MINISTÉRIO DA CIÊNCIA E TECNOLOGIA
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

GEOSS Americas/Caribbean Remote Sensing Workshop – Transforming Data into Products

Sea Surface Temperature
Chlorophyll

Milton Kampel, Dr.

BRASIL
UM PAÍS DE TODOS
GOVERNO FEDERAL

Motivation

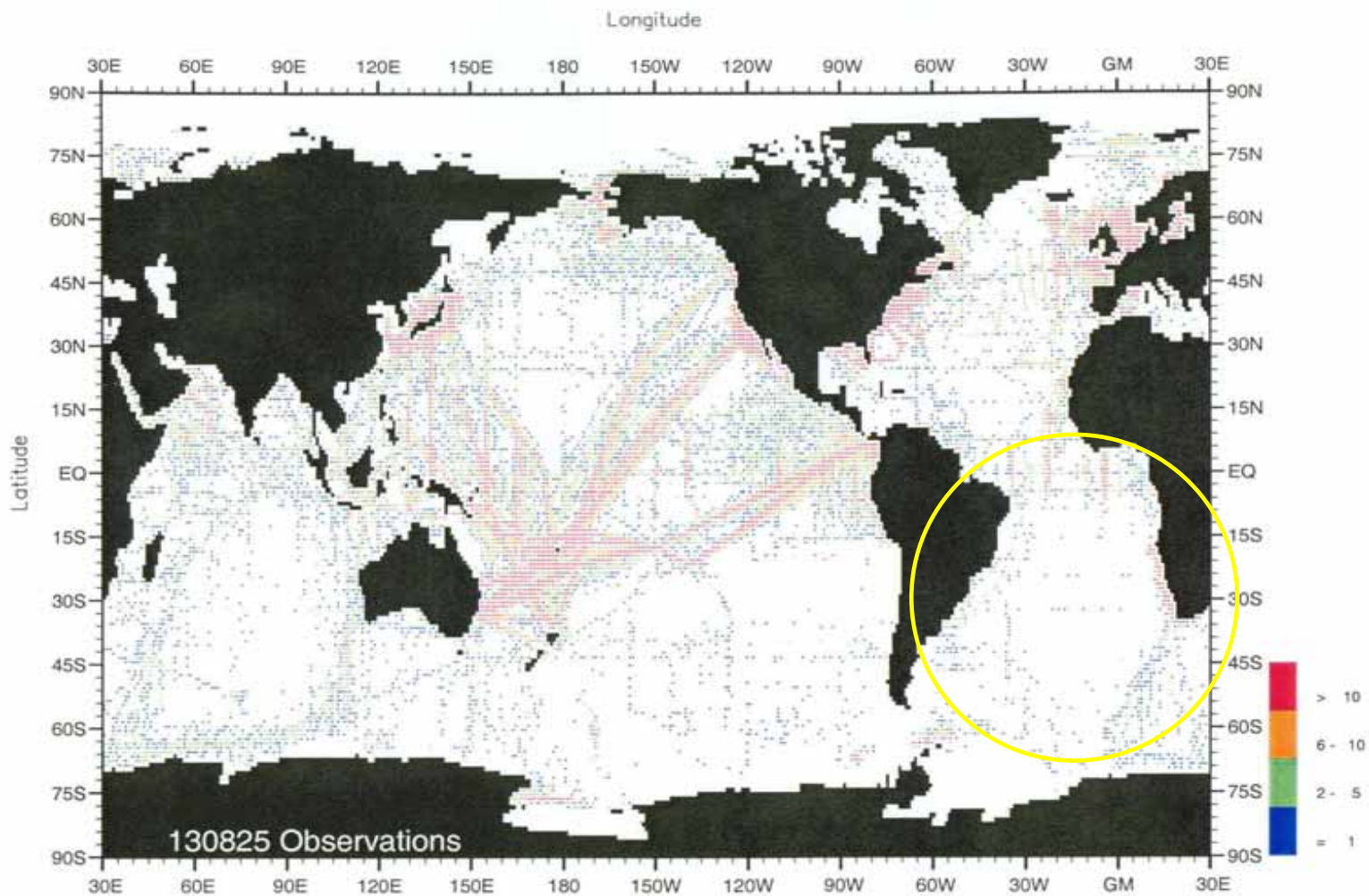


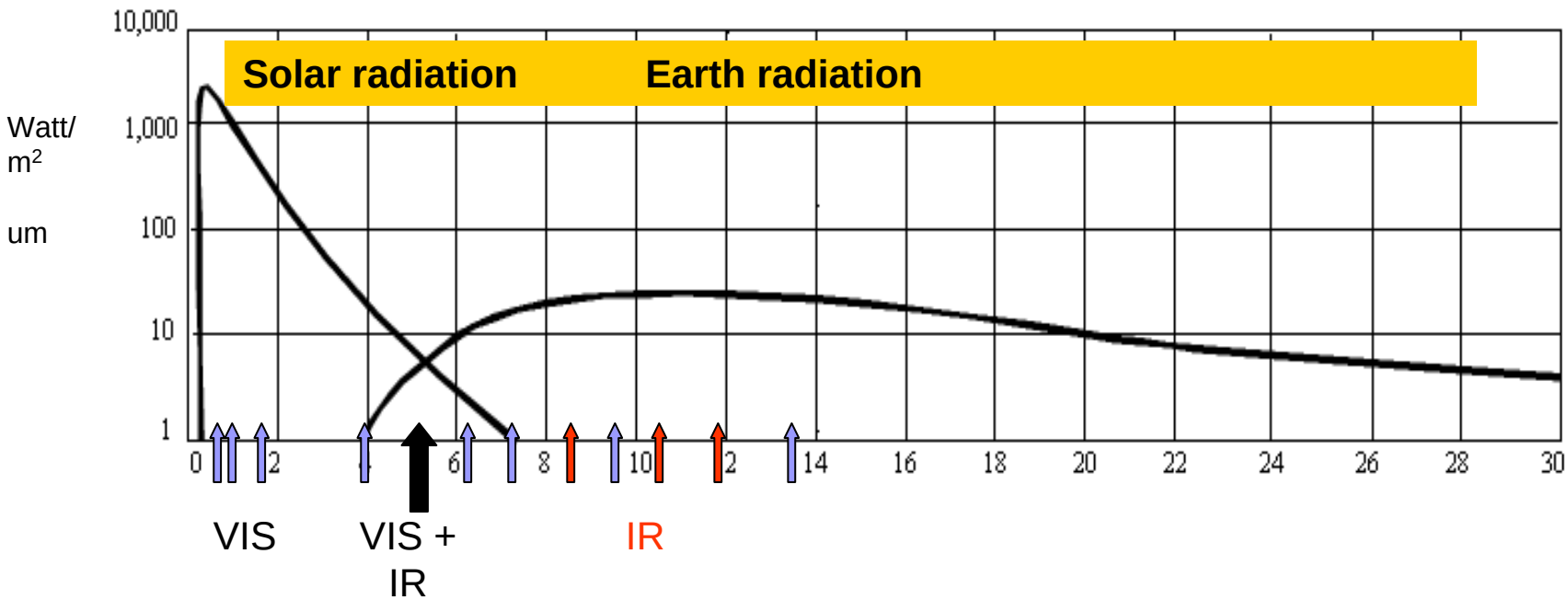
Fig. A1-1. Annual chlorophyll observations at the surface.

Meteosat Second Generation - MSG

No. Canal	Banda Espectral (µm)	Características das Bandas Espectrais (µm)			Aplicações
		Centro	Min	Max	
1	VIS0.6	0.635	0.56	0.71	Superfície, nuvens, campo de vento
2	VIS0.8	0.81	0.74	0.88	Superfície, nuvens, campo de vento
3	IV1.6	1.64	1.50	1.78	Superfície, fase nuvens
4	IV3.9	3.90	3.48	4.36	Superfície, nuvens, campo de ventos
5	VA6.2	6.25	5.35	7.15	Vapor d'água, nuvens de altitude, instabilidade atmosférica
6	VA7.3	7.35	6.85	7.85	Vapor d'água, instabilidade atmosférica
7	IV8.7	8.70	8.30	9.1	Supewrfície, nuvens, instabilidade atmosférica
8	IV9.7	9.66	9.38	9.94	Ozônio
9	IV10.8	10.80	9.80	11.80	Superfície, nuvens, campo de ventos, instabilidade atmosférica
10	IV12.0	12.00	11.00	13.00	Superfície, nuvens, instabilidade atmosférica
11	IV13.4	13.40	12.40	14.40	Altura de nuvens Cirrus, instabilidade atmosférica
12	HRV	PAN (~ 0.4 - 1.1 µm)			Superfície, nuvens

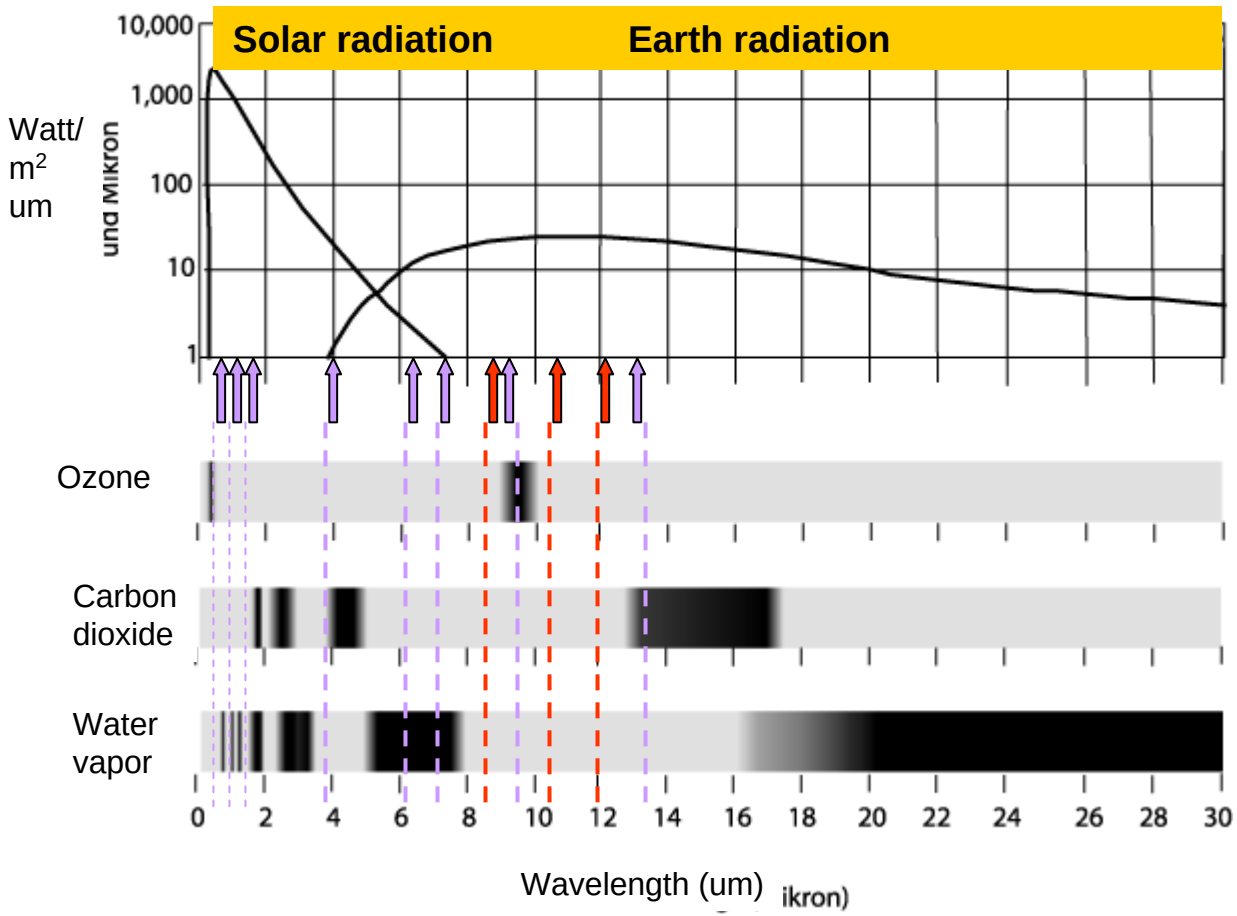
Sources: Sun - Earth

- Wavelengths < 5 μm = Solar radiation is dominant
- Wavelengths > 5 μm = Earth radiation is dominant
- C01, 02, 03, 12 = Only solar radiation
- C04 = Both Earth & Sun radiation
- C05, 06, 07, 08, 09, 10, 11 = Only Earth radiation

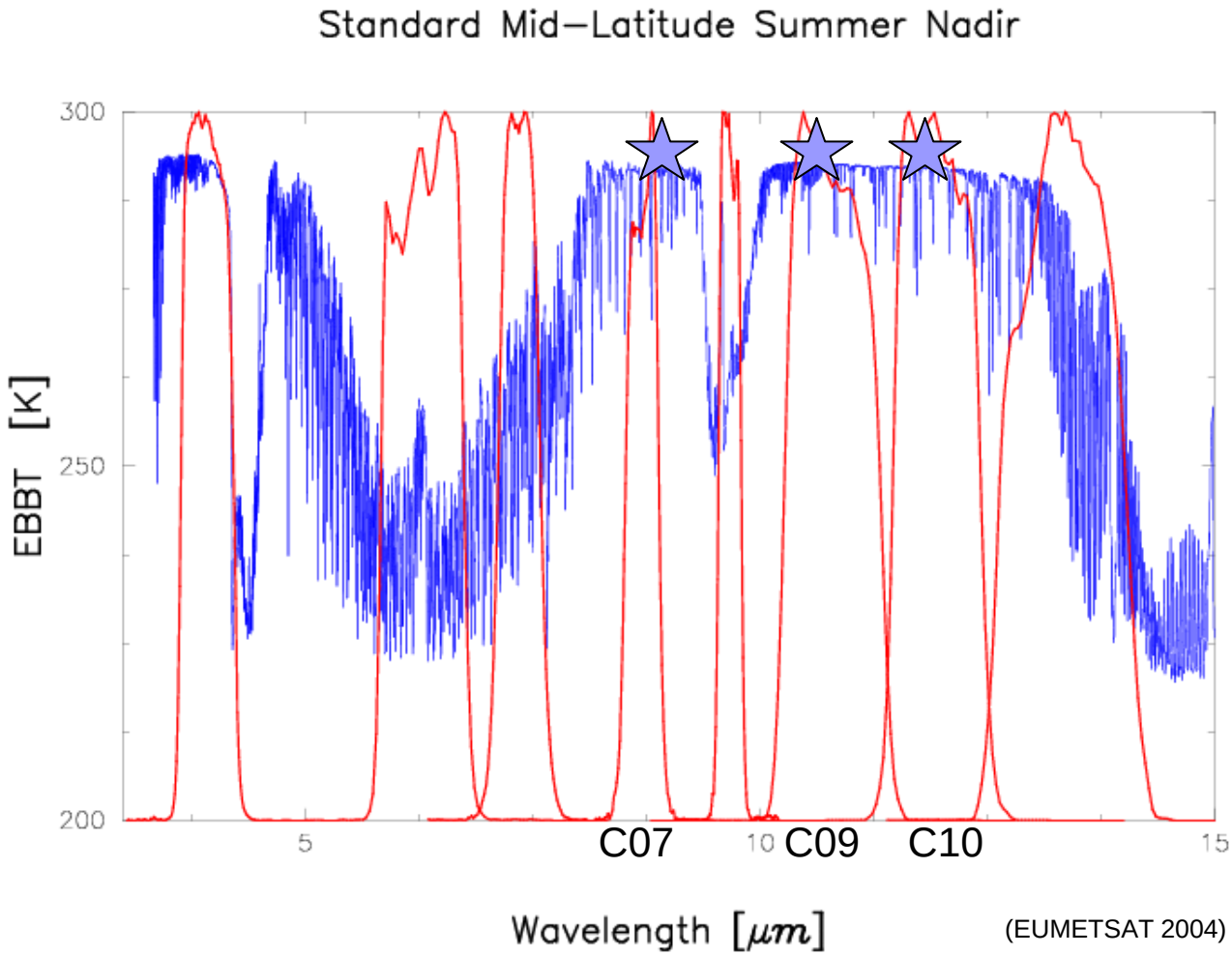


Window channels

C07: 8.7 μ
C09: 10.8 μ
C10: 12.0 μ



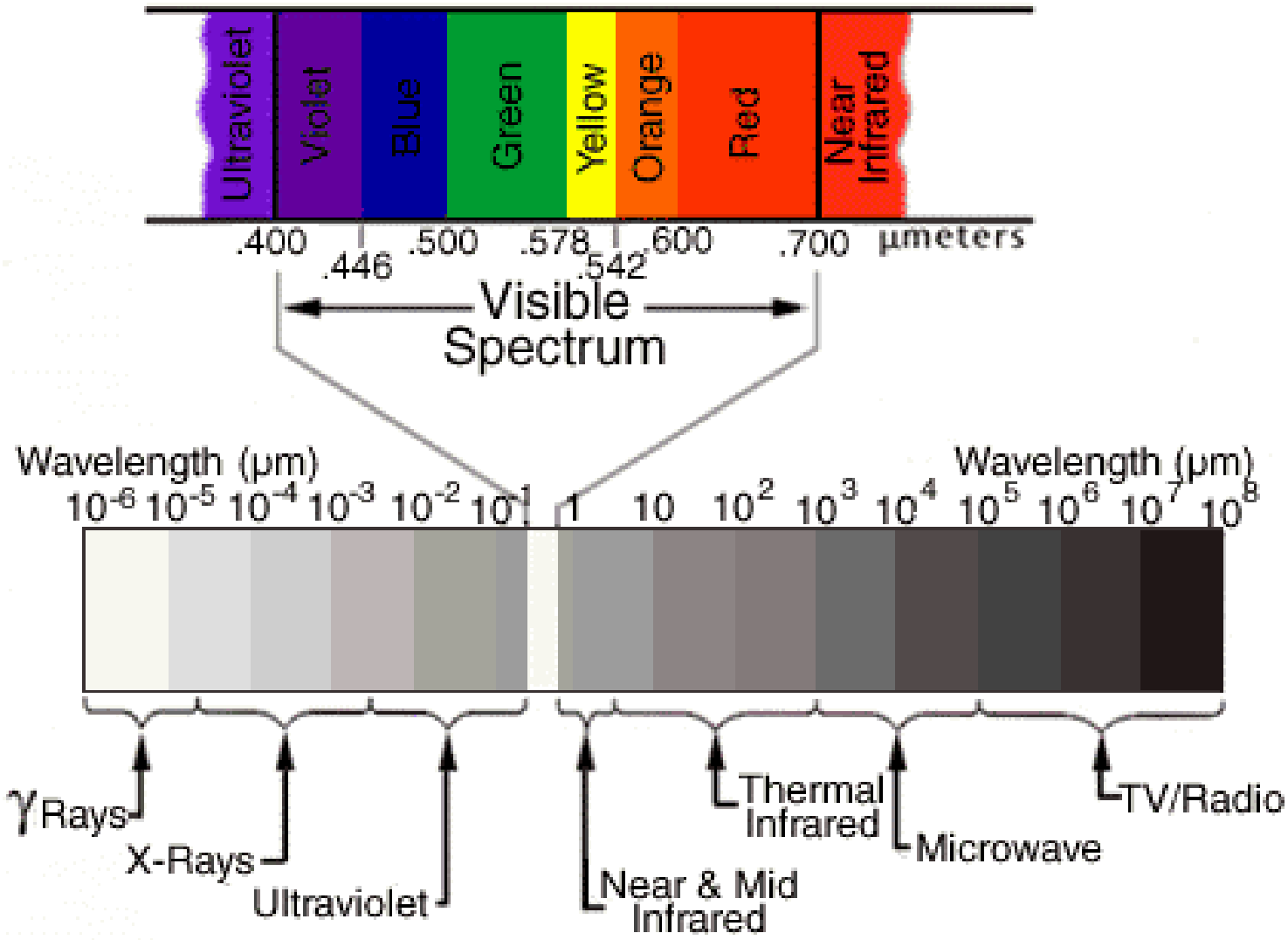
Energy spectrum



(EUMETSAT 2004)

- C07, 09, 10 located in atmospheric windows
- Low atmospheric absorption/attenuation

Eletromagnetic spectrum



Planck's Law

The radiation emitted by a black body in a certain wavelength is determined by:

$$I_\lambda = C_1 \lambda^{-5} [e^{(C_2 / \lambda T)} - 1]^{-1}$$

Where: λ= wavelength (μm)

C_1= 3,74 . 10^{-6} W.m^2 (1$^{st.}$ constant of radiation)

C_2= 1,44 . 10^{-2} m.K (2$^{nd.}$ constant of radiation)

T= temperature (K)

The wavelength where the emission is maximum is expressed by the Wien`s Law:

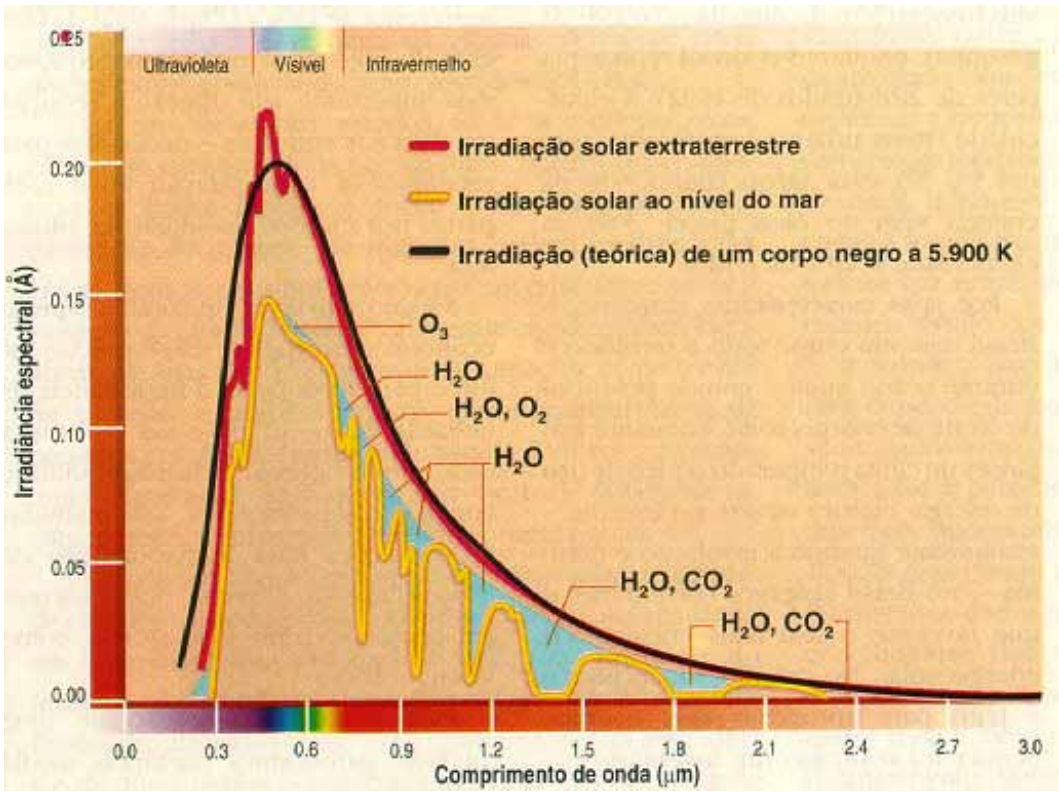
$$\lambda_{máx} T = C_3$$

Where C_3 is a constant = 2897 μm.K^{-1}.

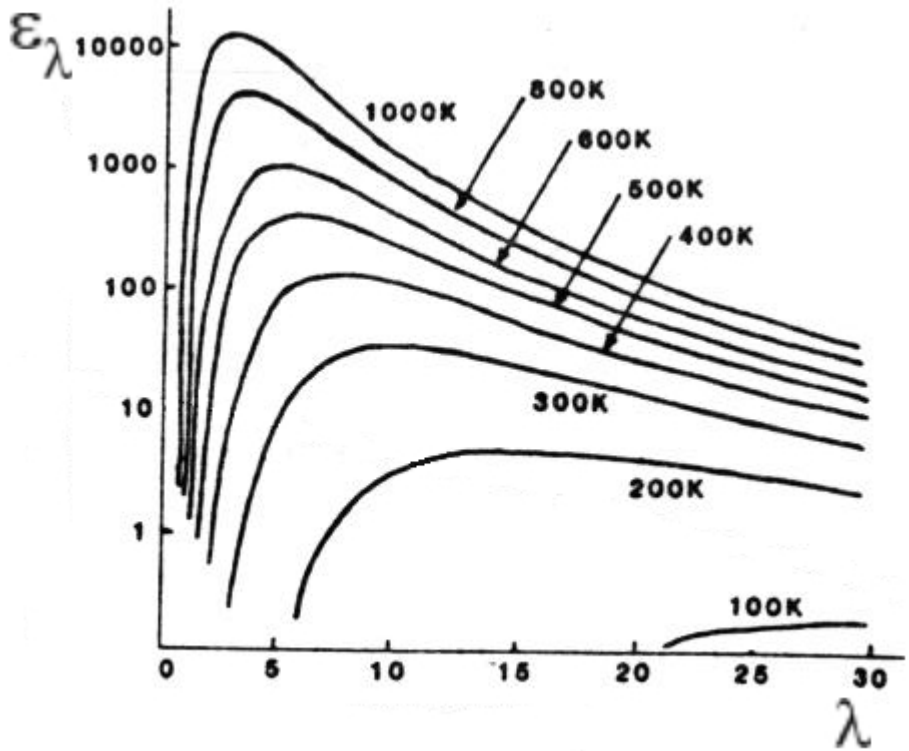
Black body: perfect radiator and the radiation emitted by area unit follows the Stefan-Boltzmann's Law:

$$M = \sigma T^4$$

Where $\sigma = 5.67 \times 10^{-8}$ W m^{-2} K^{-4}



Emissivity



$$\varepsilon_\lambda = \frac{I_\lambda \; real}{I_\lambda \; ideal}$$

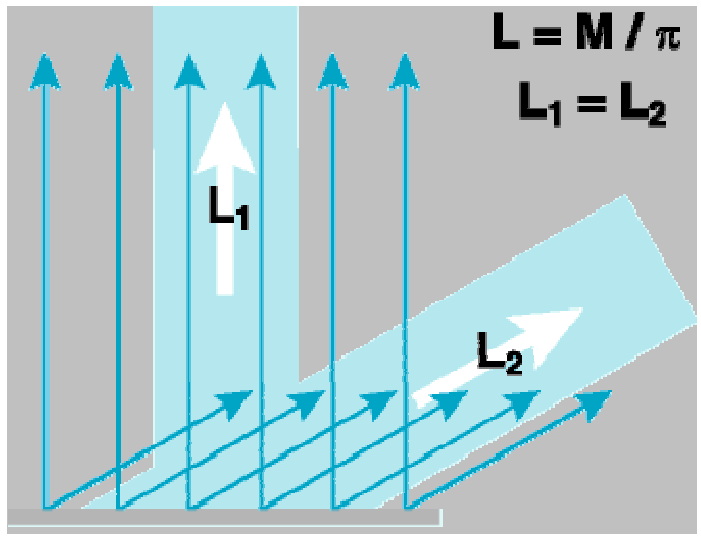
SST

The radiance (L) of a surface is measured by the orbital sensor. The radiance is the flux emitted by solid angle unit emitted by a surface in a determined direction.

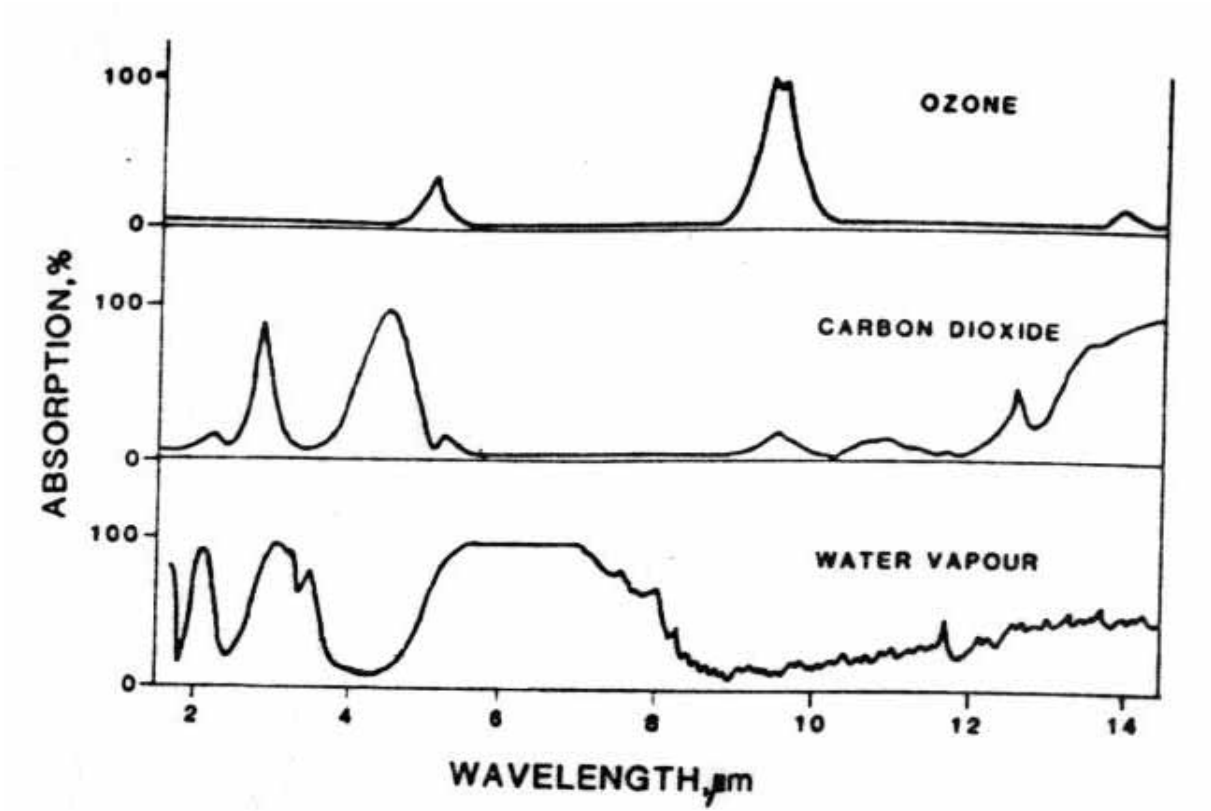
In the thermal infrared, the sea surface can be considered Lambertian, i.e., the radiance is uniform in all the direction.

$$L_\lambda = \frac{I_\lambda}{\pi}$$

$$I_\lambda = C_1 \lambda^{-5} [e^{(C_2 / \lambda T)} - 1]^{-1}$$



Atmospheric attenuation



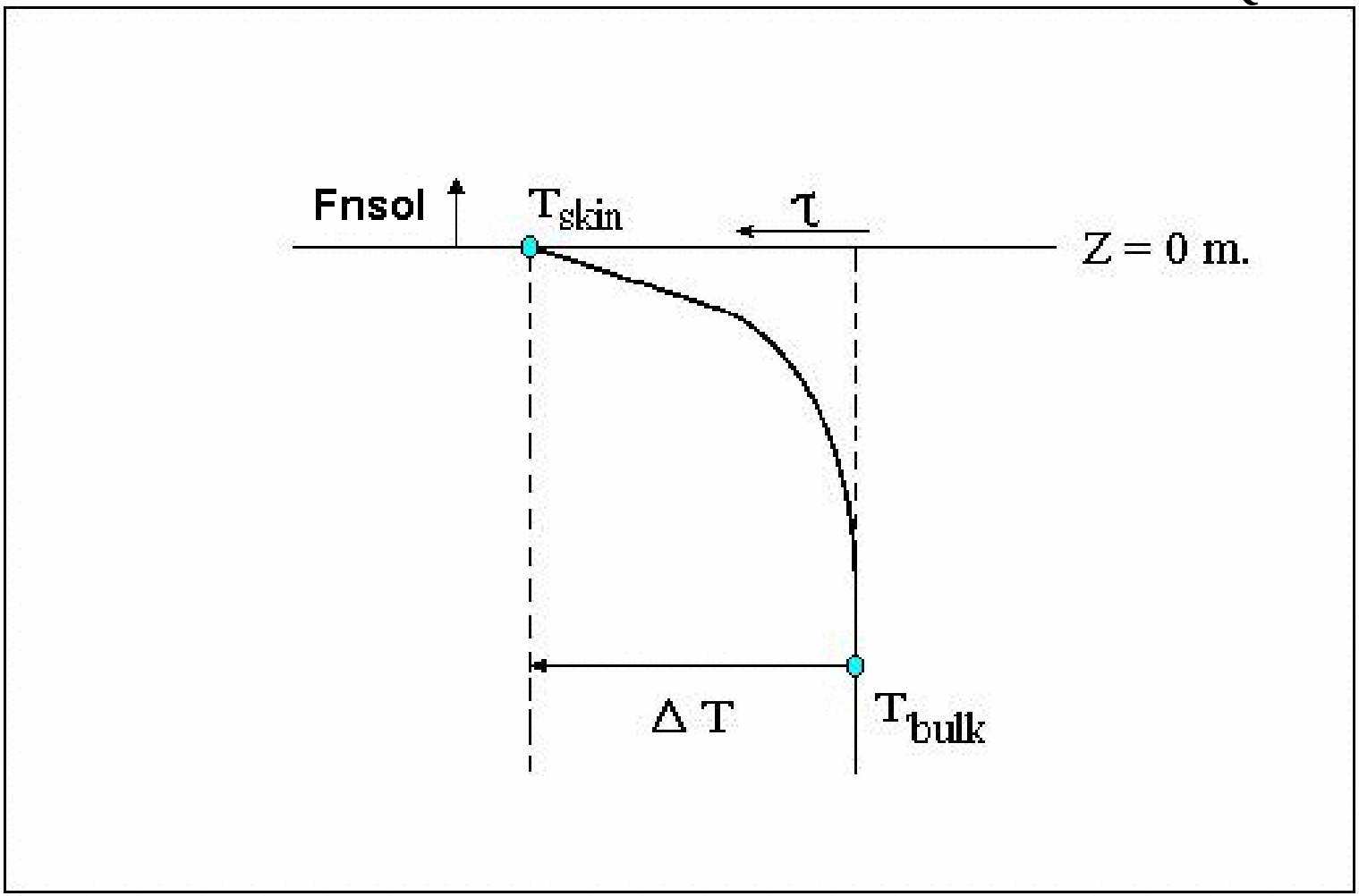
SST-MSG

- Channels 3.9, 10.8 and 12.0 µm are used in the algorithms MSG

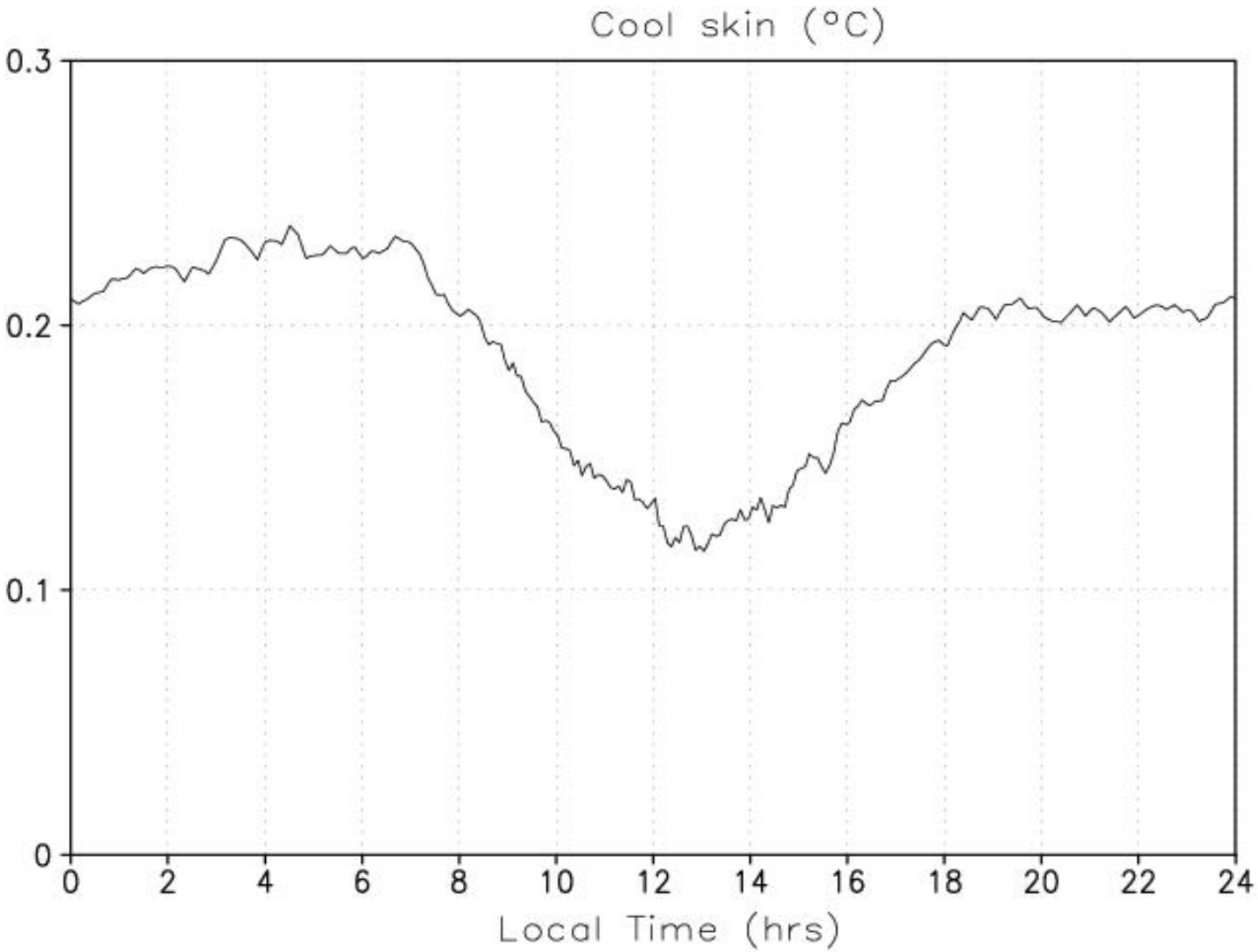
- **Definition of SST at OSI SAF (see http://www.osi-saf.org/)**:
- "Subskin-SST": Can be compared with *in situ* measurements at night (buoys)
- Equivalent to the "bulk-SST" at night
- During the day, can show a bias of various ºKelvin due to solar heating
- During the day and night, the "subskin-SST" can be converted into "skin-SST" if we subtract 0.2K

Cool skin

$\Delta T \propto Q/\tau$

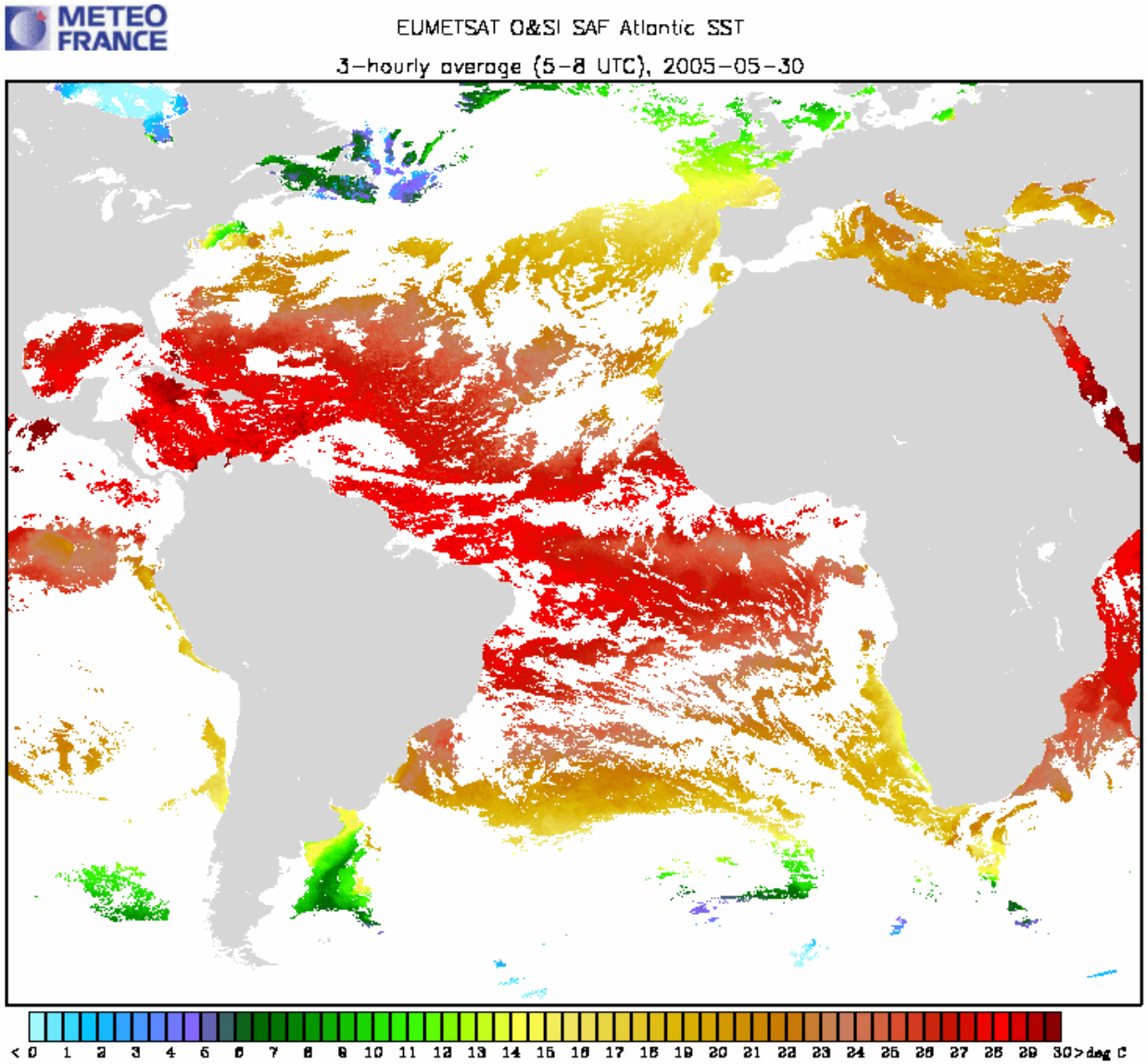


Cool skin

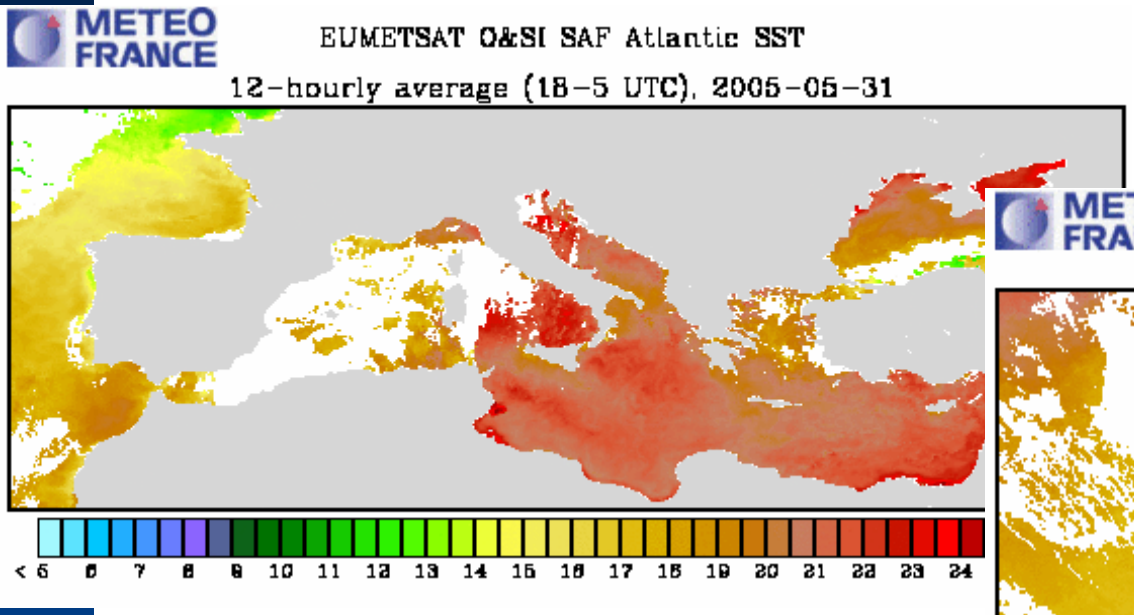


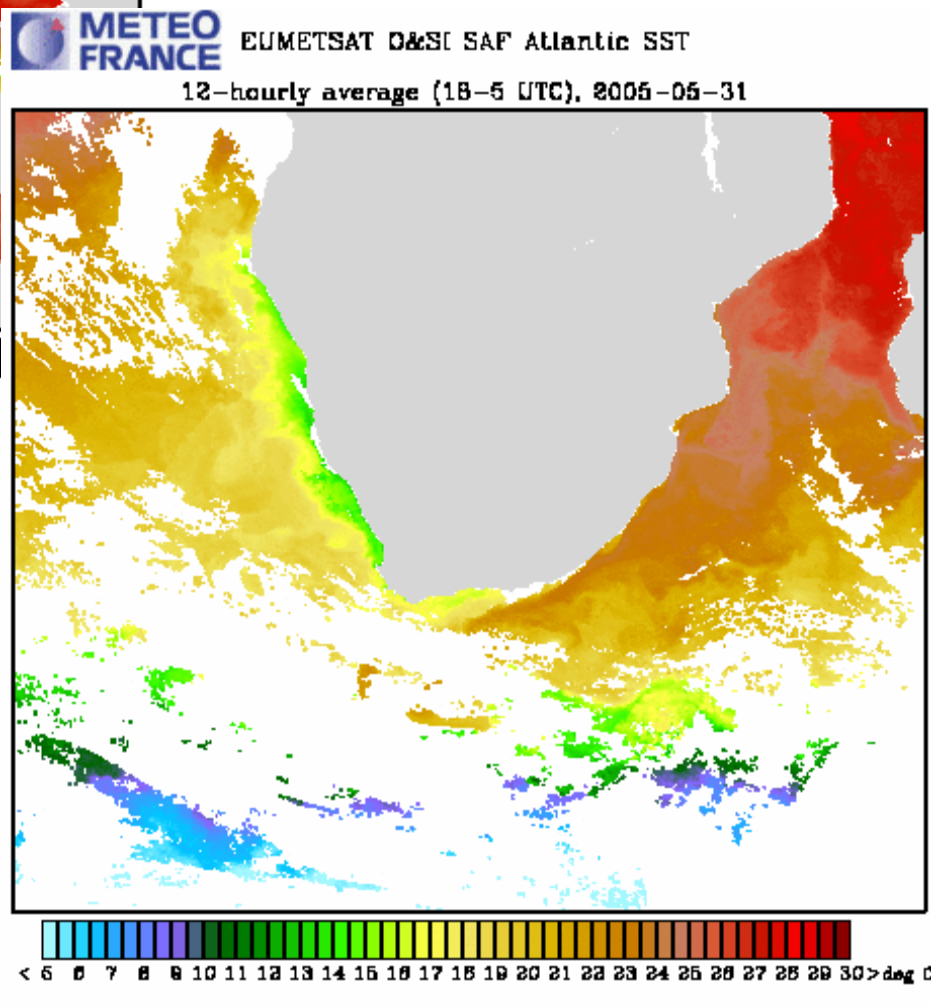
Composite: 3 hours

GAPs!

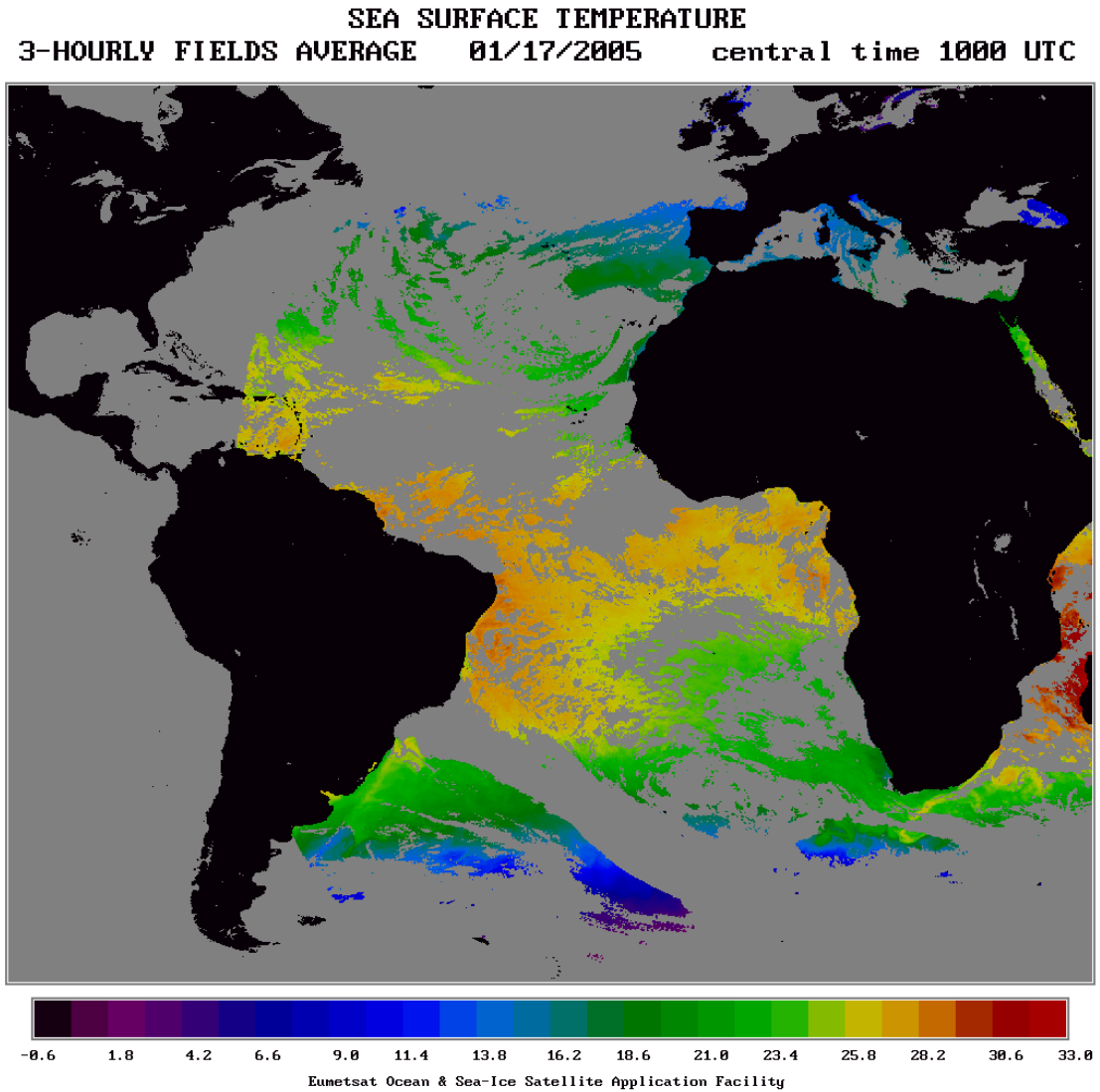


12 hours


METEO FRANCE
EUMETSAT O&SI SAF Atlantic SST
12-hourly average (18-5 UTC), 2005-05-31
< 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

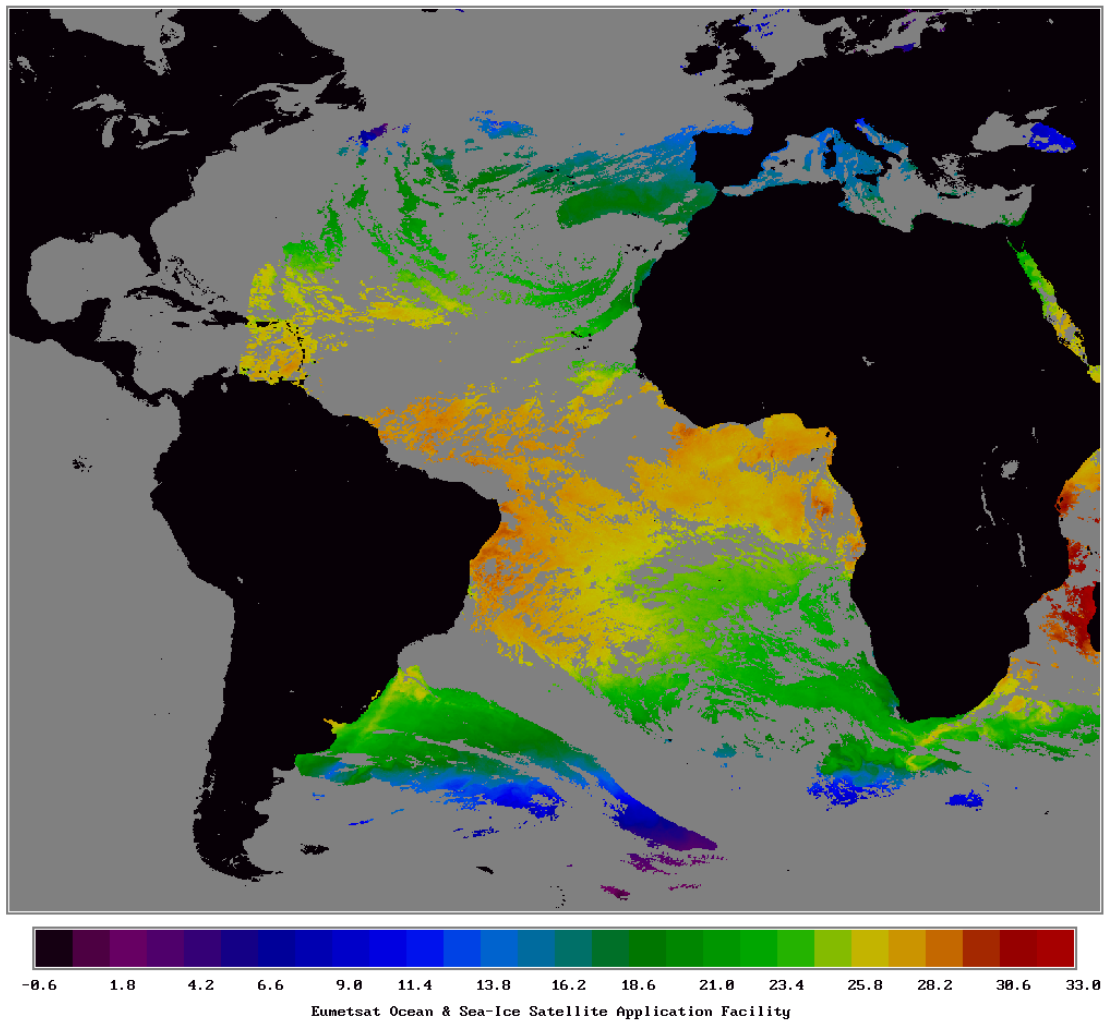

METEO FRANCE
EUMETSAT O&SI SAF Atlantic SST
12-hourly average (18-5 UTC), 2005-05-31
< 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 >deg C

More composites

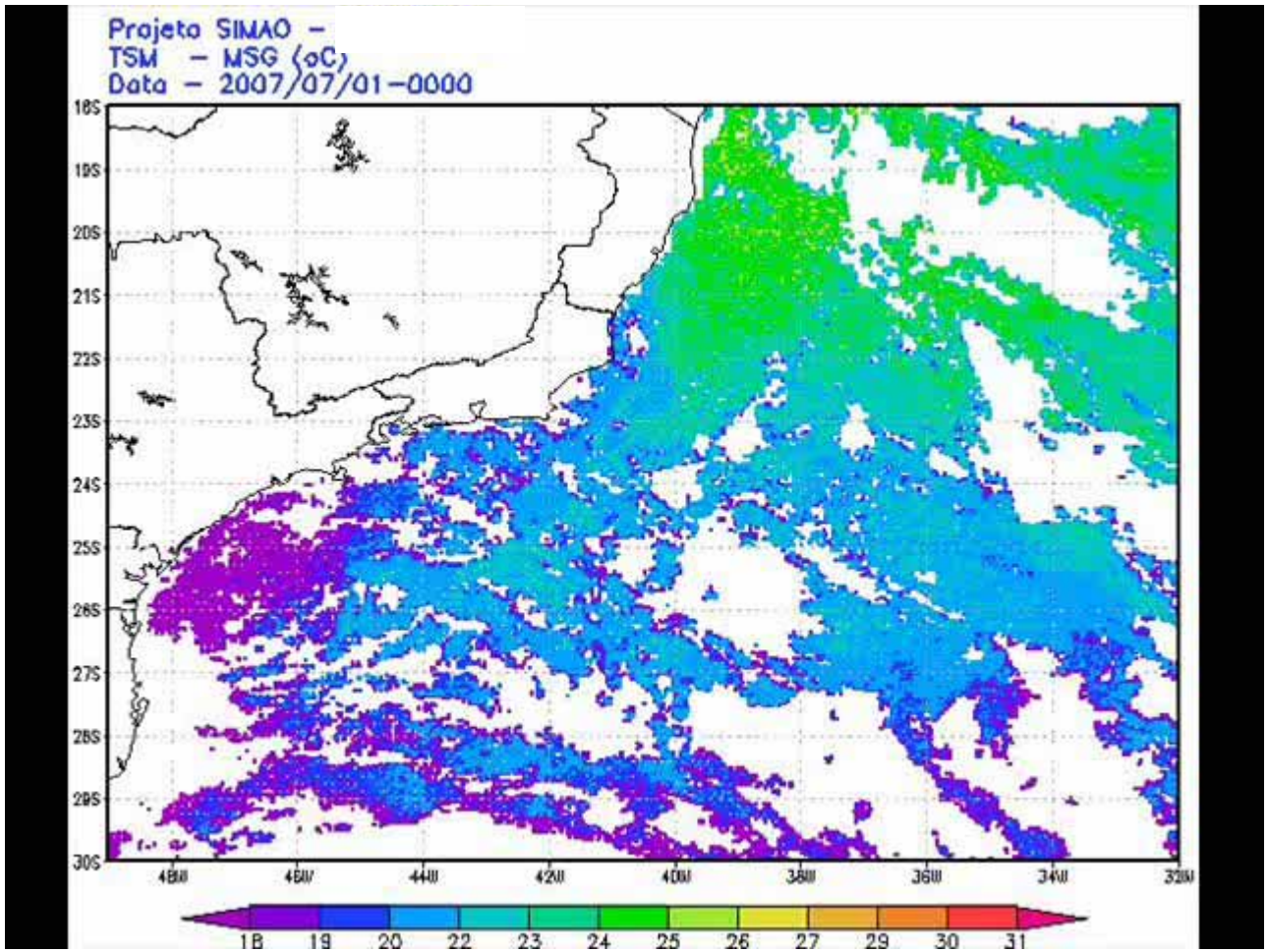


SEA SURFACE TEMPERATURE

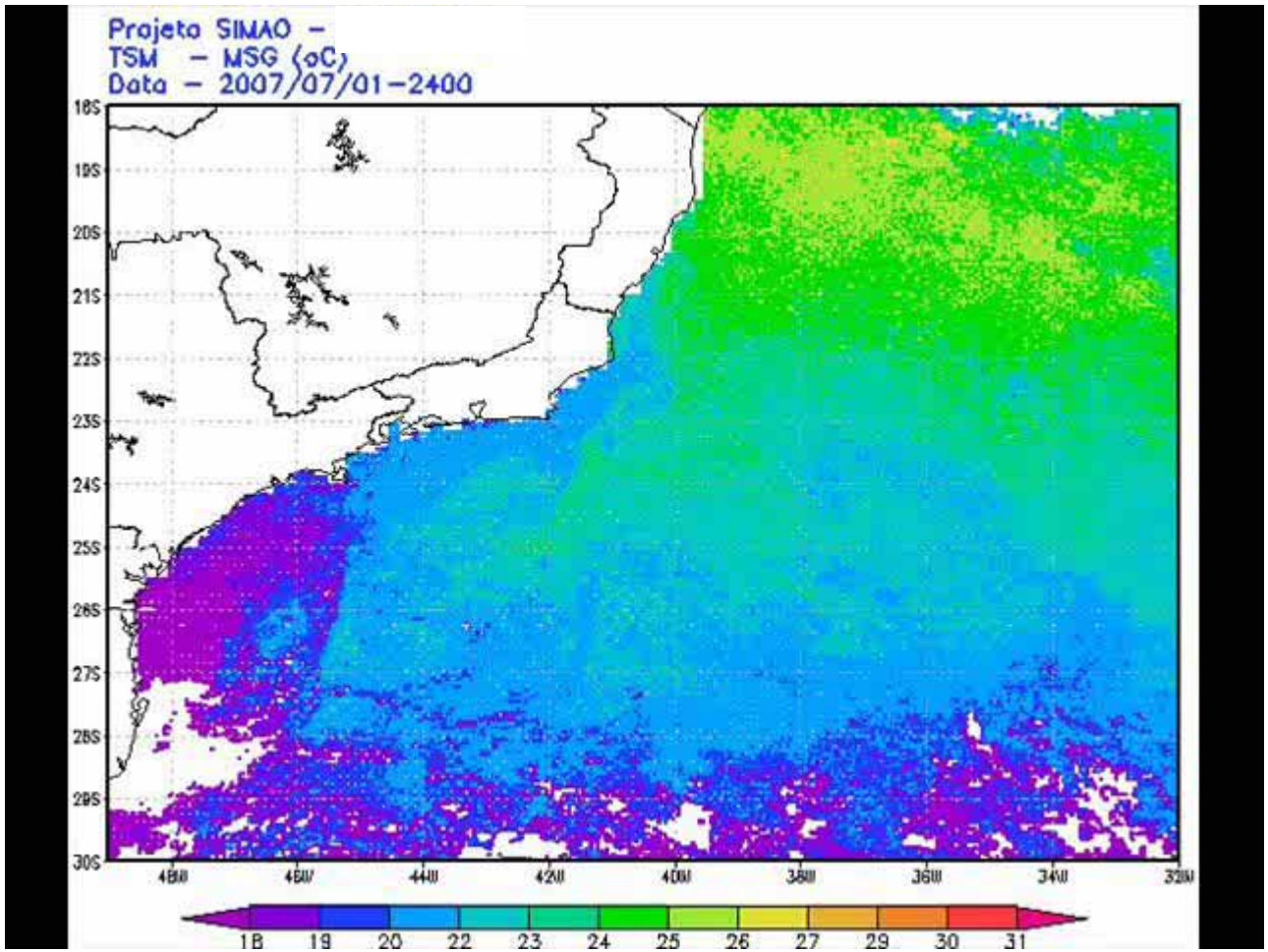
3-HOURLY FIELDS AVERAGE 01/17/2005 central time 1300 UTC



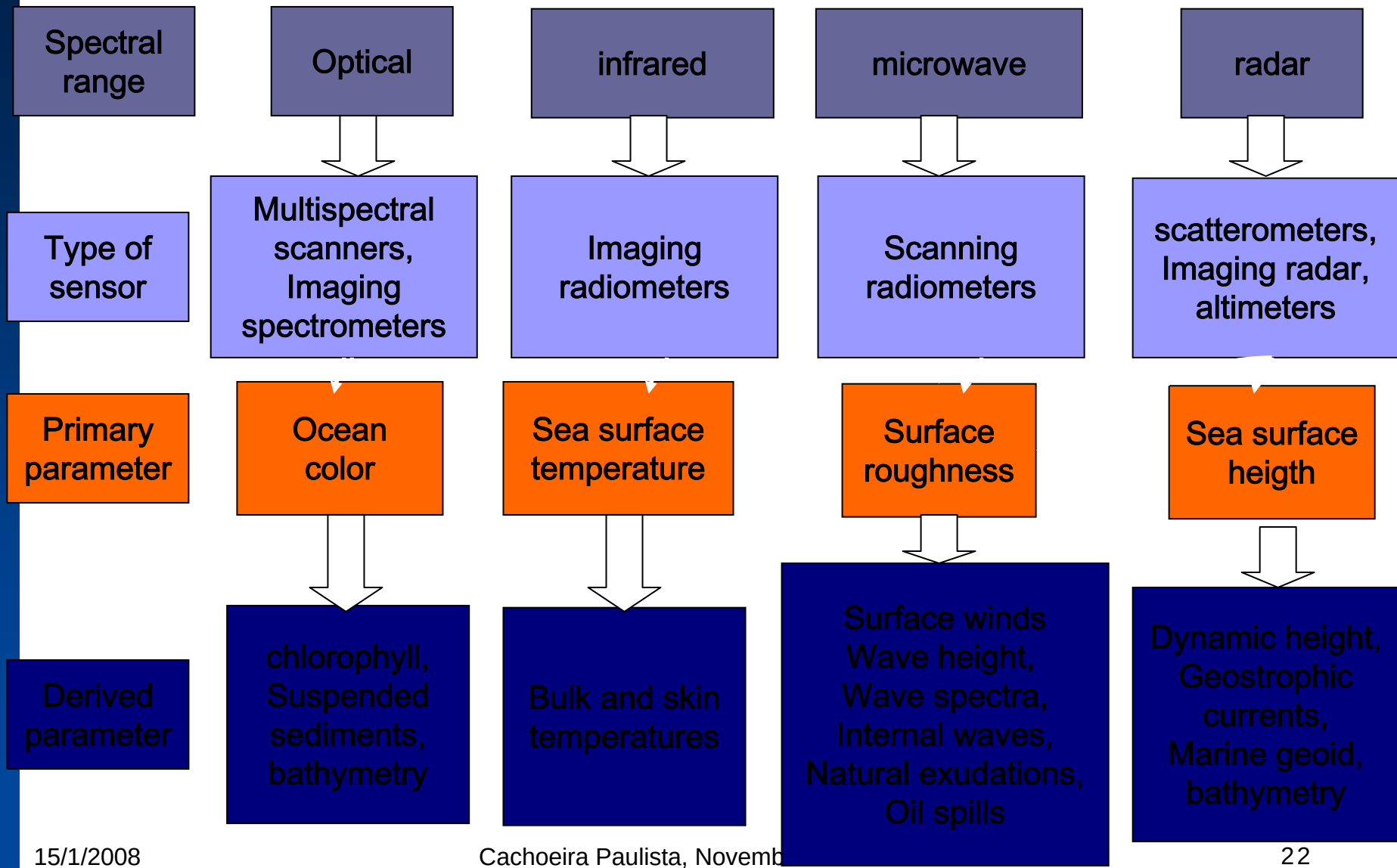
SST-MSG 3hs (INPE/CPTEC)



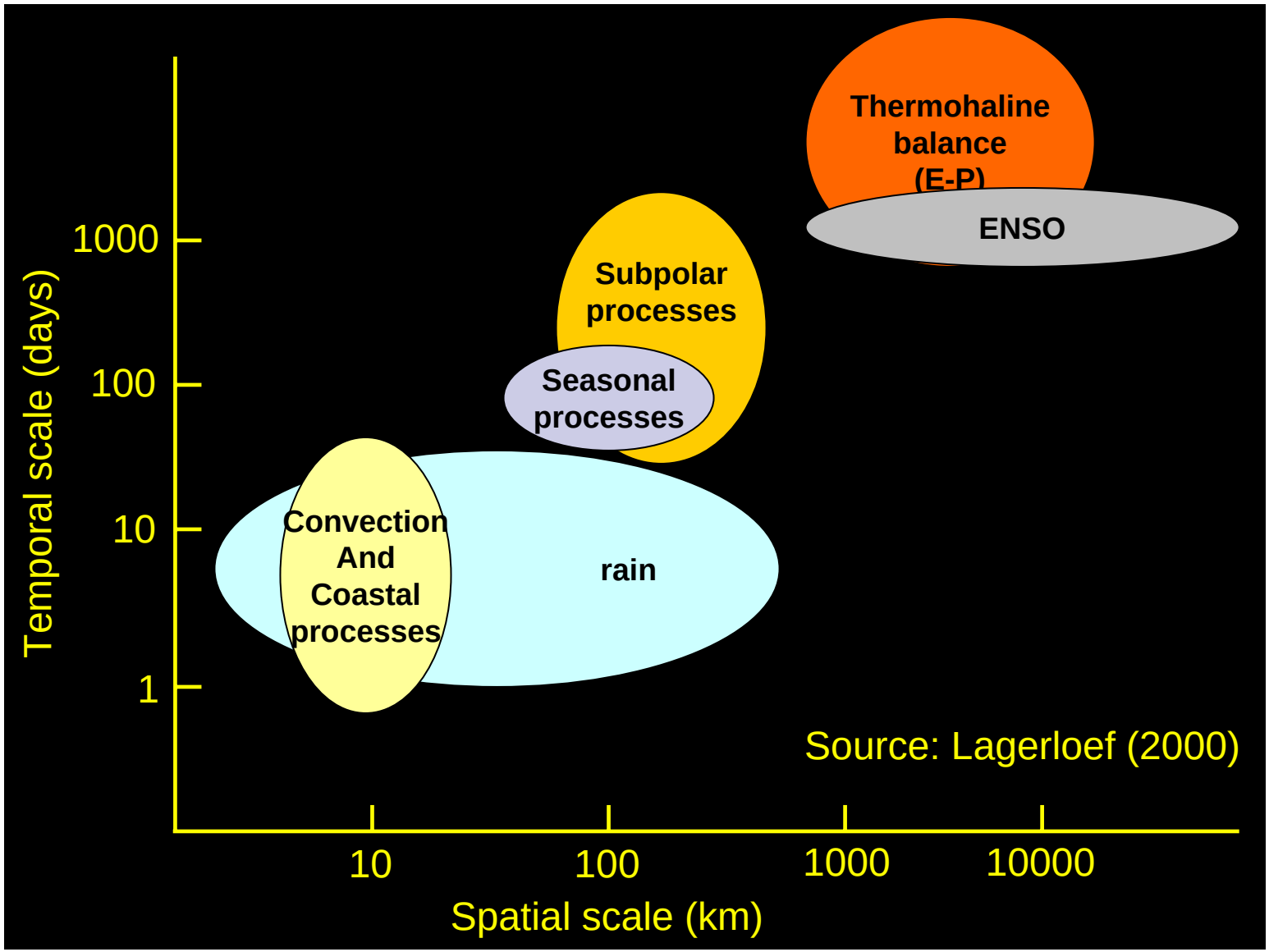
SST-MSG 24hs (INPE/CPTEC)



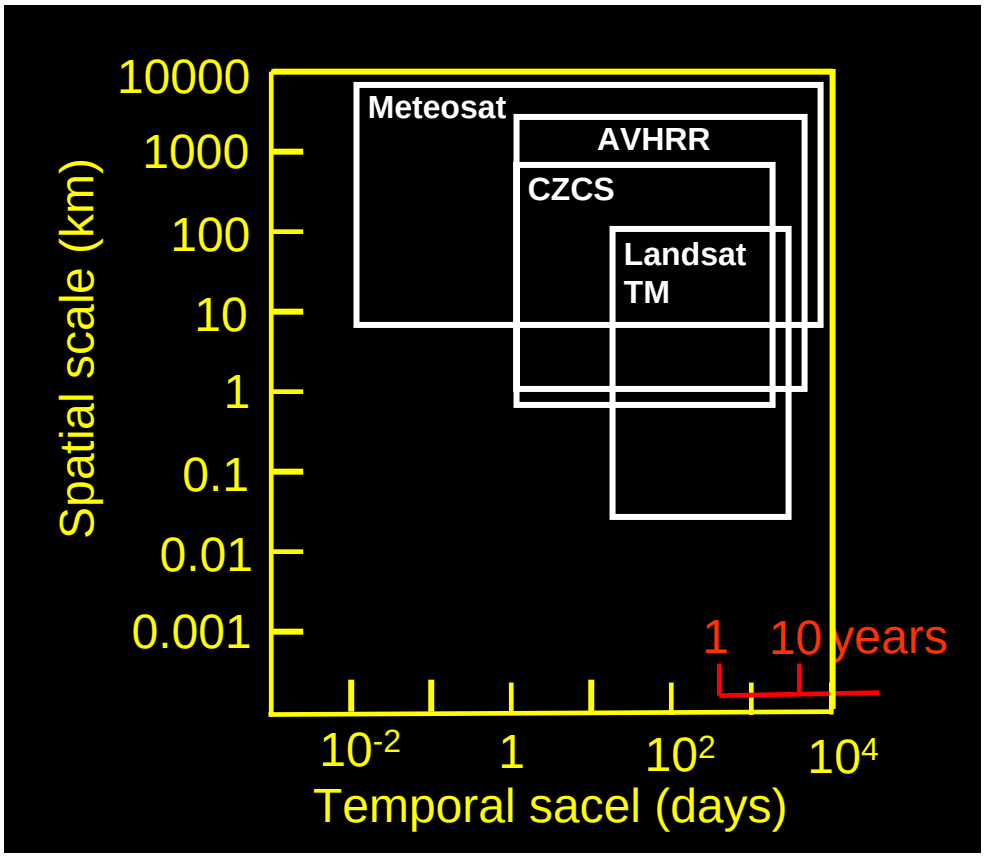
Satellite oceanography



Scales

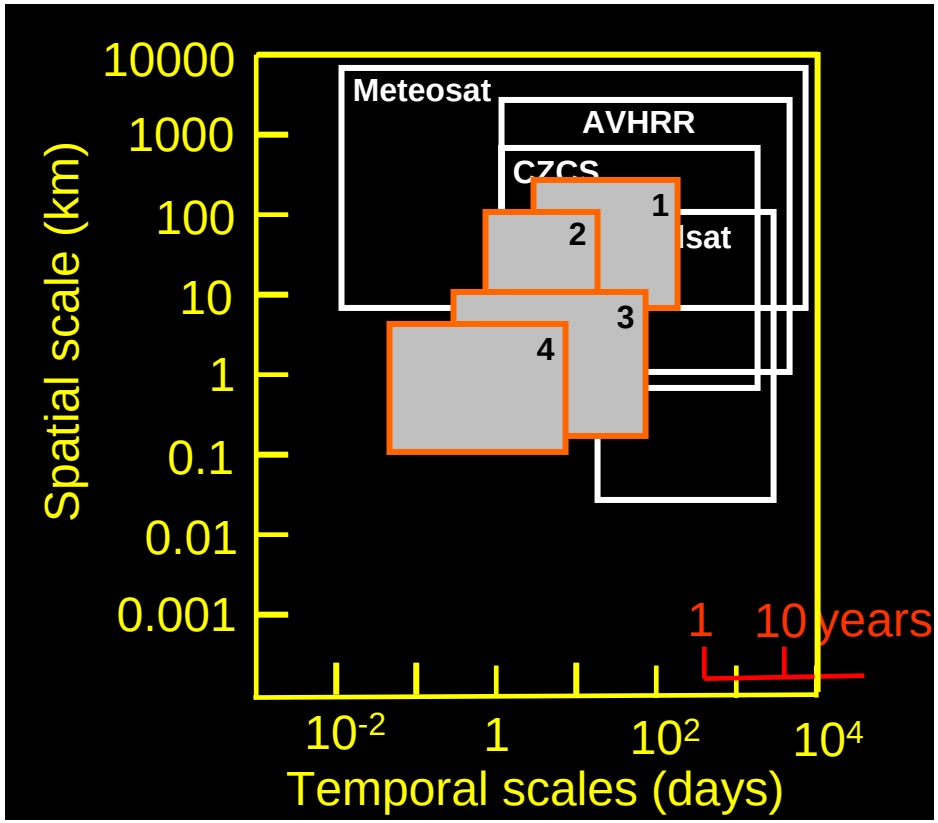

Thermohaline balance (E-P)
ENSO
Subpolar processes
Seasonal processes
Convection And Coastal processes
rain
Temporal scale (days)
1000
100
10
1
10
100
1000
10000
Spatial scale (km)
Source: Lagerloef (2000)

Sampling capacity



Source: Robinson (2004)

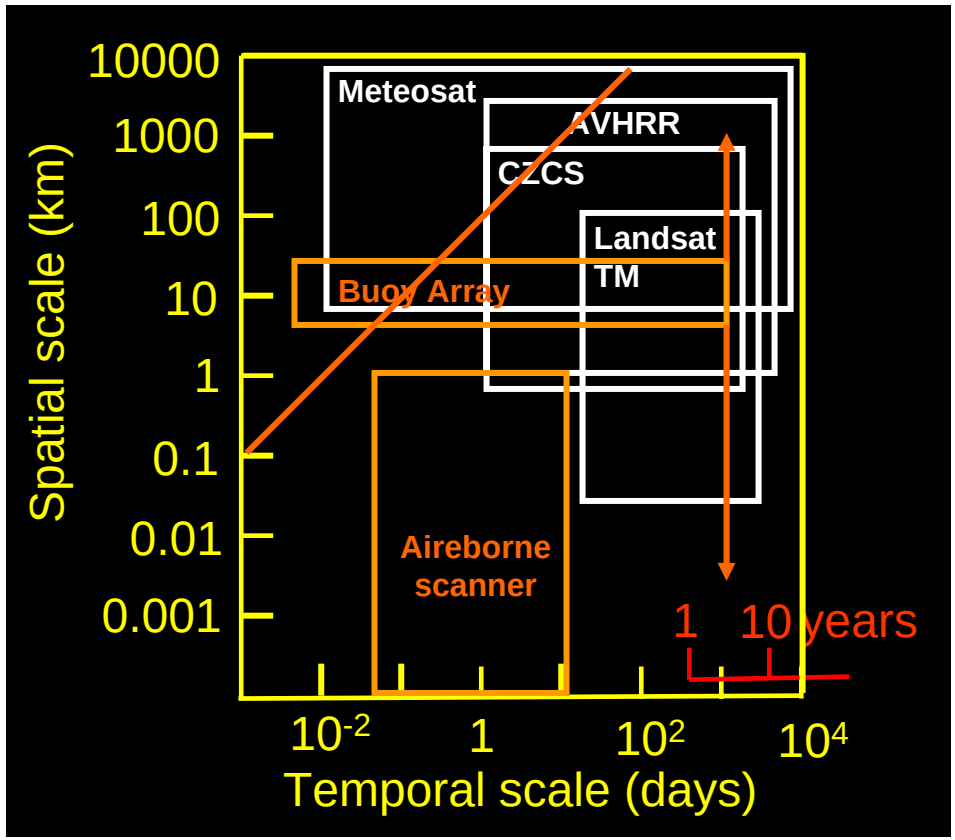
Coastal processes: scales



1: mesoscale eddies
2: coastal frontal systems
3: phytoplankton blooms
4: oild spills dispersion

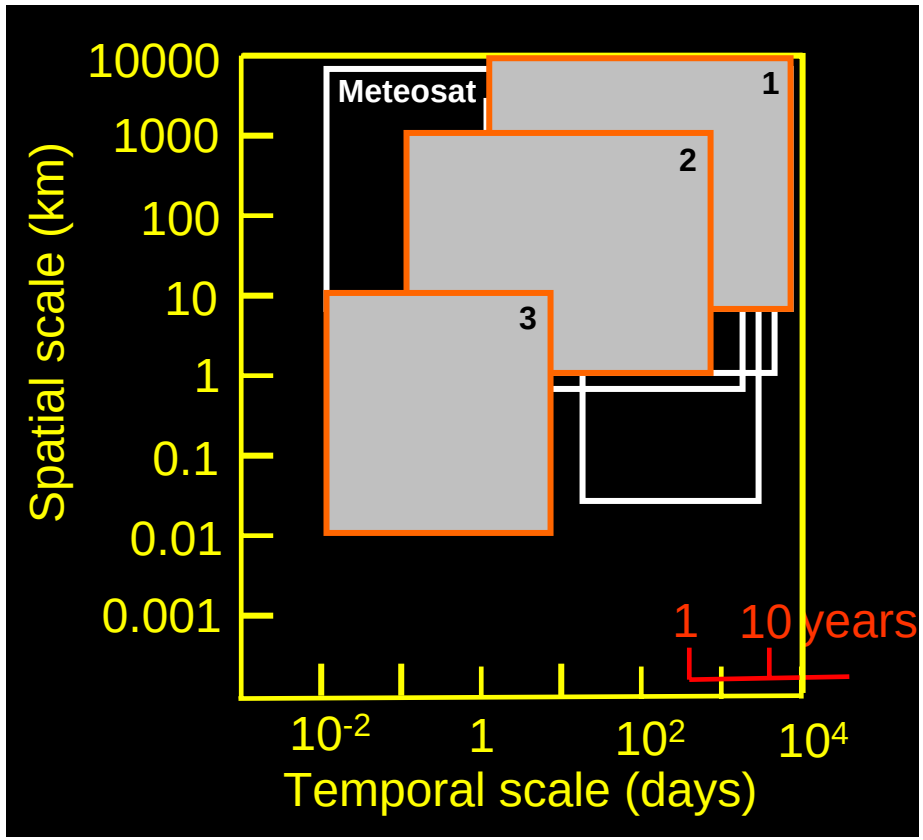
Source: Robinson (2004)

Other methods



Fonte: Robinson (2004)

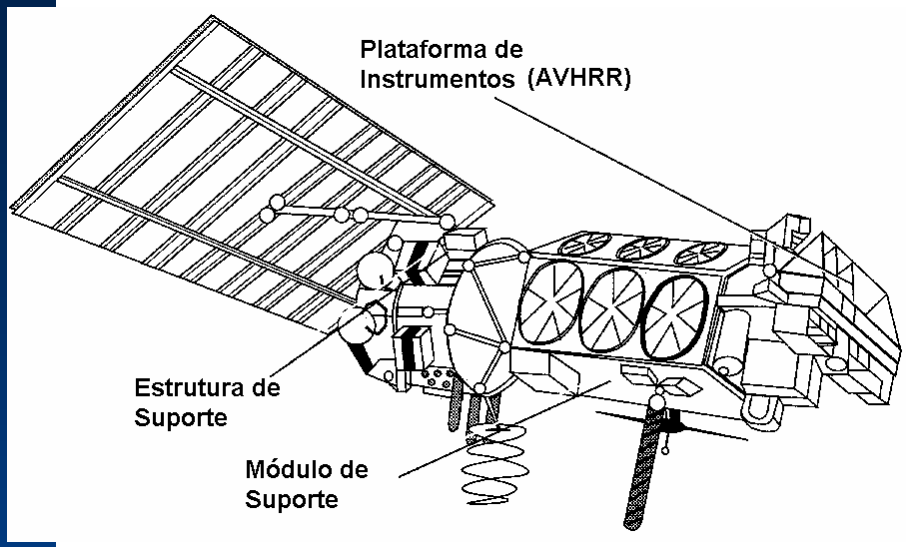
Models

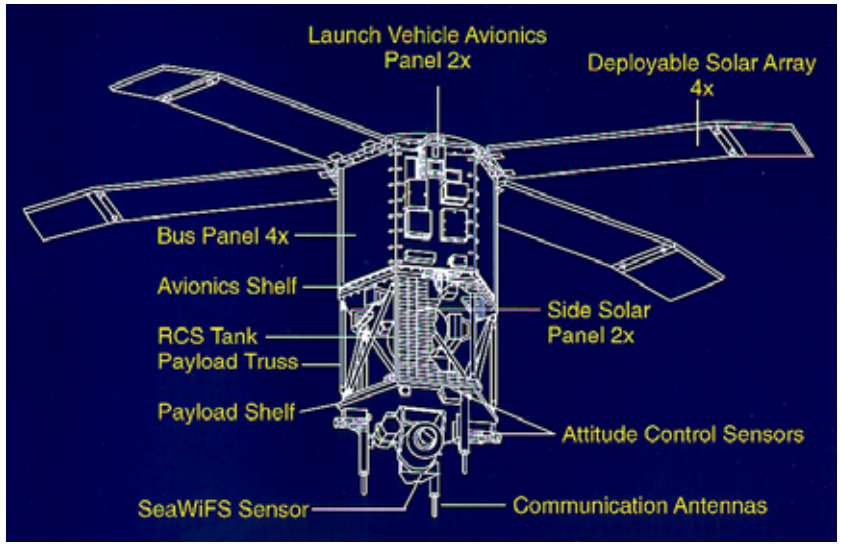


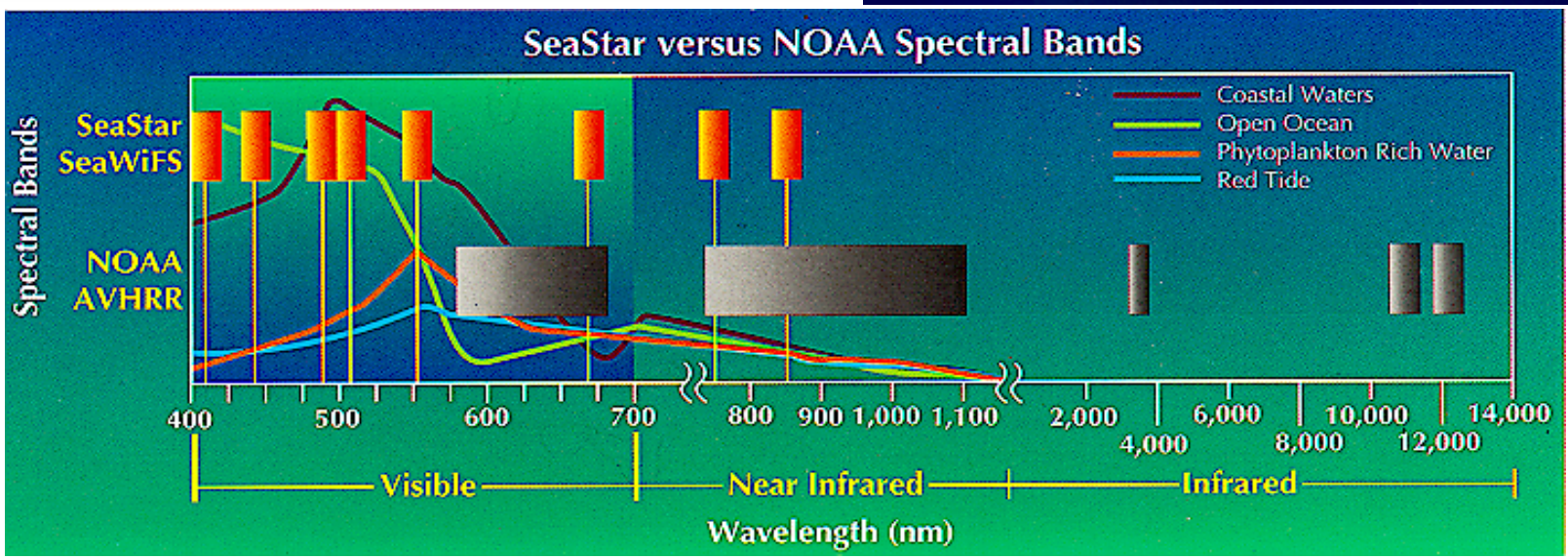
1: oceanic circulation
2: coastal circulation
3: estuarine circulation

Fonte: Robinson (2004)

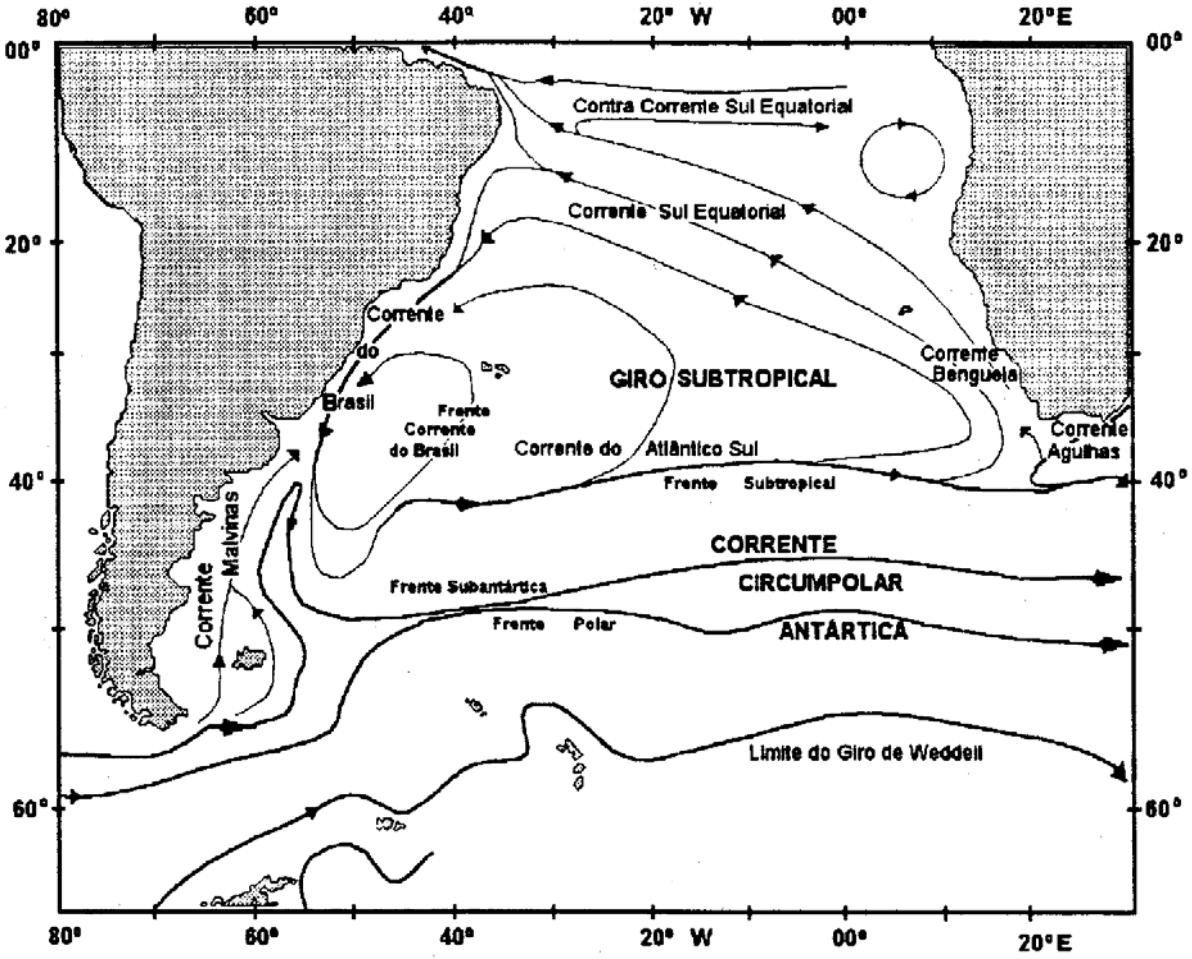
AVHRR/NOAA - SeaWiFS





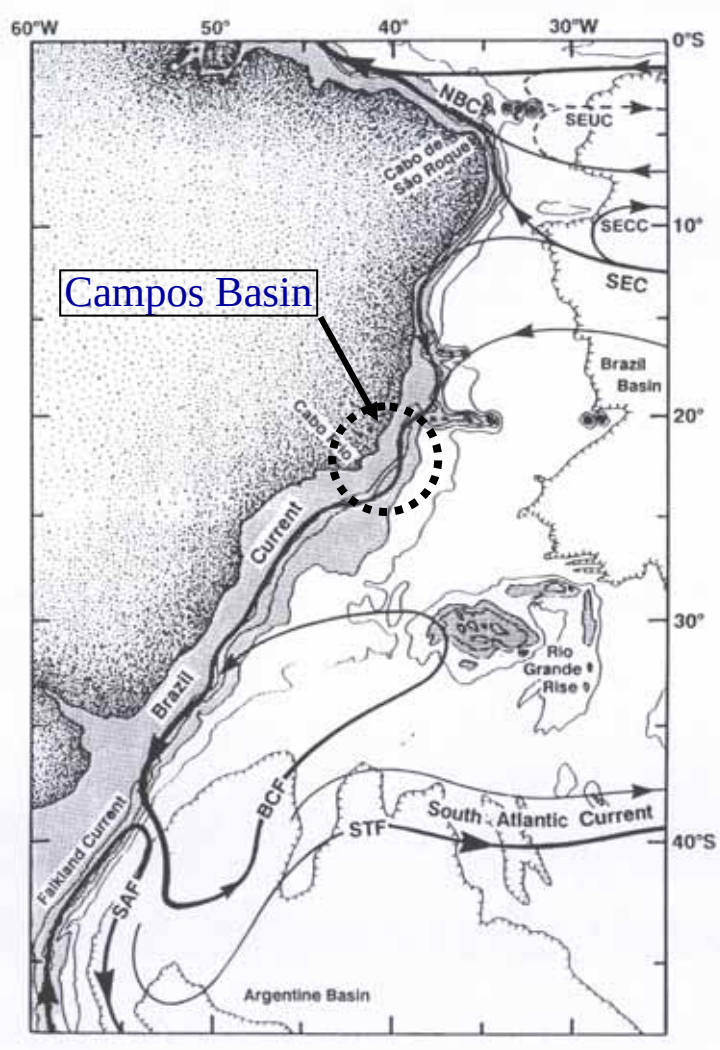


Surface circulation



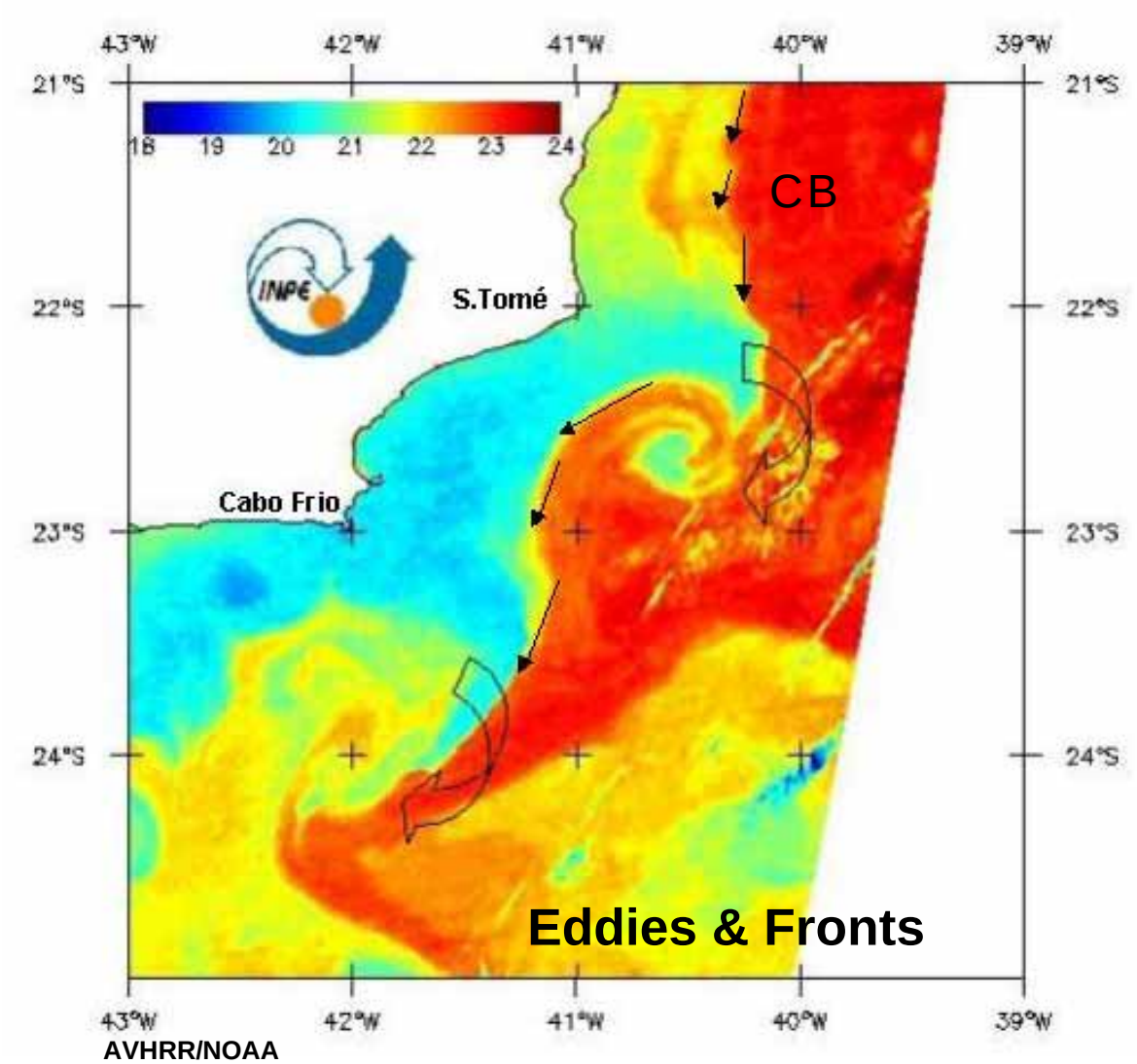
Adaptado de Peterson e Stramma, 1991

Surface circulation

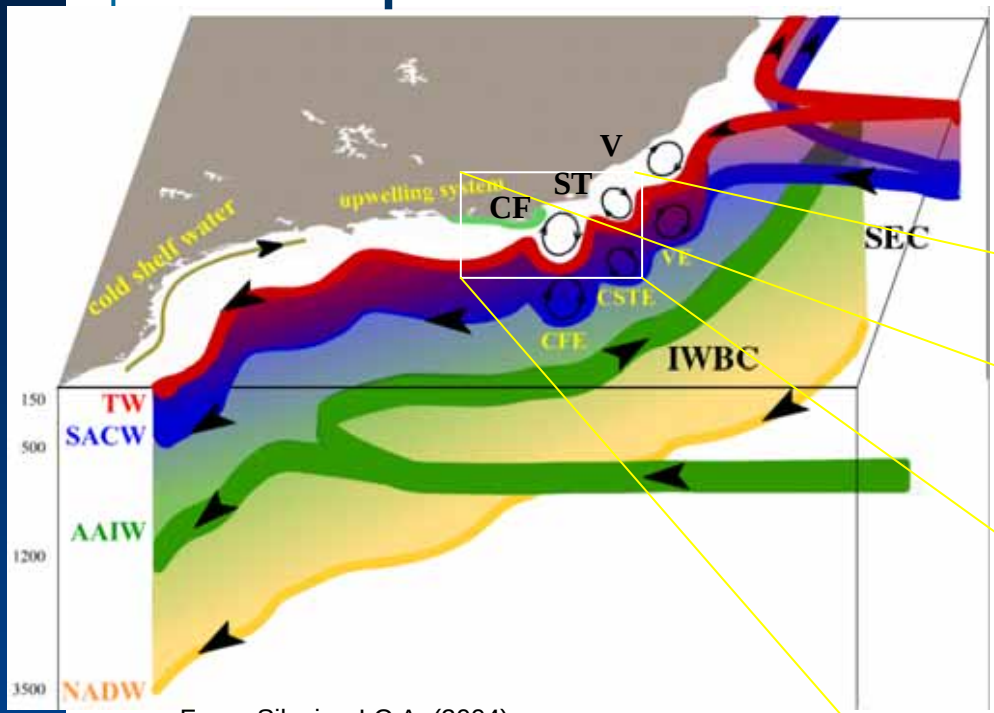


Adaptado de Peterson e Stramma, 1991

SST-NOAA/AVHRR



Conceptual scheme



From: Silveira, I.C.A. (2004)

V – Vitória eddy

ST – São Tomé eddy

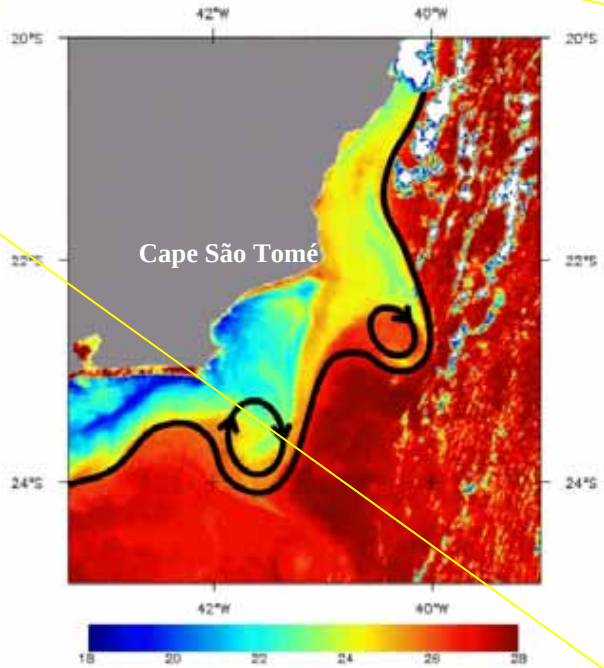
CF – Cabo Frio eddy

Water masses and currents

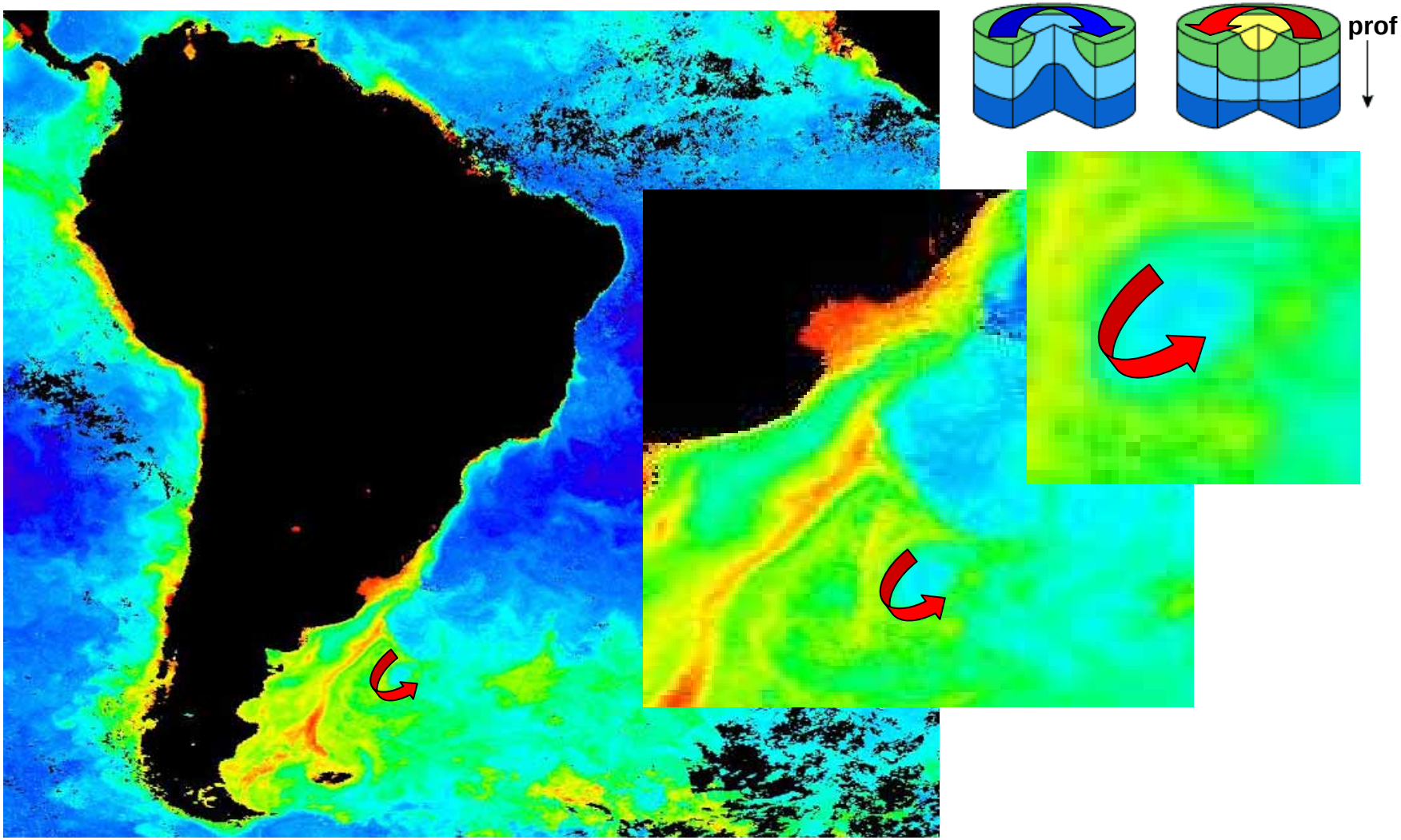
Mesoscale features

Southwestern South Atlantic

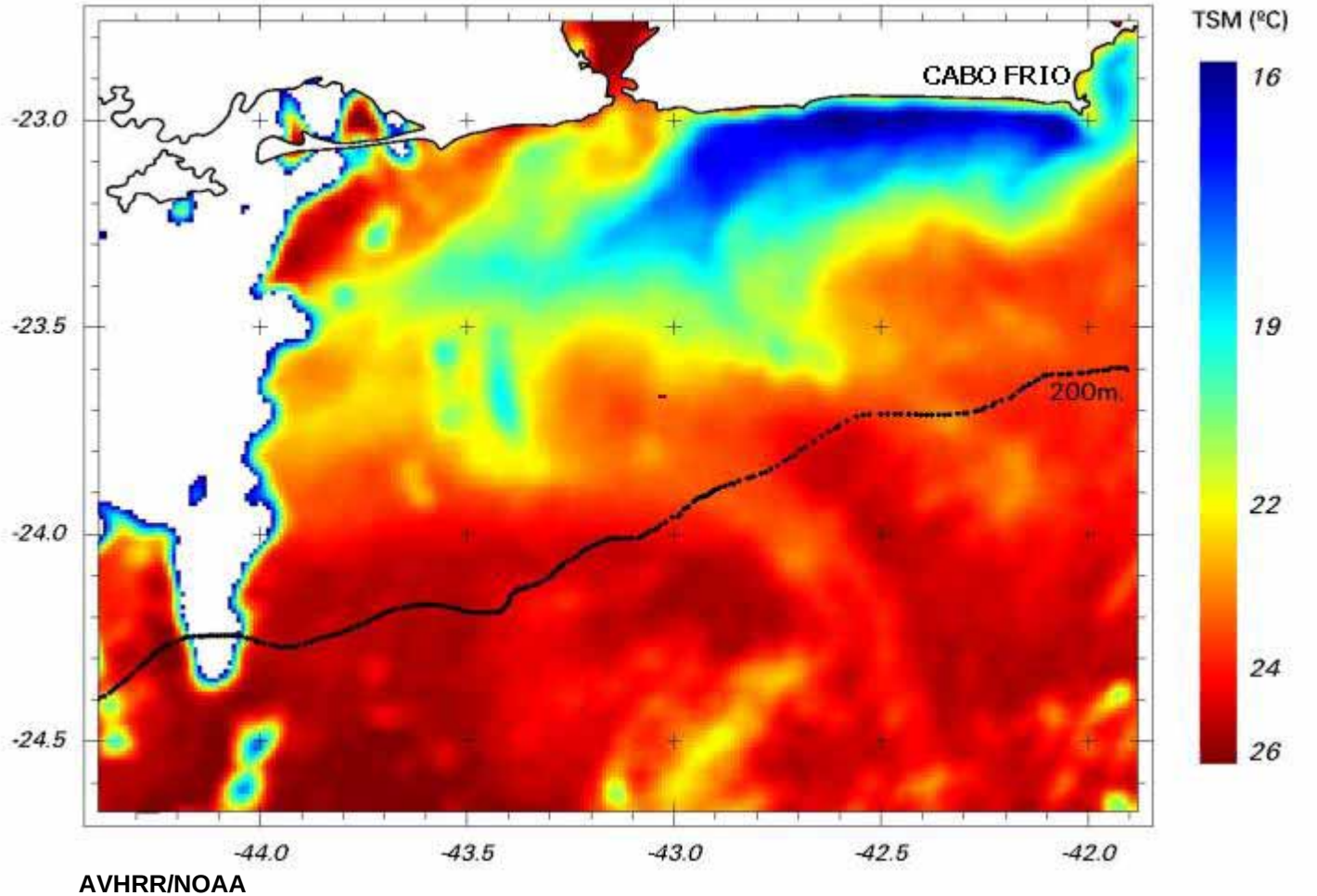
AVHRR TSM



Eddies

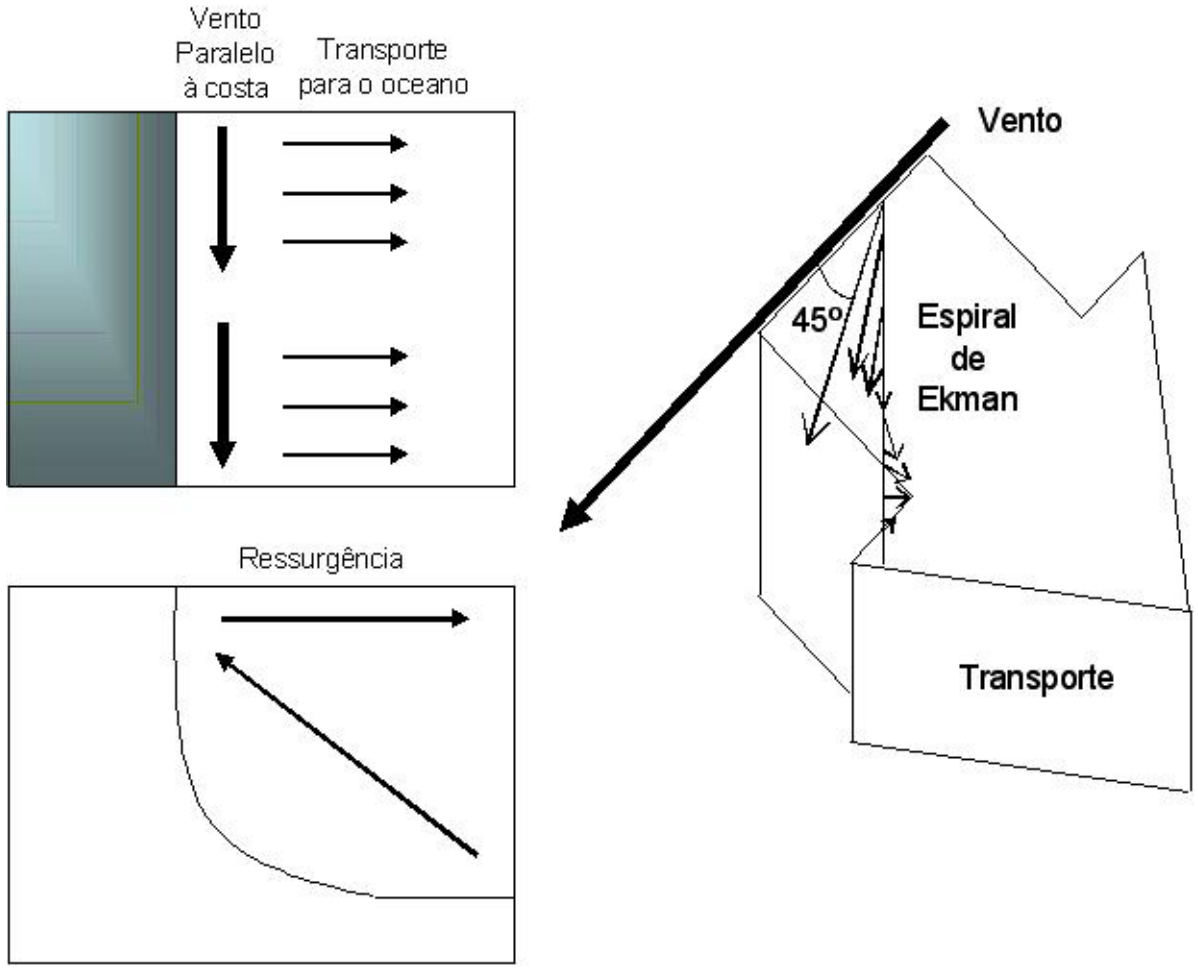


Upwelling

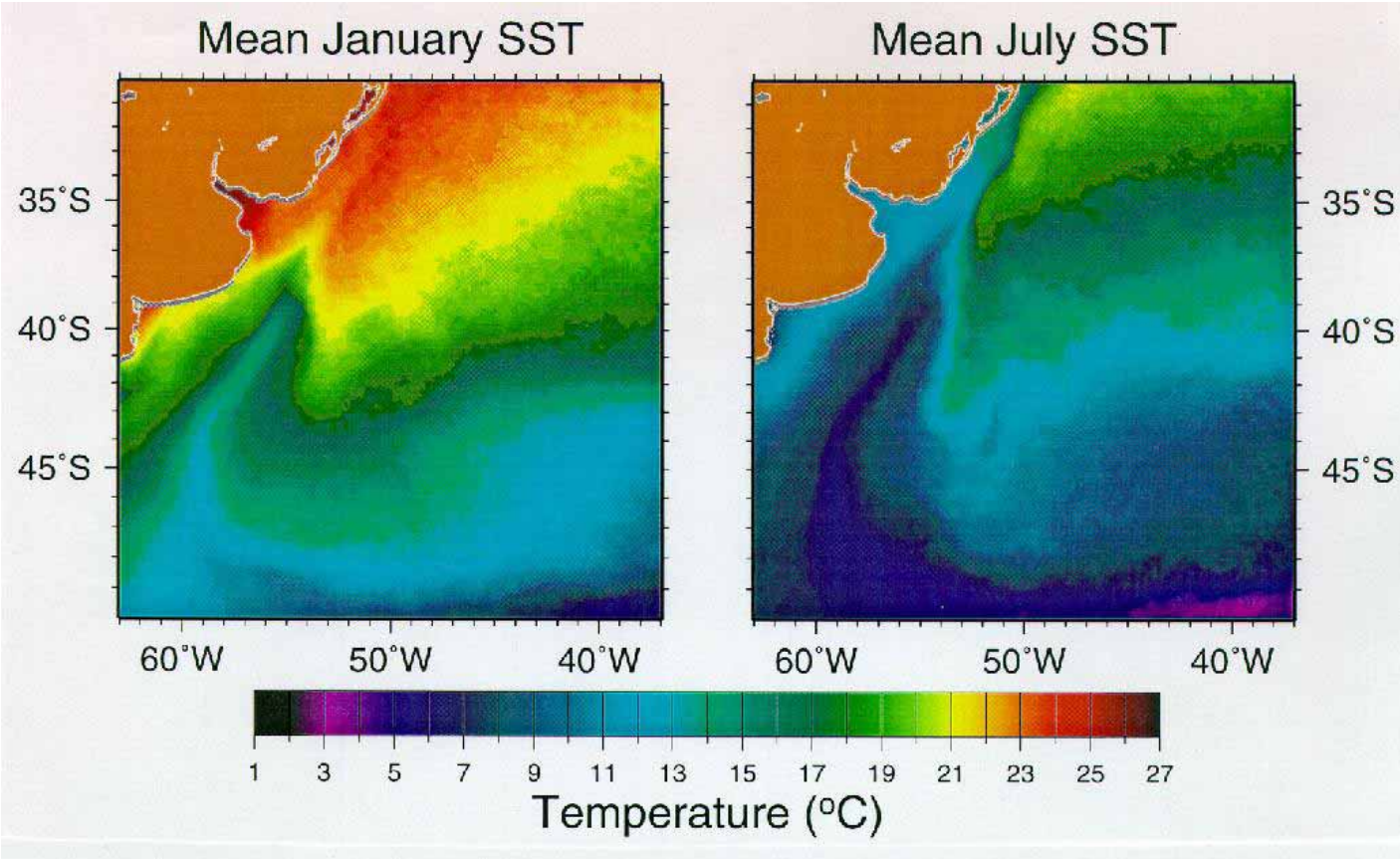


AVHRR/NOAA

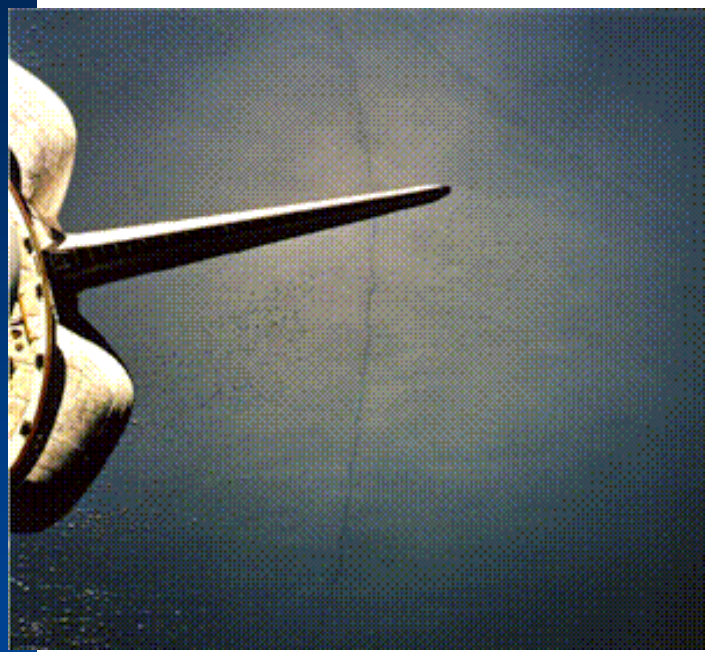
Upwelling

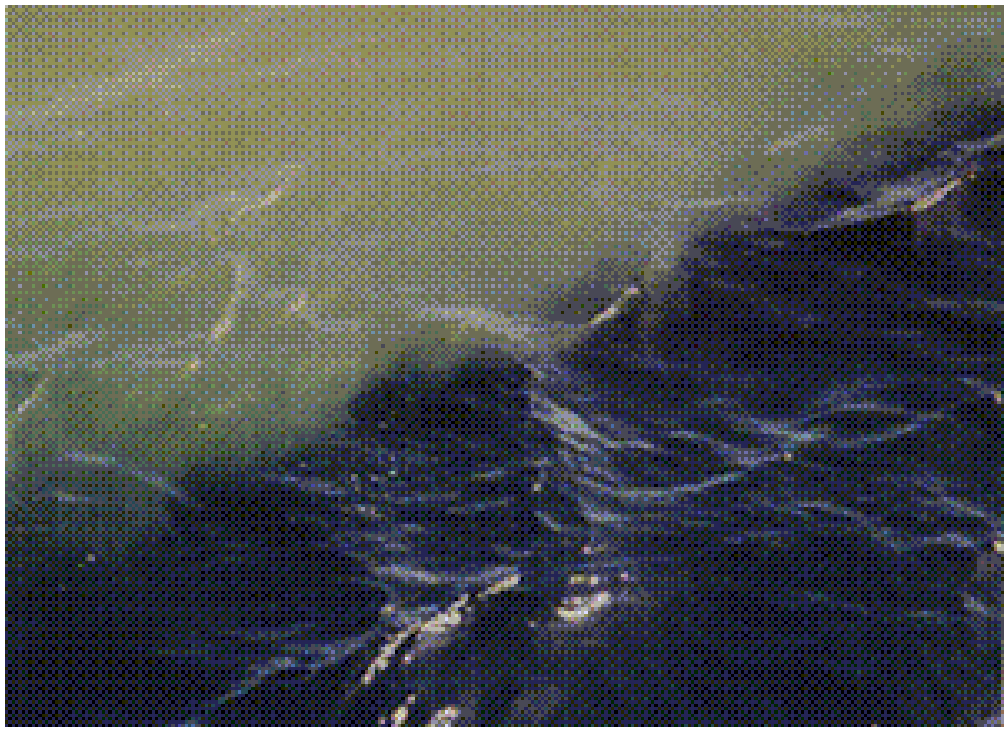

Vento
Paralelo
à costa
Transporte
para o oceano
Ressurgência
Vento
45º
Espiral
de
Ekman
Transporte

Brazil-Malvinas Confluence

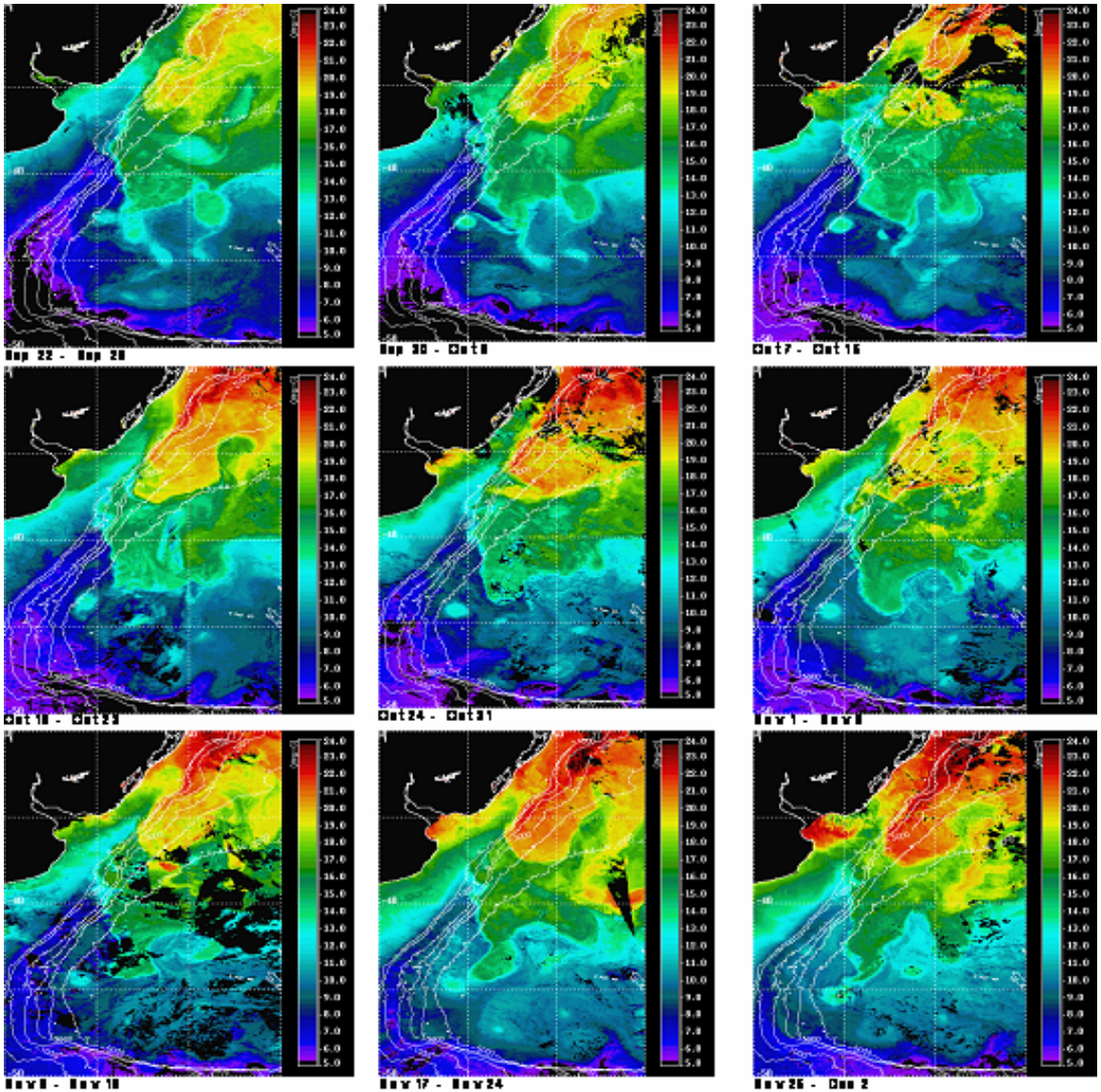


Space shuttle

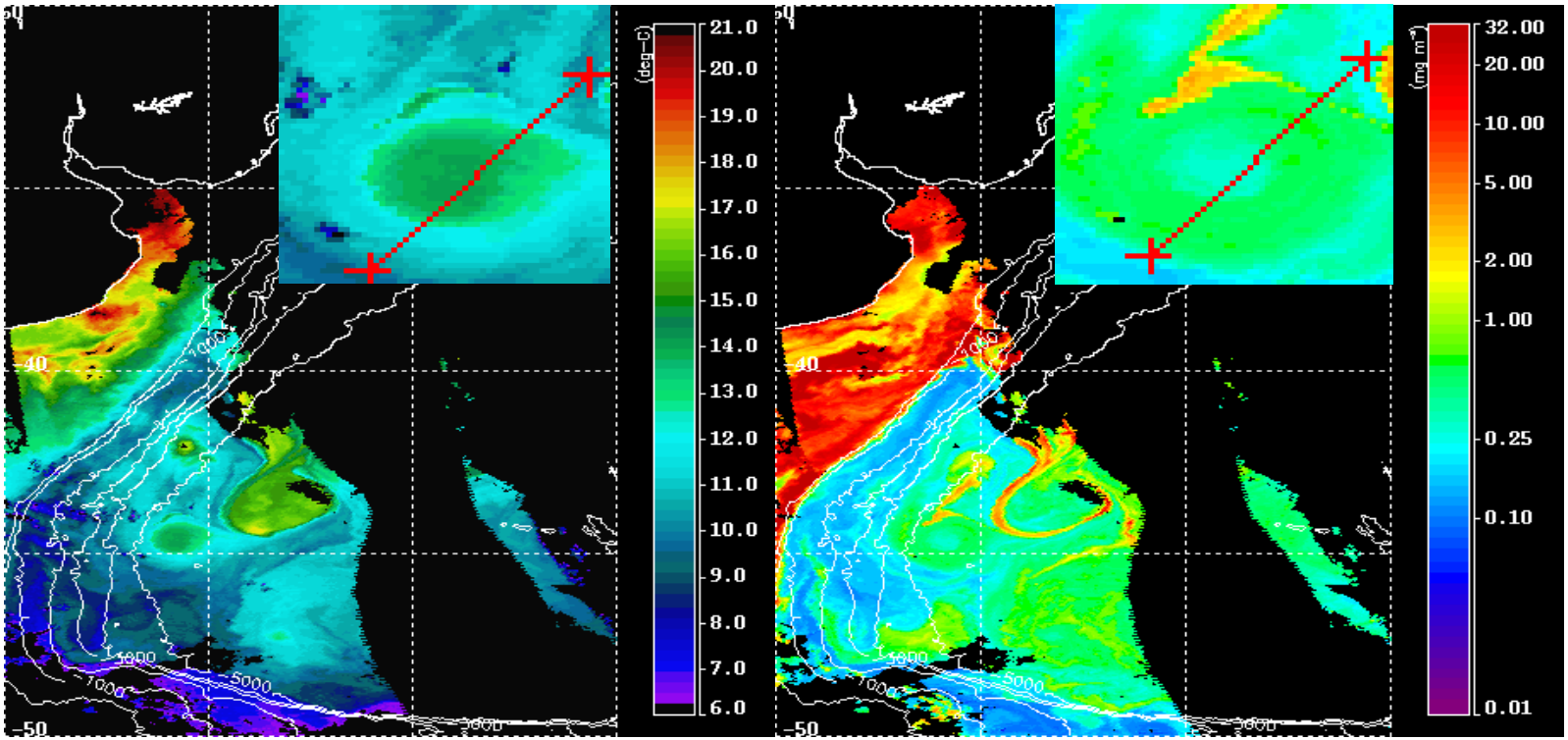


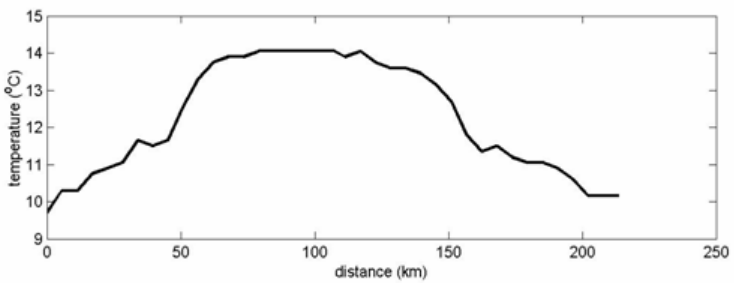


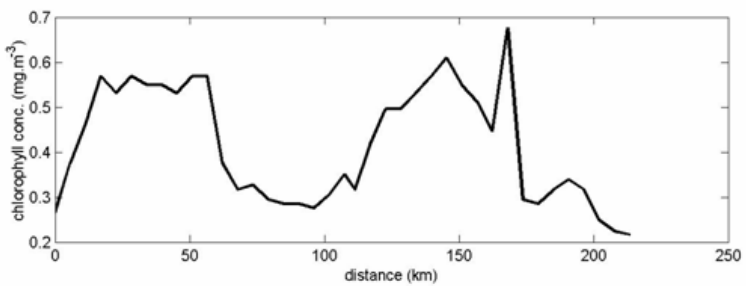
Eddies in theSouthwestern Atlantic



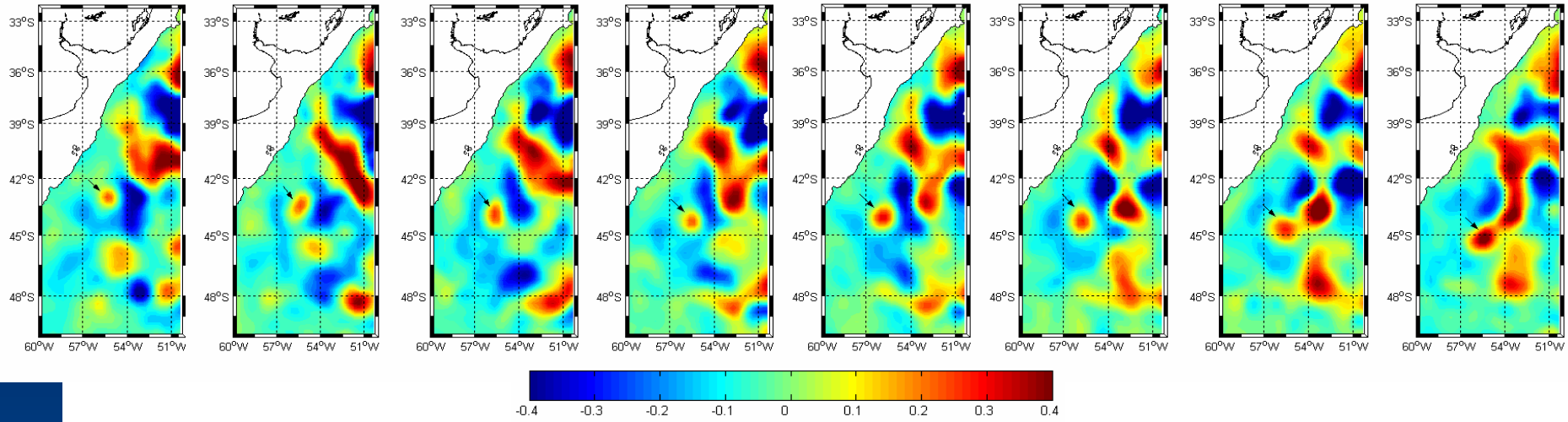
Eddies in theSouthwestern Atlantic

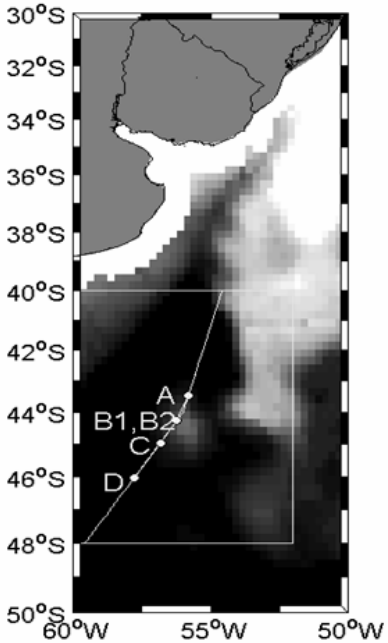


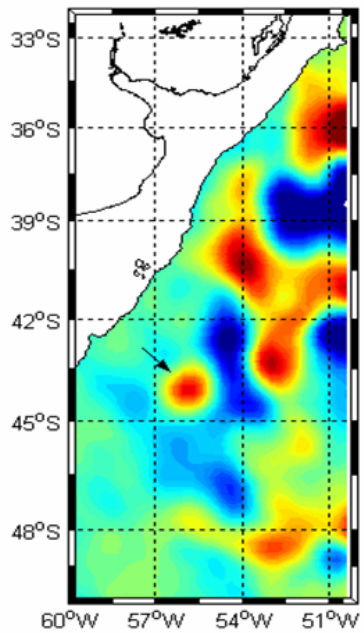




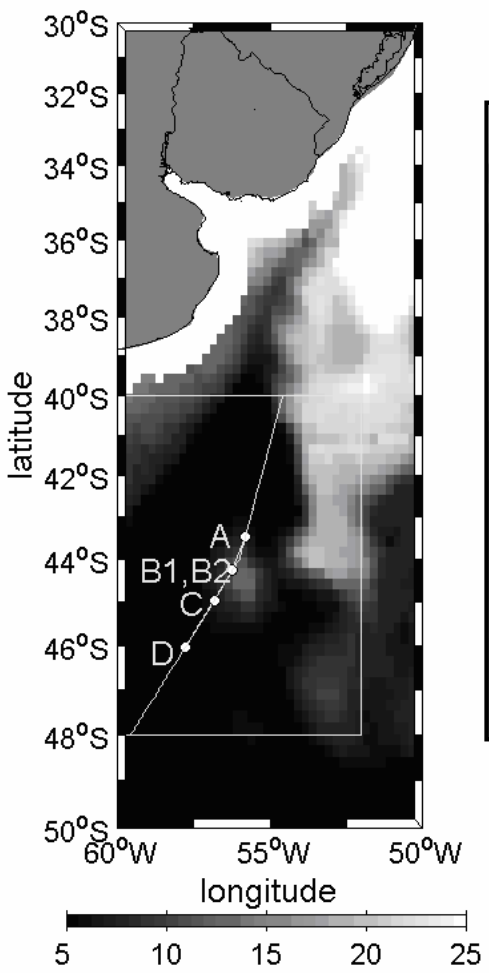
Eddies in theSouthwestern Atlantic

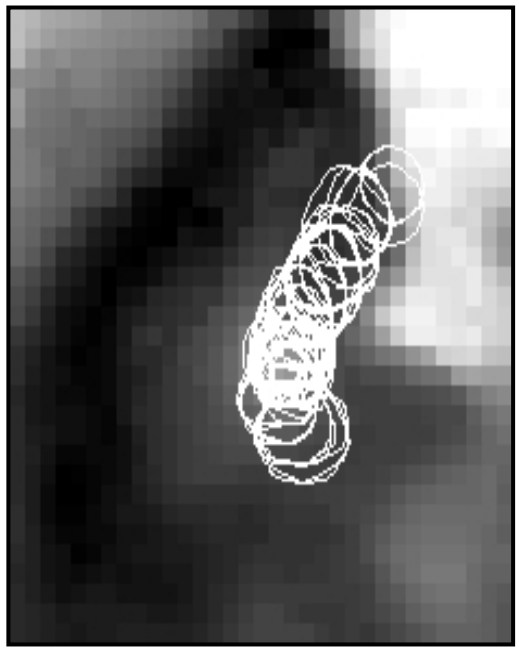


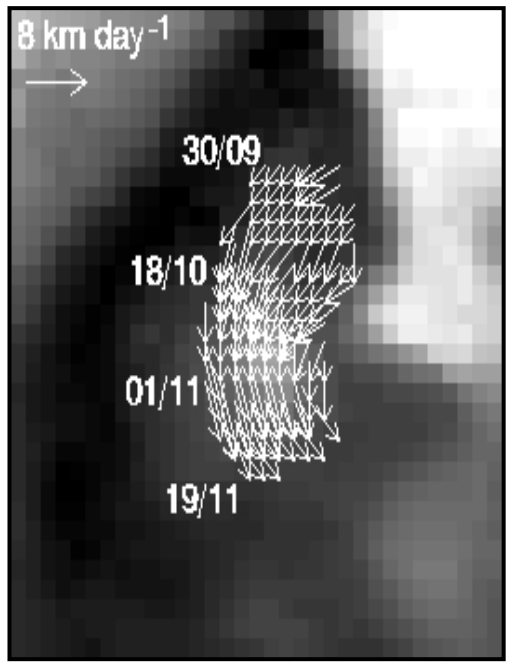




Eddies in theSouthwestern Atlantic



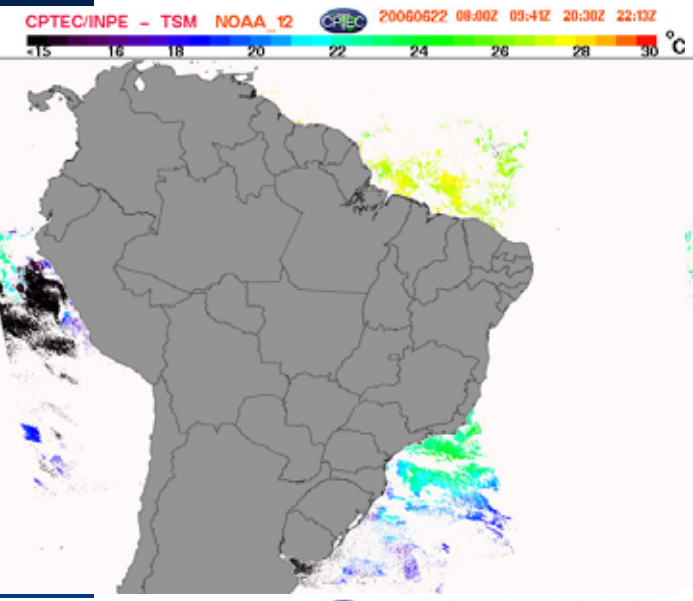


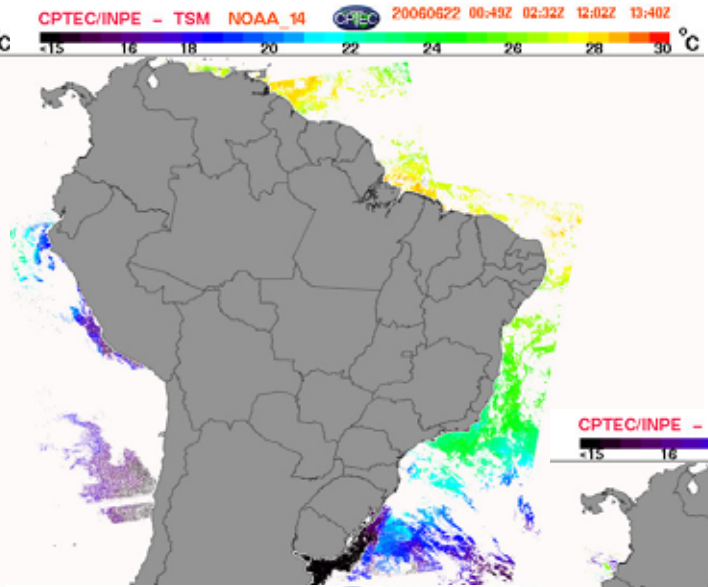


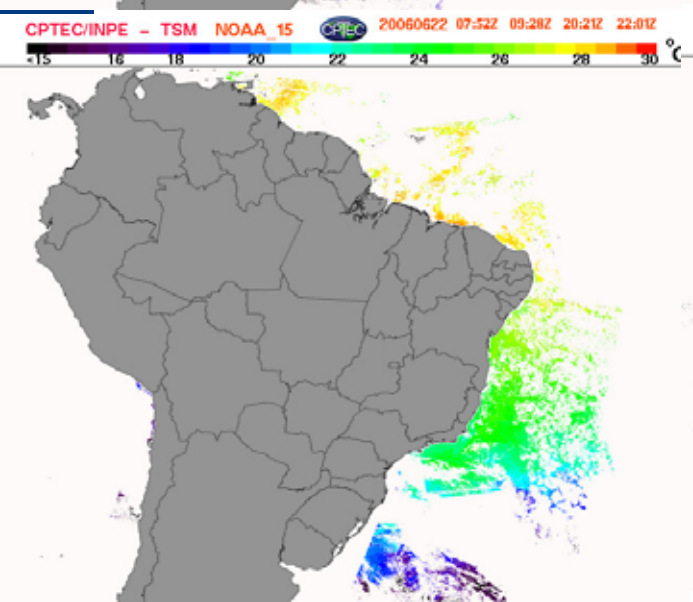
Eddies in theSouthwestern Atlantic

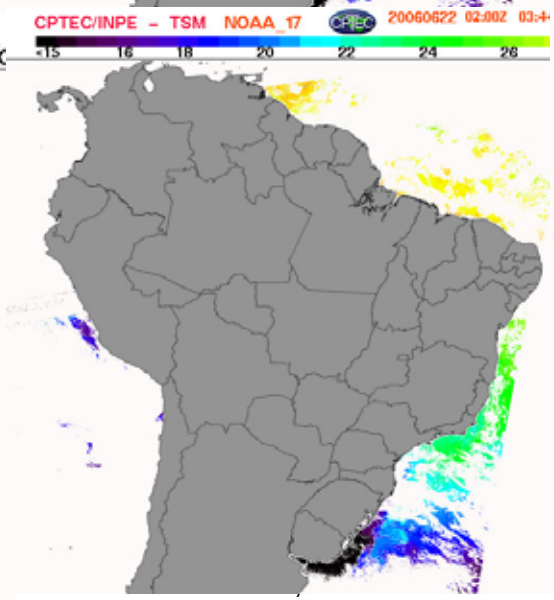
- Depth of the Isotherm 13.5 ^{o}C = 200 m;
- November-December 2002;
- Life time: 64 days;
- D = 111 x 106 km; vel.transl = 6 a 8 km/day;
- Volume = 1,37 x 10^{12} m^3;
- Salt Anom. = 1,37 x 10^{12} kg;
- Heat Content = 4,24 x 10^{18} J.

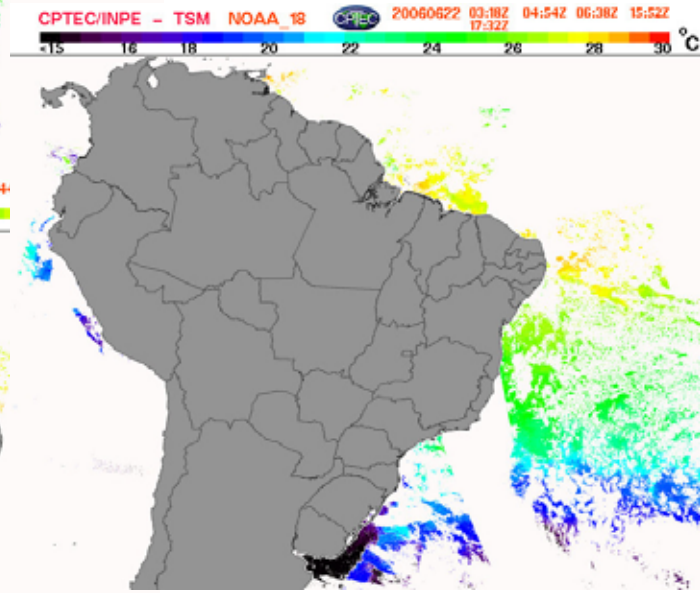
SST-NOAA/AVHRR



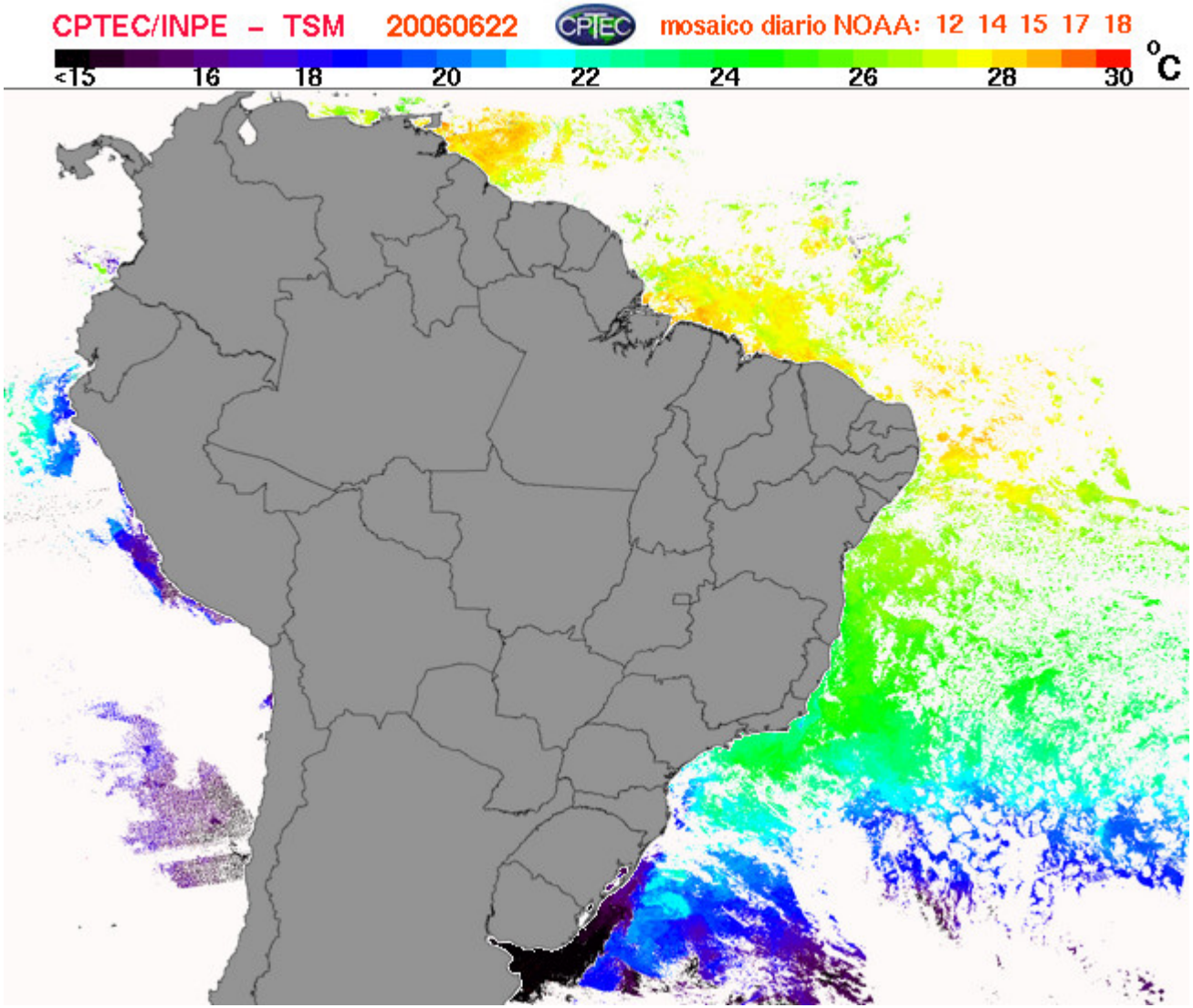








SST-NOAA/AVHRR



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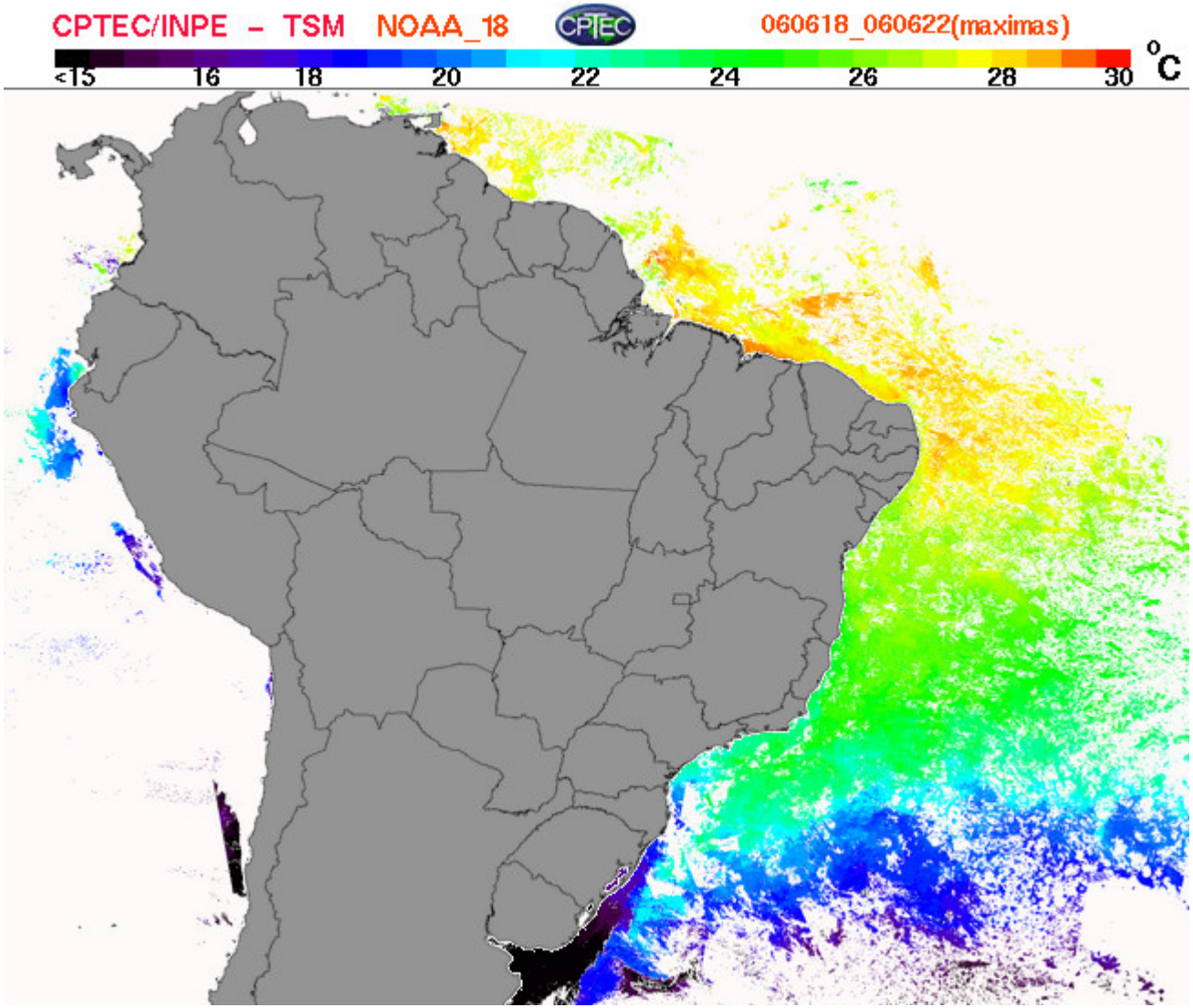

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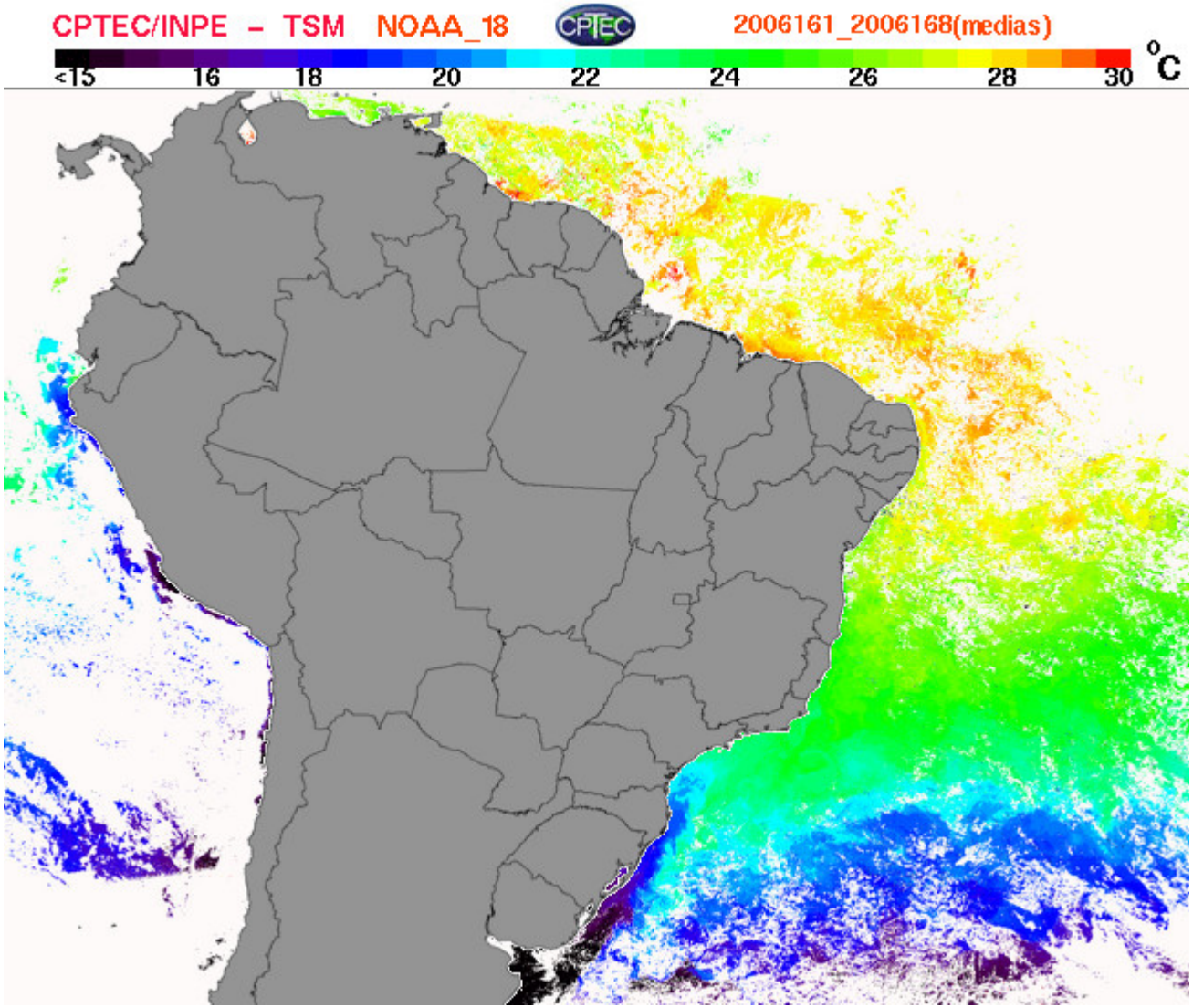

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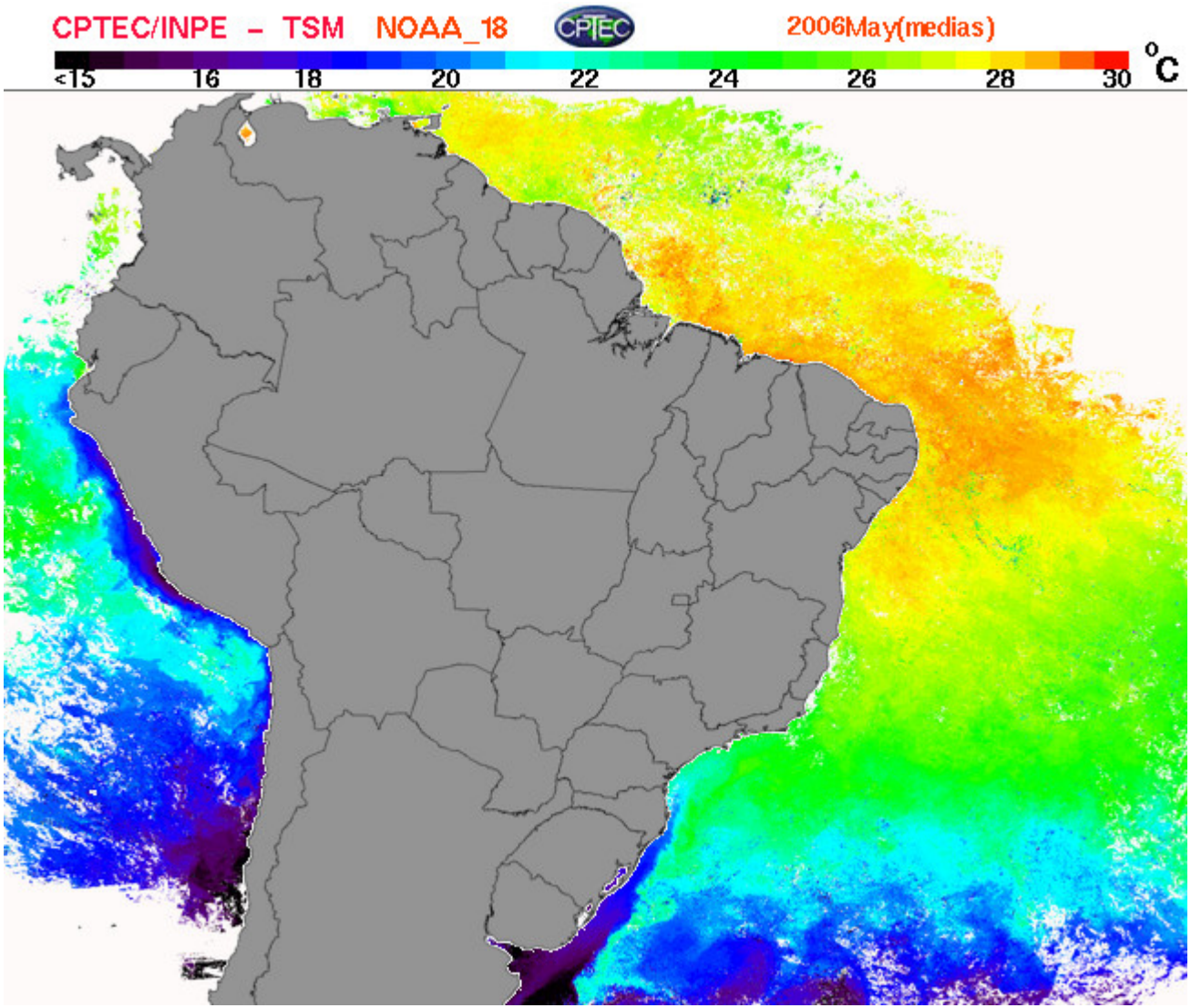
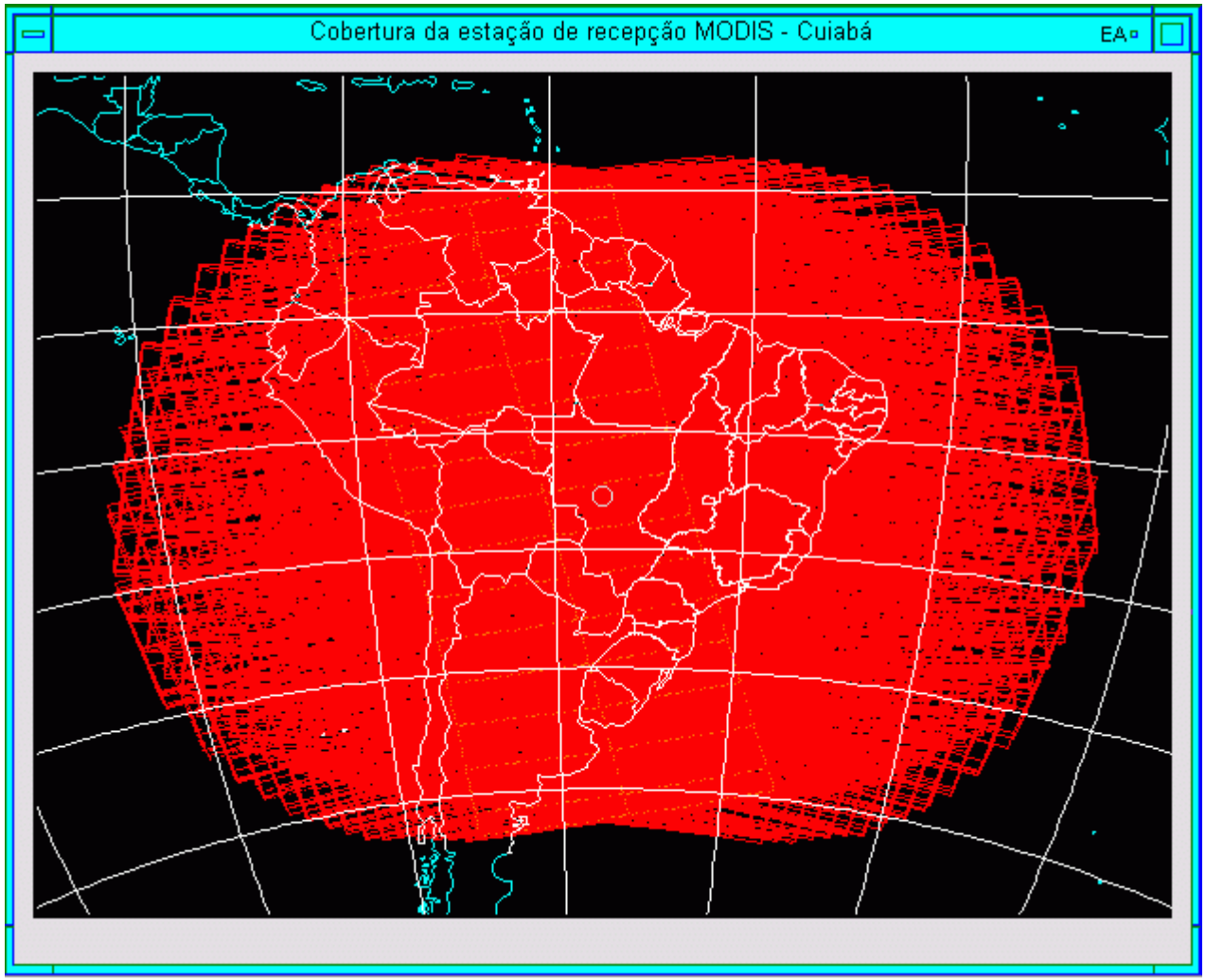
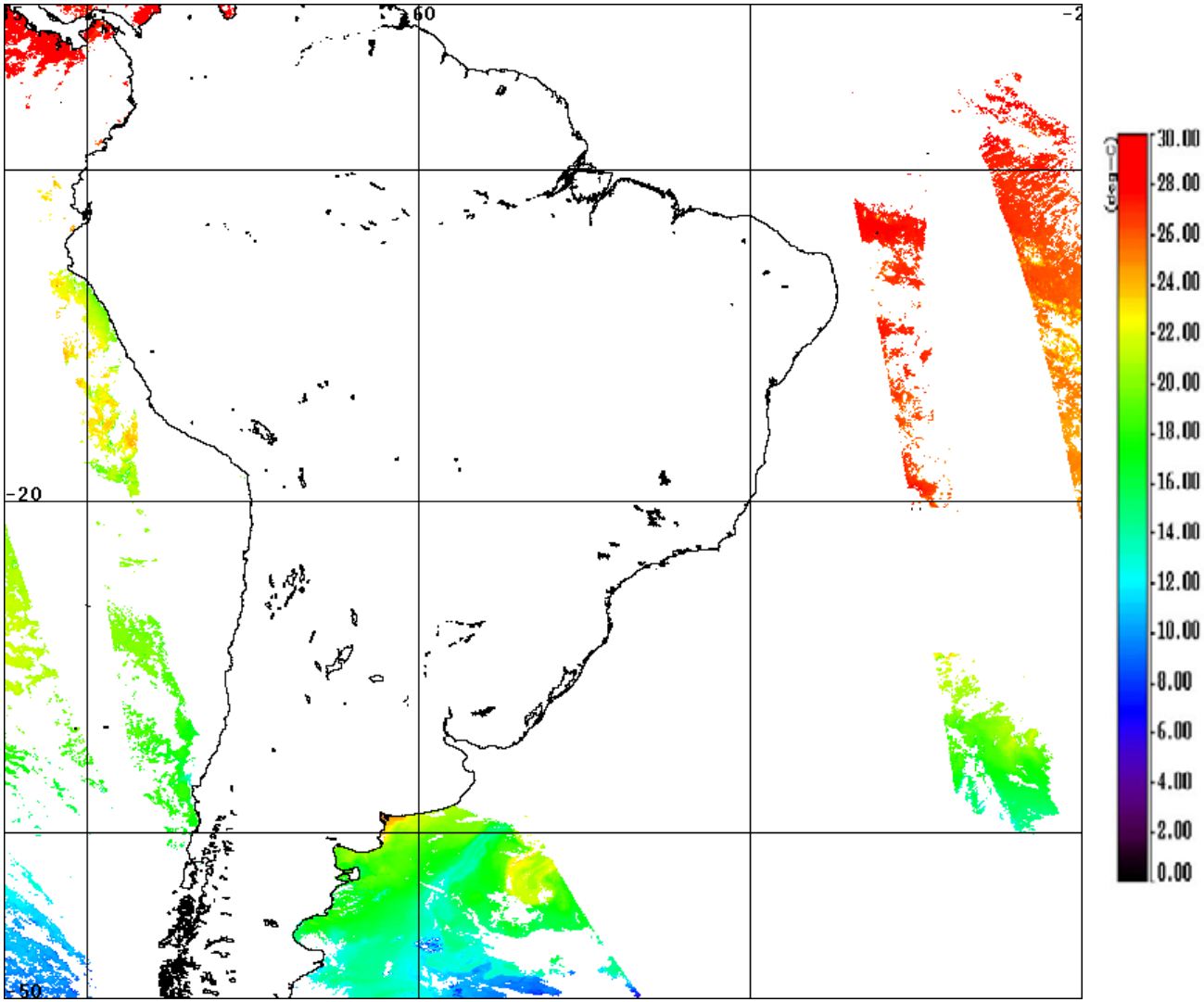


MODIS - Cuiaba



SST-MODIS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-50
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28.00
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24.00
22.00
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12.00
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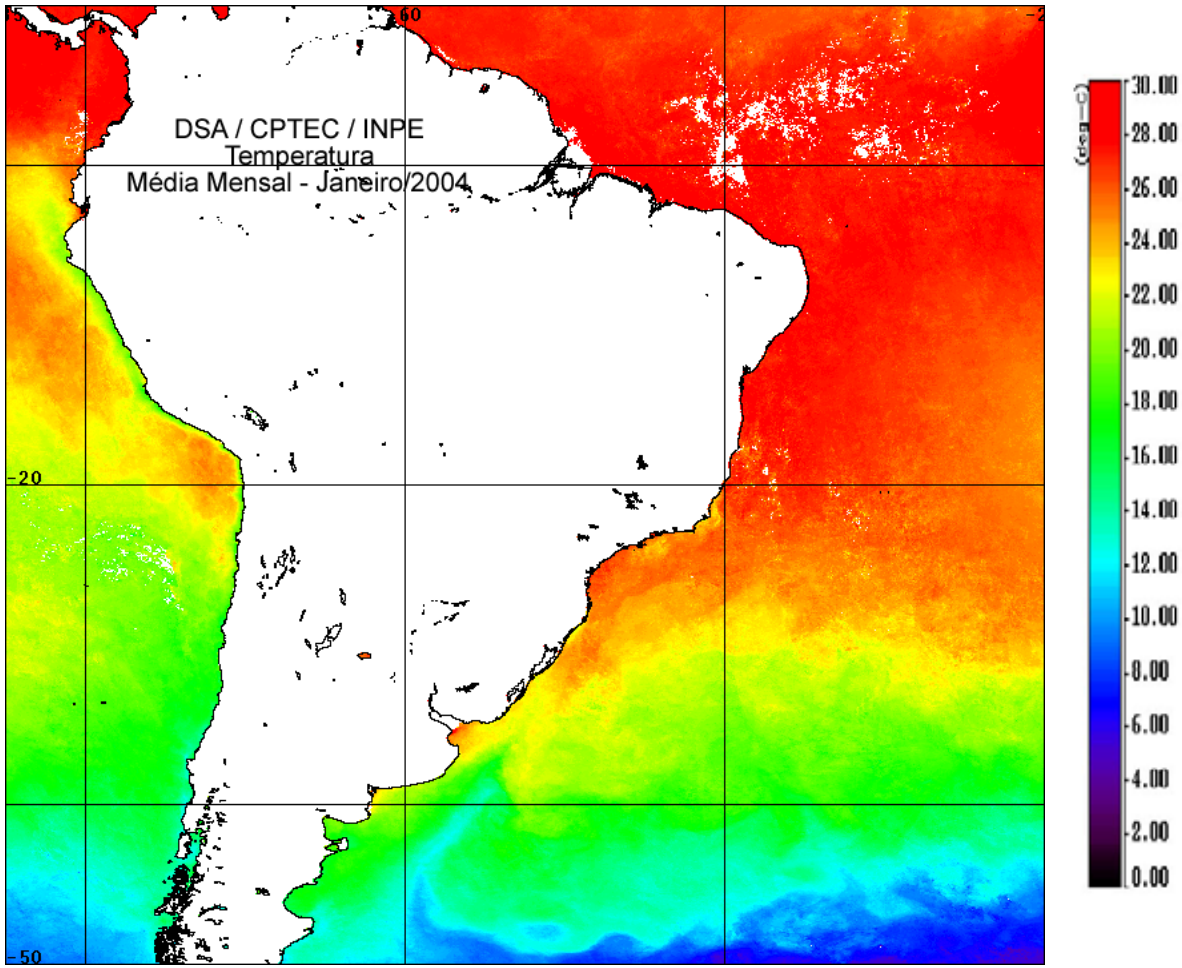
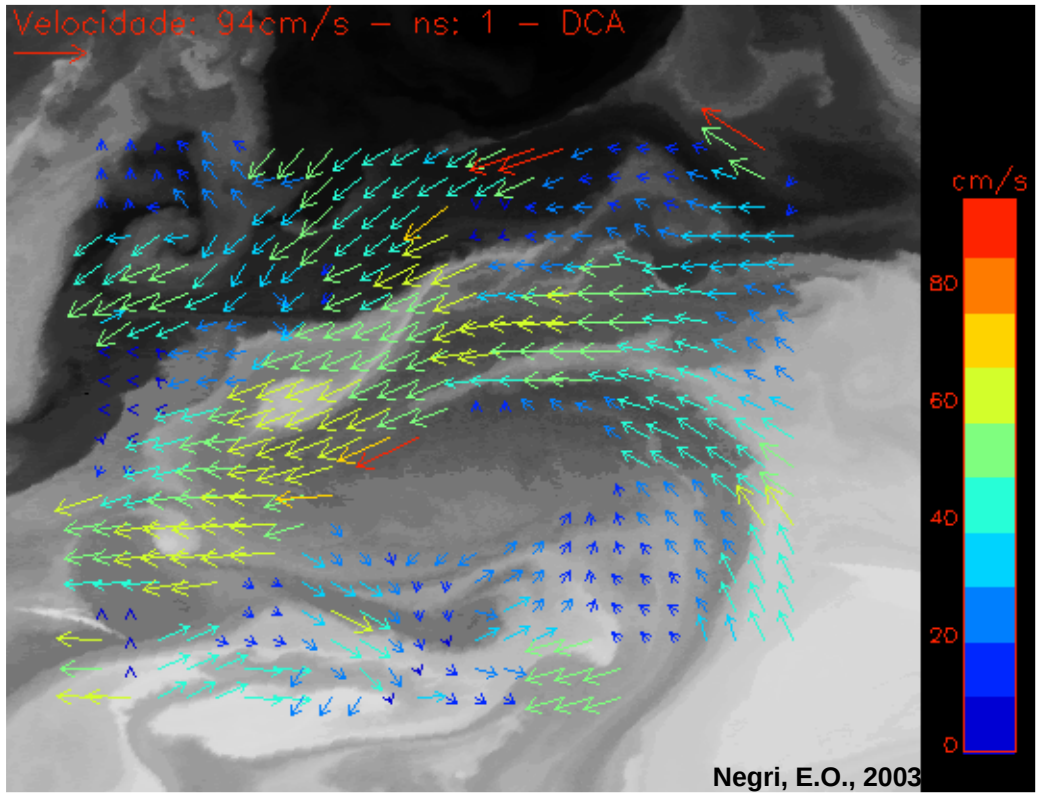
8.00
6.00
4.00
2.00
0.00

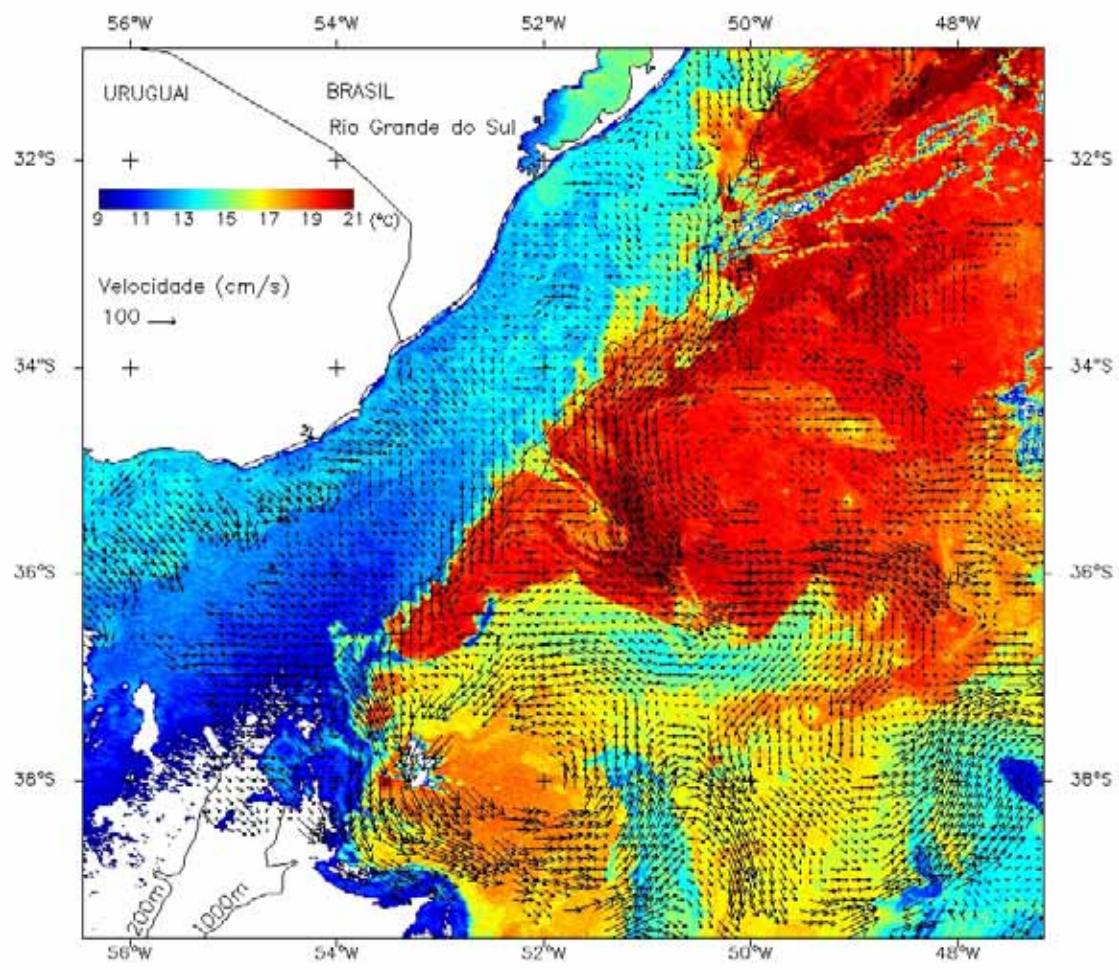
SST-NOAA/AVHRR



Surface current velocities - MCC



Surface current velocities - MCC



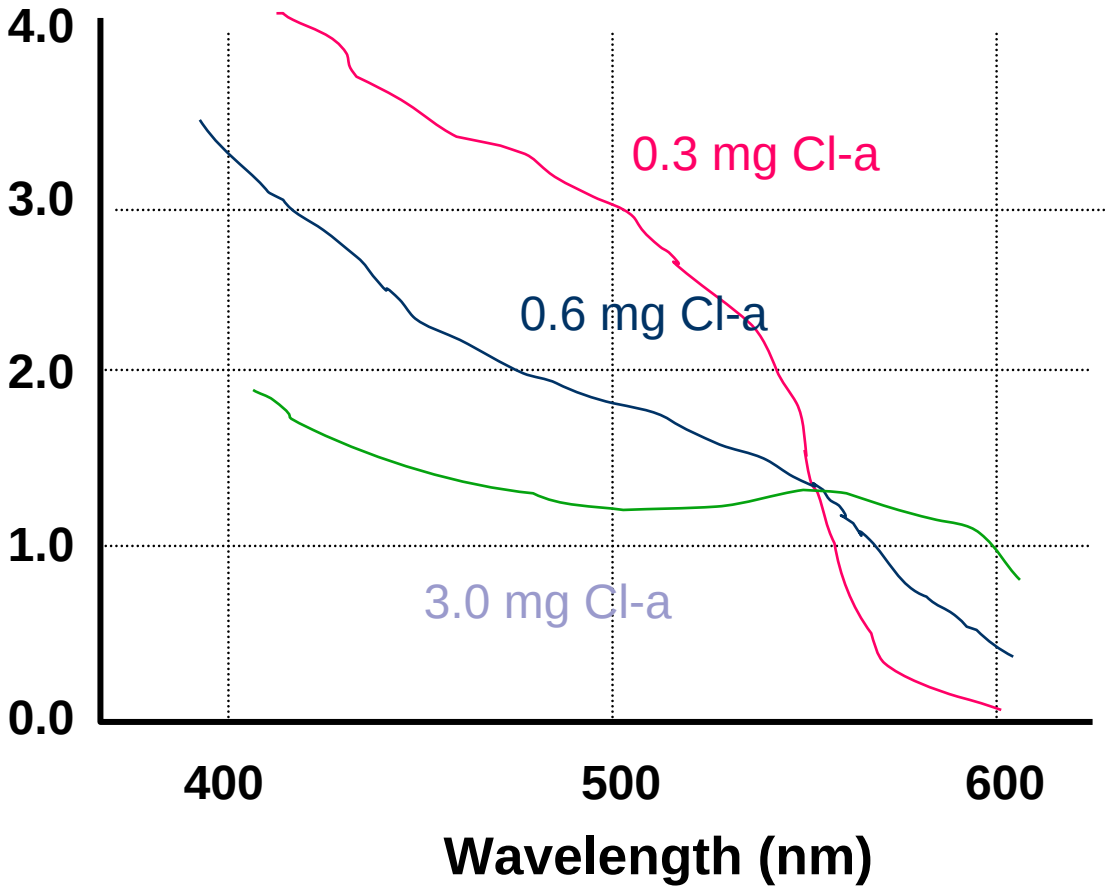
Chlorophyll

- Desde os experimentos de Clark *et* al. (1970), Morel e Prieur (1977) e Gordon e Morel (1983) ficou demonstrado que é possível quantificar a biomassa fitoplanctônica oceânica através de medidas da cor do oceano obtidas por satélite

- Os pigmentos fotossintéticos, principalmente a clorofila-*a* absorvem seletivamente a radiação solar dos comprimentos de onda nas faixas do azul e verde do espectro eletromagnético

- A concentração de clorofila-*a* é utilizada como um indexador da biomassa fitoplanctônica

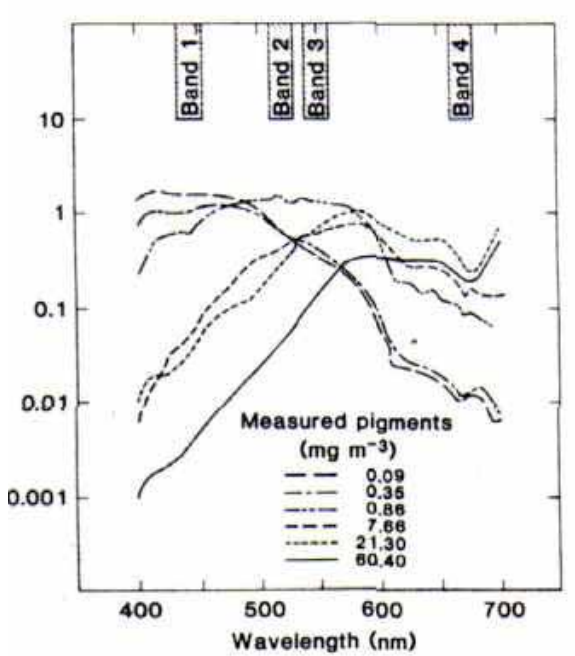
Differences in chlorophyll concentration

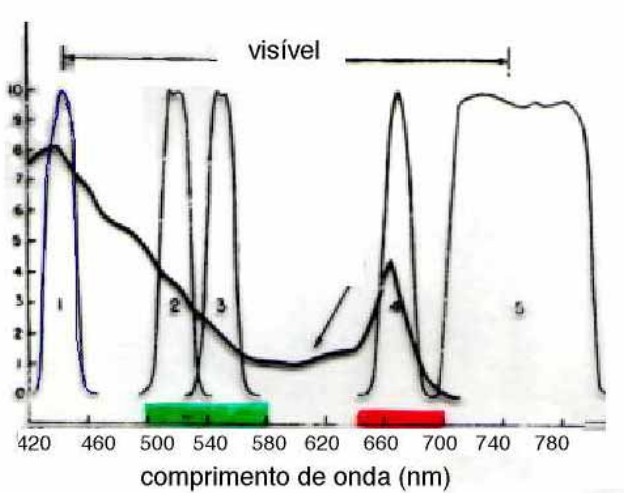


- Decrease in the blue
- Increase in the red
- No variation in the green

Empirical approach: Color index

- Phytoplankton biomass is computed as a color index
- Principle: the ligth absorption of chlorophyll-*a*

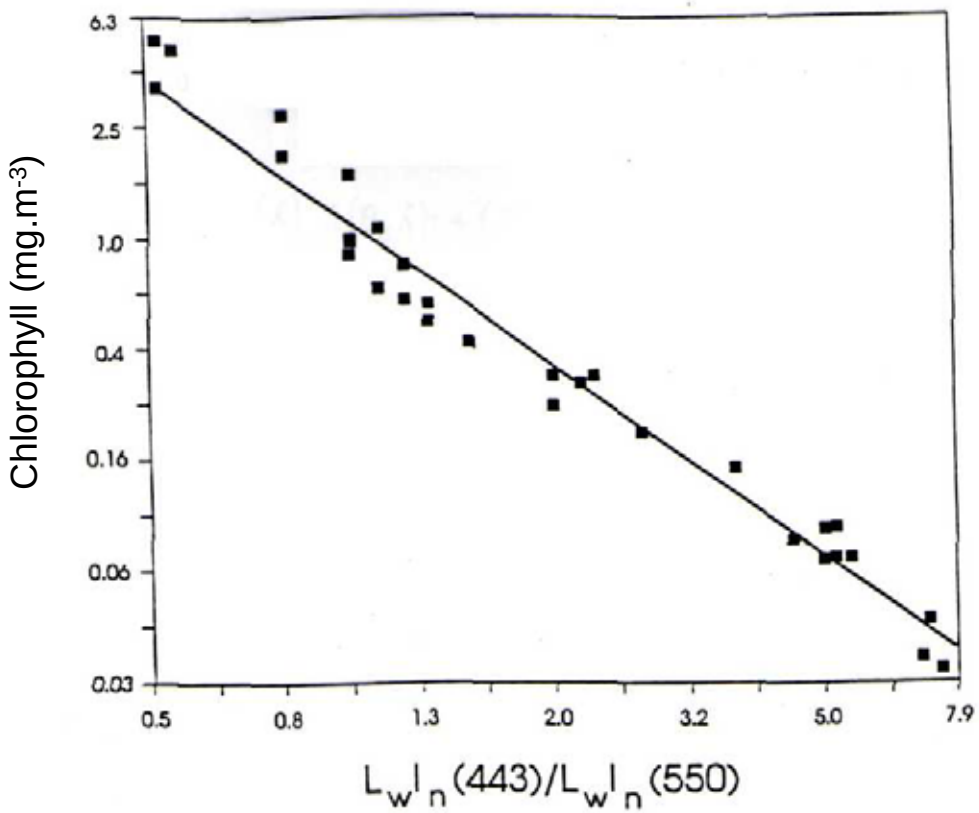




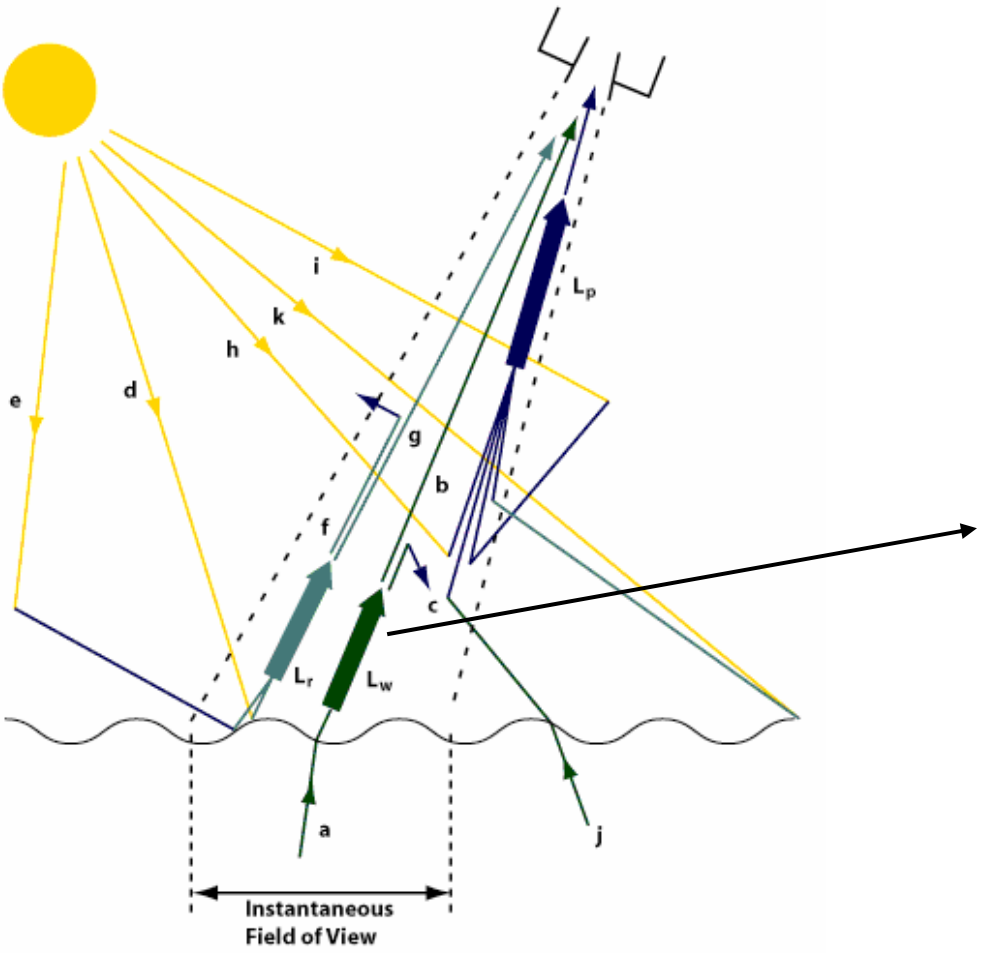
Upwellin zone in Benguela - Africa
In the center of the bloom, the light is less blue

Empirical model

- Empirical relation: *in situ* measurements of radiances *versus* chlorophyll

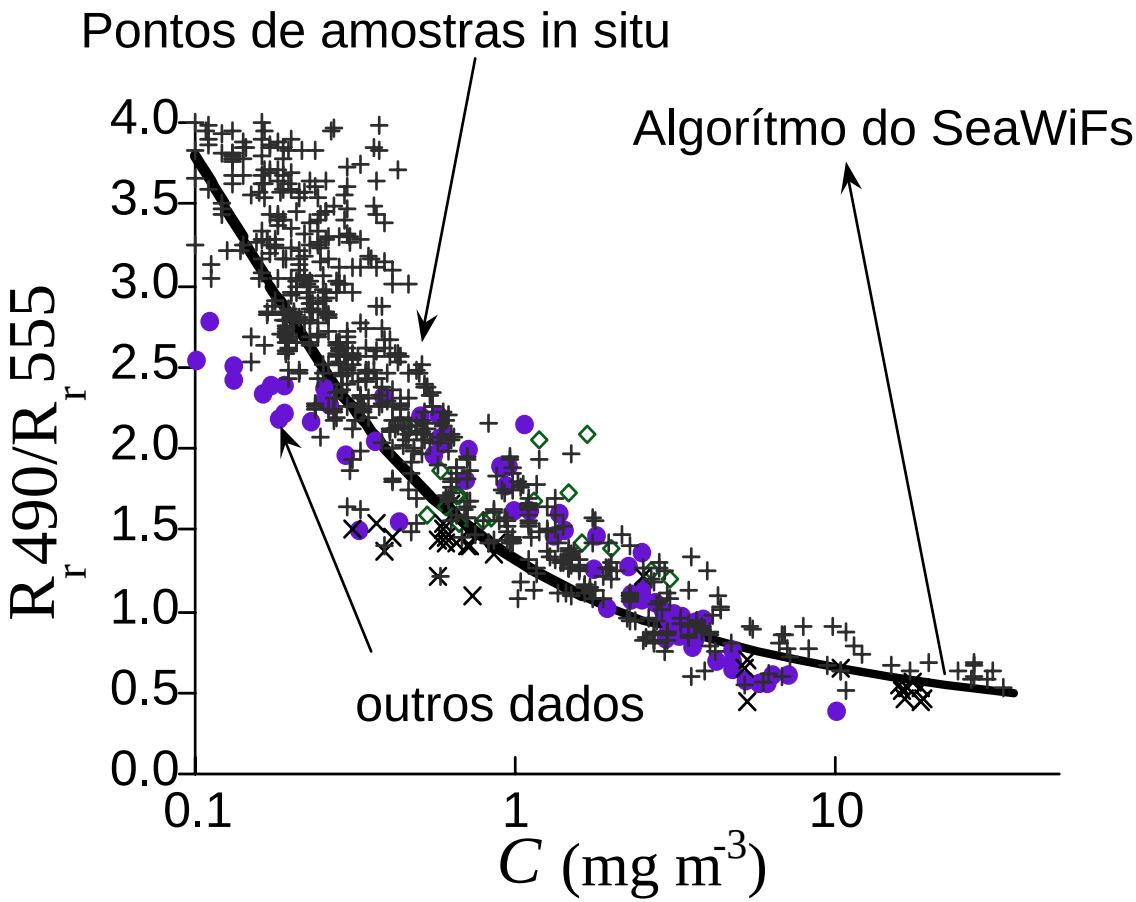


Atmospheric effects



This is the signal!

Global algorithm



Empirical x Semi-analytical algorithms

- Os algoritmos semi-analíticos têm como principal vantagem sobre os modelos empíricos de razão de bandas, a obtenção de várias propriedades ópticas simultaneamente a partir de um único espectro de radiâncias emergentes do oceano

- Entretanto, a complexidade desses modelos semi-analíticos tem dificultado seu desenvolvimento e implementação operacional

ALGORITMOS PARA CÁLCULO DA CSM

- Empíricos
  - OC2v4 (O'Reilley *et al*., 2000)

    $R_{35} = R_{RS}(490)/R_{RS}(555)$ utilizando uma função polinomial cúbica modificada (MCP)

$$C_{insitu} = 10^{(0,319-2,336R_{2S}+0,879R_{2S}^2-0,135R_{2S}^3)} - 0,071$$

  - OC4v4 (O'Reilley *et al*., 2000)

    Razão de banda máxima entre os valores de $R_{RS}(443)/R_{RS}(555)$, $R_{RS}(490)/R_{RS}(555)$ e $R_{RS}(510)/R_{RS}(555)$

$$C_{insitu} = 10^{(0,366-3,067R_{4S}+1,930R_{4S}^2+0,649R_{4S}^3-1,532R_{4S}^4)}$$

Algorithms

- Semi-analítico
  - GSM01 (Maritorena *et al.*, 2002)
  - Concentração de clorofila-*a*, coeficiente de absorção do material dissolvido e detritos [$a_{cdm}(443)$] e o coeficiente de material retroespalhado [$b_{bp}(443)$]

$$L_{WN}(\lambda) = \frac{tF_0(\lambda)}{n_w^2} \sum_{i=1}^{2} g_i \left\{ \frac{b_{bw}(\lambda) + b_{bp}(\lambda_0)(\lambda/\lambda_0)^{-\eta}}{b_{bw}(\lambda) + b_{bp}(\lambda_0)(\lambda/\lambda_0)^{-\eta} + a_w(\lambda) + Cloq_{ph}^{*}(\lambda) + a_{cdm}(\lambda_0)\exp[-S(\lambda-\lambda_0)]} \right\}^{-i}$$

  - t é a transmitância na interface oceano-atmosfera
  - $F_0(\lambda)$ é a irradiância solar extraterrestre
  - n_w é o índice de refração da água
  - $b_{bw}(\lambda)$ é o retroespalhamento da água
  - b_{bp} é o restroespalhamento pelo material particulado
  - λ_0 é o comprimento de onda 443 nm
  - η é o expoente da lei de potência para o coeficiente de retroespalhamento do material particulado

Algorithms

- Semi-analítico

$$L_{WN}(\lambda) = \frac{tF_0(\lambda)}{n_w^2} \sum_{i=1}^{2} g_i \left\{ \frac{b_{bw}(\lambda) + b_{bp}(\lambda_0)(\lambda/\lambda_0)^{-\eta}}{b_{bw}(\lambda) + b_{bp}(\lambda_0)(\lambda/\lambda_0)^{-\eta} + a_w(\lambda) + Cloq_{ph}^{*}(\lambda) + a_{cdm}(\lambda_0)\exp[-S(\lambda-\lambda_0)]} \right\}^{-i}$$

  - $a_w(\lambda)$ é o coeficiente de absorção pela água pura
  - a_{ph}^{*} é o coeficiente de absorção específico pela clorofila-*a*
  - a_{cdm} é o coeficiente de absorção pelo material dissolvido e detritos
  - S é o decaimento espectral constante para a absorção pelo material dissolvido e detritos (*cdm*)

Algorithms

- Redes neurais artificiais
  - NN (Gross *et al.*, 2000)
  - Rede multicamada *perceptron* (MLP)

SeaWiFS

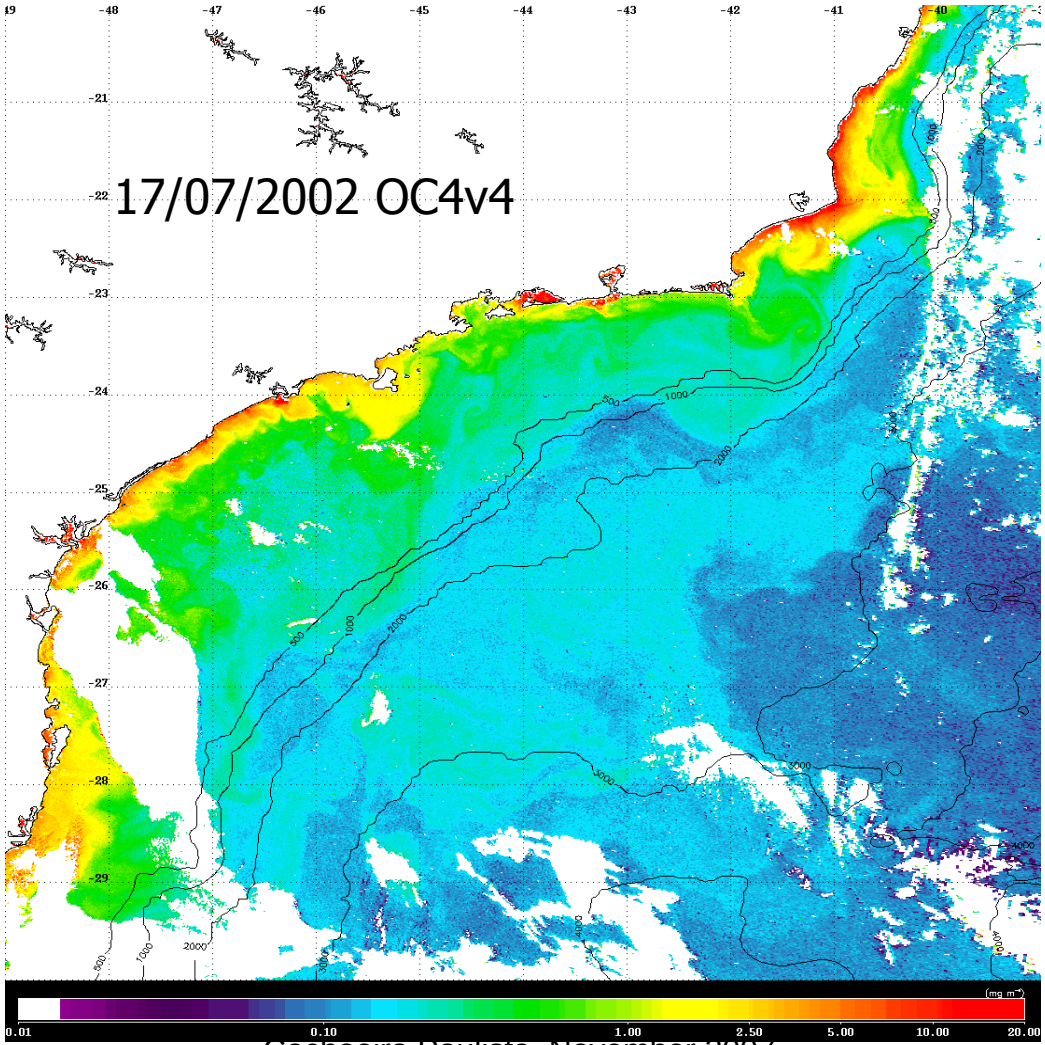
Bandas espectrais do sensor SeaWiFS

Banda	λ SeaWiFS (nm)
1	402-422
2	433-453
3	480-500
4	500-520
5	545-565
6	660-680
7	745-785
8	845-885

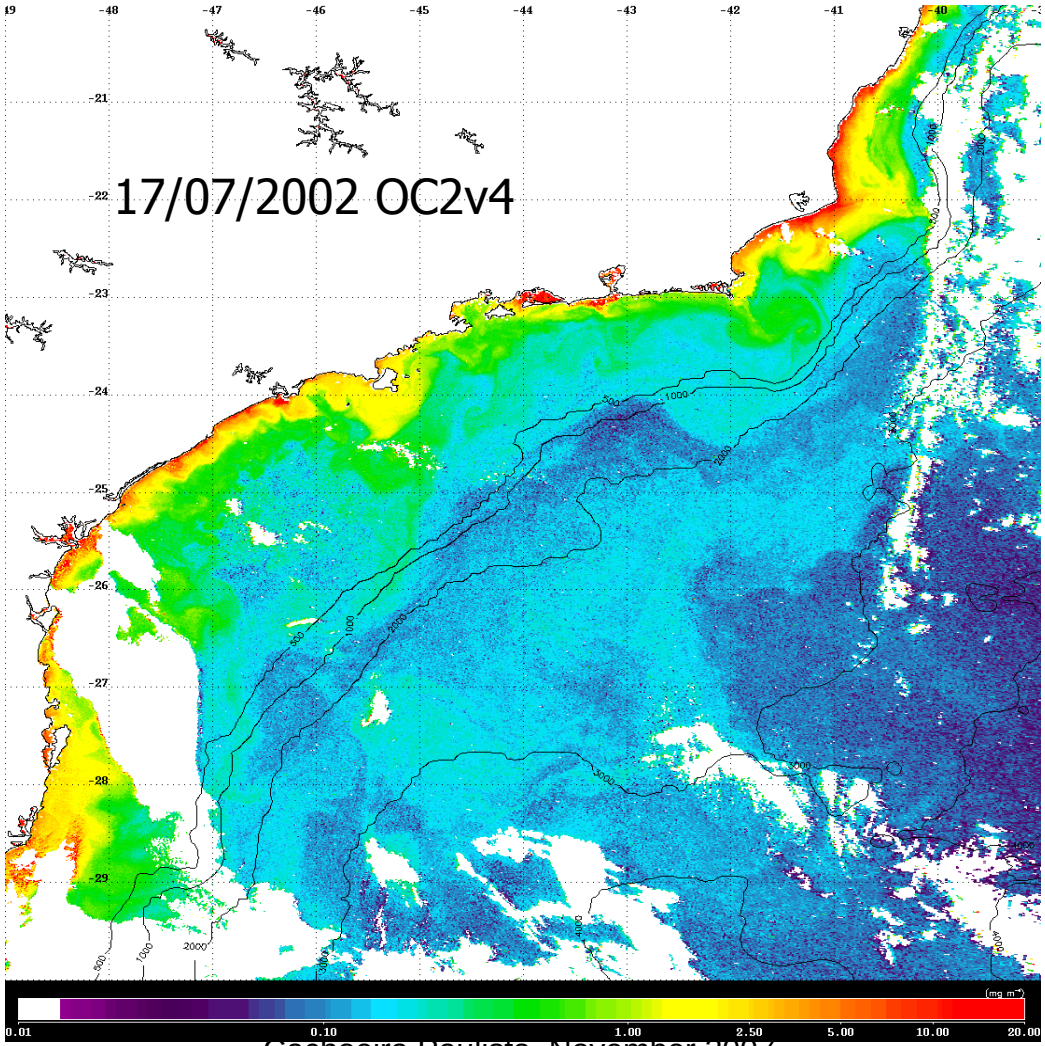
Características do sistema SeaWiFS

Resolução no nadir	1,1 km LAC; 4,5 km GAC
Tipo de órbita	Heliossíncrona, 705 km
Cruzamento com equador	12:00, ±20 min., descendente
Faixa imageada	2800 km LAC (±58,3º); 1505 km GAC (±45º)
Resolução radiométrica	10 bits

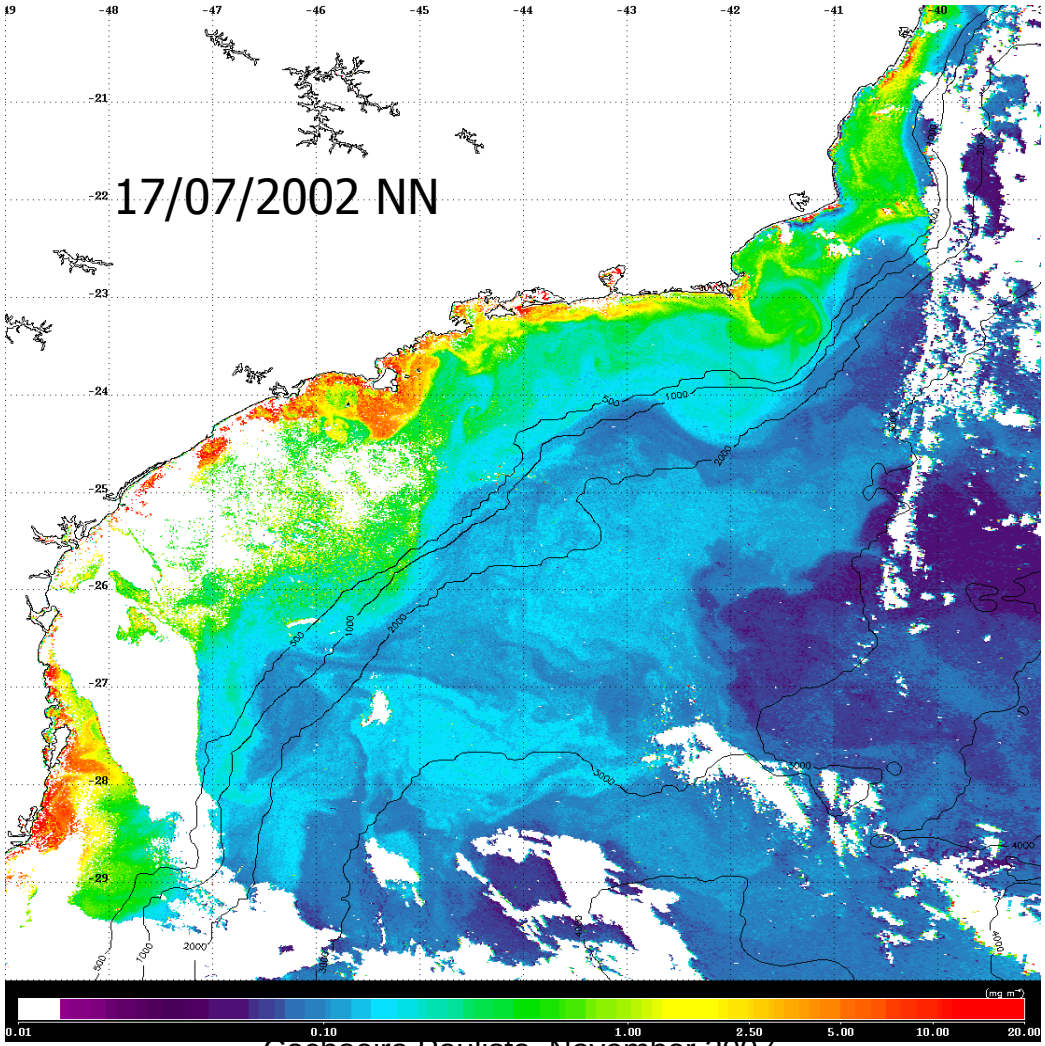
Examples



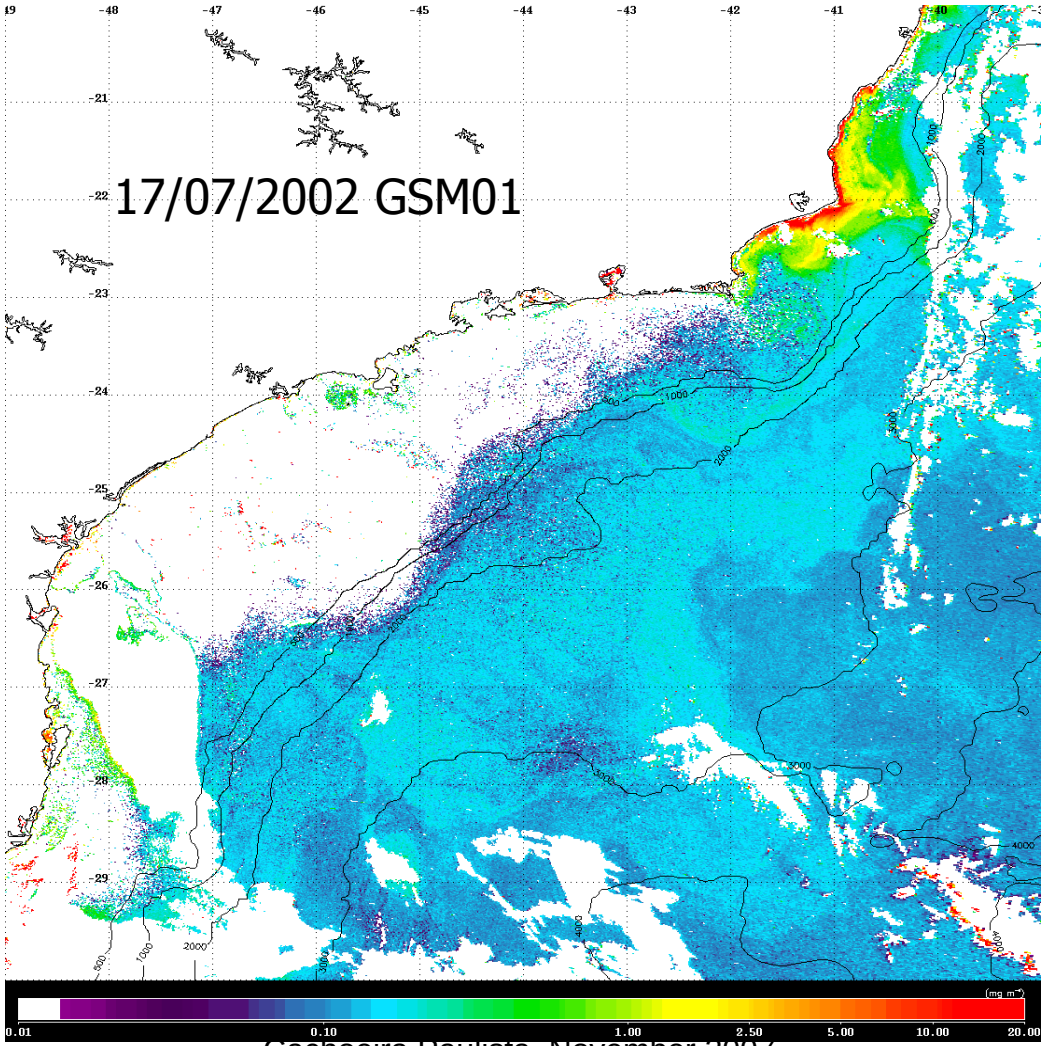
Examples



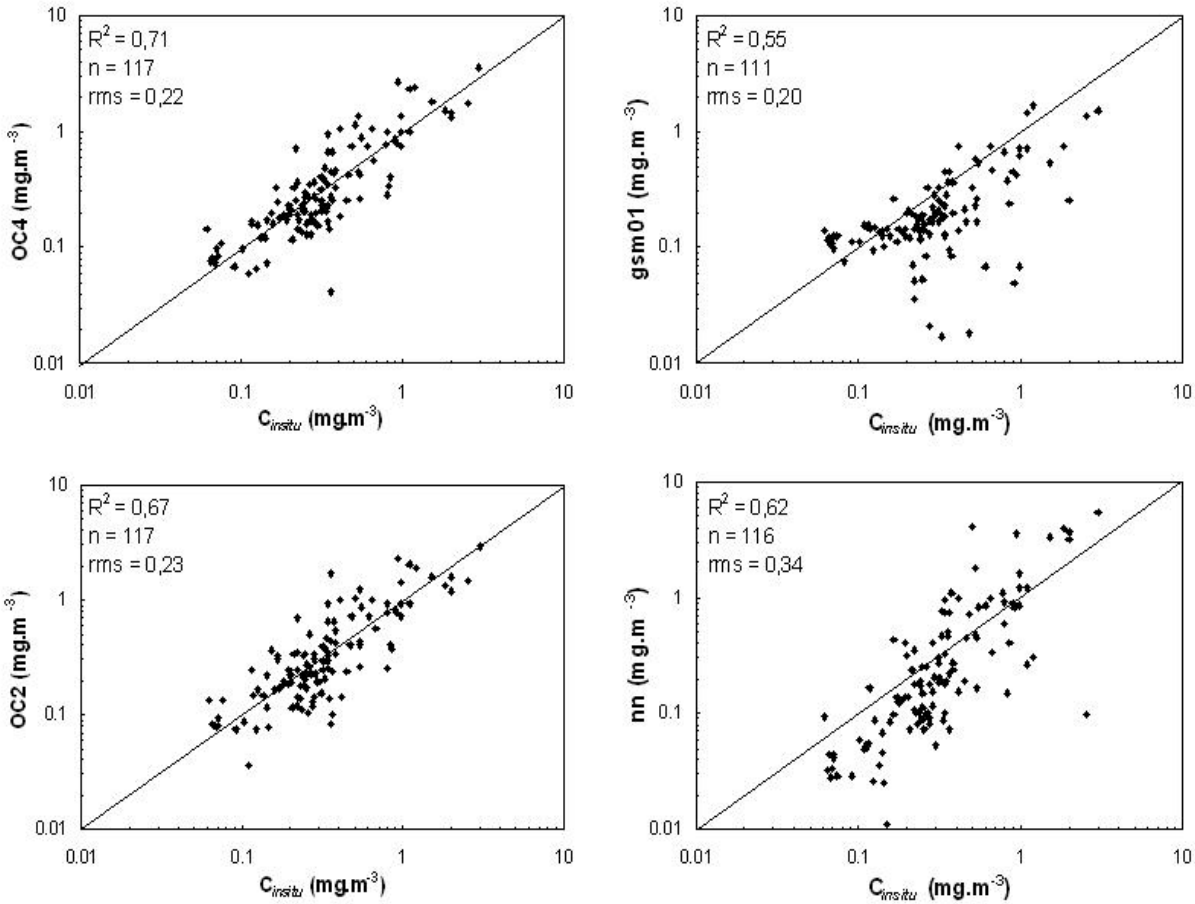
Examples



Examples



Validation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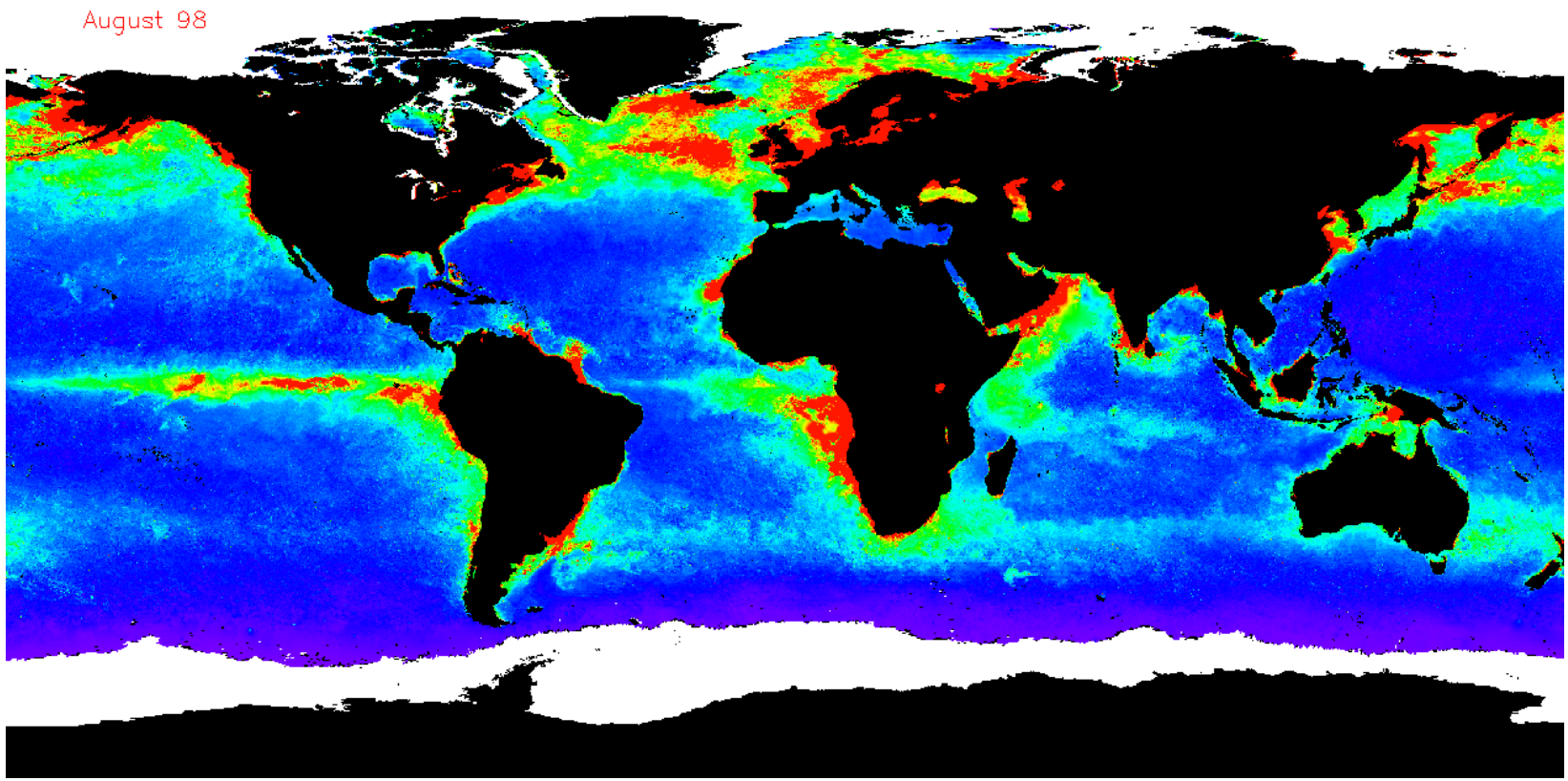
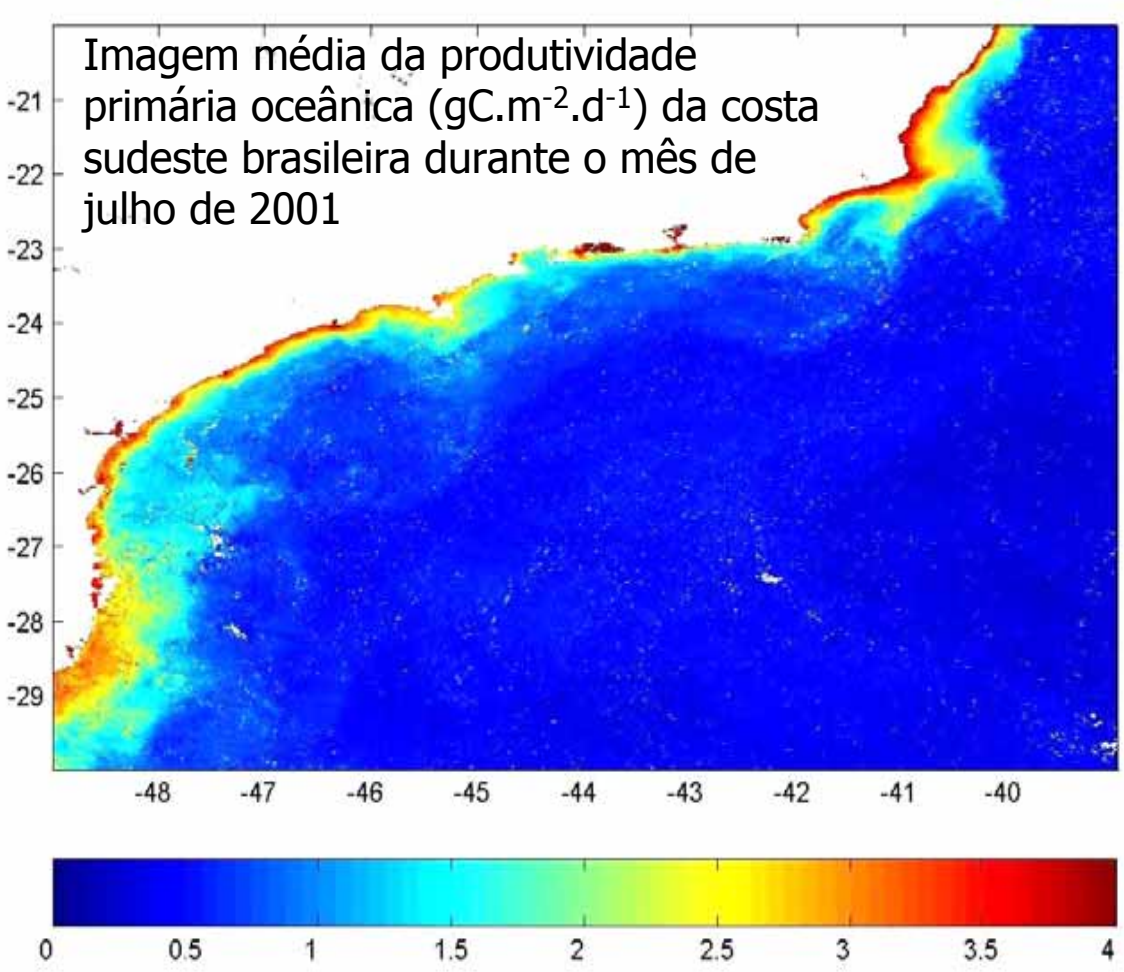
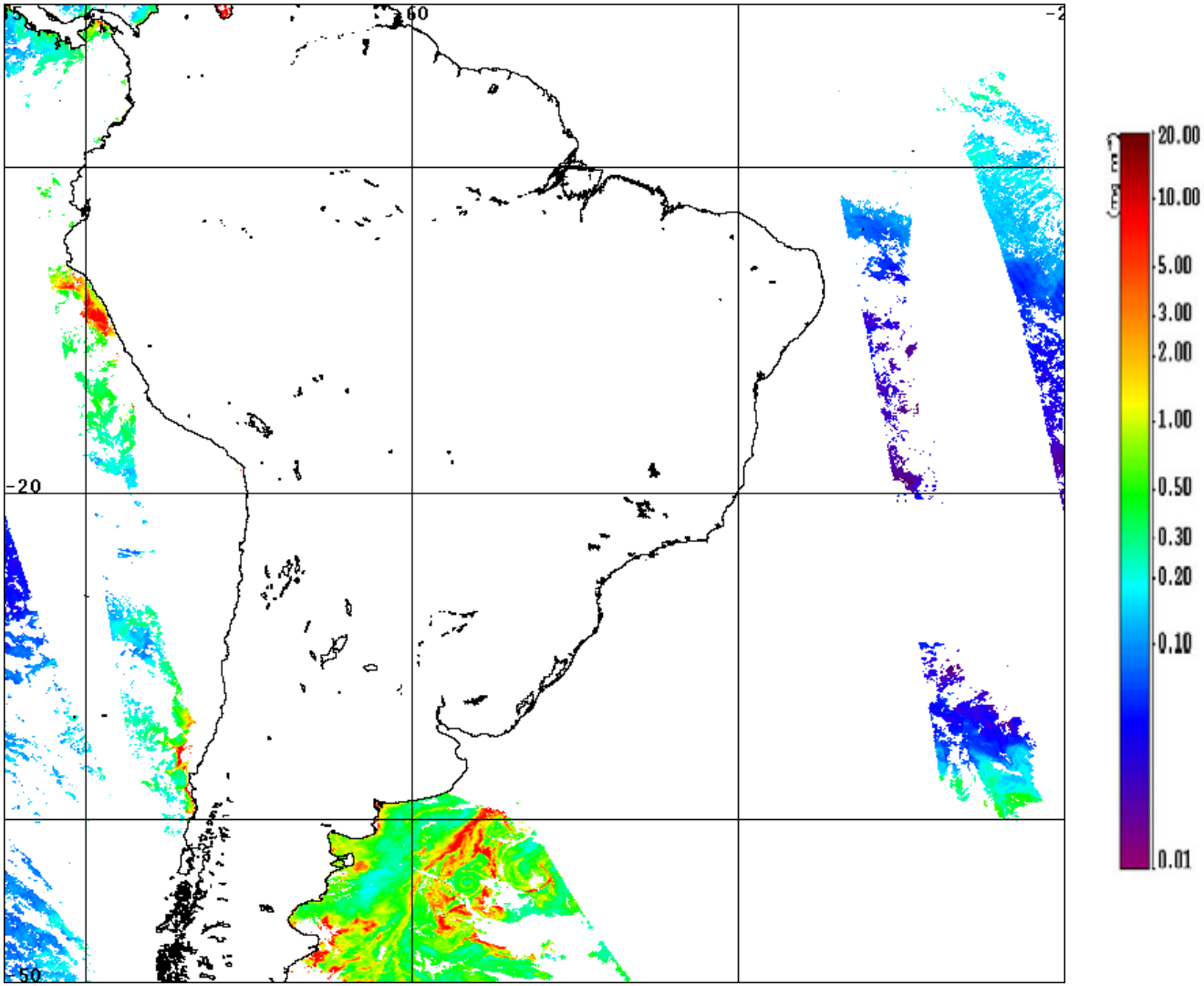
rms = 0,22
OC4 (mg.m⁻³)
C_insitu (mg.m⁻³)
R² = 0,55
n = 111
rms = 0,20
gsm01 (mg.m⁻³)
C_insitu (mg.m⁻³)
R² = 0,67
n = 117
rms = 0,23
OC2 (mg.m⁻³)
C_insitu (mg.m⁻³)
R² = 0,62
n = 116
rms = 0,34
nn (mg.m⁻³)
C_insitu (mg.m⁻³)
0.01
0.1
1
10

Primary production



Primary production

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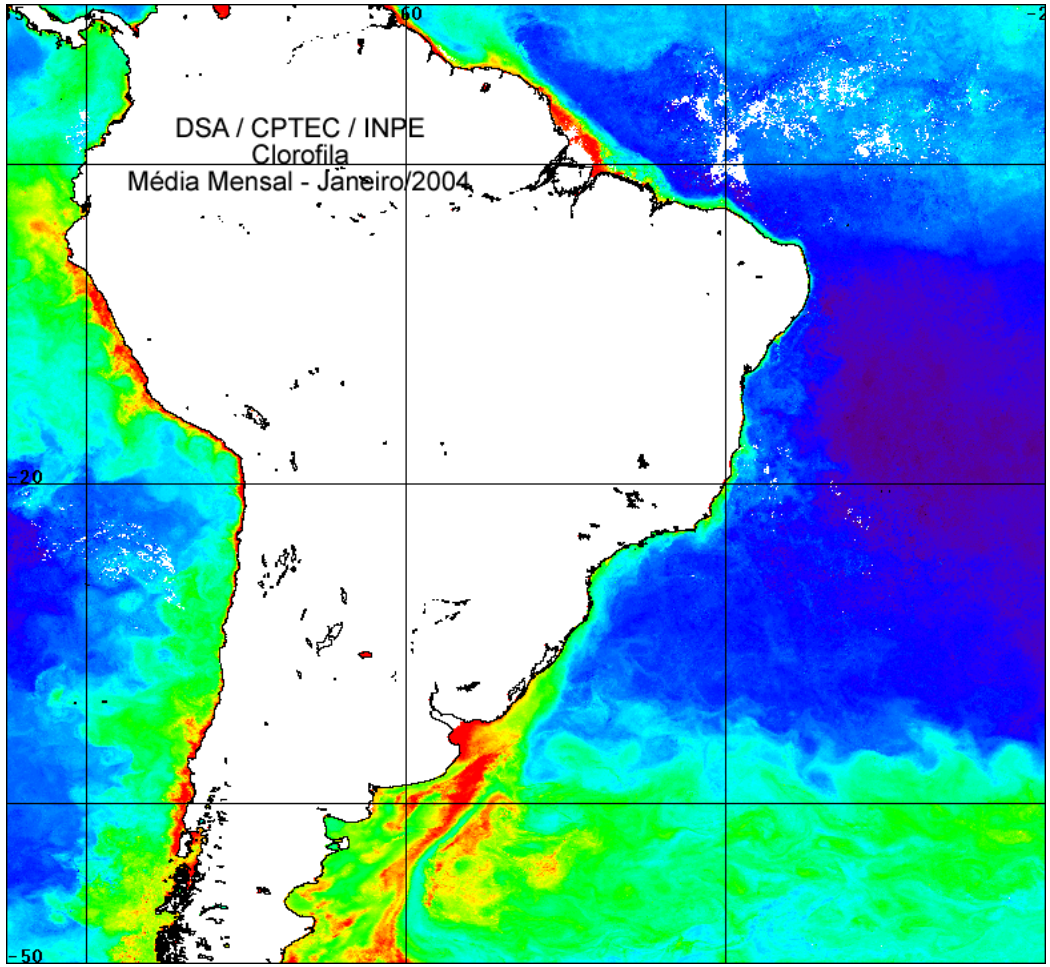
0.01


DSA / CPTEC / INPE
Clorofila
Média Mensal - Janeiro/2004
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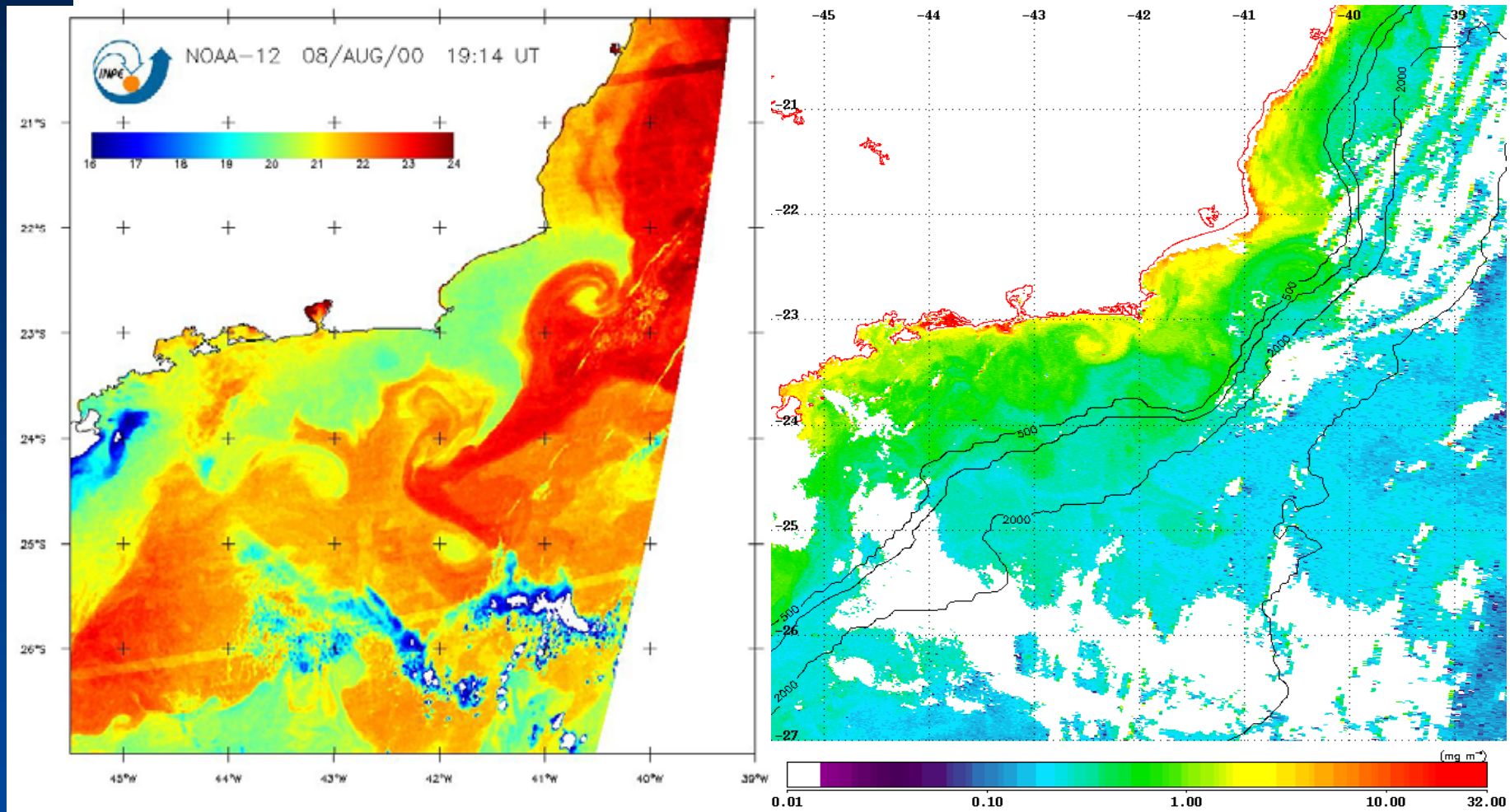
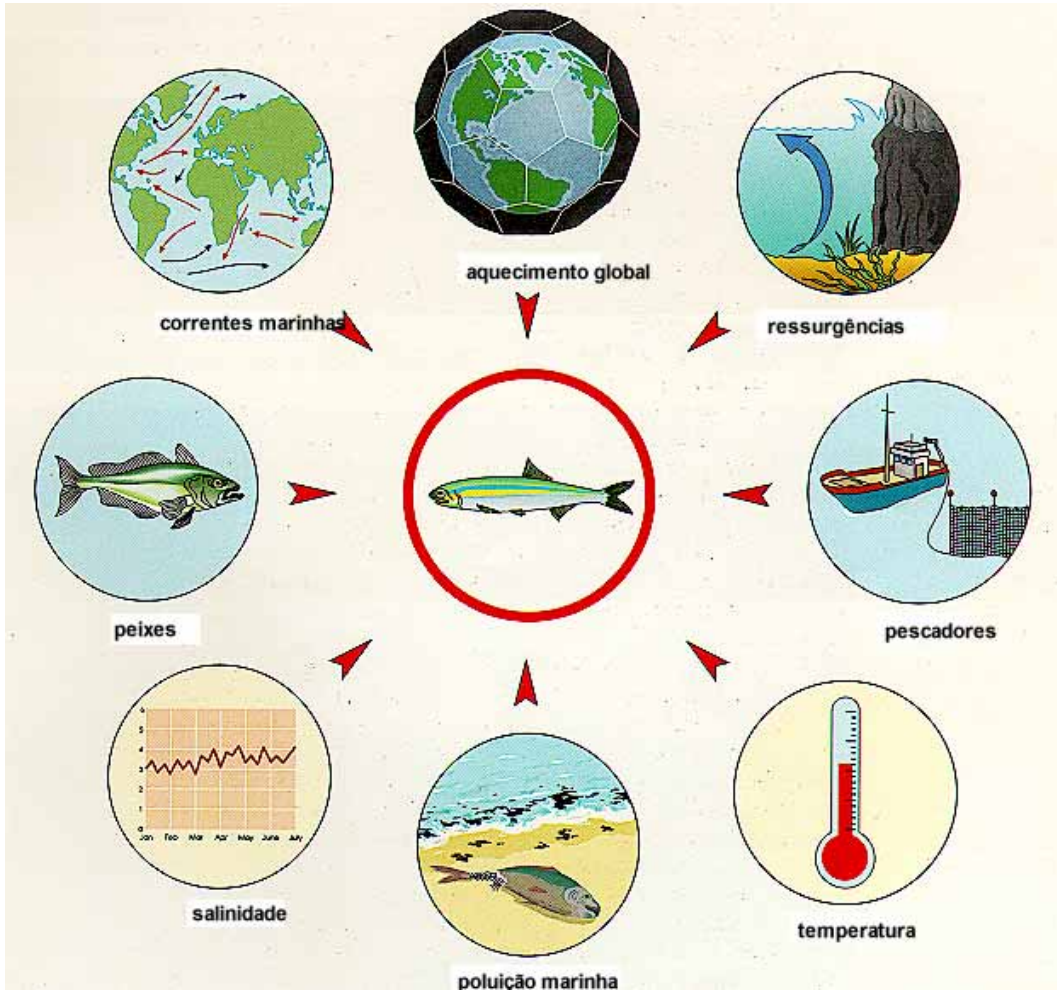
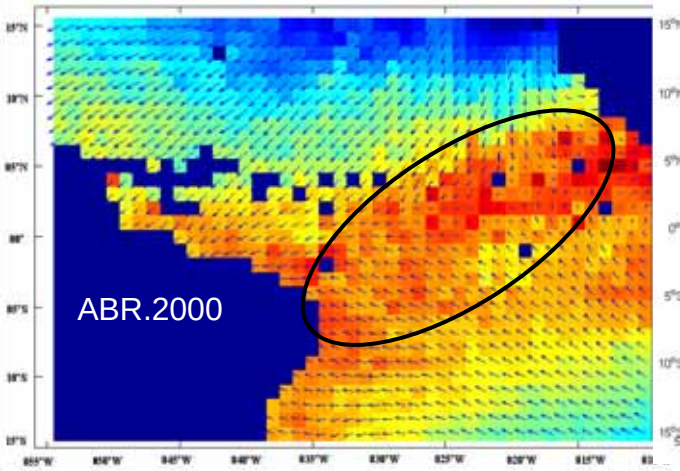
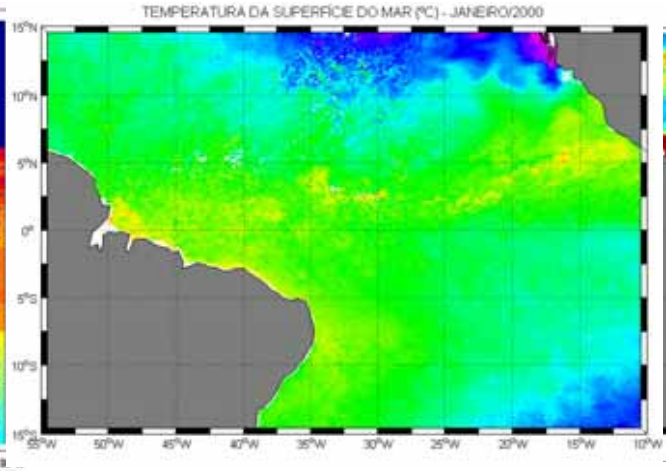
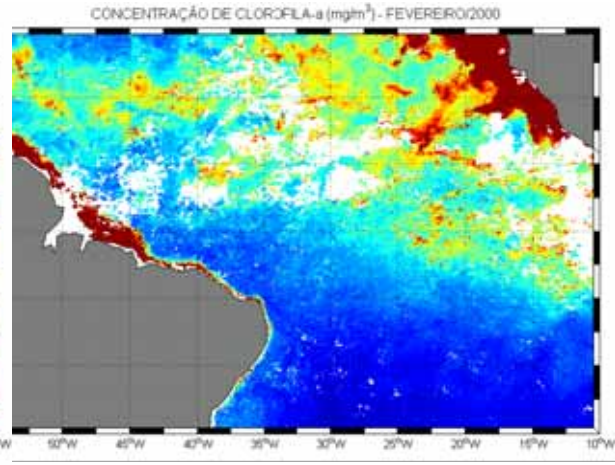
1.00
0.50
0.30
0.20
0.10
0.01

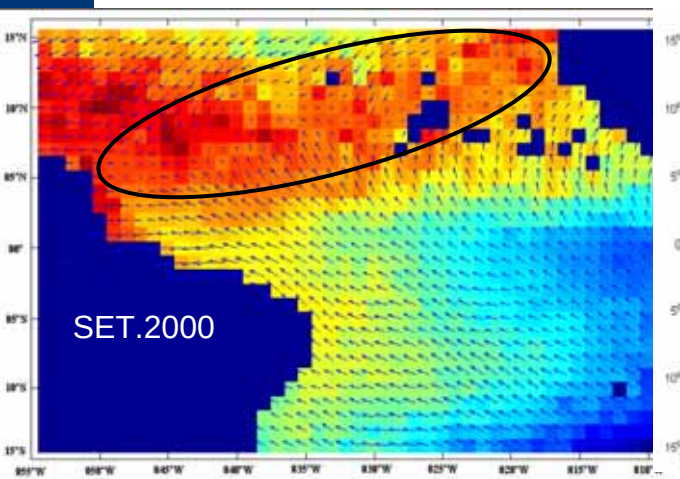

NOAA-12 08/AUG/00 19:14 UT
16 17 18 19 20 21 22 23 24
21°S
22°S
23°S
24°S
25°S
26°S
45°W
44°W
43°W
42°W
41°W
40°W
39°W
-45 -44 -43 -42 -41 -40 -39
-21 -22 -23 -24 -25 -26 -27
2000
500
2000
500
2000
500
2000
(mg m⁻³)
0.01 0.10 1.00 10.00 32.00

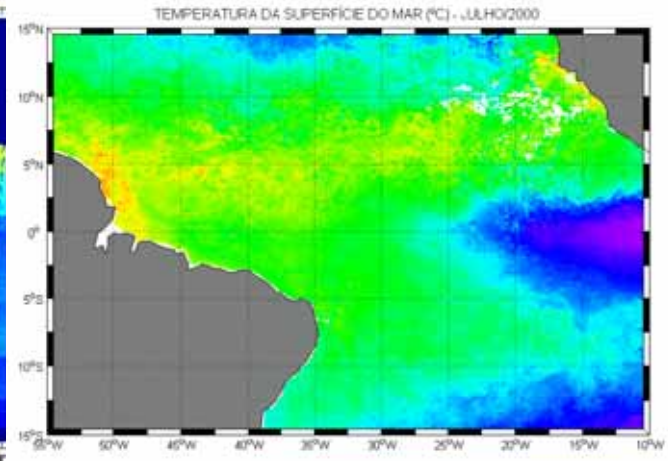

aquecimento global
correntes marinhas
ressurgências
peixes
pescadores
salinidade
poluição marinha
temperatura

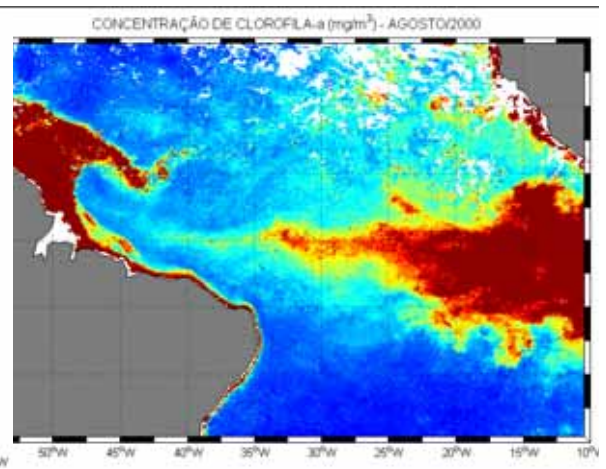


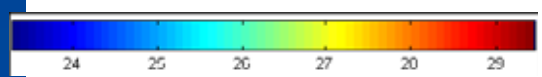


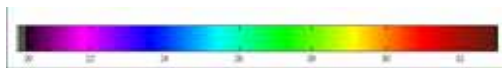




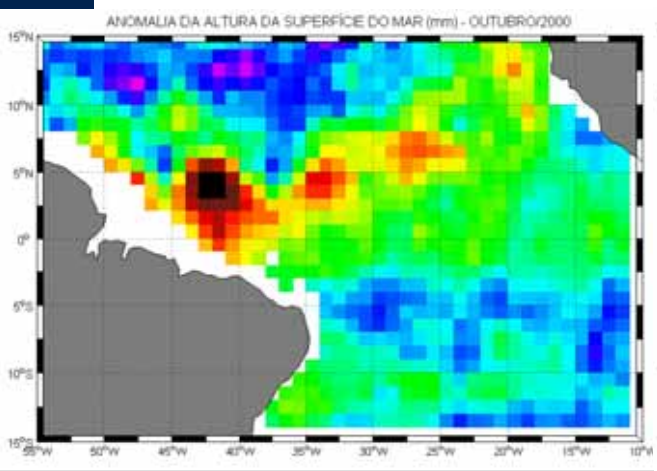


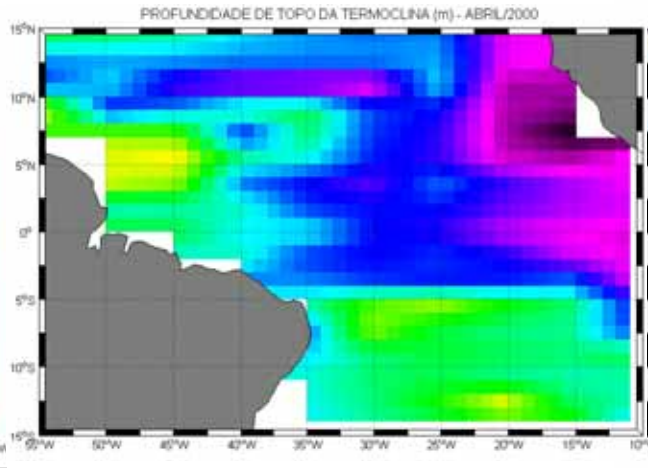


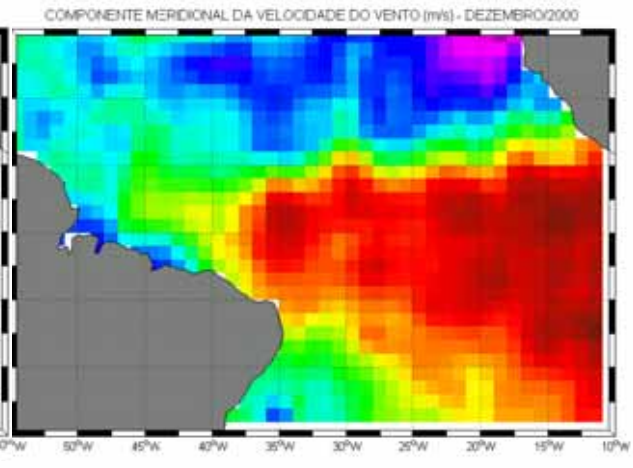


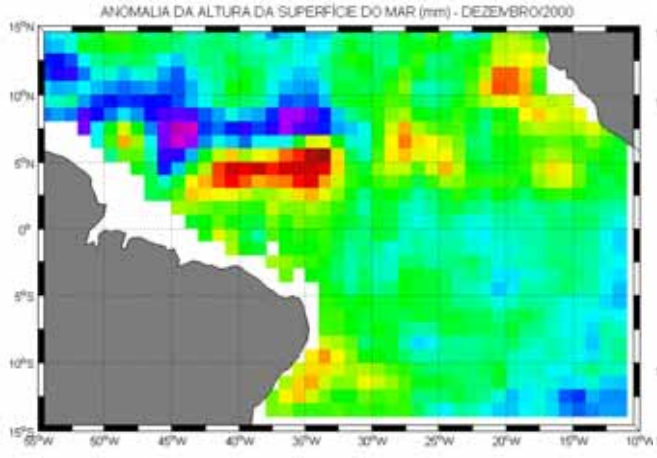


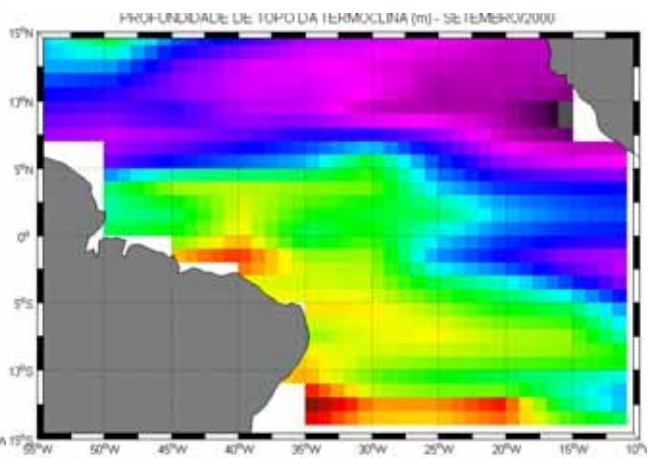
Zagaglia, 2003

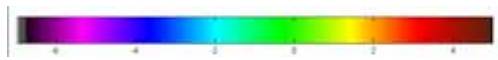


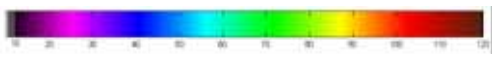




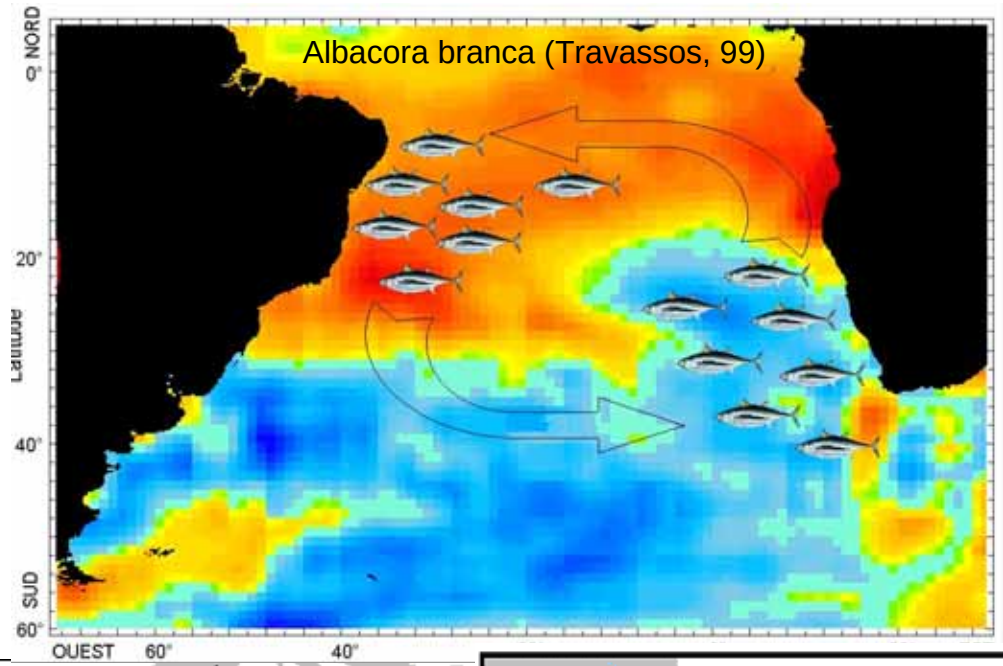


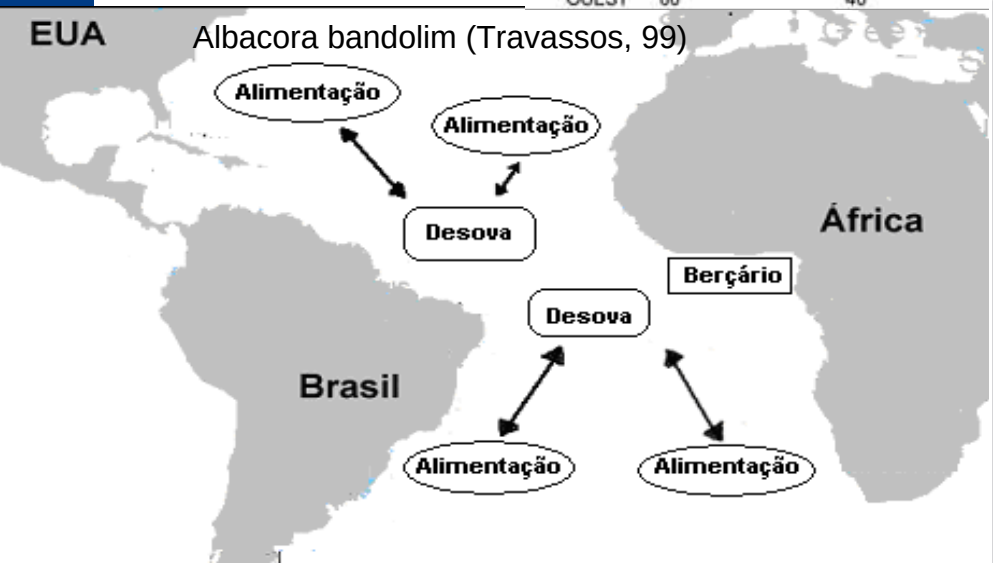


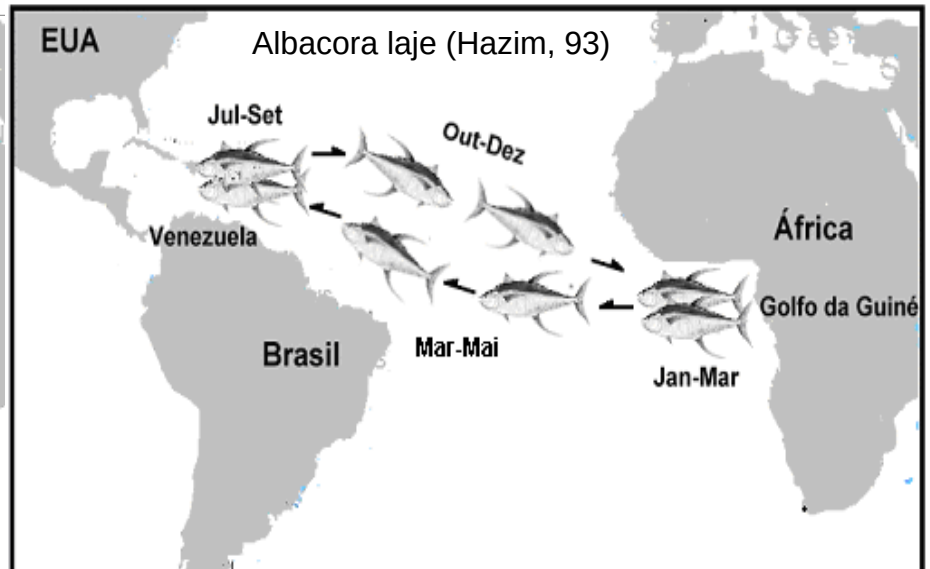


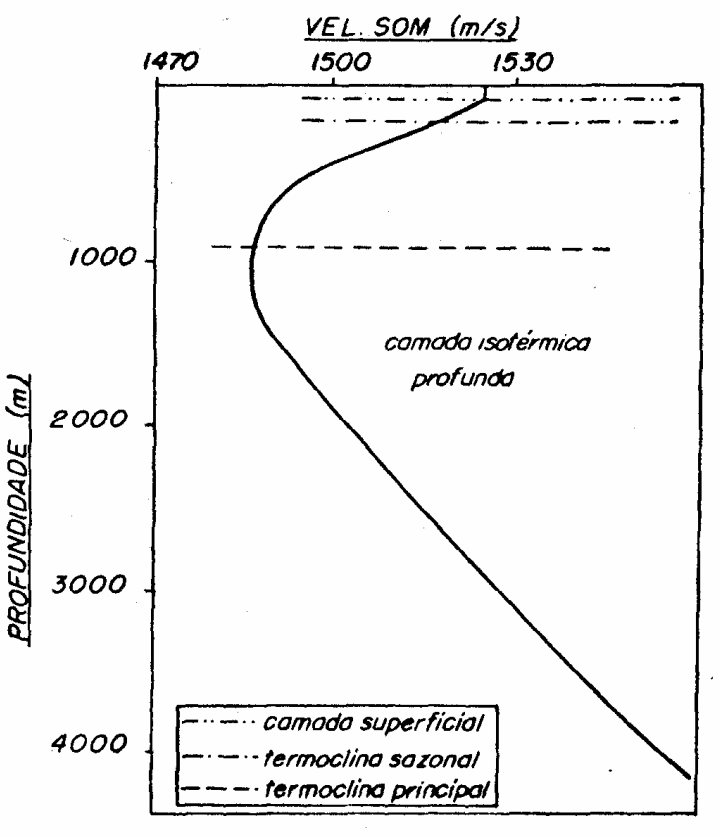


Zagaglia et al., 2005


Albacora branca (Travassos, 99)
0° NORD
20°
40°
SUD
60°
OUEST
60°
40°
Latitude

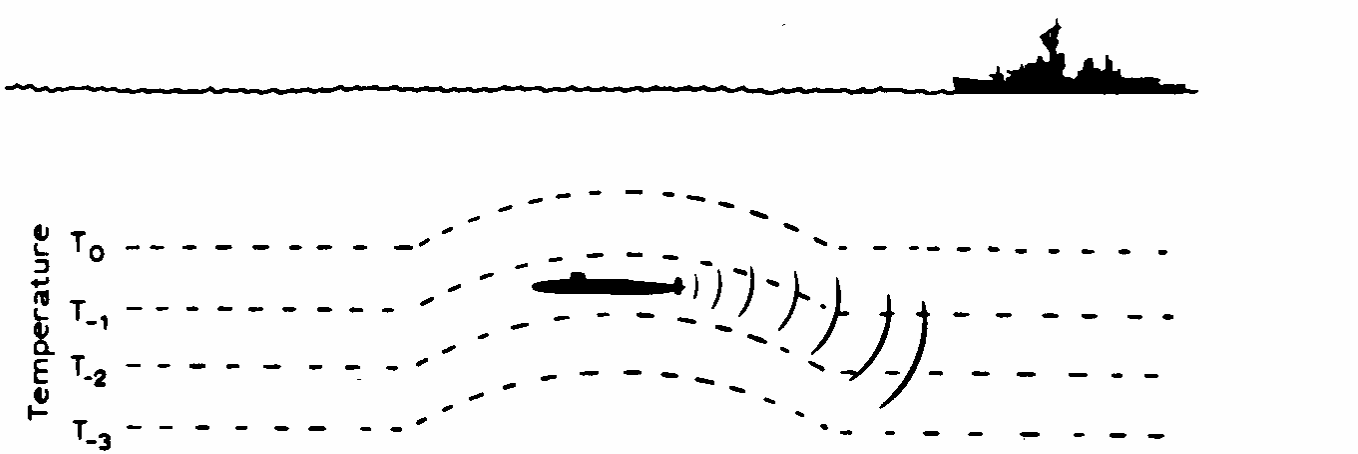

EUA
Albacora bandolim (Travassos, 99)
Alimentação
Alimentação
Desova
África
Berçário
Desova
Brasil
Alimentação
Alimentação


EUA
Albacora laje (Hazim, 93)
Jul-Set
Out-Dez
Venezuela
África
Golfo da Guiné
Brasil
Mar-Mai
Jan-Mar

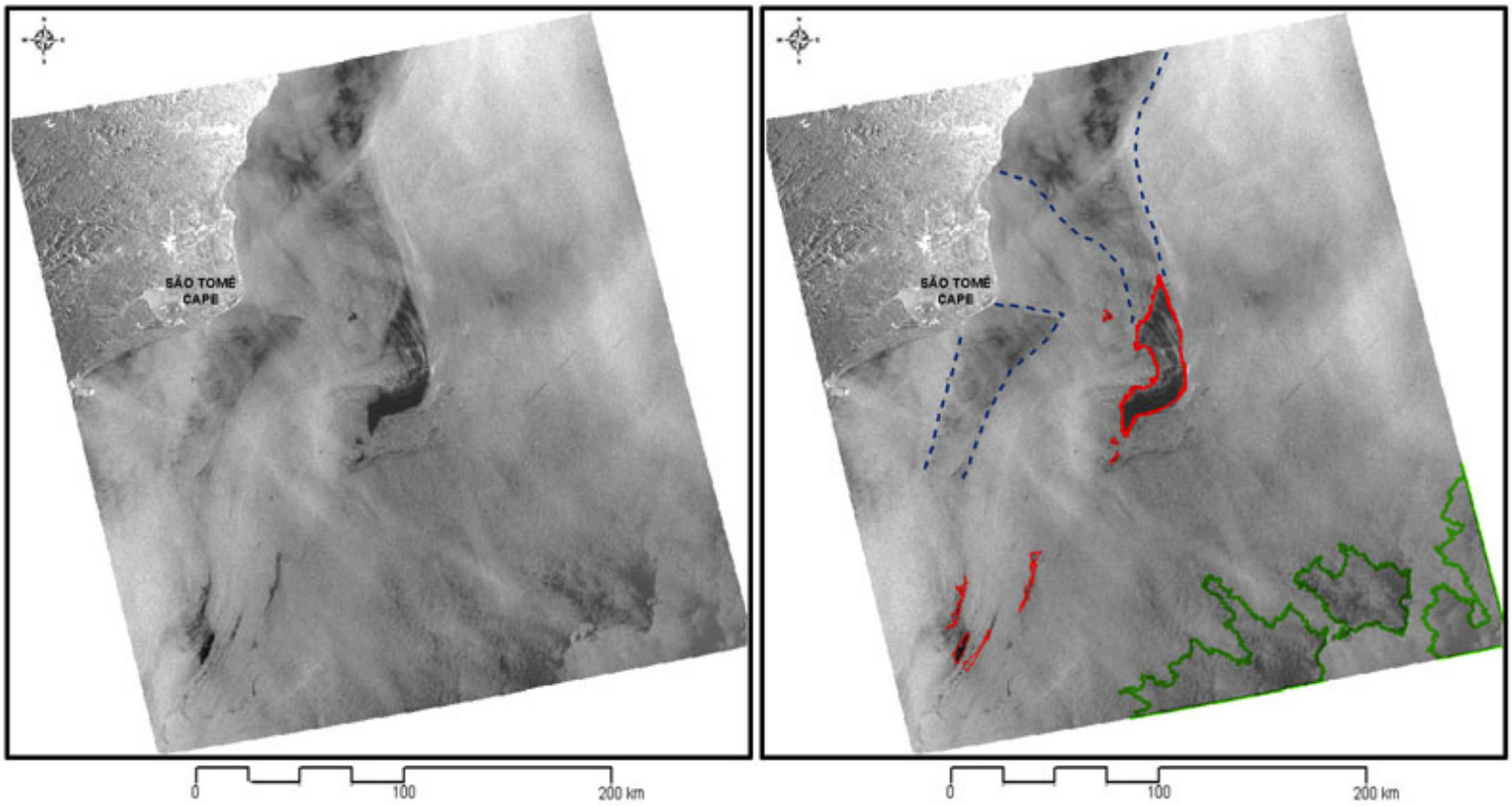


Perfil típico da velocidade do som
Stech, 1974

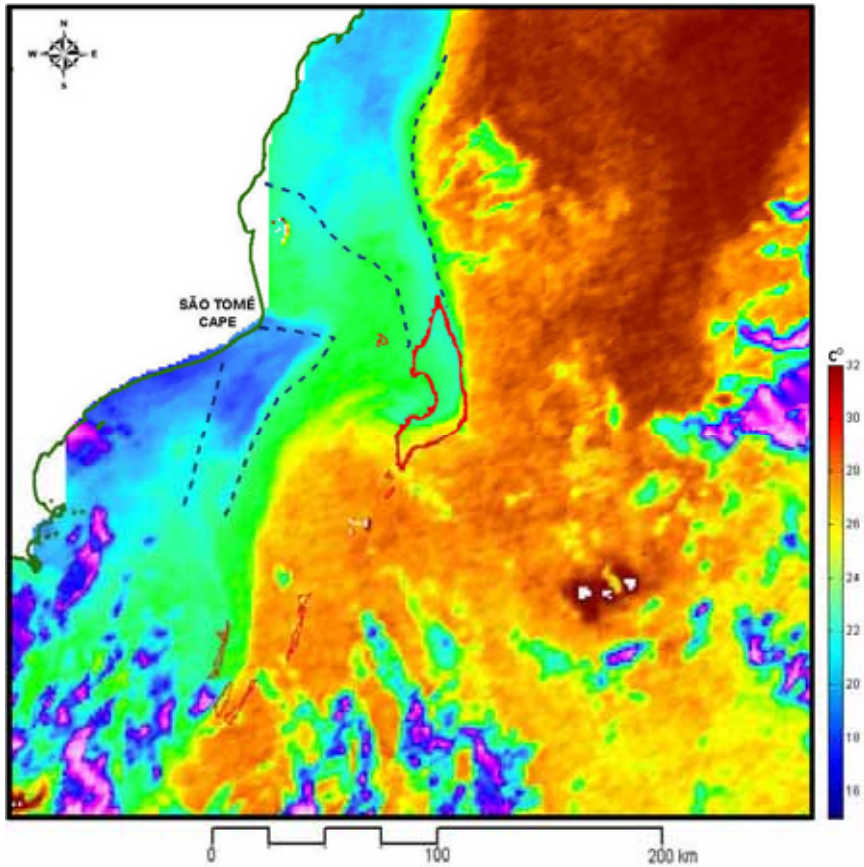
Velocidade do som, vórtice de núcleo frio
Gemmil e Khedouri, 1974



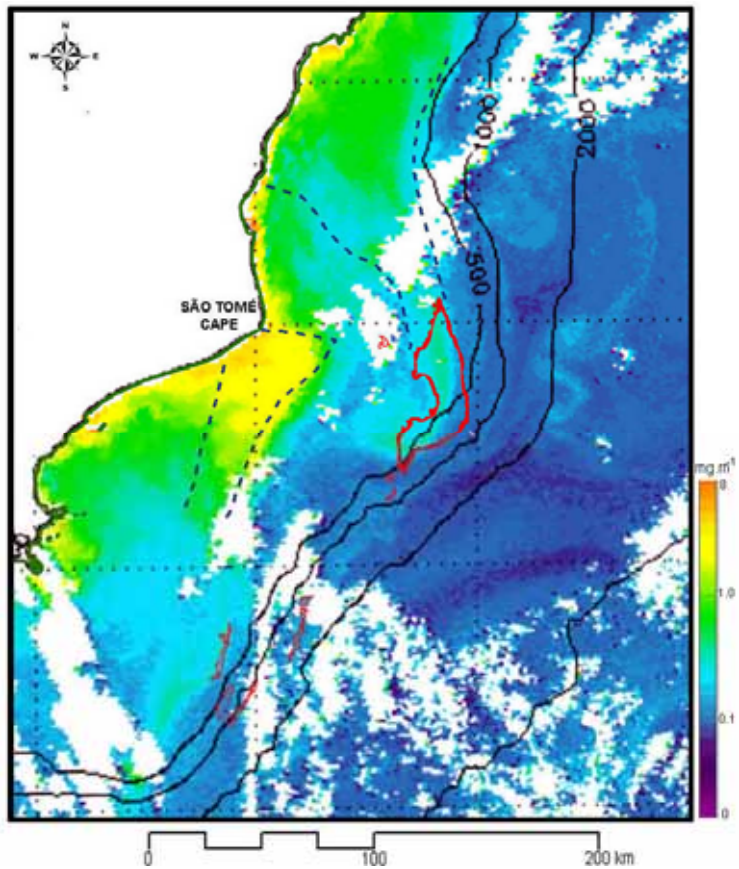
Alvos localizados no interior de um vórtice de núcleo frio não são detectados por sonares passivos, devido à refração dos raios acústicos causada pela presença de águas frias (Etter, 1991)



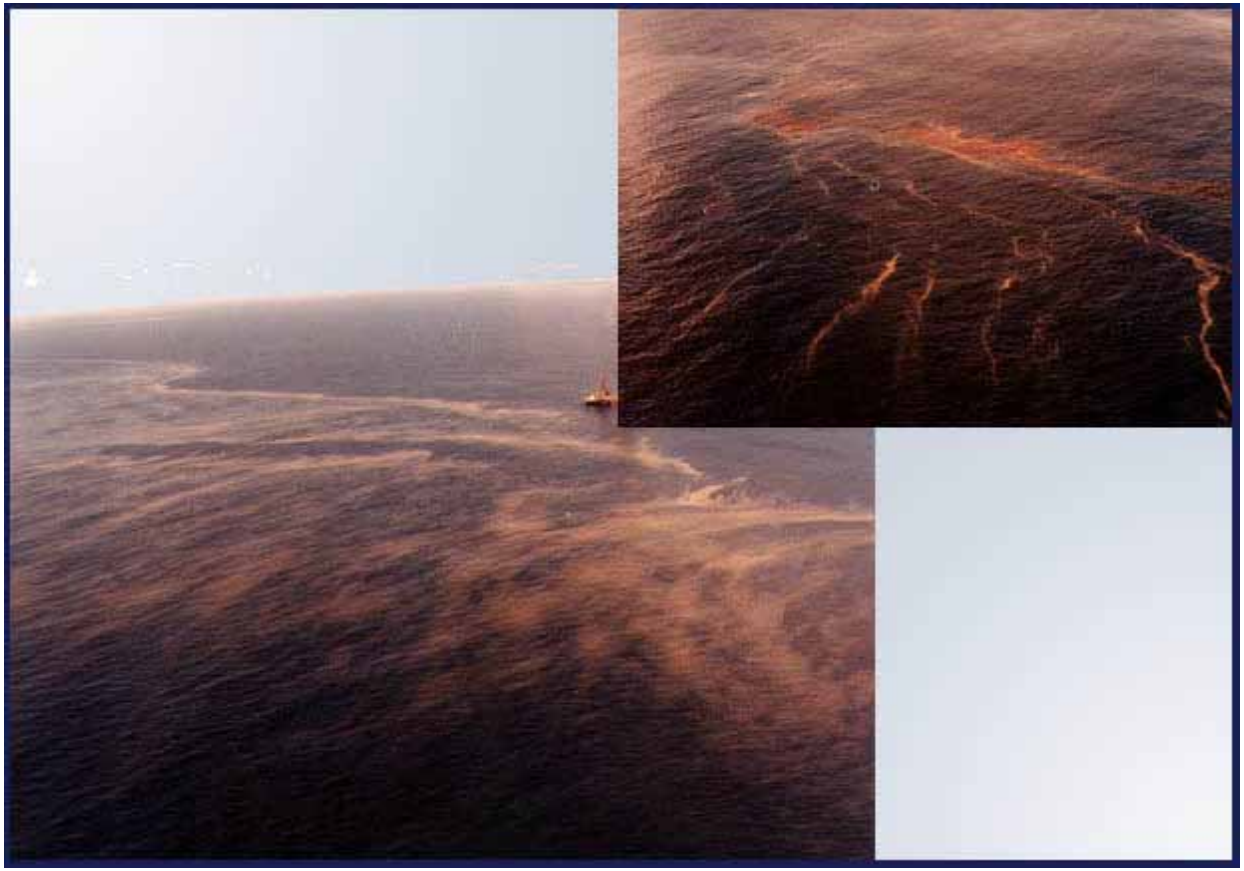
RADARSAT-1 3/abril/2002 21:11 GMT



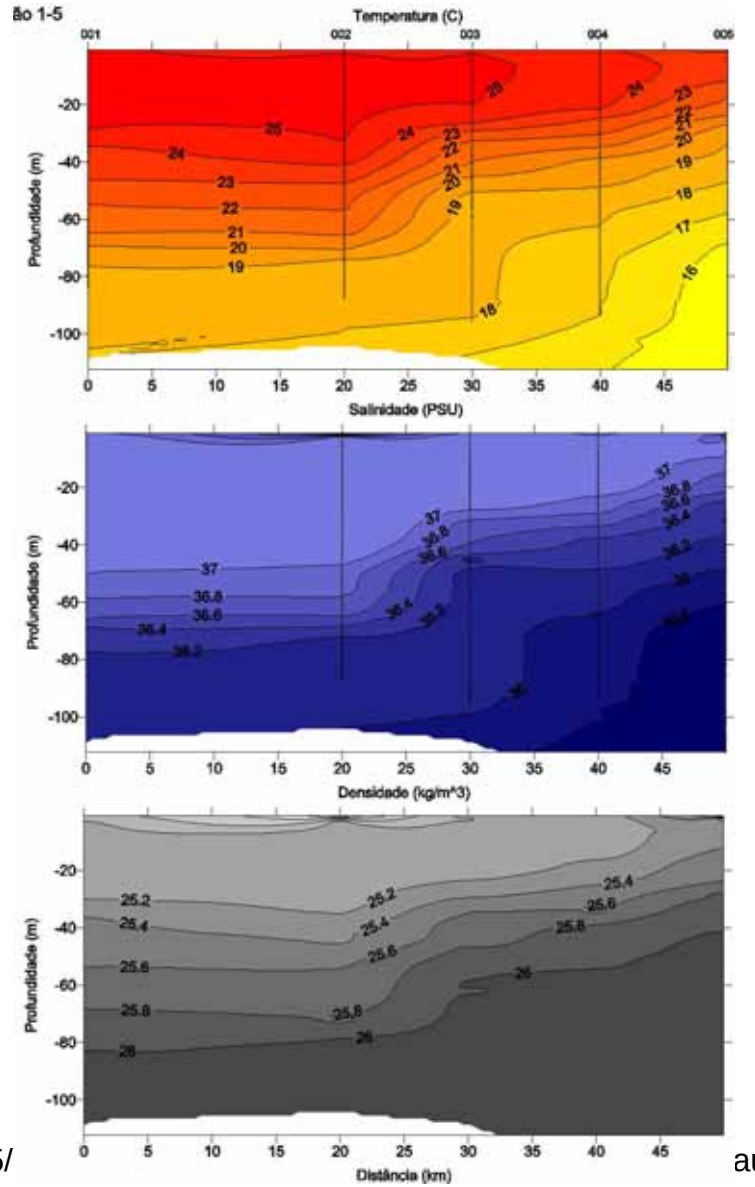
TSM 3/abril/2002 21:09 GMT
AVHRR

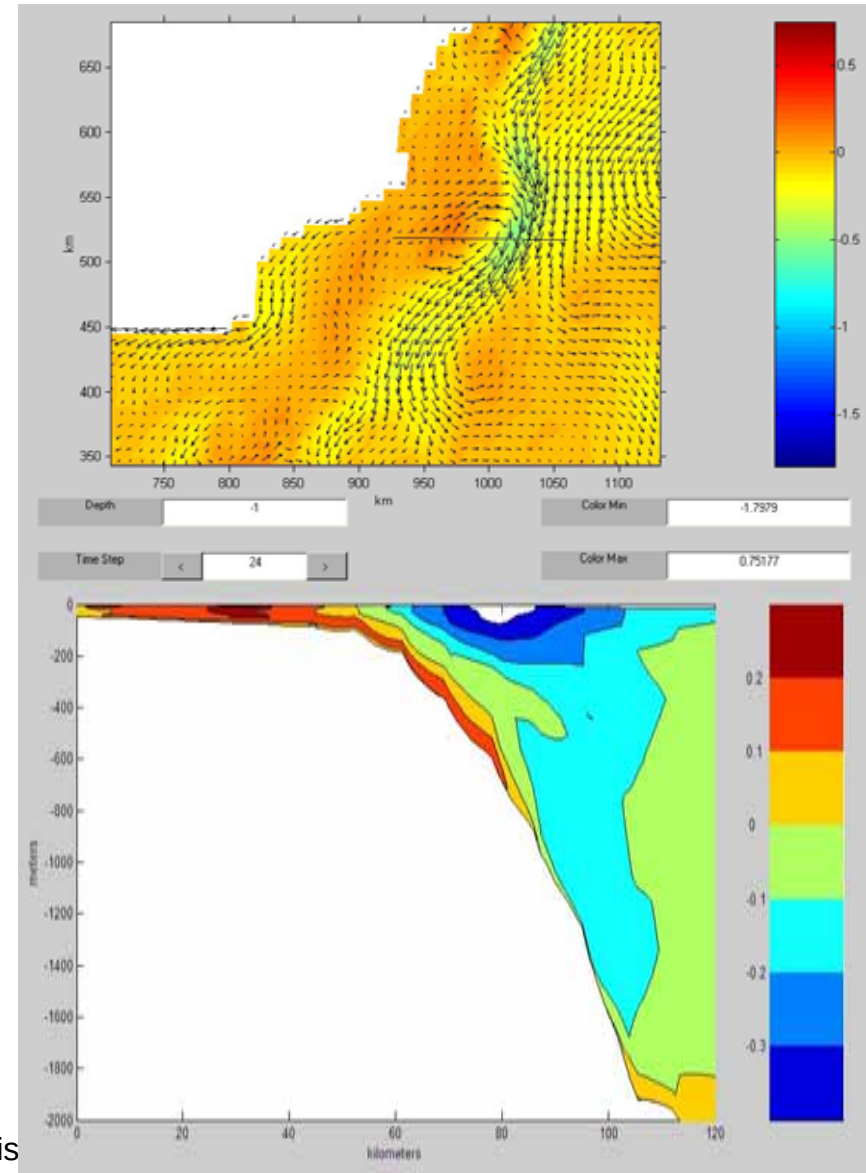


CSM 3/abril/2002 14:05 GMT
SeaWiFS

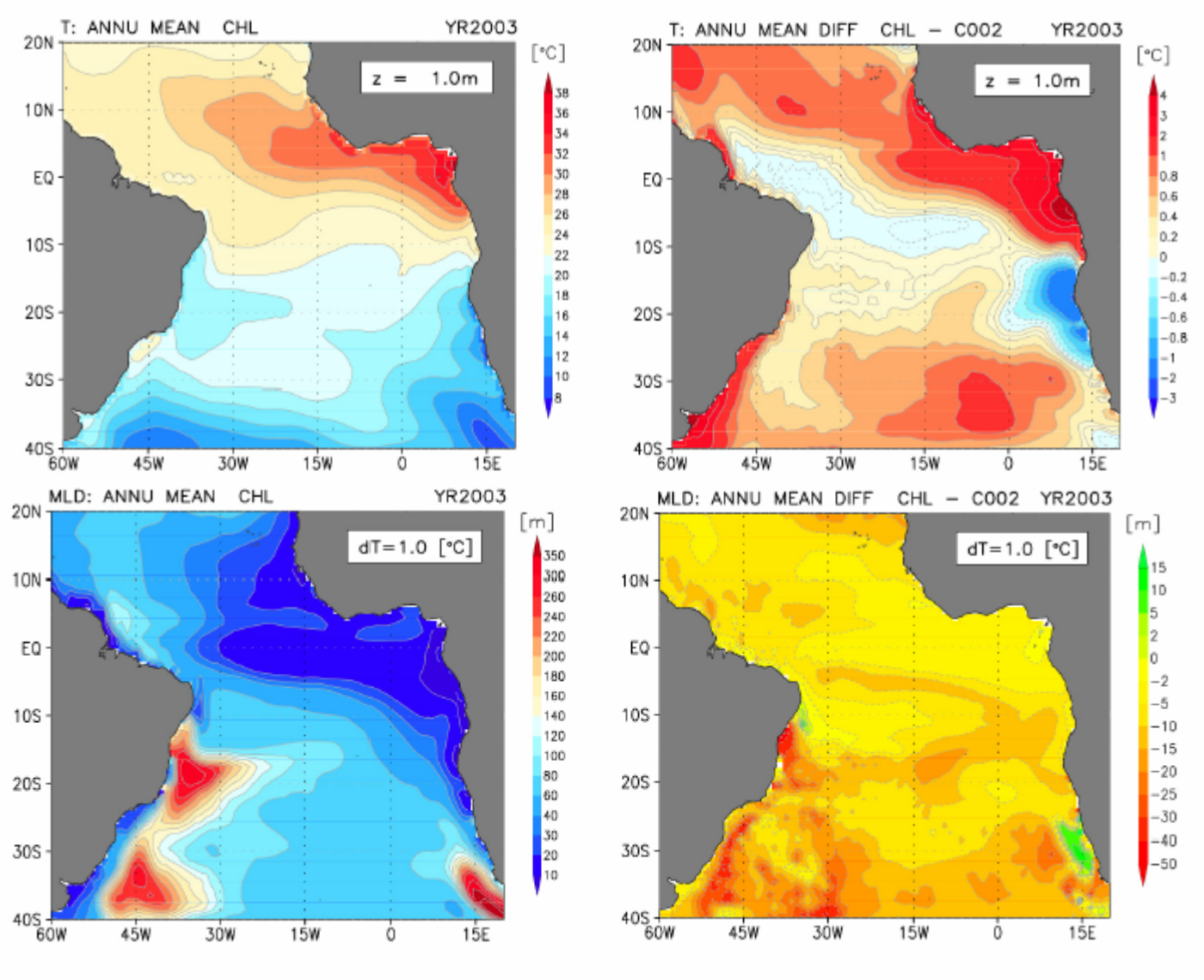


Inspeção da floração de algas com helicóptero 15 horas após a aquisição da imagem RADARSAT-1

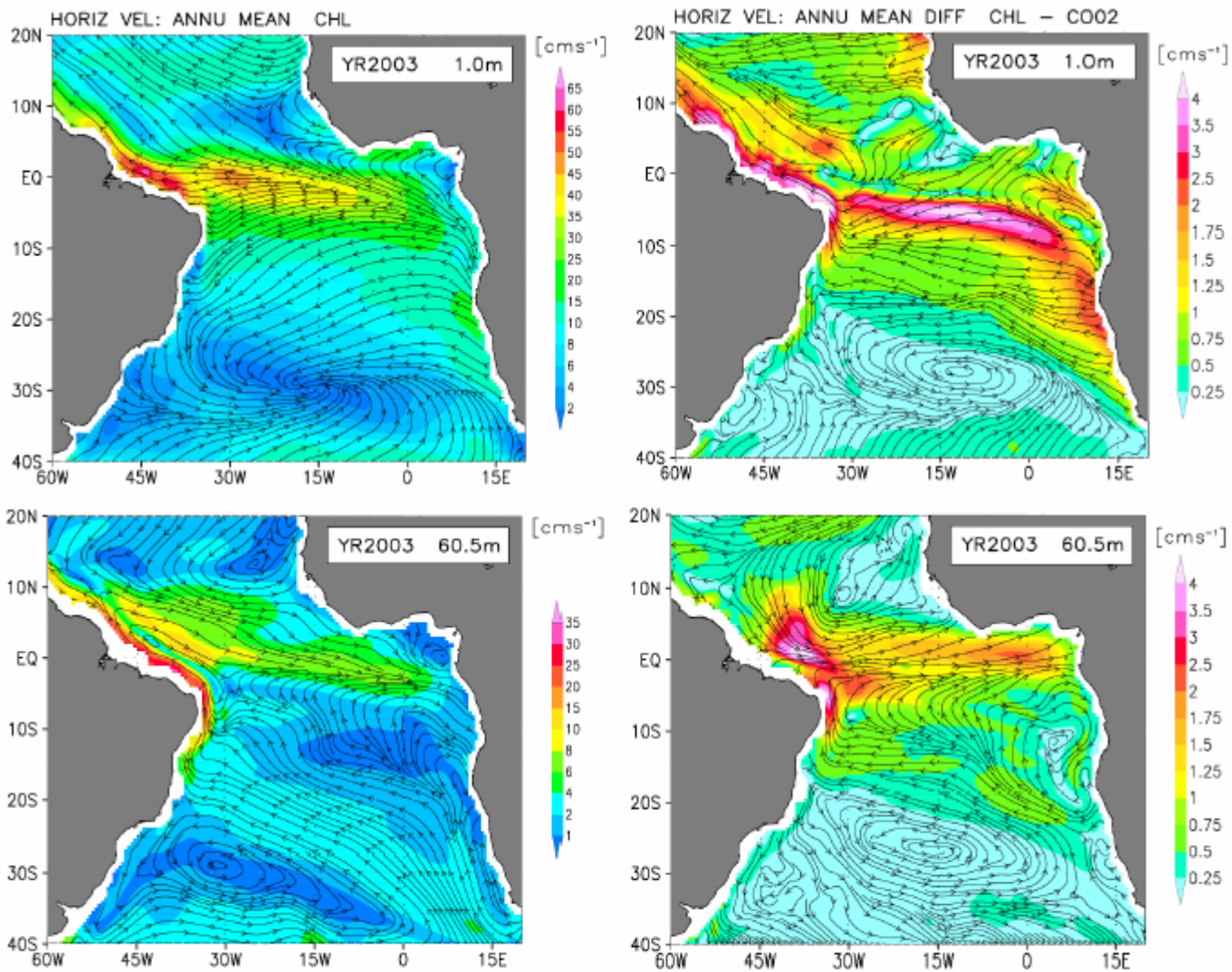

ão 1-5
Temperatura (C)
001
002
003
004
005
Profundidade (m)
Salinidade (PSU)
Densidade (kg/m^3)
Distância (km)


km
Depth
Color Min
Time Step
Color Max
meters
kilometers

The effect of chlorophyll absorption on the thermal structure and circulation



The effect of chlorophyll absorption on the thermal structure and circulation



ANTARES Network

- Promover observações dos ecossistemas costeiros da América Latina em várias escalas, desde série temporais *in situ* até observações por satélites, de modo a detectar e caracterizar as variabilidades espaço-temporais de longo-período

pogo

Global Ocean Observing System

Group for Earth Observation

IAI

International Ocean Colour Coordinating Group

ANTARES - Approach

- Integrar dados de satélites com os dados *in situ* coletados nas estações de séries temporais

- Criar uma base de dados *in* situ e de satélites para aplicações científicas, educacionais e de gerenciamento dos recursos costeiros

List of participants

Fundación La Salle de Ciencias Naturales	FLASA	Venezuela
Universidad Simón Bolívar	USB	Venezuela
Fundação Universidade Federal de Rio Grande	FURG	Brasil
Instituto Oceanográfico da Universidade de São Paulo	IOUSP	Brasil
Instituto Nacional de Pesquisas Espaciais	INPE	Brasil
Universidad de Concepción	UdeC	Chile
Instituto Nacional de Investigación y Desarrollo Pesquero	INIDEP	Argentina
Estación de Fotobiología Playa Unión	EFPU	Argentina
Instituto de Astronomía y Física del Espacio	IAFE	Argentina
Bedford Institute of Oceanography	BIO	Canada
Dalhousie University	Dal	Canada
Institute for Marine Remote Sensing, University of South Florida	ImaRS/USF	USA
Scripps Institution of Oceanography	SIO	USA
Universidad Autónoma de Baja California	UABC	Mexico

In situ time-series

Remote Sensing Centers

New Member

Candidates

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Dirección http://home.antares.ws/ Ir Vínculos

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English

ANTARES main goal is the study of long-term changes in coastal ecosystems around South 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) around South America are shared among members and with the public. Capacity building, scientific and technical collaboration are key in our task. ANTARES network is supported by IOCCG, POGO and a seed SGP project from IAI. Current participating countries are: Argentina, Brazil, Canada, Chile, Peru, USA, Venezuela.

READ MORE

Español:

El principal objetivo de ANTARES es el estudio a de los cambios a largo plazo de los ecosistemas costeros alrededor de Sudamérica, para distinguir la variabilidad natural de las perturbaciones externas (efectos antropogénicos). Para lograr este objetivo se comparten, entre los miembros y con el público en general, datos in situ de estaciones costeras y datos satelitales (temperatura y clorofila) alrededor de Sudamérica. La formación de recursos humanos, colaboración científica y técnica son clave en nuestra tarea. La red ANTARES es apoyada por IOCCG, POGO y un proyecto inicial de IAI. Los países participantes actualmente son: Argentina, Brasil, Canadá, Chile, Perú, USA, Venezuela.

LEA MAS

Português:

O principal objetivo da rede ANTARES é o estudo das mudanças de longo período em sistemas costeiros ao redor da América do Sul de modo a distinguir a variabilidade natural de perturbações externas (efeitos antropogênicos). Para alcançar este objetivo são compartilhados entre os membros da rede e o público em geral, dados in situ de estações costeiras e dados de satélites (concentração de clorofila e temperatura da superfície do mar) em torno do continente sulamericano. A capacitação de recursos humanos e a colaboração técnica e científica são consideradas fundamentais em nossa tarefa. A rede ANTARES é apoiada pelo IOCCG e POGO, e tem um projeto inicial financiado pelo IAI. Os países atualmente participantes são: Argentina, Brasil, Canadá, Chile, EUA, Peru, e Venezuela.

AER IGNIS AQVA TERRA

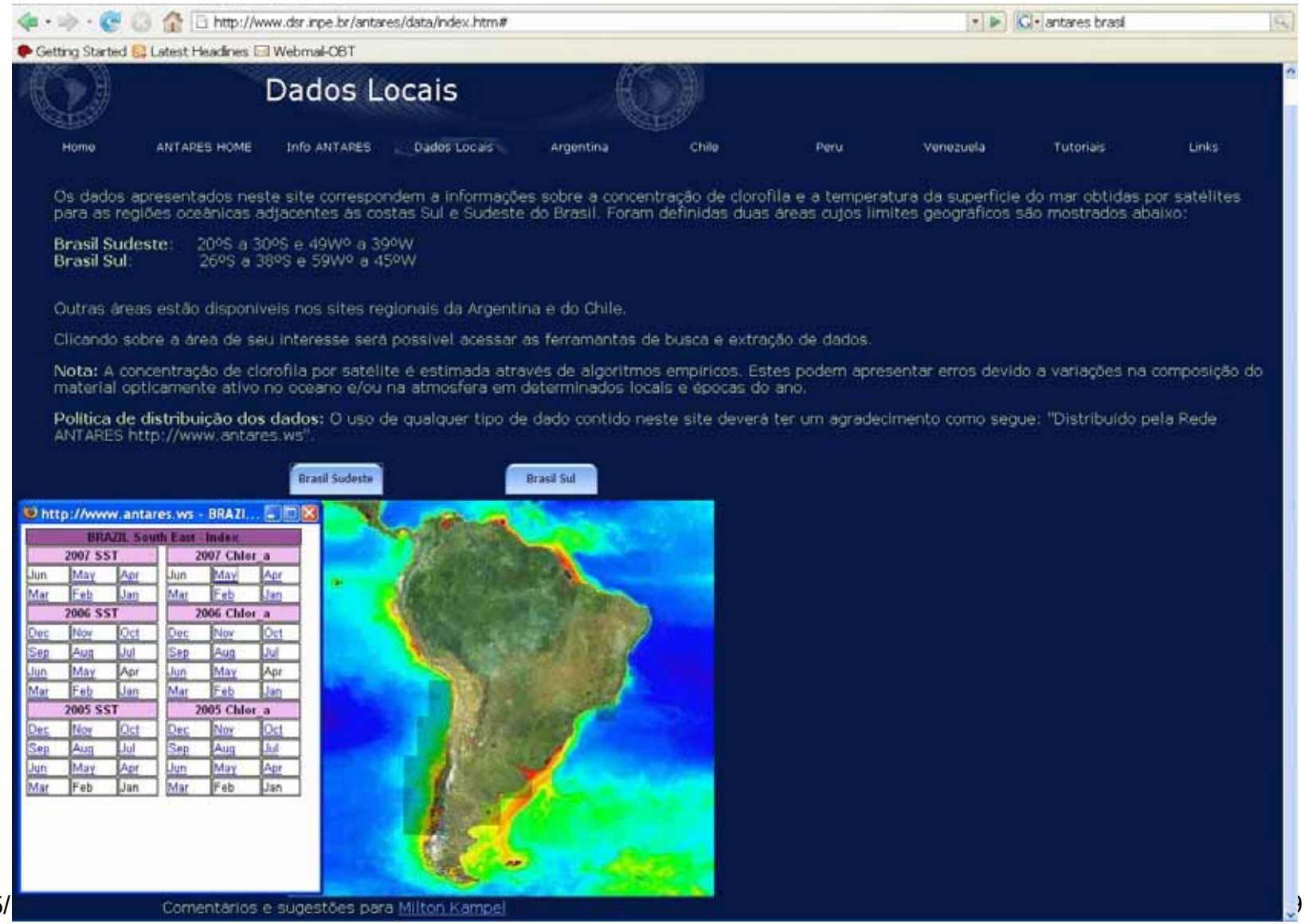
ANTARES

Internet

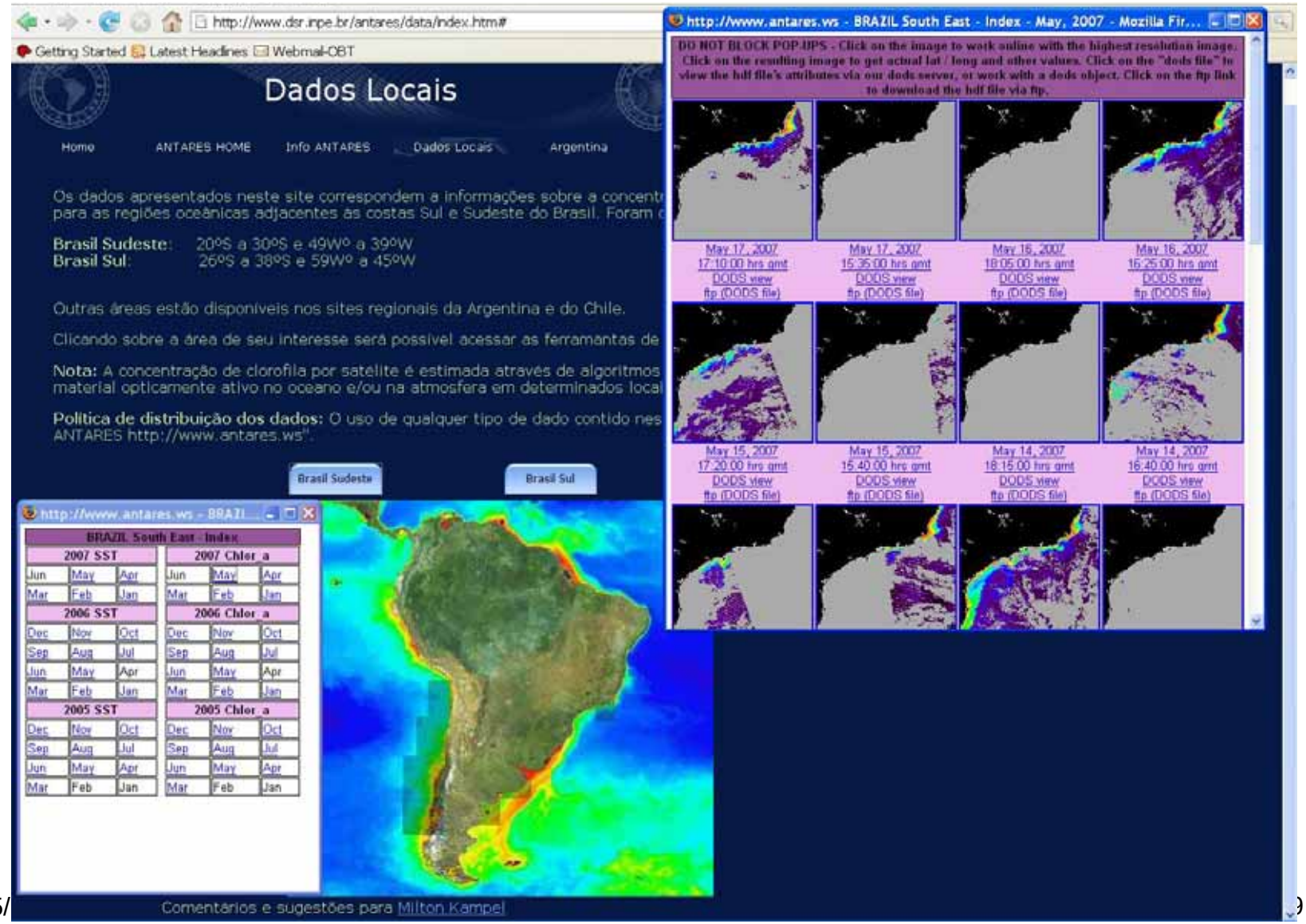
ANTARES – Local pages - Brazil

ANTARES – Local data - satellite

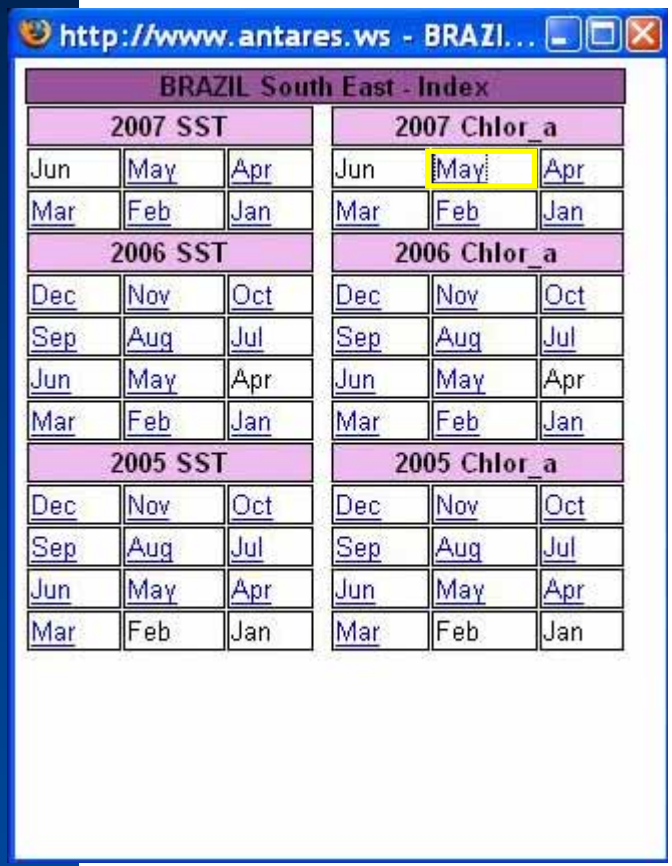
ANTARES – Brazil Southeast

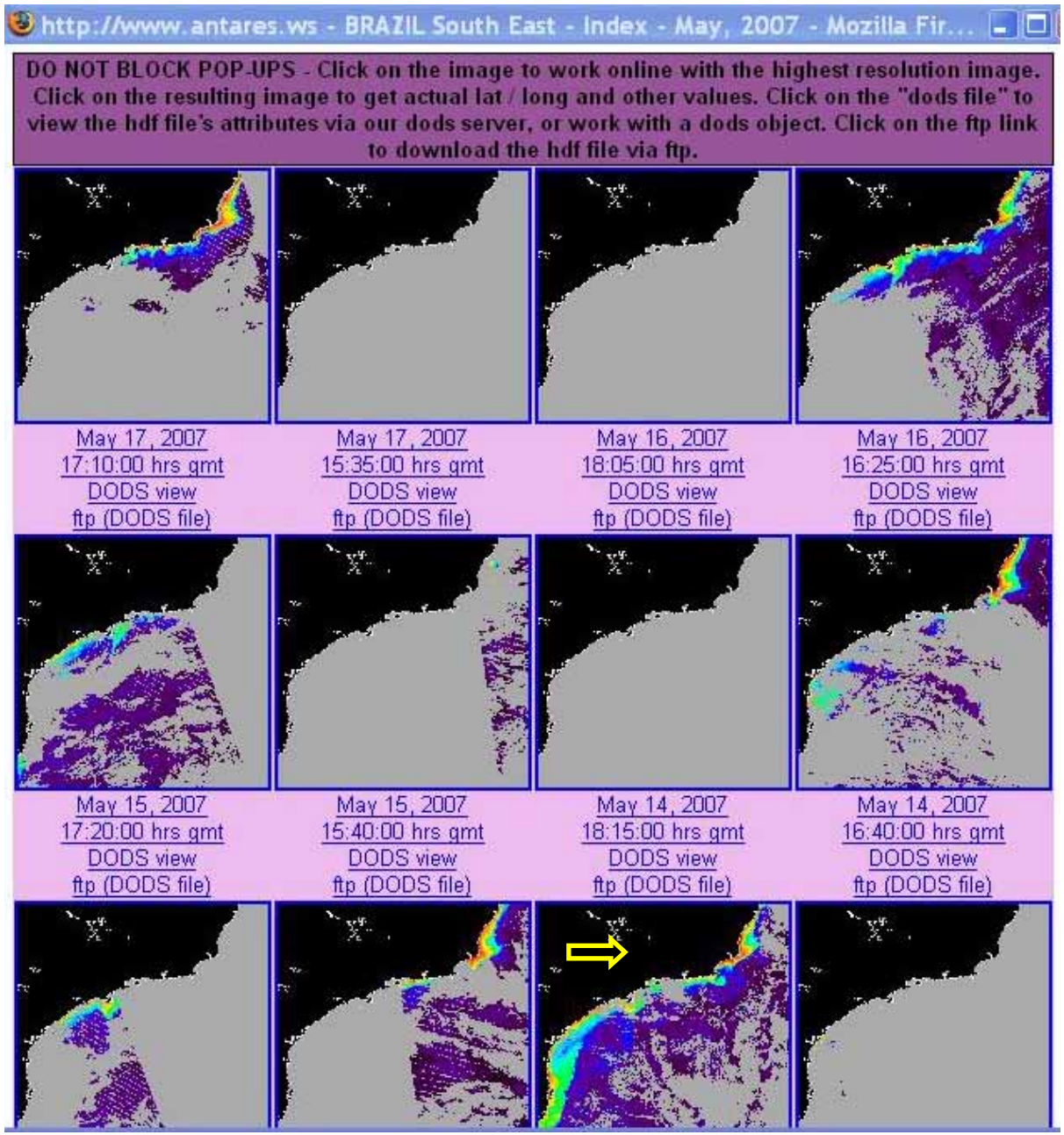


ANTARES – Brasil Southeast Chlorophyll

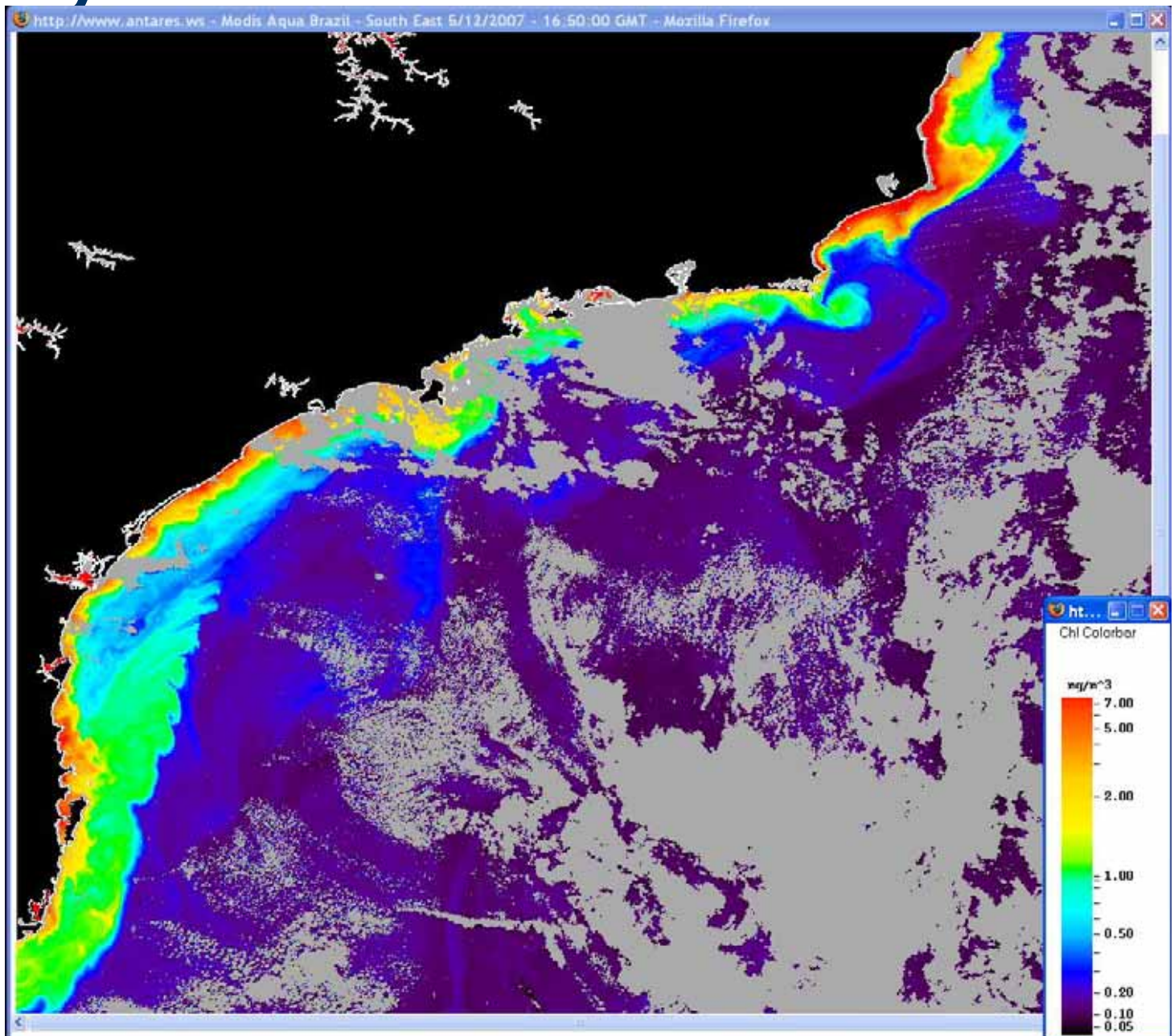


Chlorophyll

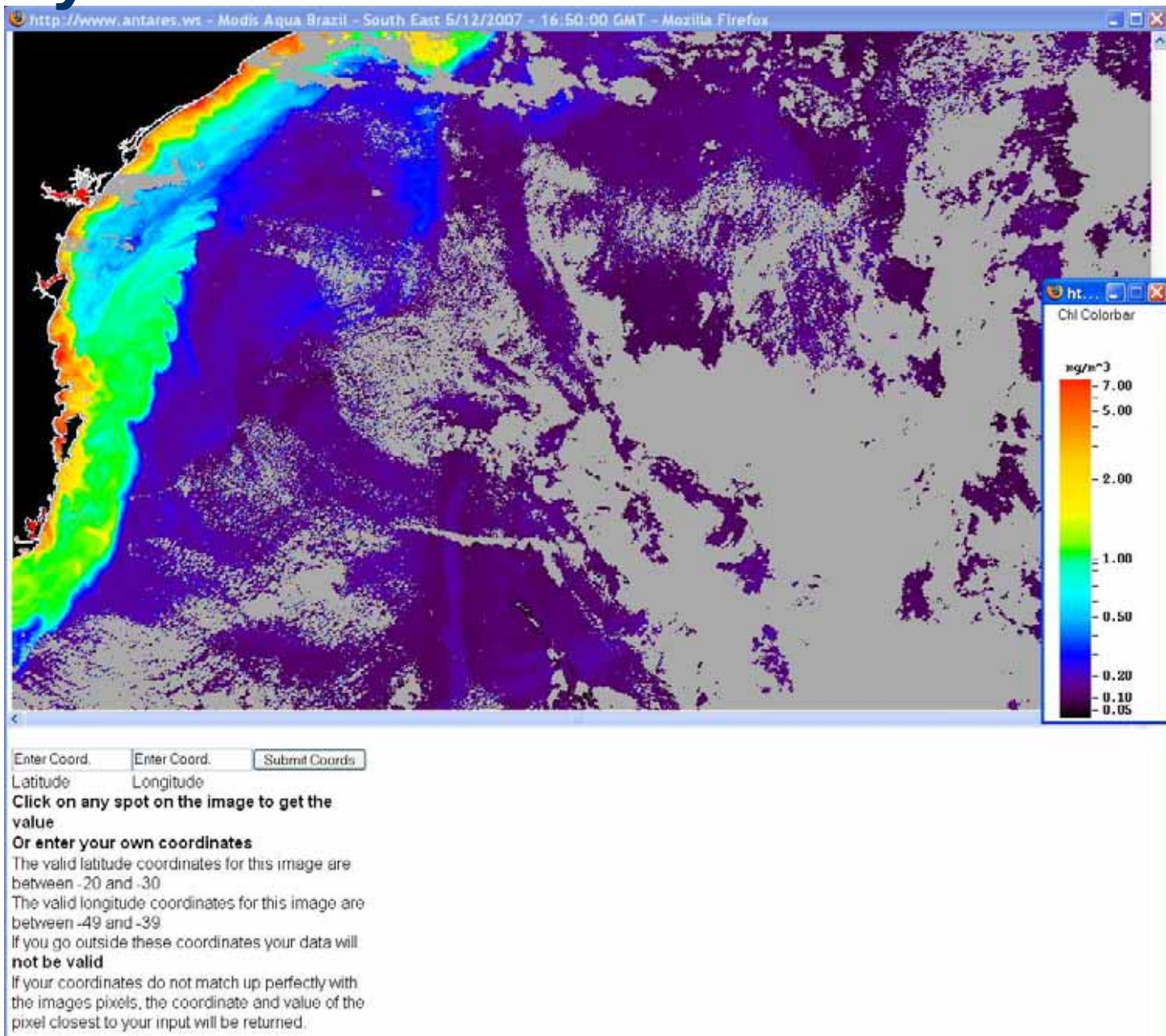




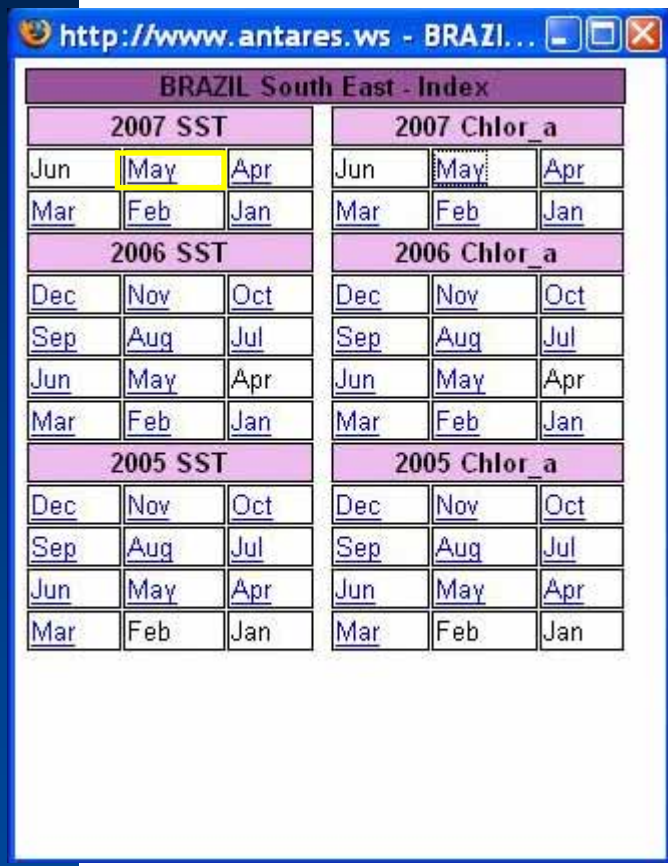
Chlorophyll 12/5/07

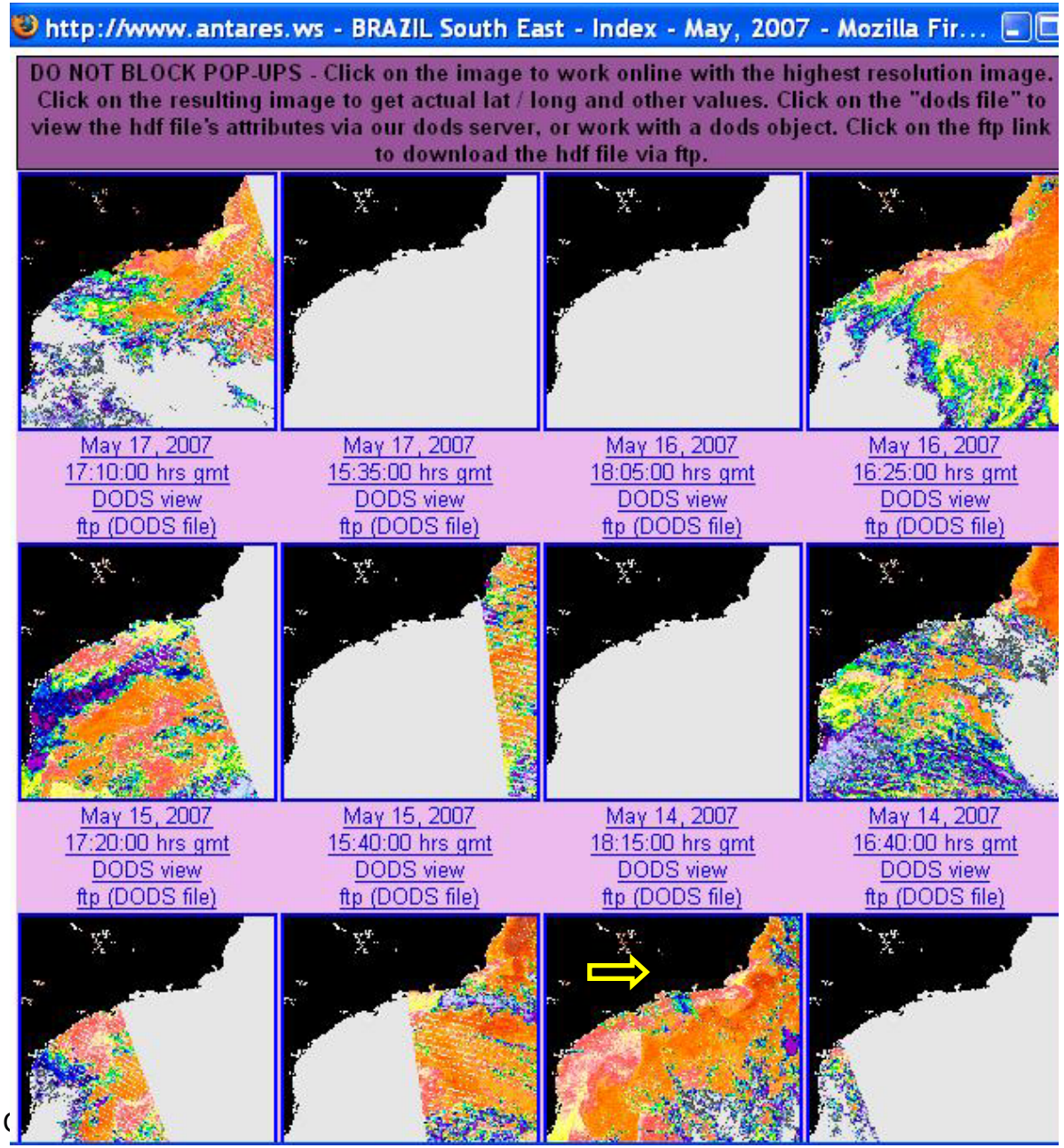


Chlorophyll 12/5/07

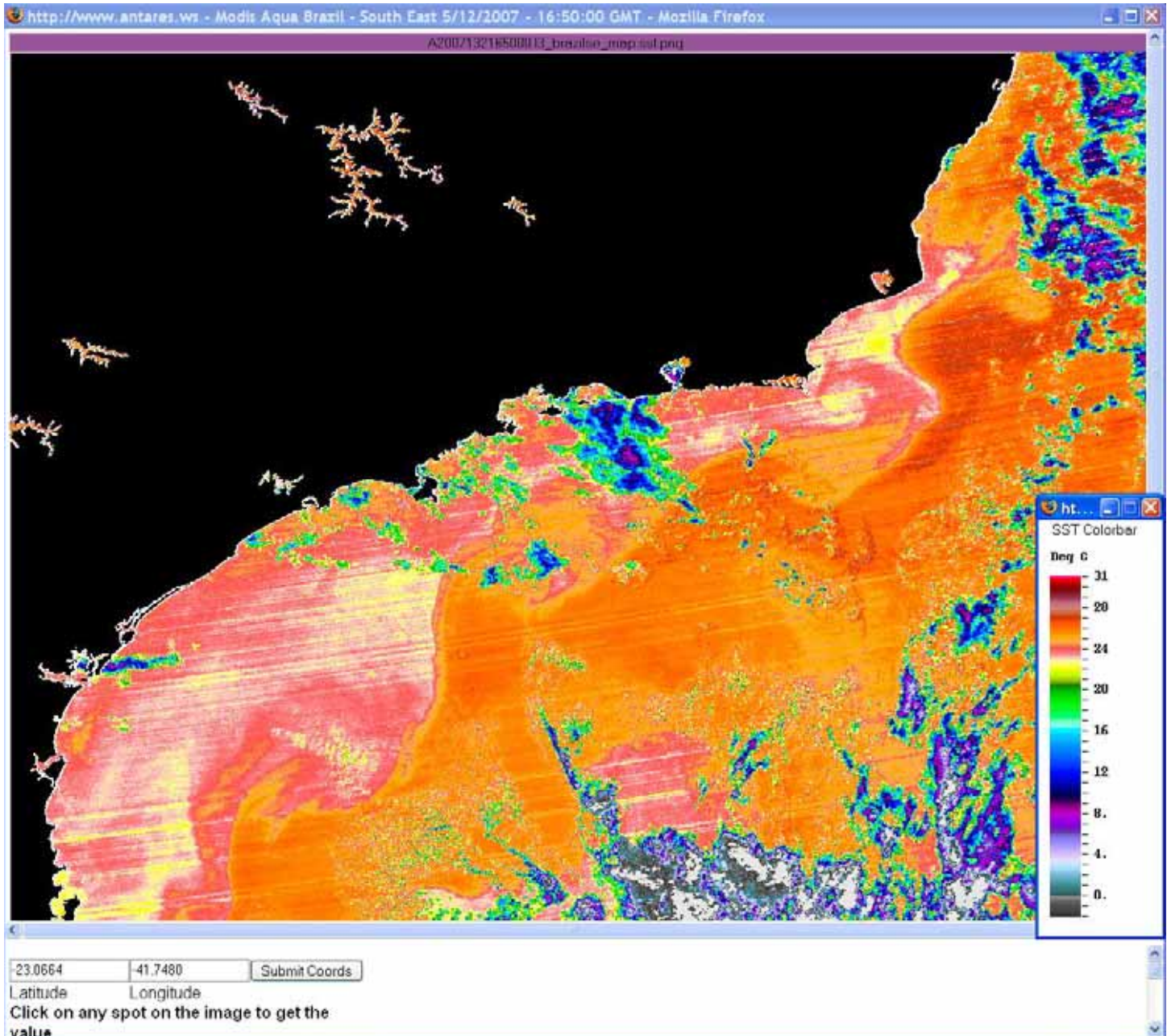


Tmeperature





Temperature 12/5/07



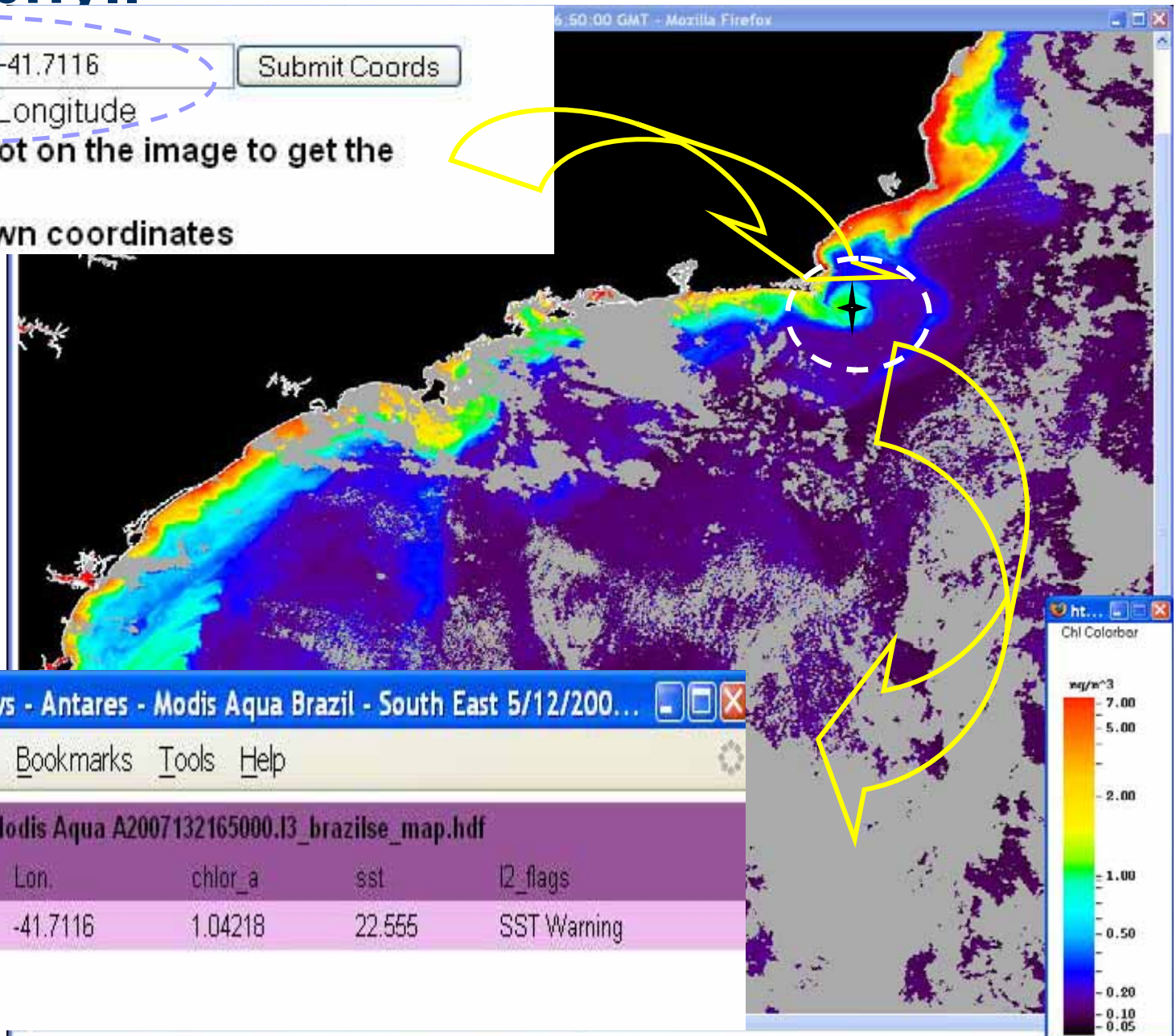
Chlorophyll

-23.0937 | -41.7116 | Submit Coords

Latitude | Longitude

Click on any spot on the image to get the value

Or enter your own coordinates



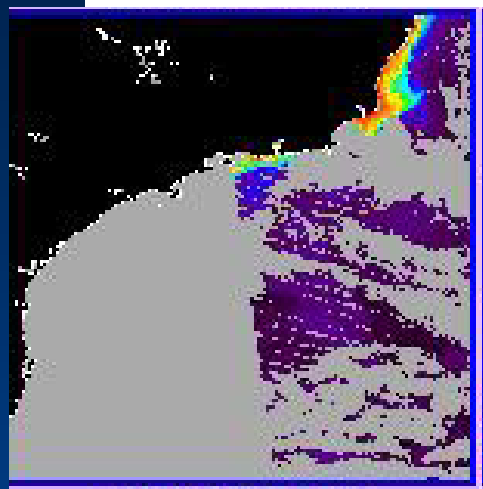
http://www.antares.ws - Antares - Modis Aqua Brazil - South East 5/12/200...

File Edit View History Bookmarks Tools Help

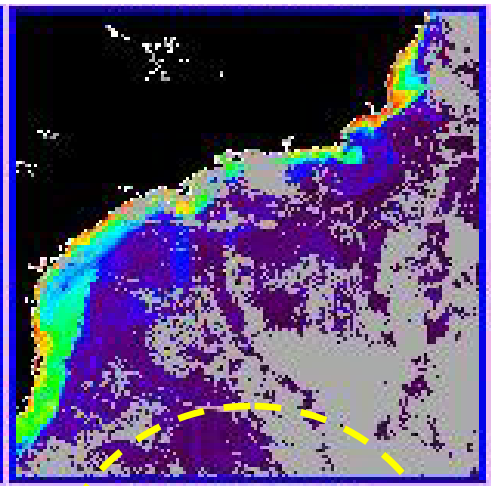
Modis Aqua A2007132165000.l3_brazilse_map.hdf

Click	Lat	Lon	chlor_a	sst	l2_flags
1	-23.0937	-41.7116	1.04218	22.555	SST Warning

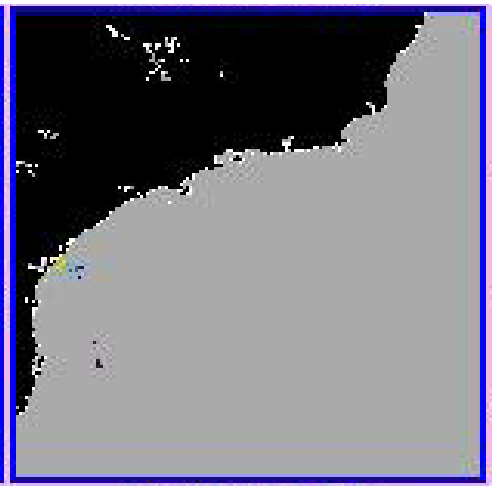
DODS – Distributed Ocean Data System



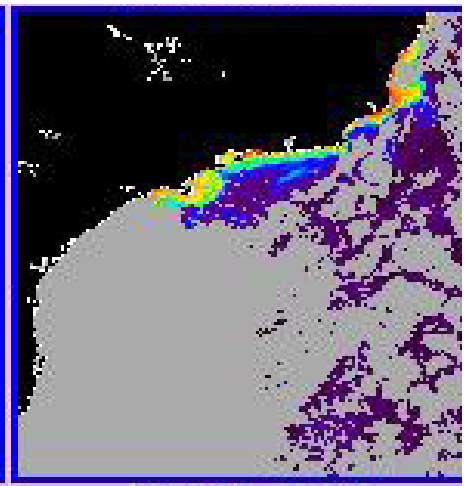
May 13, 2007
15:55:00 hrs gmt
DODS view
ftp (DODS file)



May 12, 2007
16:50:00 hrs gmt
DODS view
ftp (DODS file)

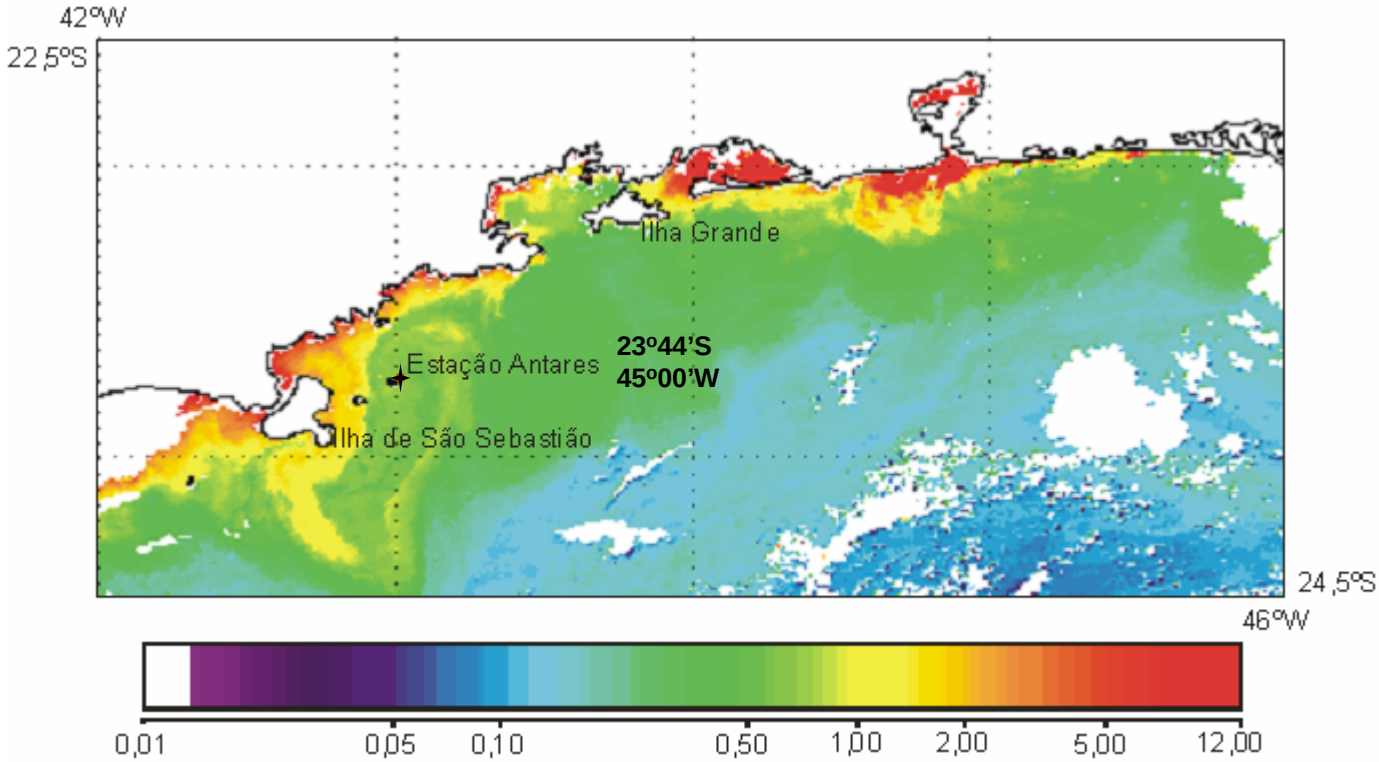


May 11, 2007
17:45:00 hrs gmt
DODS view
ftp (DODS file)



May 11, 2007
16:05:00 hrs gmt
DODS view
ftp (DODS file)

ANTARES-Ubatuba time-series station



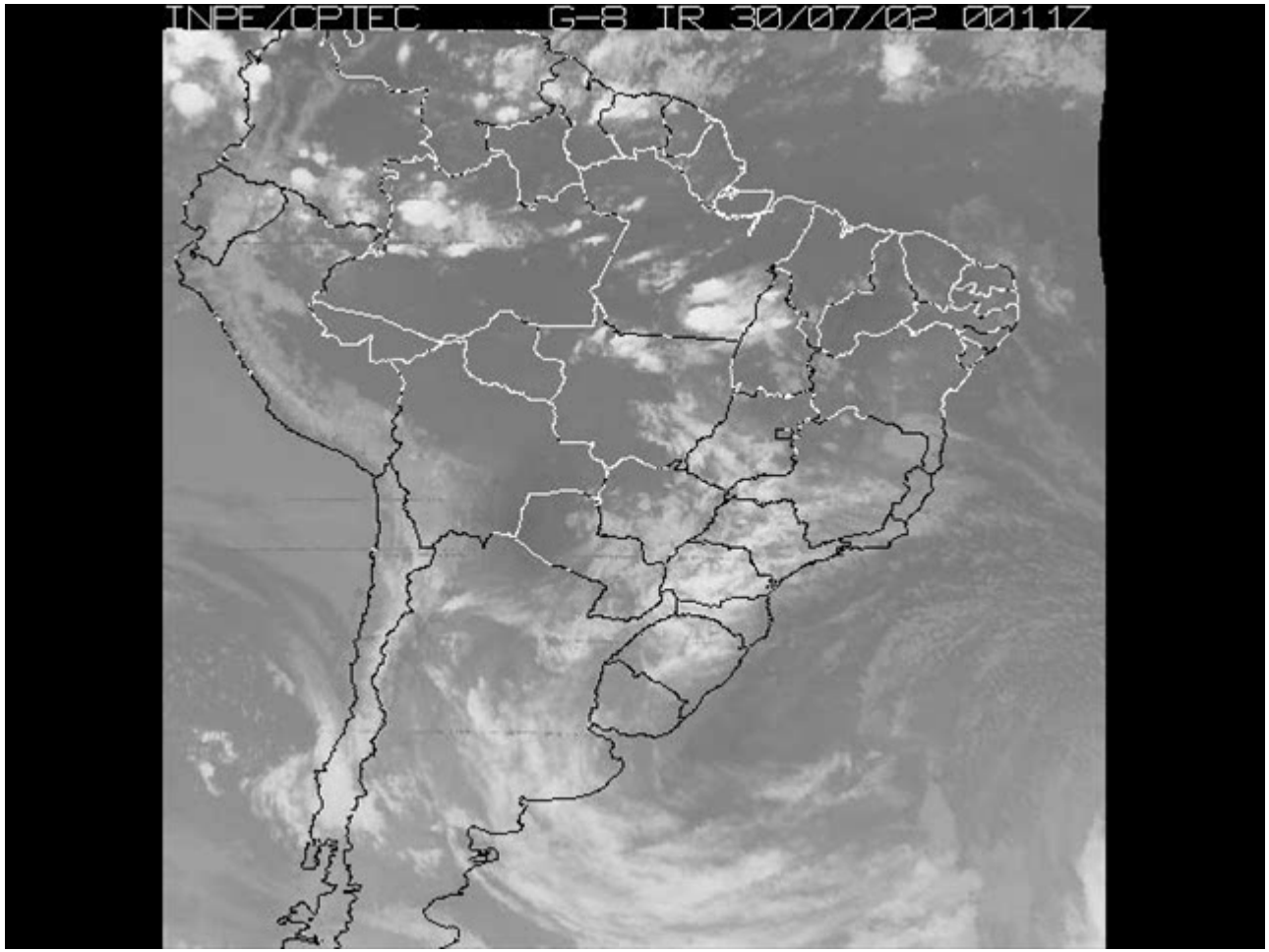
Methodology

- Série temporal mensal iniciada em dezembro 2004;
- Amostragem:
  - 0, 5, 10, 25 e 40 m;
- Variáveis:
  - Nutrientes – nitrito, nitrato, amônia, fosfato e silicato;
  - Temperatura e Salinidade;
  - Clorofila-*a;*
  - Produção primária;
  - Reflectância marinha.

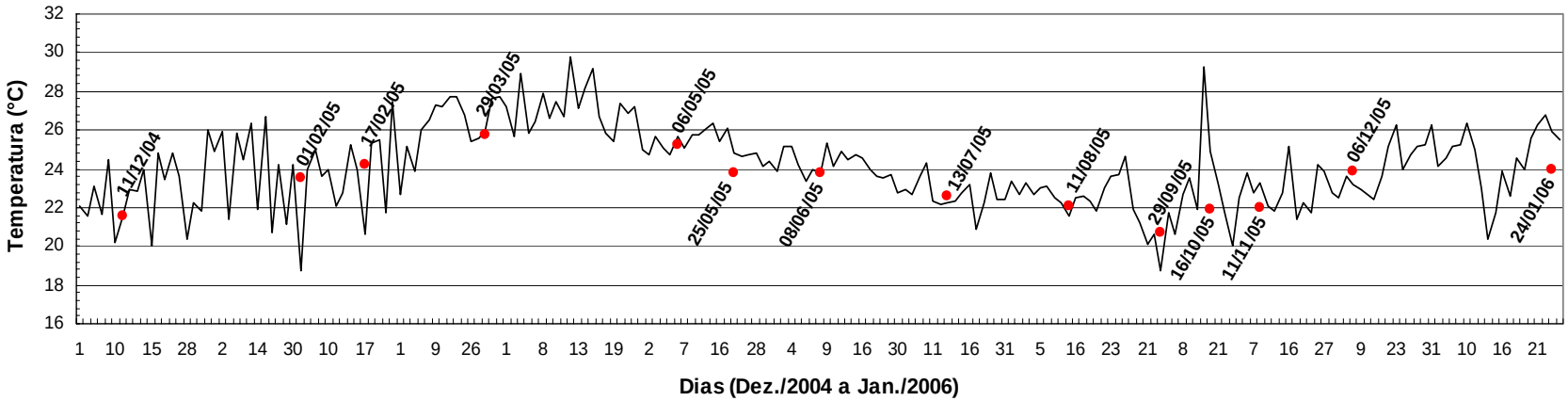
Methodology

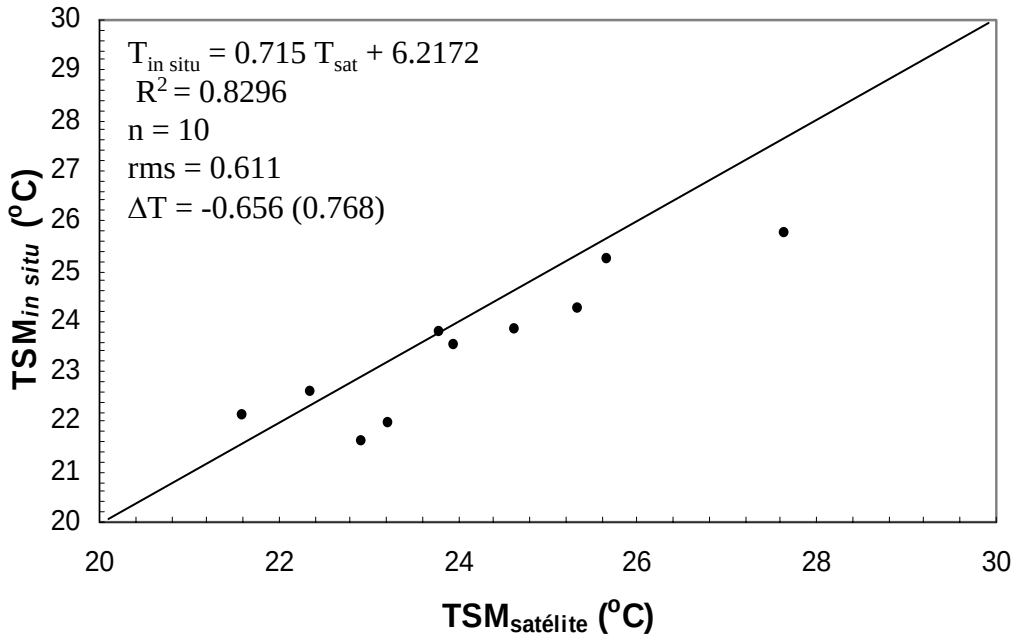
- Sensoriamento remoto:
  - Cor do oceano – clorofila, coeficiente de atenuação vertical da luz, reflectância de sensoriamento remoto;
  - Infravermelho termal – temperatura da superfície do mar;
  - Microondas – vento na superfície do mar.

GOES – cold front

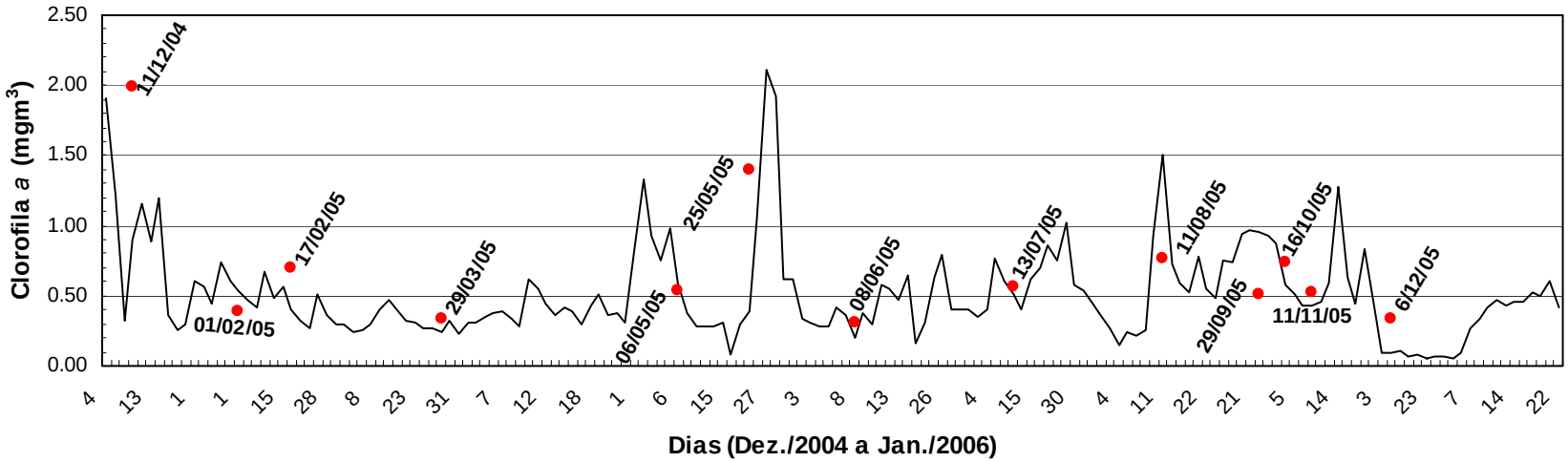


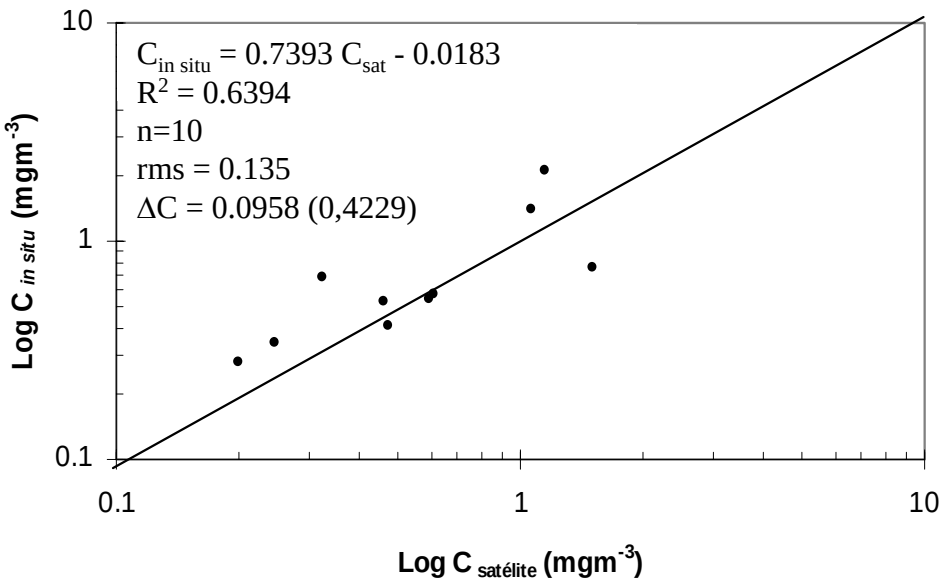
SST


Temperatura (°C)
32
30
28
26
24
22
20
18
16
11/12/04
01/02/05
17/02/05
29/03/05
06/05/05
25/05/05
08/06/05
13/07/05
11/08/05
29/09/05
16/10/05
11/11/05
06/12/05
24/01/06
1 10 15 28 2 14 30 10 17 1 9 26 1 8 13 19 2 7 16 28 4 9 16 30 11 16 31 5 16 23 21 8 21 7 16 27 9 23 31 10 16 21
Dias (Dez./2004 a Jan./2006)


$T_{in\ situ}$ = 0.715 T_{sat} + 6.2172
R^2 = 0.8296
n = 10
rms = 0.611
ΔT = -0.656 (0.768)
TSM in situ (°C)
30
29
28
27
26
25
24
23
22
21
20
20 22 24 26 28 30
TSM satélite (°C)

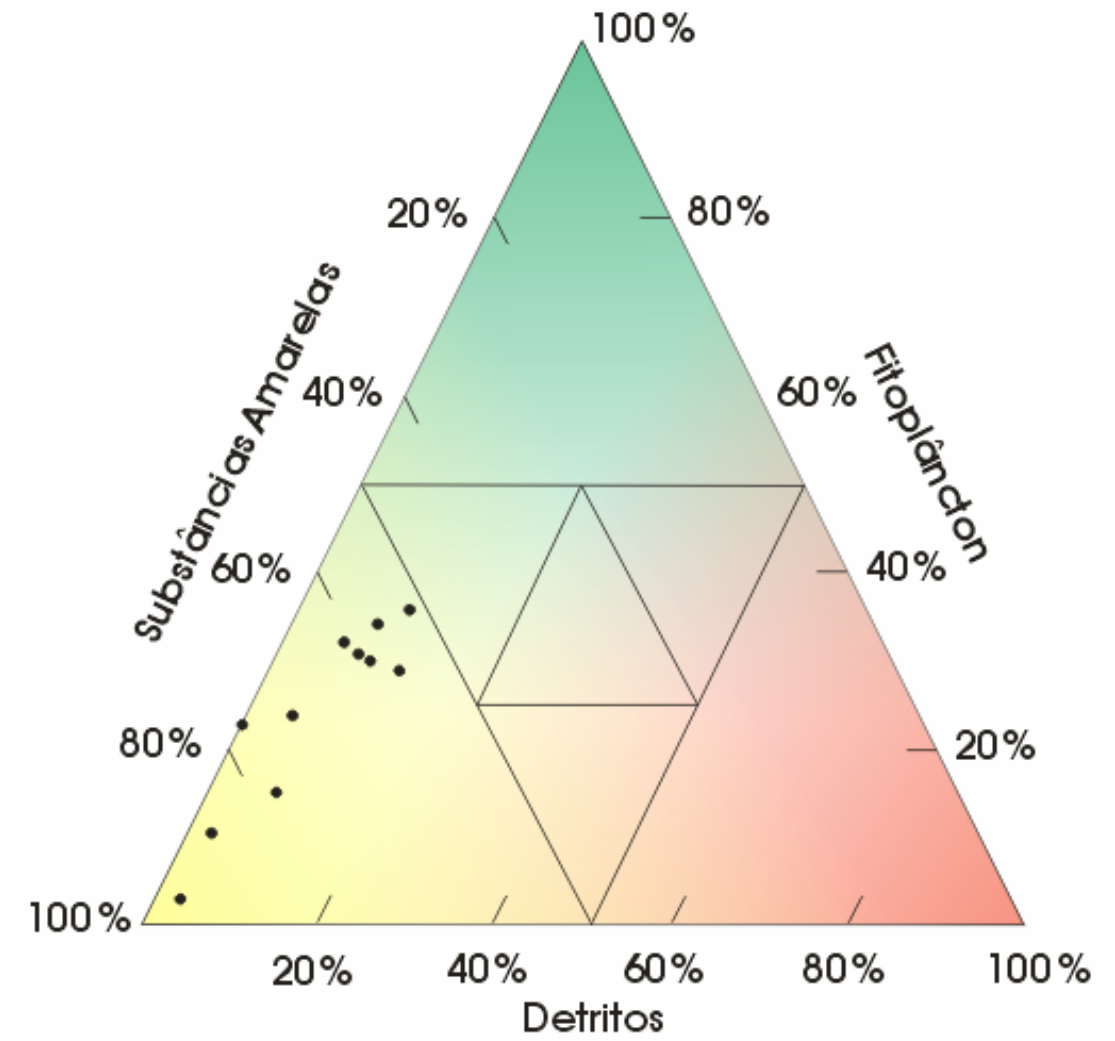
CHLOROPHYLL





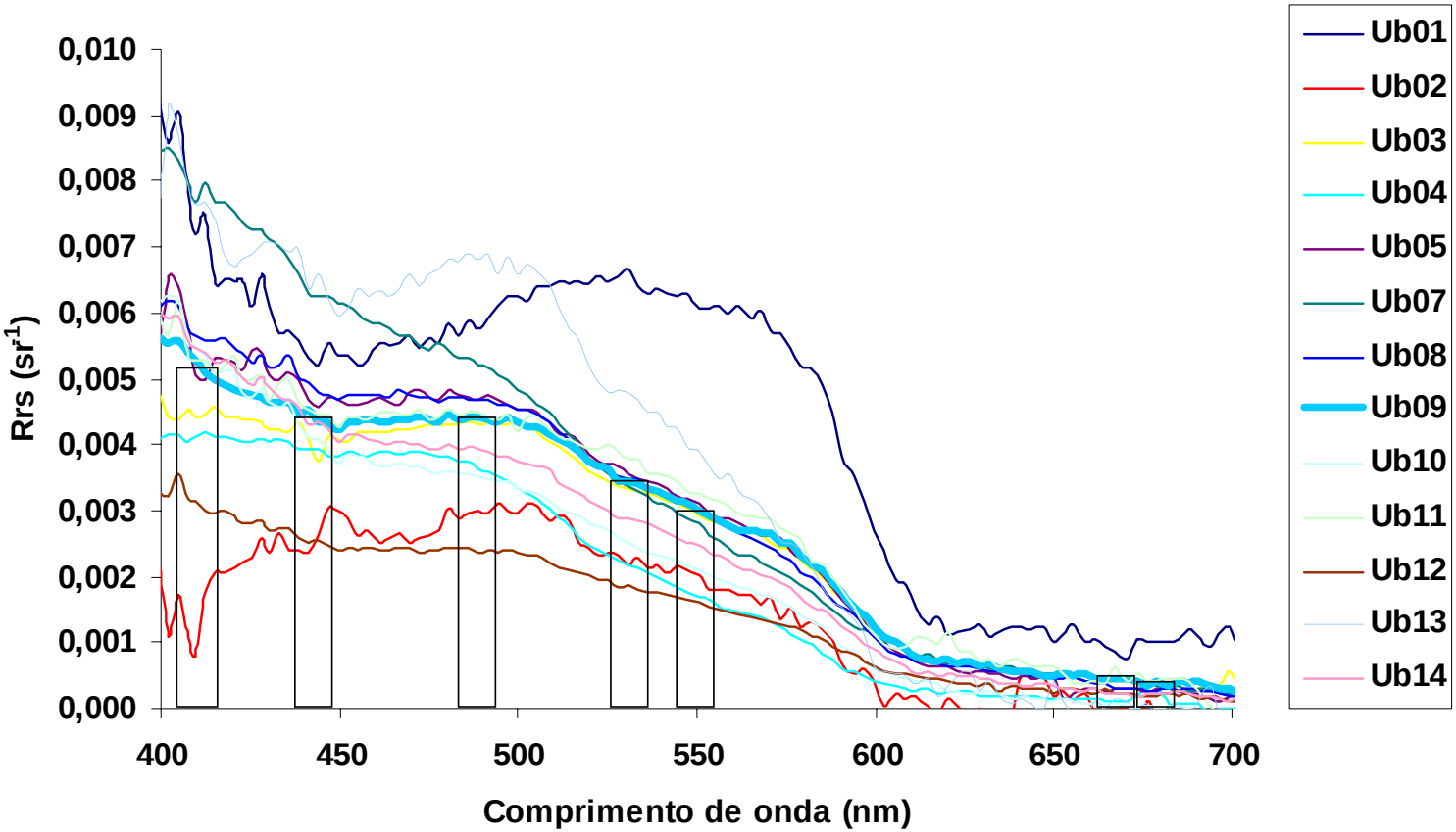
Bio-optics

$a(\lambda) = aw(\lambda)+ap(\lambda) +ag(\lambda)$



Rudorff et al, 2007a

In situ above-water radiometry



Rudorff et al, 2007b

ANTARES Links

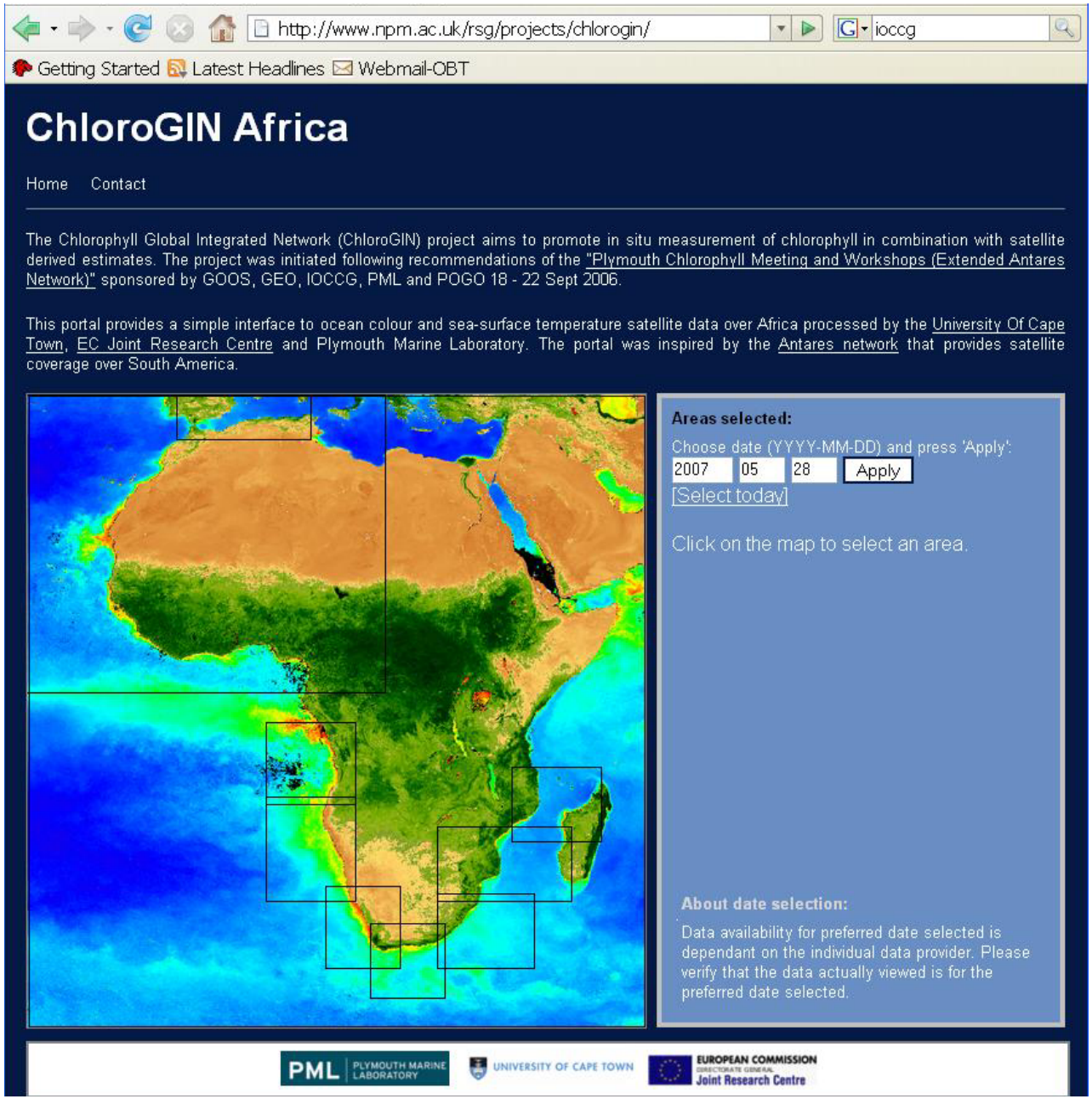
- ANTARES tem sido promovida:
  - *International Ocean-Colour Coordinating Group* (IOCCG);
  - *Partnership for the Observation of the Global Ocean* (POGO).
- ANTARES tem sido considerada nas Agendas de:
  - *Global Ocean Observing System* (GOOS) -

    Proposed as a GOOS *Ocean-Colour Pilot Study* (ChlorOGIN);
  - *Group of Earth Observation* (GEO) – *Task* 'CB-06-08 Ecosystems' in the implementation plan of the 'Global Earth Observation System of Systems (GEOSS).

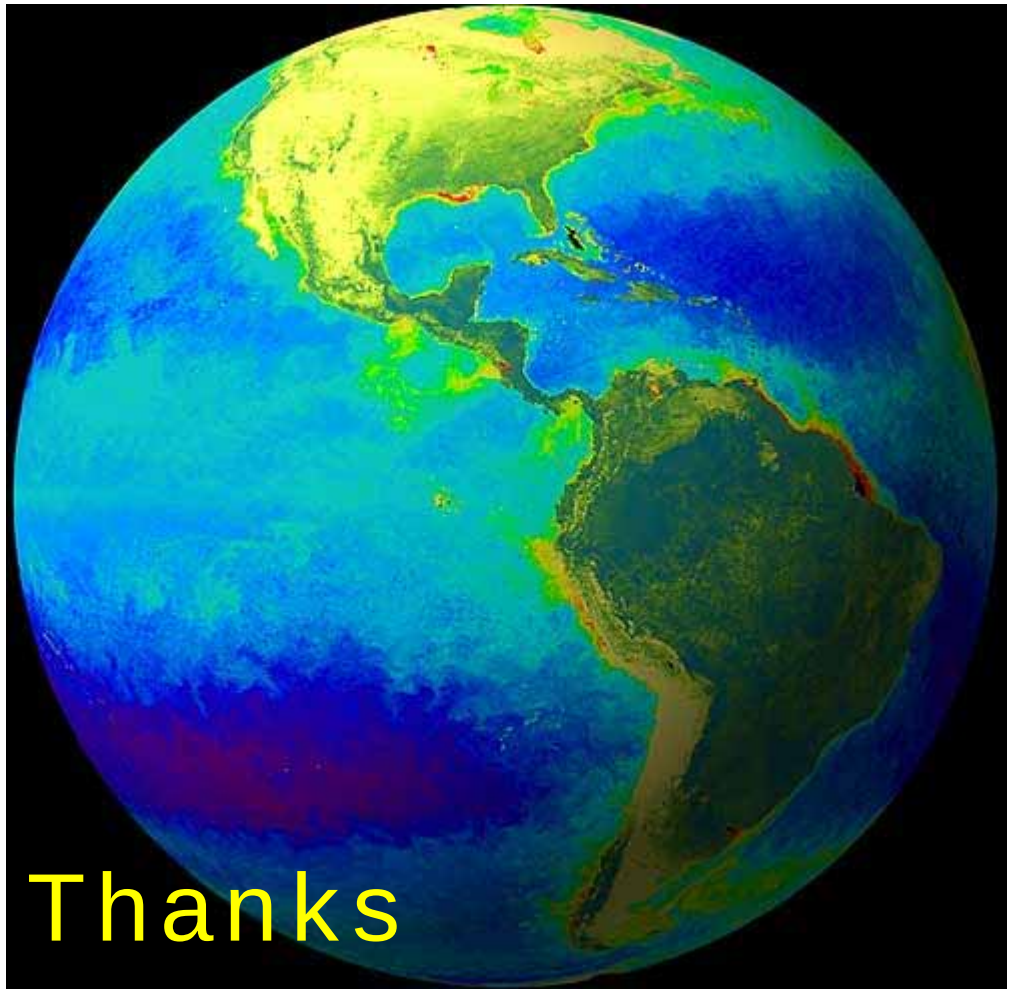
Meeting & Workshops in Plymouth

- 18 - 22 Setembro 2006
- Extensão da rede Antares
- **ChloroGIN** - Chlorophyll Global Integrated Network

ChloroGIN Africa



Muito Obrigado



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