



International Ocean Colour Science
Meeting 2015

Advancing Global
Ocean Colour
Observations

INPE NATIONAL SPACE RESEARCH INSTITUTE

Milton Kampel

IOCS 2015

San Francisco USA June 2015



WHO WE ARE

Main civilian organization for space activities in Brazil
54 years in 2015

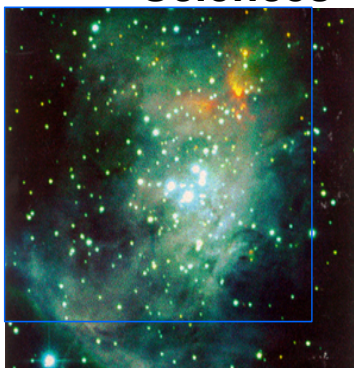


INPE headquarters, São José dos Campos, SP

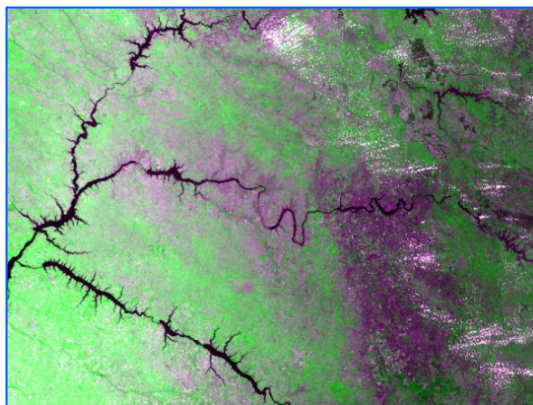


| Main areas of R&D

Space and Atmospheric Sciences



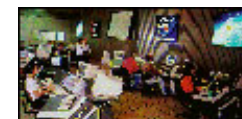
Earth Observation



Integration and Testing Laboratory



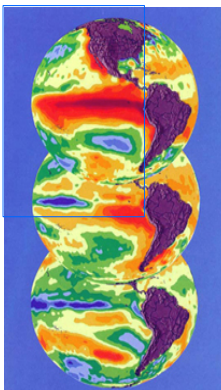
Satellite Tracking and Control



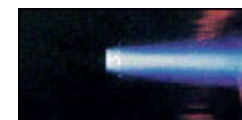
Space Engineering and Technology



Weather Forecast and Climate Studies

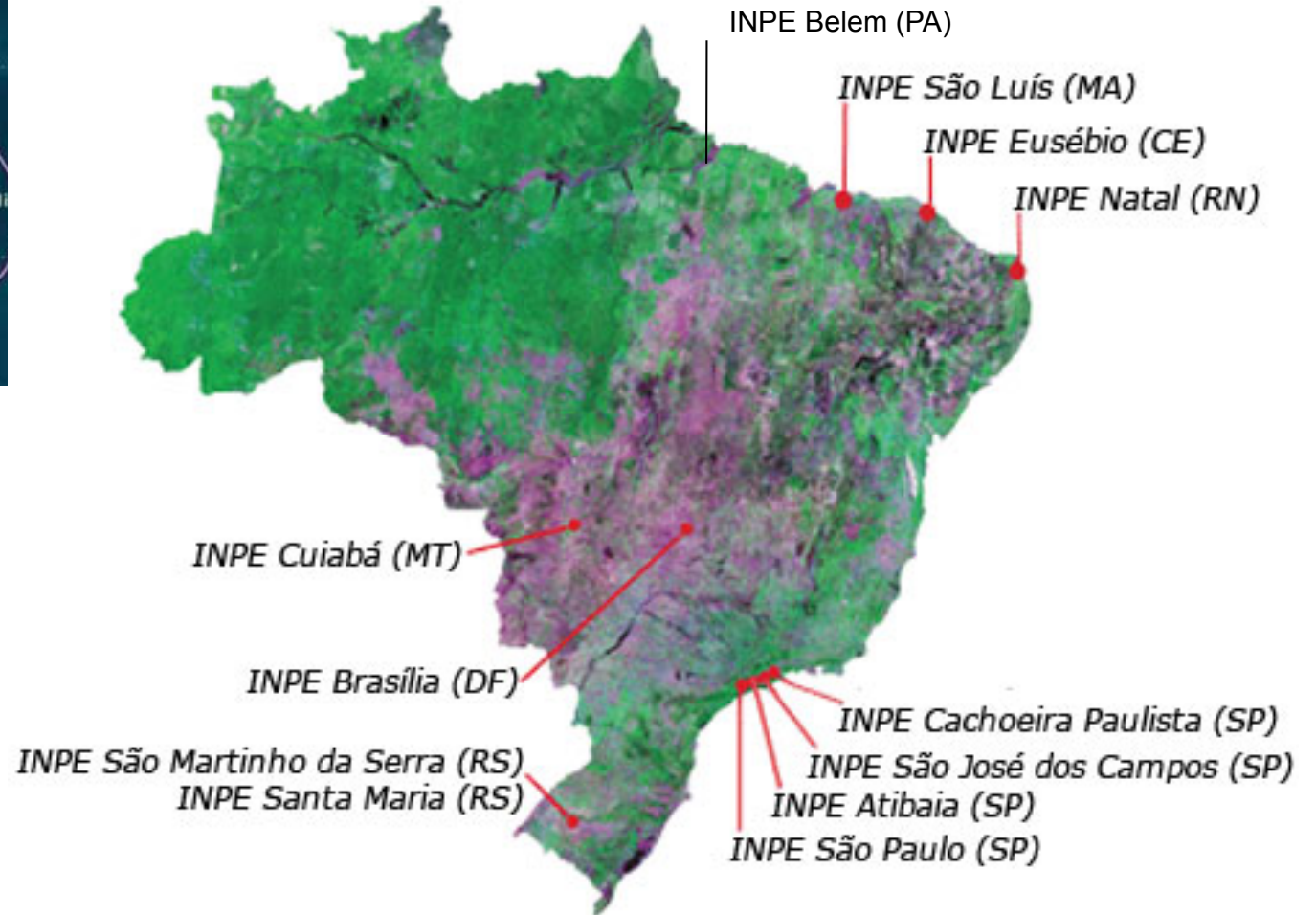


Associated laboratories





Facilities





What are the big national challenges where the Brazilian Space Program could contribute?

Energy



Agriculture



Ecosystems



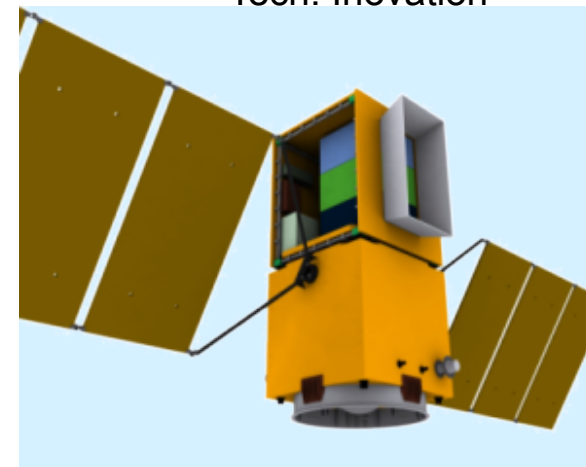
Climate Changes



Disasters



Tech. Inovation



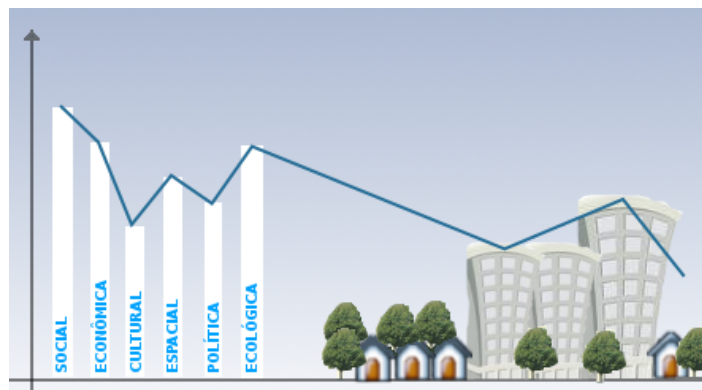
Camara

Oceanographically speaking...

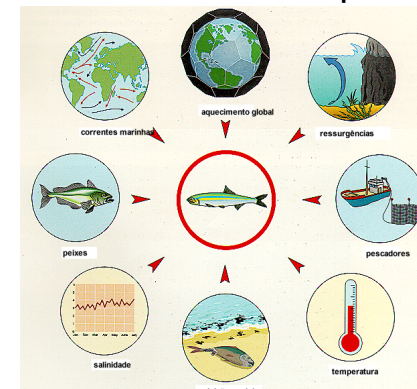
Oil&Gas



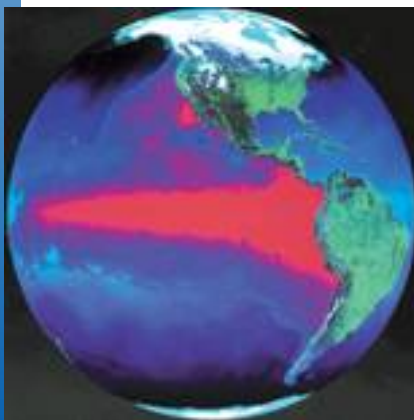
Coastal Management



Fisheries&Aquic.



Weather&Climate



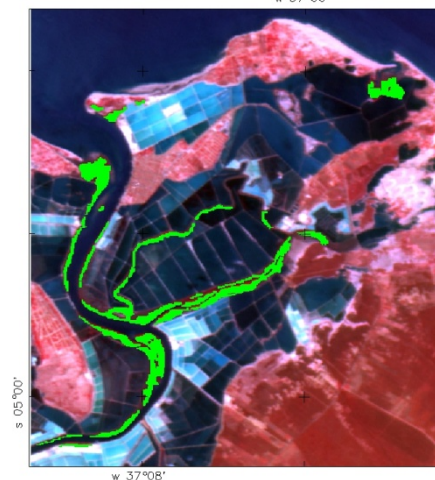
Disasters



Tech. Inovation



Ecosystems



INPE: CONVERTING DATA INTO KNOWLEDGE



SATELLITES

Earth observation, scientific,
and data collection satellites



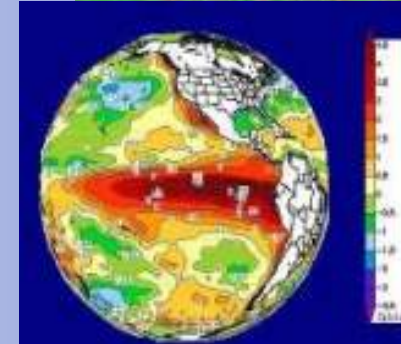
GROUND SYSTEMS

Satellite control, reception, processing
and distribution of satellite data



ANALYSIS AND MODELLING

Space Weather, Weather Prediction
and Earth System Science

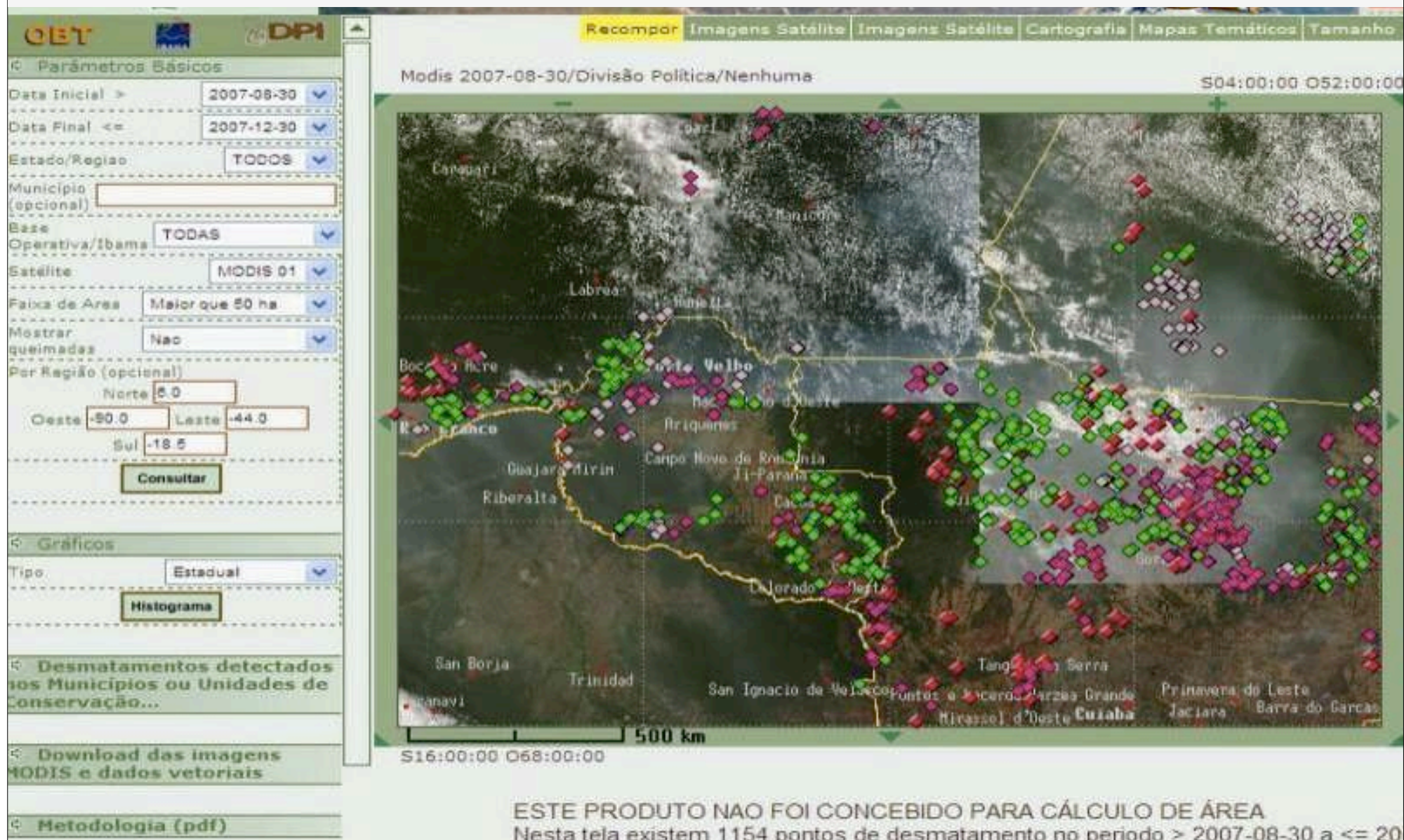


SOCIETAL BENEFITS

Innovative products
to meet Brazil's needs

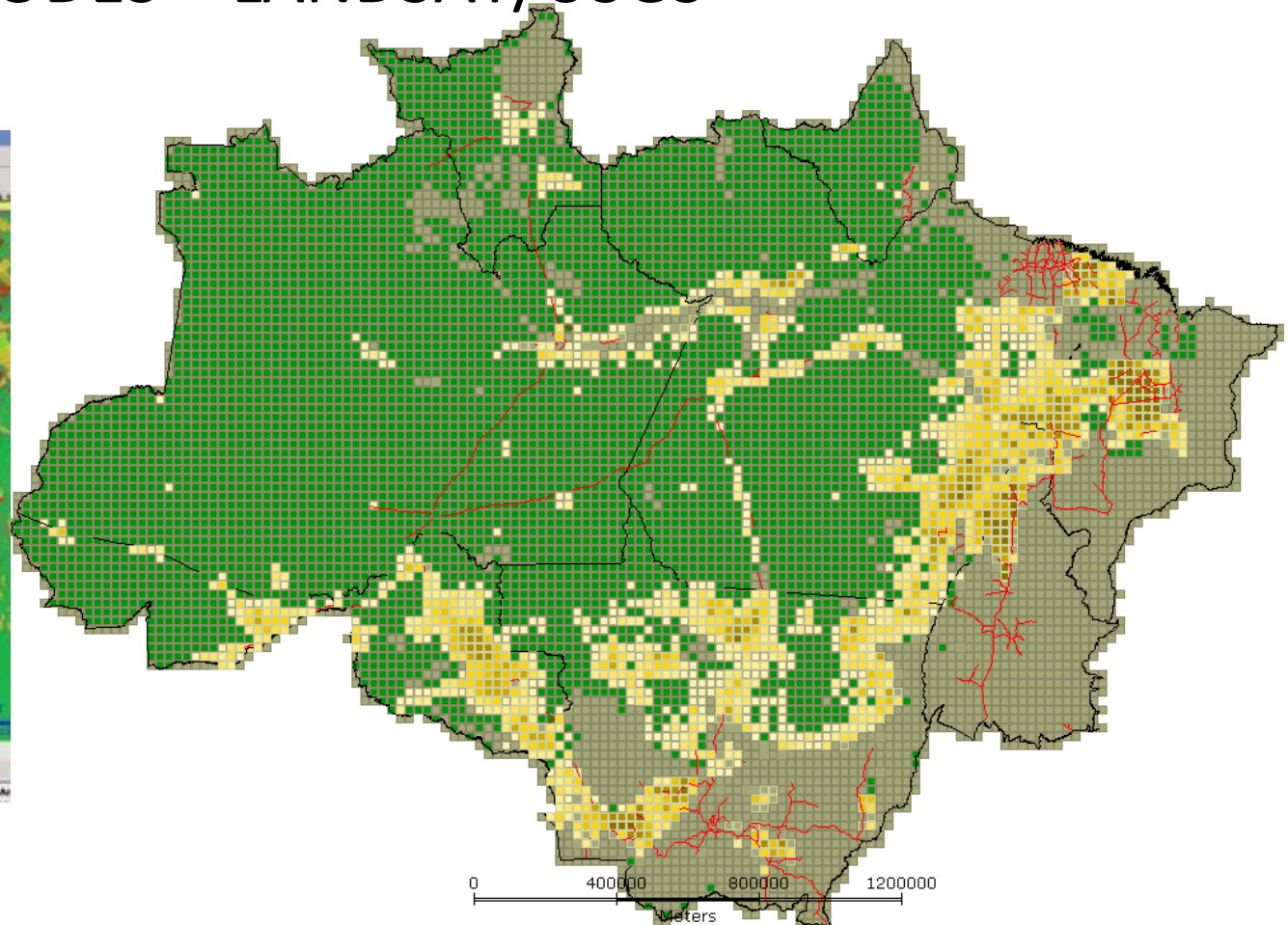


Real-time Deforestation Monitoring – DETER - MODIS/NASA



Daily warnings of newly deforested large areas

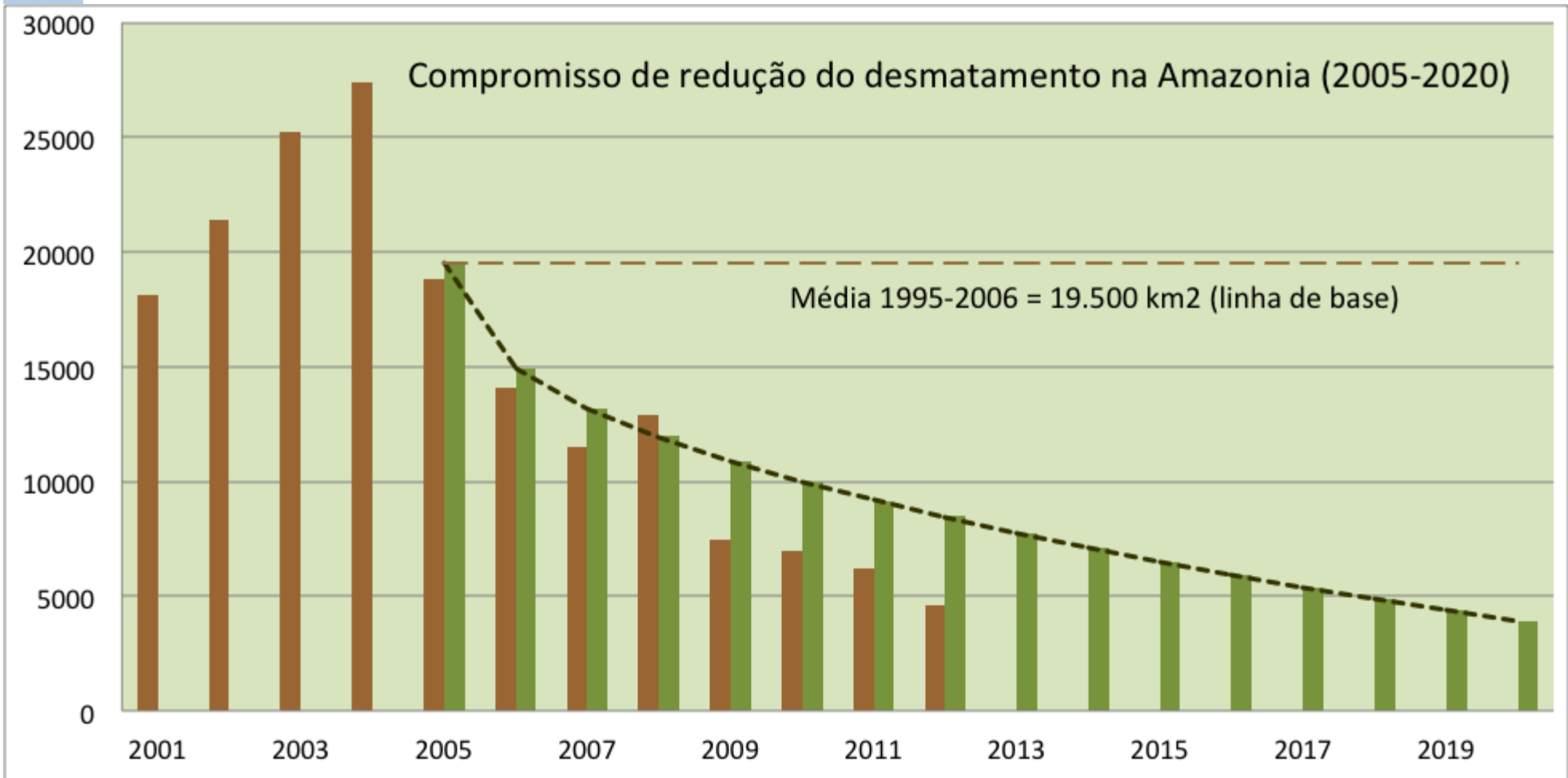
Camara, G.



Yearly detailed estimates of clear-cut areas

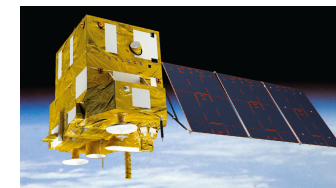


“By 2020, Brazil will reduce deforestation by 80% relative to 2005.” (pres. Lula in Copenhagen COP-15)

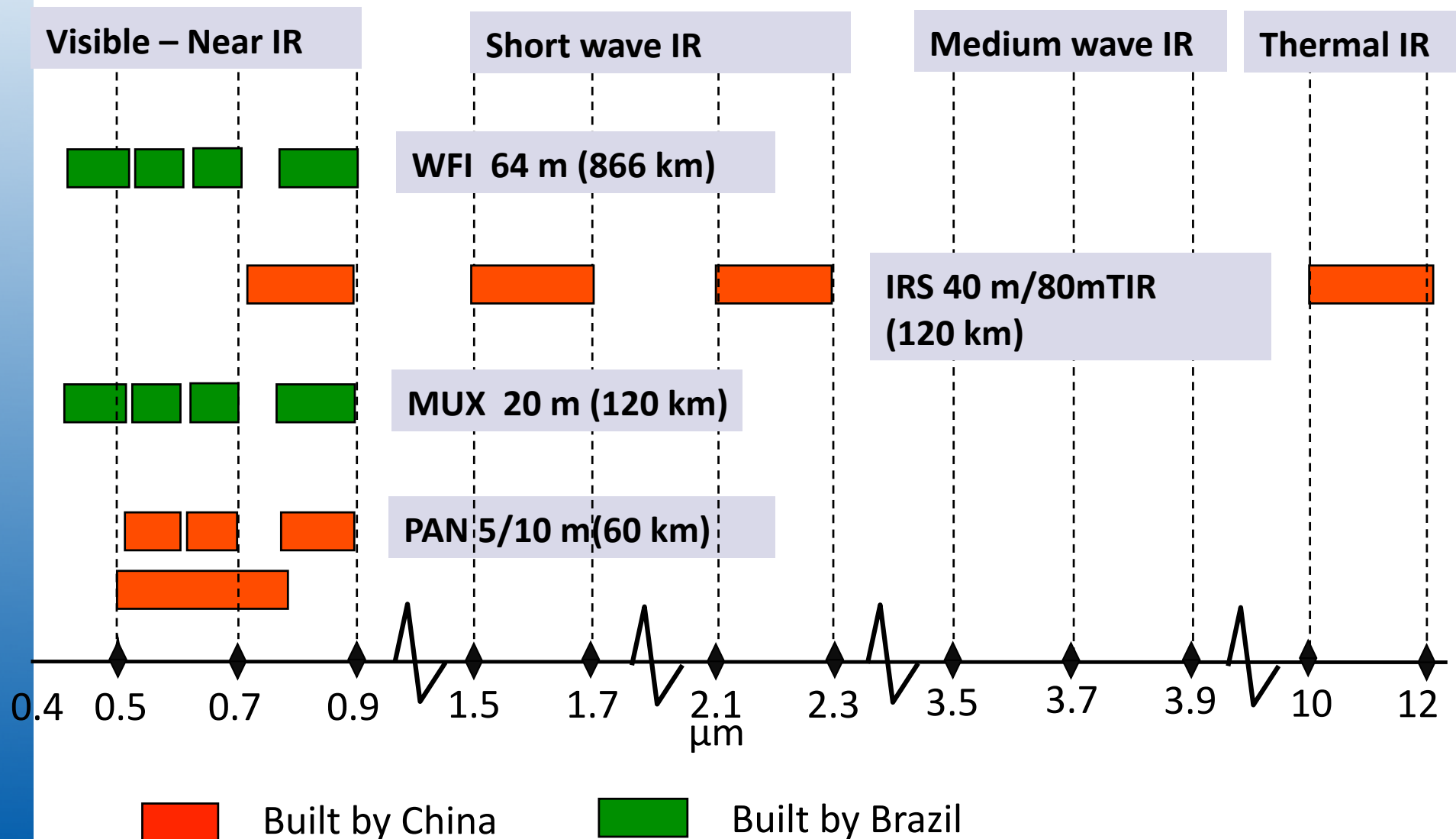




CBERS 4



CBERS 4A TLD 2018





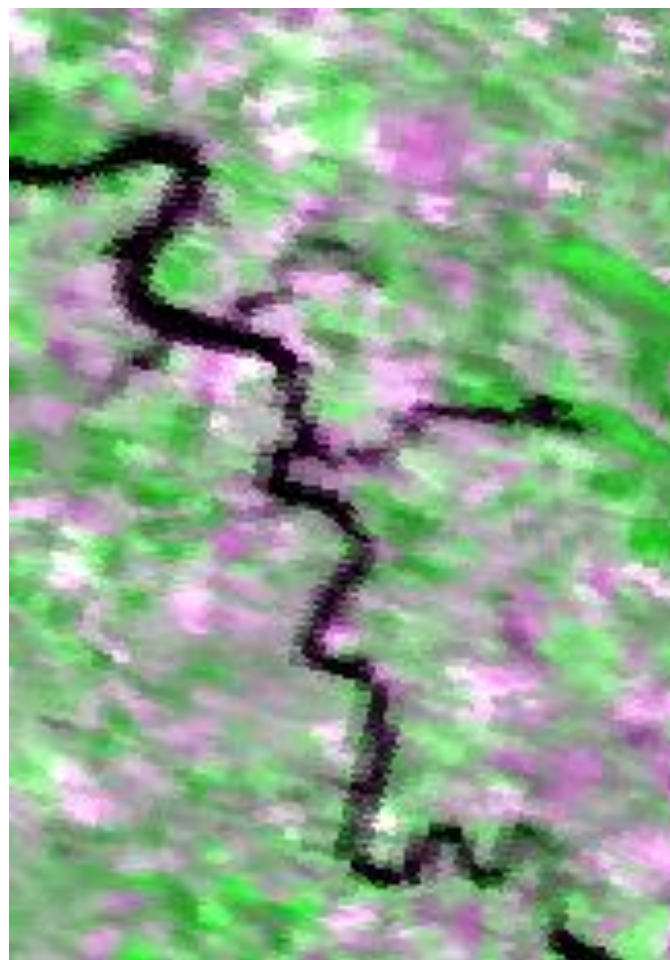
WFI x MODIS

WFI = 64 m x 64 m



R (V) G (IR) B (V)

MODIS = 250 m x 250 m



R B (V) G (IR)

Novo, E.



| WFI x LANDSAT

WFI/CBERS-4



R (V) G (V) B (A)

TM/Landsat-5



R (V) G (V) B (A)

Novo, E.



| WFI x MUX

WFI **R** (Vr), **G** (Vd), **B** (A)



Novo, E.

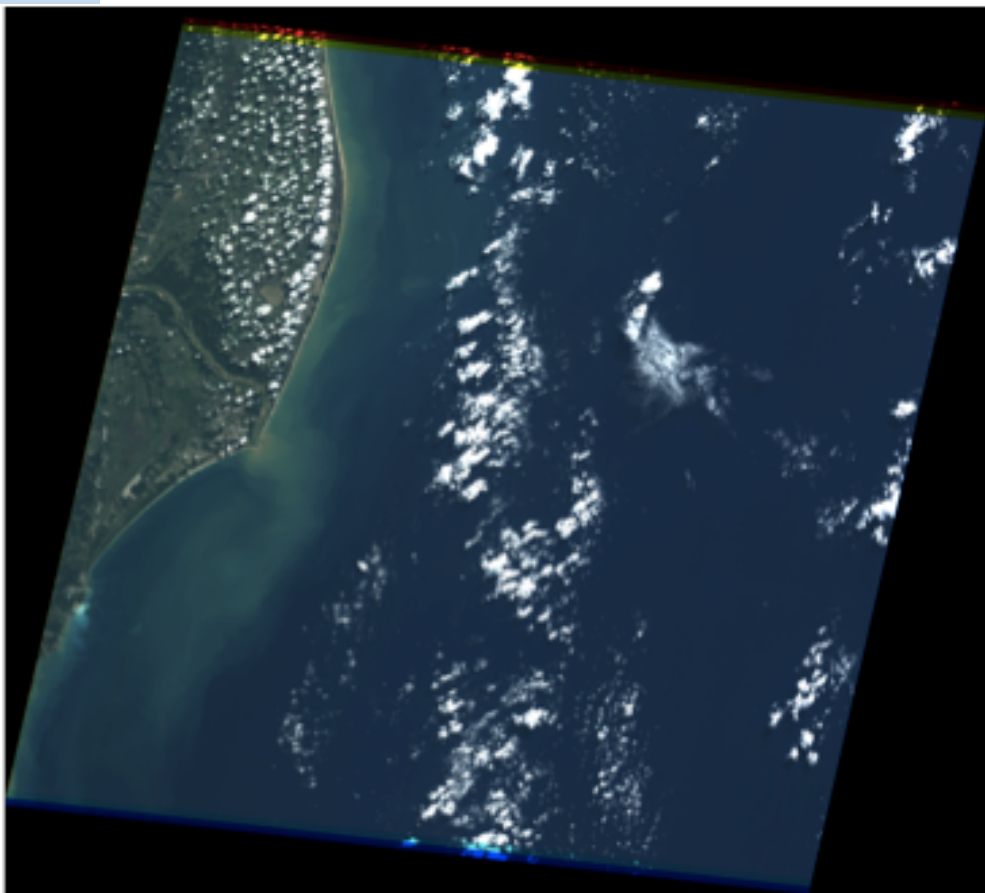
MUX **R** (Vr), **G** (Vd), **B** (A)



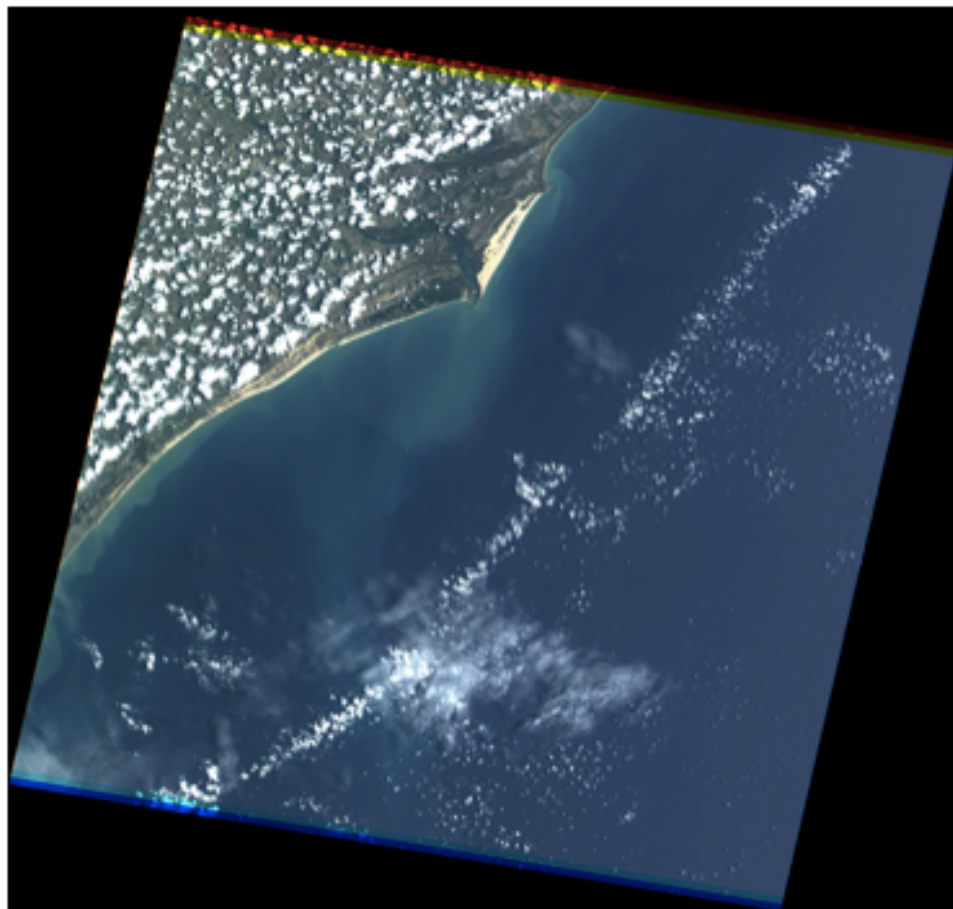


MUX 02/27/2015

MUX Rio Doce

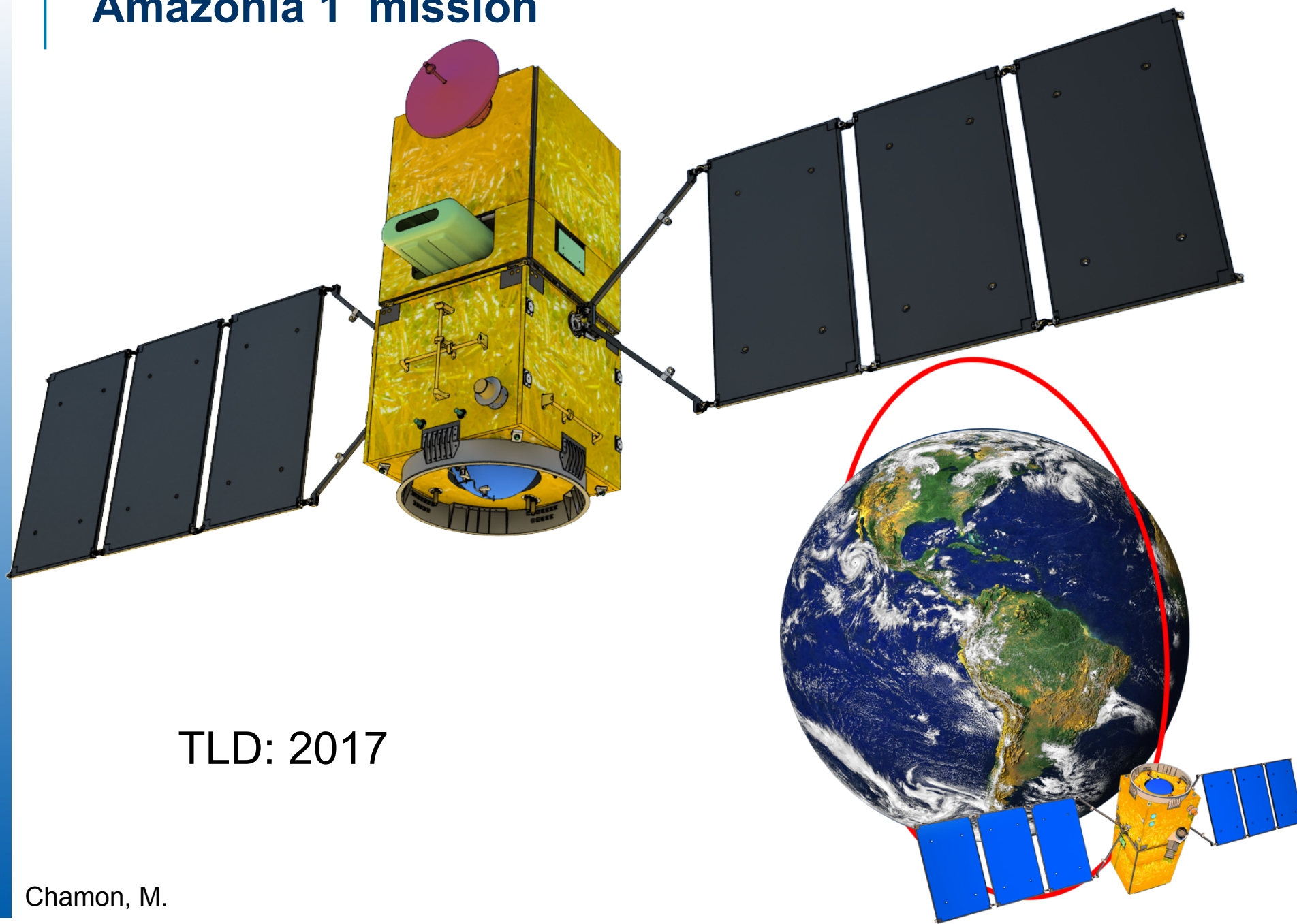


MUX Rio São Francisco





Amazonia 1 mission



TLD: 2017



Geostationary Sat. - SGDC



TLD: 2017



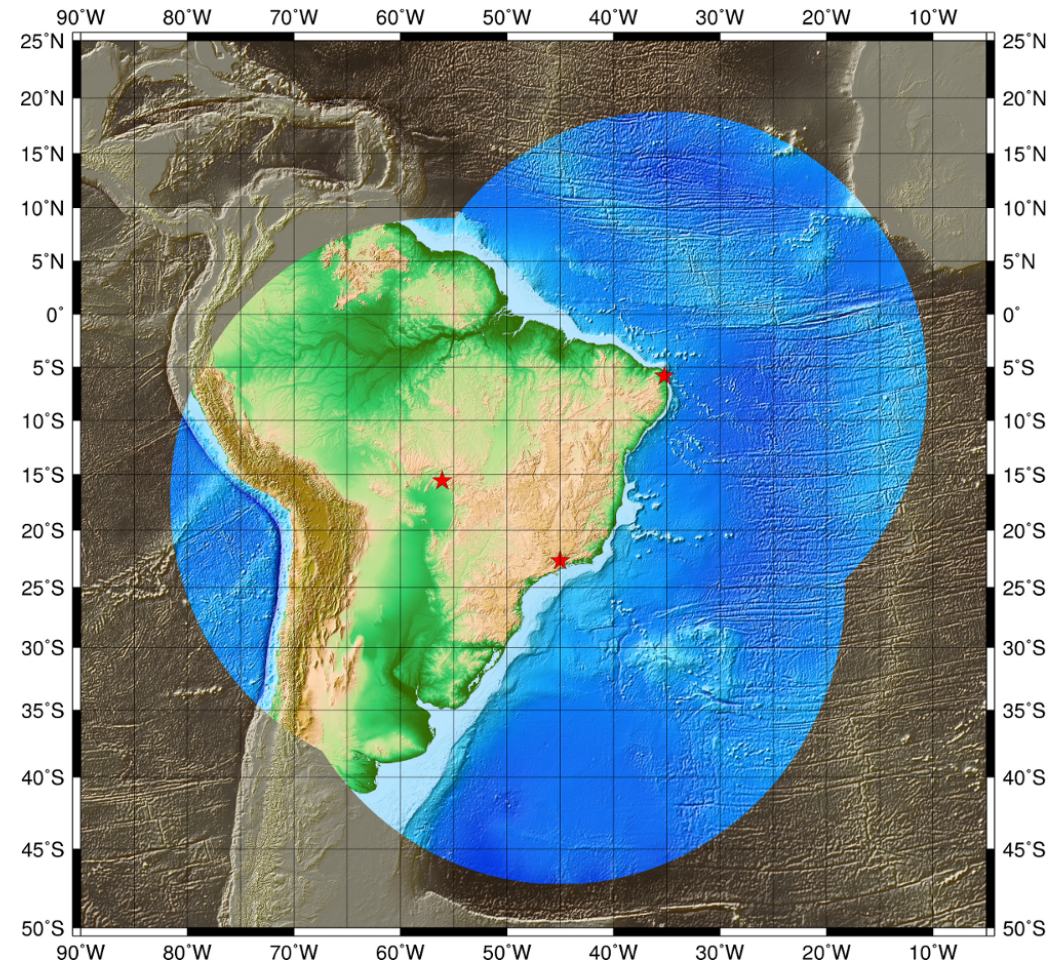
EXPANSÃO
PRÉDIO DE INTEGRAÇÃO

EXPANSÃO
PRÉDIO DAS CÂMARAS





Ground segment – receiving stations & RSDC





A Global, Coordinated, Comprehensive and Sustained System of Observing Systems





GEO SB-01

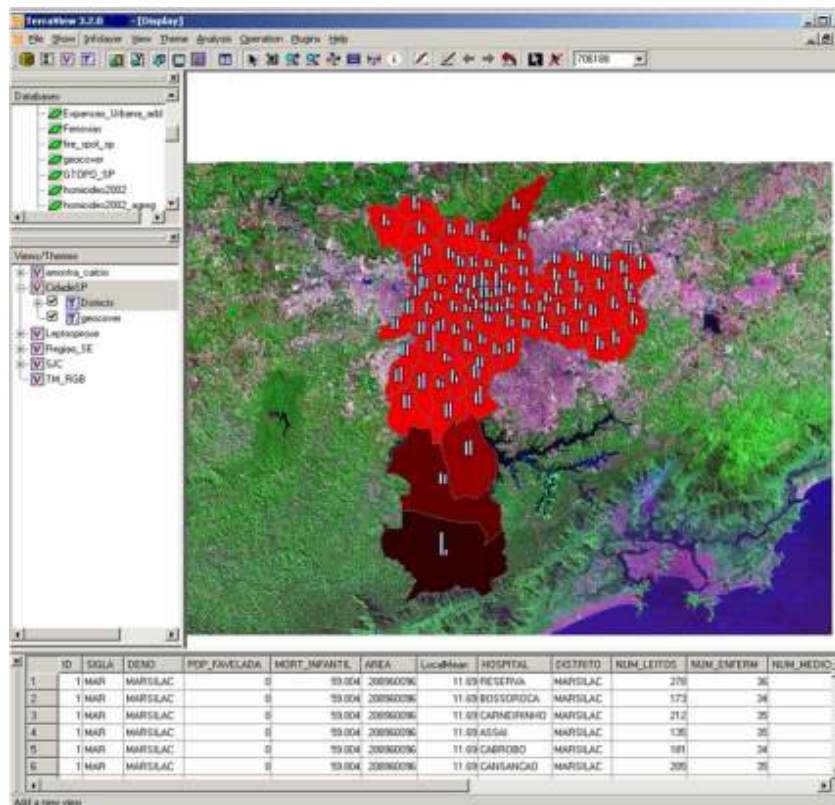
Oceans and Society: Blue Planet An Integrating Oceans Task of GEO



GEO Water Quality CoP



GIS - Softwares



Concepts

Map-based (cartographical user interfaces)

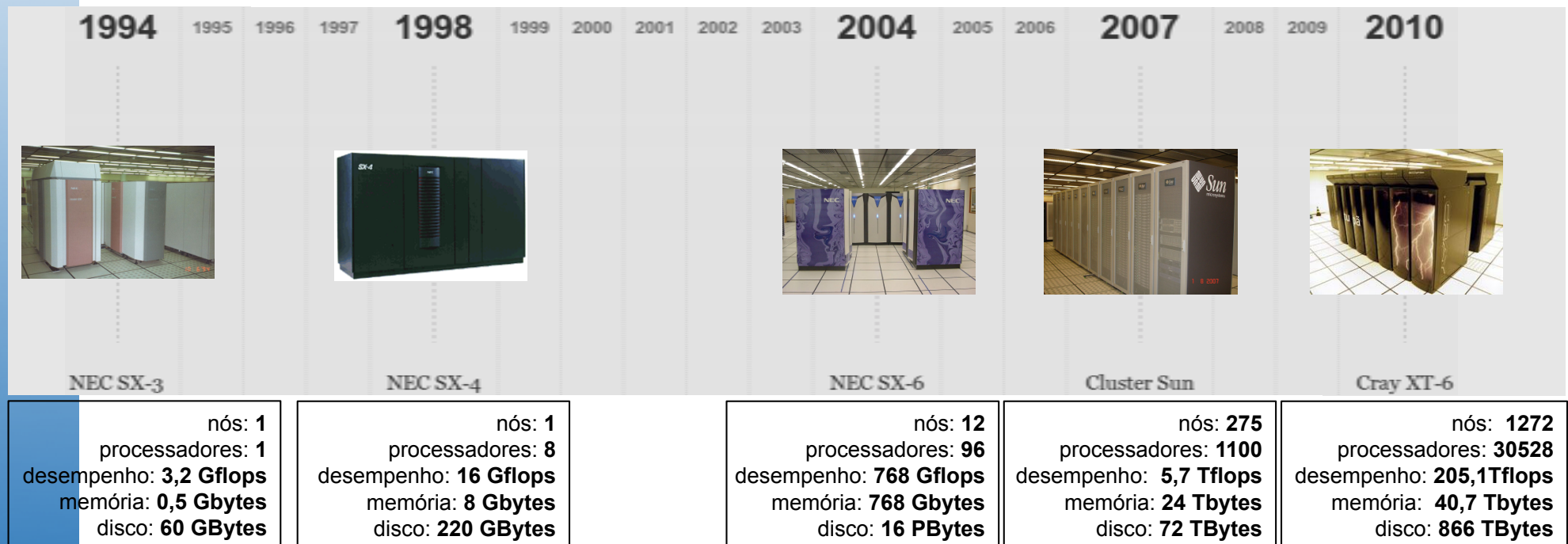
Toblerian spaces (regionalized data analysis)

Object-oriented modelling and spatial reasoning

Spatial databases (vectors and images)



Supercomputing at INPE



Tupã



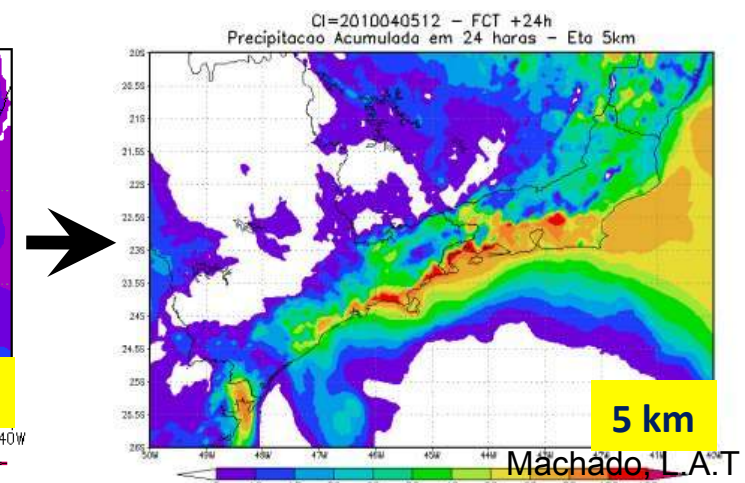
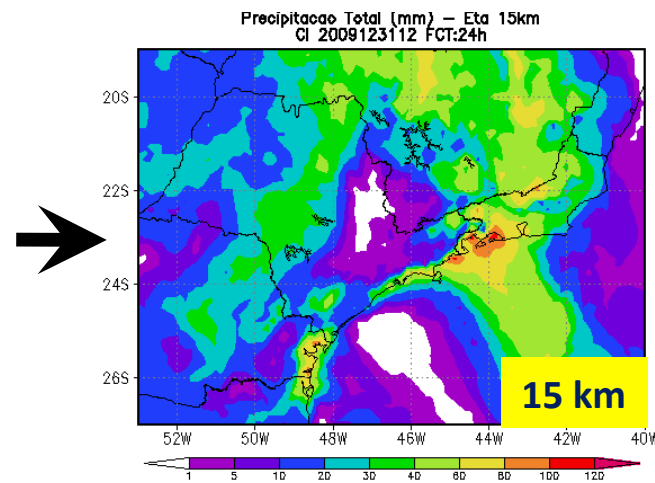
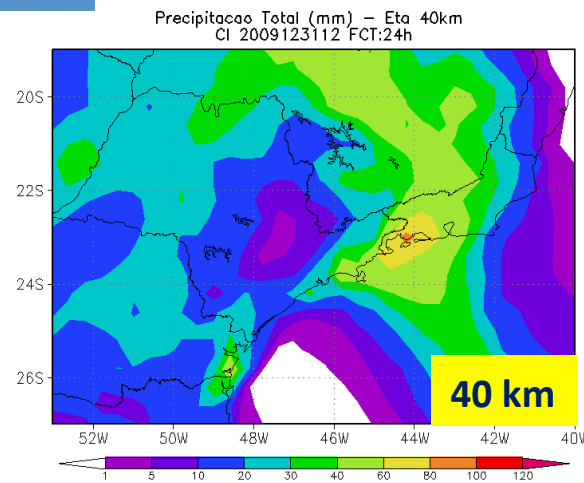
Cray XT-6: **Tupã**

\$25 million USD

29° fastest of the world

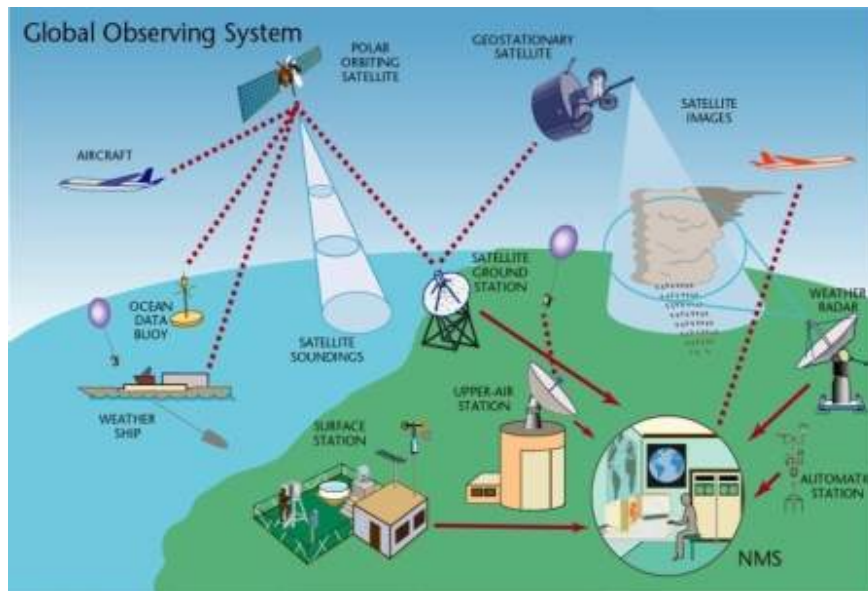
Improvement in nowcast, short-medium forecast

Better spatial resolution for weather forecast modeling
- Rain that caused tragedy in Angra dos Reis-RJ in 01/01/2010 (24h forecast) -





Numerical Weather Prediction at INPE

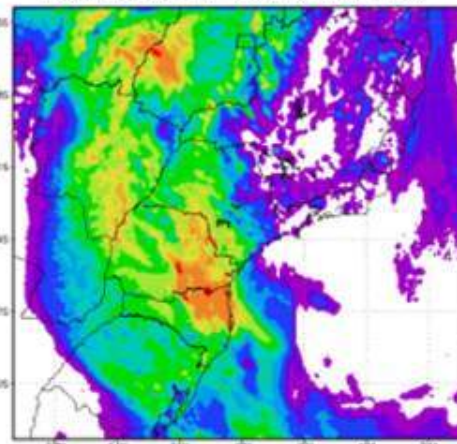


Global Weather Data



Supercomputer

Precipitação Total Acumulada em 4 dias - CI: 2004012400
Período: 20040125 12Z a 20040129 12Z



Numerical Weather Products



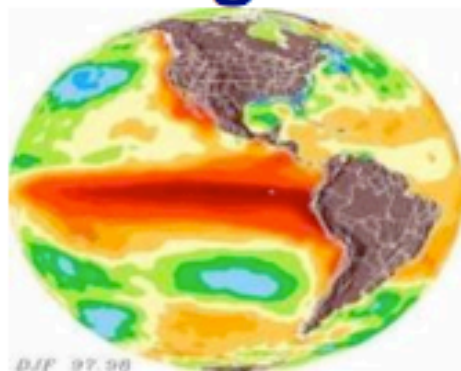
Media Info



Forecast Preparation

Climate Change Modelling

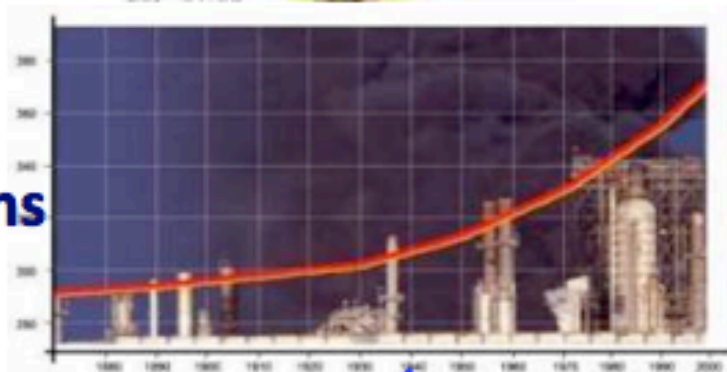
Data



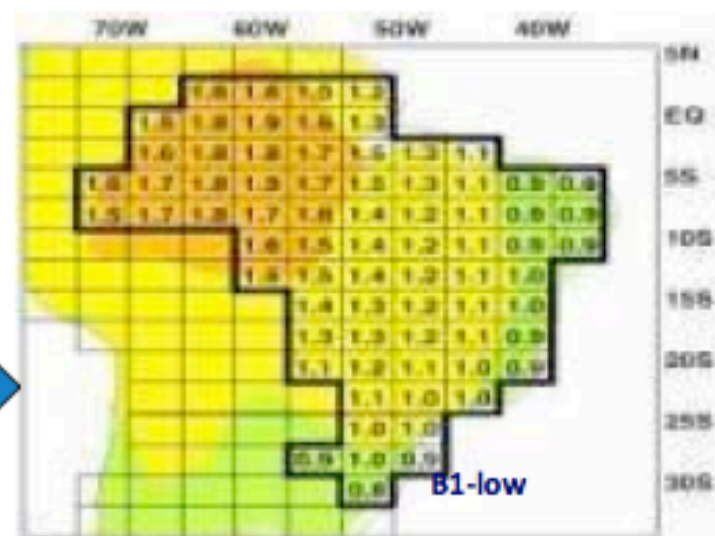
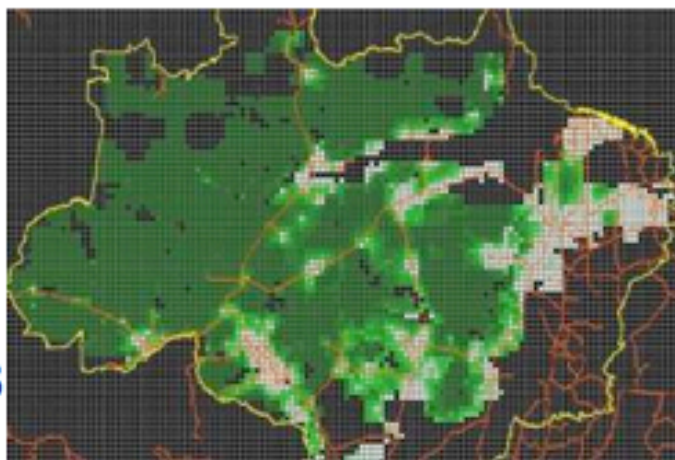
Supercomputer



GHG Emissions



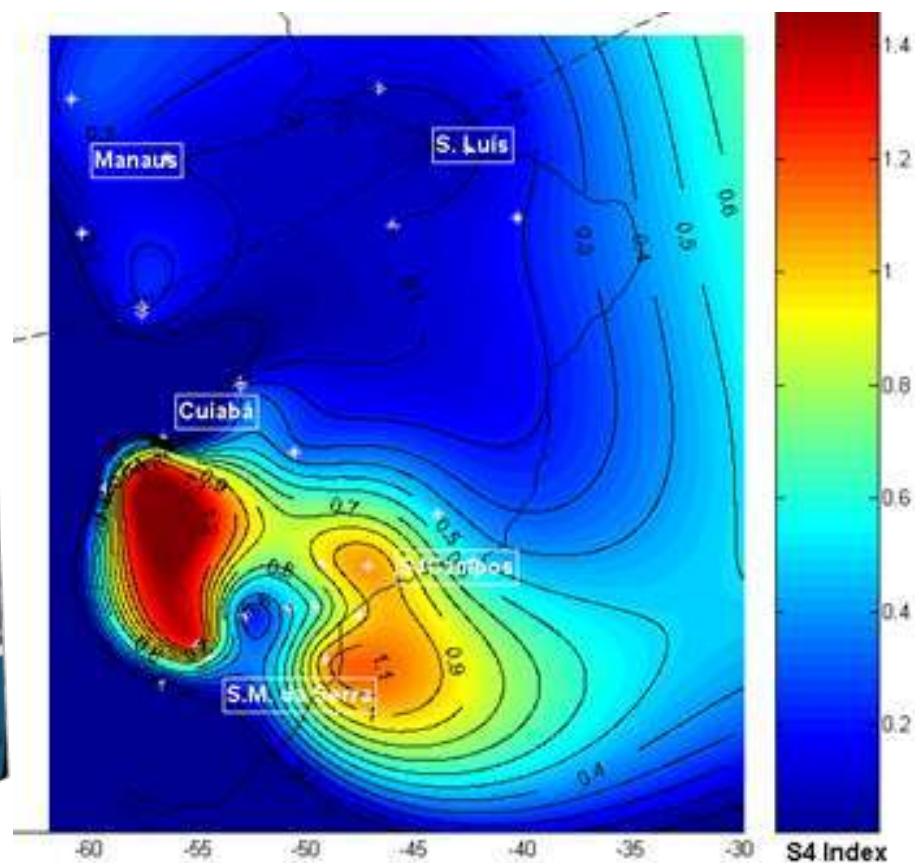
Public Policies



Regional scenarios



Space Weather Monitoring at INPE

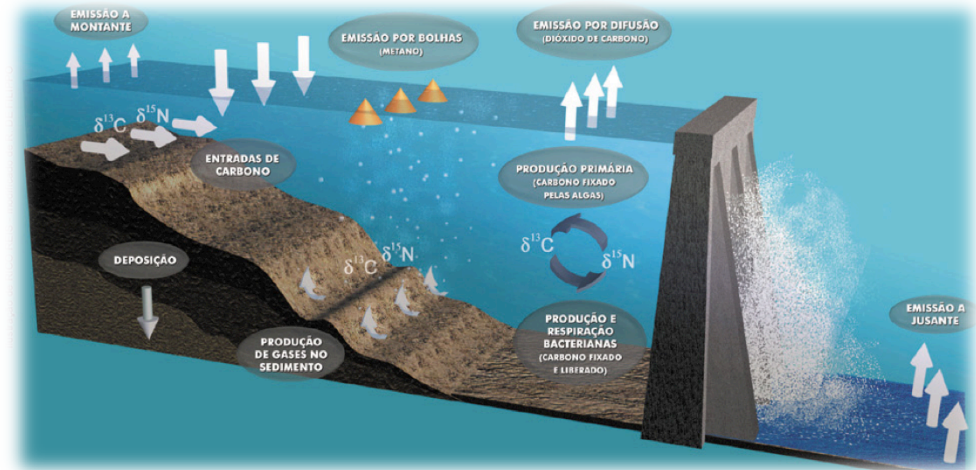


Ionospheric scintillation

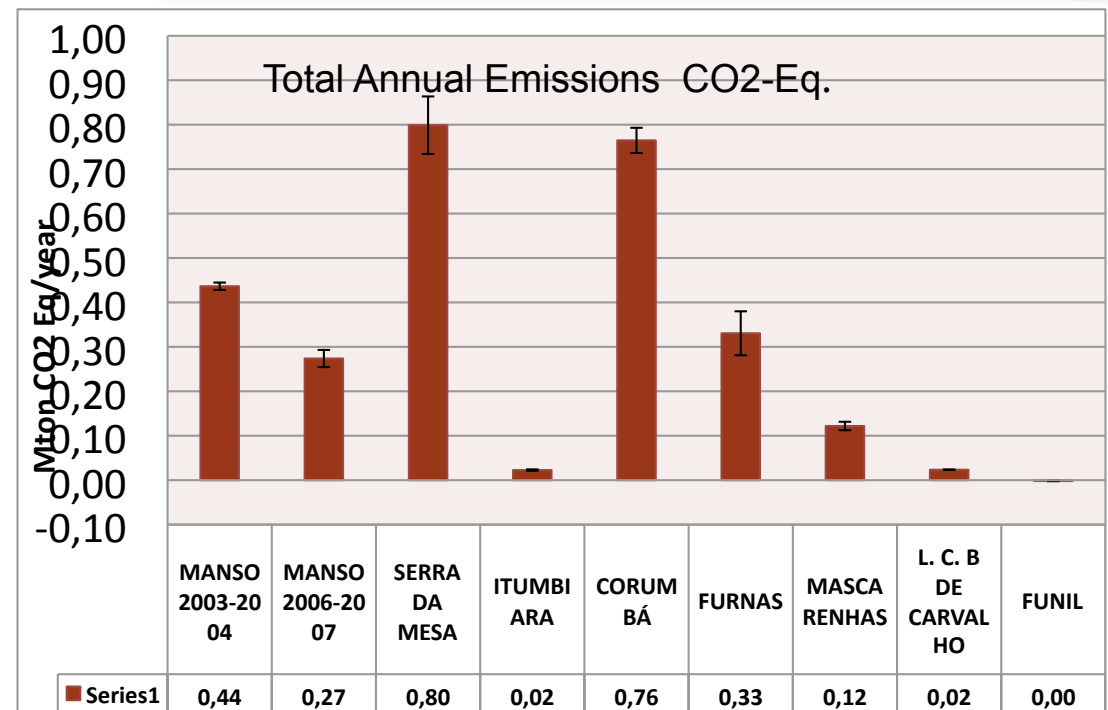
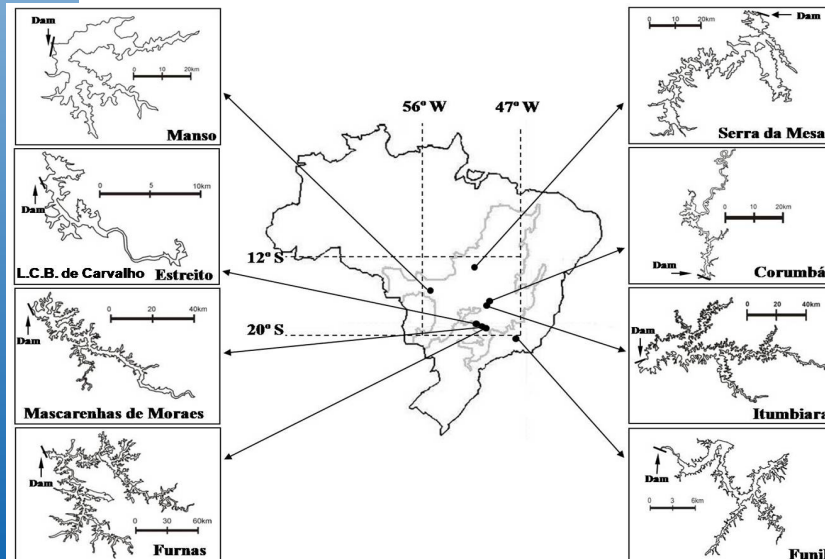
Inland waters – WQ, Environm. Biogeochem.

Carbon balance in tropical dams

To integrate studies related to the atmosphere and its interaction with various ecosystems to broaden the understanding of natural and anthropogenic processes that act in terrestrial and aquatic systems, such as emission / production of greenhouse gases, trace gases, aerosols, ozone layer, UV radiation, and deposition of chemical species.



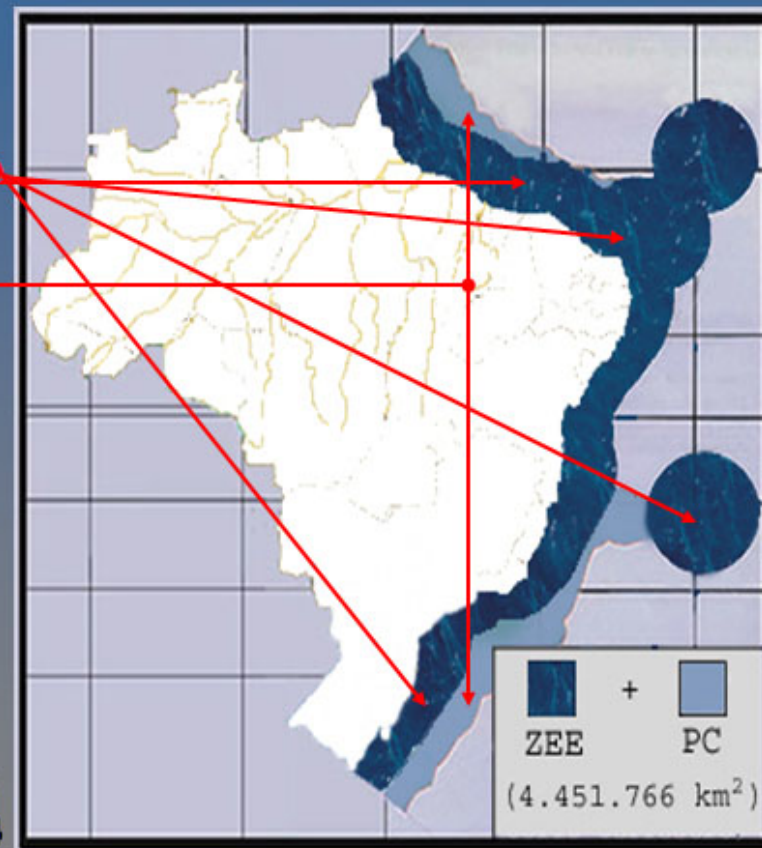
Dams under study



AMAZÔNIA AZUL

BLUE AMAZON

EEZ	$3.539.919 \text{ km}^2$
Continental Shelf	911.847 km^2
EEZ + Continental Shelf	$4.451.766 \text{ km}^2$

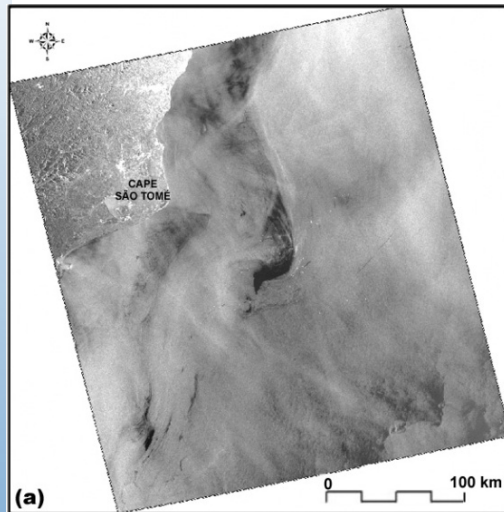


| Amazonia Azul - Blue Amazon

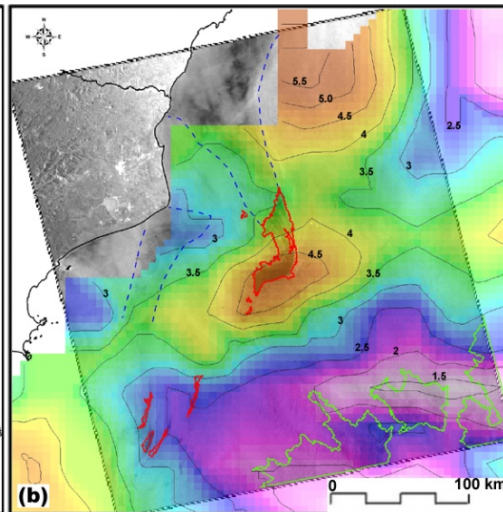




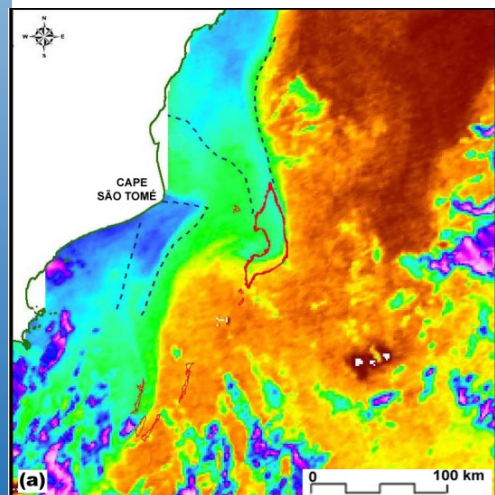
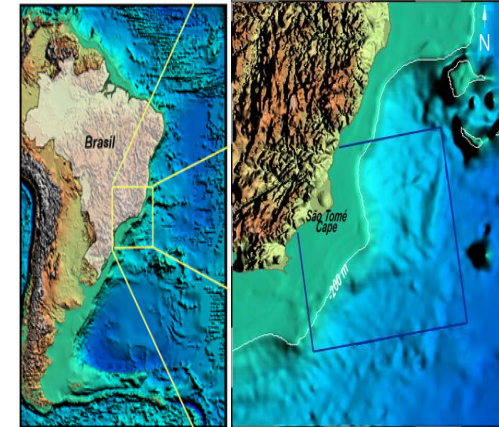
Algae blooms



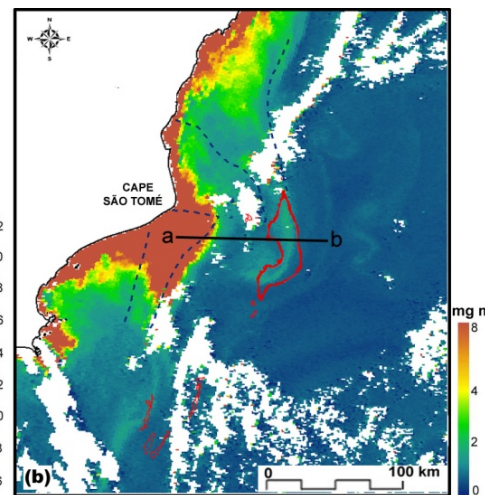
RADARSAT I (SCN) 3/4/2002 21:11 GMT



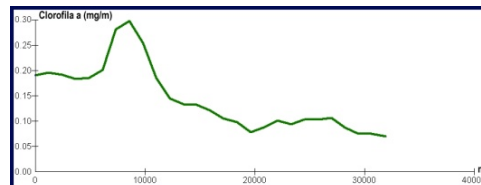
Quikscat 20:30 GMT



AVHRR 3/4/2002 21:09 GMT



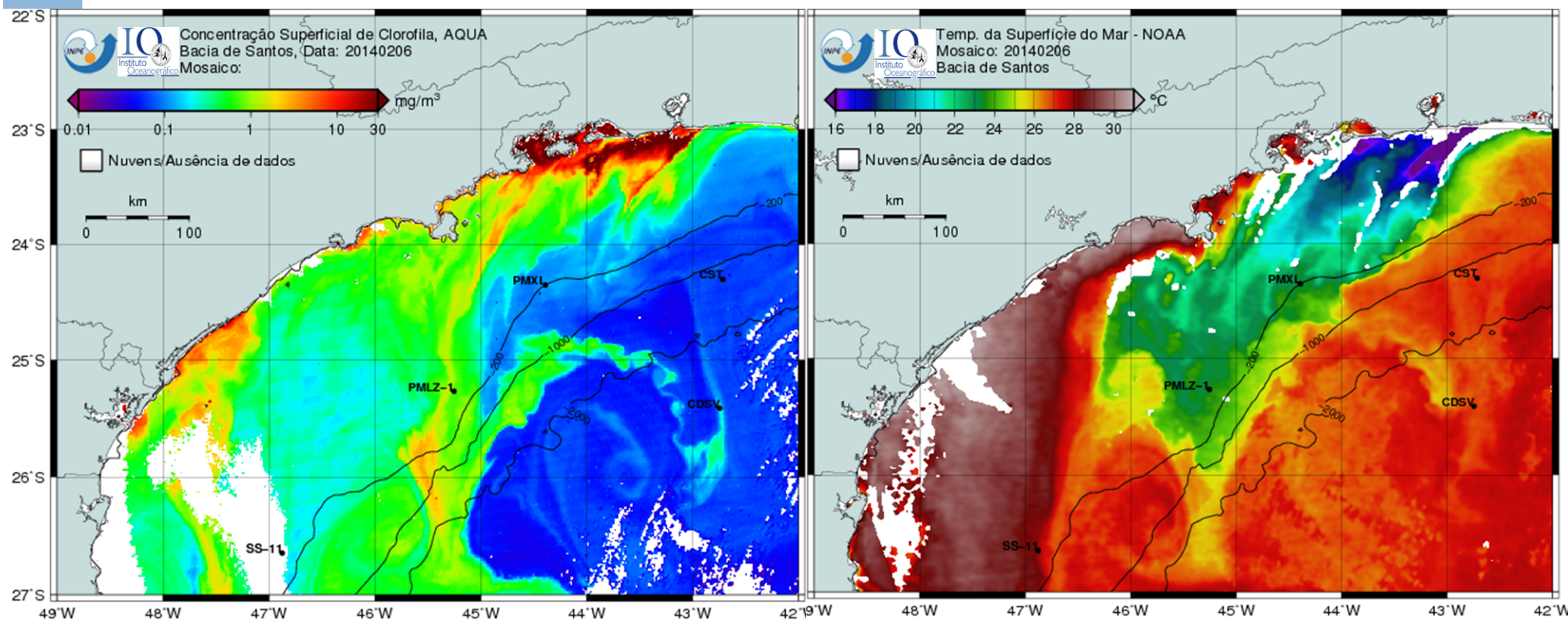
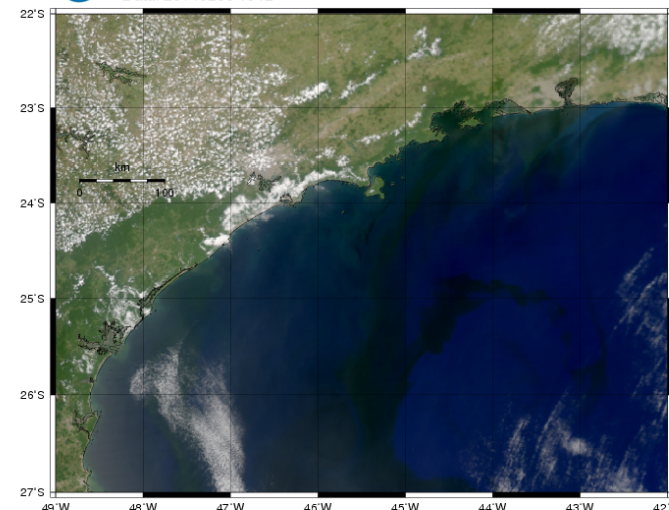
SeaWiFS 3/4/2002 14:05 GMT



Algae bloom– Feb/2014

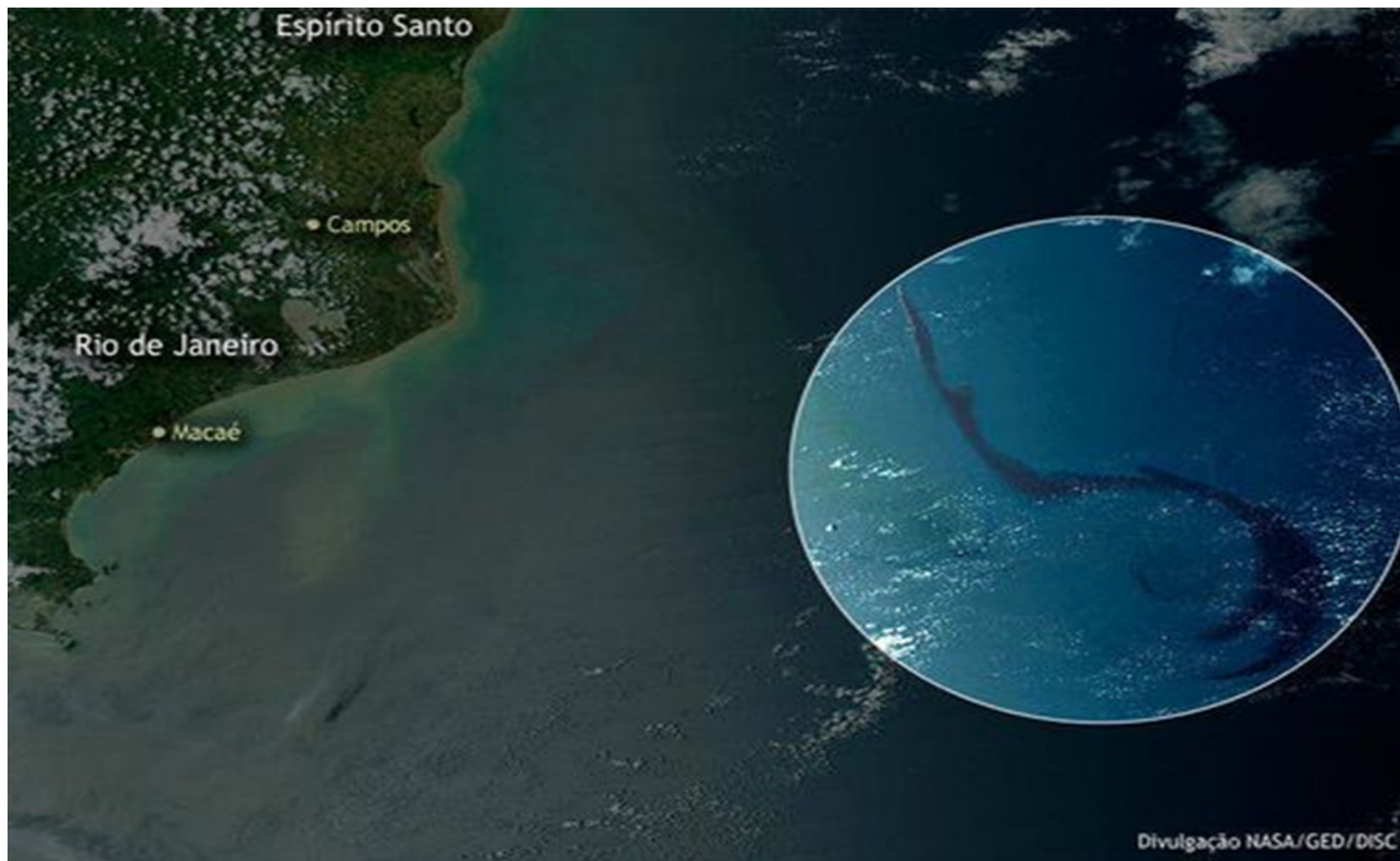


AQUA (MODIS) - COMPOSIÇÃO RGB (645 nm, 555 nm e 469 nm)
Data: 20140206 1842



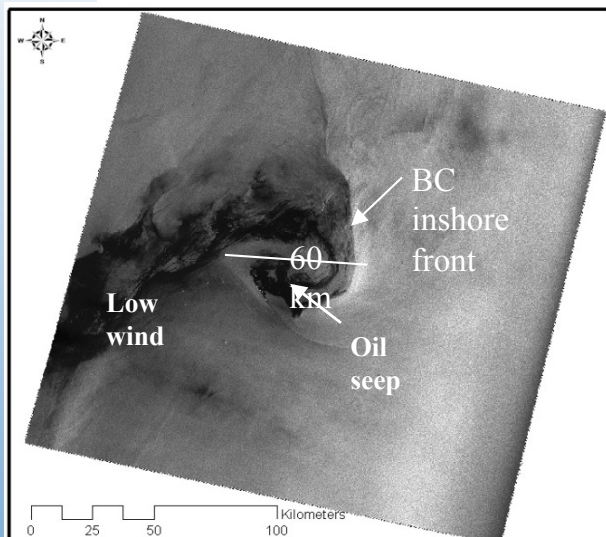


| Oil spill– 10/Nov/2011

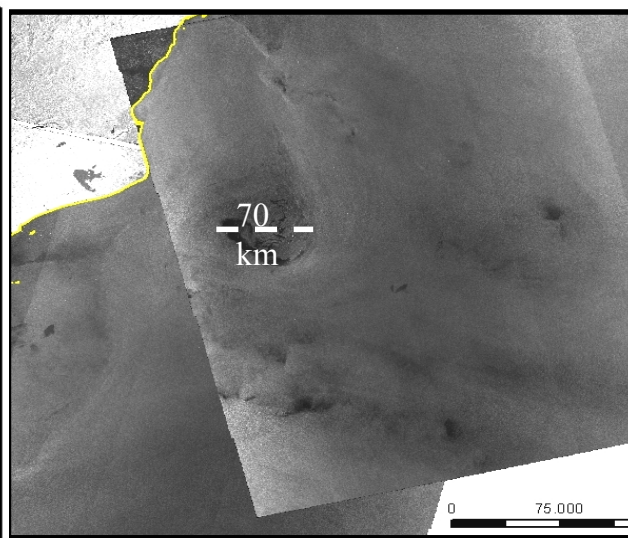




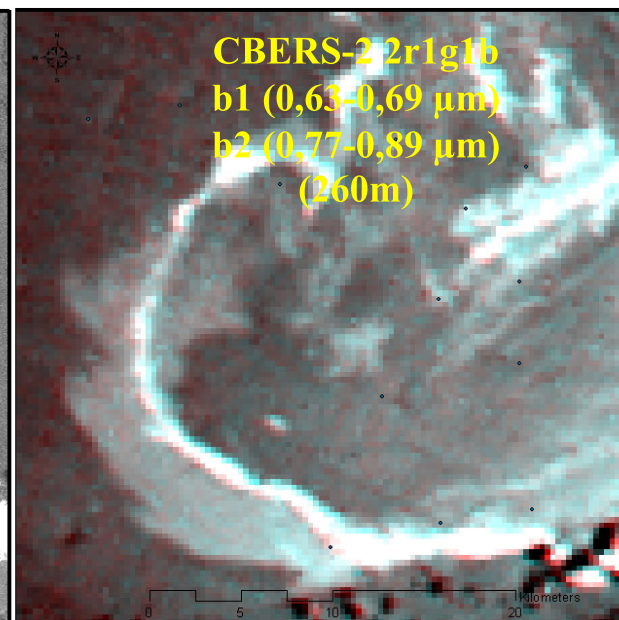
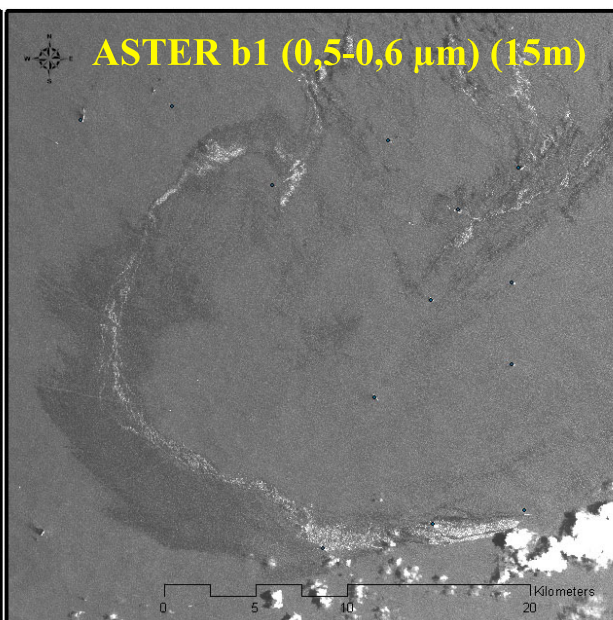
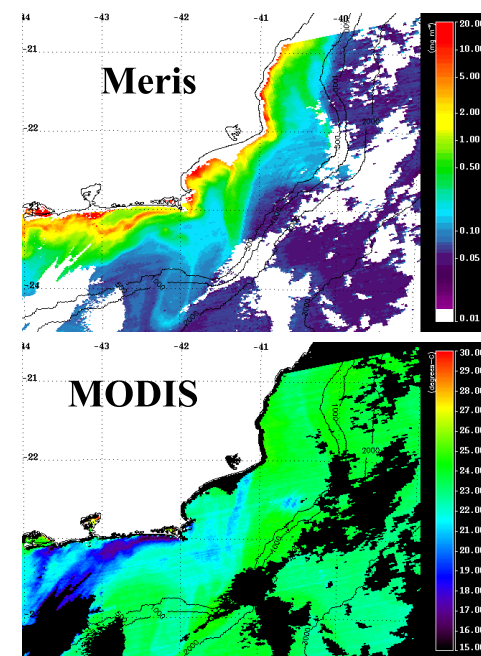
Oil seeps – Campos Basin



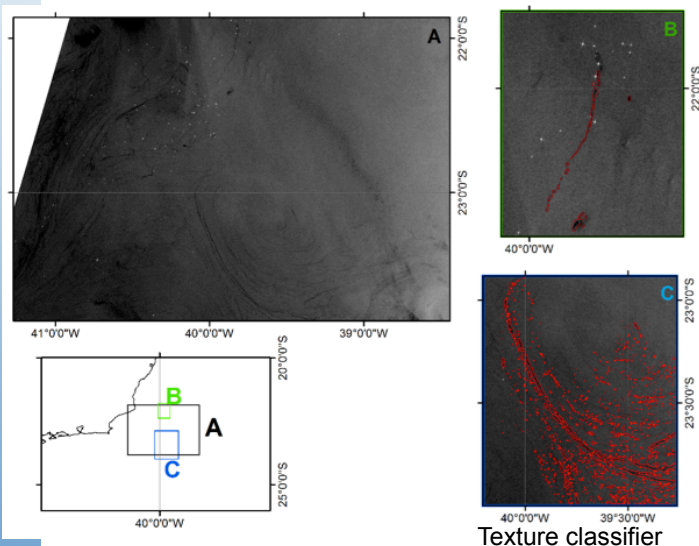
Radarsat-1 Desc, 19/11/2004 08:19 GMT



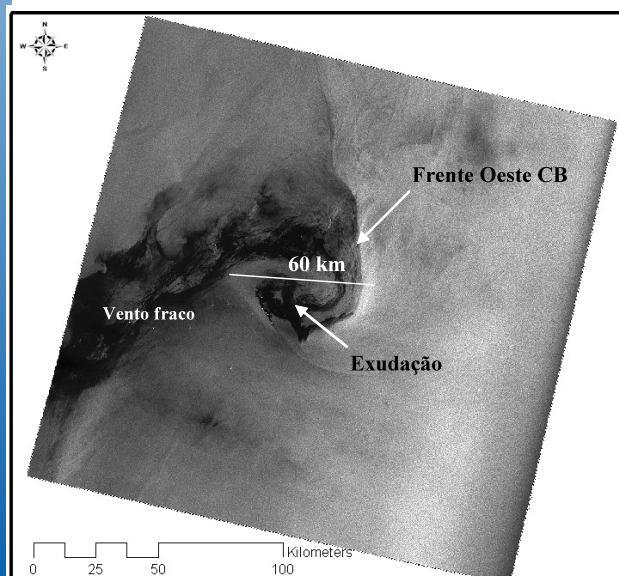
ASAR Desc, 22/11/2004 12:00 GMT



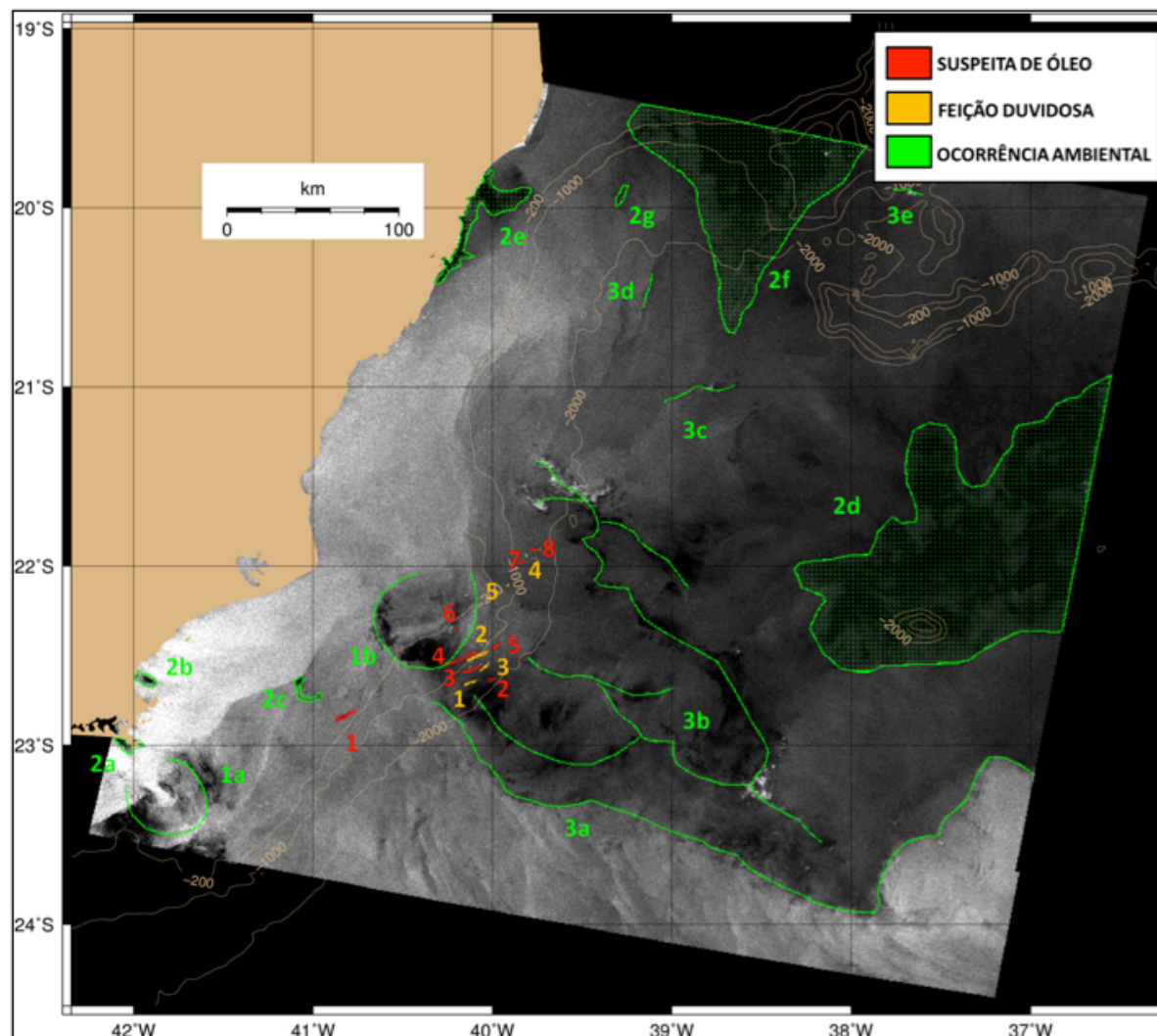
SAR Monitoring



Texture classifier



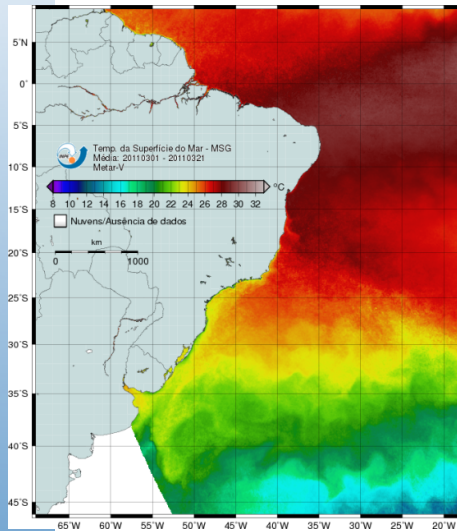
RADARSAT/Fitosat



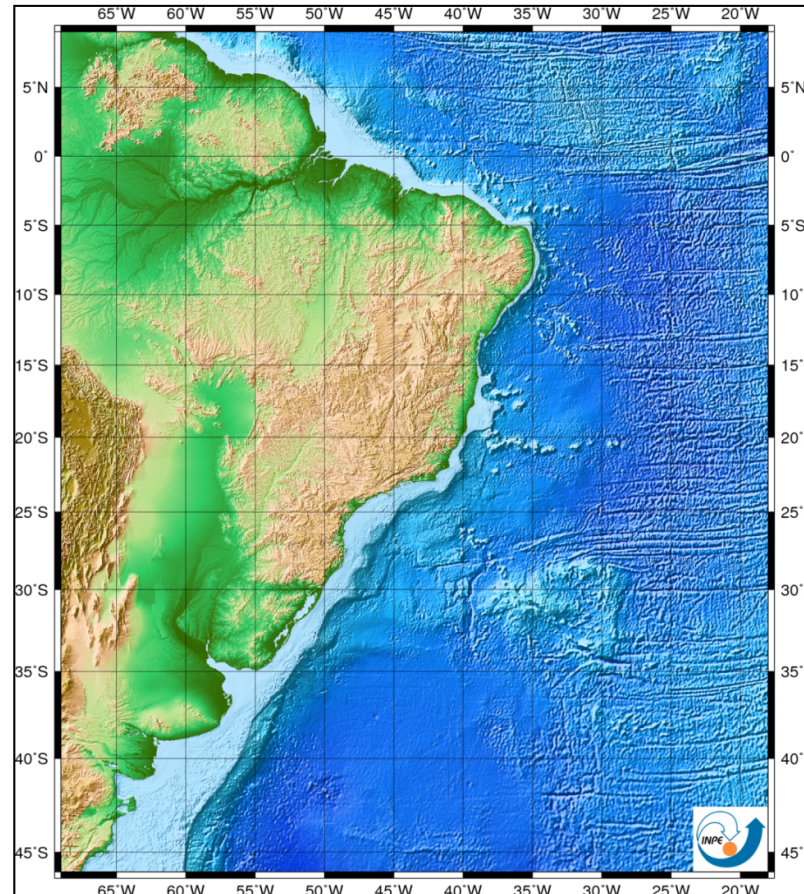
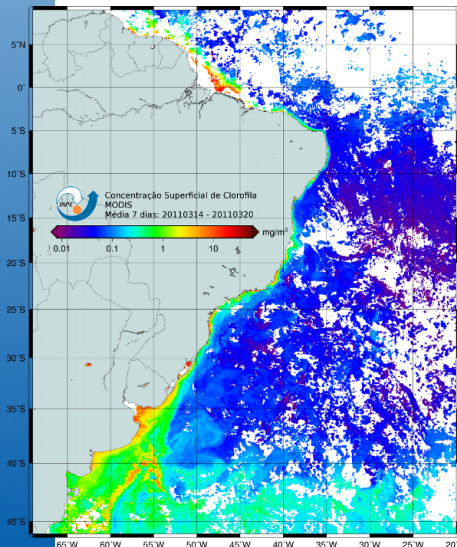


Operational MetOcean Monitoring

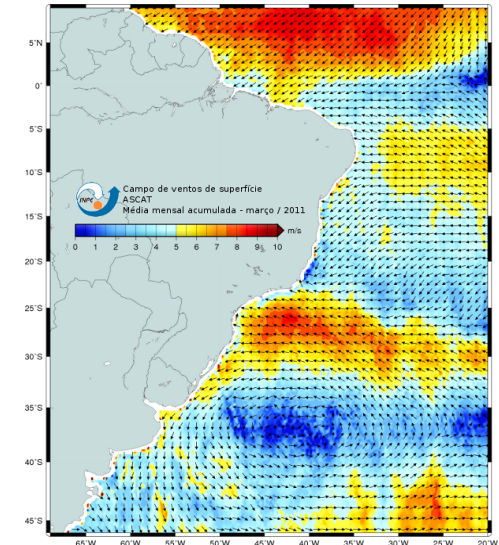
Sea Surface Temperature



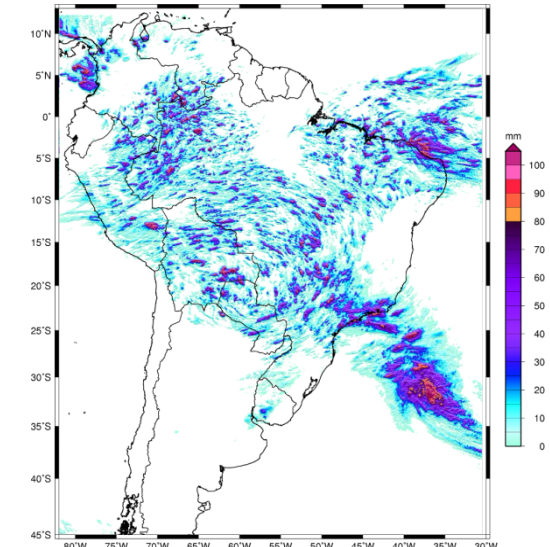
Chlorophyll Concentration



Surface Wind Vector



Satellite Precipitation

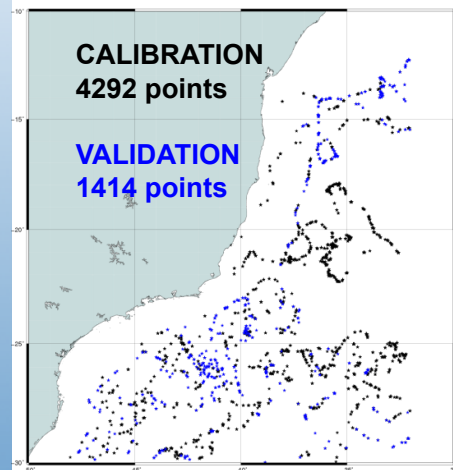




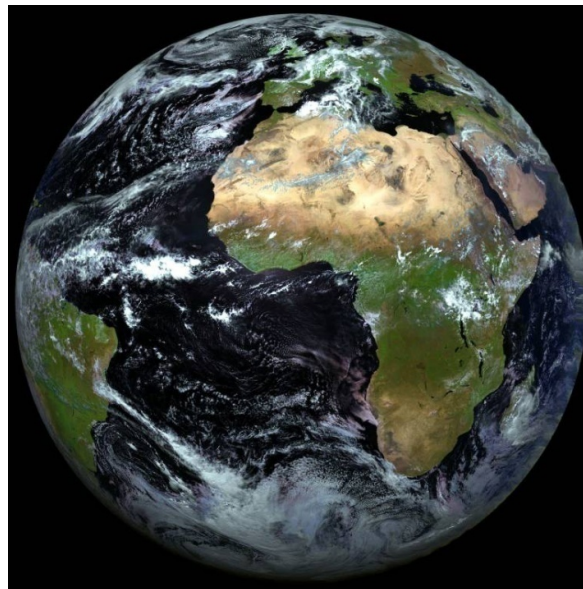
Algorithm calibration

Drifters - PNBOIA

09/2009 – 08/2010

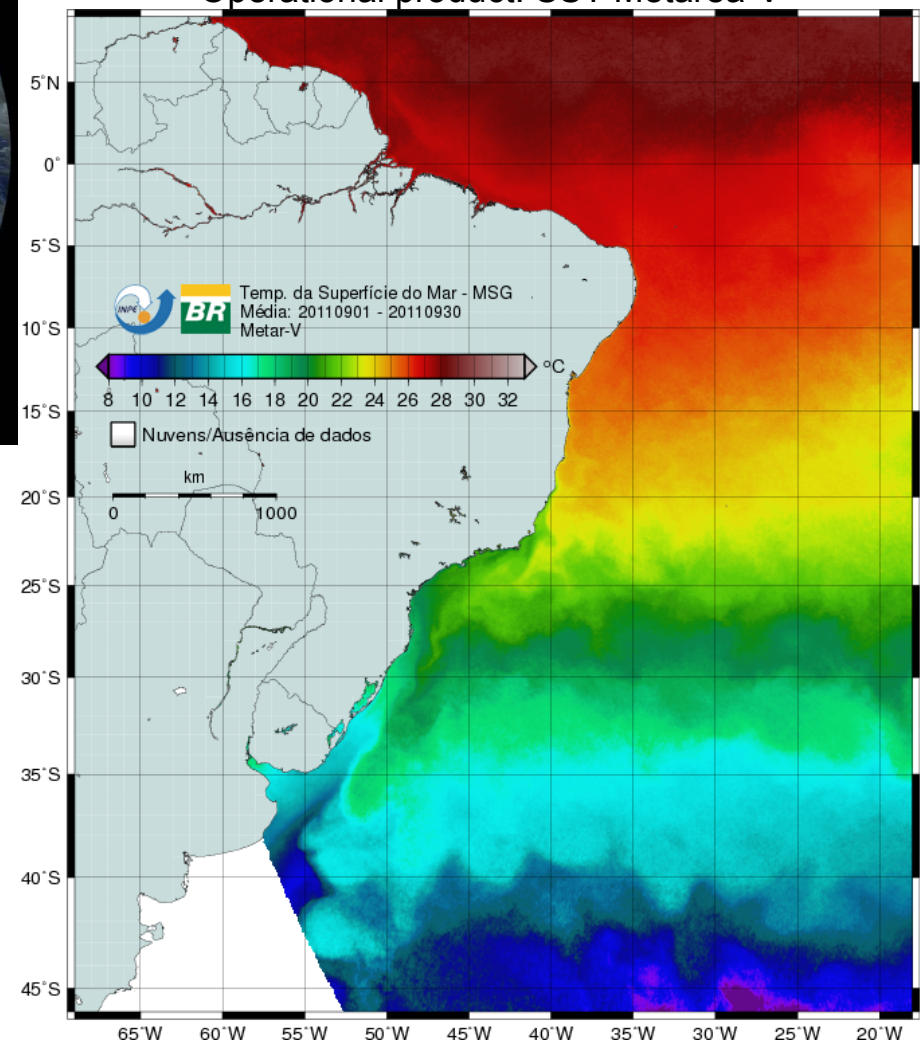


Visada do satélite

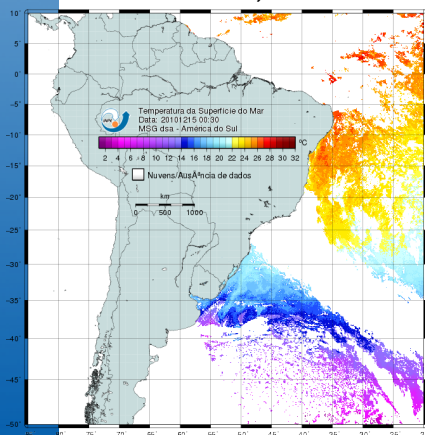


MSG9 - Geostationary
Temporal resolution 15 min
Spatial resolution ~5km

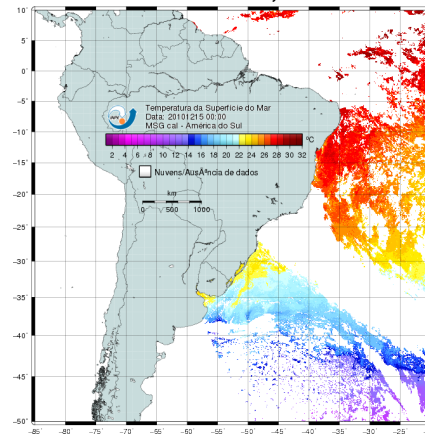
Operational product: SST Metarea-V



Original alg.
rmse: 2,49°C

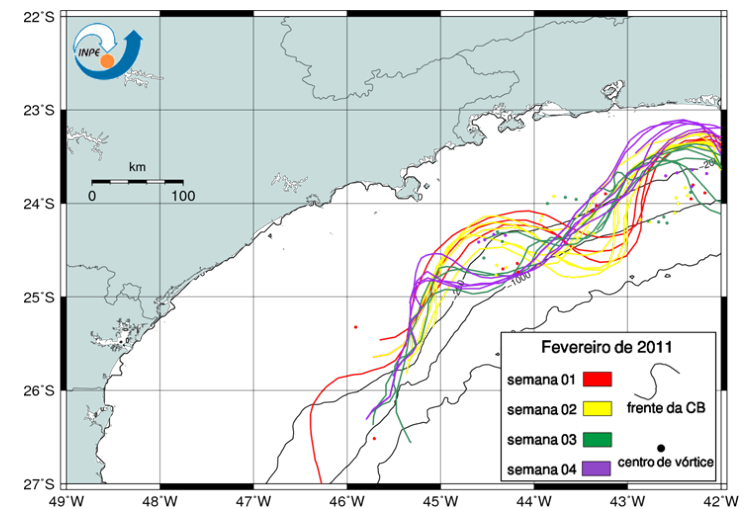
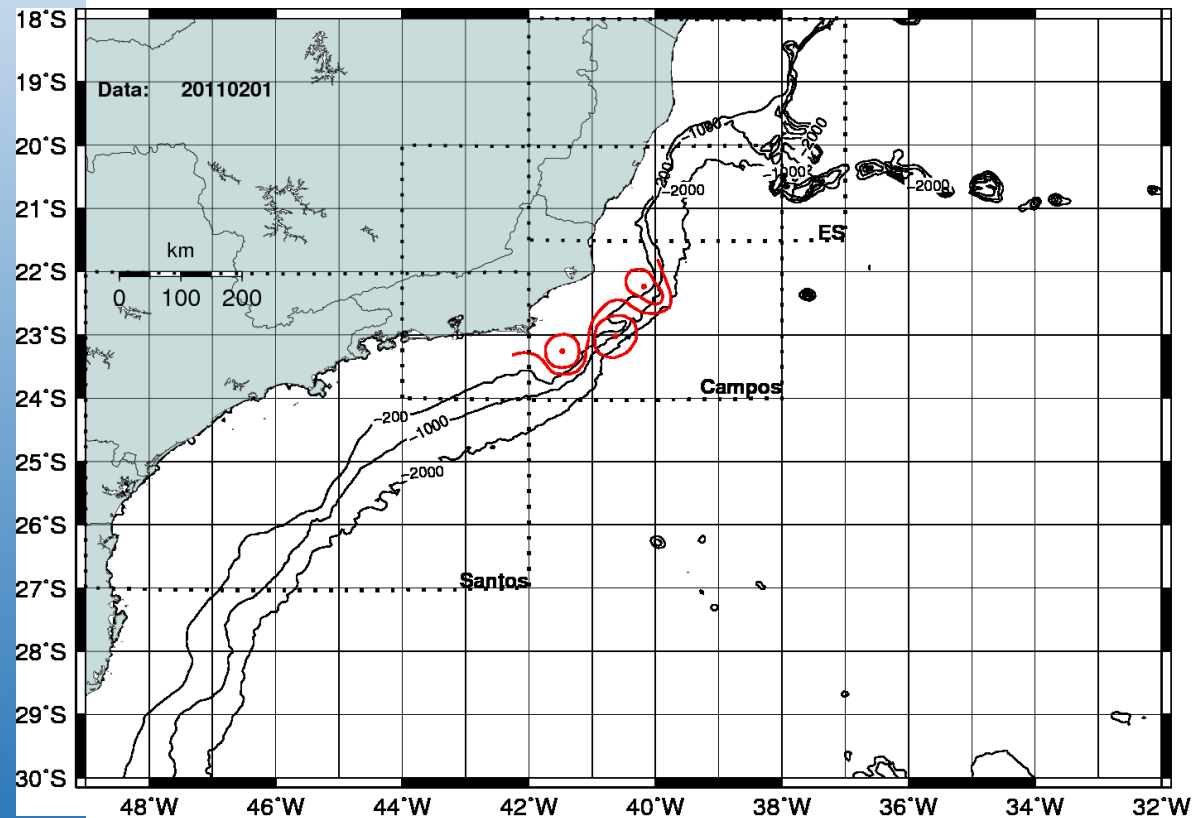


Adjusted alg.
rmse: 0,96°C





Features extraction



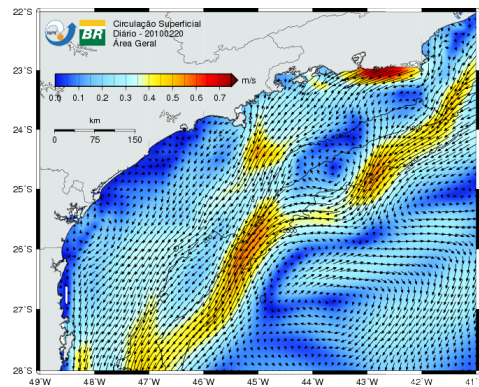


Integration with numerical modelling

NCOM model (*Navy Coastal Ocean Model*)

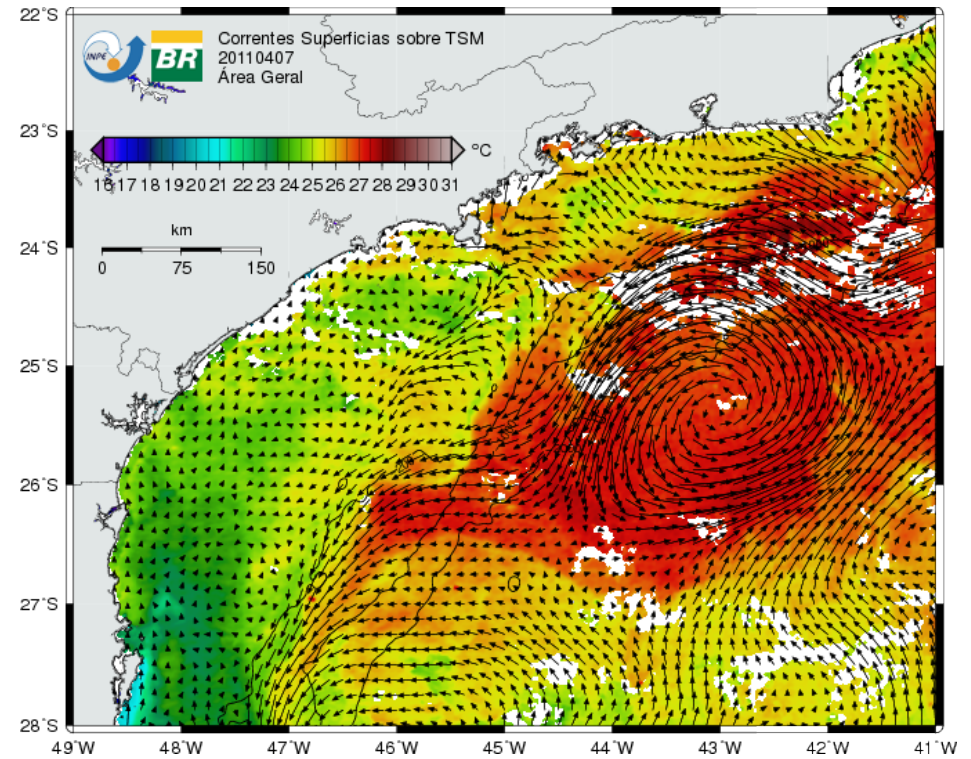
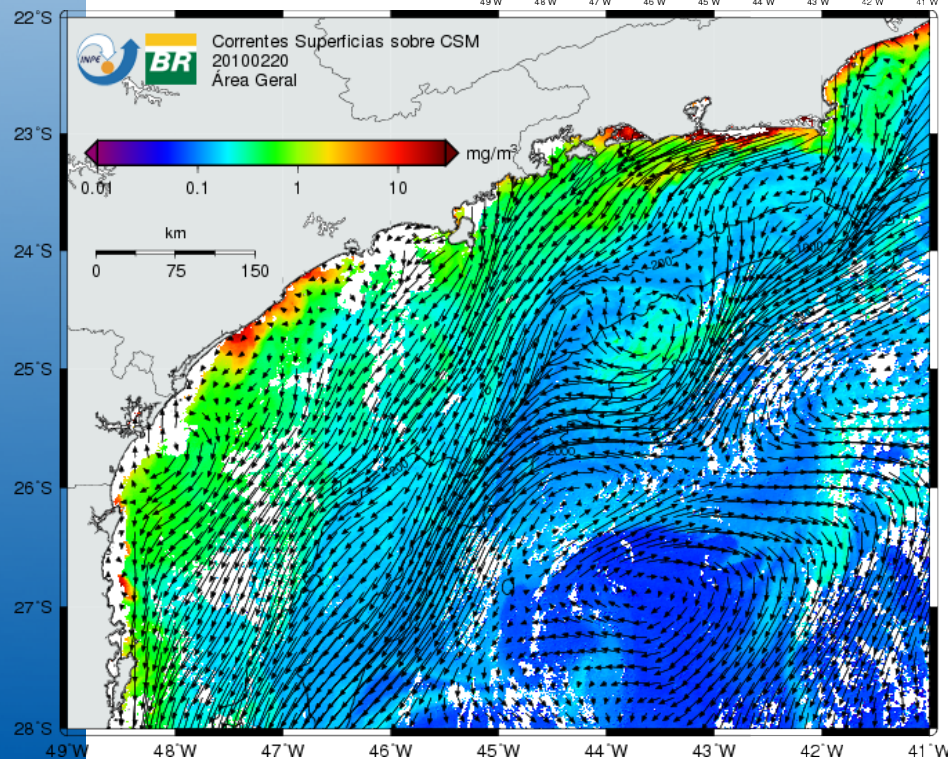
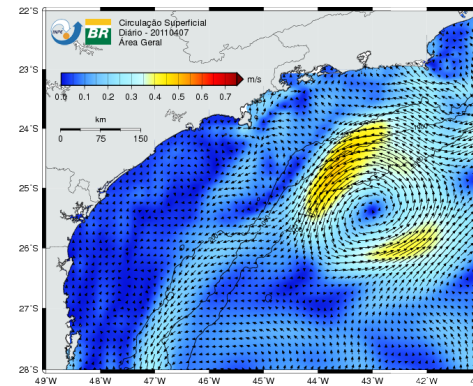
29/FEB/2010

NCOM surface circulation field
NCOM and a CHL daily
composite from MODIS



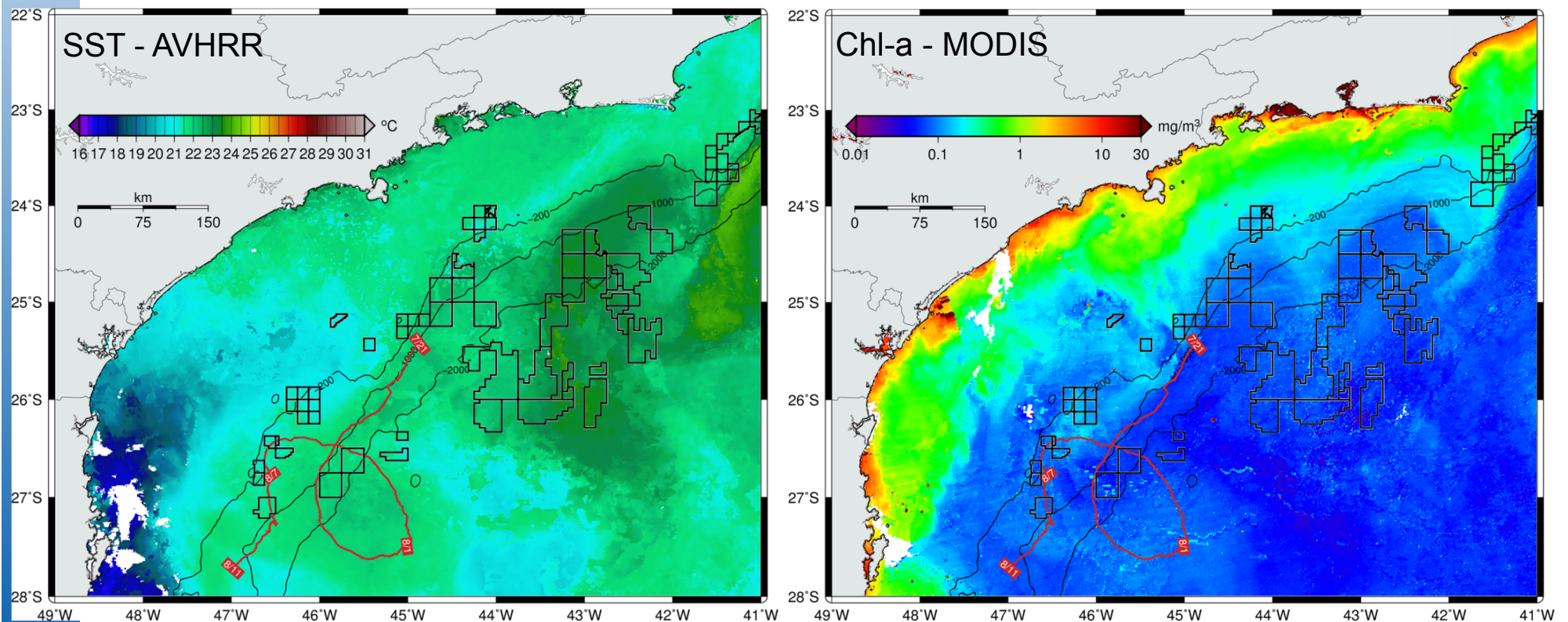
07/APR/2011

NCOM surface circulation field
NCOM and a SST daily
composite



Integration with drifters

In this example, from 07/21 to 08/11, the buoy was carried to the SW by the Brazil Current flow, being captured by an anti-cyclonic eddy

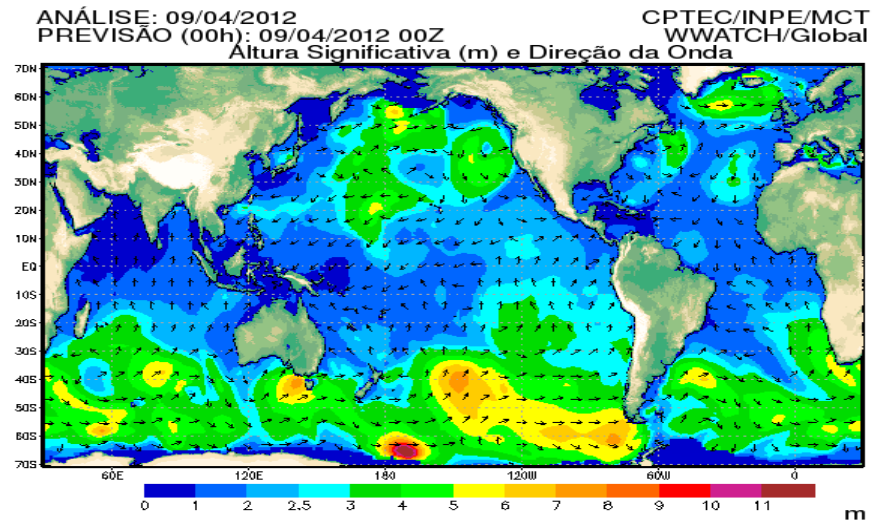




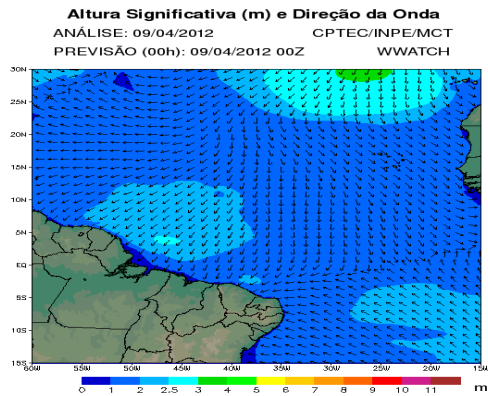
Sea State

WWATCH implemented for 5 domains

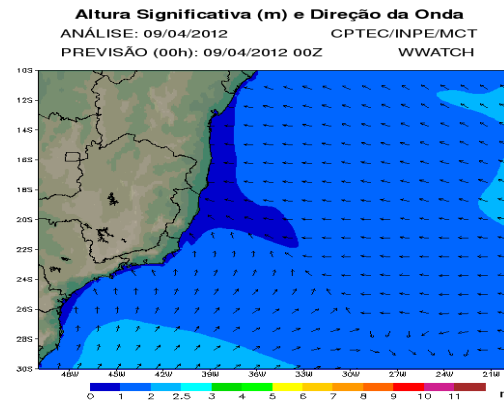
GLOBAL
 $1^\circ \times 1^\circ$



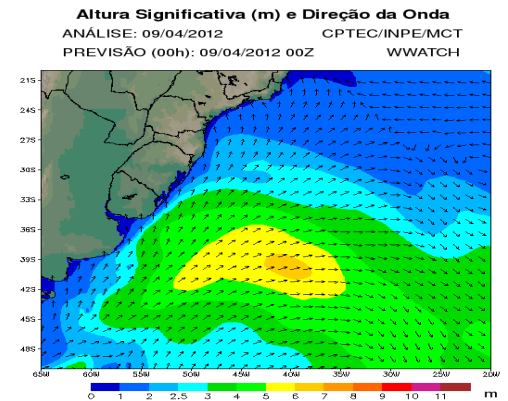
Brazilian Coast
 $0.25^\circ \times 0.25^\circ$



N-NE

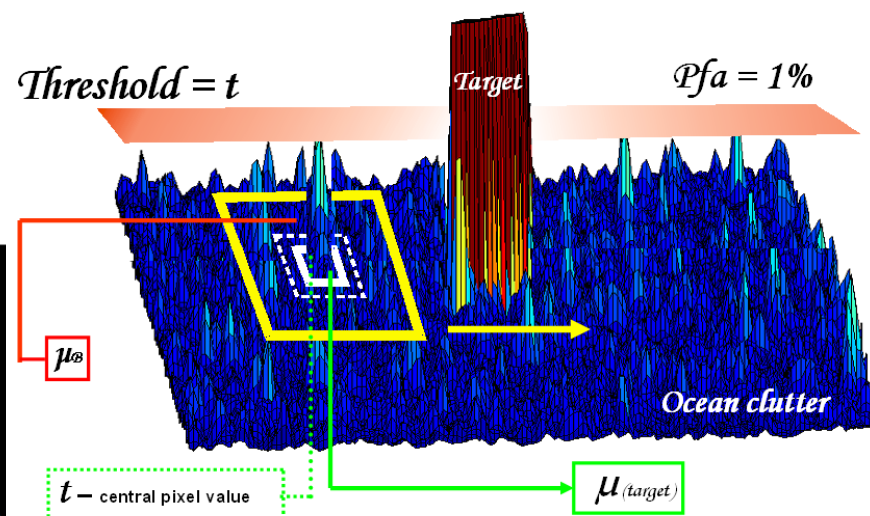
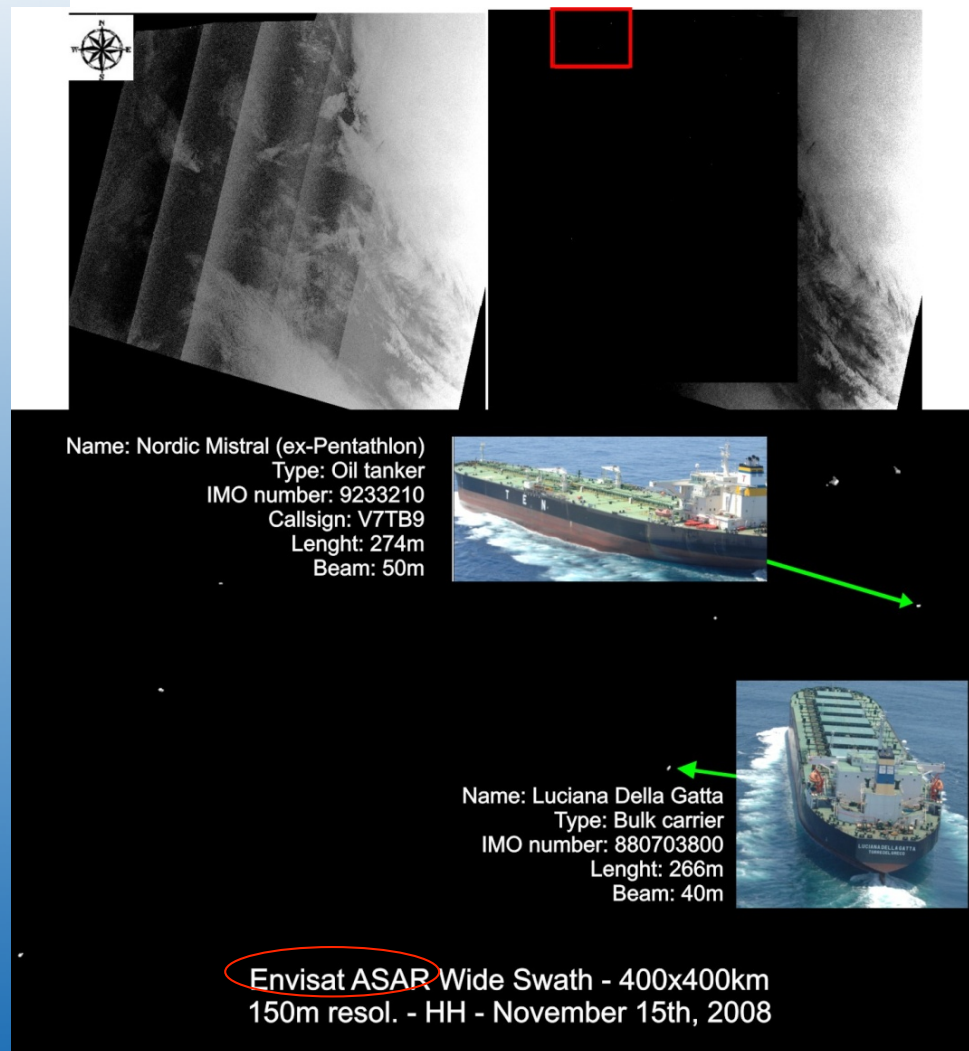


SE



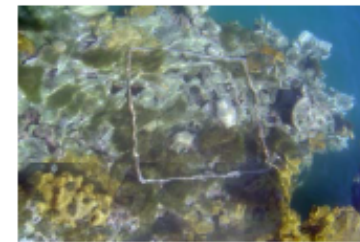
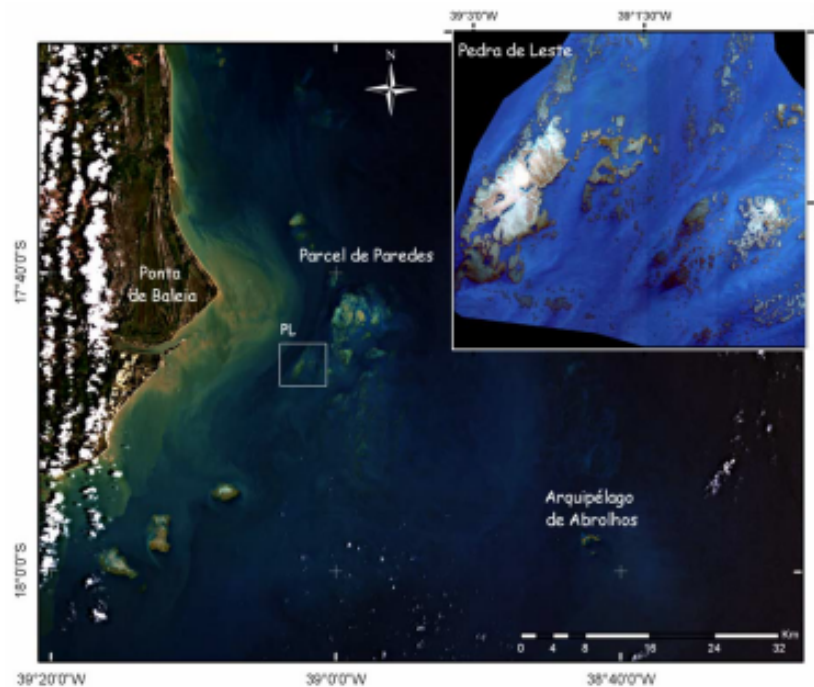
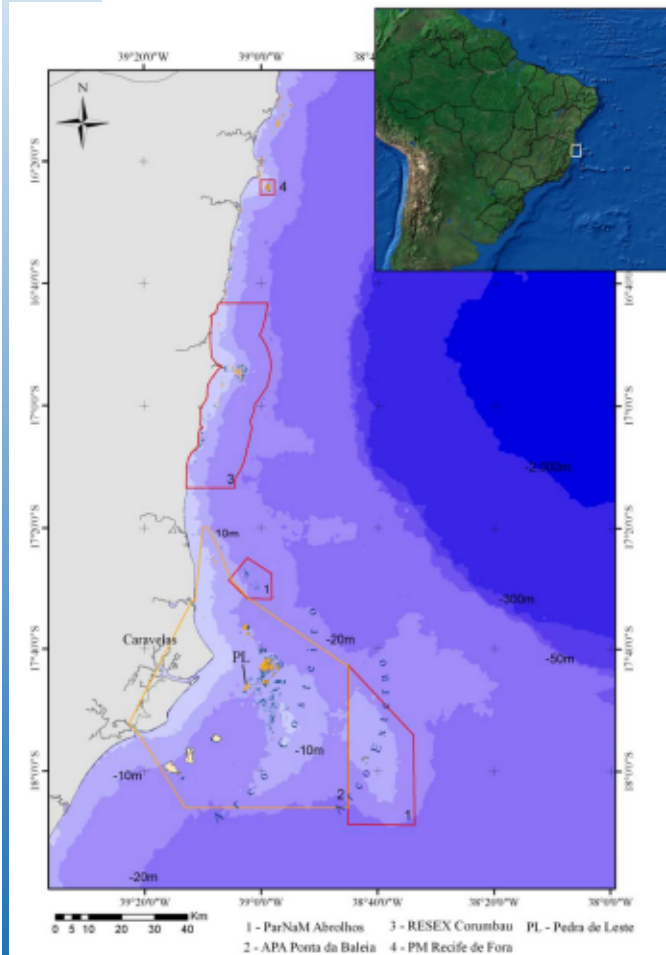
S

Ship detection- CFAR

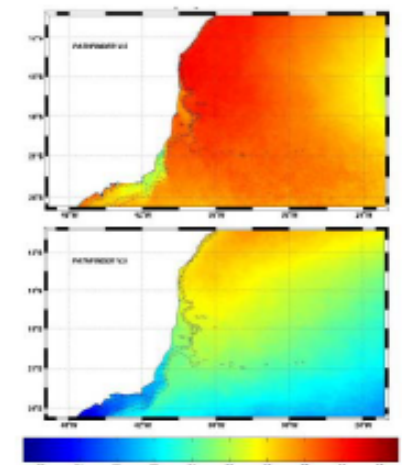
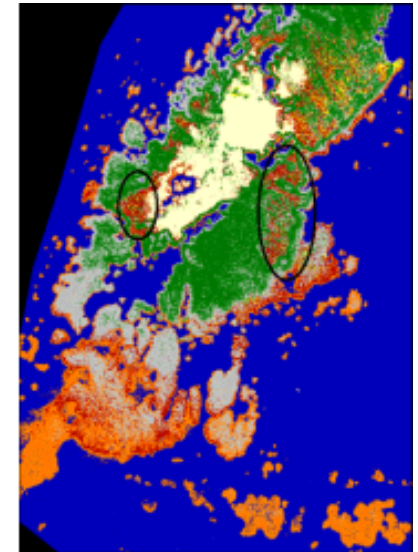


If $t_{(ij)}$ is such as represents PFA = 1% | Then, verify: If $\mu_{(target)} \geq t \Leftrightarrow$ Target ;
If $\mu_{(target)} < t \Leftrightarrow$ Clutter.

Benthic habitat mapping Coral reefs

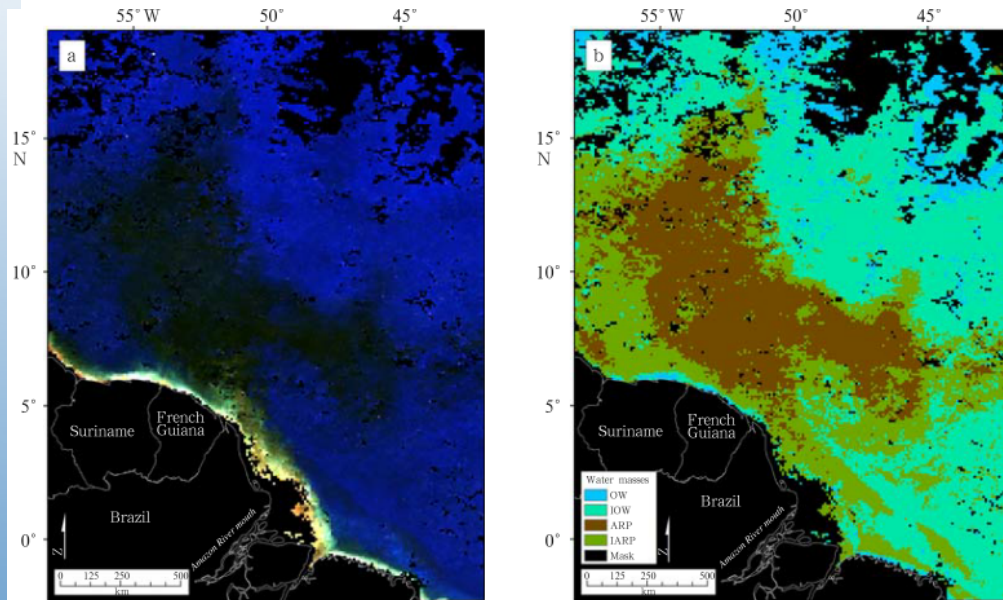


Moreira 2008

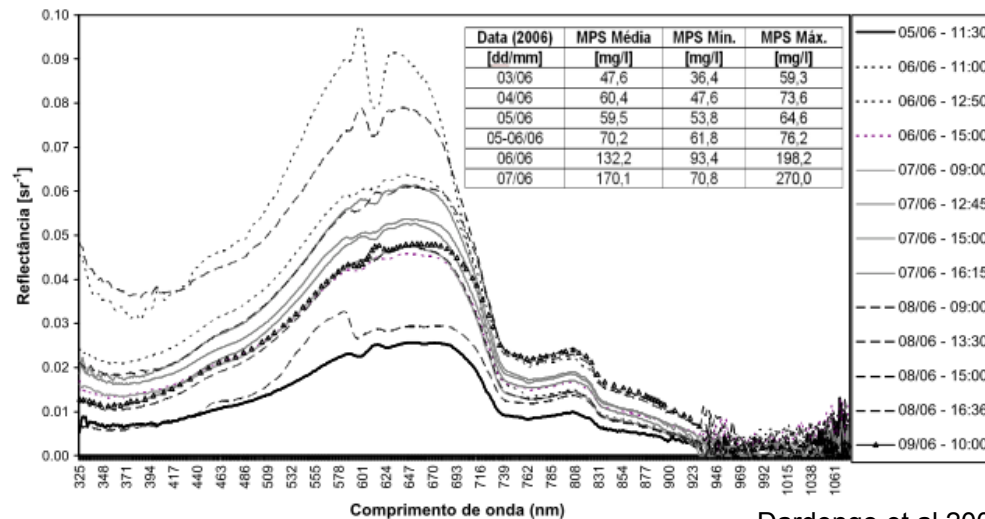
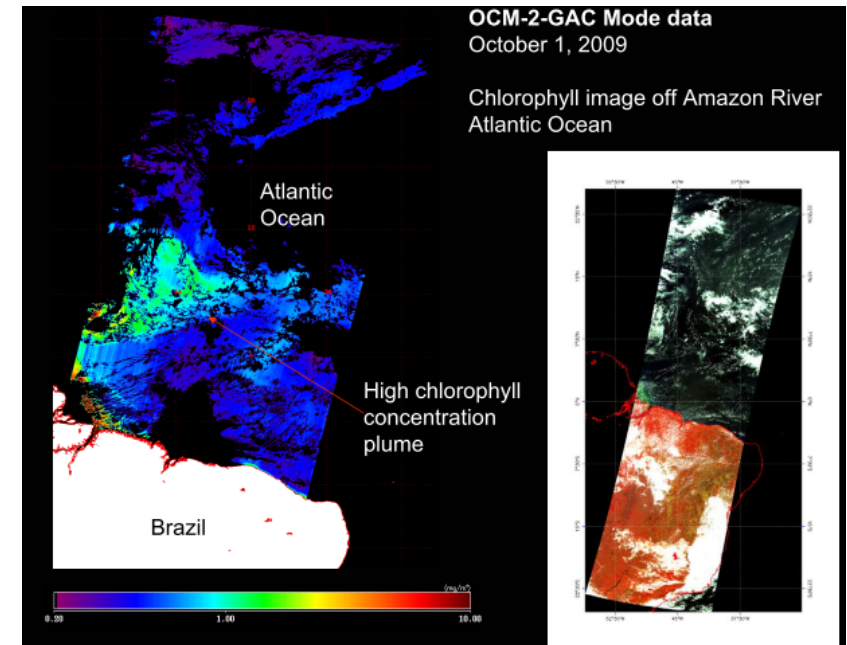


Souza et al.

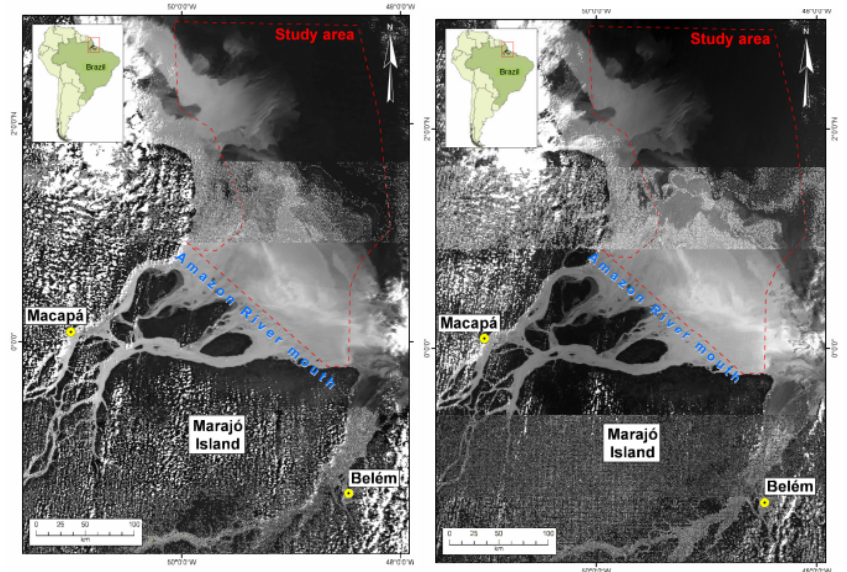
Spectral characterization of water masses



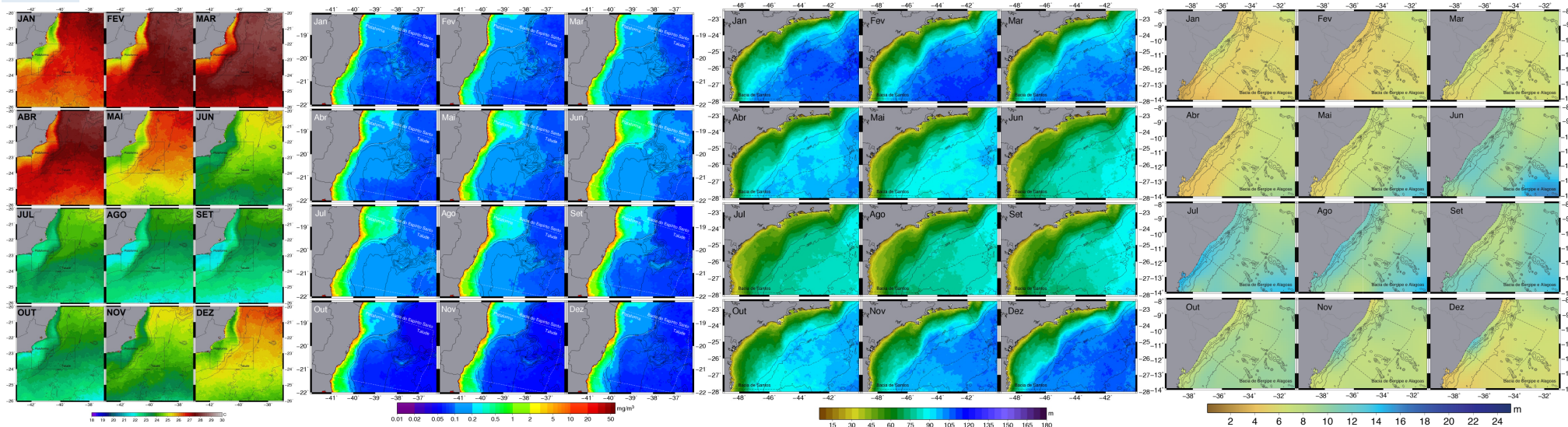
Moller et al 2010



Dardengo et al 2007



Environmental characterization

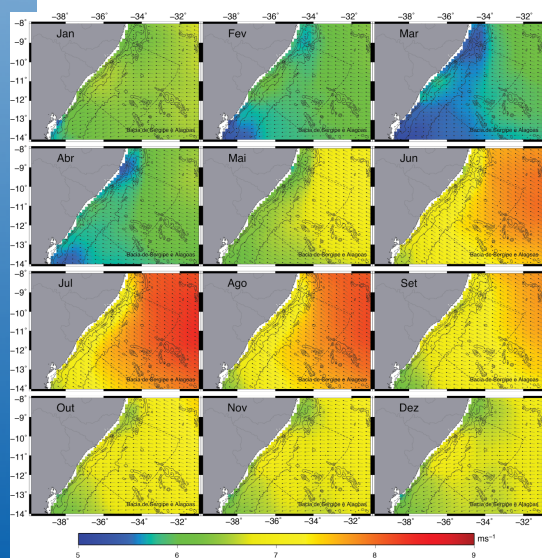


SST - Campos

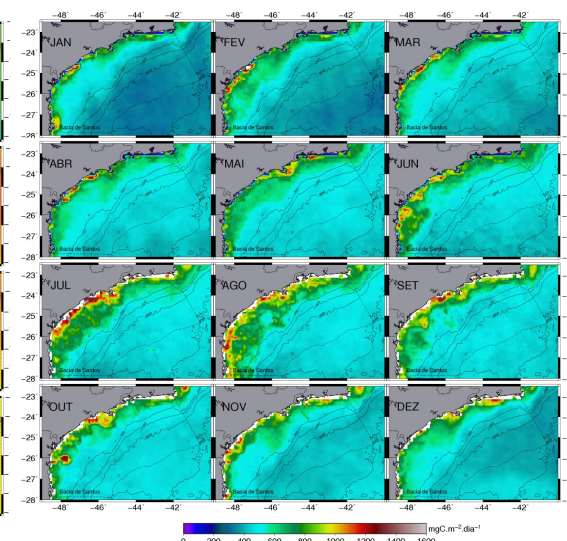
CHL - AMBES

ZEU - Santos

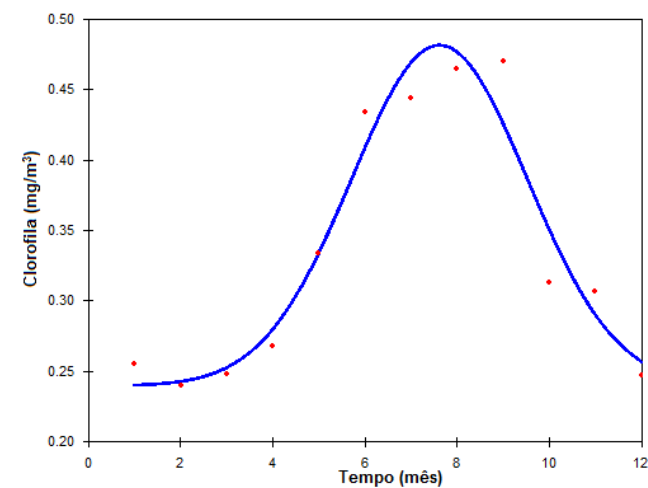
MLD - SEAL



OWV - SEAL



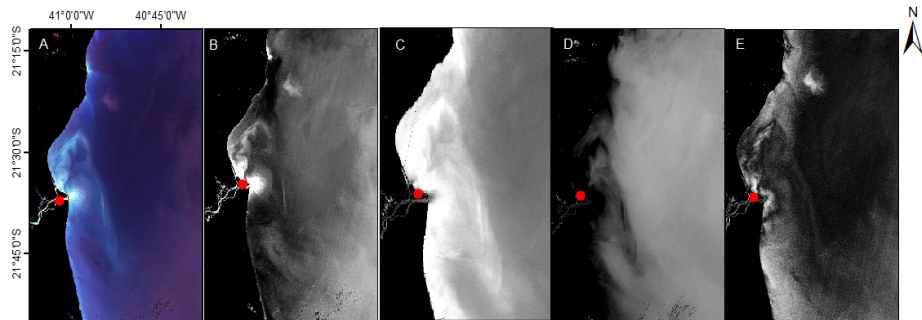
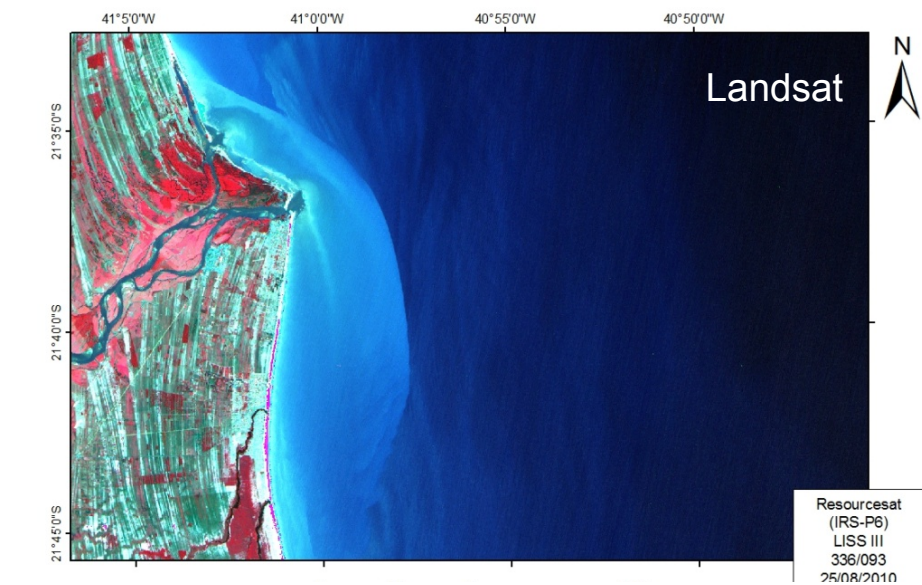
PP - Santos



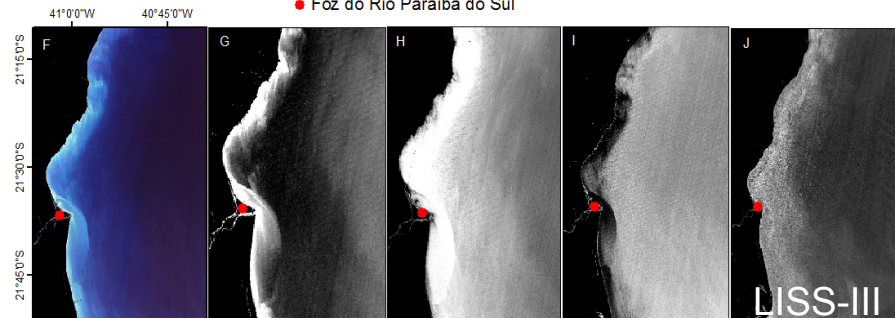
Phytoplank bloom - Campos



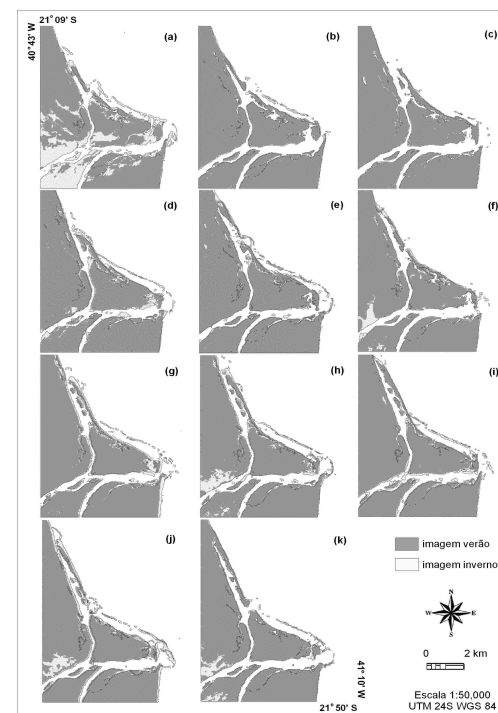
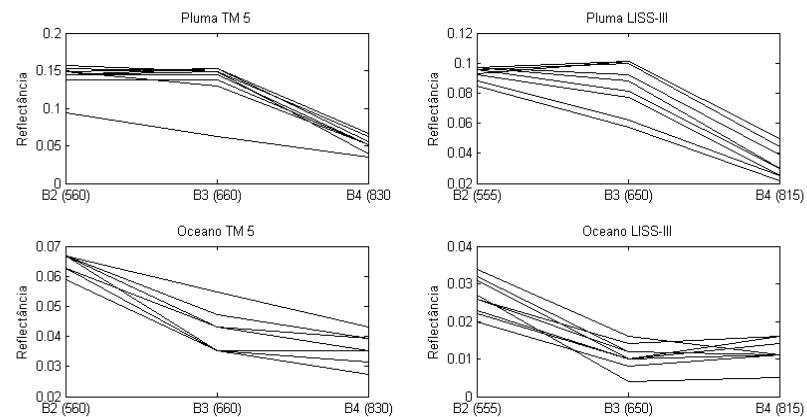
River plumes



● Foz do Rio Paraíba do Sul



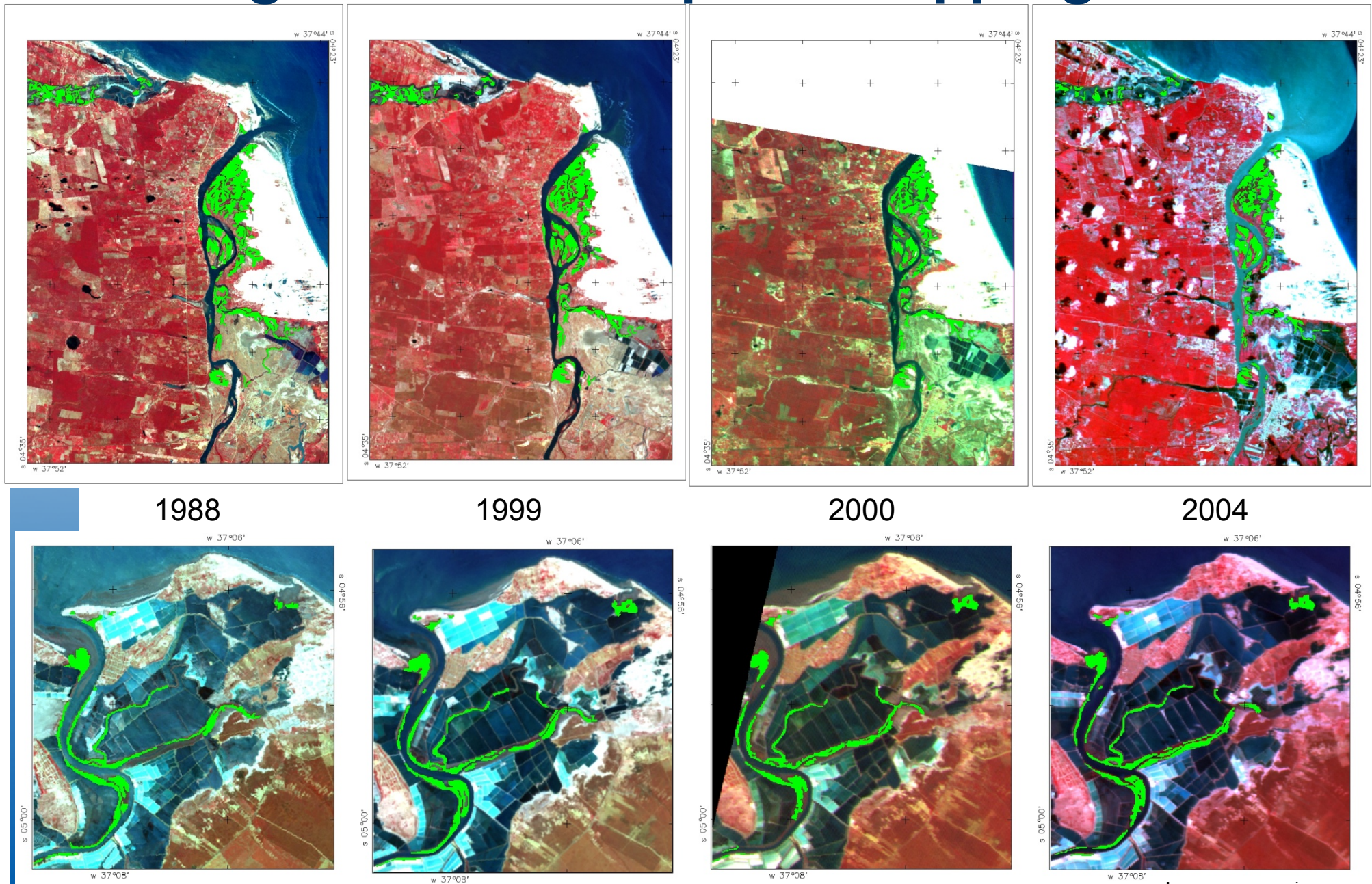
SLMA



Coastal Geomorphology

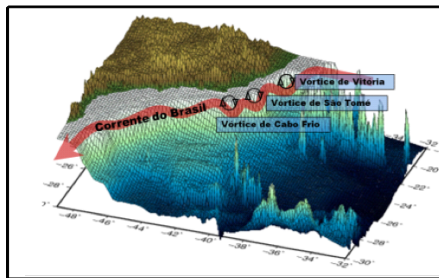


Mangrove multitemporal mapping

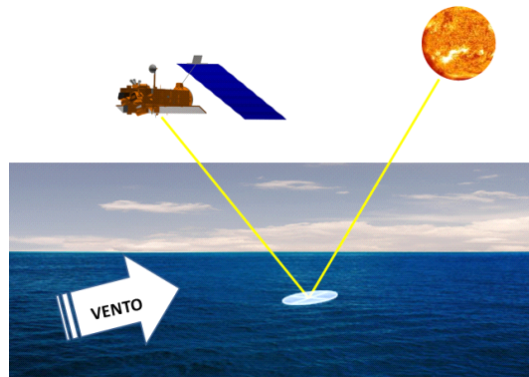
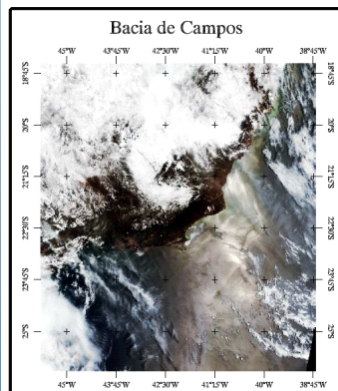




Sunlint

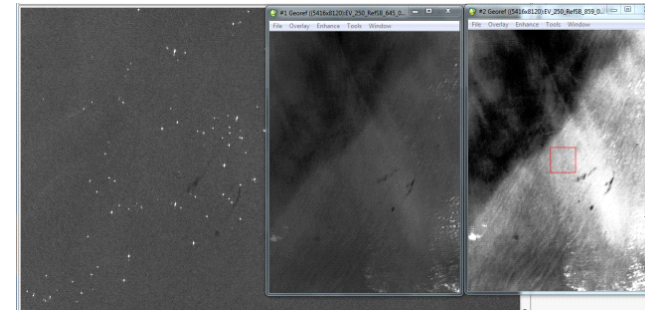


O **sunlint**, reflexão especular da luz do sol na direção de visada do sensor orbital

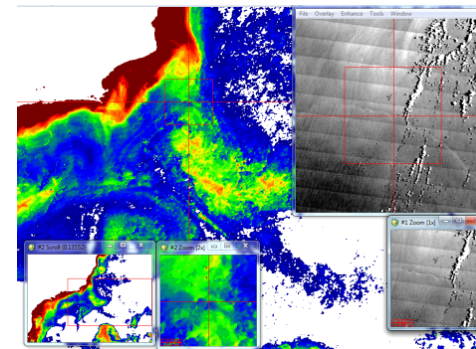


- ❑ Filmes surfactantes biogênicos
- ❑ Filmes de óleo de origem antropogênica
- ❑ Frentes e correntes
- ❑ Vórtices e meandros
- ❑ Plumagens de ressurgência

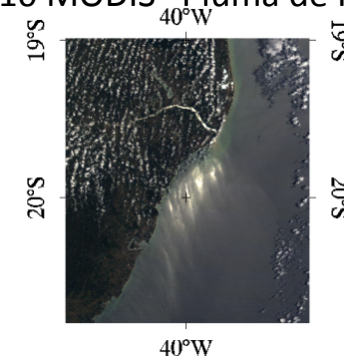
25-OUT-2009 ASAR e MODIS- Descarte de Navio



23-FEV-2010 MODIS- Frente oceanográfica

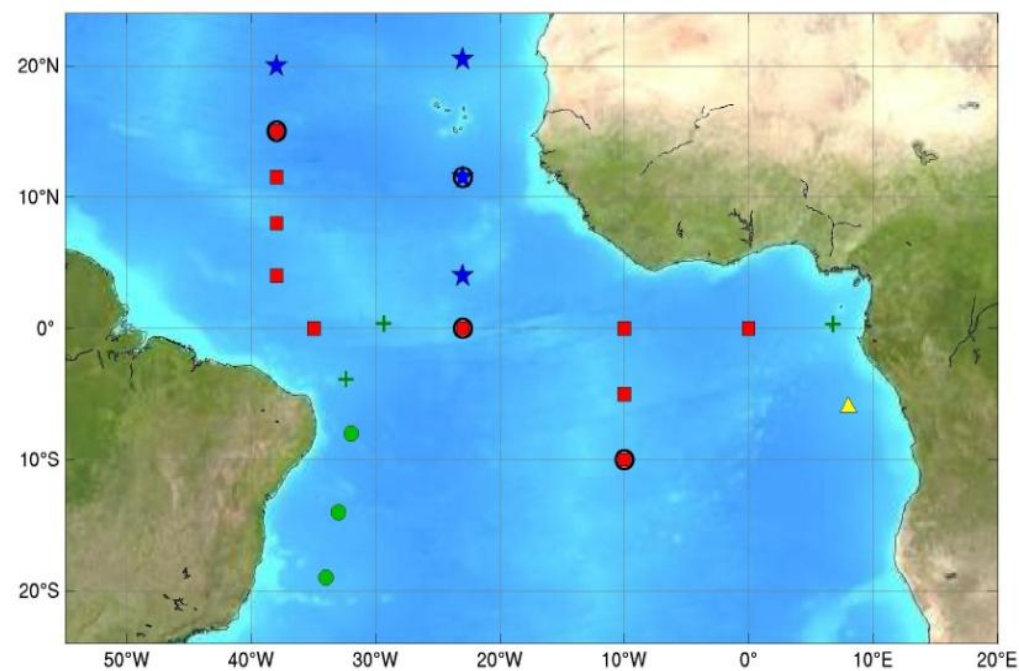


22-JAN-2010 MODIS- Pluma de Ressurgência

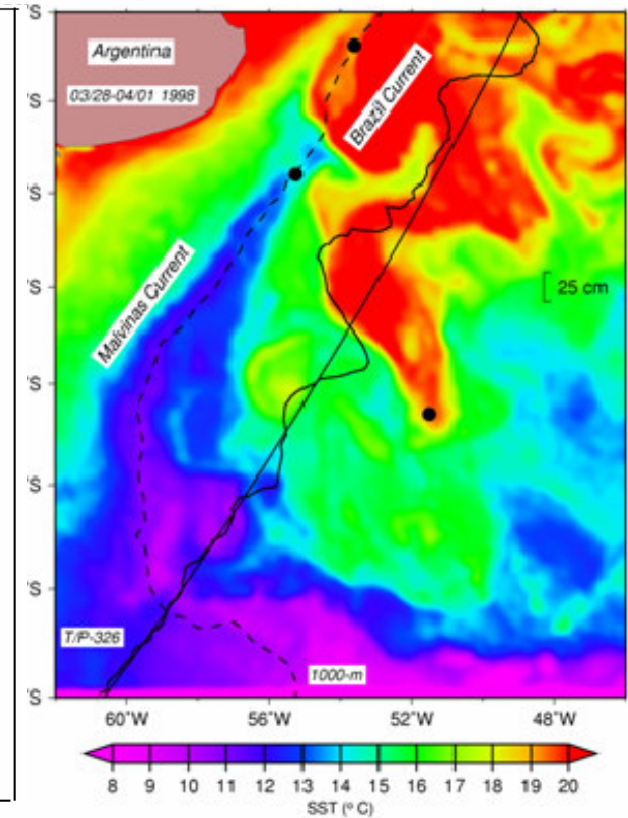
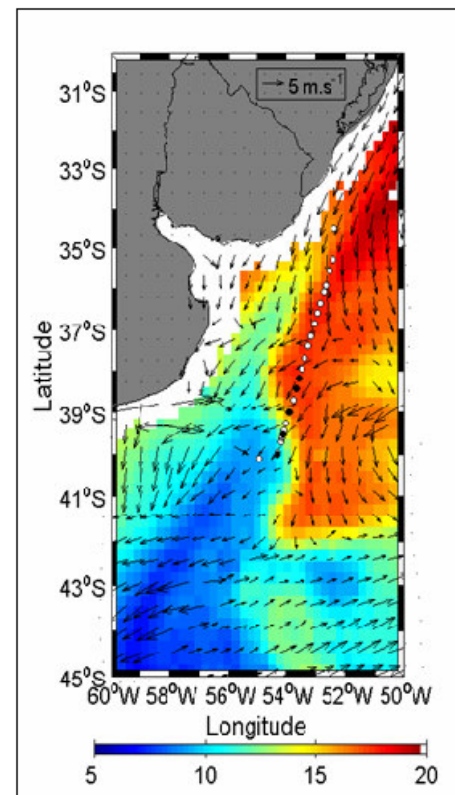
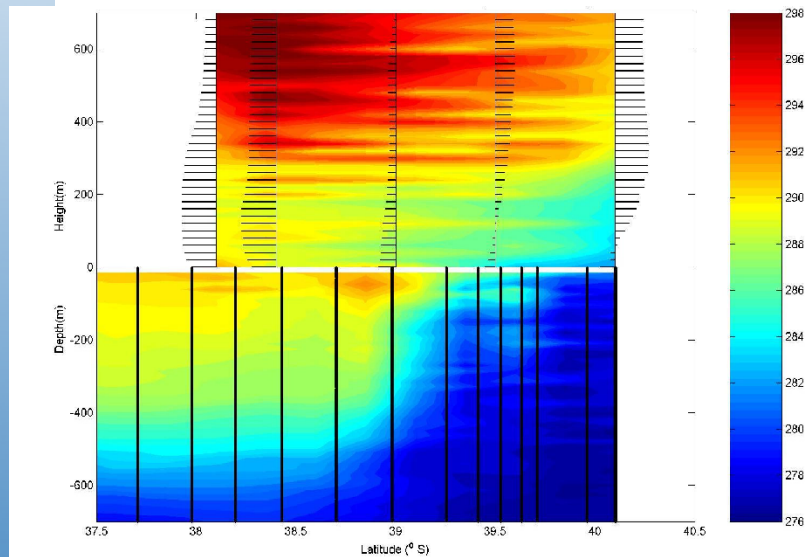




PNBOIA - PIRATA

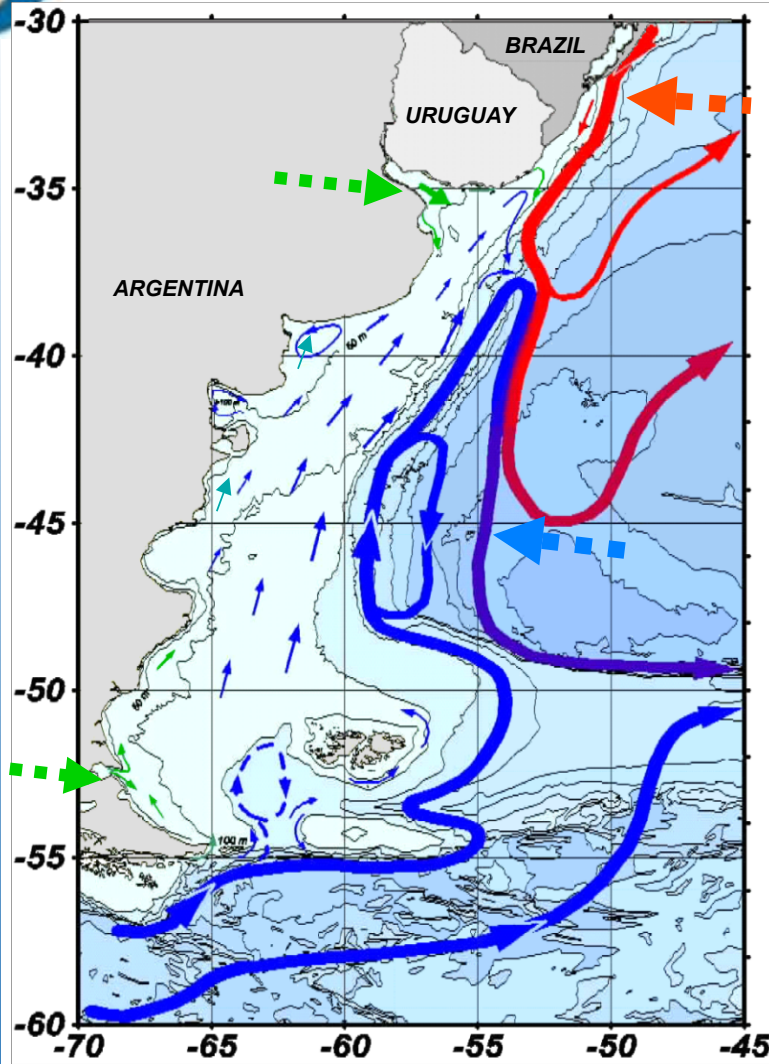
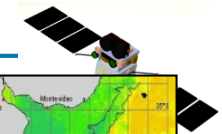


Air-sea interaction

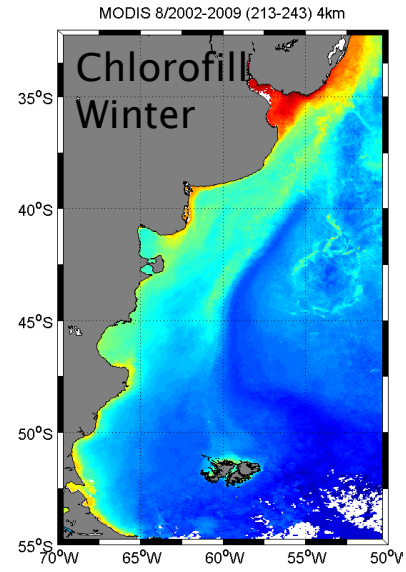
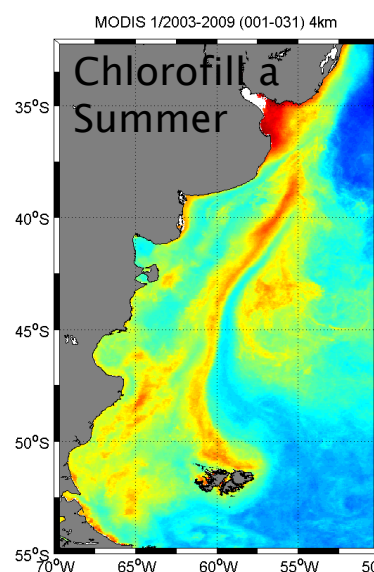
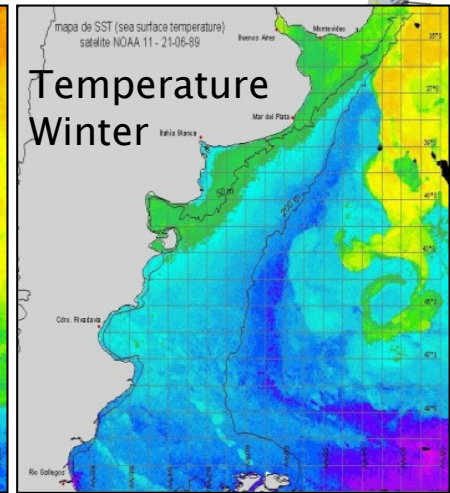
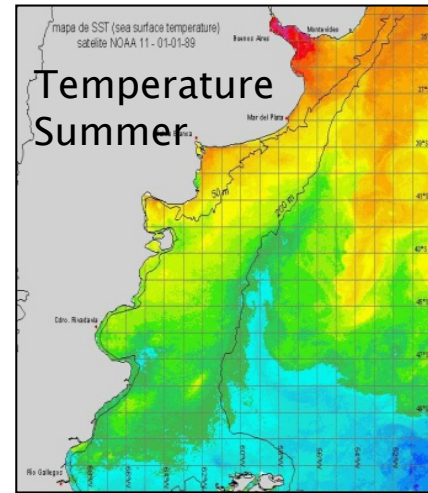




Dynamic of the Argentine Sea



The most important oceanographic forcings are discharges of fresh water (River Plate, Strait of Magellan and minor tributaries) and currents of Brazil and Malvinas. The first warm, hypersaline and oligotrophic waters and the cold water, low salinity and nutrient-rich (Malvinas).

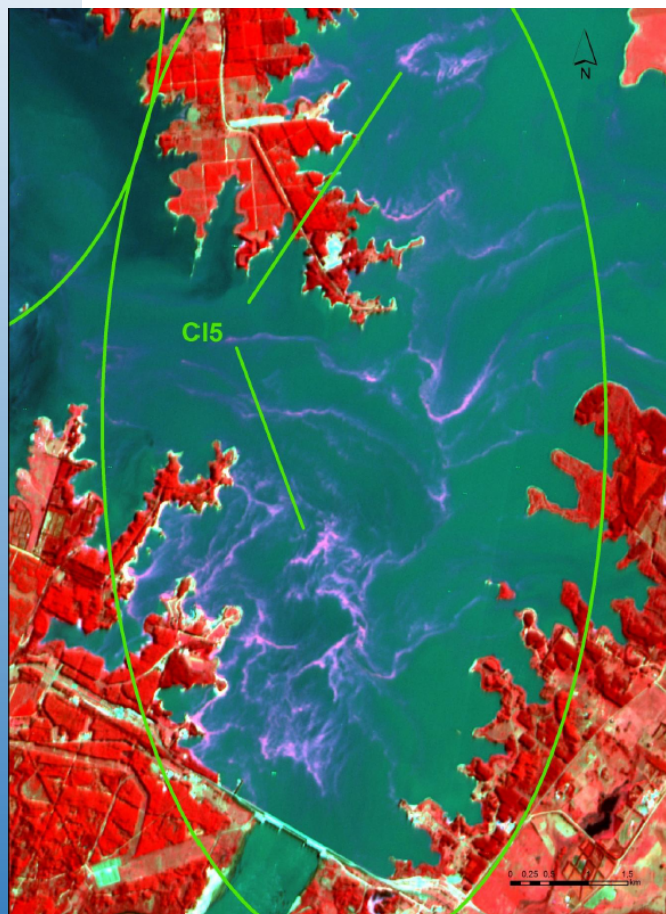


These different water masses interact with each other and with the seabed, creating processes that strongly influence the dynamics and biological characteristics of the region. This leads to the existence of important assemblages of birds and marine mammals, spawning and rearing of fish and crustaceans, large banks macroalgae and molluscs

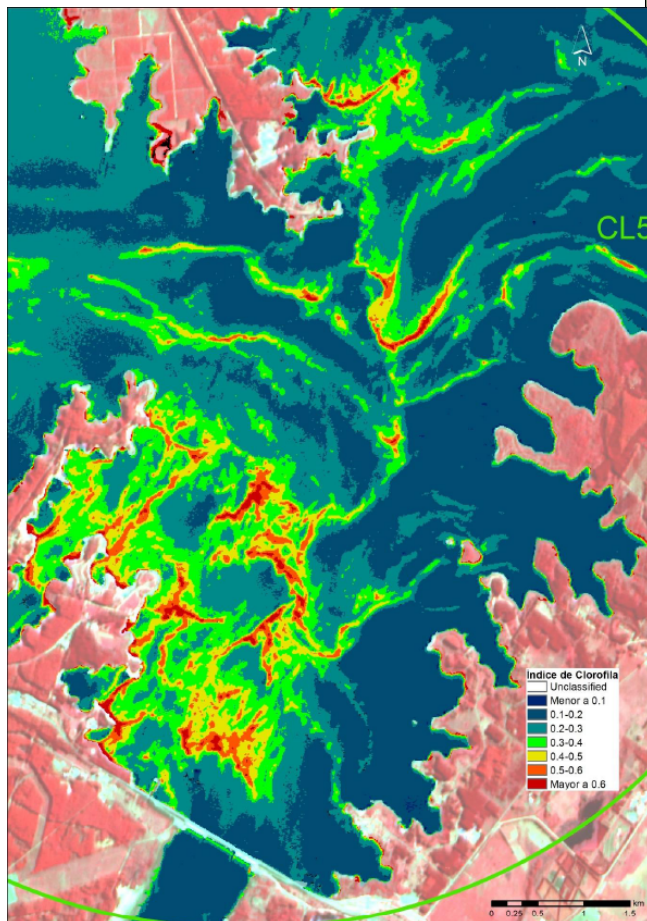


Coastal Zones, Estuaries & Inland Waters

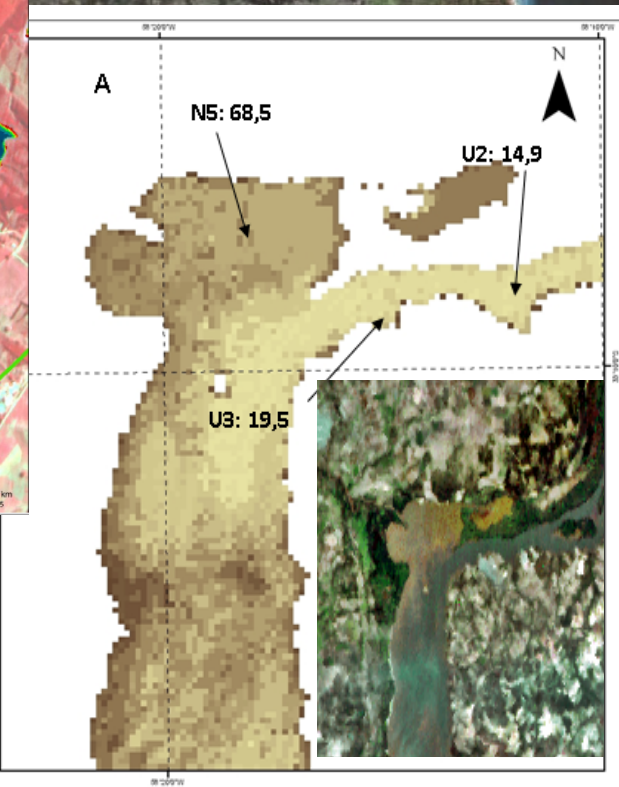
Estuary of Río de LA PLATA



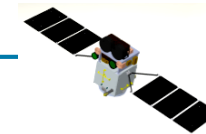
Harmful algal blooms (HABs) (ponds)



Sediments in Uruguay River



Torusio & Rabolli



SABIA-Mar mission Bilateral agreement

- Design, build, launch and operate an ocean color observing mission.
- Share tasks equally (50%-50%).
- Aim to technological development for the payload.
- Maximize the enrolment of national industries in each country.

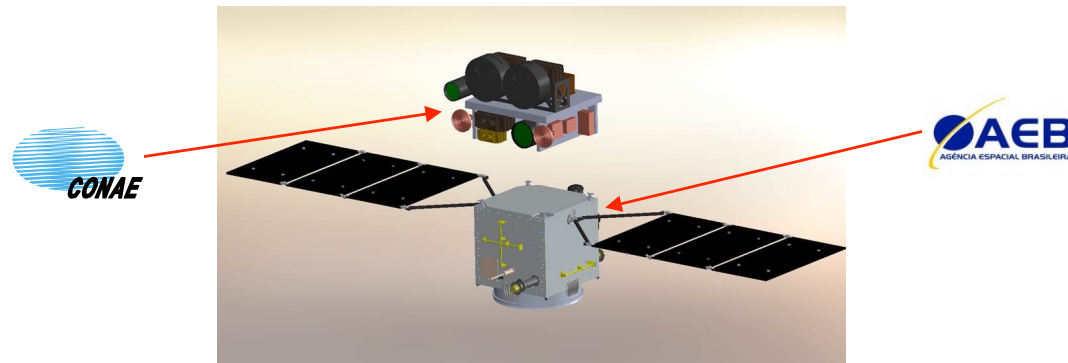
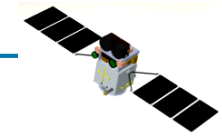
Milton Kampel – Marco Chamon – AEB/INPE

Sandra Torrusio – Daniel Caruso - CONAE





CONAE & AEB/INPE Main Partners

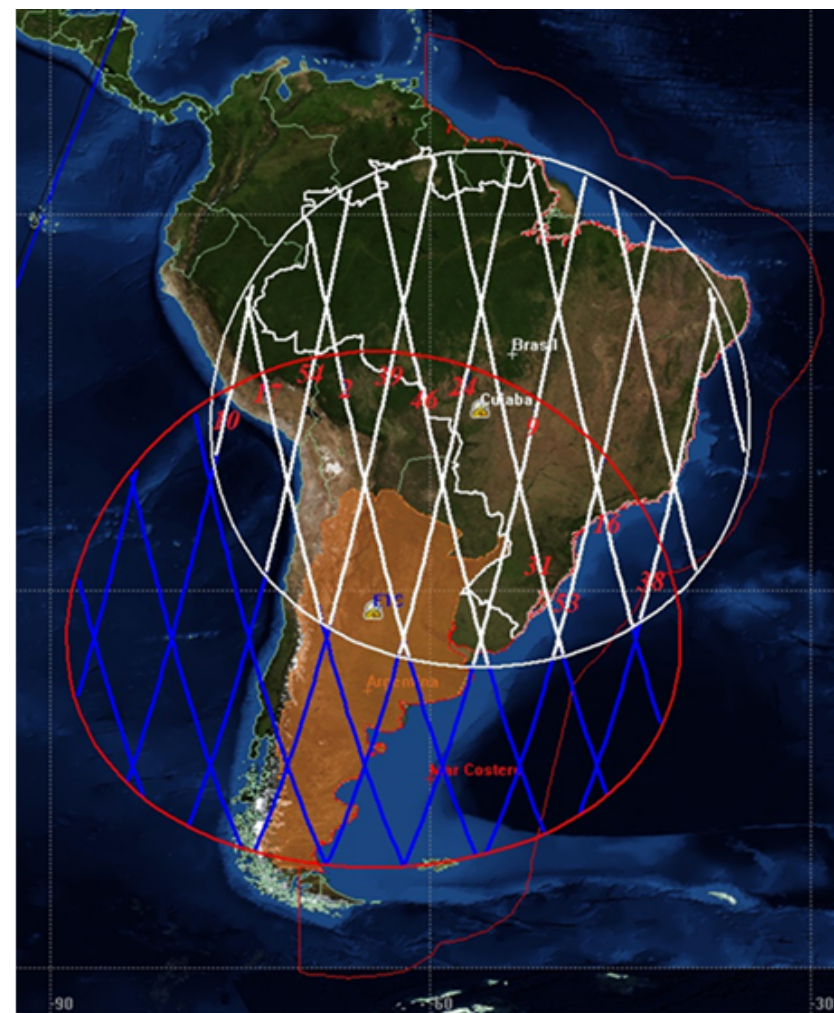


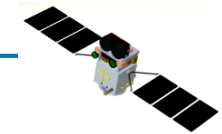
- Two satellites flying as a constellation
- Management, System Engineering, Mission Assurance and Applications developed by both Agencies [CONAE & AEB] with shared responsibilities
- Each Agency contributes with their already installed Ground Stations (S & X bands)
- Operations Control Center under AEB responsibility
- Mission Center under CONAE responsibility
- Joint Management of the Launch Services procurement



Ground segment

- Mission Requirements are fulfilled using the two [2] existing ground Stations, for both S (TT&C) & X bands (Science Data Reception)
- CUIABA in Brasil & CORDOBA in Argentina



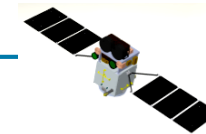


RFI - Launchers

Launch Vehicle	Payload Fairing (mm)		Performance [kg] @ 650 km SSO	Launch Base
	Diameter	Height		
Dneper	2000	2650	1000	Baikonur (Kazakhstan), Yasny (Russian Federation, Orenburg)
Falcon 9	4600	11400	7500	KSFC(kennedy Space Flight Center) VAFB (Vandenberg Air Force Base)
Cyclone 4	3700	8500	3450	Alcantara Launch Center; State of Maranhao, Brasil
Long March	3350	8880	6500	Xichang(XSLC) ; Jiuquan(JSLC); Taiquan(TSLC) China
Minotaur IV	2055	3300	1050	Alaska(Kodiak launch Complex); Cape Canaveral (Florida); VAFB (California; WFF (Wallops Island)
PSLV	2900	5400	1500	Sriharikota , India
Rockot	2380	5500	1350	Plesetsk Cosmodrome, Rusia
Taurus	2055	4500	800	KSFC(kennedy Space Flight Center) VAFB (Vandenberg Air Force Base)
TaurusII	3450	7000	4000	Alaska(Kodiak launch Complex); Cape Canaveral (Florida); VAFB (California; WFF (Wallops Island)
Vega	2380	5500	1500	Guiana Space Center (French Guiana)

Caruso, D.



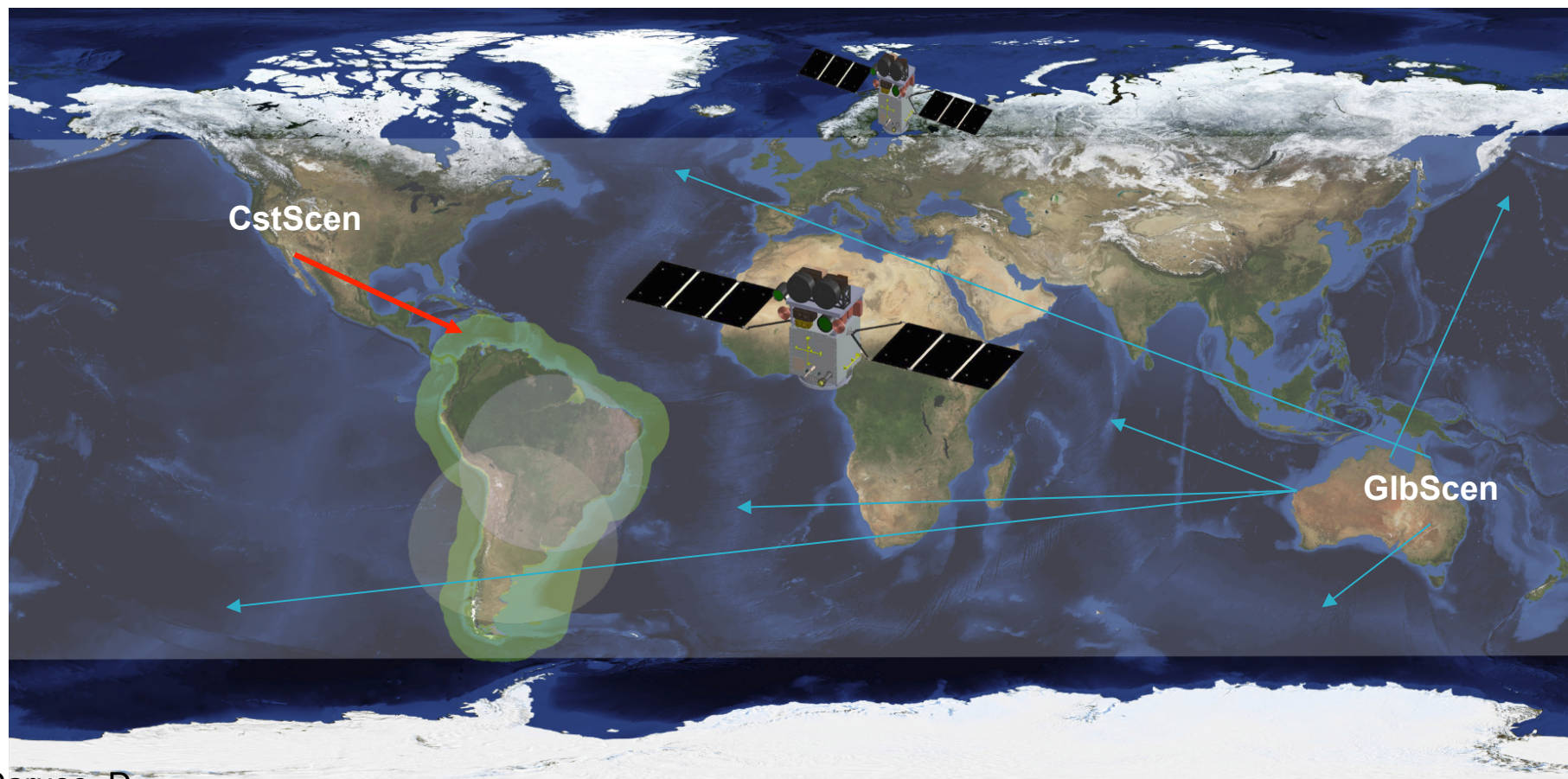


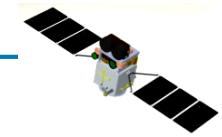
Mission Scenarios

Two planned mission scenarios defined:

Global Scenario

Coastal Scenario, which could be increased depending on resources availability

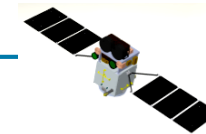




Mission Objectives

- Primary: Ocean Color Mission providing
 - 200 meters spatial resolution [NADIR], 1 day revisit time, for the measurement bands in the CstScen
 - 800 meters spatial resolution [NADIR], 1 day revisit time, for the measurement bands in the GlbScen
 - 400 meters spatial resolution, 1 day revisit time, for the atmospheric correction bands in the CstScen
 - 800 meters spatial resolution, 1 day revisit time, for the atmospheric correction bands in the GlbScen
- Secondary: Sea Surface Temperature, 400 meters [NADIR], 1 day revisit time in both scenarios
- Planned specific products to be generated are, among others:
 - Normalized water leaving radiances
 - Chl-*a* concentration, Diffuse attenuation, PAR
 - SST





Satellites

Weight

CBE= **563** kg CBE + Contingency= **686** kg

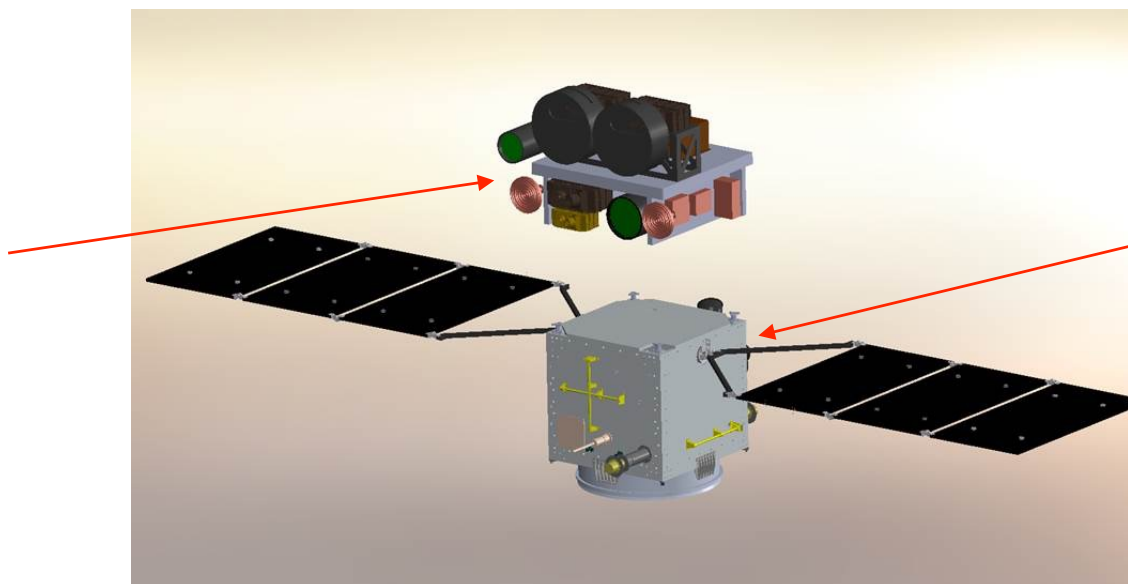
Envelope

diameter= 2 m. height = 2.2 m.

4 years mission lifetime

5 years each satellite

Payload

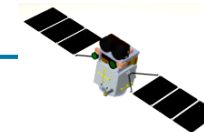


Service Module
MMP

Orbit

Circular, sun-synchronous, 645 km

Repeat cycle 4 days



| Payload

➤ Primary Instruments

- Camera VIS-NIR 11 bands //1350 km//200/800 m//14 bits
- Camera NIR-SWIR 6 bands //1350 km//400/800 m//14 bits

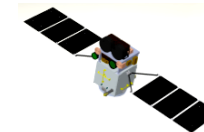
➤ Secondary⁺ Instrument

- Camera TIR [TIR] 2 bands//1350 km//400 m//14 bits

➤ Secondary Instruments

- Multi-angle Camera [MAC] 4 bands//1350 km//500 m//14 bits
- Data Collection System [DCS] UHF / Banda S
- High Sensitivity Camera [HSC] Panchromatic//1350 km//400 m//12 bits
- High Res.Techn. Cam. [HRTPC] Panchromatic//30 km//5 m//8 bits





OC & SST Instruments

Camera
VIS-NIR

B0
B1
B2
B3
B4
B5
B6
B7
B8
B9
B11

Camera TIR

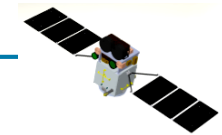
B15
B16

Band	Center Wavelength [nm]
<i>B0</i>	412
<i>B1</i>	443
<i>B2</i>	490
<i>B3</i>	510
<i>B4</i>	555
<i>B5</i>	620
<i>B6</i>	667
<i>B7</i>	680
<i>B8</i>	710
<i>B9</i>	750
<i>B10</i>	765
<i>B11</i>	865
<i>B12</i>	1044
<i>B13</i>	1240
<i>B14</i>	1640
<i>B15</i>	10800
<i>B16</i>	11800

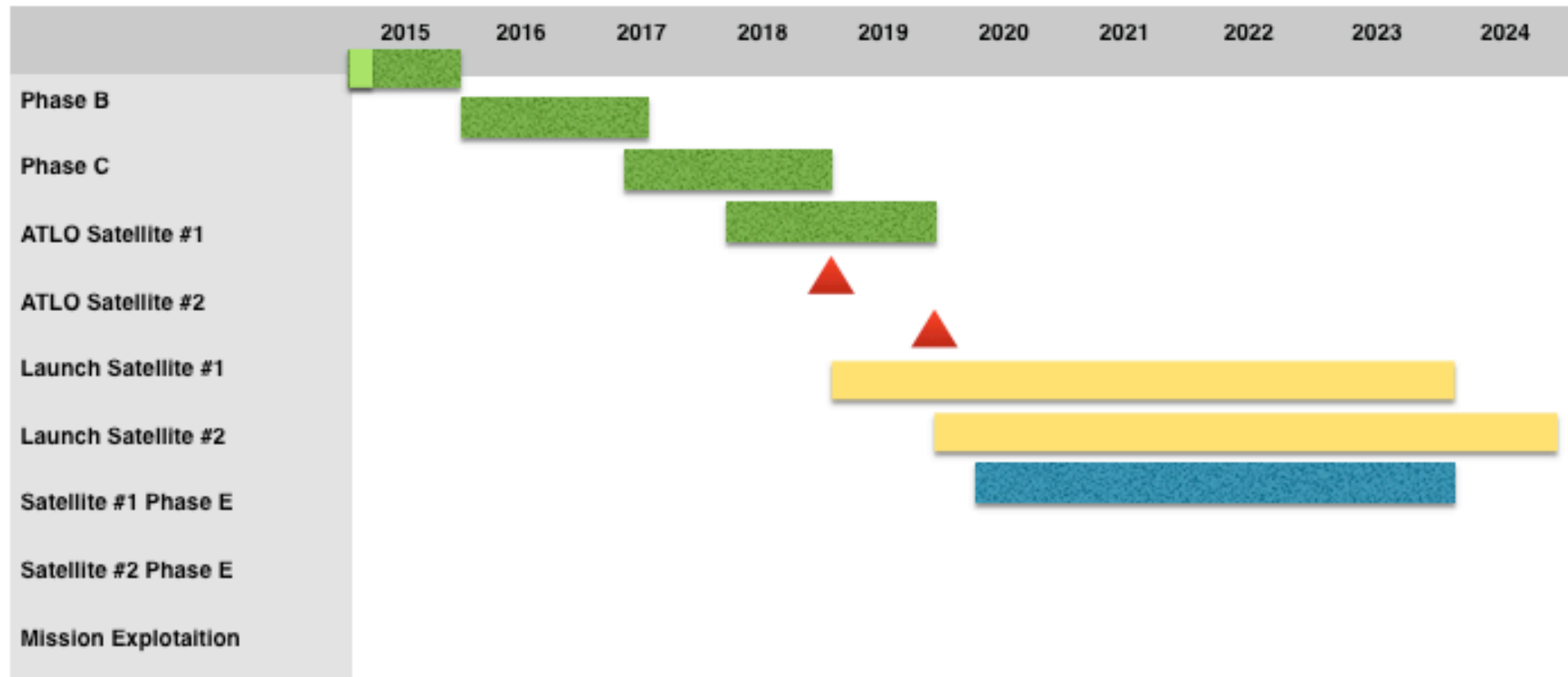
Camera
NIR-SWIR

B9
B10
B11
B12
B13
B14





Schedule





Thanks for your attention Gracias - Obrigada

Special thanks to CONAE

