International Ocean Colour Science Meeting 2017

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Research and applications of ocean colour radiometry in the very turbid waters of the Río de la Plata (Argentina)

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IAFE CONICET UBA

QUANTITATIVE REMOTE SENSING MARINE DIVISION

UMI - 3351 IFAECI CNRS CONICET

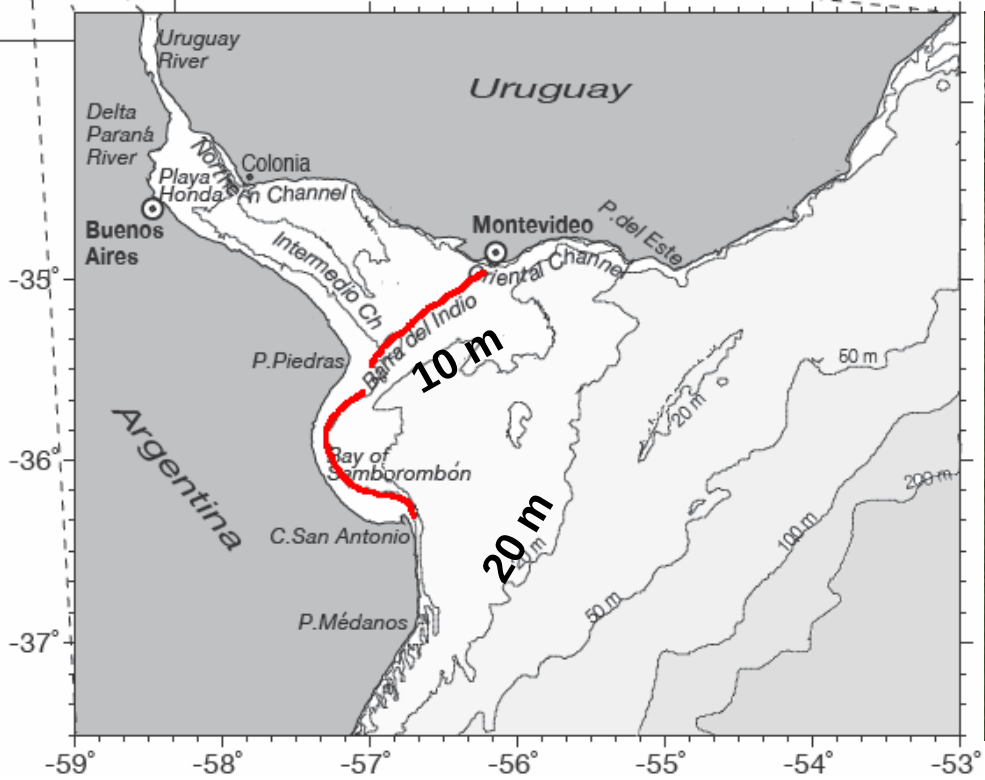
Aim & outline of the talk

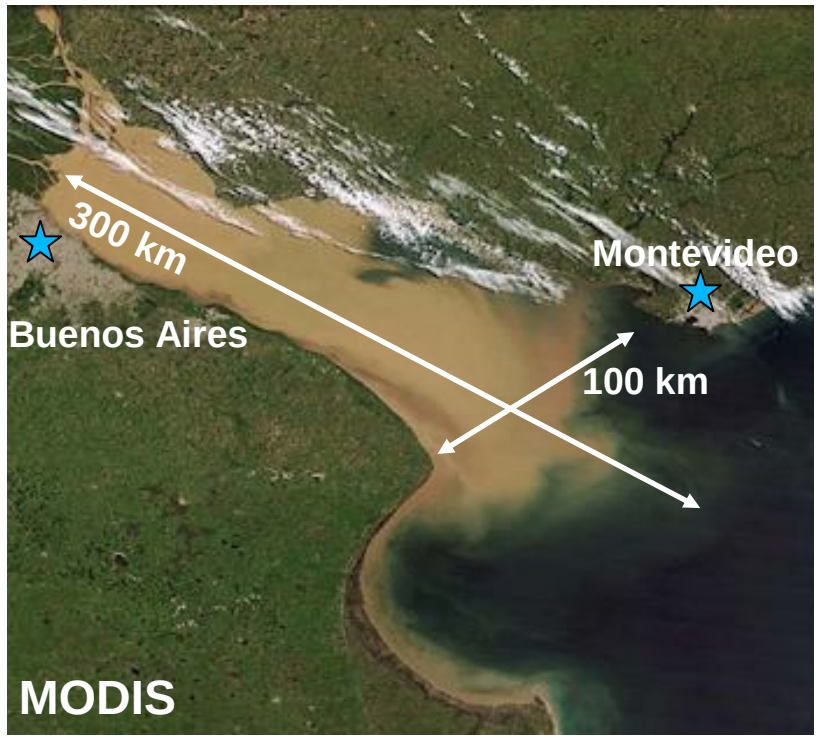
Present research results and applications of OC on the highly turbid waters of Río de la Plata (RdP)

- Present the characteristics and importance of the RdP
- Development and validation of algorithms (AC, turbidity)
- Applications (time-series analysis of T, FV detection,...)
- Context and short history of research and activities

Study Area: Río de La Plata

- Large and wide funnel-shape estuary, shallow waters (<10m);
- Drains 2da largest basin in SA (22,000 m^3/s)
- High TSM concentrations (100-300 mg/l) -> Bermejo river (~8,000 mg/l)
- Turbidity front (topography)





Environmental & Socio-Economical importance of RdP

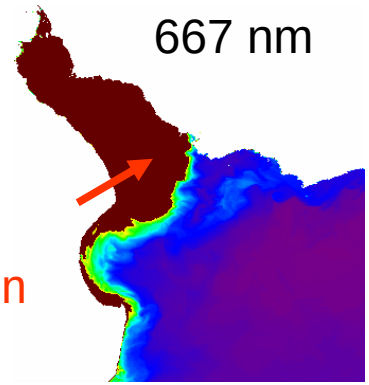
- The capital cities (Buenos Aires and Montevideo), harbours, resorts and industrial centers are located on its margins and influence zone.
- Main source of drinking water for the millions of inhabitants
- Important recreational area
- Intense dredging activities
- It acts as an important spawning and nursery area for estuarine species that are commercially exploited and support coastal fisheries of Argentina and Uruguay

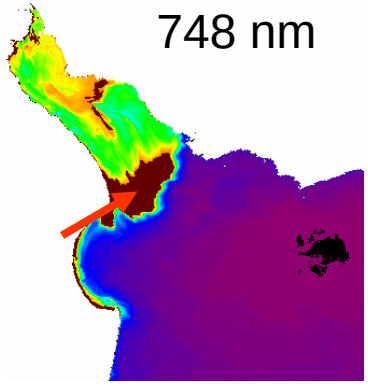
RS is a powerful and useful tool, but retrieving information is challenging and gives the opportunity to improve algorithms: AC & retrieval of in-water constituents

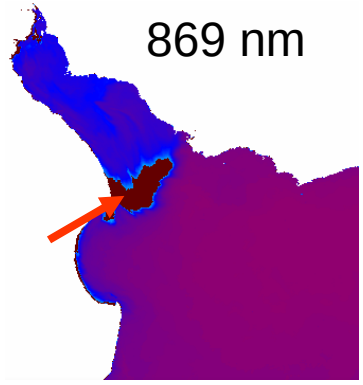
Some difficulties with OC sensors… **saturation**! (MODIS)

RED/NIR
Ocean bands
(1 Km)

Sensor
Saturation

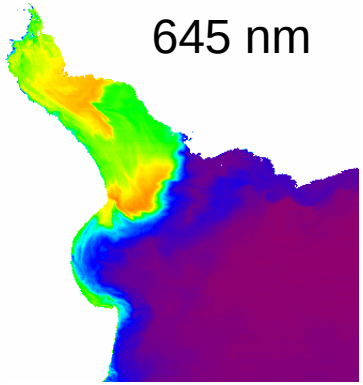


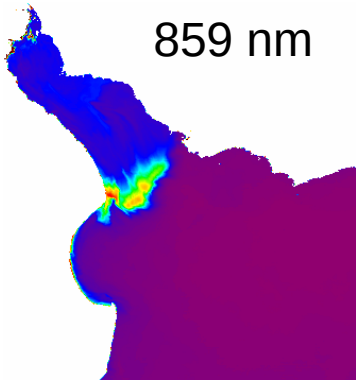




RED/NIR
Land bands
(250 m)

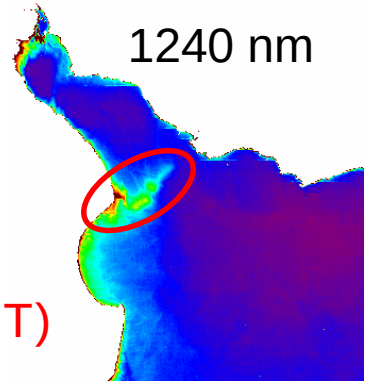
OK

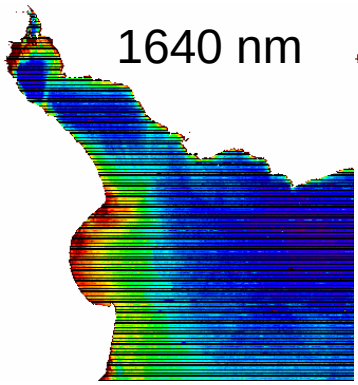


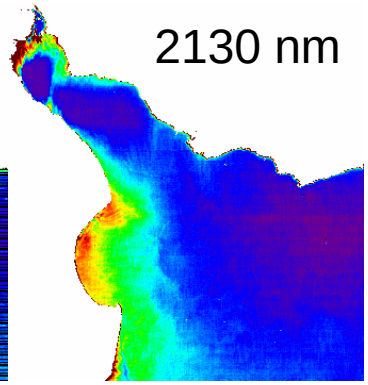


SWIR bands
(500 m)

(water signal Max T)

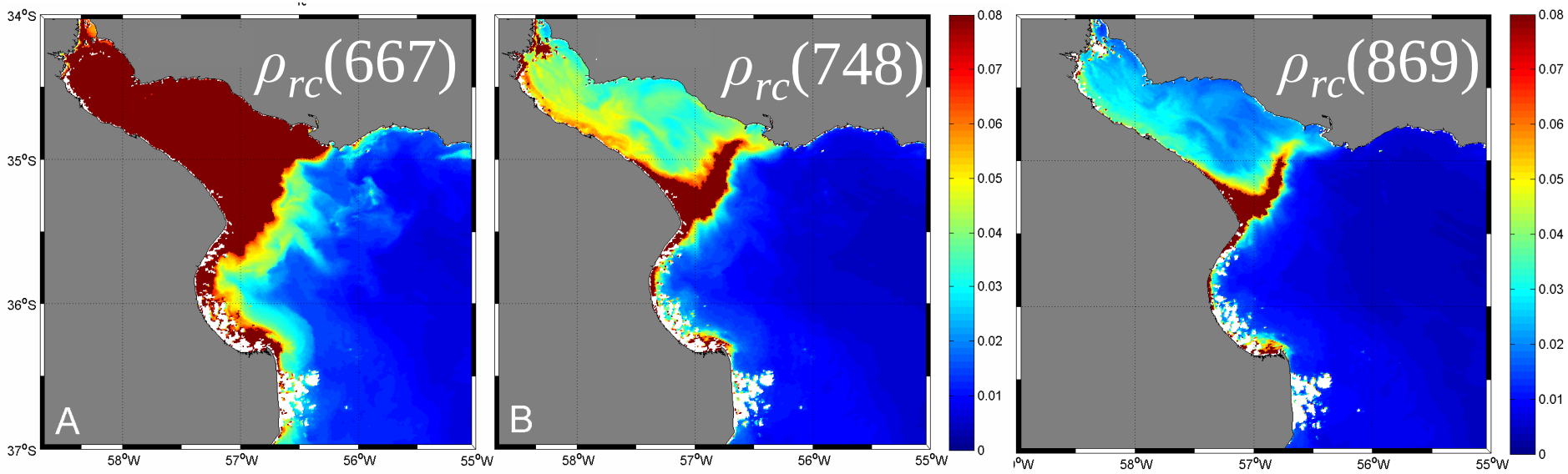






Atmospheric Correction algorithms

1) Standard NIR approach



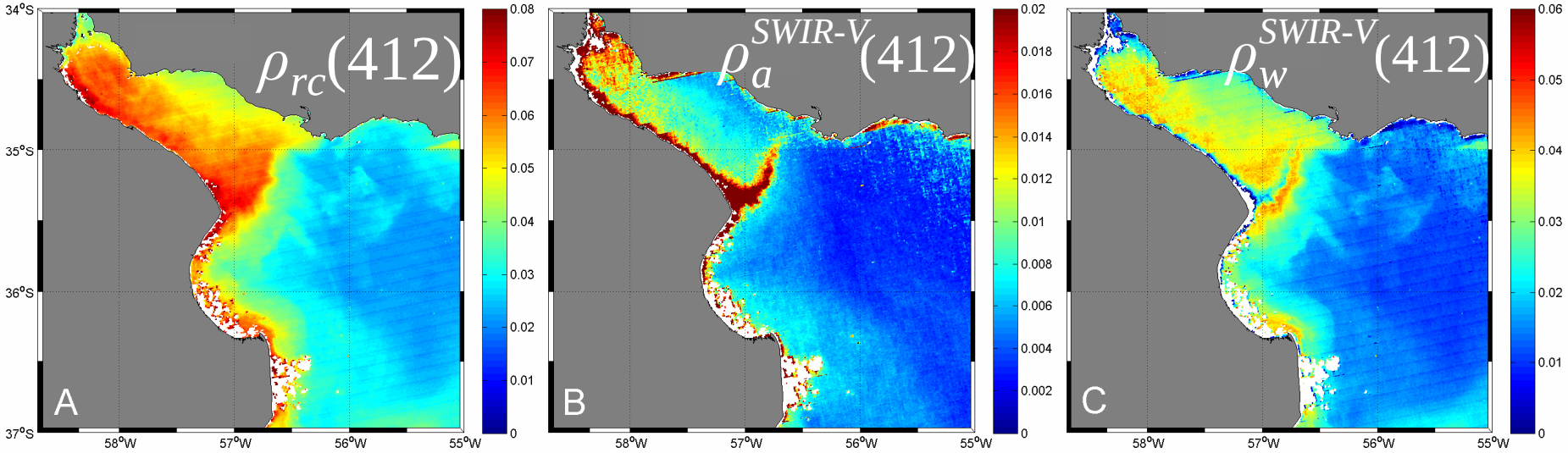
- Complete failure due to sensor saturation in the 667 and 748 nm bands which are used in the AC.

(Dogliotti et al. 2011)

AC algorithms performance (qualitative)

2) NIR-SWIR approach (SWIR-V)

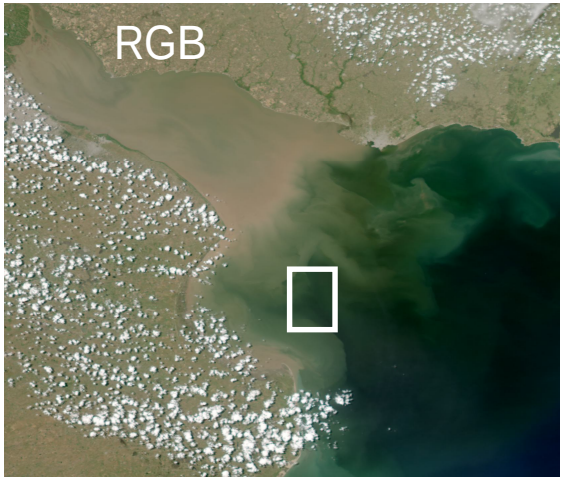
Raleigh-corrected | Aerosol | Water



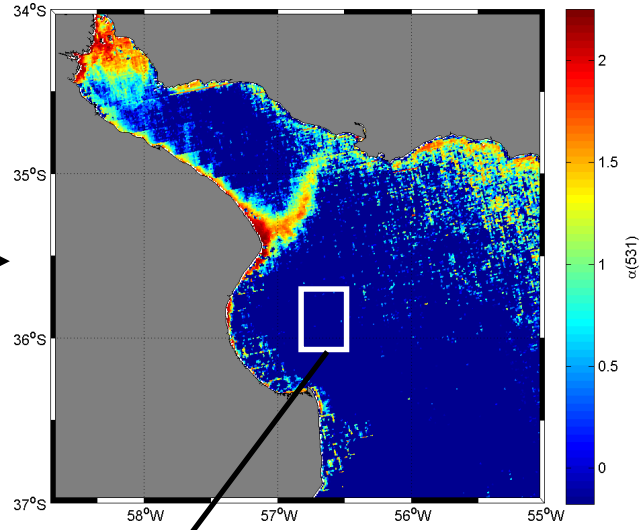
- Unphysical correlation between the atmospheric $\rho_a(412)$ product and a marine feature due to non negligible reflectance in the 1240 nm SWIR band

(Dogliotti et al. 2011)

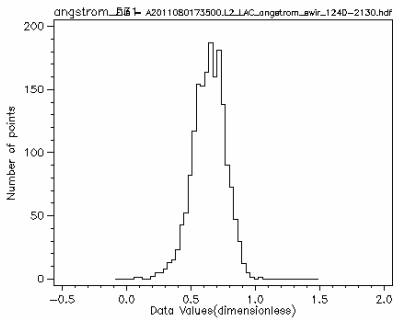
NIR/SWIR – F (Fixed aerosol type)

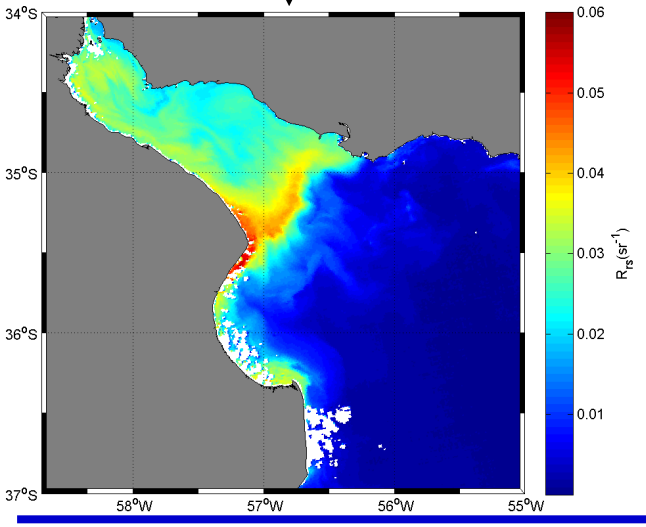


(1) SWIR(1240-2130)
α(531)



(2) AC fixed α(531)

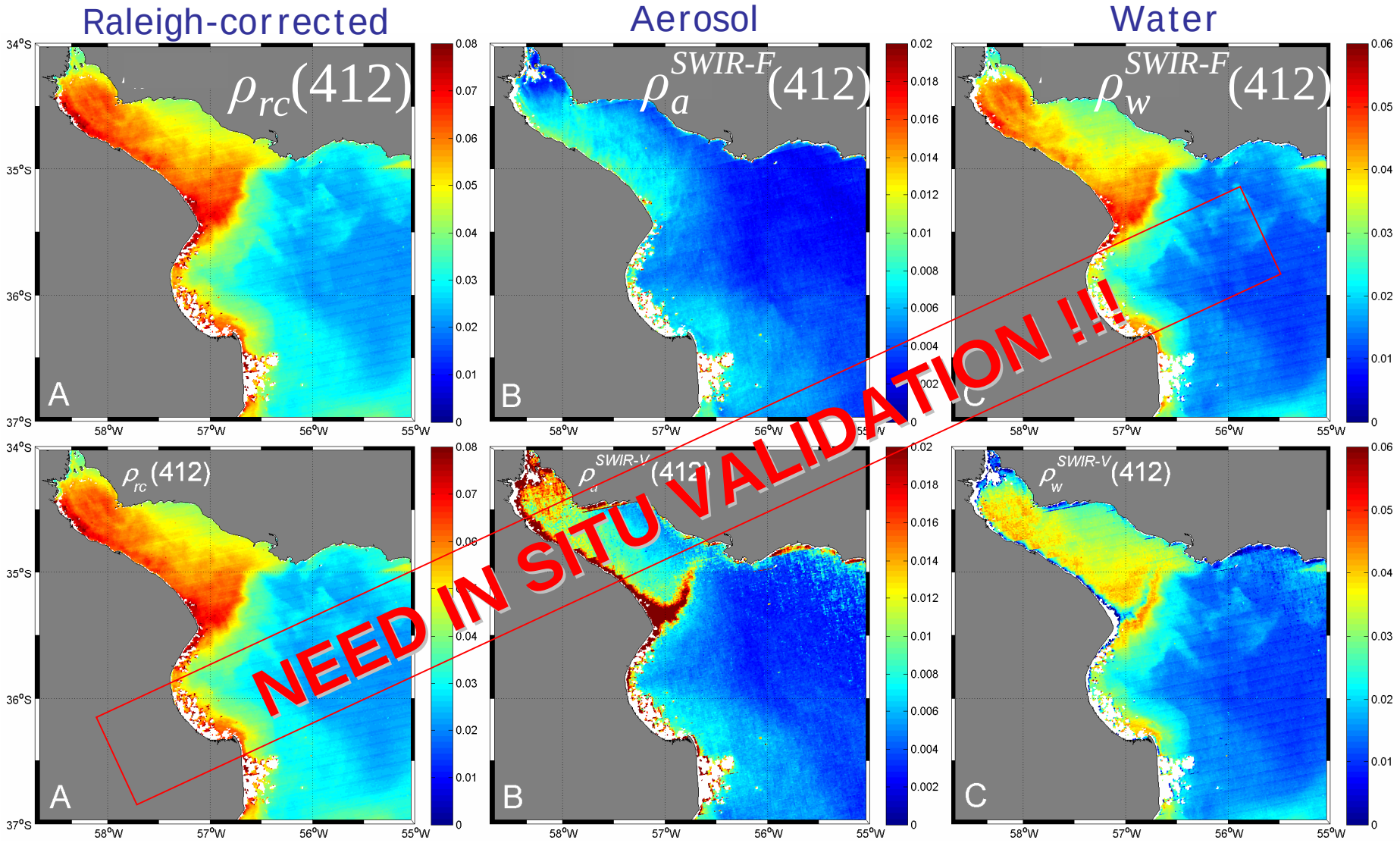




(Dogliotti et al. 2011)

AC algorithms performance (qualitative)

3) NIR-SWIR approach (SWIR-F)

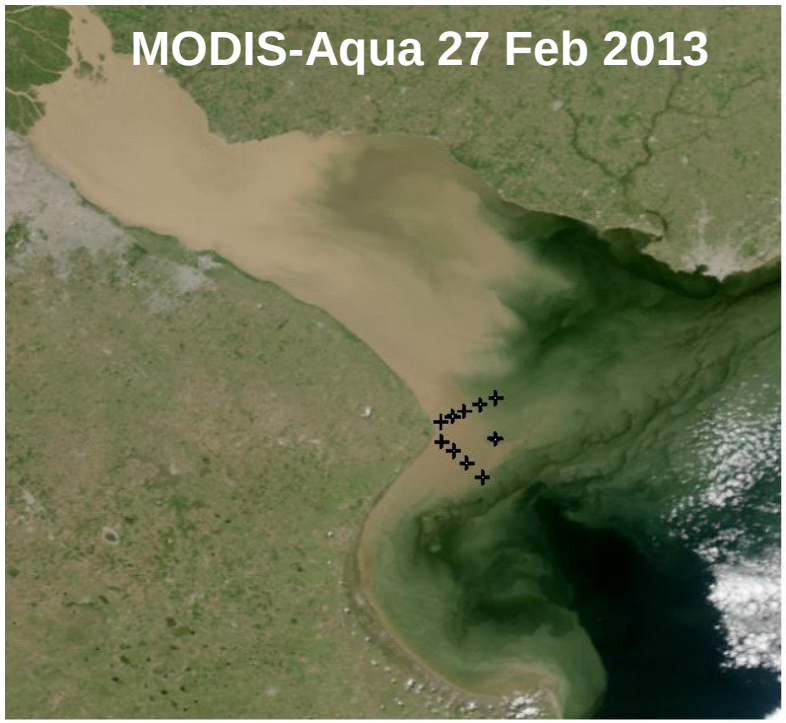


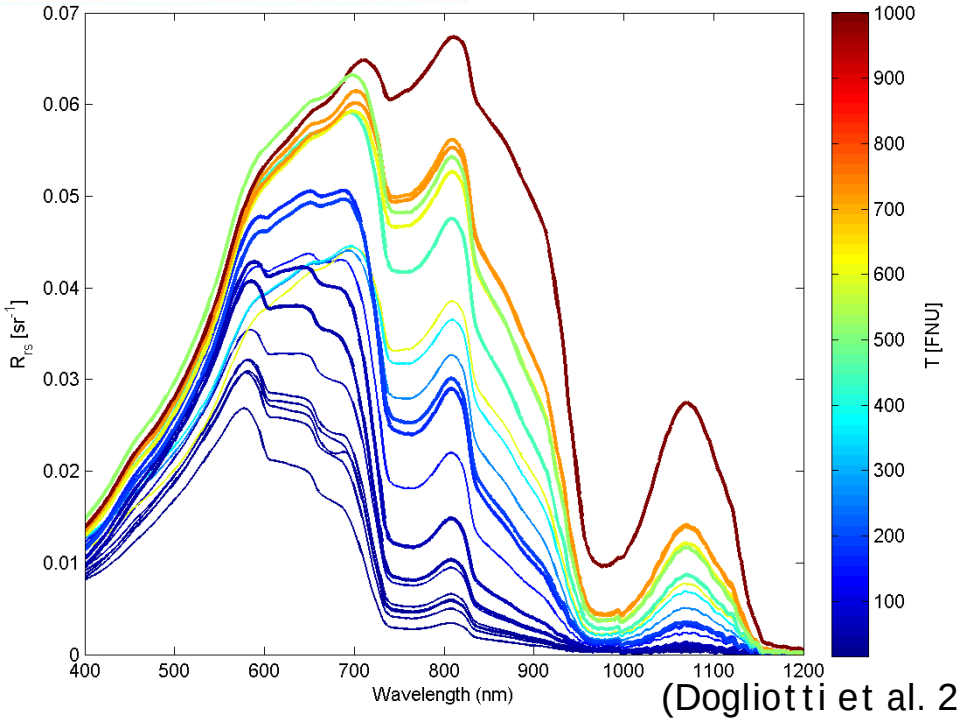
AC algorithms performance (quantitative)

Field measurements in 2013 (!!!)

- Reflectance: ASD Fieldspec FR spectrometer (350-2500 nm) <- CONAE
- Turbidity (*T*): HACH2100P ISO turbidimeter [FNU] <- IAFE
- Total Suspended Matter (*TSM*): gravimetry [mg L-1] <- DCAO/UBA

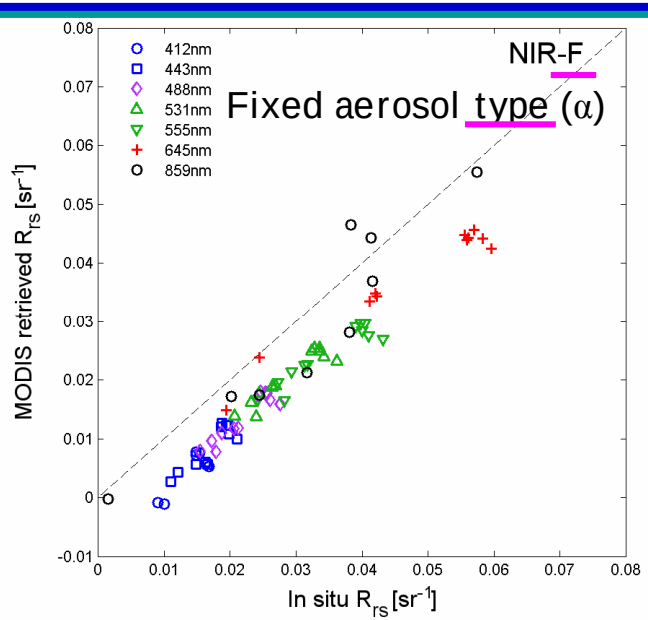
Date	*T [FNU]*	*TSM [mg L^{-1}]*	*# St.*
27 Feb 2013	16-602	16-664	11
30 Apr 2013	41- >1000	25-940	12

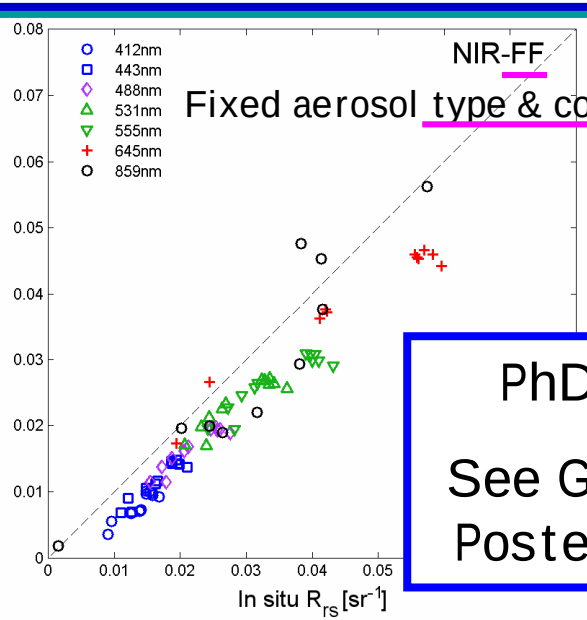




(Dogliotti et al. 2014)

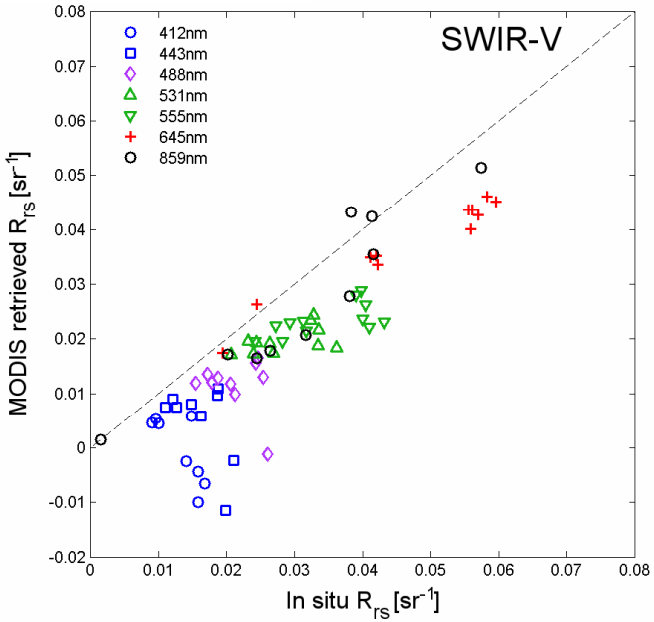
AC algorithms performance (quantitative)

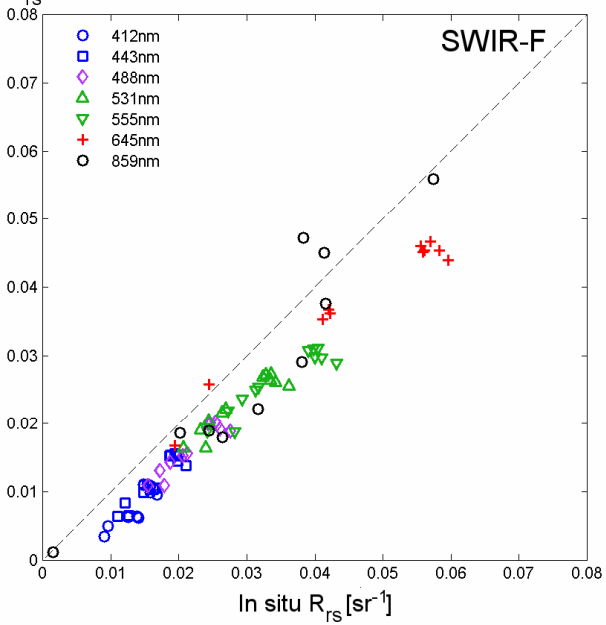


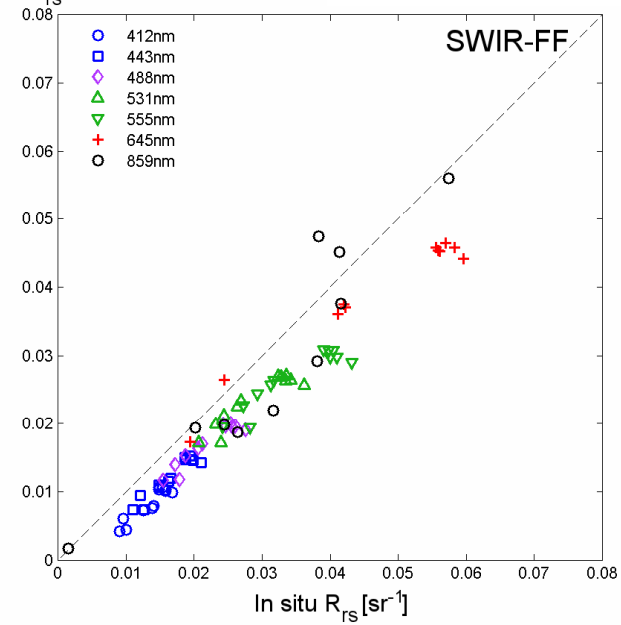


PhD Thesis

See Gossn et al Poster Session

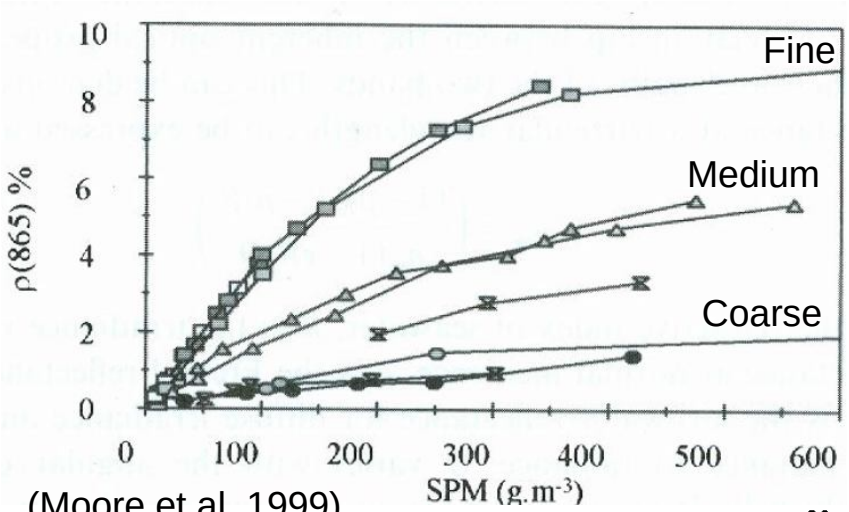






Sediments… SPM vs Turbidity

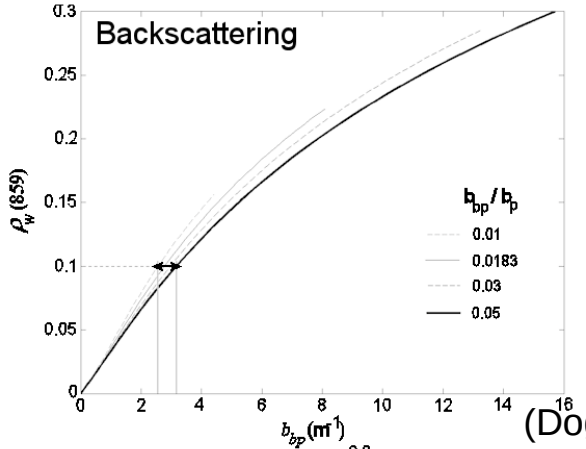
- Sediment transport studies
- quantified as mass per unit volume
- ρ_w vs SPM varies with sediment type



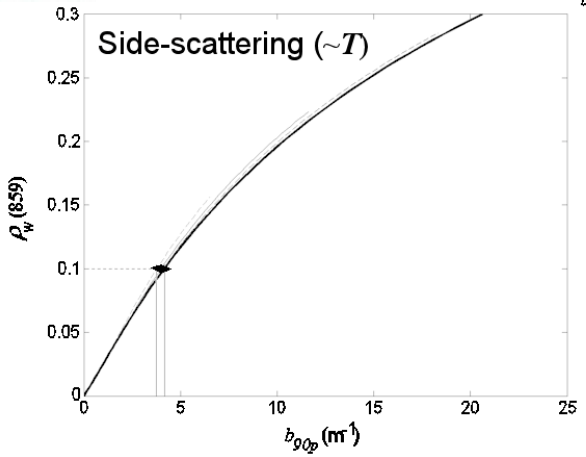
(Moore et al. 1999)

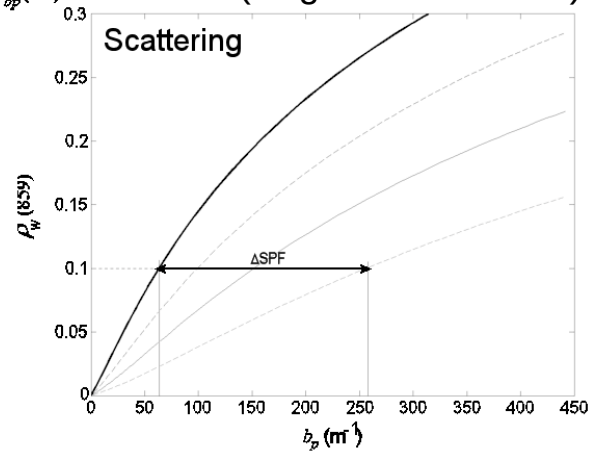
- Assess water quality
- 90° side-scattering of light at 860 nm with respect to Formazin (ISO)
- Optical property more related to ρ_w

Sensitivity to Scattering Phase Function (△SPF)



(Dogliotti et al. 2015)





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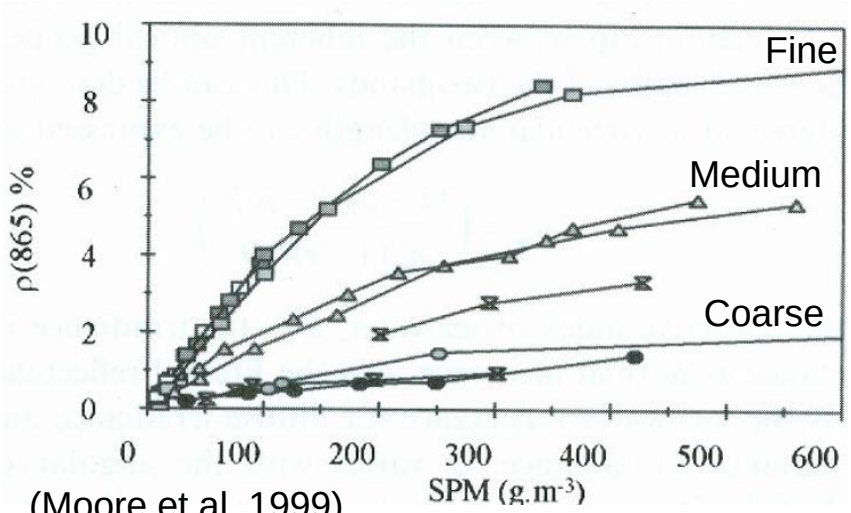


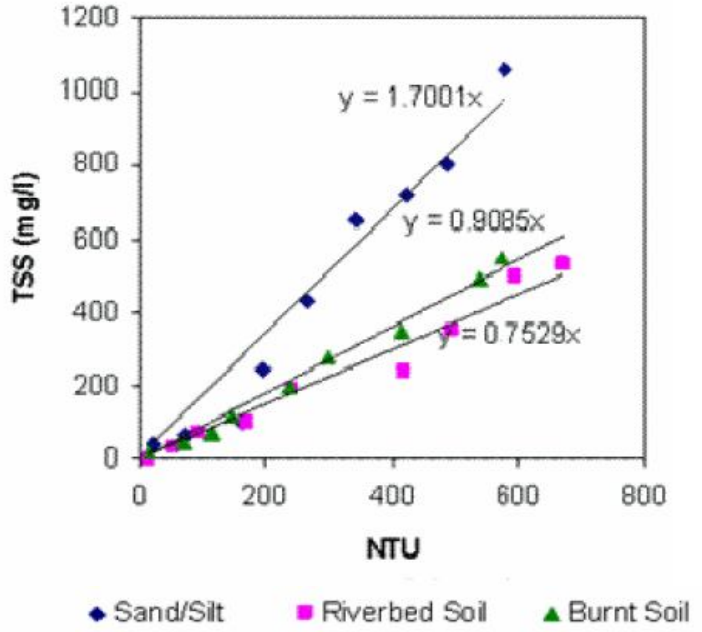
(Moore et al. 1999)

- Needs regional calibration (ρ_w & SPM)

- Assess water quality

•90° side-scattering of light at 860 nm with respect to Formazin (ISO)

•Optical property more related to ρ_w



- Highly correlated with SPM, but depends on the sediment type

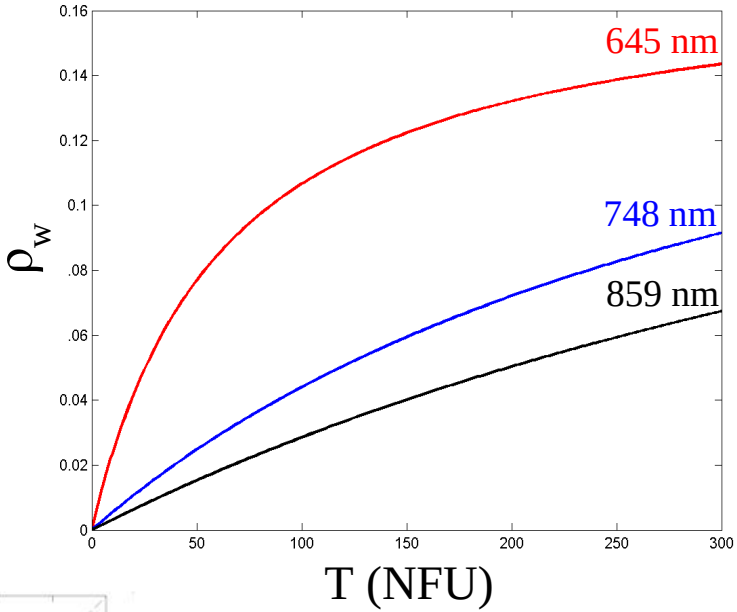
•Needs regional calibration (T & SPM)

General Turbidity algorithm

$$T_\lambda = \frac{A_T^\lambda \, \rho_w(\lambda)}{(1 - \rho_w(\lambda) / C^\lambda)} \quad [\text{FNU}]$$

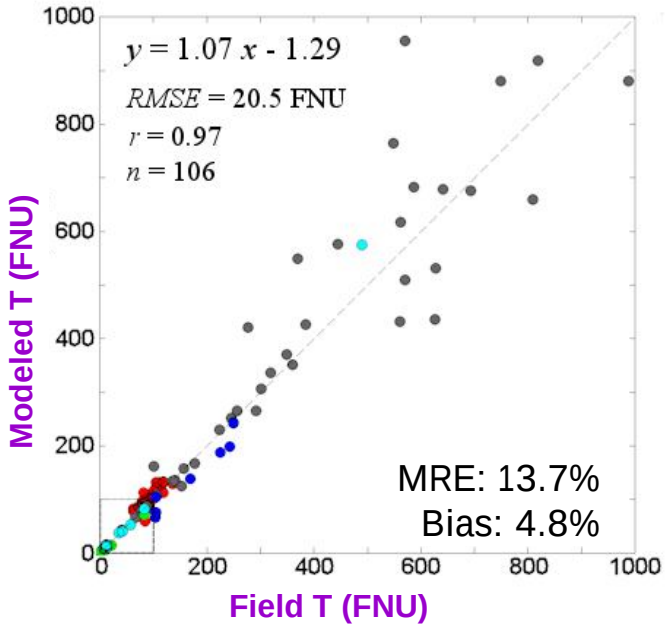
$A_T^{645} = 228.1$ FNU $C^{645} = 0.1641$

$A_T^{859} = 3078.9$ FNU $C^{859} = 0.2112$



Validation

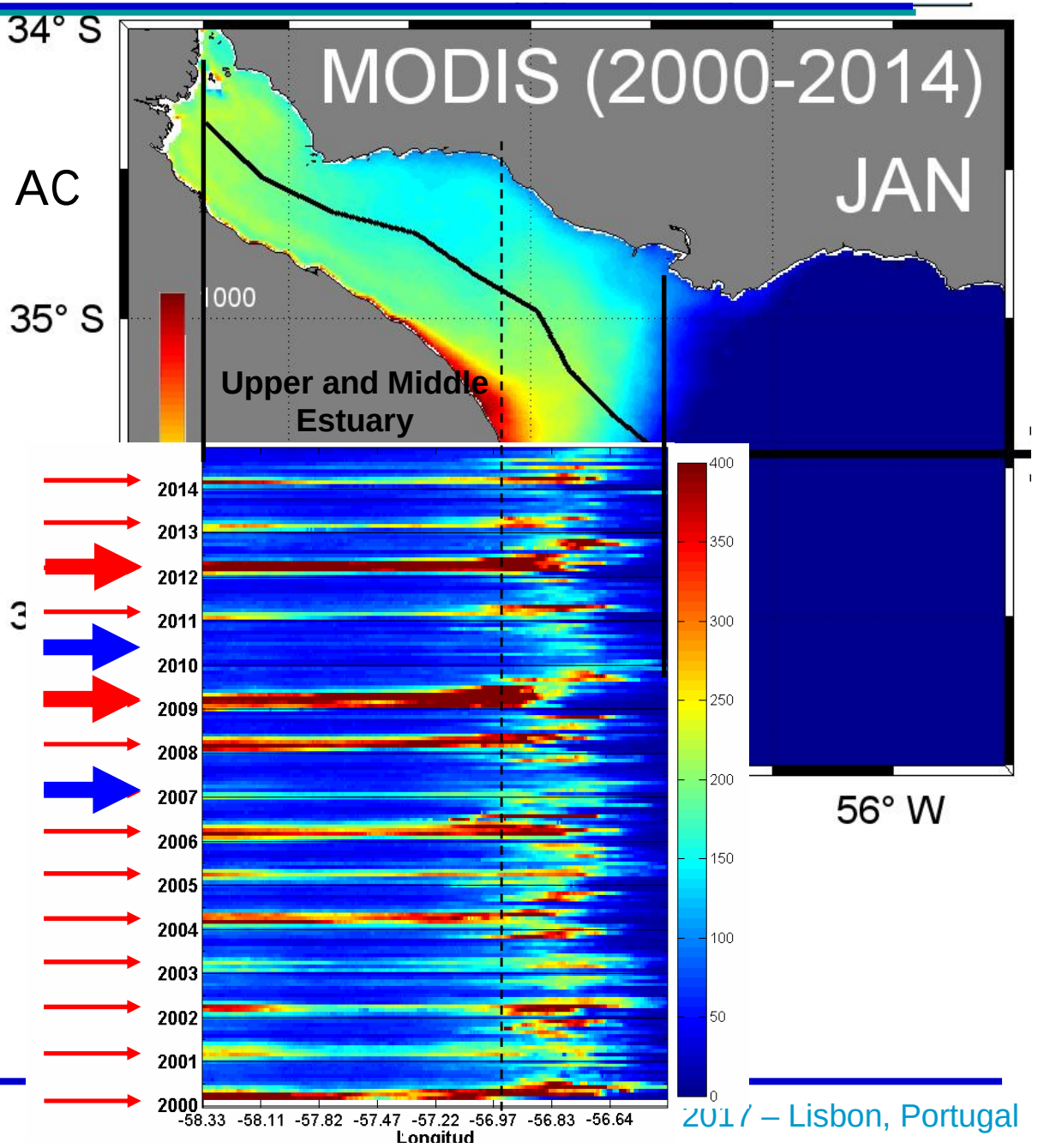
Southern North Sea
Scheldt
Gironde
French Guyana
RdP



(Dogliotti et al. 2015)

Application: Seasonal-Interannual T variability

- MODIS (2000-2014)
- NIR/SWIR switching AC
- Turbidity maps



Seasonality

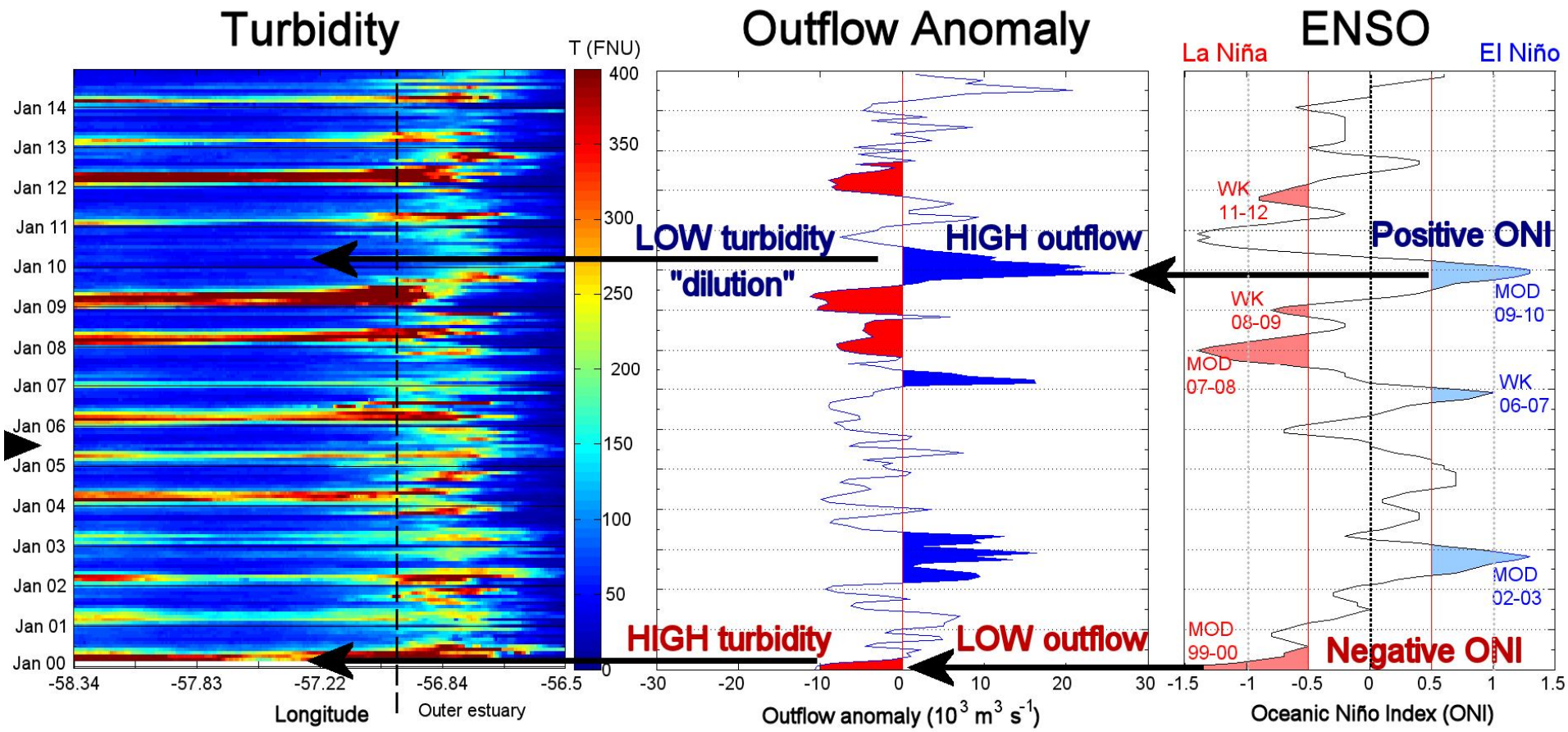
Max: Mar-Apr

Min: Aug-Sep

Inter-annual variability

Seasonal-Interannual Turbidity variability

- **RdP outflow:**
  - High discharge -> Low turbidity
  - Low discharge -> High turbidity
- **ENSO**
  - Niño -> Increased precipitation
  - Niña -> Reduced precipitation

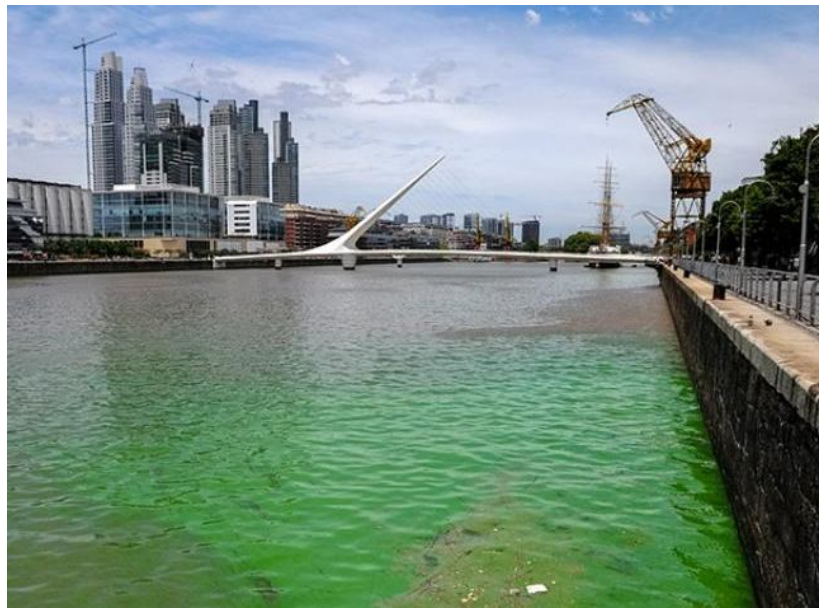


Not only sediments… not always is brown…

Blooms of cyanobacteria have been reported in the RdP (Argentina and Uruguay coasts) and their occurrence have increased in the last years

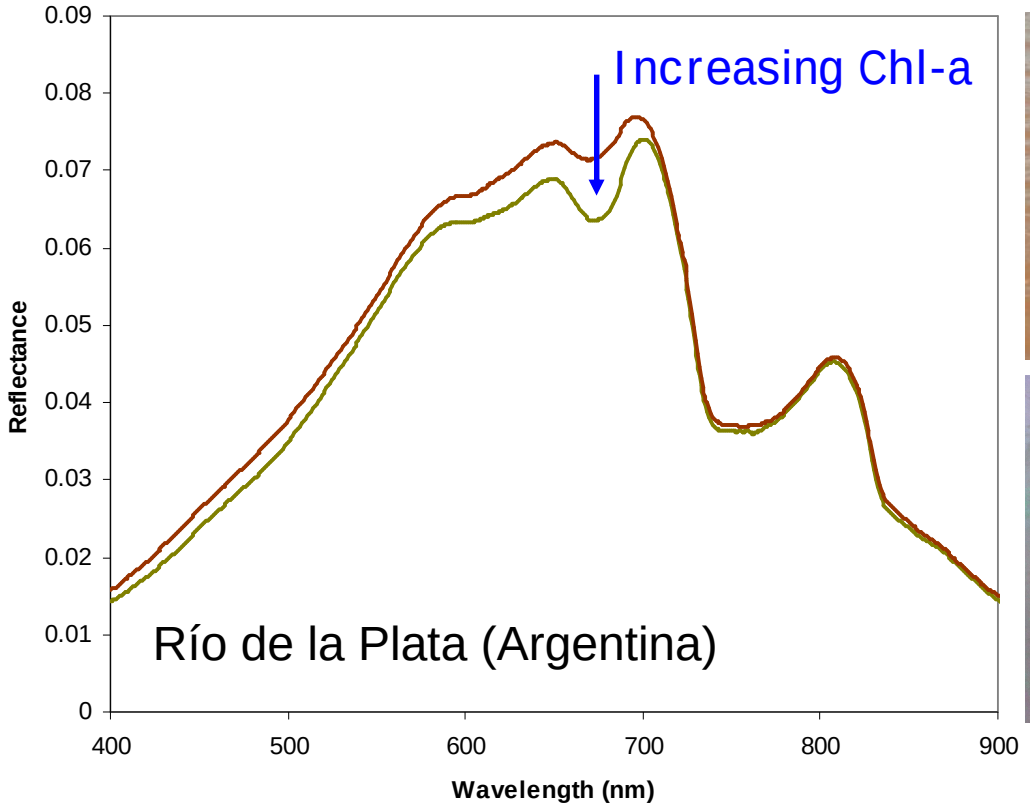
- ***Microcystis aeruginosa***
- ***Anabaena*** spp

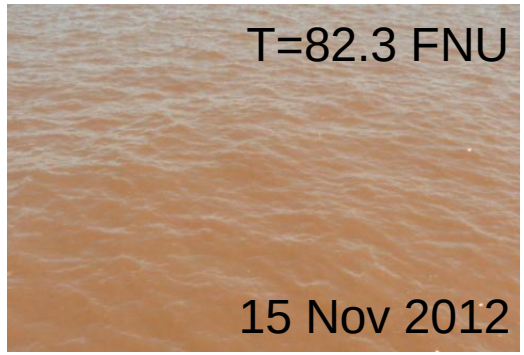
Buenos Aires November 2012

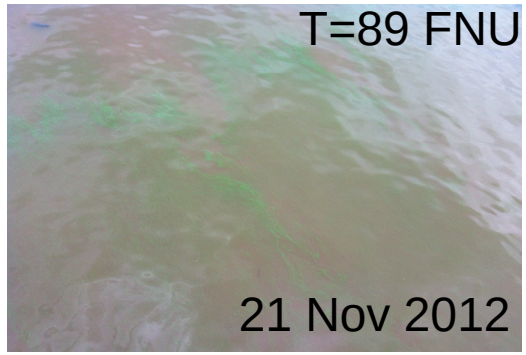


Retrieving Chl-a in turbid waters… mmm…

Nov 2012 Bloom -> Chl-a reached values ~22 mg/m^3





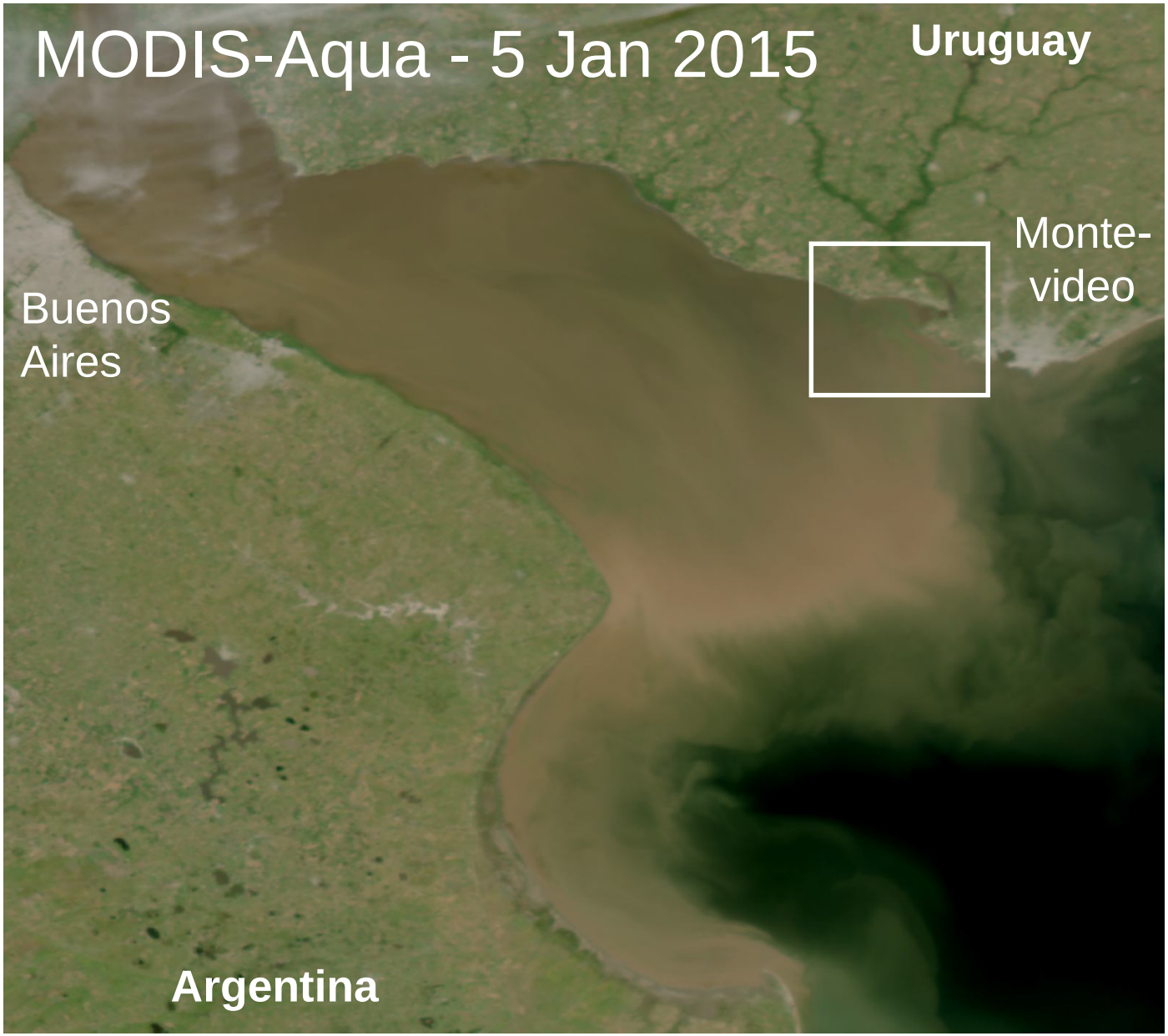


Microcystis sp.

RED:NIR ratio algo in highly productive turbid waters

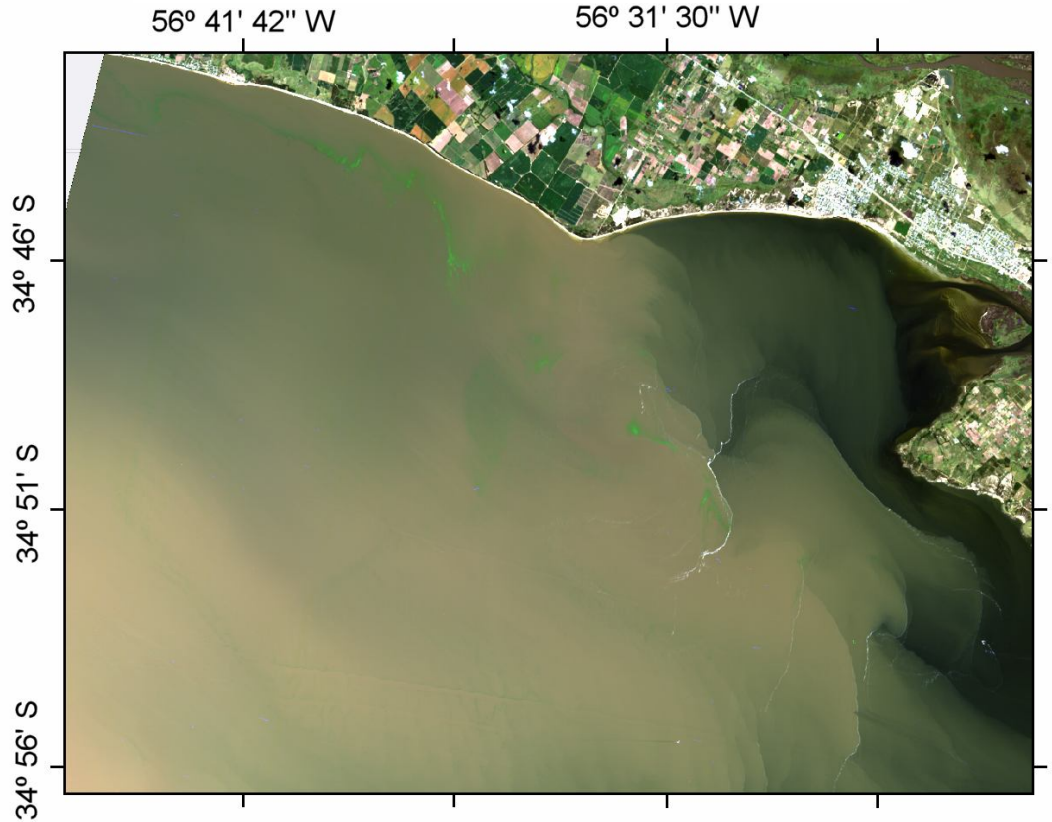
- Chl-a absorption peak at 676 nm (less affected by NAP & CDOM)
- Increase in NIR (>700nm) due to scattering

Other cyanobacterial blooms in the RdP



Other cyanobacterial blooms in the RdP

Landsat-8 RGB (23 Feb 2015)



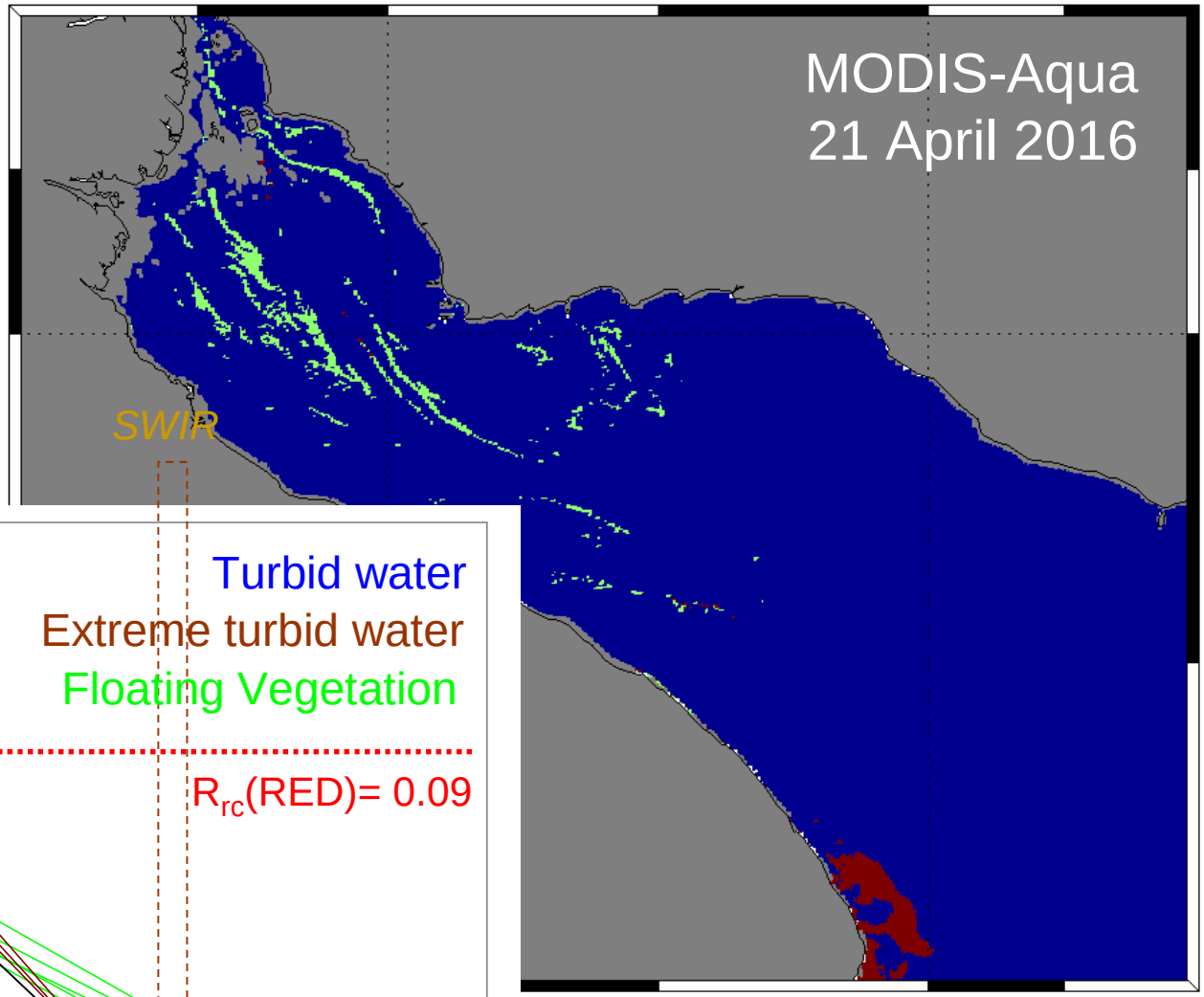
Cyanobacteria bloom (*Microcystis spp*)

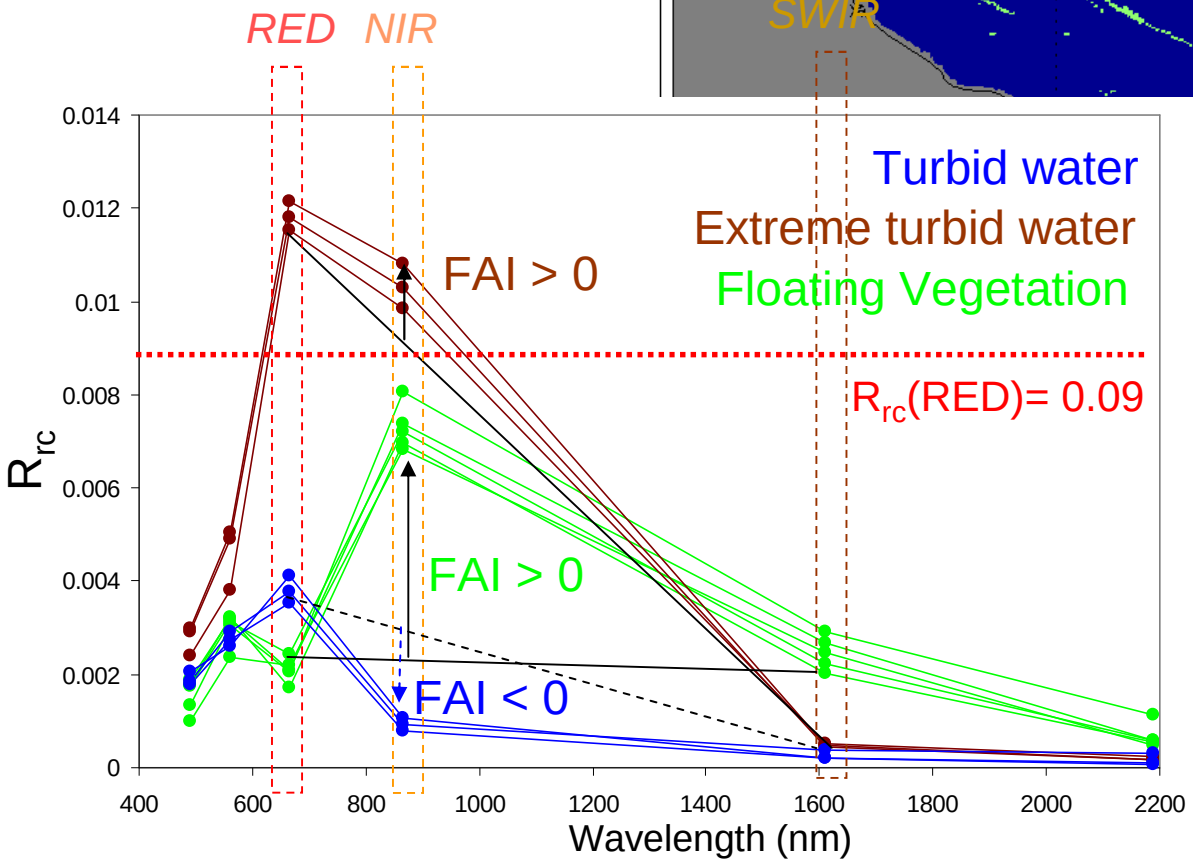
Another green (temporal) inhabitant of the RdP

Jan-Apr 2016 -> Large invasion of Floating Vegetation

Aquatic Hyacinth
(Eichhornia crassipes)

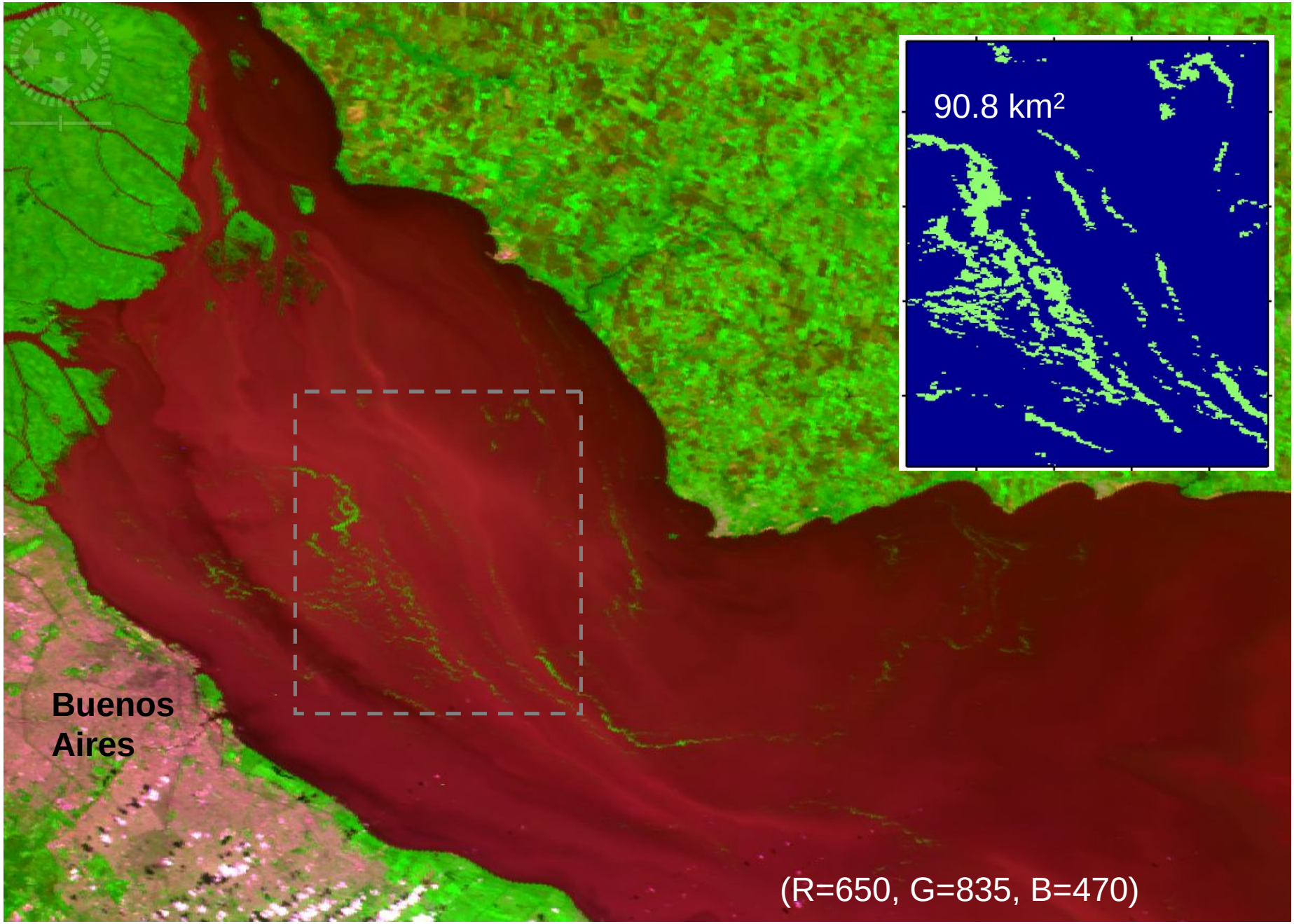
FAIT : Modified Floating Algal Index for Turbid waters





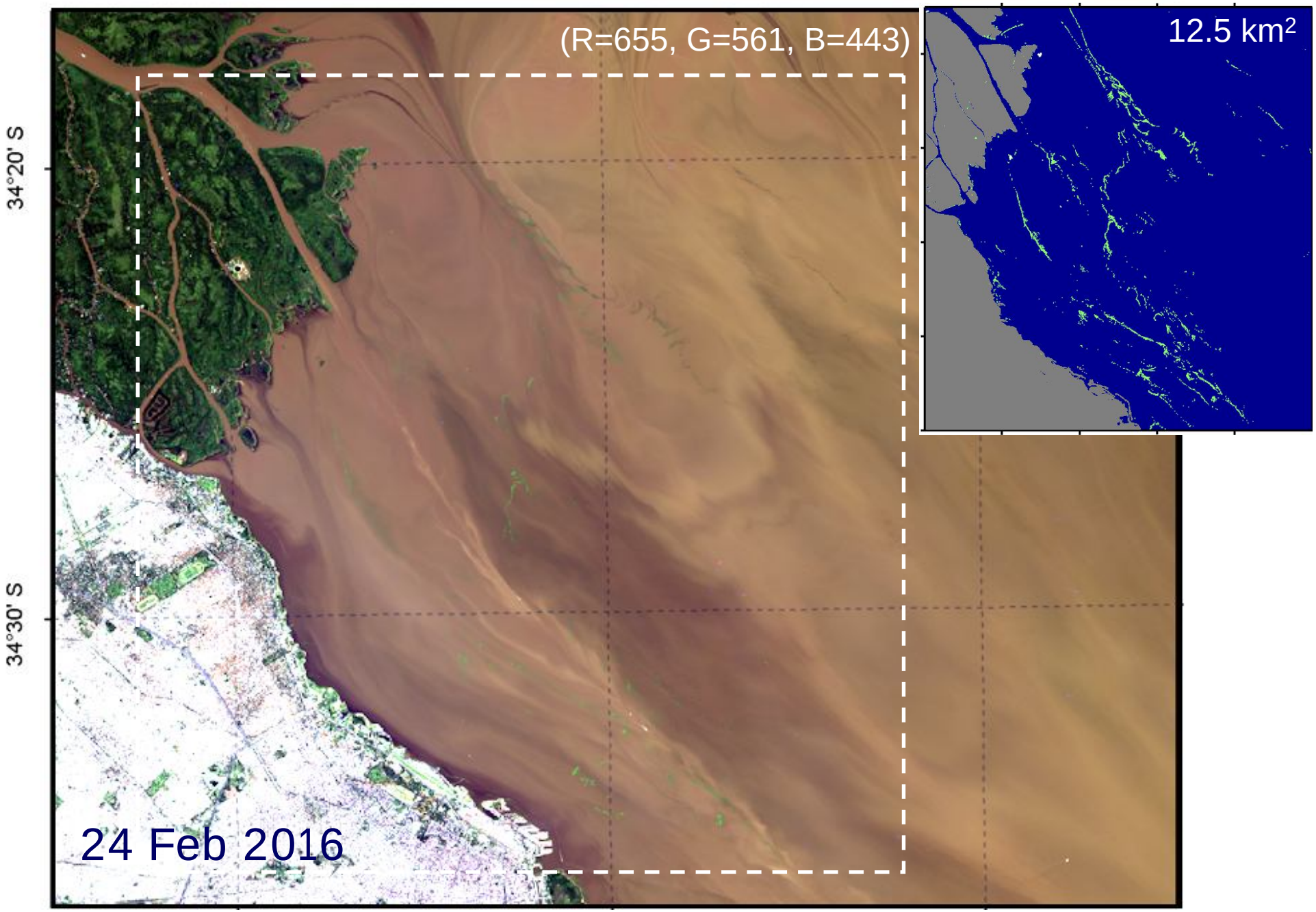
(Dogliotti et al. 2016)

PROBA-V (100 m) 22 Apr 2016 **FAIT**



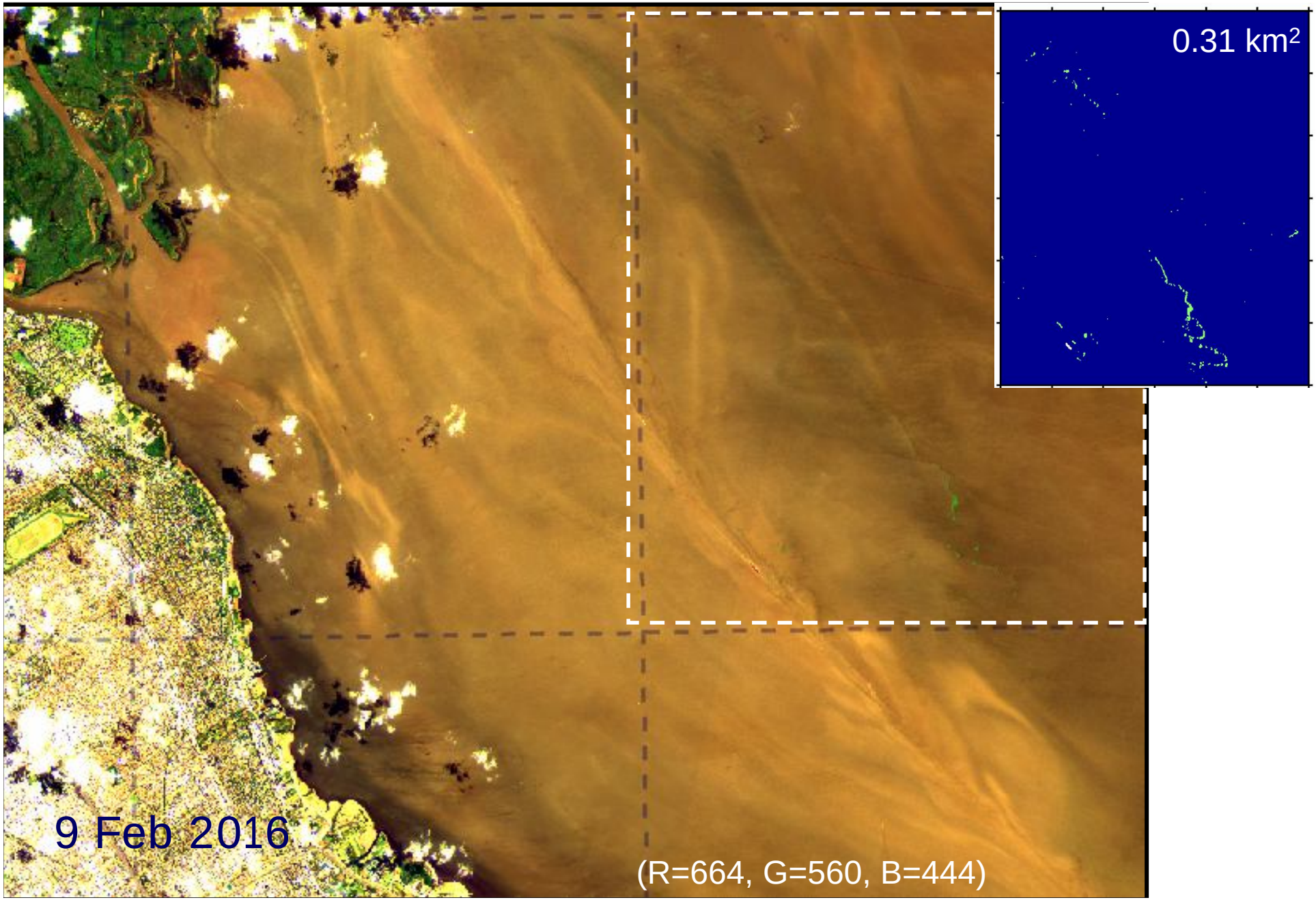
Landsat 8-OLI (30 m)

FAIT



Sentinel 2A-MSI (10 m)

FAIT



RdP: not only a highly turbid river…

It's a very interesting system to study:

- Socio-economical importance
- Challenging optically complex waters

What's next?

- Set-up a site for Cal/Val for exiting and future OC missions (Argentine-Brazilian OC mission SABIA-MAR) [AERONET-OC type or Hyperspectral]

But not everything is easy… so it worths a bit of context and short history of research and activities…

Training course - 2001

Report of the IOCCG co-ordinated course on Remote Sensing of Ocean Colour: Analysis and applications

December 3 - 13, 2001
Cape Town, S. Africa

Convenor: Professor Frank Shillington, Department of Oceanography, University of Cape Town, Rondebosch, S. Africa

A ten day training course
of ocean colour: analysis
held at the University of
from 3-13th December 2
young scientists participa
African countries, and on
Argentina [view list of p
held in the GIS lab share
of Oceanography and the
Environmental and Geog
University's upper campu
accommodated in the University of Cape Town's All Africa Ho
provided by the University Staff Club.

The course used the very dynamic Benguela Upwelling System
an example where there is good satellite data, for the "hands on
fundamental SeaWiFS image analysis. Students had access to da
composite ocean colour and SST data, and were introduced to t
cloud cover, and digital representation of the images. Typical in
such as calculating the histogram of pixel values, colour bar enh
were used by the students to display the images.

The software used was the UNESCO supported Bilko package. Each student had access to a Pentium III PC attached to the network and internet facilities. A copy of SeaDAS on a SGI ORIGIN 2000 mini supercomputer was available. Students reported that the local internet connection was far superior to what they had "at home". In fact, some students downloaded 300 Mb of data to take back with them. Unfortunately the individual CD ROM's with the Bilko software that were to be distributed to the students, did not arrive before the course ended, but these will be posted to the students shortly.

The mornings were devoted to lectures on a variety of topics by active researchers in the South African region. These included a brief report on the IOCCG functions, a review of the Benguela Upwelling System Dynamics, and elementary background to satellite remote sensing, by the convenor (Dr Frank Shillington); detection of hydrogen sulphide in the Benguela System from SeaWiFS, by Scarla Weeks (Ocean Space and UCT); introduction and hands on demonstration of SeaDAS for ocean colour processing by Herve Demarq (IRD and IDYLE research Associate); in situ pigments by Dr Ray Barlow (M &; CM); apparent and inherent optical properties, and an introduction to primary productivity, by Ph.D student Stewart Bernard; an introduction to the OCM instrument on the Indian satellite IRS-P4 by Himmat Solanki (Indian Space Applications Centre); indices and record anchovy recruitment by Dr Claude Roy (IRD and IDYLE research Associate); neural network techniques analysing satellite and chlorophyll data by Dr Anthony Richardson (ENVIFISH researcher). [view schedule]

I would like to thank all the guest lecturers that helped to make the course a success: Dr Claude Roy, IRD and UCT; Dr Anthony Richardson, UCT, Dr Ray Barlow, Marine and Coastal Management, Cape Town; Ms Scarla Weeks, Oceanspace and UCT; Mr Herve Demarcq, IRD and M &; CM, Mr Stewart Bernard, UCT. Thanks is also due to the Centre for Marine Studies manager, Mr Emlyn Balarin for handling the logistical and financial support. The IOCCG Project Scientist, Dr Venetia Stuart, provided invaluable advice. Mr Jeremy Main provided computer assistance (especially when the power failed!). Naturally the students played the major role by sharing ideas and contributing their own particular expertise in the form of discussion of their projects. I really enjoyed the experience, and trust that the students gained a great deal of knowledge from the course.

Funding

Financial assistance was from IOCCG, the French South African project IDYLE and from UCT and M &; CM in kind.

Training course - 2002

Report on Primary Production Training Course

University of Concepción, Chile
21 October - 1 November, 2002

by Dr. Trevor Platt
Bedford Institute of Oceanography, Dartmouth, Nova Scotia Canada

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An advanced course on **"Primary Production: Theory, Modelling and Estimation by Remote Sensing"** was held from October 21 to 1 November, 2002 at the University of Concepción (UdeC), Chile. It was held under the auspices of IOC/UNESCO, the Chilean Ministry of Education (MECESUP), Minera Escondida, the DAAD, the UdeC's School of Graduate Studies and the Center for Oceanographic Research (COPAS), with additional funding from the International Ocean-Colour Coordinating Group (IOCCG) and from the Partnership for Observation of the Global Ocean (POGO) to facilitate participation by students from outside Chile. In all there were 26 students, of whom 8 were from Chile and 18 from elsewhere (7 other countries). See list of students attending the training course.

The additional funding from international committees also allowed the participation of more instructors than would otherwise have been the case. The list of instructors was: Dr. Trevor Platt (Bedford Institute of Oceanography, Canada); Dr. Shubha Sathyendranath, (Dalhousie University, Canada); Dr. Vivian Lutz (Instituto Nacional de Investigación y Desarrollo Pesquero, Argentina); Dr. Cesar Fuentes-Yaco (Bedford Institute of Oceanography, Canada); Dr. Mark Dowell (University of New Hampshire, USA); and Dr. Osvaldo Ulloa (University of Concepcion, Chile). In addition, Mr. Gabriel Yuras provided assistance in the practical demonstrations.

Some of the instructors at the training course: Drs. Cesar Fuentes-Yaco, Vivian Lutz, Trevor Platt, Osvaldo Ulloa and Mark Dowell

Hands-on training - 2003

Blue EArth GLobal Expedition
BEAGLE 2003

- Background
- Cruise Details
- Bio-optical Program
- Participants
- Student Reports
- Photo Album
- BEAGLE
- JAMSTEC
- IOCCG
- POGO
- Brochure

Oceanographic Training on BEAGLE 2003

The Blue EArth GLobal Expedition (BEAGLE), an international circumpolar cruise in the Southern Hemisphere, was organized by JAMSTEC (Japan Agency for Mari
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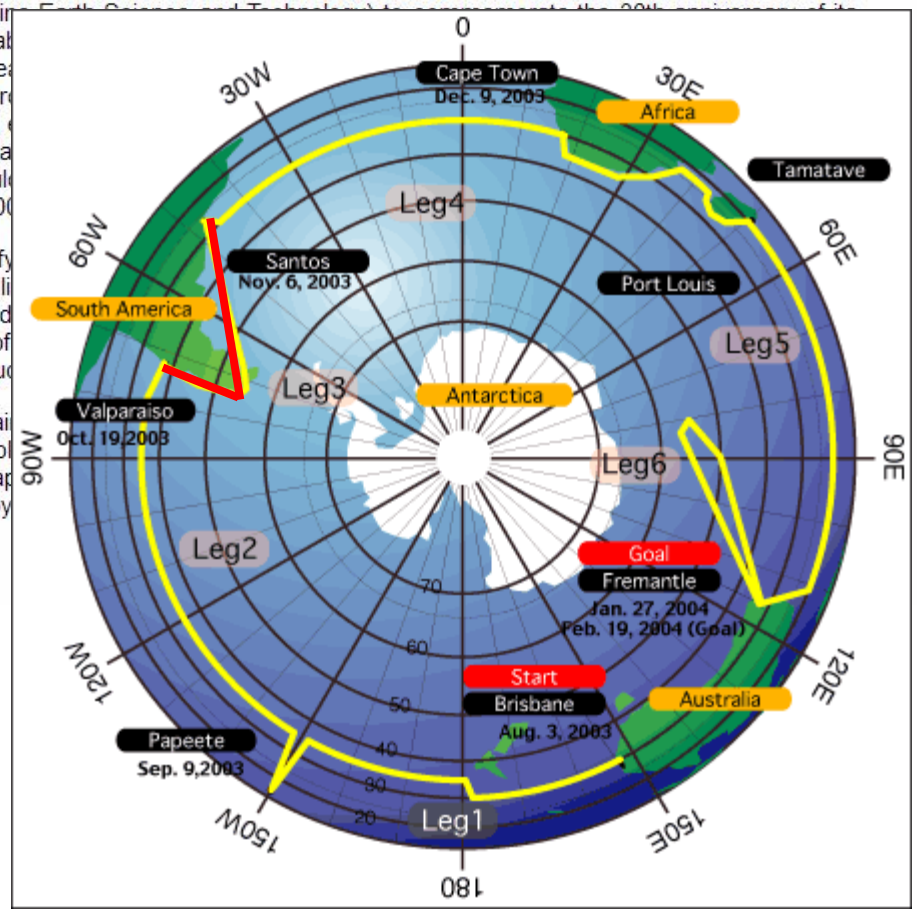
Observation of the Global Oceans (POGO) held in Brazil in 200

The main objectives of the cruise are to detect and quantify warming, through high-quality observations along the WHP li anthropogenic carbon taken up by the Antarctic Ocean. In add the cruise. These measurements can be used to validate of estimates of phytoplankton standing stocks and primary produc

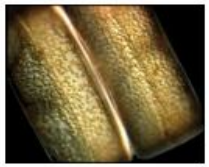
In addition, JAMSTEC offered to accommodate up to three trai IOCCG, POGO and IOC awarded a limited number of schol receive hands-on training on bio-optical and other oceanograp fees for all trainees and bio-optical specialists were covered by

Page updated 07/28/2009



Training course - 2006

Partnership for Observation of the Global Oceans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RSS VALID

Brazil Visiting Professorship

Dr. Robert Frouin of Scripps Institution of Oceanography (USA), with the help of experts from the international ocean-colour community (incuding Dr. Greg Mitchell from Scripps and Dr. Vivian Lutz from INIDEP, Argentina, Prof. Ichio Asanuma from Tokyo University and Dr. Ewa Kwiatkowska from NASA), provided training to 16 trainees from Mexico, Peru, Colombia Venezuela, Argentina, and various Brazilian institutions, in the use of remotely sensed ocean-colour data as a tool for analysing the marine ecosystem. The training course also endeavoured to further develop the ANTARES project, an integrated network of long-term time series stations in Central and South America whose main goal is to detect and understand the impact of climate change and human activities, and to provide the scientific basis for ecosystem definition and management.

The training included two major group activities, with formal lectures, theoretical work, laboratory measurements, field experiment, and data analysis. All the major aspects of ocean-colour remote sensing were covered, from fundamental principles to modeling, inversion, instrumentation, and measurements. The trainees were divided into three teams composed of biologists and physicists. Each team had to produce reports and make presentations about the work accomplished. The format allowed the trainees to learn and familiarize themselves with various aspects of ocean colour remote sensing, to apply and deal practically with the theoretical concepts introduced in the formal lectures, to interact among themselves, and to develop strategies for their individual research in biological oceanography and remote sensing. During the course, SIO journals, serials, and other materials were accessible electronically via a proxy server, which proved to be a valuable resource for the trainees.

The first activity focused on ocean colour, with lectures on processes affecting marine reflectance, modeling of marine reflectance, measurement of marine reflectance, and inversion of marine reflectance. Other lectures related to optics of particulate and soluble material in water, measurement of ocean optical properties and regional differentiation, and phytoplankton photosynthetic physiology and measurement of photosynthesis. Drs. Greg Mitchell from SIO and Vivian Lutz from INIDEP joined Dr. Robert Frouin in giving the lectures. Hands-on activities included laboratory work at the Oceanographic Institute of the University of São Paulo, and field work at the marine station in Ubatuba. Equipment purchased under the visiting professorship programme included a UV spectrophotometer and a Quantum PAR sensor. The trainees were initiated in the

A bit of history and context…

Importance of supporting young students to

- International Training courses

  - Knowledge from highly qualified professors

  - foster regional connections (like networks and collaborations)

nano
NF-POGO Alumni Network for Oceans

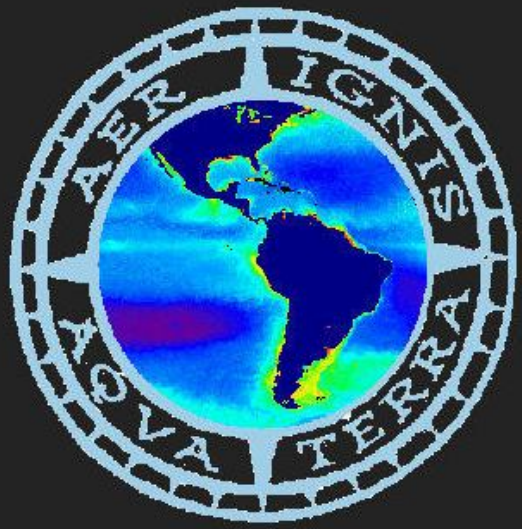
- facilitate contacts (alumni and faculty)
- promote joint research

ANTARES

- Latin American Network to study long-term changes in coastal ecosystems (in situ time-series and RS data)
- Key tasks: capacity building, scientific and tech. collaboration

ANTARES

ChloroGIN - ANTARES



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Welcome to Antares Network Home page

The Antares network was created in July 2003 under the auspices of the IOCCG and POGO and a seed SGP project from IAI. In (2006) Antares grew from ***South American*** to ***Latin American*** (incorporating Mexico). Furthermore, Antares served as a seed for a global network created in September 2006 named ***Chlorophyll Globally Integrated Network (ChloroGIN)*** of which Antares forms its Latin American Regional branch.

ANTARES main goal is the study of long-term changes in coastal ecosystems in sites around Latin America to distinguish those due to natural variability from those due to external perturbations (anthropogenic effects). To achieve this goal in situ data from coastal stations, and satellite data (temperature and chlorophyll) from the region are shared among members and with the public. Capacity building, scientific and technical collaboration are key in our task. Current participating countries are: Argentina, Brazil, Canada, Colombia, Chile, Ecuador, Mexico, Peru, USA, Venezuela.

A bit of history and context…

Importance of supporting young students to

- International Training courses

  - Knowledge from highly qualified professors

  - foster regional connections (like networks and collaborations)

nano NF-POGO Alumni Network for Oceans

ANTARES

- Hands-on experience (e.g. the MIRAI, AMT, ...)
- Post-doc experiences in renown labs and institutions
- National and International collaborations


CCG
International
Ocean Colour
Coordinating Group


THE NIPPON
FOUNDATION


pogo

THANKS !!!

IUPAP
INTERNATIONAL UNION OF
PURE AND APPLIED PHYSICS


esa


NASA


CONAE


International Council for Science
SCOR
Scientific Committee on Oceanic Research


UNESCO
United Nations
Educational, Scientific and
Cultural Organization
Intergovernmental
Oceanographic
Commission


CONICET


CNPq
Conselho Nacional de Desenvolvimento
Científico e Tecnológico


Belgian Science Policy Office
belspo


JRC
EUROPEAN COMMISSION


ICTP