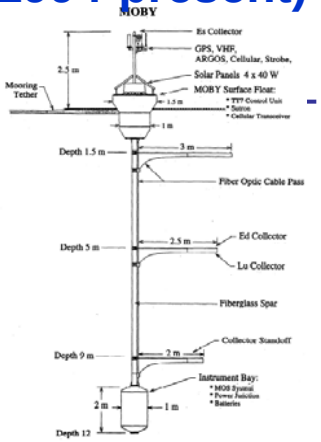
Requirements for field data supporting Cal/Val programs

1. Traceable (measurements should have well defined uncertainties quantified, when possible and appropriate, through reference standards);
2. Globally distributed (measurements should represent the wide range of geophysical conditions that remote sensing products are expected to observe);
3. Continuous (time-series of quality assured data are fundamental for assessing remote sensing products from individual and mostly successive space missions);
4. Cross-site consistent (measurement uncertainties should be likely the same for all measurement sites and measurement conditions);
5. Accessible (measurement availability, through suitable data policies, is a key element for any actual cal/val program).

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Vicarious Calibration Sites in the history of Ocean Color

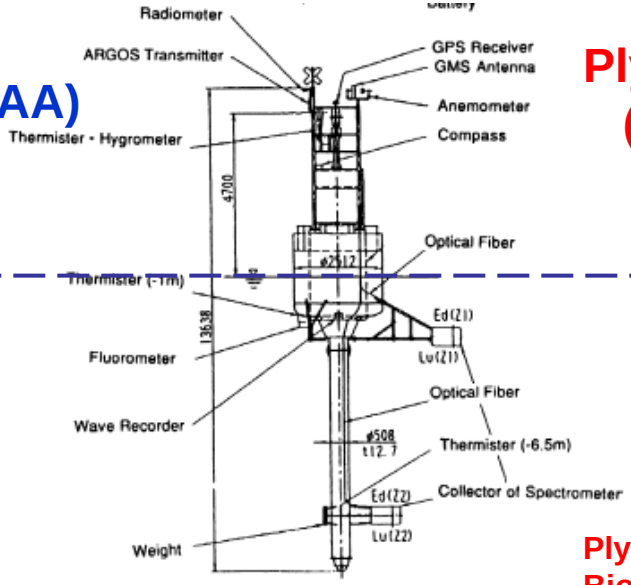
MOBY (NASA-NOAA) (1994-present)



MOBY: Marine Bio-Optical Data Buoy

Site: Hawaiian Archipelago

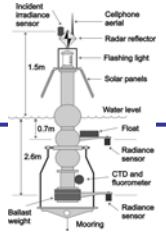
YBOM (NASDA) (1996-1997)



YBOM: Yamato Bank Optical Mooring Buoy System

Site: Japan Sea

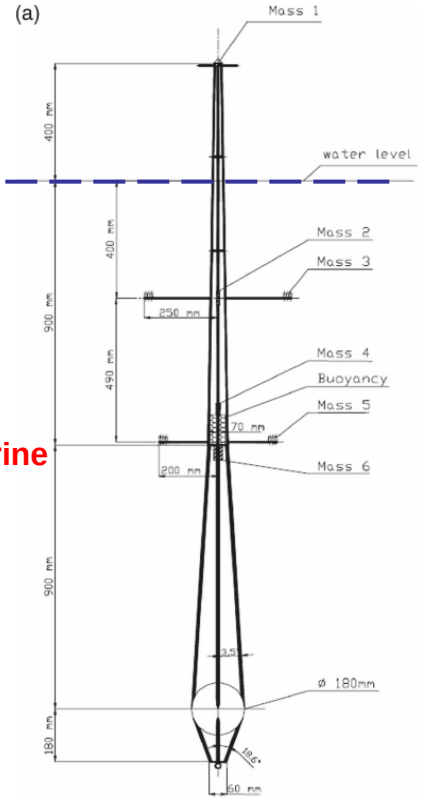
PlyMBODy (PML) (1997-1998)



PlyMBODy: Plymouth Marine Bio-Optical Data Buoy

Site: English Channel

BOUSSOLE (LOV-CNES-ESA) (2004-present)



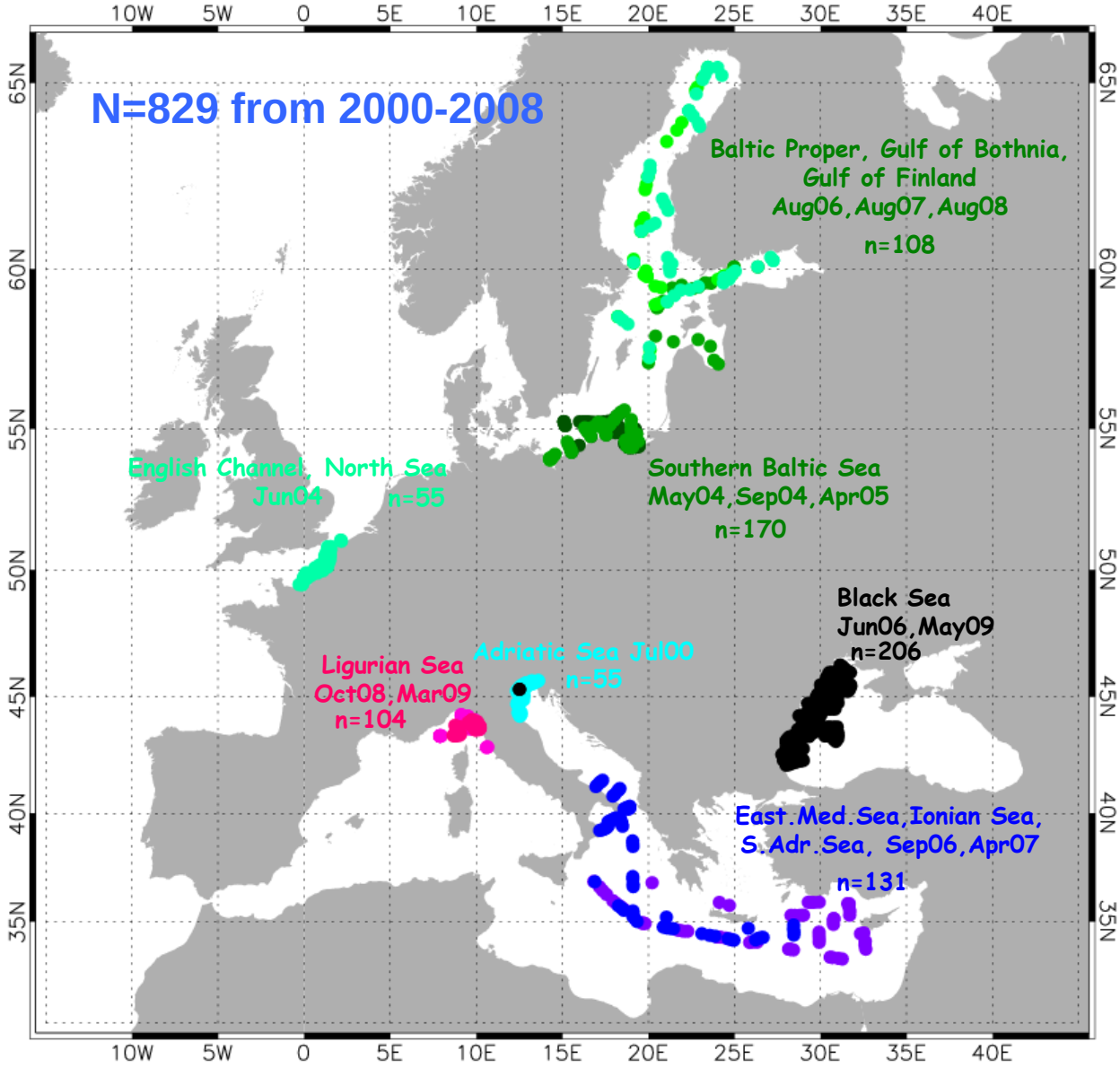
BOUSSOLE: Buoy for the Acquisition of a Long-Term Optical Time-Series

Site: Ligurian Sea

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

BiOMaP (Bio-Optical Marine Properties): a European Ocean Color Development Program

BiOMaP measurements are produced applying cross-site identical and consolidated: technology, measurement and calibration protocols, processing codes and quality assurance criteria.



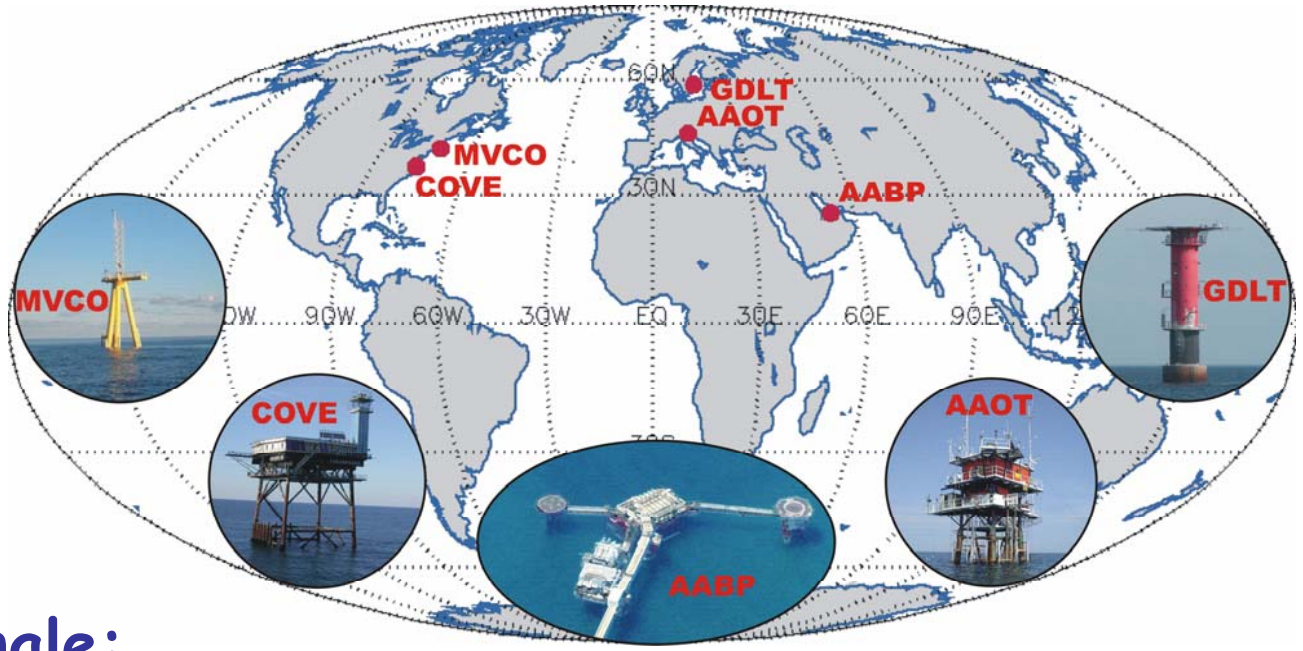
J.F. Berthon, F. Mélin and G. Zibordi. Ocean Colour Remote Sensing of the Optically Complex European Seas, in: V. Barale and M. Gade ed.s, "*Remote Sensing of the European Seas*", Springer, Dordrecht (NL), 35-52, 2007.

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

AERONET-OC

Joint Research Centre

AERONET – Ocean Color is an sub-network of the Aerosol Robotic Network (AERONET), supporting ocean color validation activities with highly consistent time-series of normalized water leaving radiance, $L_{WN}(\lambda)$.



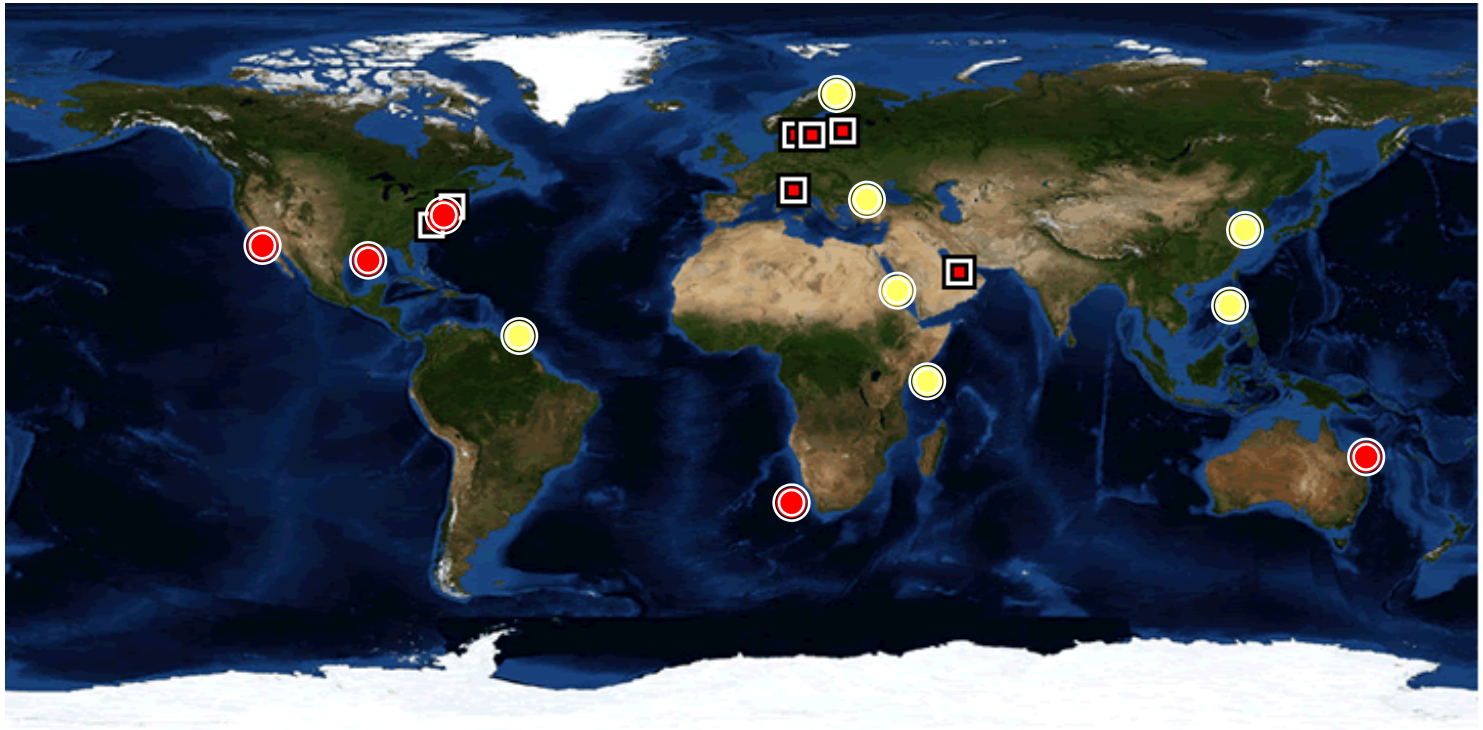
Rationale:

- Autonomous radiometers operated on fixed platforms in coastal regions;
- Identical measuring systems and protocols, calibrated using a single reference source and method, and processed with the same code;
- Standardized products of normalized water-leaving radiance and aerosol optical thickness, accessible in almost real-time through web interface.

G.Zibordi et al. A Network for Standardized Ocean Color Validation Measurements. Eos Transactions, 87: 293, 297, 2006.

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

AERONET- Ocean Color (2002-present)



Active sites Planned sites Identified sites

Current management and responsibilities

- **NASA** manages the network infrastructure (i.e., handles the instruments calibration and, data collection, processing and distribution within AERONET).
- **JRC** has the scientific responsibility of the processing algorithms and performs the quality assurance of data products.
- **Individual PIs** are responsible for establishing and maintaining AERONET-OC sites.

AERONET-OC: Quality assurance levels

AERONET-OC products are classified at different quality assurance levels:

Level 1.0 ->
- $L_{WN}(\lambda)$ from complete measurement sequences.

Level 1.5 ->
- Cloud screened using aerosol optical thickness data;
- Tested with respect to quality parameters (e.g., low variance in replicate measurements, no appreciably negative value);

Level 2.0 ->
- Consistent pre- and post-deployment calibration values;
- Consistent $L_{WN}(\lambda)$ spectral shapes.

Fully quality assured data typically include 10-15% of the initial measurements

G.Zibordi, B.Holben, I.Slutsker, D.Giles, D.D'Alimonte, F.Mélin, J.-F. Berthon, D. Vandemark, H.Feng, G.Schuster, B.Fabbri, S.Kaitala, J.Seppälä. AERONET-OC: a network for the validation of Ocean Color primary radiometric products. *Journal of Atmospheric and Oceanic Technology, 26, 1634-1651*, 2009.

Uncertainties

Source	L_{WN}				
	412	**443**	**488**	**551**	**667**
Absolute calibration	2.7	2.7	2.7	2.7	2.7
Sensitivity change	0.4	0.2	0.2	0.2	0.2
Correction	1.6	2.0	2.8	2.9	1.9
t_d	1.5	1.5	1.5	1.5	1.5
ρ	1.8	1.3	0.7	0.6	2.5
W	1.1	0.8	0.4	0.4	0.4
Environmental effects	3.1	2.1	2.1	2.1	6.4
Quadrature sum	**5.1**	**4.5**	**4.7**	**4.7**	**7.8**

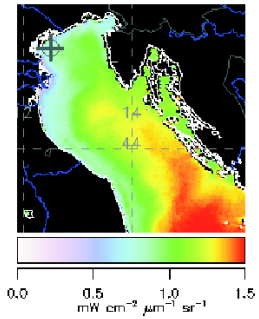
~5% (400-600 nm)

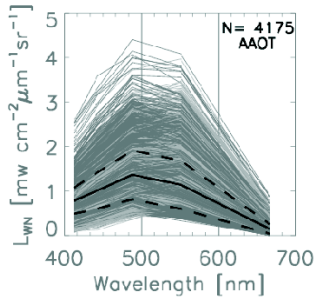
G.Zibordi, B.Holben, I.Slutsker, D.Giles, D.D'Alimonte, F.Mélin, J.-F. Berthon, D. Vandemark, H.Feng, G.Schuster, B.Fabbri, S.Kaitala, J.Seppälä. AERONET-OC: a network for the validation of Ocean Color primary radiometric products. *Journal of Atmospheric and Oceanic Technology* , 26, 1634-1651, 2009.

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

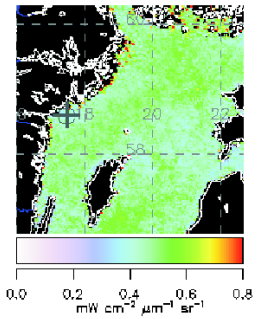
Examples of AERONET-OC Sites

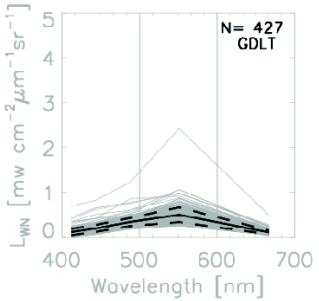
Joint Research Centre



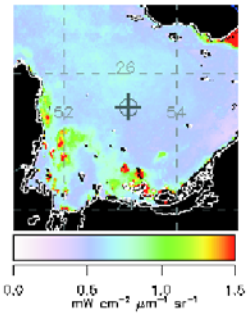


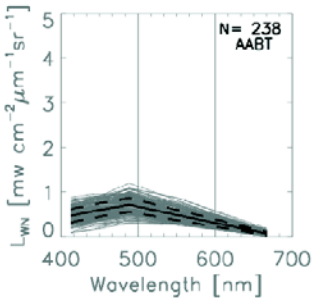
Site: AAOT
Location: Northern Adriatic Sea
Water type: Case-1/Case-2
Period: 2002-present





Site: GDLT
Location: Northern Baltic Proper
Water type: Case-2
Period: 2005-present (summer)





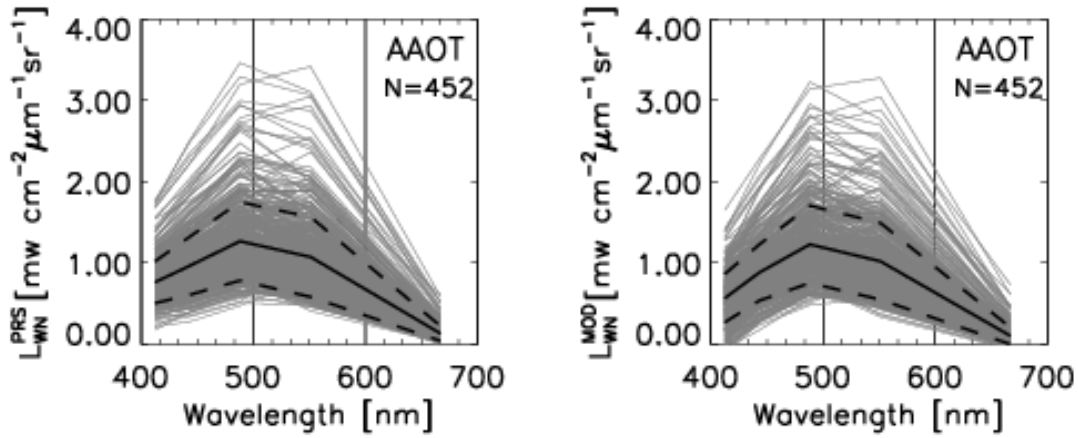
Site: AABT
Location: Persian Gulf
Water type: Case-1
Period: 2005-2008

Zibordi, G., Holben, B., Slutsker, I., Giles, D'Alimonte, D., Mélin, F., Berthon, J.-F., Vandemark, D., Feng, H., Schuster, G., Fabbri, B. E., Kaitala, S., Seppälä, J. (2009). AERONET-OC: a network for the validation of Ocean Color primary radiometric products. *J. Atmos. Oceanic Technol., 26, 1634-1651.*

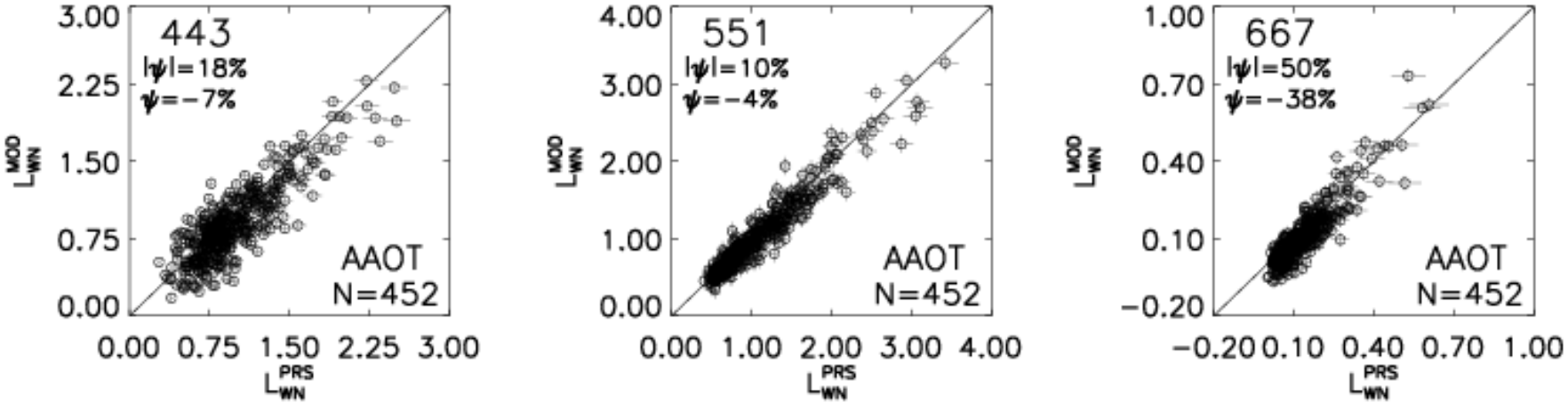
EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Joint Research Centre

An example of satellite radiometric products validation (MODIS at the AAOT)



***In situ* and satellite derived L_{WN} spectra**



Satellite (MODIS) versus *in situ* (AERONET-OC) L_{WN} match-up analysis

G.Zibordi, J.-F.Berthon, F.Mélin, D. D'Alimonte and S.Kaitala. Validation of satellite ocean color primary products at optically complex coastal sites: northern Adriatic Sea, northern Baltic Proper and Gulf of Finland. *Remote Sensing of Environment* (in press), 2009.

Conclusion

Ocean Color (like any remote sensing activity generating geophysical products) requires consolidated field programs capable of delivering traceable, globally distributed, cross-site consistent, continuous, and accessible field measurements.

The former step, needed to support the generation of remote sensing data products fully qualified for climate studies and applications, cannot be accomplished without a major co-ordination effort among: Space and Environment Agencies, Research and Development Institutions, Data Users.

Thanks!

Any question?