Teleconexões Oceano-Atmosfera e Impactos no Clima Regional: Presente e Futuro

Jose A. Marengo
Head, CCST INPE
jose.marengo@inpe.br

ciência para sustentabilidade

www.ccst.inpe.br

Coupled Phenomena

Why is there a need for considering coupled modes ?
There are at least two major reasons why it is clear that realistic description of climate cannot be done without considering the atmosphere and ocean at the same time

Teleconnections

The interactions between atmosphere and oceans in the tropics dominate the variability at interannual scales. The Sea Surface Temperature affects the atmosphere generating giant wave patterns that extend over the planet

Thermohaline Circulation

The deep oceanic circulations is driven by fluxes of heat and fresh water that change temperature and salinity of the water. Dense water (cold and saline) sink deep down creating a worldwide circulation as light water (fresh and warm) upwells through the world ocean, affecting the global sea surface temperatures, which in turn change the dominant mode of climate variability through the teleconnections.

What is a "Teleconnection"? Why are Teleconnections Important in Climate Science?

Teleconnections are defined as:

1. A linkage between weather changes occurring in widely separated regions of the globe.
2. A significant positive or negative correlation in the fluctuations of a field at widely separated points. Most commonly applied to variability on monthly and longer timescales, the name refers to the fact that such correlations suggest that information is propagating between the distant points through the atmosphere.

This linkage can be accomplished by alterations of regional tropospheric temperatures which create changes in the large-scale pressure and wind fields, and/or by the advection of material from one region to another (such as from blowing dust or emissions of pollutants that are advected by the wind).
Teleconnections as related to radiative forcings.

The acceptance of sea surface anomaly patterns as a surface climate forcing that affects the weather at large distances, of course, is an accepted teleconnection effect. Indeed, this teleconnection effect is why there are major global climate anomalies when an El Niño occurs.

The influence of spatially heterogeneous climate forcing by land-use/land-cover change and by aerosol clouds as they produce teleconnections, however, is less accepted by the climate community despite the clear parallel between climate forcing from sea surface temperature anomalies and these forms of climate forcing.

Each of these climate forcings is spatially coherent, persist for long time periods, and significantly affect the fluxes of heat, moisture, and momentum into and out of the atmosphere.

Teleconnections were first noted by the British meteorologist Sir Gilbert Walker in the late 19th century, through computation of the correlation between time series of atmospheric pressure, temperature and rainfall. They served as a building block for the understanding of climate variability, by showing that the latter was not purely random.

Indeed, the term El Niño-Southern Oscillation (ENSO) is an implicit acknowledgment that the phenomenon underlies variability in several locations at once. It was later noticed that associated teleconnections occurred all over North America, as embodied by the Pacific-North American teleconnection pattern.

In the 1980s, improved observations allowed to detect teleconnections at larger distances throughout the troposphere.Concomitantly, the theory emerged that such patterns could be understood through the dispersion of Rossby waves due to the spherical geometry of the Earth

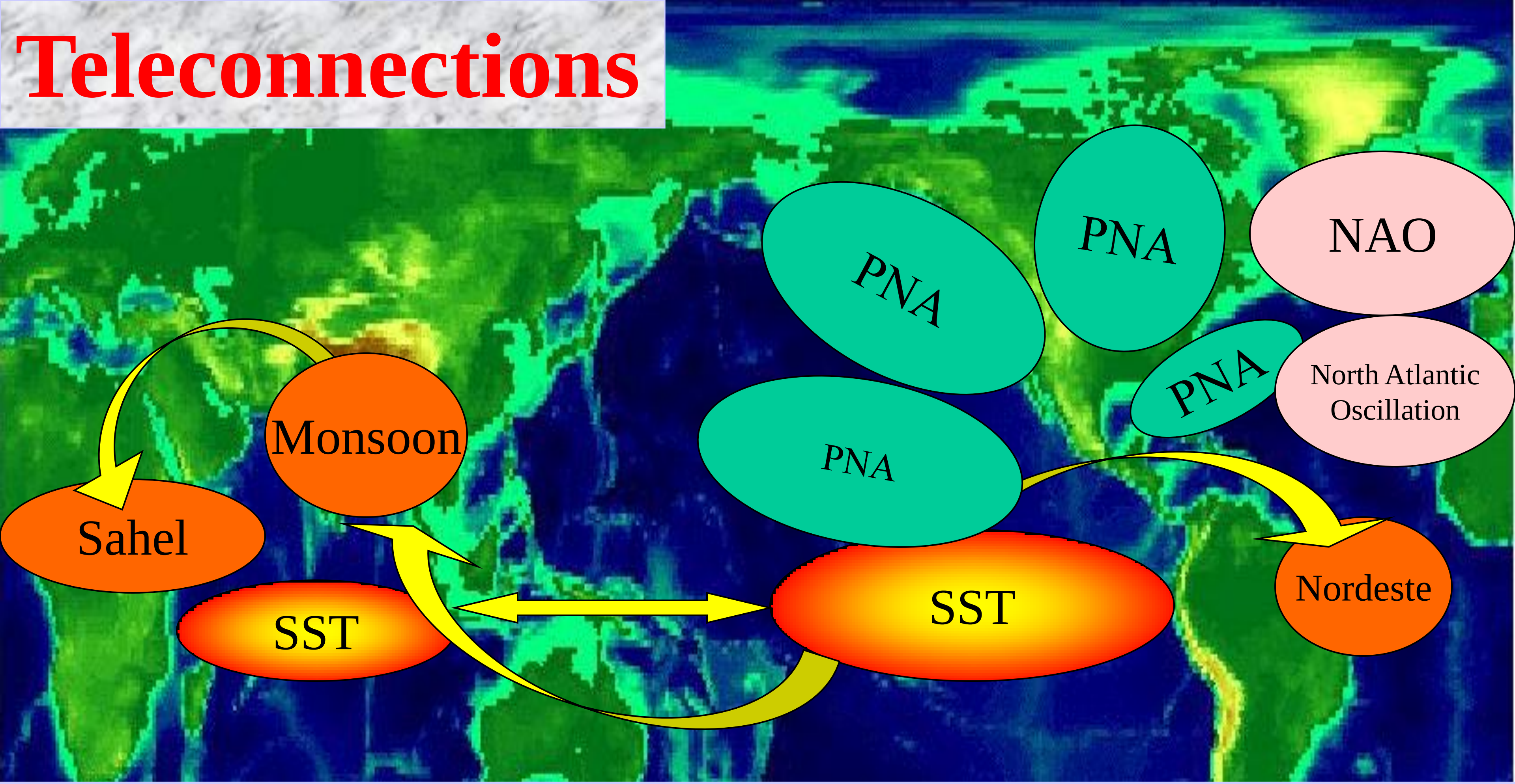
Teleconnection pattern

The term "teleconnection pattern" refers to a recurring and persistent, large-scale pattern of pressure and circulation anomalies that spans vast geographical areas.

Teleconnection patterns are also referred to as preferred modes of low-frequency (or long time scale) variability. Although these patterns typically last for several weeks to several months, they can sometimes be prominent for several consecutive years, thus reflecting an important part of both the interannual and interdecadal variability of the atmospheric circulation.

Many of the teleconnection patterns are also planetary-scale in nature, and span entire ocean basins and continents. For example, some patterns span the entire North Pacific basin, while others extend from eastern North America to central Europe. Still others cover nearly all of Eurasia.

Teleconnections



The interactions between atmosphere and oceans in the tropics dominate the variability at interannual scales. The main player is the variability in the equatorial Pacific. Wavetrains of anomaly stem from the region into the mid-latitudes, as the Pacific North American Pattern (PNA). The tropics are connected through the Pacific SST influence on the Indian Ocean SST and the monsoon, Sahel and Nordeste precipitation. It has been proposed that in certain years the circle is closed and and a full chain of teleconnections goes all around the tropics. Also shown is the North Atlantic Oscillation a major mode of variability in the Euro_atlantic sector whose coupled nature is still under investigation.

Avoid confusion

Teleconnections (remote associations)→

Teleconnection patterns (depiction of those remote associations→

Indices of teleconnections (quantification of those patterns)→

Oscillations of those teleconections (timing of those teleconnection patterns-intraseasonal, seasonal, interanual, long term)

Teleconnections Patterns

NAO – North Atlantic Oscillation

PDO – Pacific Decadal Oscillation

ENSO – El Nino / Southern Oscillation

PNA – Pacific North American

PSA – Pacific South American

Effects of on climate variability and climate change?

ENSO:

Tropical influence

Every 3-8 years

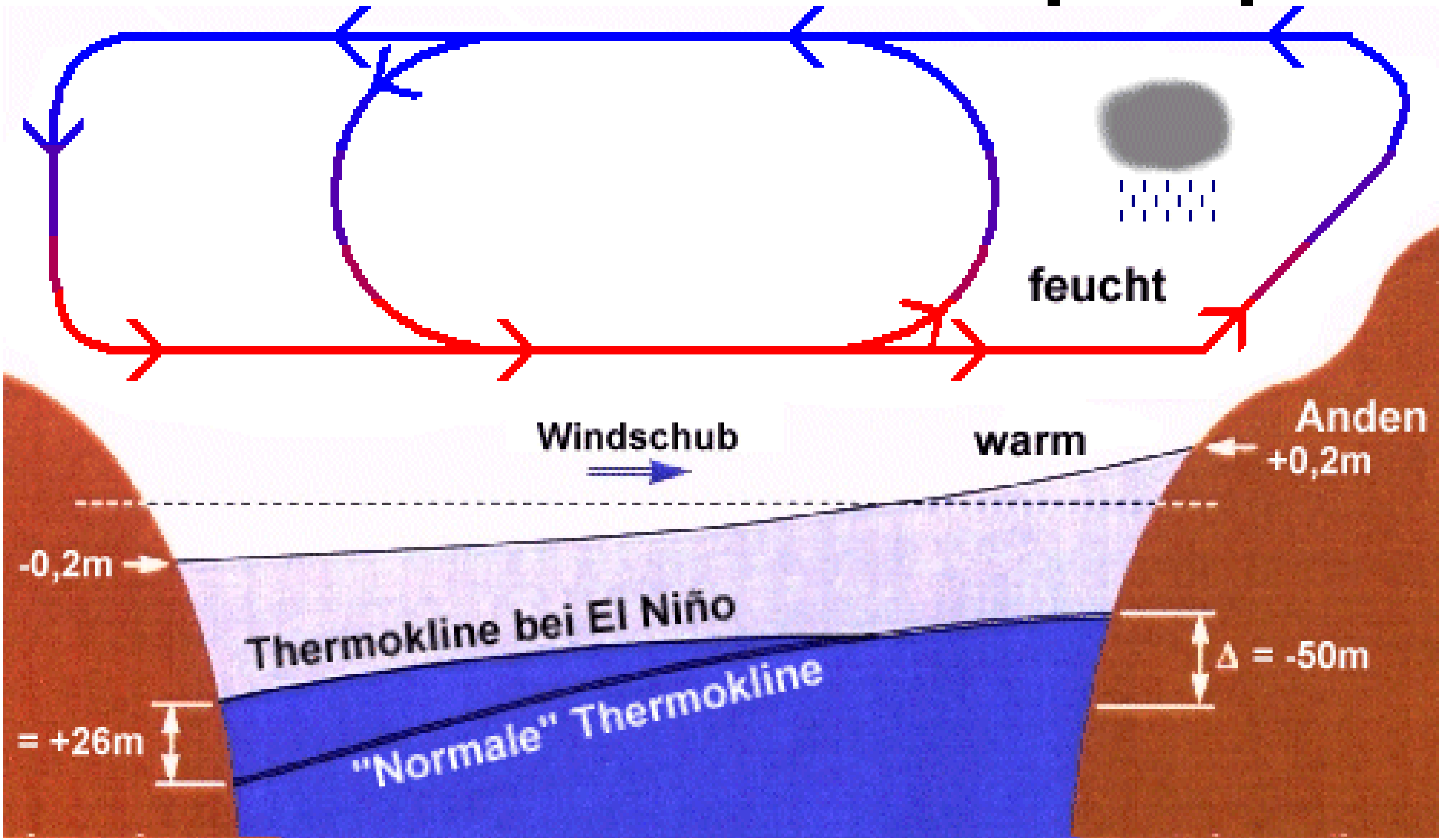
Pressure loss over E Pacific

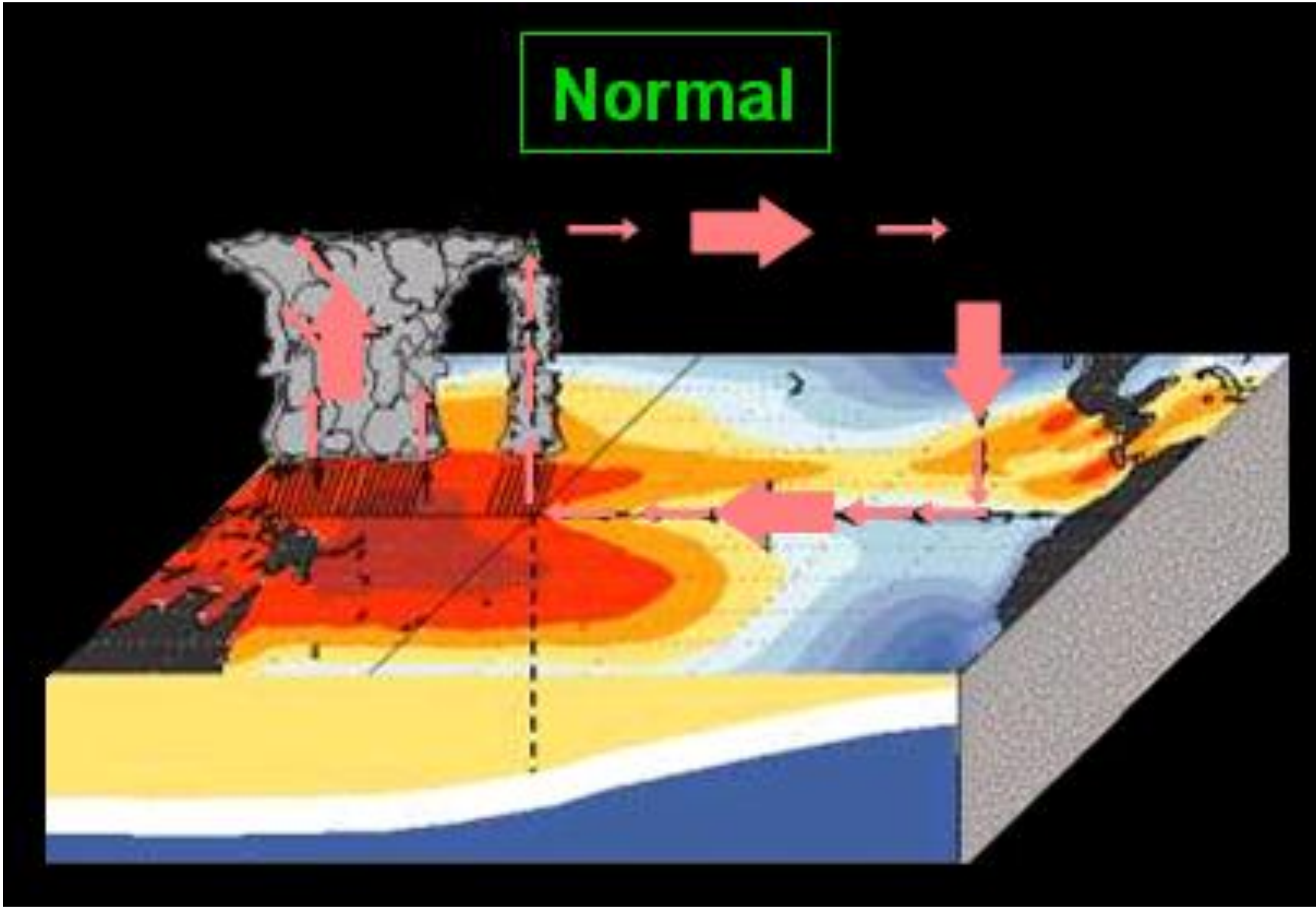
Pressure rise over W Pacific

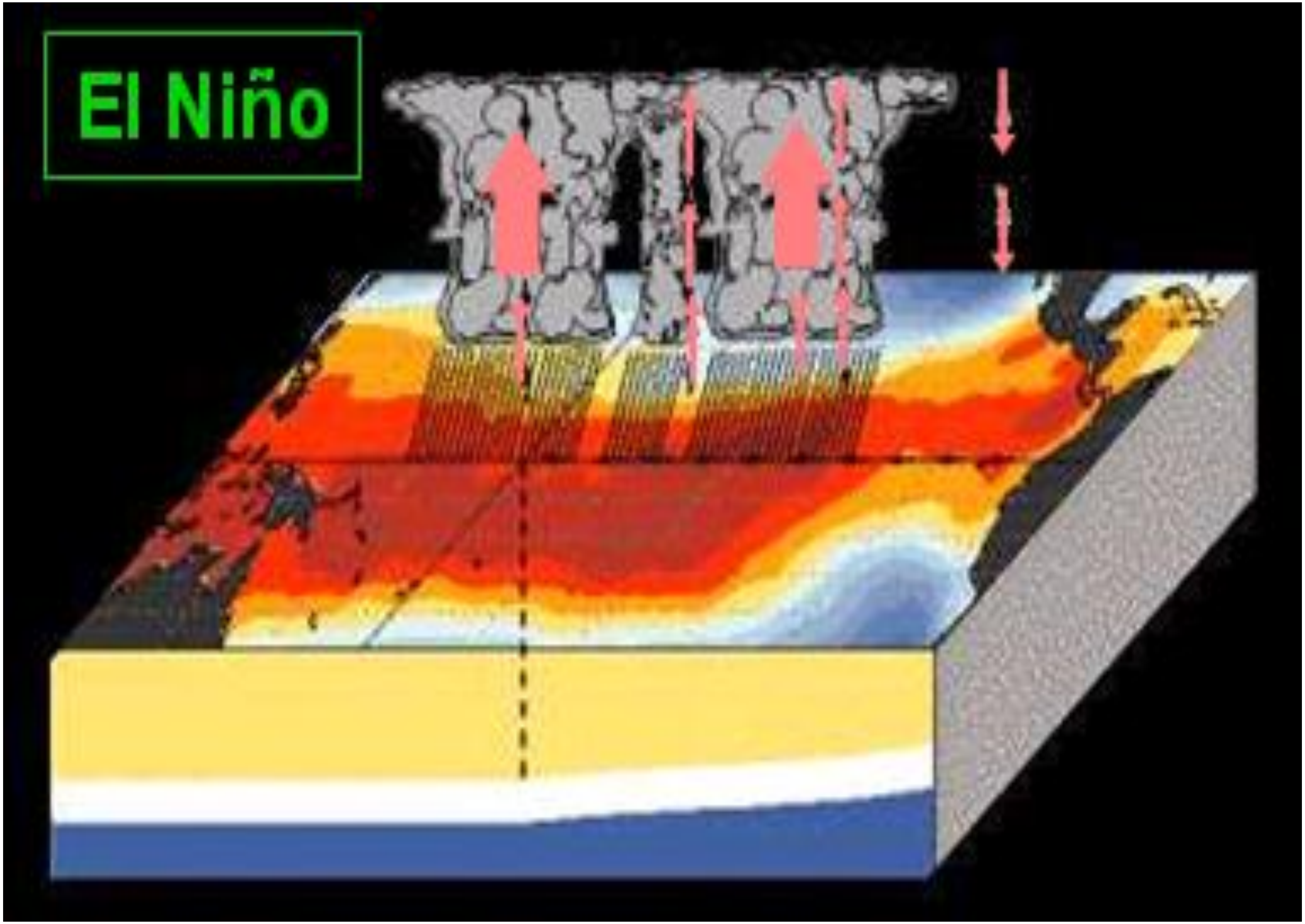
Trade winds decrease

Possible flip flop of Walker Circulation

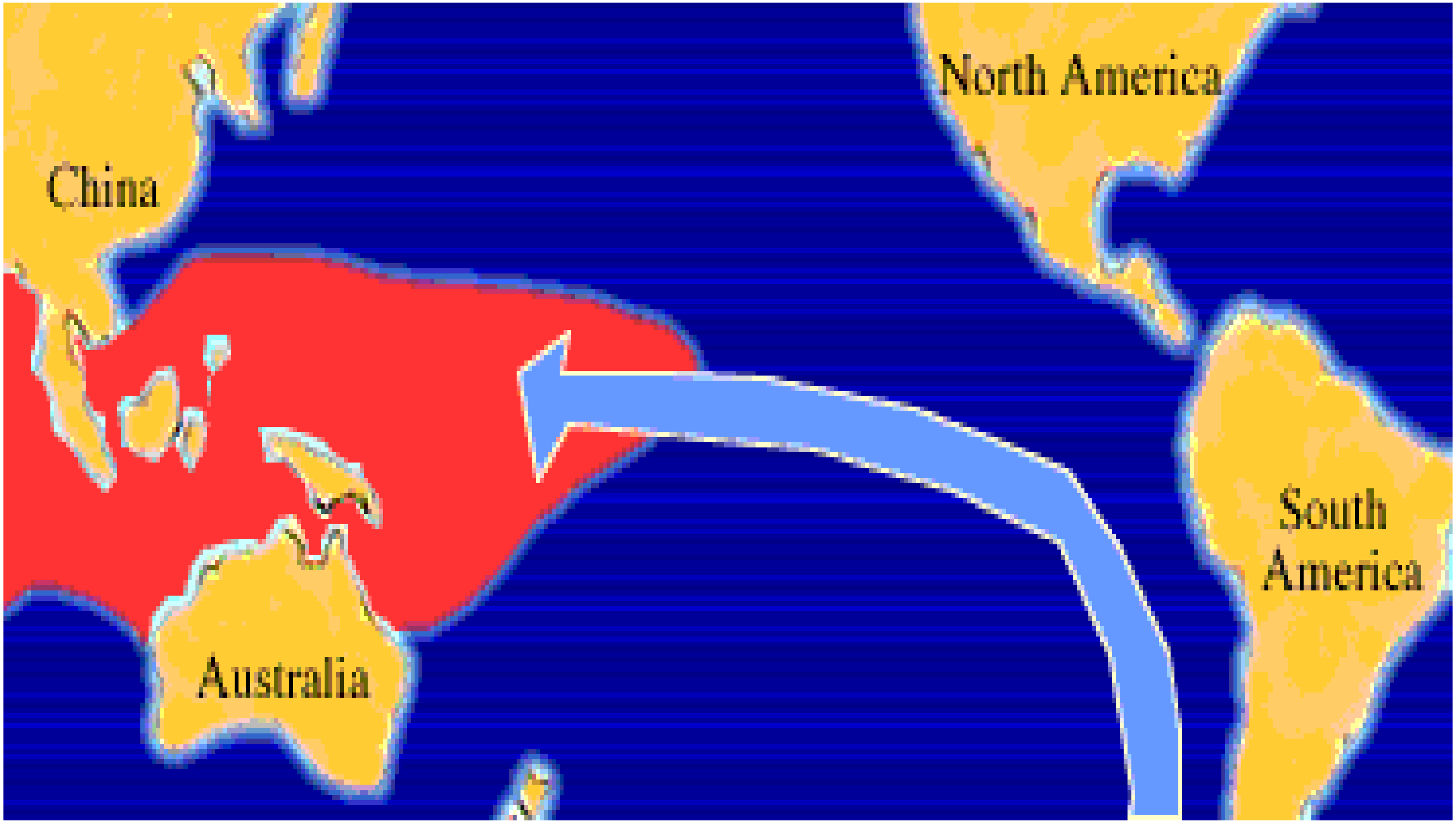
Walker Circulation flip-flop



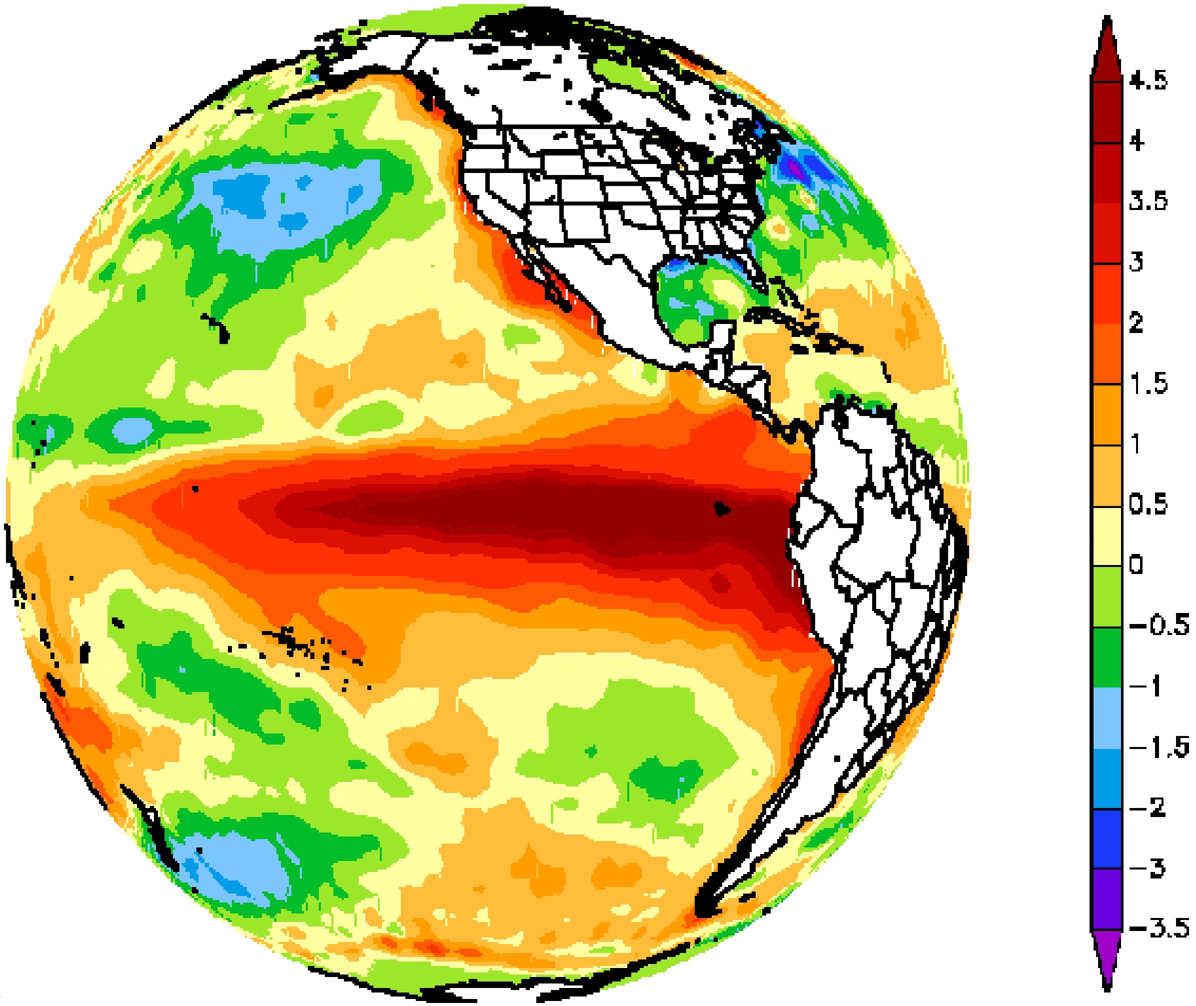

Normal


El Niño

El Nino warming and moving eastward



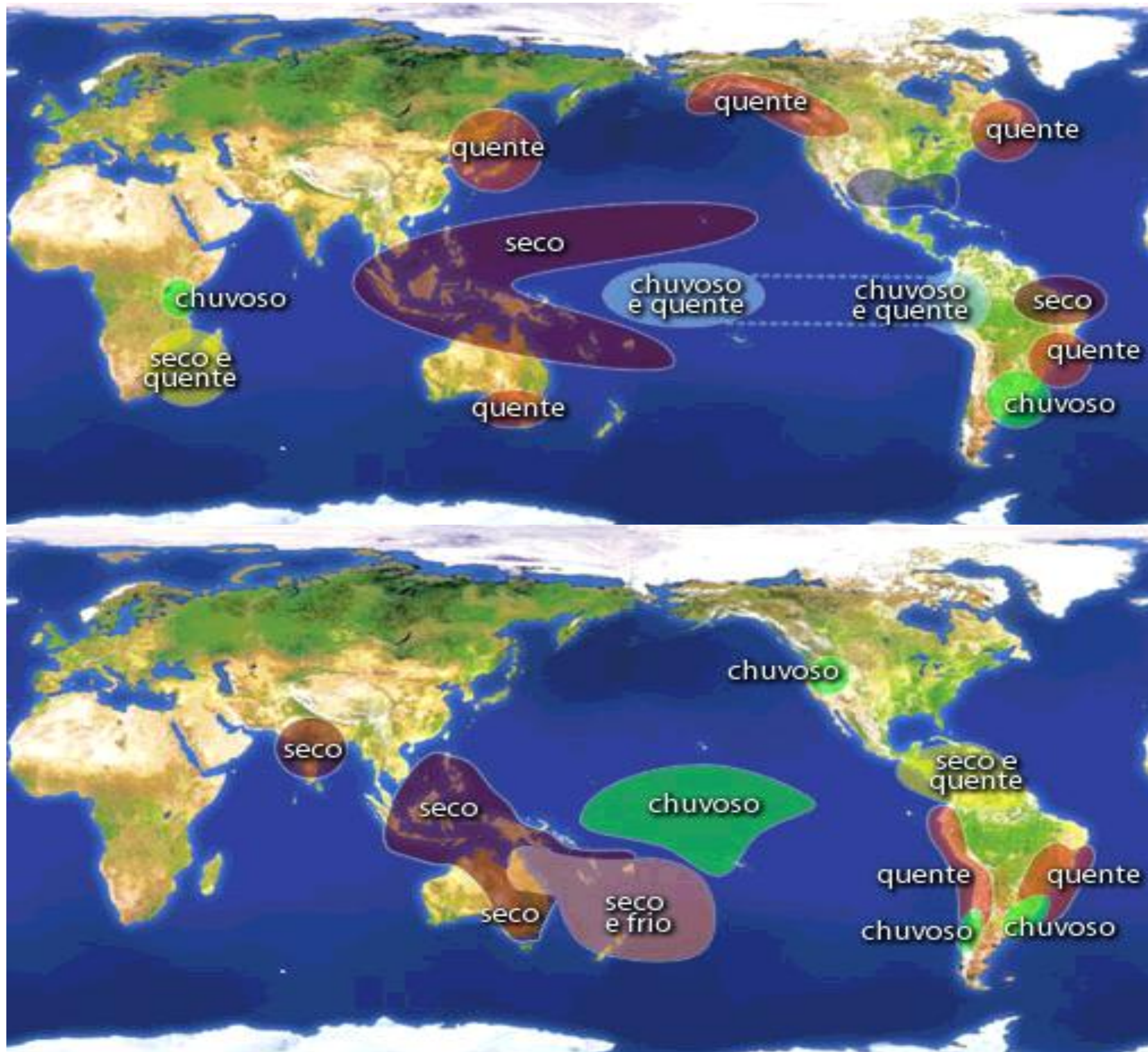
Anomalia de Temperatura da Superficie do Mar (Celsius)



E L NIÑO

DJF

JJA

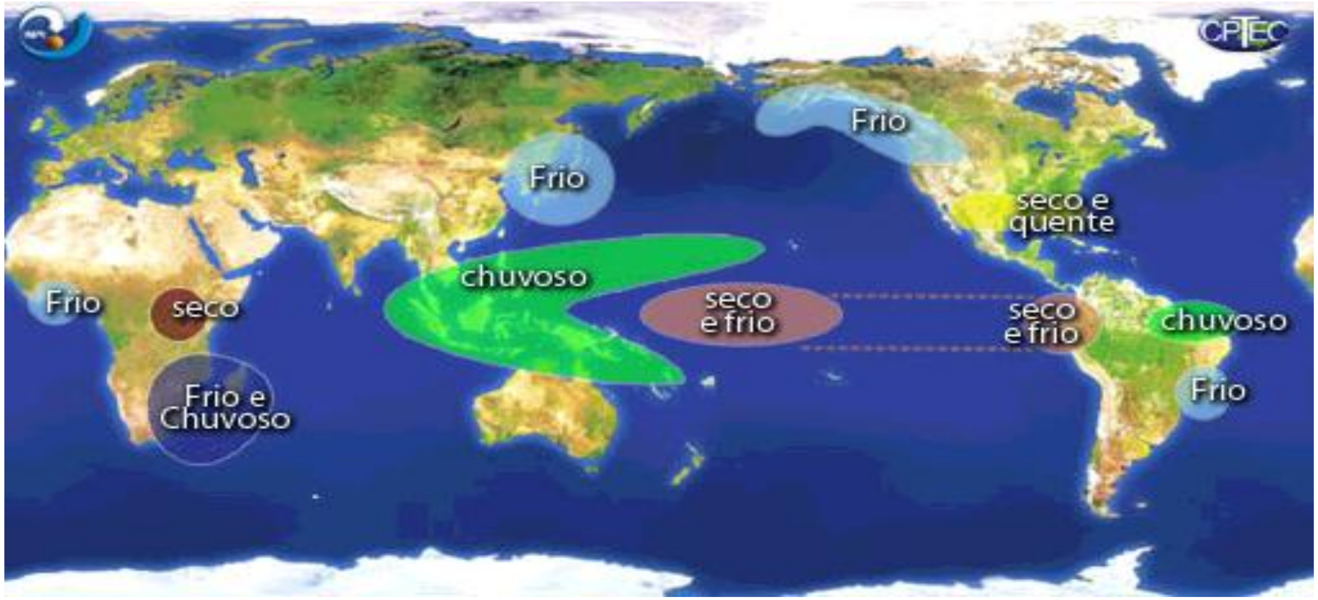


A strong El Niño usually meant a weaker Indian monsoon, but this anticorrelation has weakened in the 1980s and 1990s, for controversial reasons.

L

A

DJF



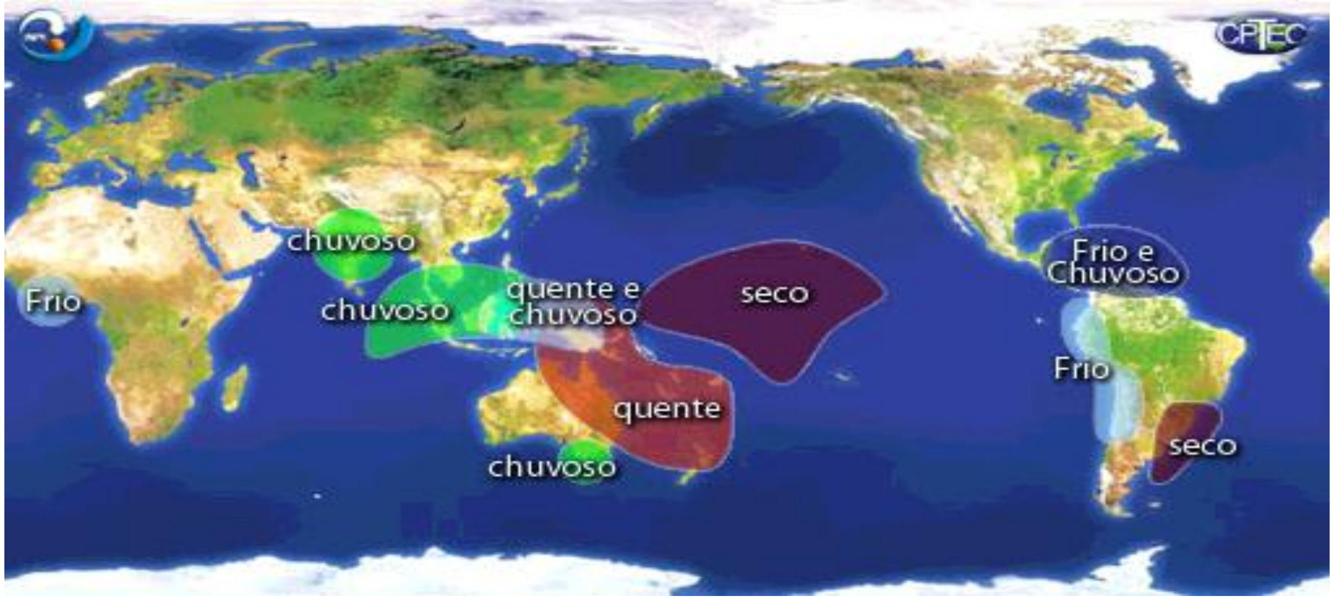
N

I

Ñ

A

JJA



Fonte:

PDO:

Influences jet stream location

Multi year variability (20-30 years)

Effect on ecosystem productivity in Pacific

Effects of on climate variability and change?

Currently on a negative PDO phase (less inten se El Ninos)

PDO - phases:

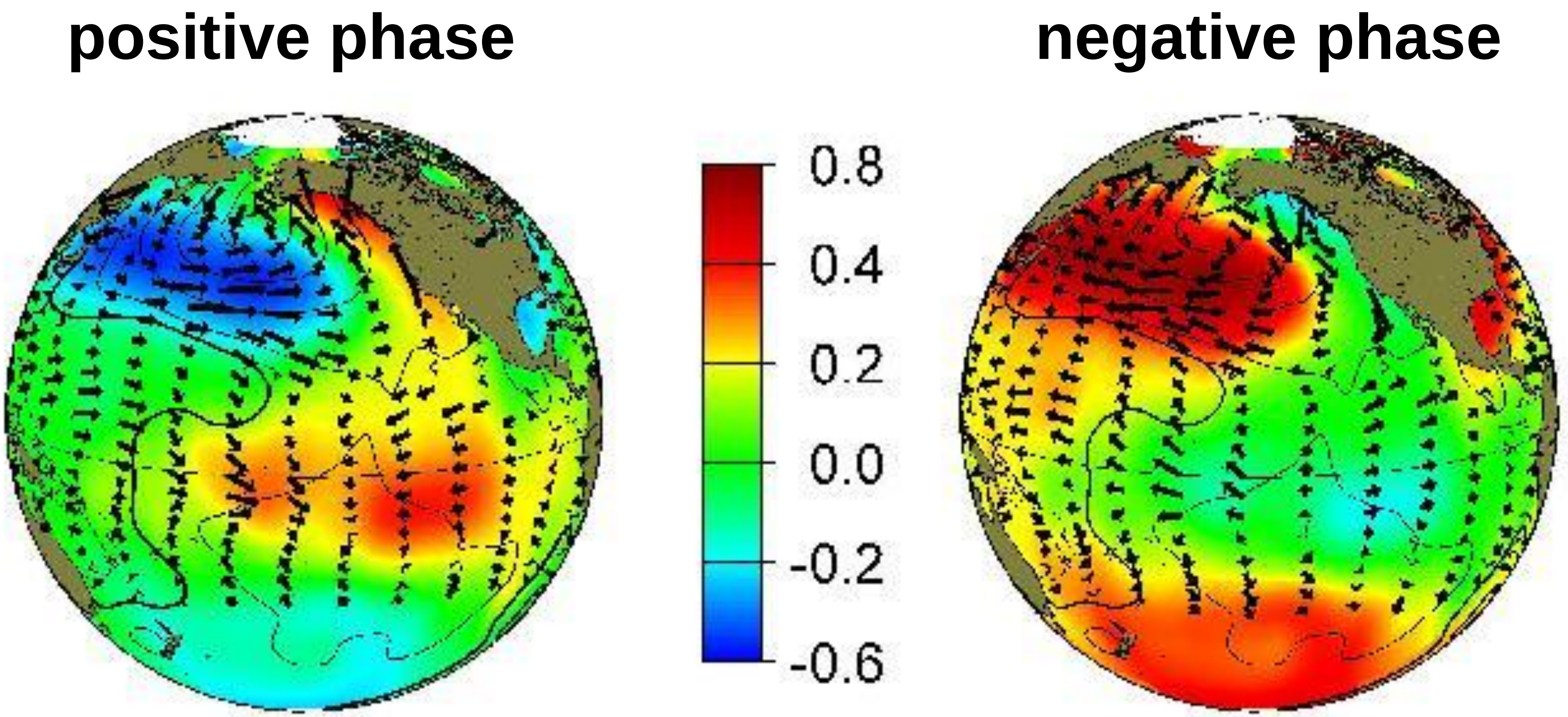
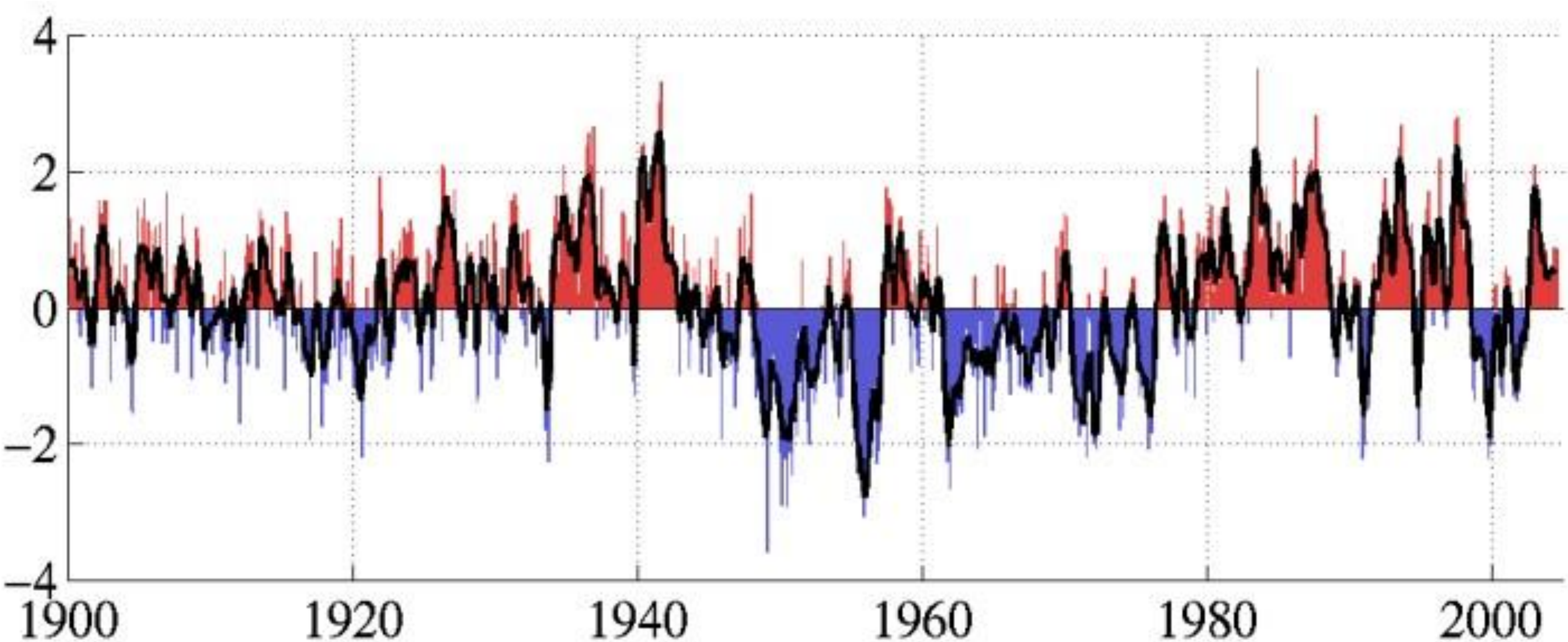


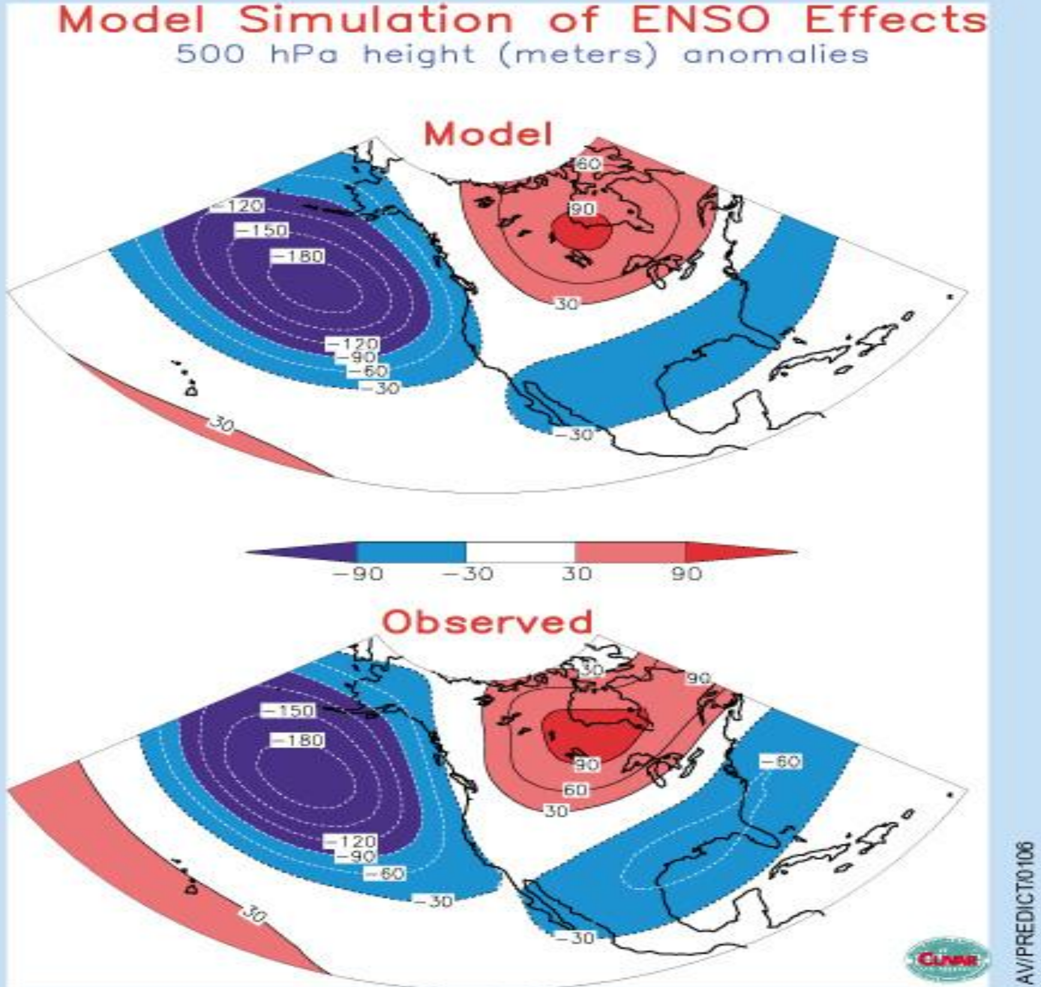
Image courtesy of Stepen Hare and Nathan Mantua, University of Washington, units are degrees Celsius

PDO - record:

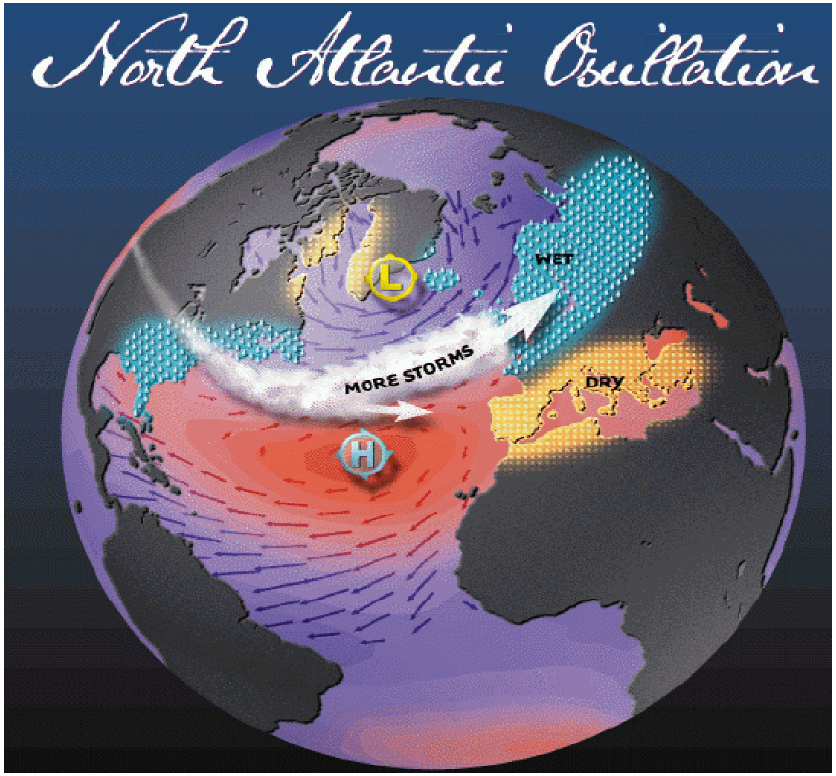


PNA

Dynamical Seasonal Prediction



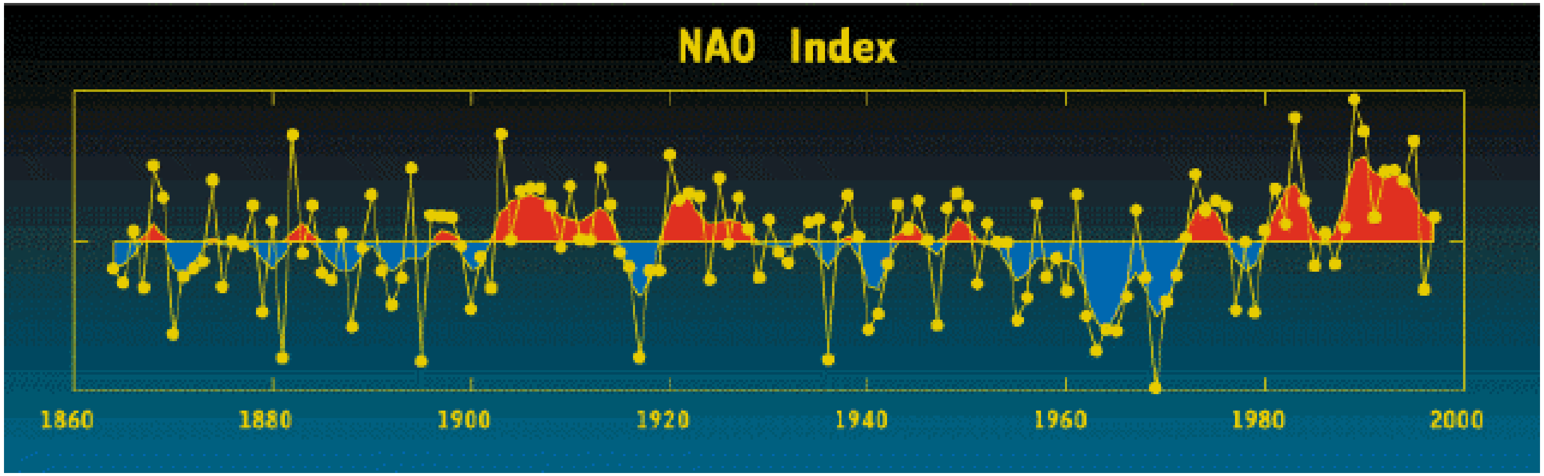
A remarkable example of the ability of the current atmospheric GCMs to simulate the observed circulation anomalies with prescribed global sea surface temperature. Top panel: Ensemble mean (9 members) difference of model simulated seasonal (JFM) mean 500 hPa height anomaly for the (warm) years (1983, 1987, 1992) minus the cold years (1985, 1989) for the COLA model. Bottom panel shows the corresponding difference for the observations. The spatial correlation coefficient between the two maps is 0.98. From: Shukla et al., BAMS 2000, 81, 2593-2606..


North Atlantic Oscillation
WET
MORE STORMS
DRY
L
H

NAO (+)


North Atlantic Oscillation
DRY
FEWER STORMS
WET
L
H

NAO (-)


NAO Index
1860
1880
1900
1920
1940
1960
1980
2000

NAO +:

Positive phase: Low low over N-Atlantic and strong subtropical high.

Pressure difference increase ➔ strong westerlies

The eastern US experiences mild and wet winter conditions

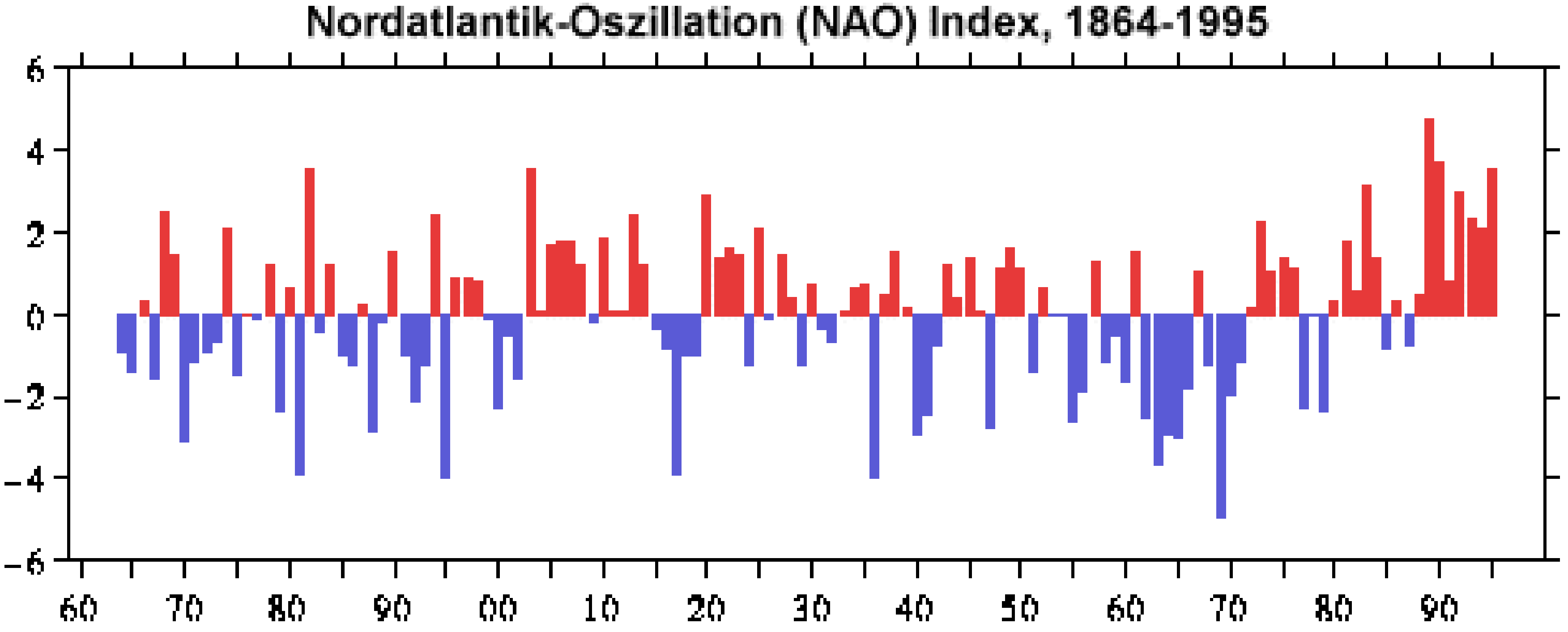
NAO -:

The negative NAO index phase shows a weak subtropical high and a weak Icelandic low

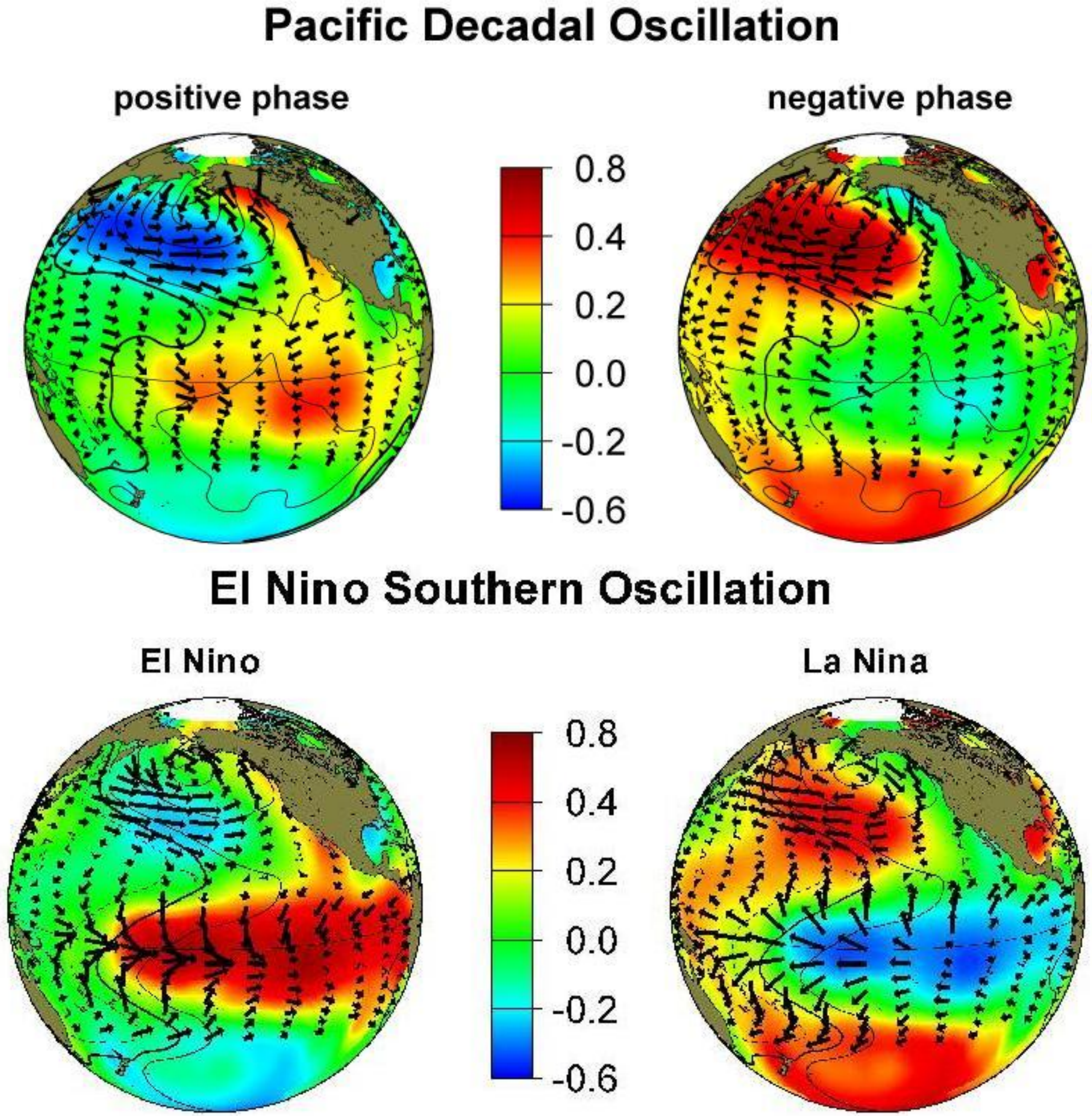
The reduced pressure gradient results in fewer and weaker winter storms crossing on a more west-east pathway

Moist air in Mediterranean, cold air to N-Europe. The US east coast snowy weather conditions

NAO Index:


Nordatlantik-Oszillation (NAO) Index, 1864-1995
6
4
2
0
−2
−4
−6
60
70
80
90
00
10
20
30
40
50
60
70
80
90

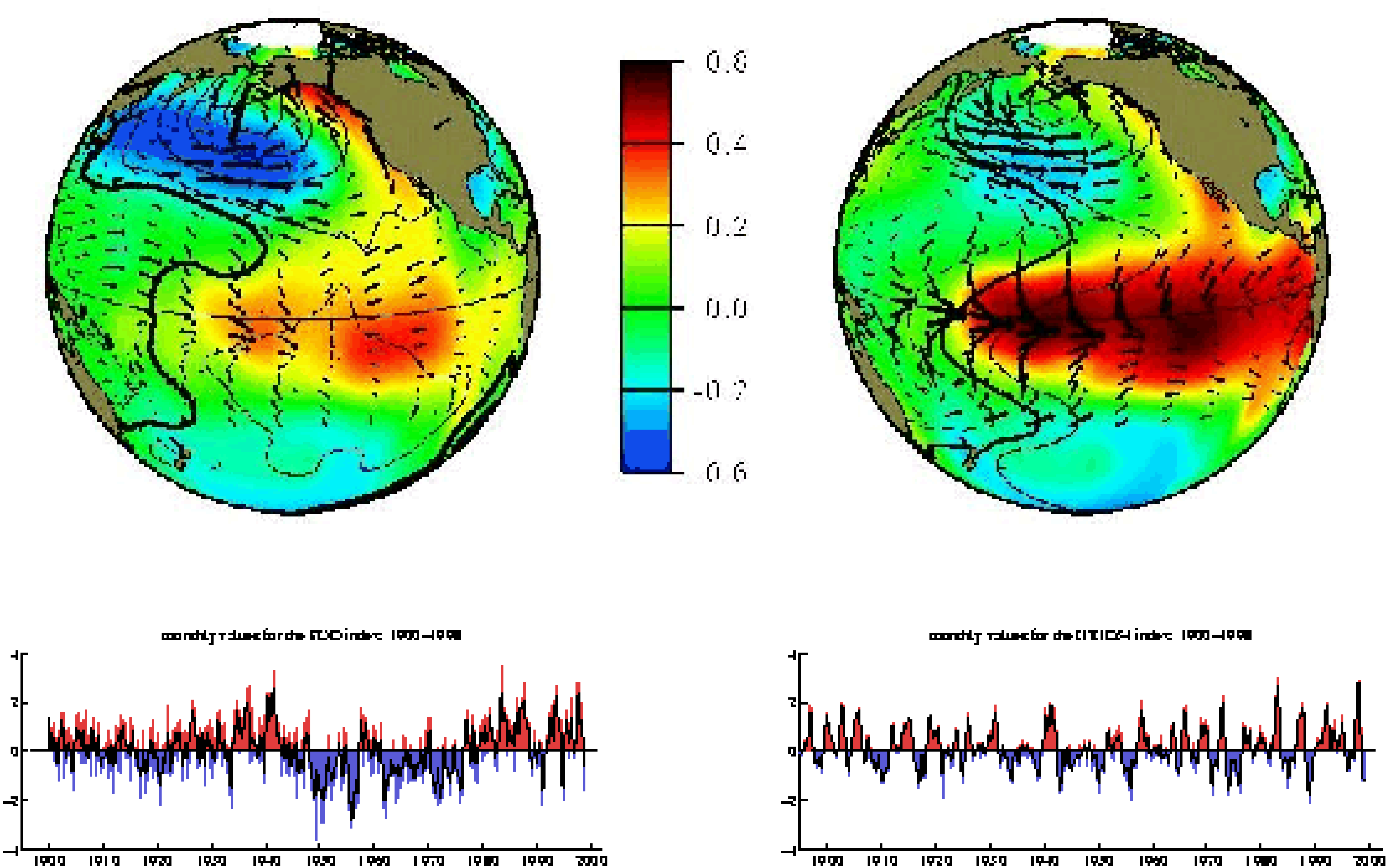
ENSO and PDO



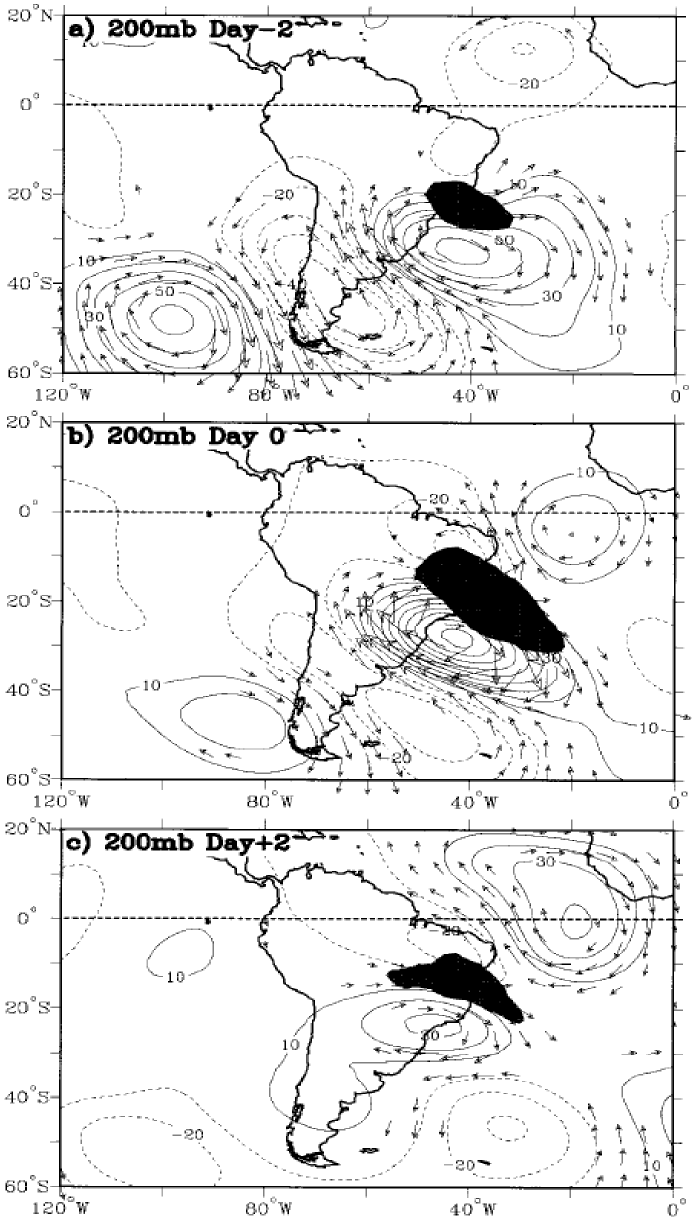
Pacific Decadal Oscillation
positive phase
negative phase
0.8
0.4
0.2
0.0
-0.2
-0.6
El Nino Southern Oscillation
El Nino
La Nina
0.8
0.4
0.2
0.0
-0.2
-0.6

ENSO and PDO

Pacific Decadal Oscillation **El Niño/Southern Oscillation**



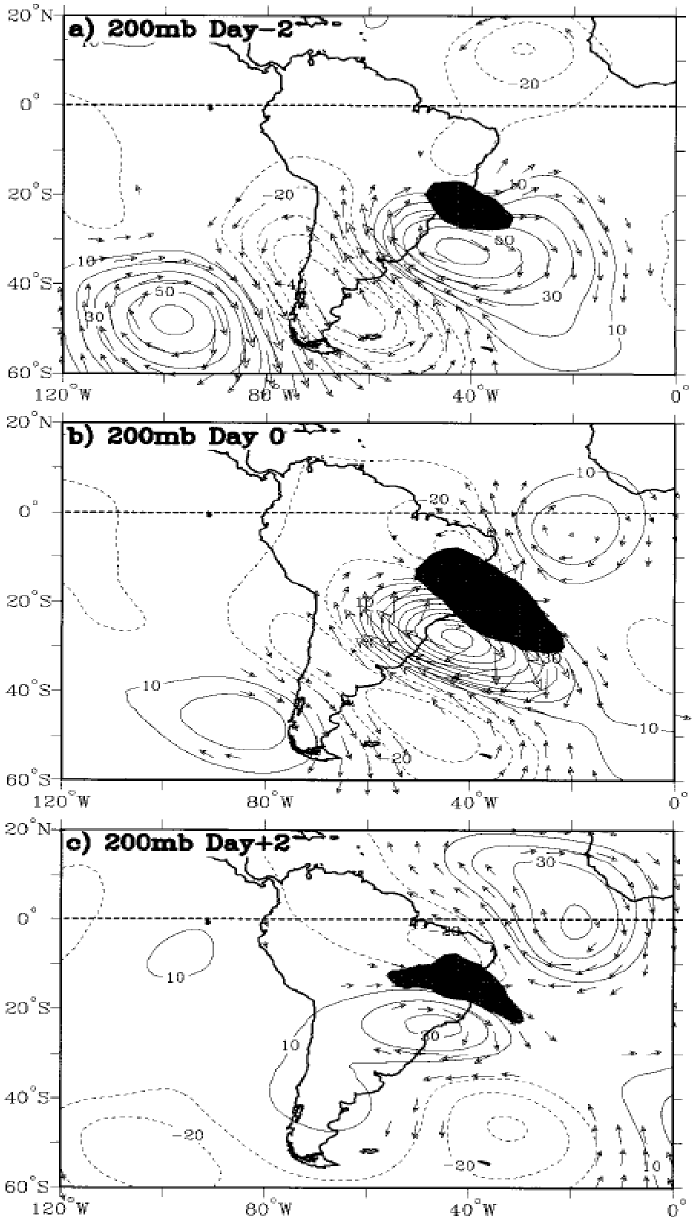
Teleconection-intraseasonal



Submonthly Convective Variability over South America and the South Atlantic Convergence Zone (Liebmann et al 1999)

200-mb streamfunction, wind, and OLR perturbations associated
with a **2**30 W m**2**2 deviation in 2–30-day filtered OLR in
the region 20**8**–30**8**S, 40**8**–30**8**W during DJF.

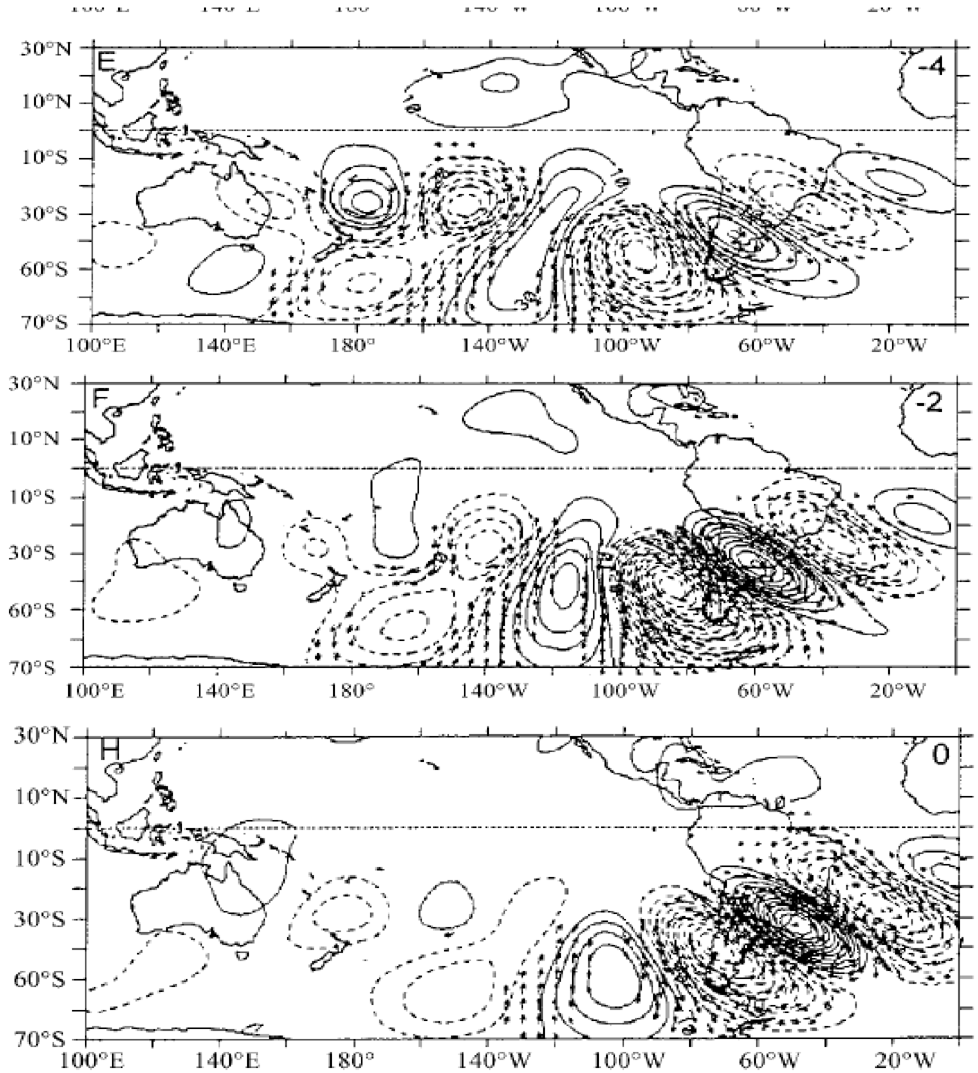
Teleconection-intraseasonal



Submonthly Convective Variability over South America and the South Atlantic Convergence Zone (Liebmann et al 1999)

200-mb streamfunction, wind, and OLR perturbations associated
with a **2**30 W m**2**2 deviation in 2–30-day filtered OLR in
the region 20**8**–30**8**S, 40**8**–30**8**W during DJF.

Teleconection-intraseasonal

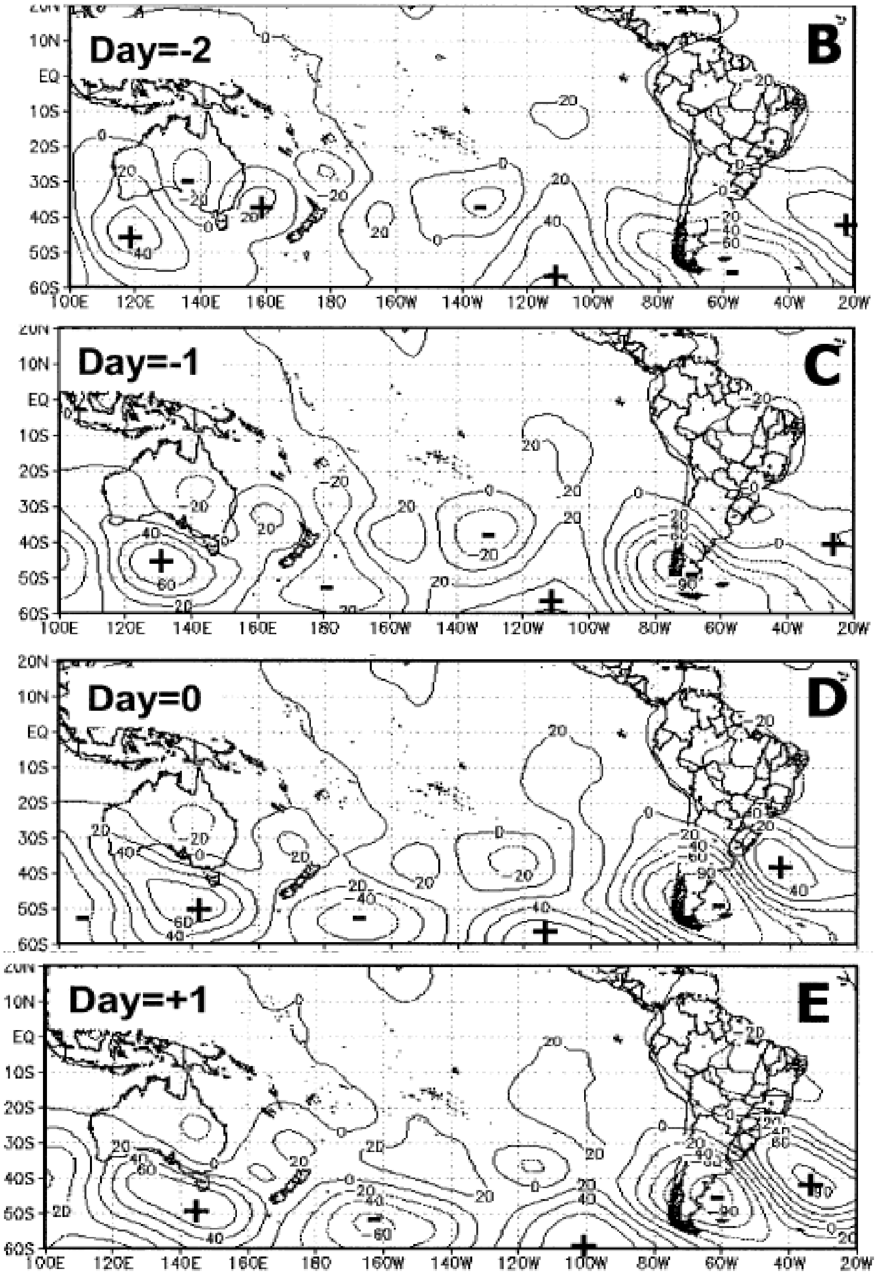


Upper-air wave trains over the Pacific Ocean and wintertime cold surges in tropical-subtropical South America leading to Freezes in Southern and Southeastern Brazil

J. A. Marengo[1], T. Ambrizzi[2], G. Kiladis[3], and B. Liebmann[4]

200 hpa height and wind perturbation associated with a -4.65 C cooling in Londrina, PR. During May-September 1970-1998

Teleconection-intraseasonal



Climatology of the Low-Level Jet East of the Andes as Derived from the NCEP–NCAR Reanalyses: Characteristics and Temporal Variability

JOSE A. MARENGO AND WAGNER R. SOARES

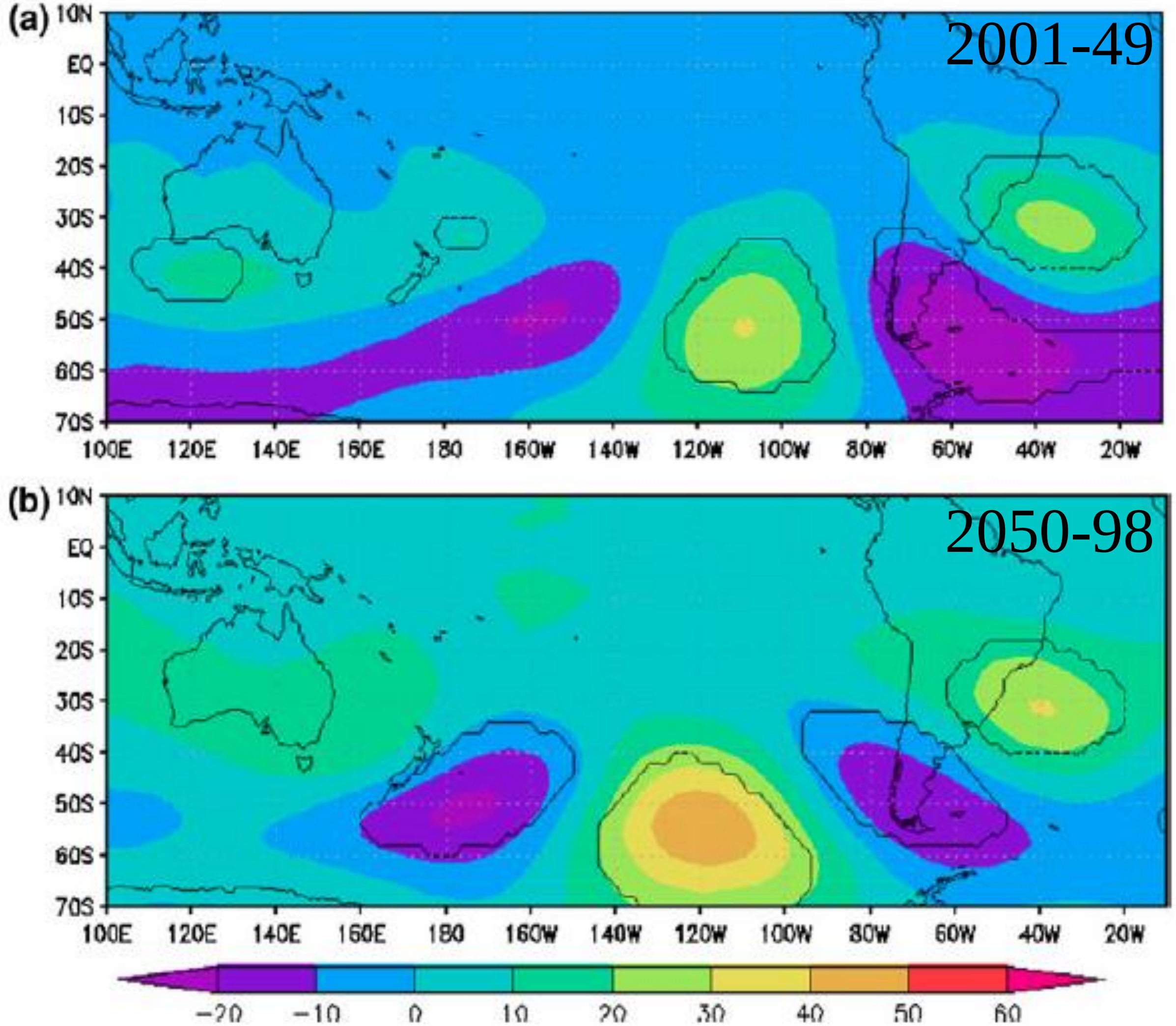
CPTEC/INPE, São Paulo, Brazil

CELESTE SAULO AND MATILDE NICOLINI

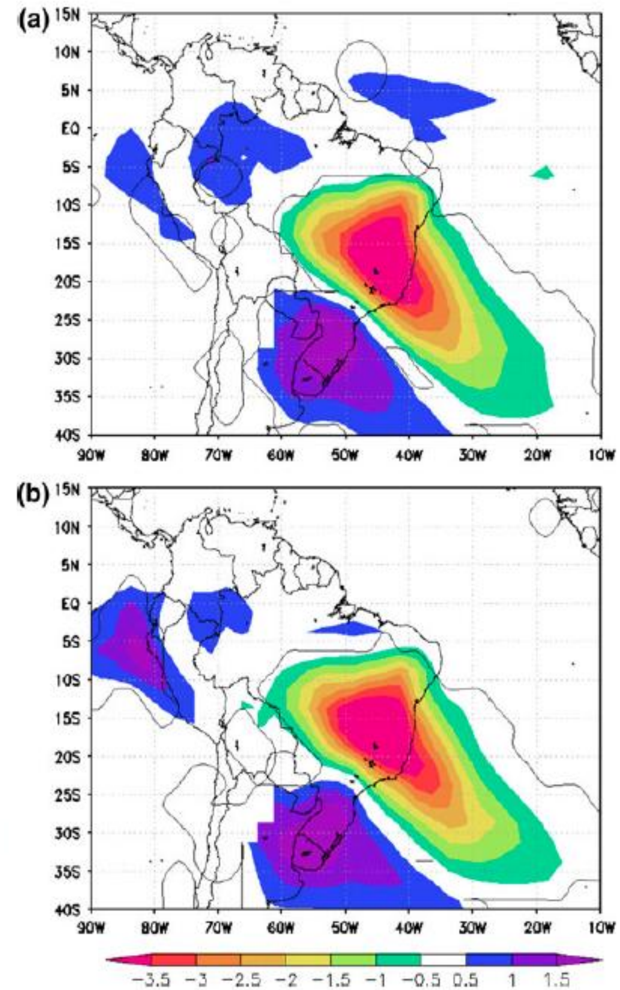
CIMA/University of Buenos Aires, Buenos Aires, Argentina

Upper-level NCEP–NCAR reanalysis 200-hPa geopotential height anomalies for SALLJ composite during the warm season (NDJF), for episodes detected at grid boxes closest to Santa Cruz and Mariscal Estigarribia simultaneously

Composite differences of DJF 500 Z hPa anom

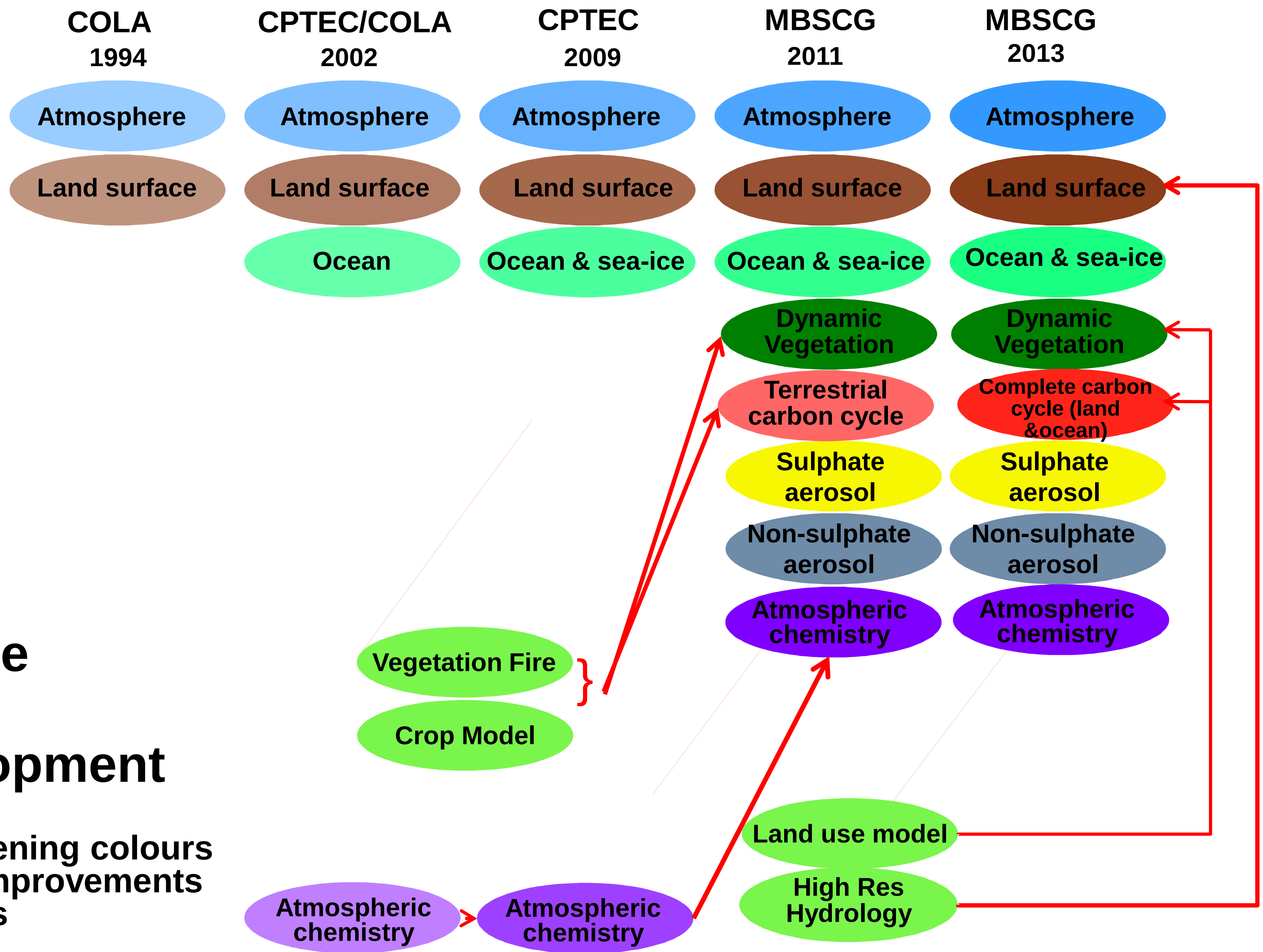


Composite differences of DJF rainfall



Los mecanismos fisicos que explican la tendencia positiva de precipitación proyectada para fines del siglo 21→relacionada con cambios en la variabilidad interanual forzada por las sst del indico-pacifico tropical y que tambien repercutieron en cambios en las teleconexiones hacia Sudamerica (Junquas et al. 2012-CMIP3 modelos para el futuro)→ PSA Pacific South American pattern

Development of the MBSCG at INPE → need for coupled AO model development



Off-line model development

Strengthening colours denote improvements in models

Sources: P Nobre, G.Sampaio

Brazilian Model of the Global Climate System (MBSCG)

INPE-CCST leads a multi-institutional and international effort to build the MBSCG, that incorporates the components of the climate systems (dynamic vegetation, surface processes, atmospheric chemistry, aerosols, ice, marine biogeochemistry and the carbon cycle into the CPTEC atmosphere-ocean coupled model being run at the new INPE CRAY-XT6 Tupã supercomputer

The MBSCG is based on the structure of the Global Coupled Atmosphere-Ocean model from CPTEC INPE

The MBSCG is a "community" type model, where national and international collaboration is undergoing for the model development

•There are 4 components:

-Atmosphere: Global climate model from CPTEC

-Ocean: Ocean global model from GFDL (MOM4 and its se ice and marine biogeochemistry components)

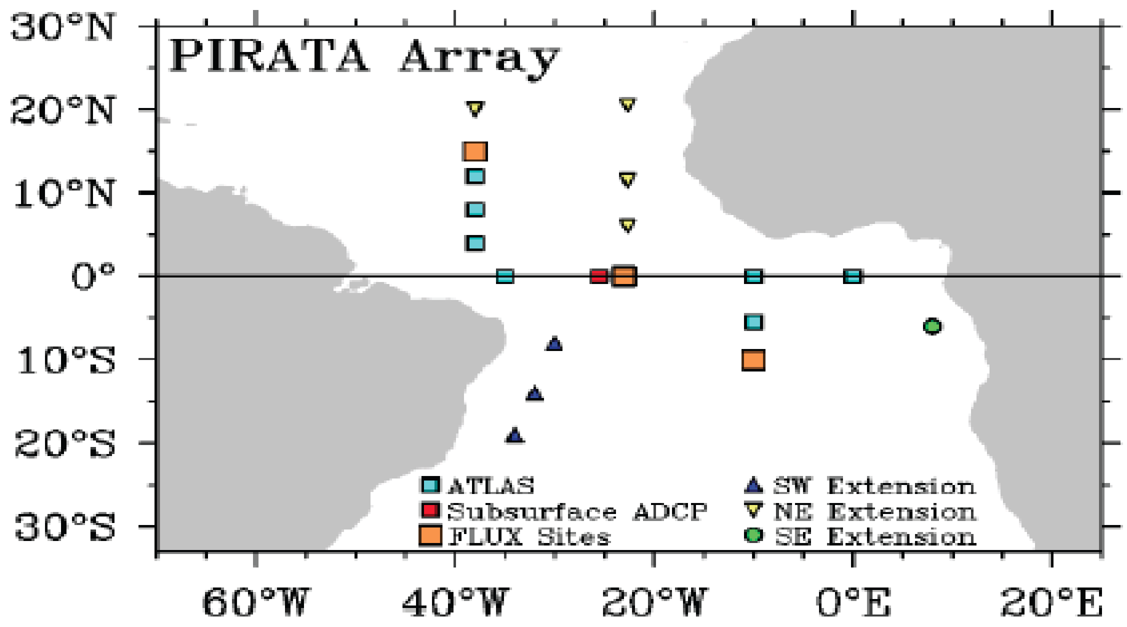
-Surface: IBIS land surface model (*Integrated Biosphere Simulator*; Foley et al., 1996; Kucharik et al., 2000)

-Atmospheric chemistry model: CCATT-BRAMS (developed by K. Longo e S. Freitas)

Observational systems in the oceans..!!

We need them..!

PIRATA array map and implementation history



T•A•O Array *configuration*

Find