SeaPRISM, Venice Tower and BOUSSOLE

Sean Bailey
Presenting for Stan Hooker, Giuseppe Zibordi and David Antoine

April 14, 2004

Code 971
S. Hooker

Above-Water Ocean Color Vicarious Calibration and Algorithm Validation

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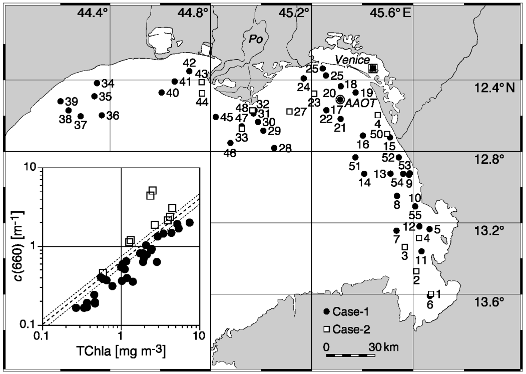
Above- and In-Water Comparisons From a Small Boat Campaign

One of the objectives of the ADRIA-2000 campaign in the northern Adriatic Sea was to investigate the capabilities of the above-water method on a small boat (less than 10m length).



The stations were all in coastal waters with water depths ranging from 5–30 m, but the water types were predominantly Case-1.

The environmental conditions during the cruise were usually excellent: clear skies, low wind speeds (and wave heights), and the chlorophyll concentration spanned 0.3–8.0 mg m^{-3}.

The anisotropy of the upwelled radiance leaving the sea creates an intercomparison problem, because in-water measurements are made at nadir, whereas above-water measurements are frequently made at a nadir angle of 40° (or 45°). When dealing exclusively with Case-1 waters, the bidirectionality of the light field (usually parameterized by the so-called Q-function) and the functional dependence of the variables can be simplified. In particular, it is assumed that the IOPs are related to the chlorophyll a concentration (Morel and Prieur 1977). Using this assumption and omitting the wavelength dependence for brevity, the ratio of the above- and in-water L_W quantities is given by:

$$\frac{\hat{L}_W(\phi',\vartheta)}{\tilde{L}_W} = \frac{\Re(\theta',W)}{\Re_0}\,\frac{Q_n(\theta,C_a)}{Q(\theta,\phi',\theta',C_a)}$$

where θ' is the above-water viewing angle refracted by the air–sea interface, the R term merges all the effects of reflection and refraction (Morel and Mueller 2002). The above-water measurements collected at a particular viewing angle can be transformed on a case-by-case basis as if they were made vertically at nadir (Hooker and Morel 2003) using Q-function look-up tables (Morel and Gentili 1996). The application of the most recent version of the Q-function tables (Morel et al. 2002) to correct the above-water S95 method is denoted Q02.

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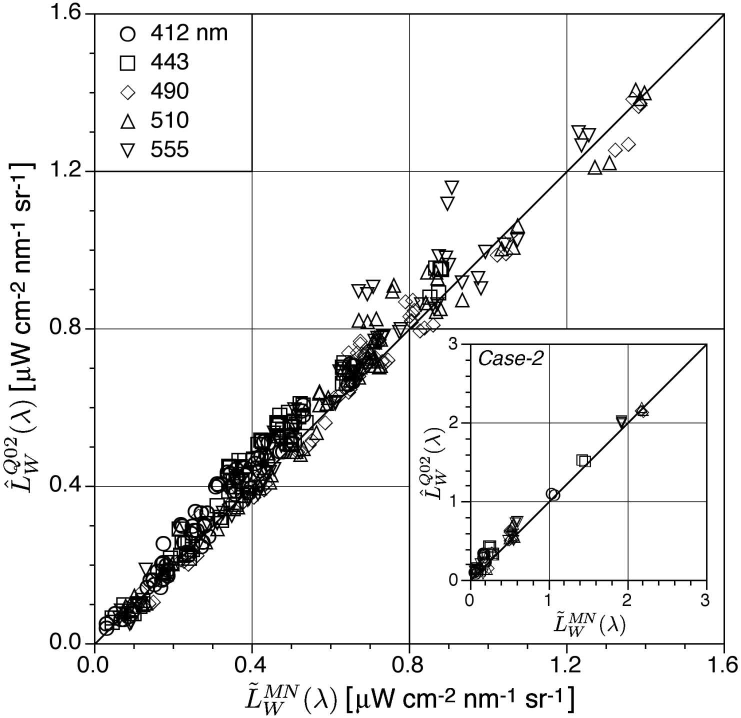
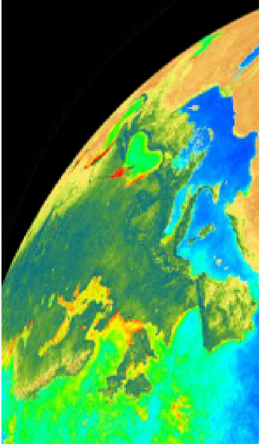
Intercomparisons of Above- and In-Water AOP Methods in Coastal Waters

A comparison of the above- (Q02) and in-water (MN) determinations of water-leaving radiances begins with only using data for which the time difference between the two types of measurements was 5 min or less. Furthermore, any in-water profiles that included vertical stratification that was not properly resolved by the in-water profiler were discarded (hydrographic and IOP data were used in this analysis), but multiple casts that occurred in a short time period were combined to increase the vertical resolution of the observations. Using the in-water results as the reference (or truth), the average RPD for all the data (Case-1 and Case-2) is 1.7%, which is very nearly the level of uncertainty in calibration.



SBH/14Apr04

Ocean Color



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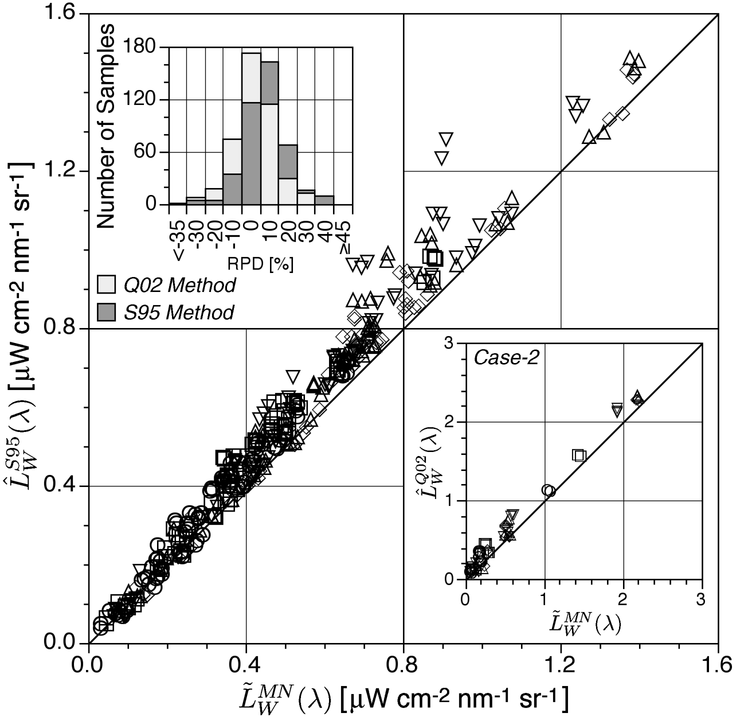
A Comparison of the Original S95 Method and the New Q02 Method

The excellent Q02 results lead naturally to a comparison with the original S95 protocol to see how much of the improvement is a result of the processing refinements rather than some unidentified aspect of the data acquisition. The S95 results for the same data show a clear bias with respect to the in-water (MN) water-leaving radiances. The positive shift is seen in the plot and the histograms. The average RPD for the Q02 method was 1.7% and the average RPD for the S95 method is 7.7%, so the approximately 6% improvement is associated with including a bidirectional (*Q*-factor) correction plus a more accurate surface reflectance from Mobley (1999).



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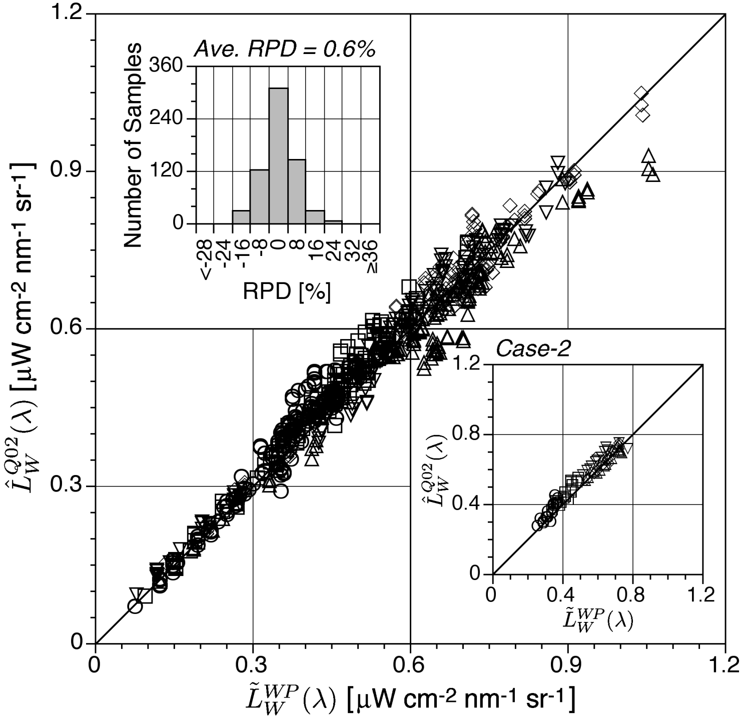
Above- and In- Water Determinations of Water-Leaving Radiances

Given the established capabilities of the Q02 method, it is appropriate to consider an above- and in-water comparison where the former are obtained on an offshore platform, but unequivocally free of any perturbations. The inset panels show the RPD histogram, and separate comparisons for the Case-2 stations. The RPD values are computed using the in-water results as the reference in the calculations. Unlike the ADRIA-2000 results, the comparisons show almost no bias This is most likely the result of all the radiometers for the tower campaigns being calibrated at the JRC calibration facility (in the other campaigns the sensors were calibrated at different facilities).



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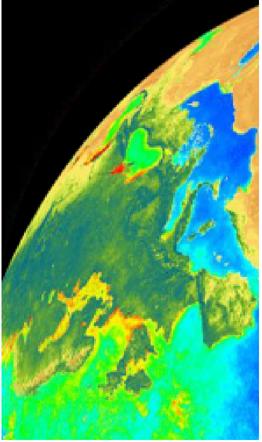


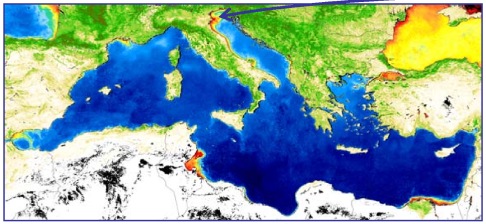
Coastal Atmosphere and Sea Time Series (CoASTS)

Objectives: 1. Monthly data collection at the Acqua Alta Oceanographic Tower (AAOT)

2. Data exploitation in ocean color products development and validation.

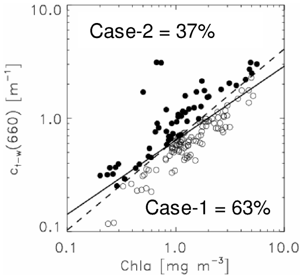
Time frame: July 1995 – September 2005

The AAOT site (45.31 N, 12.50 E)



Monthly Chla composite from SeaWiFS imagery (September 1998)

AAOT

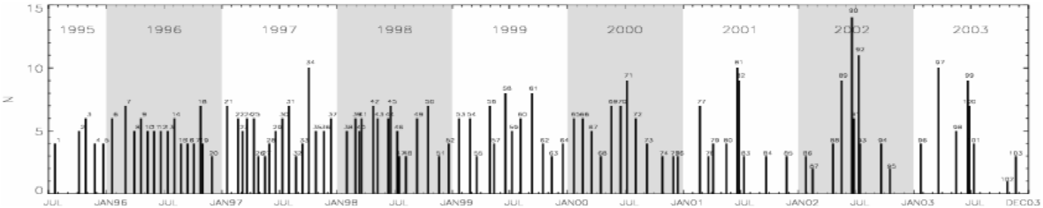


CoASTS campaigns

MERIS (01/03/02)

MODIS (18/12/99)

SeaWiFS (01/08/97)



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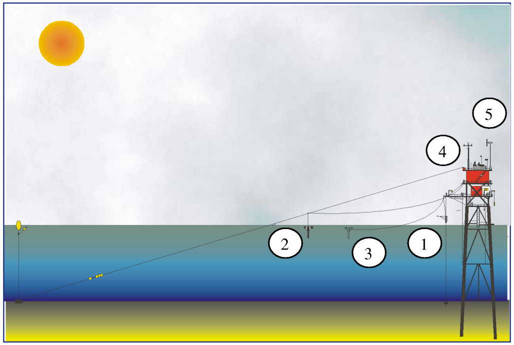
ies Institute for Environment and Sustainability

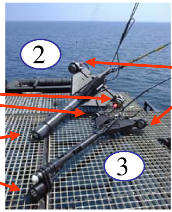
INLAND & MARINE WATERS

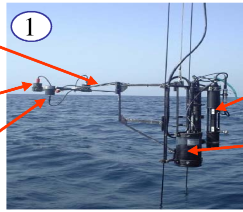
AAOT Optical Systems

$E_d(0^+,\lambda)$, $E_i(0^+,\lambda)$

$E_s(\lambda)$, $L_i(\theta,\phi,\lambda)$, $L_w(\lambda)$

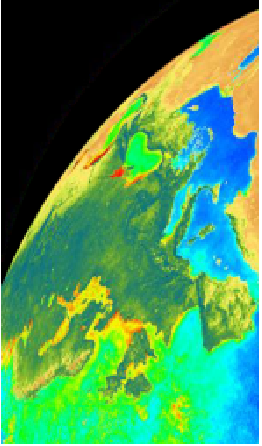






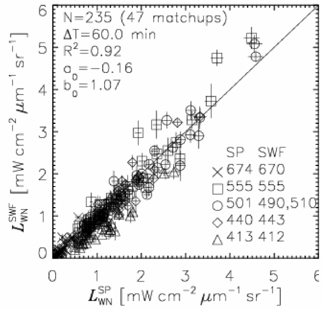
INLAND & MARINE WATERS

Ocean Color

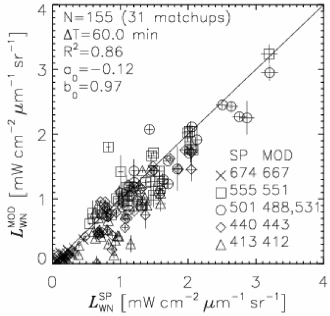


Ocean Color Sensors Intercomparison

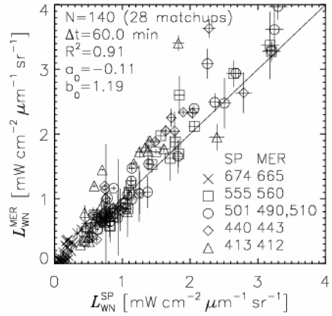
AAOT, May 2002-May 2003, 3X3 pixels, θ<56°, θ_0<70°, ΔT=60 min; L_{WN}>0



SeaWiFS



MODIS



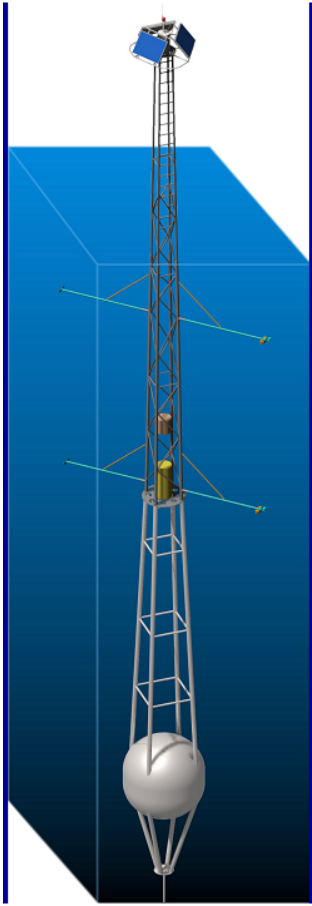
MERIS

G.Zibordi, F. Mélin, S. B. Hooker, D. D'Alimonte and B. Holben. An autonomous above-water system for the validation of ocean color radiance data. *IEEE Transactions in Geoscience and Remote Sensing* , 42:401-415, 2004 .

GSFC NASA

IMW INLAND & MARINE WATERS

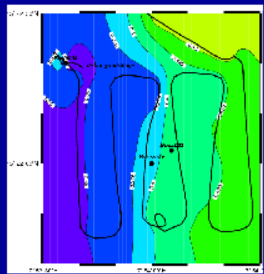
EUROPEAN COMMISSION
JOINT RESEARCH CENTRE



The “BOUSSOLE” project

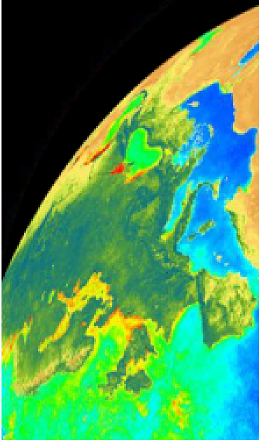
(BOUée pour l’acquiSition de Séries Optiques à Long termE)

P.I. : David ANTOINE
Laboratoire d’Océanographie de Villefranche



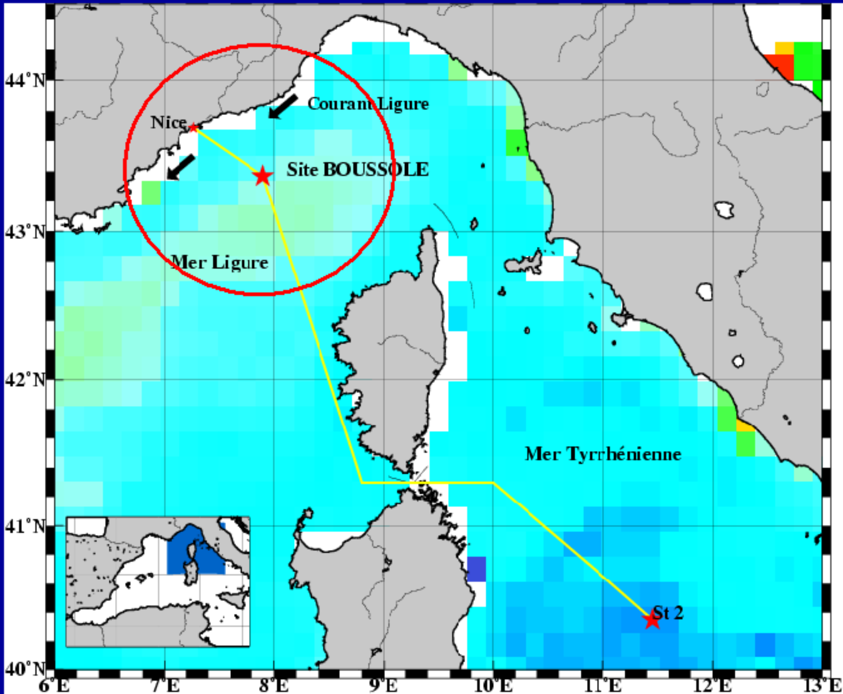
« short title » :
Building a time series of surface ocean optical properties for satellite ocean color cal/val and (bio)optics research

Ocean Color



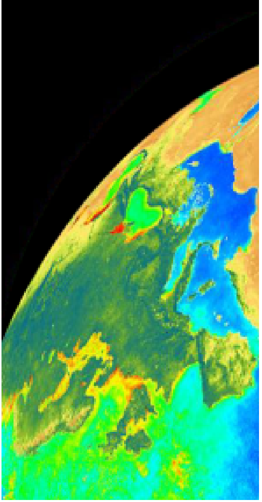
The site where we collect data : "BOUSSOLE" site & program

"Buoy for the acquisition of a long-term (bio)optical series"

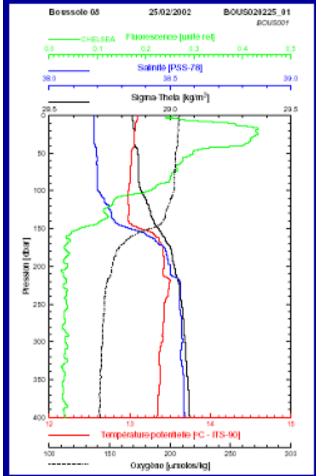


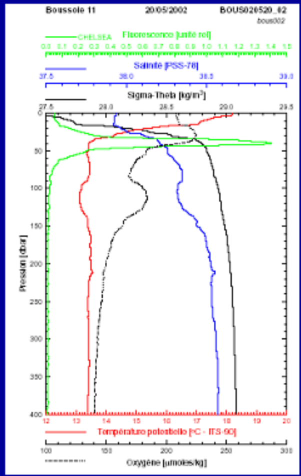
Monthly cruises (started July 2001) + a new type of optical buoy (since Sept. 2003)

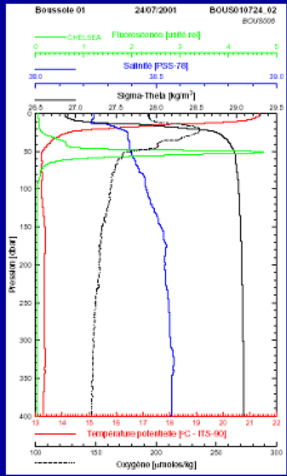
Marine optics, Bio-optics, Ocean color calibration / validation program (MERIS, SeaWiFS, POLDER)

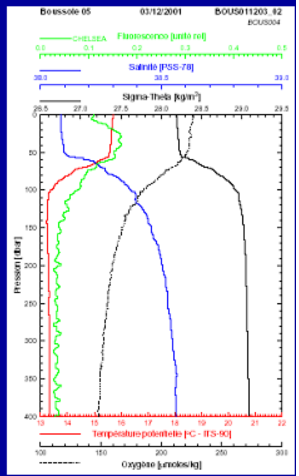


Site characteristics
(oligotrophic to eutrophic)









Winter, maximum of the water mixing
Chl up to ~2-3 mg m^{-3}

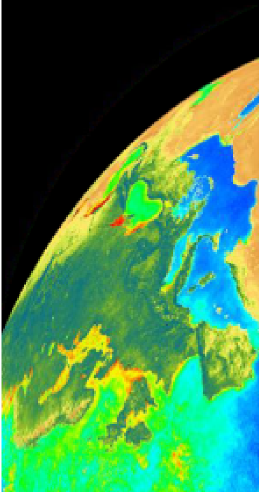
mixed layer down to 200 meters

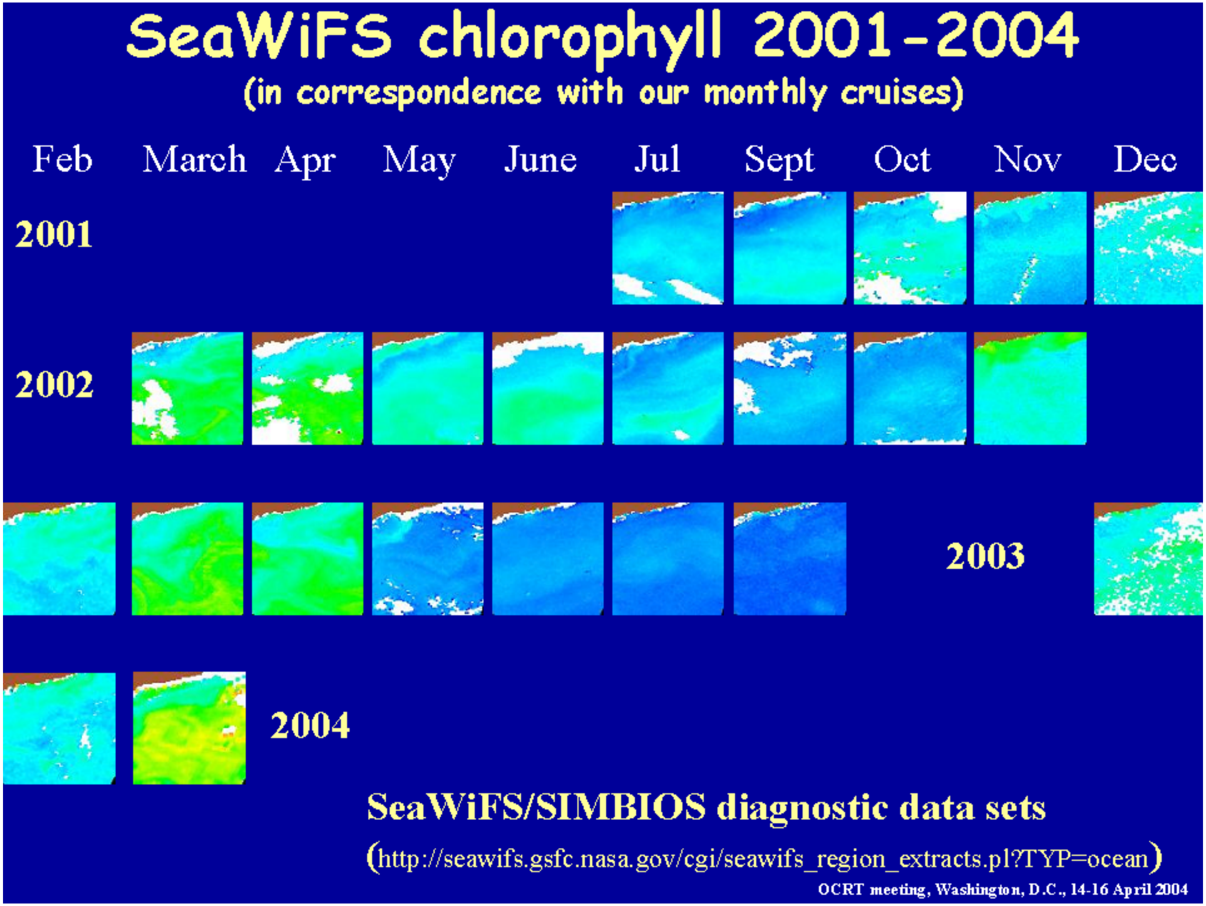
Spring, establishment of the deep chlorophyll maximum around 50 meters
Chl ~ 0.3 mg m^{-3}

Summer, maximum of the stratification. DCM is maximum, with surface Chl ~ 0.05 mg m^{-3} (up to 1 in the DCM)

Fall, erosion of the thermocline, the DCM progressively disappears
Chl ~ 0.5 mg m^{-3}

Ocean Color





SeaWiFS chlorophyll 2001-2004
(in correspondence with our monthly cruises)
Feb
March
Apr
May
June
Jul
Sept
Oct
Nov
Dec
2001
2002
2003
2004
SeaWiFS/SIMBIOS diagnostic data sets
(http://seawifs.gsfc.nasa.gov/cgi/seawifs_region_extracts.pl?TYP=ocean)
OCRT meeting, Washington, D.C., 14-16 April 2004

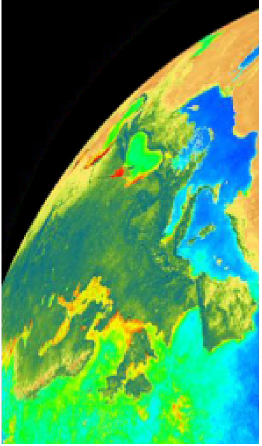
Motivations

Establishing a time series of inherent and apparent optical properties (IOPs and AOPs), with two parallel objectives :

- **<u>Science objectives</u> : short-term changes in IOPs and AOPs, relationships between both, role of CDOM, seasonal and inter-annual changes, bidirectionality of the ocean reflectance...**

- **<u>Operational objective</u> : vicarious calibration of ocean color observations from space, and validation of the level-2 "geophysical products" (*e.g.*, chlorophyll, normalized radiances).**

Ocean Color



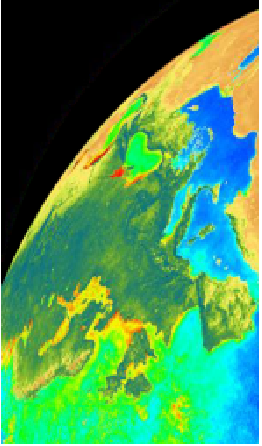
Strategy

Combination of 3 elements :

- A <u>deep sea mooring</u>, collecting data on a "continuous" basis

- <u>Monthly cruises</u> for collecting data that are not accessible to the mooring (vertical profiles, water sampling), as well as for servicing the mooring

- A <u>coastal AERONET station</u>, providing the necessary information about the aerosol properties, which are a central element of the vicarious calibration process



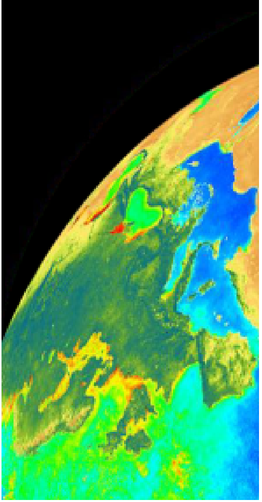
Measurement suite

- **Buoy:** Surface irradiance (E_s), downwelling irradiance (E_d), upwelling irradiance (E_u) and upwelling radiance at nadir (L_u) at 4 and 9 meters (7 λ's), attenuation coefficient, backscattering coefficient (2 λ's), chlorophyll fluorescence. Temp., Pressure, Salinity at 9 meters, buoy tilt and compass.

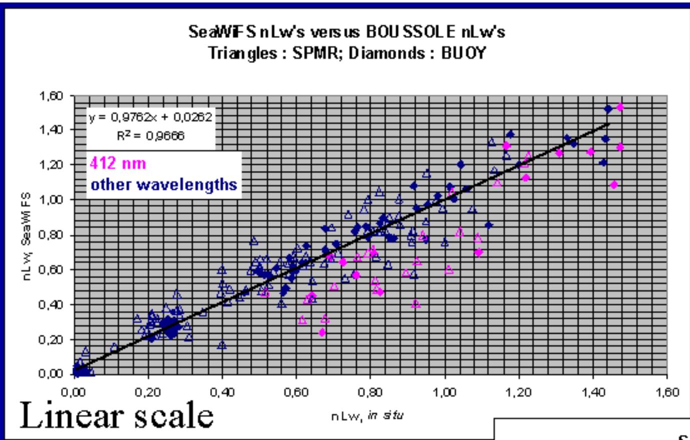
- **Monthly cruises** In-water profiles of E_d and E_u at 13 λ's (SPMR/SMSR), above water determination of L_w, phytoplankton pigments (HPLC), phytoplankton absorption (filtered water), total absorption, scattering and attenuation coefficients at 9 λ's (AC9 profiles), backscattering profile (Wetlabs' eco VSF) and CDOM fluorescence (Wetlabs' CDOM WetStar). Aerosol optical thickness.

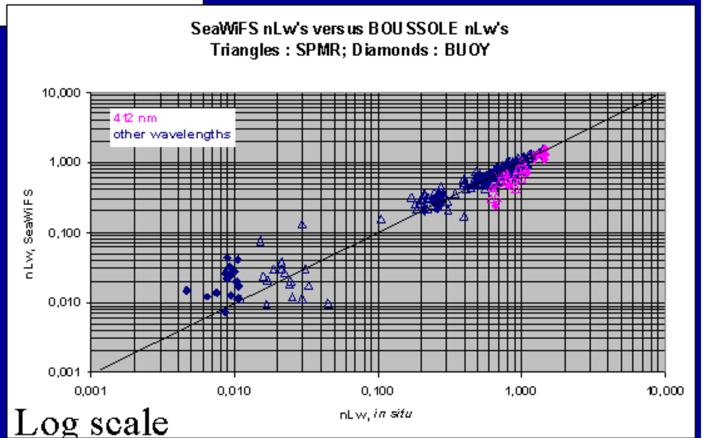
- **Coastal AERONET Station (sun photometer)** : aerosol optical thickness, sky radiances (aerosol type).

Ocean Color



Examples of SeaWiFS matchups (nLw's)





15 points from the buoy (3-month deployment in fall 2003) & 18 from the SPMR (monthly cruises)

Project "time table"

Monthly cruises started in July 2001

Buoy deployments :

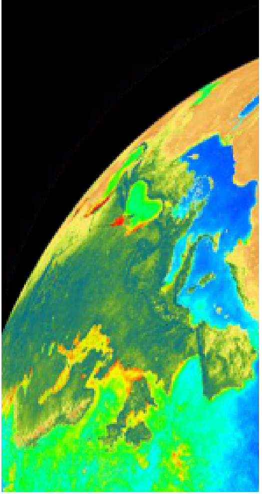
- July to October 2000 : qualification deployment
- May 2002 : first, unsuccessful deployment
- Sept 6 - Dec 6, 2003 : 3-month successful deployment
- Since March 4, 2004 : buoy again at sea
- Plan is now to make rotations on site with 2 systems

AERONET site, data collection periods :

- July 2002 to April 2003
- January 2004 - ongoing

Project should extend throughout the MERIS life

Ocean Color



Funding Agencies / Supports

European Space Agency

Centre National d'Etudes Spatiales, France

National Aeronautics and Space Administration of the USA

The SIMBIOS project

Centre National de la Recherche Scientifique, France

Institut National des Sciences de l'Univers, France

Observatoire Océanologique de Villefranche sur mer, France