# Influências de teleconexões na variabilidade de precipitação em algumas regiões do Brasil

Iracema F.A. Cavalcanti

Instituto Nacional de Pesquisas Espaciais

# Variabilidade climática

- Por que uma região tem excesso de chuva em alguns anos e déficit em outros? Influências locais e **influências de grande escala**

- **Através de teleconexões**

- O que é teleconexão?
- Como identificar?
- Quais são as principais características?

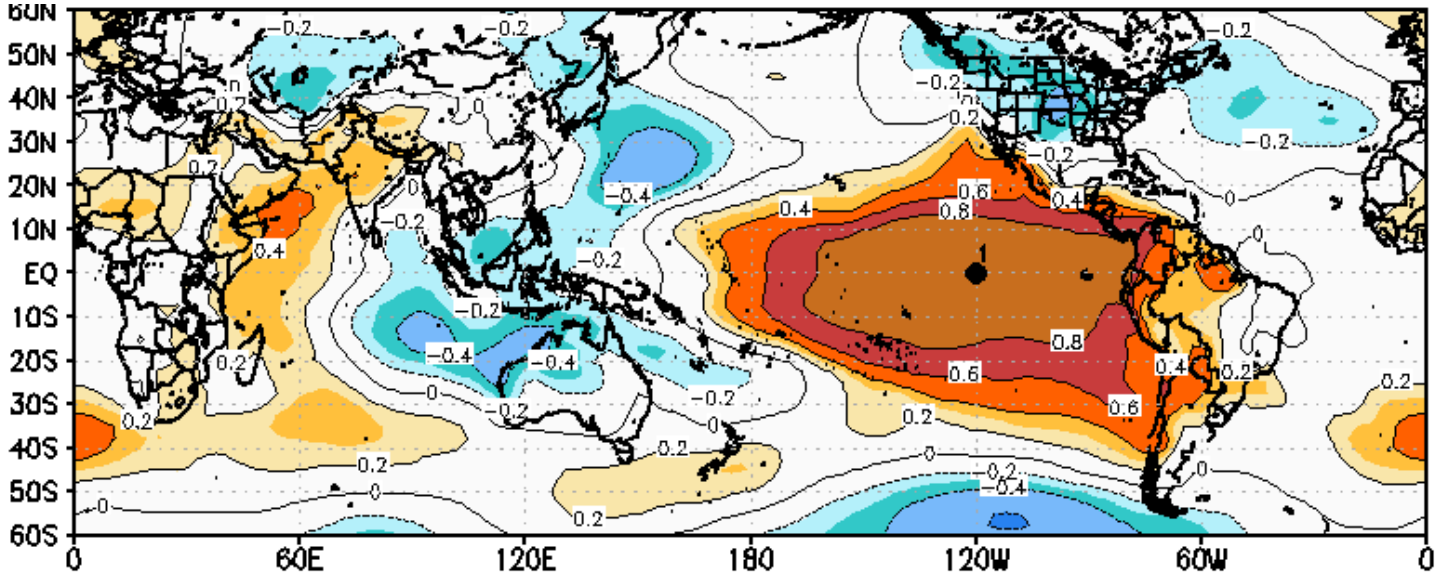
- Quais são as principais teleconexões que afetam a América do Sul e influências na precipitação.

# O que é teleconexão?

- **Relação entre variabilidades em lugares distantes.**

**tele: distante conexão: relação**

Exemplo: Oscilação Sul




Baixa pressão
Indonesia

Alta pressão
Pacífico Leste

# Como identificar as teleconexões?

## Análise de correlação

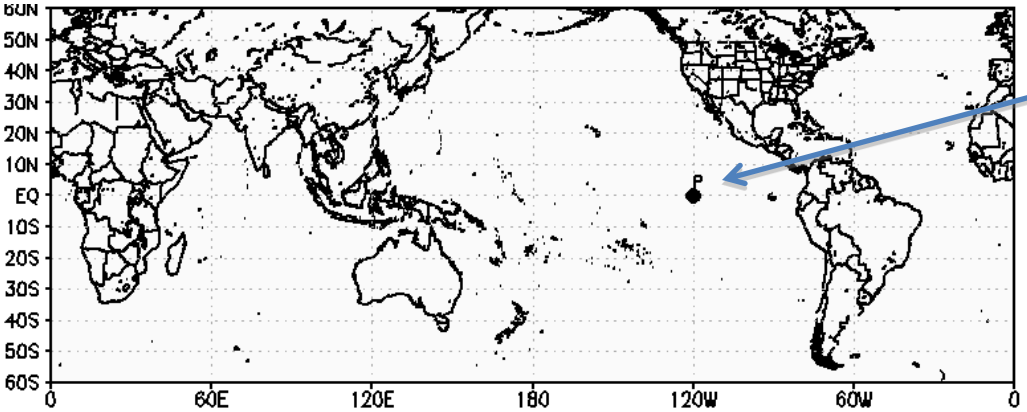
covariância

$$r = \frac{\sum_{i=1}^{N} (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{N} (x_i - \bar{x})^2} \sqrt{\sum_{i=1}^{N} (y_i - \bar{y})^2}}$$

Desvio Padrão

Y: Variável no ponto P

X: Variável em todos os outros pontos

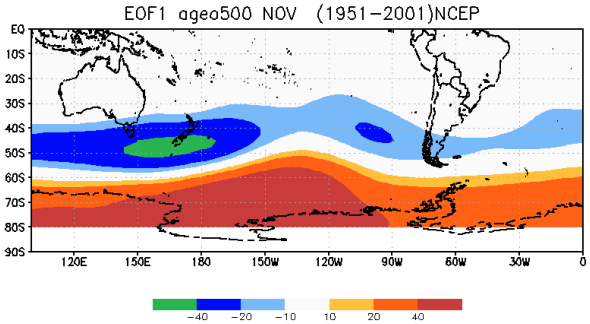


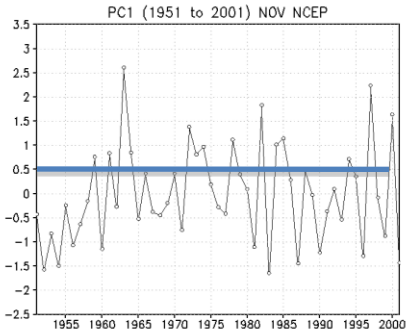

P (0, 120W)

# Como identificar?

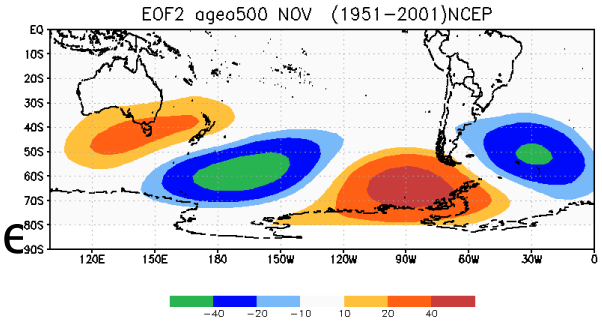
- Funções Ortogonais Empíricas (EOF)
- Método para obter padrões espaciais dos principais modos de variabilidade (auto vetores)
- A classificação dos modos é obtida pela variância explicada de cada modo ( autovalores)
- A série temporal dos coeficientes fornece a amplitude e indica a variabilidade temporal.

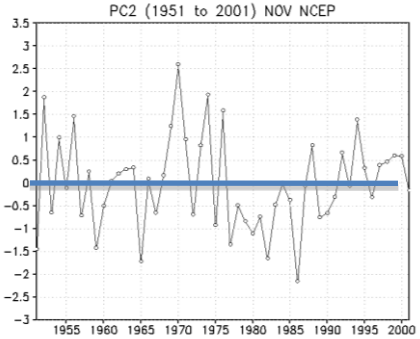
EOF1




EOF2




## Outros métodos estatísticos

Métodos estatísticos

↓ destacar

modos de variabilidade preferenciais na atmosfera

↓ Indicar

teleconexões

# Quais são as principais teleconexões que afetam a América do Sul ?

- **El Nino- Southern Oscillation (ENSO)**
- **Madden and Julian Oscillation**
- **Centros de ação da Oscilação do Atlantico Norte (NAO)**
- **Southern Annular Mode (SAM)**
- **Pacific South America (PSA) pattern**
- ***Modo Transpolar (TPI)***

**Oscilações - relação entre 2 centros de ação**
**Trens de onda- centros alternados de anomalias**

# Como anomalias em regiões tropicais podem ser conectadas com anomalias em lugares distantes?

divergência

Circulação Anticiclônica

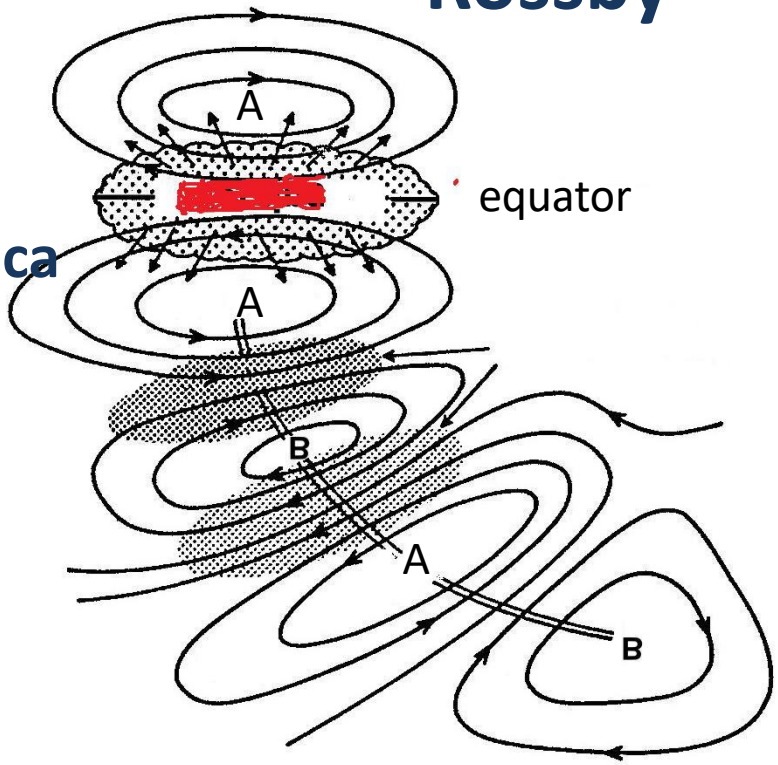
Convecção

Ascenção

Baixa Pressão

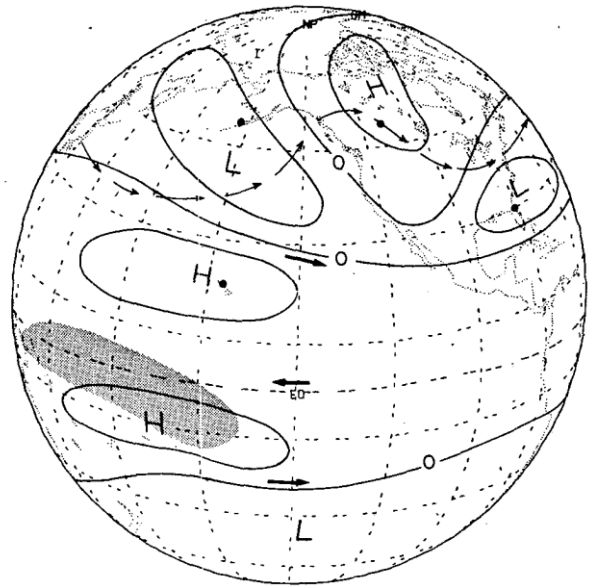
anomalias TSM

## Trens de onda de Rossby

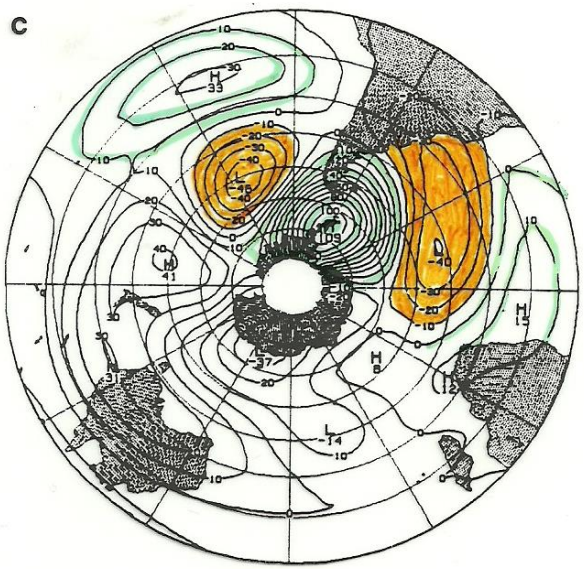


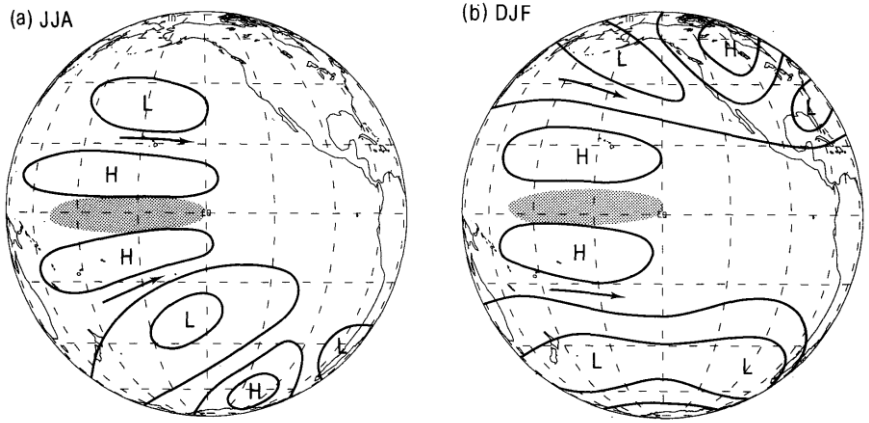
# Trens de Onda de Rossby sobre o Pacífico formados a partir de convecções anômalas na região tropical

Pacific North America (PNA)
Horel &Wallace (1981)




Pacifc South America (PSA )
Mo e Ghil, 1987



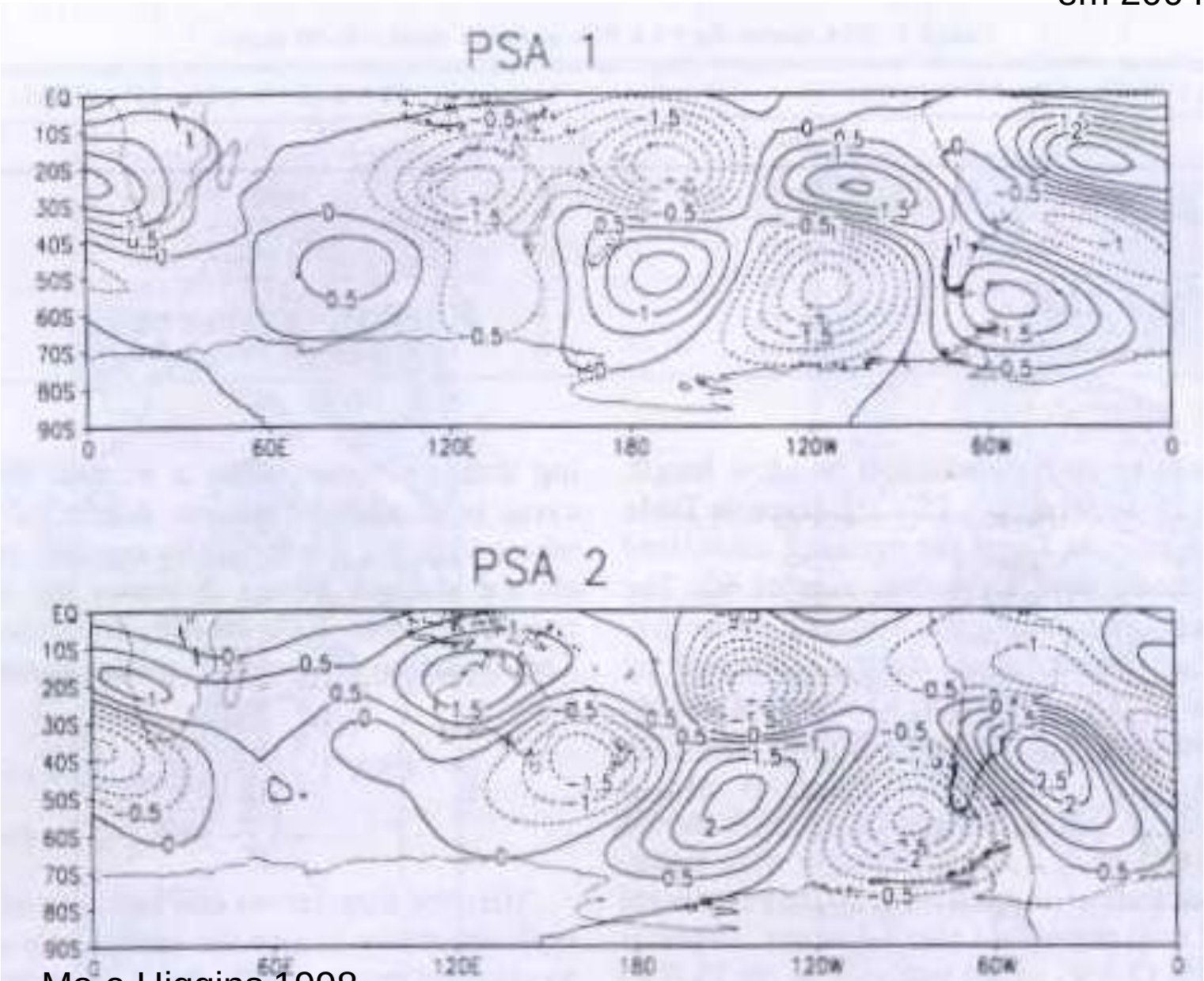




Karoly 1989

# Pacific South America (PSA)

# Pacific South America (PSA)

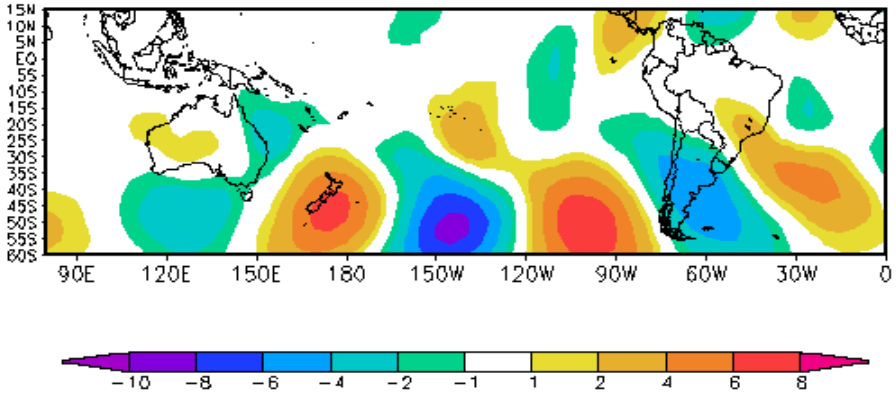
Função de corrente em 200 hPa JJA



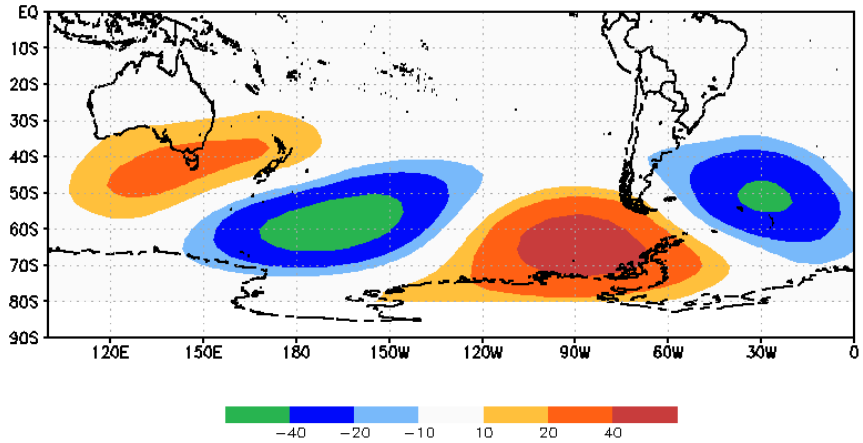

Mo e Higgins 1998

# Pacific South America Pattern (PSA)

Diversas variáveis
Diversas escalas de tempo



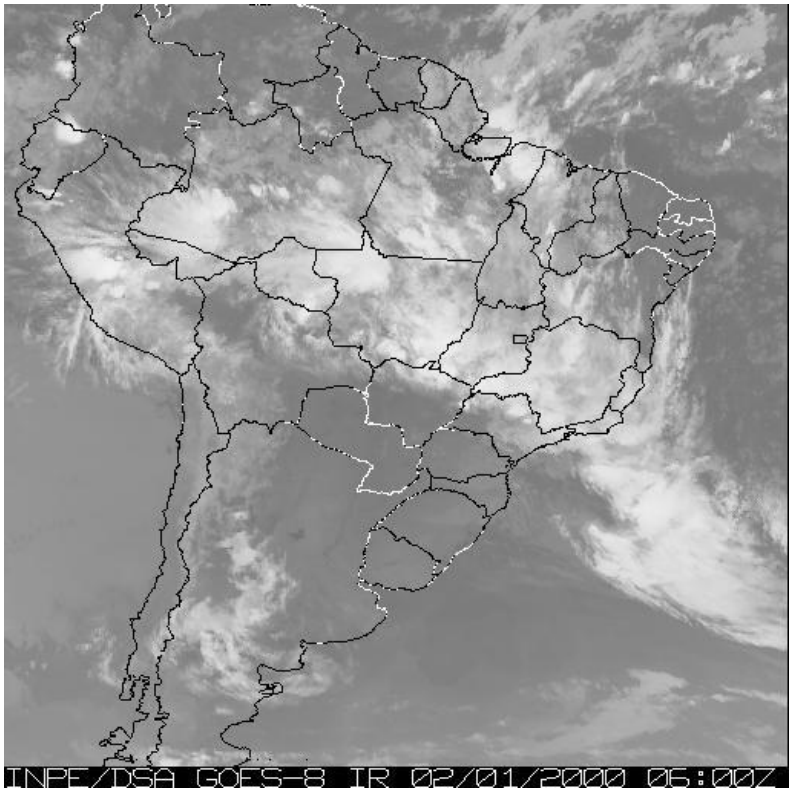

**EOF1 vento meridional em 200 hPa**
**NDJFMA**
**Variabilidade intrasazonal**



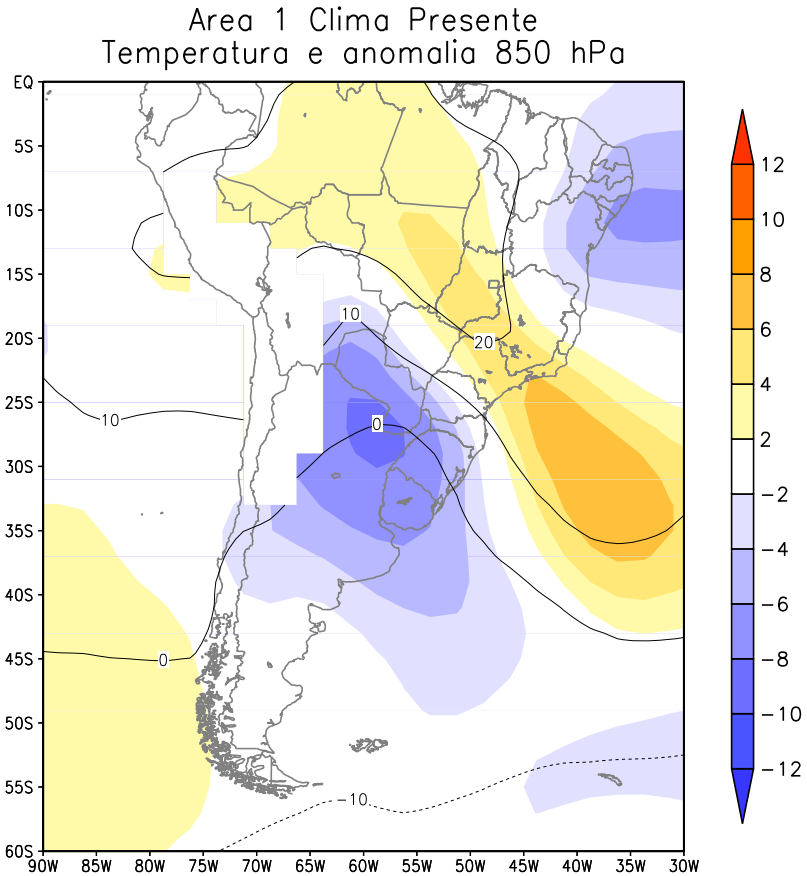

**EOF2 Geopotencial at 500 hPa**
**Novembro**
**Variabilidade interanual**

# Qual é a influência dessa configuração no Brasil e América do Sul?

**VERÃO:**
**Zona de Convergência do Atlântico Sul**
**ZCAS**

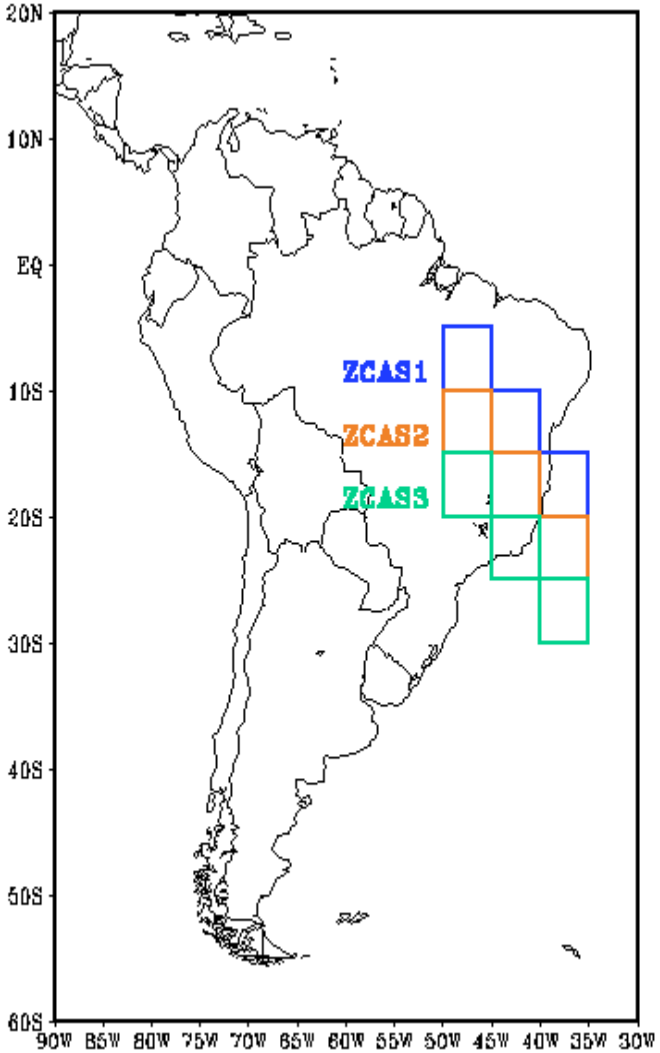



**INVERNO:**
**entradas de ar frio**

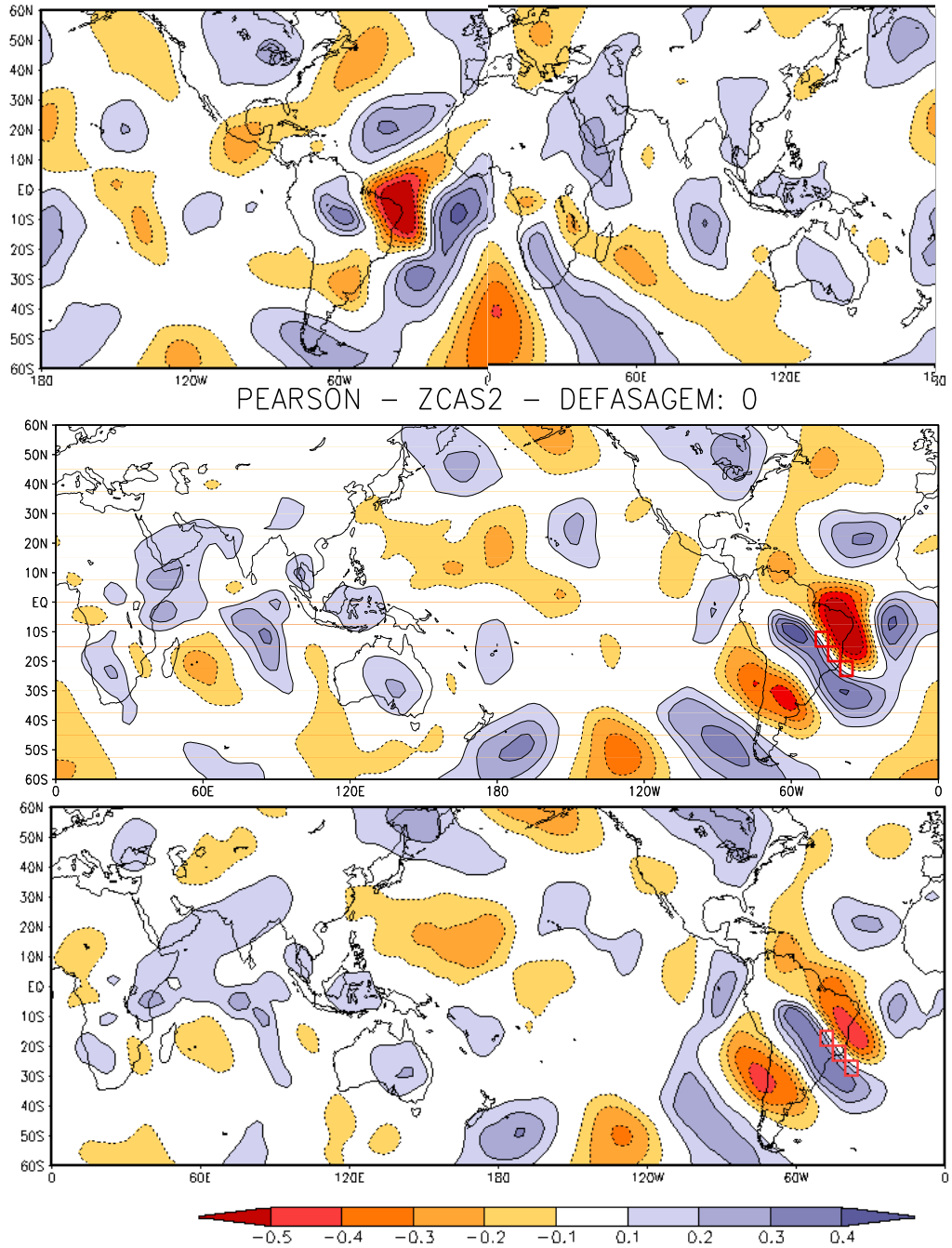


# Relação PSA e ZCAS

## Novembro a April

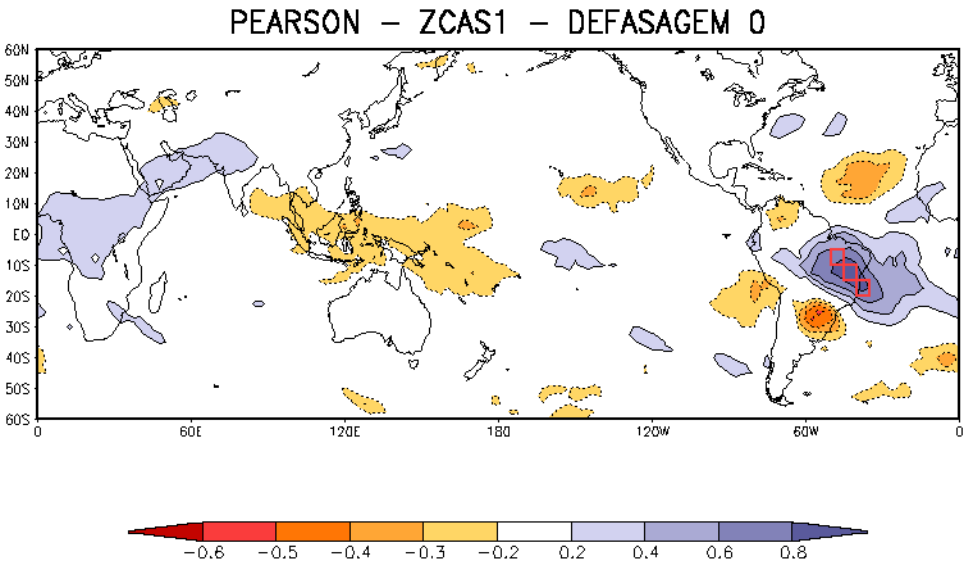


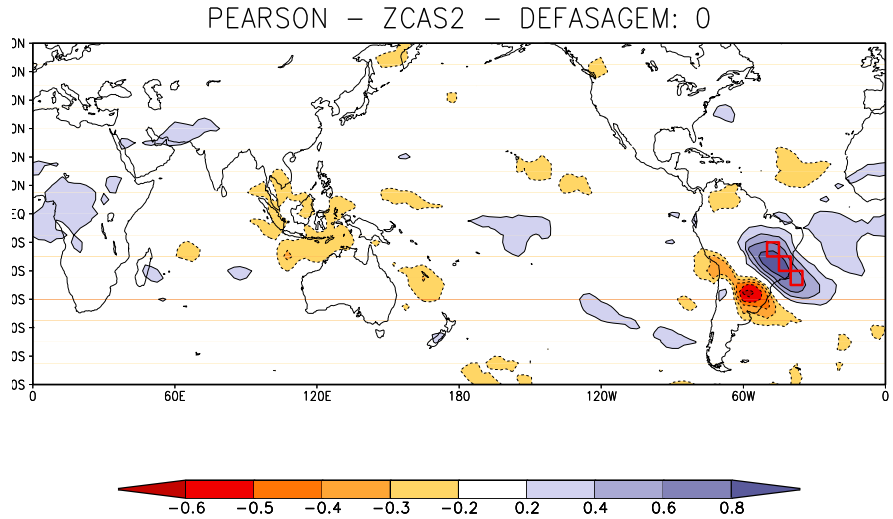

## Correlação aolr SACZ X v

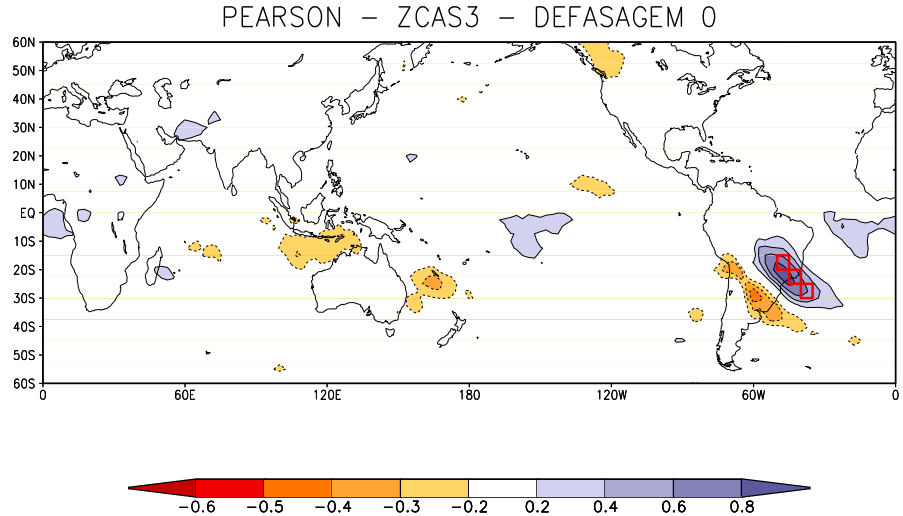



**Cunningham e Cavalcanti (2006)**

# Correlação aolr SACZ X aOLR

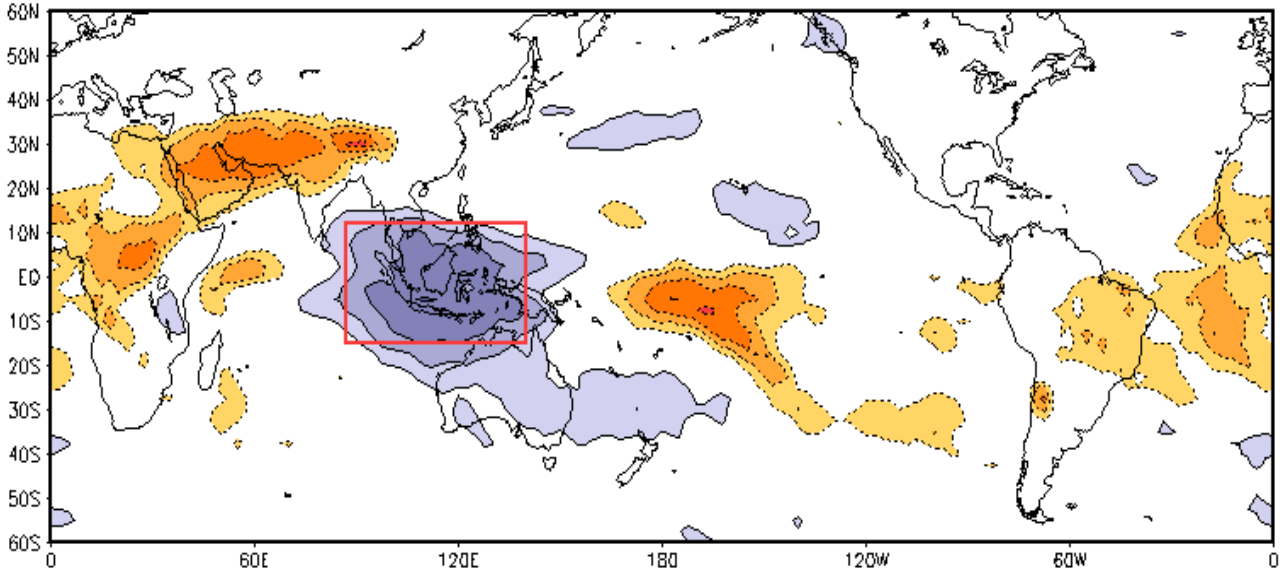


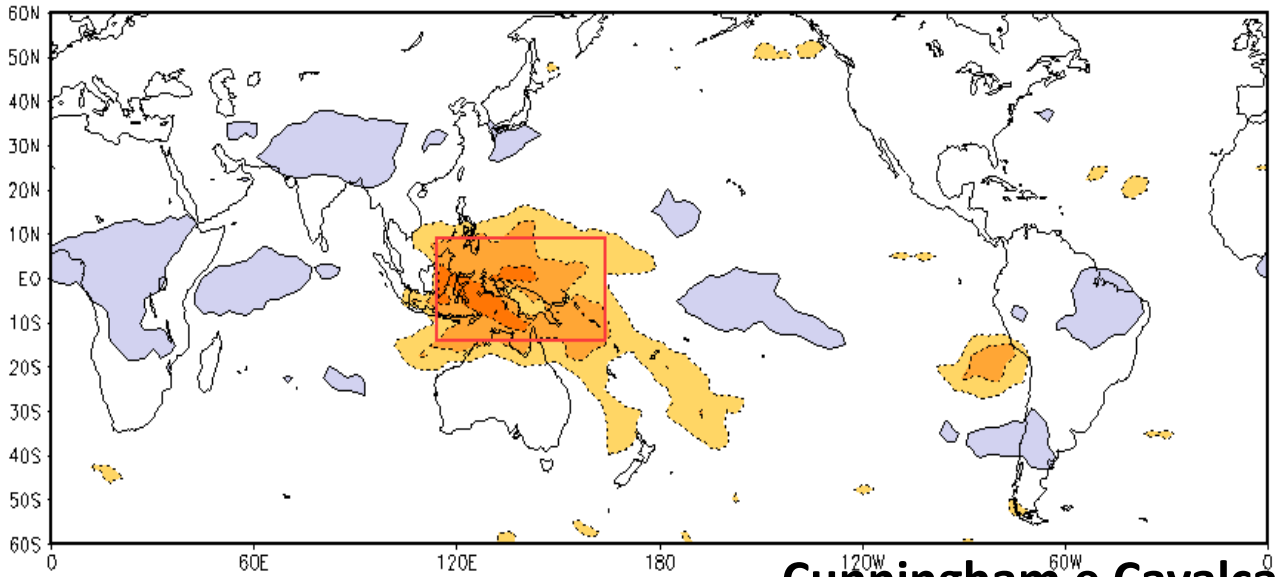




**Cunningham e Cavalcanti (2006)**

# Correlação de OLR na Indonésia com OLR nos outros pontos




Padrão de dipolo leste oeste entre a Indonésia e o Pacífico

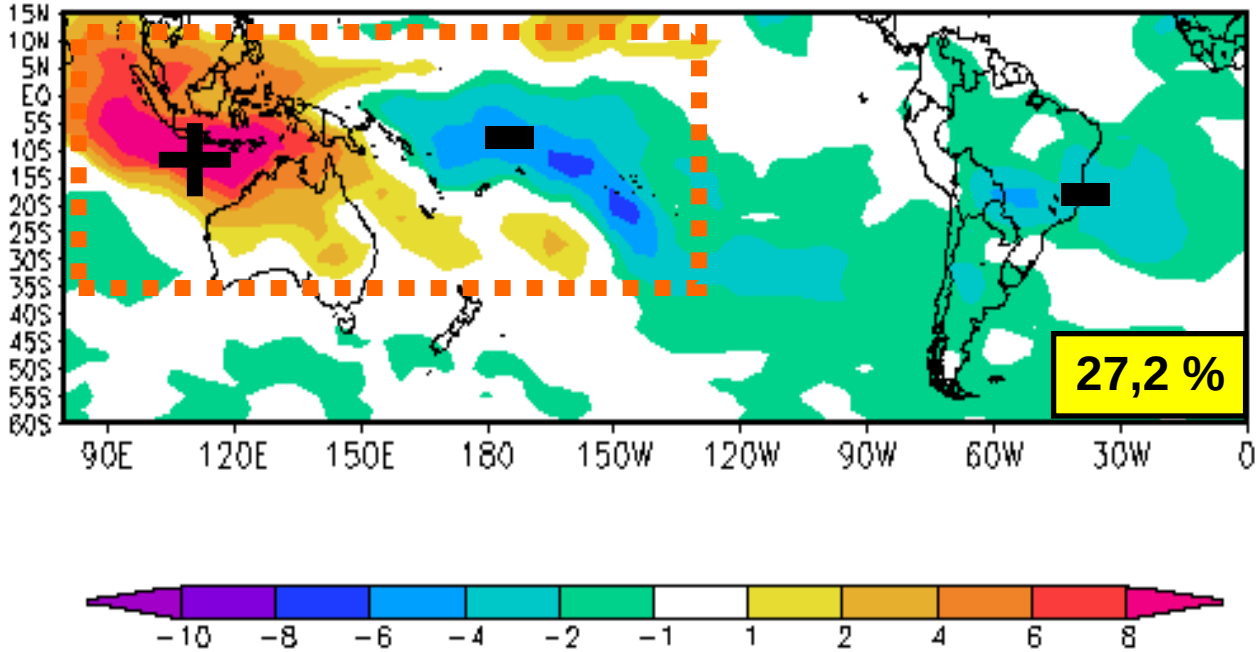



**(+25 dias)**

Em aproximadamente 25 dias os padrões do dipolo leste-oeste se apresentam invertidos

**Cunningham e Cavalcanti (2006)**

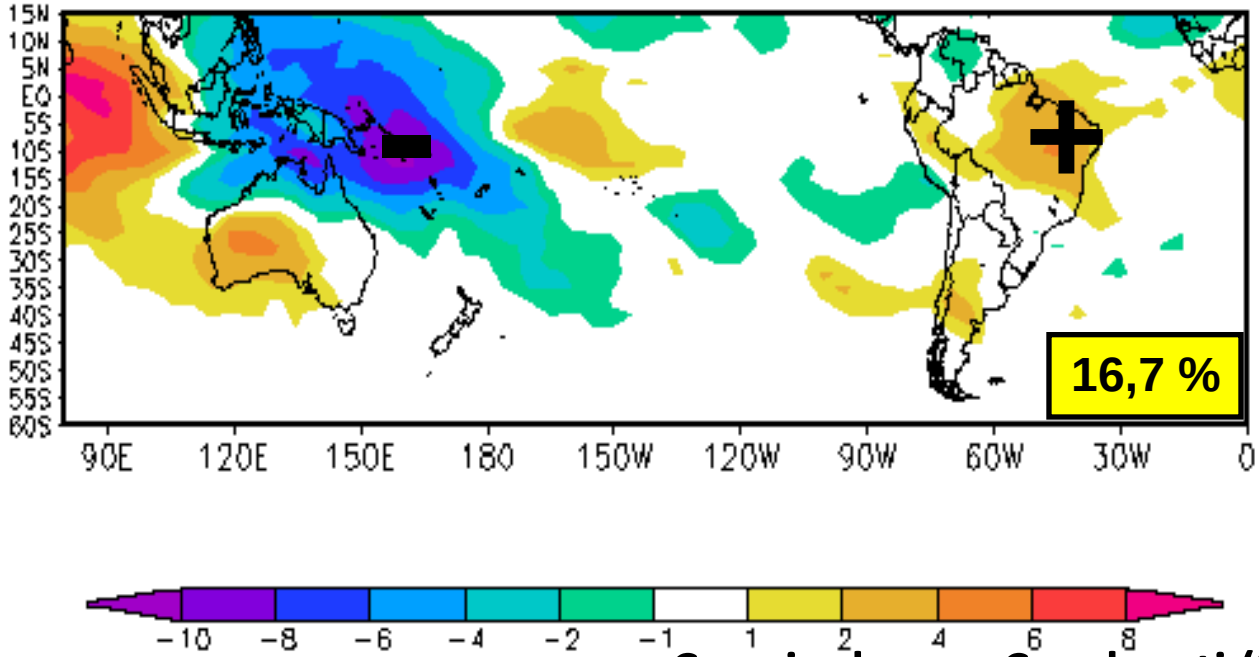
**EOF OLR**




Dipolo leste-oeste

Relação oposta entre a convecção na Indonésia e a convecção na ZCAS

Convecção na ZCPS em fase com a ZCAS



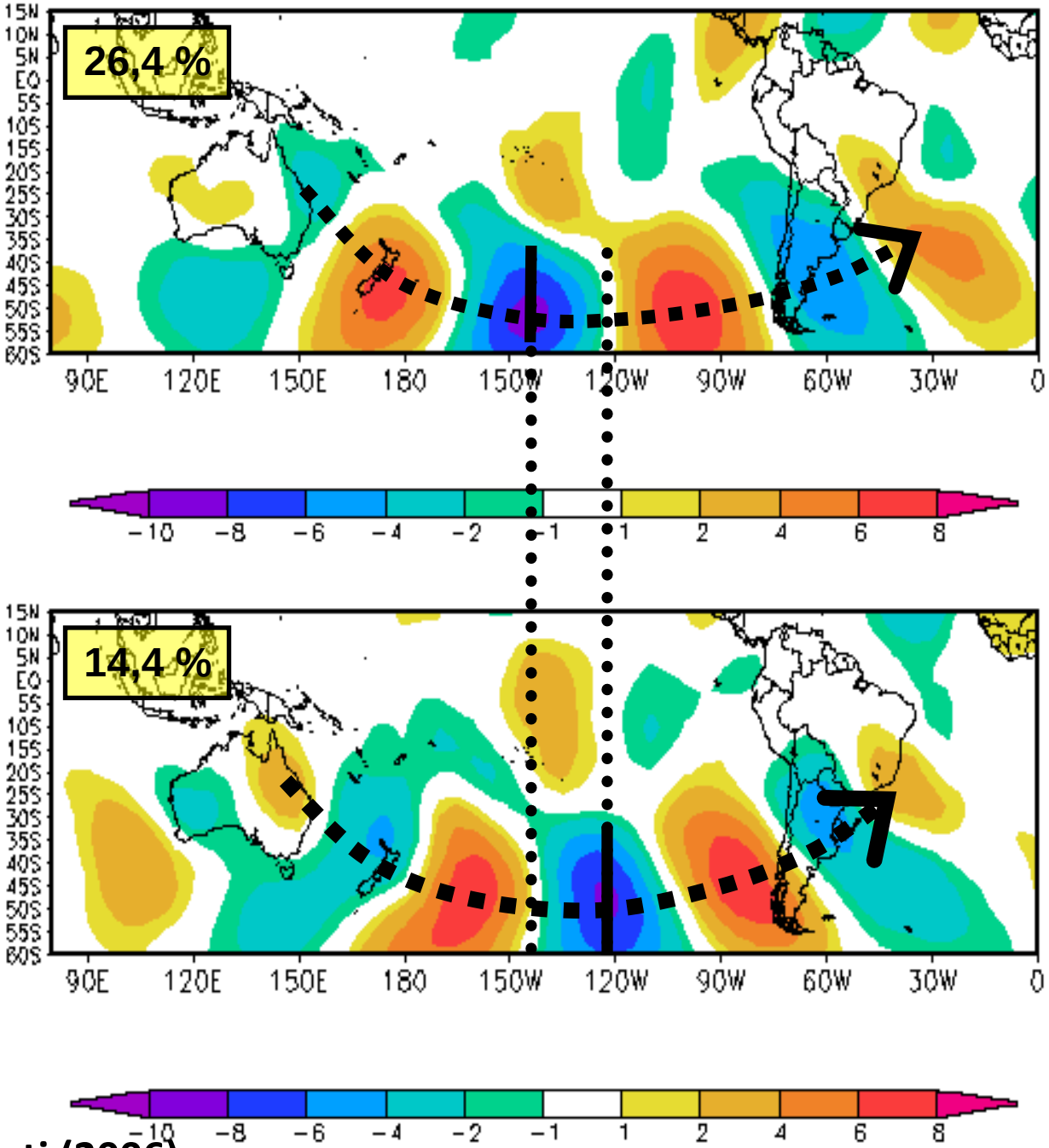

Existência de uma oscilação em fase oposta entre a ROL no Nordeste da América do Sul e sobre o leste da Indonésia (padrão visto nas análises de correlação)

**Cunningham e Cavalcanti (2006)**

# EOF Geo 500 hPa

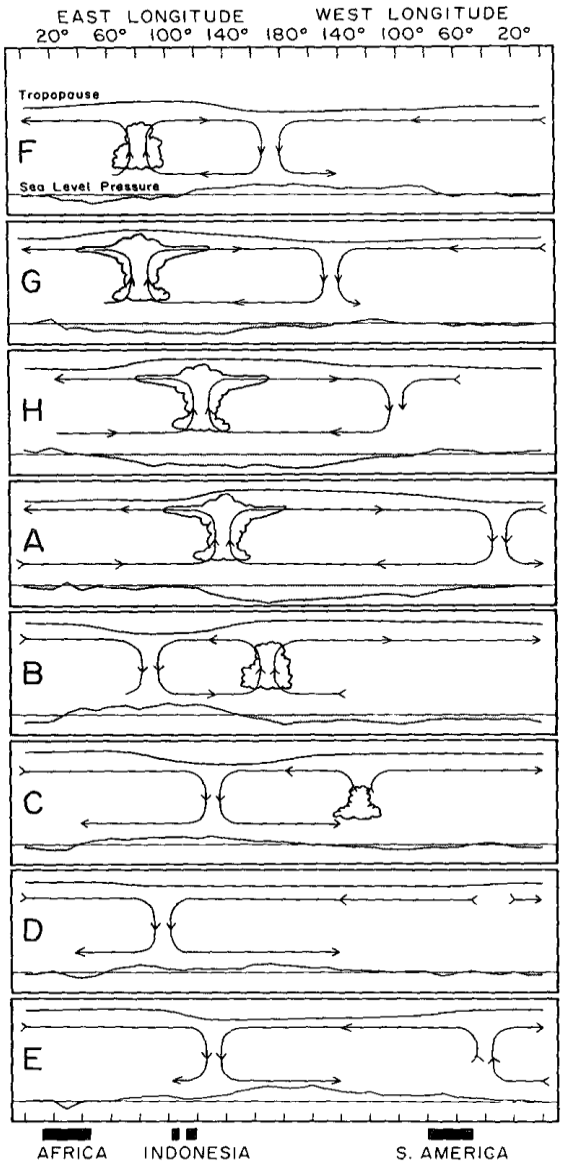
Mostram padrões tipo PSA, com um trem de onda em forma de arco, conectando a região da Indonésia à América do Sul, até a região de formação da ZCAS.

Deslocamento dos centros




**Cunningham e Cavalcanti (2006)**

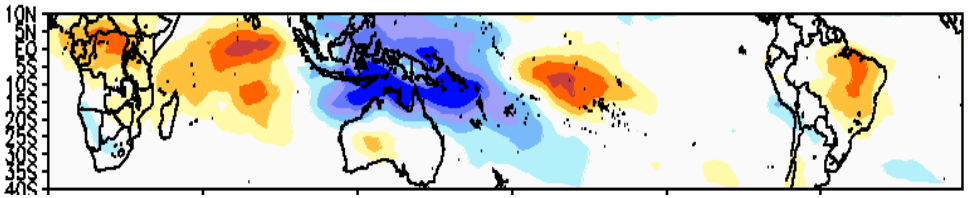
# Oscilação Madden and Julian (MJO)




Madden and Julian 1996

É uma oscilação tropical identificada por regiões com grandes áreas de convecção e outras adjacentes sem conveção

EOF2 30-90 days DJF



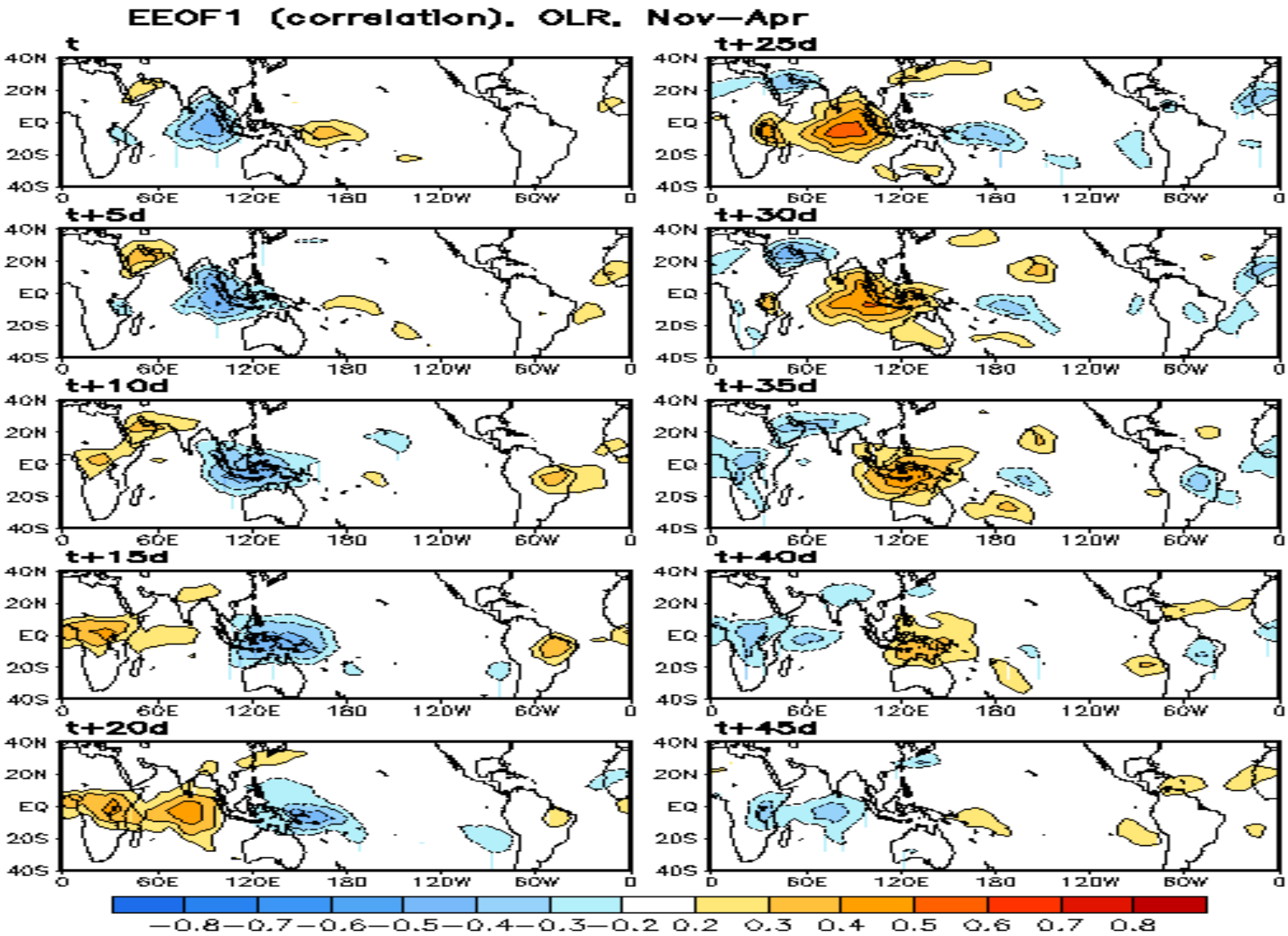
**Como pode ser identificada?**

**Dados filtrados (30-60 dias)**

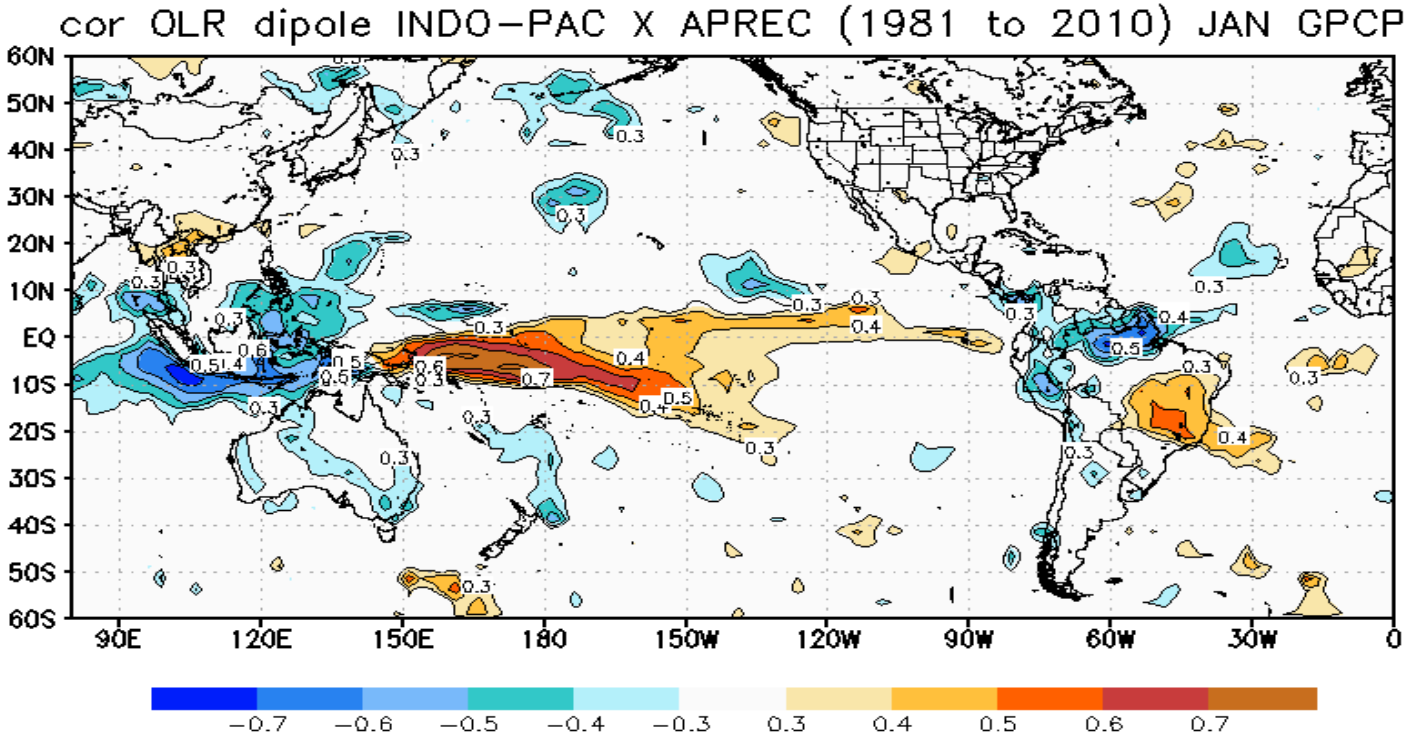
**Principal característica:**

**Deslocamento da convecção para leste.**

# MODO 1- OLR

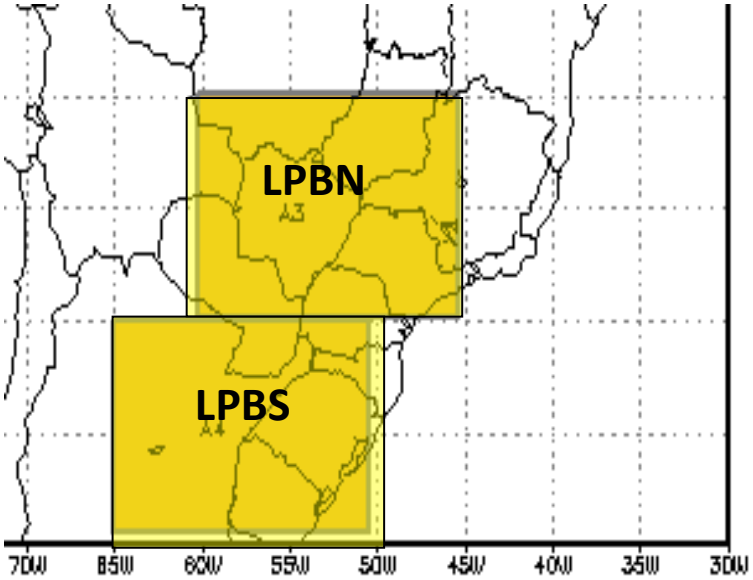

EEOF1 (correlation), OLR, Nov–Apr
t
t+5d
t+10d
t+15d
t+20d
t+25d
t+30d
t+35d
t+40d
t+45d
40N
20N
EQ
20S
40S
0
60E
120E
180
120W
60W
0
−0.8 −0.7 −0.6 −0.5 −0.4 −0.3 −0.2 0.2 0.3 0.4 0.5 0.6 0.7 0.8

# Relação entre região Indonésia/Pacífico Oeste e América do Sul




Cavalcanti et al. (2016)

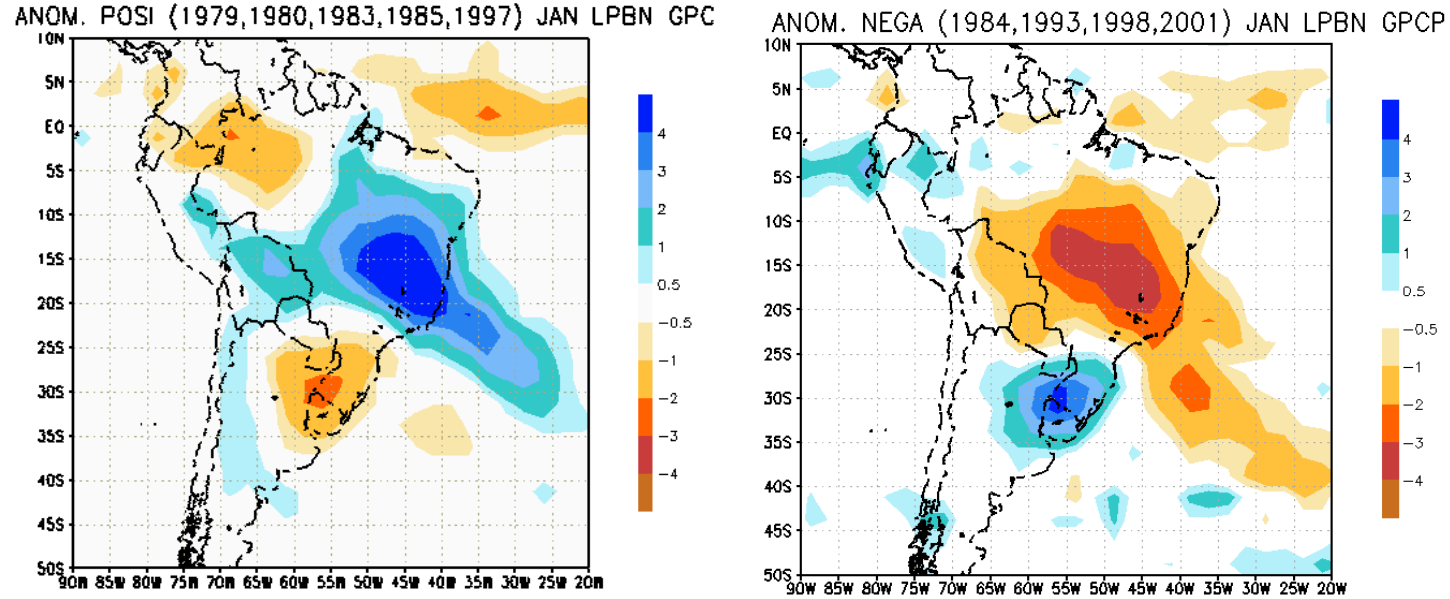
# Precipitação extrema La Plata e teleconexões



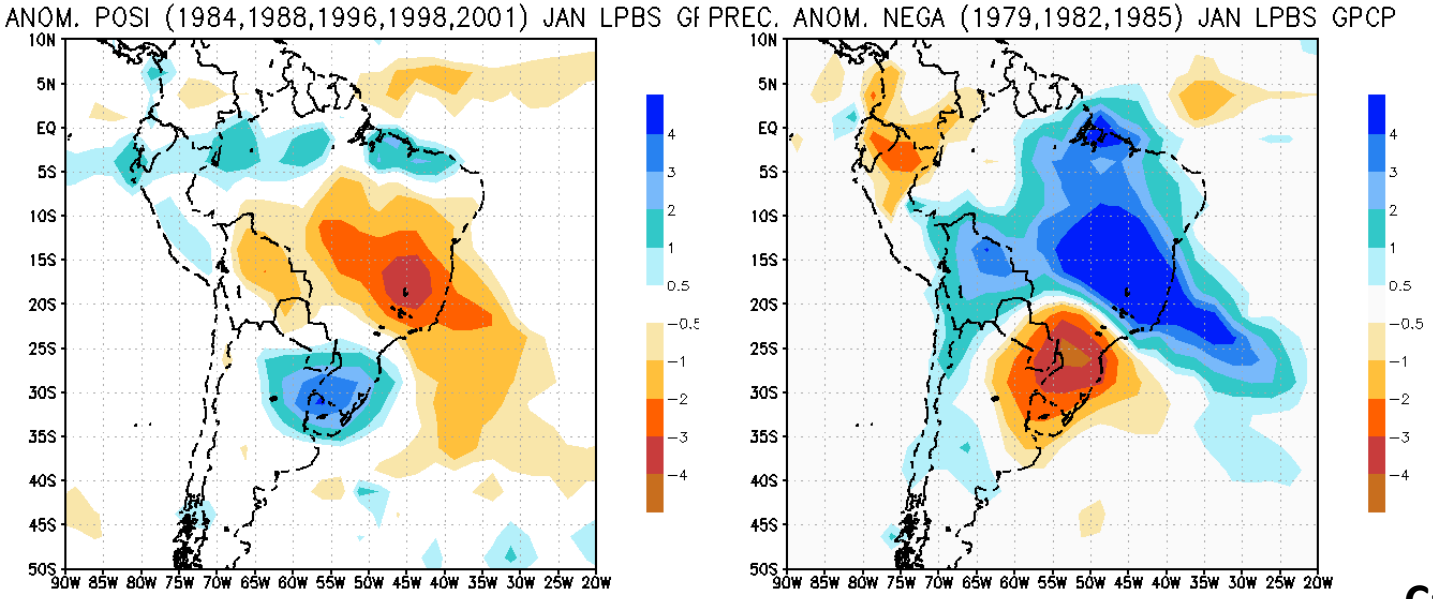
# Compostos de casos extremos, severos e moderados

WET

DRY



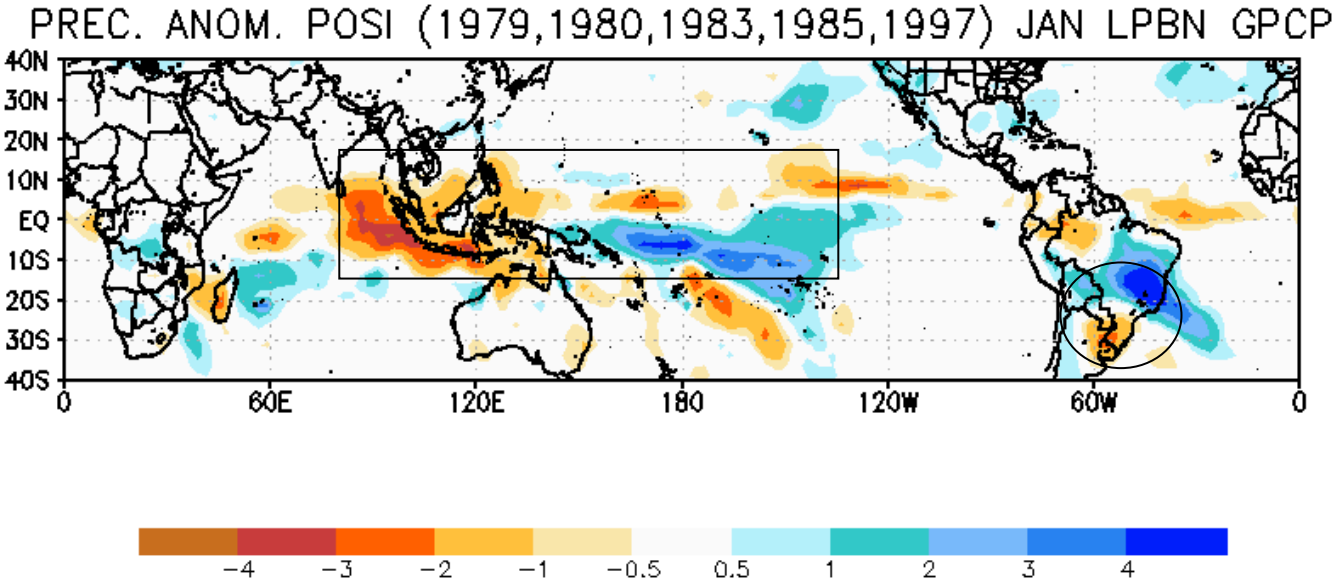

NLPB



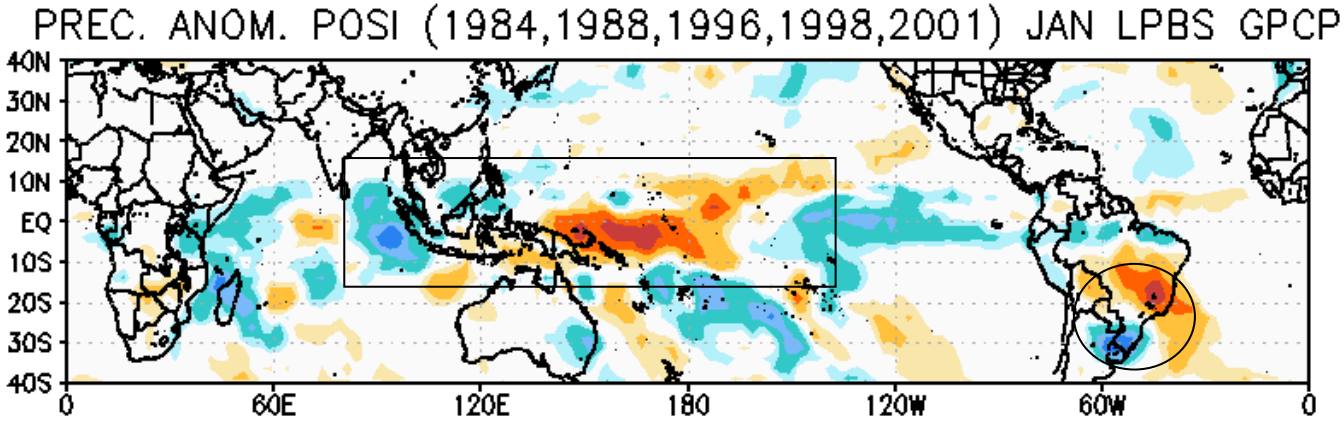

SLPB

**Cavalcanti et al. 2012**

# Anomalias de Precipitação



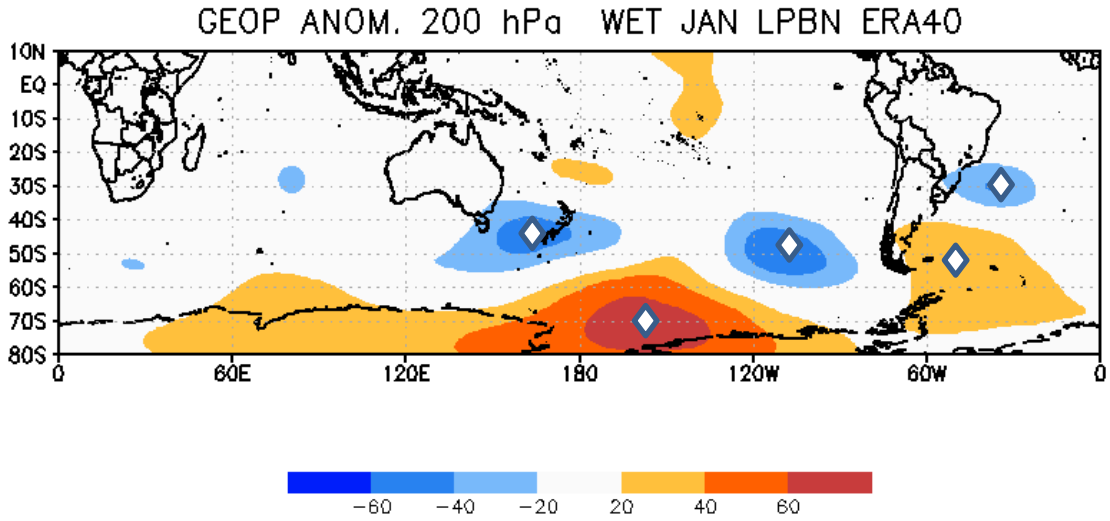

NLPB




SLPB

**Cavalcanti et al. 2012**

# Anomalia geopotencial 200 hPa

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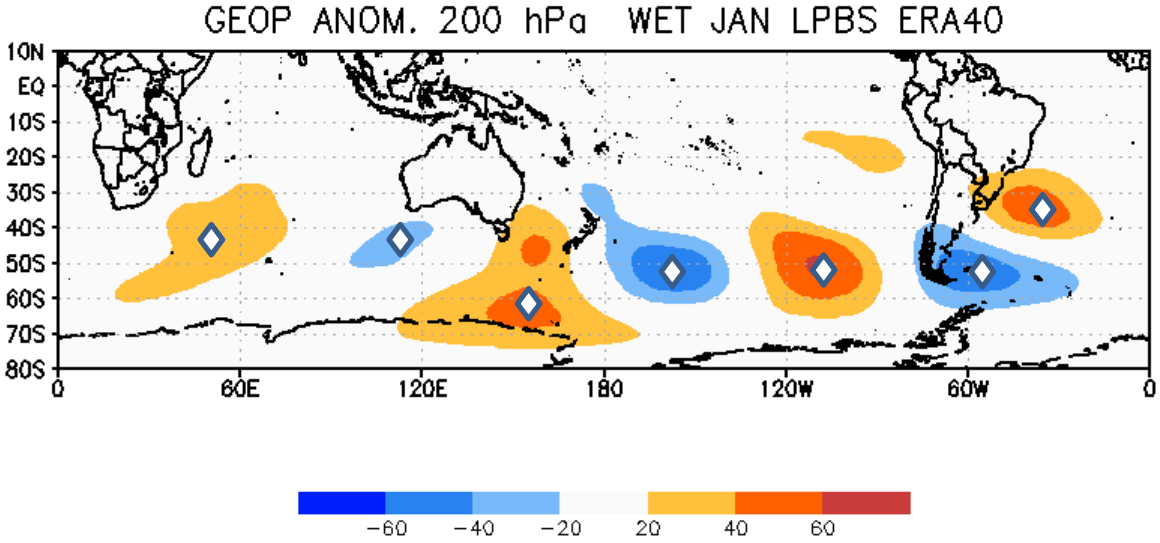



SLPB

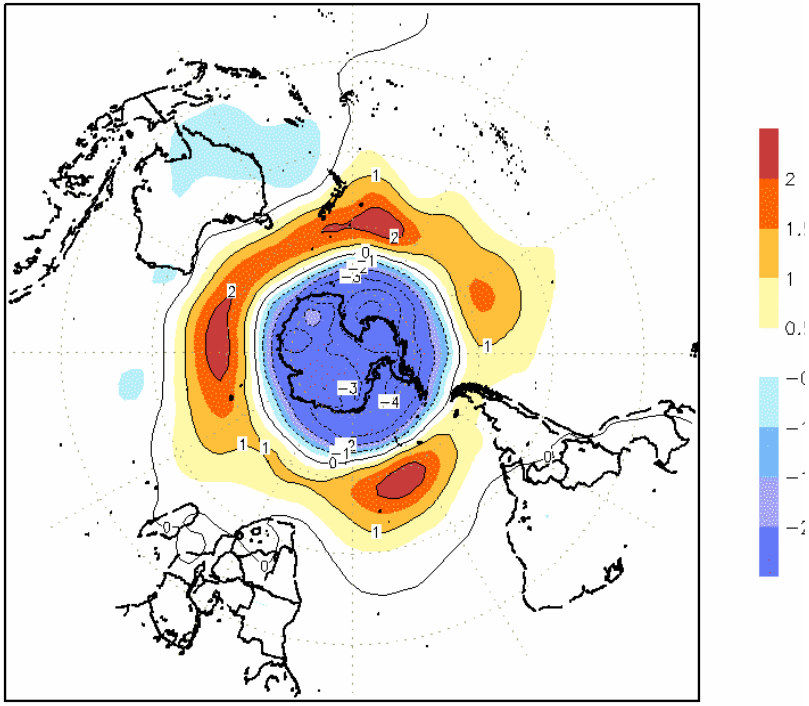
**Cavalcanti et al. 2012**

# Modo Anular Sul
# Southern Annular Mode (SAM)

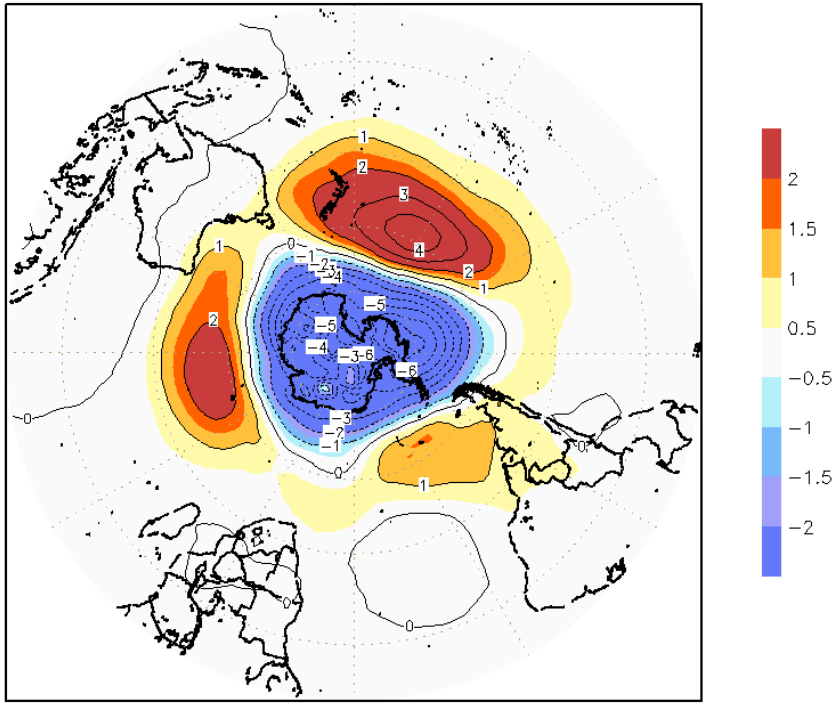
# O Que é Modo Anular do Hemisfério Sul ou Oscilação Antártica?

## Anomalias opostas entre as regiões polares e latitudes médias

JAN

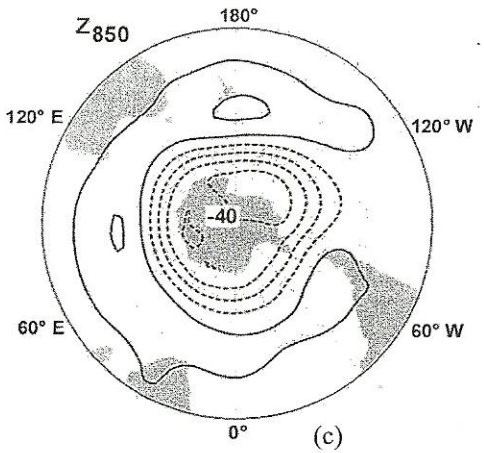


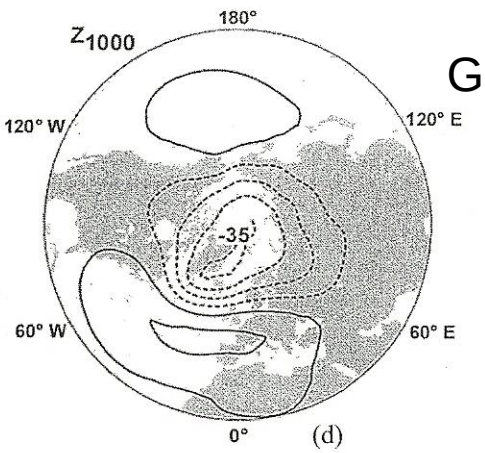

JUL



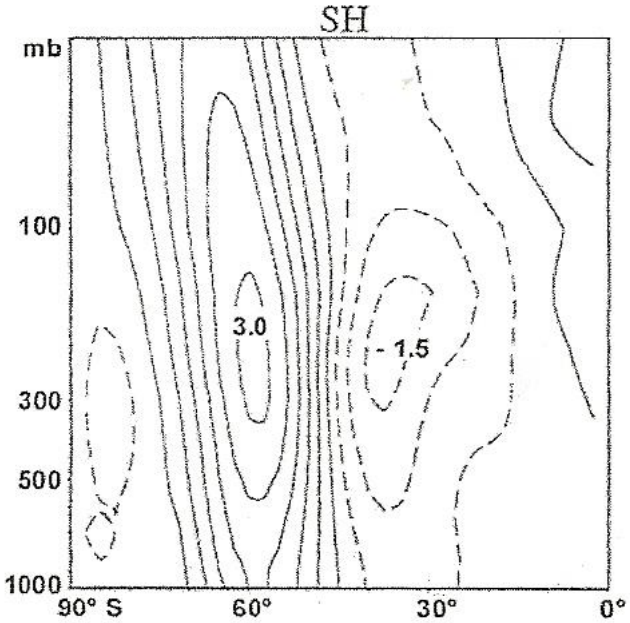
# Modo anular nos 2 Hemisférios

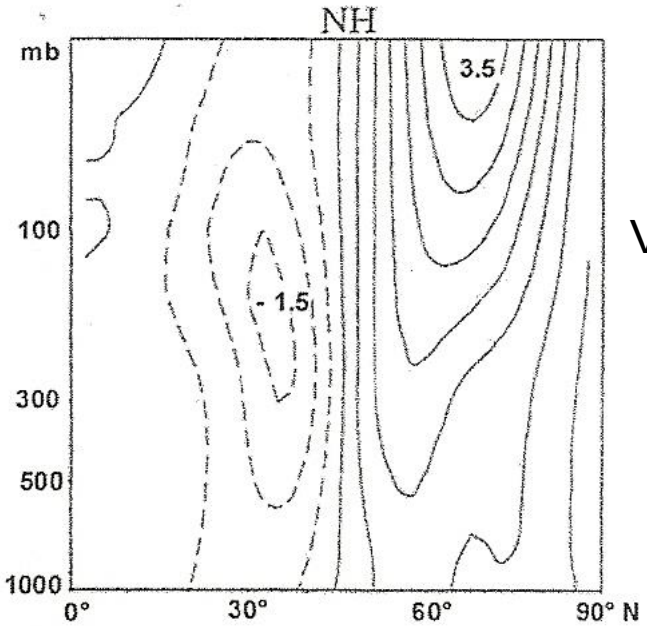
Geo em 850 hPa




Geo em 1000 hPa hPa

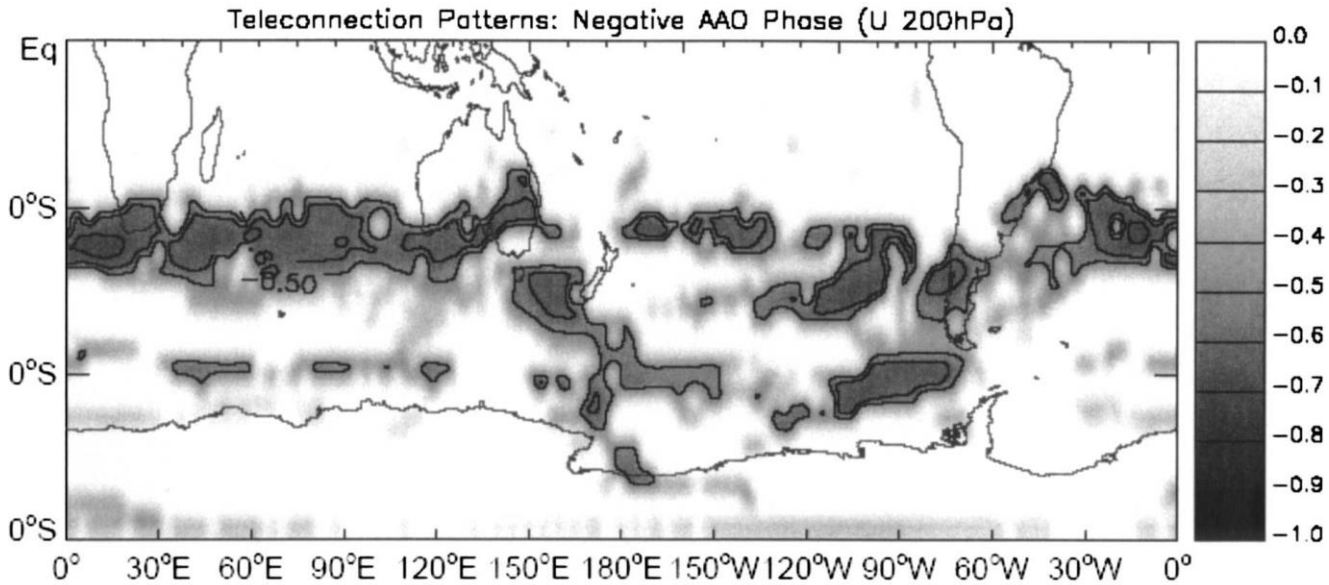


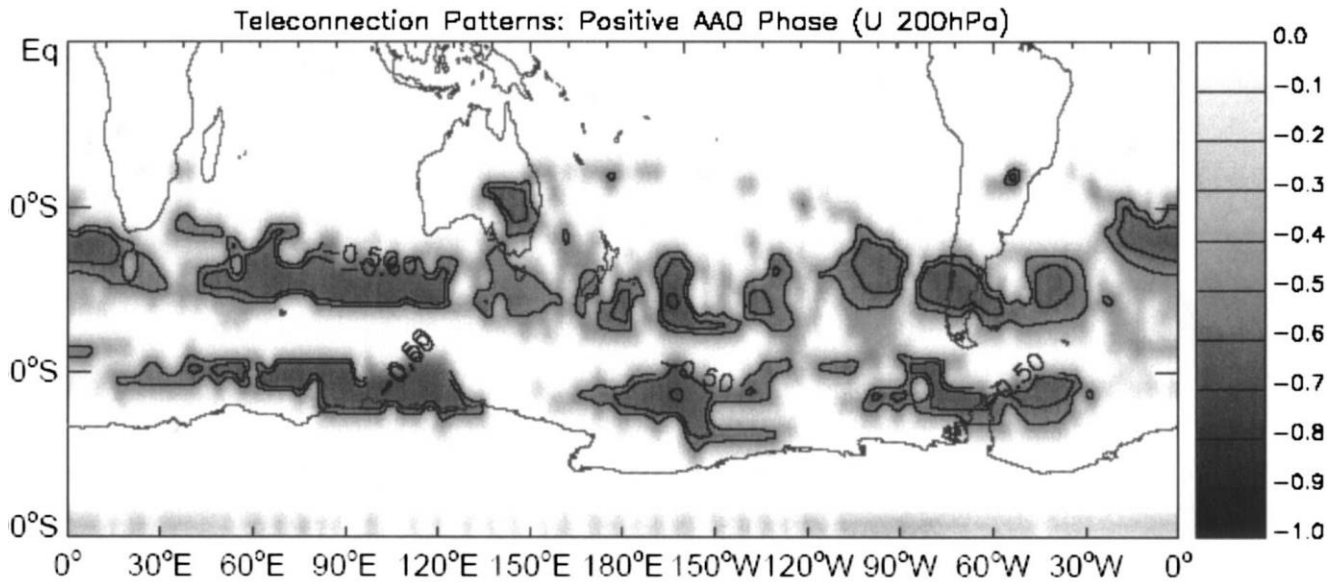

Vento zonal

Thompson and Wallace, 2000

# INFLUÊNCIAS SOBRE A AMÉRICA DO SUL




Fase negativa

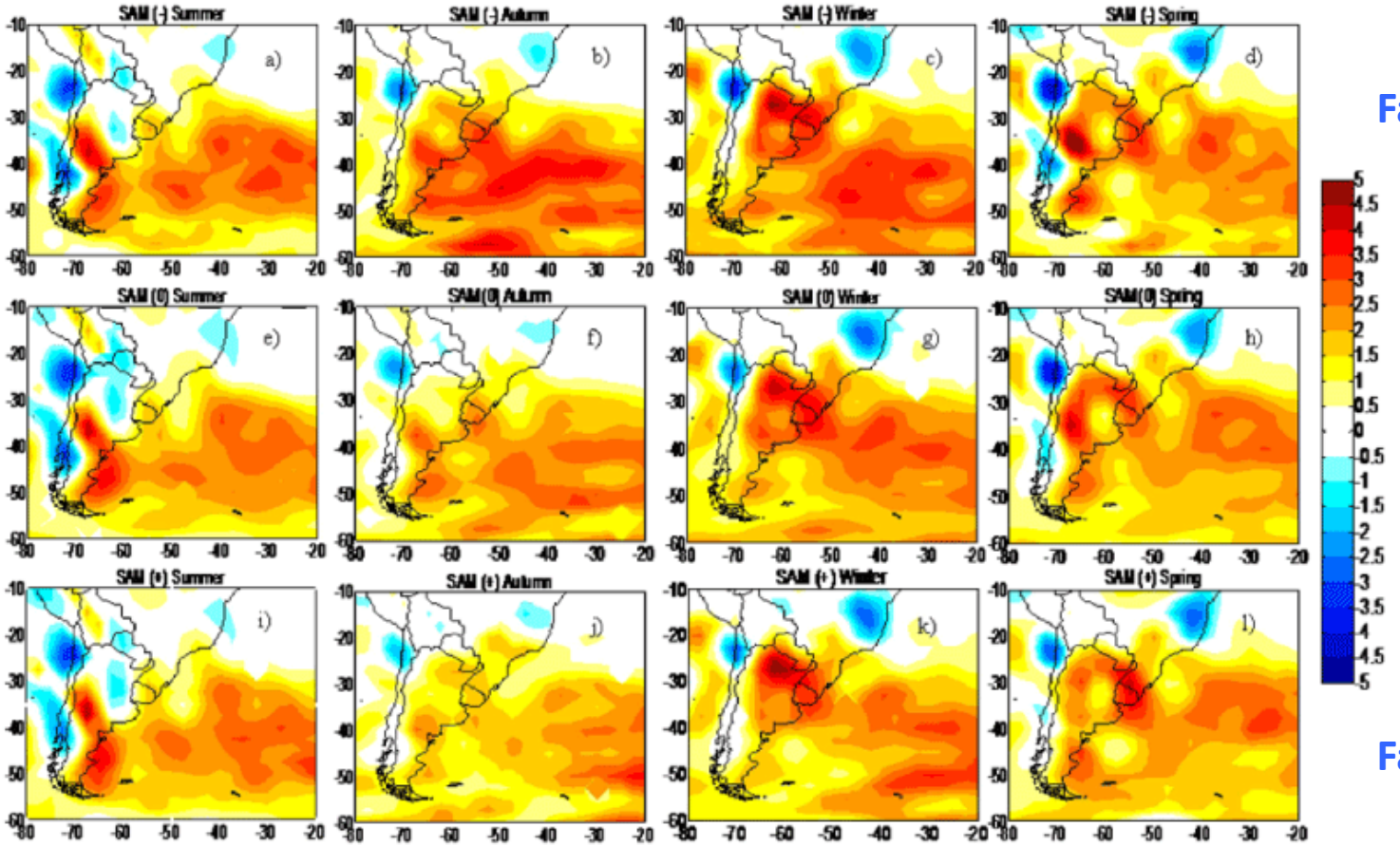



Fase positiva

Carvalho et al (2004)

# INFLUÊNCIAS SOBRE A AMÉRICA DO SUL

Função frontogenética




Fase negativa

Fase neutra

Fase positiva

**Figure 2 -** Frontogenetic function for the negative (a-d), neutral (e-h) and positive (i-l) SAM phases and for the summer (a, e and i), autumn (b, f and j), winter (d, g and k) and spring (d, h and j) seasons in the period 1980-1999. Positive (negative) values indicate frontogenesis (frontolysis). Results were multiplied by 10-11 K $m^{-1}$ $s^{-1}$.

Reboita et al. 2009

# INFLUÊNCIAS SOBRE A AMÉRICA DO SUL

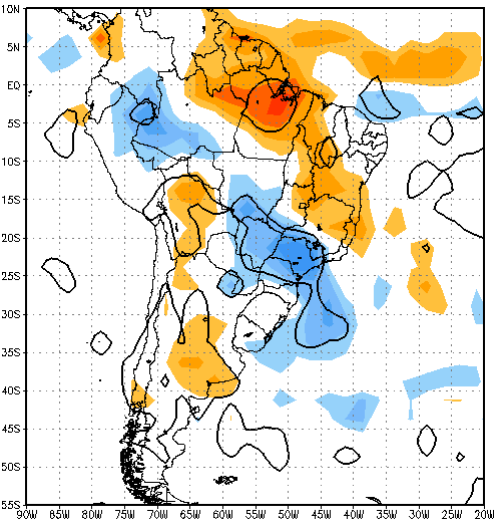
Anomalias de Precipitação

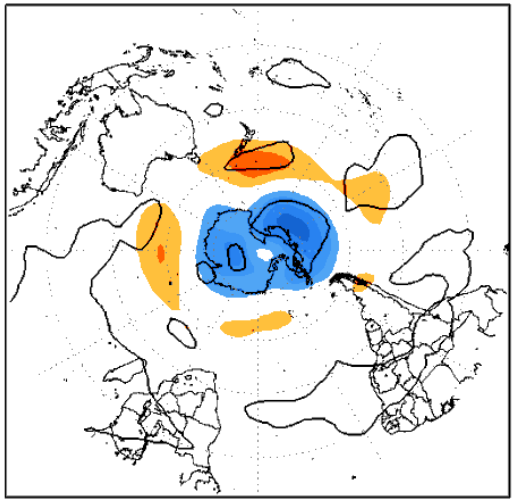
**DJF**

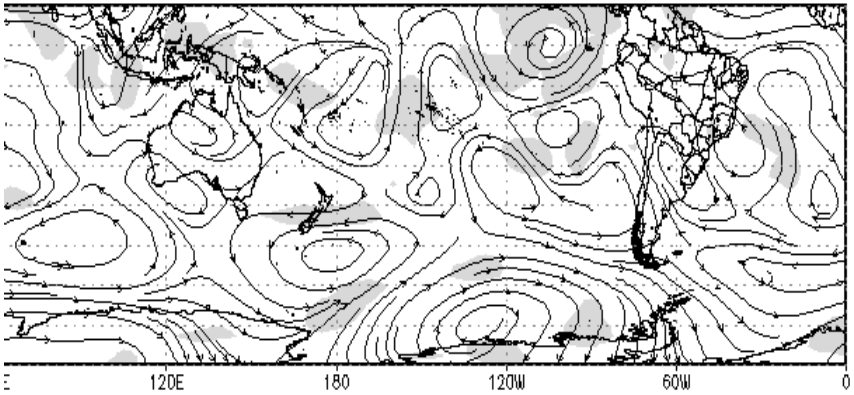
**Ageo 500 hPa**

chuvoso

**200 hPa**

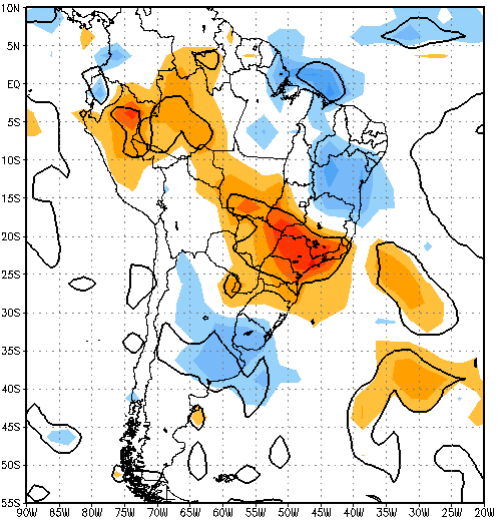


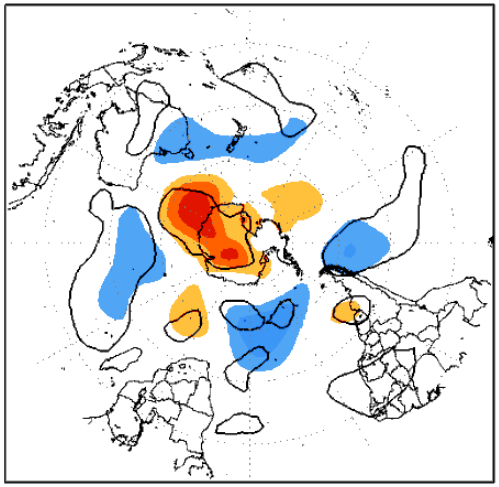



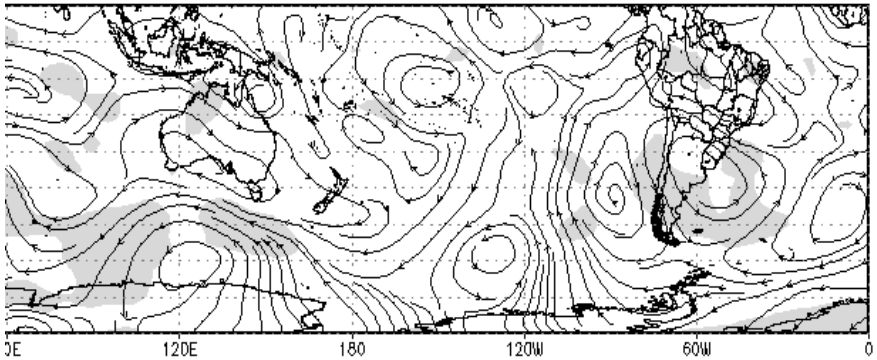



seco

**200 hPa**





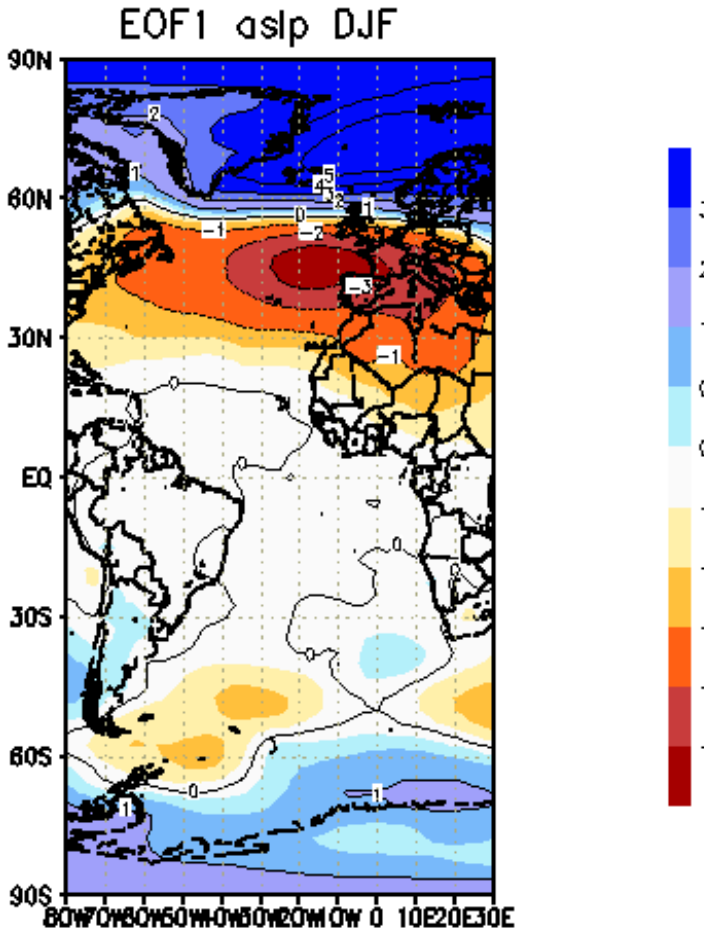

Vasconcellos and Cavalcanti (2009)

**Configuração tipo PSA**

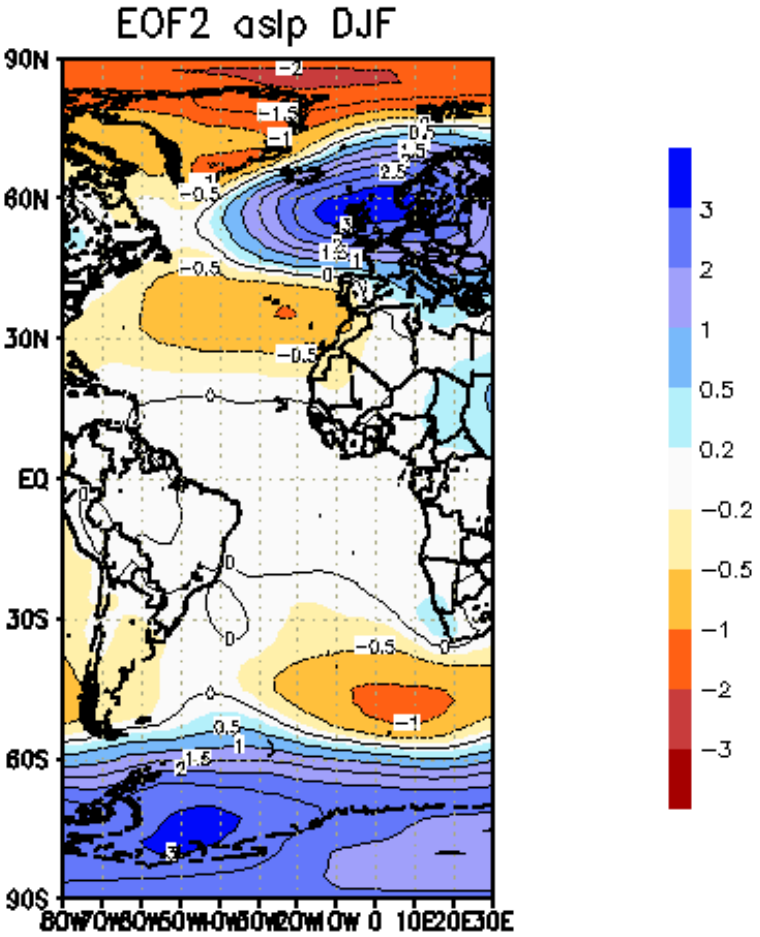
# Influências extratropicais na ZCIT e na precipitação do NE.

# Variabilidade sobre o Oceano Atlântico

## OSCILAÇÃO DO ATLÂNTICO NORTE (NAO)

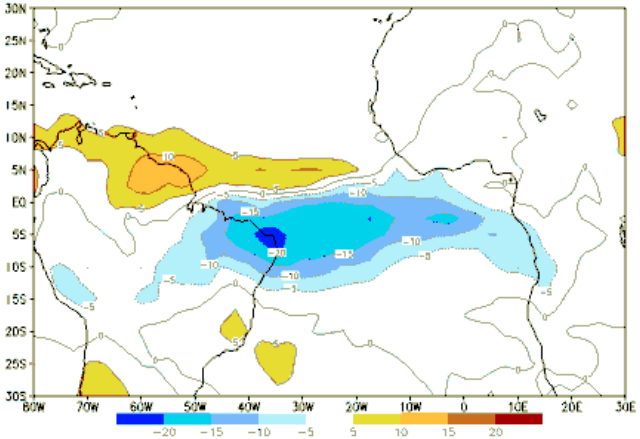



## NAO2

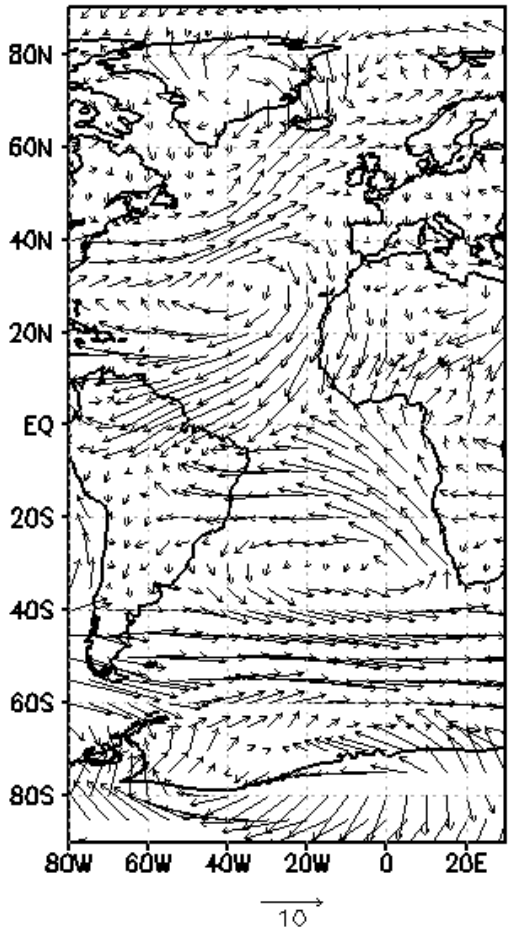


# Posição da ZCIT e influências extratropicais

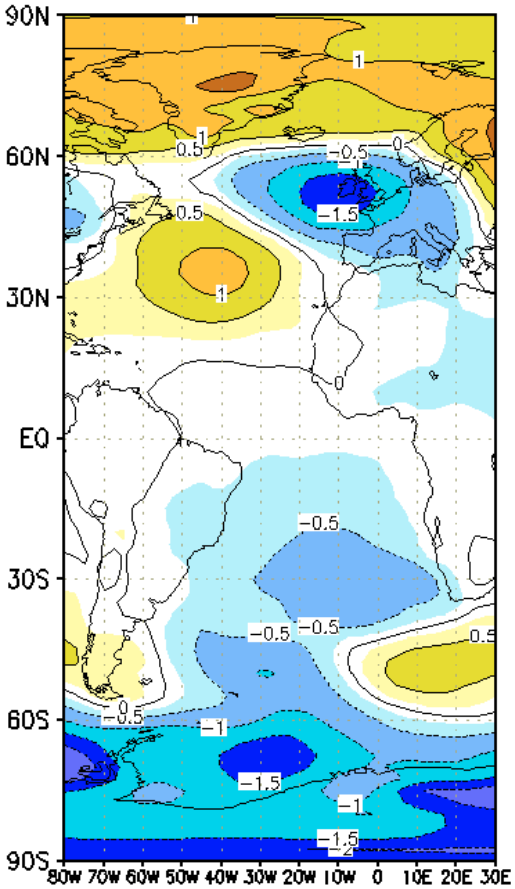
Abril aOLR



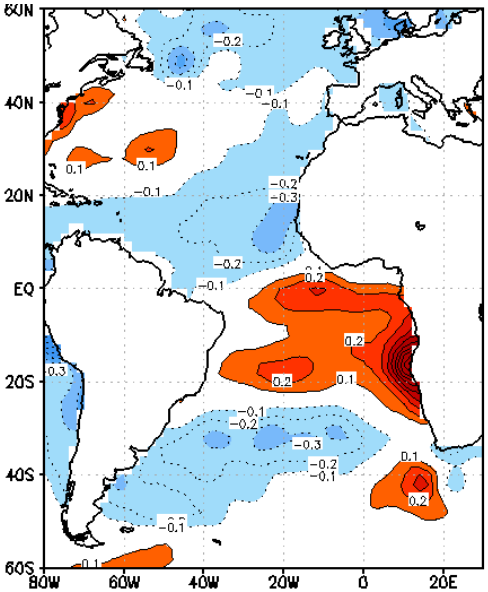
Abril 925 hPa




DJF aSLP

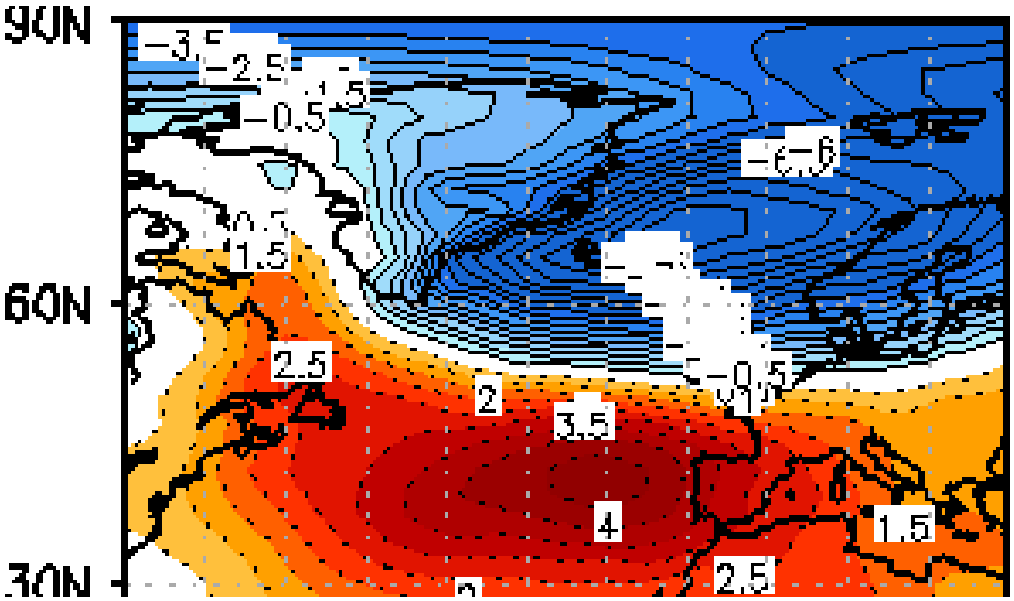



Abril aSST

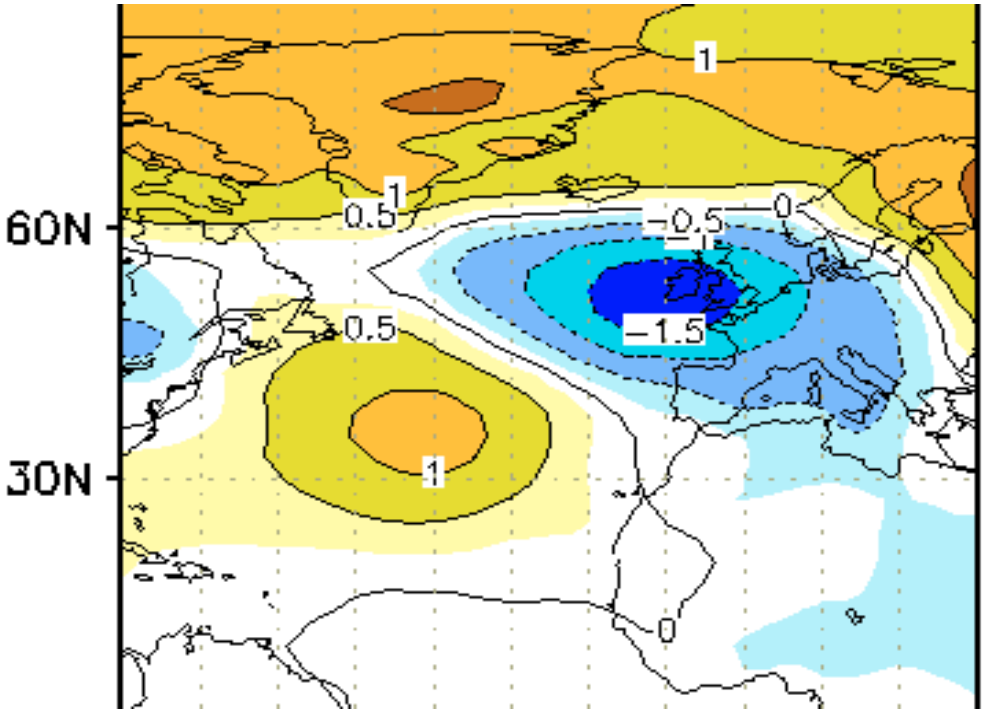



**(Souza and Cavalcanti, 2009)**

# INDICES



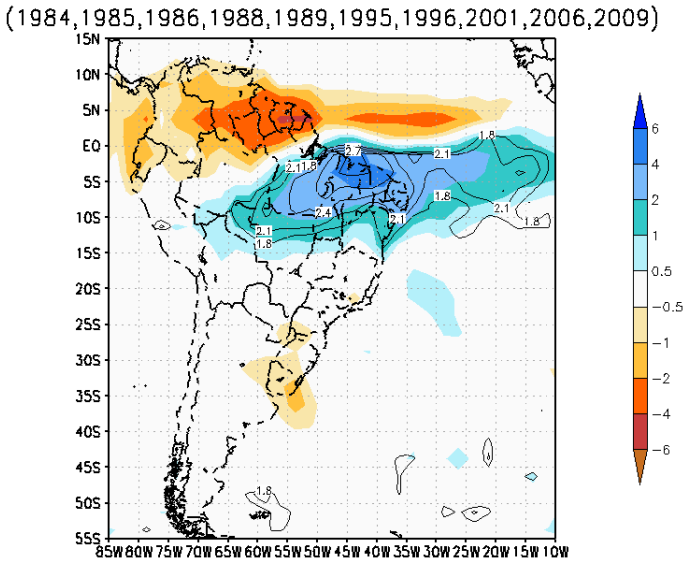

- **NAOI**
- **North Atlantic Oscillation Index**



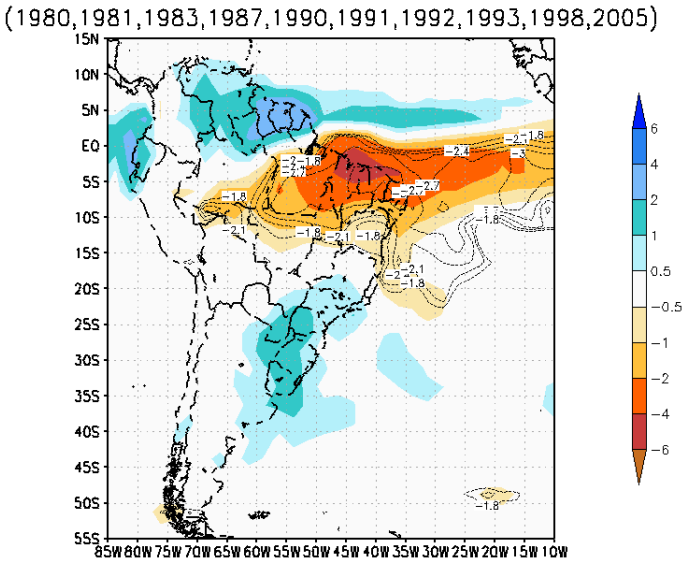

- **NAI**
- **North Atlantic Index**
- **Souza and Cavalcanti (2009)**

# Precipitação Extrema NE e NAO2

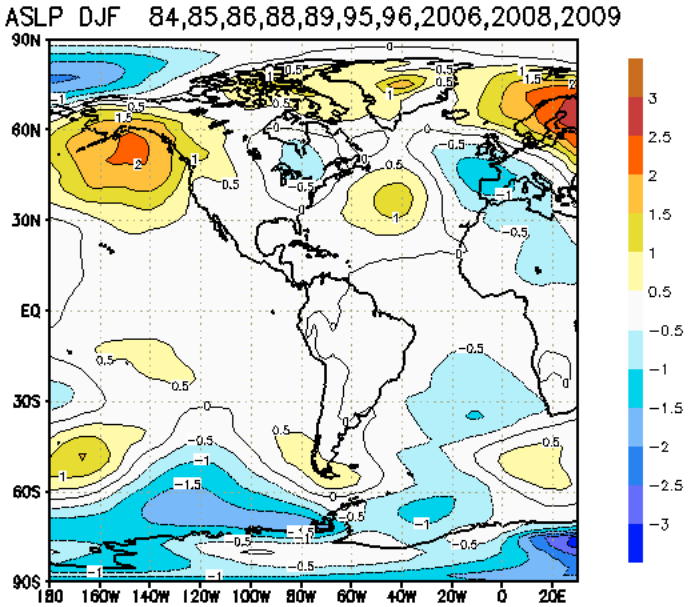
## Anos chuvosos NE em Abril

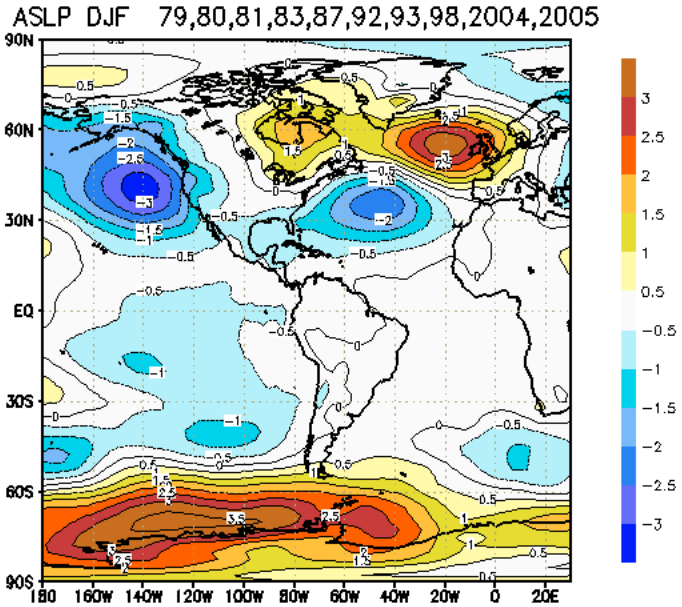



## Anos secos NE em Abril




Mesma configuração em DJF dos centros de ação associados ao NAI

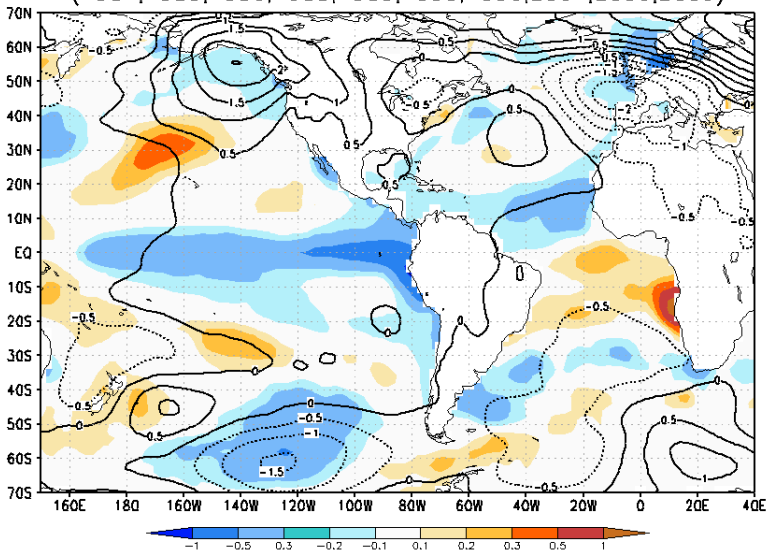


# DJF

## Casos chuvosos em Abril

(1984,1985,1986,1988,1989,1995,1996,2001,2006,2009)

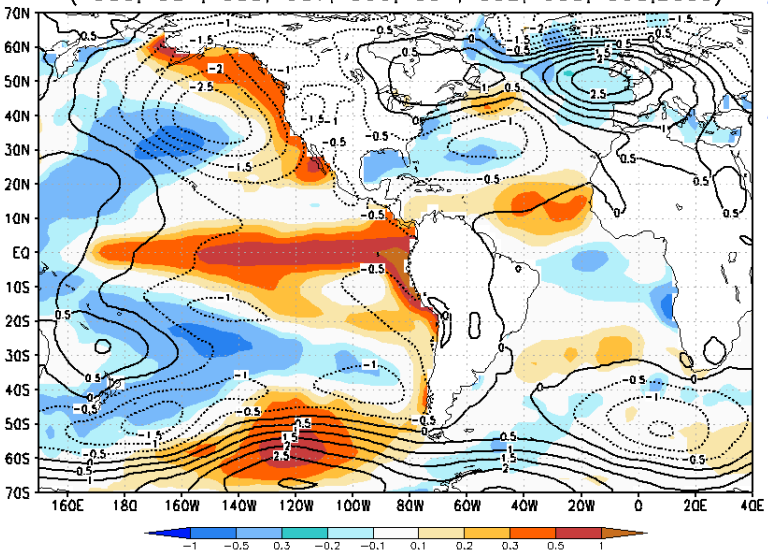



## Casos secos em Abril

(1980,1981,1983,1987,1990,1991,1992,1993,1998,2005)

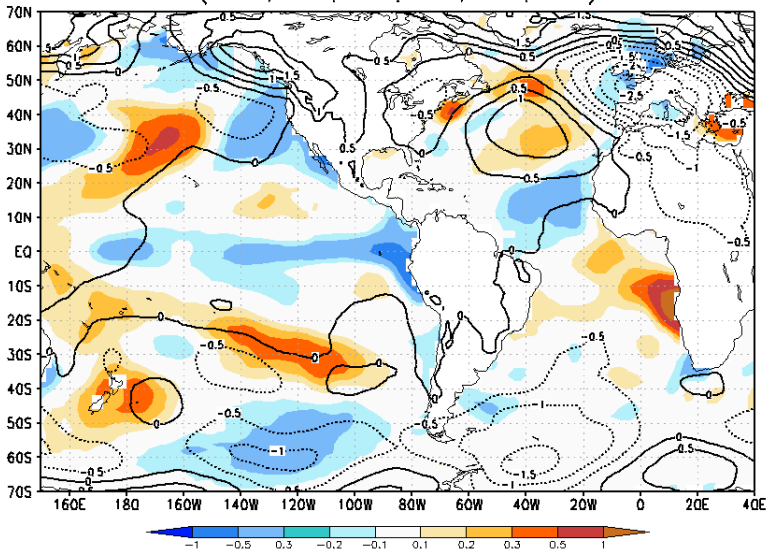
ASST

ASLP



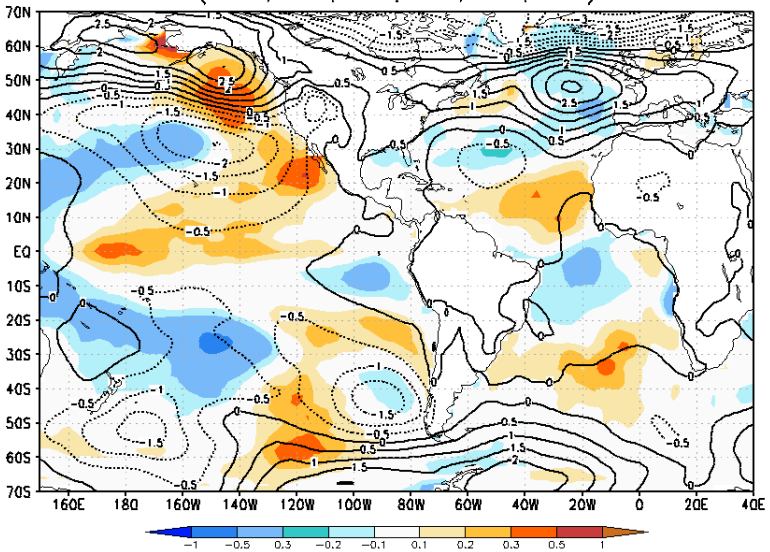

## Sem La Nina

(1984,1986,1995,2001,2006,2009)

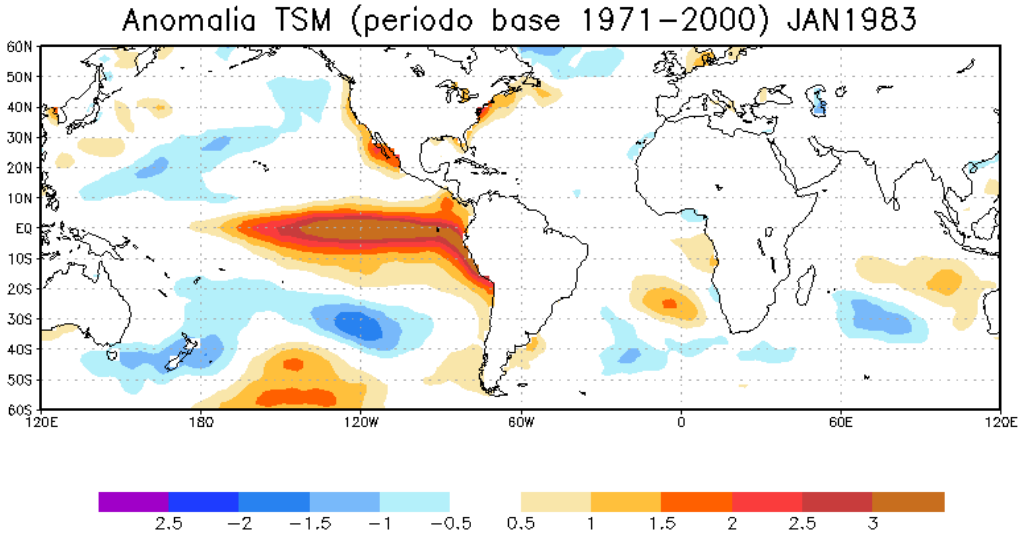



## Sem El Nino

(1980,1981,1990,1991,1993,2005)

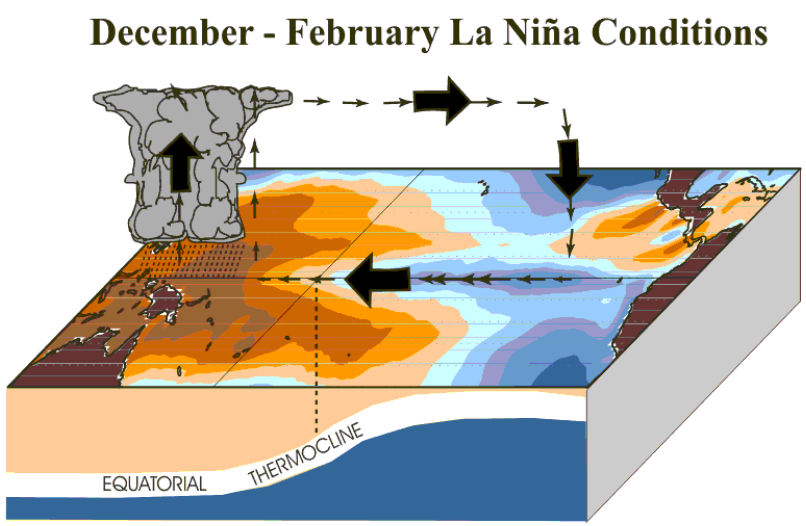


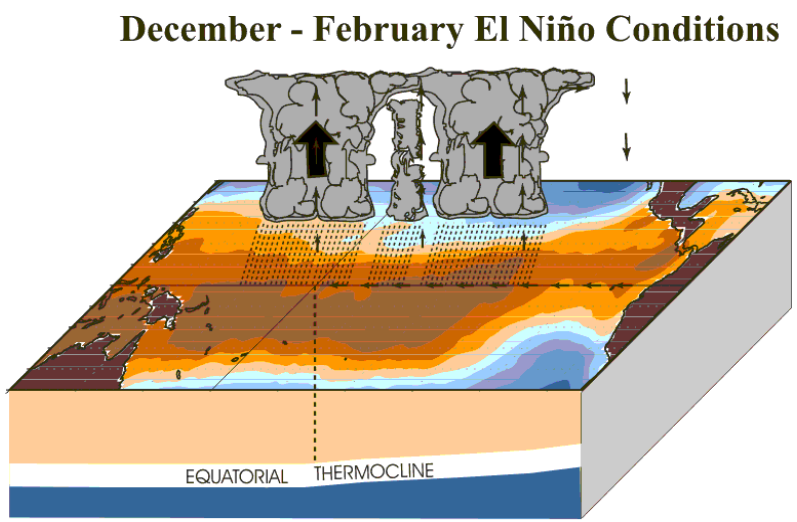
# El Nino- Southern Oscillation (ENSO)




Águas mais quentes que o normal no Pacífico leste e central

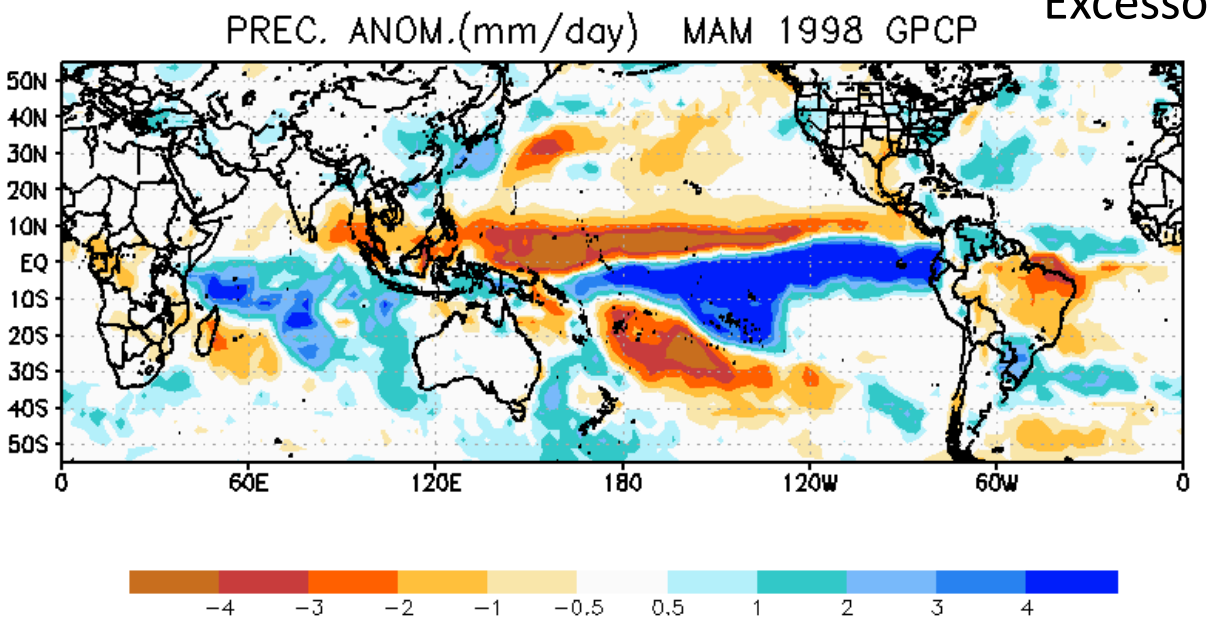
Convecção anômala sobre o Pacífico leste e central

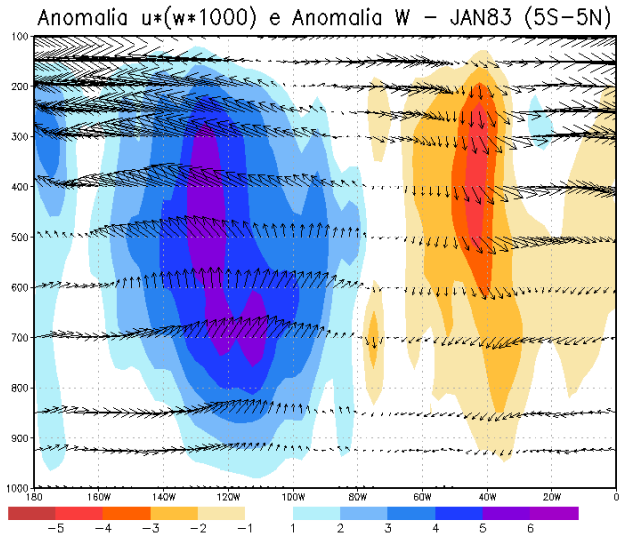


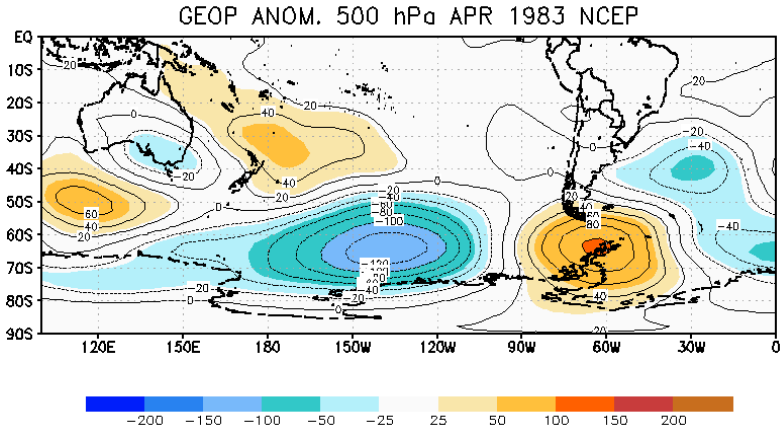



# Influências do El Nino no Brasil

Secas na Amazonia e no Nordeste
Excesso de chuvas no Sul

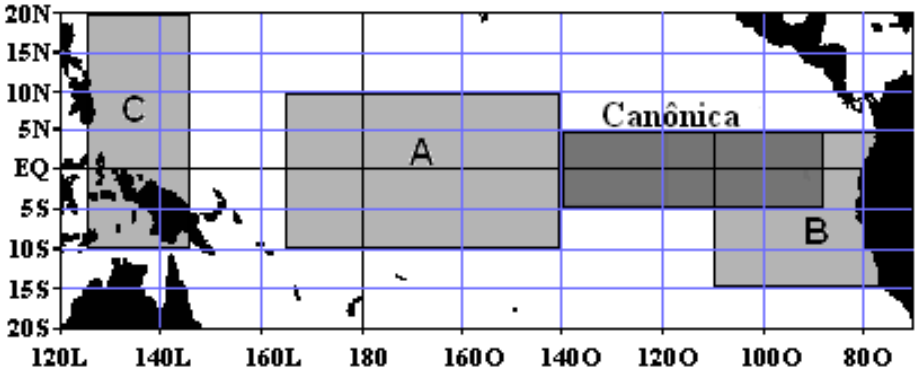


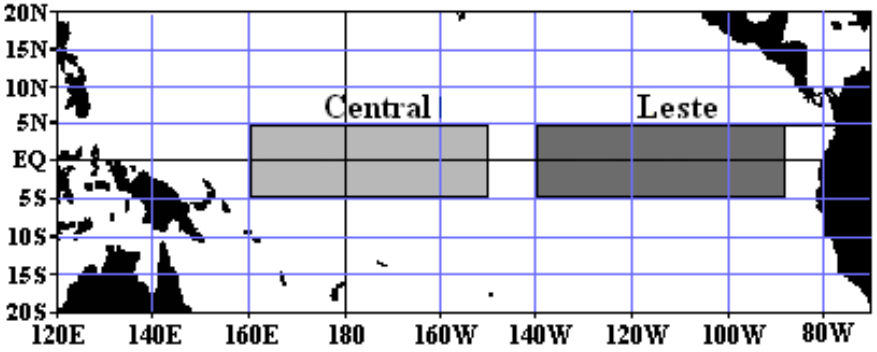



# Tipos diferentes de ENSO

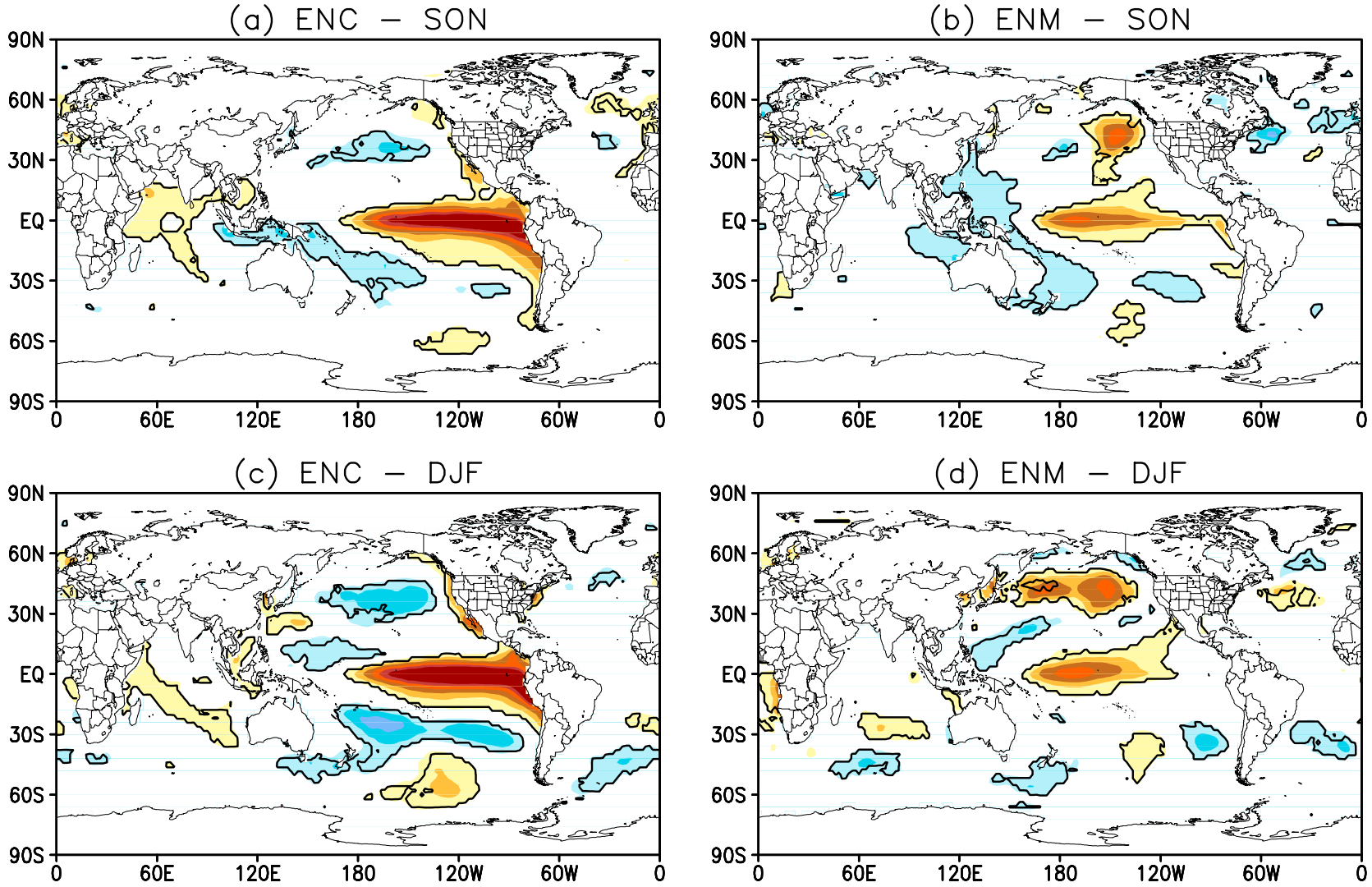
- ENSO Canônico
- ENSO Modoki
- ENSO Modoki+A
- ENSO Central e Leste



# EL Nino Canônico

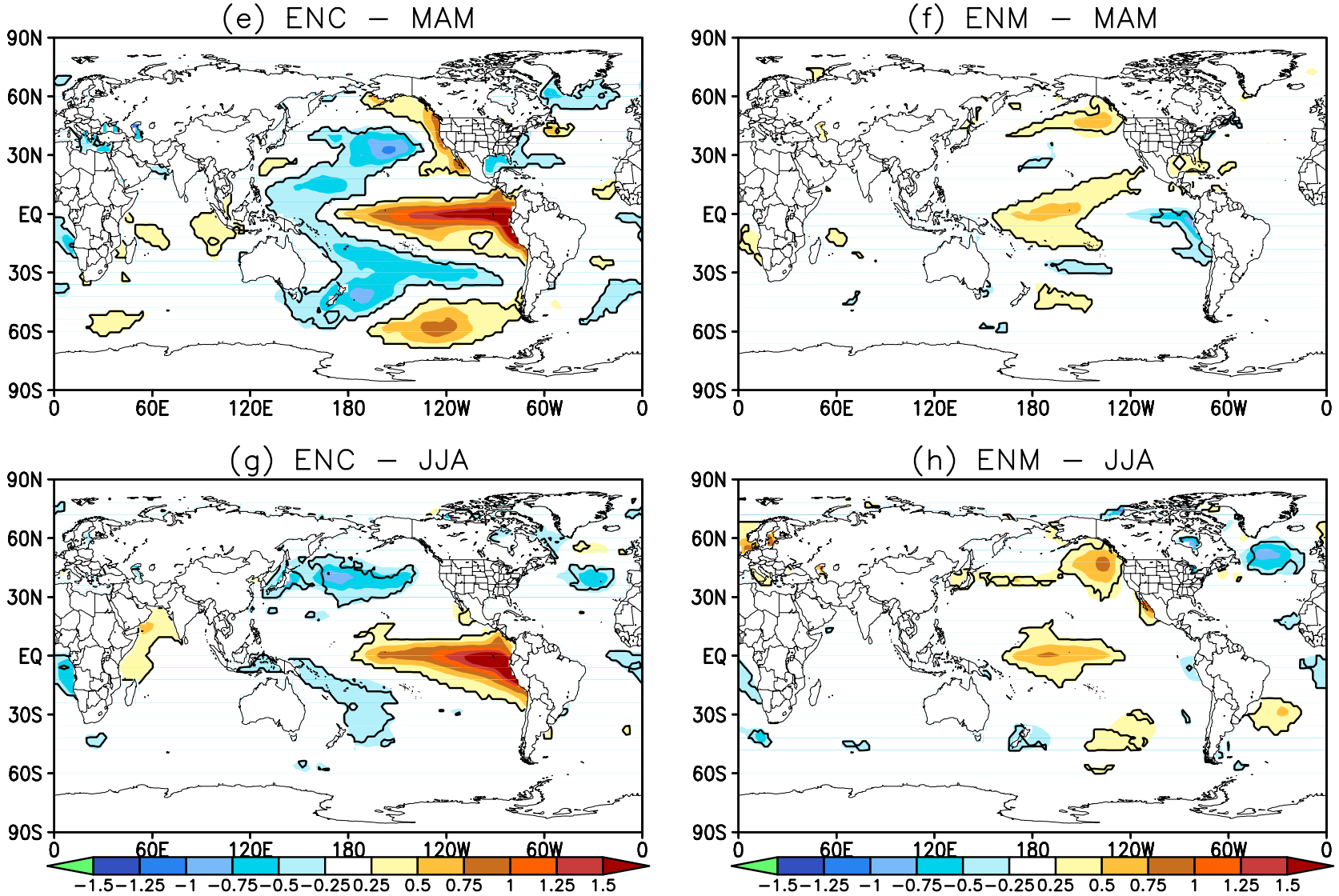
# EL Nino Modoki+A




**Tedeschi et al. 2012**

# EL Nino Canônico

# EL Nino Modoki+A




Tedeschi et al. 2012

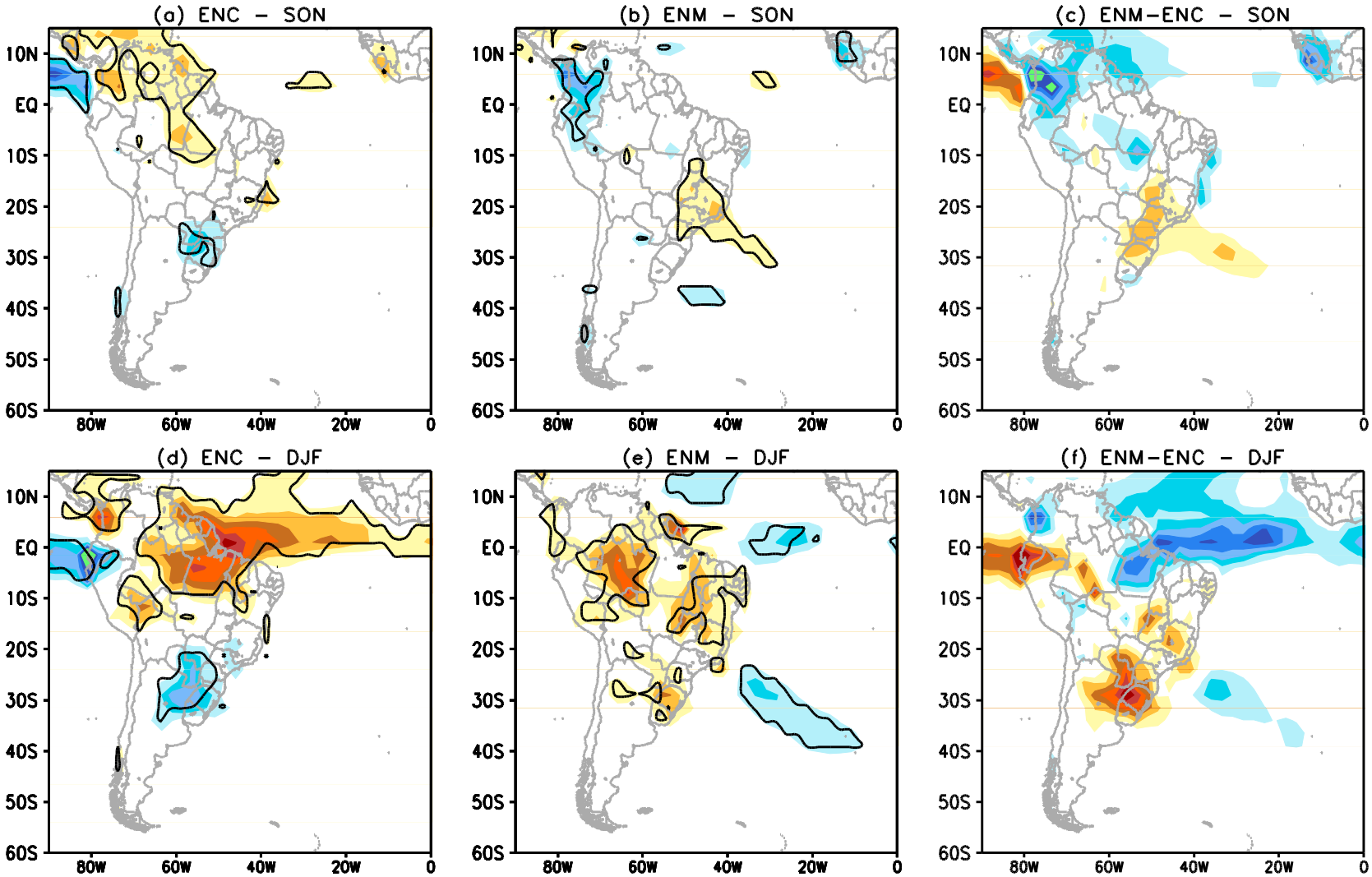
Tedeschi et al. 2012

# Anomalias de Precipitação

## EL Nino Canônico

## EL Nino Modoki+A

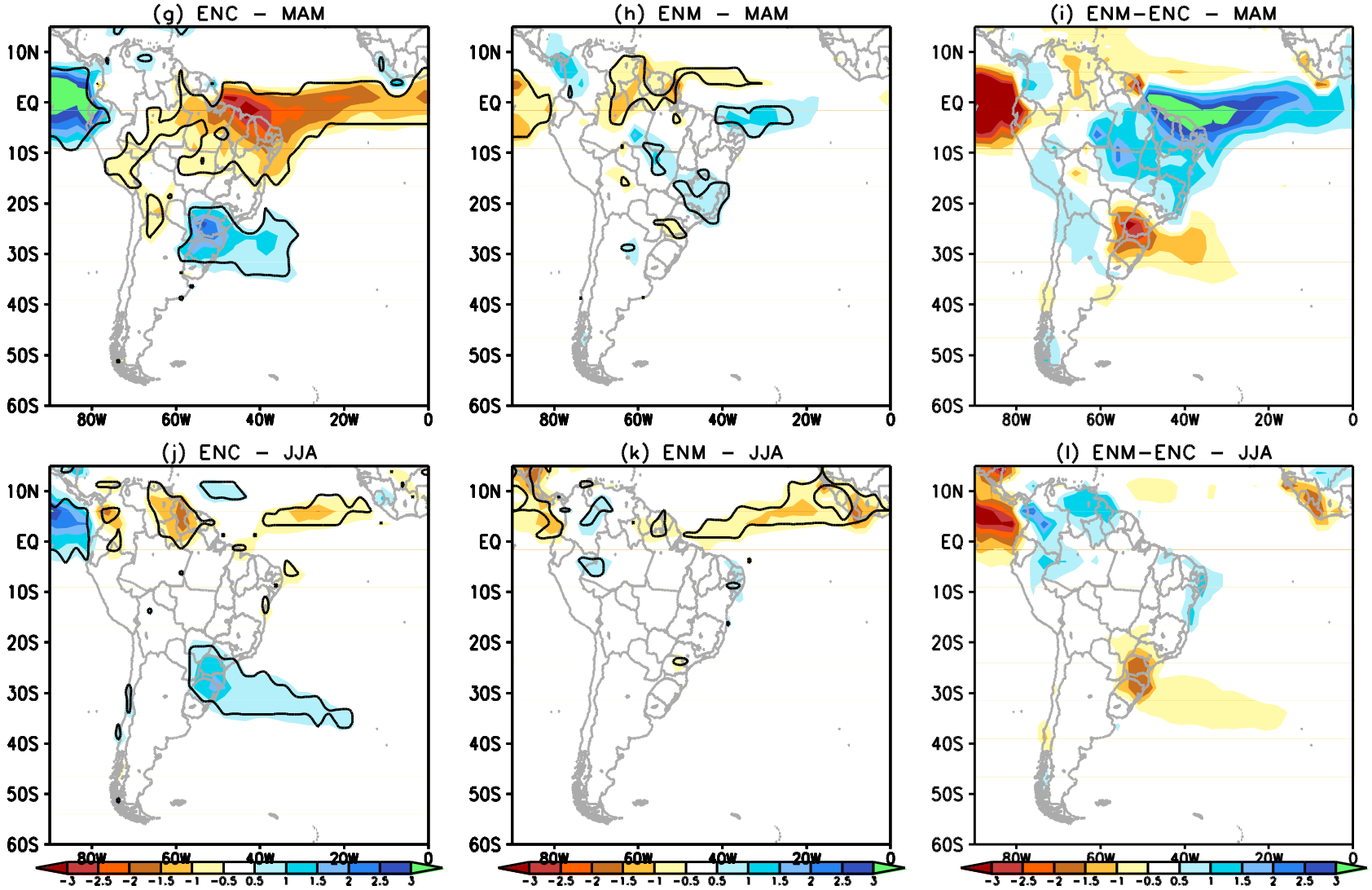
## Difere(Modoki+A)-Canônico



Tedeschi et al. 2012

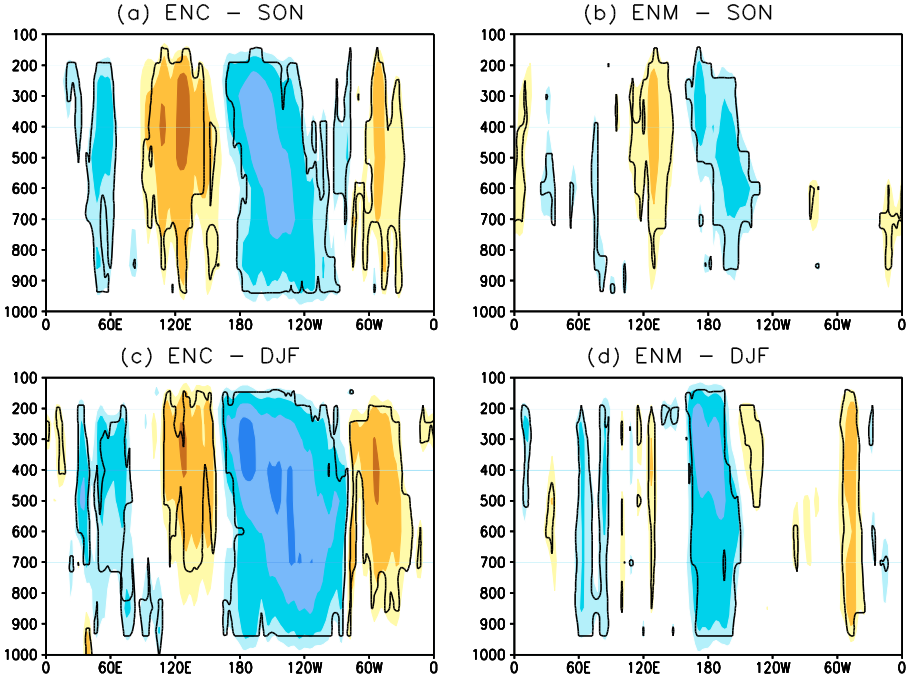
# Anomalias de Precipitação

## EL Nino Canônico | EL Nino Modoki+A | Difere(Modoki+A)-Canônico

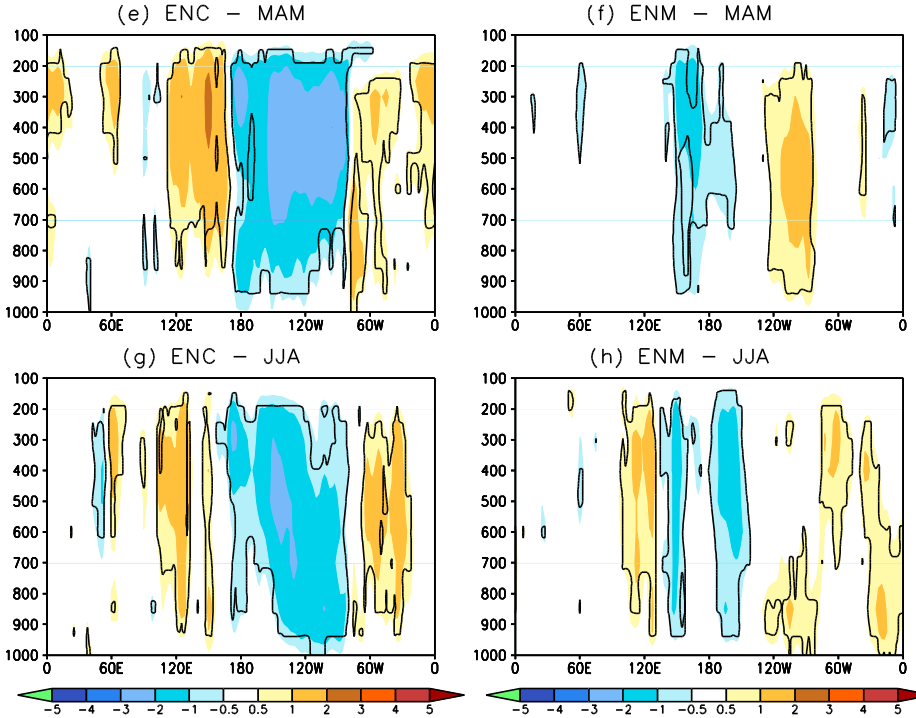


# Movimentos ascendentes e subsidentes

**EL Nino Canônico** **EL Nino Modoki+A**



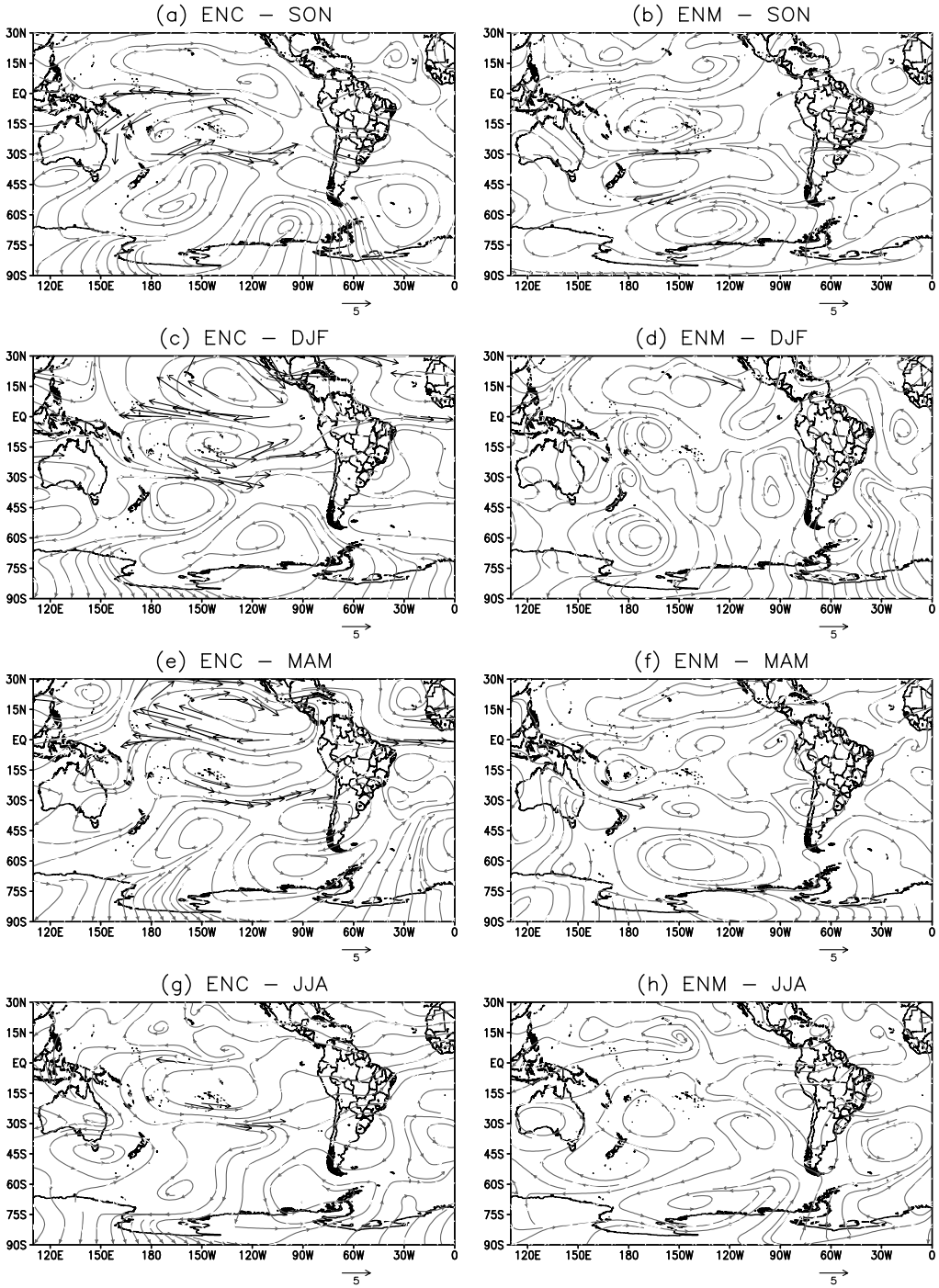

**EL Nino Canônico** **EL Nino Modoki+A**




**Tedeschi et al. 2012**

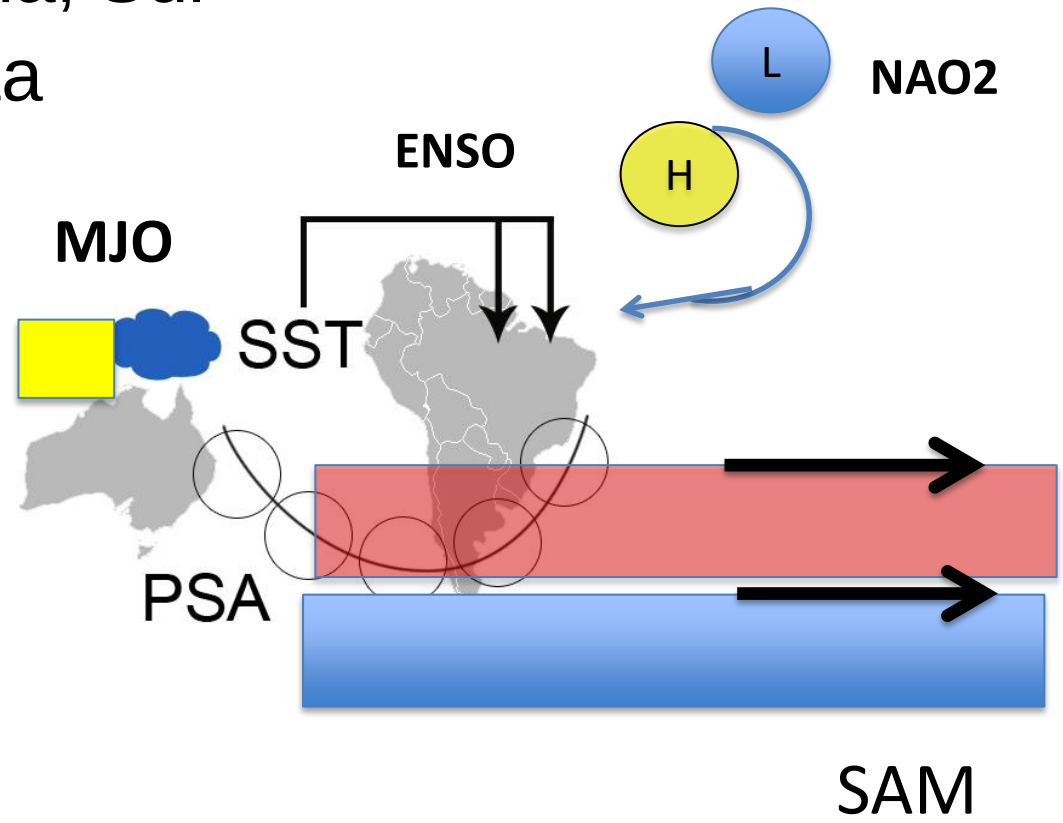
# Escoamento em 200 hPa

**Diferenças nos centros dos trens de onda nos 2 casos, implicando em circulações anômalas diferentes sobre o sul do Brasil**




**Tedeschi et al. 2012**

# Conclusão

Teleconexões na atmosfera têm influência na precipitação em diversas regiões da América do Sul e Brasil, como

- ENSO :  NE, Amazônia, Sul
- PSA: SE, Sul, La Plata
- MJO: NE, SE, Sul
- SAM: Sul, SE
- NAO2: NE