

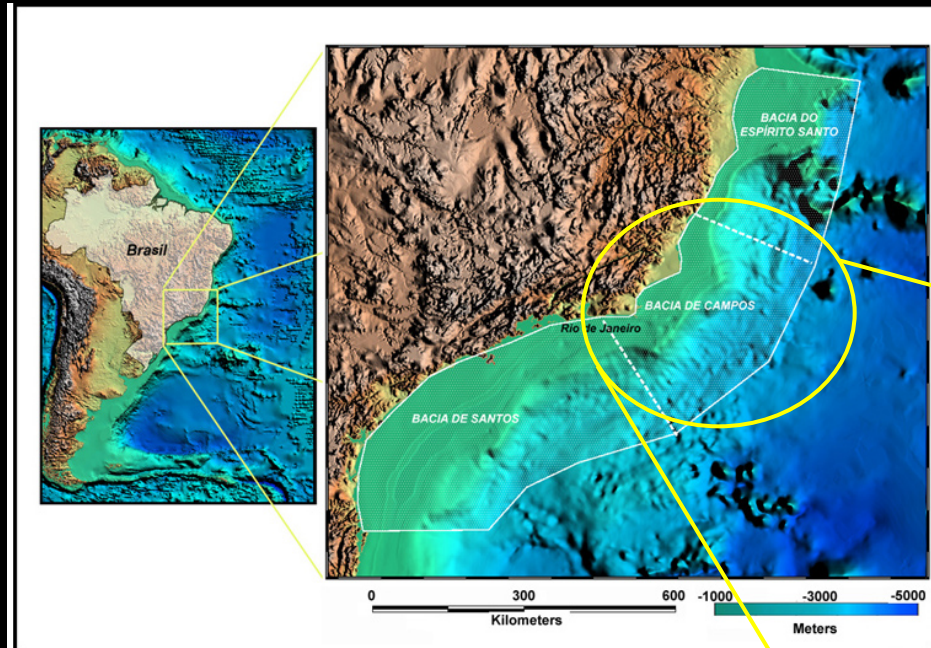
# An assessment of the usefulness of SAR images to help better locating the Brazil Current surface inshore front

<sup>1</sup>Lorenzetti, J.A., <sup>1</sup>M. Kampel, <sup>2</sup>G.B. França, <sup>3</sup>A. Sartori

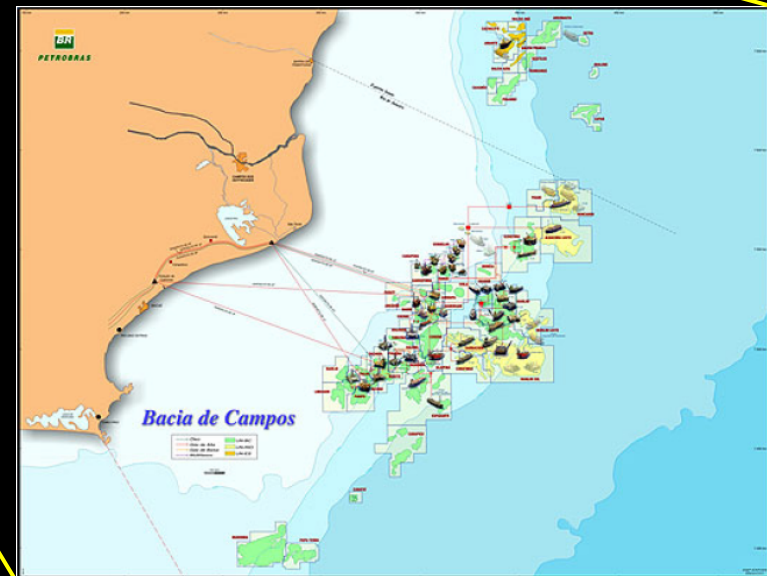
<sup>1</sup>National Space Research Institute – INPE, Brazil  
<sup>2</sup>Federal University of Rio de Janeiro – UFRJ, Brazil  
<sup>3</sup>Research Center –CENPES, Petrobrás, Brazil

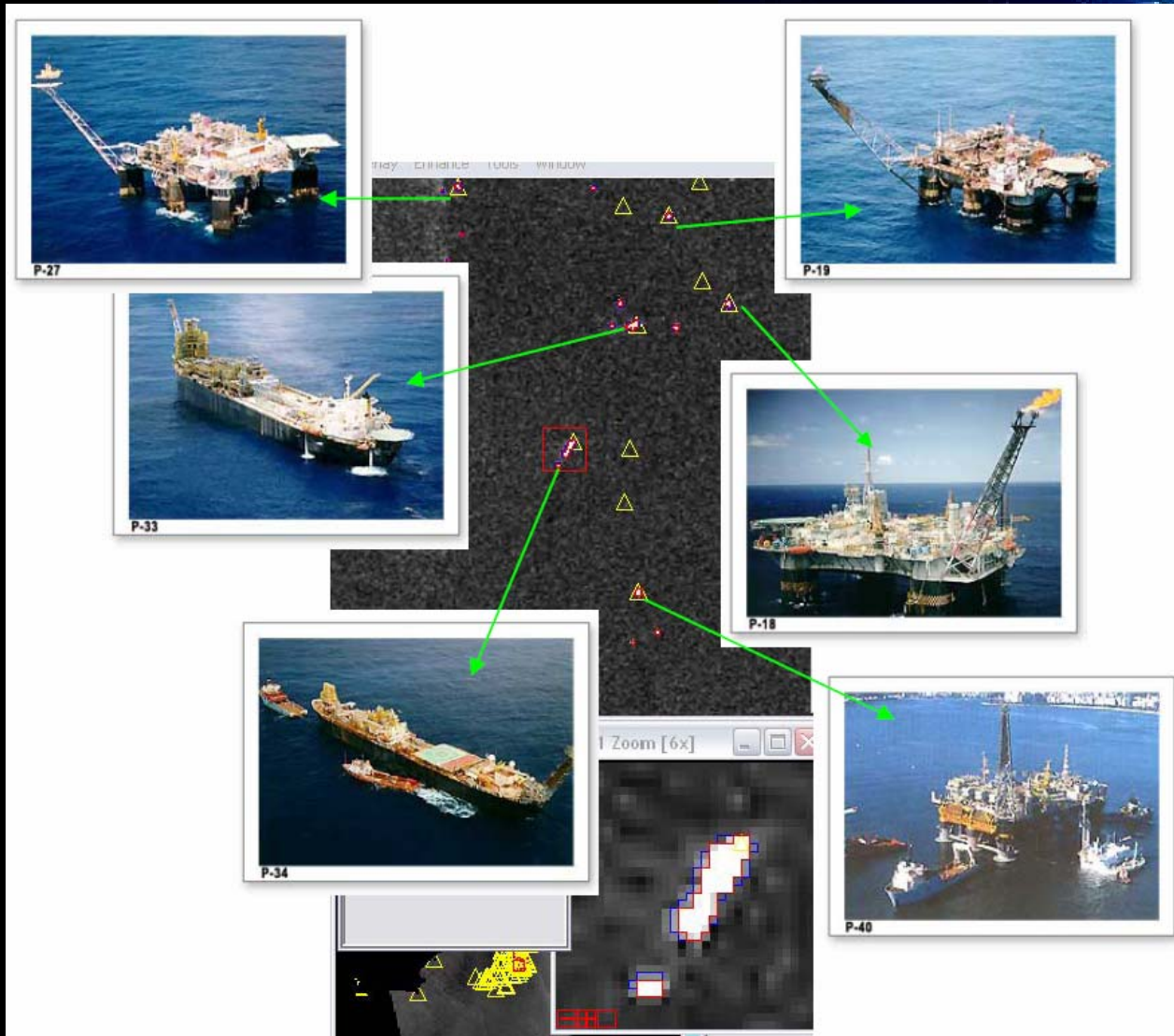


# Campos Basin



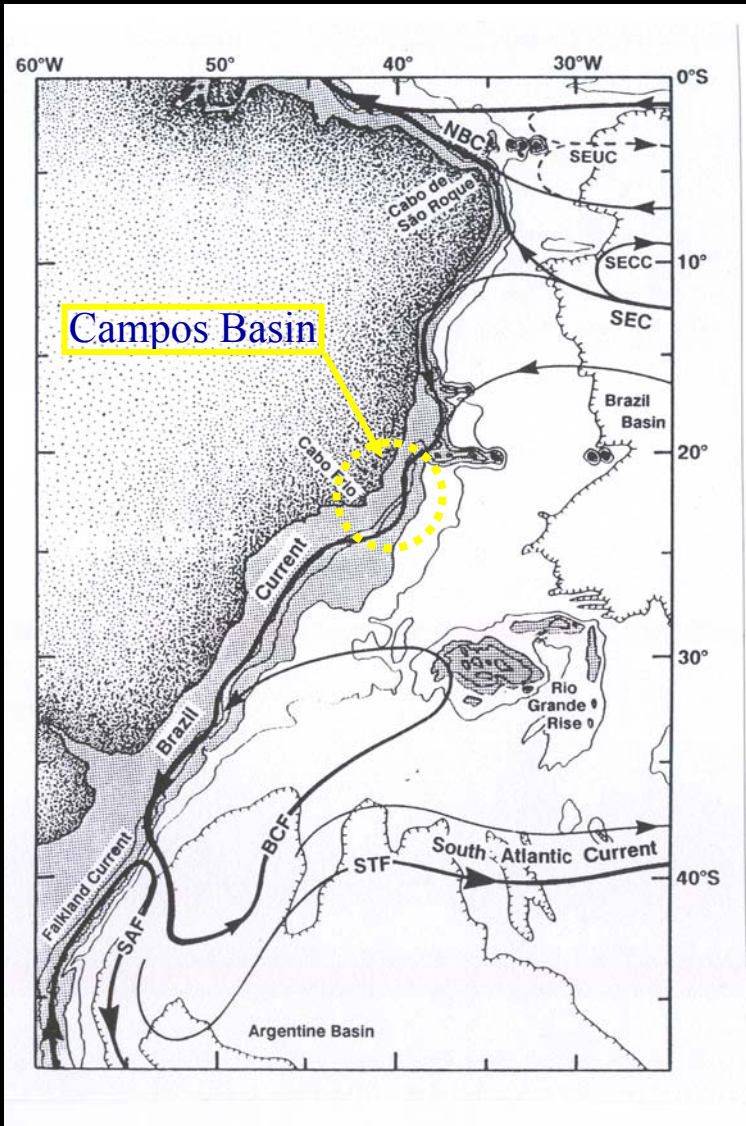
- 100,000 sq km
- 64 production and drilling platforms,
- 89% of national oil production
- “Floating city” of about 40,000 people





Jan. 21-25, 2008

ESA SeaSAR 2008, Frascati.

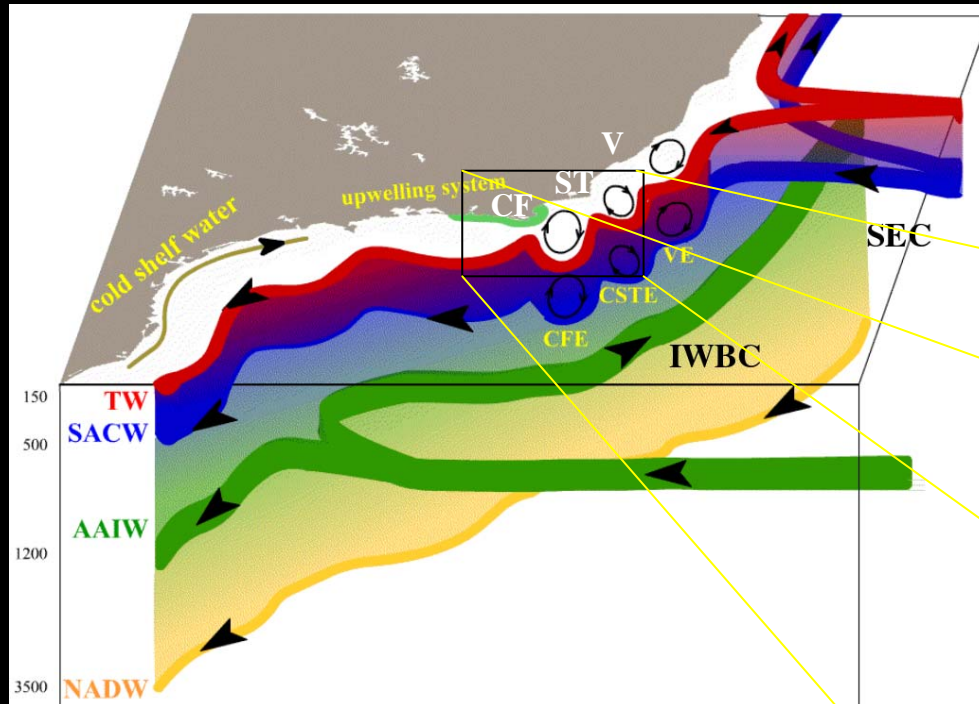


## Mean surface circulation at SW South Atlantic

From: Peterson and Stramma, 1991



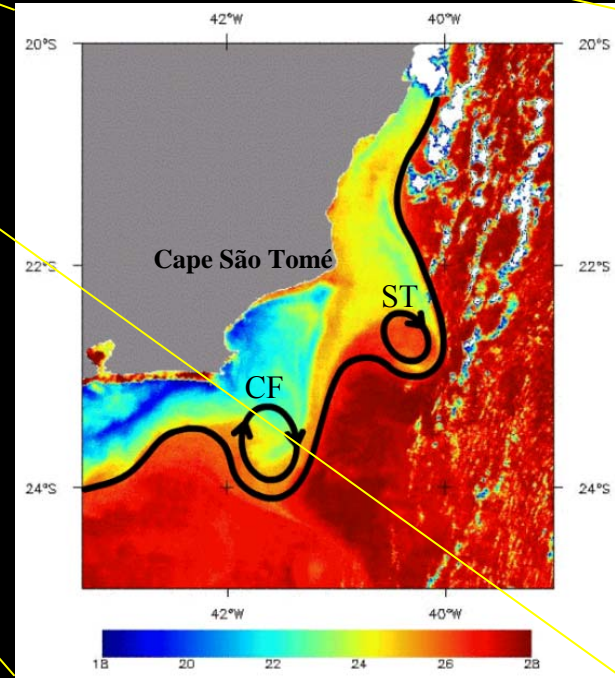
Conceptual display of Water Masses-Currents with mesoscale features for  
SW South Atlantic



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

- V – Vitória Eddy
- ST – São Tomé Eddy
- CF – Cabo Frio Eddy

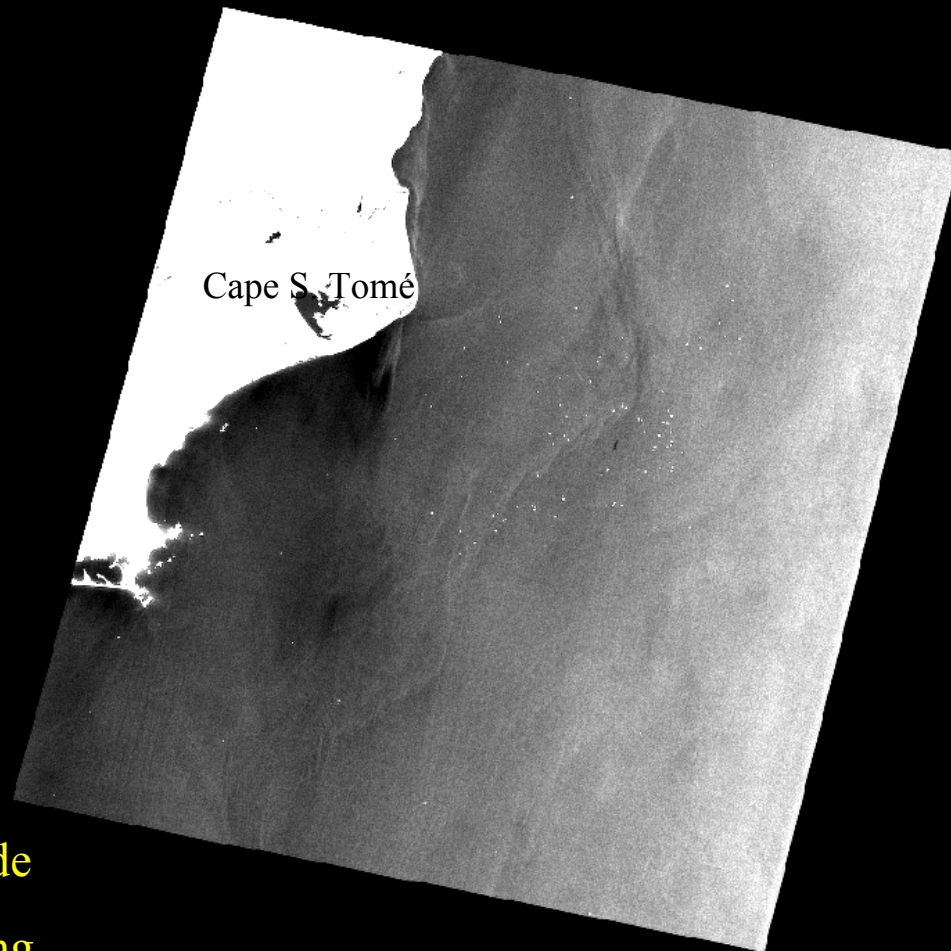
AVHRR SST



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ESA SeaSAR 2008, Frascati.

## A SAR View of Campos Basin



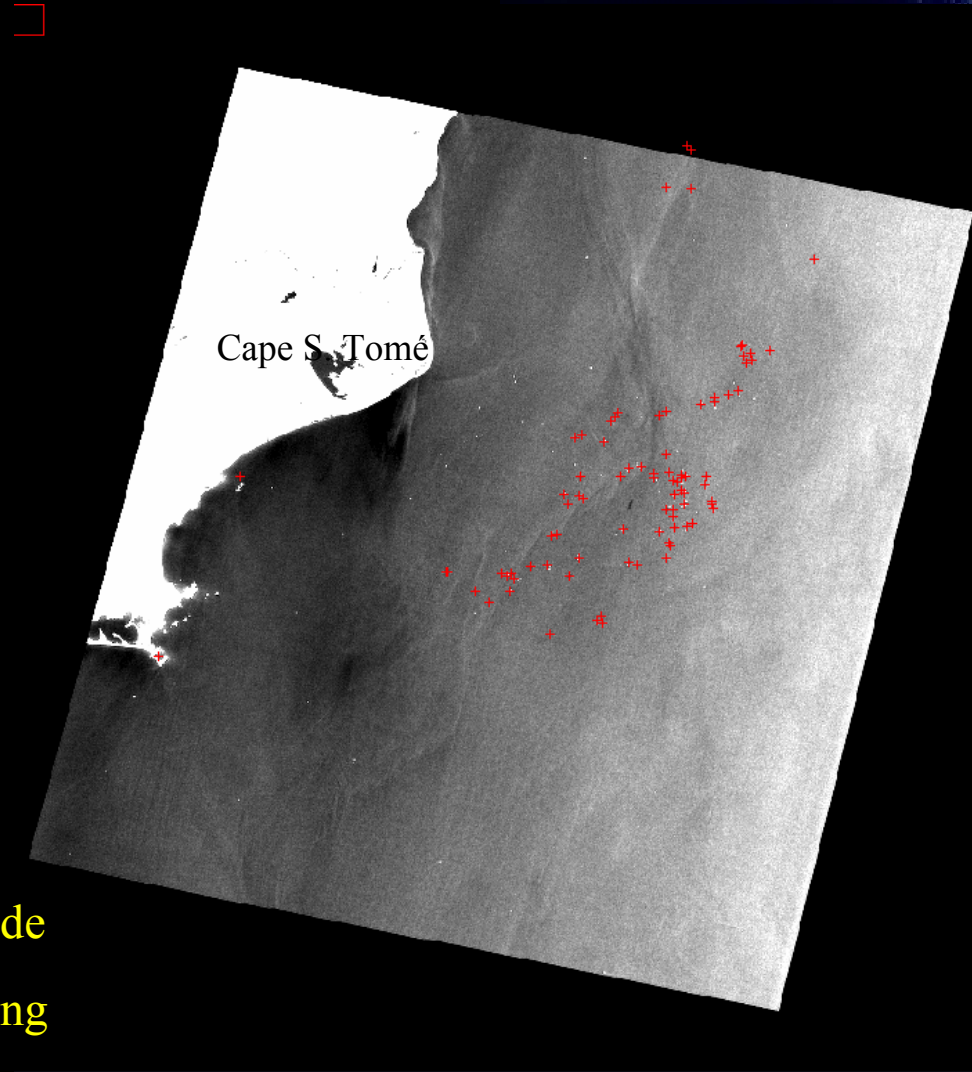
Radarsat-1 ScanSAR Wide

Aug. 12, 2005, Descending

Jan. 21-25, 2008

ESA SeaSAR 2008, Frascati.

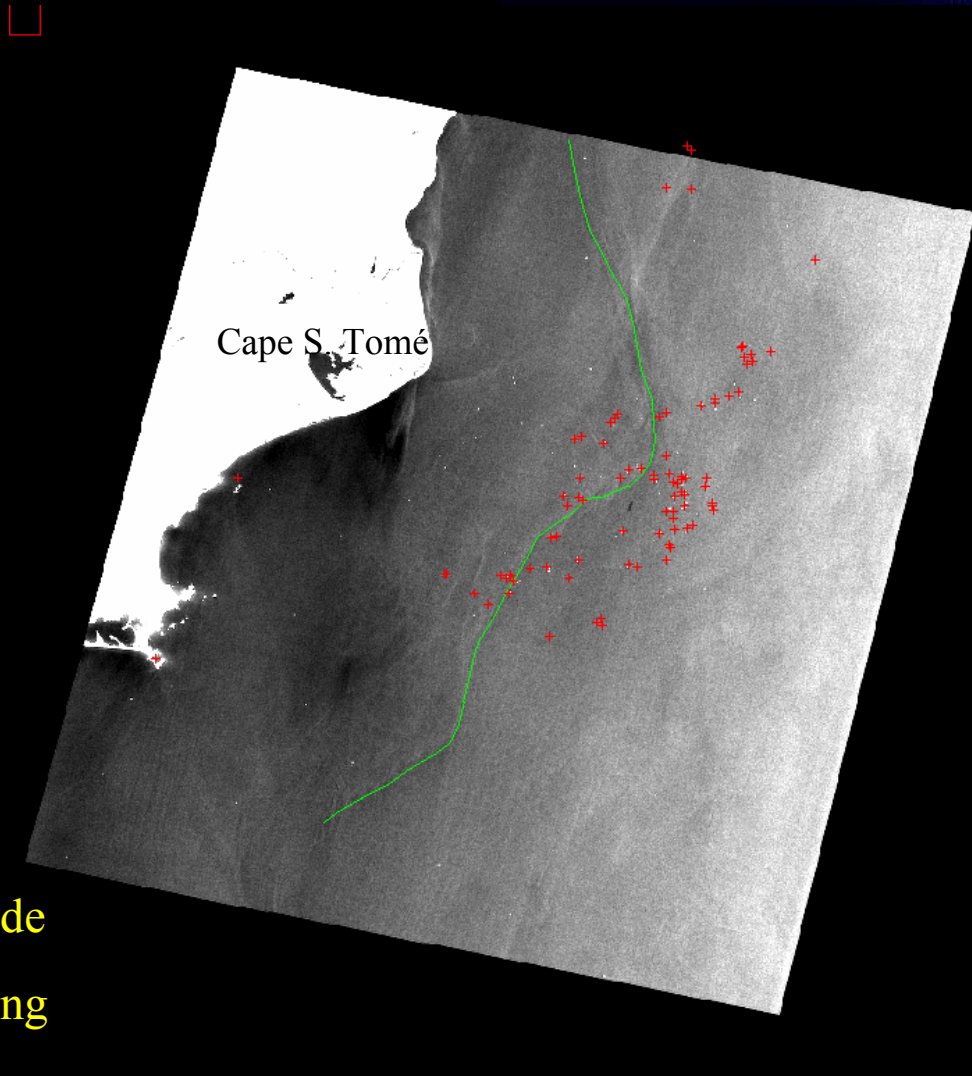
# A SAR View of Campos Basin



Red Crosses: Oil  
Platforms

Radarsat-1 ScanSAR Wide  
Aug. 12, 2005, Descending

# A SAR View of Campos Basin



Red Crosses: Oil  
Platforms

Green Line: Brazil Current  
Front

Radarsat-1 ScanSAR Wide  
Aug. 12, 2005, Descending



## Campos Basin Ocean Modelling Efforts



- The position of the BC front is a very important element in determining the flow field near the oil platforms in the Campos Basin;
- Initializing the model with a good position of the front will provide a much better prognostic forecast;
- Thermal IR SST images can provide a good estimate of frontal position in the absence of clouds;
- Problem with IR images for the region is the high cloud cover ;
- Possible solutions: a) IR/microwave blend SST images such as the GHRSSST, b) GOES IR time composites; c) use of IR and microwave images together with SAR frontal mapping.



## Campos Basin Ocean Modelling Efforts



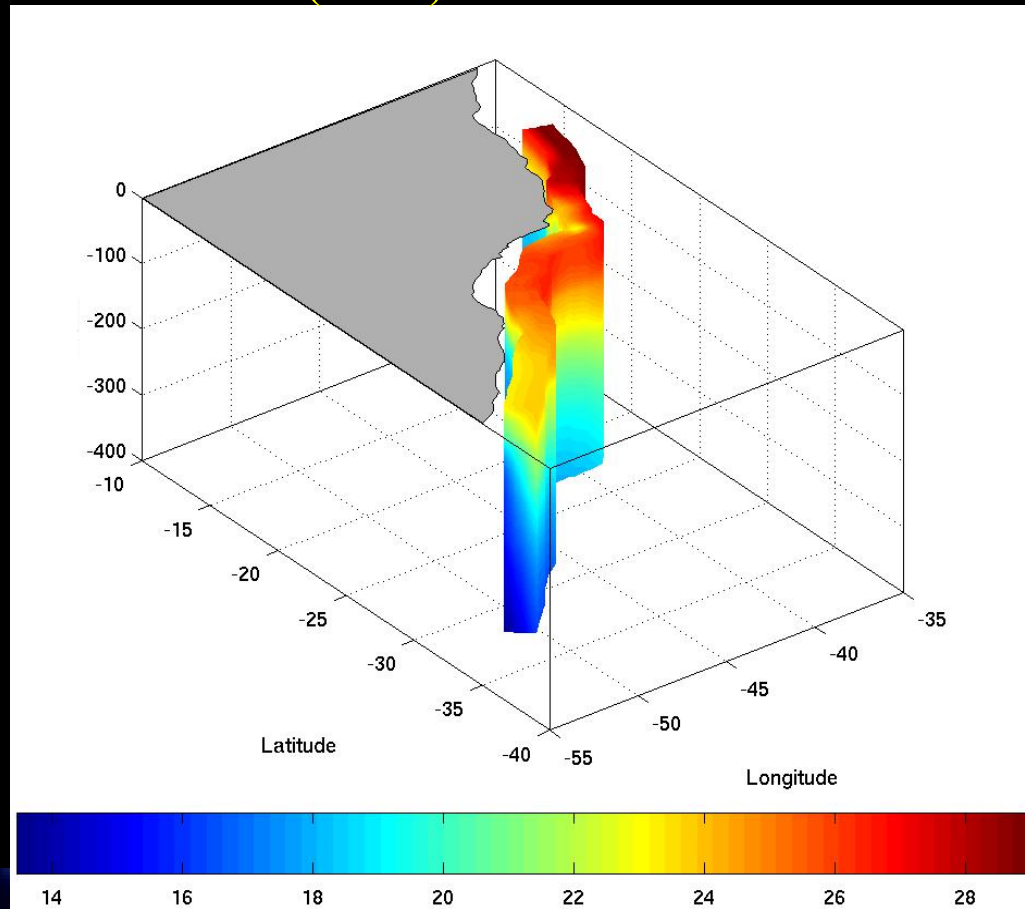
**A possible methodology:** the so-called “Feature Oriented Regional Model-FORM” that combines a previous knowledge of the main oceanic features present in the area with the development of parametric models of these features (Gangopadhyay et al., 1997).

### FORM Protocol:

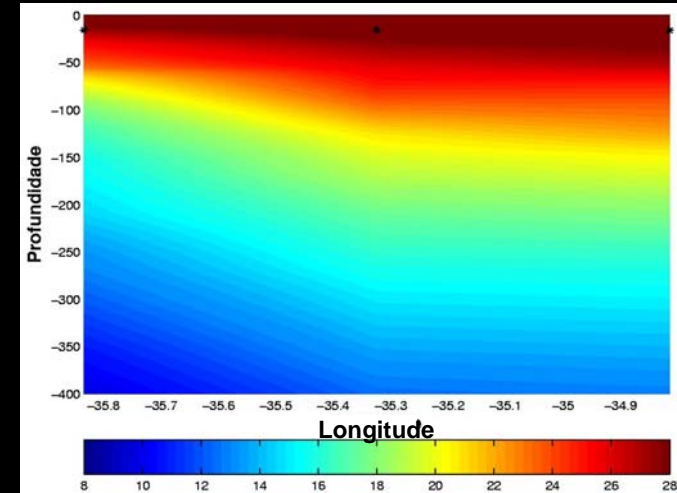
- I – Identification of water masses and ocean features relevant for the regional dynamic;
- II – Previous knowledge of the climatological regional circulation;
- III – Collection of synoptic *in situ* and satellite data;
- IV - Construction of the individual feature models (FM);
- V – Interpolation/merging FMs with climatology using e.g. Multiple Scale Objective Analysis;
- VI – Numerical Simulation.

# Campos Basin Ocean Modelling Efforts

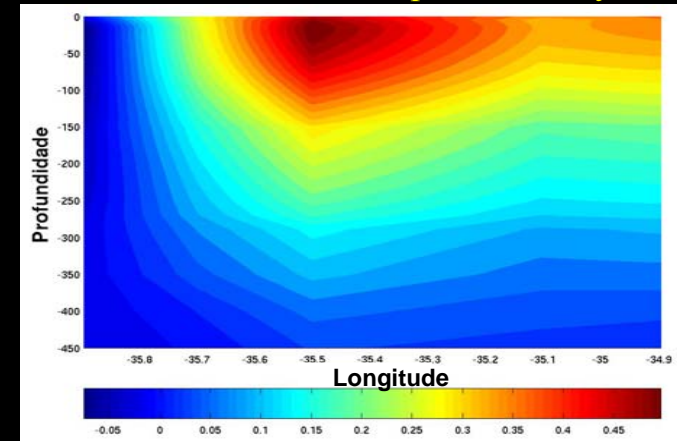
## A Feature Model for Brazil Current from Calado (2006)



### Temperature



### Meridional Geostrophic Velocity



### Sections at 24 S



## The GODAE High Resolution SST data set

GHRSSST data were obtained from global OSTIA (*Operational Sea Surface Temperature and Sea Ice Analysis*) which uses Optimum Interpolation of data from different satellites and IR and microwave radiometers and *in situ* data.

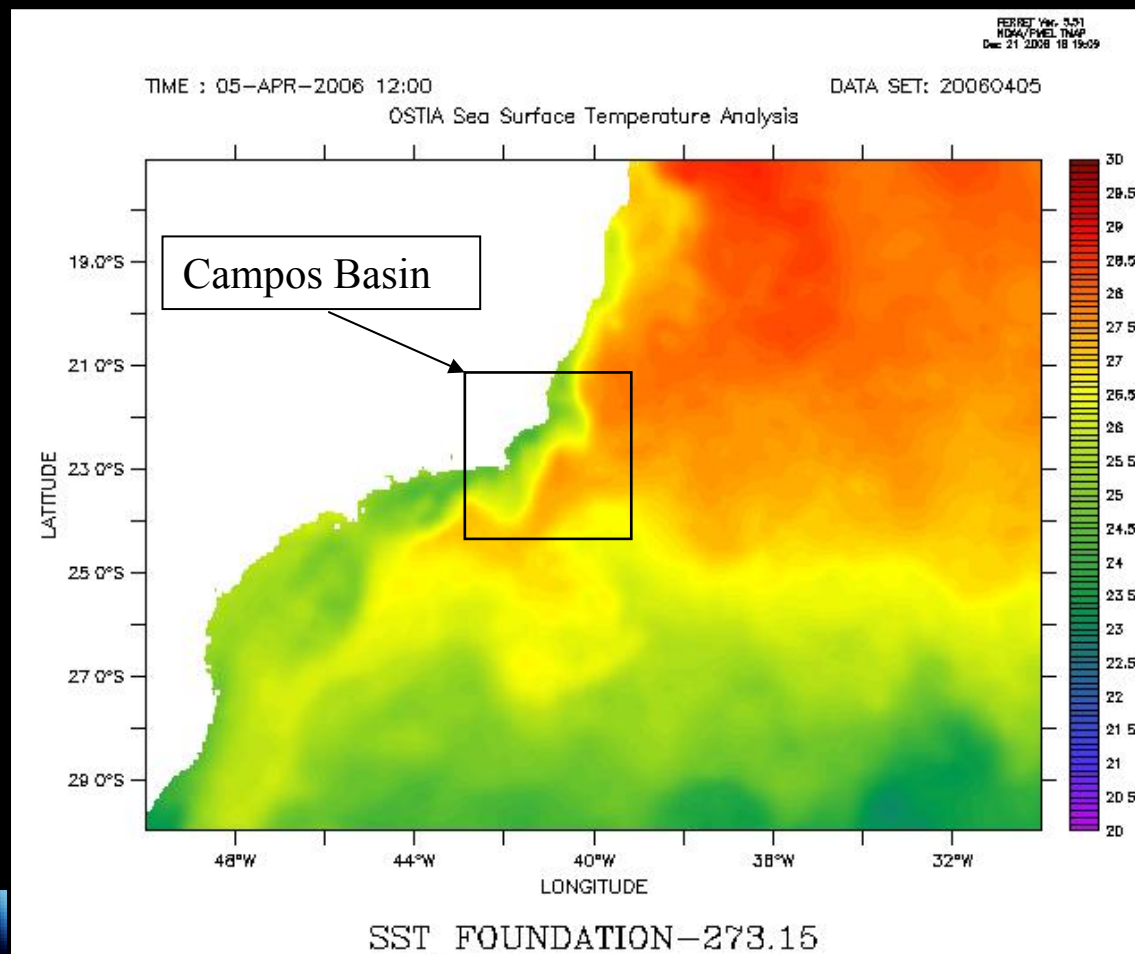
Spatial resolution:  $1/20^\circ$  (aprox. 5.5 km)





## An example of GHRSSST map for SW South Atlantic

April 05, 2006



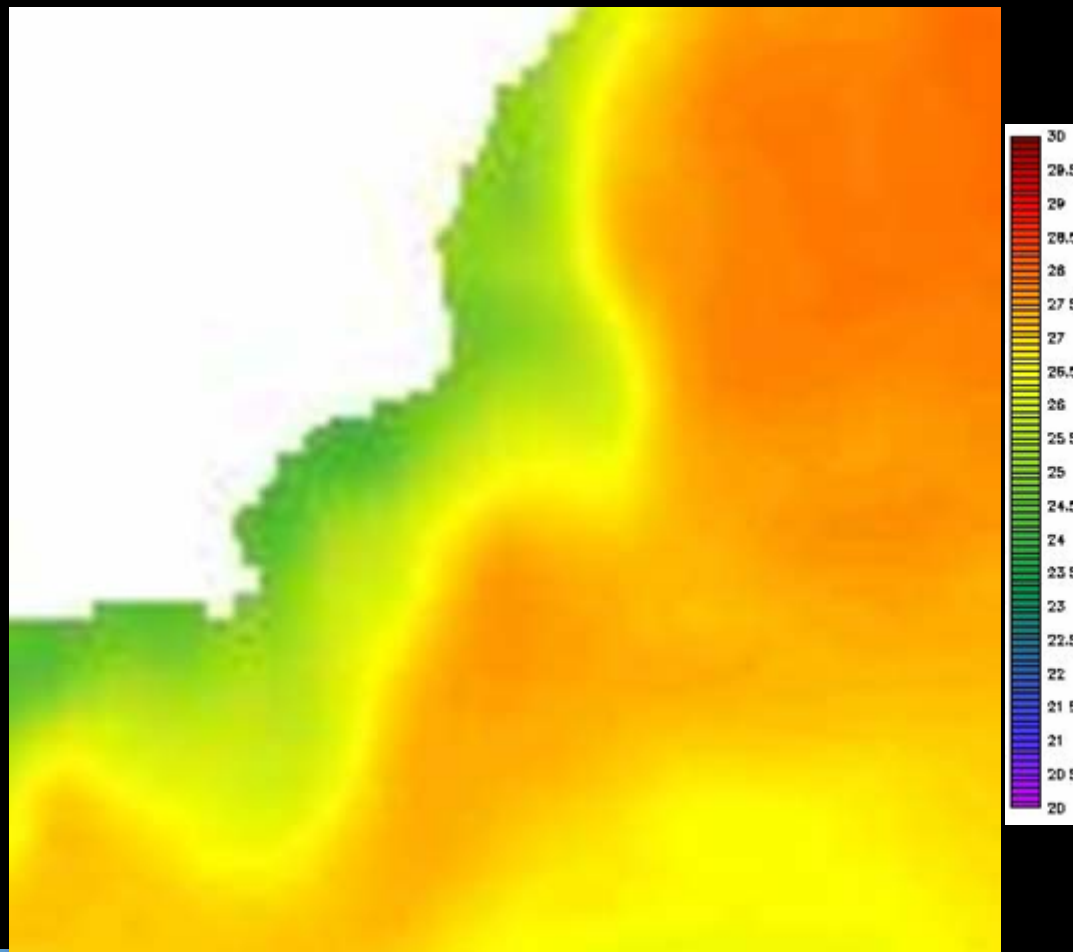
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GHRSSST map for Campos Basin (a zoom of previous slide)

April 05, 2006

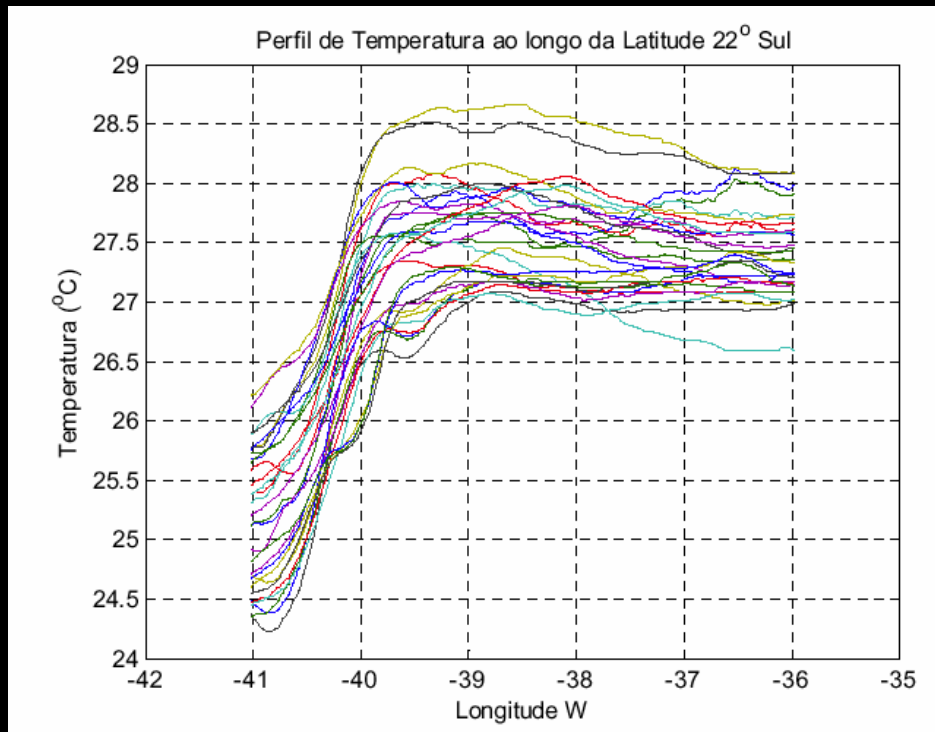


Jan. 21-25, 2008

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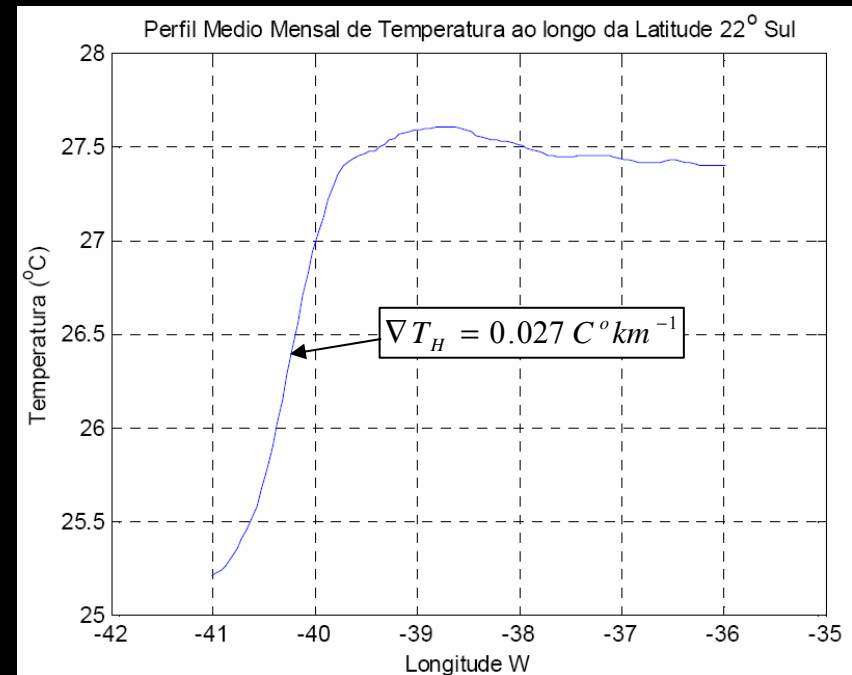


## GHRSSST



Longitudinal SST profiles at BC frontal region at 22°S for April 2006 from the 5.5 km resolution GHRSSST data set.

## GHRSSST

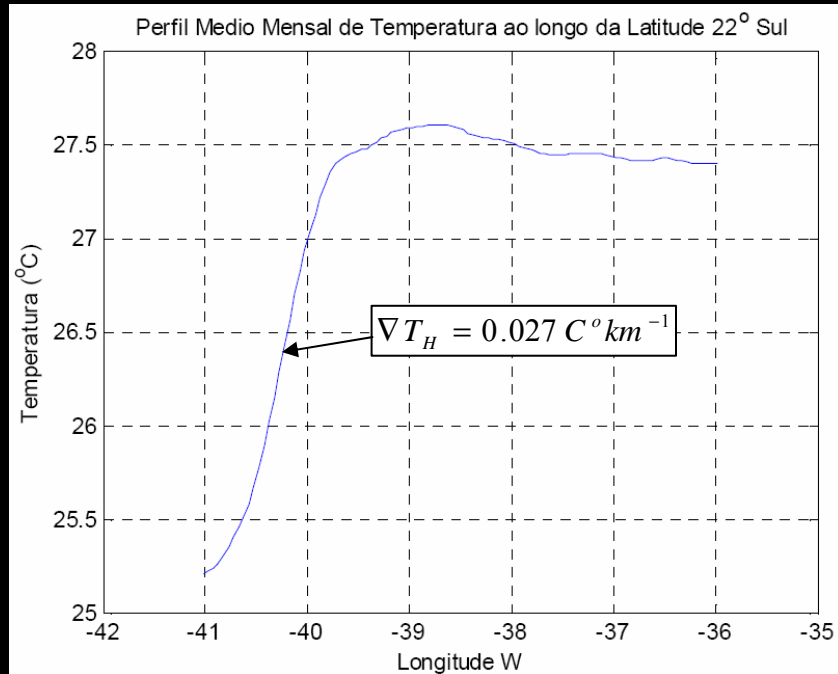


April 2006 monthly mean SST longitudinal profile of the BC frontal region at 22°S



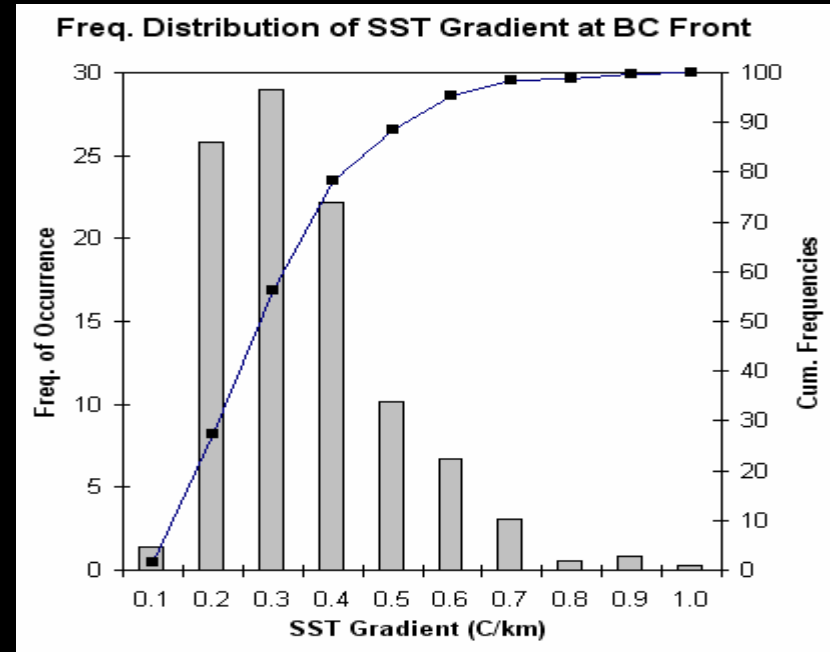


## GHRSSST



Mean SST longitudinal profile of the BC frontal region at 22°S for April 2006 from the 5.5 km resolution GHRSSST data set.

## AVHRR



SST gradient at BC frontal region in Campos Basin based on AVHRR data set from 2000 to 2002.



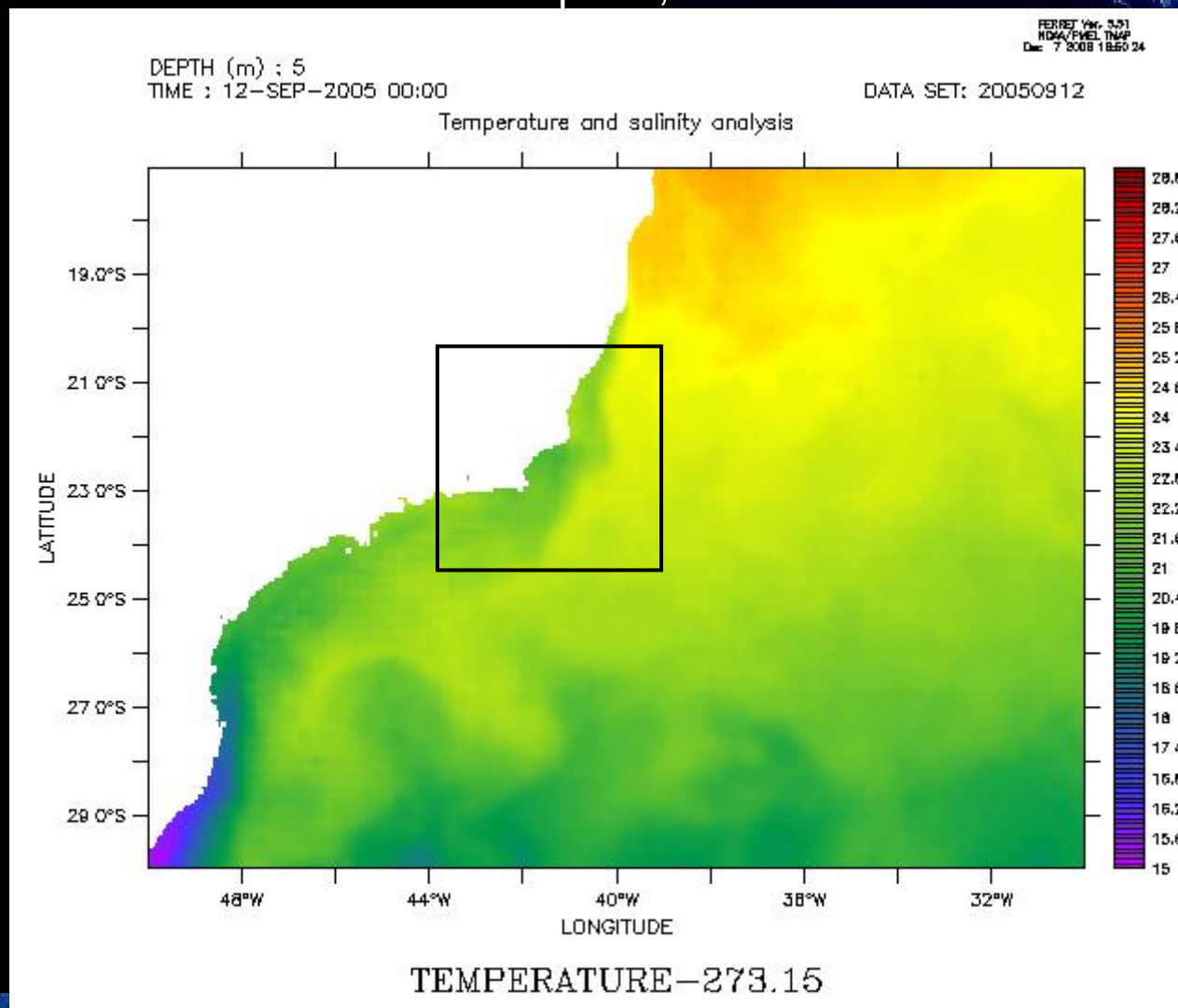
# Frontal Detection in SAR Images



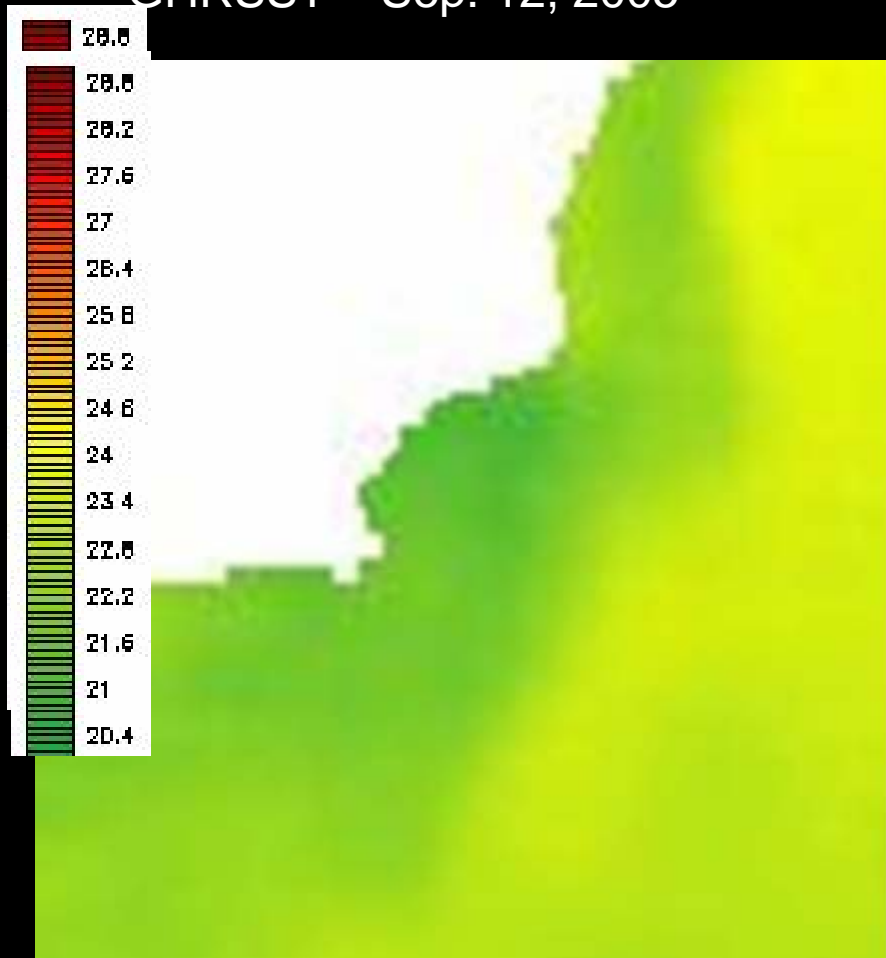
## Physical Mechanisms Modulating Surface Roughness

- a) Accumulation of natural surfactants in regions of current convergence;
- b) Interaction of short waves with surface current gradients;
- c) Wave breaking effects;
- d) Changes in atmospheric stability associated to SST gradients

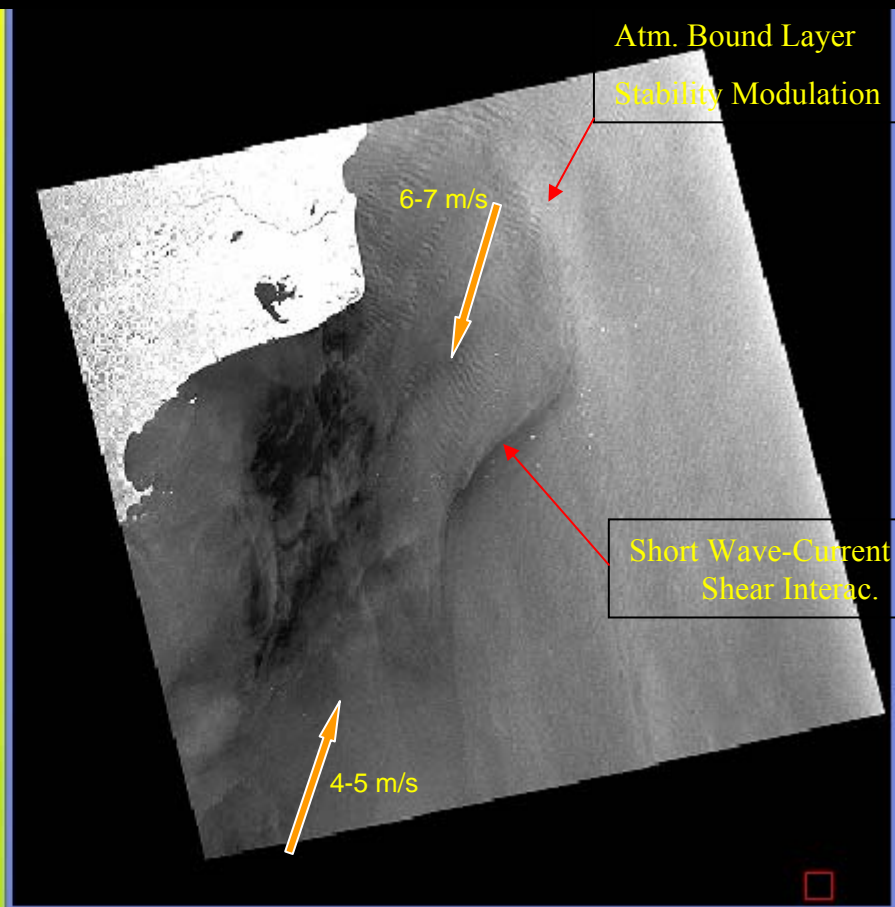
# GHR SST – Sep. 12, 2005



GHRSSST – Sep. 12, 2005



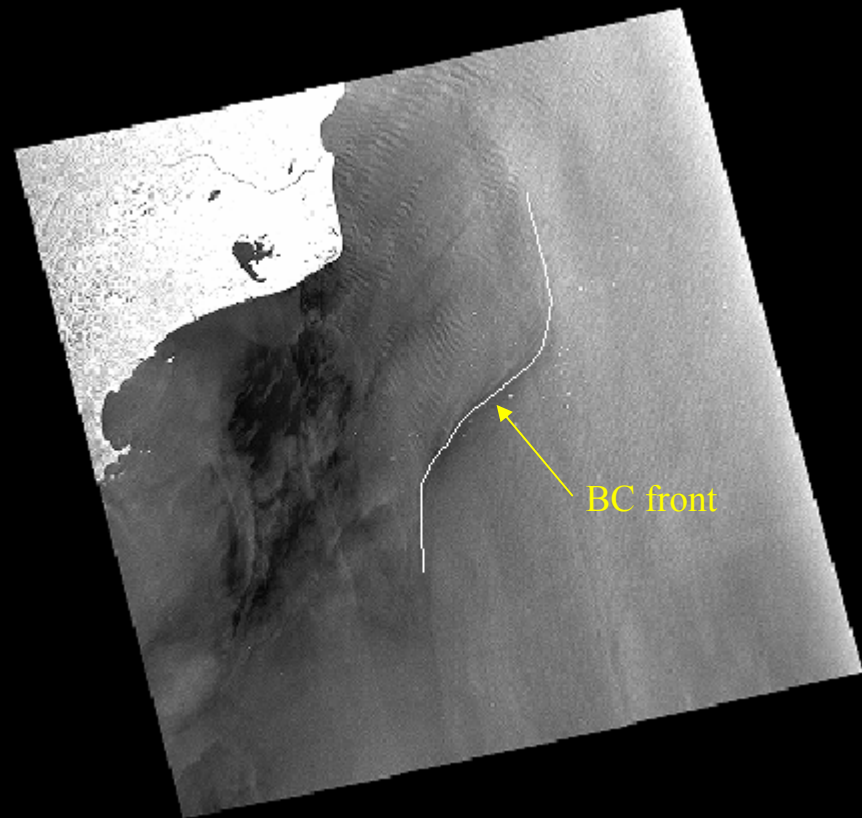
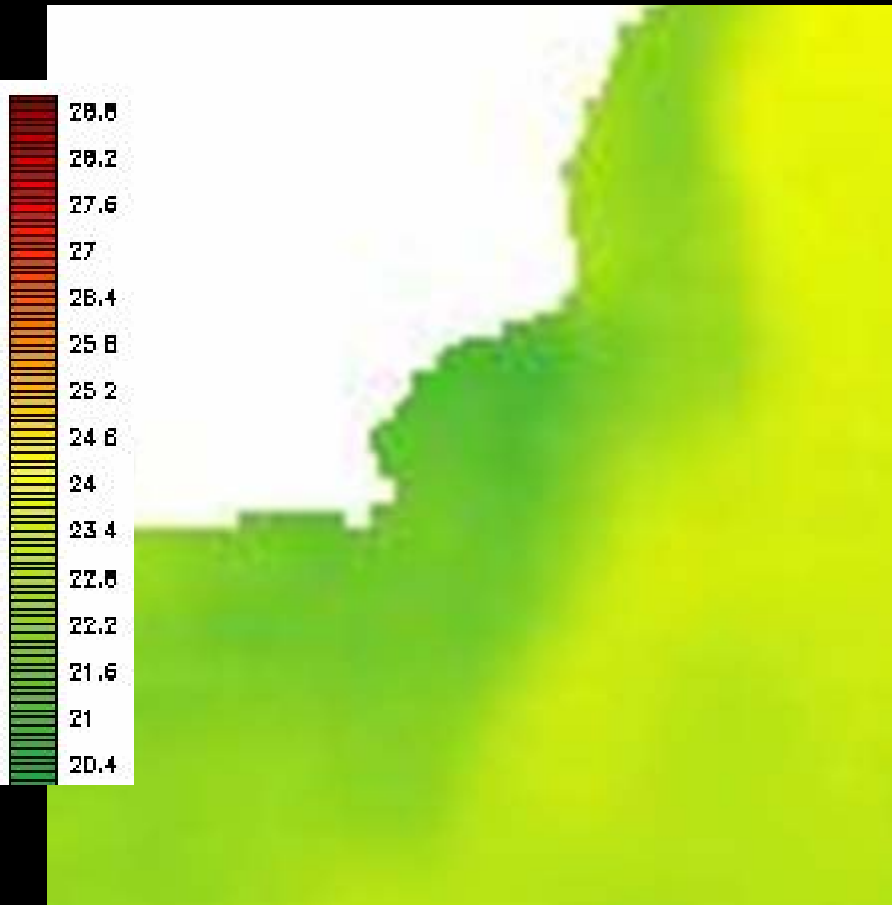
Radarsat-1 ScanSAR Sep. 12, 2005





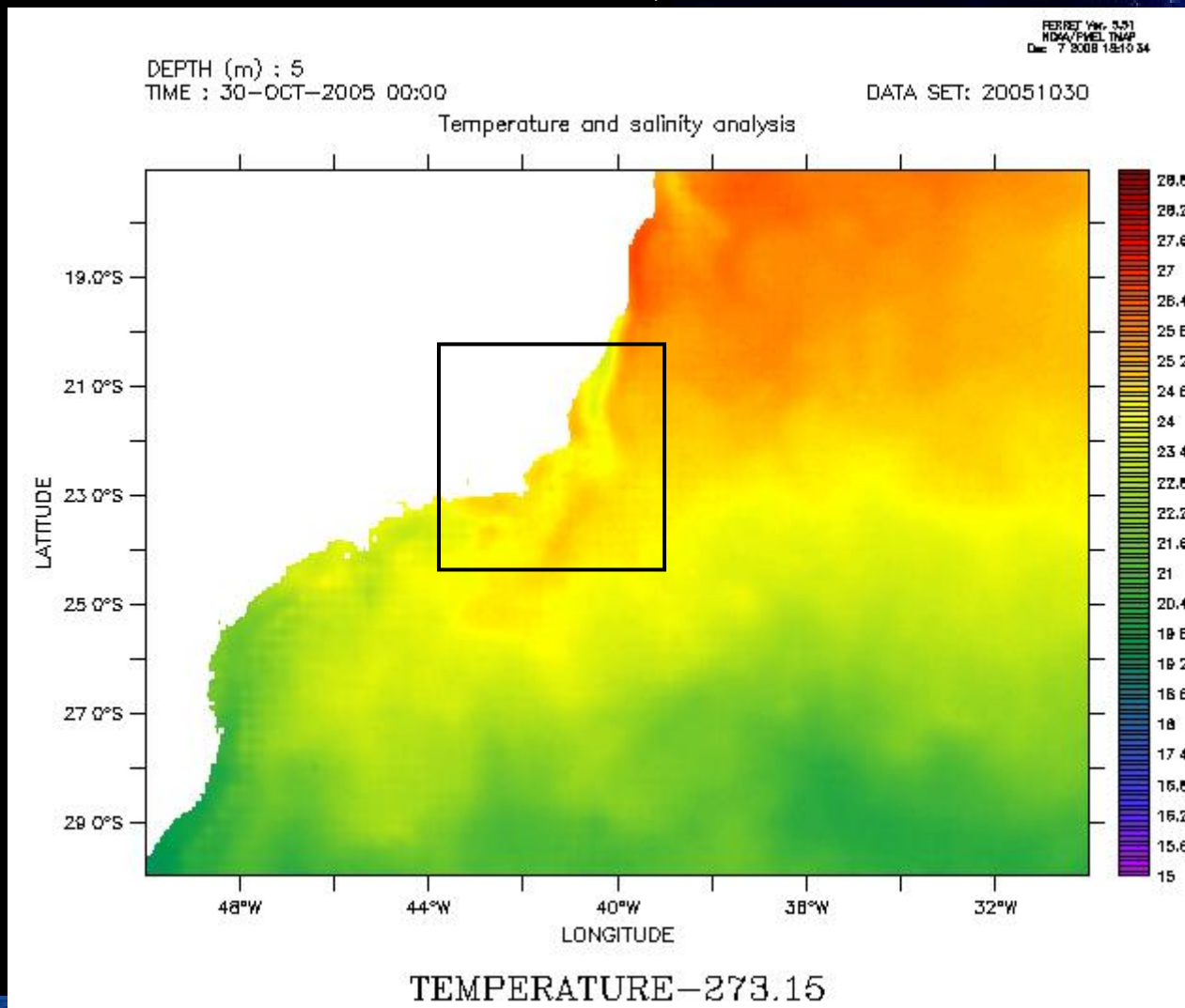
GHR SST – Sep. 12, 2005

Radarsat-1 ScanSAR Sep. 12, 2005

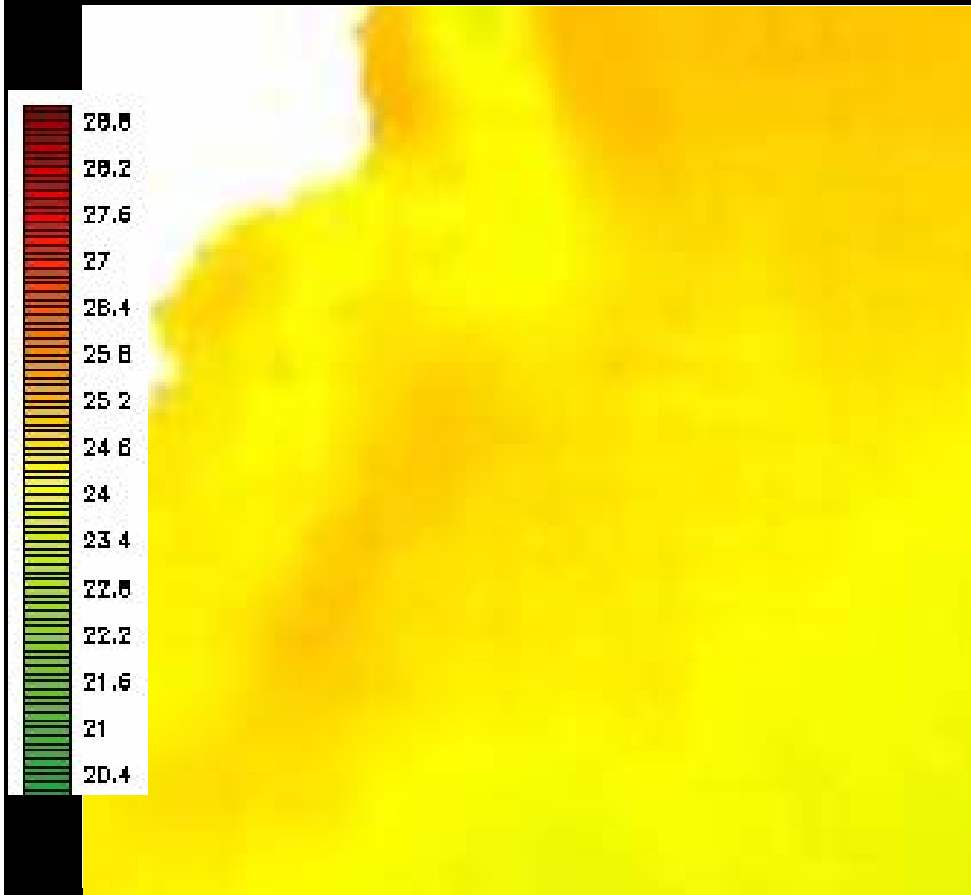




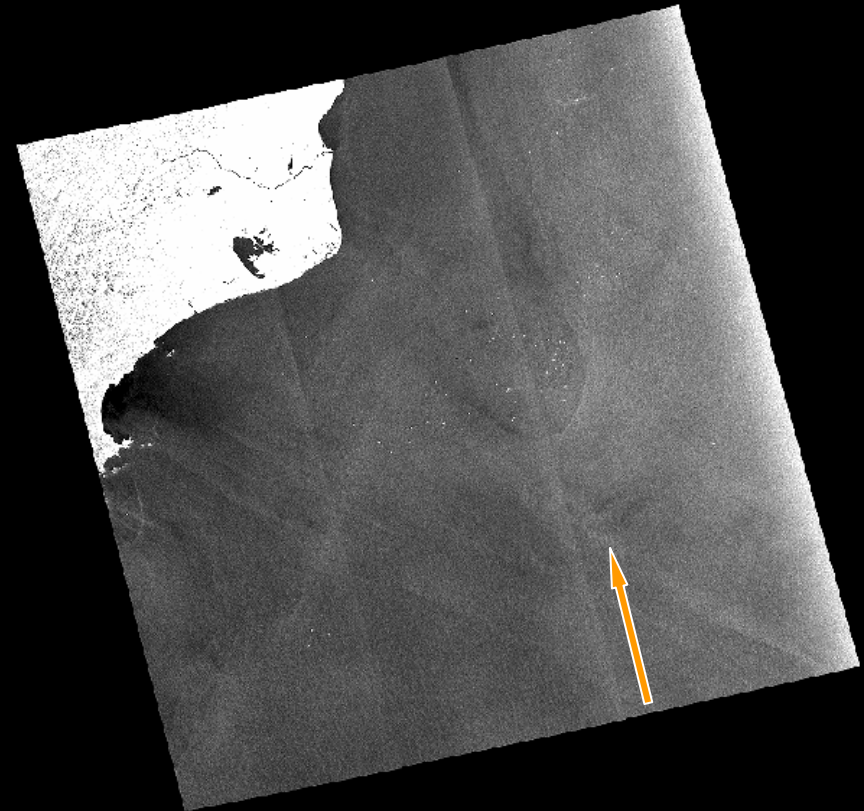
# GHR SST – Oct. 30, 2005



GHR SST – Oct. 30, 2005



Radarsat-1 ScanSAR Oct. 30, 2005



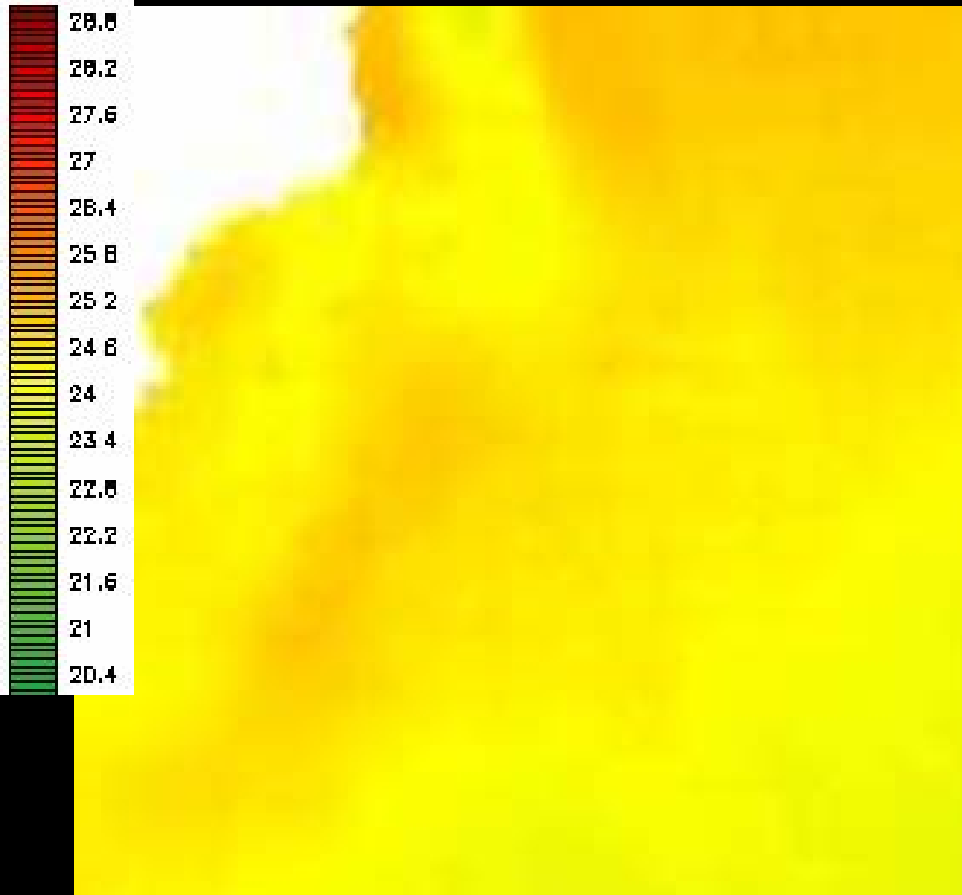
wind direction

Jan. 21-25, 2008

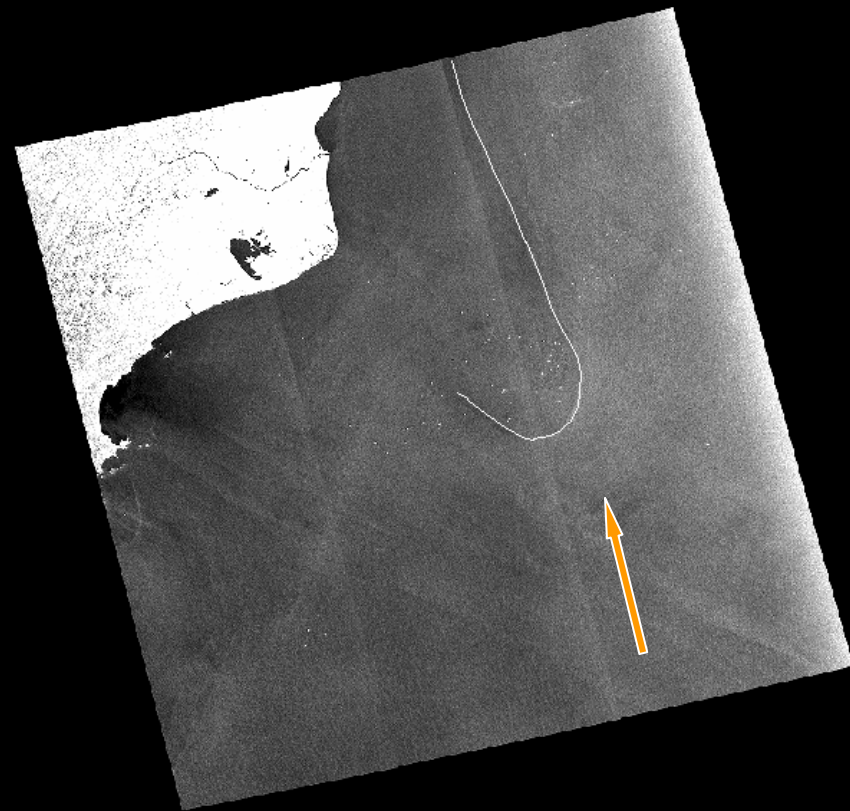
ESA SeaSAR 2008, Frascati.



GHRSSST – Oct. 30, 2005



Radarsat-1 ScanSAR Oct. 30, 2005

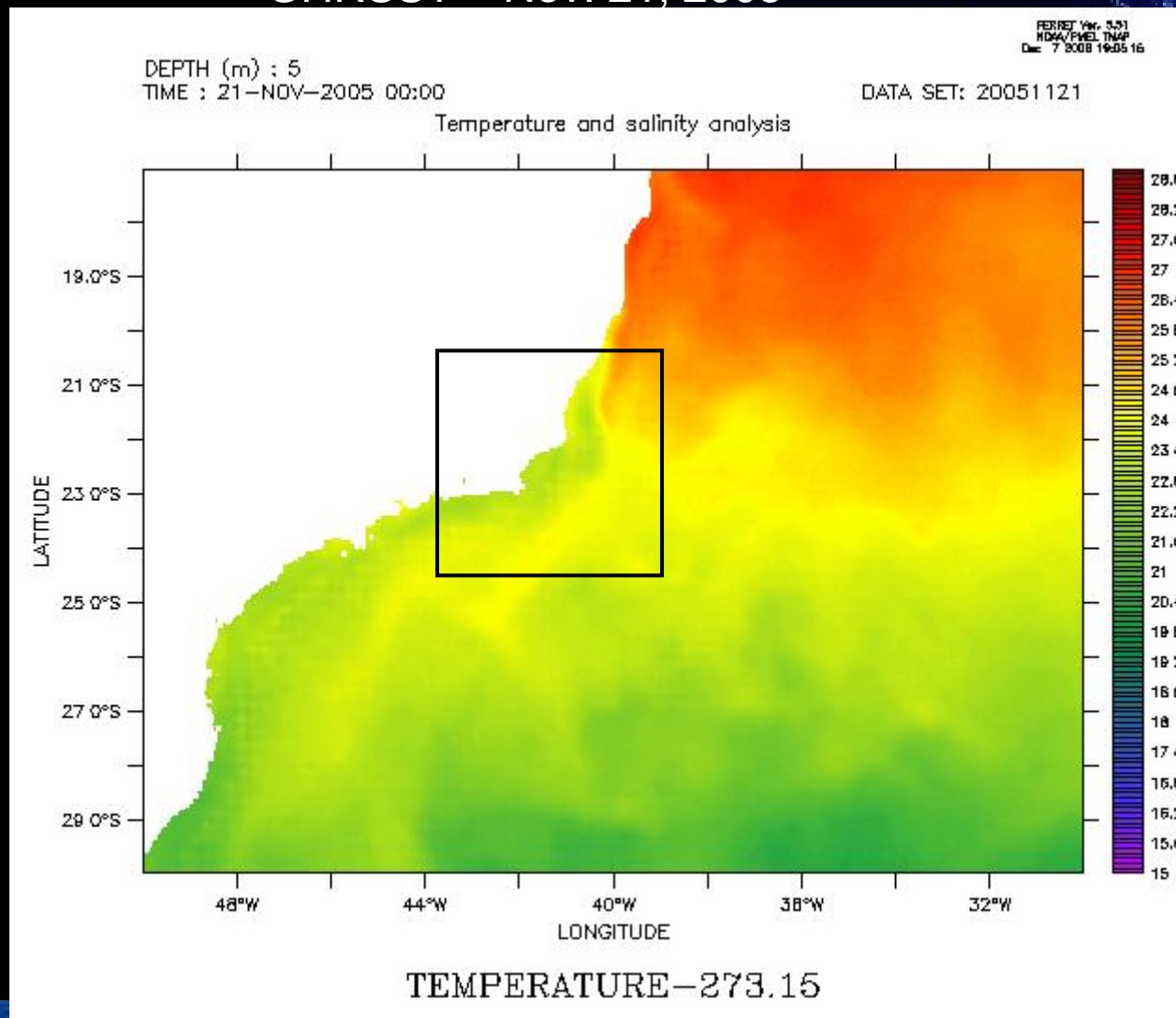


Jan. 21-25, 2008

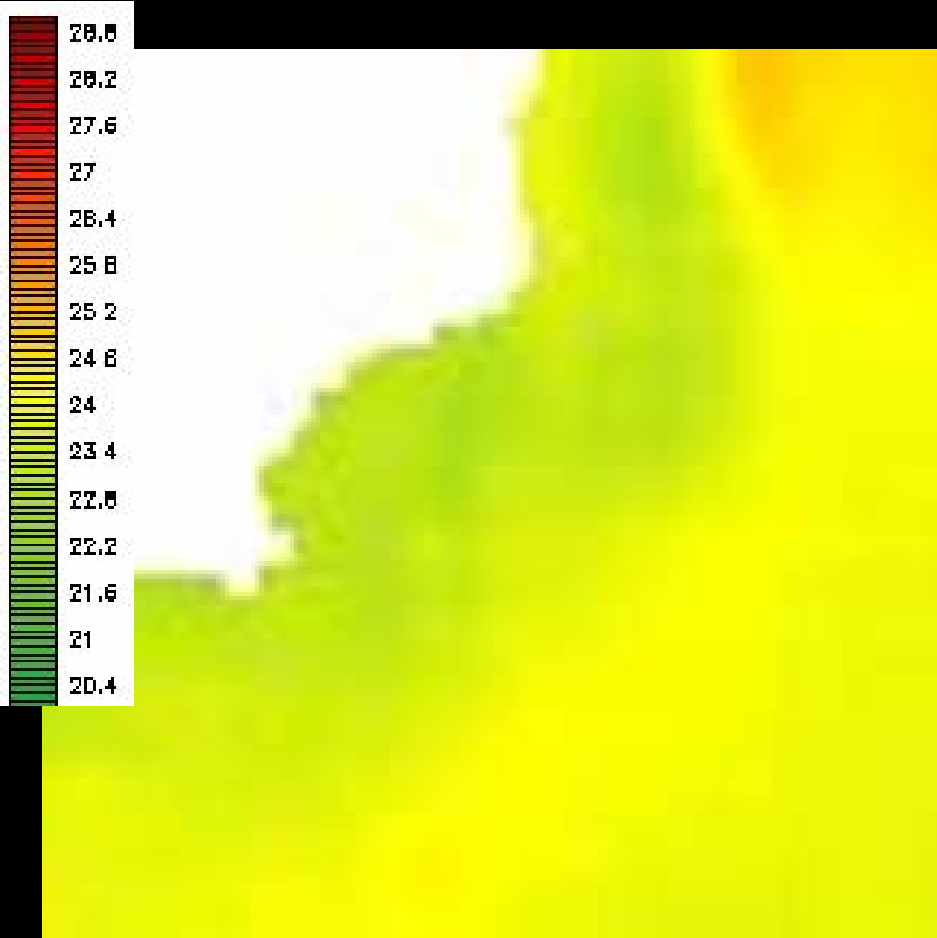
ESA SeaSAR 2008, Frascati.

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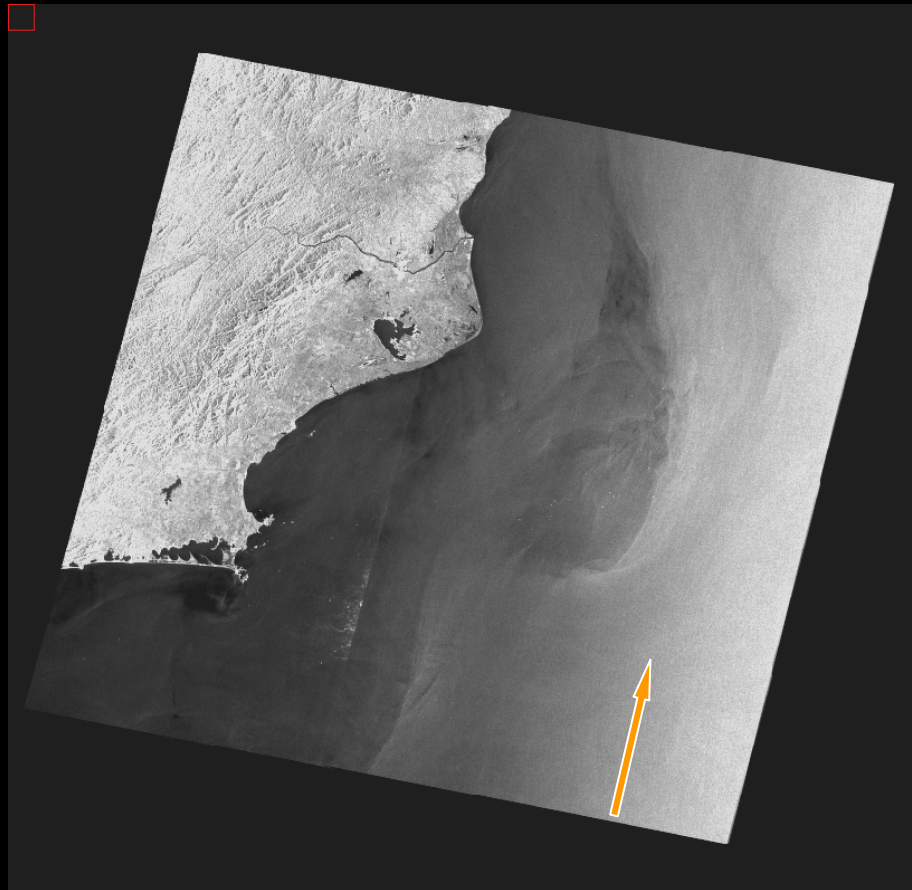
# GHR SST – Nov. 21, 2005



# GHRSSST – Nov. 21, 2005



# Radarsat-1 ScanSAR Nov. 21, 2005



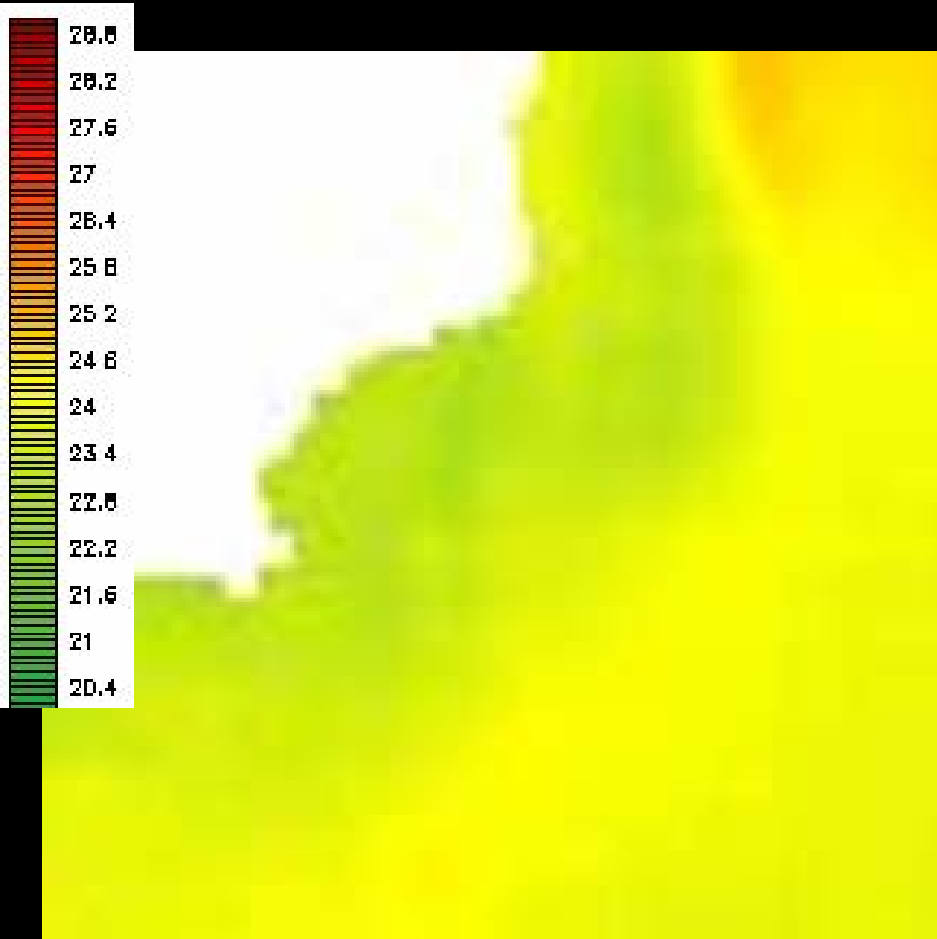
Jan. 21-25, 2008

ESA SeaSAR 2008, Frascati.





GHR SST – Nov. 21, 2005




Radarsat-1 ScanSAR Nov. 21, 2005



Jan. 21-25, 2008

ESA SeaSAR 2008, Frascati.



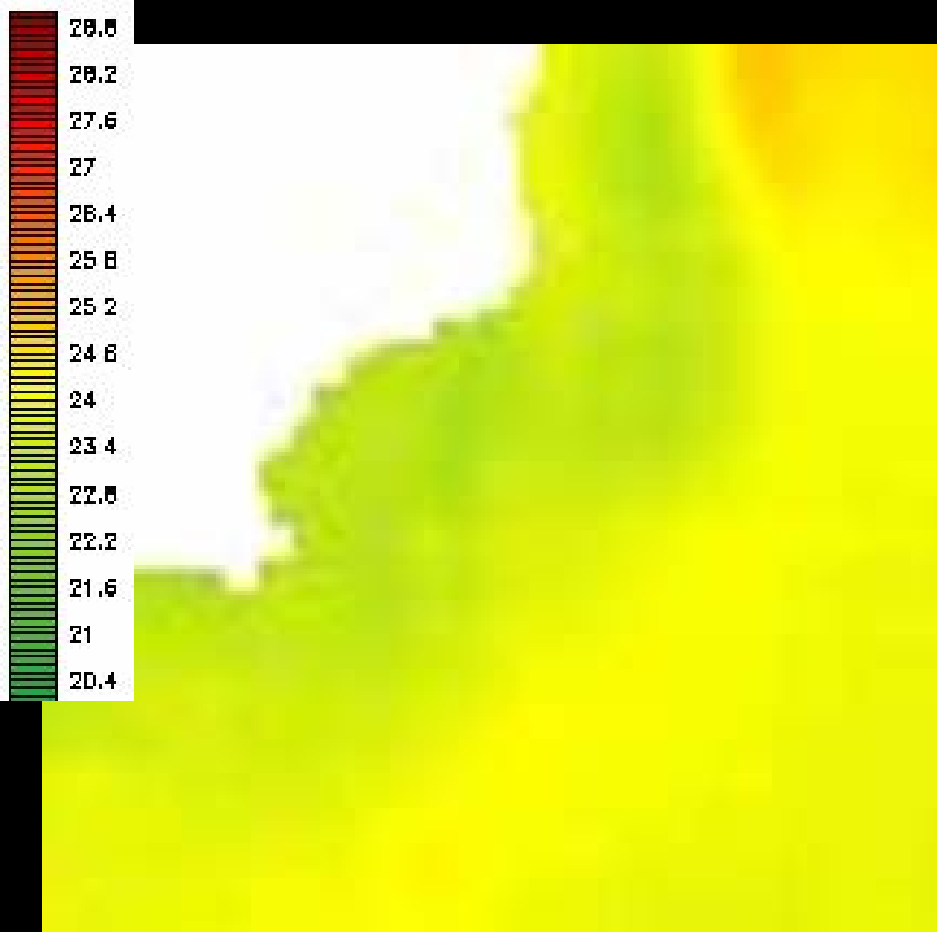
Johannessen et al. (1996), using a development of Lyzenga (1991), presents the following expression for the perturbation of NRCS across an oceanic front caused by short wave/current gradients:

$$\Delta\sigma_0 = \left( \frac{\sqrt{(du/dx)^2 + (dv/dx)^2}}{\beta_r} \right) \cos(\phi - \psi) g(\phi, \phi_w)$$

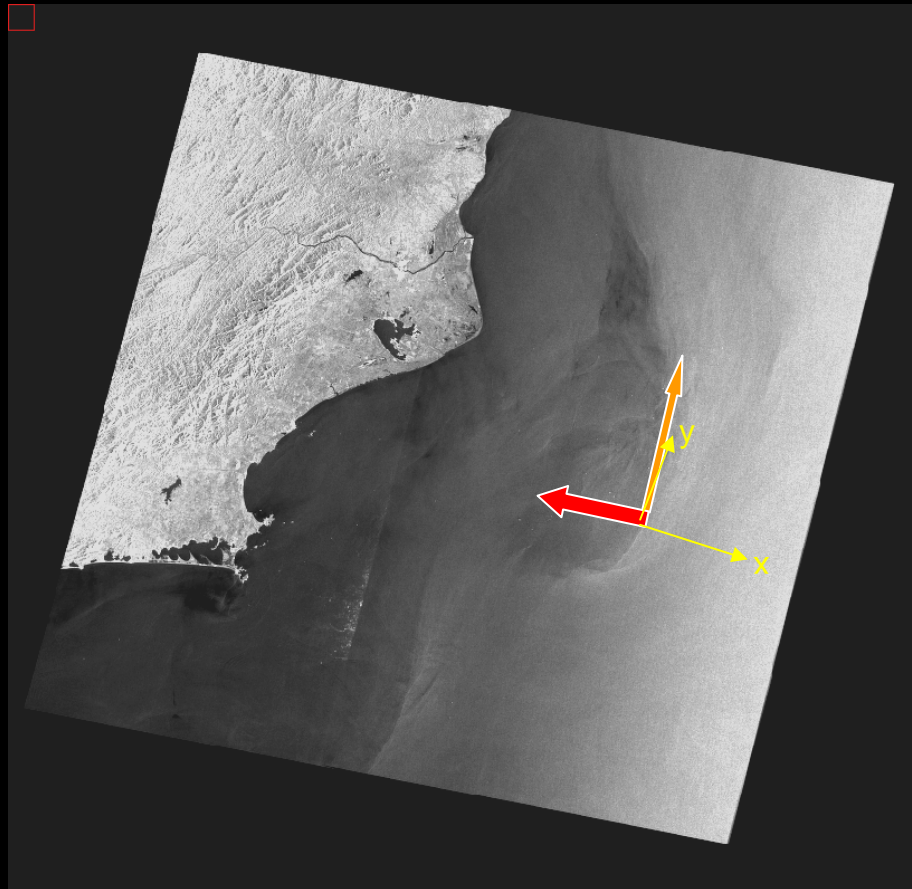
Where,  $\Phi$  is the SAR look angle relative to the orientation of the front, and  $\Psi$  is parameter measuring the relative strength of shear versus convergence.  $\beta_r$  is the wave spectrum relaxation rate.

Function  $g$  depends on wind direction, ratio of group to phase velocity of short waves,  $p$  and  $n$  parameters that control wave spectrum falloff in  $k$  and azimuth.

GHR SST – Nov. 21, 2005



Radarsat-1 ScanSAR Nov. 21, 2005



$$\phi_W = 95^\circ; \phi_R = 185^\circ; x_{rot} = -10^\circ$$

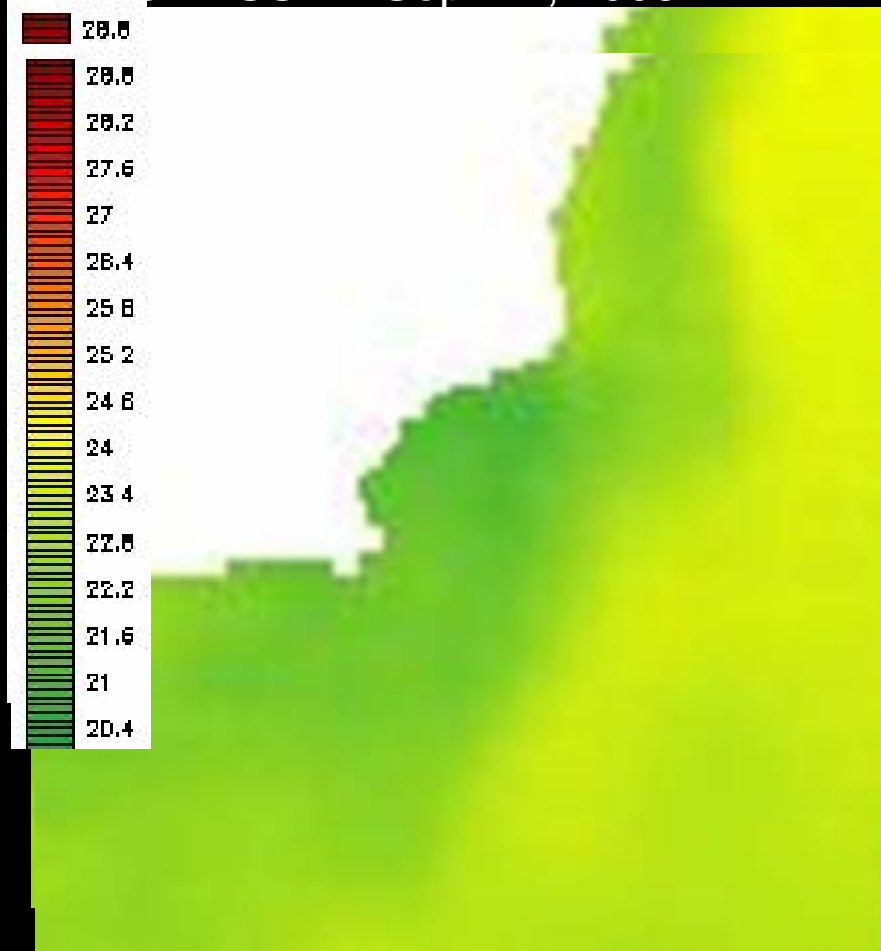


Jan. 21-25, 2008

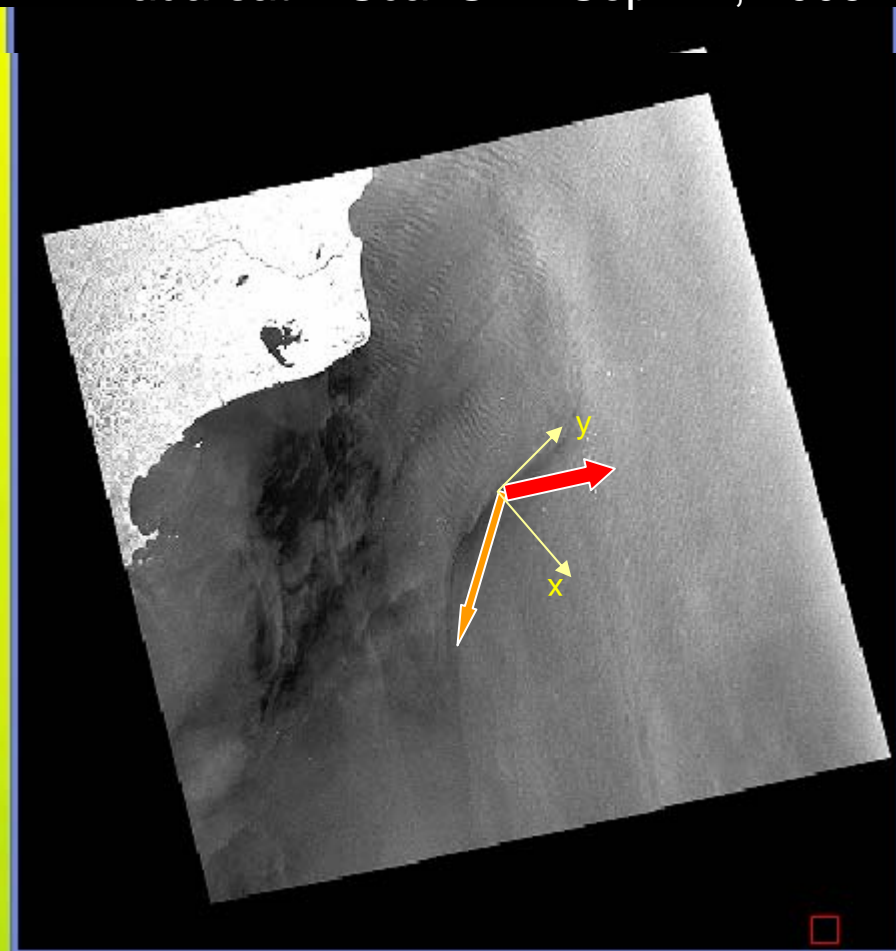
ESA SeaSAR 2008, Frascati.


$$\frac{\sigma_f - \sigma_0}{\sigma_0} < 0 (> 0) \text{ for } \frac{\partial u}{\partial x} > 0 (< 0)$$

GHRSSST – Sep. 12, 2005



Radarsat-1 ScanSAR Sep. 12, 2005



 SAR look direction

 wind direction

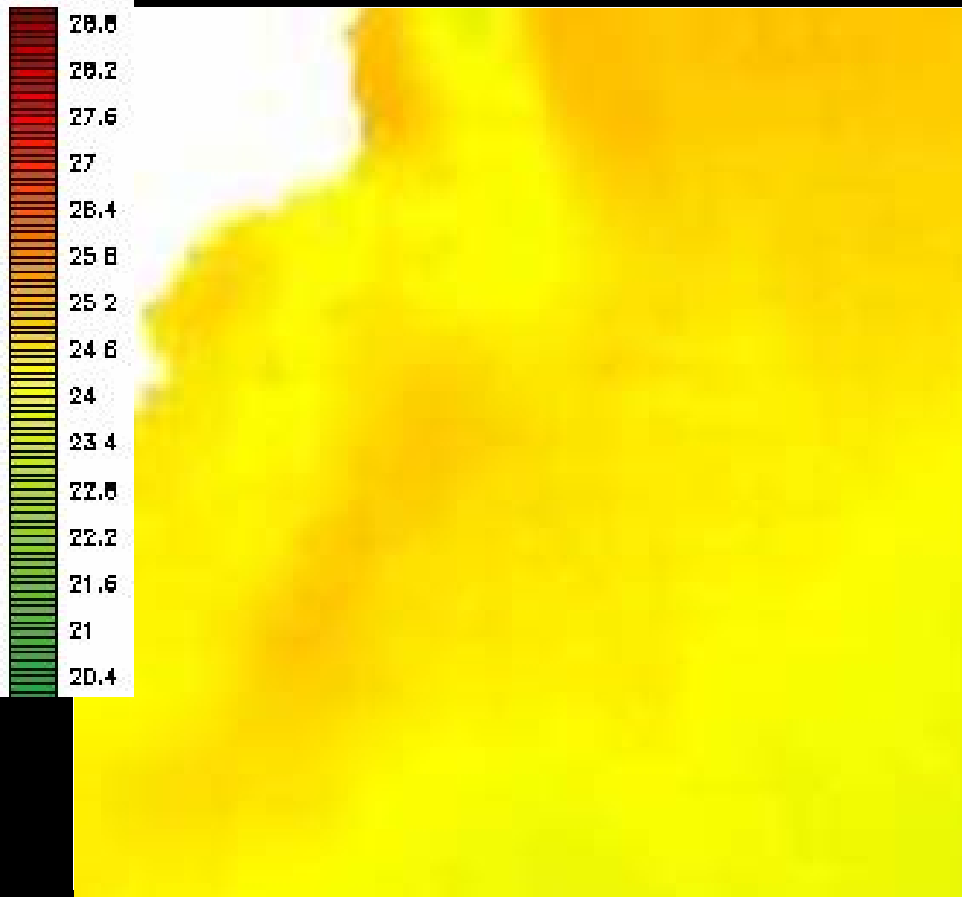
Jan. 21-25, 2008

ESA SeaSAR 2008, Frascati.

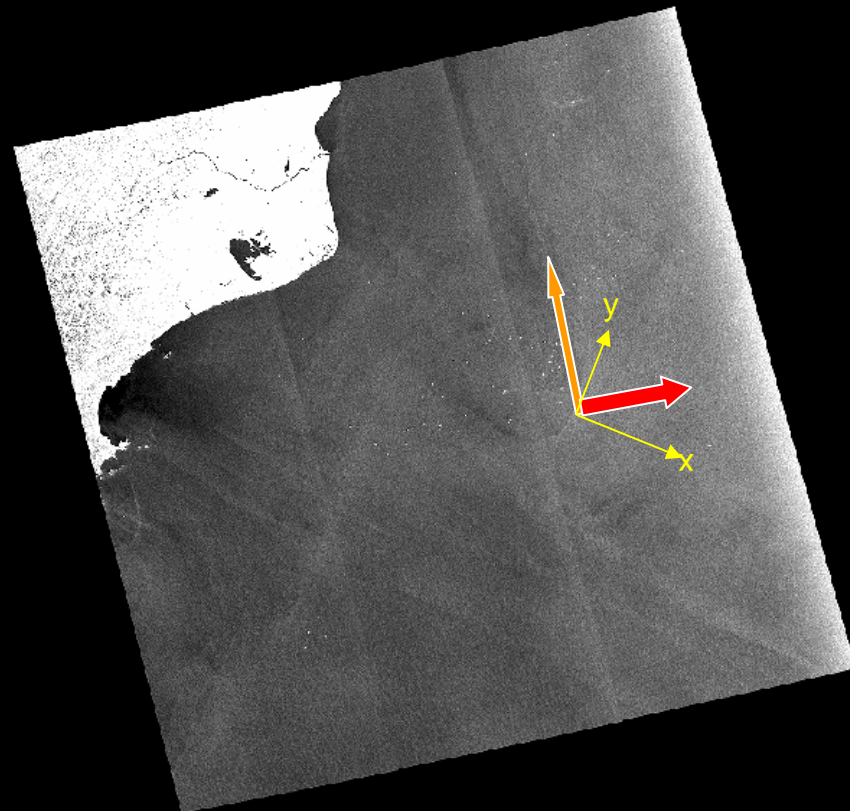
$$\phi_w = 300^\circ; \phi_r = 68^\circ; x_{rot} = -60^\circ$$

$$\frac{\sigma_f - \sigma_0}{\sigma_0} < 0 (> 0) \text{ for } \frac{\partial u}{\partial x} > 0 (< 0)$$


GHRSSST – Oct. 30, 2005



Radarsat-1 ScanSAR Oct. 30, 2005



 SAR look direction

 wind direction

$$\phi_w = 128^\circ; \phi_R = 38^\circ; x_{rot} = -30^\circ$$

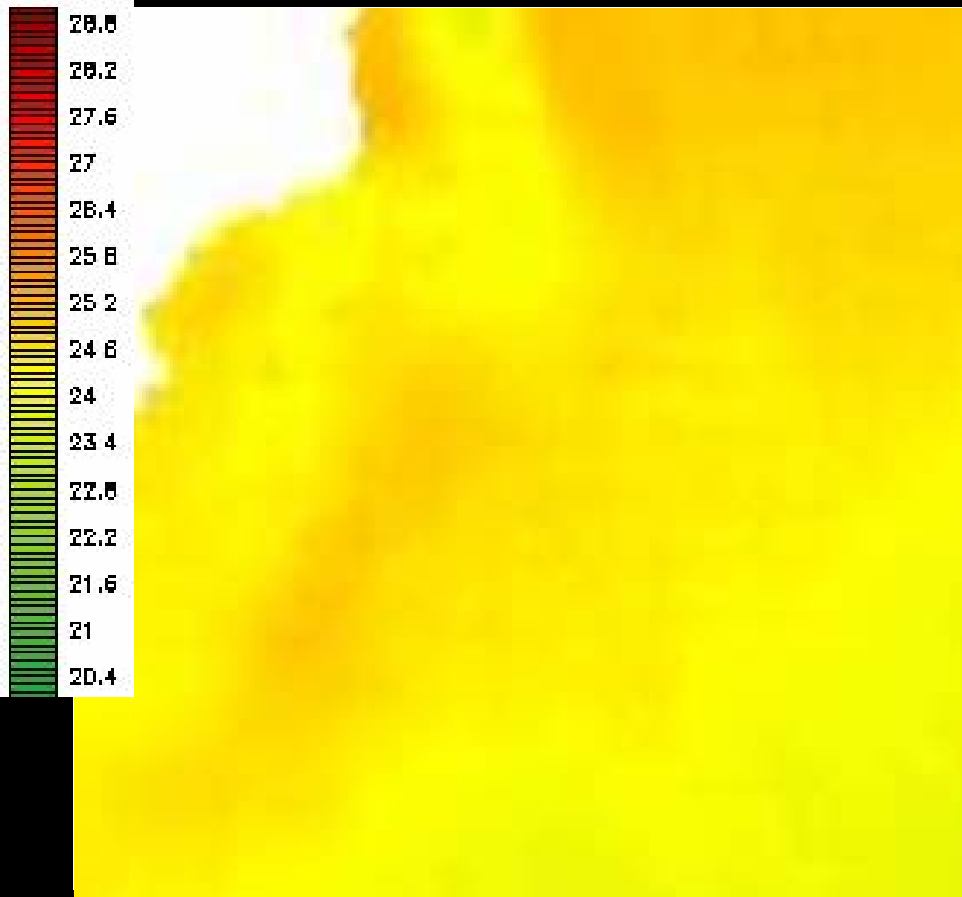
Jan. 21-25, 2008

ESA SeaSAR 2008, Frascati.

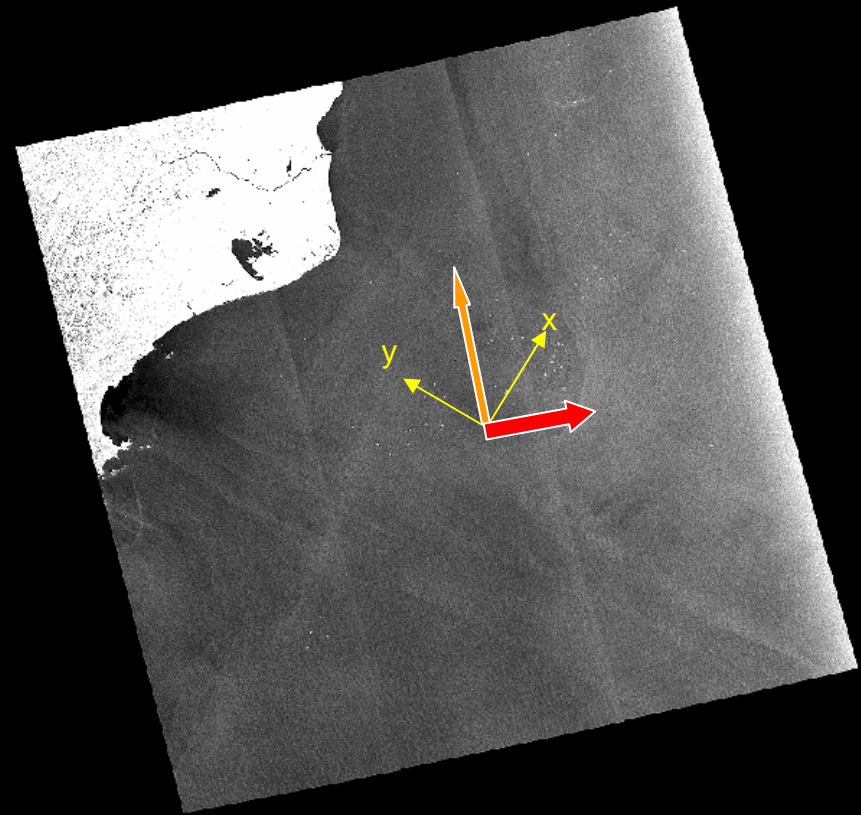
$$\frac{\sigma_f - \sigma_0}{\sigma_0} < 0 (> 0) \text{ for } \frac{\partial u}{\partial x} > 0 (< 0)$$



GHRST – Oct. 30, 2005



Radarsat-1 ScanSAR Oct. 30, 2005



$$\phi_W = 45^0; \phi_R = -45^0; x_{rot} = 50^0$$

Jan. 21-25, 2008

ESA SeaSAR 2008, Frascati.

$$\frac{\sigma_f - \sigma_0}{\sigma_0} < 0 (> 0) \text{ for } \frac{\partial u}{\partial x} < 0 (> 0)$$

# Conclusions

- ✓ SAR images can be used at Campos Basin for locating BC inshore frontal zone (not always but about 30-40% of the time). This would be particularly crucial during episodes of heavy or persistent cloud cover;
- ✓ Both, short wave-current gradients interaction or MBL stability modulation seem to be at play in making the frontal zone visible in the SAR images of the region;
- ✓ An implementation and better validation of a radar imaging model such as Lyzenga (1991), Johannessen et al. (1996), Romeiser et al. (1997), Kudryavtsev et al. (2005) could provide information about flow kinematics and MBL dynamics at the frontal zone;
- ✓ Johannessen et al. (1996) model used for presented SAR images produced very weak NRCS modulations at BC front;
- ✓ The use of SAR images for frontal extraction in the context of a modelling effort such as the FORM for a better initialization of a regional ocean model for the region seems promising methodology and is being investigated at moment.



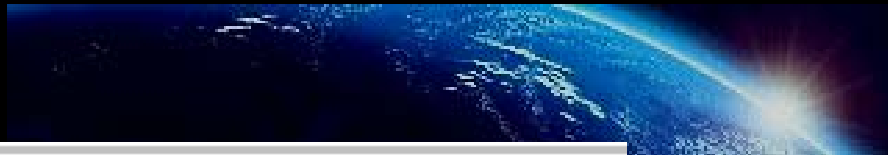
# THANKS

Jan. 21-25, 2008

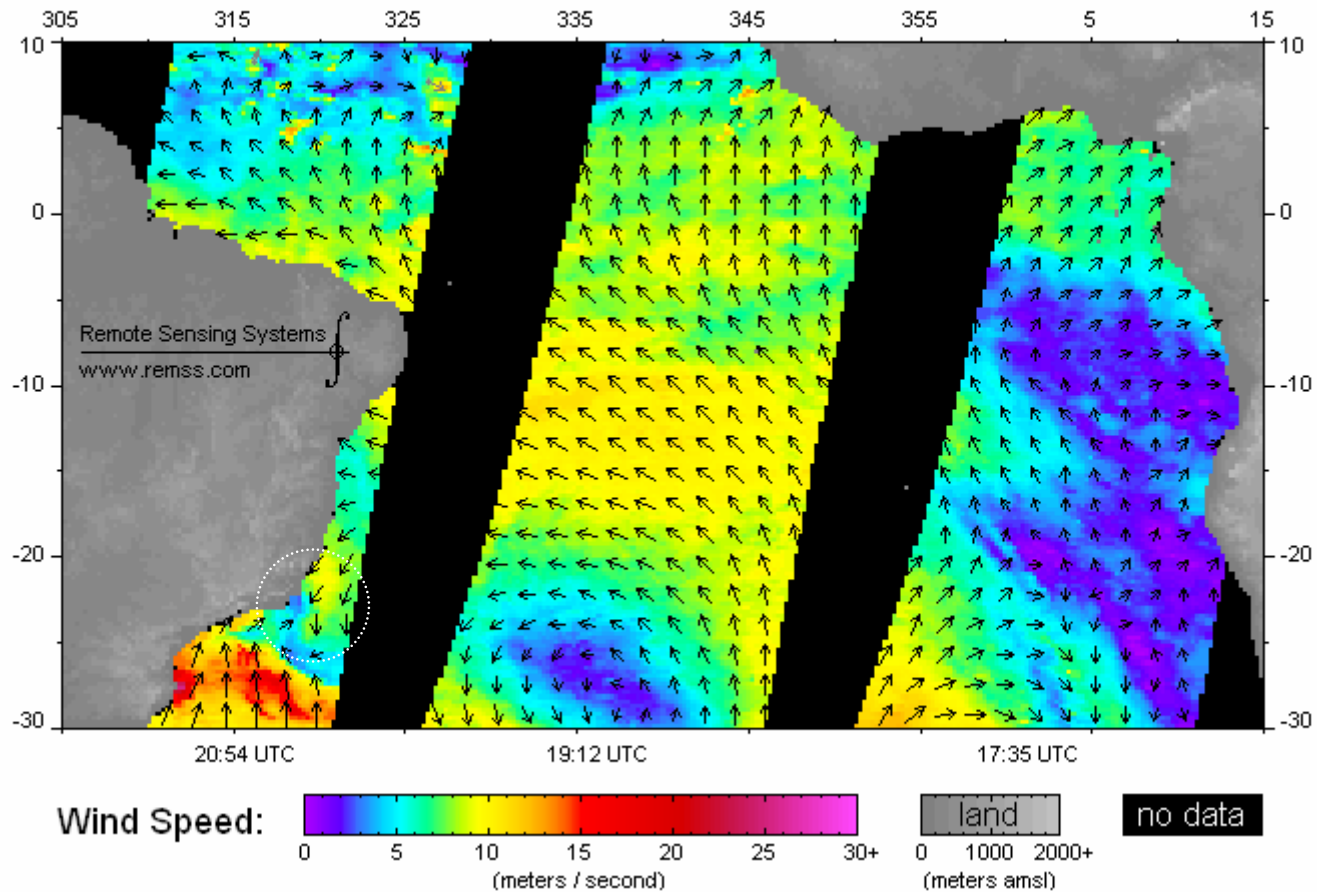
ESA SeaSAR 2008, Frascati.

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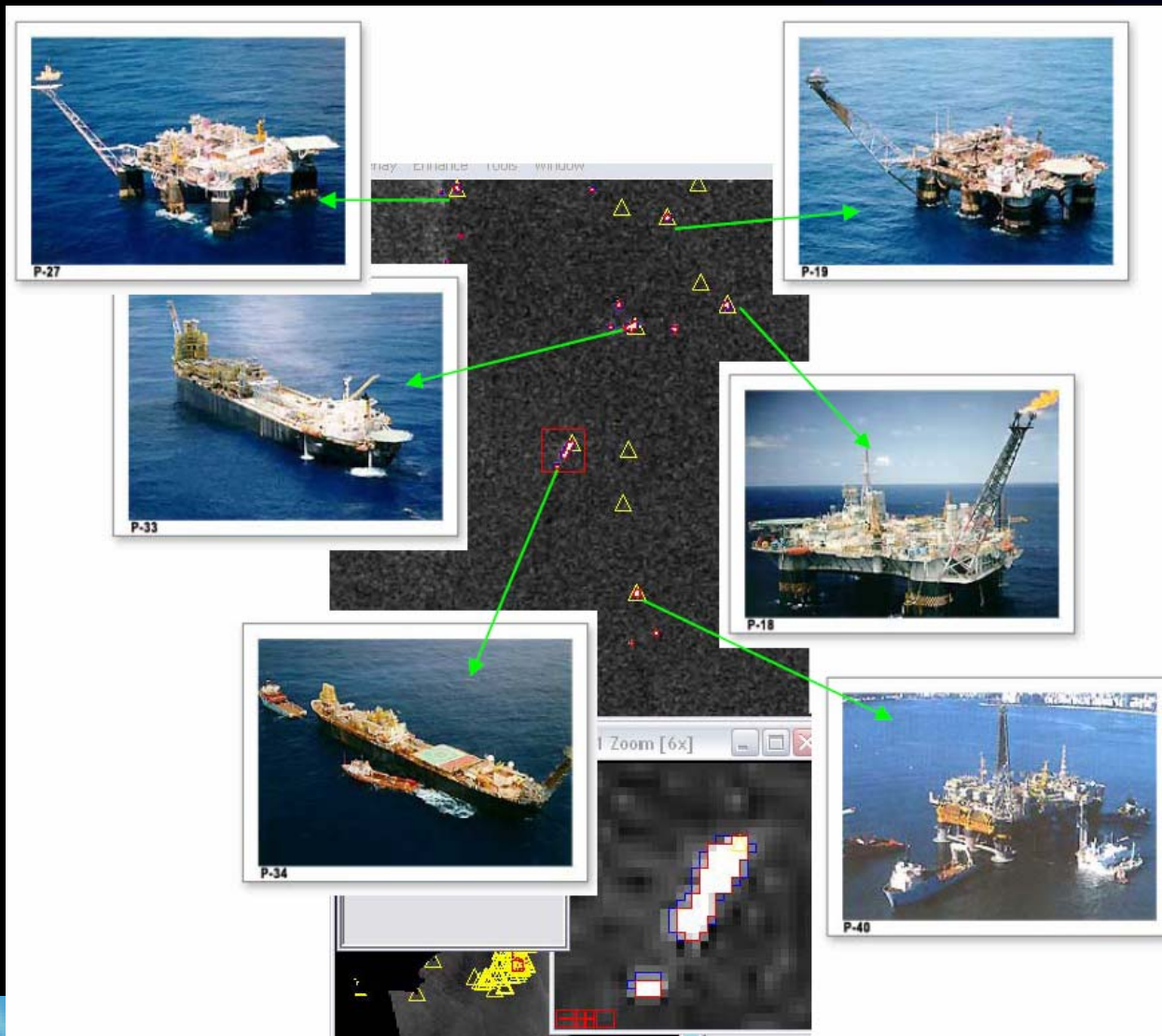
QuikScat wind vectors: 2005/09/12 - evening passes - Atlantic, Tropical, South



Jan. 21-25, 2008

ESA SeaSAR 2008, Frascati.



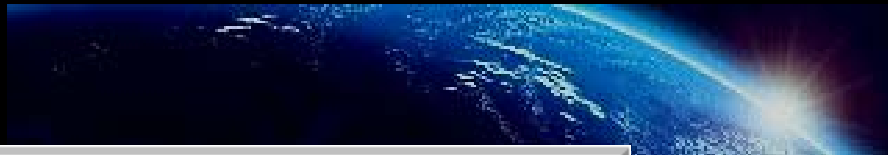


Jan. 21-25, 2008

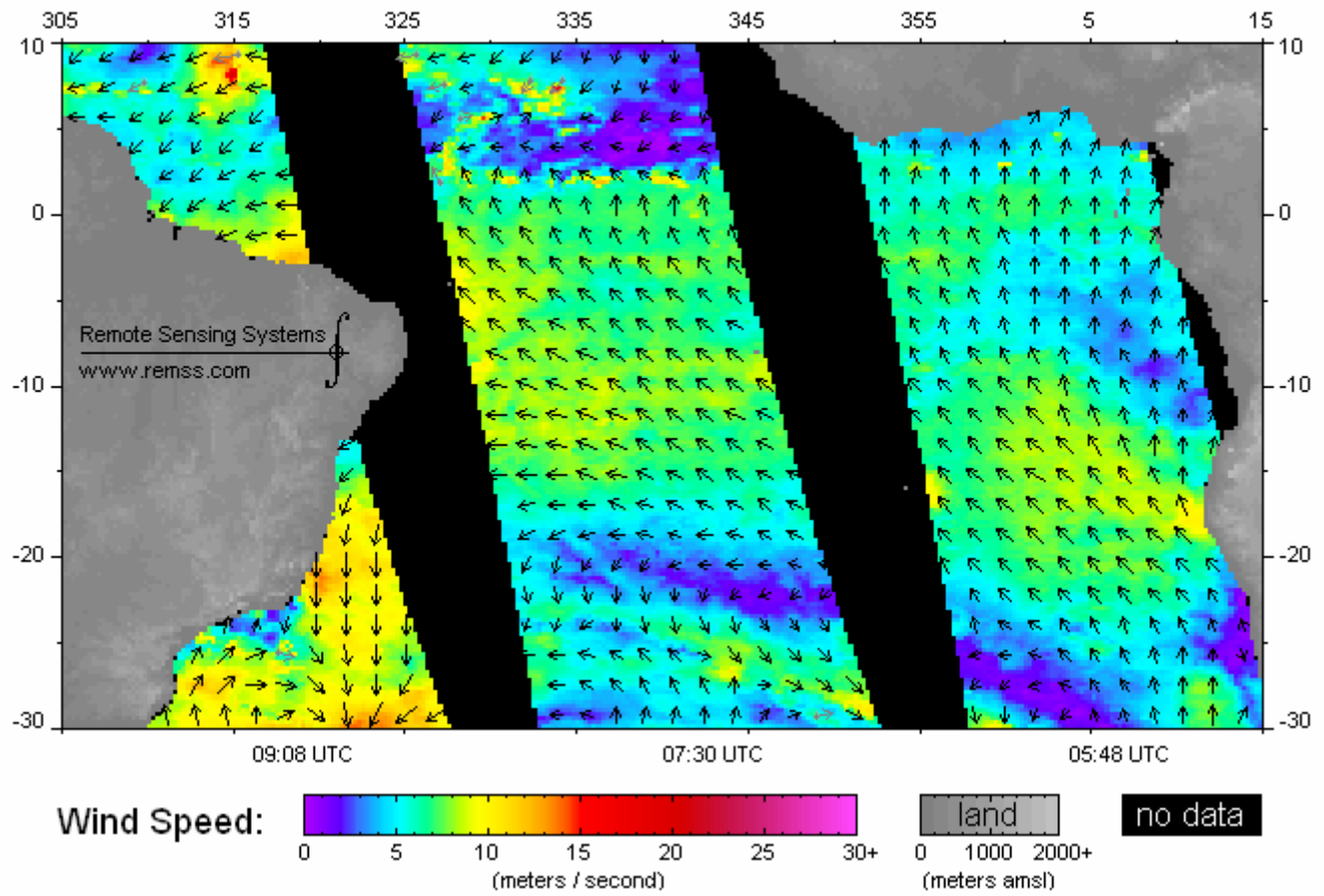
ESA SeaSAR 2008, Frascati.

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QuikScat wind vectors: 2005/10/18 - morning passes - Atlantic, Tropical, South



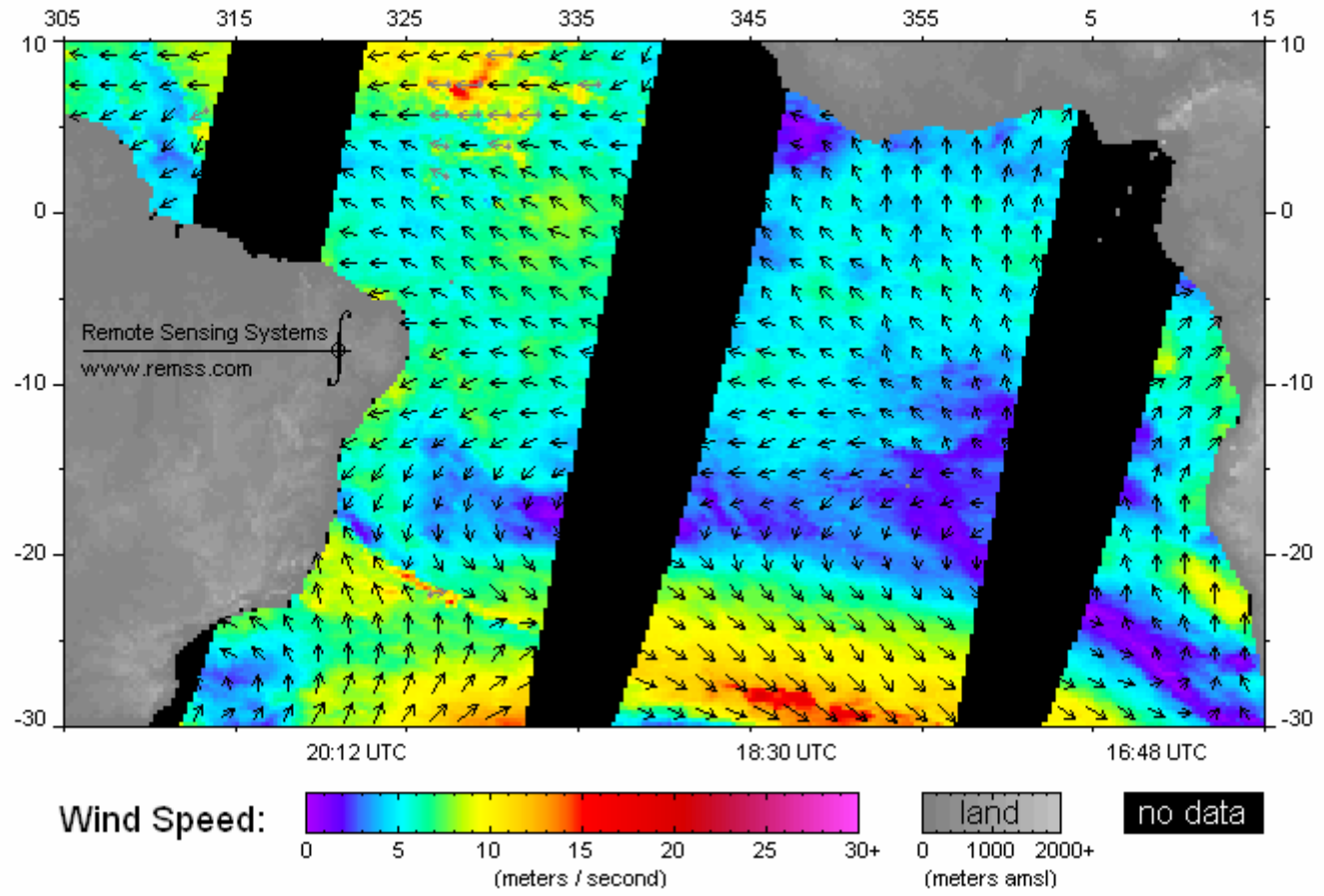
Jan. 21-25, 2008

ESA SeaSAR 2008, Frascati.





QuikScat wind vectors: 2005/10/30 - evening passes - Atlantic, Tropical, South

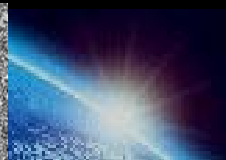


Jan. 21-25, 2008

ESA SeaSAR 2008, Frascati.





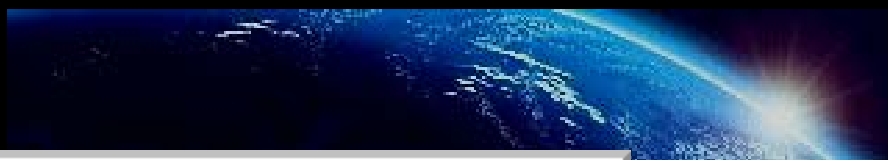


Jan. 21-25, 2008

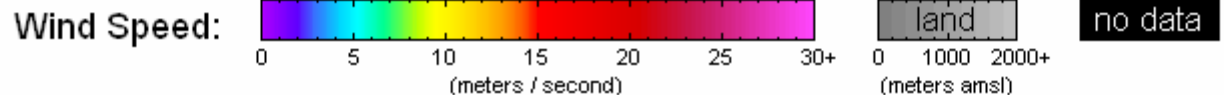
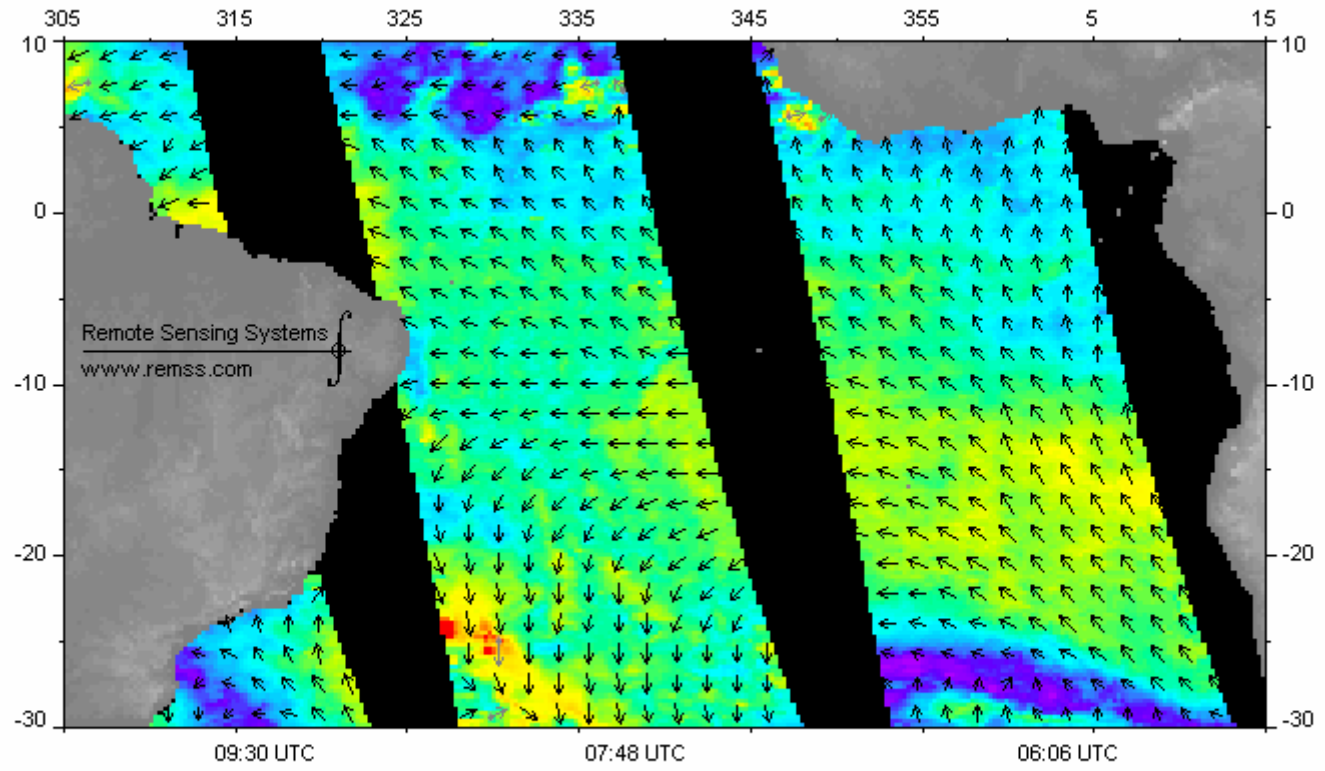
ESA SeaSAR 2008, Frascati.

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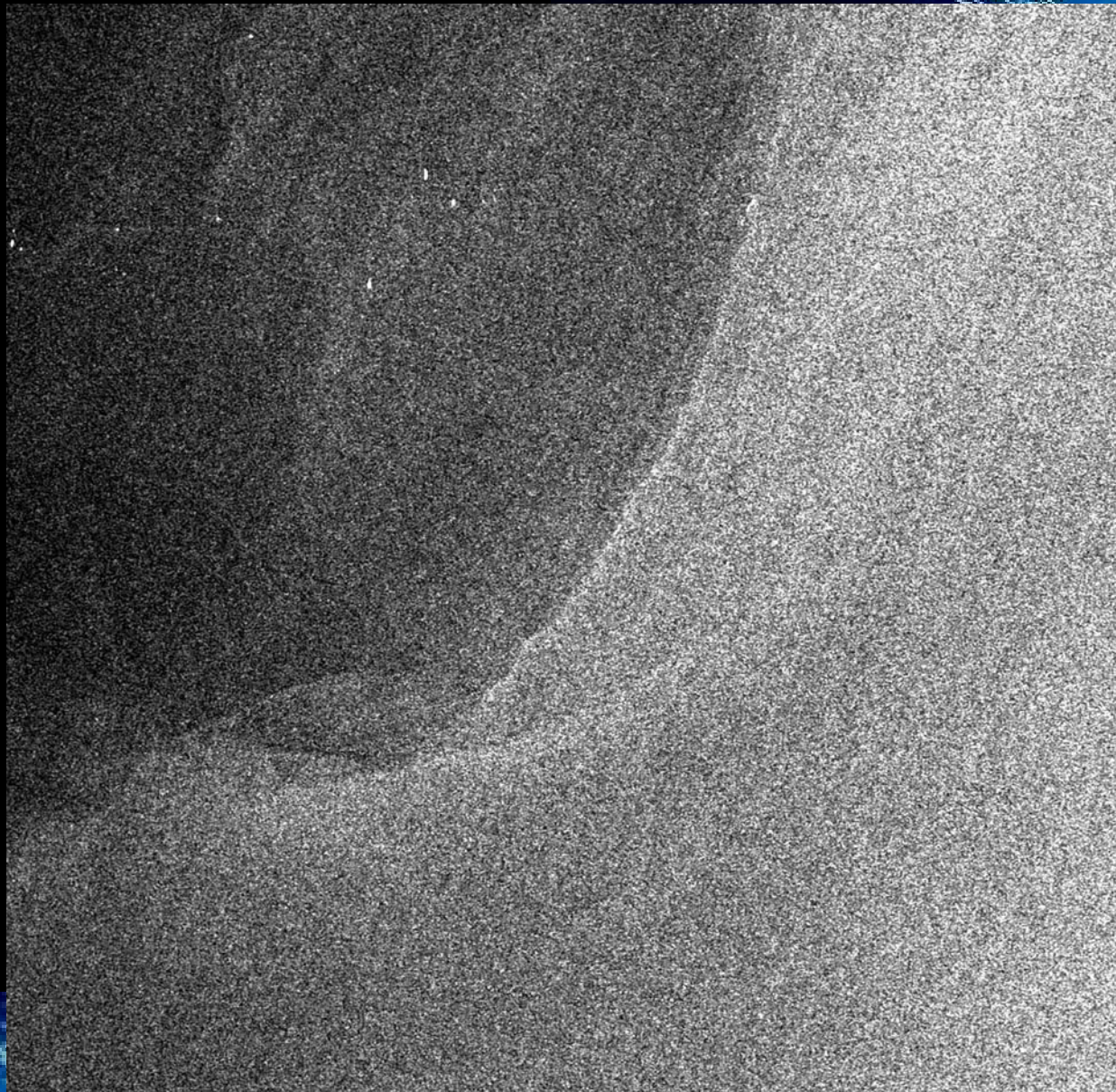
QuikScat wind vectors: 2005/11/21 - morning passes - Atlantic, Tropical, South



Jan. 21-25, 2008

ESA SeaSAR 2008, Frascati.

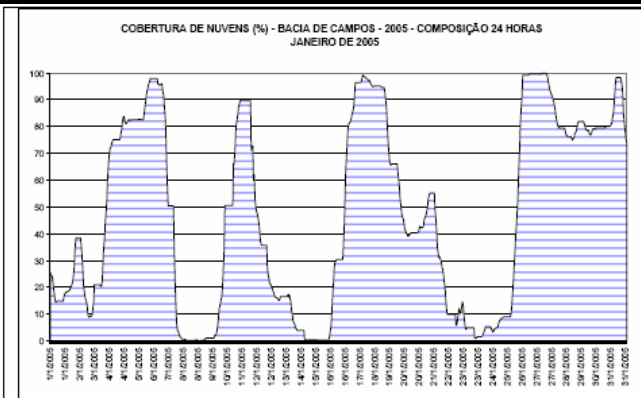
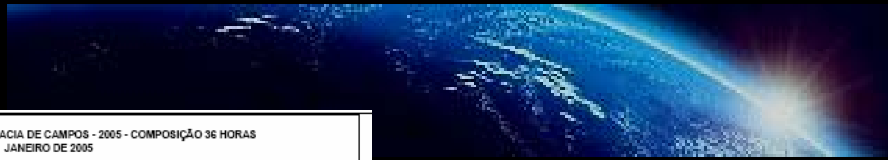




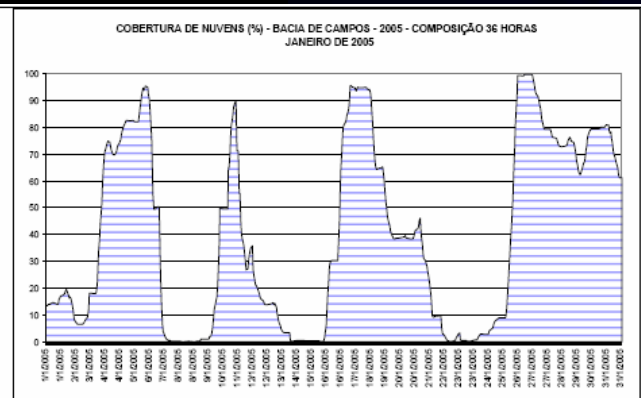
Jan. 21-25, 2008

ESA SeaWiFS 2008, 11ascan1.

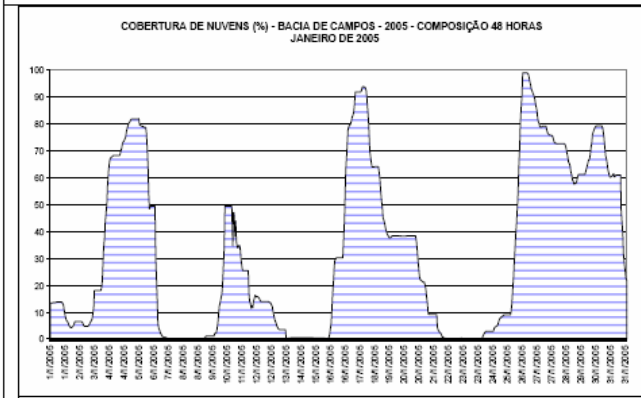




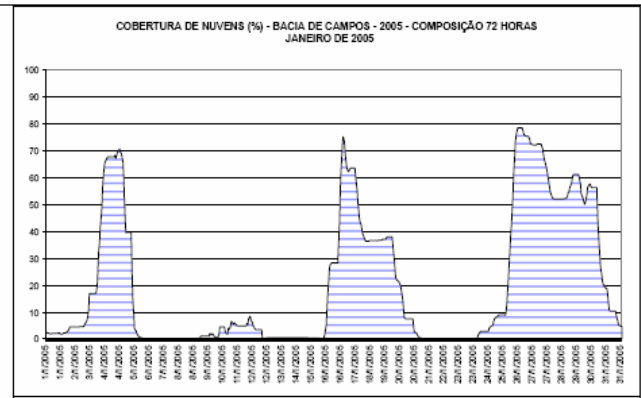
(a)



(b)



(c)



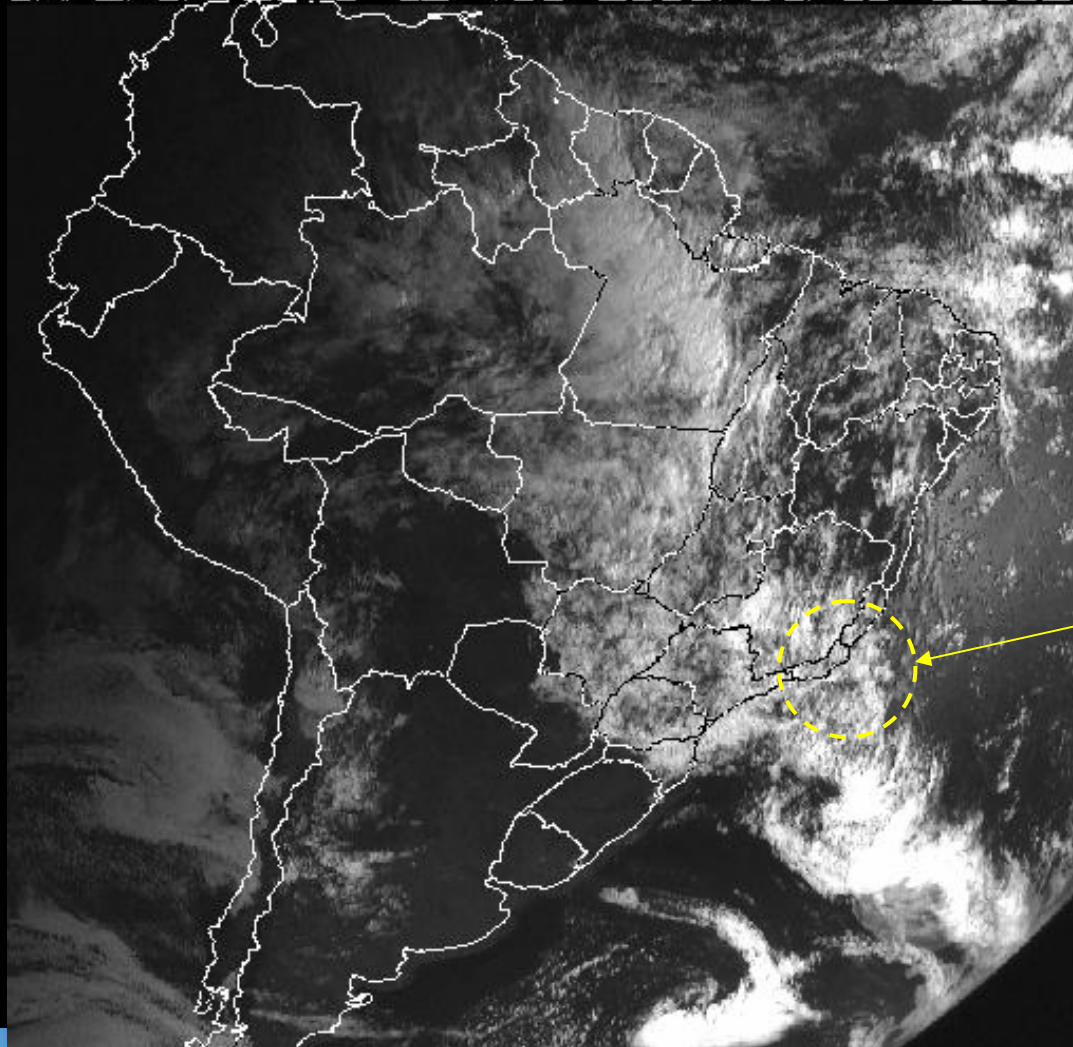
(d)



Percent of cloud cover at Campos Basin for time compositing of GOES IR images: a) 24 h; b)48 h; c) 36 h and d) 72 h. January 2005.

# South Atlantic Convergence Zone (SACZ) – Jan. 18, 2005

INPE/CPTEC\_G-12 VIS 2005/01/18 1139Z



Campos Basin



Jan. 21-25, 2008

ESA SeaSAR 2008, Frascati.

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