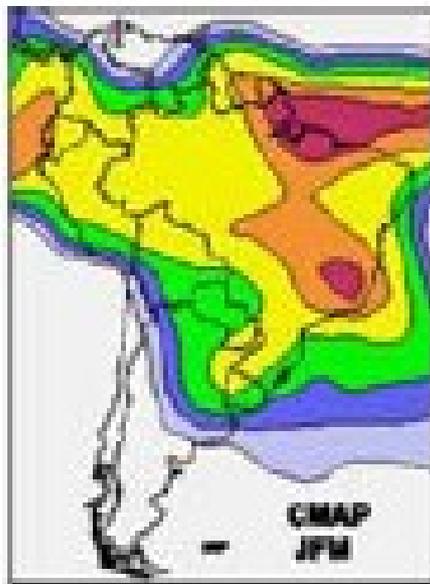


# Variabilidad interanual y decaderial

# Variabilidad Interanual de las Lluvias

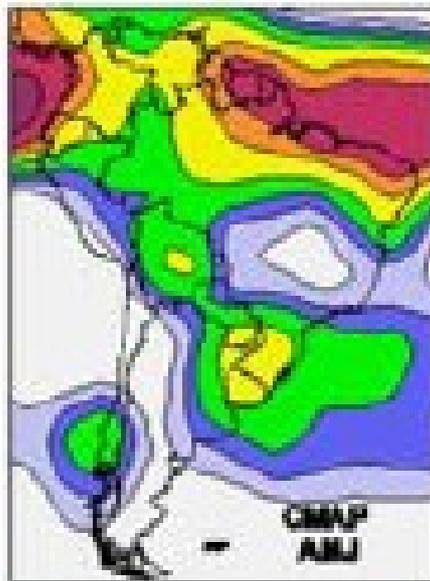
(a)

JFM



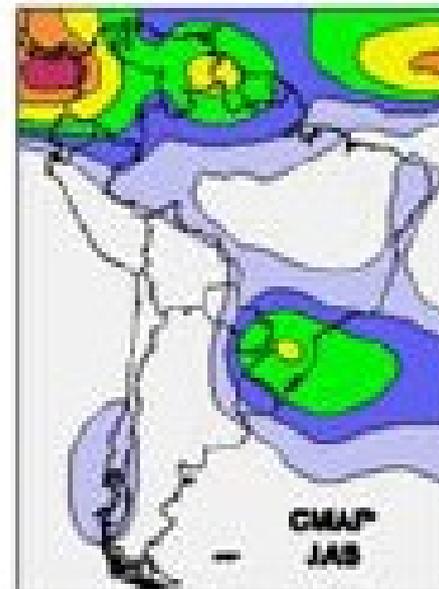
(b)

AMJ



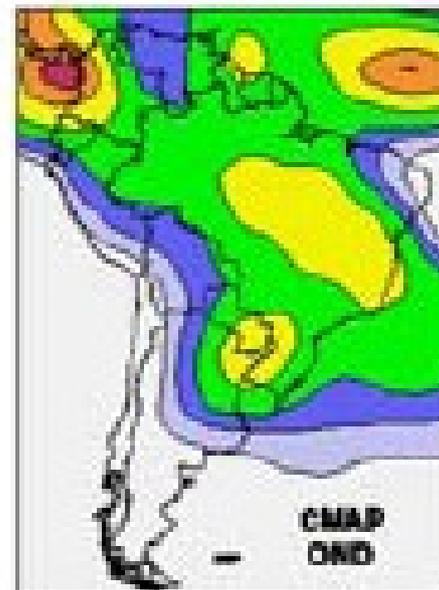
(c)

JAS



(d)

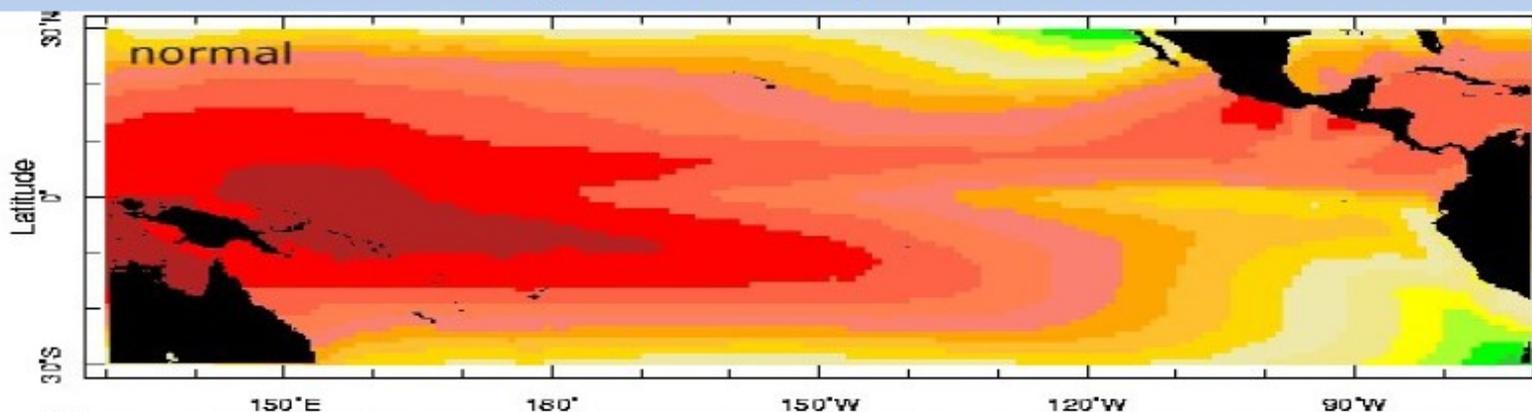
OND



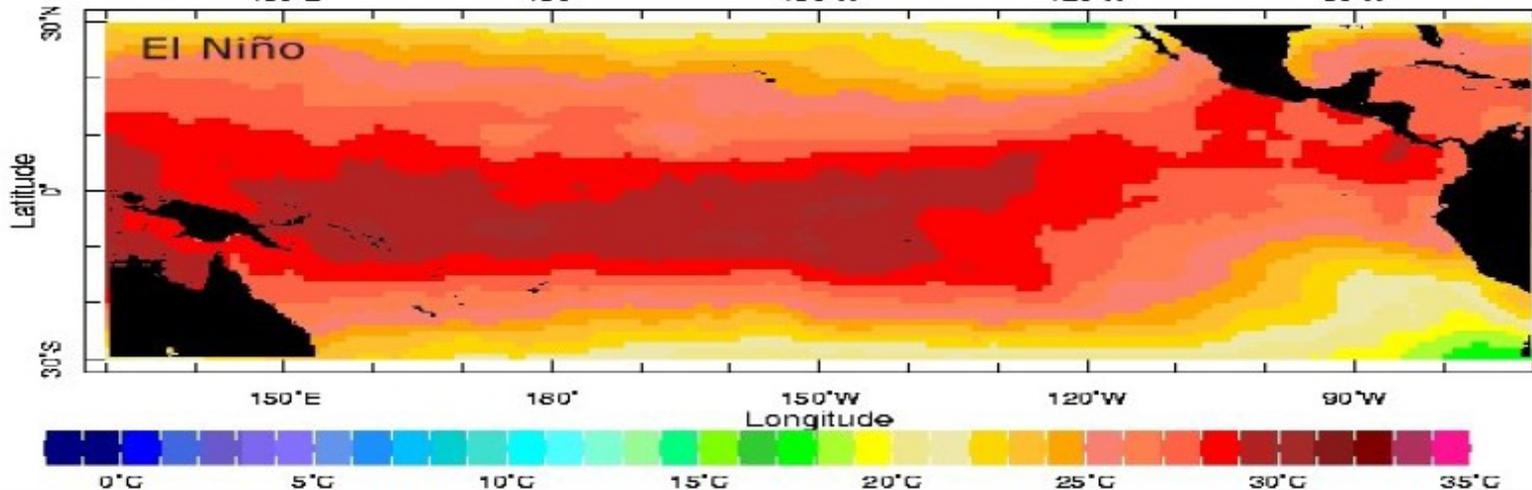
# El Niño-Oscilación Sur

Temperatura de superficie del mar

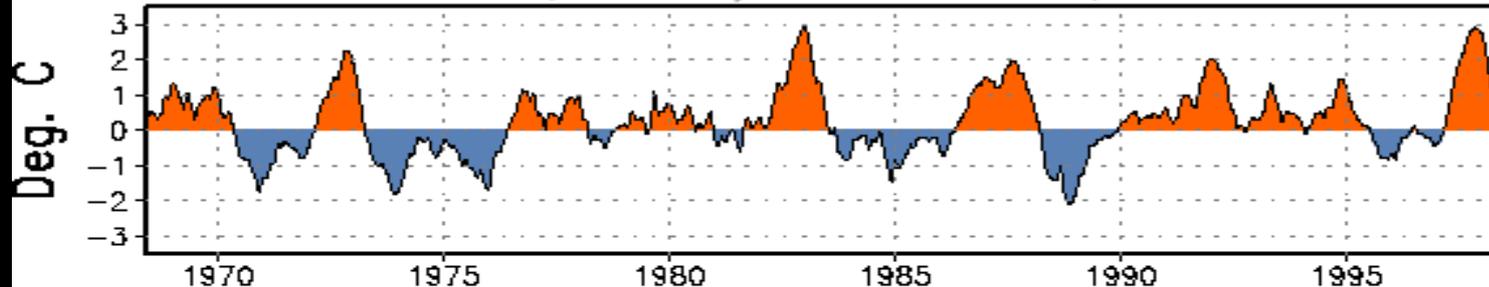
Diciembre  
promedio



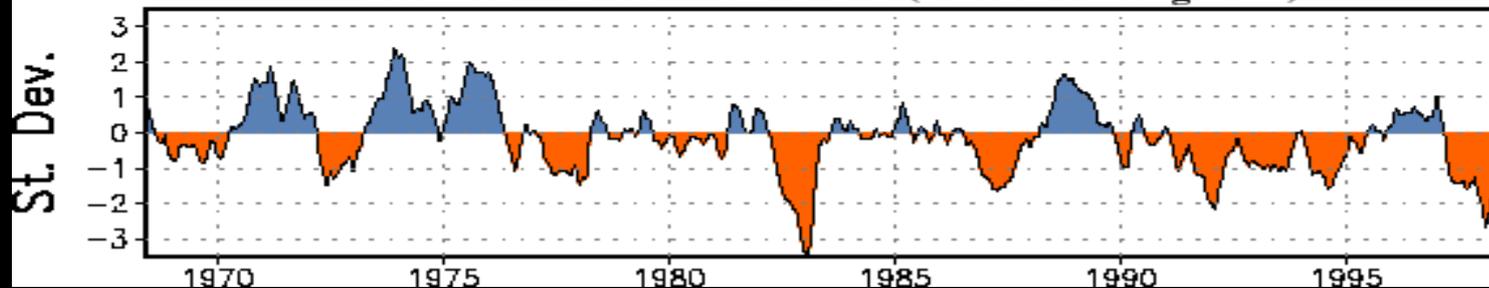
Diciembre 82



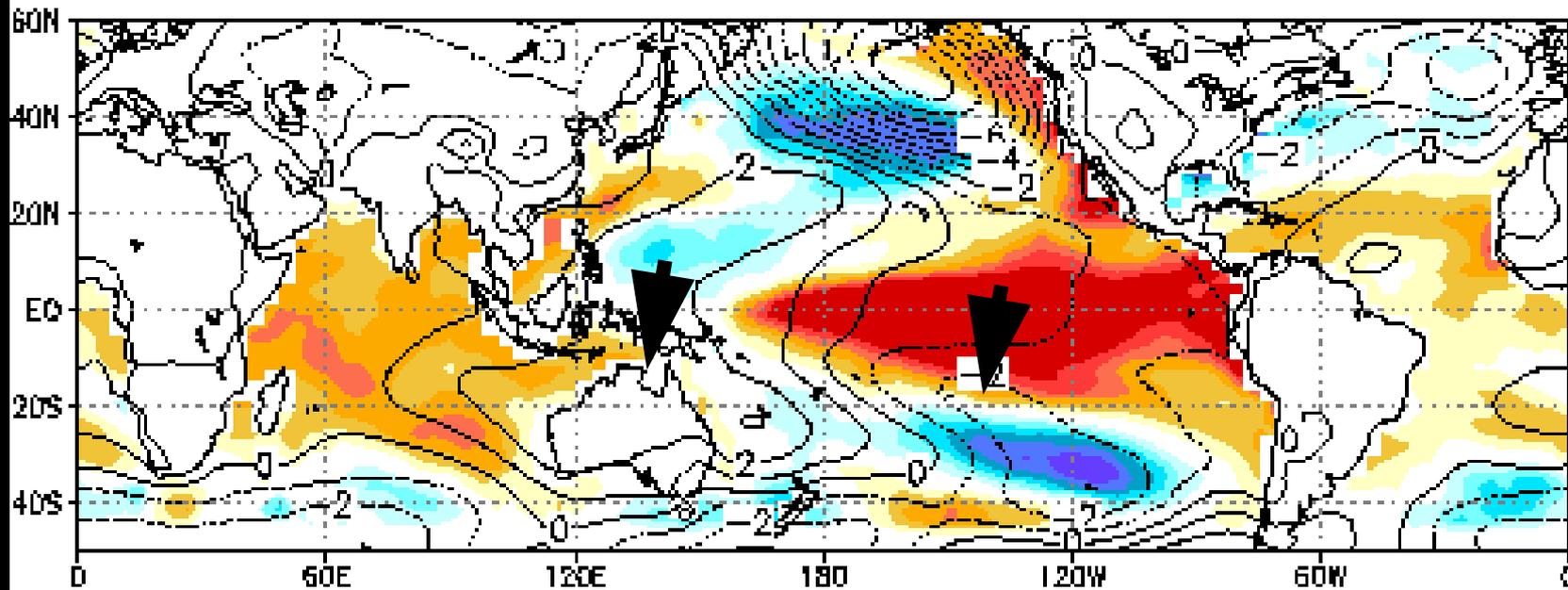
### Ocean Temperature Departures (°C) for Niño 3.4 (5°N-5°S, 170°W-120°W)



### Tahiti - Darwin SOI (3 month-running mean)



### Observed SLP (mb) / SST (°C)



# Aceituno 1988

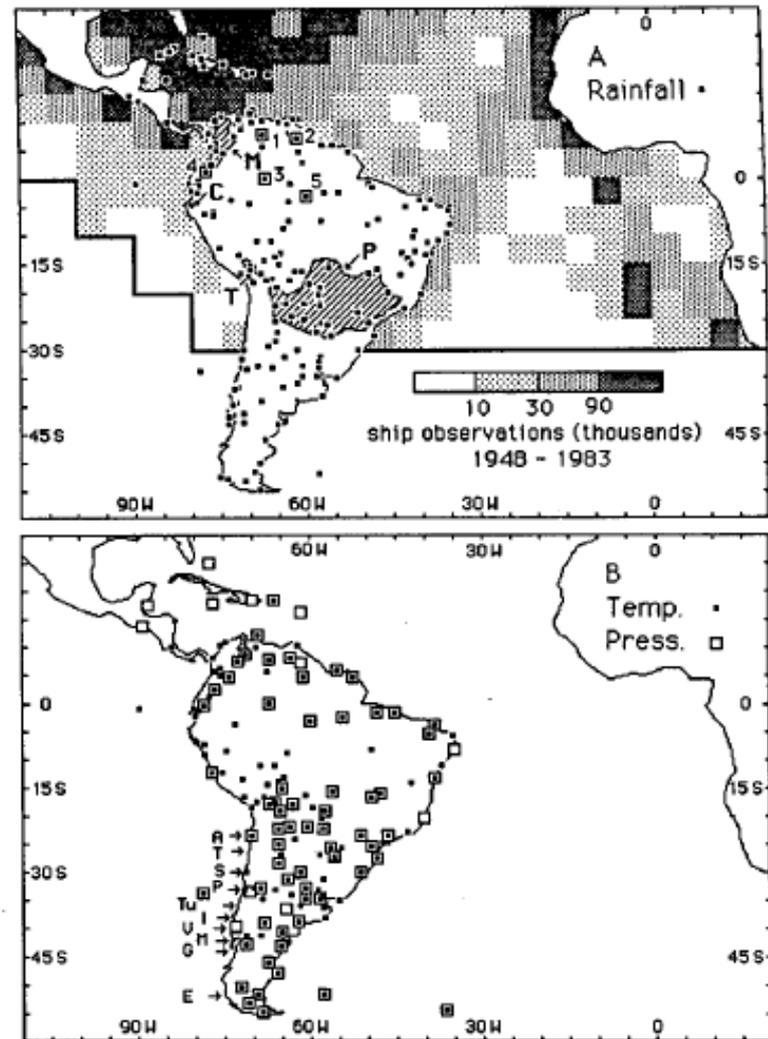


FIG. 1. Orientation maps. (a) Rainfall stations are indicated by dots. Squares and numbers identify stations referred to in Table 2 (1: San Fernando; 2: Ciudad Bolivar; 3: Uaupes; 4: Ospina Pérez; 5: Manaus); the catchments for the Magdalena, Chira, and Paraná rivers, and Lake Titicaca are indicated by the letters M, C, P and T, respectively, and the boundary of area covered by ship observations by heavy solid line; dot rasters (explanation inside the figure) indicate number of ship observations for 5-deg square areas during 1948-83. (b) Stations with temperature (dots) and pressure (squares) observations. Arrows and letters along the coast of Chile indicate stations used in the analysis of meridional pressure profiles referred to in Table 1. A: Antofagasta, T: Taltal, L: La Serena, P: Punta Angeles, Tu: Punta Tumbes, I: Isla Mocha, V: Valdivia, M: Puerto Montt, G: Isla Guafo, E: Evangelistas.

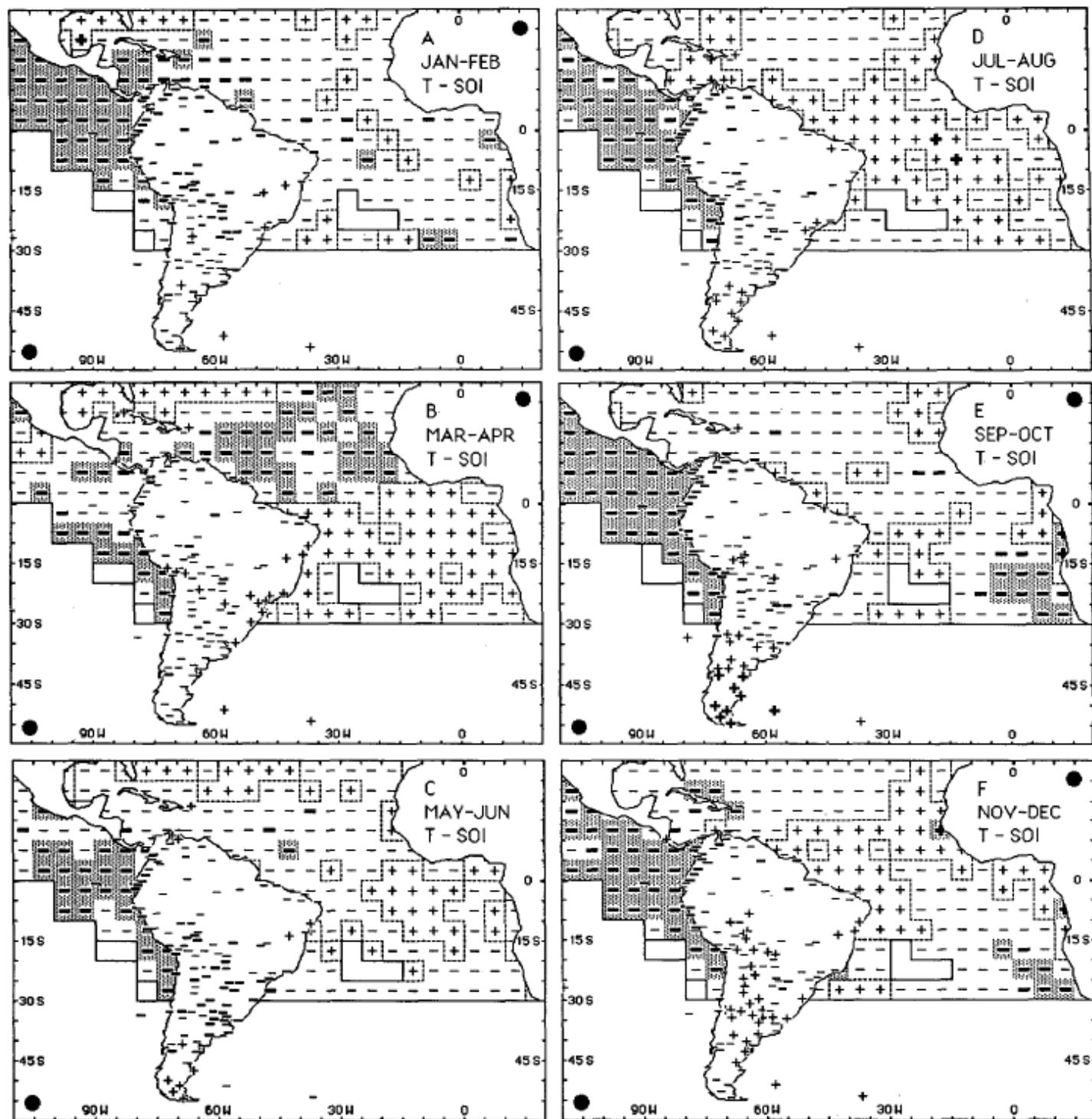


FIG. 8. Patterns of correlation between a Southern Oscillation index (Parker, 1983) and sea surface temperature as well as air temperature at land stations for bi-monthly intervals during 1948-83. (a) January-February, (b) March-April, (c) May-June, (d) July-August, (e) September-October, and (f) November-December. Symbols as in Fig. 5.

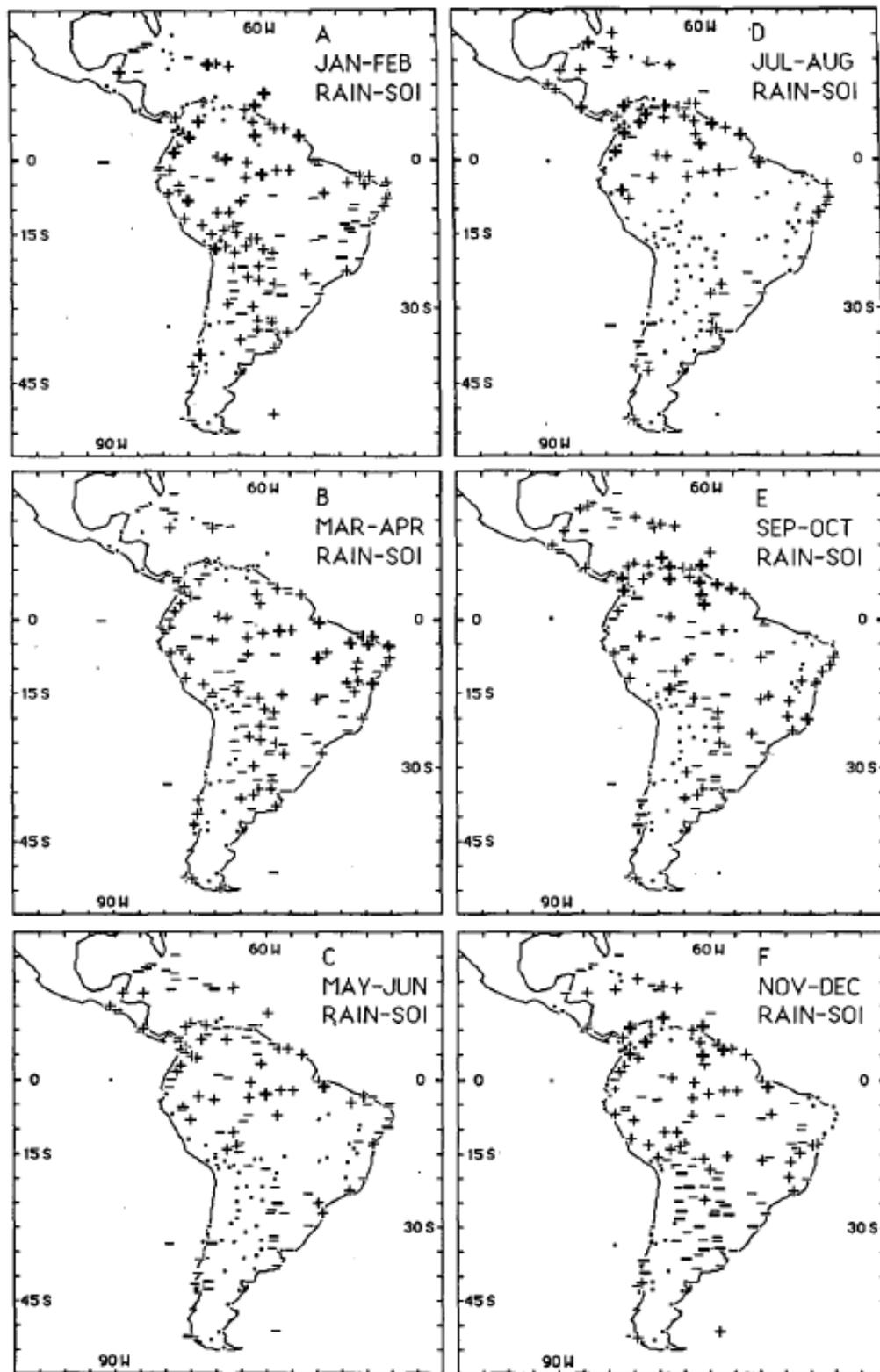


FIG. 9. Patterns of correlation between a Southern Oscillation index (Parker, 1983) and station rainfall. (a) January–February, (b) March–April, (c) May–June, (d) July–August, (e) September–October, and (f) November–December. Plus and minus signs denote the sign of the correlation, and boldface type marks values locally significant at the 5 percent level. Quenouille's (1952, p. 168) method was used to account for the reduction of effective degrees of freedom due to persistence. Dots indicate stations with less than 100 mm of rain for the bi-monthly interval.



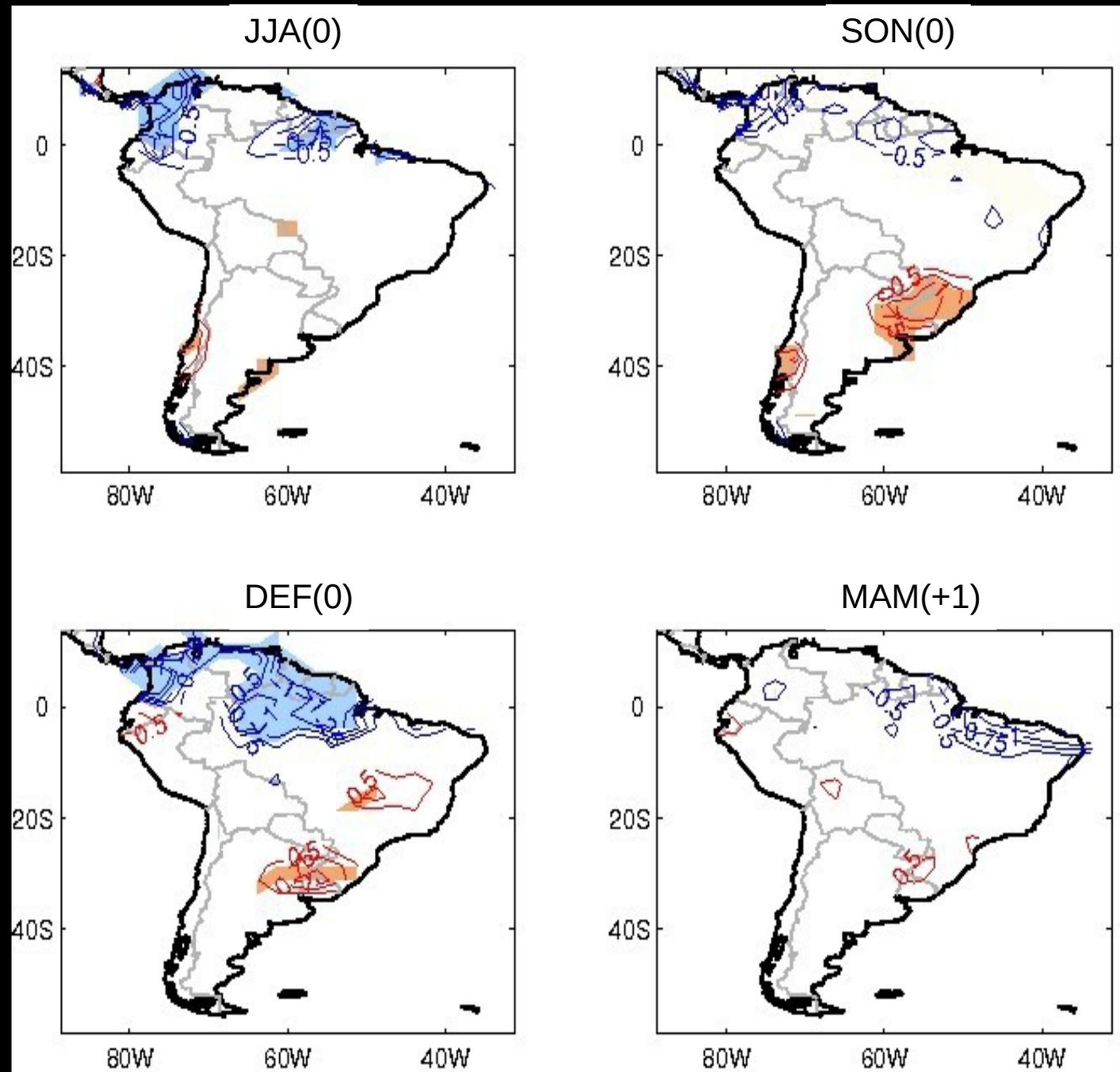
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# Influencia promedio de El Niño

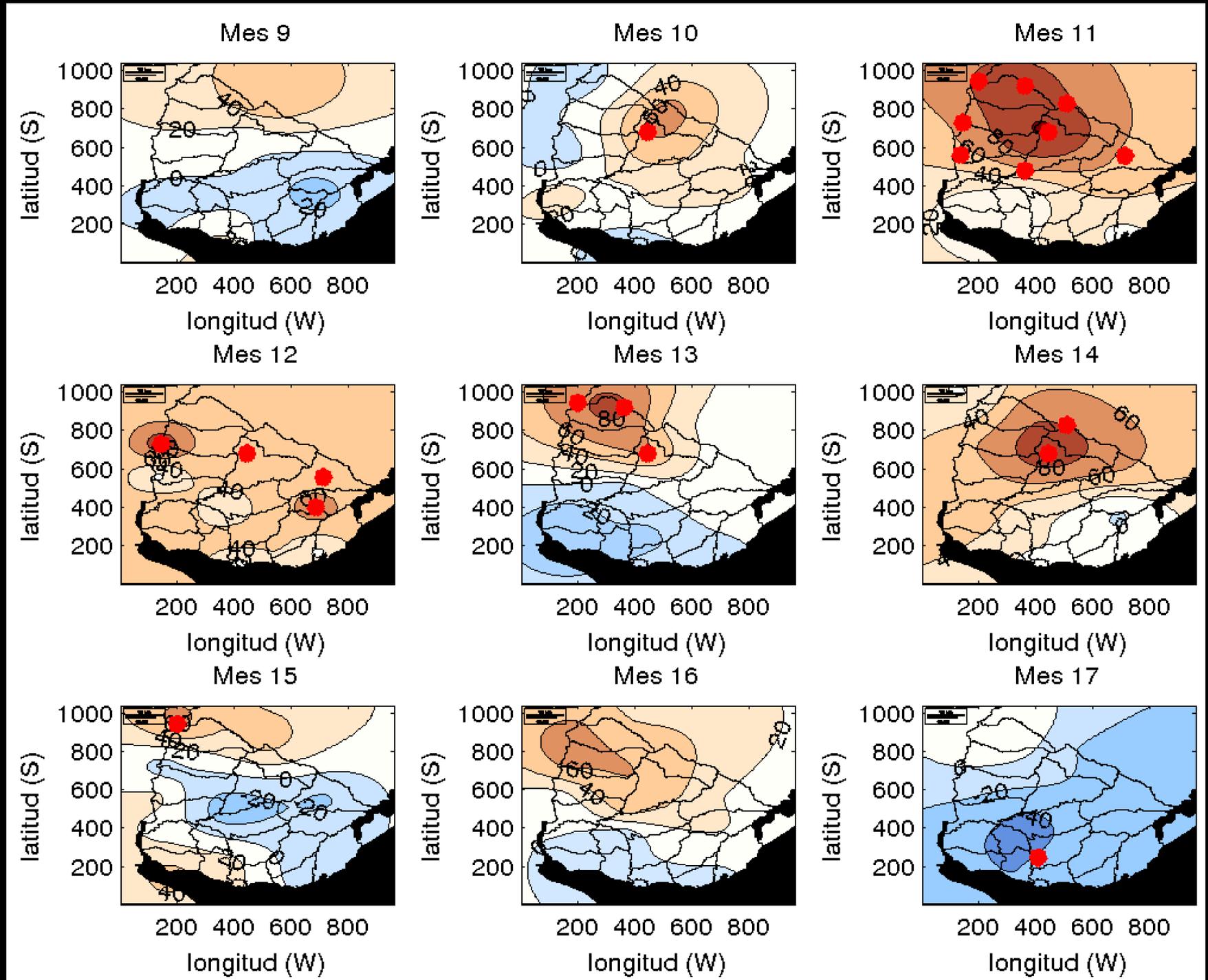
Históricamente  
El Niño induce  
anomalías de lluvias  
sobre Sudamérica.

Cuenca del Plata:  
lluvias por encima  
de lo normal durante  
primavera y verano.

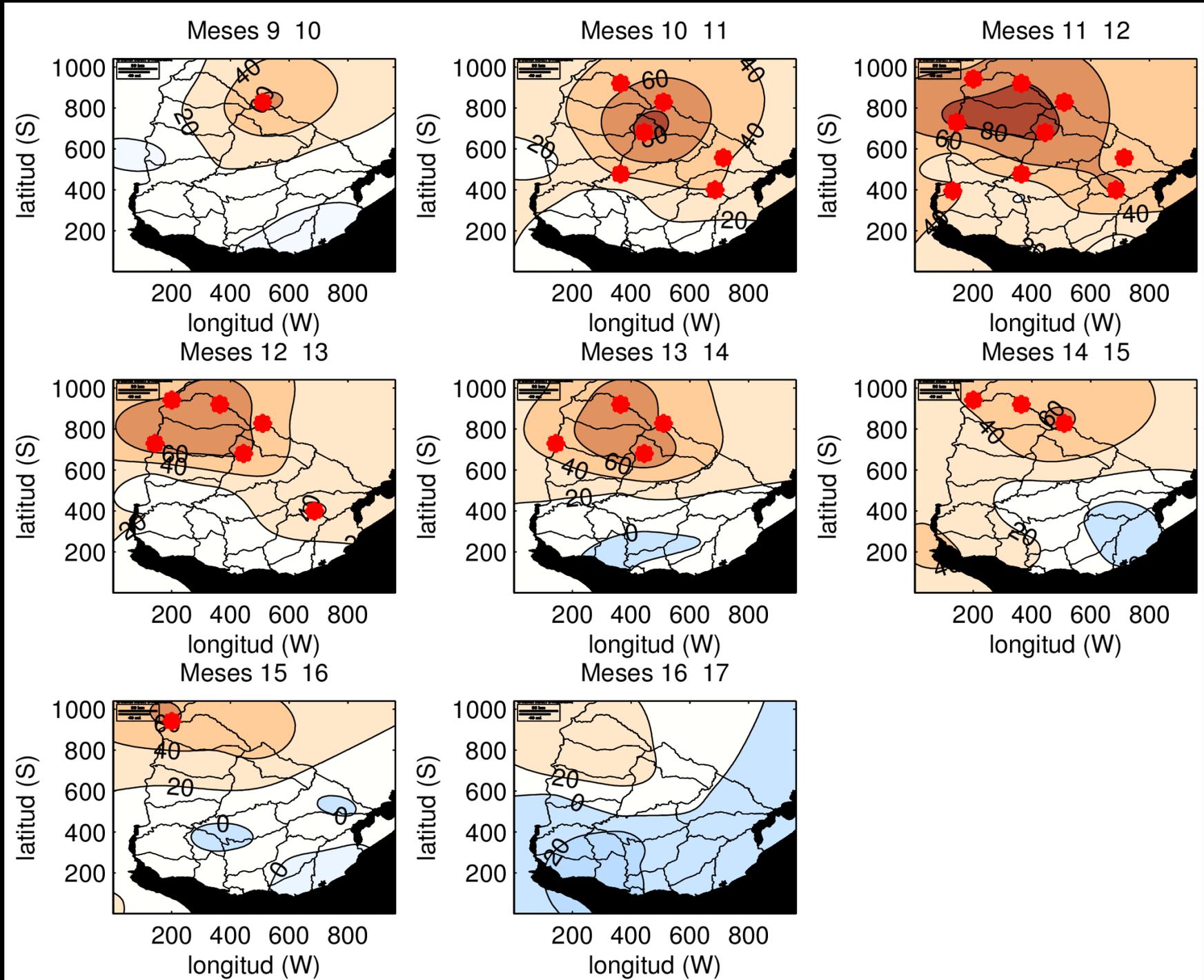
La Niña induce  
anomalías aprox.  
opuestas.



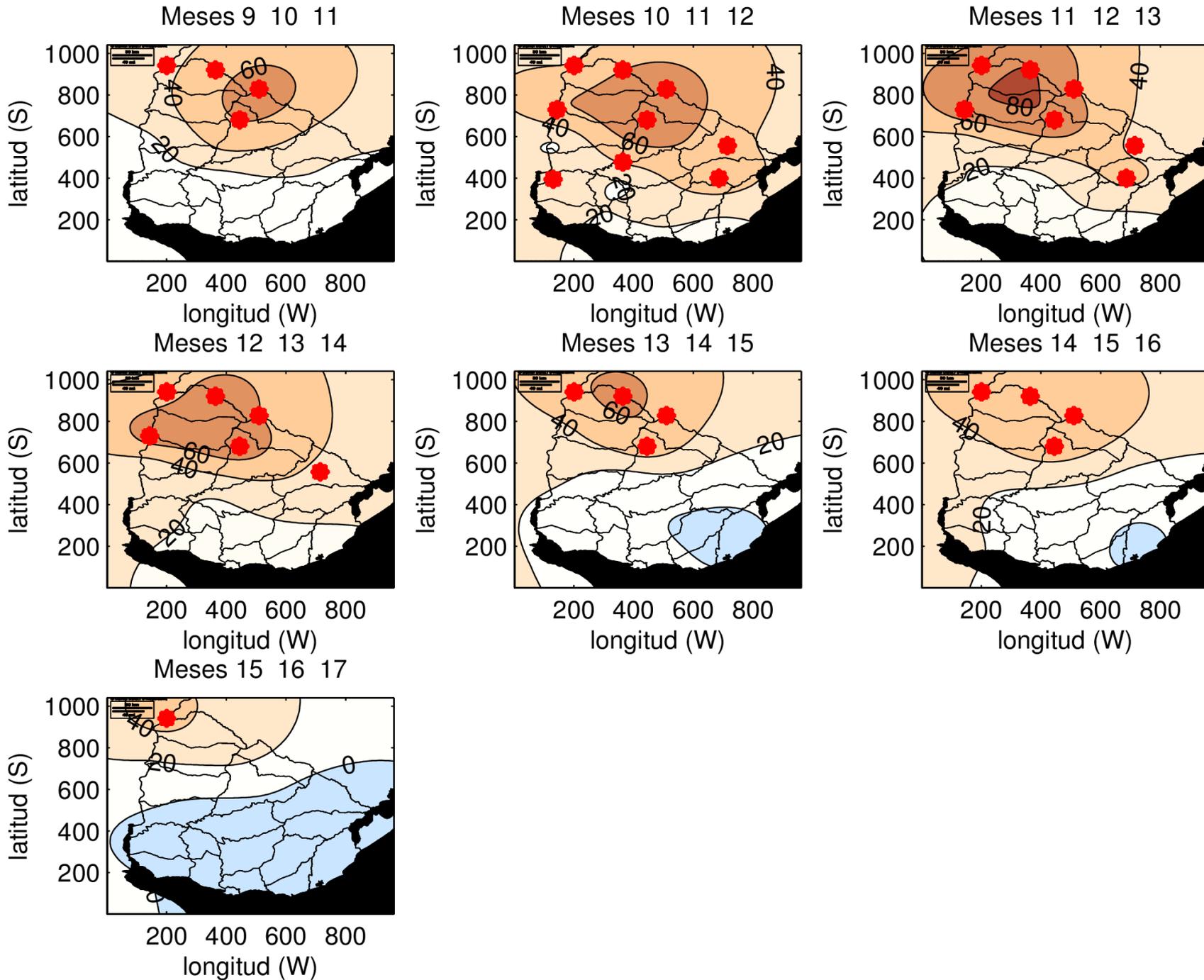
# Niño promedio - mensual



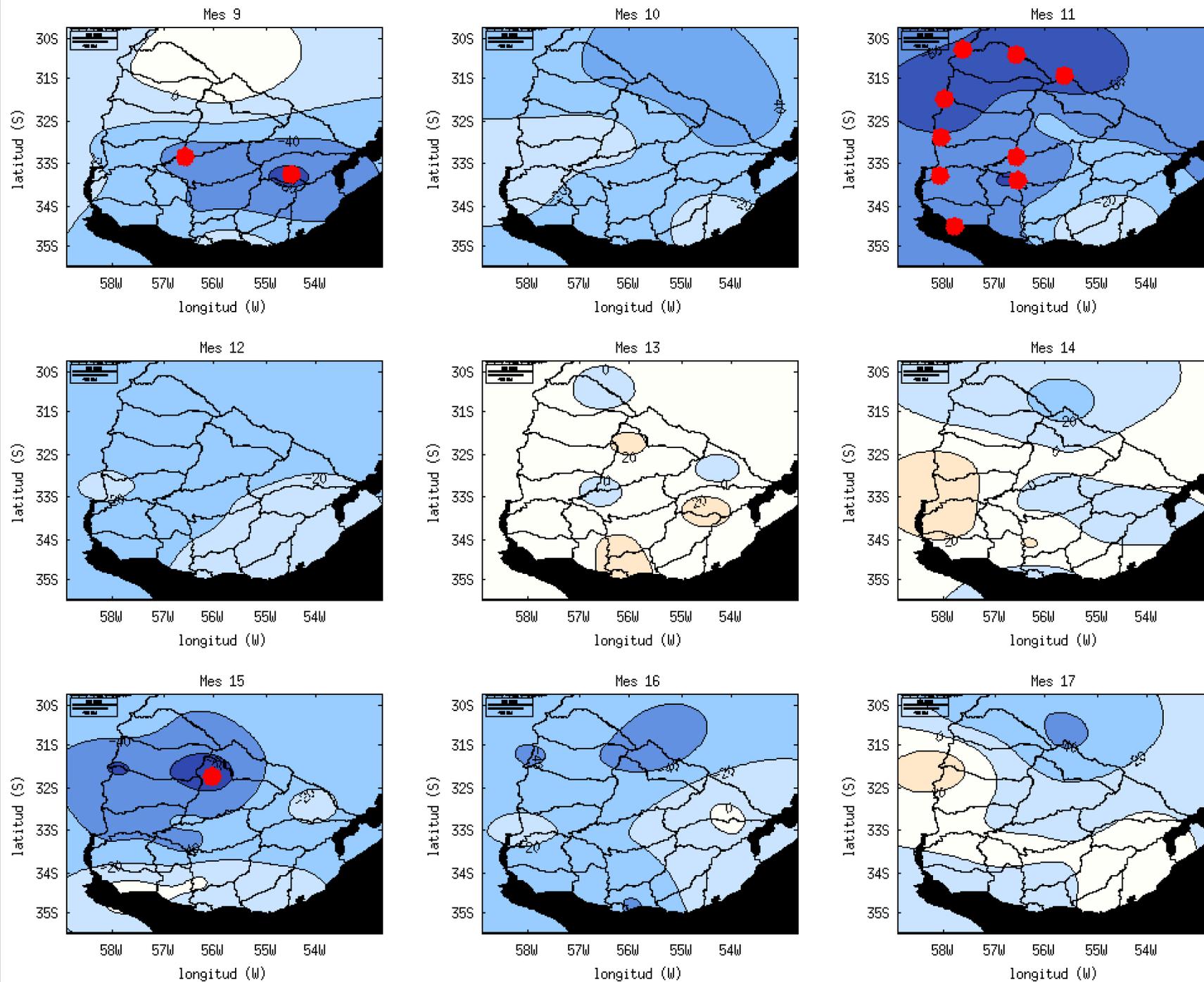
# Niño promedio - bimensual



# Niño promedio - trimestral

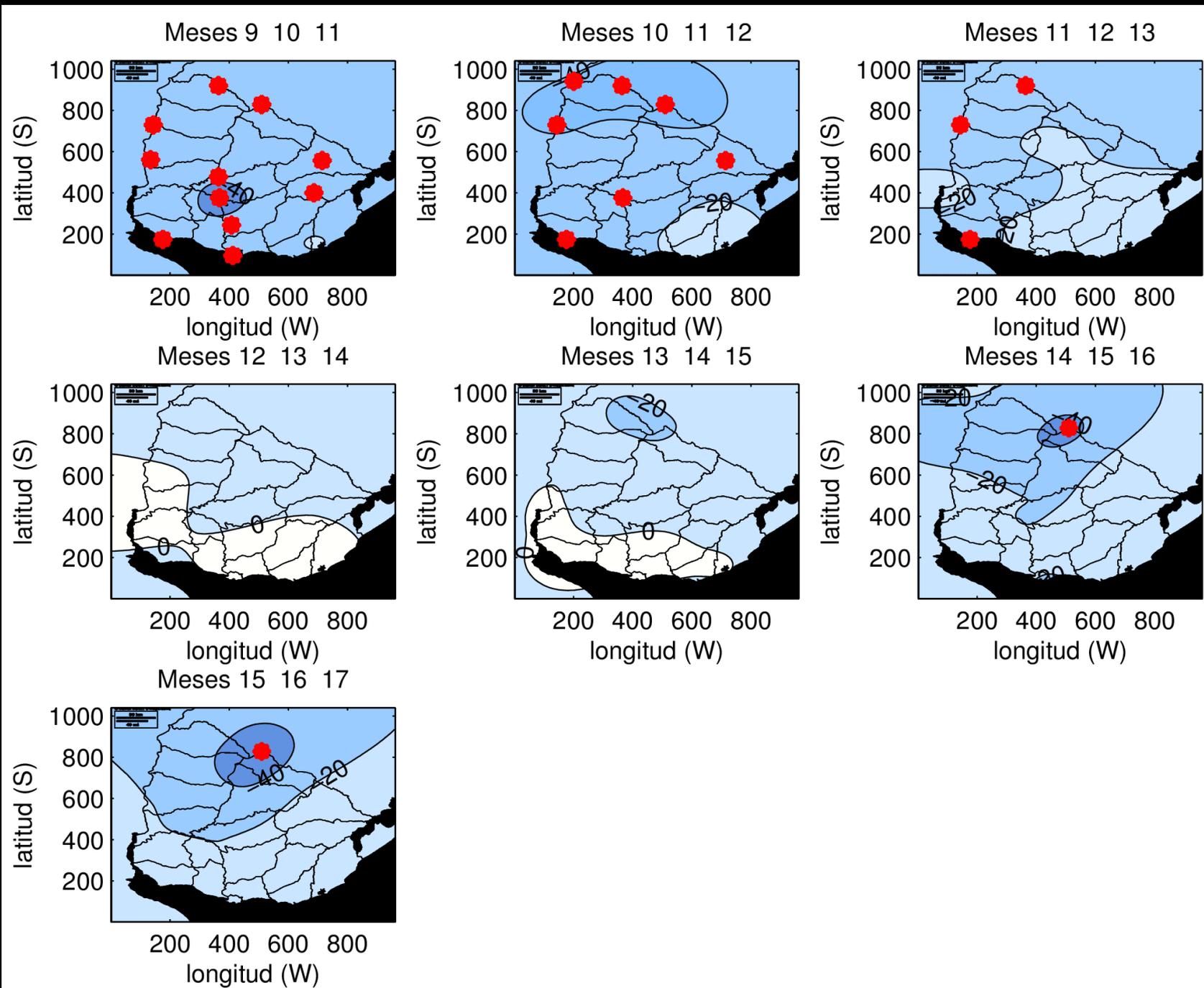


# Niña promedio - Mensual

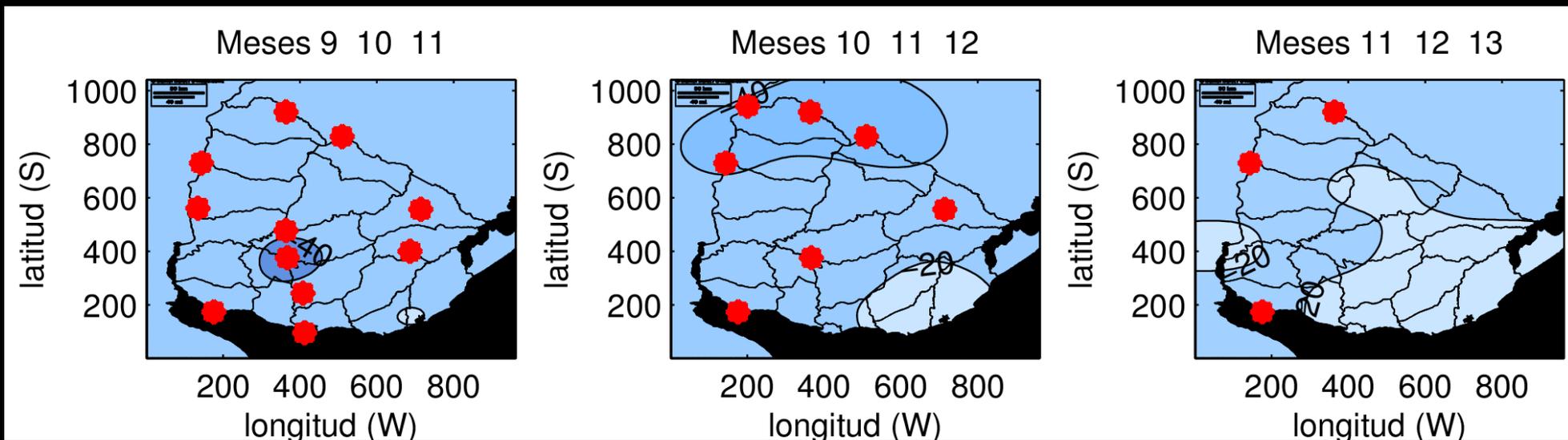
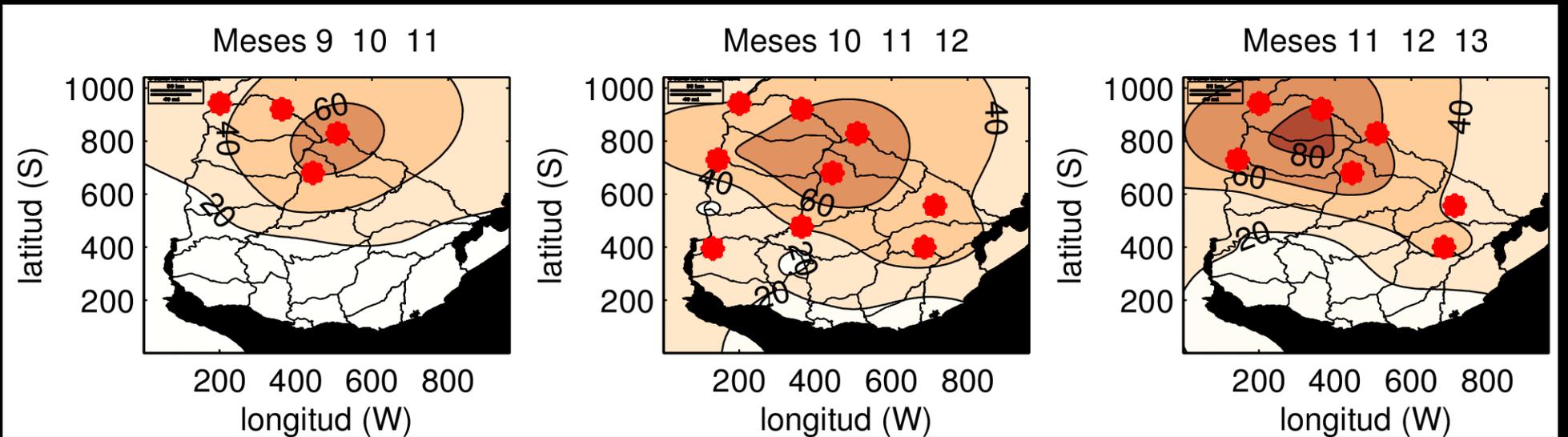




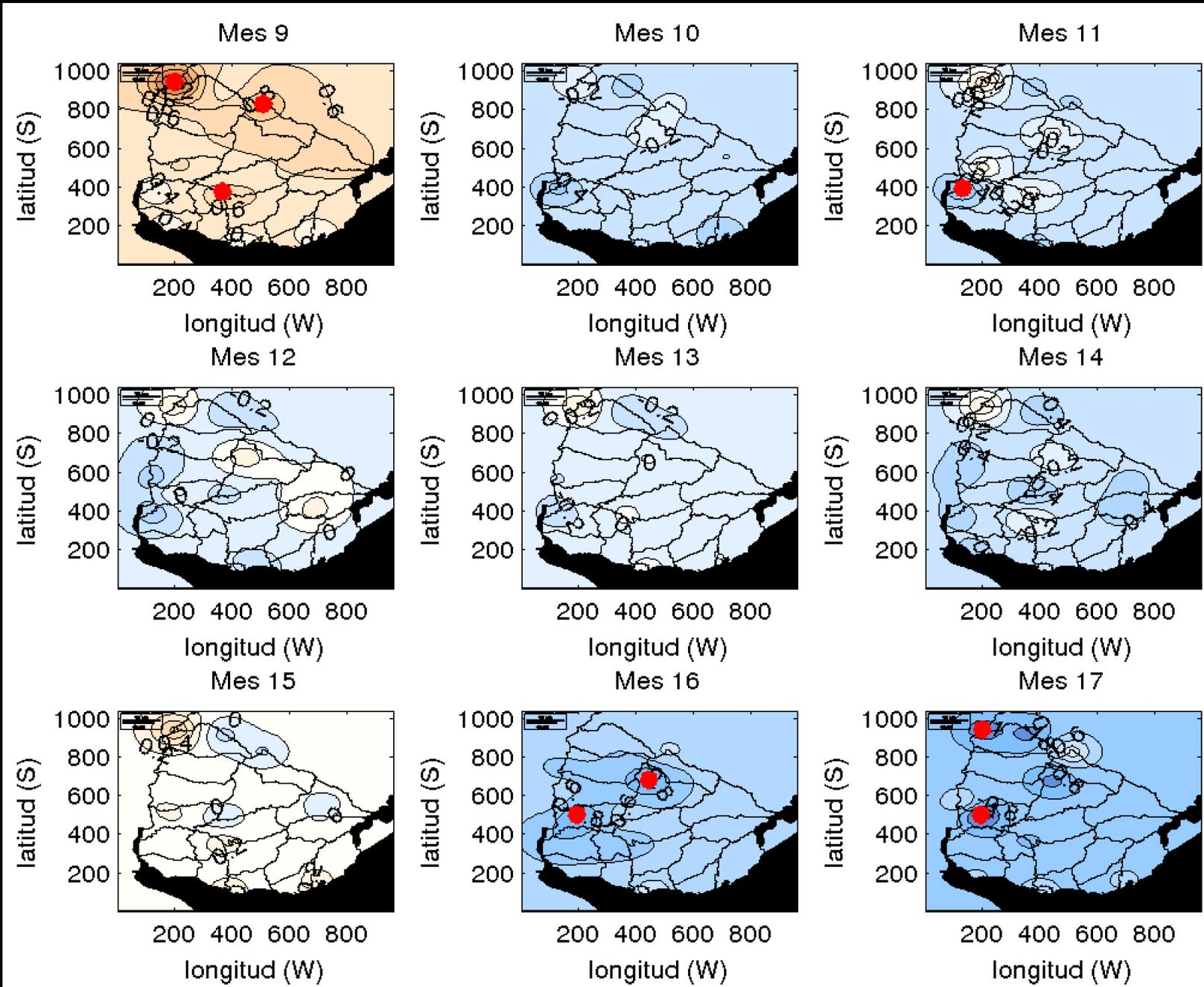
# Niña promedio - trimestral



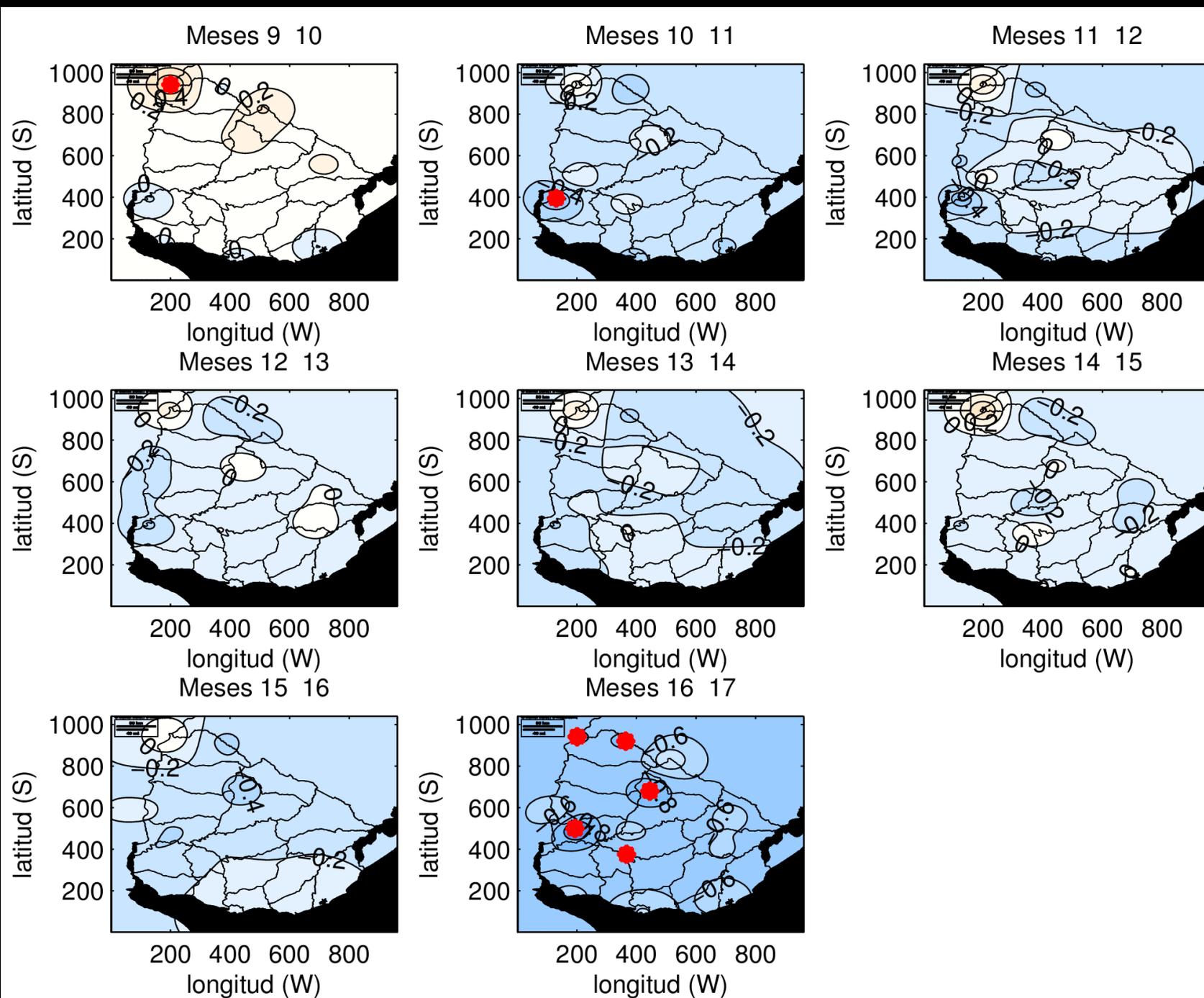
# Impacto de Niño y Niña son similares y opuestos?



# Niño promedio - mensual

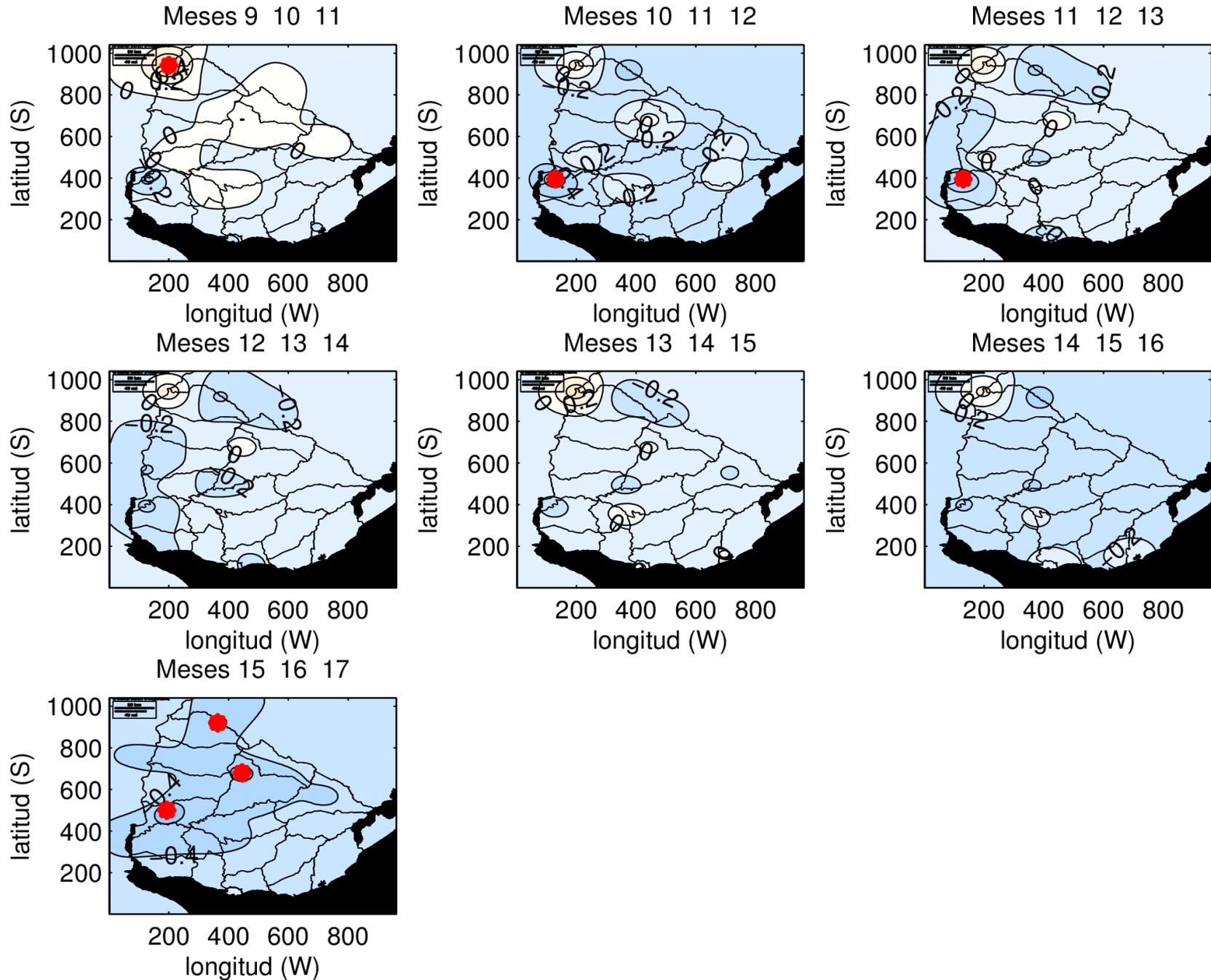


# Niño promedio - bimensual

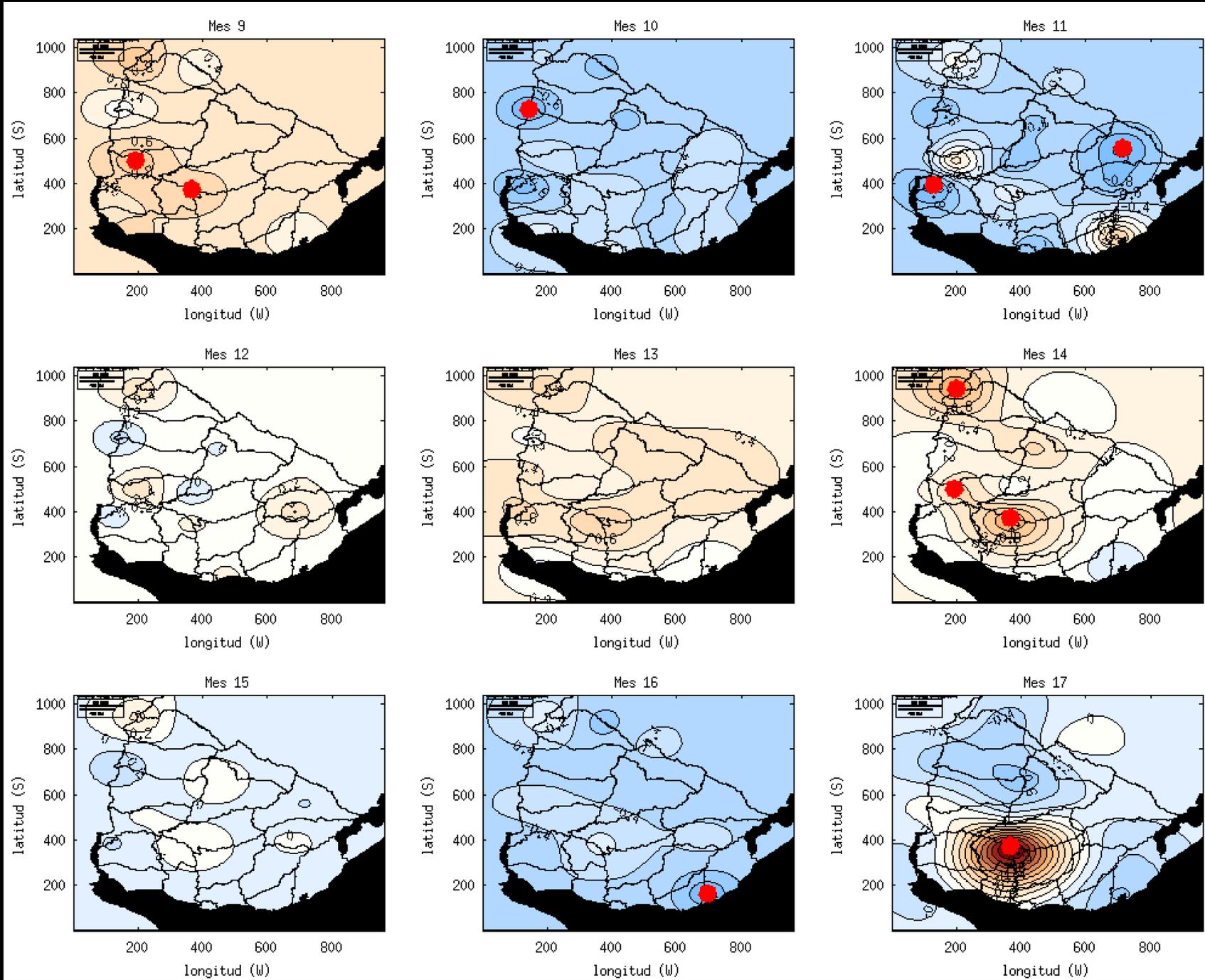


Temperatura

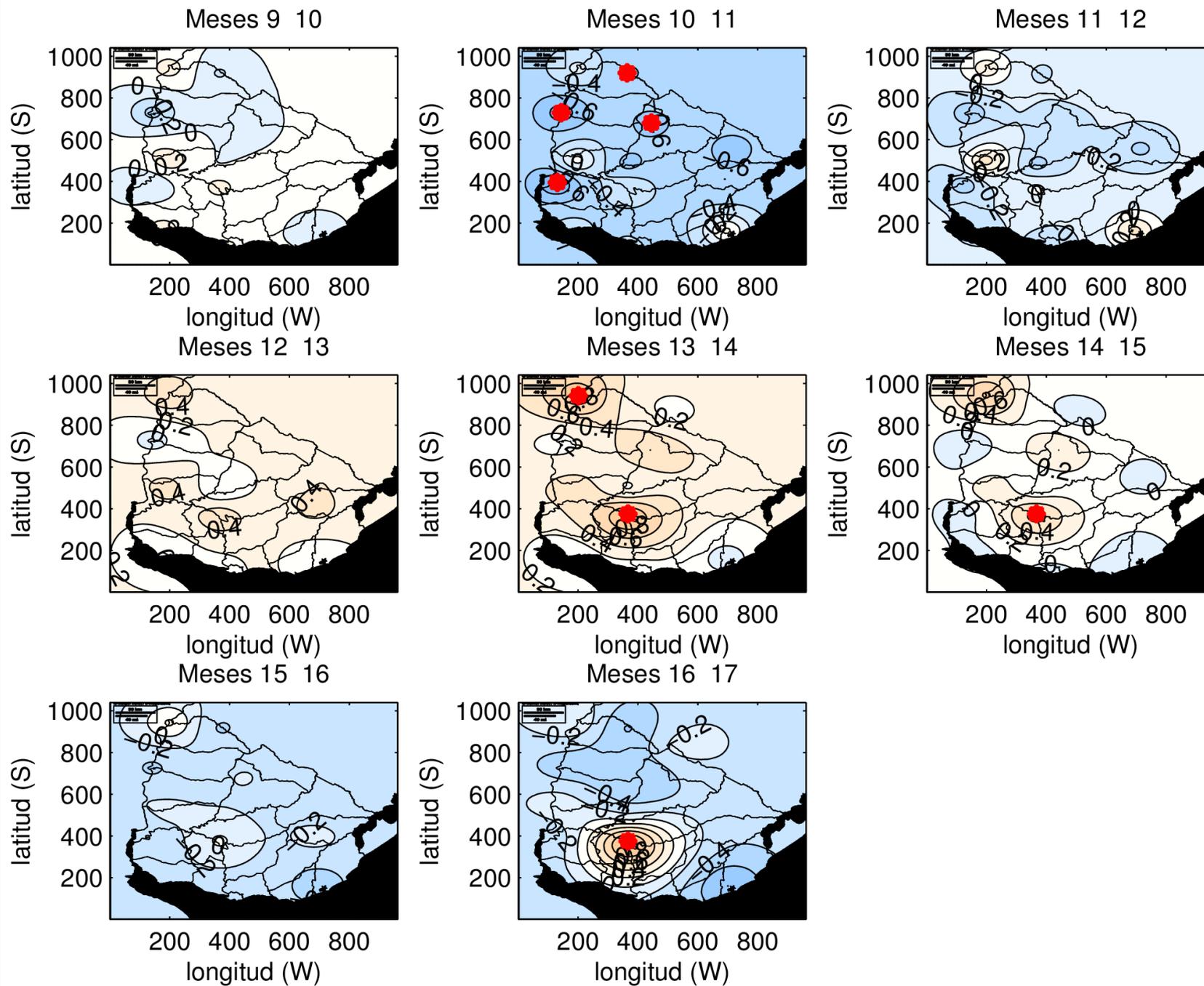
# Niño promedio - trimestral



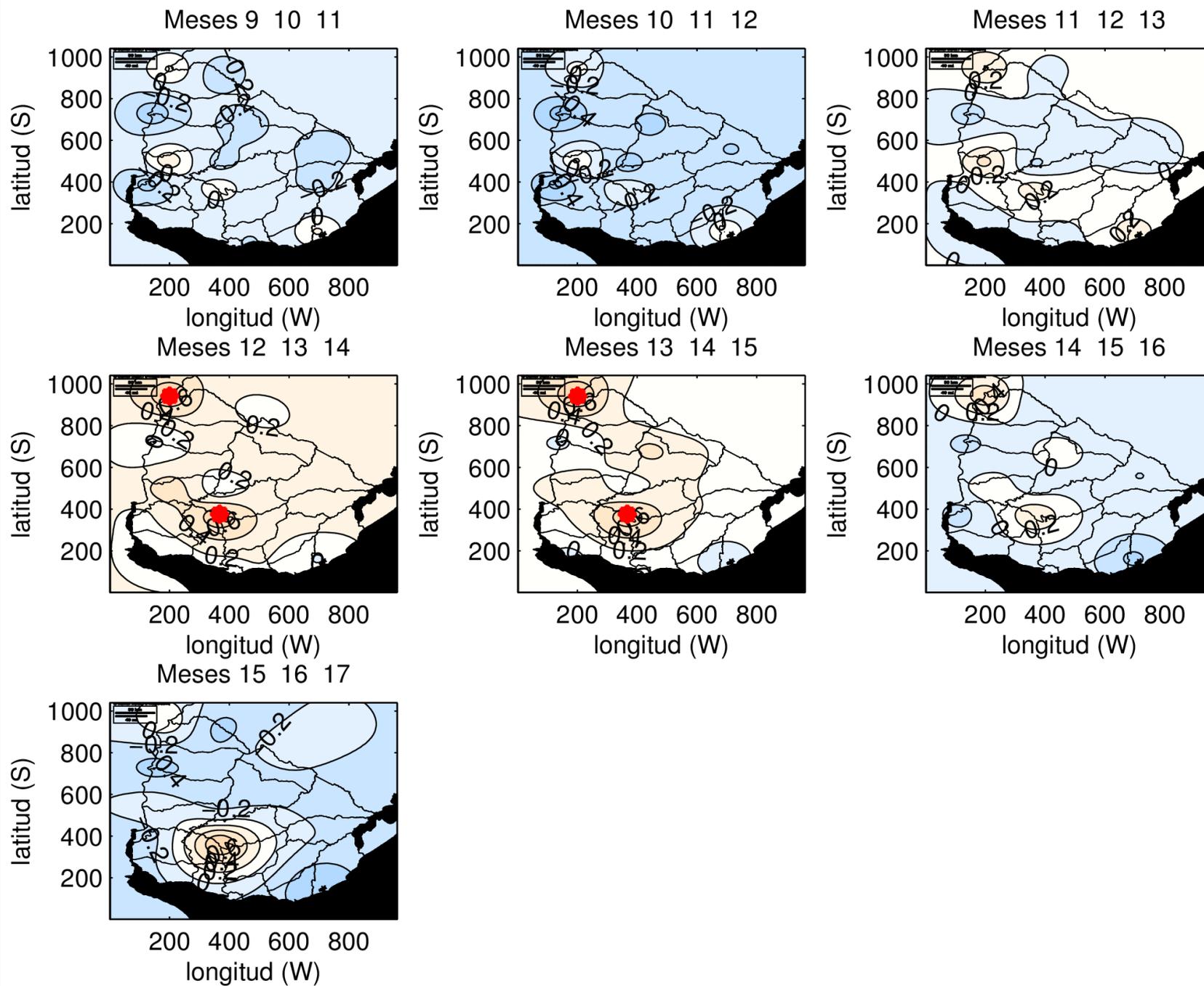
# Niña promedio - mensual



# Niña promedio - bimensual



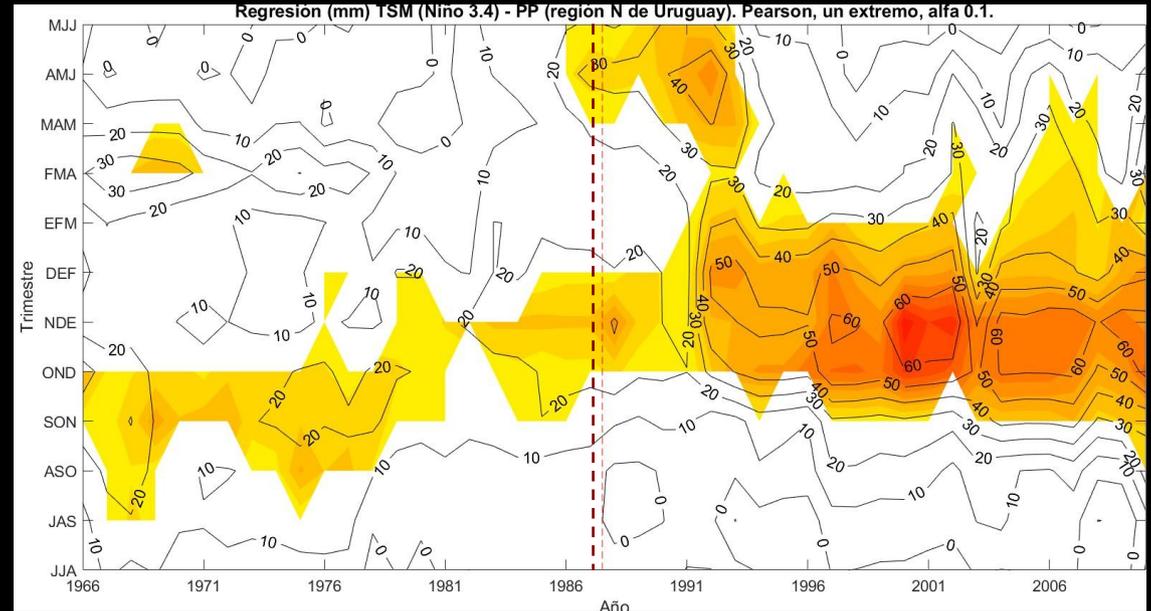
# Niña promedio - trimestral



# Variabilidad interdecadal de la relación entre ENOS y las lluvias sobre Uruguay

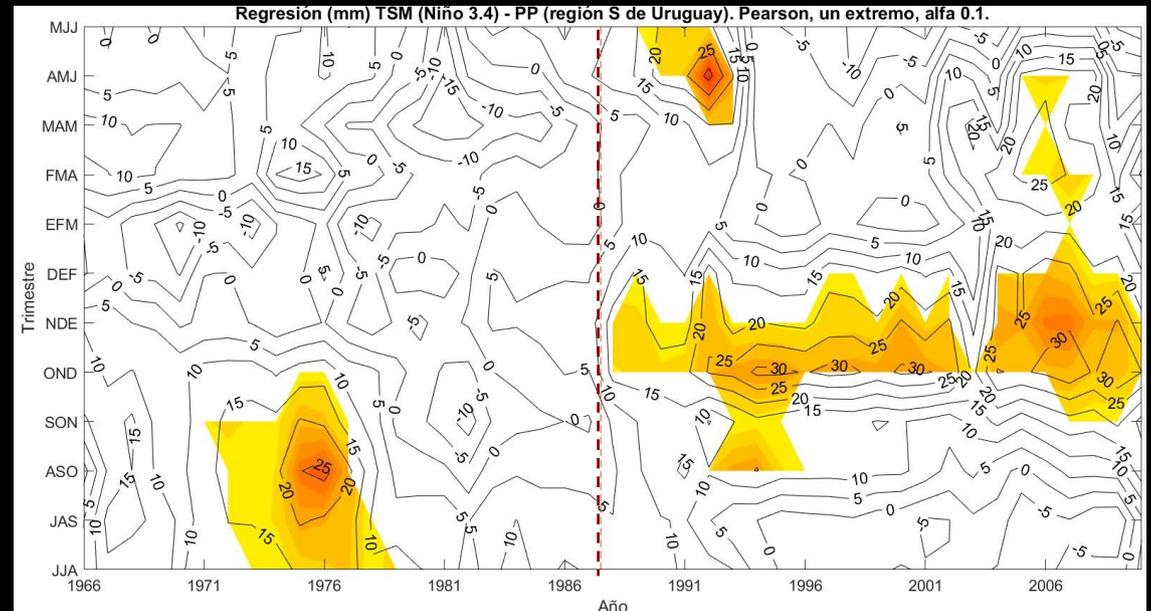
Zona Norte

Señales significativas mayormente sobre primavera – verano.



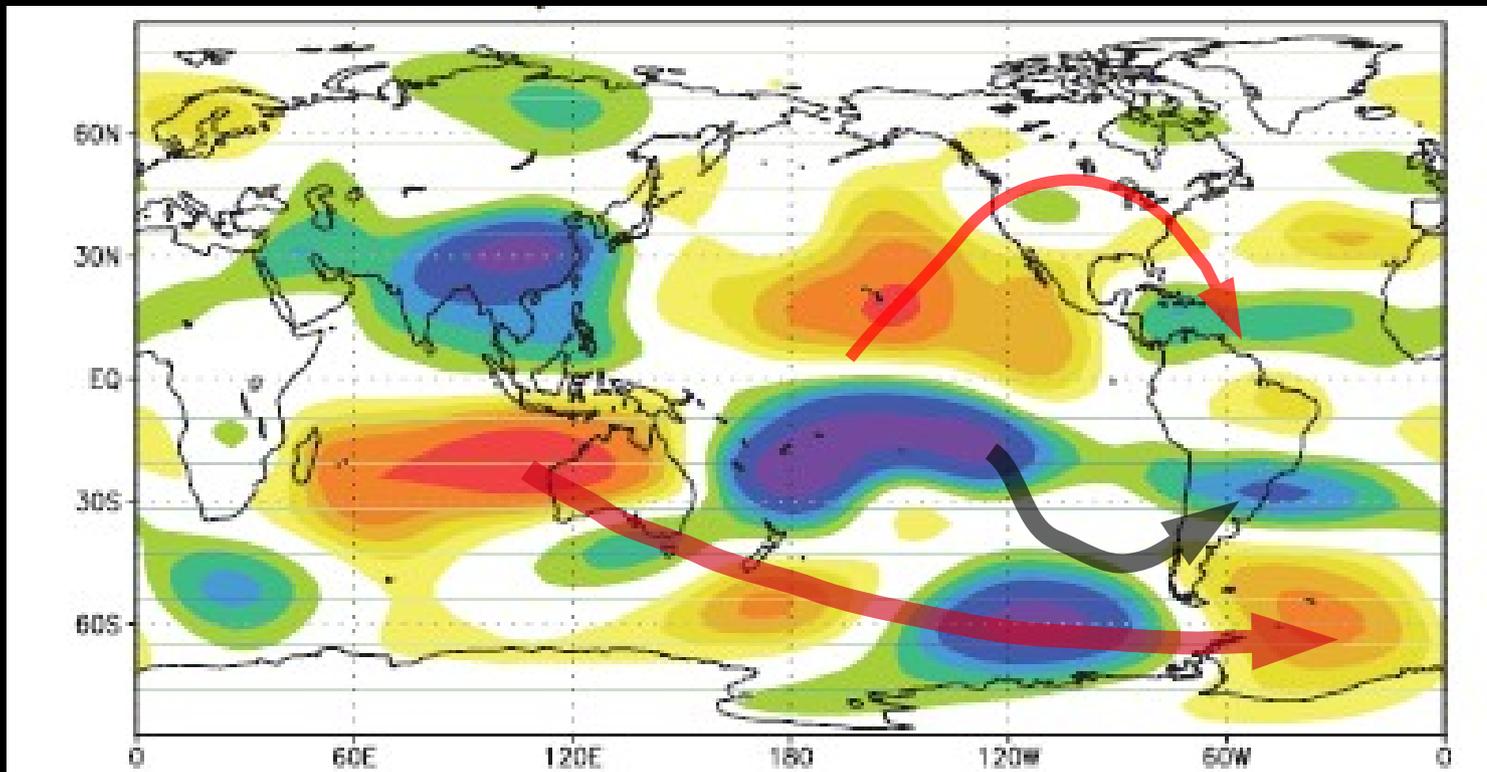
Zona Sur

Aumento significativo del impacto de ENSO sobre Uy a fines de los 1980.

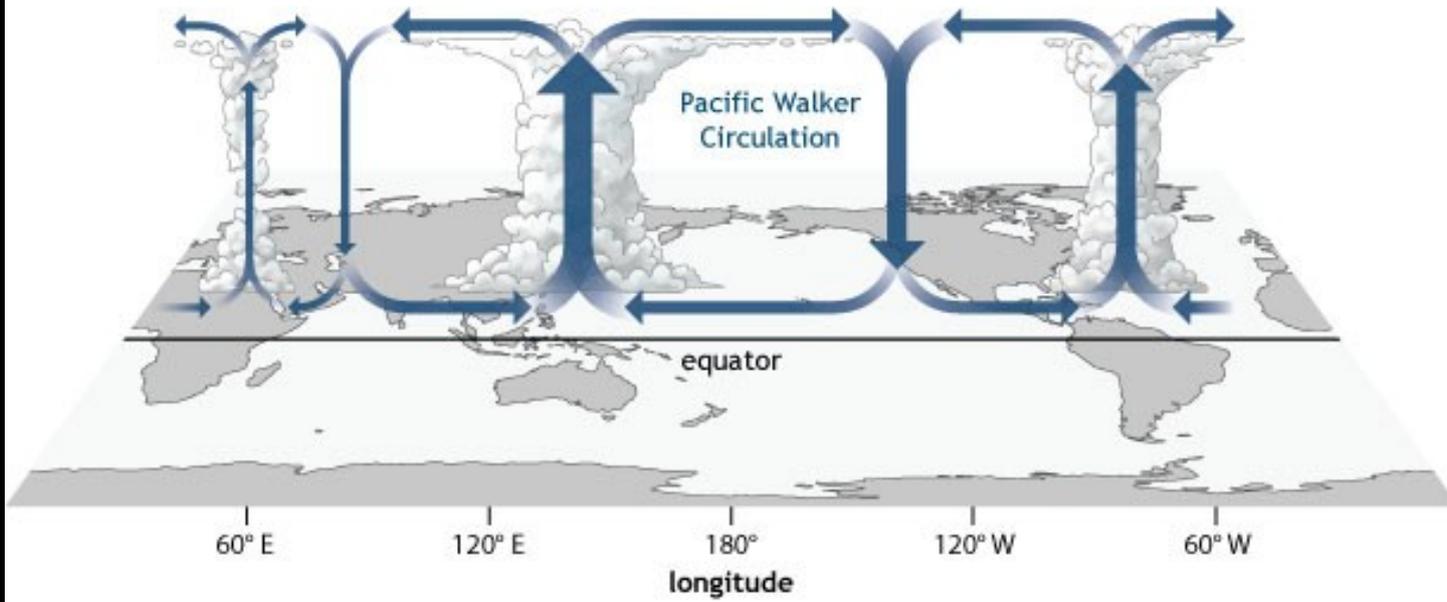


# Mecanismos físicos de impacto de ENSO

- Cambios en la corriente en chorro subtropical en 200mb, a través de la propagación de ondas de Rossby en altura  
→ provee condiciones de ascenso favorables en Cuenca del Plata
- Cambios en regiones de ascenso y descenso tropicales

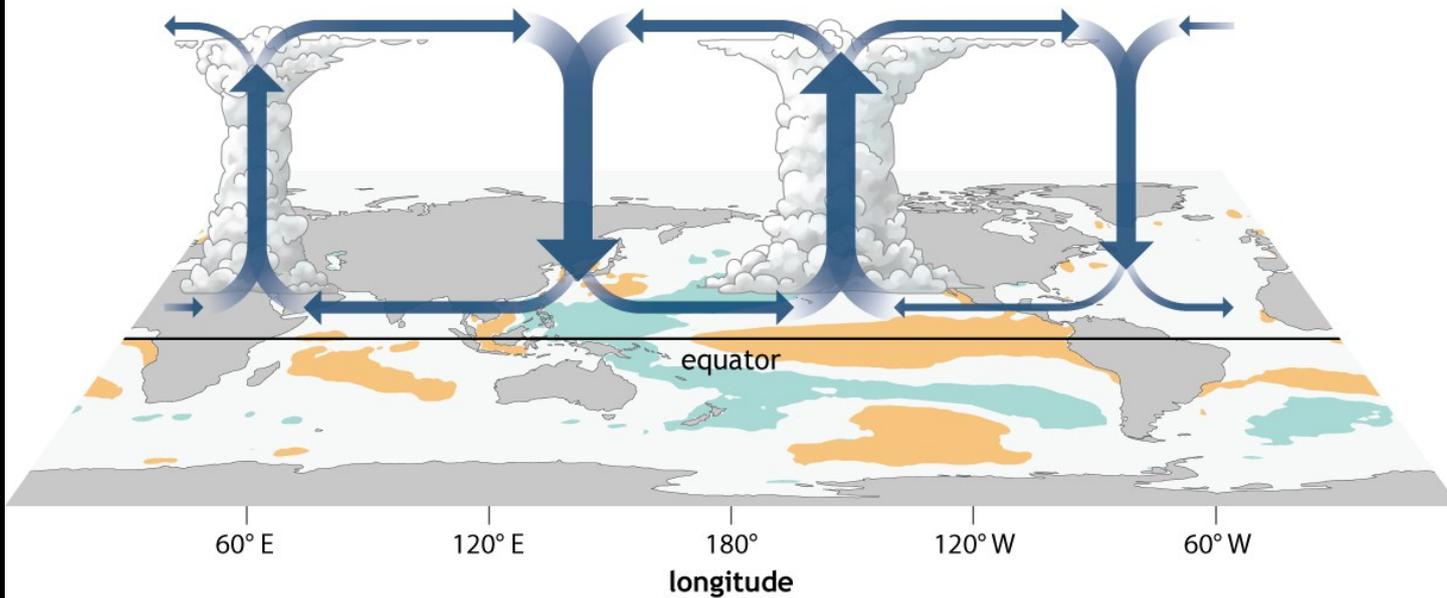


### Neutral conditions



NOAA Climate.gov

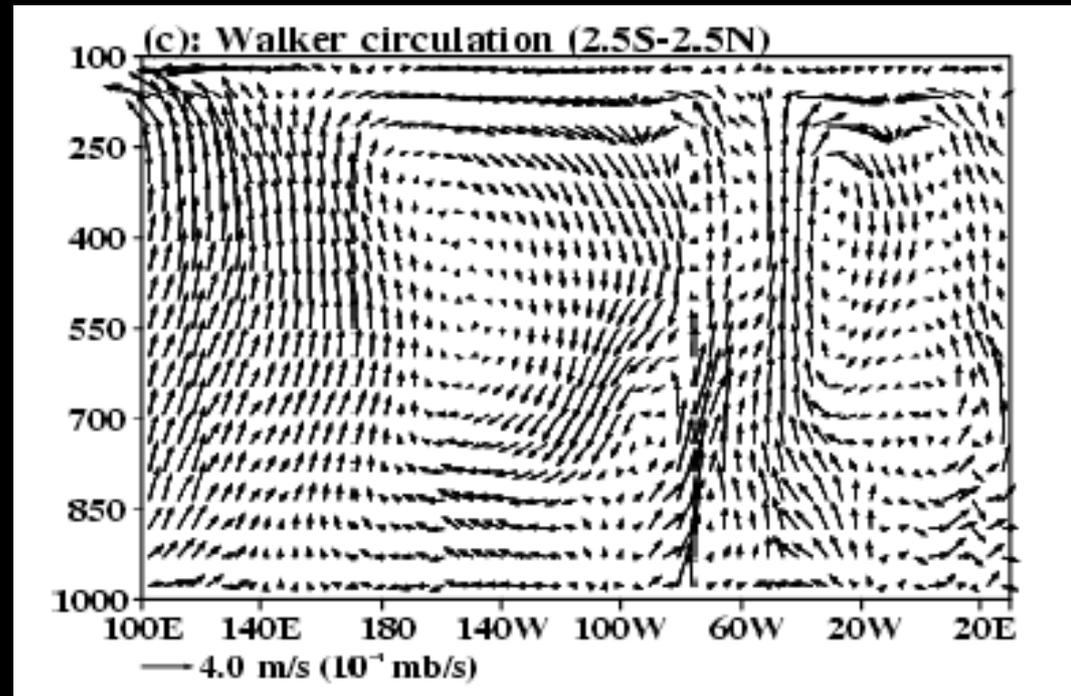
### El Niño conditions



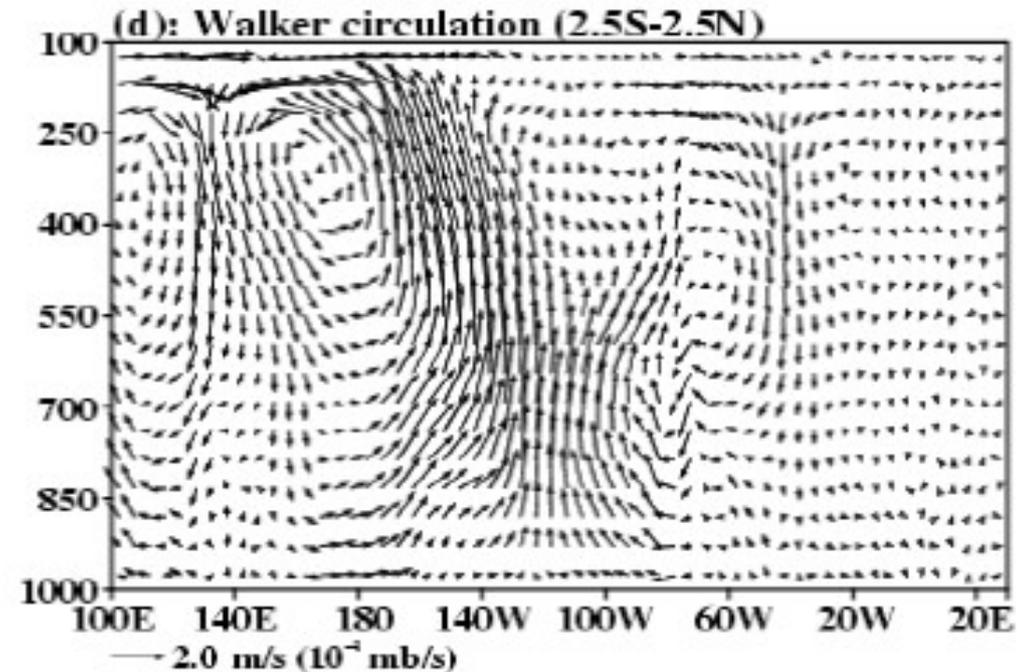
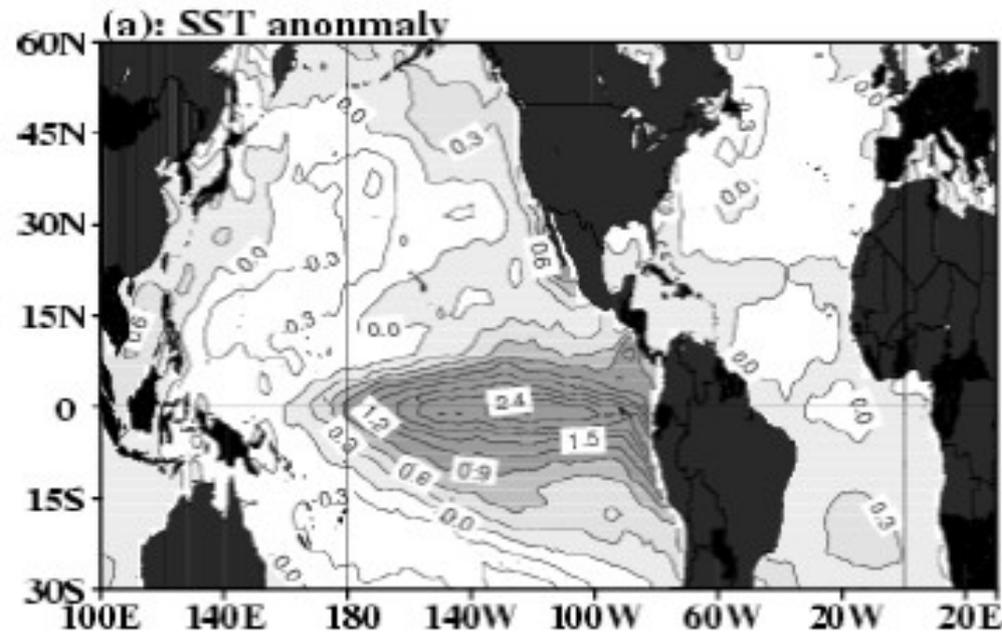
NOAA Climate.gov

# Climatologia en Enero

Wang 2005



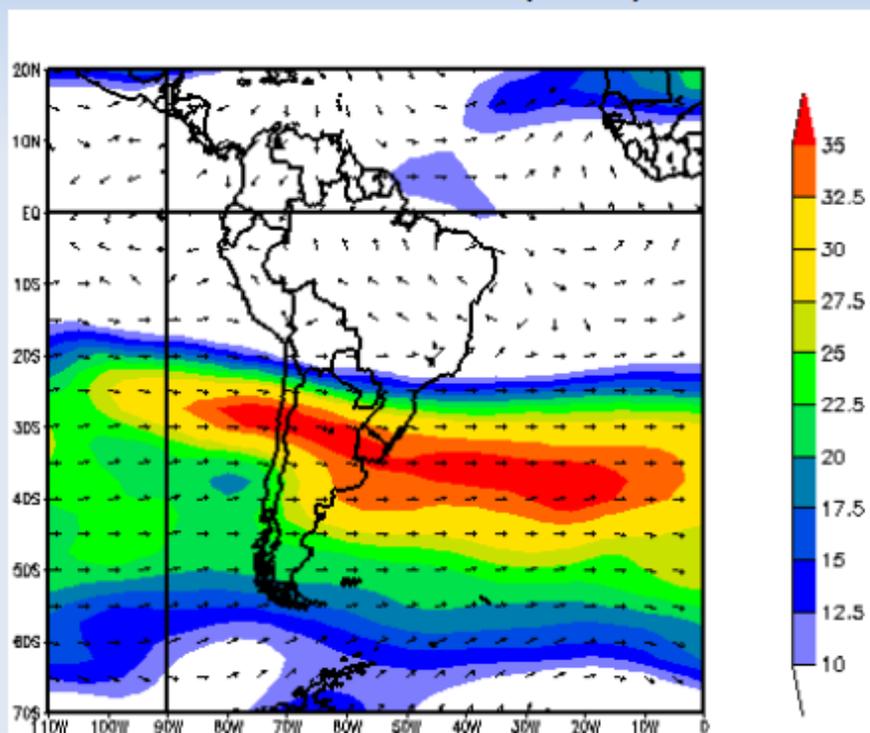
## ENSO and Atmospheric Circulations



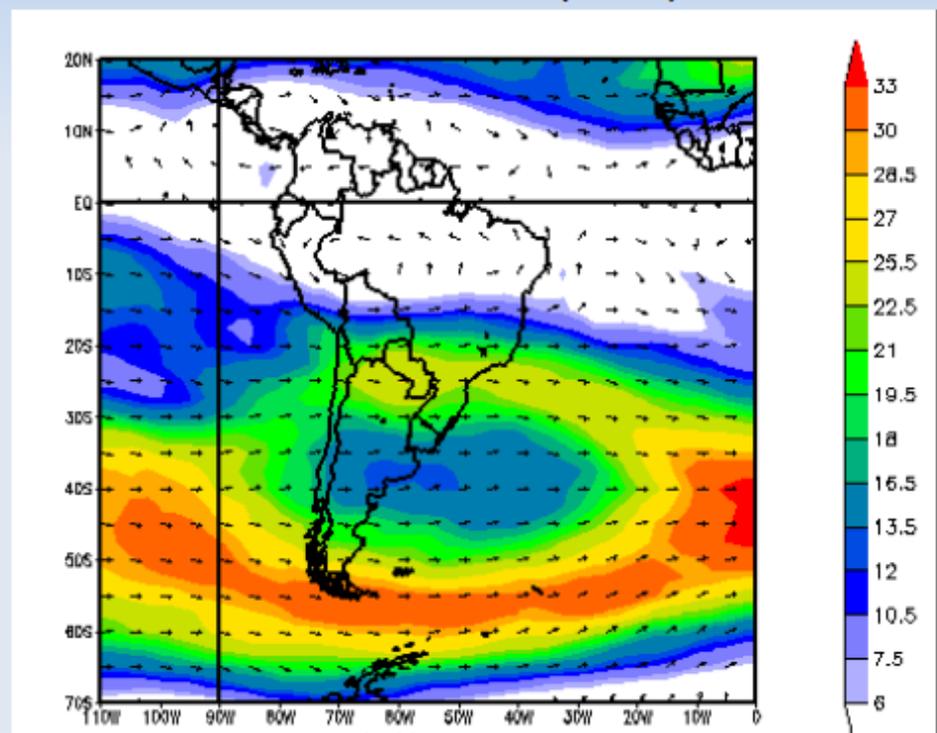
## ¿Cómo impacta ENSO sobre Uruguay?

Cambia la posición e intensidad de la corriente en chorro en altura

Nov 1997 (Niño)



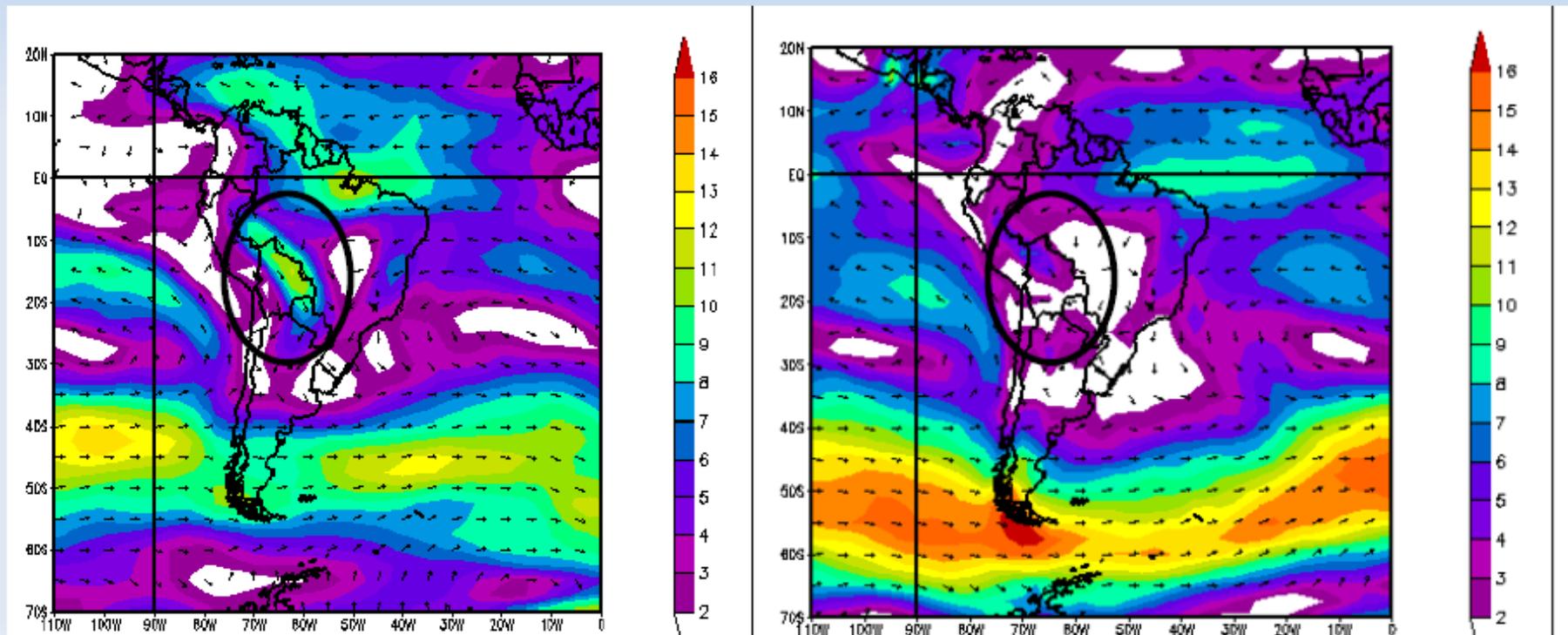
Nov 1999 (Niña)

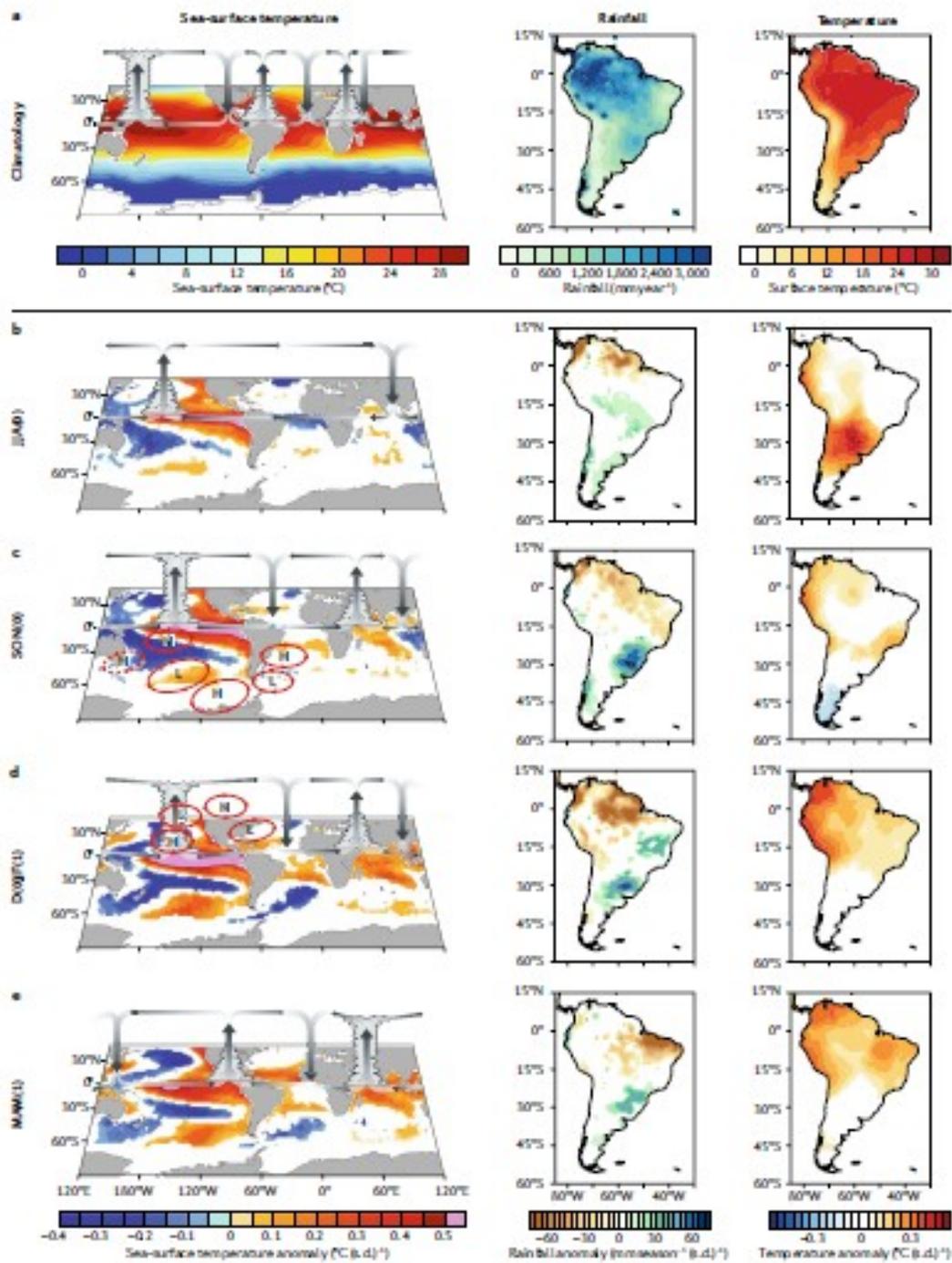


El Niño aumenta la intensidad del Jet de capas bajas aumentando el transporte de humedad desde el norte a Uruguay. La Niña lo disminuye

Nov 1997 (Niño)

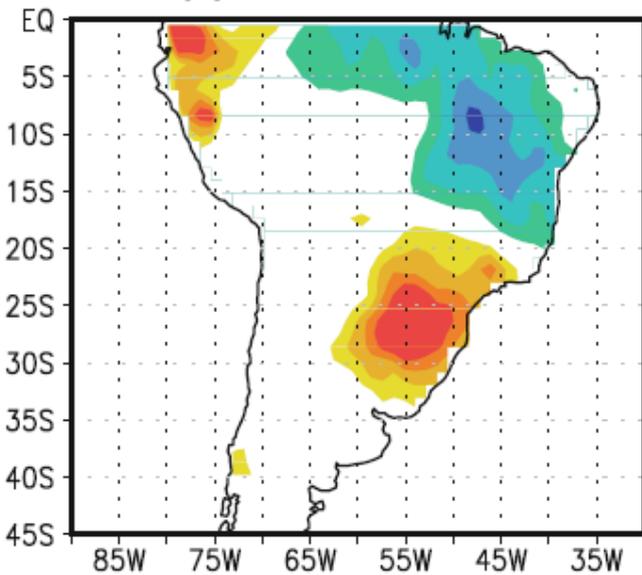
Nov 1999 (Niña)



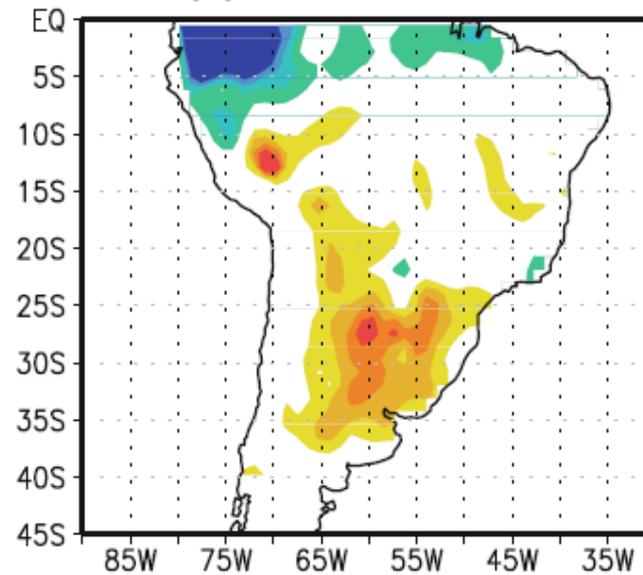


# La Plata basin precipitation variability in spring: role of remote SST forcing as simulated by GCM experiments

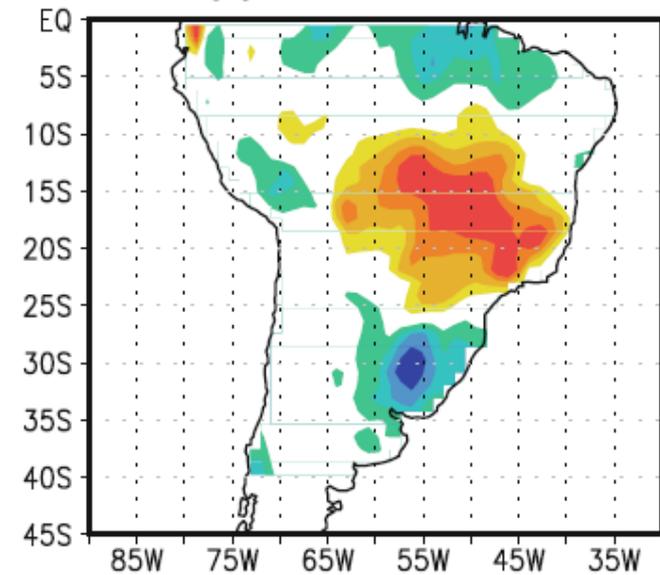
(a) CRU EOF1 (24.5%)



(b) CRU EOF2 (11.7%)

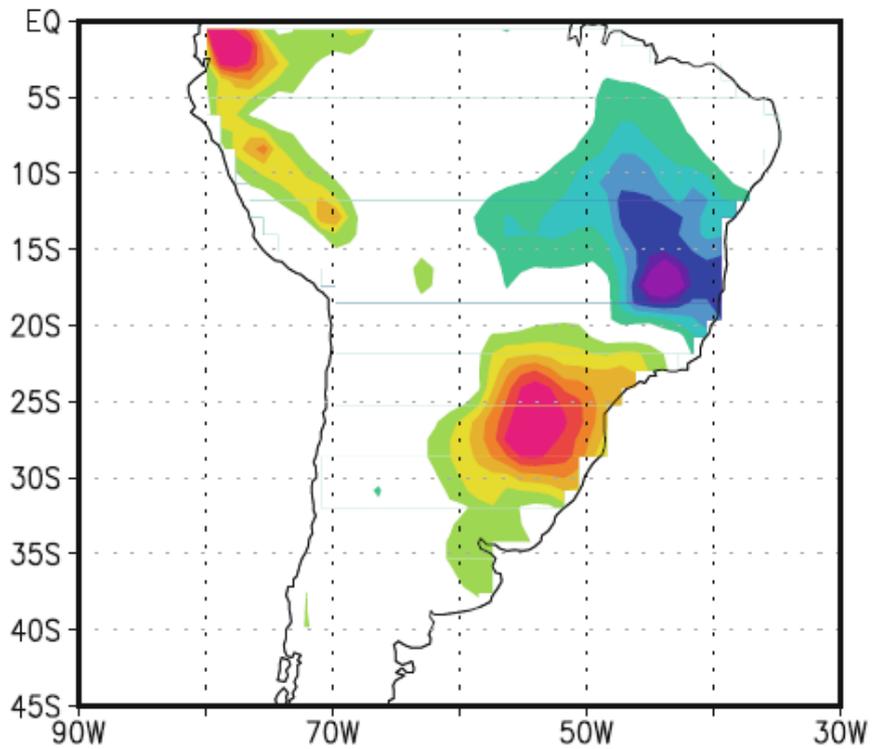


(c) CRU EOF3 (8.9%)

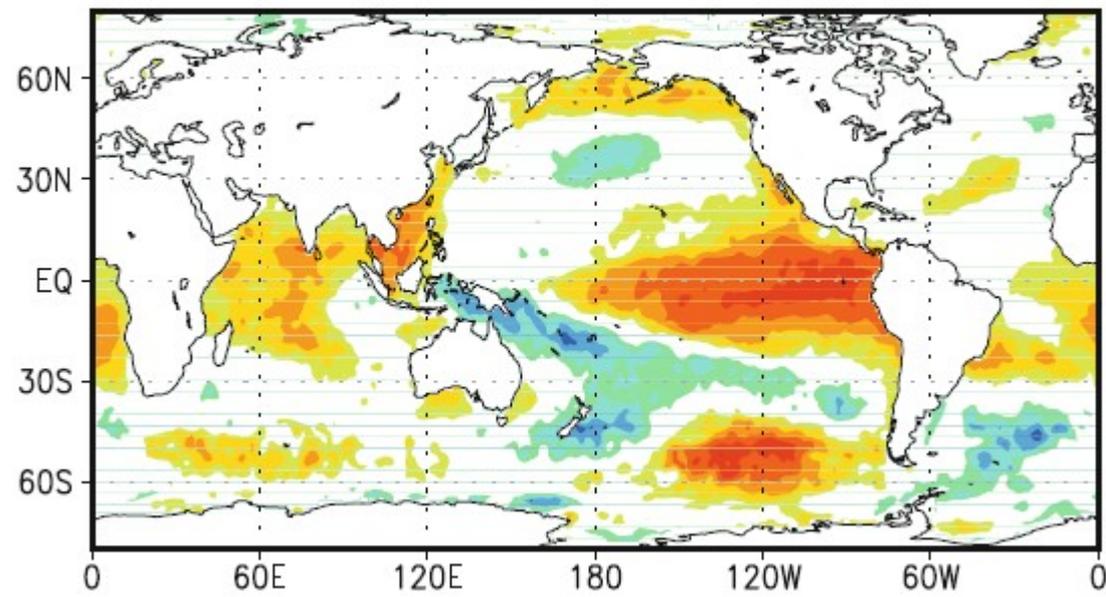


EOFs OND precipitation

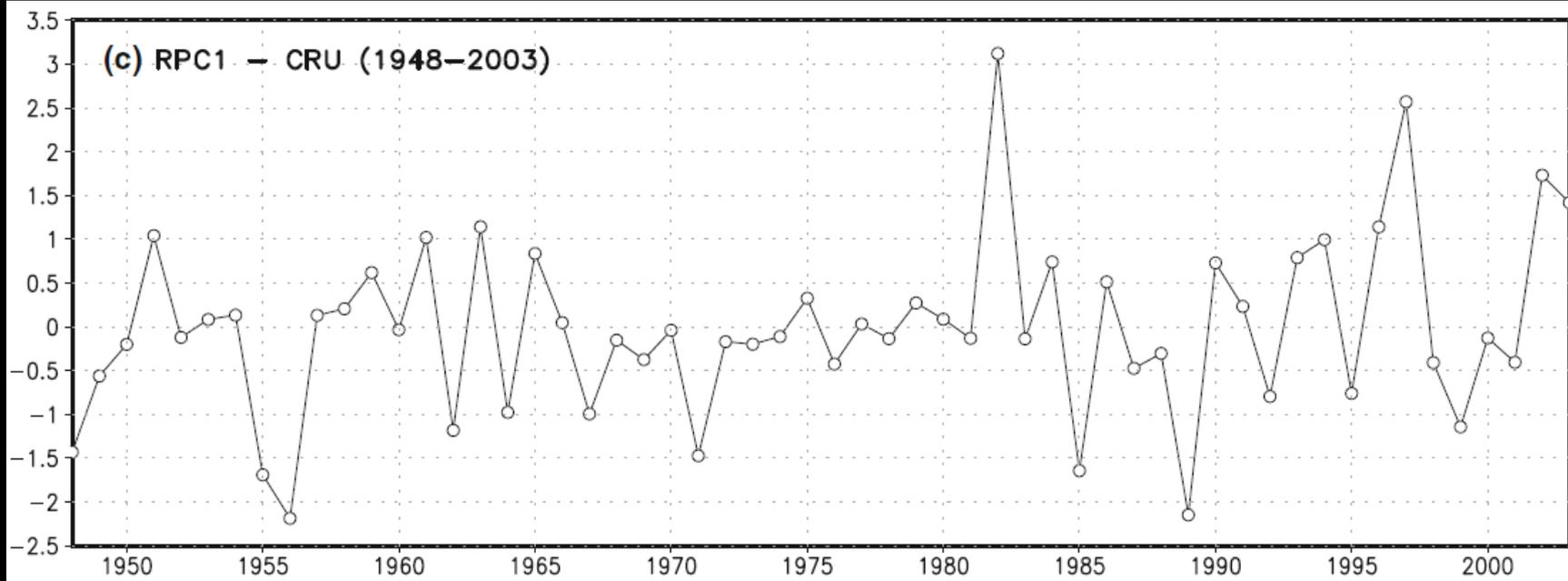
**(a) REOF1 - CRU (16.5%)**



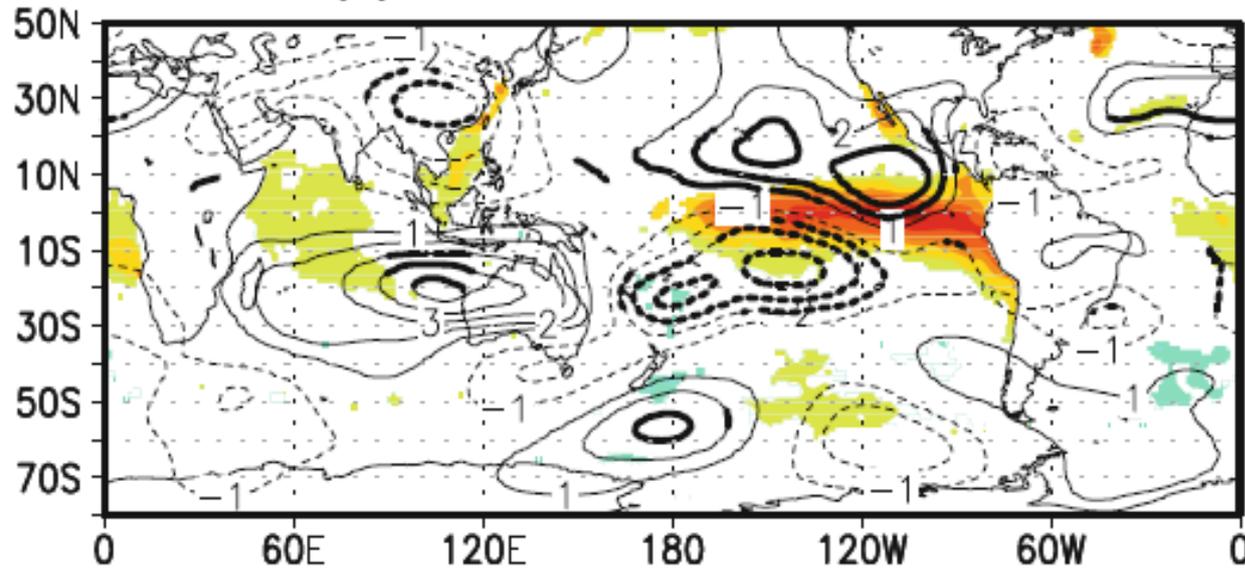
**(a) HadISST/CRU**



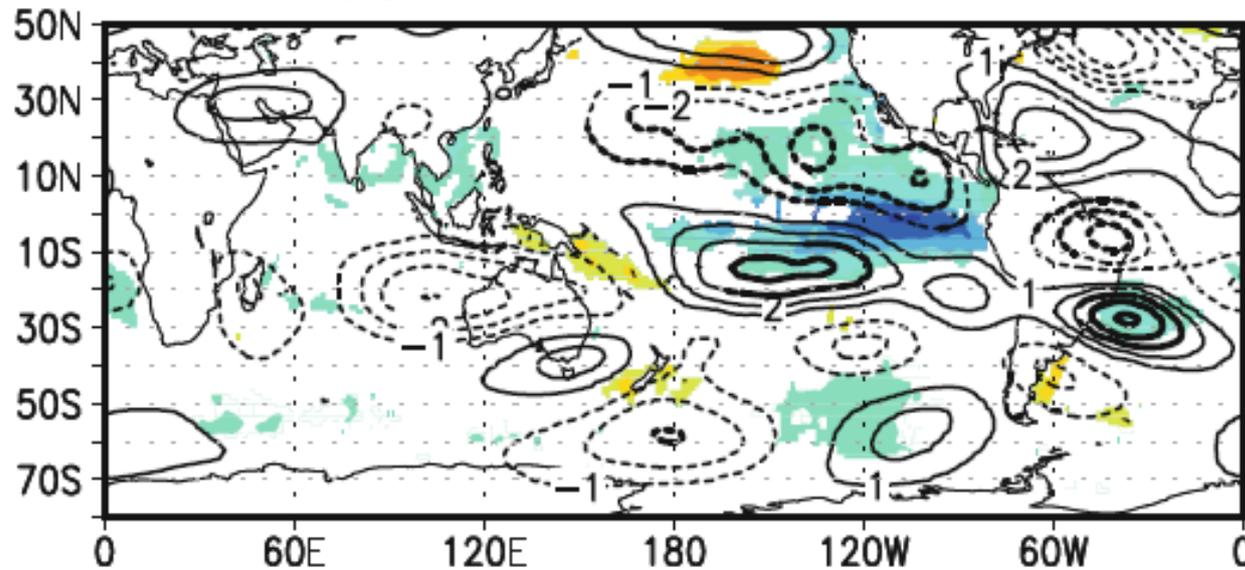
**(c) RPC1 - CRU (1948-2003)**



**(a)** wet LPB HadISST/CRU

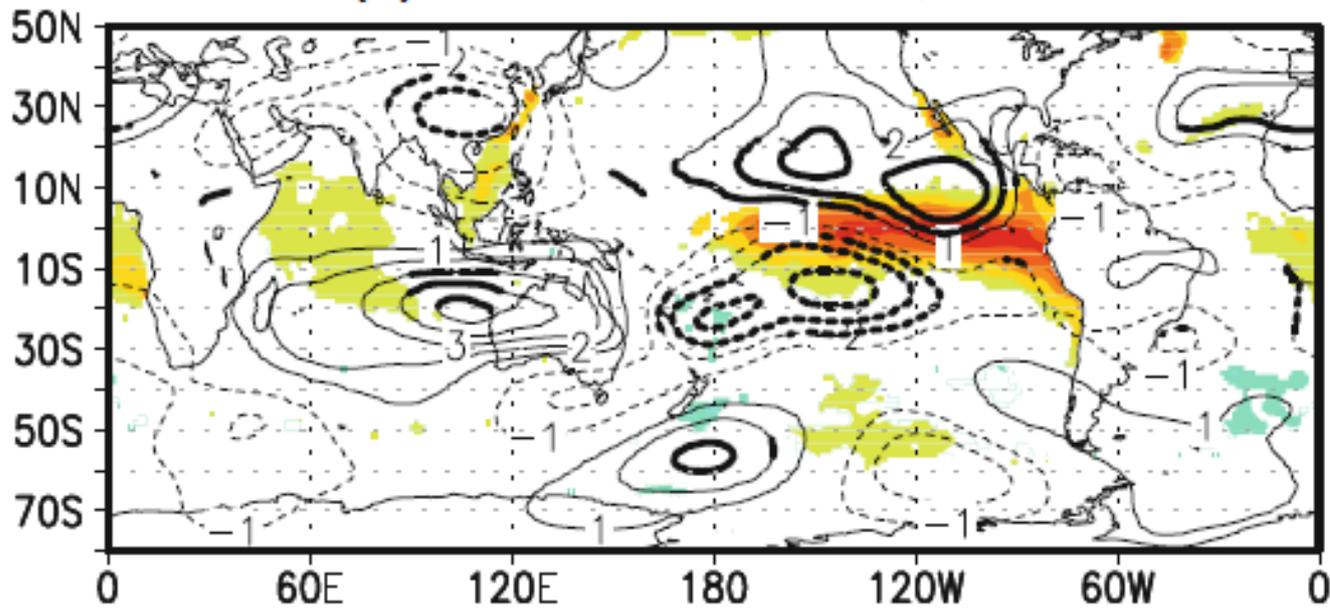


**(b)** dry LPB HadISST/CRU

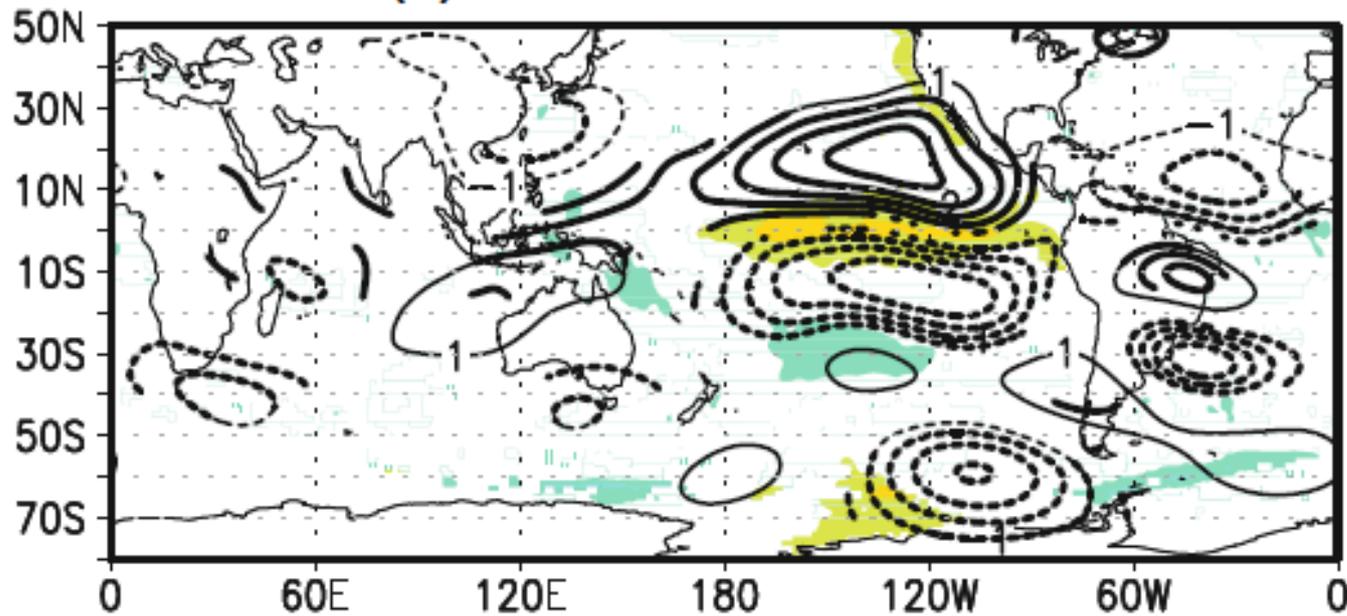


Composites funcion corriente 200 hPa y SST para casos + y - de REFO1

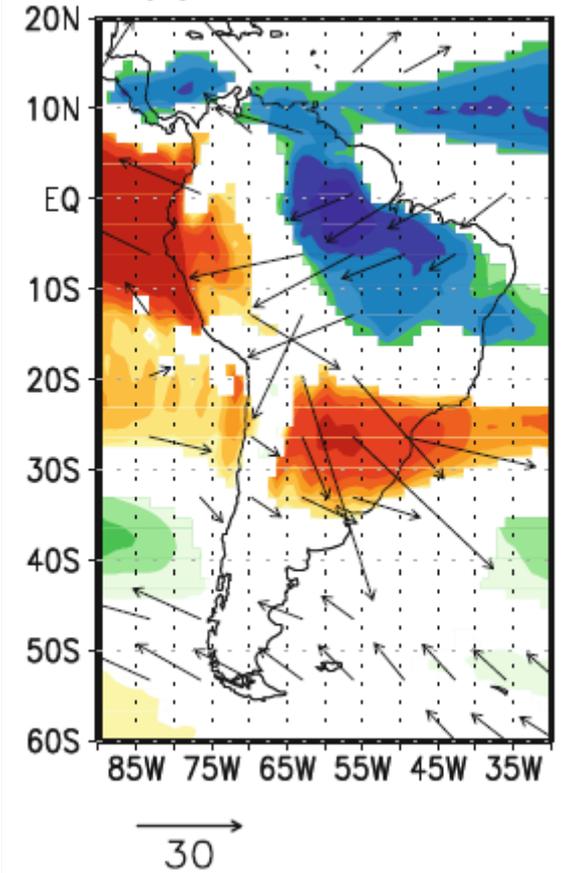
**(a)** wet LPB HadISST/CRU



**(c)** wet LPB AMIP-type

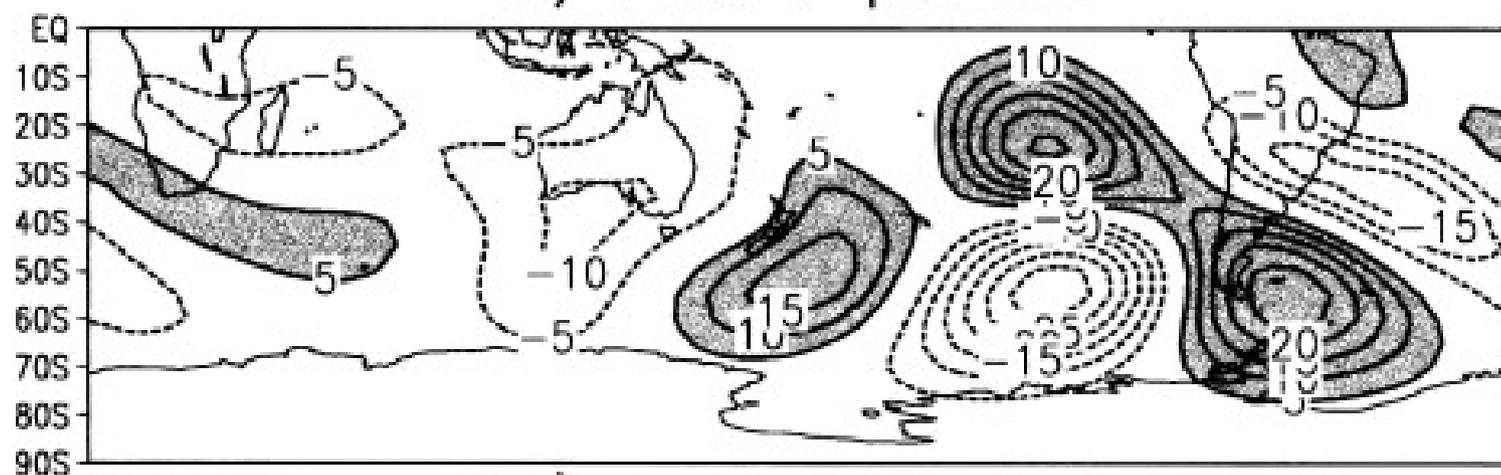


**(a)** In Phase Positive

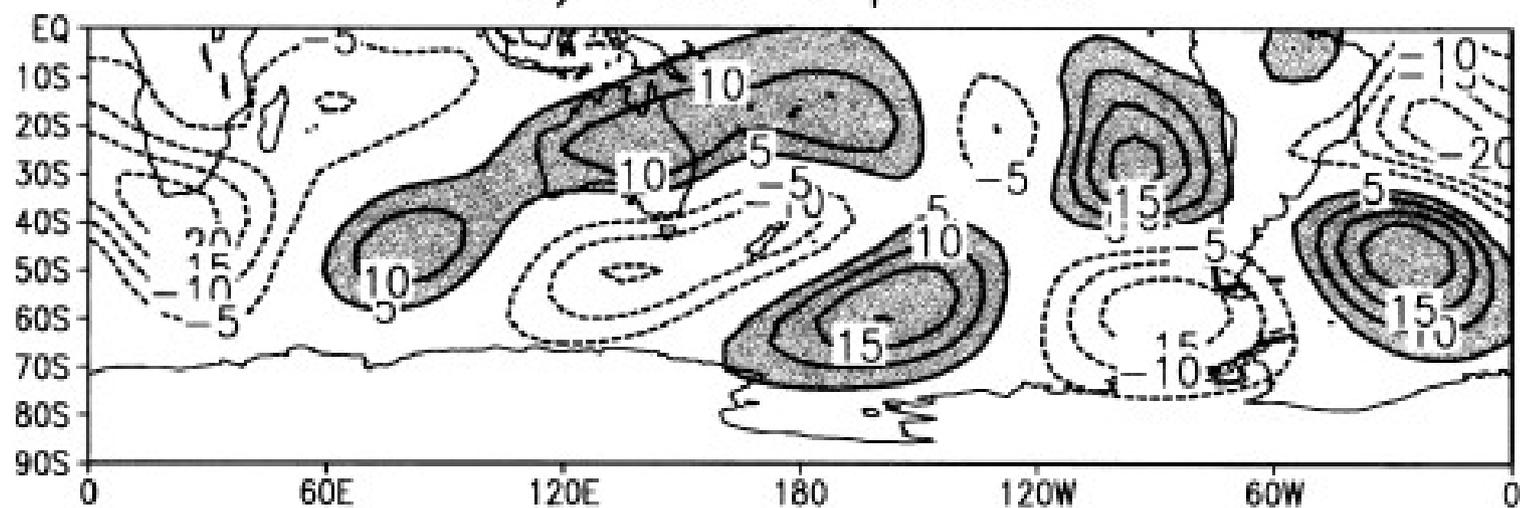


Flujo de humedad y conv.

c) PSA 1 psi200



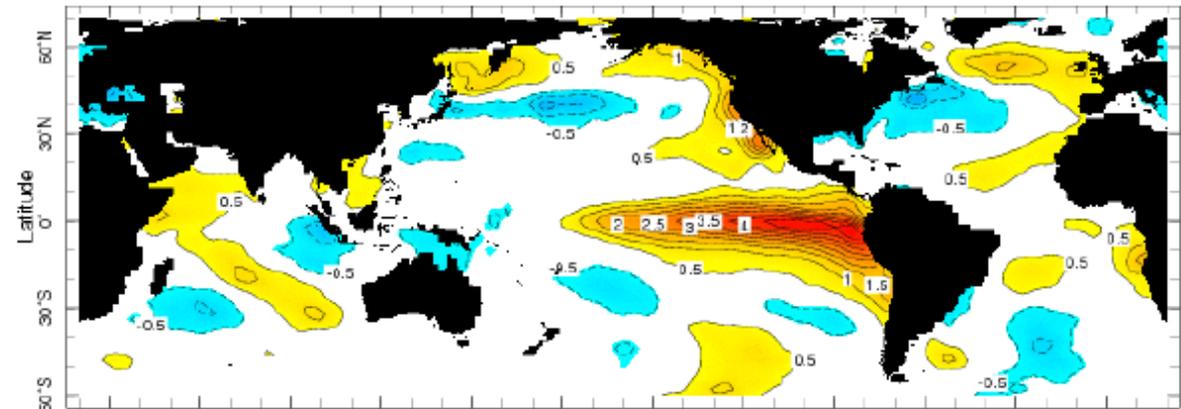
d) PSA 2 psi200



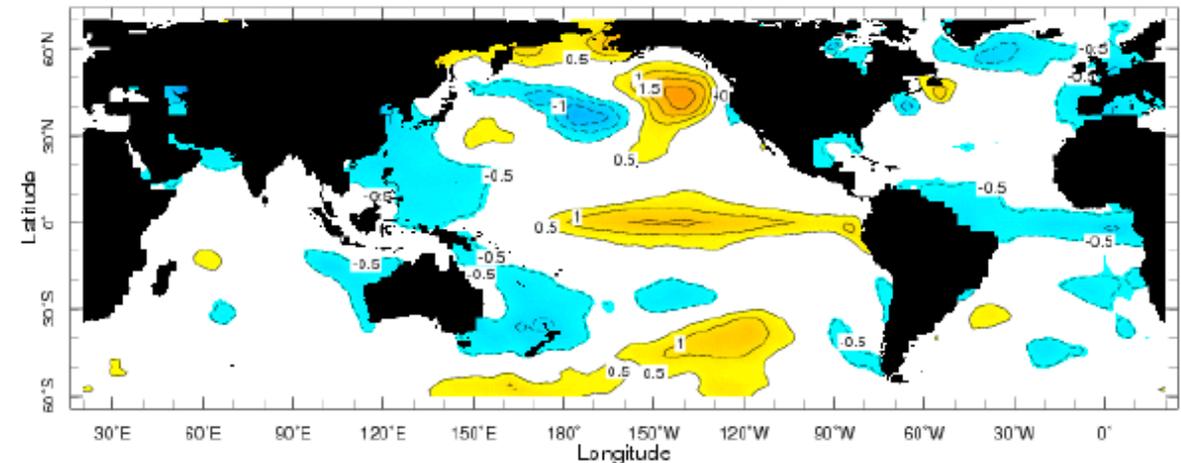
## Varianza en las anomalías asociadas a ENSO

- ¿Por qué el impacto de los eventos Niño/Niña no es siempre igual?
  - Porque el patrón de anomalías de temperatura de las aguas ecuatoriales del Pacífico es diferente en estructura y magnitud
  - Porque la señal de ENSO interacciona con las de otros modos de variabilidad

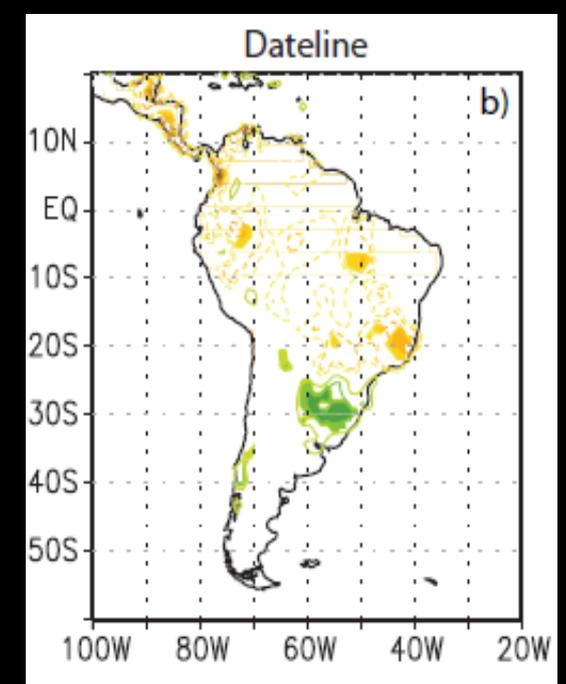
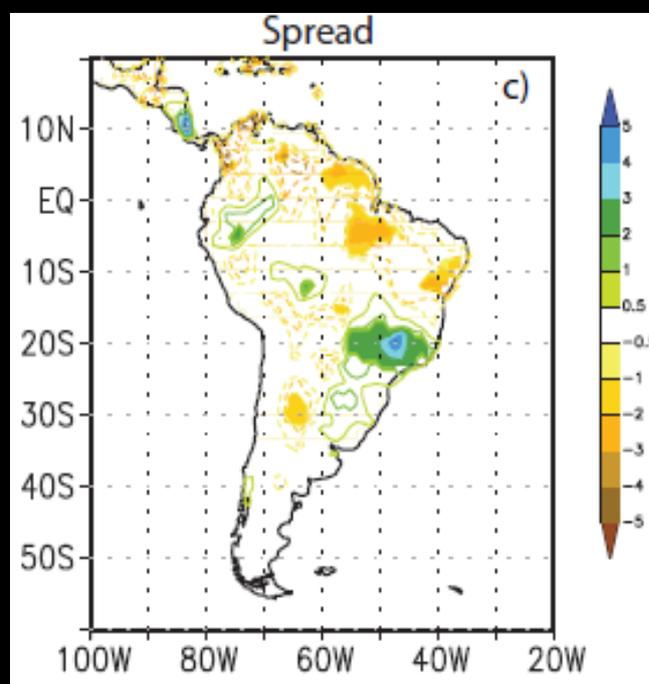
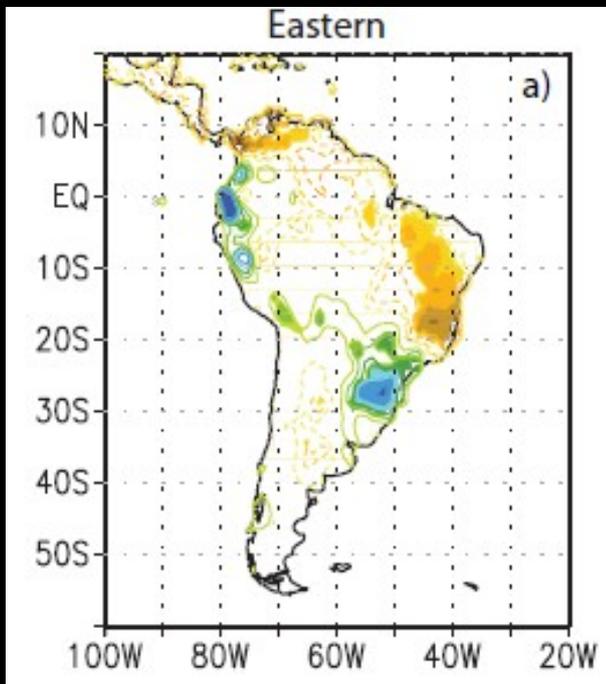
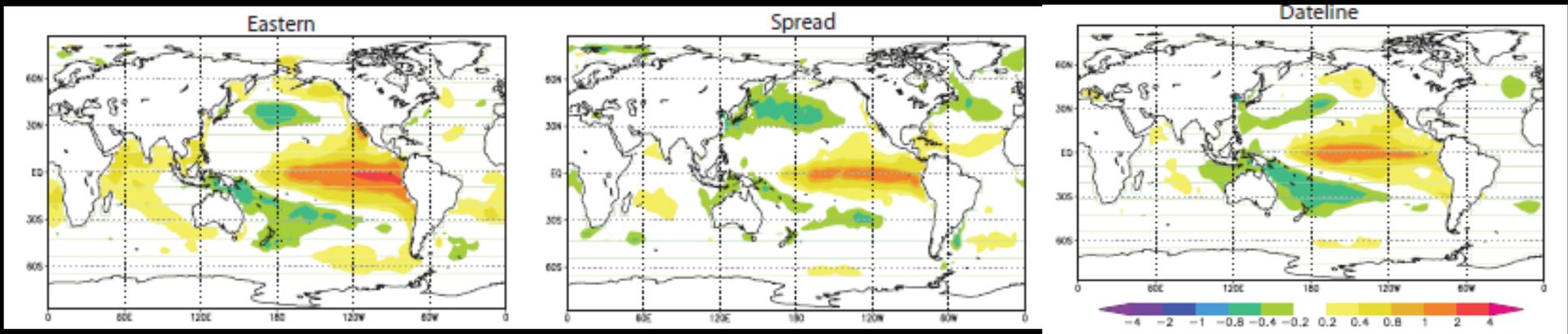
zlev 0.0 meters Time Nov 1997



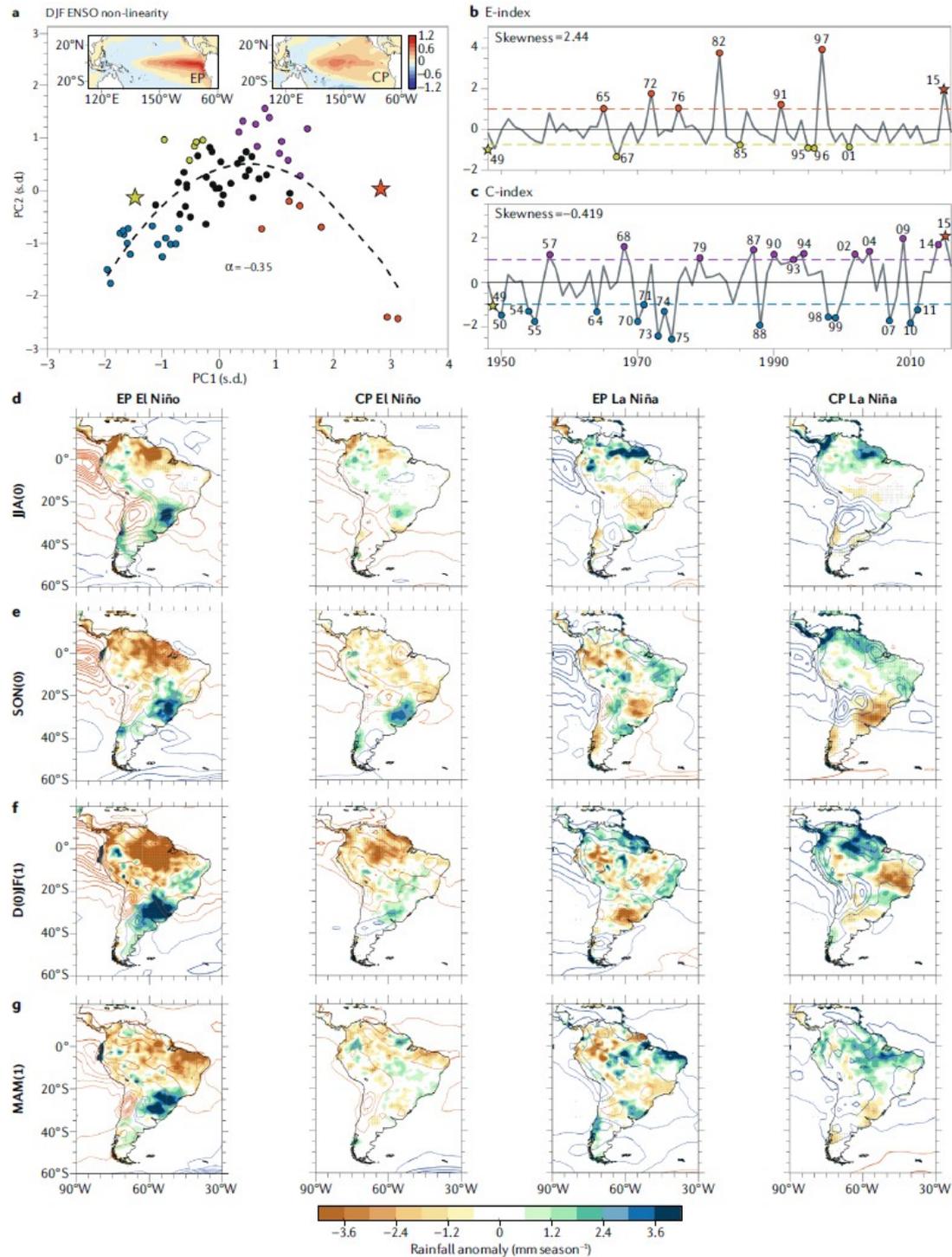
zlev 0.0 meters Time Nov 1991



# No todos los Niños son iguales: impacto sobre lluvias en primavera depende de intensidad y patrón de anomalía de TSM



# REVIEWS

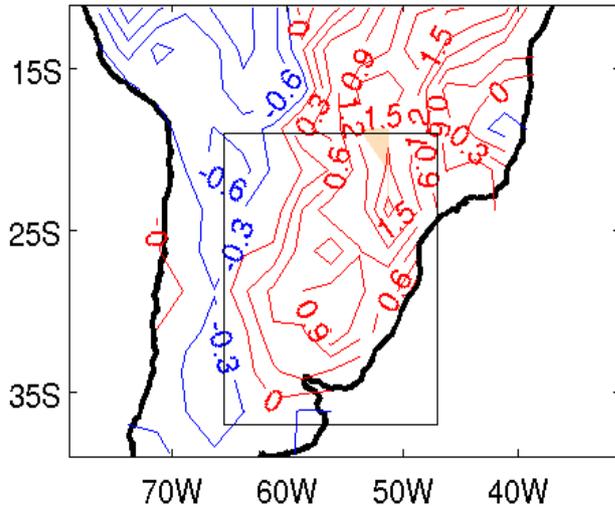


# Interferencia de ENSO con otros modos de variabilidad

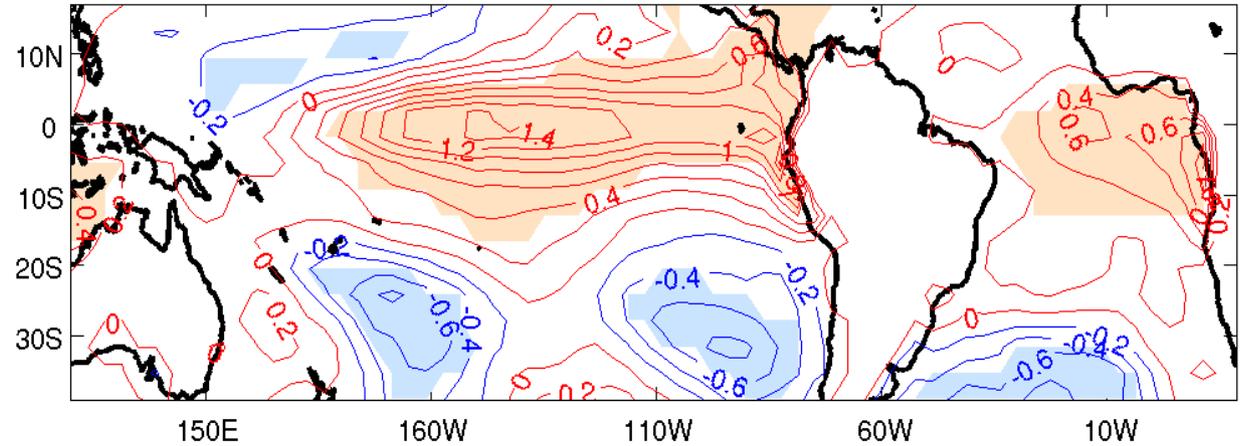


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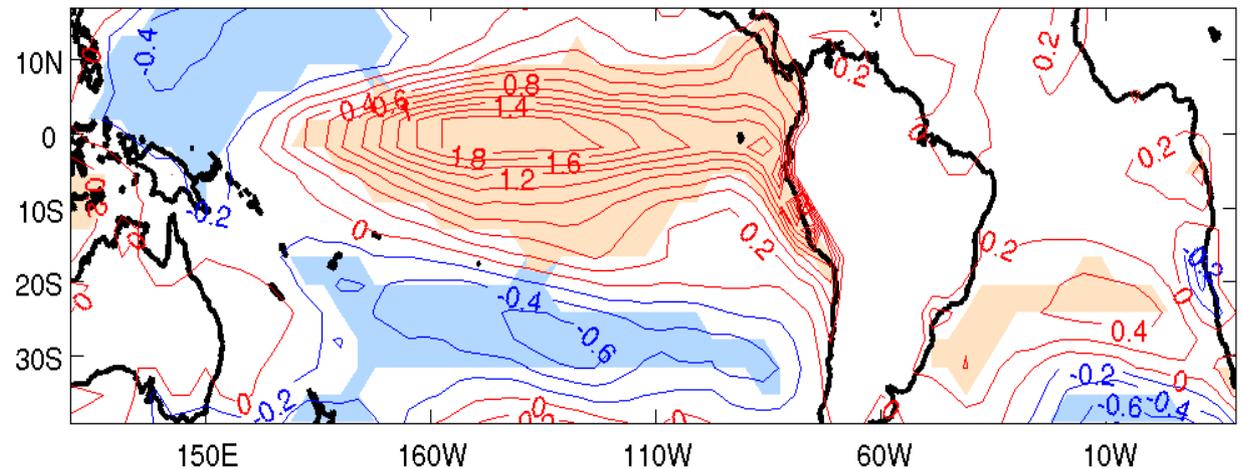
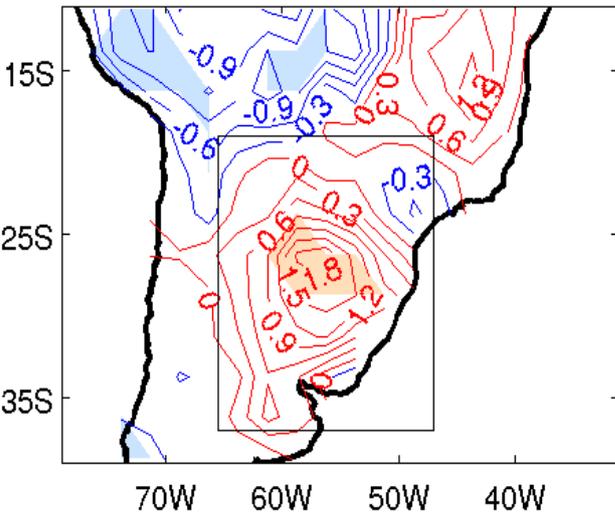
# Eventos El Niño que coinciden con anomalías positivas de TSM en el Atlántico tienen menos influencia sobre las lluvias en la cuenca del Plata en verano



El Niño events [1963 1994 1997 2002]

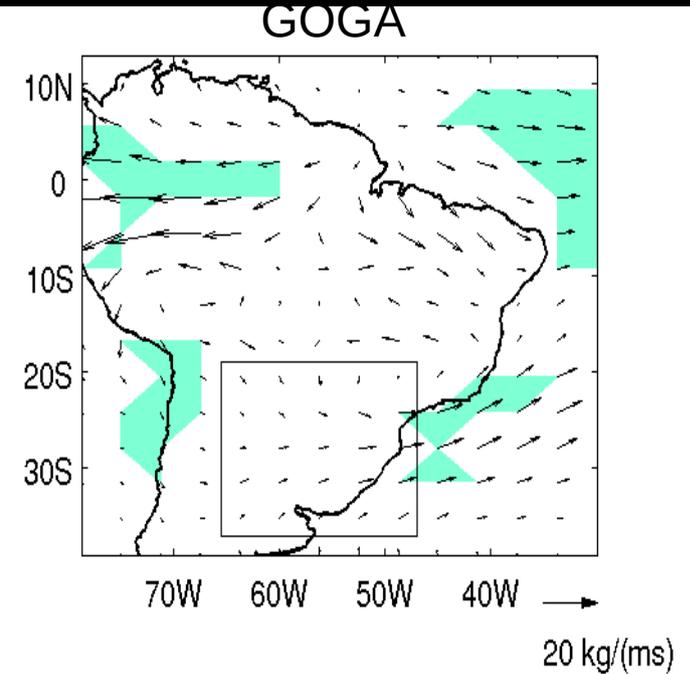
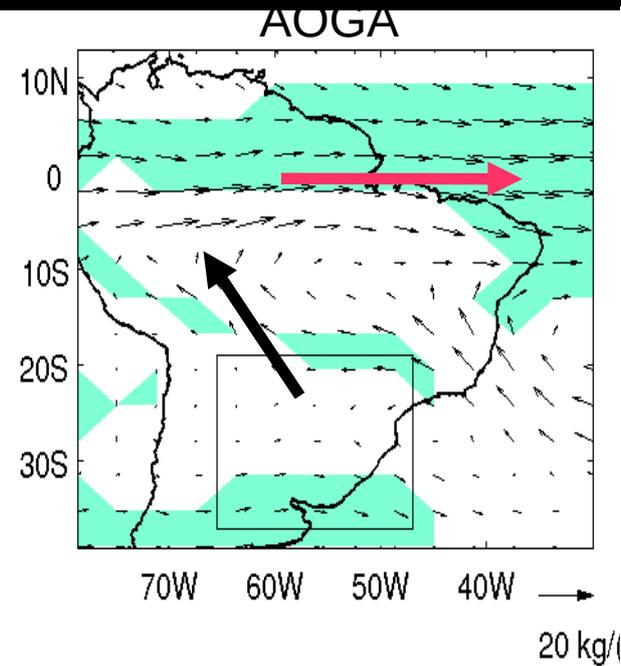
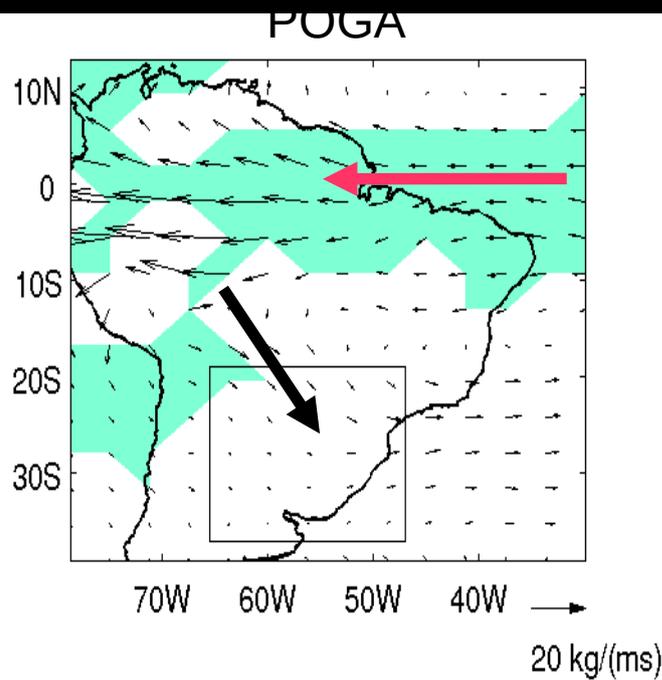
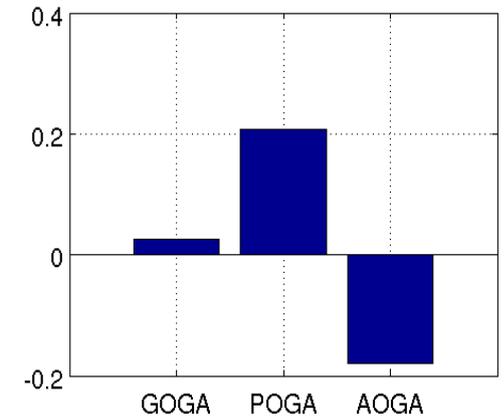
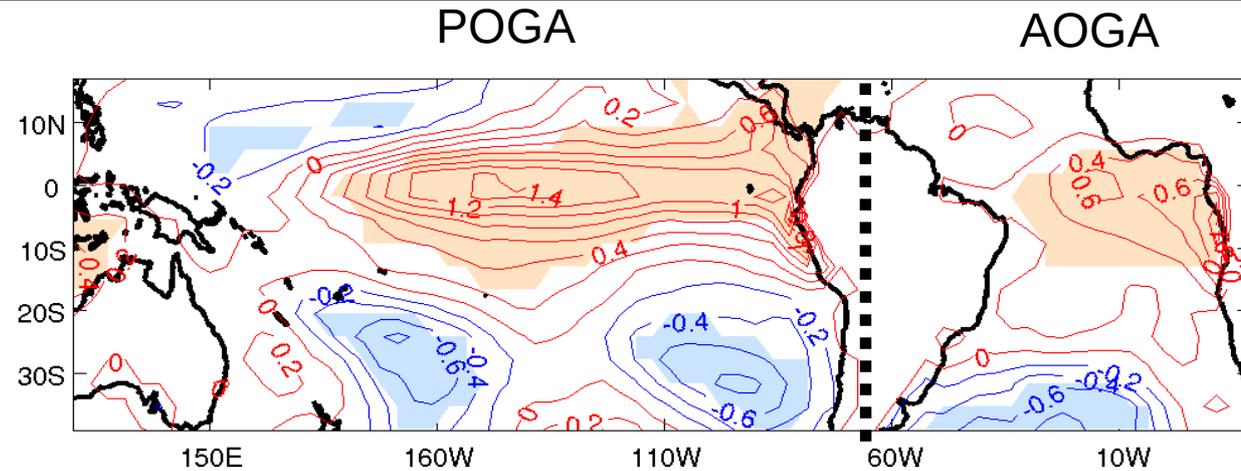


El Niño events [1957 1965 1968 1972 1982 1986 1991]



Positive SSTa in the Pacific increase the moisture flow to SESA; the Atlantic decreases it.

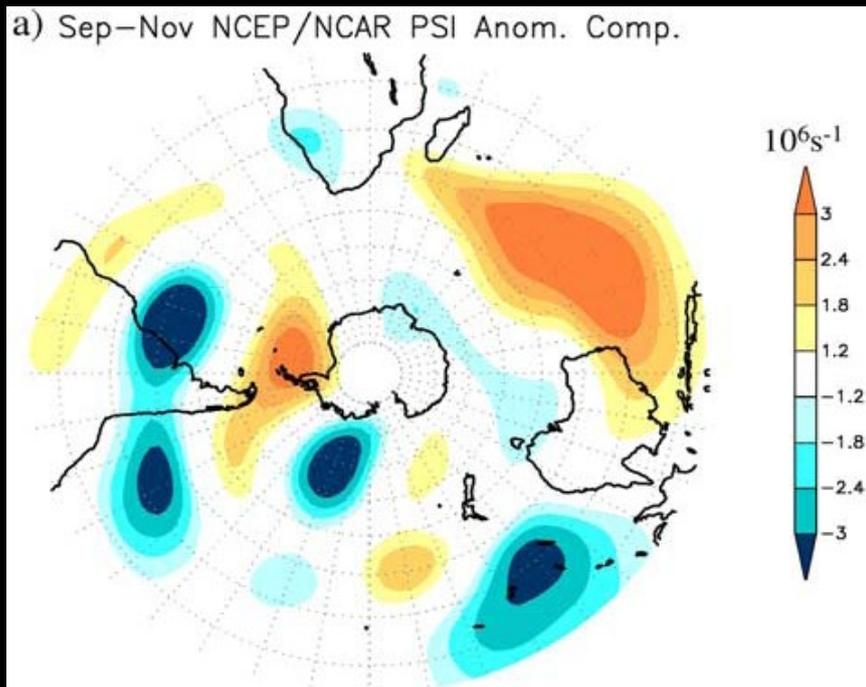
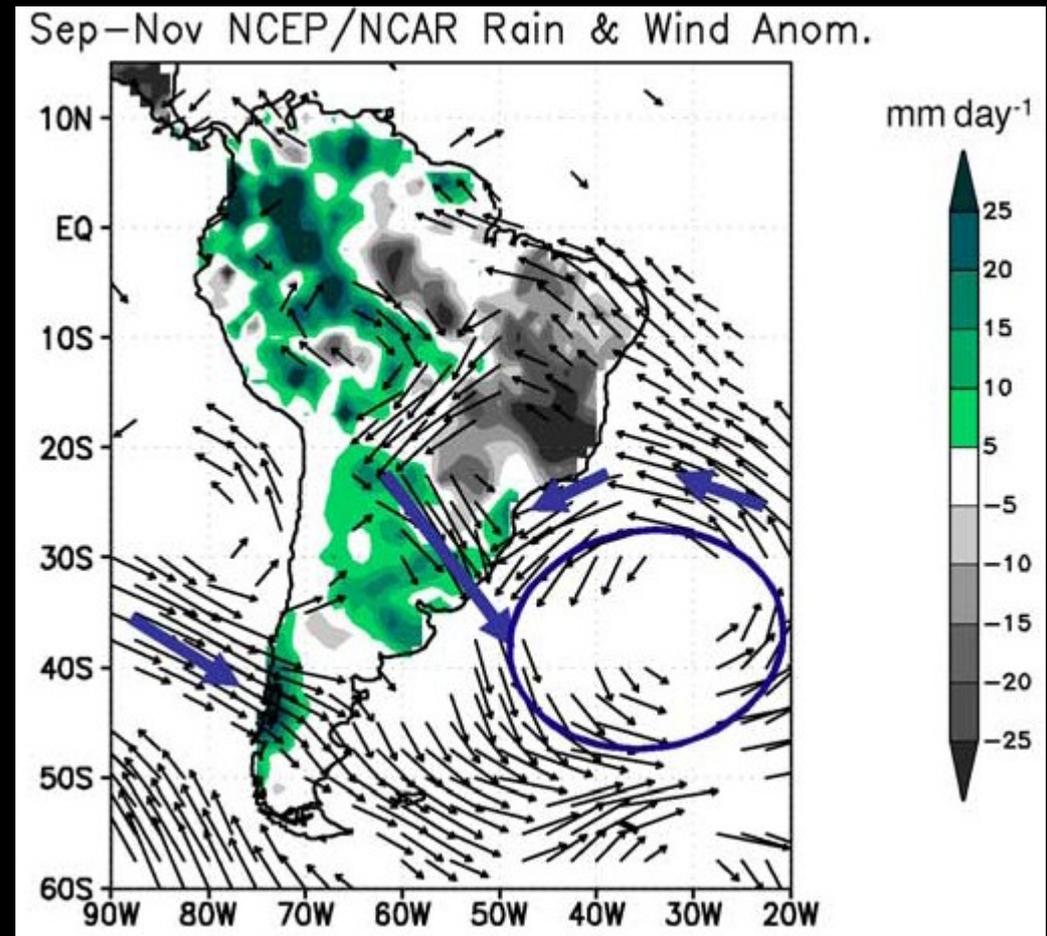
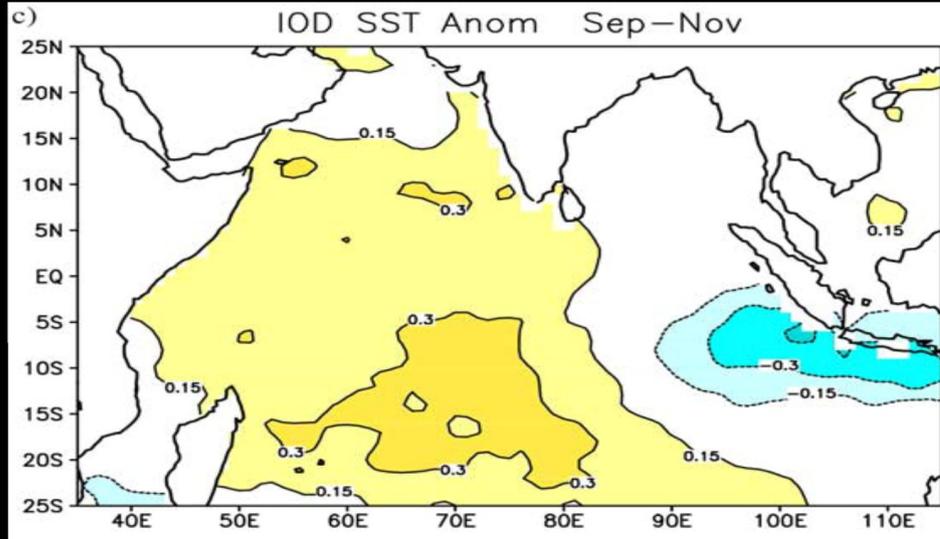
Rainfall anomalies





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# El océano Índico también influye las lluvias sobre América del Sur (Chan et al 2008)

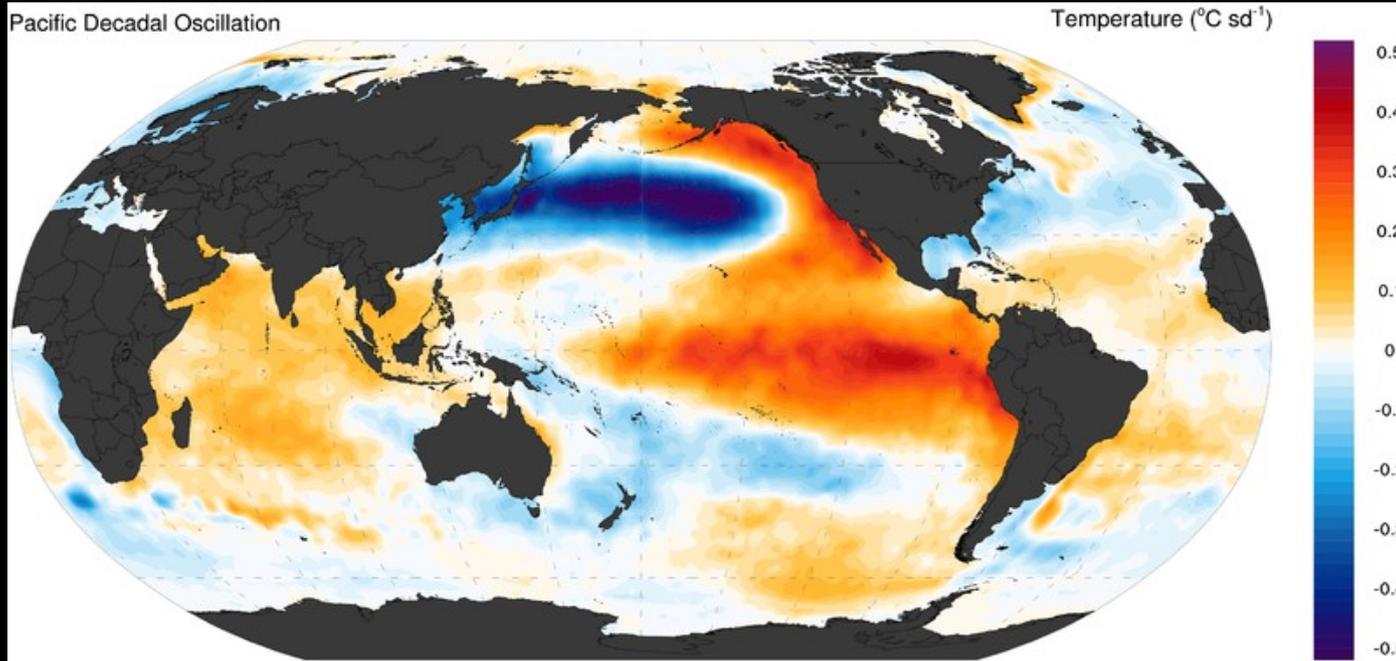


Las anomalías de TSM en el Índico fuerzan una onda atmosférica que cambia la circulación en Sudamérica aumentando el flujo de humedad desde el Amazonas hacia la cuenca del Plata y disminuyéndola en el norte de Brasil.



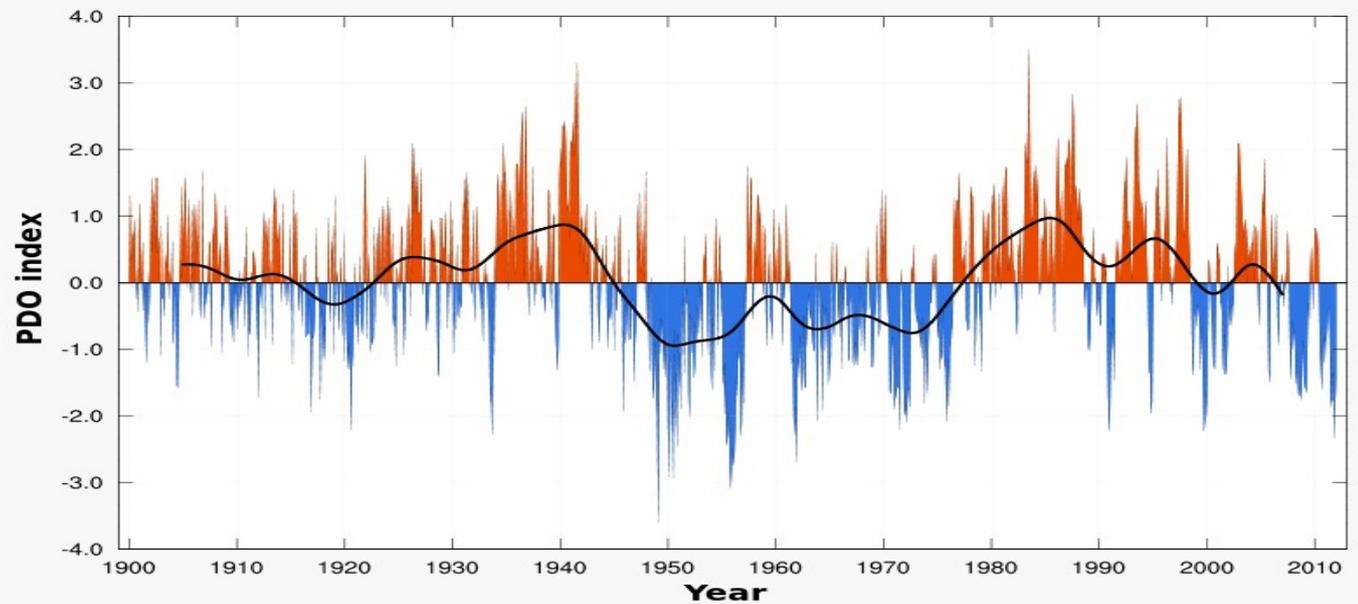
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# Oscilación decadal del Pacífico



“Oscilacion” con un periodo cercano a 60 años

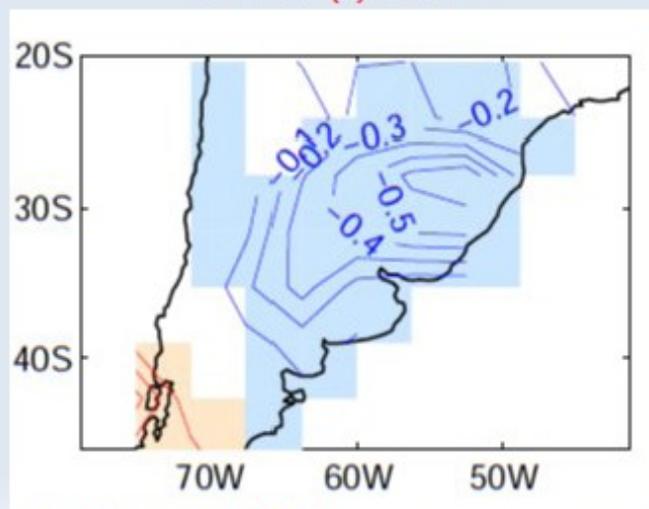
Mantua et al (1997)



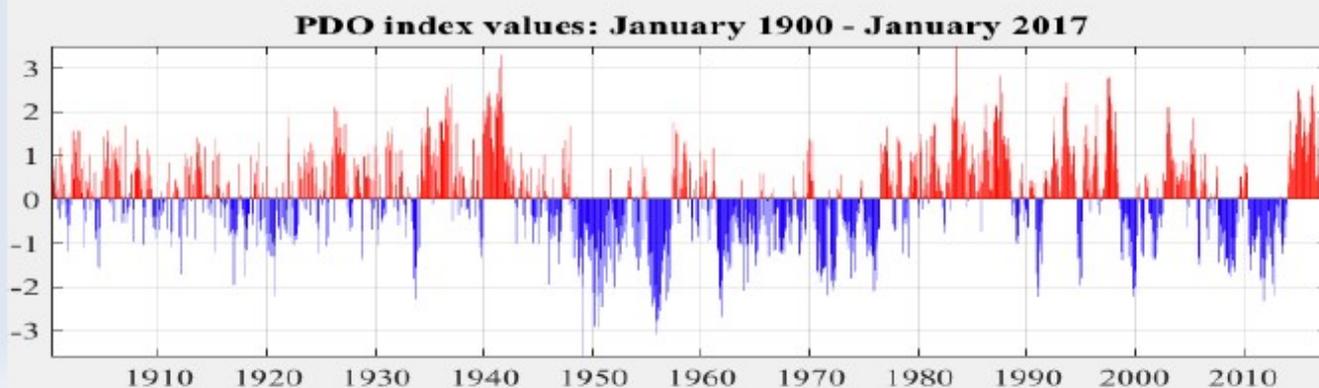
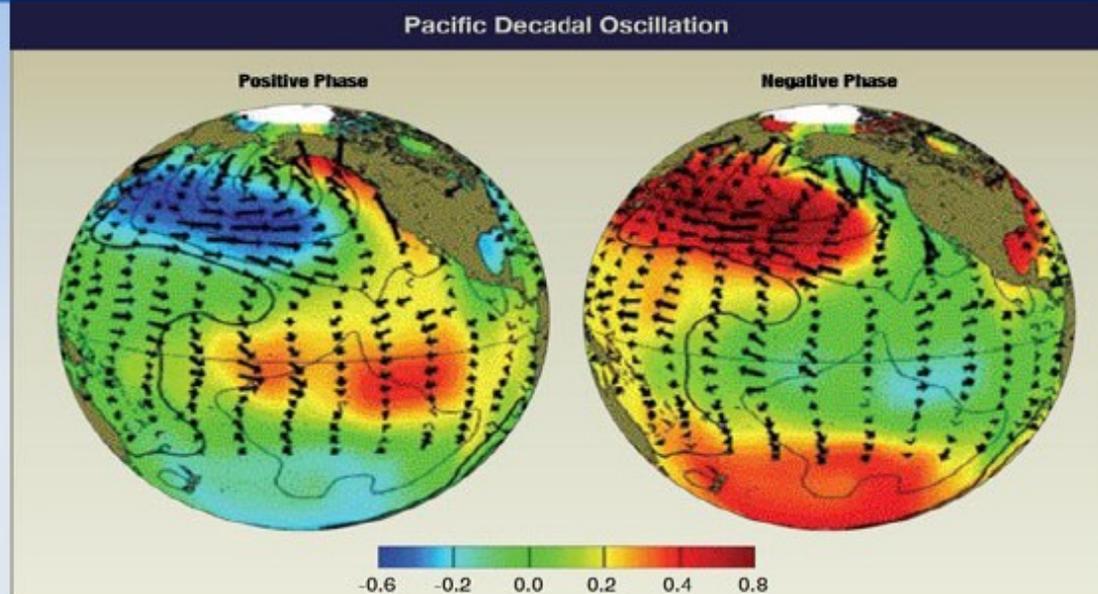
# Oscilación Decadal del Pacífico

Modo de variabilidad oceánico, que consiste en un calentamiento (enfriamiento) de las aguas tropicales (extratrop norte) del Pacífico, y vice versa.

Anomalía de lluvias  
PDO (-) DEF



Barreiro et al (2014)



# Anomalías de lluvia

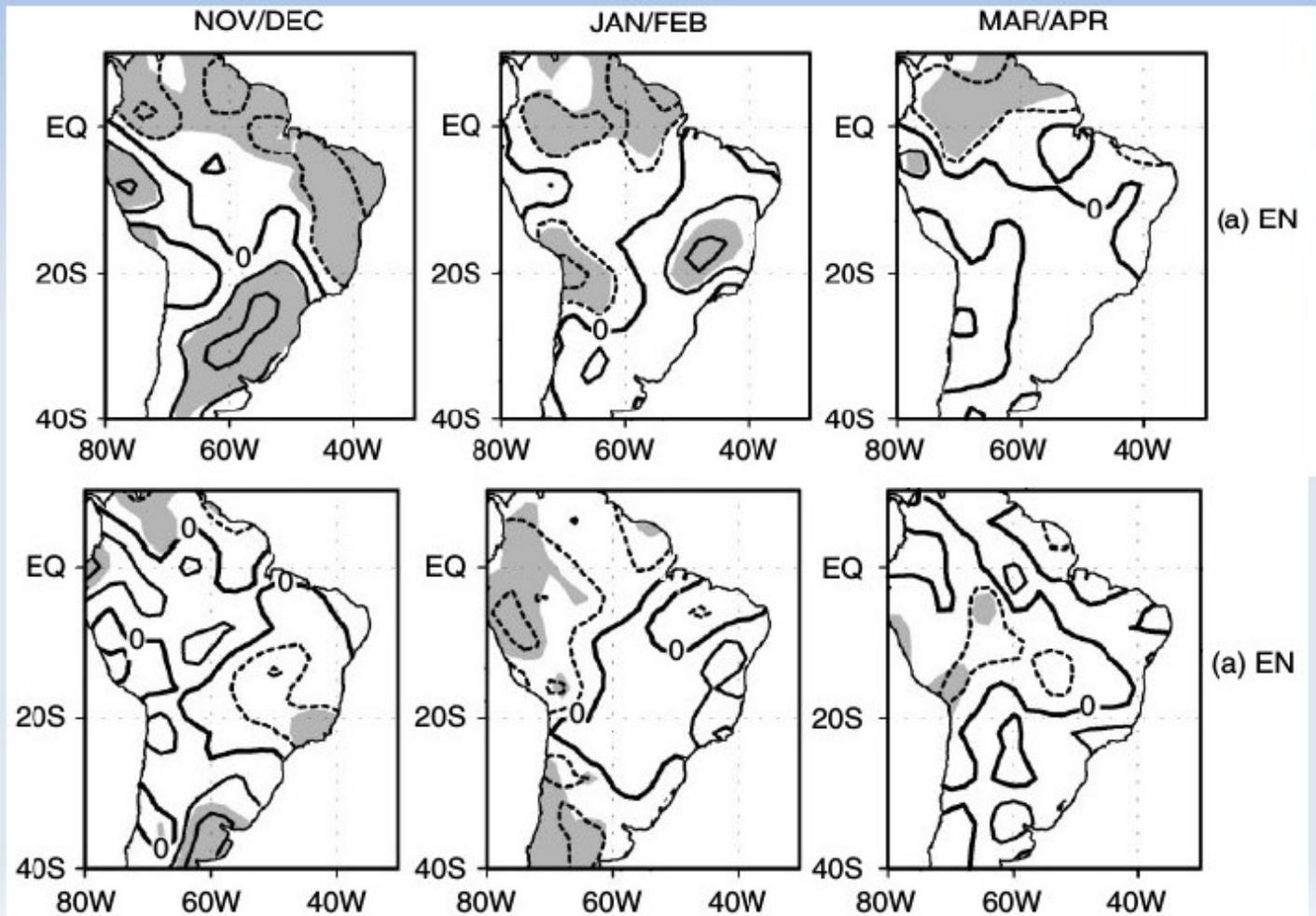
Niño + PDO positivo

Interferencia constructiva

Niño + PDO negativo

Interferencia destructiva

Kayano y Andreoli 2007



## Anomalías de Lluvia

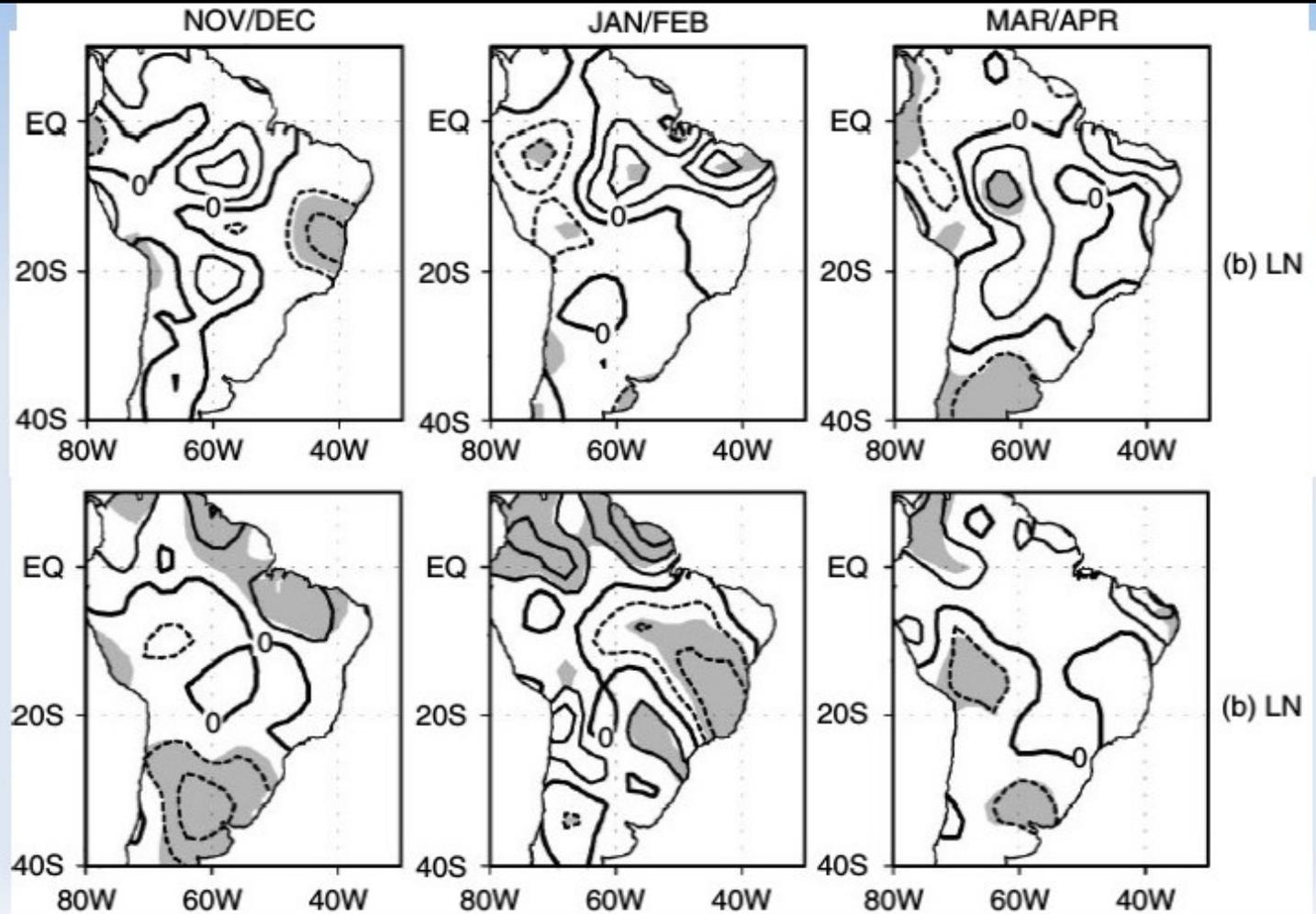
Niña + PDO positivo

Interferencia destructiva

Niña + PDO negativo

Interferencia constructiva

Kayano y Andreoli 2007

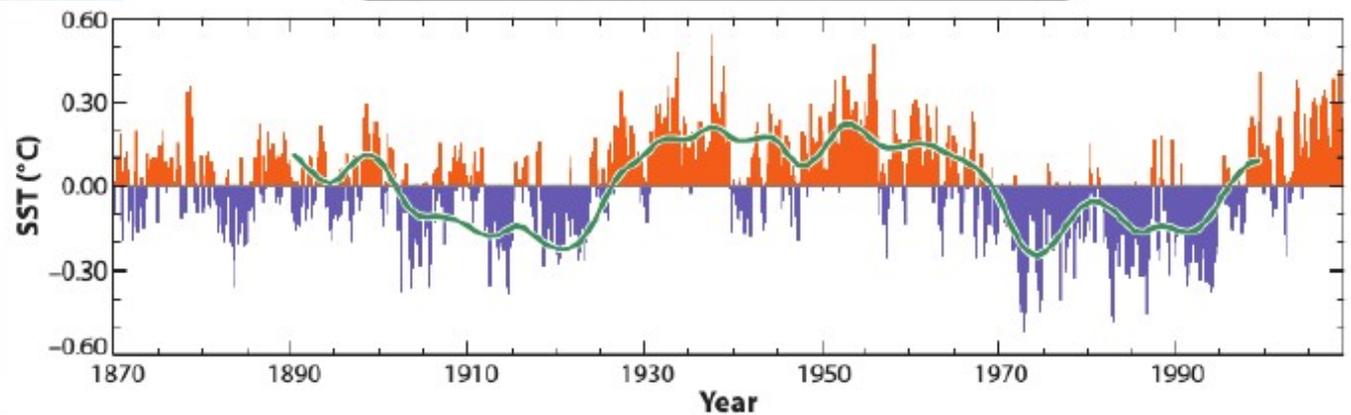
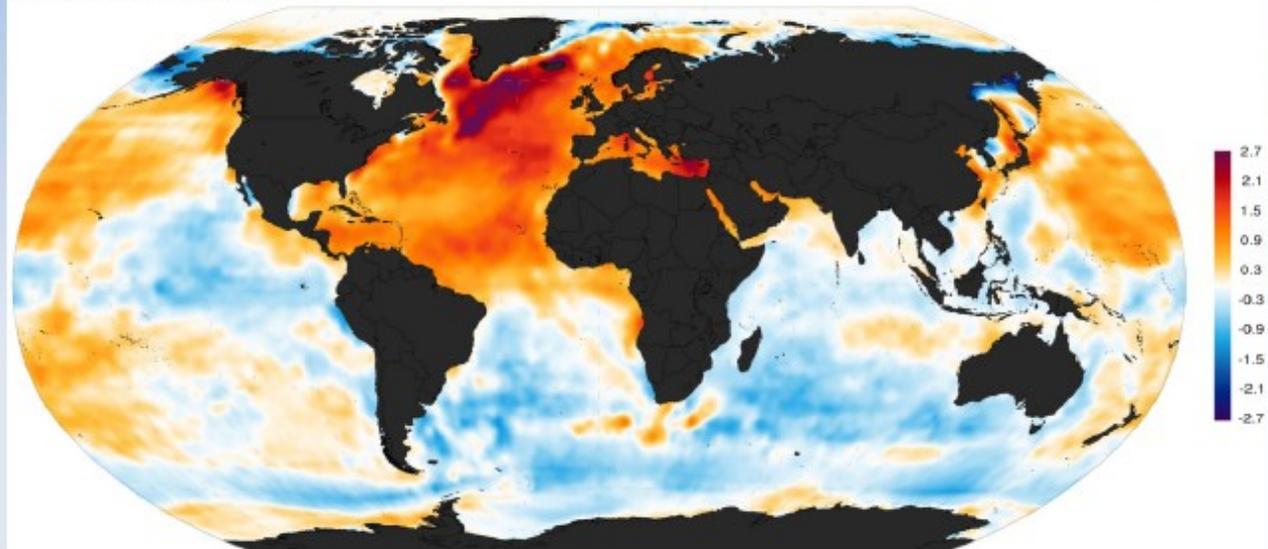


# Oscilación Multidecadal del Atlántico

Modo de variabilidad oceánico que consiste en un calentamiento/enfriamiento del Atlántico norte con un “período” de 65-80 años.



Atlantic Multidecadal Oscillation



## Anomalías de lluvia

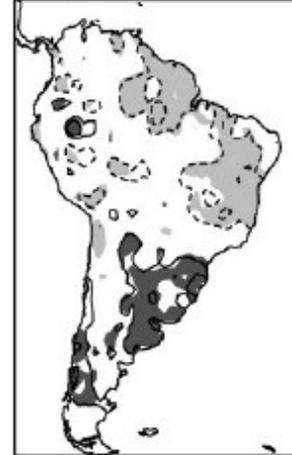
Niño + AMO positiva

Interferencia destructiva

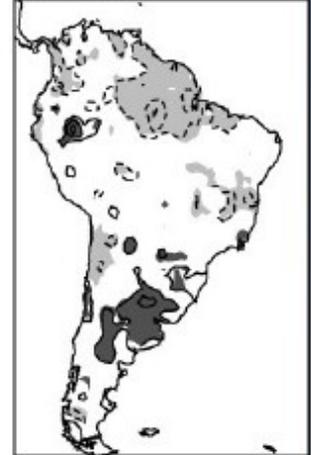
SON(0)



OND(0)



NDJ(0)



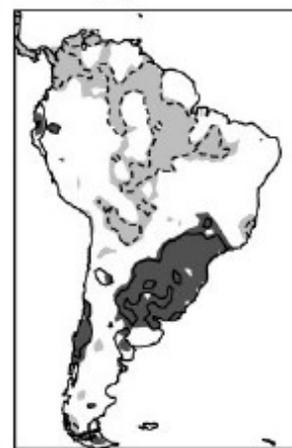
Niño + AMO negativa

Interferencia constructiva

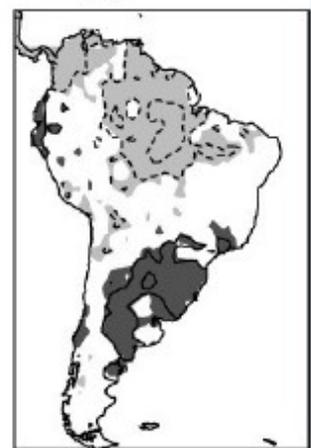
SON(0)



OND(0)



NDJ(0)



## Anomalías de lluvia

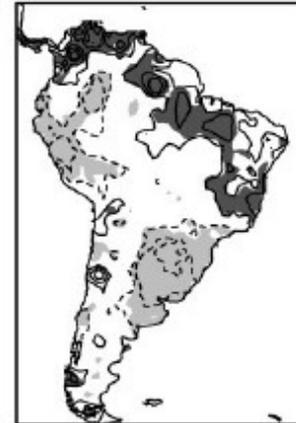
Niña + AMO positiva

Interferencia constructiva

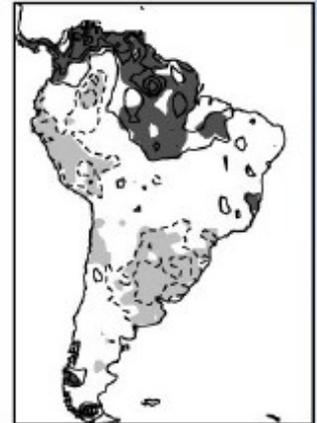
SON(0)



OND(0)



NDJ(0)



SON(0)



OND(0)



NDJ(0)



Niña + AMO negativa

Interferencia destructiva

# Land-atmosphere coupling in El Niño influence over South America

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Unidad de Ciencias de la Atmósfera, Instituto de Física, Facultad de Ciencias, Universidad de la República, Montevideo 11100, Uruguay

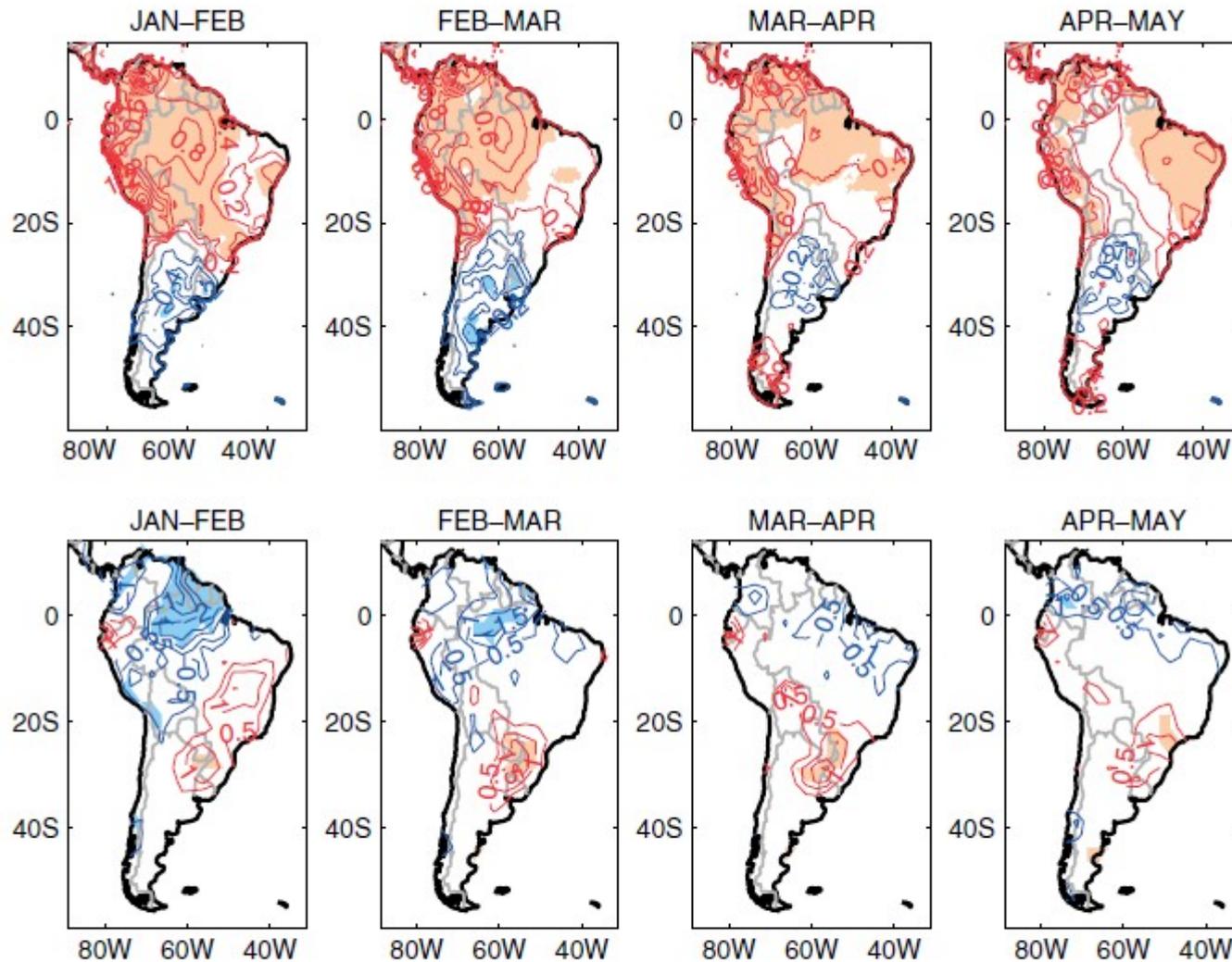
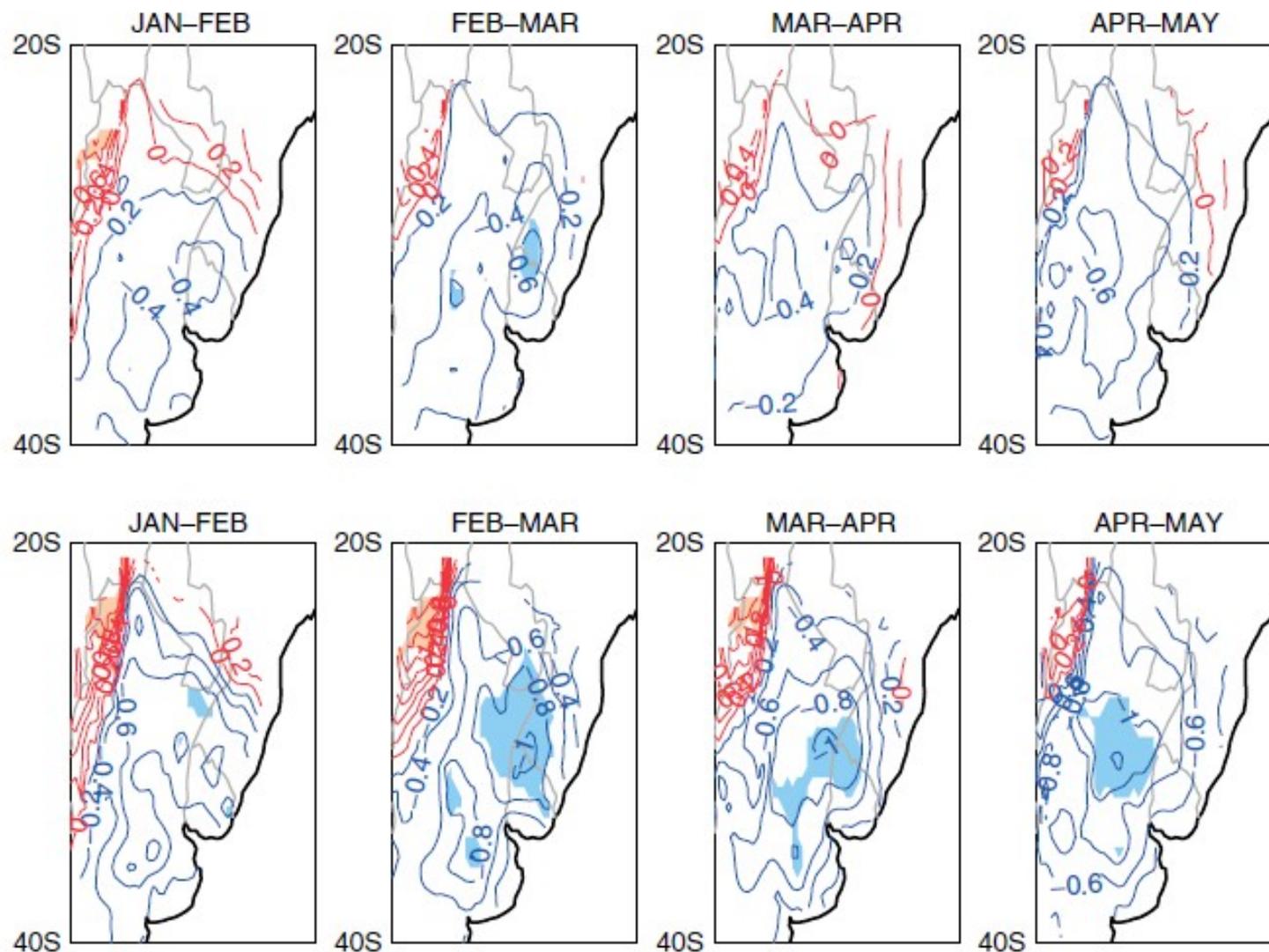


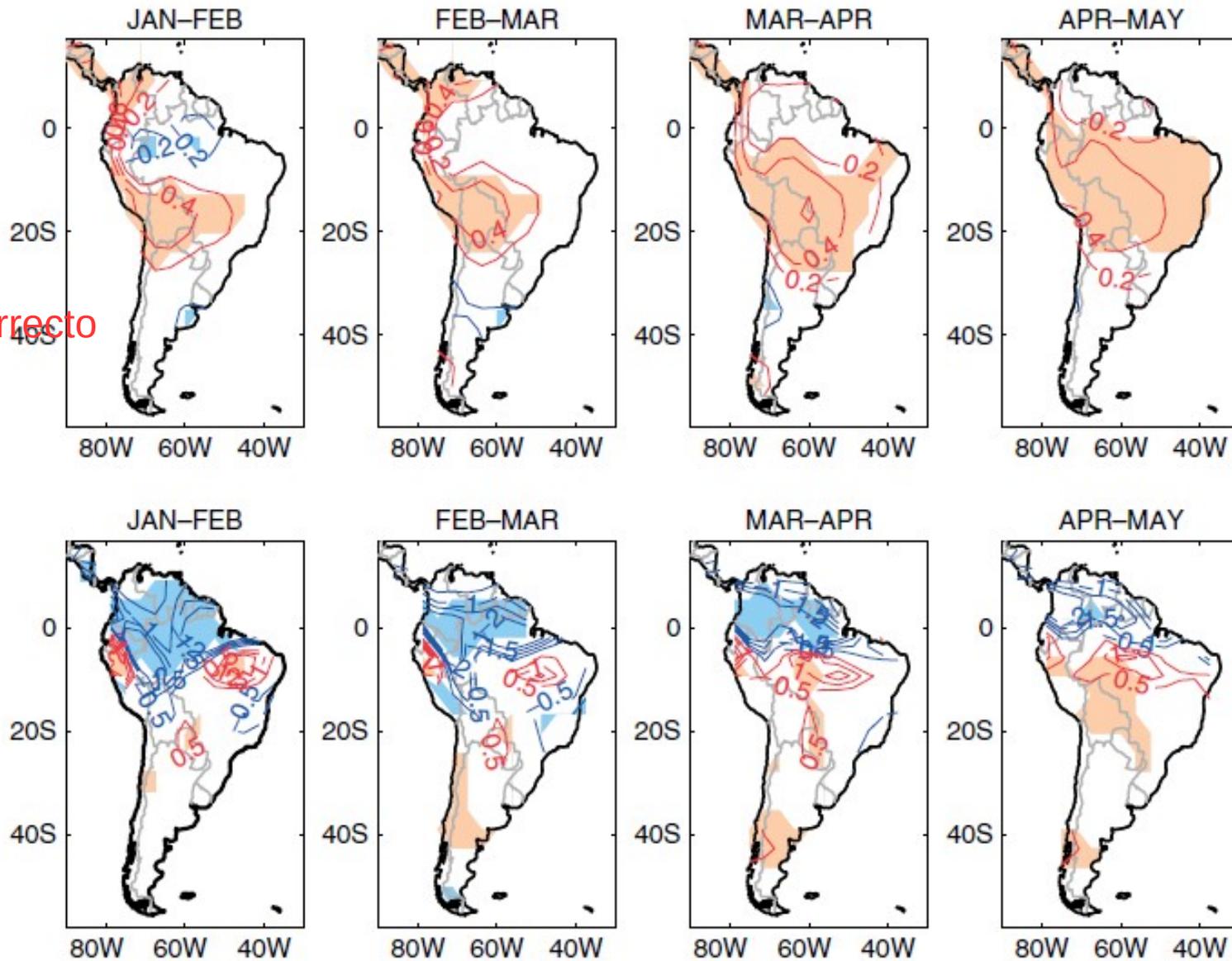
Figure 1. Composites of CRU surface air temperature ( $^{\circ}\text{C}$ , above) and PREC-L rainfall ( $\text{mm d}^{-1}$ , below) for different bimesters. Composites are constructed as the average of El Niño years minus neutral years. Shading indicates significance at the 5% level calculated using a two-sided Student's t-test.



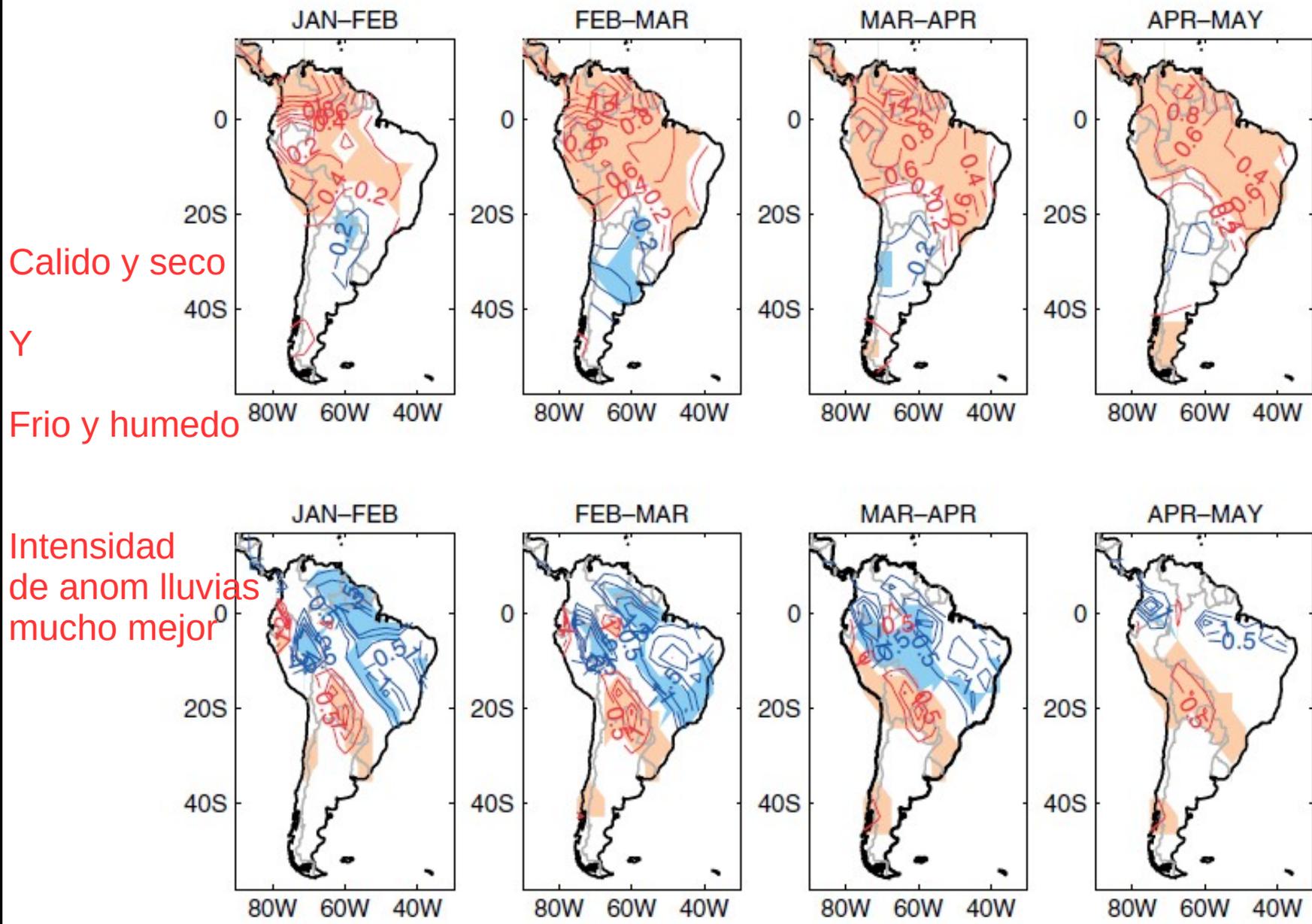
**Figure 2.** Composites of mean surface temperature ( $^{\circ}\text{C}$ , above) and maximum surface temperature ( $^{\circ}\text{C}$ , below) from the work by Tencer *et al.* (2010) data set for different bimesters during El Niño years. Since this data set comprises the period 1961–2000 the composites are constructed using only the El Niño and neutral years between these dates. Significance as in Figure 1.

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signo incorrecto

Lluvias ok  
signo



**Figure 3.** Composites of surface air temperature ( $^{\circ}\text{C}$ , above) and rainfall ( $\text{mm d}^{-1}$ , below) for the model simulation with climatological soil moisture in different bimesters. Composites and shading as in Figure 1.



Calido y seco  
Y  
Frio y humedo

Intensidad  
de anom lluvias  
mucho mejor

**Figure 4.** As Figure 3, but for the model simulation with interactive soil moisture. Note the large similarity with the observed anomalies shown in Figure 1.