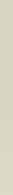


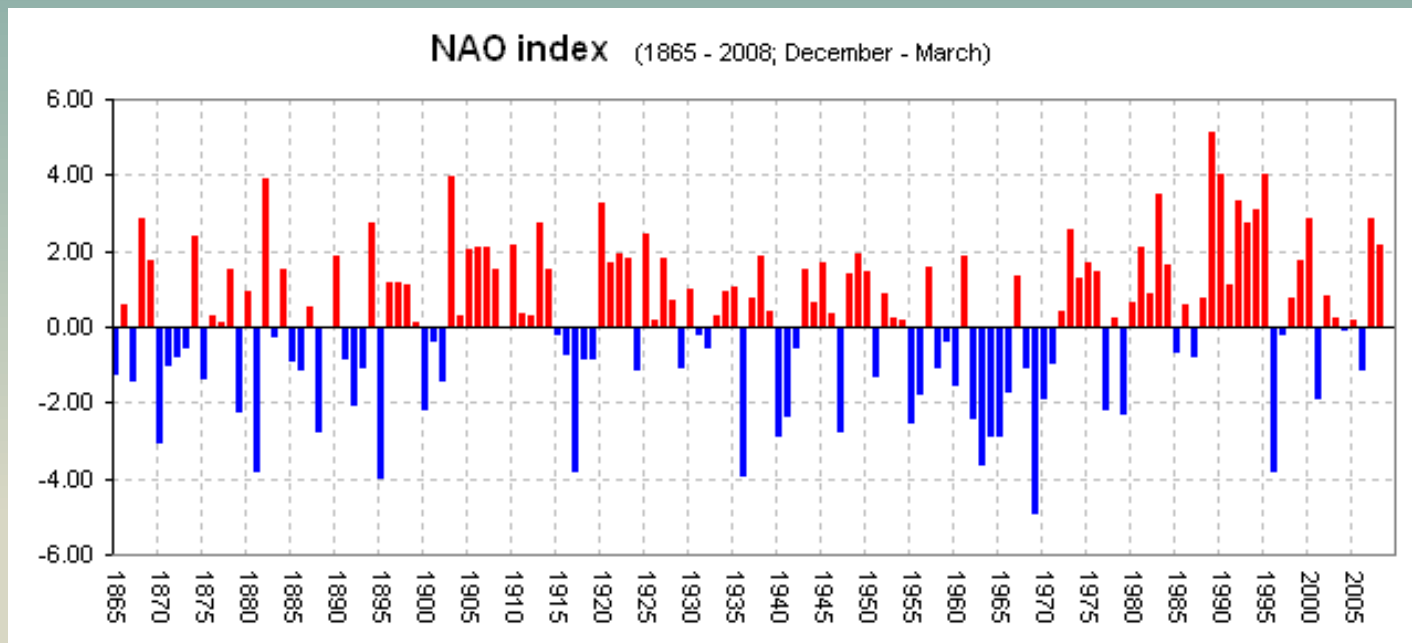
# VARIABILIDADE CLIMÁTICA

TÉCNICAS EM CLIMATOLOGIA



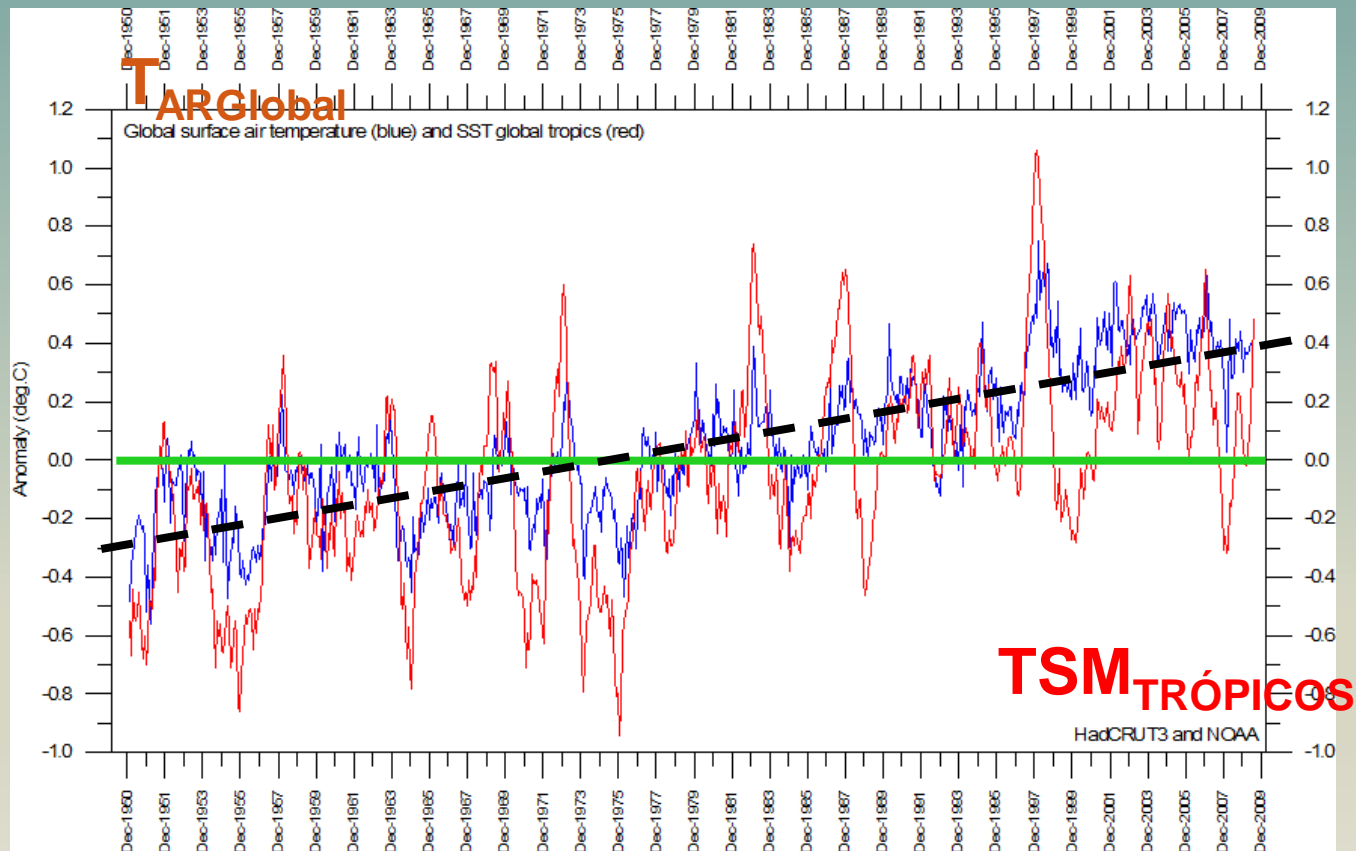
# VARIABILIDADE CLIMÁTICA

## CARACTERIZAÇÃO



# ANOMALIA MENSAL

## MÉDIA CLIMATOLÓGICA MENSAL VALOR MÉDIO MENSAL EM CADA TEMPO



1960

2009

# MÉDIA E ANOMALIA

JAN1960	24.5
Fev1960	25.6
Mar1960	24.3
...	...
...	...
...	...
média	24.2

$$\bar{X} = \frac{X_1 + X_2 + \dots + X_N}{N}$$

média

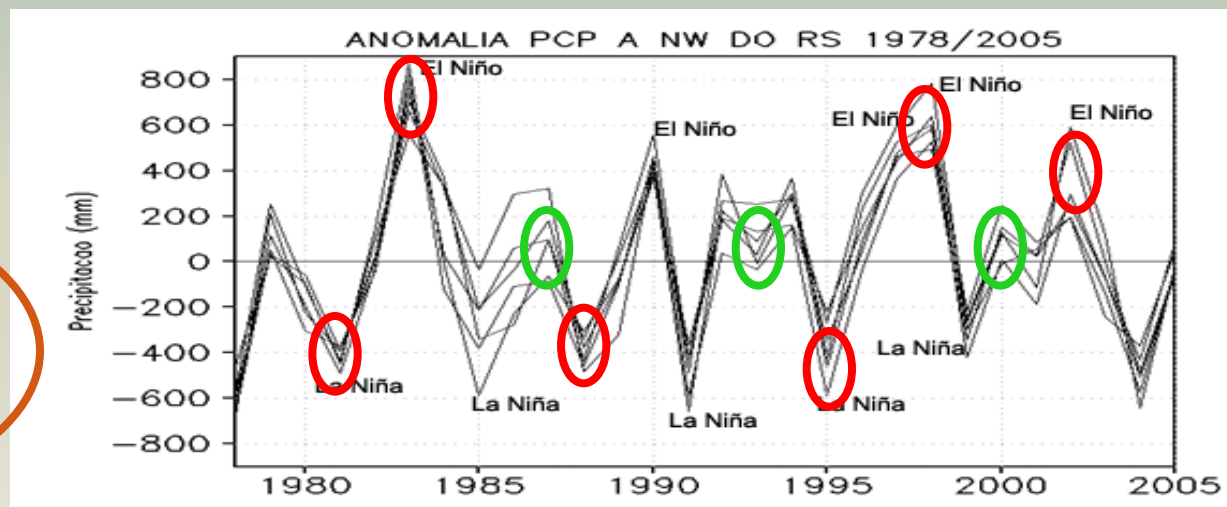
$$\bar{X} = \frac{1}{N} \sum_{i=1}^{i=N} X_i$$

média

$$X' = (X_i - \bar{X})$$

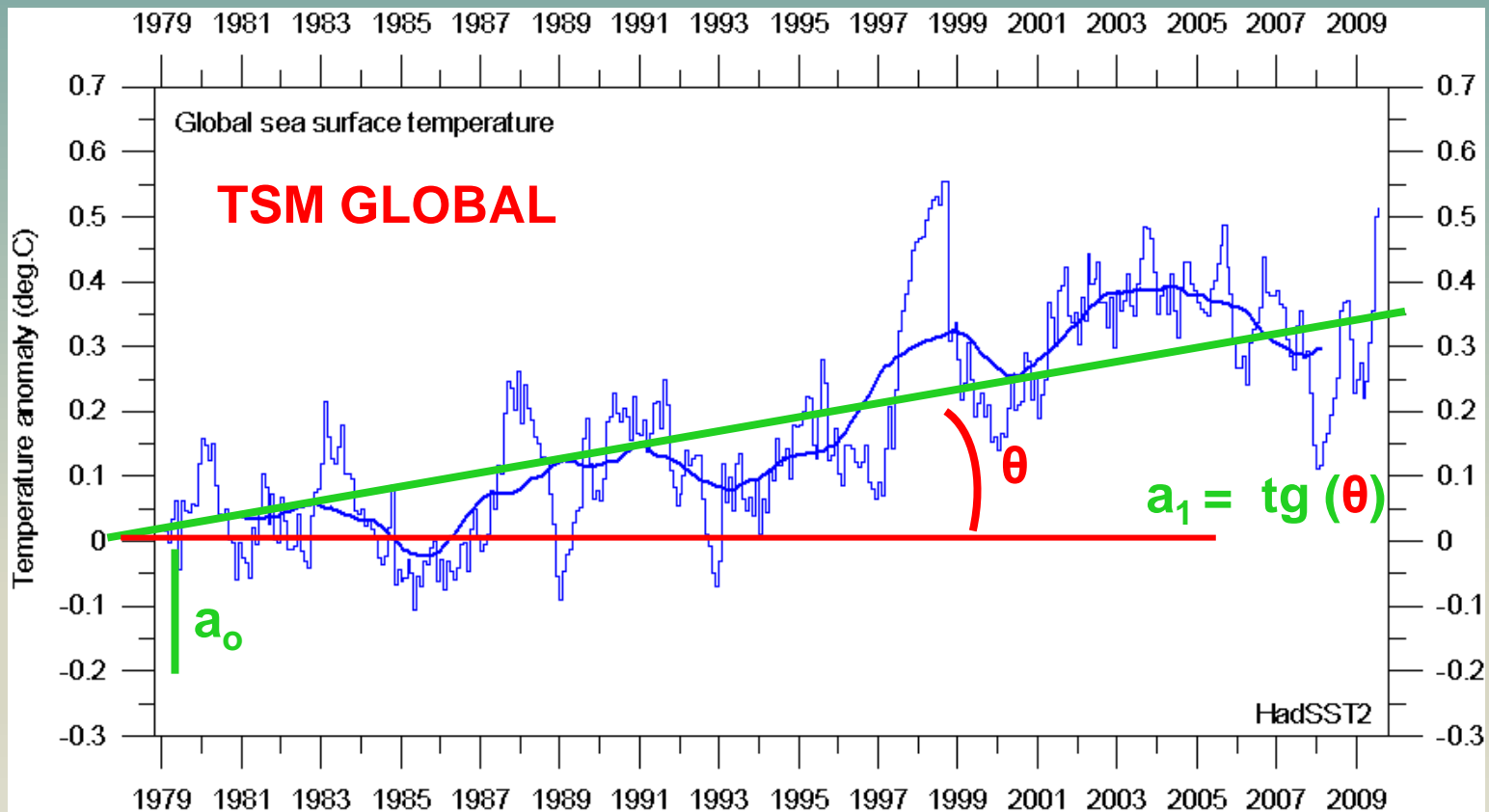
anomalia

Média nem sempre representa bem a série dos dados



# TENDÊNCIA LINEAR

$a_0$  ???  
 $a_1$  ???



Reta verde  $\longrightarrow$   $\hat{y} = a_0 + a_1 * \text{tempo}$  tempo = 1 ... N

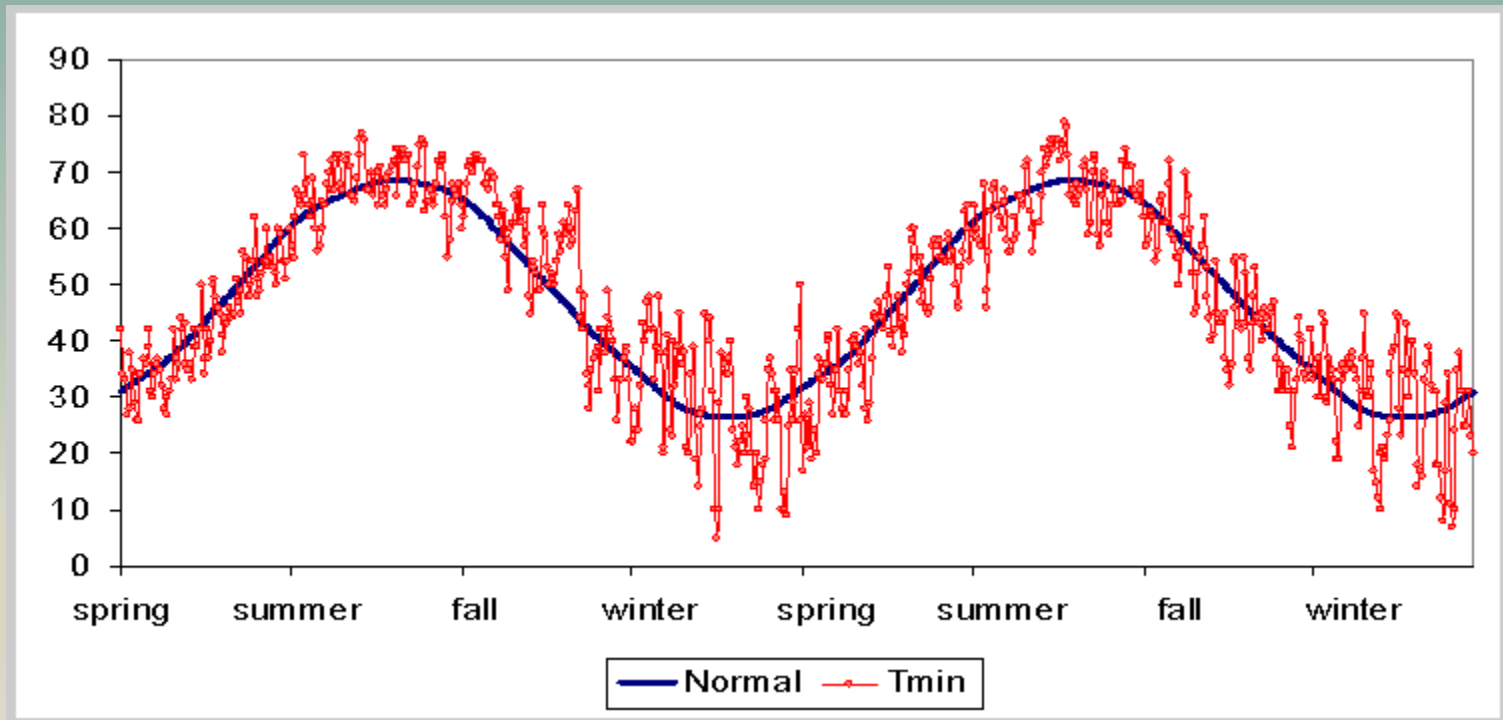
# TENDÊNCIA LINEAR

**Pode-se trabalhar sem a tendência linear para eliminar a influência de tendências de mais longo prazo**

mudanças climáticas

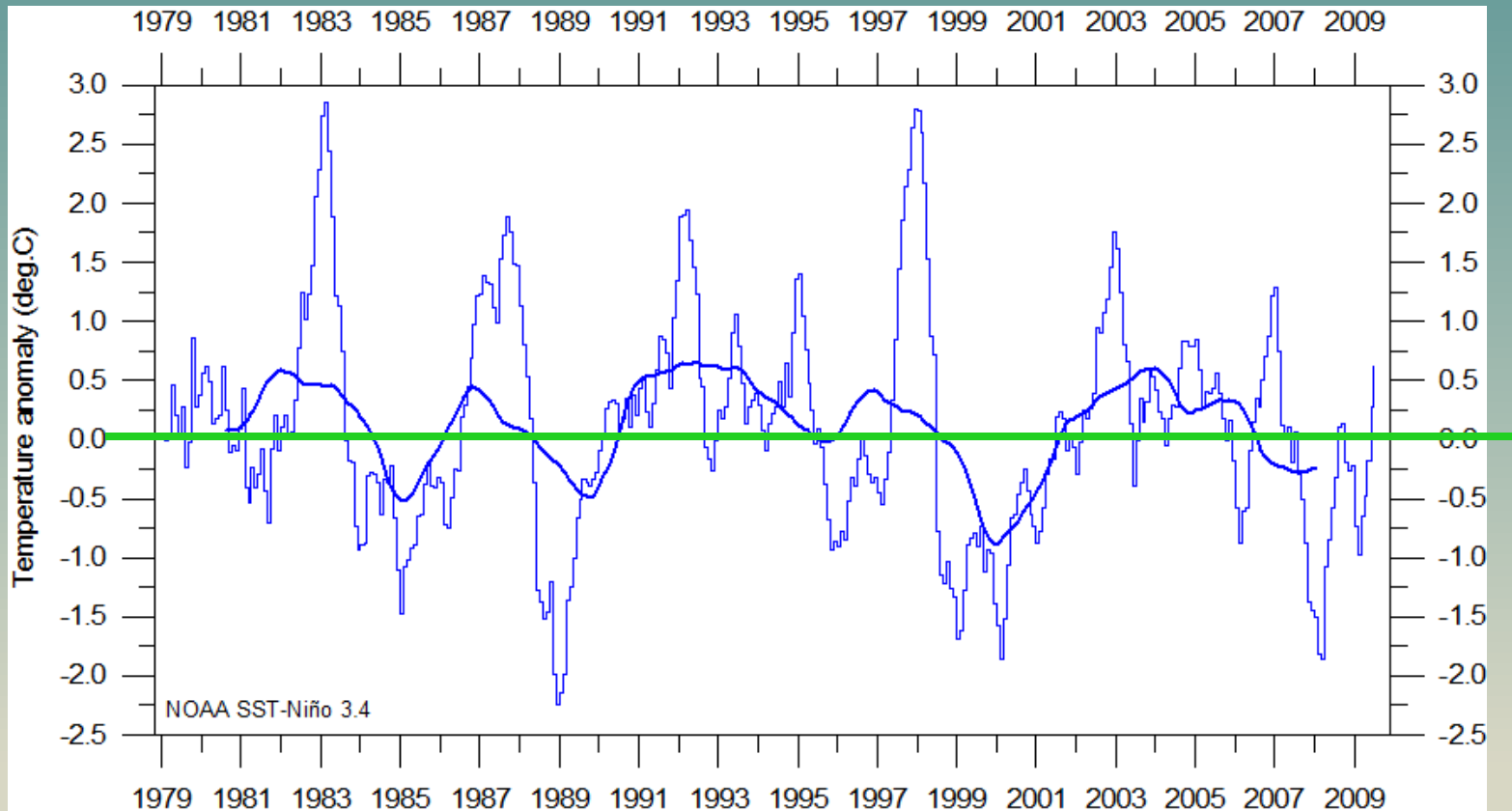
# CICLO SAZONAL

O ciclo sazonal pode ser retirado da série temporal pois é um ciclo bem conhecido



Temperatura mínima para dois anos no Central Park, NY, e curva senoidal ajustada

# TSM NIÑO3-4



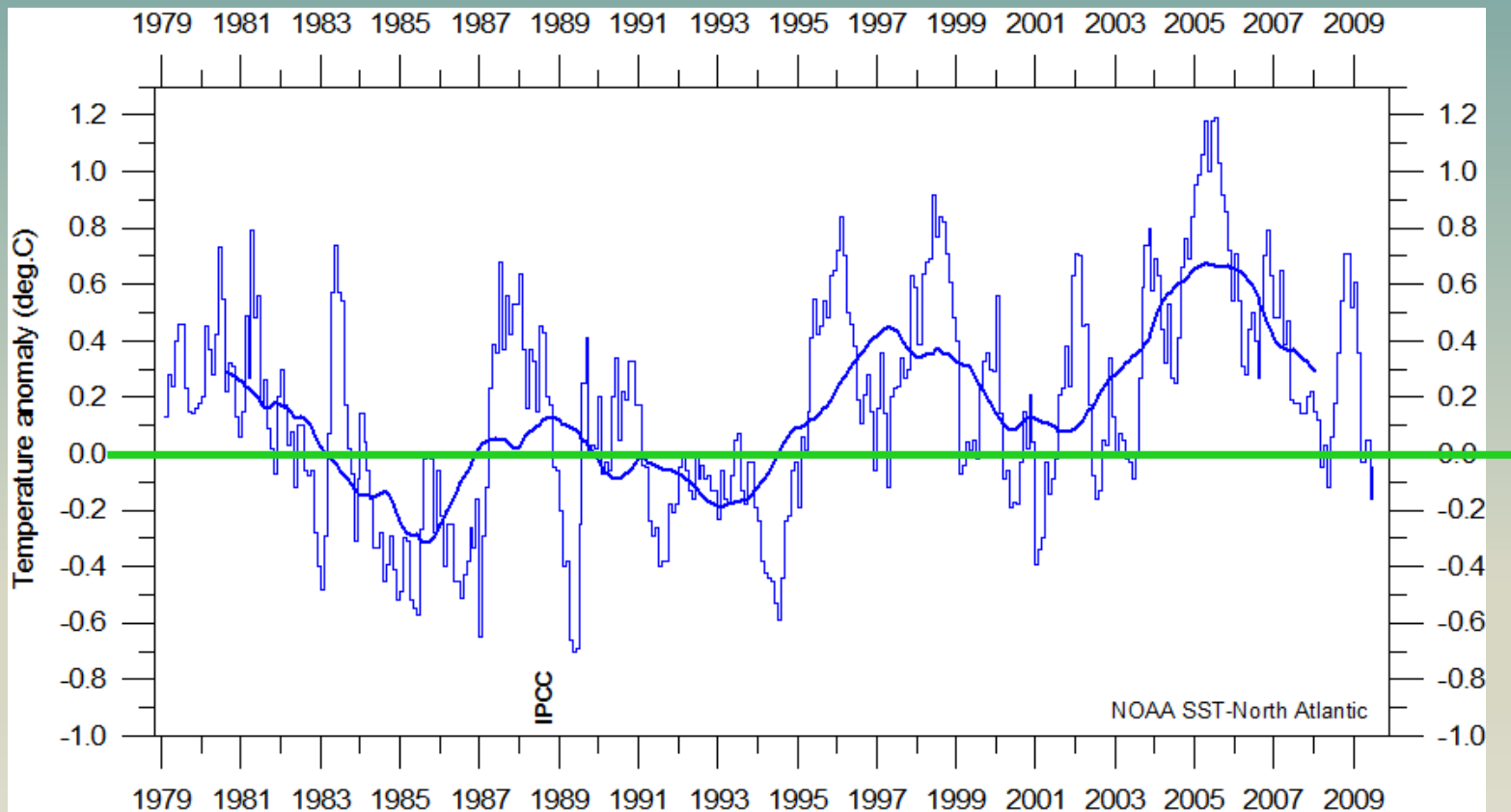
## Suavização

Média móvel com janela  $N = 5$

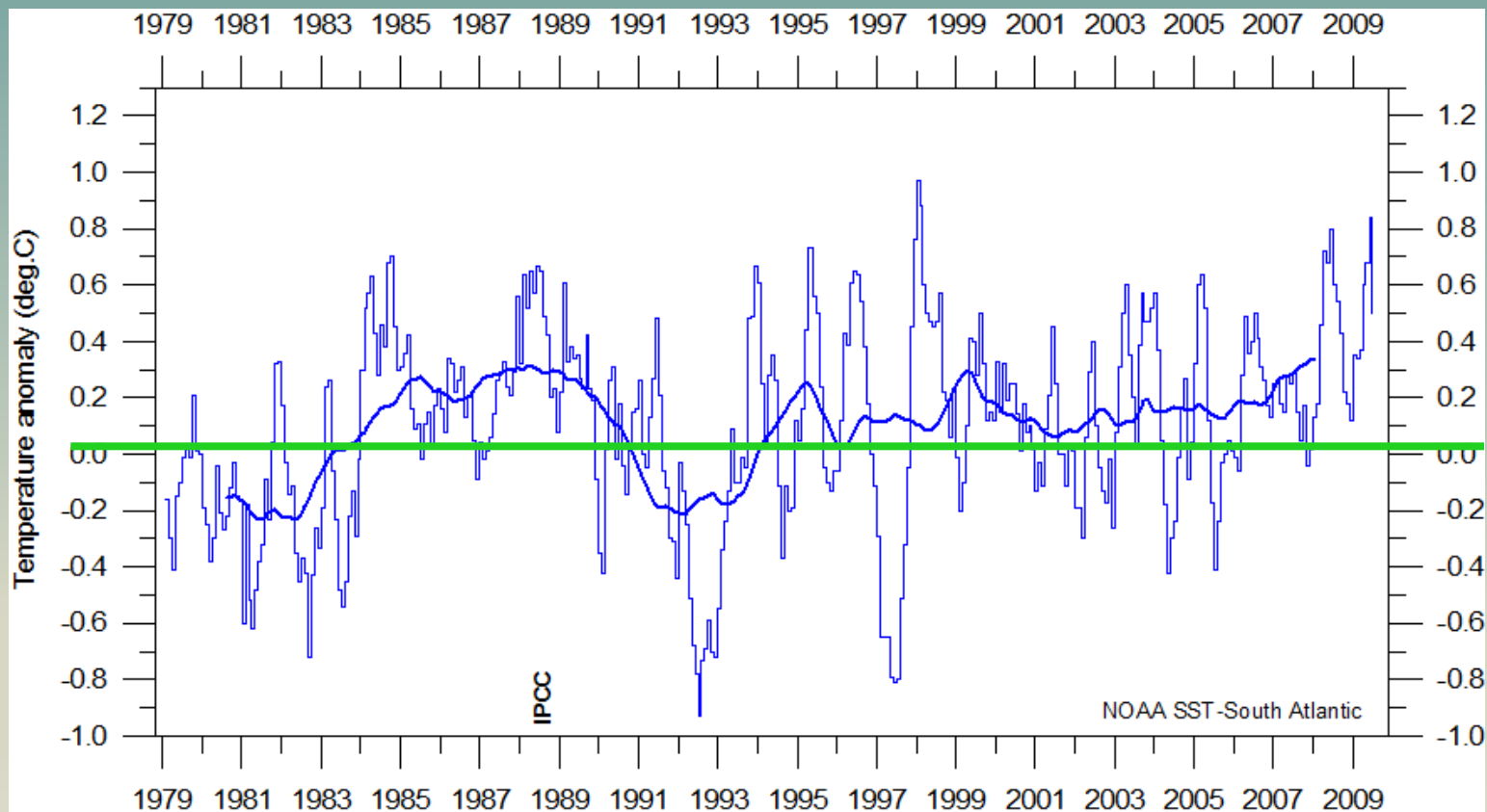
$$X_i = \frac{X_{i-2} + X_{i-1} + X_i + X_{i+1} + X_{i+2}}{N}$$



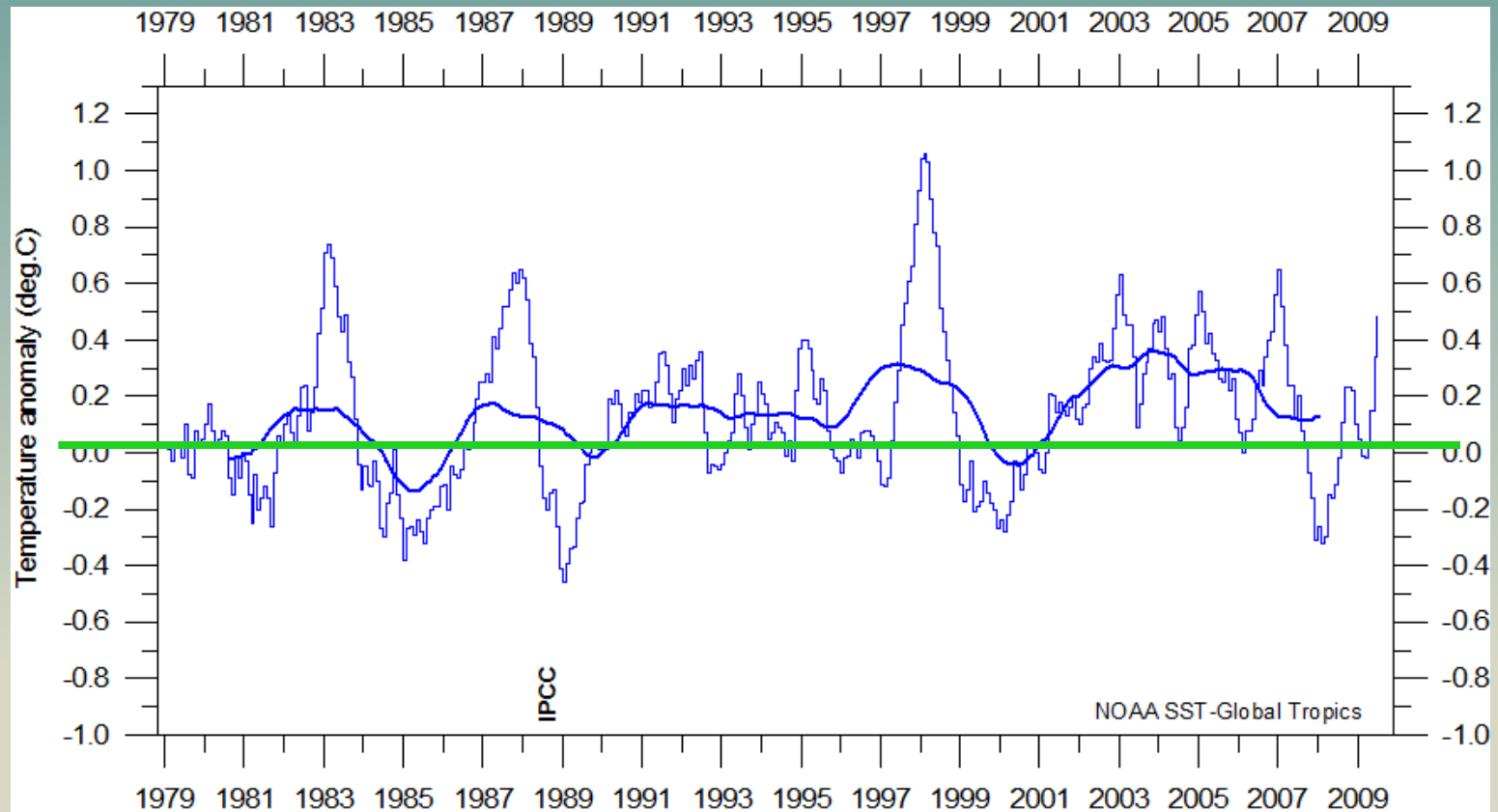
# ANOMALIA TSM ATLÂNTICO NORTE



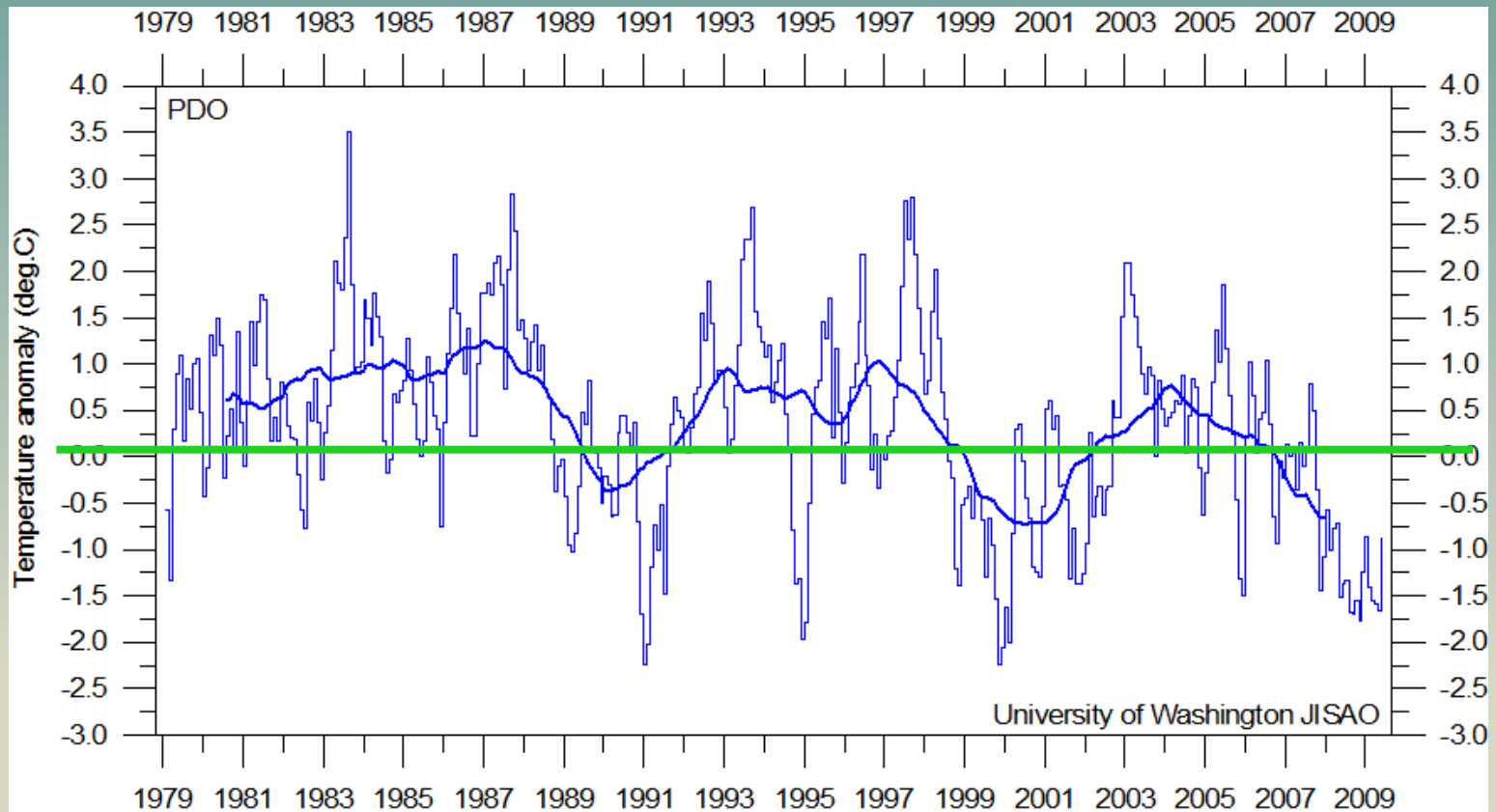
# ANOMALIA TSM ATLÂNTICO SUL



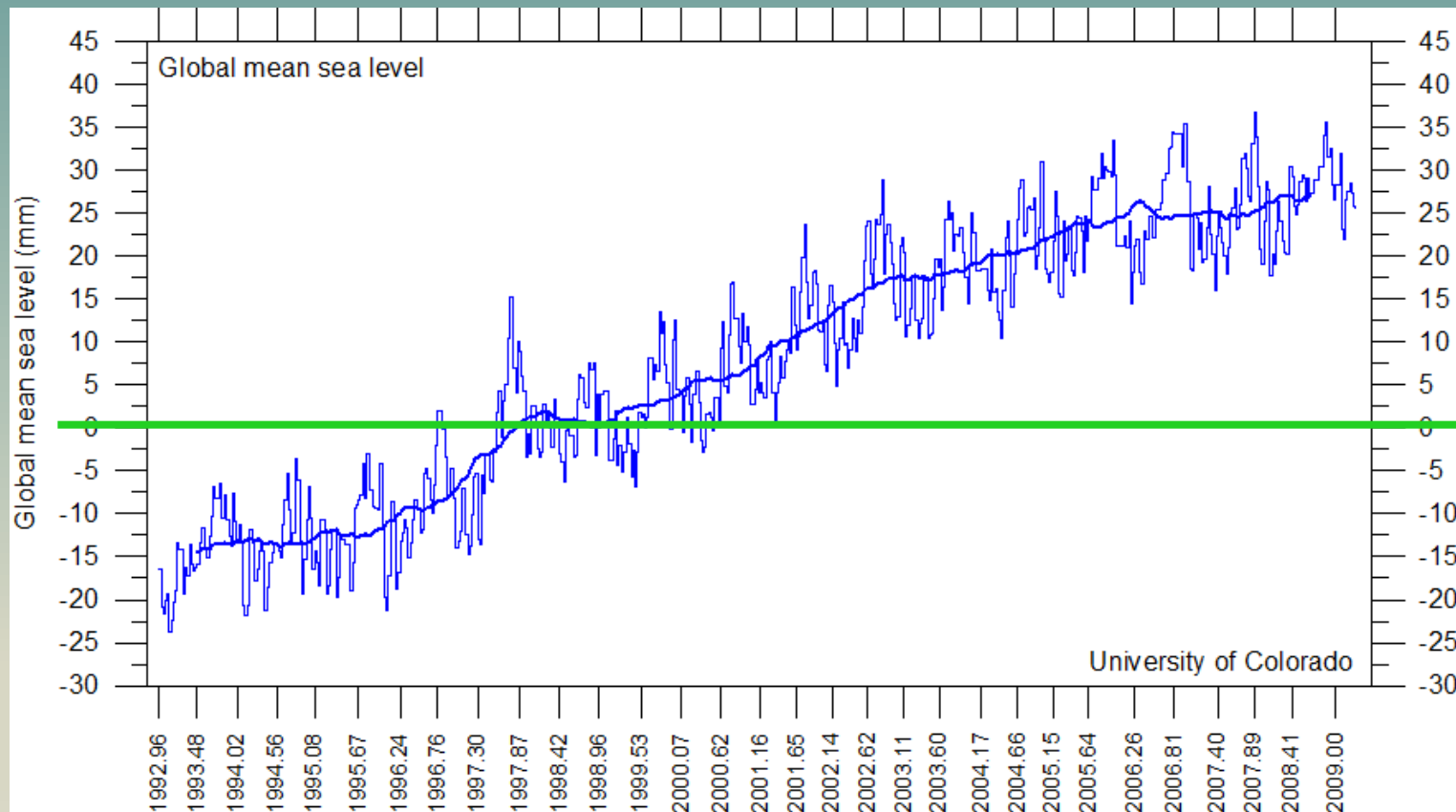
# ANOMALIA TSM TROPICAL



# OSCILAÇÃO DECADAL DO PACÍFICO



# NÍVEL MÉDIO DO MAR MÉDIA GLOBAL

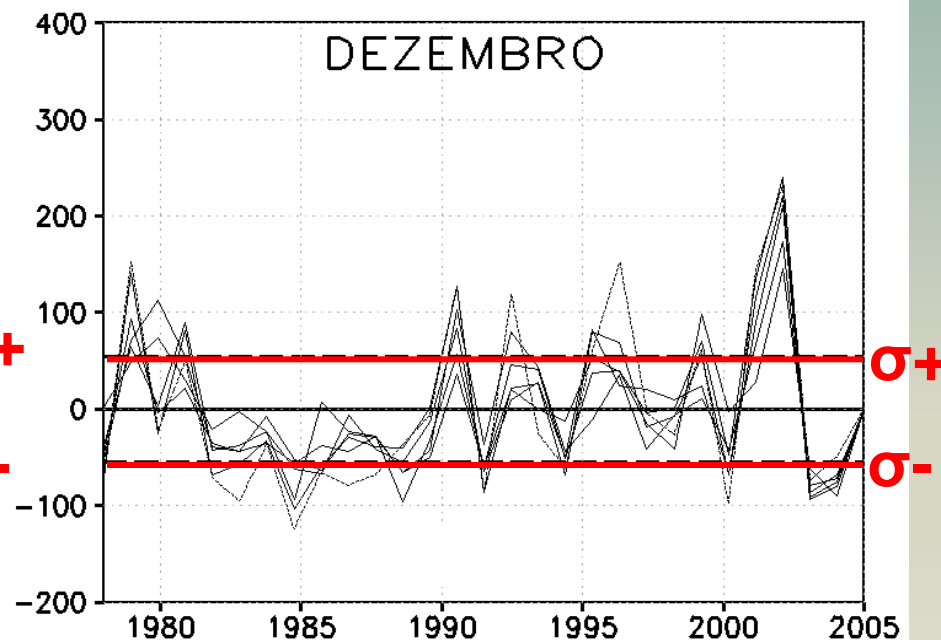
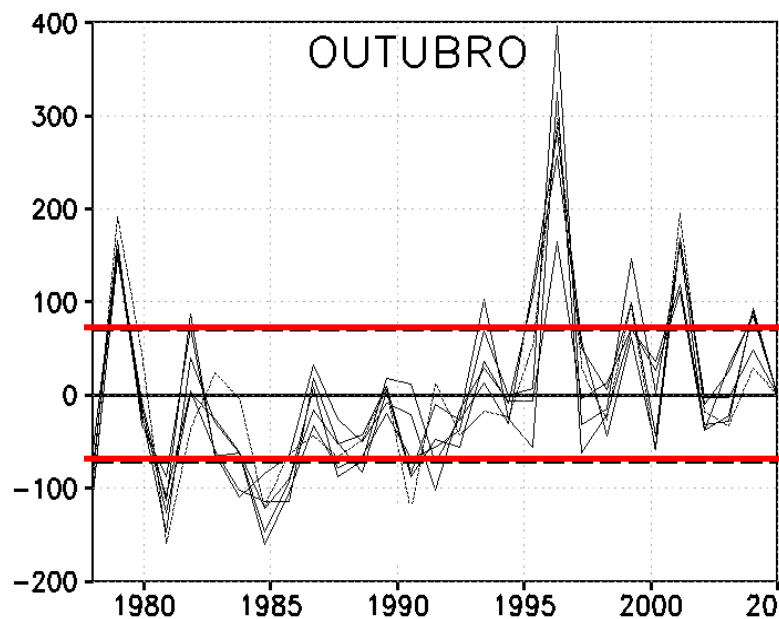


# DESVIO PADRÃO E VARIÂNCIA

## ANOMALIA PRECIPITAÇÃO NO RS 1978-2005

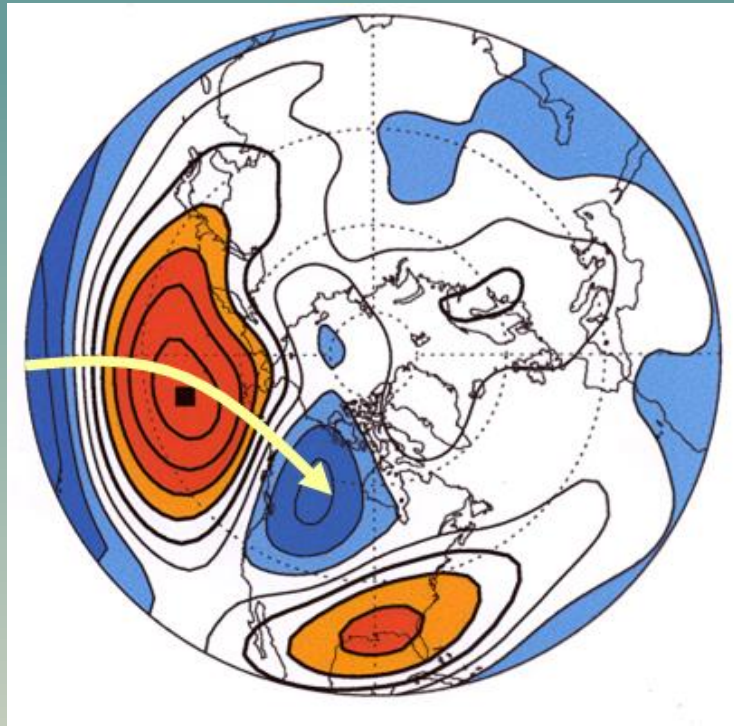
$$\sigma = dp = \frac{1}{(N-1)} \left\{ \sum (x_i - \bar{x})^2 \right\}^{1/2}$$

$$\text{var} = \sigma^2$$





# CORRELAÇÃO ESPACIAL

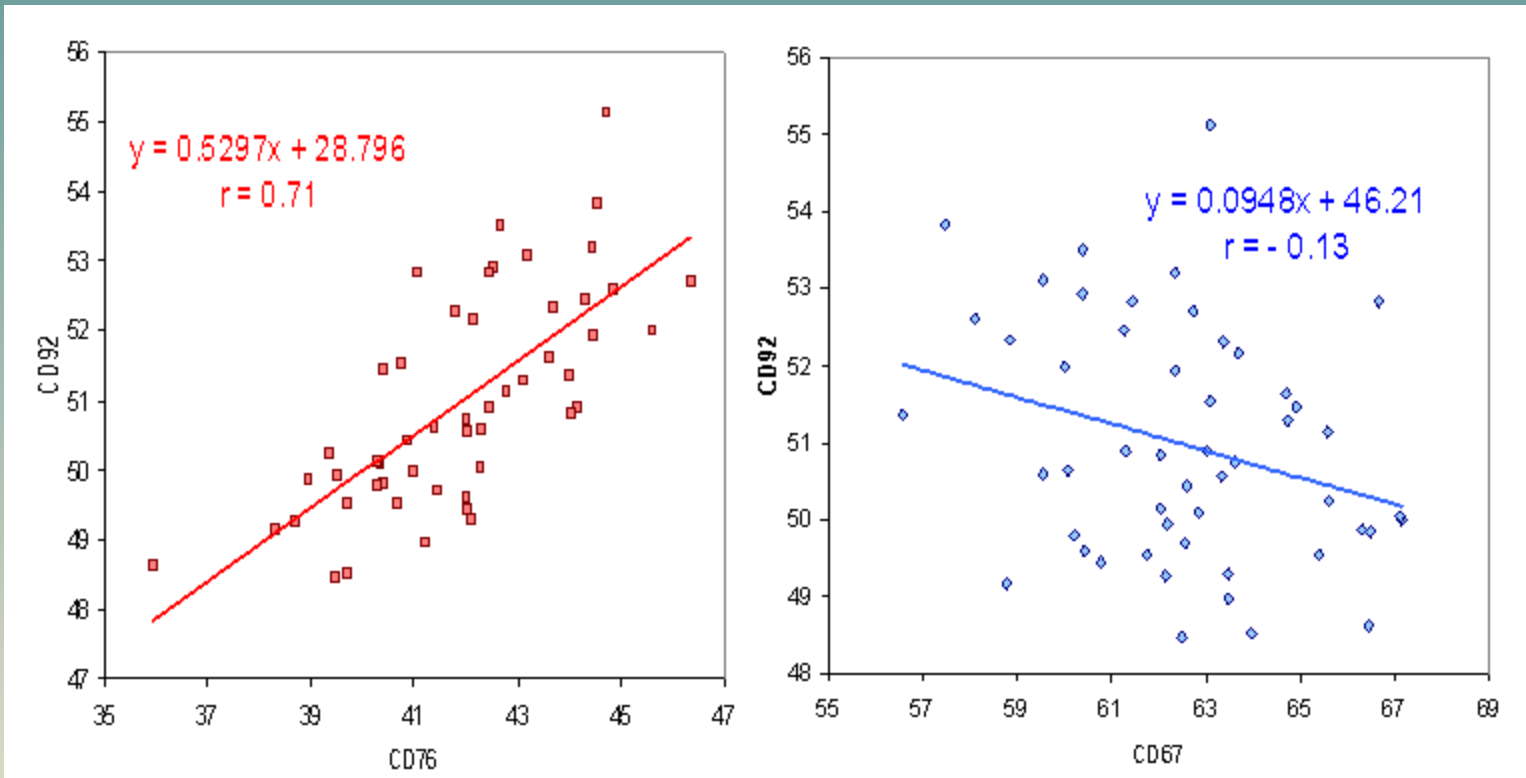


Spatial distribution of correlation of the 500 mb geopotential height anomaly time series (Seasonal JFM) at all points on the Northern hemisphere with the time series at a specified “base point” - North Pacific. Red colors positive correlation, blue colors negative correlation. Yellow arrow indicate meridional orientation of spatial structure existing in the correlation pattern. Picture courtesy of Prashant Sardeshmukh, CDC/OAR



Inserir dados correlação leila vazão tsm

# CORRELAÇÃO E REGRESSÃO



Diagramas de dispersão para temperatura

eixo x: variável observada

eixo y: variável prevista

**ENSO**  
**EL NIÑO-SOUTH OSCILLATION**

**ENOS**  
**EL NIÑO-OSCILAÇÃO SUL**

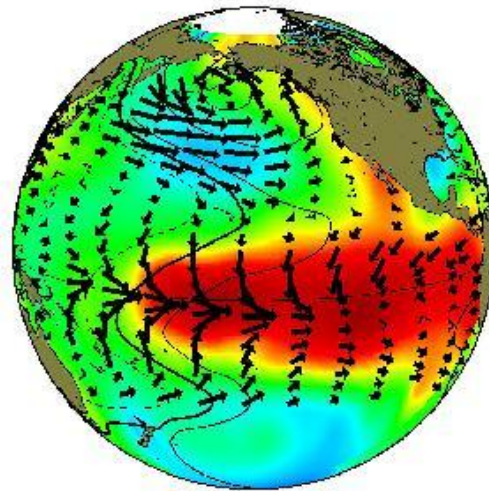
**VARIABILIDADE INTERANUAL**

# PACÍFICO

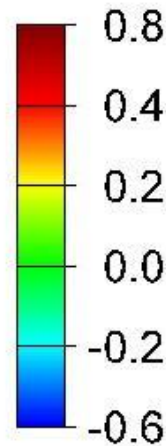
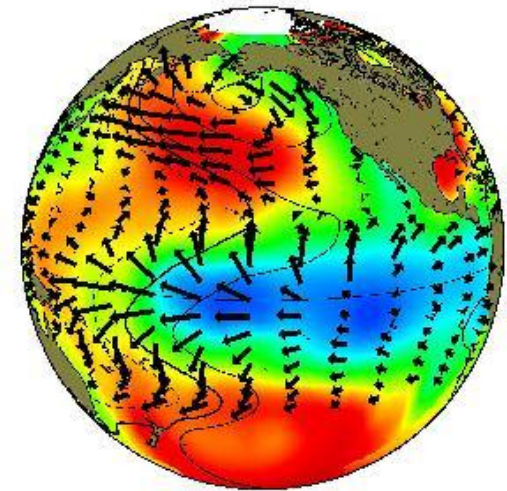
## VARIABILIDADE INTERANUAL ENOS

### El Nino Southern Oscillation

El Nino



La Nina



EOF ACP

# ENOS EL NIÑO-OSCILAÇÃO SUL

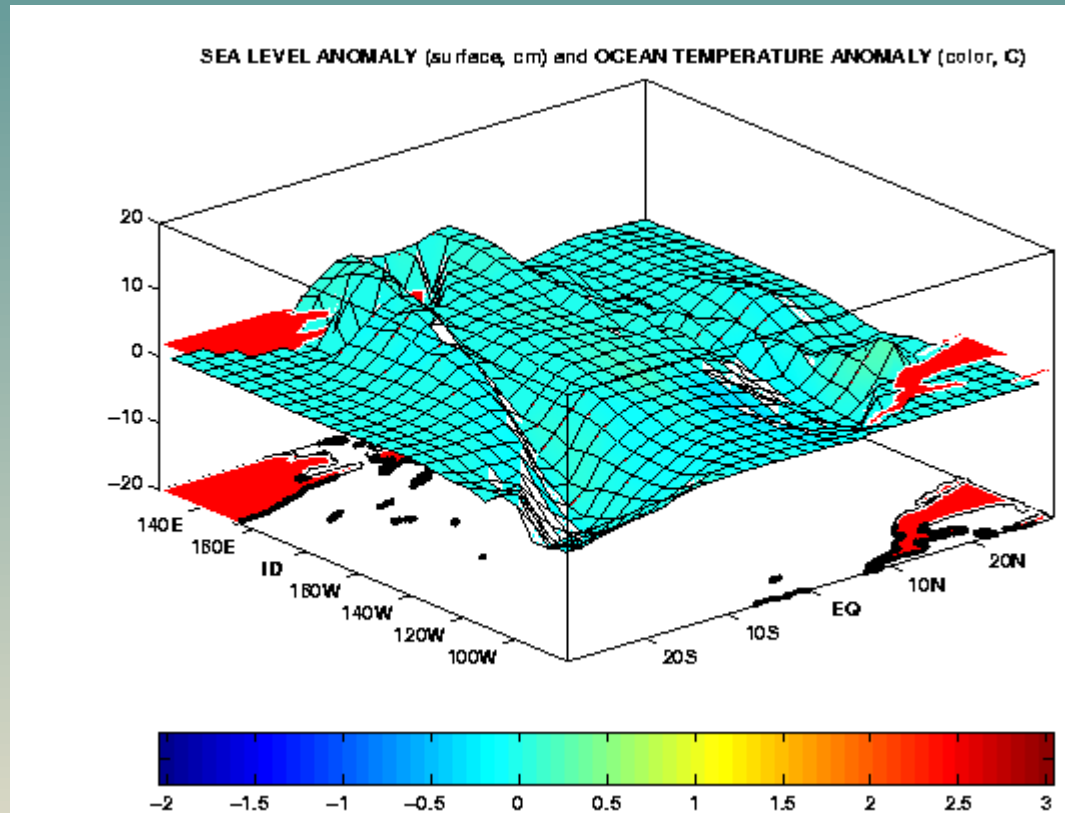
O papel vital da interação oceano-atmosfera na variabilidade interanual tropical é ilustrado mais dramaticamente pelo fenômeno ENOS

**ENOS é um processo acoplado oceano-atmosfera causado pela requerida redistribuição de calor e momento atmosférico no Pacífico Equatorial**

# ENOS EL NIÑO-OSCILAÇÃO SUL

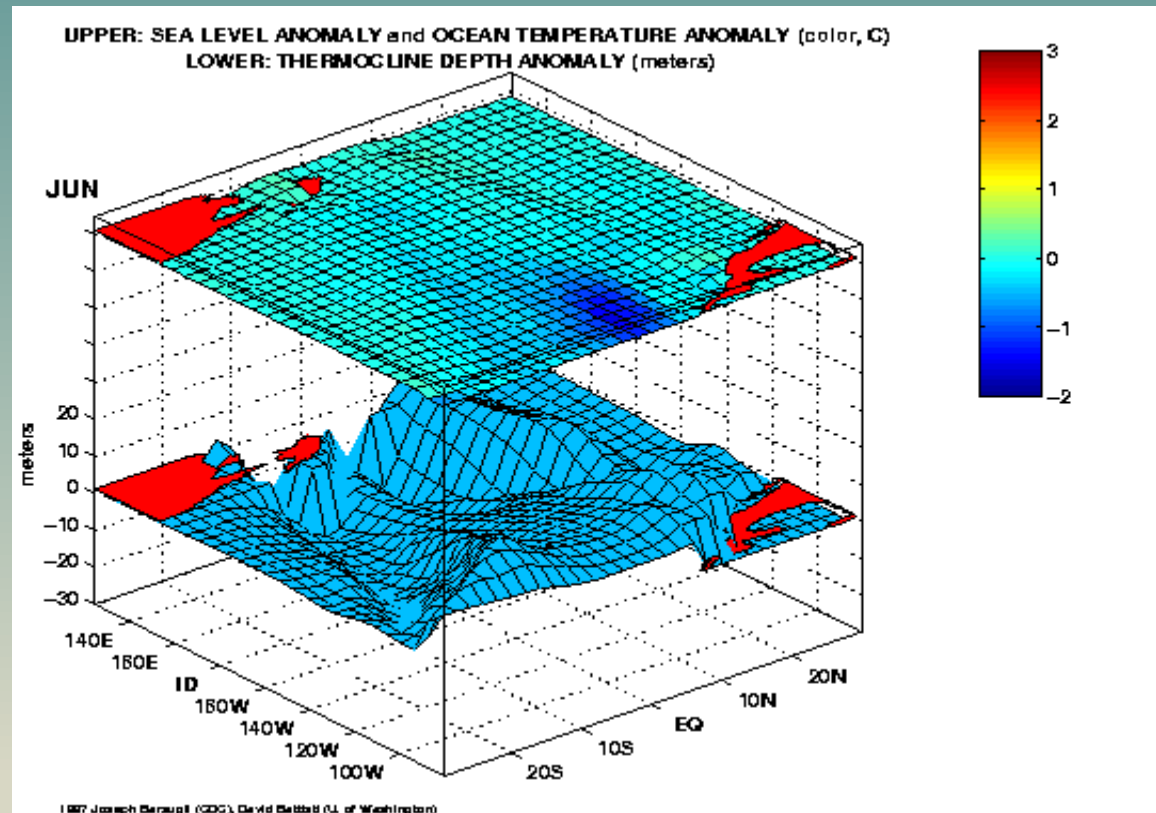
- **A distribuição zonal de aquecimento superficial tropical (continental e oceânica) produz um padrão de circulação leste-oeste, como a circulação de Walker, e dispara o maior deslocamento do padrão de precipitação tropical e convecção profunda, alterando a circulação atmosférica e o clima em todo o globo**
- **Os extremos do ENOS, chamados de El Niño e La Niña, englobam um grande conjunto de condições climáticas**

# ENOS EL NIÑO-OSCILAÇÃO SUL



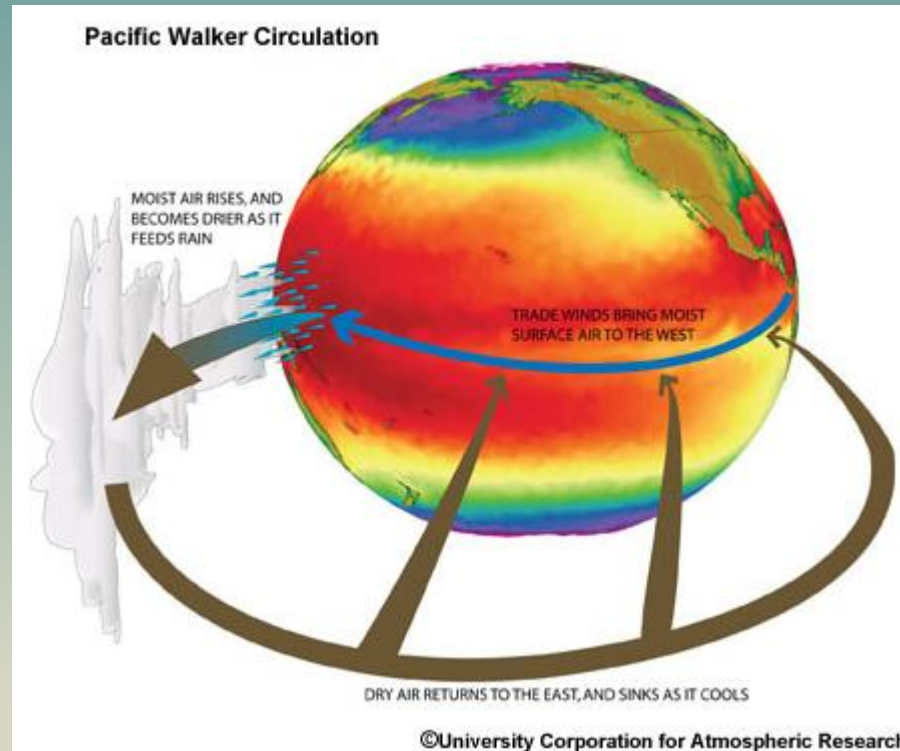
[http://www.esrl.noaa.gov/psd/people/joseph.barsugli/mov\\_tao.gif](http://www.esrl.noaa.gov/psd/people/joseph.barsugli/mov_tao.gif)

# ENOS EL NIÑO-OSCILAÇÃO SUL

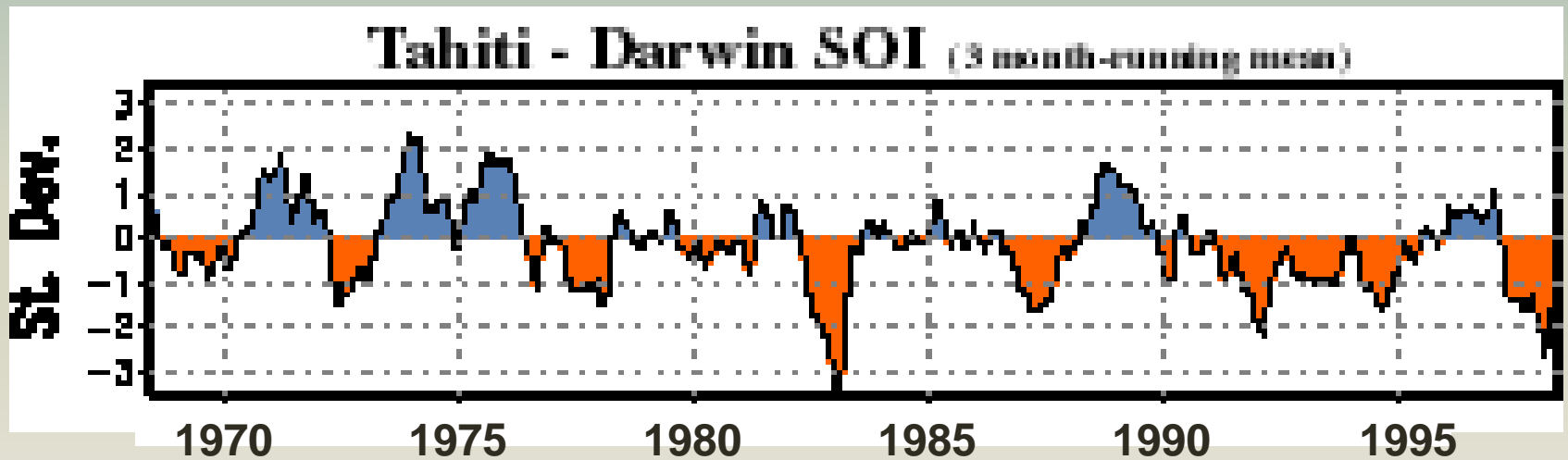
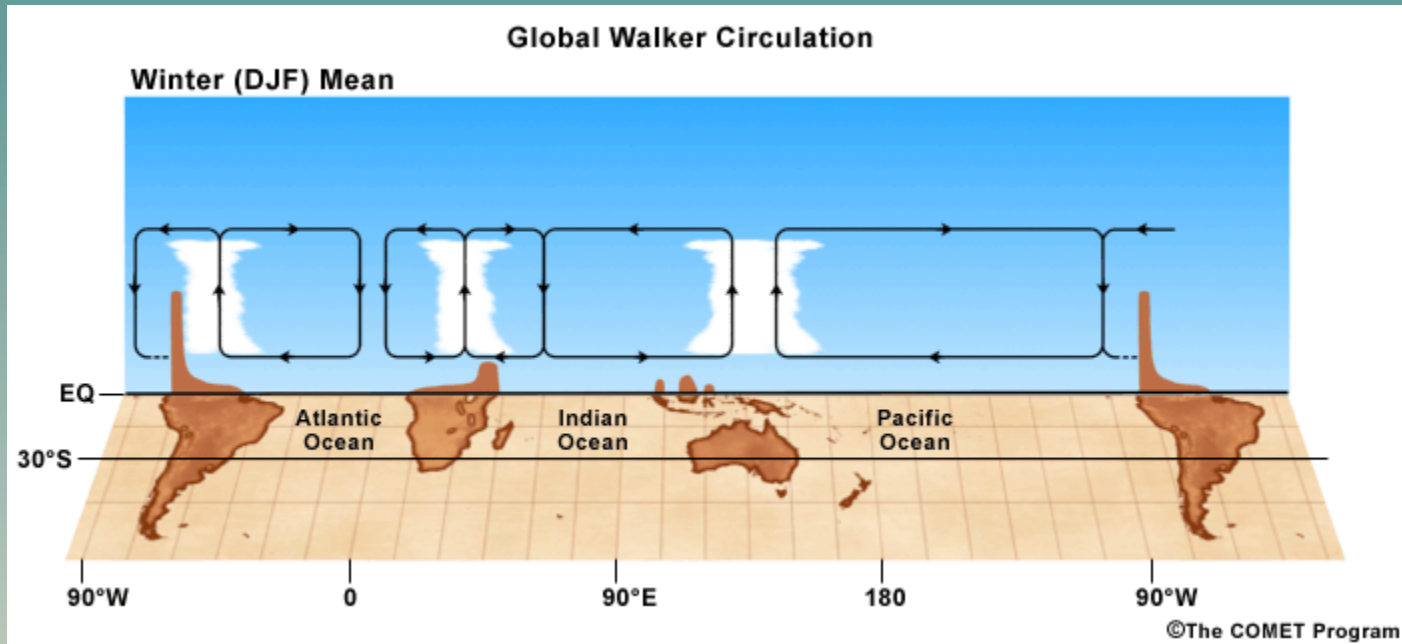




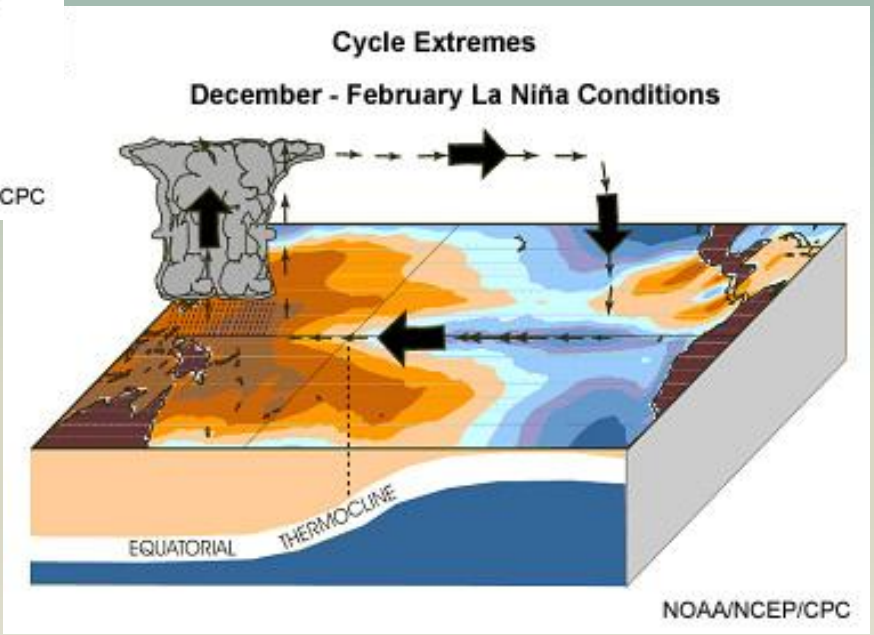
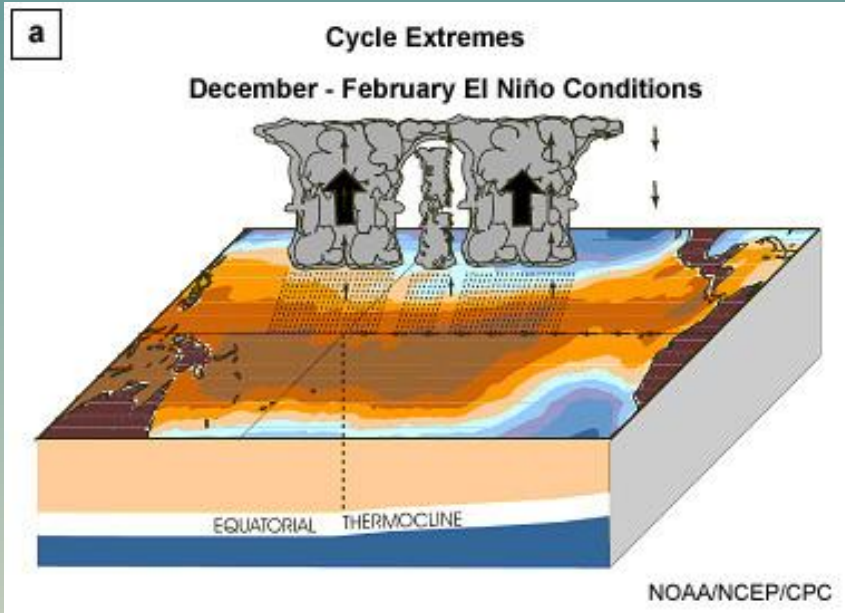
# CIRCULAÇÃO DE WALKER



# CIRCULAÇÃO DE WALKER



# ENOS



# CIRCULAÇÃO DE WALKER

Além da circulação meridional da célula de Hadley, os trópicos também exibem um padrão de movimento ascendente e descendente na direção leste-oeste

Estas células zonais existem devido ao grande gradiente leste-oeste da TSM e à estrutura térmica dos Oceanos Pacífico e Atlântico tanto quanto pelo aquecimento das regiões continentais

A maior região com precipitação intensa ocorre sobre o **Continente Marítimo ??????**

Tormentas e chuva forte são alimentados por intensa forçante solar, abundante evaporação proveniente do aquecimento do Índico e Pacífico aquecidos, e das circulações de brisa que forçam a convecção na escala de dias.

# CIRCULAÇÃO DE WALKER

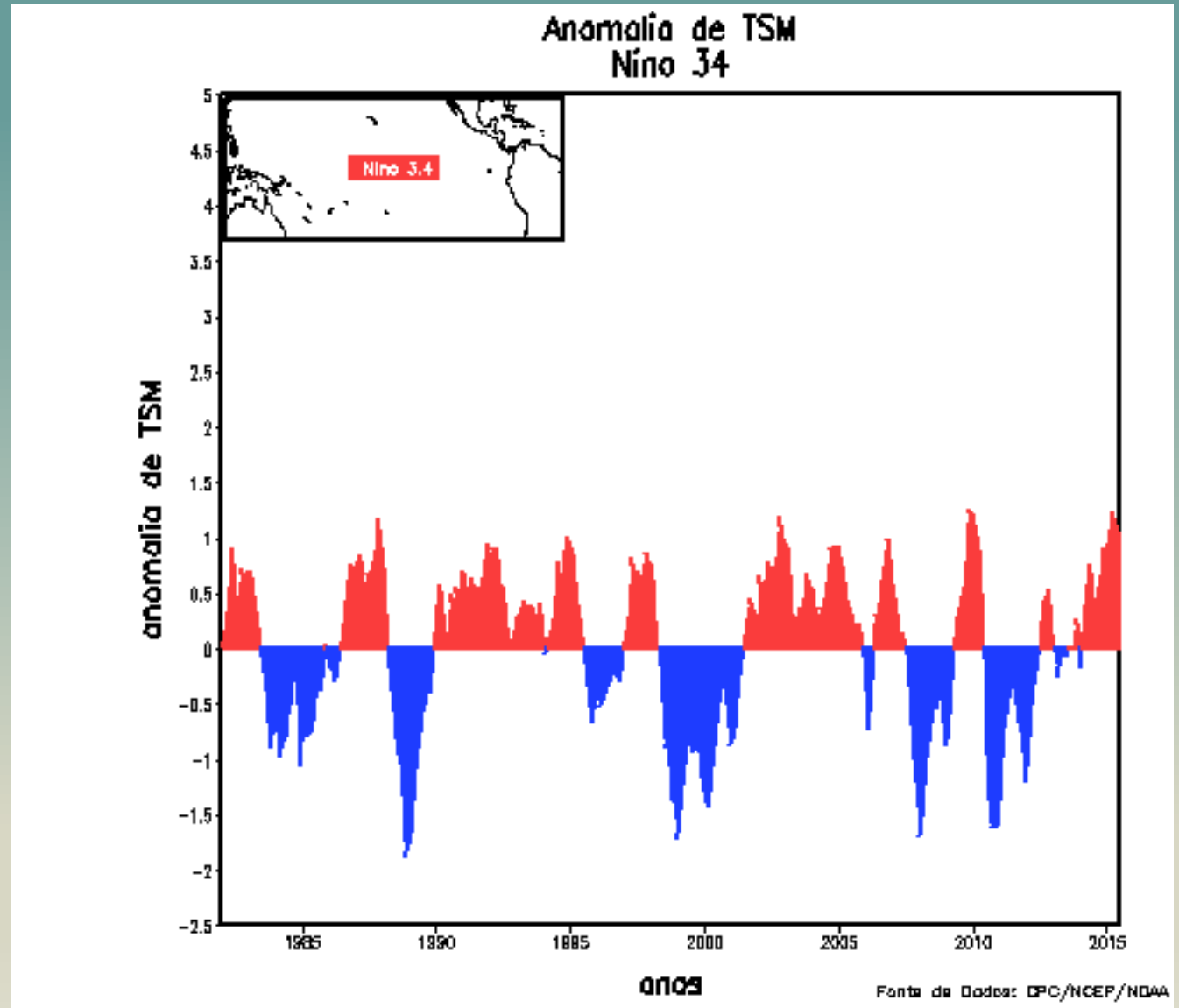
A liberação de calor latente por estes grandes sistemas de tormentas aumentam o movimento ascendente e o escoamento superficial de leste e oeste, dirigindo uma grande célula de circulação ao longo do equador

Movimento correspondente ocorre sobre o Pacífico Leste mais frio.

A grande célula de circulação sobre o Pacífico foi primeiramente descrita pelo meteorologista **Sir Gilbert Walker**. Grandes regiões convectivas também ocorrem com o aquecimento da África e América do Sul tropicais, com movimento subsidente entre os continentes

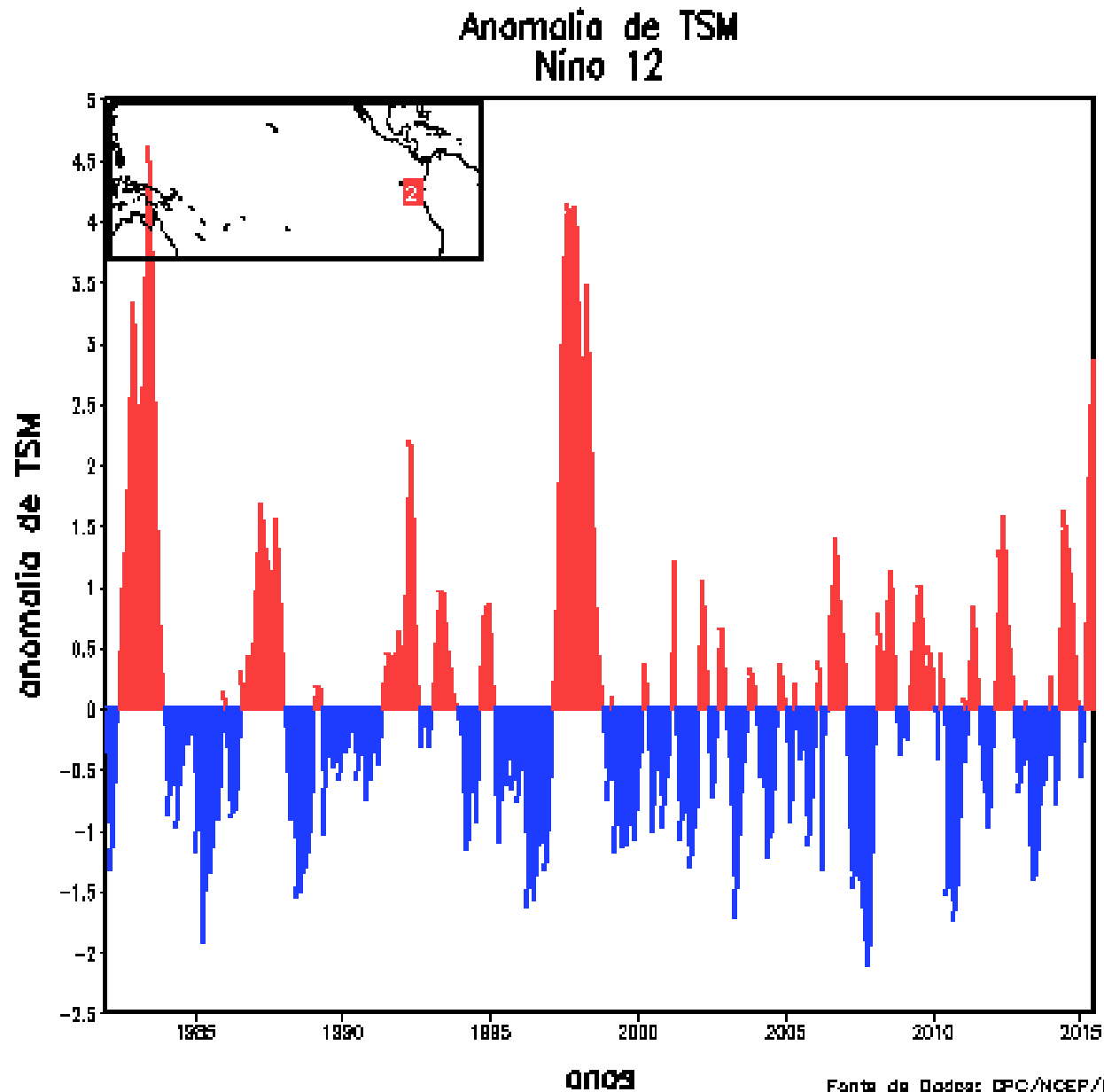
As células de circulação leste-oeste são chamadas comumente como “Circulação de Walker”

# ENOS



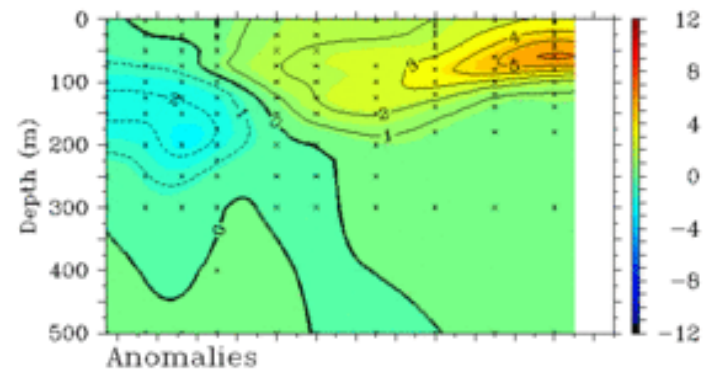
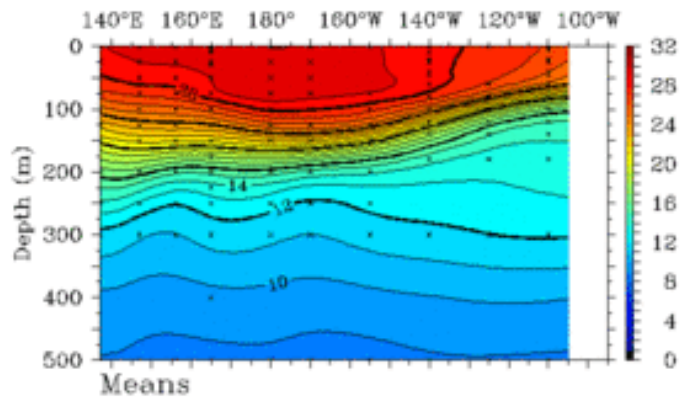
Qual é o estado atual do Pacífico?

# ENOS



# ENOS

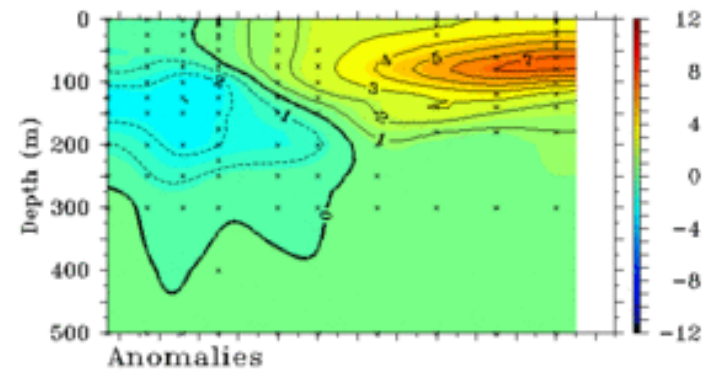
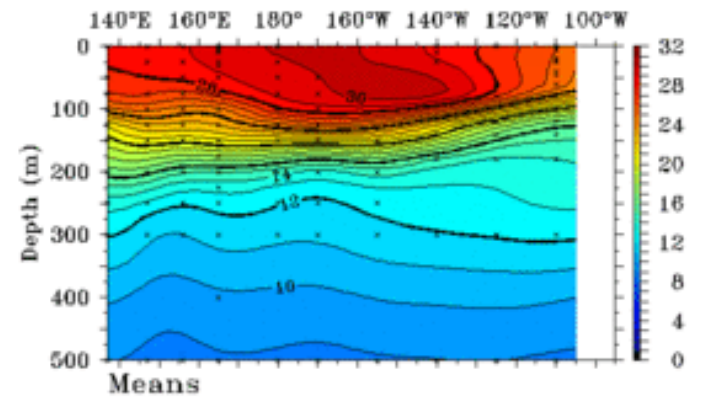
Monthly Mean TAO Temperatures (°C)  
July 2015 2°S to 2°N Average



TAO Project Office/PMEL/NOAA

Aug 21 2015

TAO/TRITON 5-Day Temperature (°C)  
End Date: August 29 2015 2°S to 2°N Average



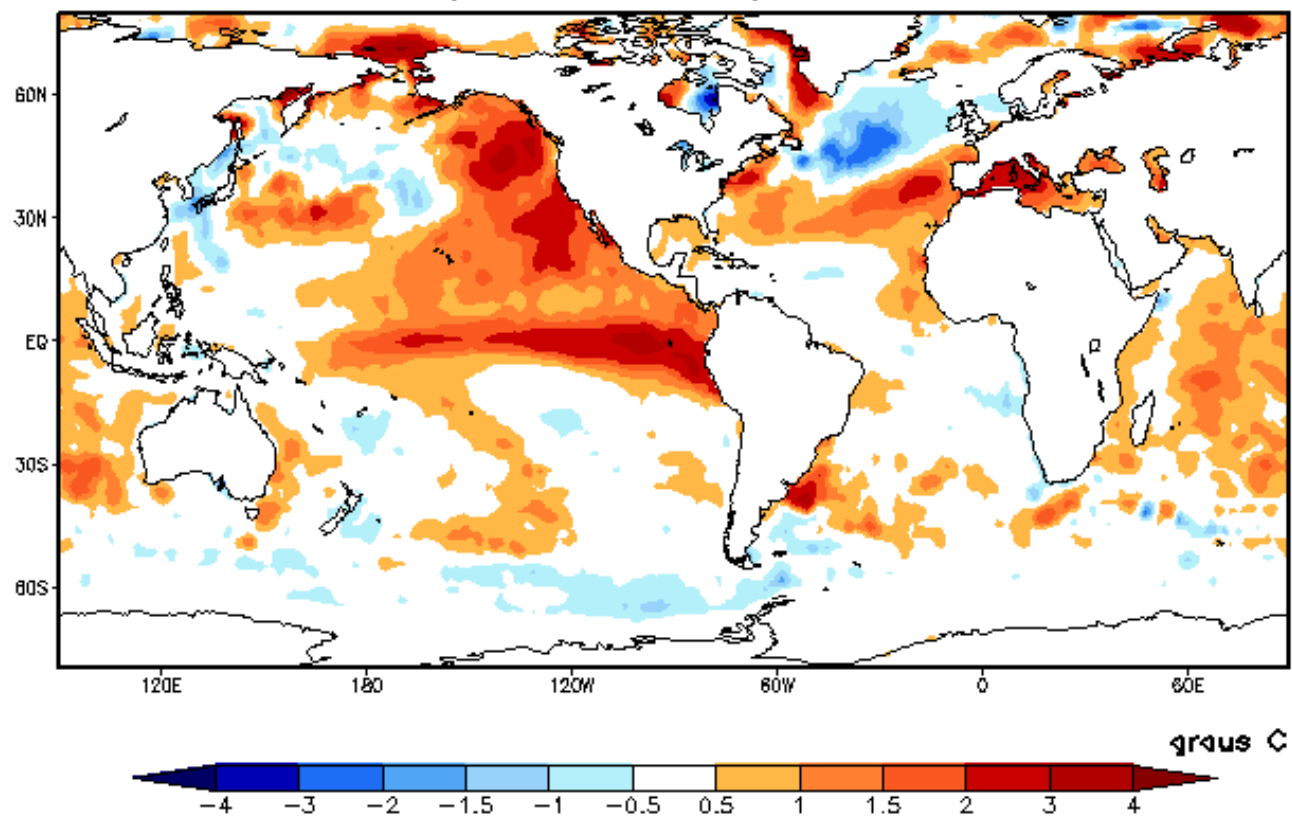
TAO Project Office/PMEL/NOAA

Aug 30 2015



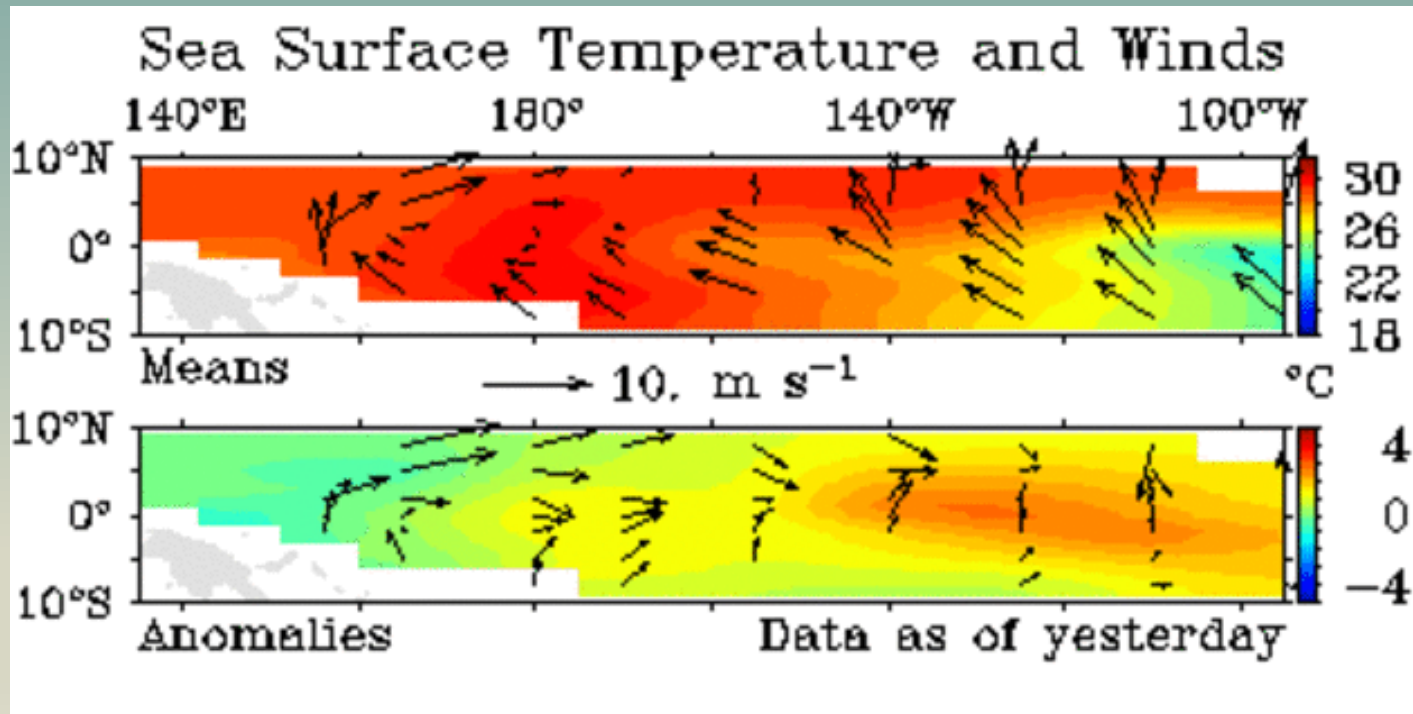
# ENOS

Anomalia de Temperatura da Superfície do Mar JUL2015



# ENOS

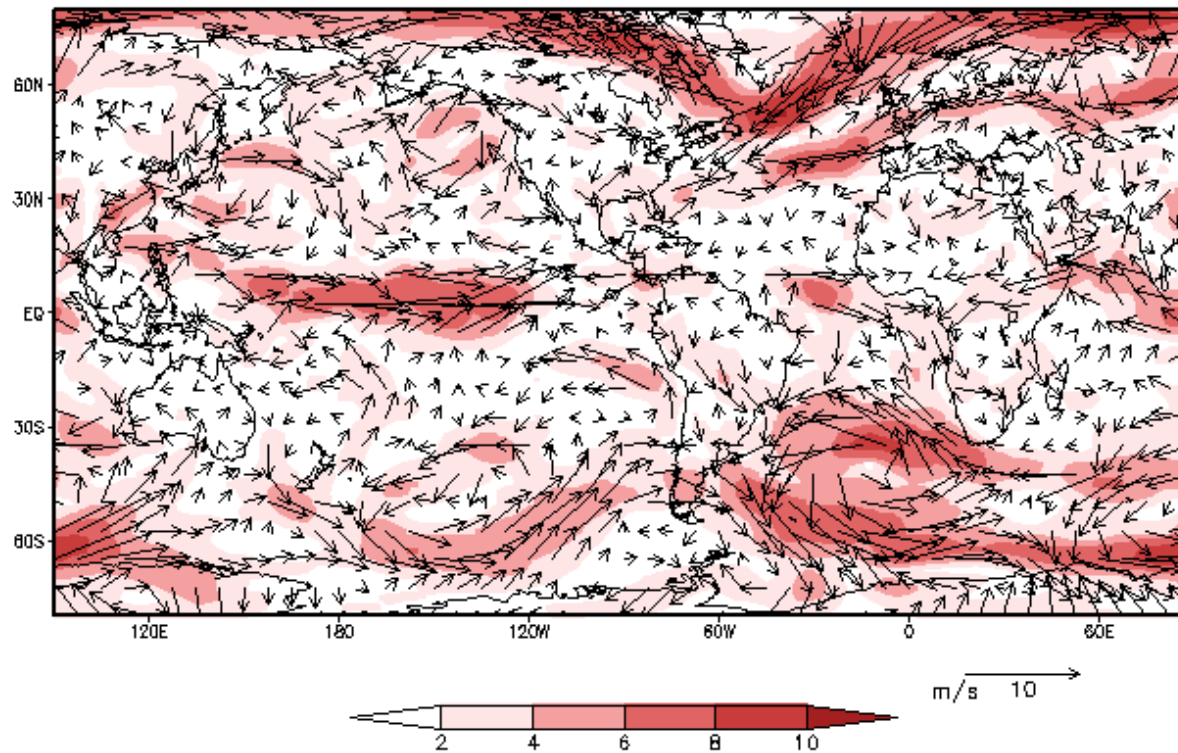
AGOSTO 2015



# ENOS

INPE/CPTEC

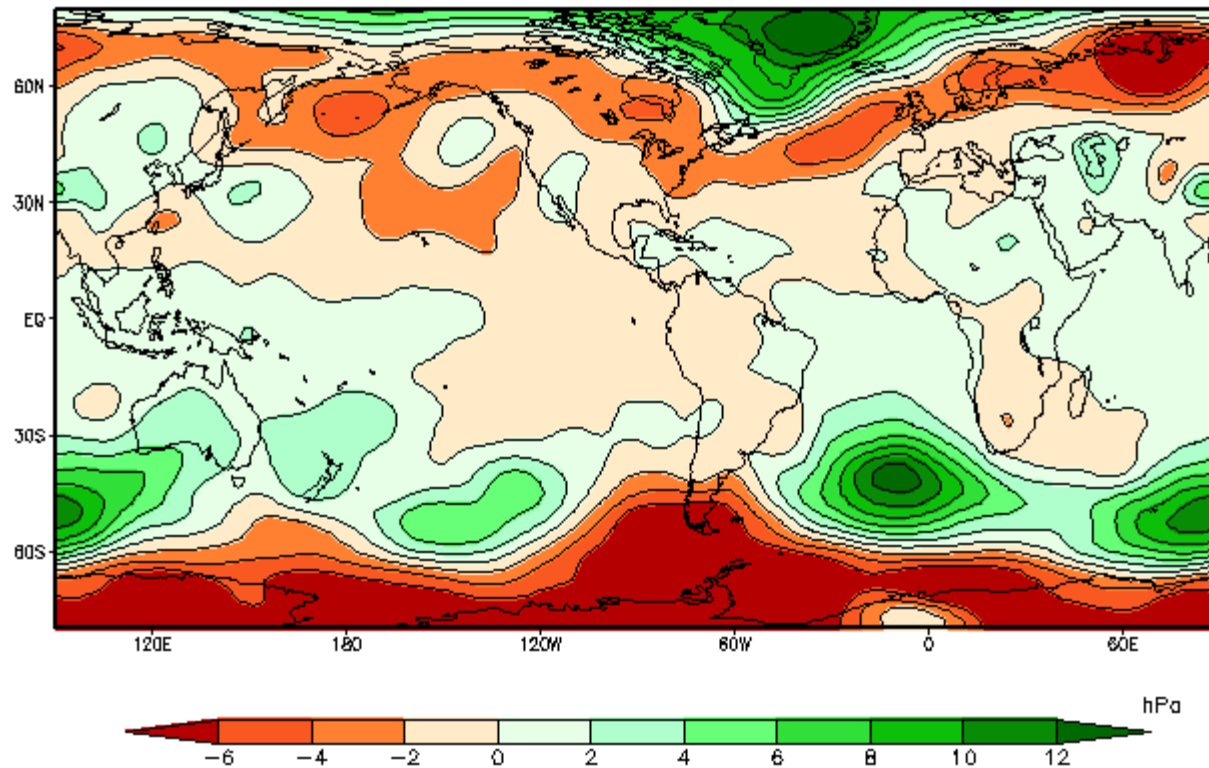
Anomalia de Vento em 850 hPa JUL2015



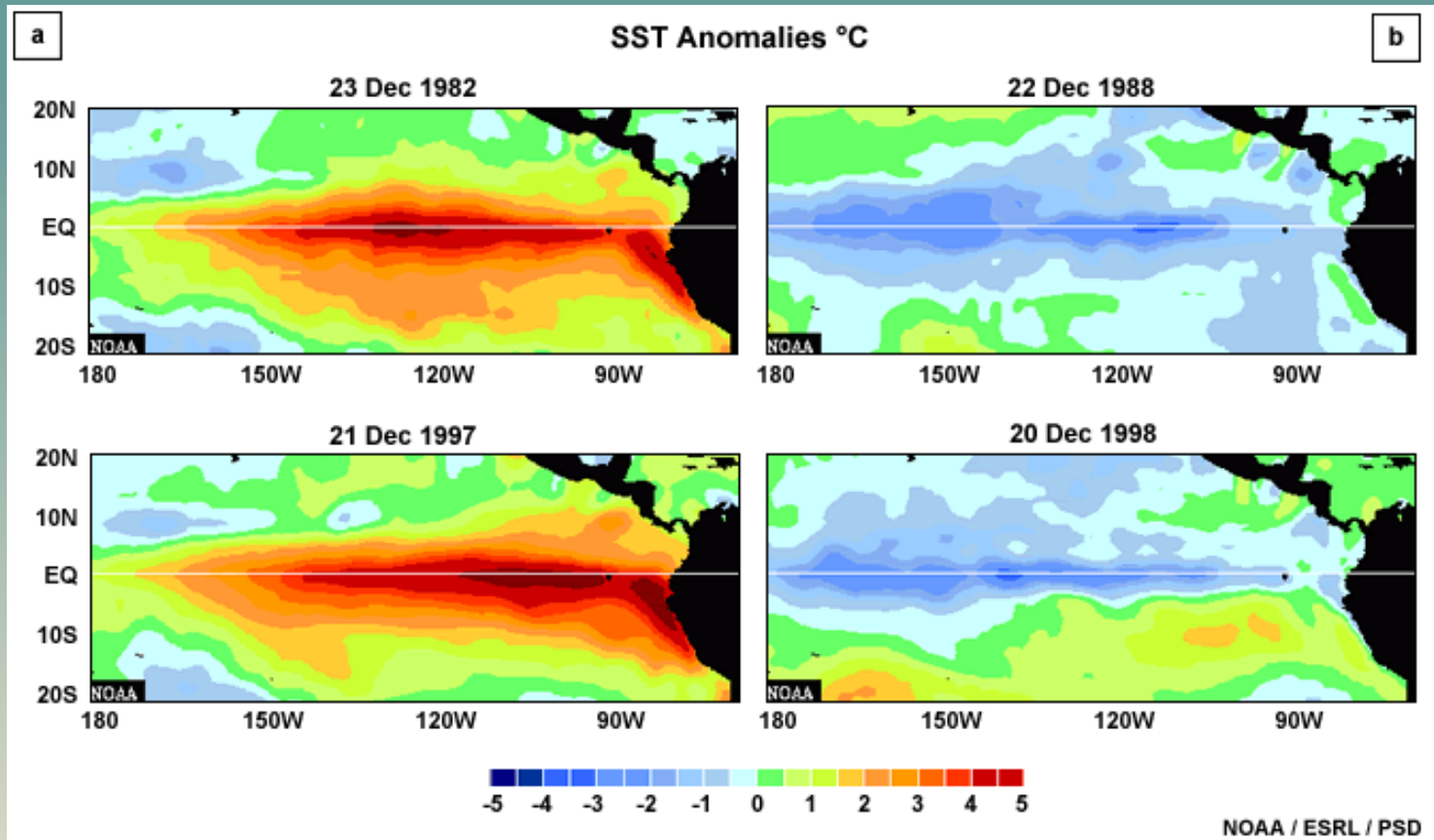
# ENOS

INPE/CPTEC

Anomalia de Pressao ao Nivel do Mar JUL2015



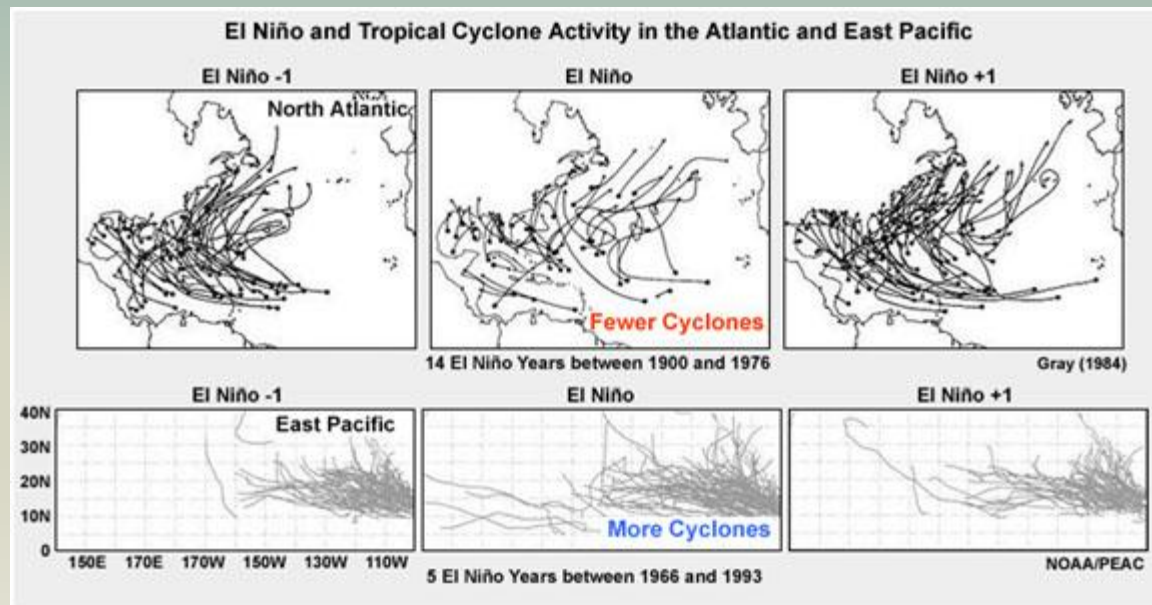
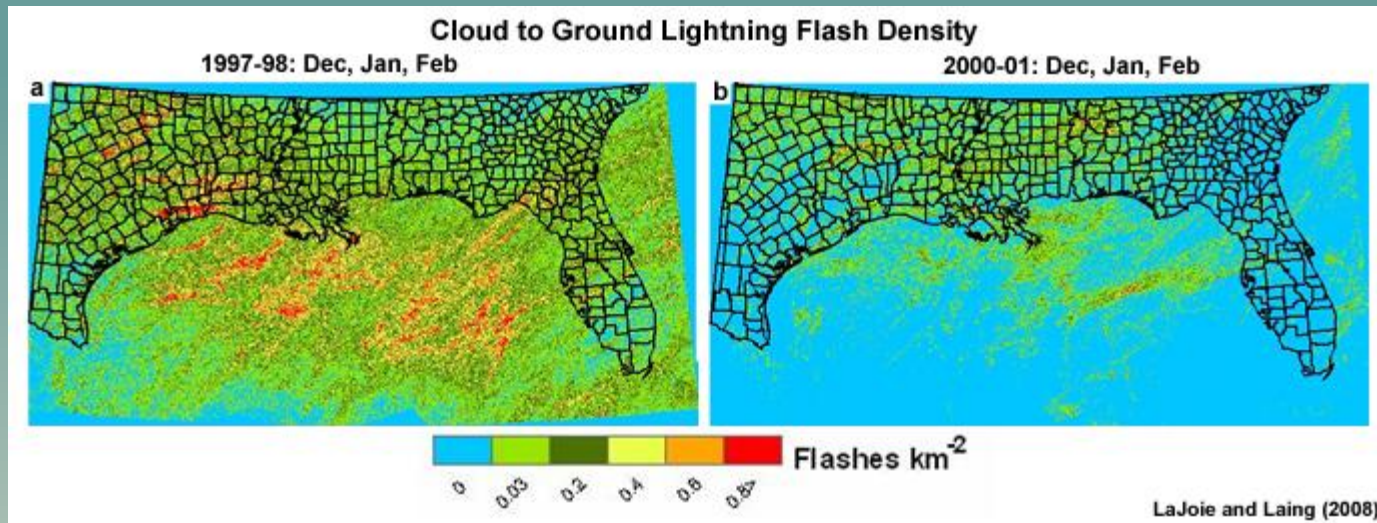
# ENOS



[http://www.meted.ucar.edu/tropical/textbook\\_2nd\\_edition/media/flash/sst\\_anim\\_two\\_strong\\_el\\_nino.swf](http://www.meted.ucar.edu/tropical/textbook_2nd_edition/media/flash/sst_anim_two_strong_el_nino.swf)

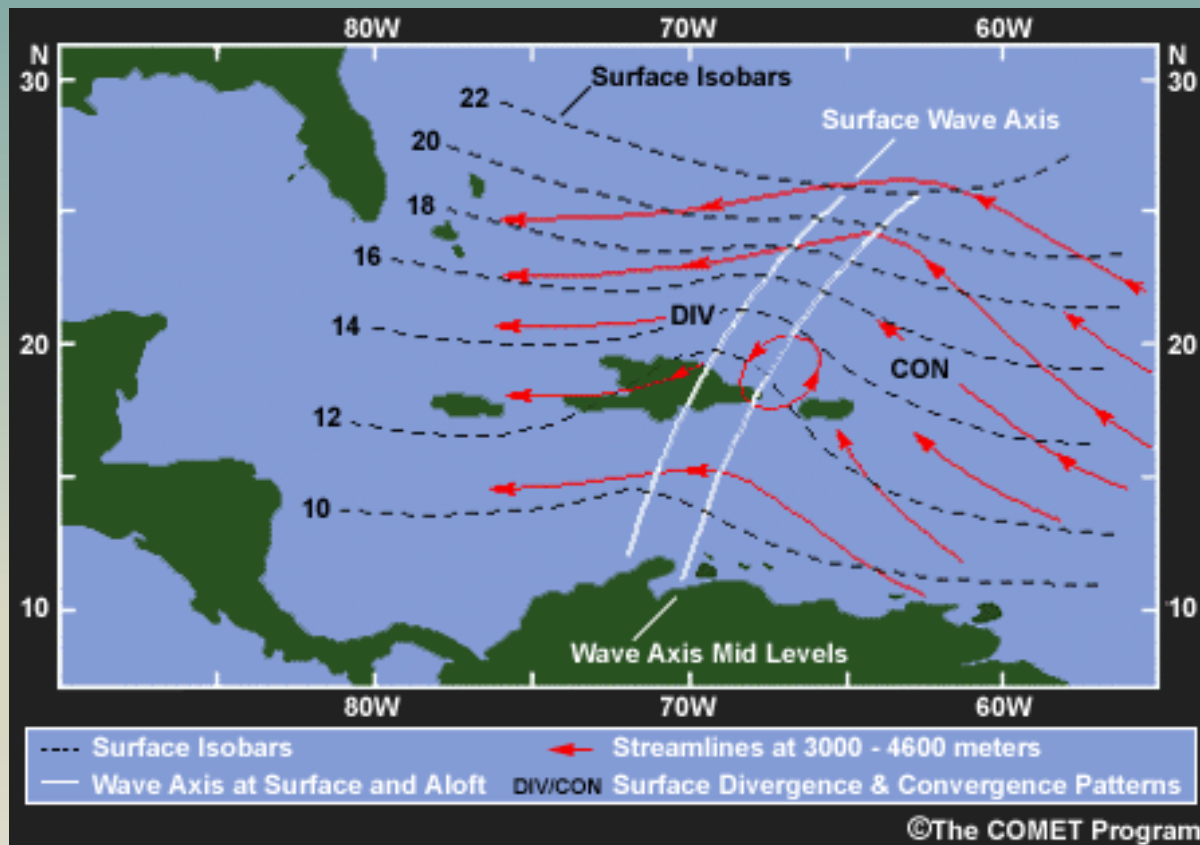
[http://www.meted.ucar.edu/tropical/textbook\\_2nd\\_edition/media/flash/sst\\_anim\\_two\\_strong\\_lanina.swf](http://www.meted.ucar.edu/tropical/textbook_2nd_edition/media/flash/sst_anim_two_strong_lanina.swf)

# ENOS

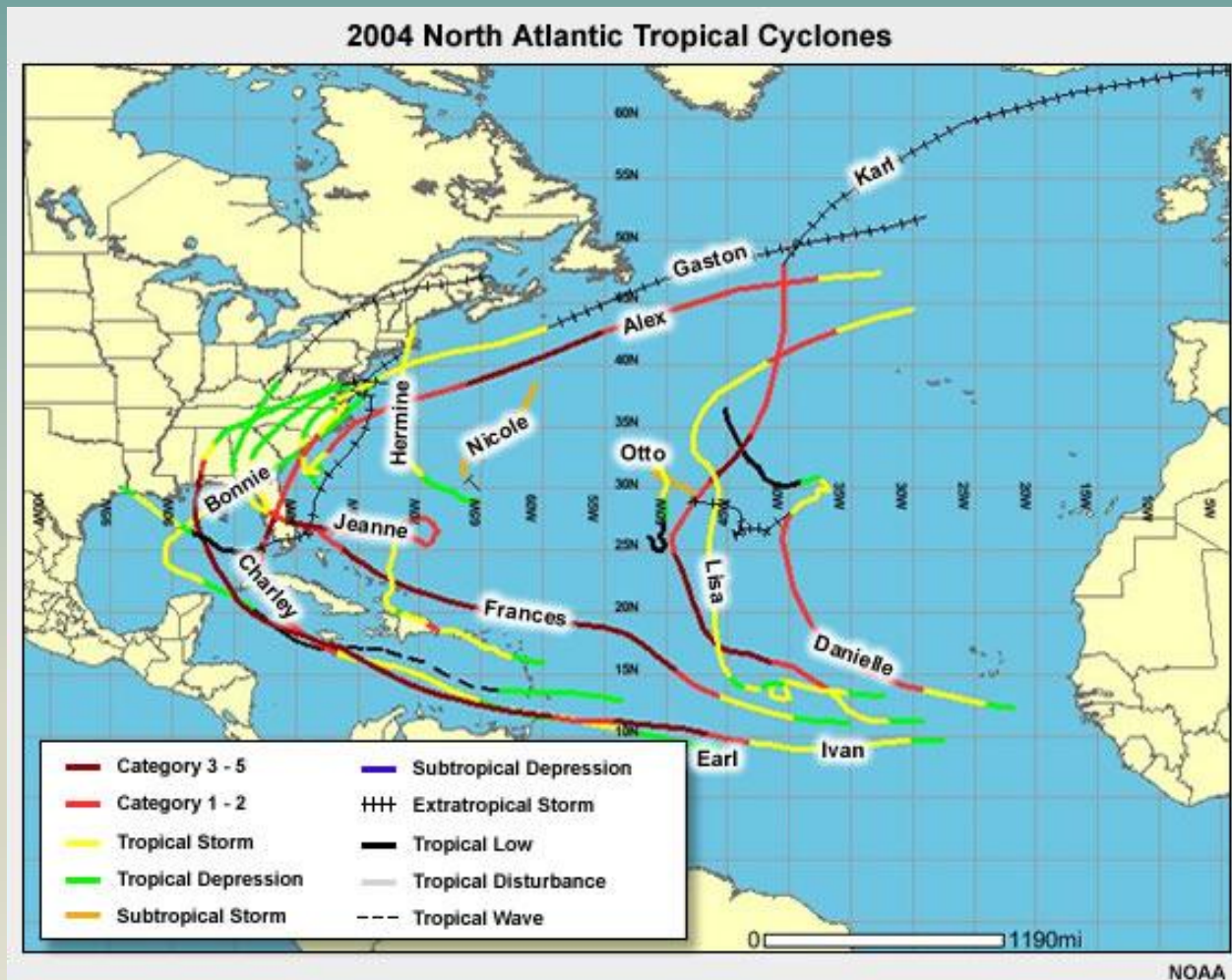


# FURACÃO

## EIXO DA TORMENTA



# TRAJETÓRIAS CICLONES TROPICAIS 2004



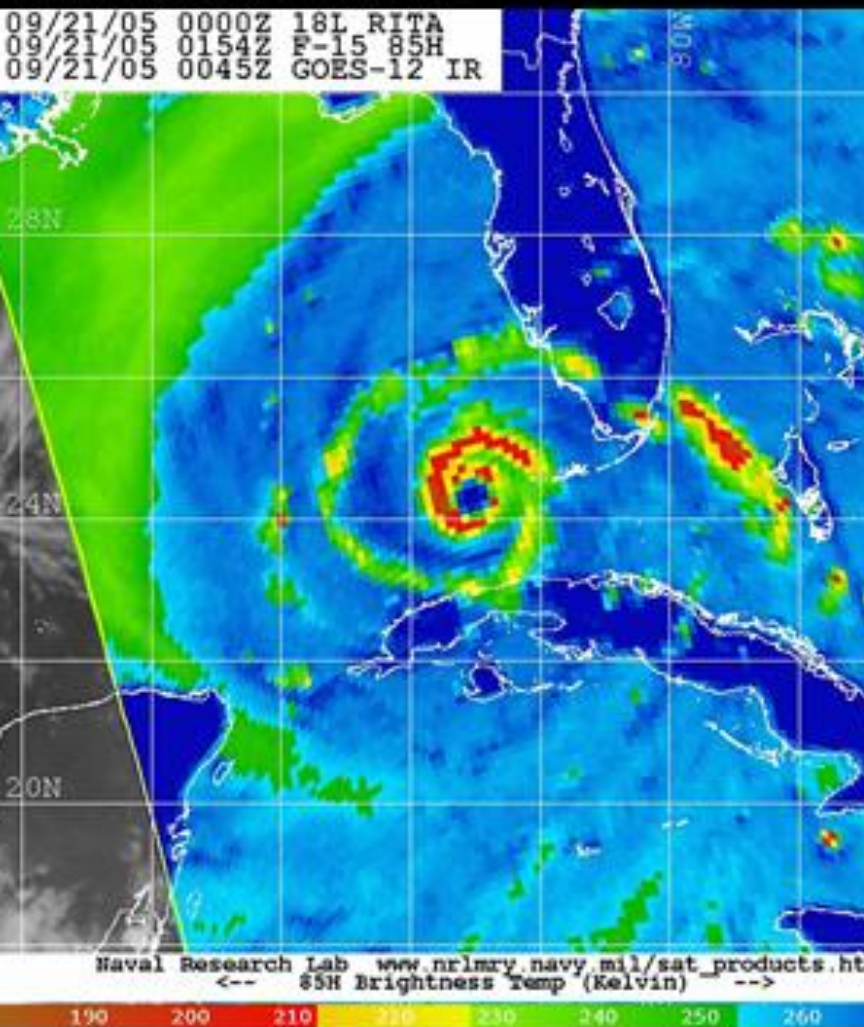


# IMAGEM SATÉLITE BRILHO

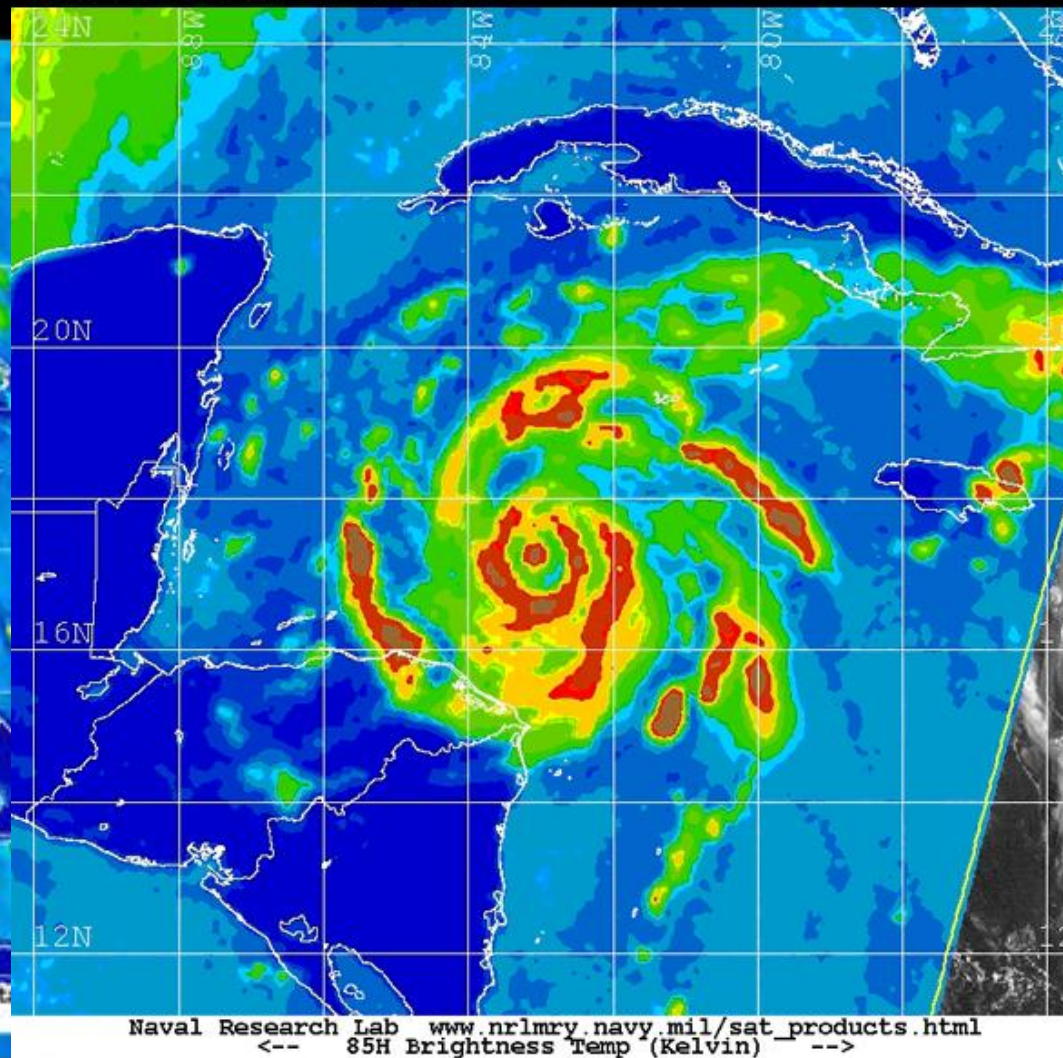
# TEMPERATURA DE

Hurricane Rita, 21 Sep 2005

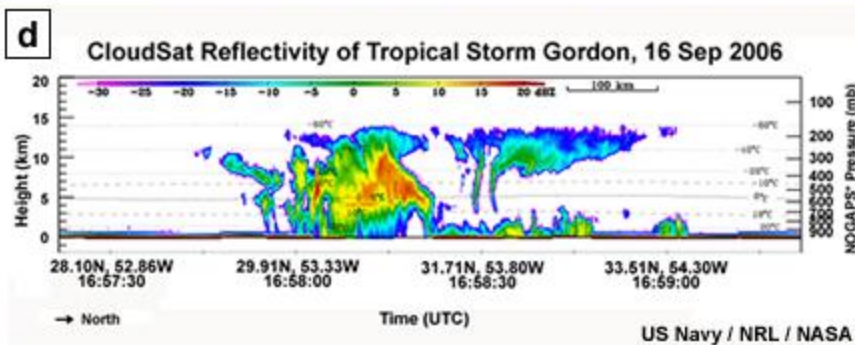
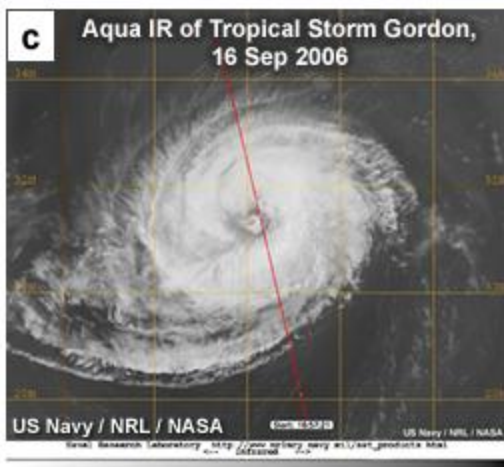
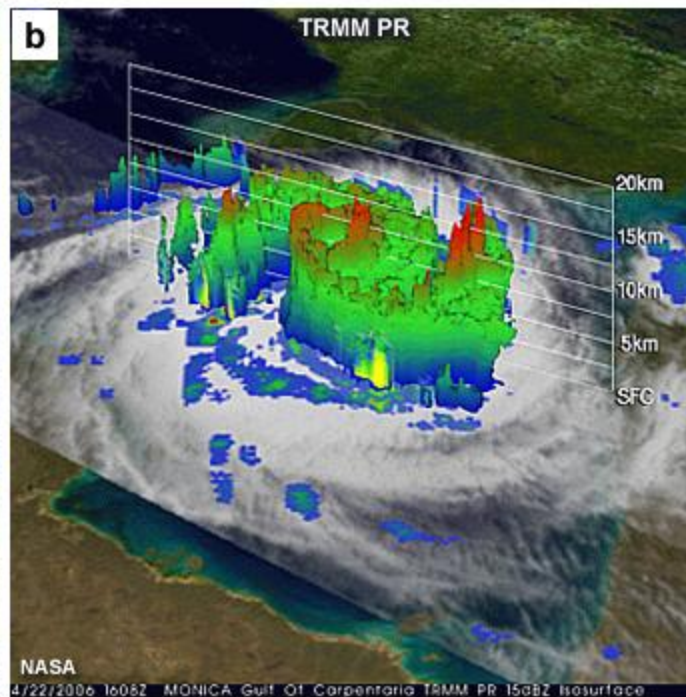
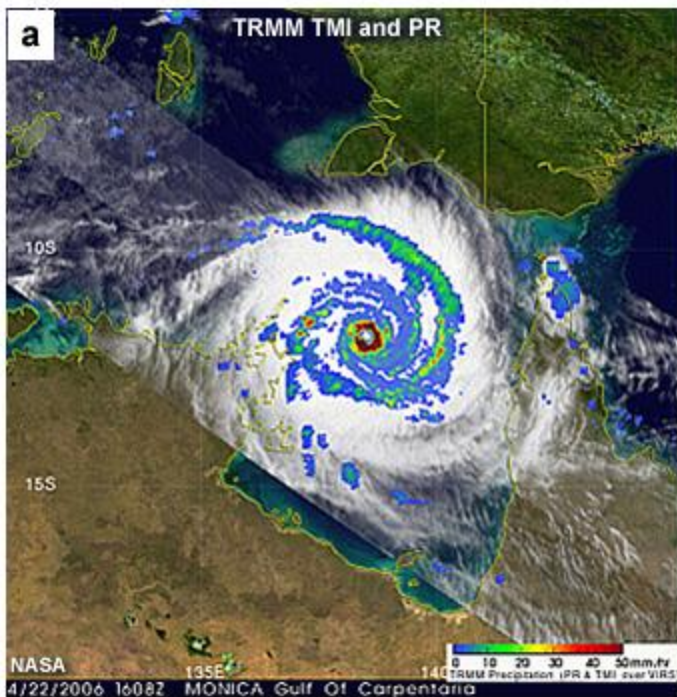
09/21/05 0000Z 18L RITA  
09/21/05 0154Z F-15 85H  
09/21/05 0045Z GOES-12 IR



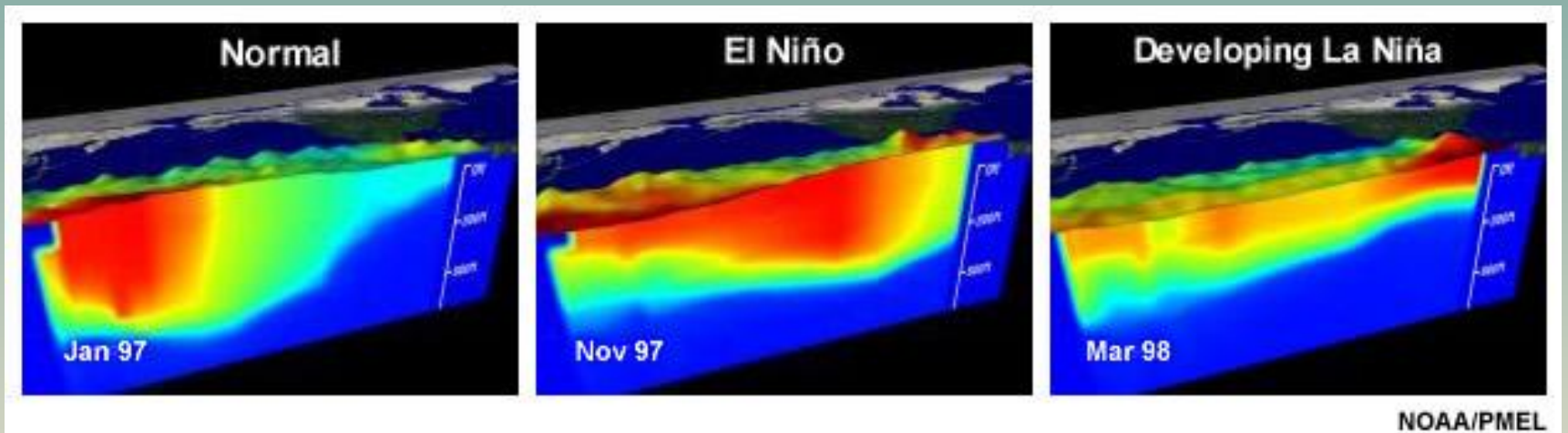
Hurricane Wilma 1400 UTC 19 Oct 2005



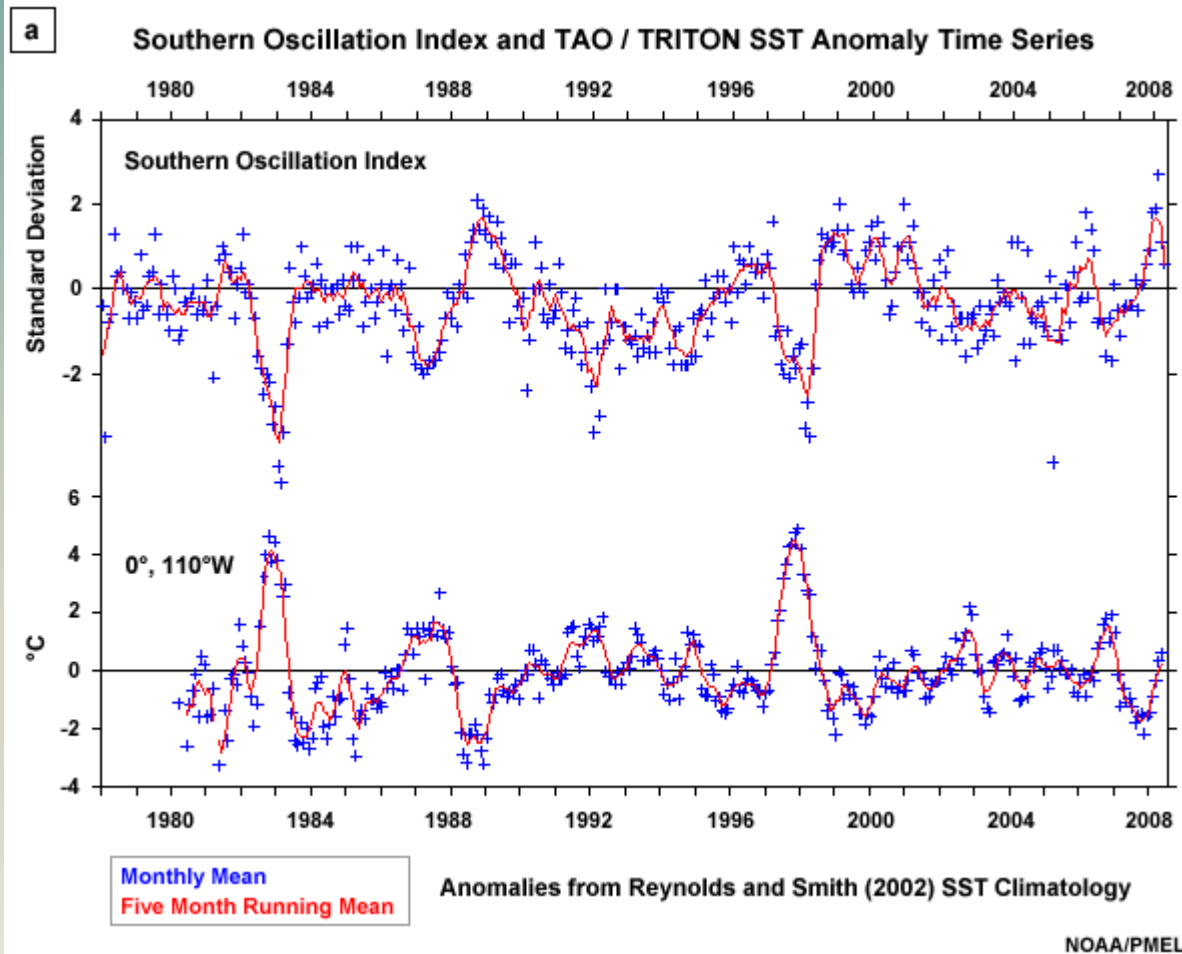
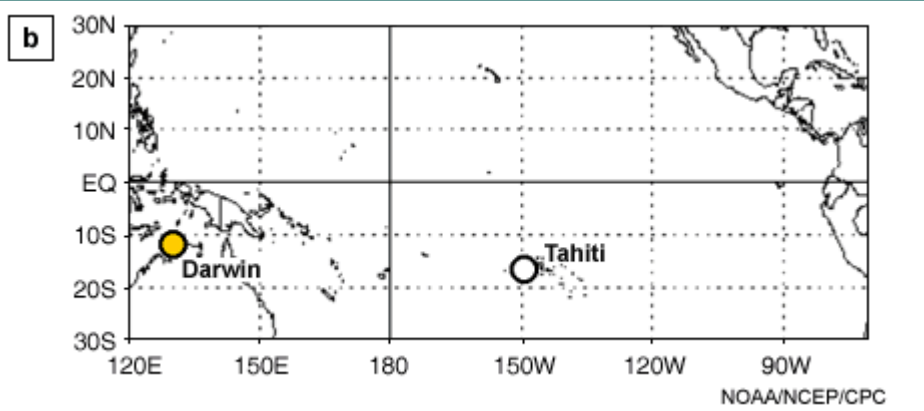
Tropical Cyclones observed by Satellite Precipitation Radar, Cloud Radar, Microwave and IR Imagers



# ENOS

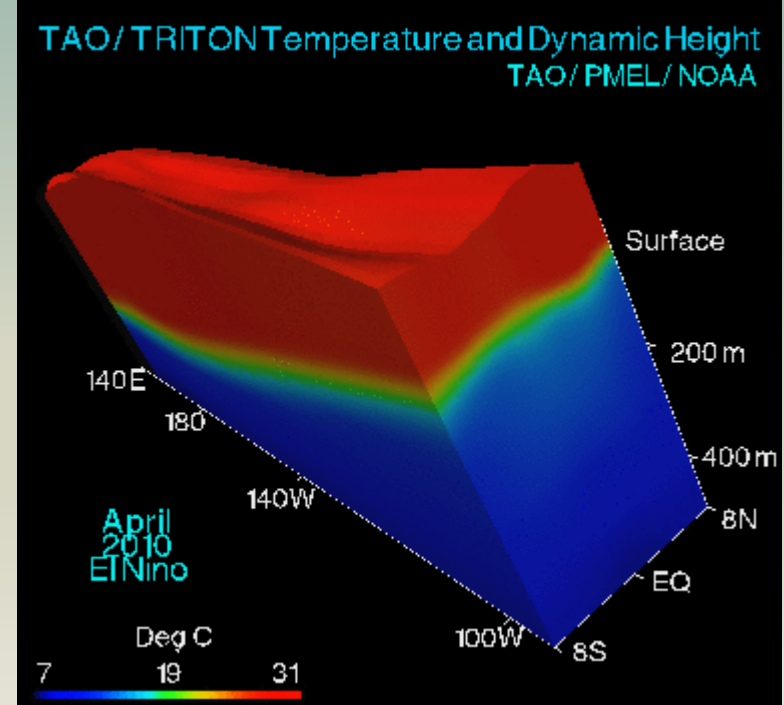
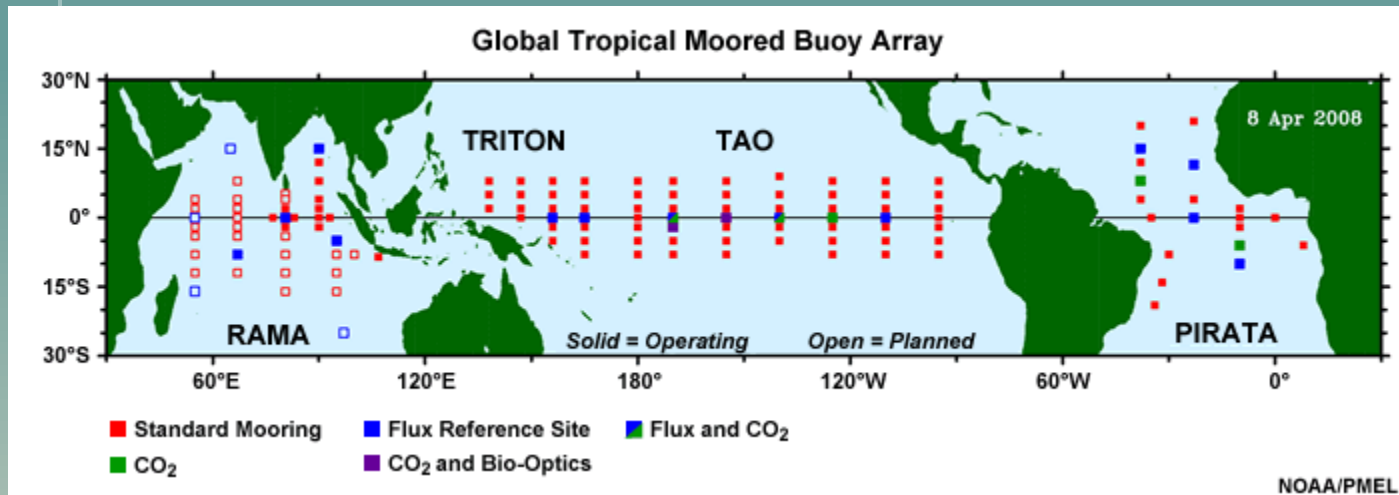


# ENOS



$$SOI = 10 \frac{(P_{diff} - P_{diffav})}{Stdev(P_{diffav})}$$

# MONITORAMENTO



# EL NIÑO 1997

[http://www.meted.ucar.edu/afwa/climo/stats/3\\_5\\_1\\_pop.htm](http://www.meted.ucar.edu/afwa/climo/stats/3_5_1_pop.htm)

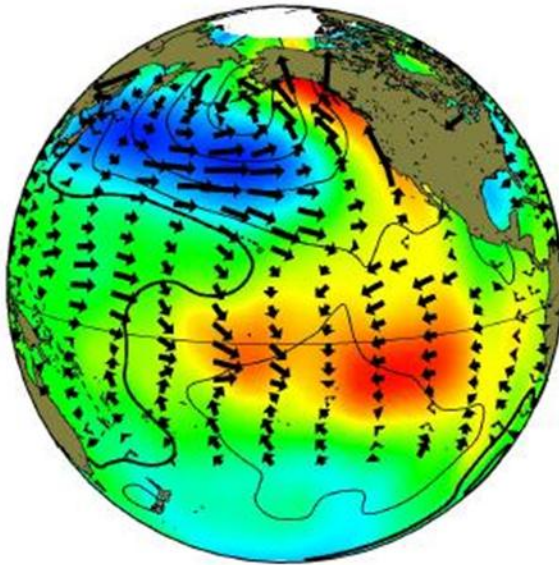
**JAN 1997    DEZ 1998**

# OSCILAÇÃO DECADAL DO PACÍFICO

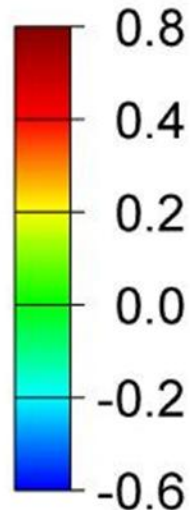
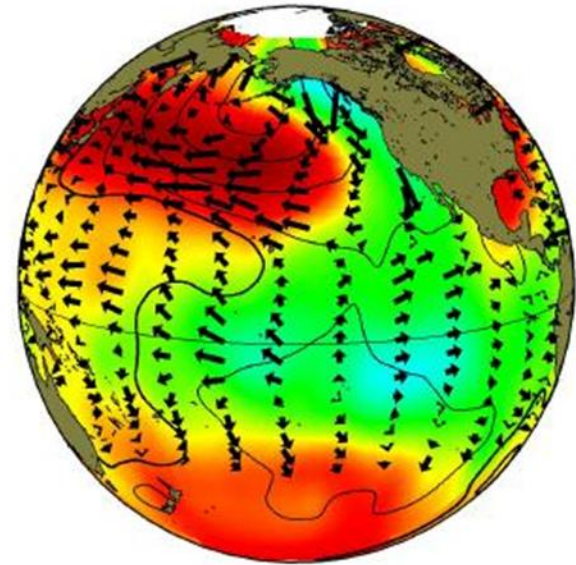
PDO ODP

## Pacific Decadal Oscillation

positive phase



negative phase



# OSCILAÇÃO DECADAL DO PACÍFICO

Além da variabilidade intrasazonal **OMJ**  
interanual **ENOS**

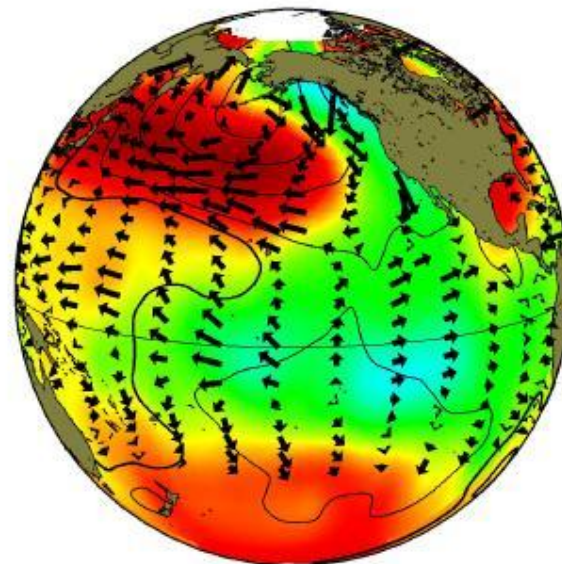
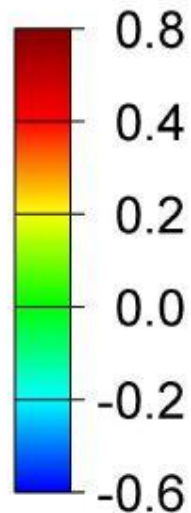
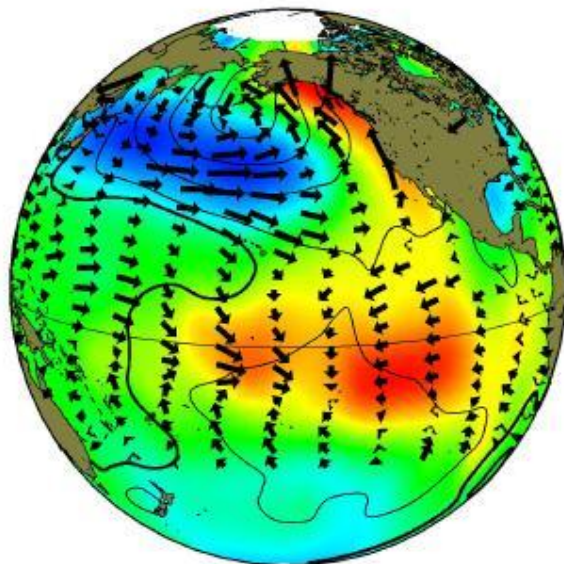
Interações tropicais e extratropicais  
estão associadas à **escala decadal**



# Pacific Decadal Oscillation

positive phase

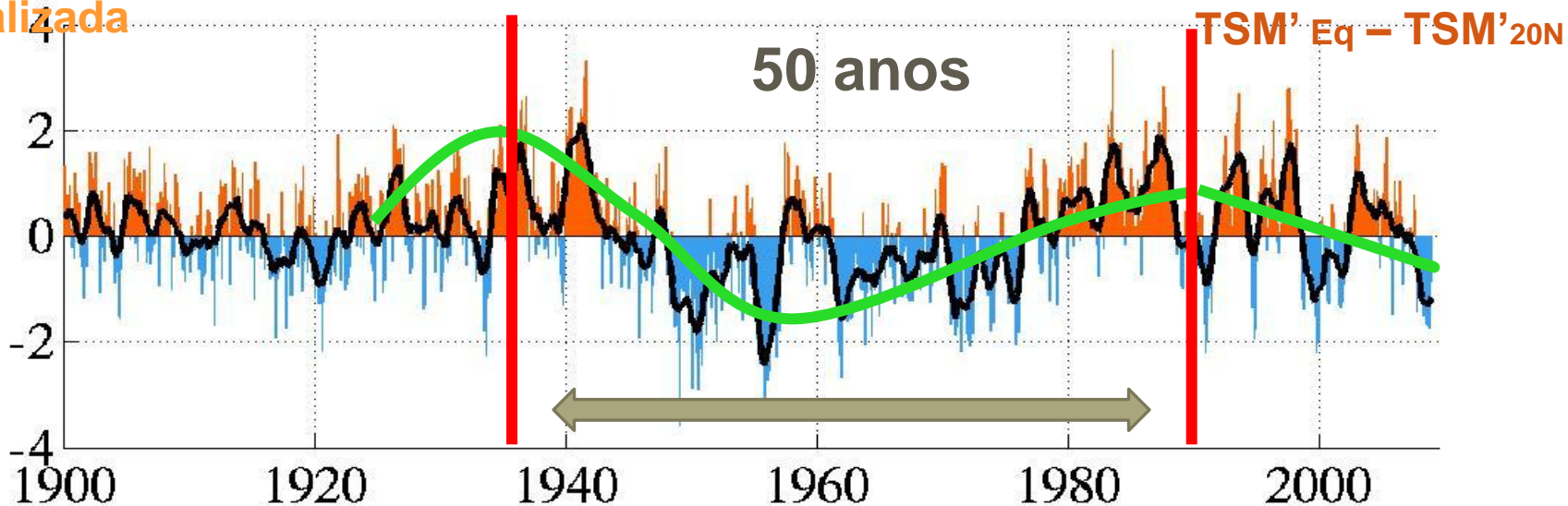
negative phase



Anomalia  
vento

1º modo CP  
normalizada

monthly values for the PDO index: 1900-2008



# OSCILAÇÃO DECADAL DO PACÍFICO

A ODP refere-se à oscilação do Pacífico Norte e a anomalias atmosféricas num período de **20-30 anos**

É fortemente correlacionada com o ENOS

Ambos atingem a maior amplitude durante o inverno boreal – HN (**verão no HS**)

# OSCILAÇÃO DECADAL DO PACÍFICO

Diferentemente do ENSO, o sinal da ODP nos trópicos é menos importante do que no Pacífico Norte e na América do Norte

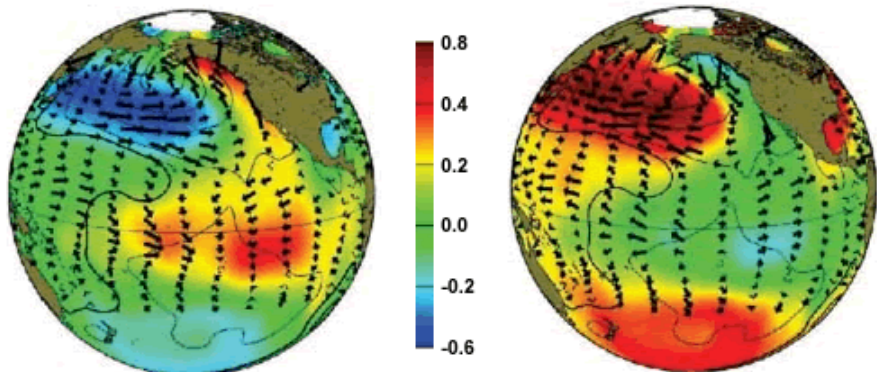
O padrão da ODP é similar ao do PNA interanual

## Pacific Decadal Oscillation

a

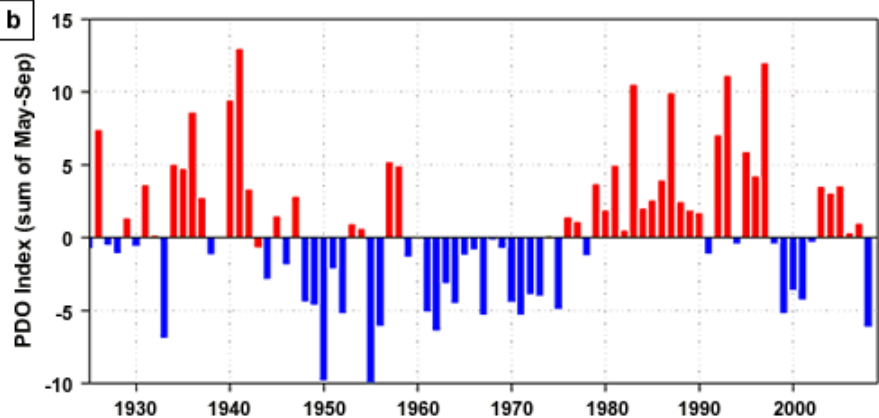
positive phase

negative phase



Steven Hare

b



NOAA / NWFS

$PDO > 0$



condições úmidas no SW dos EUA

$PDO < 0$



condições secas no SW dos EUA

**PDO é altamente correlacionada com grandes alterações de cardumes e ecossistemas no Pacífico Norte**

**As causas da PDO não são conhecidas, o que limita sua previsibilidade; contudo algumas simulações climáticas têm produzido oscilações similares à da PDO**

# OSCILAÇÃO DECADAL DO PACÍFICO

**Animation of PDO SST**

<http://www.pmel.noaa.gov/vrml/overland/movies/pdosmall2.mpg>

# OSCILAÇÃO DO ATLÂNTICO NORTE

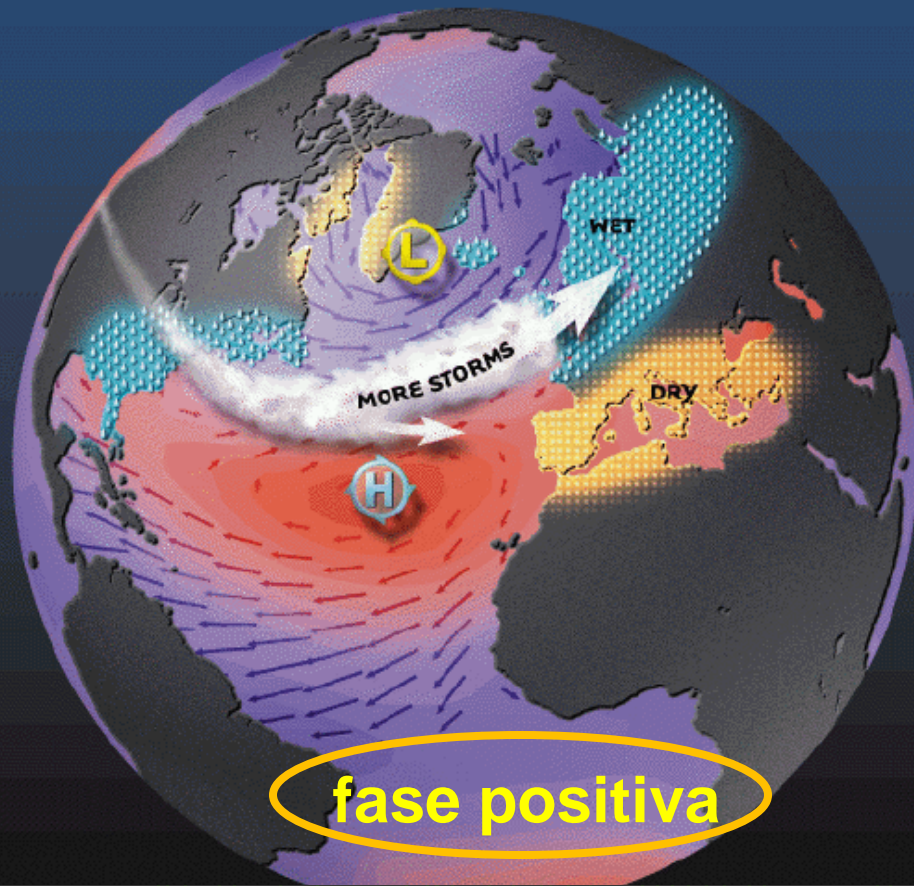
NAO OAN

# NAO OSCILAÇÃO DO ATLÂNTICO NORTE

- O índice NAO é definido como a diferença de anomalias de pressão atmosférica entre a **alta subtropical dos Açores** e a **baixa polar da Islândia** durante a estação de inverno -
- dezembro a março

$$I_{NAO} = P'_{AltaAçores} - P'_{BaixaIslândia}$$

$$\text{anom pressão} = P' = \text{PRESSÃO tempo (i)} - \text{PRESSÃOclim}$$

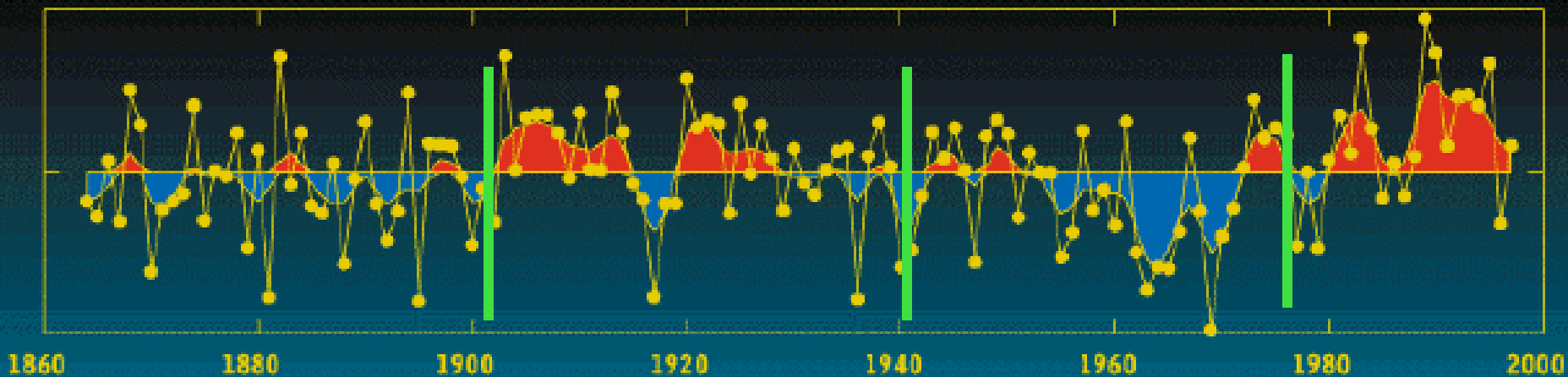


fase positiva



fase negativa

### NAO Index





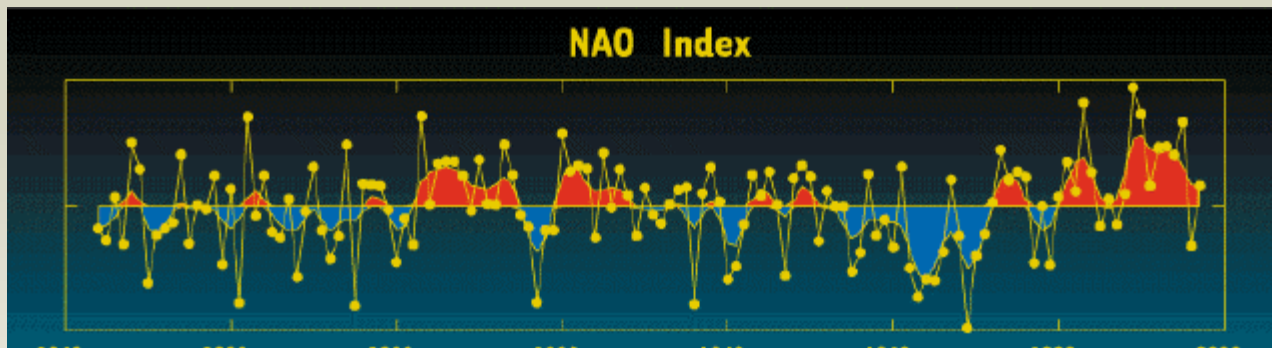
# NAO NORTH ATLANTIC OSCILLATION

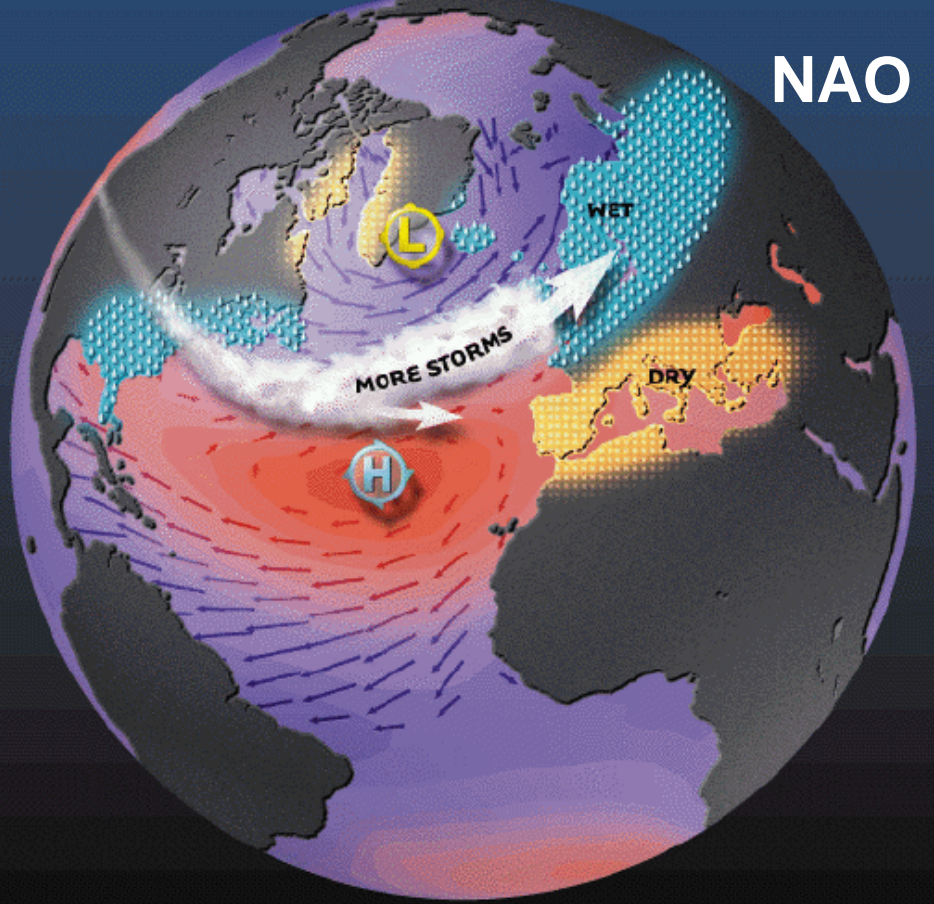
É um modo dominante de variabilidade climática de **inverno**  
**?????**

Atua desde a América do Norte até a Europa e parte do norte da Ásia

É uma oscilação de **grande escala** na atmosfera entre a alta subtropical dos Açores e a baixa polar da Islândia

O índice que representa esta oscilação varia de ano para ano, mas exibe uma tendência de ficar em uma mesma fase por intervalos que duram muitos anos





## FASE POSITIVA

**INTENSA** ALTA PRESSÃO DOS AÇORES  
INTENSA BAIXA PRESSÃO DA ISLÂNDIA

O aumento da diferença de pressão resulta em ventos mais intensos cruzando o Atlântico em uma trajetória mais de norte

**Isso resulta em invernos mais quentes e úmidos na Europa**

**E invernos mais frios e mais secos no norte do Canadá e Groelândia**

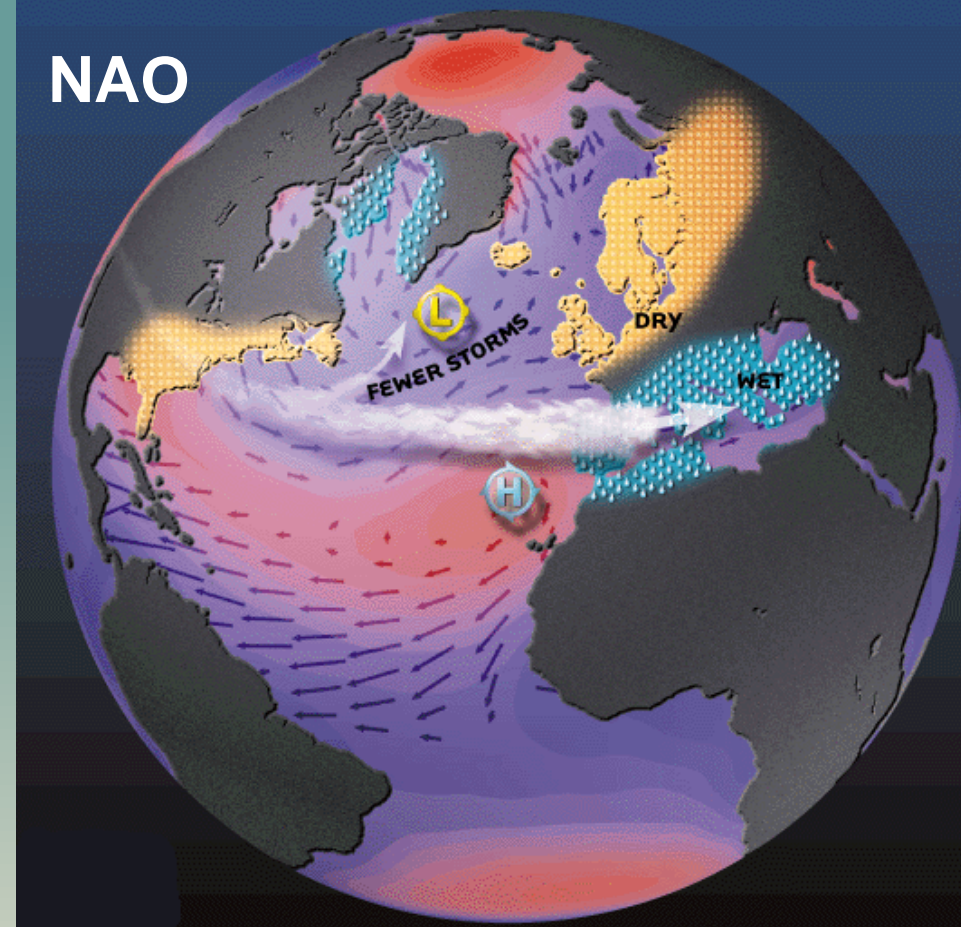
**O leste dos EUA experimenta condições suaves (temp) e úmidas no inverno**

## FASE NEGATIVA

**FRACA** ALTA PRESSÃO DOS AÇORES  
**FRACA** BAIXA PRESSÃO DA ISLÂNDIA

O gradiente de pressão reduzido resulta em poucas e fracas tormentas de inverno que cruzam o Atlântico Norte numa trajetória mais na direção oeste-leste

NAO

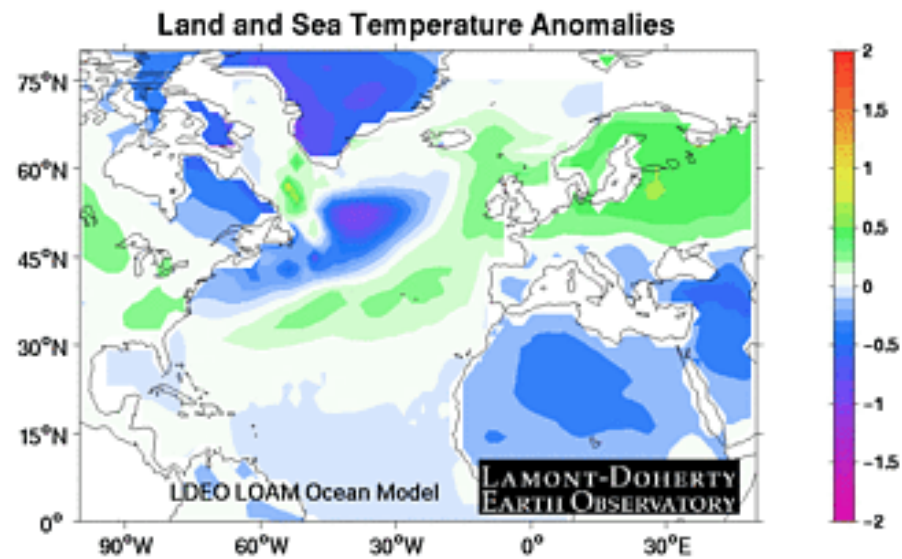
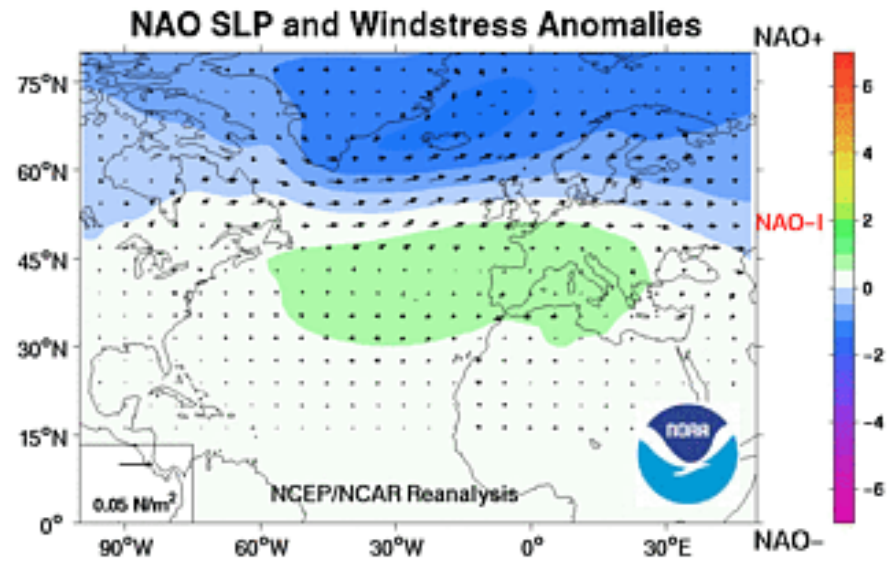


**Levam ar mais úmido para o Mediterrâneo e ar mais frio para o norte da Europa**

**A costa leste dos EUA experimenta a entrada de massas de ar mais frio e tempo com condições para nevascas**

**A Groelândia, contudo, terá invernos com temperaturas menos frias**

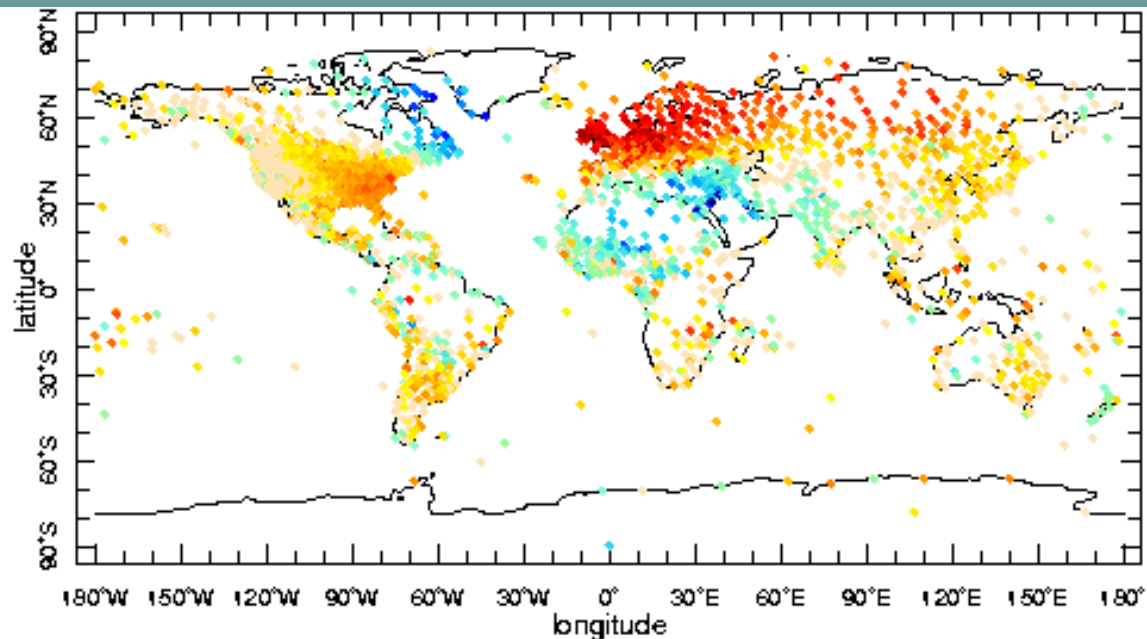
# NAO



# NAO NORTH ATLANTIC OSCILLATION

Idem ao slide anterior

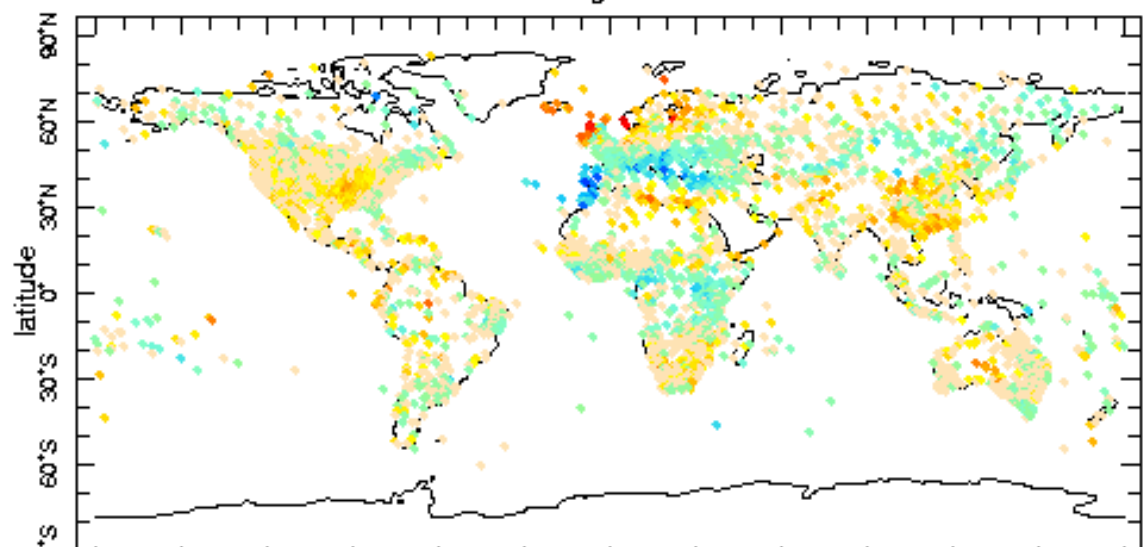
<http://www.ldeo.columbia.edu/res/pi/NAO/>



Correlação linear

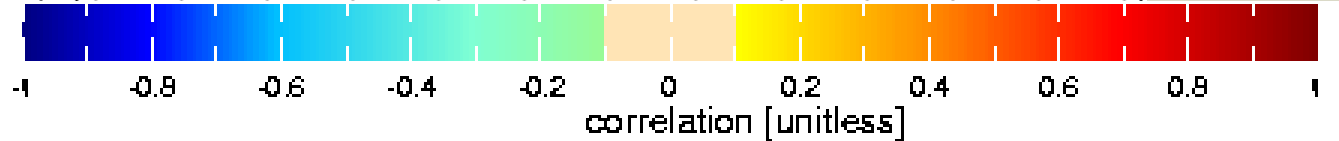
NAO

temperatura inverno



NAO

precipitação inverno



IMPACTS ASSOCIATED WITH A POSITIVE NAO YEAR.



**NORTHEASTERN US**  
Increased temperature results in decreased number of snow days



**NORTH SEA**  
Increased wave height affects safety of oil rigs and their operators



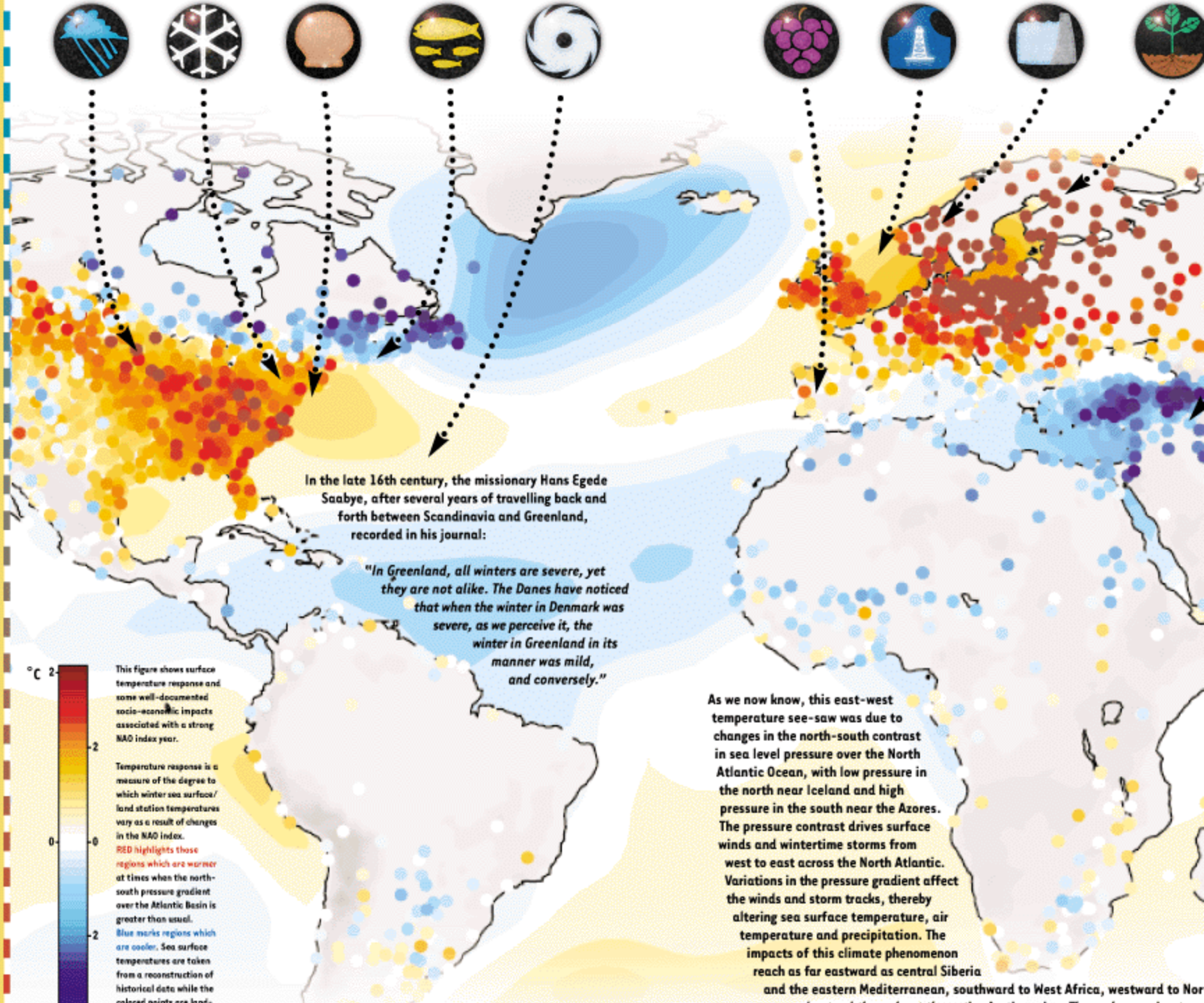
**NORWAY**  
Surplus water in hydroelectric reservoirs provides potential for selling surplus electricity



**SCANDINAVIA**  
Length of the plant growth season is lengthened by 20 days



**CENTRAL US**  
Increased precipitation



This figure shows surface temperature response and some well-documented socio-economic impacts associated with a strong NAO index year.

Temperature response is a measure of the degree to which winter sea surface/land station temperatures vary as a result of changes in the NAO index.

RED highlights those regions which are warmer at times when the north-south pressure gradient over the Atlantic Basin is greater than usual.

Blue marks regions which are cooler. Sea surface temperatures are taken from a reconstruction of historical data while the colored points are land.

As we now know, this east-west temperature see-saw was due to changes in the north-south contrast in sea level pressure over the North Atlantic Ocean, with low pressure in the north near Iceland and high pressure in the south near the Azores. The pressure contrast drives surface winds and wintertime storms from west to east across the North Atlantic. Variations in the pressure gradient affect the winds and storm tracks, thereby altering sea surface temperature, air temperature and precipitation. The impacts of this climate phenomenon reach as far eastward as central Siberia and the eastern Mediterranean, southward to West Africa, westward to North America.

No final do **século 16**, o missionário Hans Egede Saabye, depois de muitas idas e vindas entre a Escandinávia e a Groelândia, publicou em seu jornal:

**“Na Groelândia todos os invernos são severos, contudo, não são parecidos. Os dinamar-queses noticiaram que quando o inverno na Dinamarca era severo, como nós o percebemos, o inverno na Groelândia era, de sua maneira, mais ameno, e vice-versa.”**



# Human Impacts

## ENERGY PRODUCTION & CONSUMPTION

### US HYDROPOWER PRODUCTION

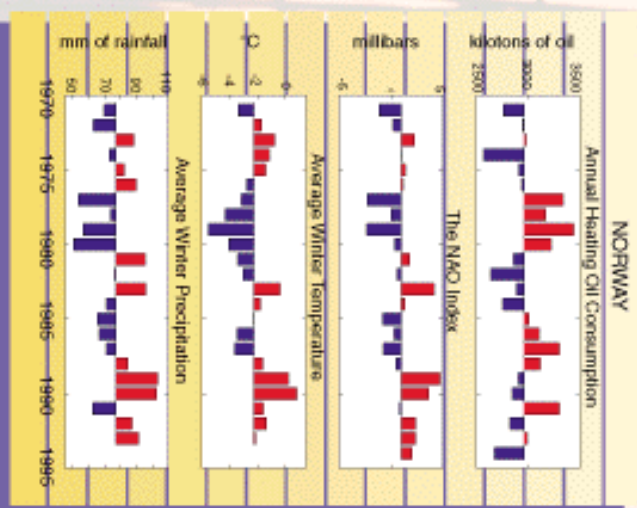
In the United States hydropower supplies 12% of the nation's electricity. Hydropower produces more than 90,000 megawatts of electricity, which is enough to meet the needs of 28.3 million consumers. Hydropower accounts for over 90% of all electricity that comes from renewable resources (such as solar, geothermal, wind and biomass).

A primary goal of reservoir operators at hydropower facilities is optimizing flood protection vs. energy generation. If reservoir operators underestimate flood volume, the reservoir system will be unable to fully regulate flow. As a result, water must be spilled over into spillways. Environmental damage due to flooding and financial loss due to decreased generating capacity result. The link between a positive MAO and increased East Coast precipitation suggests that reservoir operators in this region could gain from knowing more about the MAO.

### ENERGY CONSUMPTION AND PRODUCTION IN NORWAY AND THE MAO

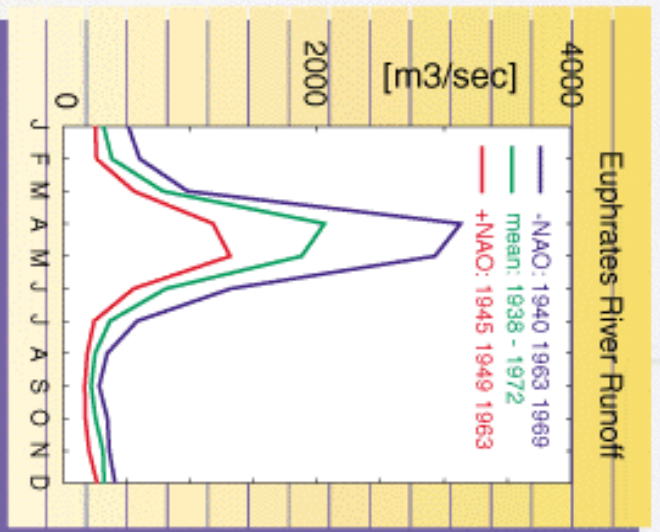
The demand for heating oil in Norway clearly shows human sensitivity to changes in the MAO. Cooler winters and a generally negative MAO prevailed during the late 1970's resulting in a greater demand for heating oil. Things changed in the early 1980's as the MAO index switched to a positive phase and Norway became warmer, resulting in decreased demand for heating oil. These changes in demand vary by 10-15% of the average demand between 1970 - 1995.

Norway is the world's sixth largest hydropower producer, and the largest producer of hydropower in Europe. Annual winter precipitation in Norway can be thought of as a surrogate for streamflow and hence hydropower generation. Between 1980 and 1993, a period of increasingly positive MAO years, precipitation was higher than normal, resulting in increased water inflow for power generation.



# HYDROLOGY & WATER RESOURCE MANAGEMENT

Freshwater constitutes only ~2.5% of the total volume of water on earth, and two-thirds of it is trapped in glacial ice. Only 0.77% of freshwater is held in places more accessible to humans such as aquifers, lakes, rivers, and the atmosphere. River runoff is the most accessible source and accounts for much of the water used for irrigation agriculture, industry, and hydropower generation. New dam construction has the potential to increase accessible runoff by ~10% over the next 30 years, however population is projected to increase by more than 45% during that period. As a result humans will become increasingly sensitive to natural variations in precipitation and river runoff.



Perhaps the most sensitive of all regions is the Middle East, where usable freshwater is already scarce. With population increasing by 3.2% each year and irrigation practices consuming upwards of 80% of available water supply, water is a key variable affecting regional public health and political stability. Much of the current focus in Middle Eastern water policy has been the environmental and socio-economic impacts associated with increased damming along the Tigris-Euphrates River system.

Turkey, because it has the good fortune of being situated at the headwaters of the Tigris-Euphrates River system, can literally turn off the supply of water to its downstream neighbors and has threatened to do so on occasion. For example, when the Ataturk Dam was completed in 1990, Turkey stopped the flow of the Euphrates entirely for one month, leaving Iraq and Syria in considerable distress. However natural climate variability, which has no

political alliances, can be attributed to variations in Turkish precipitation and Euphrates River runoff and is linked to changes in the NAO. Even the recent trend in the NAO index can be seen in historical precipitation data; with droughts occurring in Turkey during the 1980s and the early 1990s and wet conditions generally occurring during the 1960s and the late 1970s.



# Human Impacts

# OSCILAÇÃO MULTIDECADAL DO ATLÂNTICO

OMA

# ATLANTIC MULTIDECADAL OSCILLATION AMO

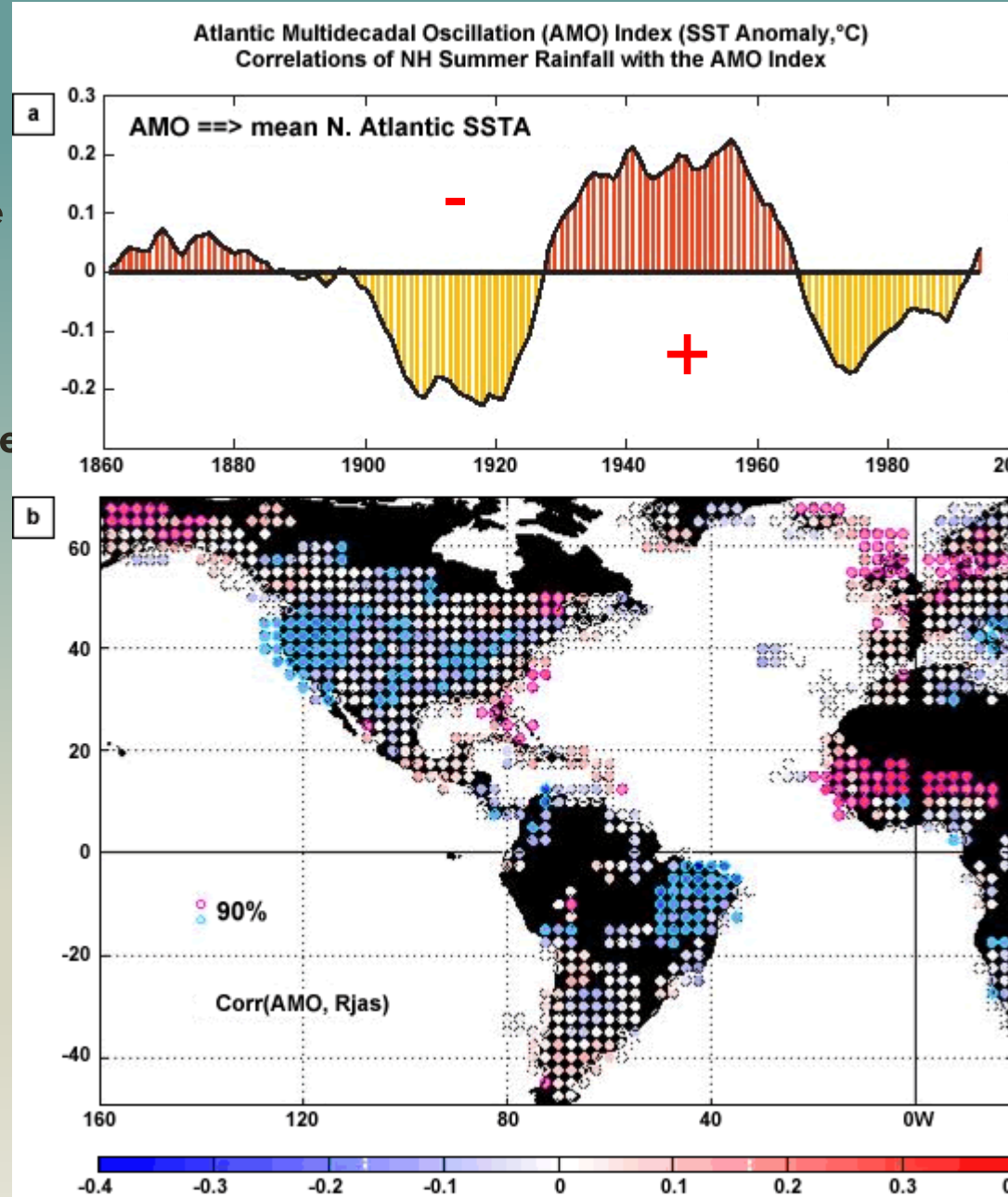
Mede variações na TSM e no cisalhamento vertical dos ventos horizontais em grandes áreas do Atlântico Tropical, com periodicidade de 20-40 anos

Influencia os extratropicais pelo deslocamento das altas subtropicais e das correntes de jato

## Figura

(a) IOMA: média móvel de 10 anos da anomalia de TSM do Atlântico Norte sem tendência (ATSM, °C).

(b) Correlação do IOMA com a chuva de JAS. Vermelha representa correlação positiva e azul, correlação negativa.



# OSCILAÇÃO MULTIDECADAL DO ATLÂNTICO OMA

Quando o Atlântico Tropical Norte está anormalmente quente (fase positiva da OMA), menos chuva cai sobre a maior parte do EUA e nordeste da América do Sul

E mais chuva cai no sul do Alaska, norte da Europa, oeste da África e sudeste dos EUA

Secas persistentes no Meio-Oeste dos EUA, tal como a da década de 30 – anos de Tempestades de Areia (Dust Bowl Years), esteve associada à fase positiva da Oscilação Multidecadal do Atlântico

# OSCILAÇÃO MULTIDECADAL DO ATLÂNTICO OMA

O efeito "dust bowl" (taça de pó) foi provocado por condições persistentes de seca, favorecidas por anos de práticas de manejo do solo que o deixaram susceptível às forças do vento.

O solo, despojado de umidade, era levantado pelo vento em grandes nuvens de pó e areia tão espessas que escondiam o sol durante vários dias. Estes dias eram referidos como "brisas negras" ou "vento negro".



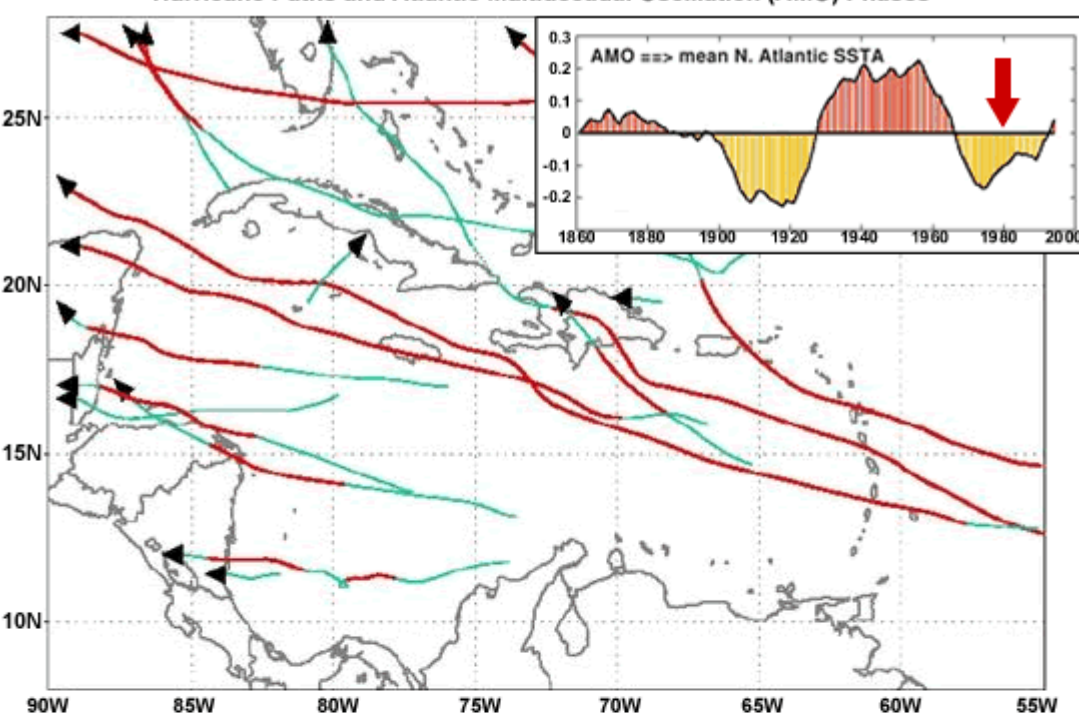
**OMA**

Texas 1935 - o Dust Bowl

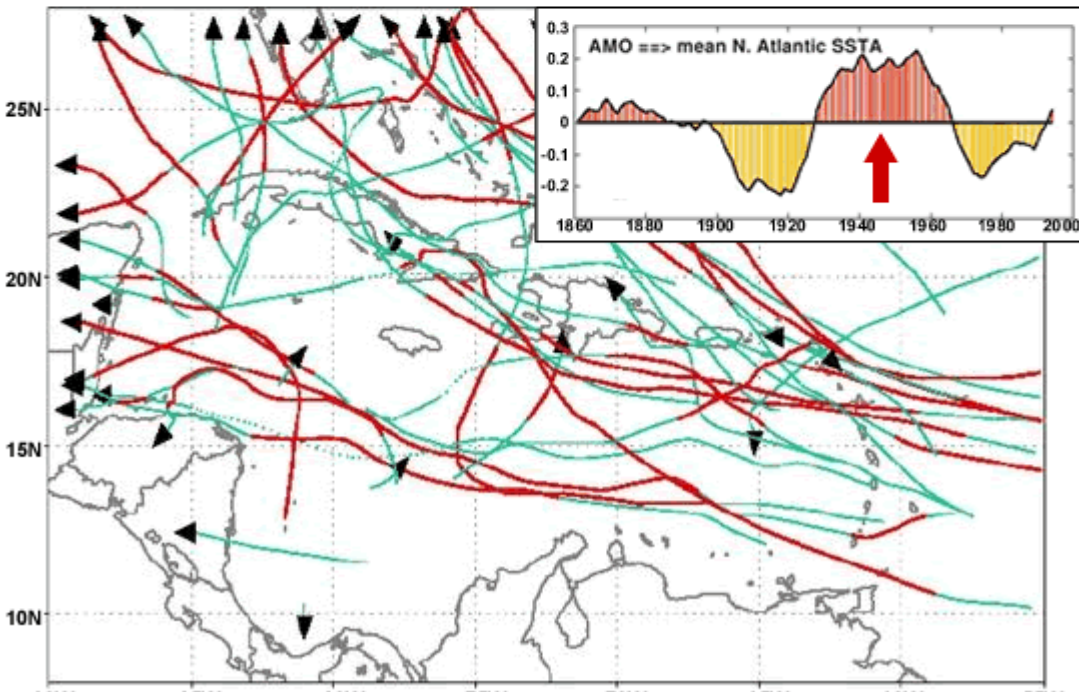


Dallas, South Dakota 1936 Dust Bowl

# OMA



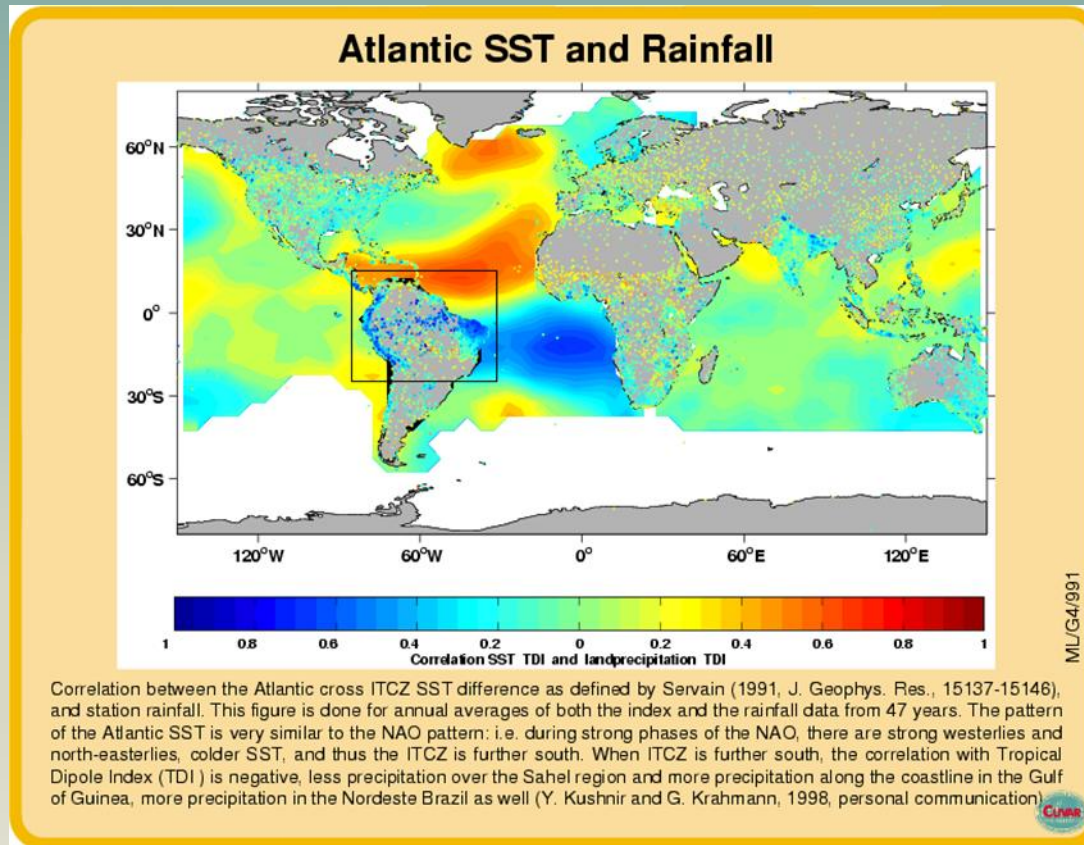
A Oscilação Multidecadal do Atlântico também está associada à atividade multidecadal dos furacões no Atlântico.



**Mais** tormentas tropicais tornam-se furacões durante a fase **quente** da OMA do que durante a fase fria.

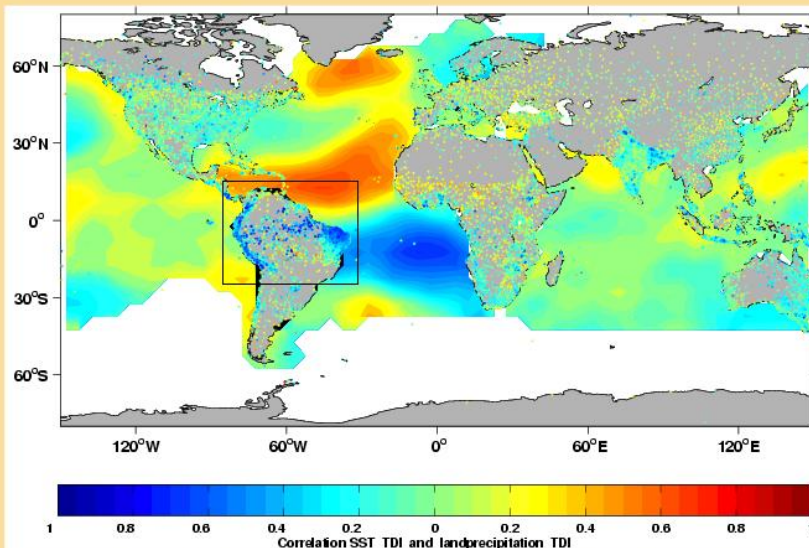


# GRADIENTE MERIDIONAL DO ATLÂNTICO TROPICAL



# GRADIENTE MERIDIONAL DO ATLÂNTICO TROPICAL

Atlantic SST and Rainfall



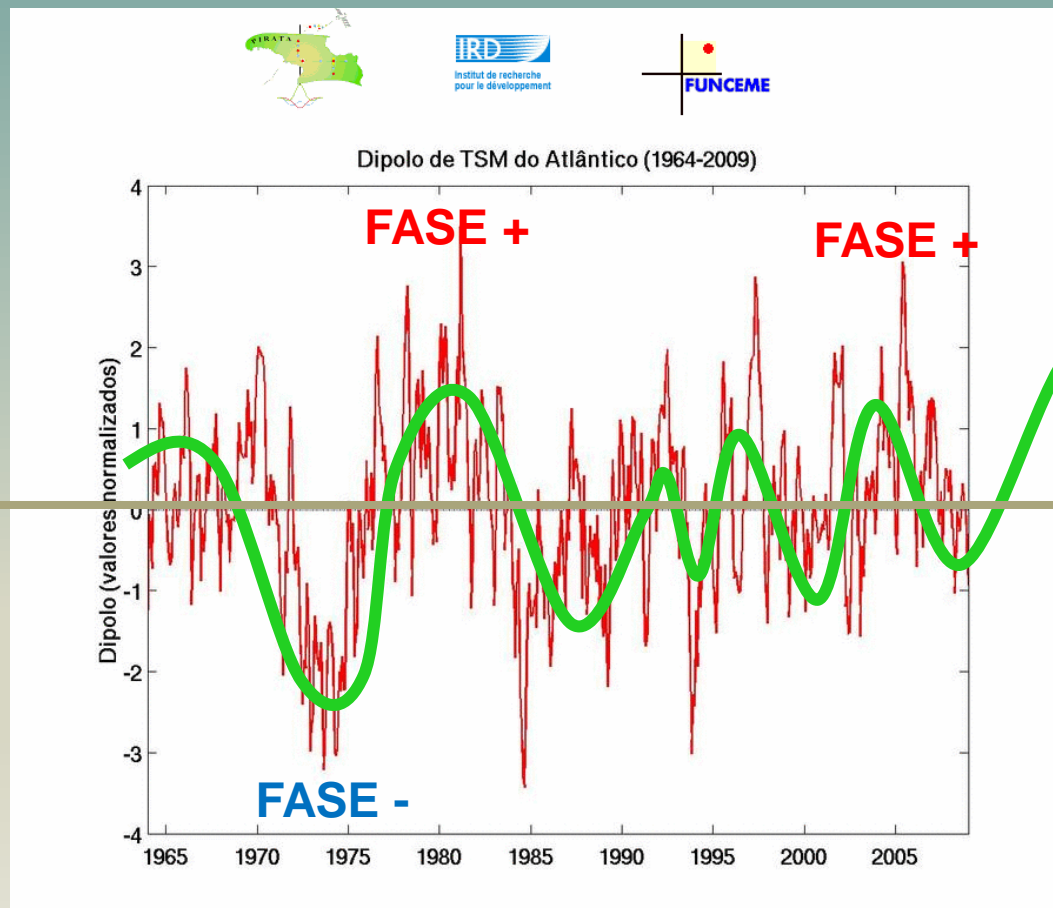
ML/G4/991

Correlation between the Atlantic cross ITCZ SST difference as defined by Servain (1991, J. Geophys. Res., 15137-15146), and station rainfall. This figure is done for annual averages of both the index and the rainfall data from 47 years. The pattern of the Atlantic SST is very similar to the NAO pattern: i.e. during strong phases of the NAO, there are strong westerlies and north-easterlies, colder SST, and thus the ITCZ is further south. When ITCZ is further south, the correlation with Tropical Dipole Index (TDI) is negative, less precipitation over the Sahel region and more precipitation along the coastline in the Gulf of Guinea, more precipitation in the Nordeste Brazil as well (Y. Kushnir and G. Krahnmann, 1998, personal communication).



$$ID = TSM'_{ATN} - TSM'_{ATS}$$

# GRADIENTE MERIDIONAL DO ATLÂNTICO TROPICAL



# GRADIENTE MERIDIONAL DO ATLÂNTICO TROPICAL

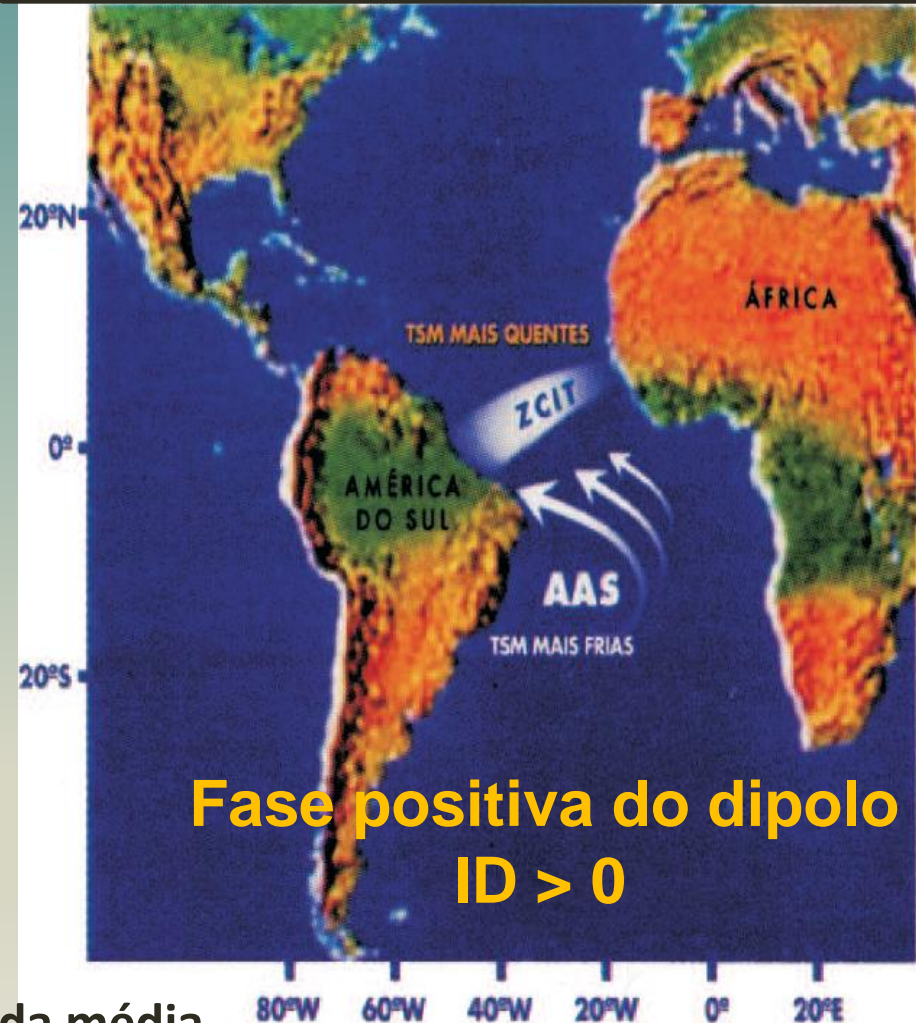
$$ID = TSM'ATN - TSM'ATS$$

Quando as águas no Atlântico Sul estão mais frias que o normal, o Sistema de Alta Pressão do Atlântico Sul e os ventos alísios de sudeste se intensificam

**Se neste mesmo período o Atlântico Norte estiver mais quente que o normal, o Sistema de Alta Pressão do Atlântico Norte e os ventos alísios de nordeste estarão mais fracos**

Este padrão favorece o deslocamento da ZCIT para posições mais ao norte da linha do Equador e é propício à

ocorrência de anos com chuva abaixo da média ou muito abaixo da média para o setor norte do Nordeste do Brasil.



# GRADIENTE MERIDIONAL DO ATLÂNTICO TROPICAL

Quando as águas no Atlântico Norte estão mais frias que o normal, o Sistema de Alta Pressão do Atlântico Norte e os ventos alísios de nordeste se intensificam.

Se neste mesmo período o Atlântico Sul estiver mais quente que o normal, o Sistema de Alta

Pressão do Atlântico Sul e os ventos alísios de sudeste estarão mais fracos.

Este padrão favorece o deslocamento da ZCIT para posições mais ao sul da

$$ID = TSM'_{ATN} - TSM'_{ATS}$$

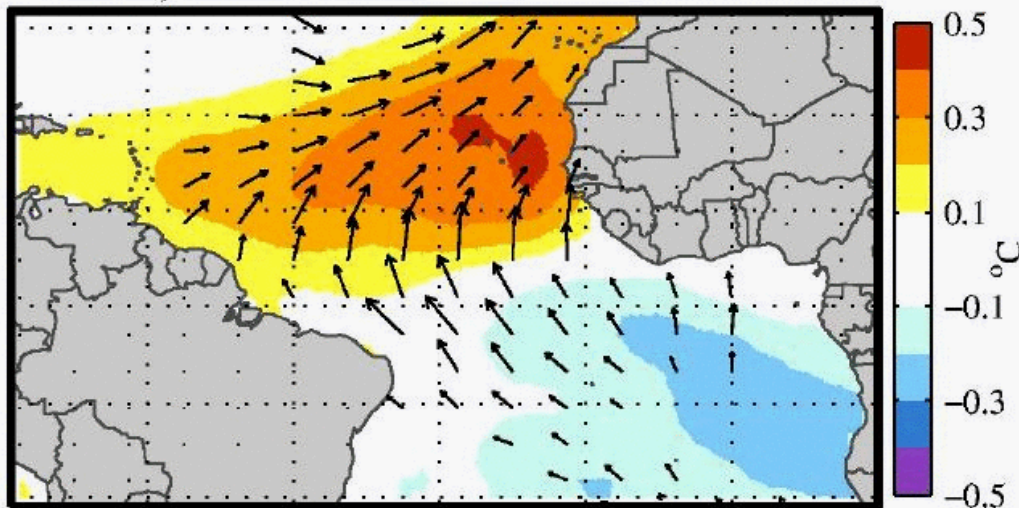


linha do Equador e é propício à ocorrência de anos com chuva acima da média ou muito acima da média para o setor norte do Nordeste do Brasil.

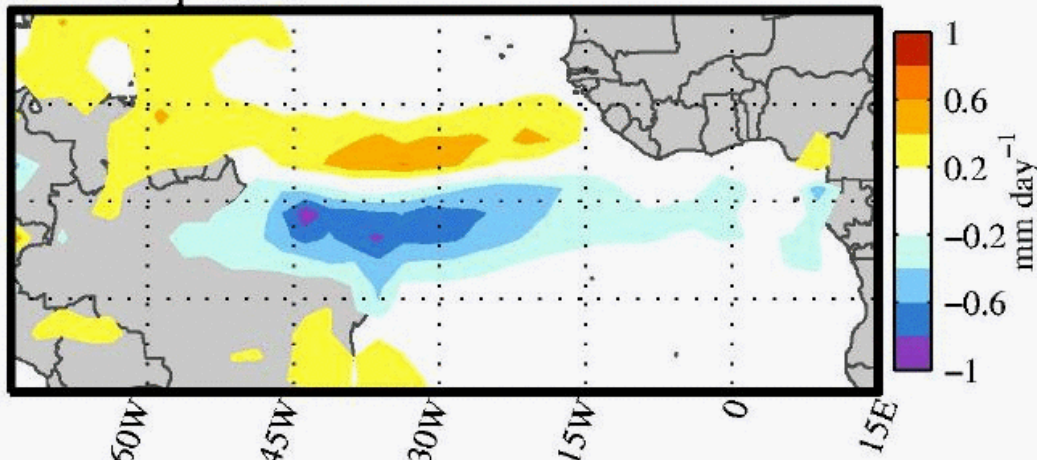
# GRADIENTE MERIDIONAL DO ATLÂNTICO TROPICAL

## Atlantic: MCA mode 1

SST, 10m Winds



Precipitation



Padrão espacial do 1° modo PC

Mapa de regressão do 1° modo da MCA relativo a TSM e vento a 10 metros

Vetores de vento foram plotados onde o coeficiente de correlação excedeu 0.27 (ao nível de significância de 95%)

Mesmo que o de cima, mas para precipitação (mm/21 dias)

Áreas sombreadas indicam nível de confiança superior a 95%

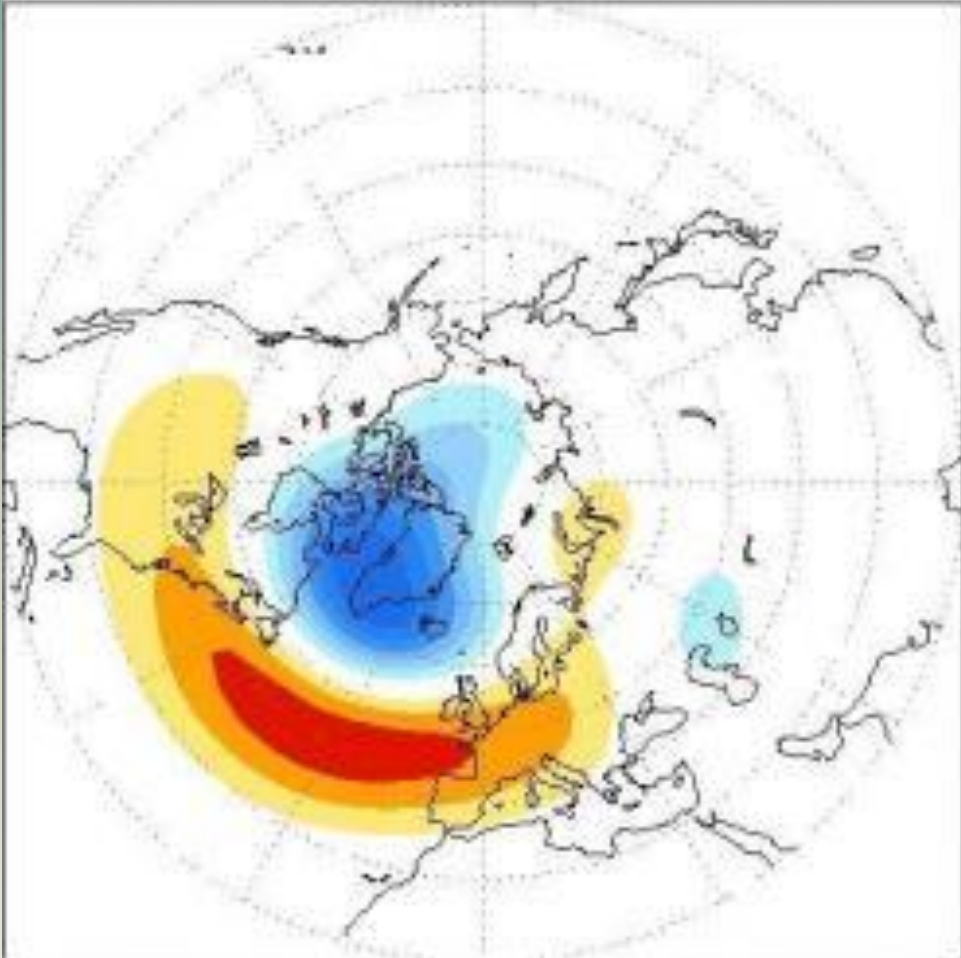
(Chiang e Vimont, 2004)

# MODOS ANULARES

<http://www.atmos.colostate.edu/ao/introduction.html>

# NORTH ATLANTIC OSCILLATION - NAO

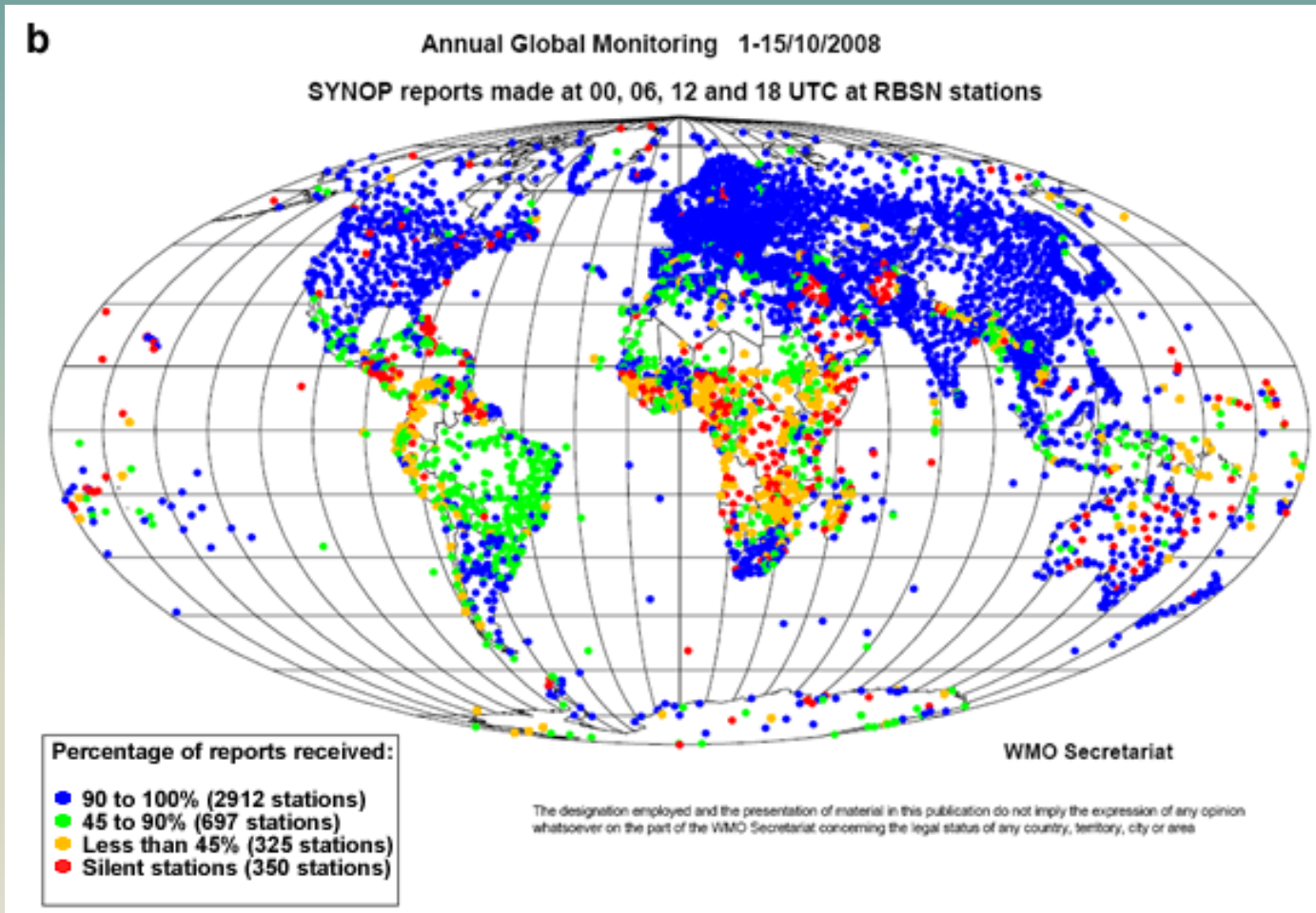
REOF (10.2%) shown as regression map of 500mb height (m)



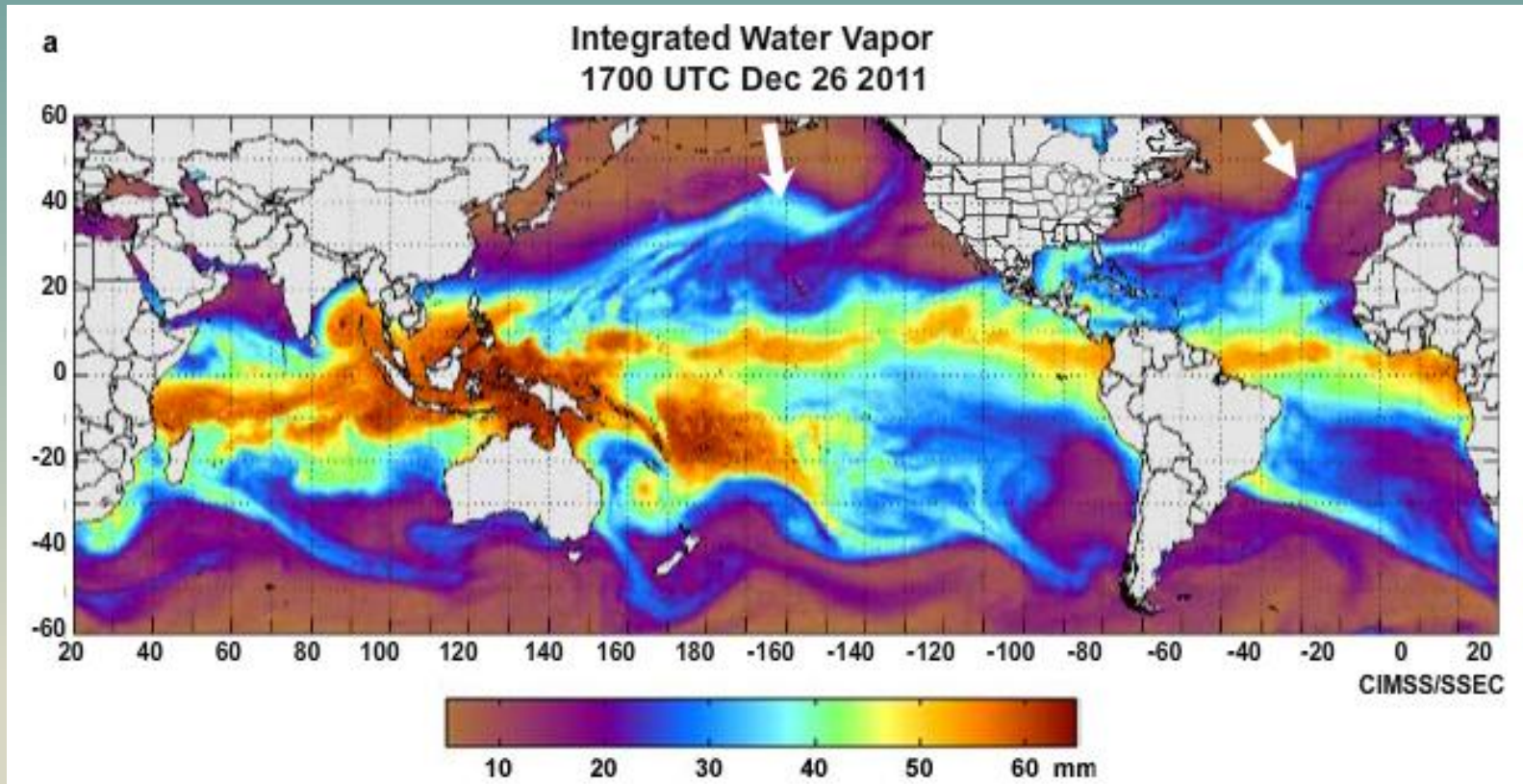


# MONITORAMENTO GLOBAL 00, 06, 12 E 18 UTC

## Estações de superfície

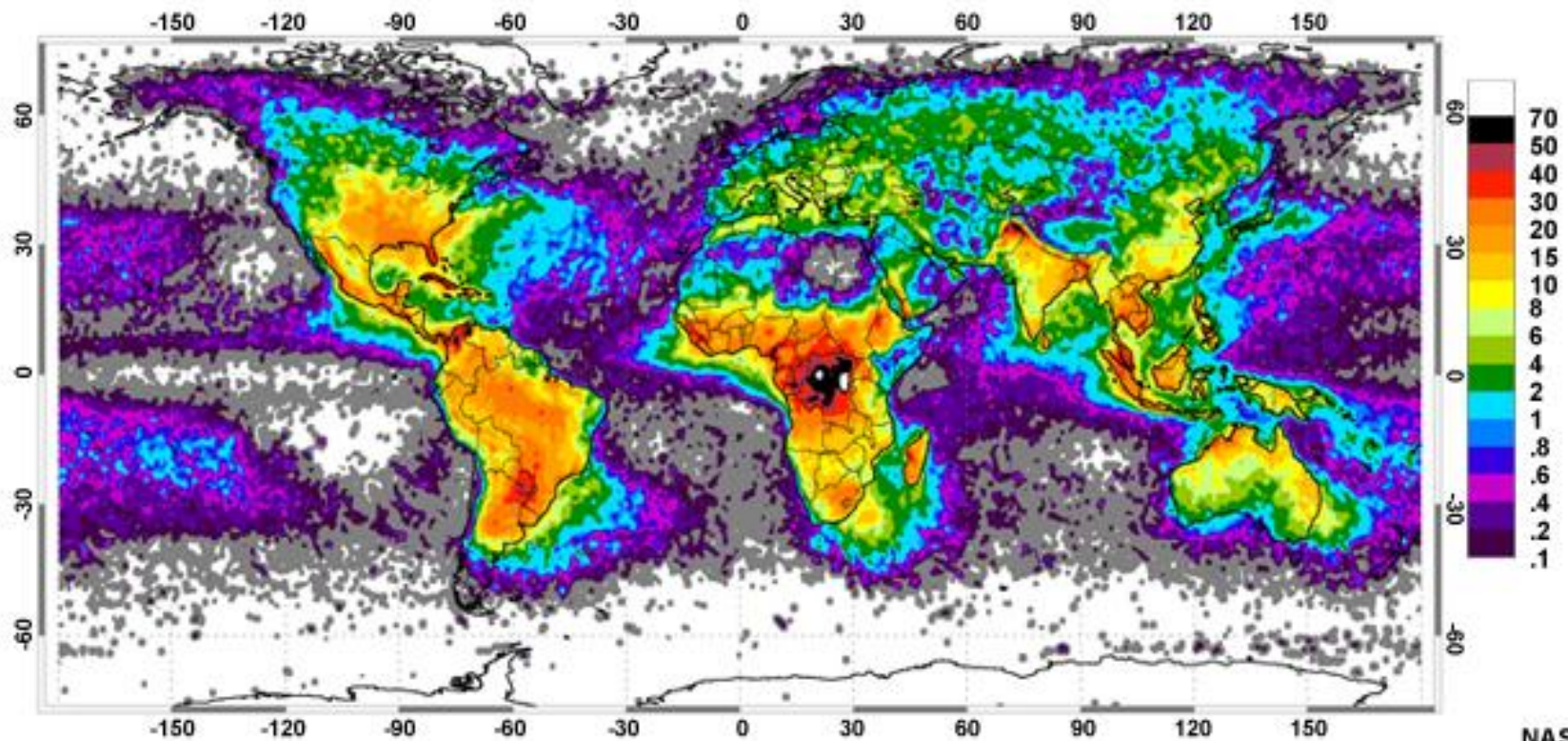


# VAPOR D'ÁGUA INTEGRADO NA ATMOSFERA



# DESCARGAS ELETROMAGNÉTICAS

Annual averaged number of lightning flashes per km<sup>2</sup> from LIS and OTD sensors



# SITES MATERIAL

<http://www.education.noaa.gov/cweather.html>

<http://www.schoolscience.co.uk/> vulcão

<http://resources.schoolscience.co.uk/ICI/11-14/materials/match1pg2.html>