Earth Observation for Sustainable Development

R&D and Application Activities of Remote Sensing in SW-S Atlantic

MILTON KAMPEL, INPE
milton.kampel@inpe.br

Linking Earth Observation Data and Sustainable Development Across the Atlantic, 3-5 Dec., Estoril, PT

What brings me here today?

- The SENSING project aims to focus efforts on scientific developments that can address emerging global problems in the field of environmental change, sustainable development, health and food security.
- The idea here is to comment on some activities of EO/RS in the SW-S Atlantic region, to further expand international partnerships, collaborations and personnel training at an international level helping INPE to achieve its mission to produce science and technology using EO data to find solutions for societal problems.

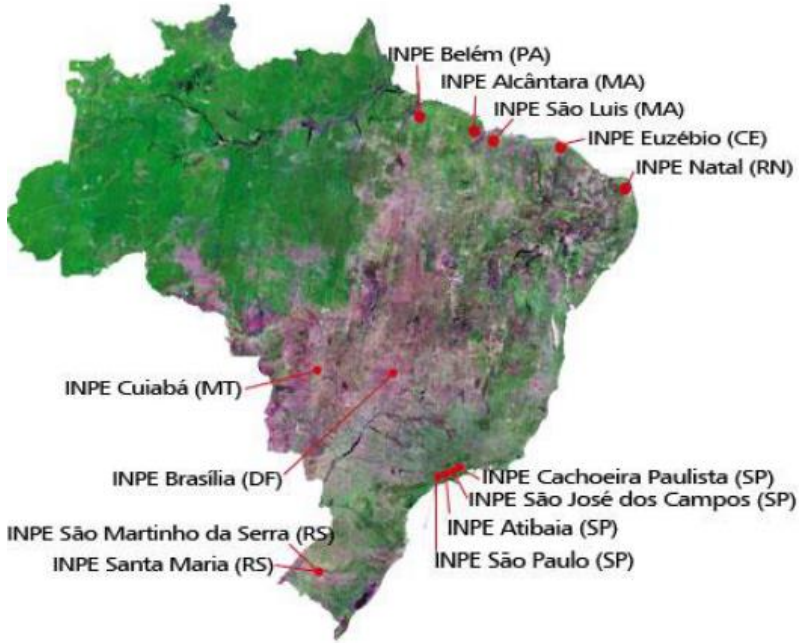
Outline

- Introduction
  - Who we are? What we do?
- EO/RS Applications in the SW-S Atlantic waters.
- Oil slick monitoring.

Institutional Presentation

Mission

To develop, operate and use space systems for the advancement of science, technology and applications in the areas of outer space and Earth environment, and offer innovative products and services for the benefit of Brazil. http://www.inpe.br/institucional/sobre_inpe/missao.php



http://www.inpe.br/institucional/sobre_inpe/instalacoes.php#sede35

Staff 1,000 people + ~600 students + [post-docs + other fellowships]

Space & Atmospheric Science

Weather & Climate

Space Technology

Earth System Sciences

Satellite Tracking & Control

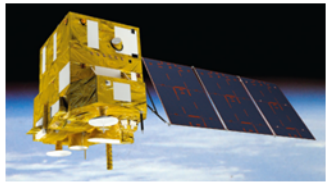
Integration & Testing Lab.

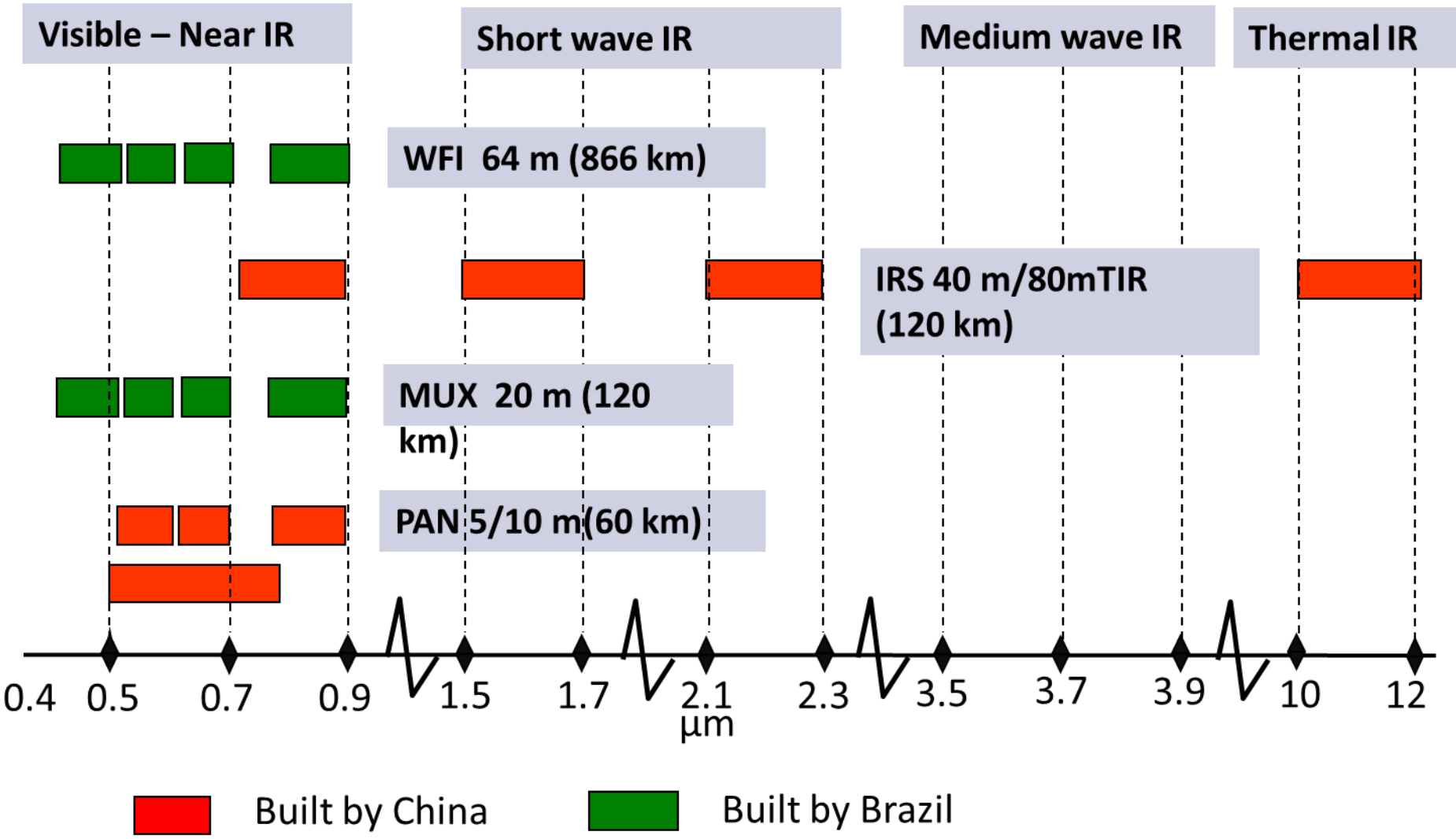
Associated Laboratories

Earth Observation

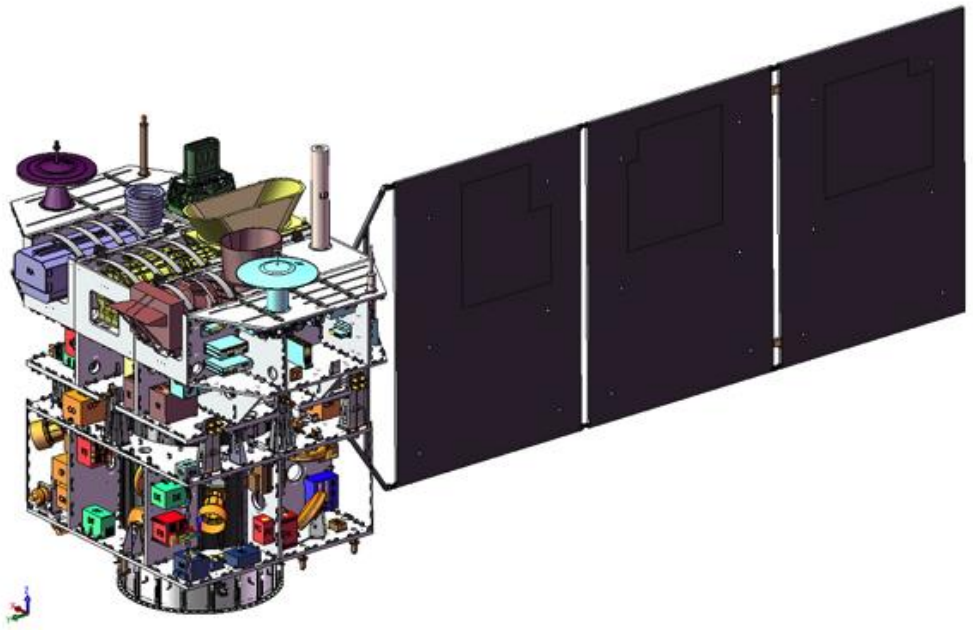
http://www.inpe.br/institucional/pesquisa_desenvolvimento/

CBERS 4




Visible – Near IR
Short wave IR
Medium wave IR
Thermal IR
WFI 64 m (866 km)
IRS 40 m/80mTIR (120 km)
MUX 20 m (120 km)
PAN 5/10 m (60 km)
0.4
0.5
0.7
0.9
1.5
1.7
2.1
2.3
3.5
3.7
3.9
10
12
µm
Built by China
Built by Brazil

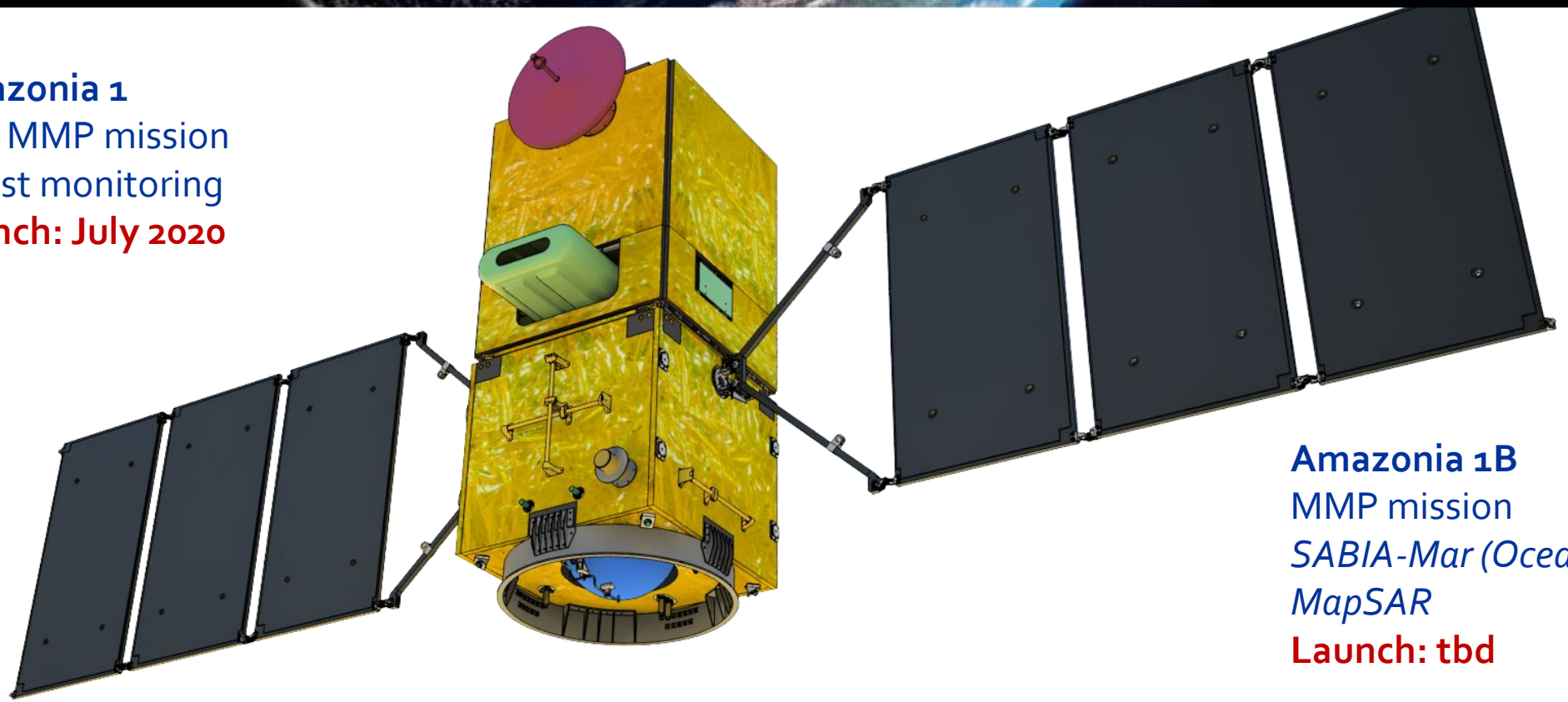
CBERS-4A



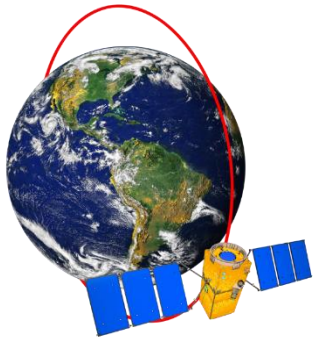
Sun synchronous orbit
Altitude = 628 km
Inclination = 97.89º
Revisiting rate = 31 days
Descending node at 10h30 local time
Launch: December 2019

Cameras	MUX	*WPM*	WFI
Manufacturer	Brazil	China	Brazil
Type	Push broom	Push broom TDI	Push broom
Revisiting rate	31 days	31 days	5 days
Quantization	8 bits	10 bits	10 bits
Swath	95 km	92 km	684 km
Band 1	0.45 - 0.52 µm	0.45 - 0.52 µm	0.45 - 0.52 µm
Band 2	0.52 - 0.59 µm	0.52 - 0.59 µm	0.52 - 0.59 µm
Band 3	0.63 - 0.69 µm	0.63 - 0.69 µm	0.63 - 0.69 µm
Band 4	0.77 - 0.89 µm	0.77 - 0.89 µm	0.77 - 0.89 µm
Band 5 (PAN)		0.45 - 0.90 µm	
Resolution	16 m	2 m, 8 m	55 m

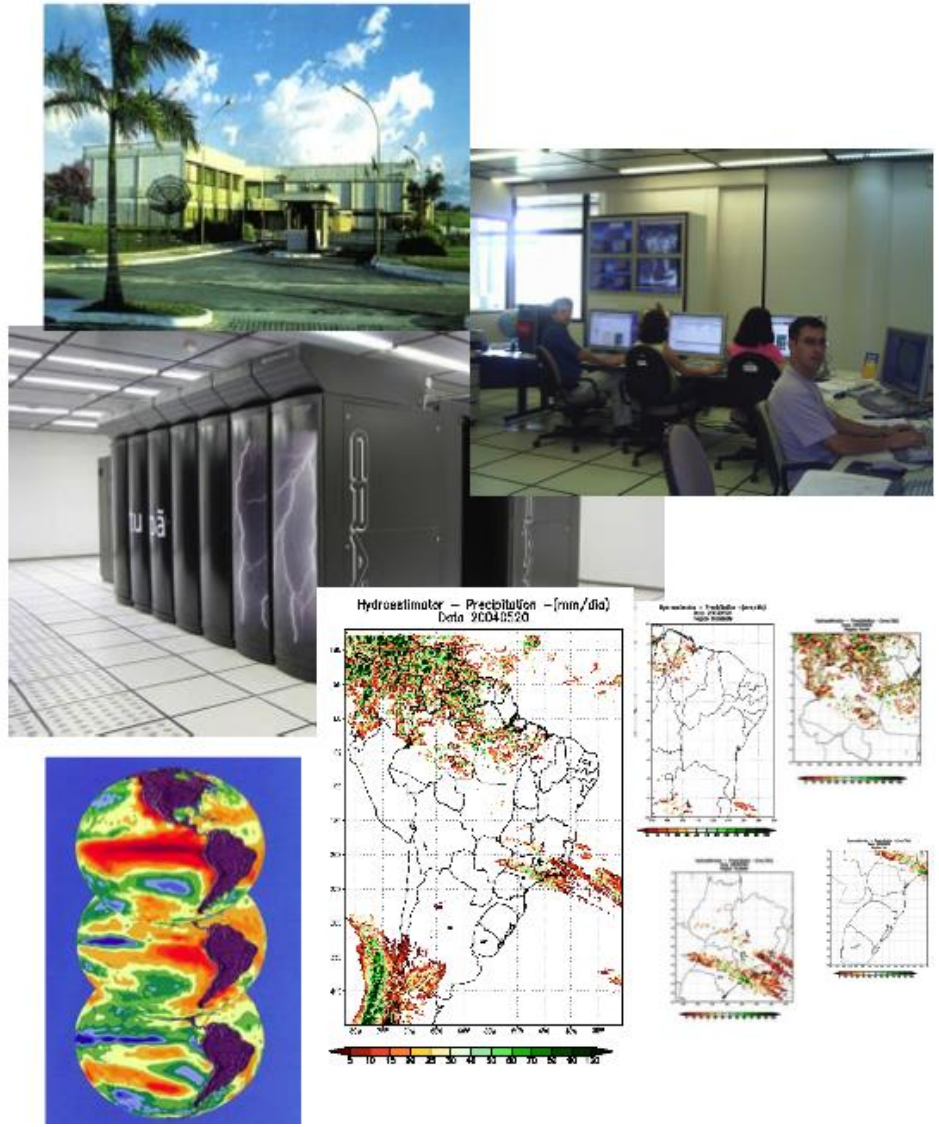
Amazonia 1
First MMP mission
Forest monitoring
Launch: July 2020



Amazonia 1B
MMP mission
SABIA-Mar (Oceans)
MapSAR
Launch: tbd



Center for Weather Forecast and Climate Studies



- Modelling physical processes relevant to the atmosphere and oceans
- Operational Weather & Climate Forecasting
- Meteorology and ocean monitoring using satellite
- High performance computer modelling
- High level graduate education and capacity building *(currently with more than 60 PhD students)*

Earth Observation

http://www.obt.inpe.br/

It involves scientific and technological knowledge in the fields of remote sensing and geoprocessing, survey of natural resources and monitoring of the environment. It conducts research, development and applications in the fields of Remote Sensing and Digital Image Processing.

DIVISIONS

DSR

DPI Divisão de Processamento de Imagens

OGI

PROGRAMS

Amazônia e Outros Biomas

CBERS

Espaço e Sociedade

Remote Sensing

Agricultura

Águas Interiores

Ecossistemas Tropicais e Ciências Ambientais

Estudos Urbanos

Geologia e Geomorfologia

Oceanografia

Recursos Florestais

Sensoriamento Hiperespectral e Espectrorradiometria

Zoneamento e outros Estudos em Geoprocessamento

GEOINFORMATICS

SPRING

TerraLib

TerraView

TerraME

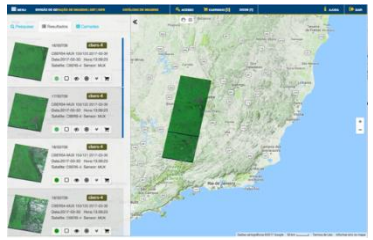
GeoDMA

TerraHidro

TerraAmazon

TerraMA²

SATELLITE MISSIONS & DATA CENTER



UN SDGs

15 LIFE ON LAND

13 CLIMATE ACTION

14 LIFE BELOW WATER

6 CLEAN WATER AND SANITATION

EDUCATION & DIFFUSION

Pós-Graduação Sensoriamento Remoto

Pós-Graduação Ciência do Sistema Terrestre

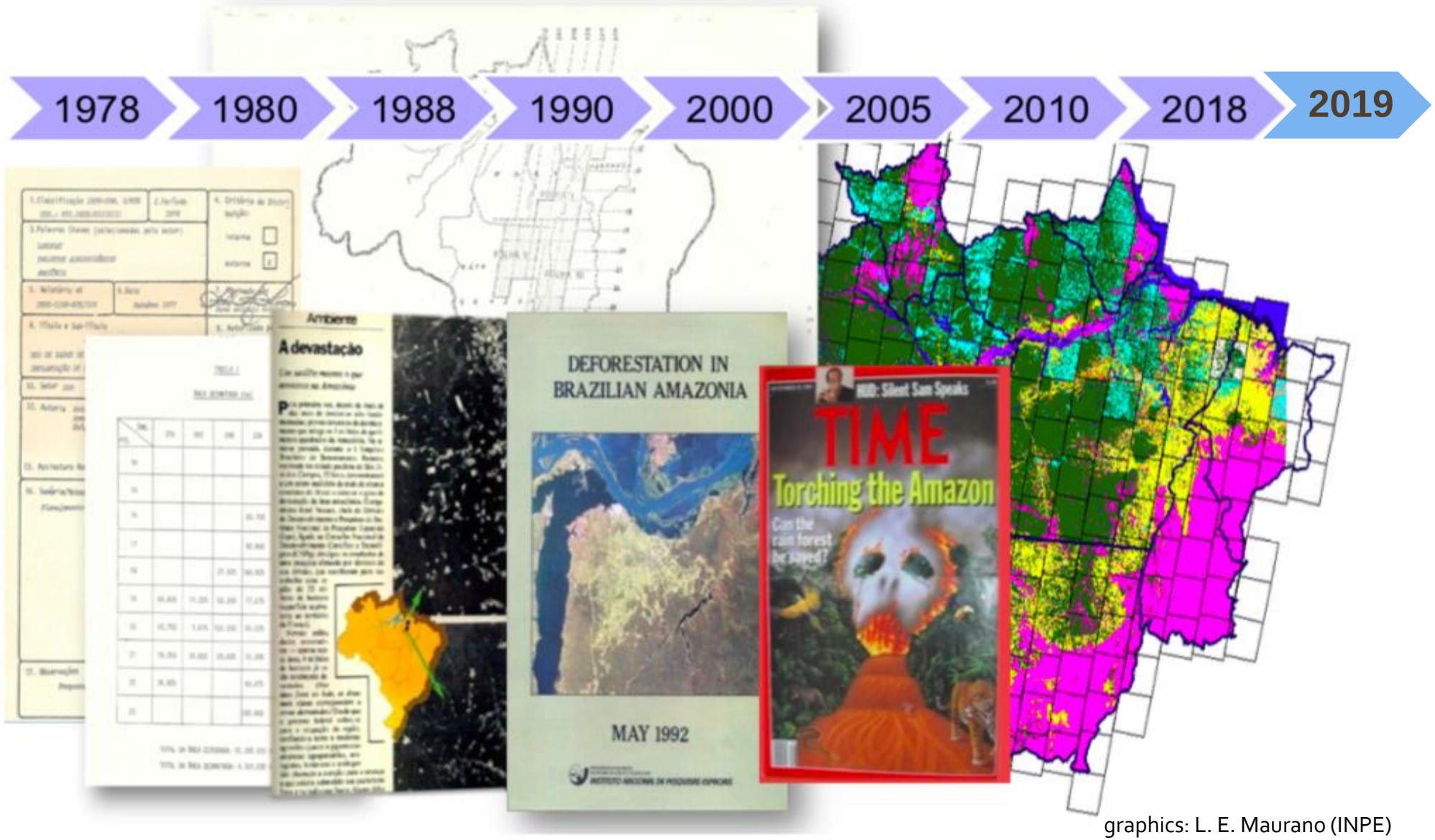
Pós-Graduação Computação Aplicada

XIX SBSR Simpósio Brasileiro de Sensoriamento Remoto

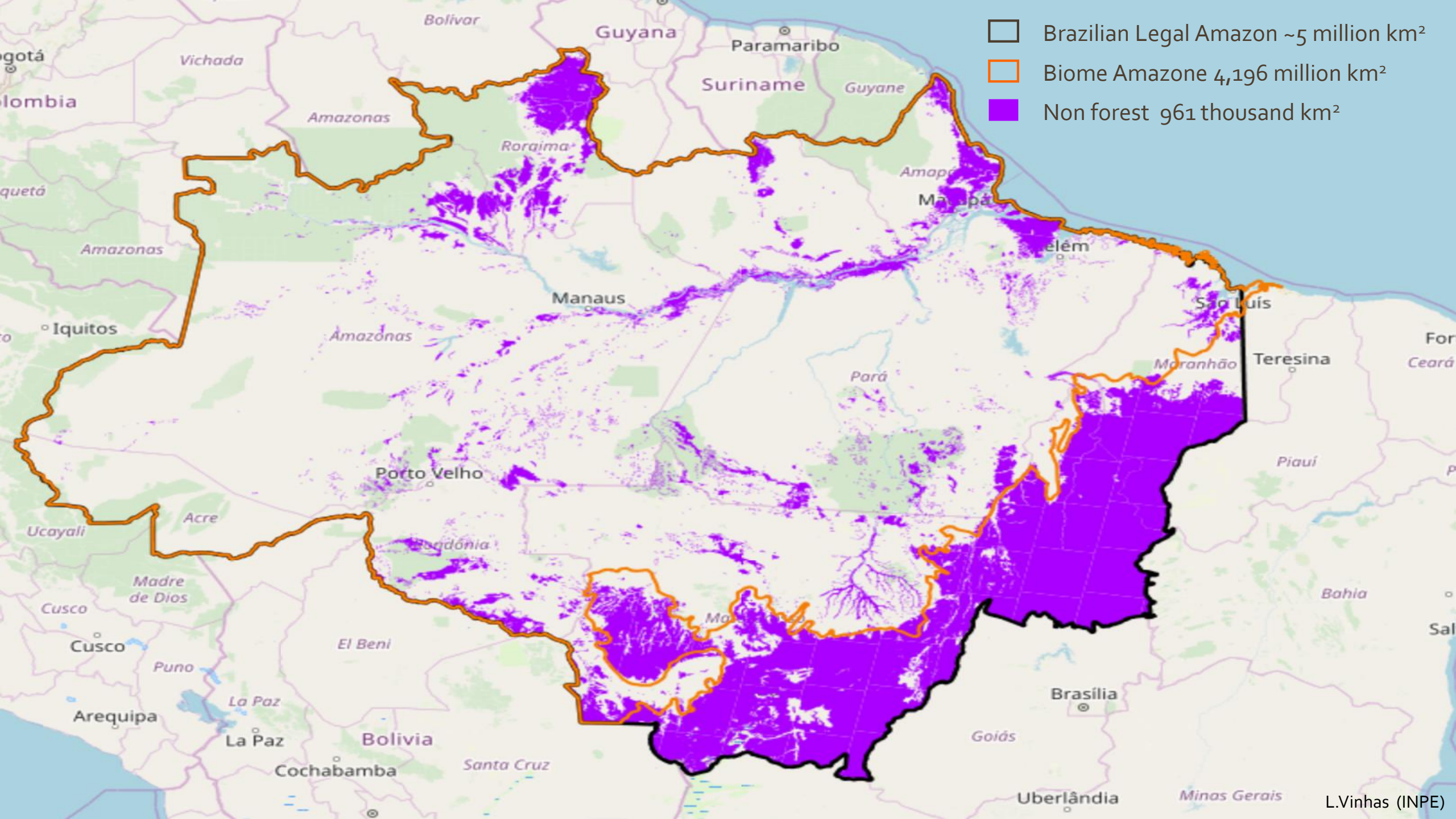
GEOINFO 2018 XIX Brazilian Symposium on GeoInformatics

7º Simpósio de Geotecnologias no Pantanal

INPE's Environmental Monitoring Systems: Land Cover, Deforestation Alerts and Fire



graphics: L. E. Maurano (INPE)


Brazilian Legal Amazon ~5 million km²
Biome Amazone 4,196 million km²
Non forest 961 thousand km²
Guyana
Paramaribo
Suriname
Guyane
Bolivar
Vichada
Amazonas
Roraima
Amapá
Belém
Manaus
São Luís
Iquitos
Teresina
Maranhão
Pará
Piauí
Ceará
Porto Velho
Acre
Ucayali
Rondônia
Madre de Dios
Cusco
El Beni
Puno
La Paz
Arequipa
Bolivia
Cochabamba
Santa Cruz
Brasília
Goiás
Bahia
Minas Gerais
Uberlândia
L.Vinhas (INPE)

Programa de Monitoramento de Queimadas e Incêndios Florestais por Satélites
Satellite Forest Burn and Fire Monitoring Program

Operational Data generation

- Active Fires
- Burned Area
- Risk of Fire/ Meteorology for Fires

Main Information Systems

- Queimadas Data base - BDQueimadas
- TerraMA²Q (Situation room)
- CIMAN VIRTUAL (Combat operations)
- SISAM (Environmental data)
- System GGT (ANEEL)

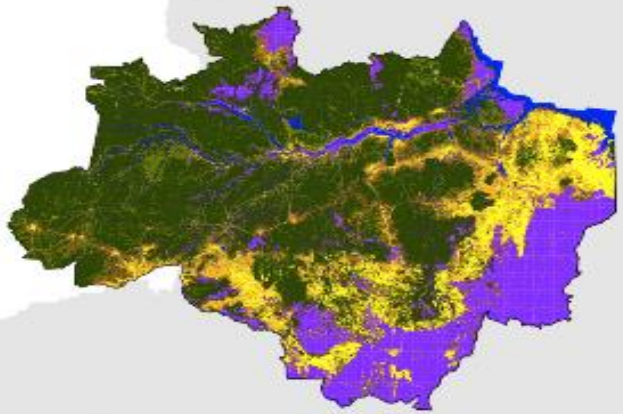
www.inpe.br/queimadas

Using EO data to monitor the land cover of our territory

PRODES

Deforestation monitoring

SINCE 1988



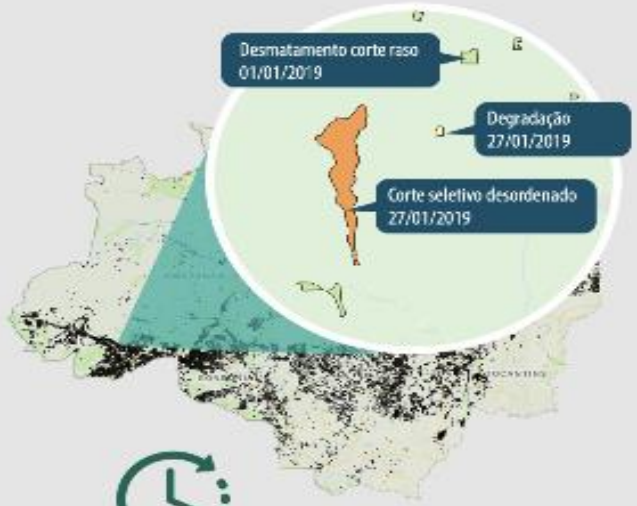
Annual maps

www.terrabrasilis.dpi.inpe.br

DETER

NRT degradation monitoring

SINCE 2004

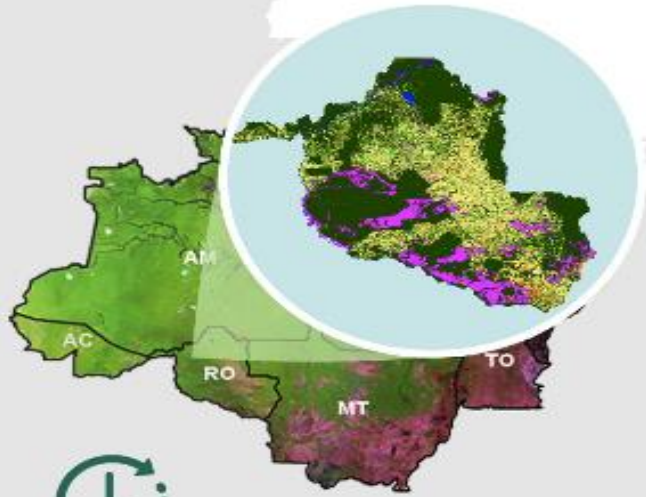


Daily alerts

TERRACLASS

Monitoring of the land use in deforested areas

SINCE 2004



Biannual maps

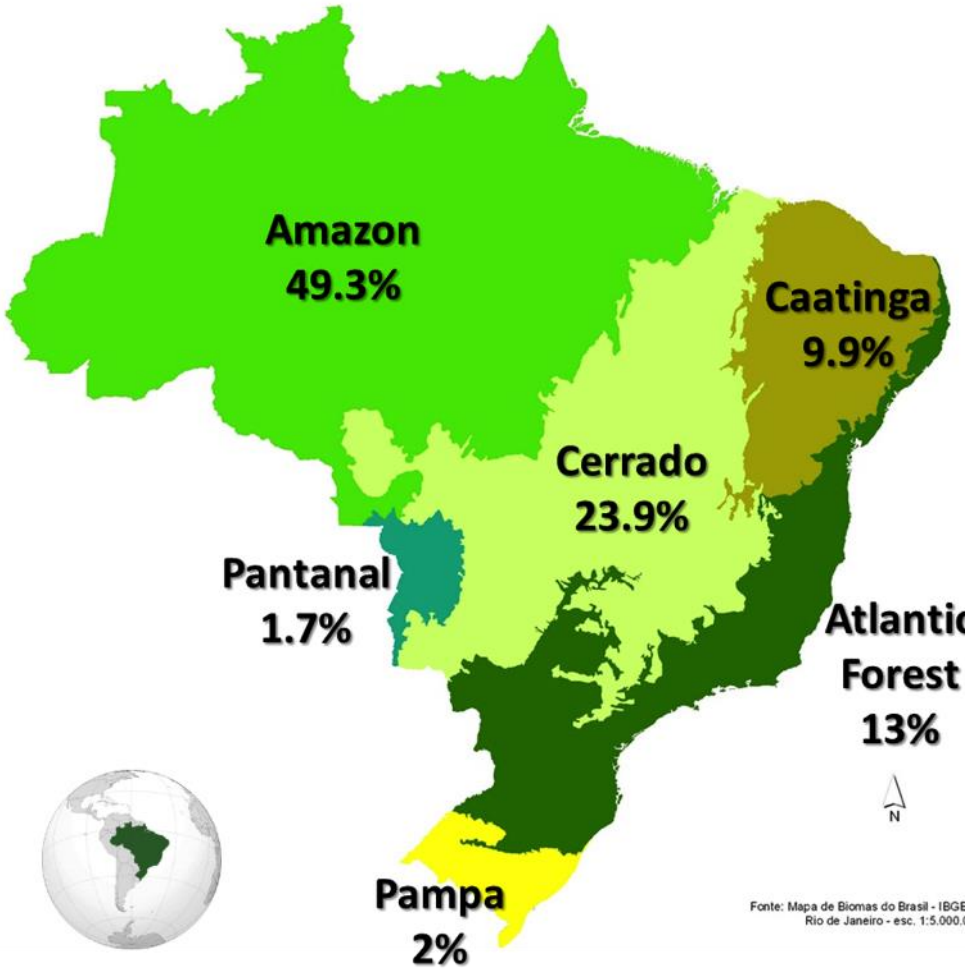
www.terraclass.org.br

Expand our monitoring activities to other Brazilian biomes

Amazon ✓

Pantanal

Pampa



Cerrado ✓

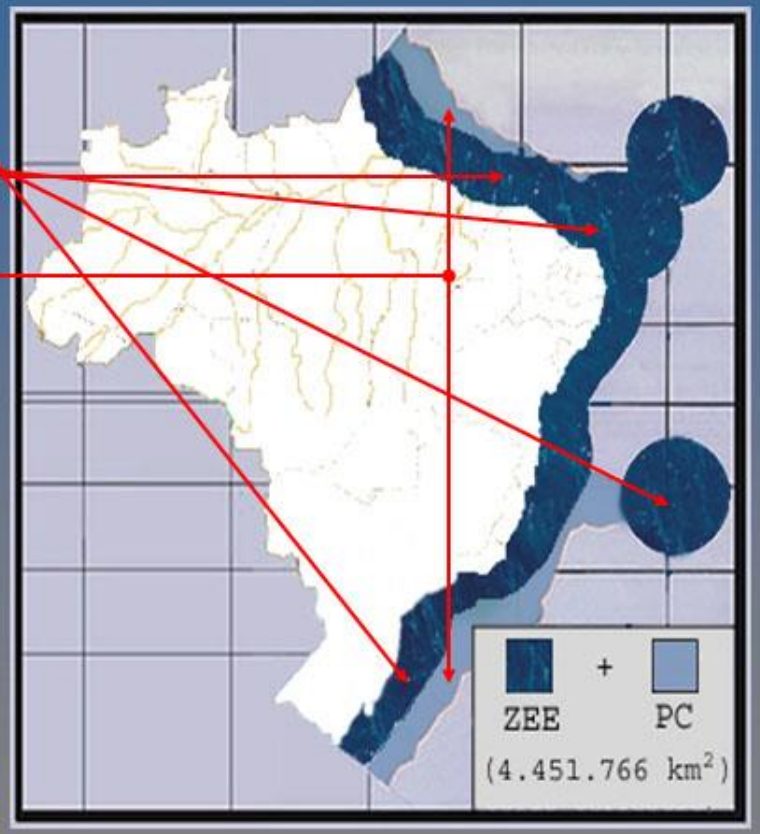
Caatinga

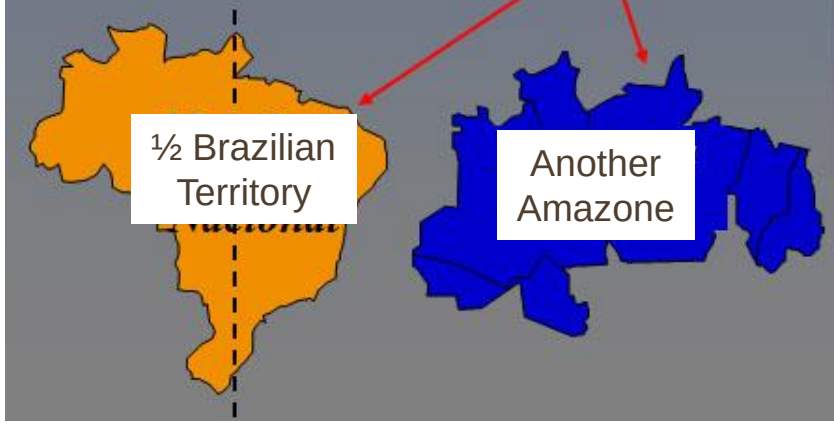
Atlantic Forest

AMAZÔNIA AZUL

BLUE AMAZON

EEZ	3.539.919 km²
Continental Shelf	911.847 km²
EEZ + Continental Shelf	4.451.766 km²





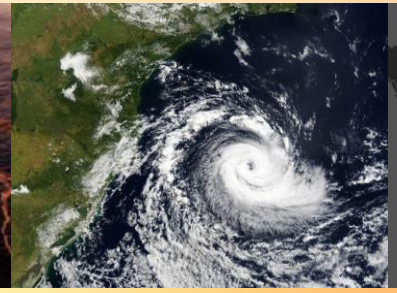
Corals/Reefs

Mangroves

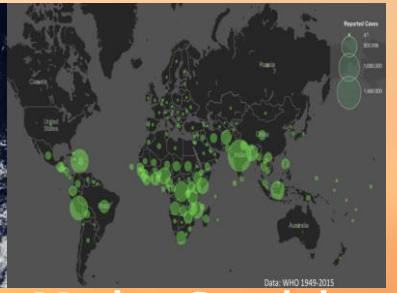
Aquaculture

Algae blooms

Climate

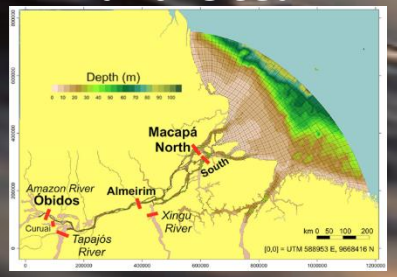


Health

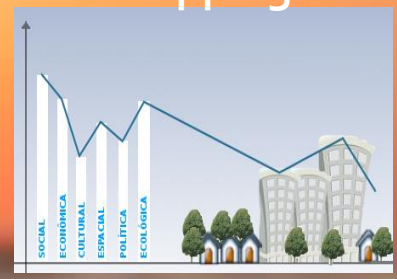


Oil & Gas

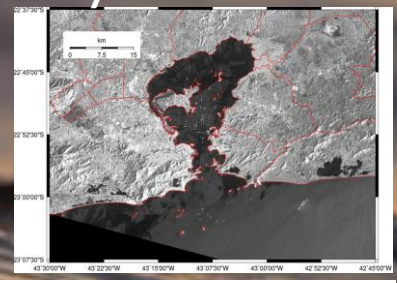
Land-Ocean



Marine Spatial Mapping



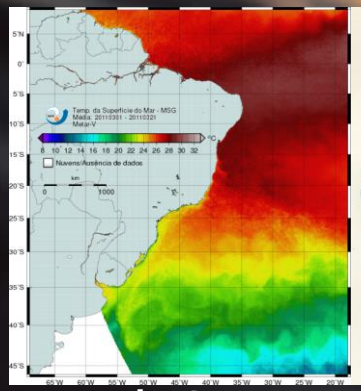
Bays & Estuaries



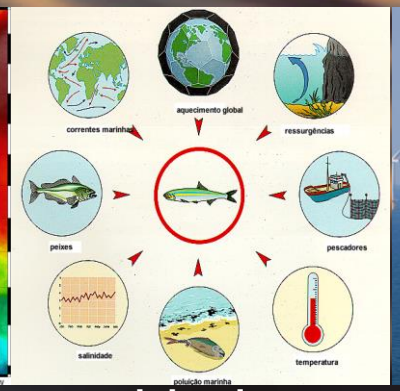
MOceanS

Oceano por Satélite

Air-Sea

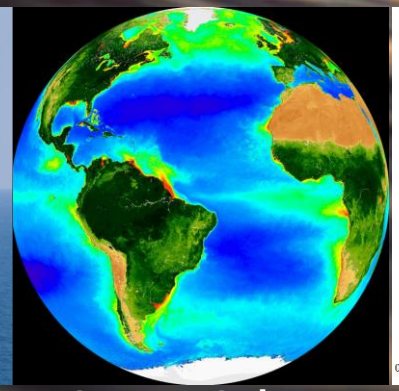


Fisheries

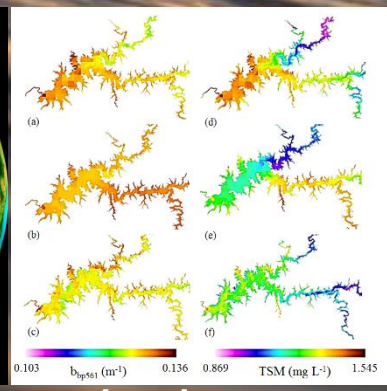


Wind Power

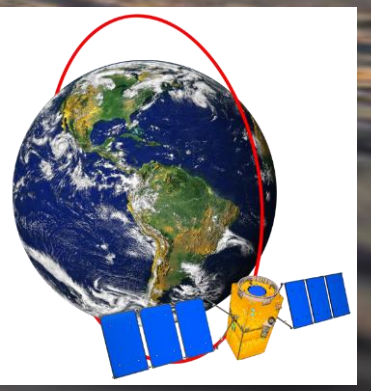
Ocean Colour



Inland waters

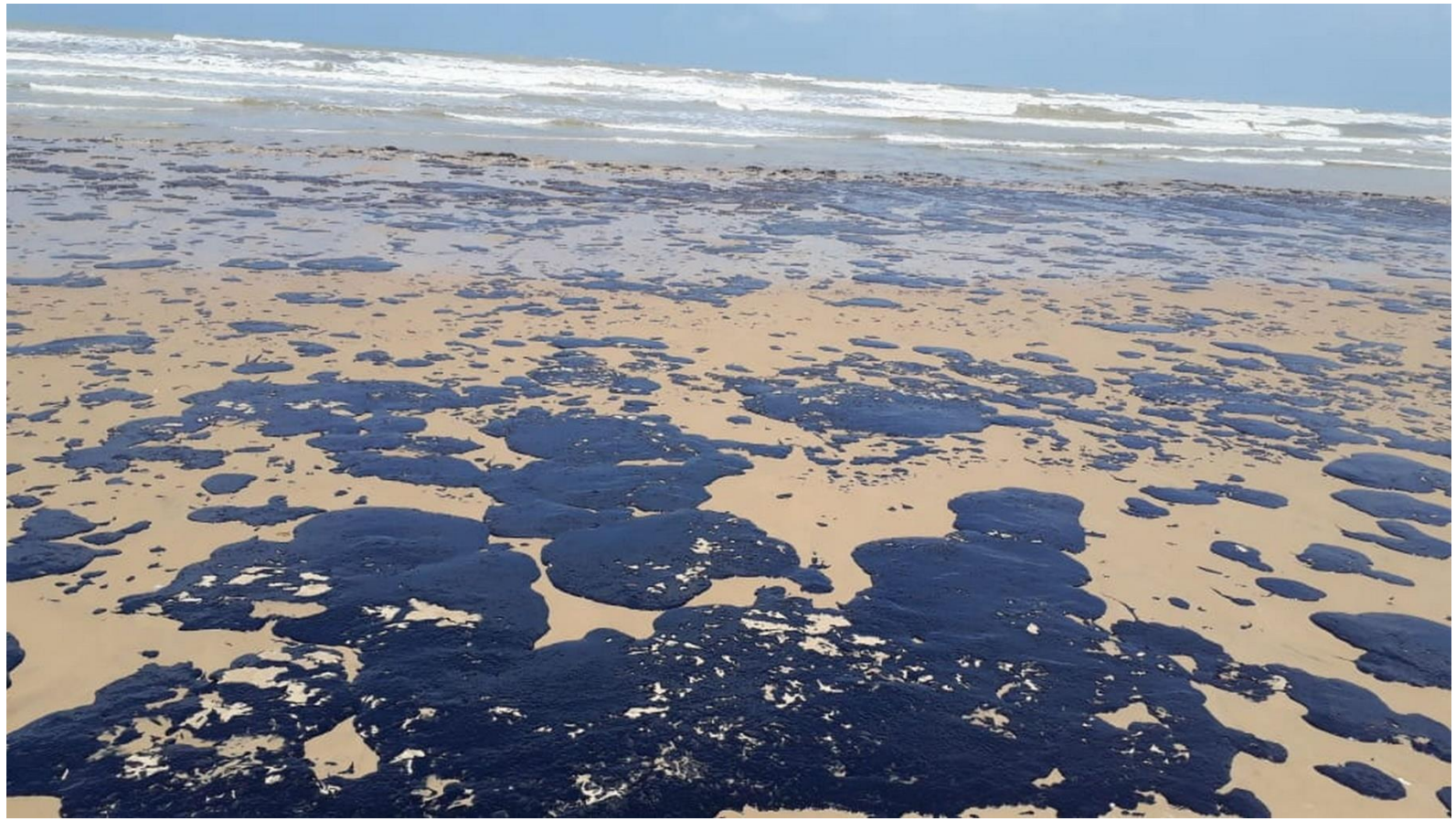


Sat Missions



Observed Oil Slicks

August 30 the first patches appear on the coast of Paraíba



Sergipe, www.ibama.gov.br

Marquez&Oliveira, 2019

Observed Oil Slicks

November 7 reaches the beaches of Espírito Santo already in the form of traces

Marquez&Oliveira, 2019

São Mateus, Source: BRA Navy

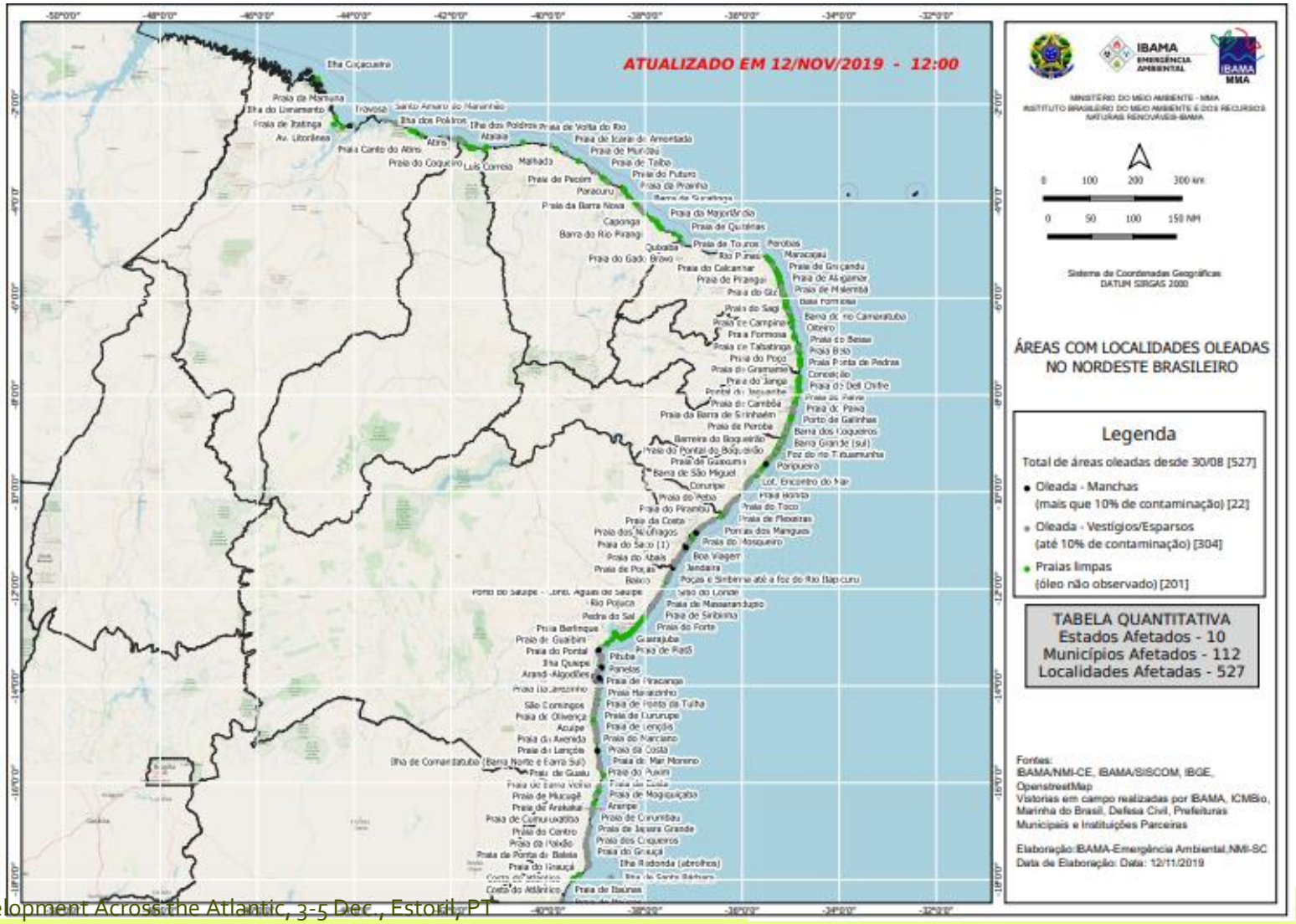
Observed Oil Slicks

Until November 11th:

- 10 states
- 112 municipalities
- 527 localities

+ 2000 km of coastline reached!

+ 4500 tons of waste collected



http://www.ibama.gov.br/

Marquez&Oliveira, 2019

Reached Fauna

3. MANEJO DE FAUNA OLEADA

3.1. Ocorrências em 12/11/19: 1 animal oleado
- AL: 1 tartaruga marinha morta

3.2. Total de ocorrências: 134 animais oleados (tabelas a seguir)

FAUNA OLEADA - Ocorrências até 12/11/2019					
UF	Ave	Mamífero marinho	Outros	Tartaruga marinha	TOTAL
AL	6	1	1	20	28
BA	19	1	7	26	53
CE	1			11	12
MA				2	2
PE				3	3
PI				3	3
RN	1			14	15
SE	3		4	11	18
TOTAL	30	2	12	90	134

FAUNA OLEADA - Ocorrências até 12/11/2019			
UF	Morto	Vivo	TOTAL
AL	21	7	28
BA	36	17	53
CE	9	3	12
MA	1	1	2
PE	3		3
PI	3		3
RN	10	5	15
SE	14	4	18
TOTAL	97	37	134

Source: Ibama

97 dead animals, most sea turtles

Maranhão, www.bbc.com
Marquez&Oliveira, 2019

REUTERS

Socioeconomic and human impacts

Not yet accounted for!

Coral Coast in Alagoas
Source: Felipe Brasil

Work fronts

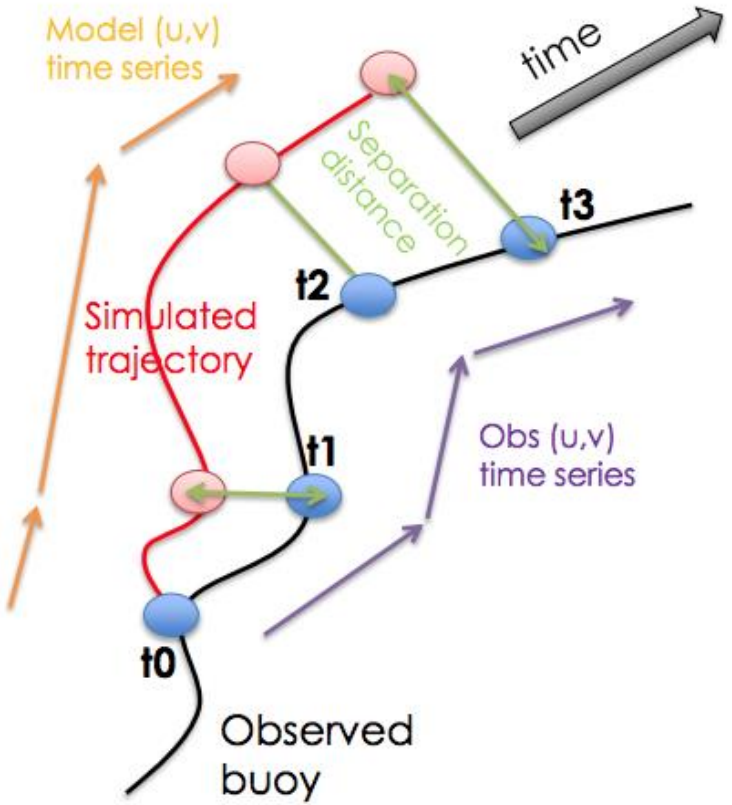
1. Try to identify the **location** of possible source of oil spill.
2. Identify possible **trajectories** of oil spilled into the sea.
3. Check for oil spot identification by **satellite monitoring**.
4. Verify or refute third-party oil **identification reports**.
5. Identify possible locations to be **reached** by oil.

Marquez&Oliveira, 2019

Source: Ibama.gov.br

Numerical Modeling Challenges

- ✓ Hydrodynamic models along with dispersion models are employed to estimate the behavior of oil in the sea.
- ✓ Models and data sources with different characteristics.



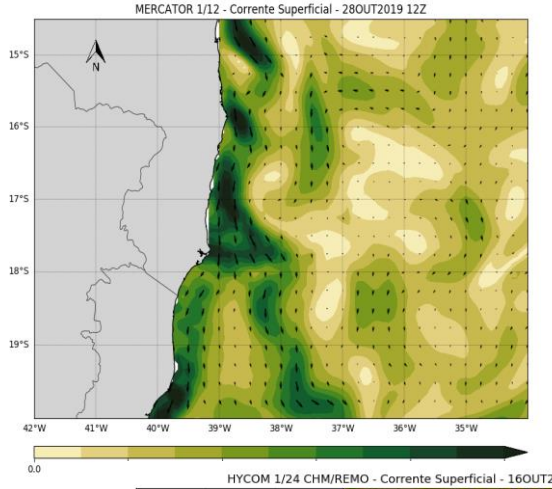
Marquez&Oliveira, 2019

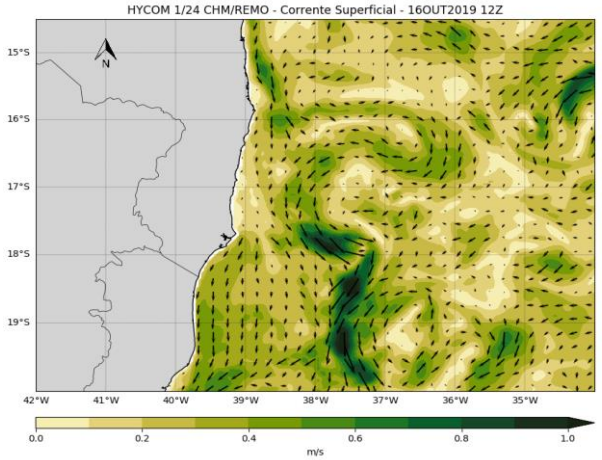
Numerical Modeling Challenges

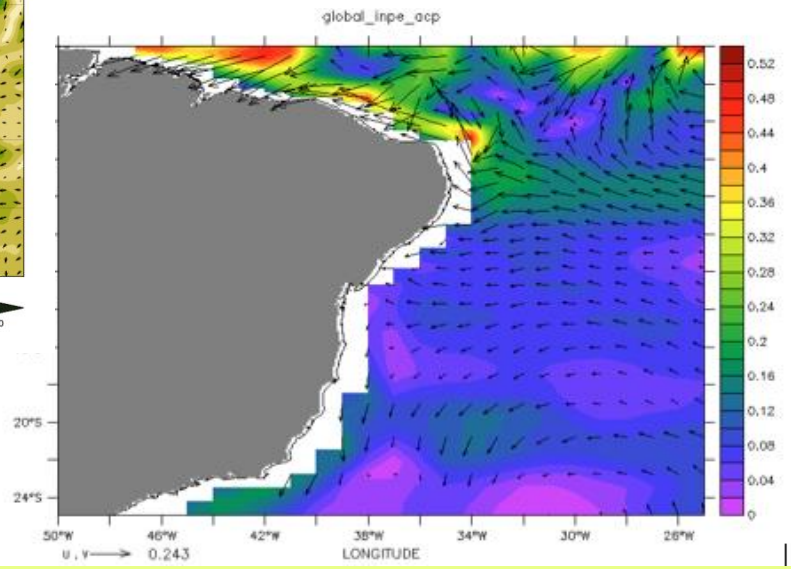
Mercator (Global Analysis and Forecasting)
- 9 days
- 1/12 degree

Hycom Navy (regional forecast)
- 5 days
- 1/24 degree

- Seasonal Forecast - CPTEC (Global Forecast)
- 90 days
- 1/4 x 1 degree (lat x lon)







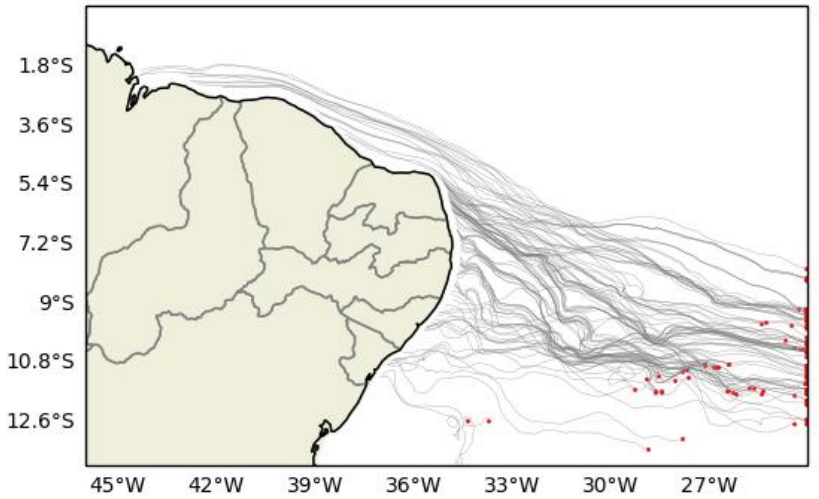
Marquez&Oliveira, 2019

Numerical Modeling Approach

BACKTRACK in TIME

- Identify possible locations and date of origin of the oil.
- Volume estimation shed across scenarios: Optimistic, Realistic, Pessimistic.
- Allowance for future simulations.
- Lagrangian Particle Model PARCELS (oceanparcels.org)
- Different current fields = different paths. !!!

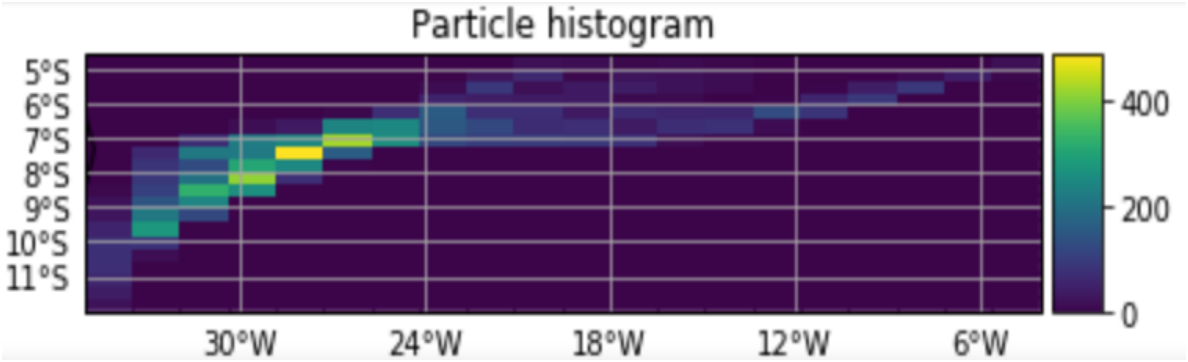
Hycom Navy Regional Forecasting Model



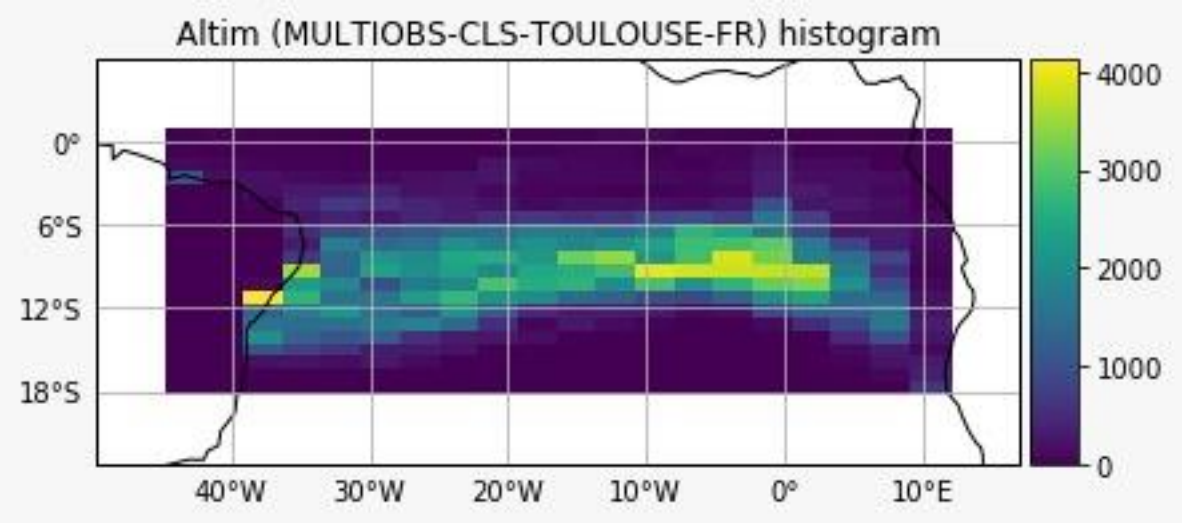
Marquez&Oliveira, 2019

Numerical Modeling Approach

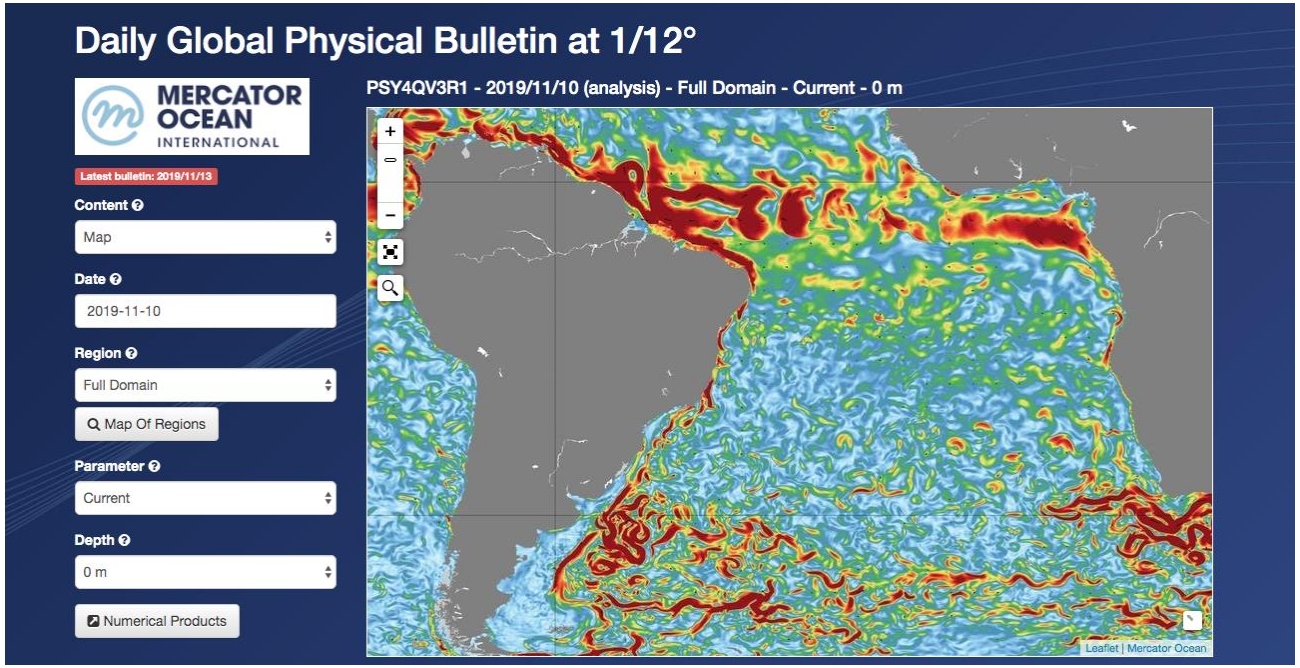
CPTEC Seasonal Forecasting Model



Altimeter and scatterometer data analysis



Mercator Ocean International & Copernicus



Marquez&Oliveira, 2019

Satellite Monitoring Challenges

- ✓ Synthetic Aperture Radar (SAR) images are commonly used for satellite oil slick detection and monitoring.
- ✓ Sentinel-1 A / B (Copernicus): free images since 2014.
- ✓ The sensors are not programmed to acquire offshore images in all modes and only detect surface slicks.

Marquez&Oliveira, 2019

Satellite Monitoring Challenges

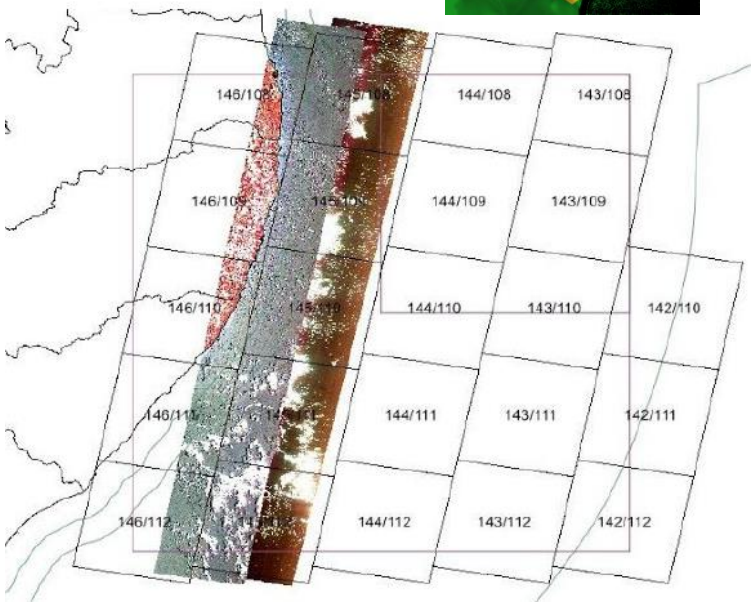
- ✓ Oil patches reach the coast in subsurface, also in a disaggregated manner.
- ✓ Some oil not associated with the event was also identified.
- ✓ Too many false positives.
- ✓ *In the period of probable occurrence (May-Jul) there is no sunglint effect in the south-equatorial zone, making it difficult to identify the possible source at sea in medium resolution optical images.*

Marquez&Oliveira, 2019

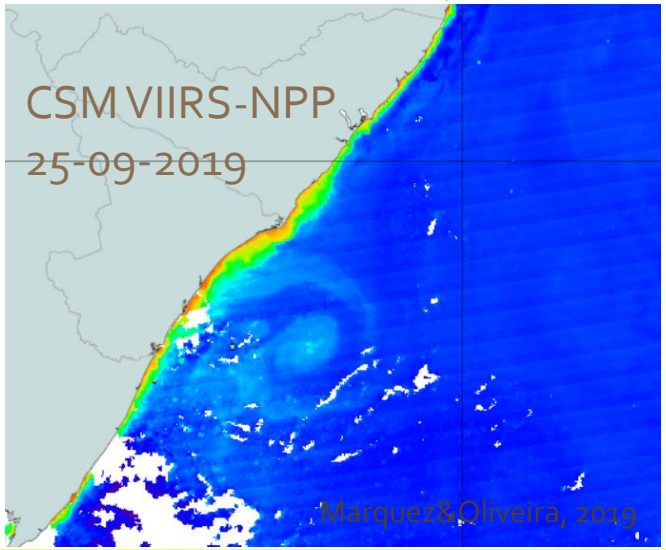
Pernambuco, www.ibama.gov.br

Satellite Oil Monitoring

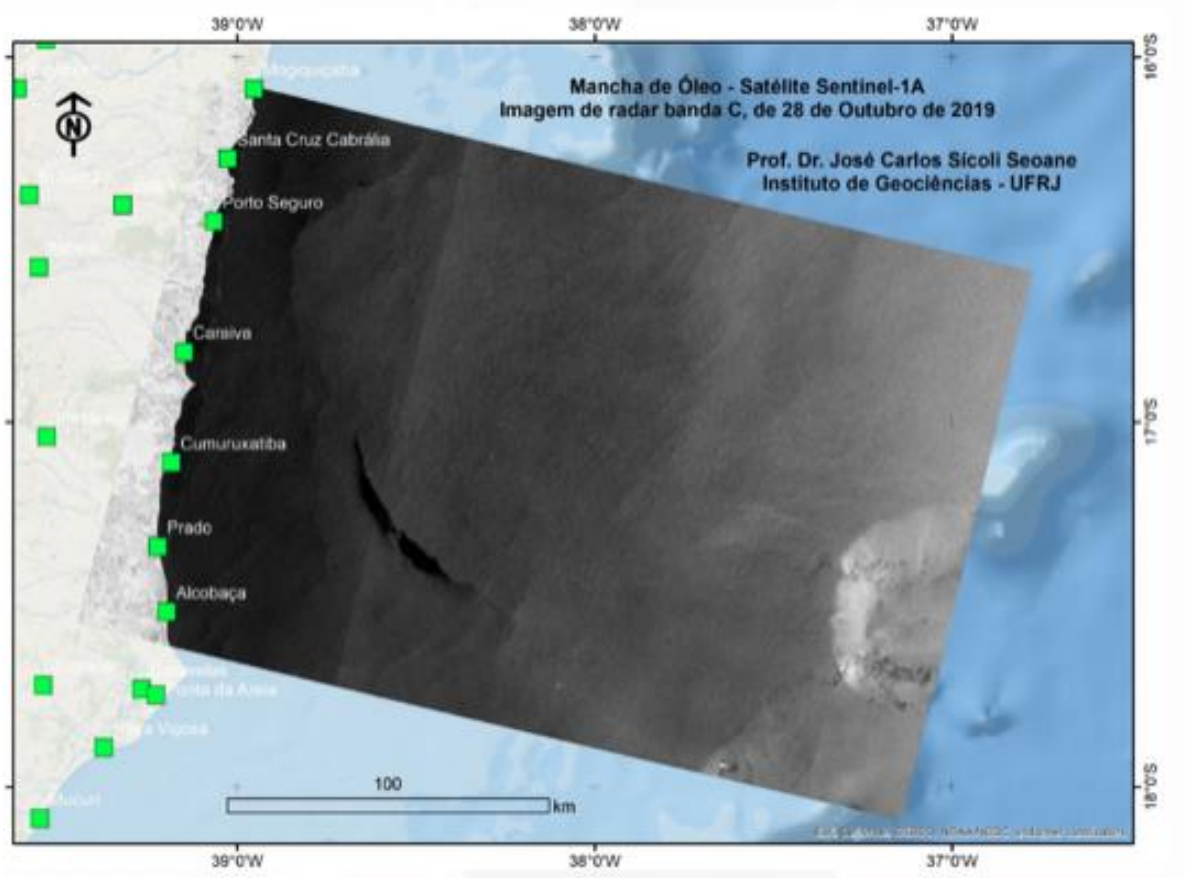
- ✓ *Monitor possible surface and subsurface oil slicks in priority areas of the Northeast and Southeast coast of Brazil.*
- ✓ *Evaluate spots identified by INPE and third parties, refuting or corroborating the alleged detections, with complementary meteoceanographic data.*
- ✓ *Support other activities with satellite ancillary data.*

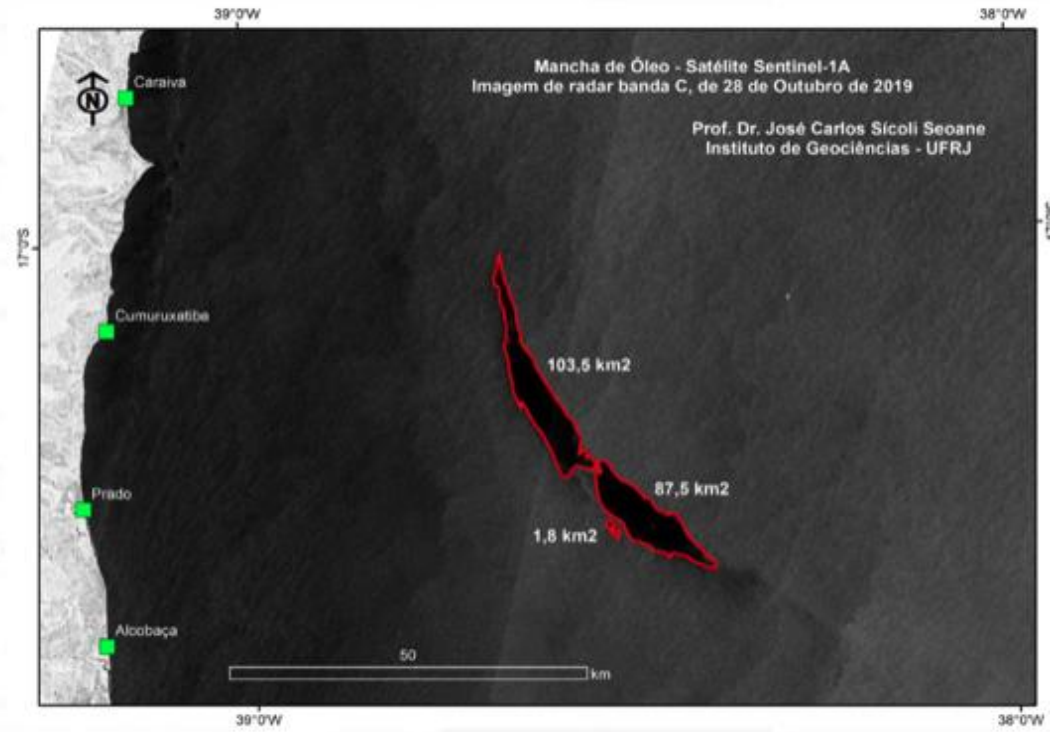


- *SAR Sentinel-1 A/B*
- *Optical images CBERS 4A (AWFI, PAN10M), MODIS, OLCI, VIIRS, MSI, OLI*
- *High resolution*



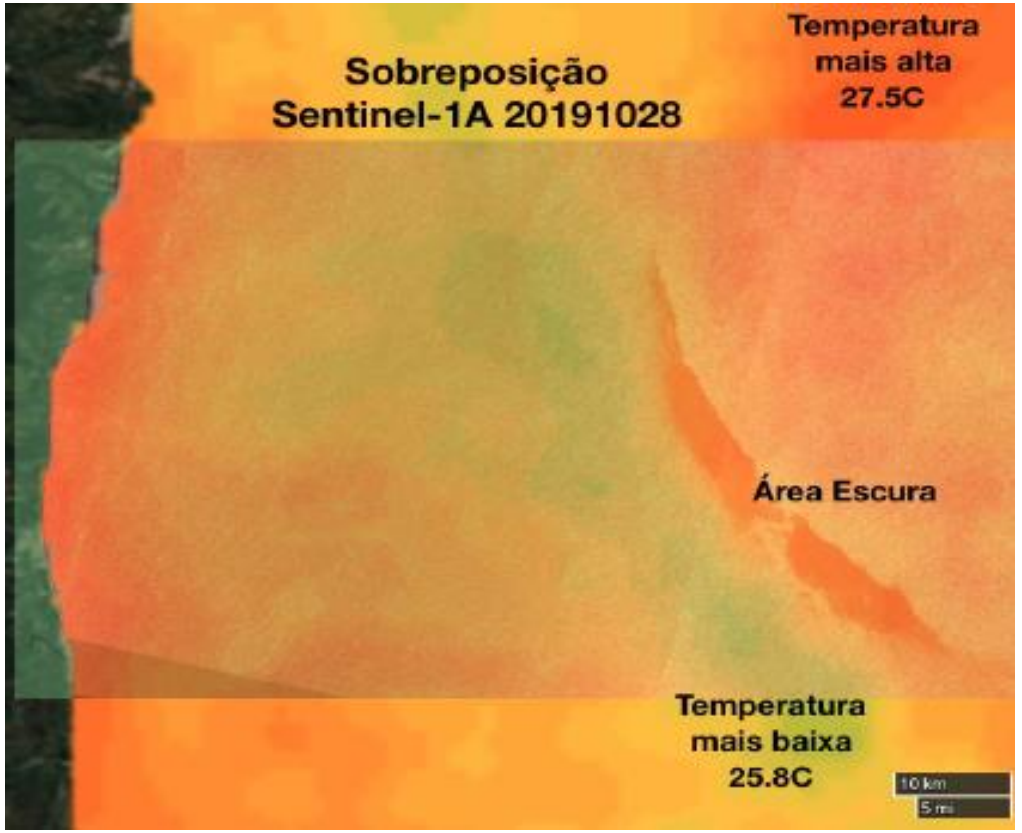
Case 1: Slick detected in southern BA on October 28





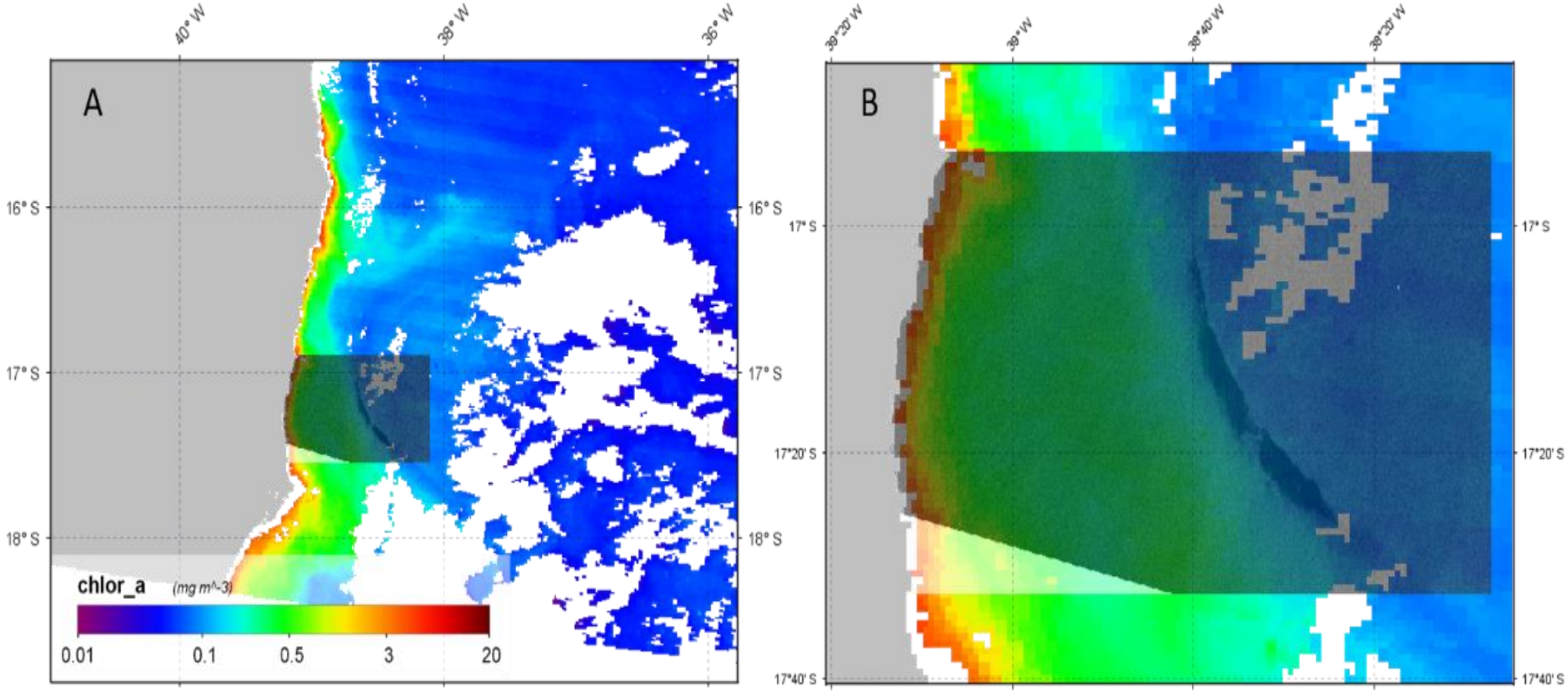
Case 1: Slick detected in southern BA on October 28

CBERS4 AWFI 28/11/19



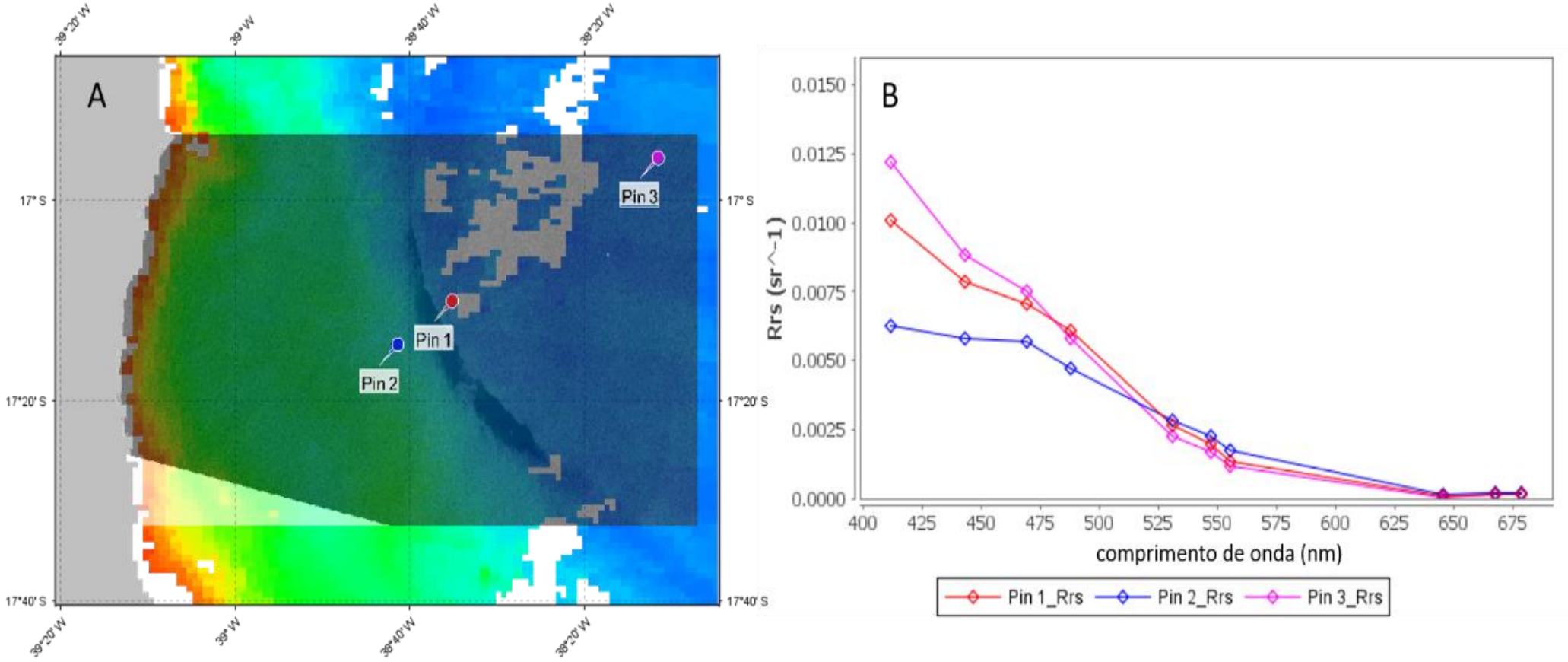
SST MUR 28/11/2019

Case 1: Slick detected in southern BA on October 28



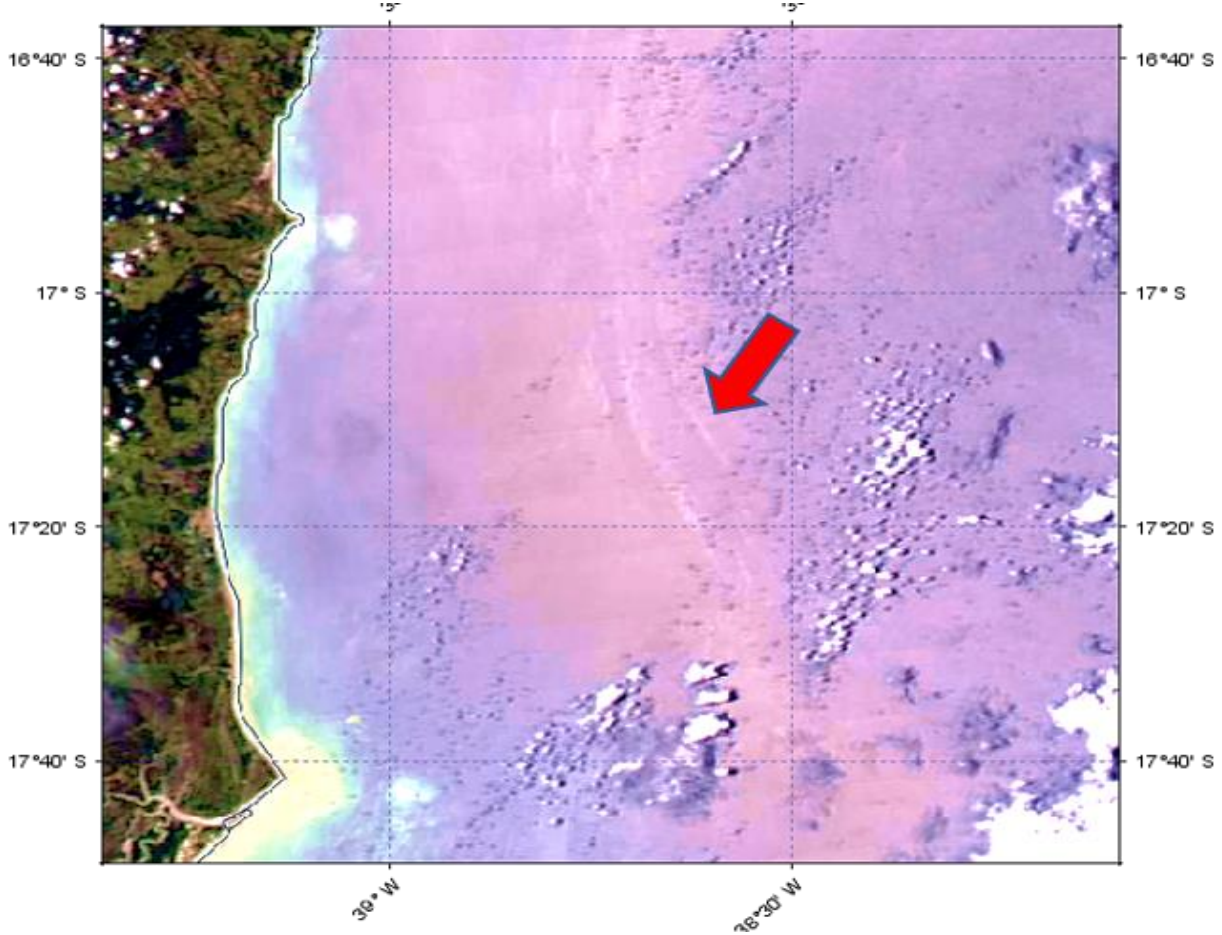
CSM MODIS + S1A (28/10/2019)

Case 1: Slick detected in southern BA on October 28

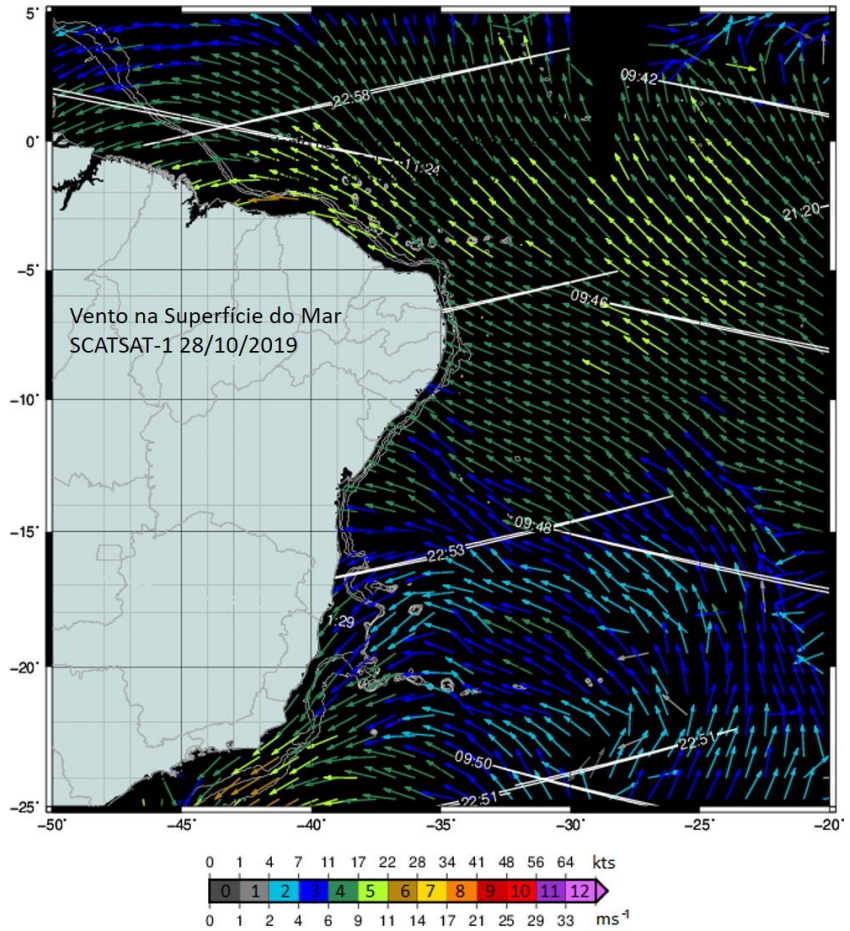


CSM MODIS + S1A (28/10/2019)

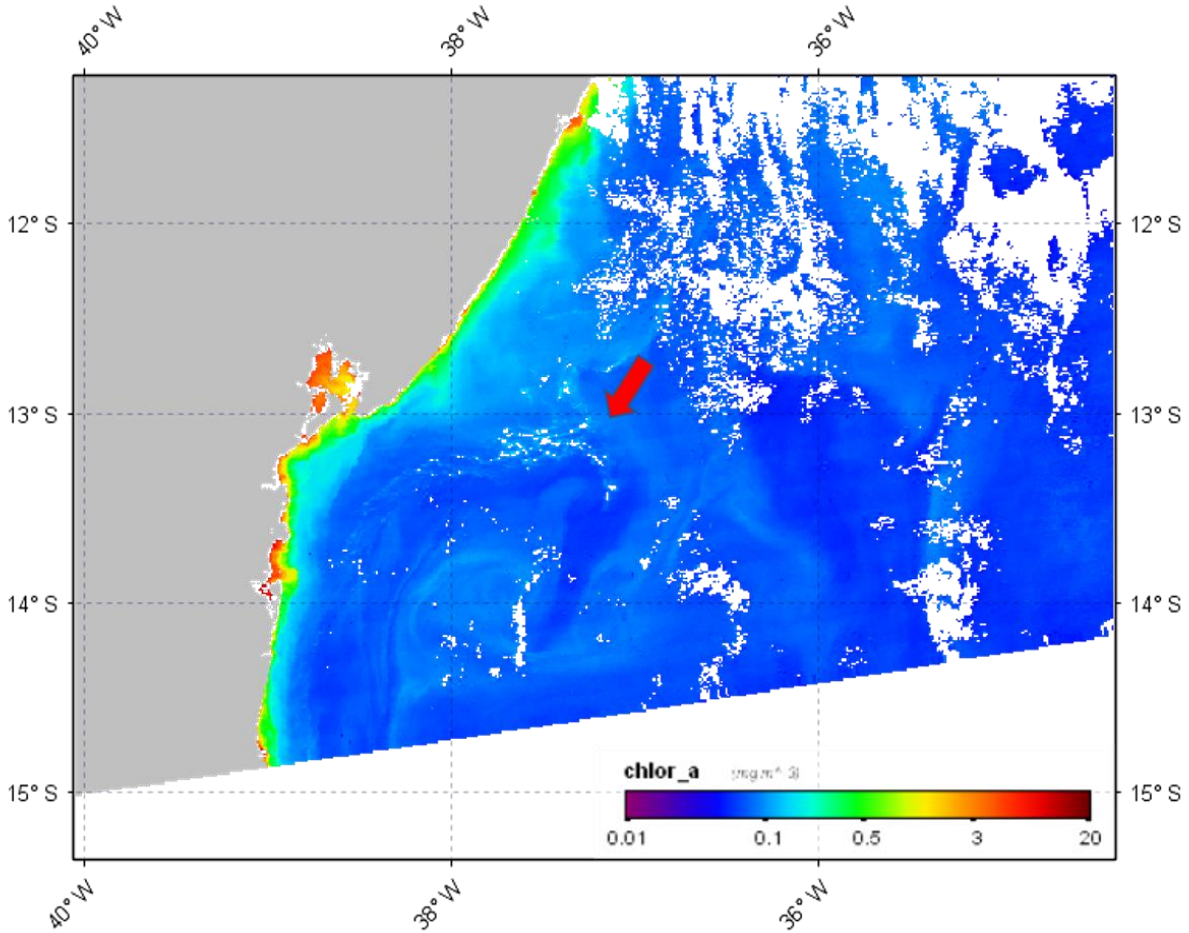
Case 1: Slick detected in southern BA on October 28



RGB MODIS (28/10/2019)



Case 1: Slick detected in southern BA on October 28



CSM MODIS (26/10/2019)

Source: IBAMA

Future Perspectives

- ✓ Satellite monitoring continues with focus on areas where oil could still reach.
- ✓ Support from Oc. Navy Ship Vital de Oliveira Ship and R99 Air Force aircraft
- ✓ Modeling is focused on identifying the place of origin and the areas where oil can still reach.