

# Coral bleaching analysis in the western tropical Atlantic



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Tropical Atlantic and PIRATA-15 Meeting  
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# BRAZILIAN CORAL REEF MONITORING PROGRAMM (SA NODE GCRMN)

- species identification
- size measurements
- more indicators (regional and local)
- basic data sent to reef check
- "status of the reefs" reports (GCRMN SA node)
- other publications (technical and academic)

Zaira Matheus



Ministério do Meio Ambiente





# What is the problem ?

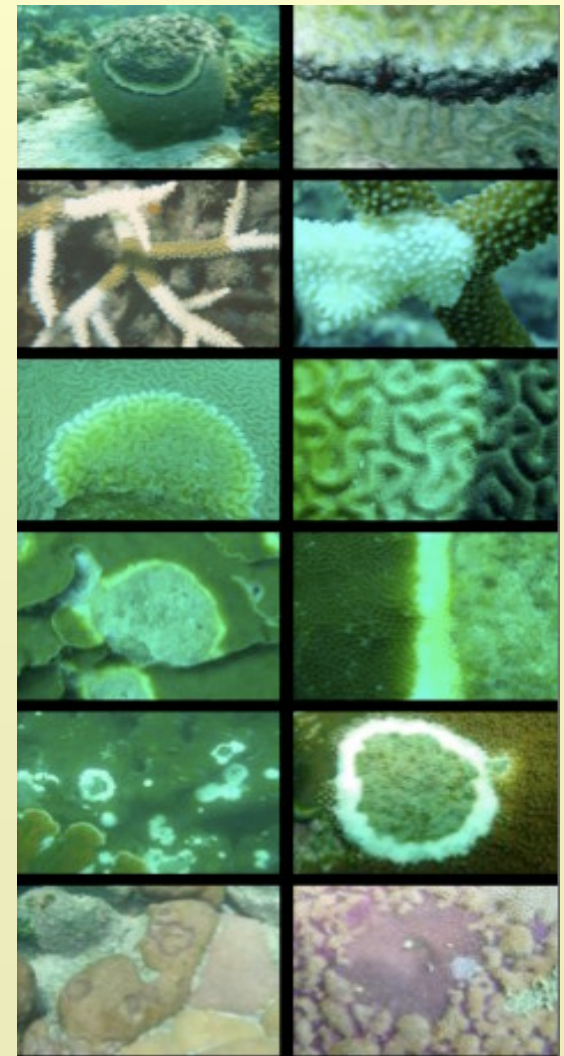
## *Status of Coral Reefs Around the World (Wilkinson, 2004)*

- “The major emerging threat to coral reefs in the last decade has been coral bleaching and mortality associated with global climate change.”
- “20% of the world’s coral reefs have been effectively destroyed and show no immediate prospects of recovery”;
- “24% of the world’s reefs are under imminent risk of collapse through human pressures; and a further 26% are under a longer term threat of collapse”;

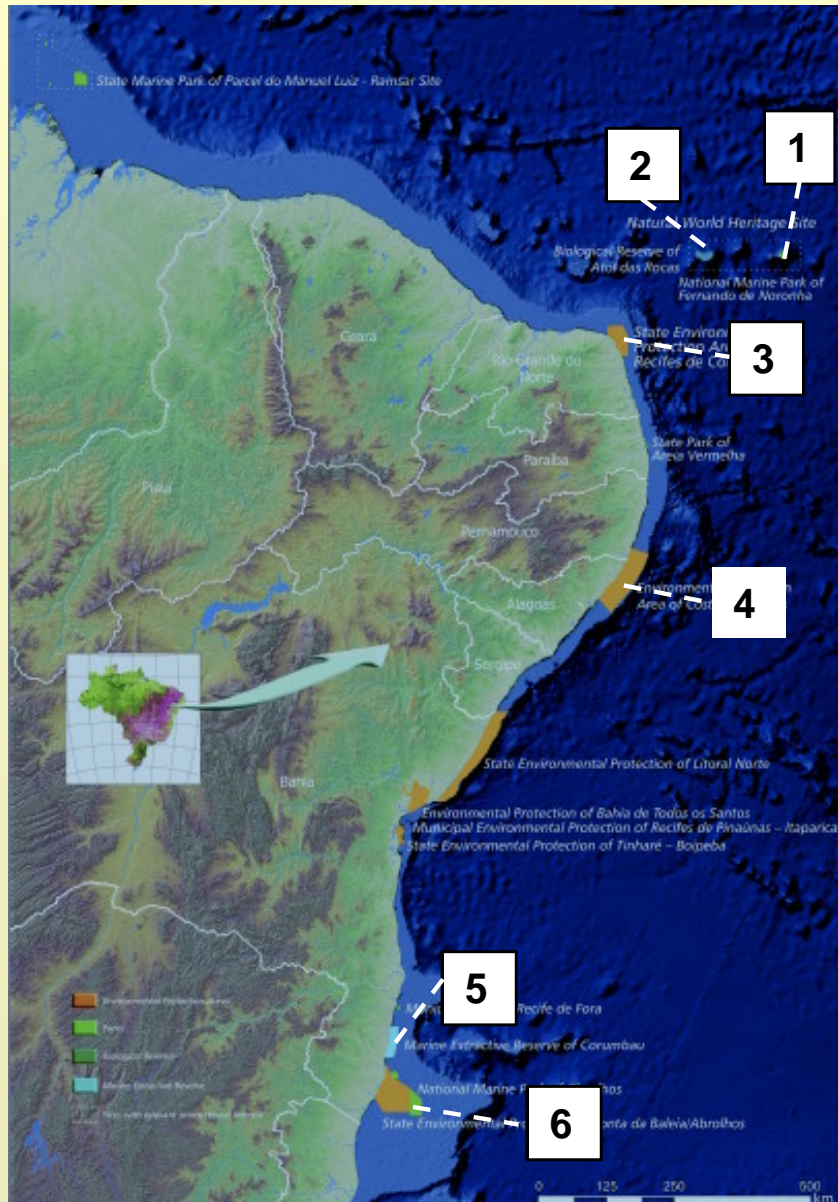


### *“The Top Ten” threats*

1. Coral bleaching due to SST elevation;
2. Rising levels of CO<sub>2</sub> in seawater;
3. Diseases, Plagues and Invasives;
4. ...
5. ...



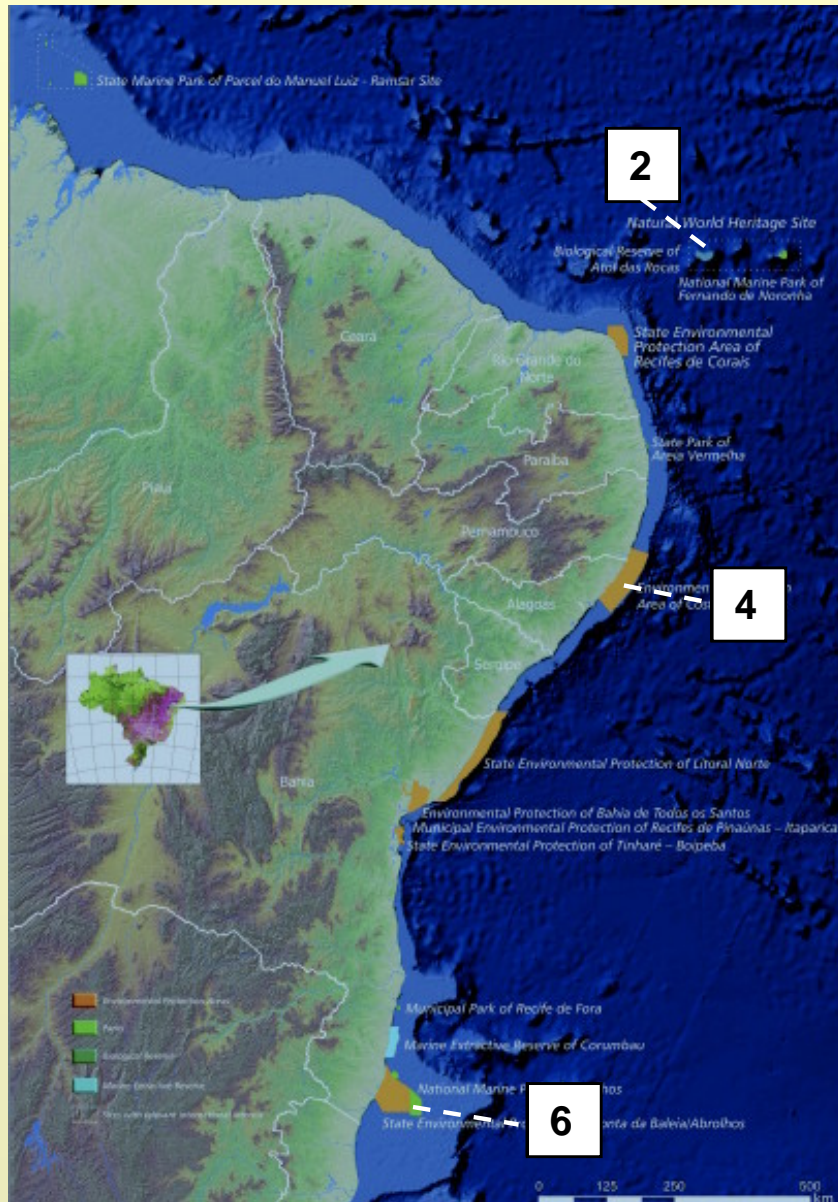
# Coral reefs in South Atlantic



## ● Brazilian Coral Reef Monitoring Program (SA Node GCRMN)

- 1 Parque Nacional Marinho de Fernando de Noronha
- 2 Reserva Biológica do Atol das Rocas
- 3 Área de Proteção Ambiental Recifes de Corais
- 4 Área de Proteção Ambiental da Costa dos Corais
- 5 Reserva Extrativista de Corumbaú
- 6 Parque Nacional Marinho de Abrolhos

# Coral reefs in South Atlantic



## Rocas (4°S34°W)



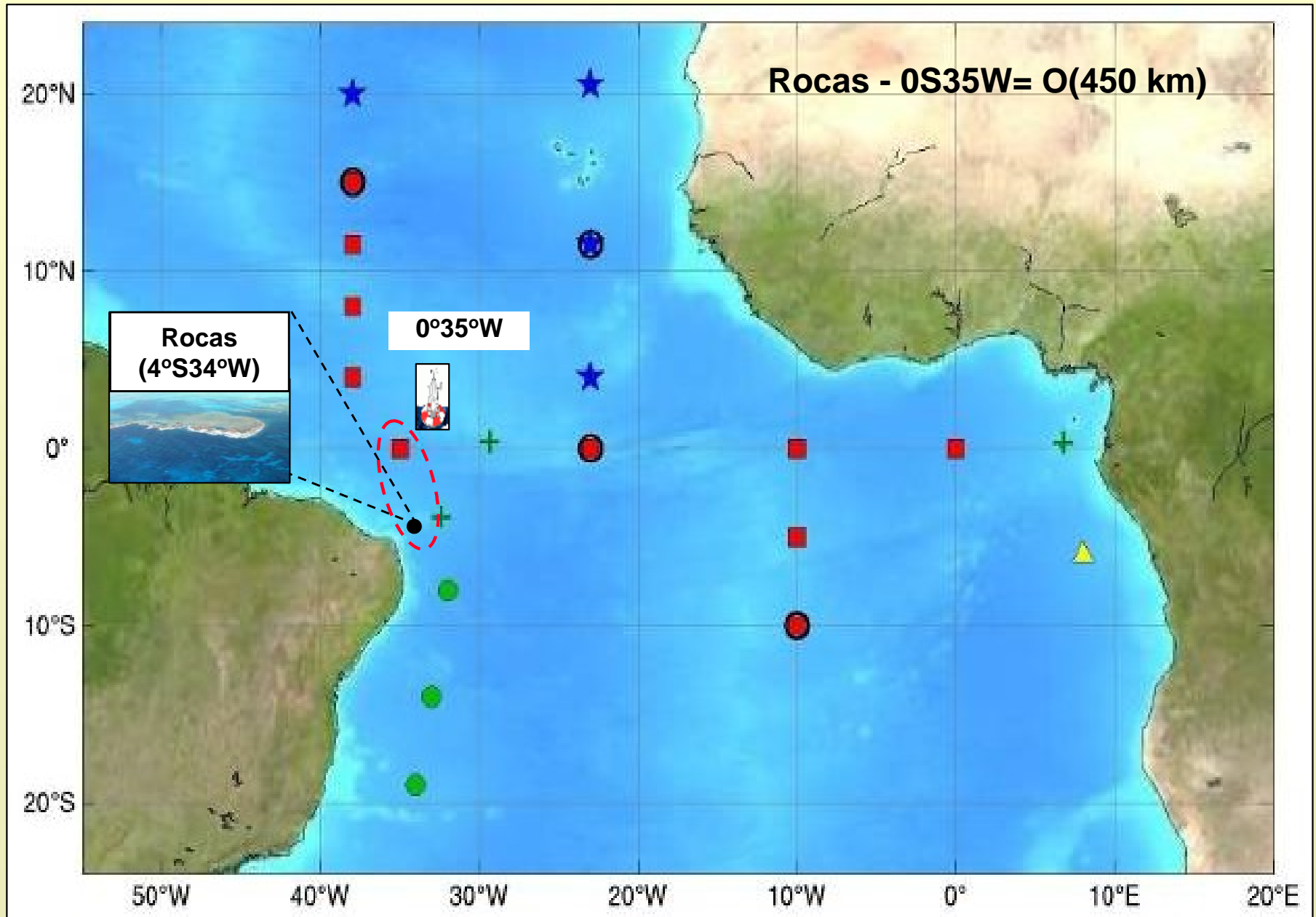
## Tamandaré (9°S35°W)



## Abrolhos (18°S39°W)



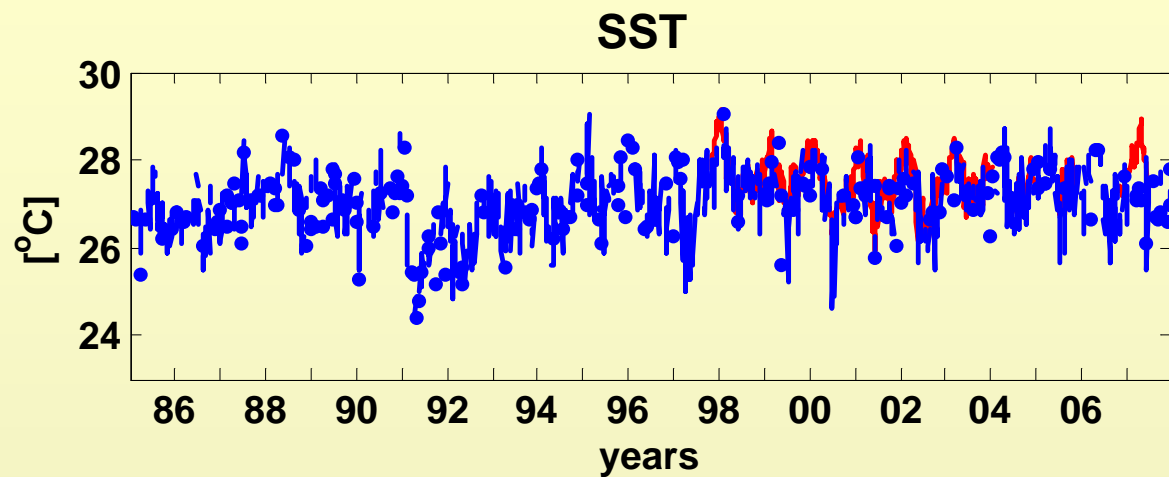
# Are we able to find any correlation between PIRATA data and coral bleaching events ?



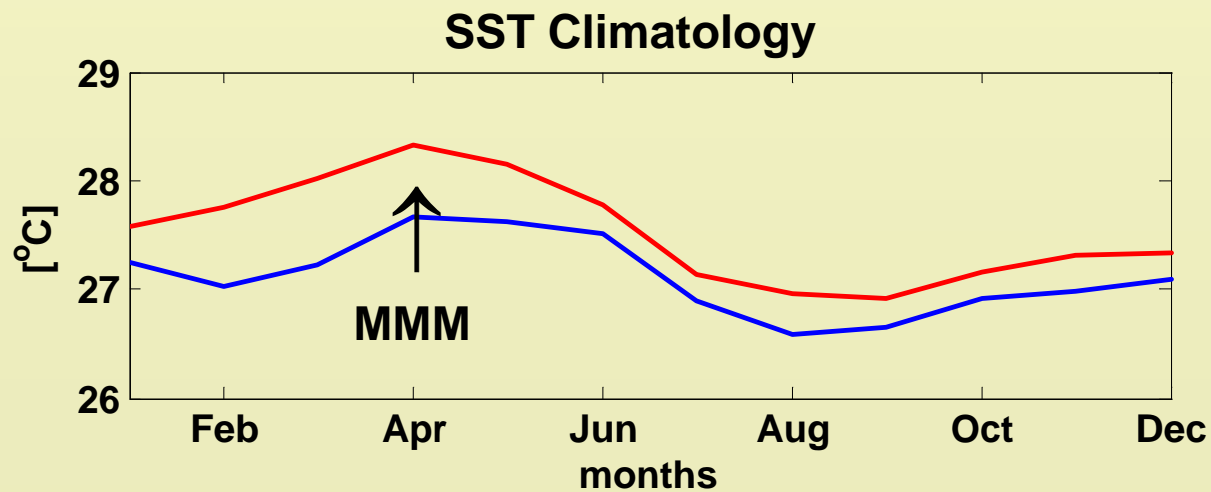
# Rocas – PIRATA 0°35°W



x



— 0°35°W AVHRR  
— 0°35°W PIRATA

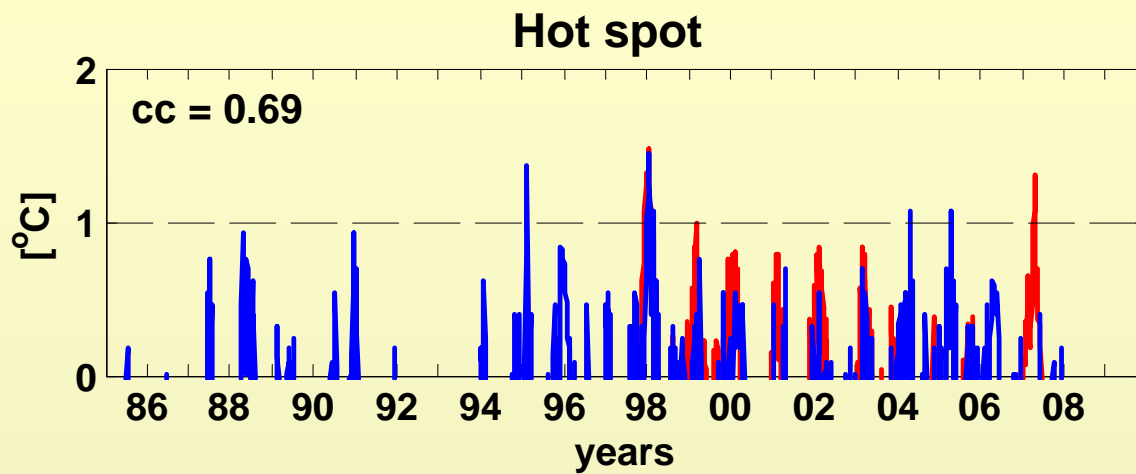


Monthly Mean Maximum  
(MMM)

# Rocas – PIRATA 0°35'W

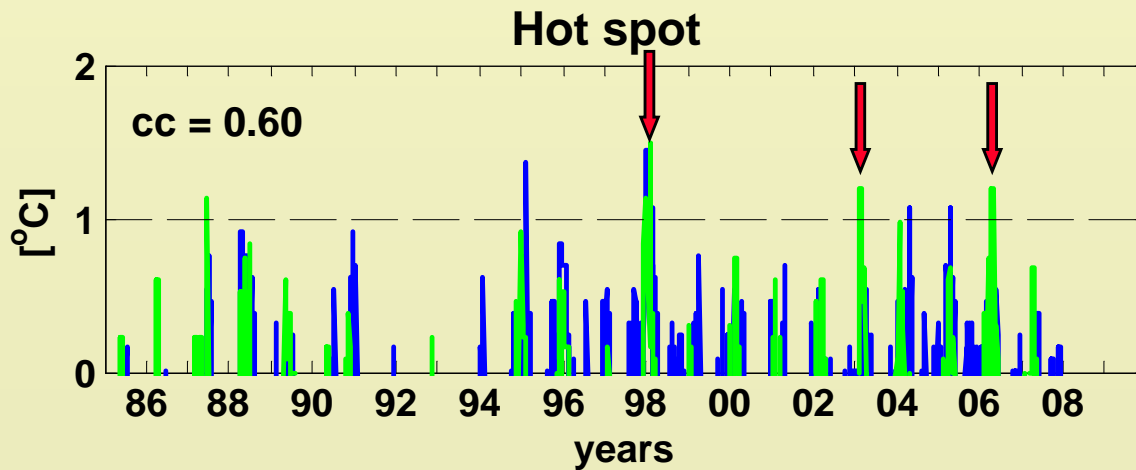


x



— 0°35'W AVHRR  
— 0°35'W PIRATA

Hot spot = (SST – MMM)

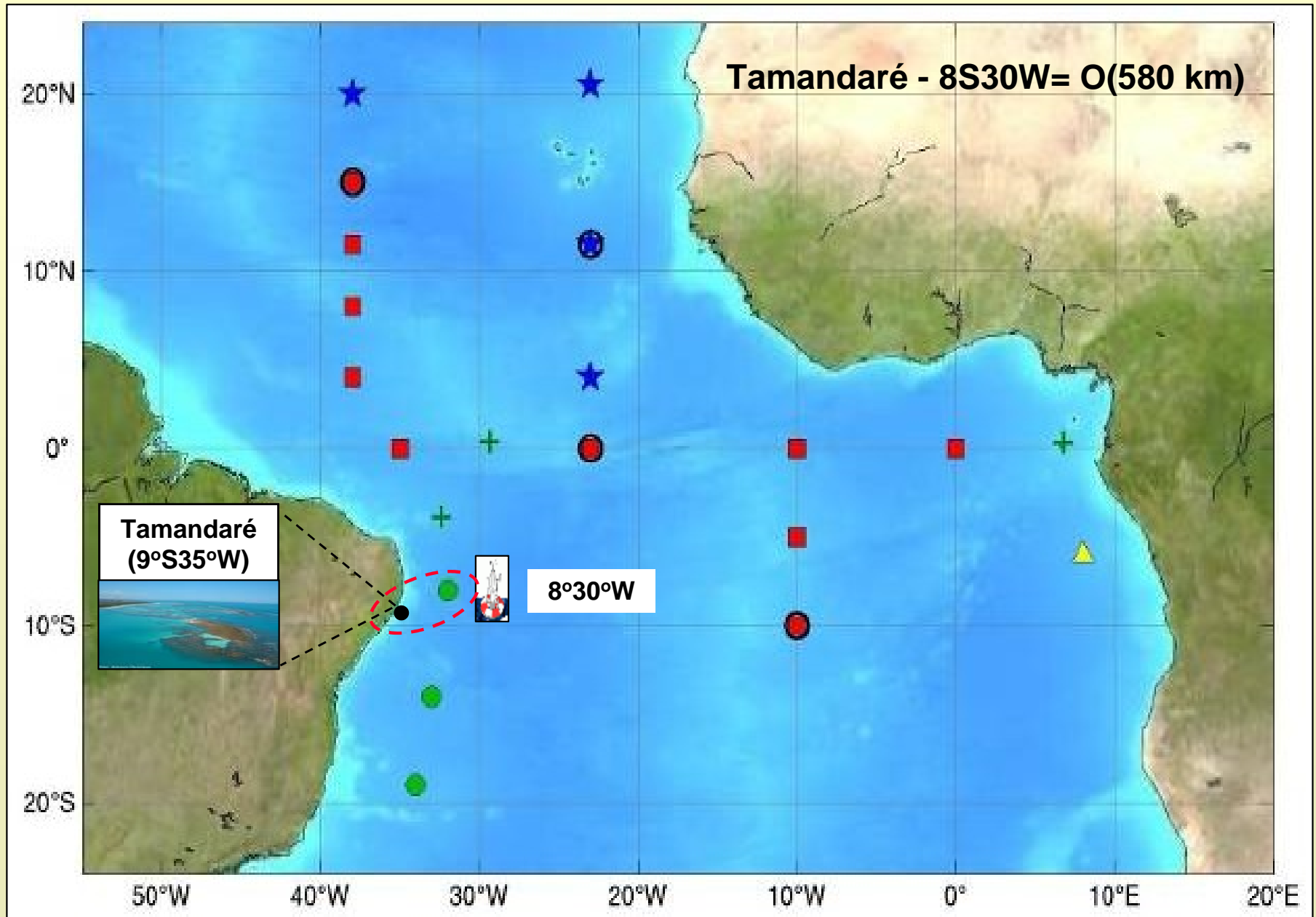


— 0°35'W AVHRR  
— Rocas AVHRR



**Bleaching events:**  
 1998 - Strong  
 2003 - Observed  
 2007 - Observed  
 2009 - ~ 50%

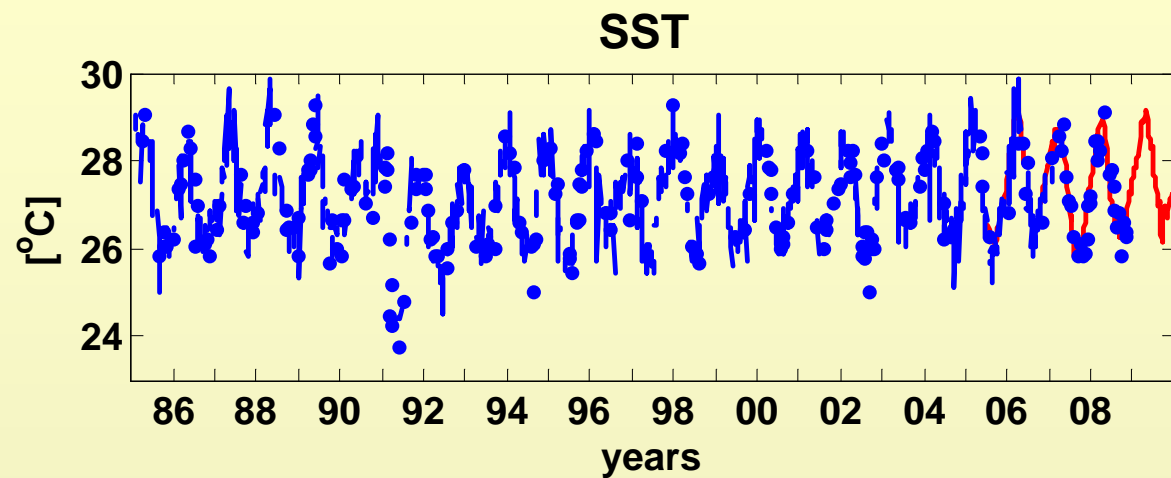
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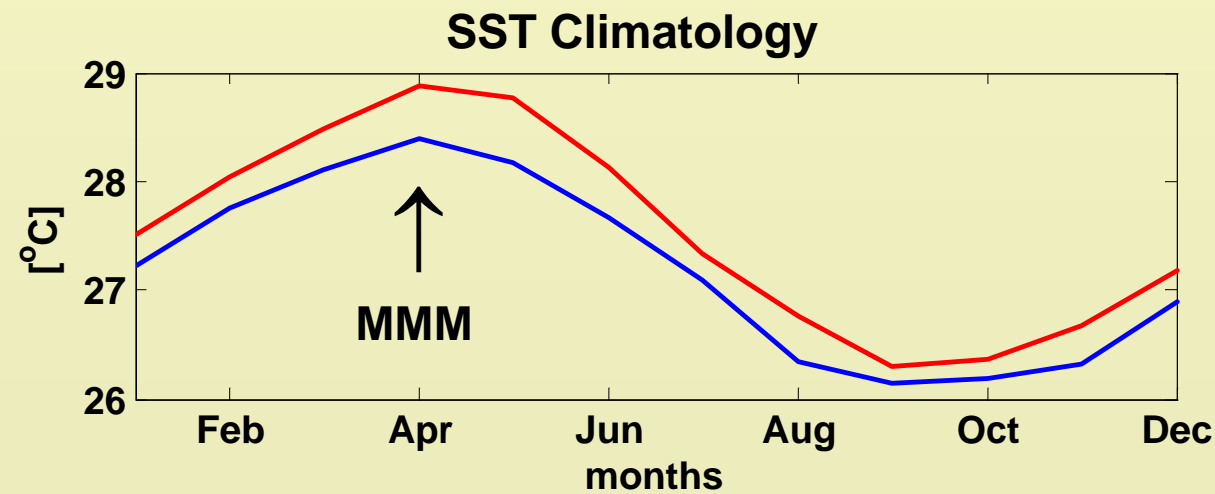
# Tamandaré – PIRATA 8°S30°W



X



— 8°30'W AVHRR  
— 8°30'W PIRATA

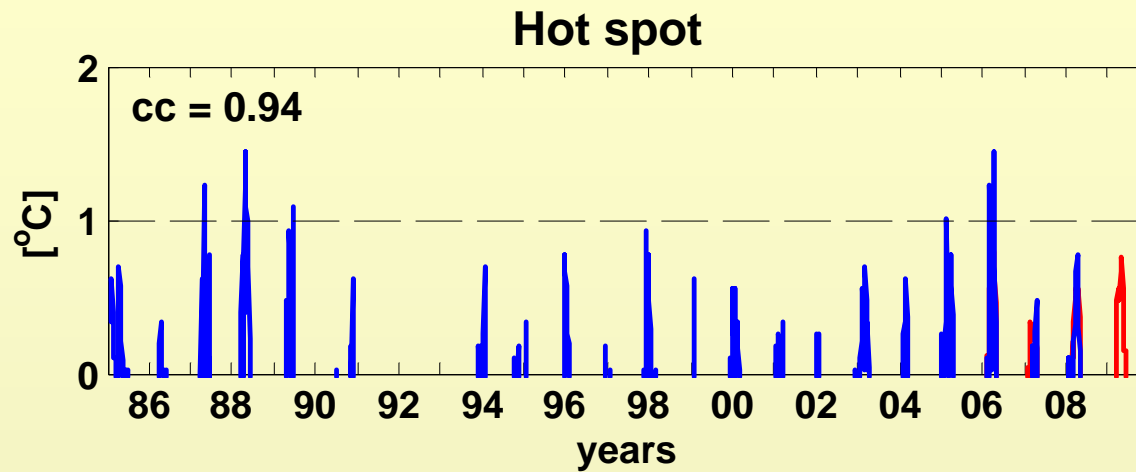


Monthly Mean Maximum  
(MMM)

# Tamandaré – PIRATA 8°S30°W

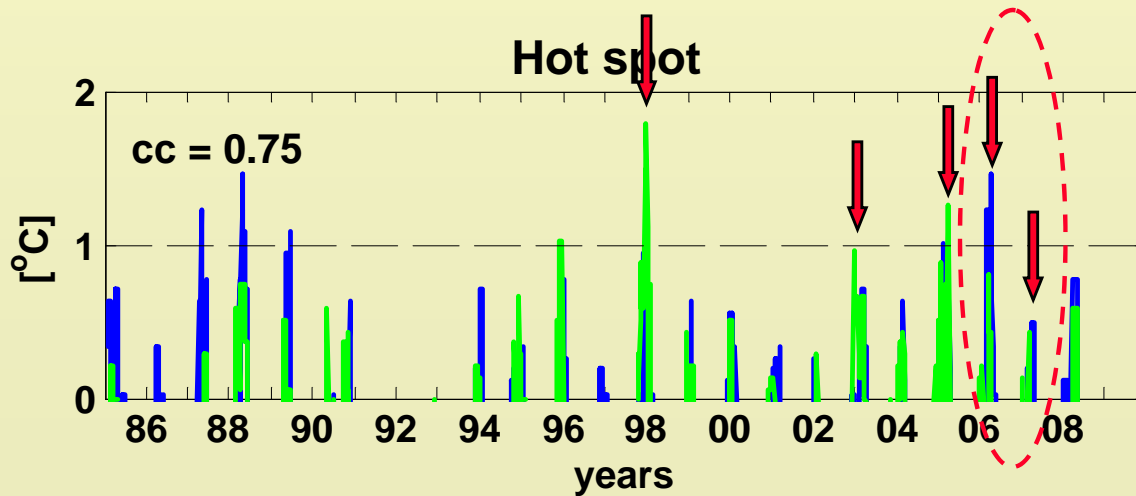


x



— 8°30'W AVHRR  
 — 8°30'W PIRATA

Hot spot = (SST – MMM)

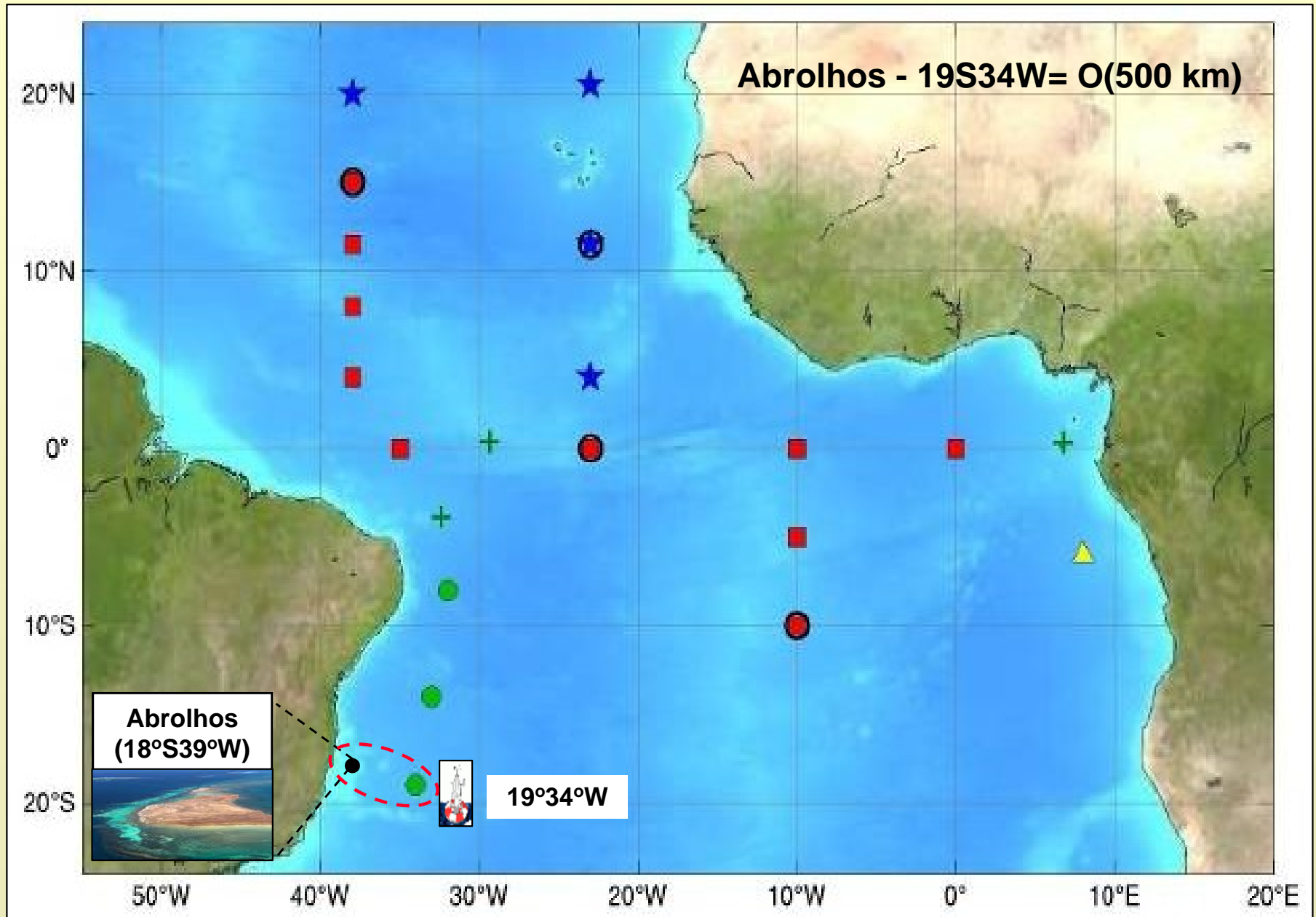


— 8°30'W AVHRR  
 — Tamandaré AVHRR

- ↓ **Bleaching events:**
- 1998 - Strong
  - 2003 - 5-20%
  - 2005 - 10-15%
  - 2006 - 5-10%
  - 2007 - 5-10%

??

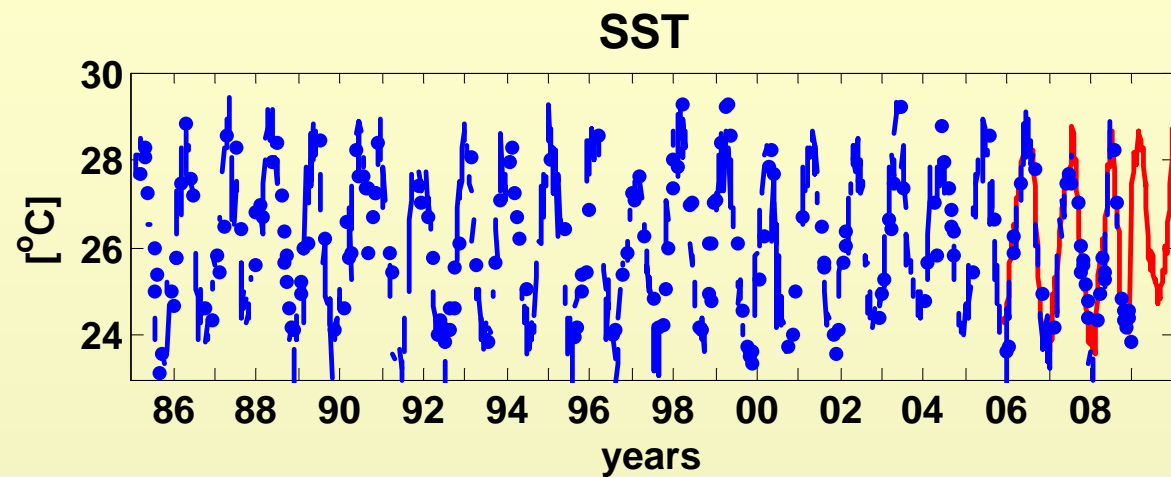
# Are we able to find any correlation between PIRATA data and coral bleaching events ?



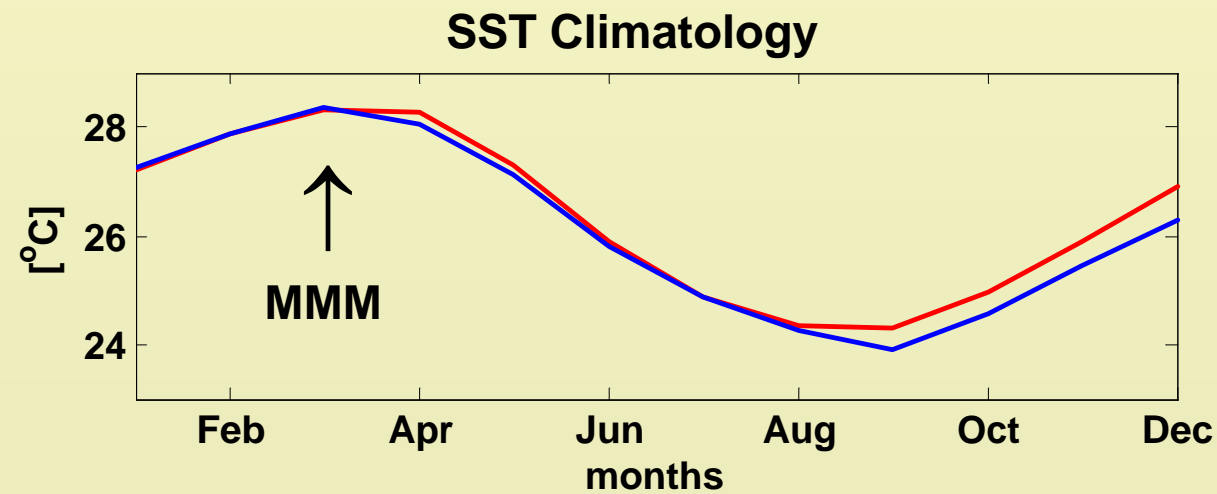
# Abrolhos – PIRATA 19°S34°W



x



— 19°34°W AVHRR  
— 19°34°W PIRATA

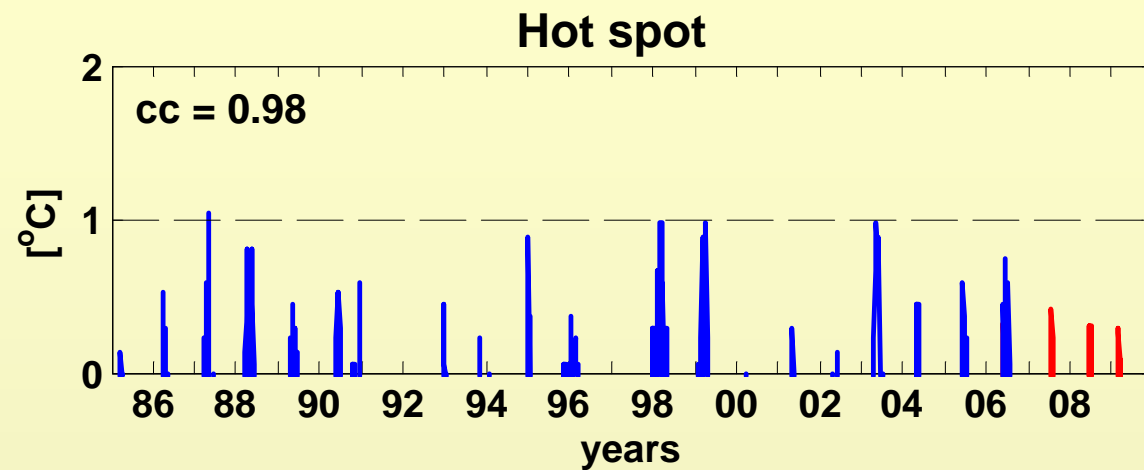


Monthly Mean Maximum (MMM)

# Abrolhos – PIRATA 19°S34°W

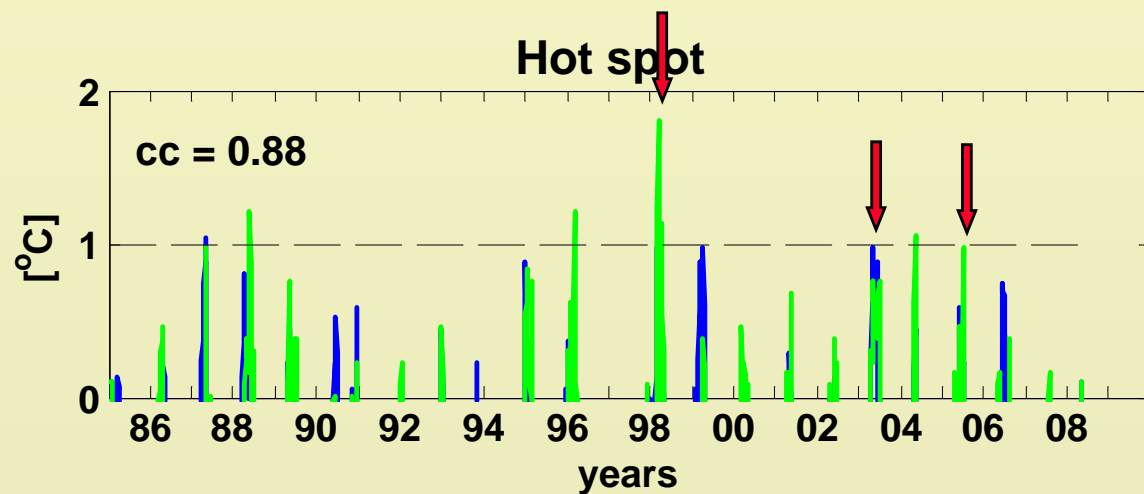


X



— 19°34°W AVHRR  
— 19°34°W PIRATA

Hot spot = (SST – MMM)



— 19°34°W AVHRR  
— Abrolhos AVHRR



**Bleaching events:**

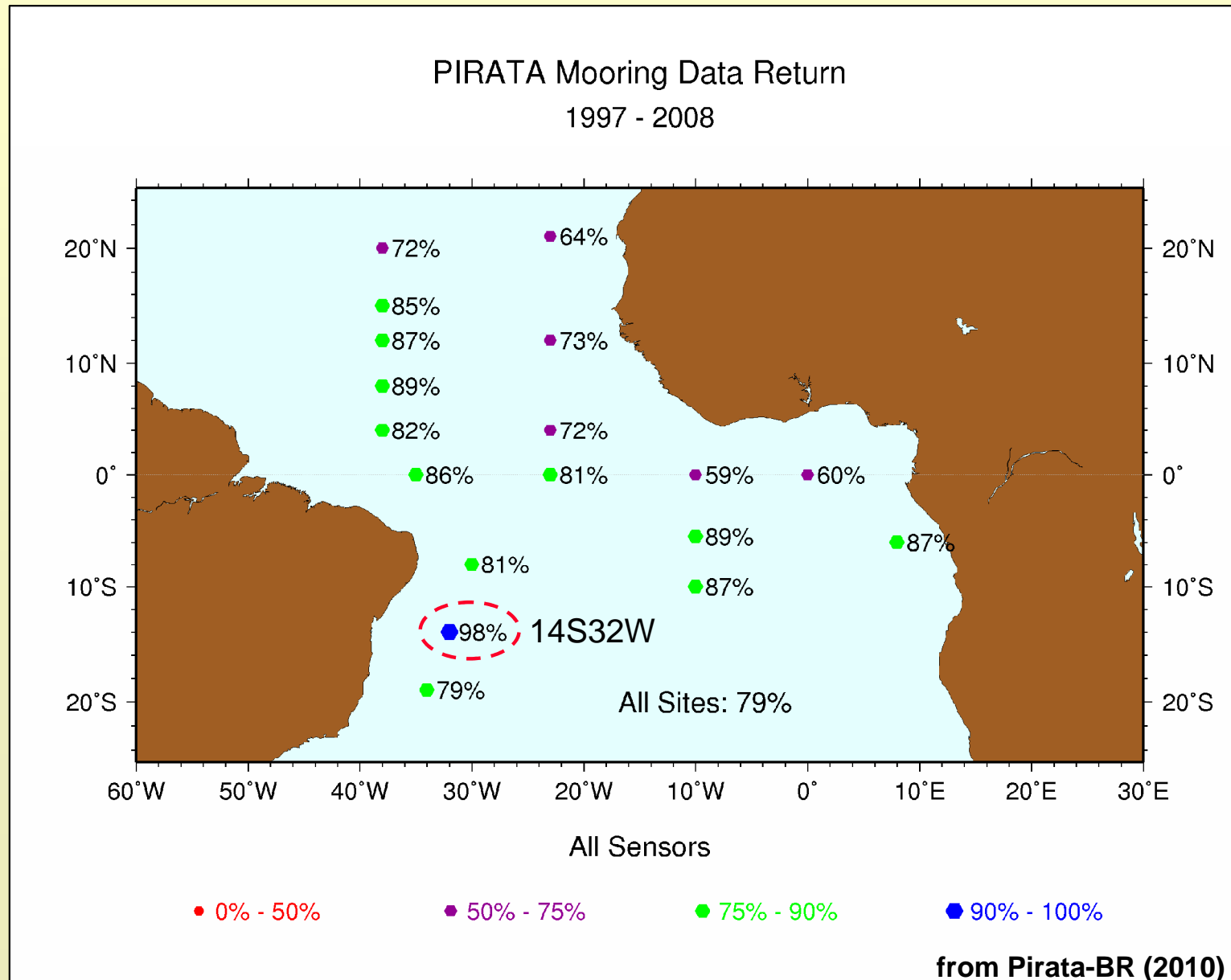
1998 - > 60%

2003 - 9-39%

2005 - 5-20%



# Bleaching forecasting = local SST forecasting



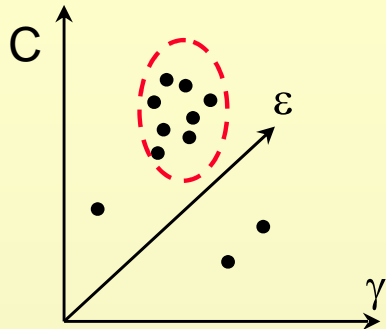
# Numerical simulations

## Regional ROMS-12 - Basin scale ORCA-12



<b>Domain</b>	<b>Tropical/equatorial Atlantic</b>
<b>Horizontal mesh</b>	<b>ROMS-12: 1/12° (5°S-25°S ; 20°W-47°W)</b> <b>ORCA-12: 1/12° (40° S-20° N ; 70.5° W-19.5° E )</b>
<b>Vertical mesh</b>	<b>ROMS-12: 40 NZ</b> <b>ORCA-12: 50 NZ</b>
<b>Time integration</b>	<b>ROMS-12: 2002-2007</b> <b>ORCA-12: 2002-2007</b>
<b>Conditions at three lateral open boundaries (North, East and South)</b>	<b>ROMS-12: Daily mean OGCM/ECCO (Currents/T-S)</b>
<b>Forcings at top</b>	<b>ROMS-12: Monthly-averaged heat and fresh water fluxes derived from COADS + Daily mean QuickSCAT for wind stress</b> <b>ORCA-12: Daily flux from ECMWF (CLIO bulk formula) + GPCP (precipitation) + Dai &amp; Trenberth (runoff)</b>
<b>Topography</b>	<b>ROMS-12: ETOPO2</b> <b>ORCA-12: ETOPO2 + BEDMAP + GEBCO</b>

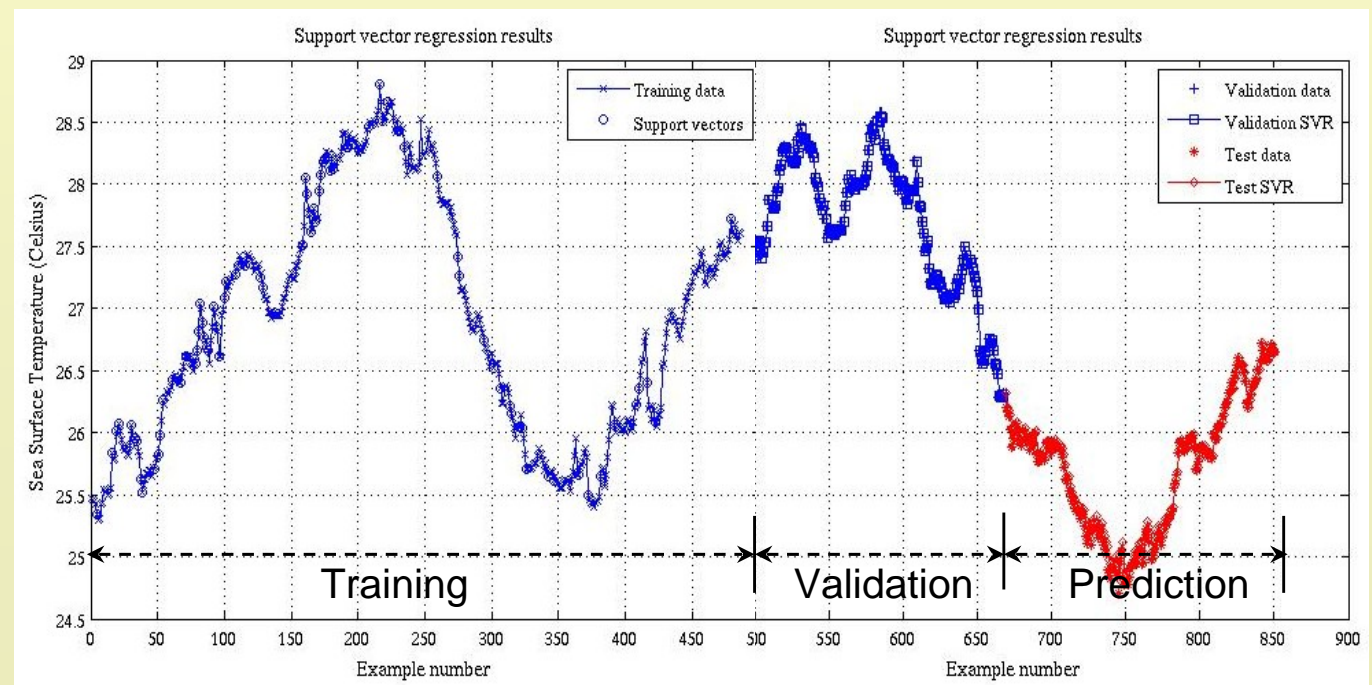
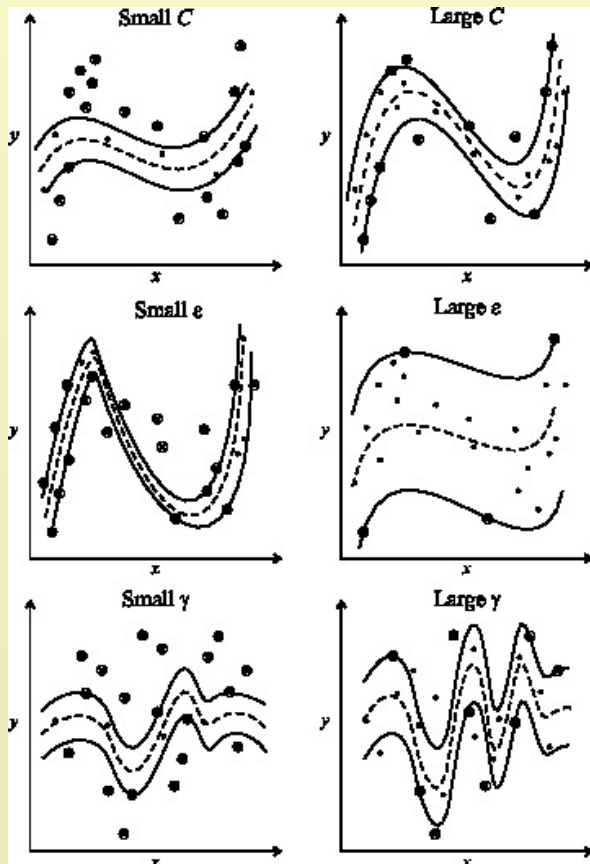
# Support Vector Machine-Particle Swarm Optimization (SVM-PSO)



$$v_{ij}(t+1) = \chi \{ v_{ij}(t) + c_1 \cdot u_1 [p_{ij}(t) - s_{ij}(t)] + c_2 \cdot u_2 [pg_j(t) - s_{ij}(t)] \}, j = 1, 2, 3$$

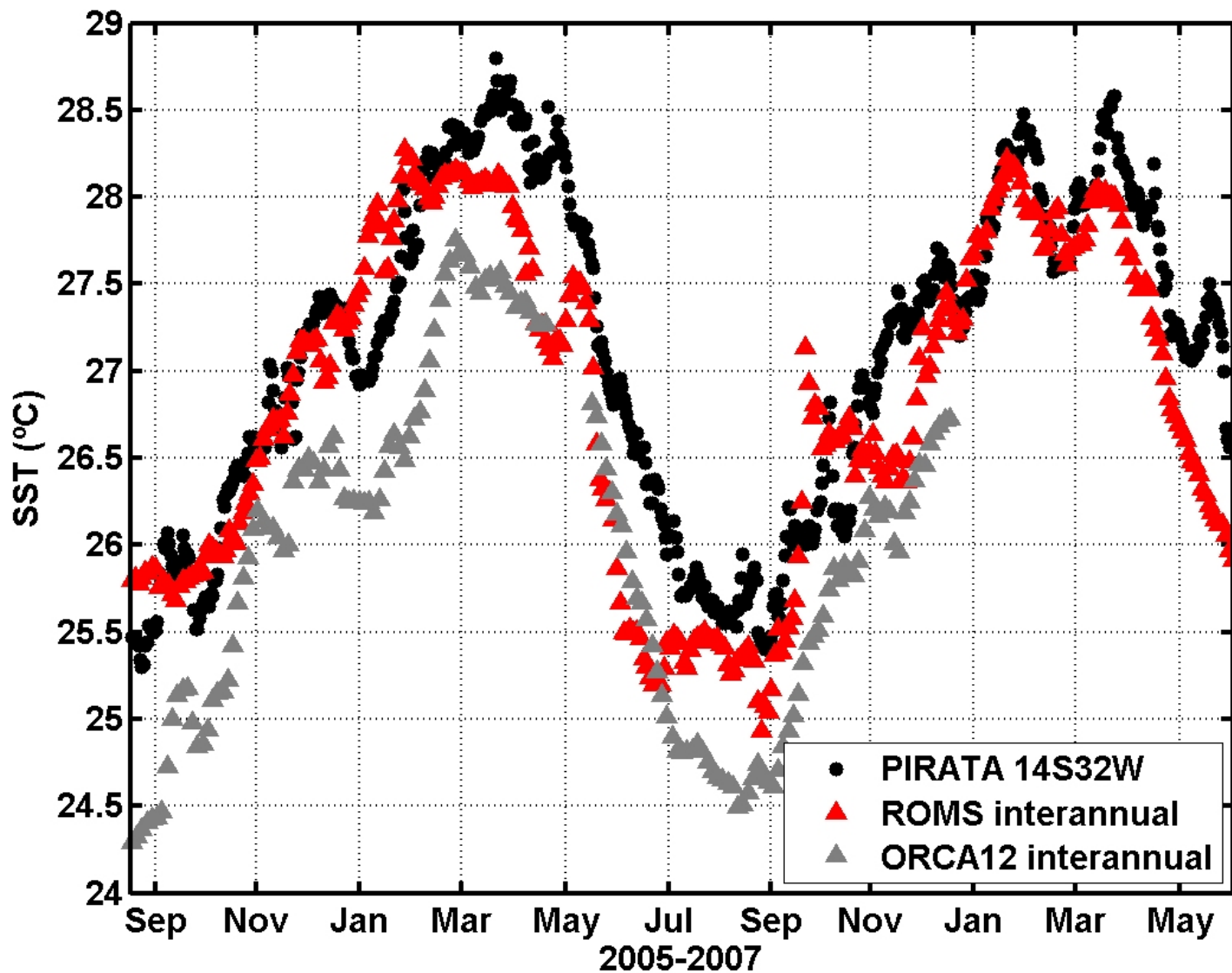
$$s_{ij}(t+1) = s_{ij}(t) + v_{ij}(t+1)$$

$$NMRSE = \sqrt{\frac{\sum_i (y_i - \hat{y}_i)^2}{\sum_i y_i^2}}$$



# Numerical simulations

## Regional ROMS-12 - Basin scale ORCA-12

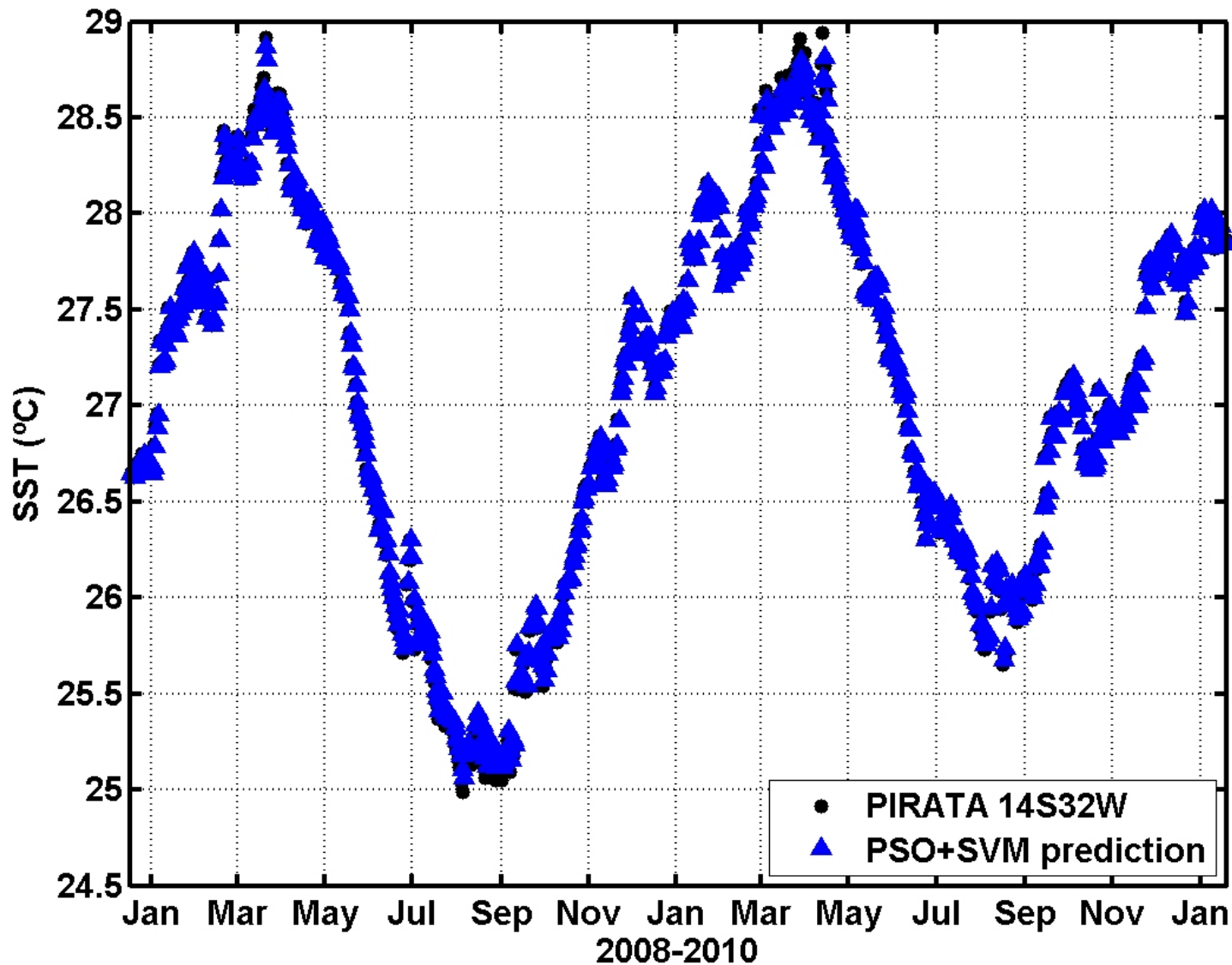


$$\text{NMRSE} = \sqrt{\frac{\sum_i (y_i - \hat{y}_i)^2}{\sum_i y_i^2}}$$

▲ NMRSE = 0.019

▲ NMRSE = 0.034

# Support Vector Machine-Particle Swarm Optimization (SVM-PSO)



$$\text{NMRSE} = \sqrt{\frac{\sum_i (y_i - \hat{y}_i)^2}{\sum_i y_i^2}}$$

▲ NMRSE = 0.003



# Summary

- The Brazilian Coral Reef Monitoring Program started in 2002 and has been conducted at six localities, including 4 federal MPAs along 2000 km;
- SST anomalies calculated from AVHRR/NOAA satellite and PIRATA measurements were correlated and the satellite derived Hot spot values in the position of the buoys and in three bleaching sites suggest that PIRATA data can be used as a first order indicator for coral reef stressing;
- SST-time series generated by SVM-PSO technique and obtained from regional (ROMS12) and basin scale (ORCA-12) numerical modeling were compared to PIRATA data and a best SST prediction was obtained with SVM-PSO approach;
- The observed divergence between sea data and simulations seems to be associated to local interactions with other environmental variables and that those can be acting to exacerbate or attenuate, at a local scale, global temperature elevations;
- *In situ* meteorological and oceanographic sensors (such as wind, solar radiation, currents, rain, etc.) are needed to improve the use of optimization and/or numerical modeling techniques for reef bleaching forecasting in South Atlantic.



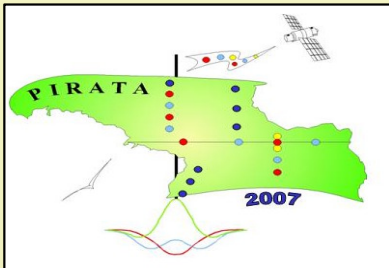
# Acknowledgements



➔ Brazilian Ministry of Environment  
**MMA**



➔ Brazilian National Coral Reef Monitoring Program  
**Reef Check - Brazil**



➔ Prediction and Research Moored Array in the Tropical Atlantic  
**PIRATA**



➔ Transport de masse et de chaleur dans la zone de divergence du CSE dans l'Atlantique  
**Mercator/TransAt**

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*Thank you.*



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