Workshop
Hydrological Optics : Measurements and Modelling

Convidado Externo – Emmanuel Boss – University of Maine

Projeto: FAPESP 2015/19653-0

Organizado pelo

Laboratório de Instrumentação de Sistemas Aquáticos (LabISA) – INPE/OBT

19 e 20 de abril de 2016

10 às 18:00 horas

Auditório do Instituto Interamericano para Pesquisas em Mudanças Globais - **IAI**

Auditório José Simeão de Medeiros – **LabGeo**

Sala 27 - **Prédio Asa**

Instituto Nacional de Pesquisas Espaciais - INPE

São José dos Campos - SP

Participantes

Apoio Financeiro

Attempts, efforts and difficulties in studying coastal waters through ocean color in southern Brazil

Mauricio A. Noernberg
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Center for Marine Studies - CEM
Coastal Oceanography and Remote Sensing Lab.
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About the Center for Marine Studies

- Professors: 52
- Laboratories: 22

Undergraduate Degree

- Oceanography
- Engineering (2015):
  - Aquaculture
  - Civil
  - Environmental

Graduate Degree (M.Sc. - Ph.D)

- Coastal and Ocean Systems

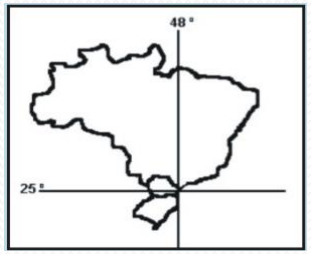
Research Areas

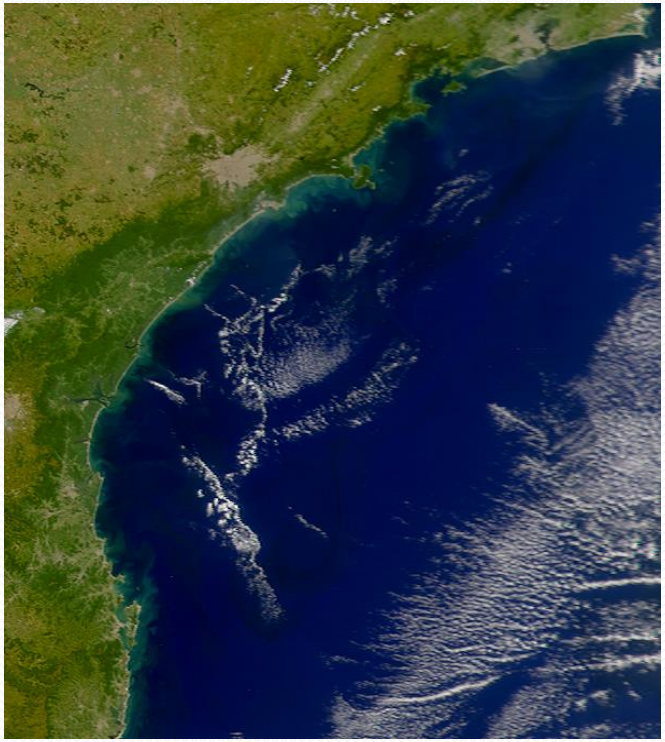
- Coastal and Ocean Dynamics
- Marine Biogeochemistry and Pollution
- Biology and Ecology of Coastal and Ocean Systems
- Integrated Coastal Zone Management

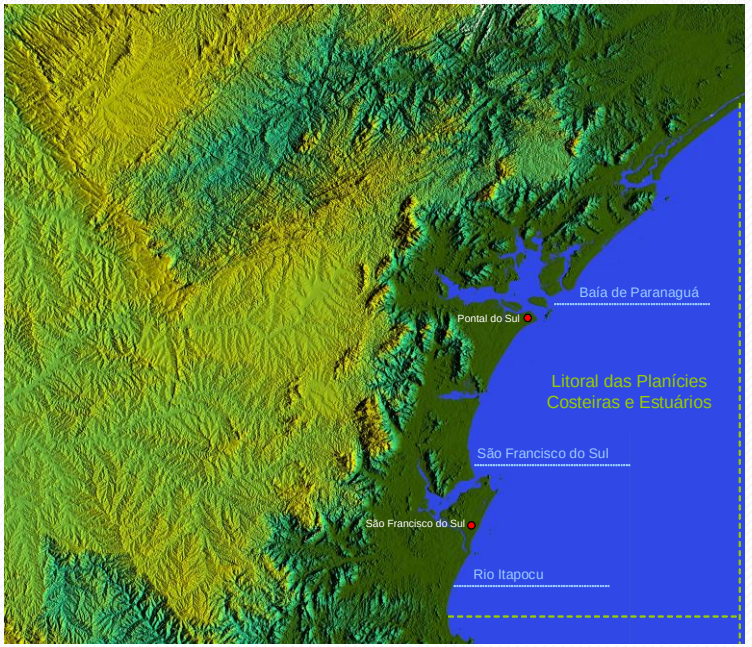
www.cem.ufpr.br

About the Region

Paranaguá Estuarine Complex

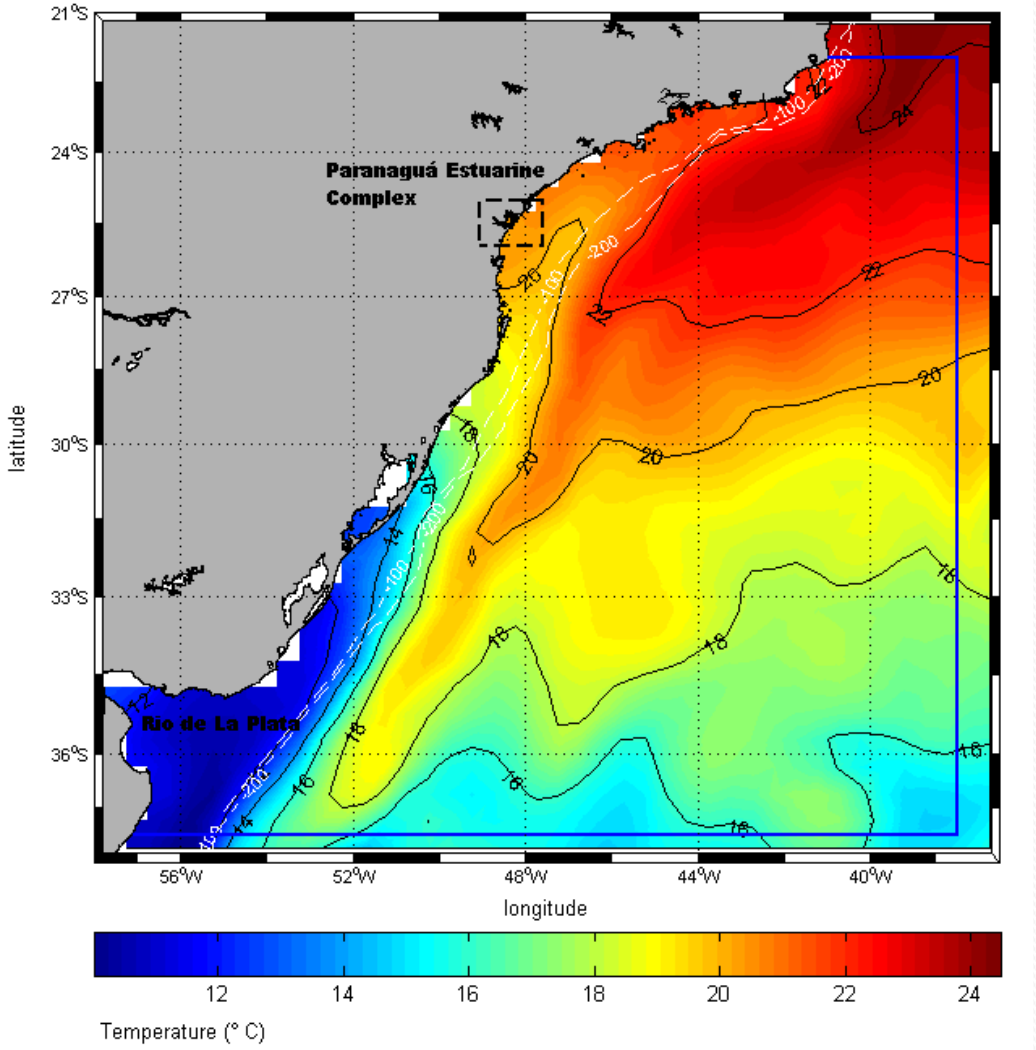






- Coast of the coastal plains and estuaries
- Great embayment (24º - 27º S)
- Large coastal plain up to 50 km
- Largest continuos area of Atlantic Forest

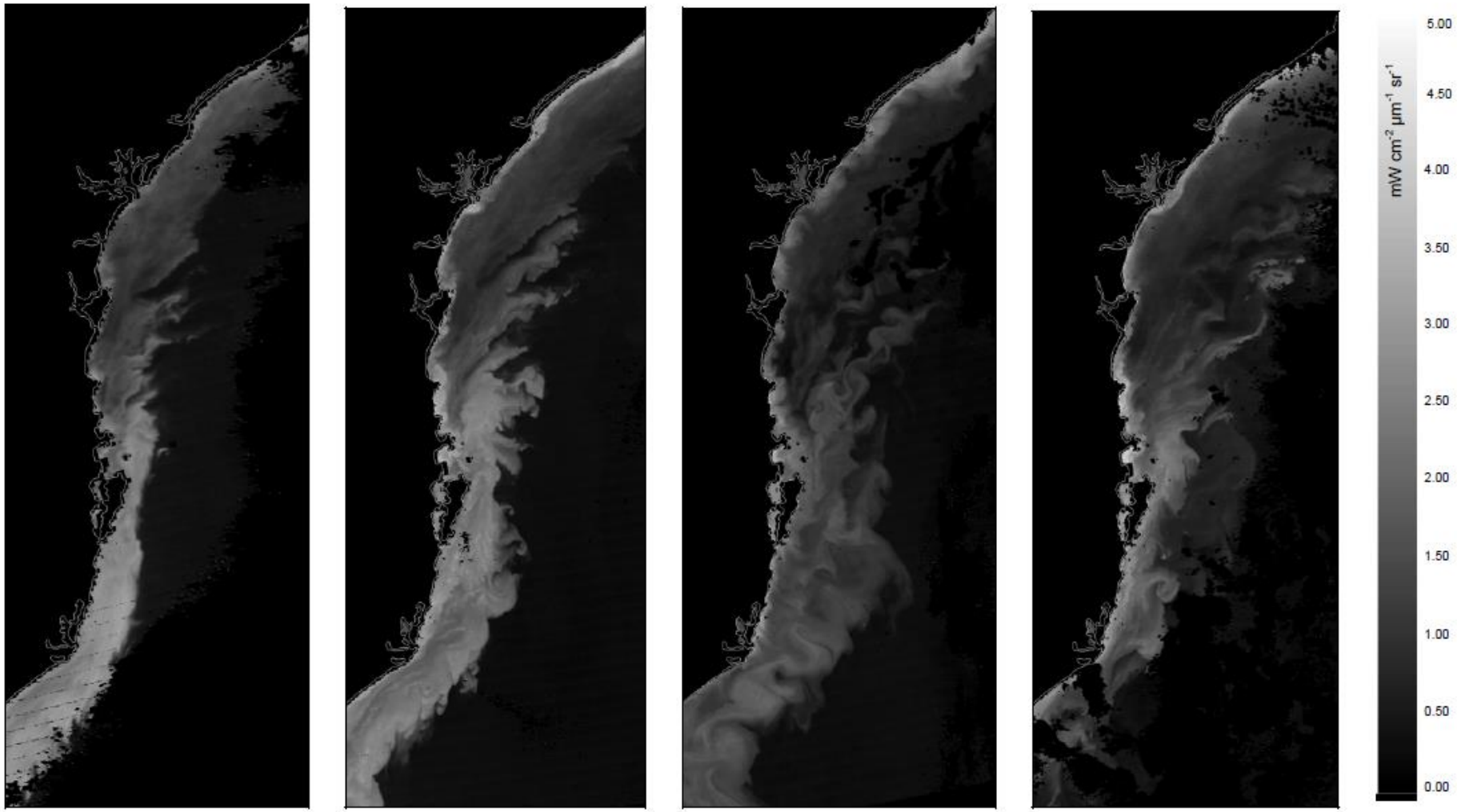
Seasonal Oceanographic Features



- **Summer** – Tropical Water (T>25°C and S>36) from Brazil Current.

- **Winter** - the Rio de la Plata waters form a low salinity tongue (T>10°C and S≤33.5) that affects the circulation, stratification and the distributions of nutrients and biological species over a wide extent of the adjacent continental shelf.

Mesoscale Processes – Wind response

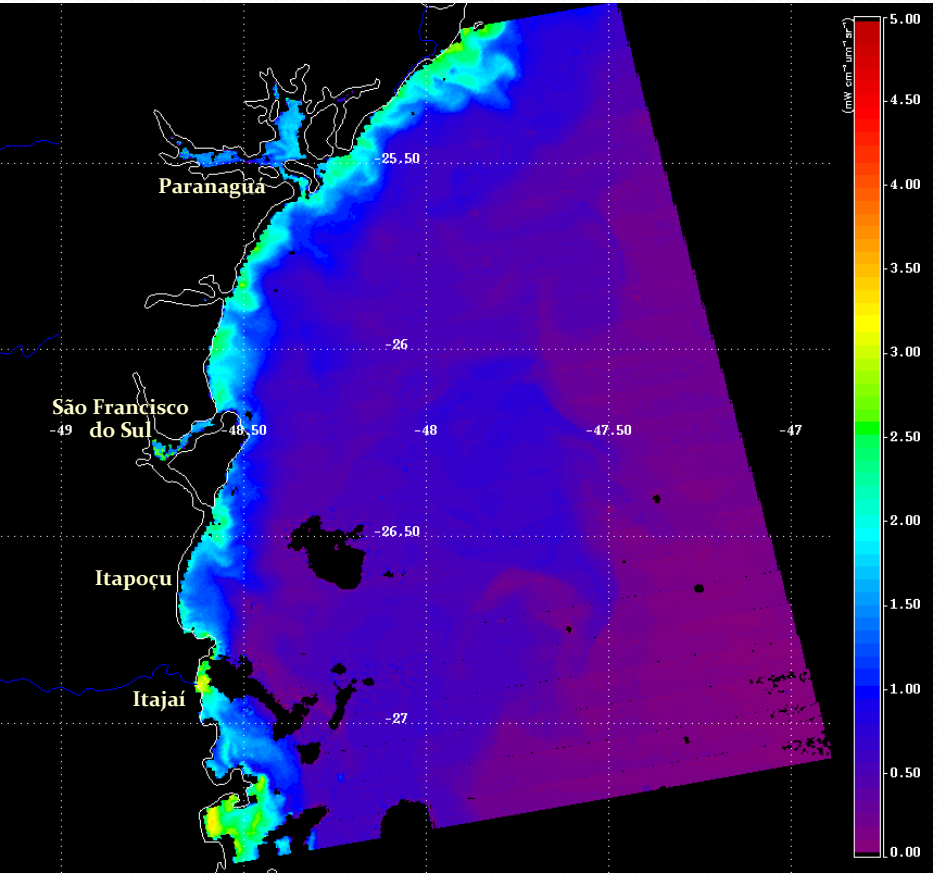


a) Dia 233 b) Dia 234 c) Dia 237 d) Dia 241

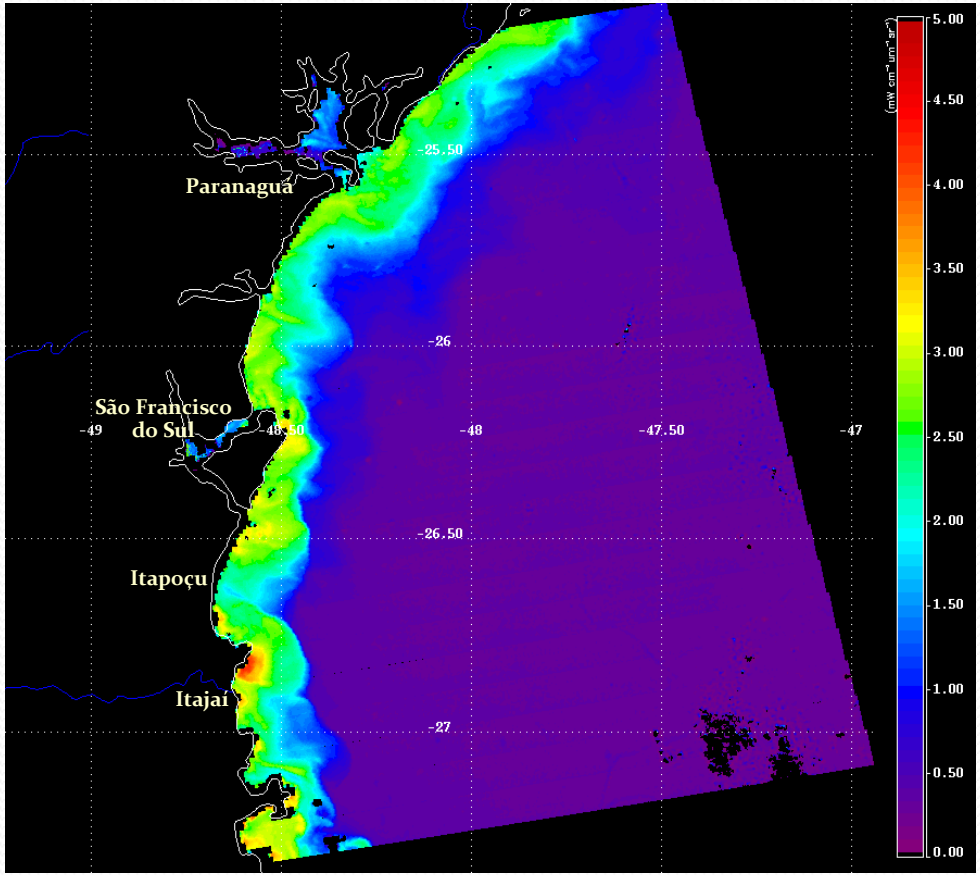
Modis (nL_w–555) - (Noernberg & Freitas, 2007).

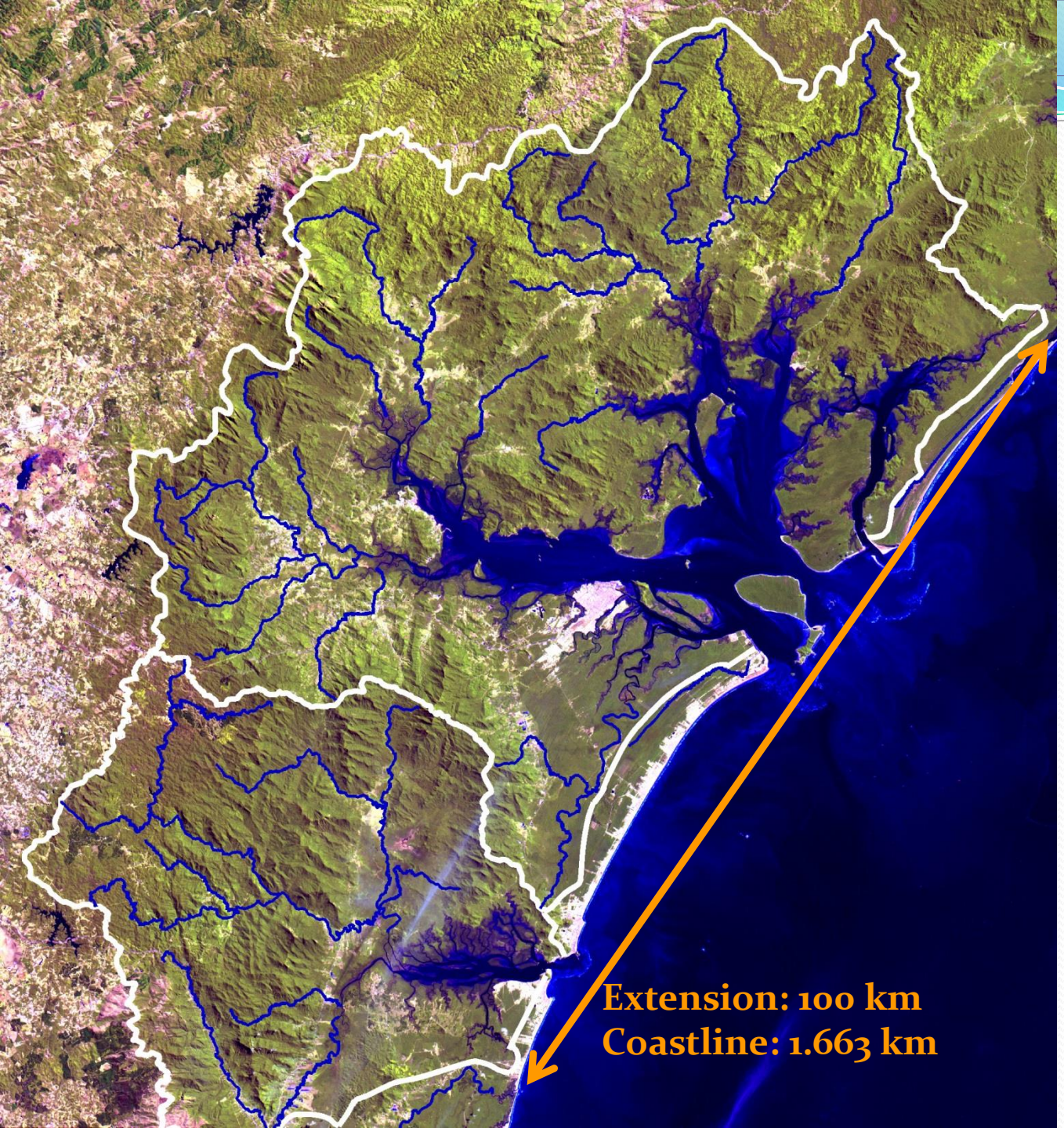
Freshwater discharge

09/08/2006 – ~7 mm in 7 days



22/11/2006 – ~100 mm in 7 days





Paranaguá Estuarine Complex

Drainage basin:
3.870 km^2

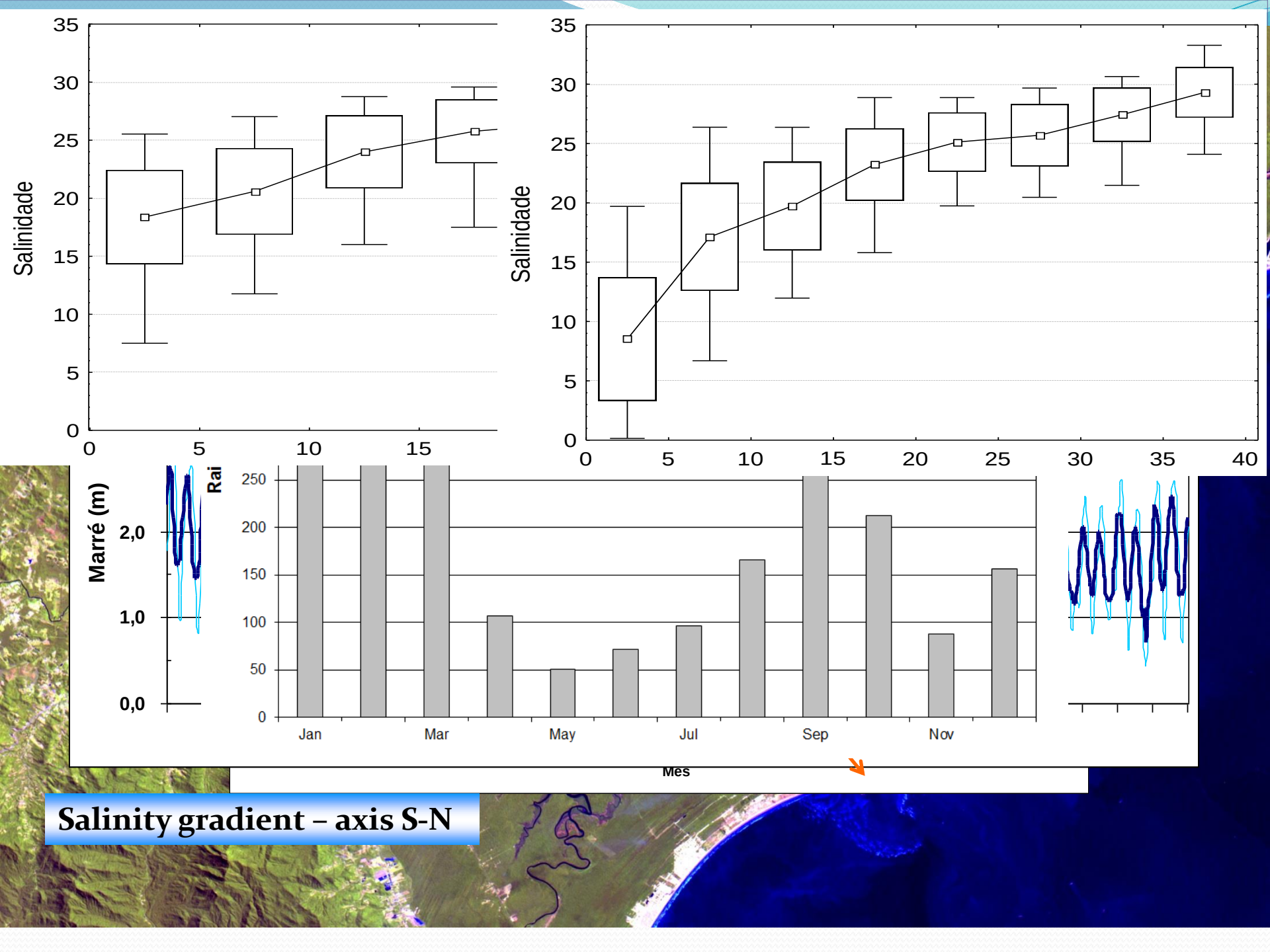
Drainage density:
1,12 rivers/km^2

Fresh water runoff:
200 m^{-3} s^{-1}

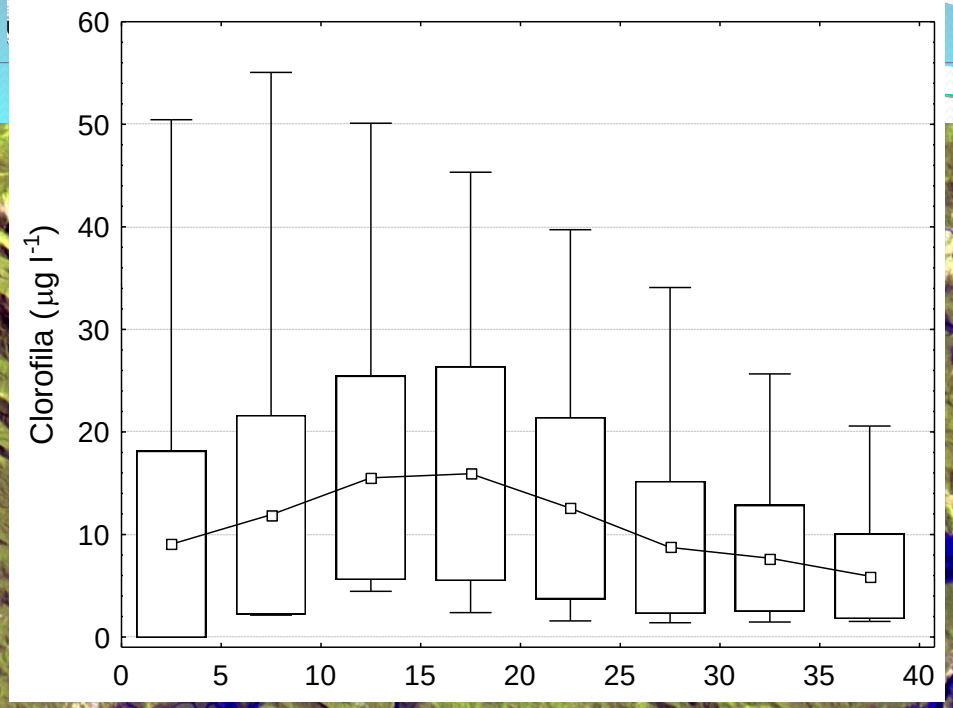
water body: 552 km^2

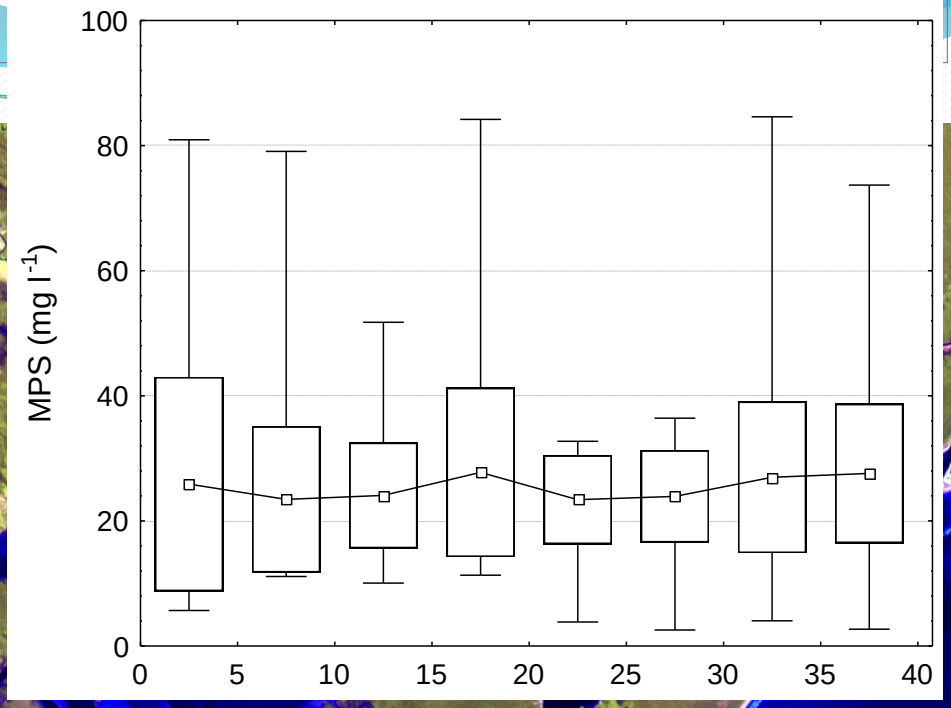
Tidal flats: 24%

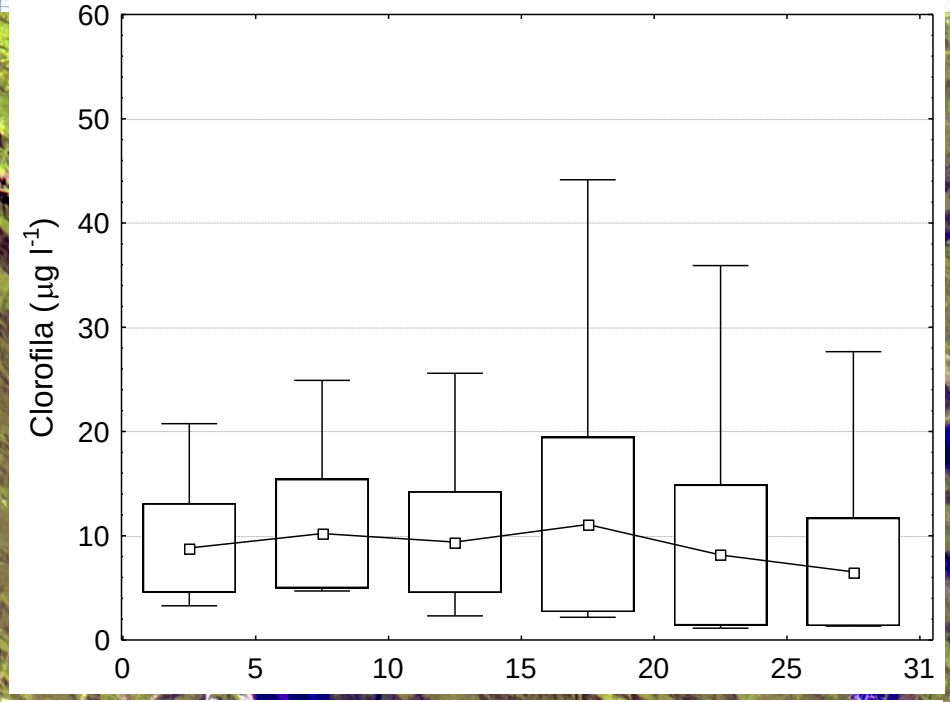
Mangroves: 296 km^2

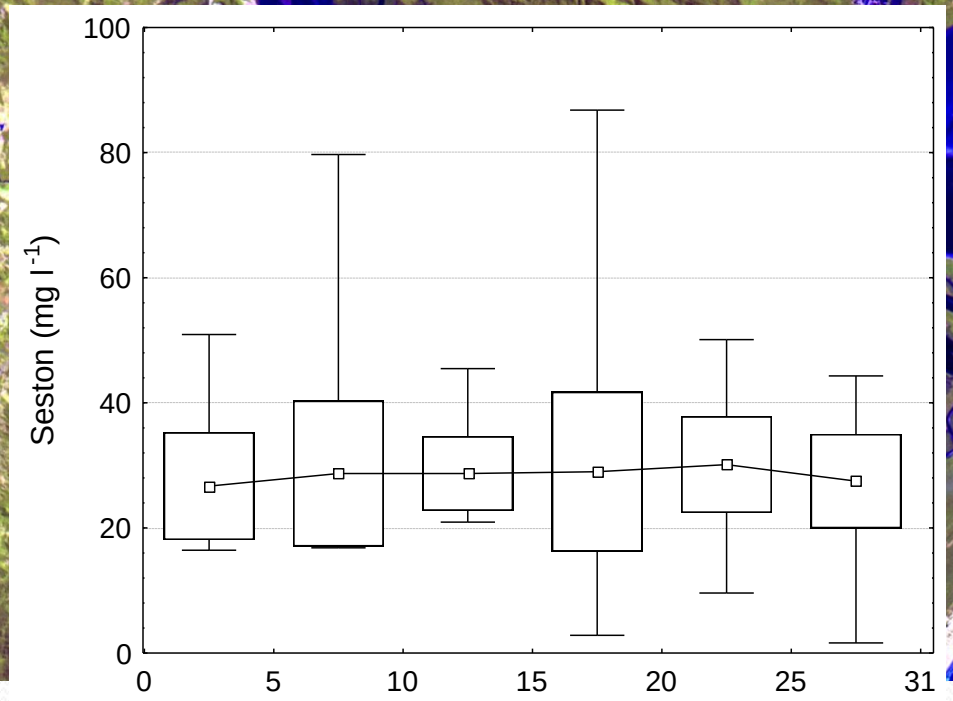


Salinity gradient – axis S-N


Clorofila (µg l-1)
0
10
20
30
40
50
60
0
5
10
15
20
25
30
35
40

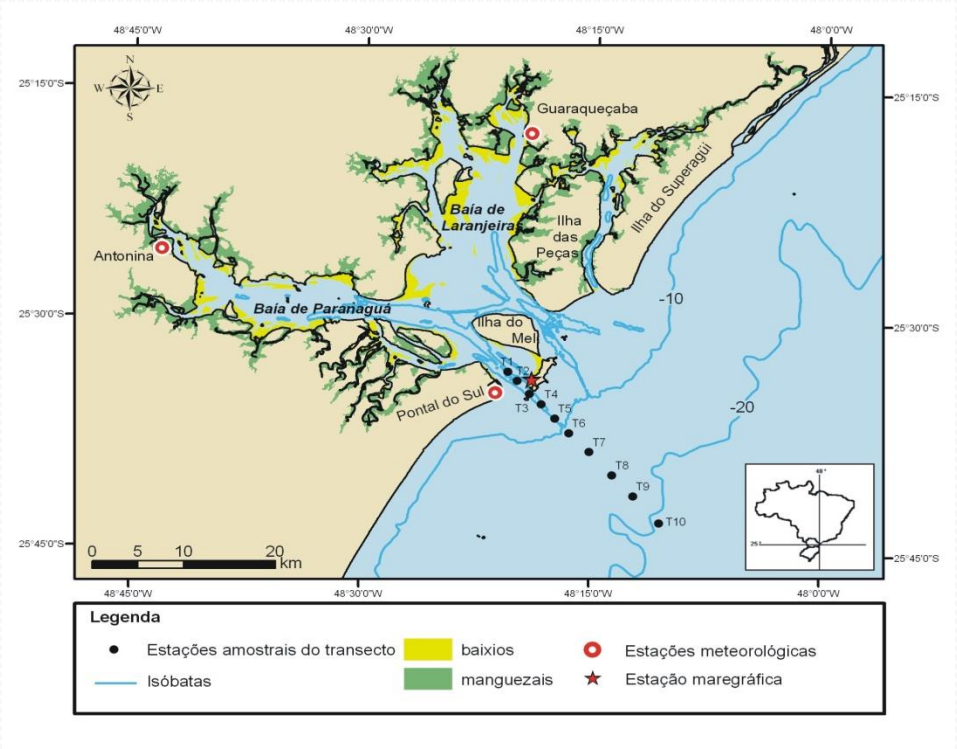

MPS (mg l-1)
0
20
40
60
80
100
0
5
10
15
20
25
30
35
40


Clorofila (µg l-1)
60
50
40
30
20
10
0
0
5
10
15
20
25
31

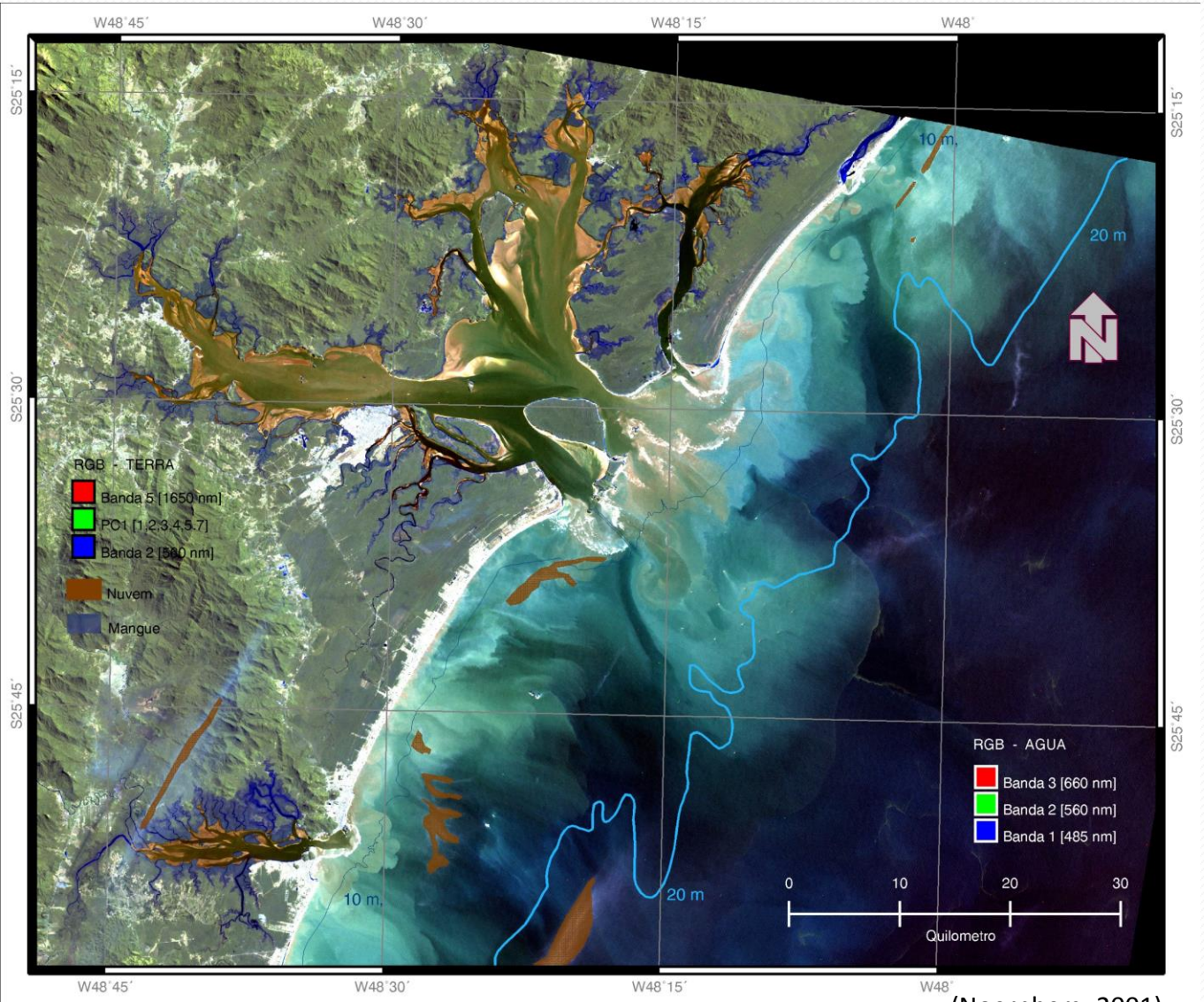

Seston (mg l-1)
100
80
60
40
20
0
0
5
10
15
20
25
31

Ocean Color

T1 T2 T3 T4 T5 T6 T7 T8



Bio-optics in situ



(Noernberg, 2001)

- Montly - Aug/2011

- No radiometrics data (until 2016)

- AOC concentration and absorption

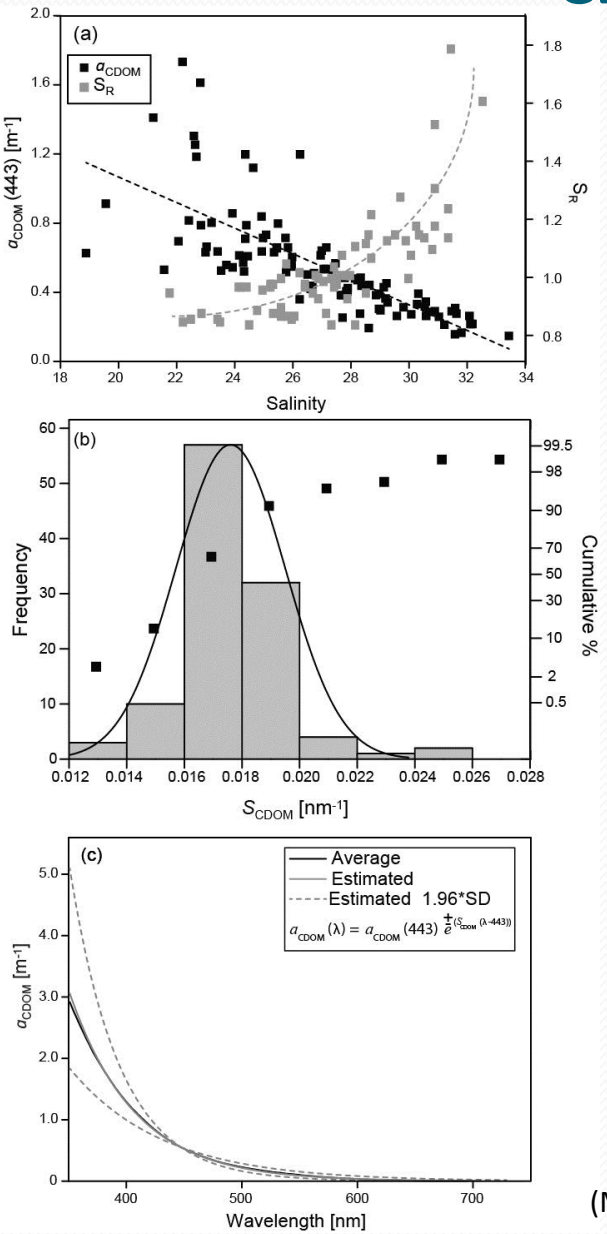
-NASA protocols:
Mitchell *et al*. (2002, 2004)

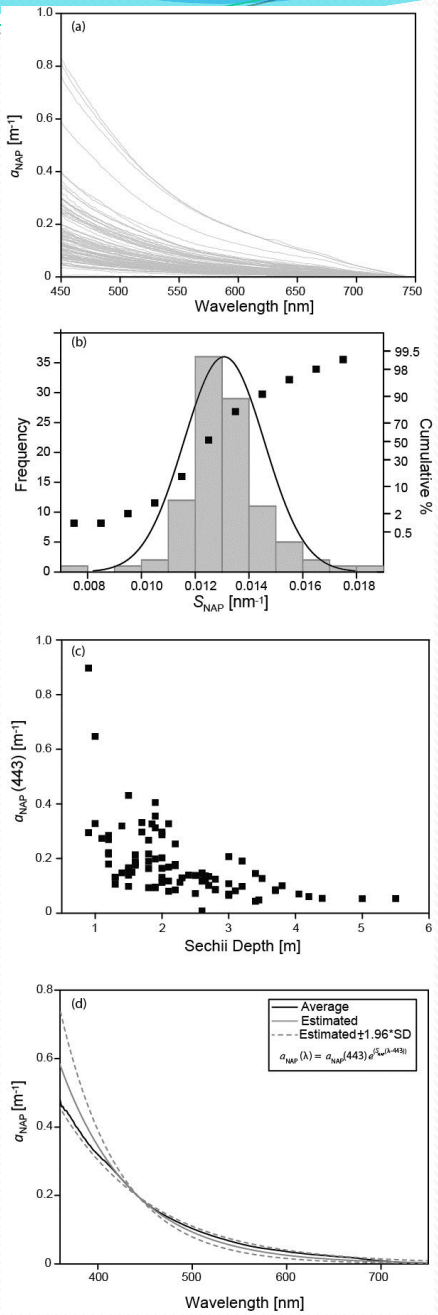
Specific spectral signature:

- *Coscinodiscus wailesii**
- *Rhodomonas lens*
- *Prorocentrum minimum*
- *Tetraselmis suecica*
- Pleurosigma sp.

* exotic

CDOM and NAP

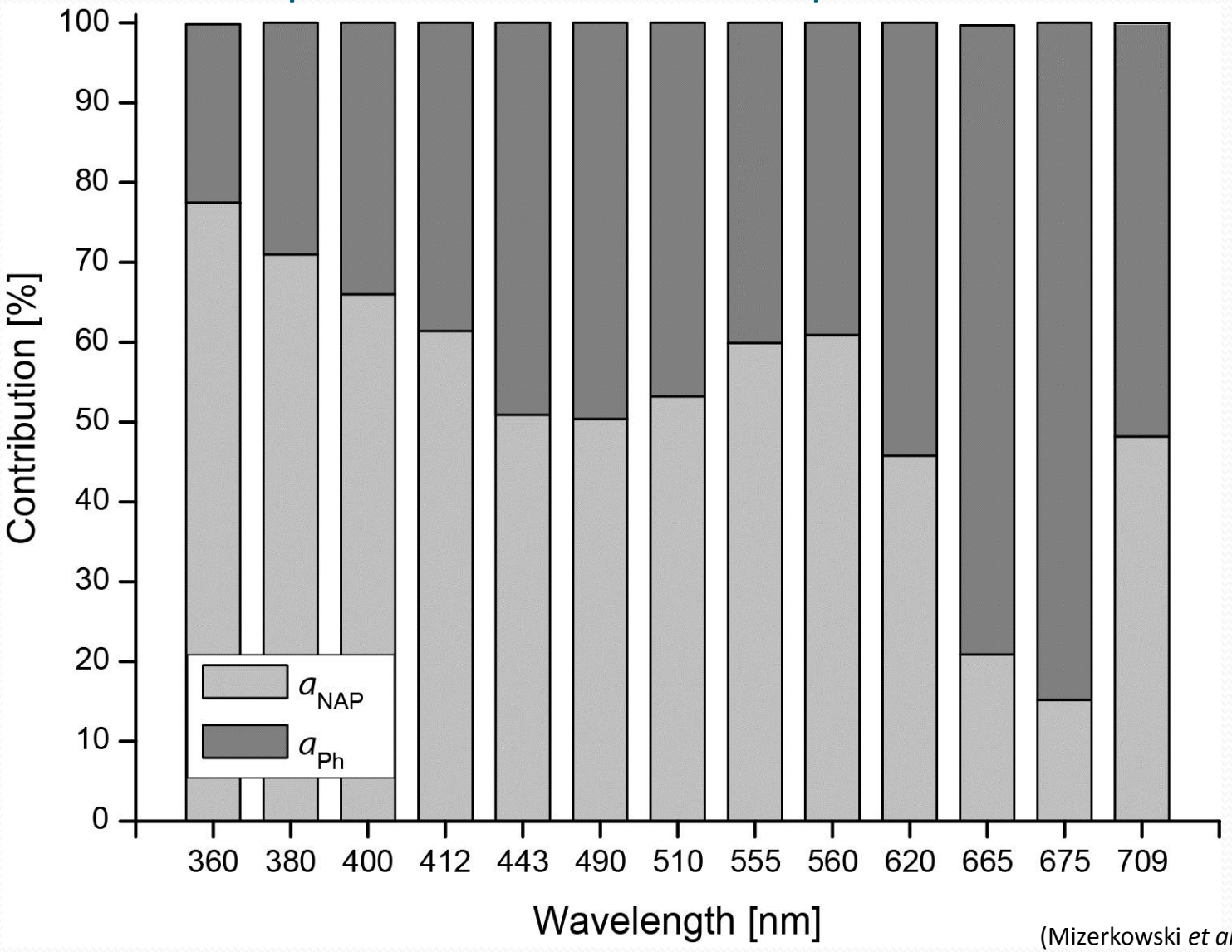




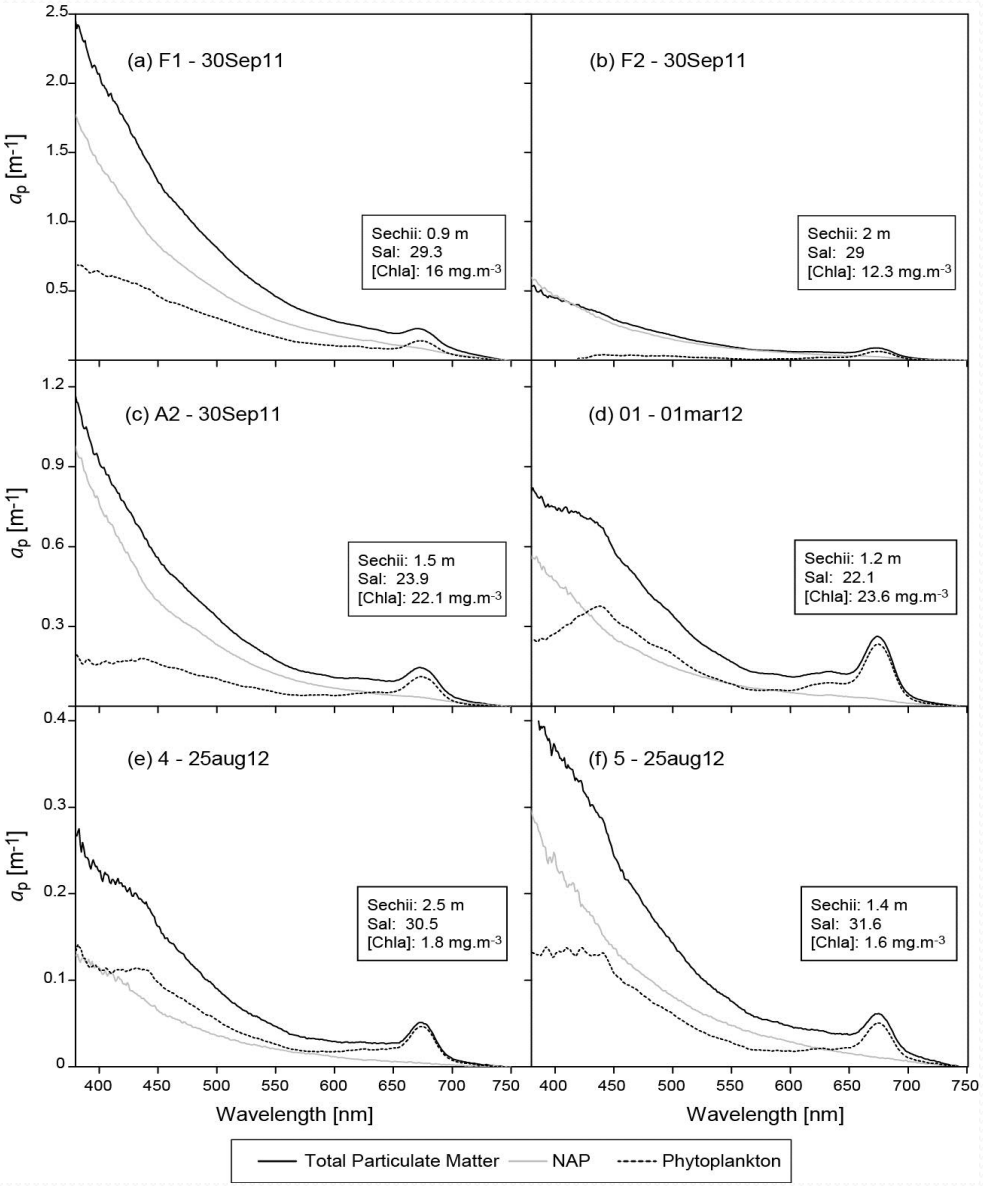
No clear correlation was detected between a_{NAP} or S_{NAP} with variables such as salinity, chlorophyll or SPM concentration

(Mizerkowski *et al*, 2013)

Average contribution of NAP and phytoplankton to the total particulate matter absorption



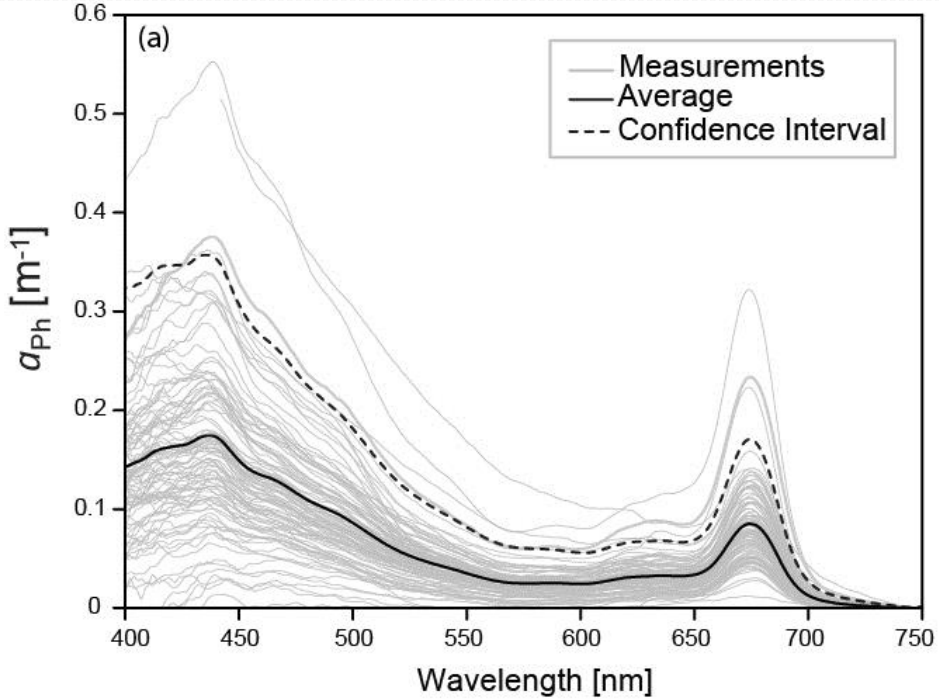
(Mizerkowski *et al*, 2013)

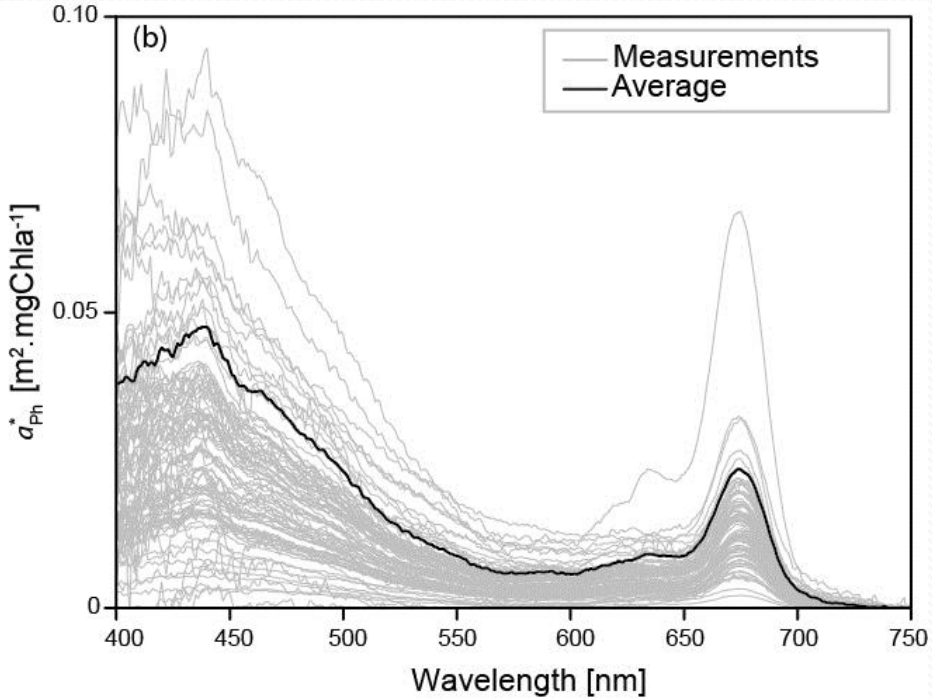


Absorption spectra of total particulate matter (a_p), NAP (a_{NAP}) and phytoplankton (a_{Ph})

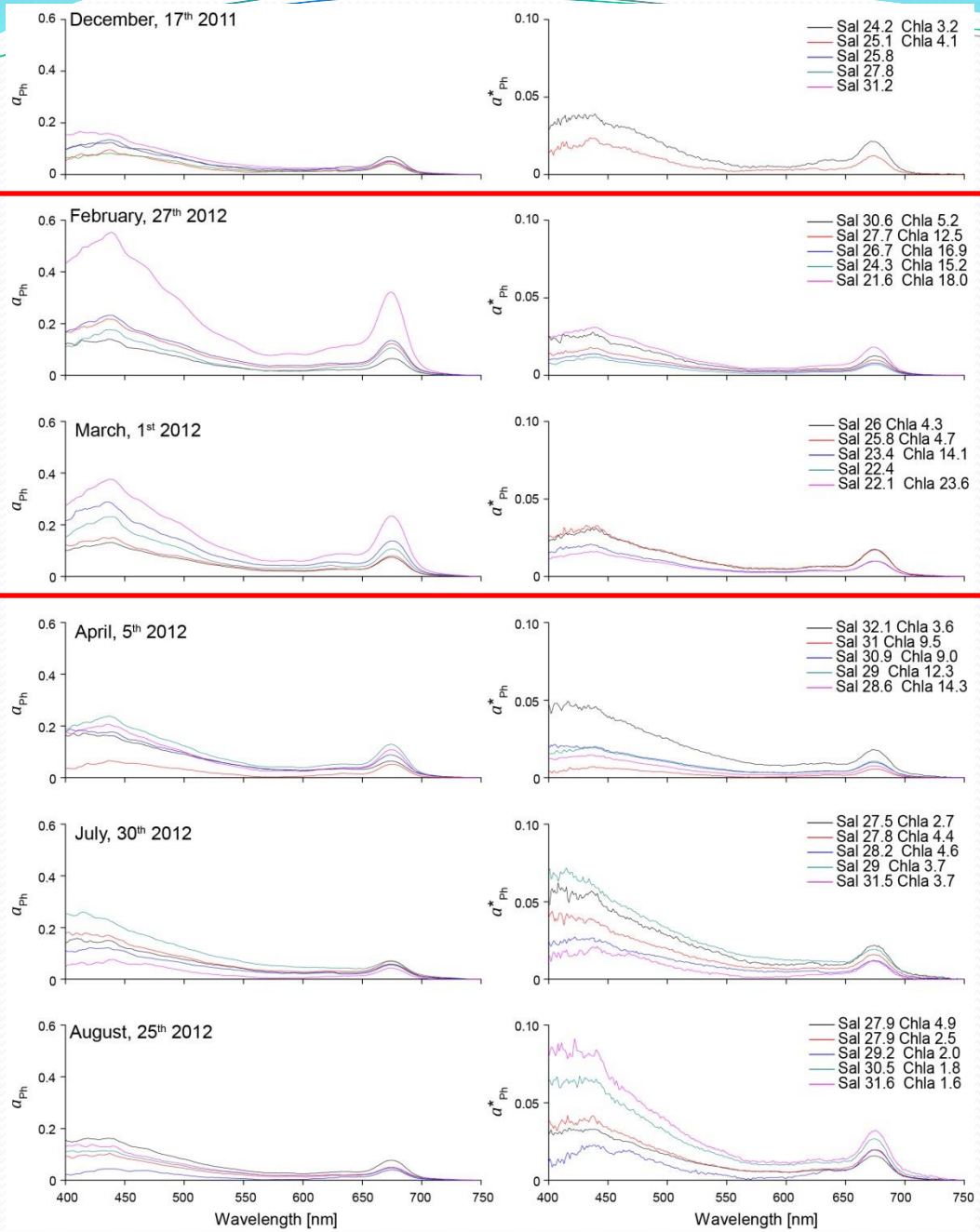
(Mizerkowski *et al*, 2013)

Phytoplankton



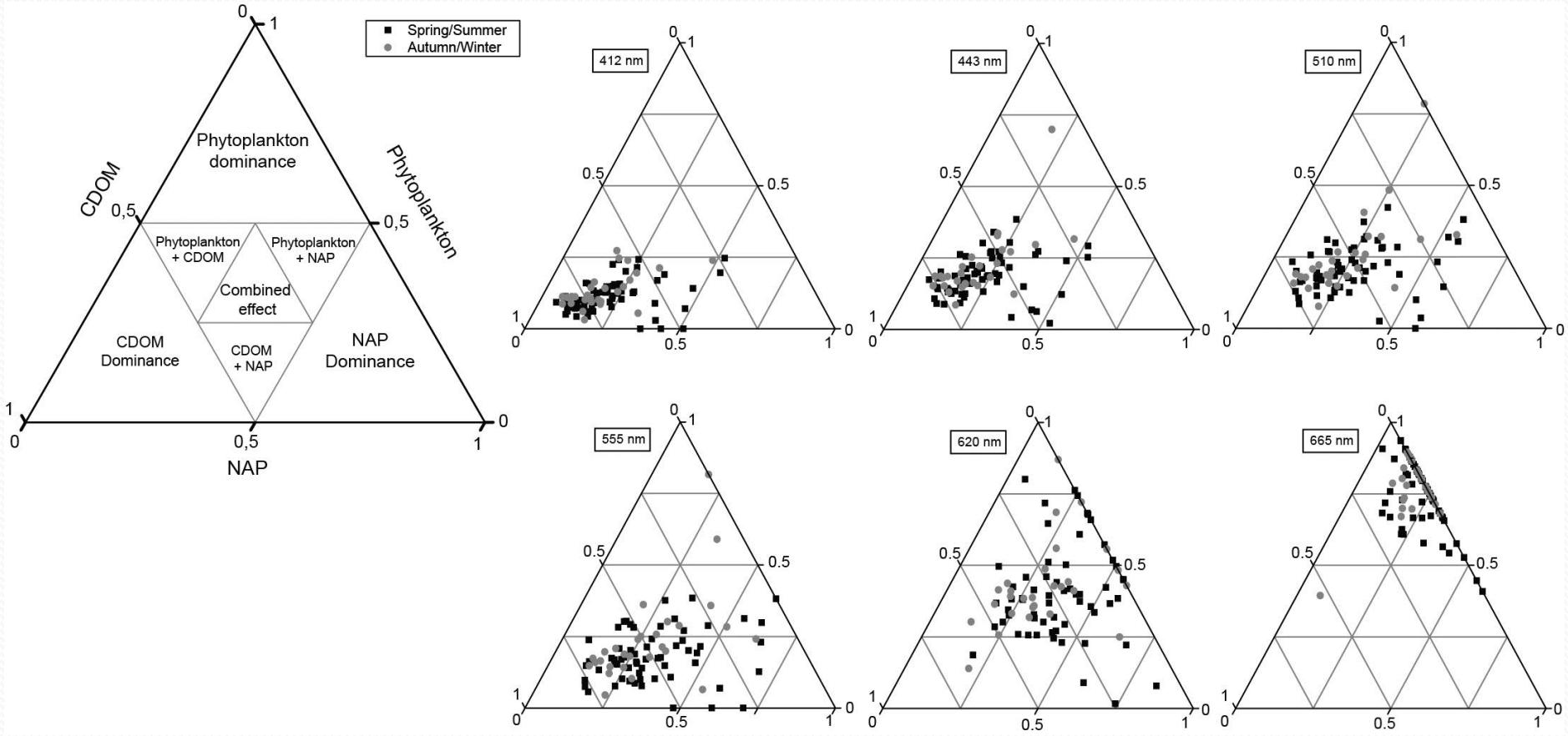


(Mizerkowski *et al*, 2013)



Absorption spectra (left) and specific absorption (rigth) of phytoplankton for bloom events (February and March 2012) and low-production periods (December 2011 and April to August 2012).

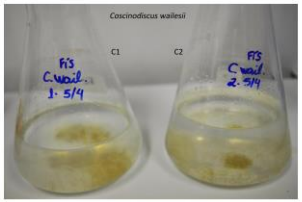
Relative contributions of CDOM, NAP and Chla to the absorption signal

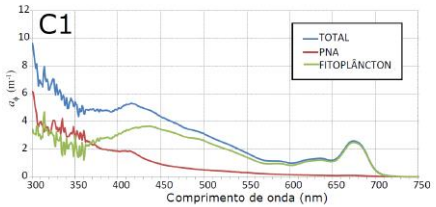


(Mizerkowski *et al*, 2013)

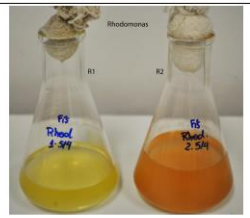
Phytoplankton Cultivation

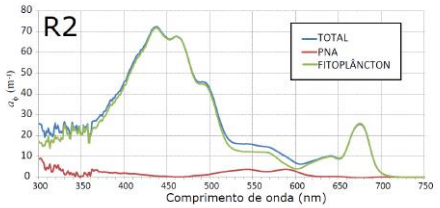
C. wailesii
Cl-*a*: 81,2 µg/l
Cl-*c*: 7,8 µg/l
67,2 céls/ml



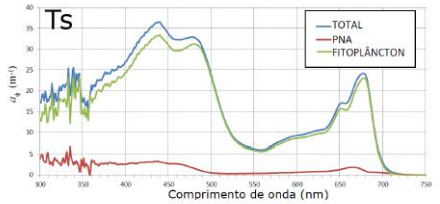


R. lens
Cl-*a*: 221,3 µg/l
Cl-*c*: 11,9 µg/l
699000 céls/ml

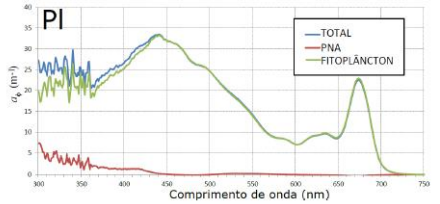




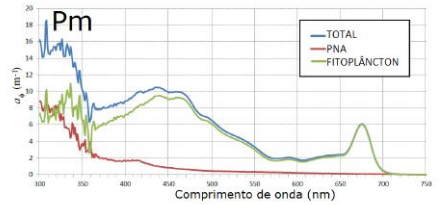
T. suecica
Cl-*a*: 814 µg/l
Cl-*b*: 385,3 µg/l
980000 céls/ml



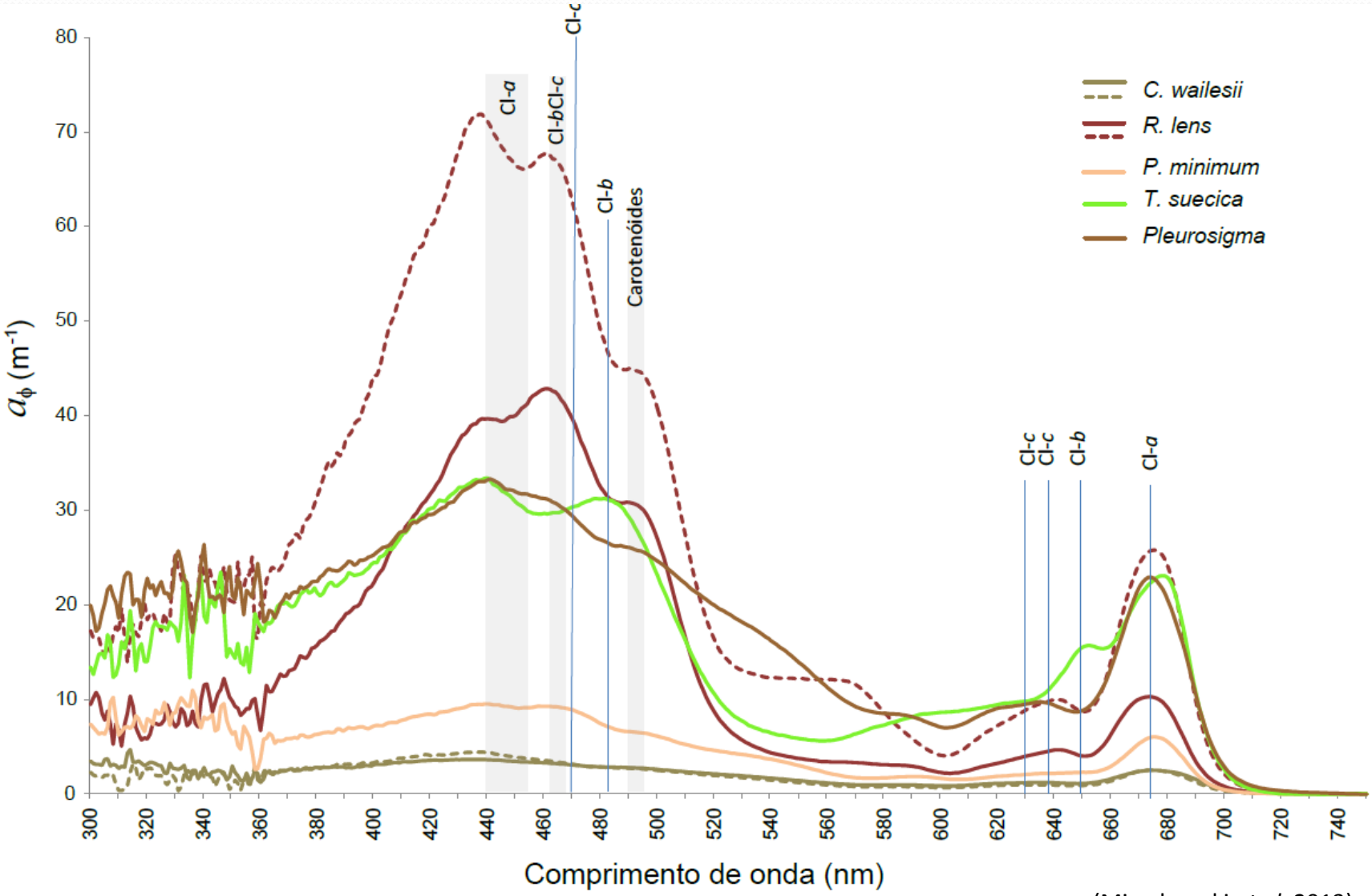
Pleurosigma sp.
Cl-*a*: 383,4 µg/l
Cl-*c*: 12,5 µg/l
70300 céls/ml



P. minimum
Cl-*a*: 57,9 µg/l
Cl-*c*: não detectado
115000 céls/ml

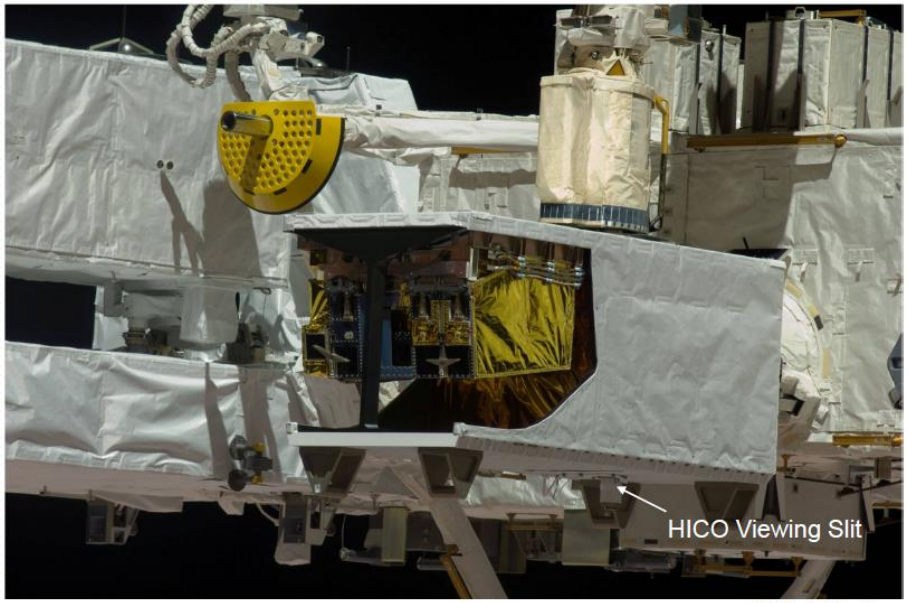


(Mizerkowski *et al*, 2013)

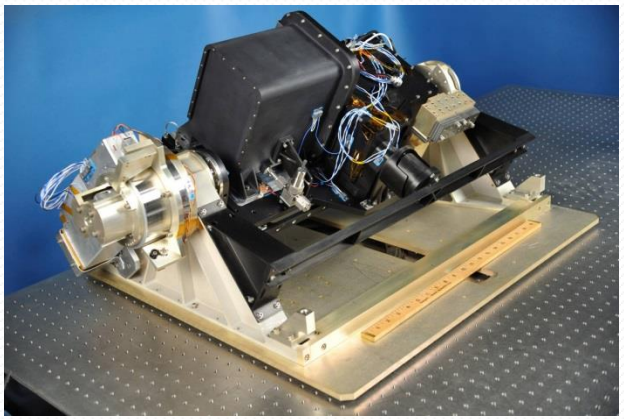


(Mizerkowski *et al*, 2013)

Hyperspectral Imager for the Coastal Ocean - HICO



NASA Photo

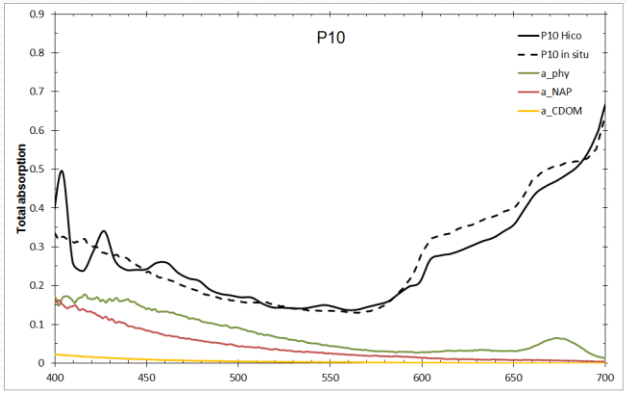


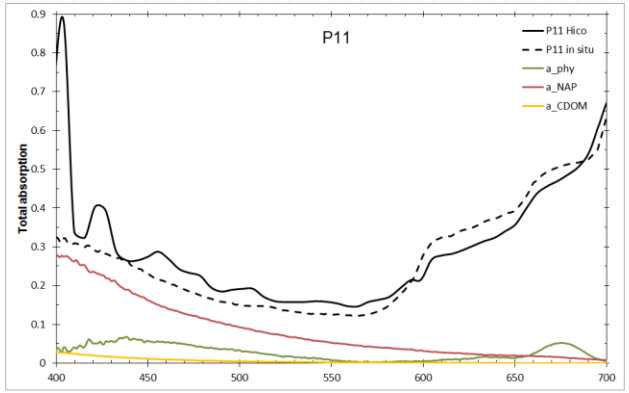
- September 24, 2009: HICO installed on ISS Japanese Module Exposed Facility (2011-2014)
- HICO sensor
  - is first spaceborne imaging spectrometer designed to sample coastal oceans
  - samples coastal regions at 100 m (380 to 1000 nm: at 5.7 nm bandwidth)
  - has high signal-to-noise ratio to resolve the complexity of the coastal ocean
- Scene Size = ~50 x 200 km

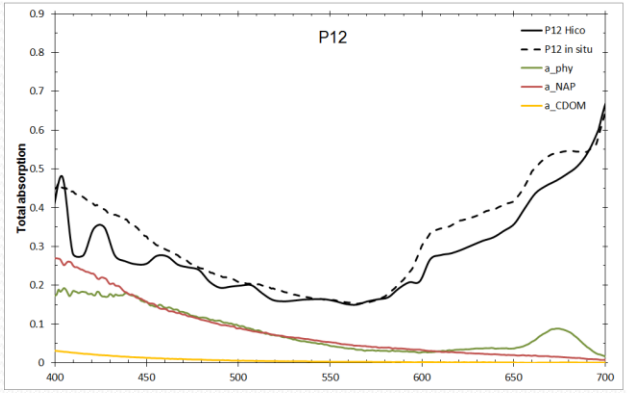
Total absorption

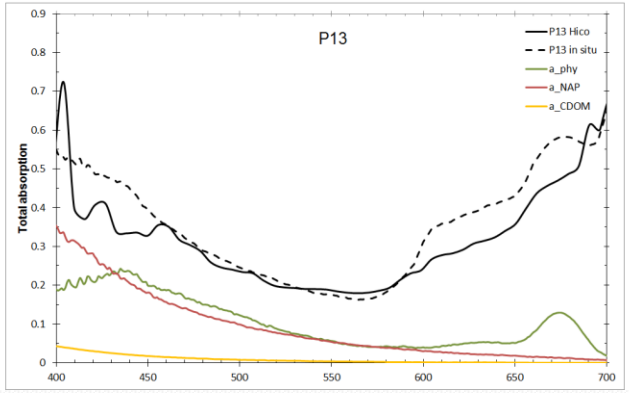
HICO-QAA x *insitu*

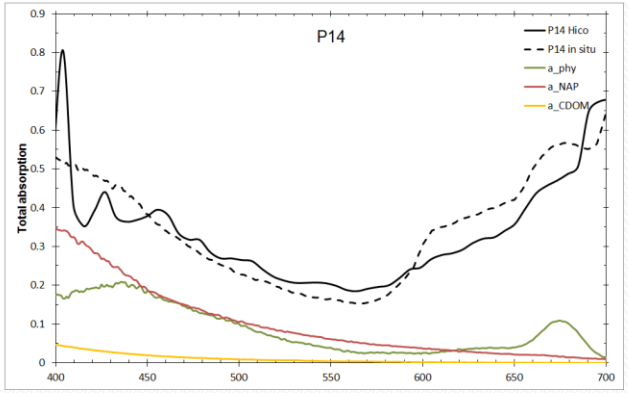
05 April 2011









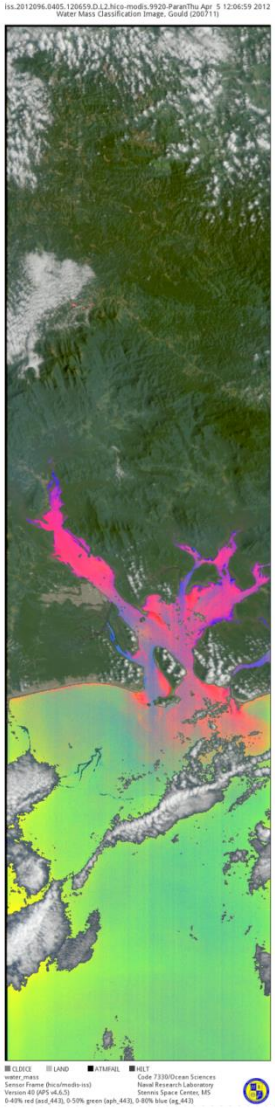


(Noernberg *et al*, 2015)

Table 2. Chlorophyll a concentration (µg l^{-1}s).

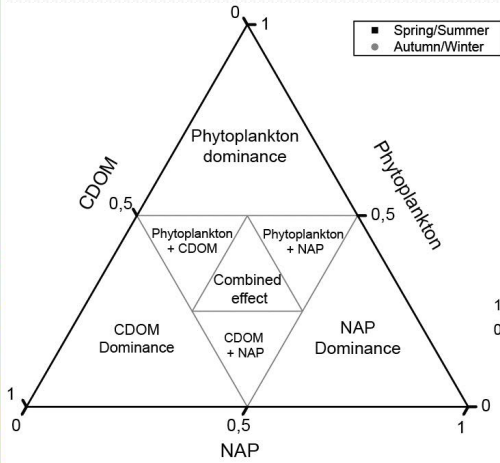
Station #	*in situ*	OC3 SA-model *a* in situ	OC3 HICO
1	14.3	8.27	3.98
2	12.3	7.40	2.92
3	9	5.23	2.39
4	9.5	4.66	2.33
5	3.6	3.55	2.53

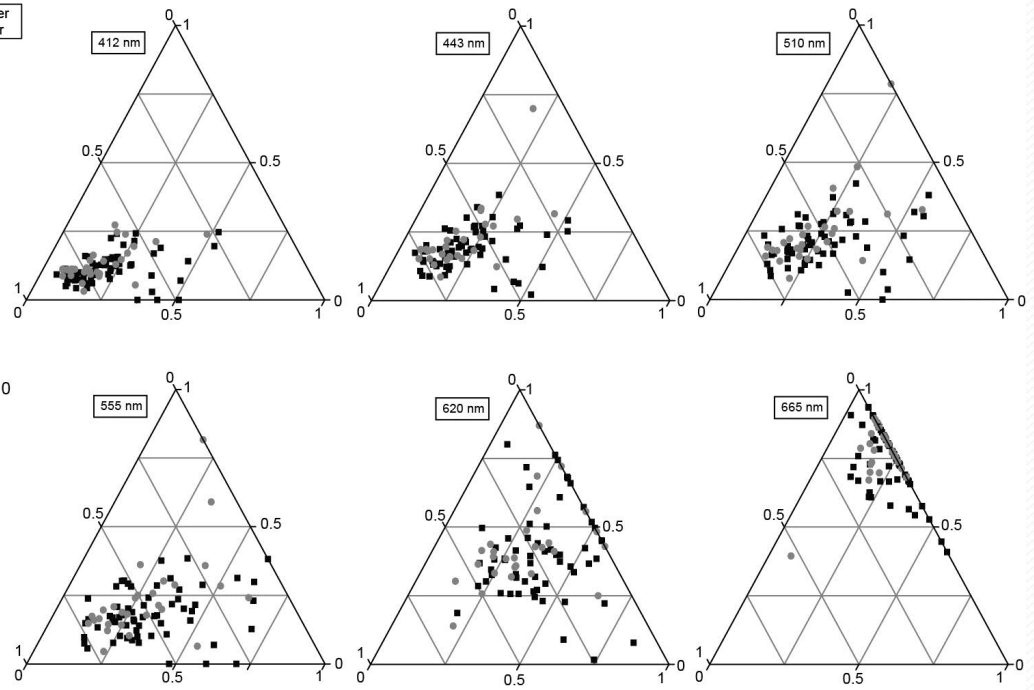
Coastal Water Mass Classification



Absorption Coefficient

- Non-algal Particles (R)
- Chlorophyll-a (G)
- Colored Dissolved Organic Matter (CDOM) (B)

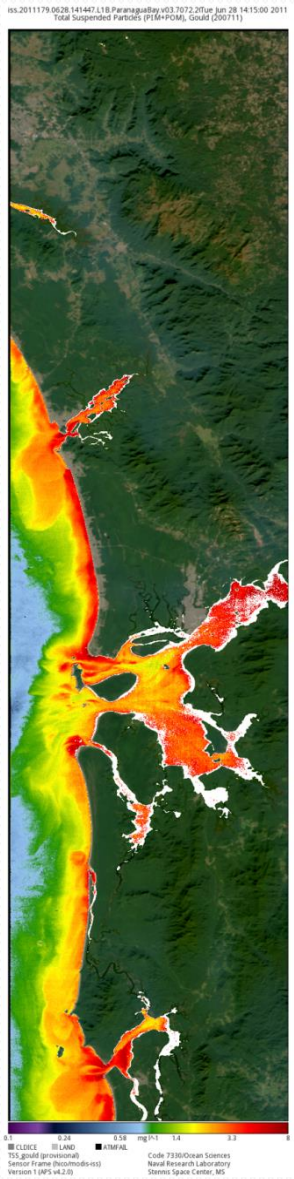




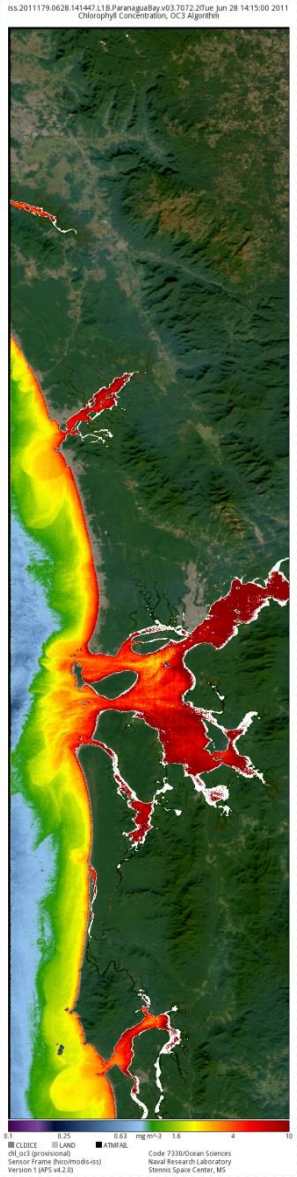
With collaboration of Richard W. Gould from NRL

Water Quality - Hyperspectral

True color



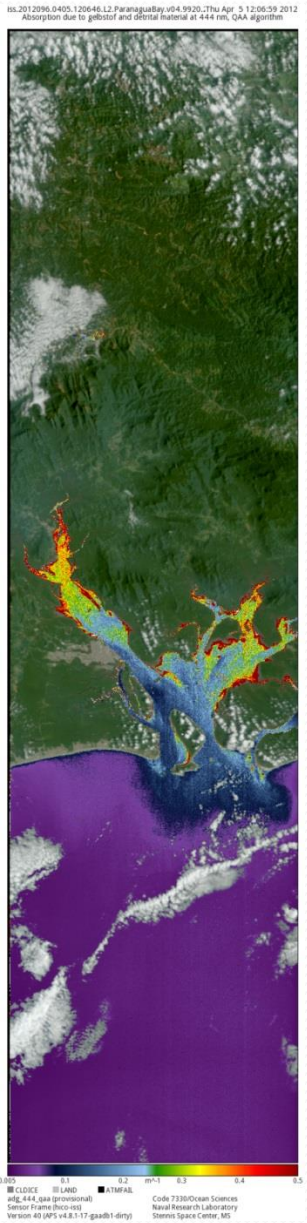
TSS



chl_oc3

05 April 2012 – APS/NRL

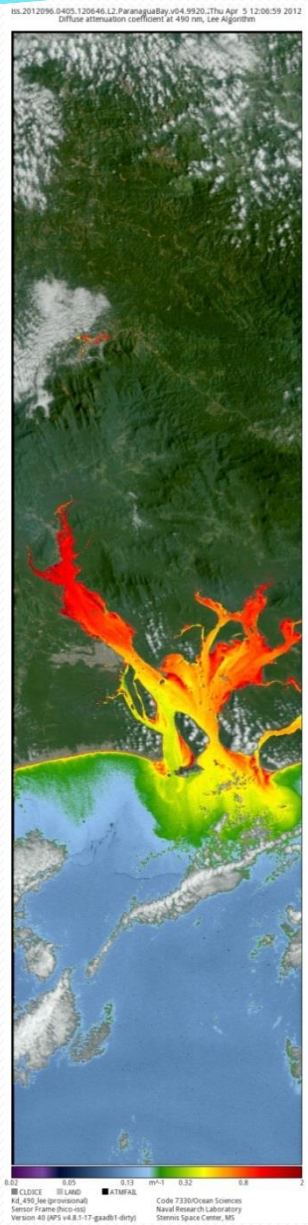
True color



adg_444_qaa

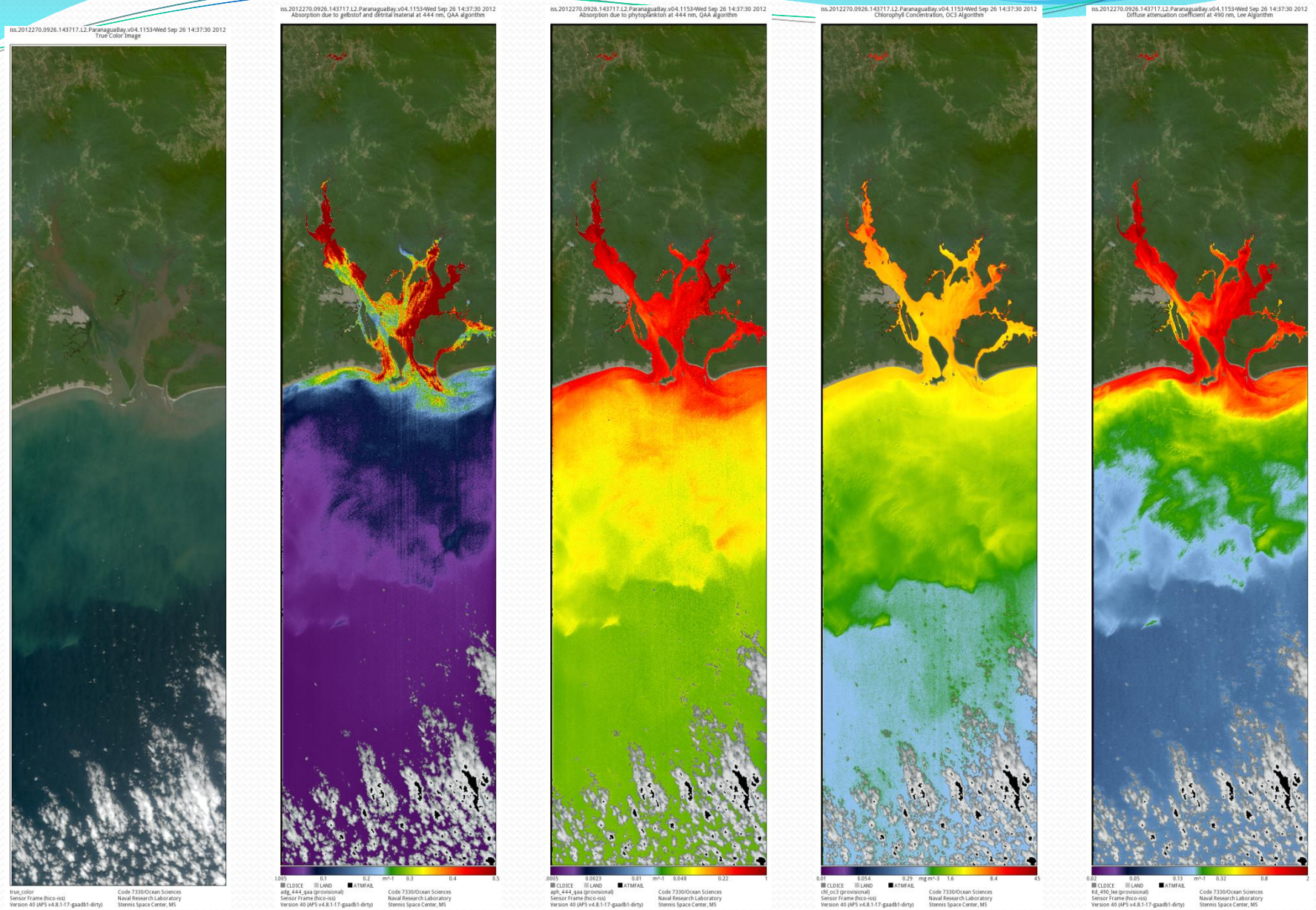
aph_444_qaa

chl_oc3



Kd_490

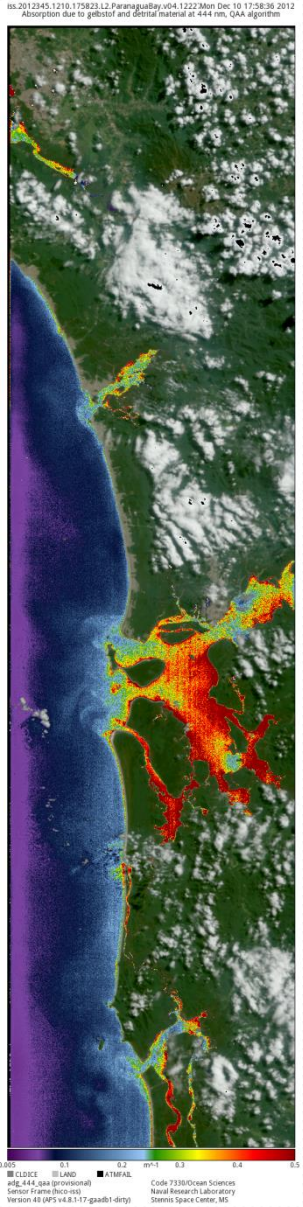
26 September 2012 – APS/NRL



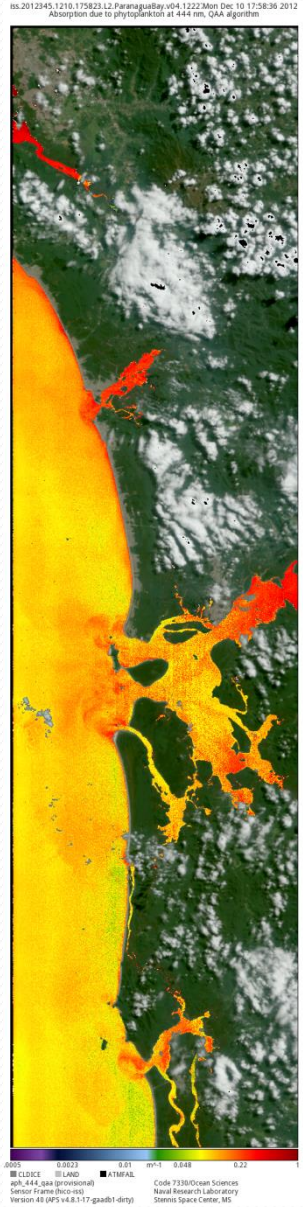
True color | adg_444_qaa | aph_444_qaa | chl_oc3 | Kd_490

10 December 2012 – APS/NRL

True color



adg_444_qaa



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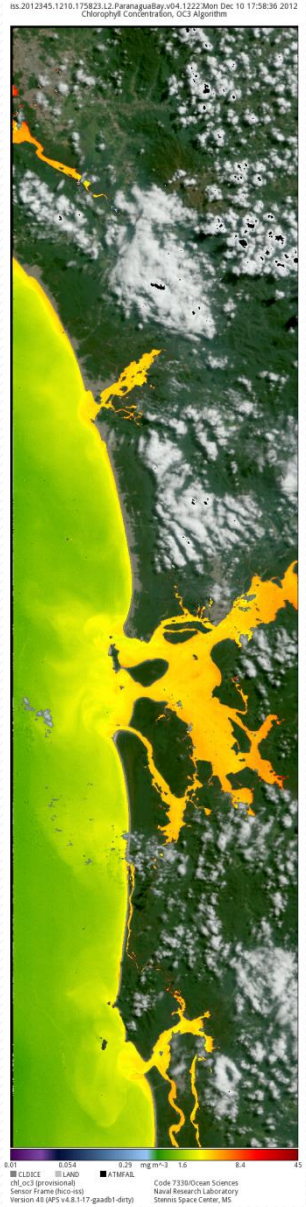

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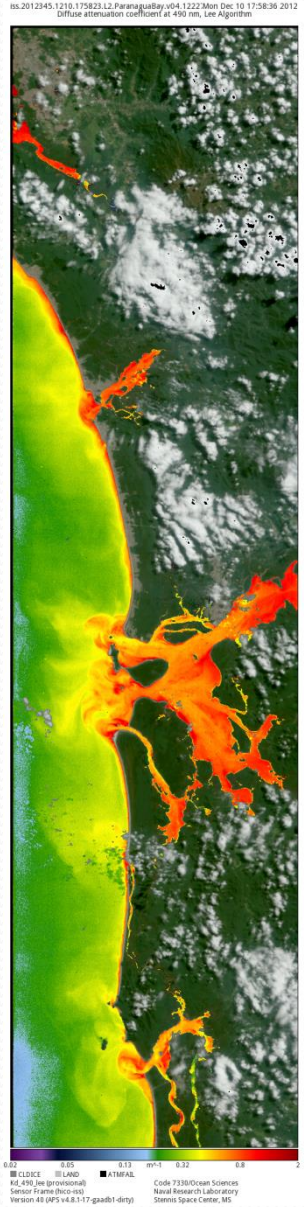
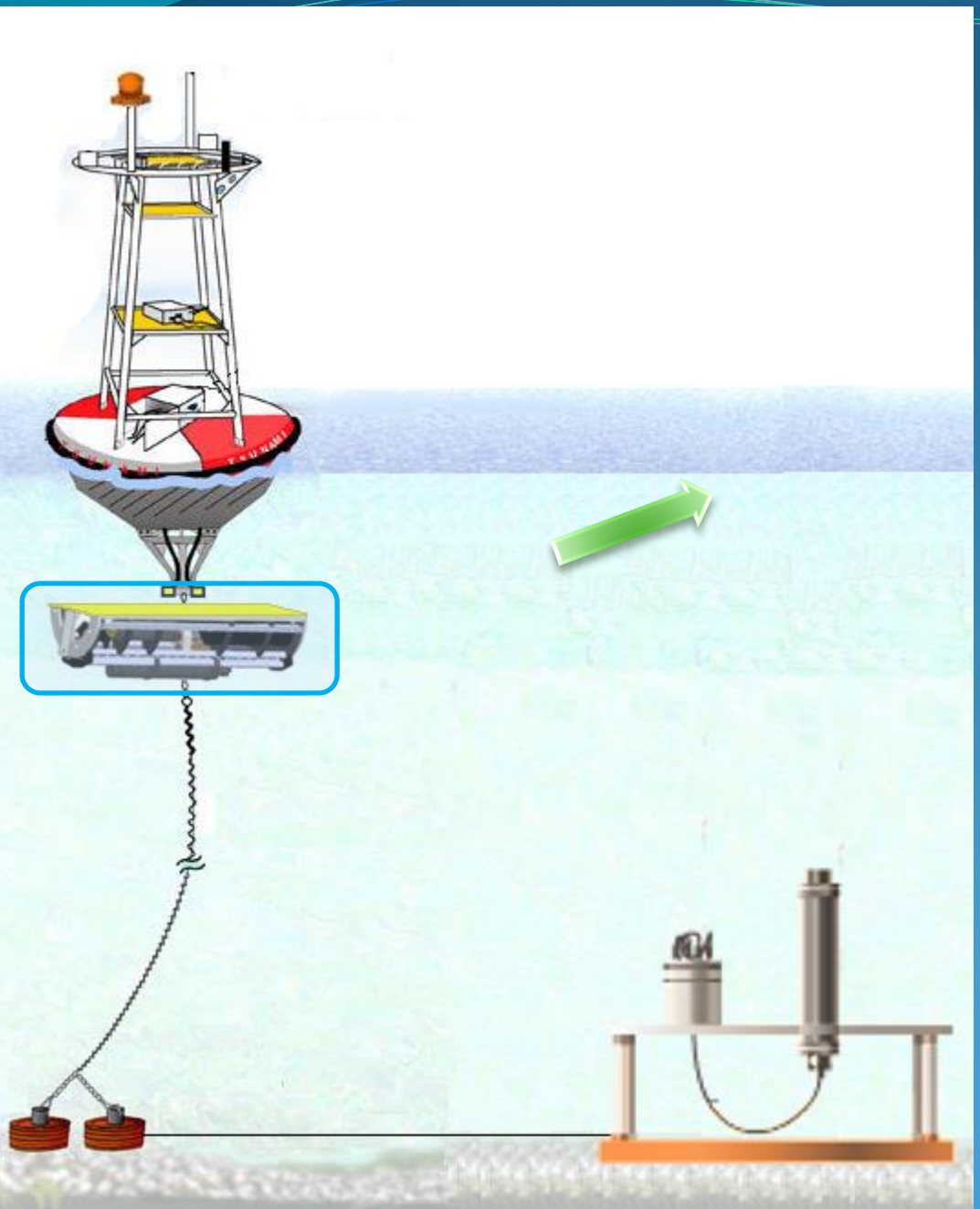


Kd_490

Challenges and future

- Keep and improve the *insitu* data
- Radiometric data
- Pigments analysis (HPLC)
- Atmospheric correction – Regional algorithm
- Remove the bottom influence
- Time series - Meteo-oceanographic buoy



- CO^2 concentration
- Backscatter
- Chlorophyll
- Colored Dissolved Organic Matter
- Nitrate
- Dissolved O2
- Depth
- pH
- Salinity
- Sea Surface Temperature
- Turbidity

(Satlantic Inc.)

SiMCosta

Brazilian Ocean Observing System

Thank you!