El Niño, South American Monsoon, and Atlantic Niño links as detected by a decade of QuikSCAT, TRMM and TOPEX/Jason Observations

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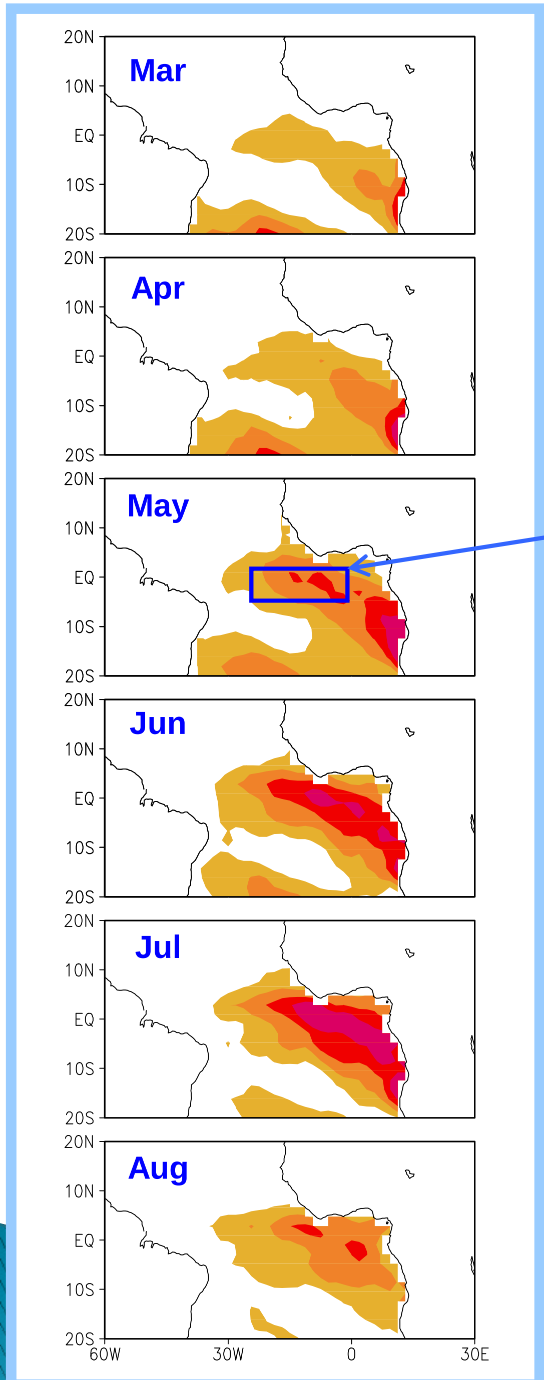
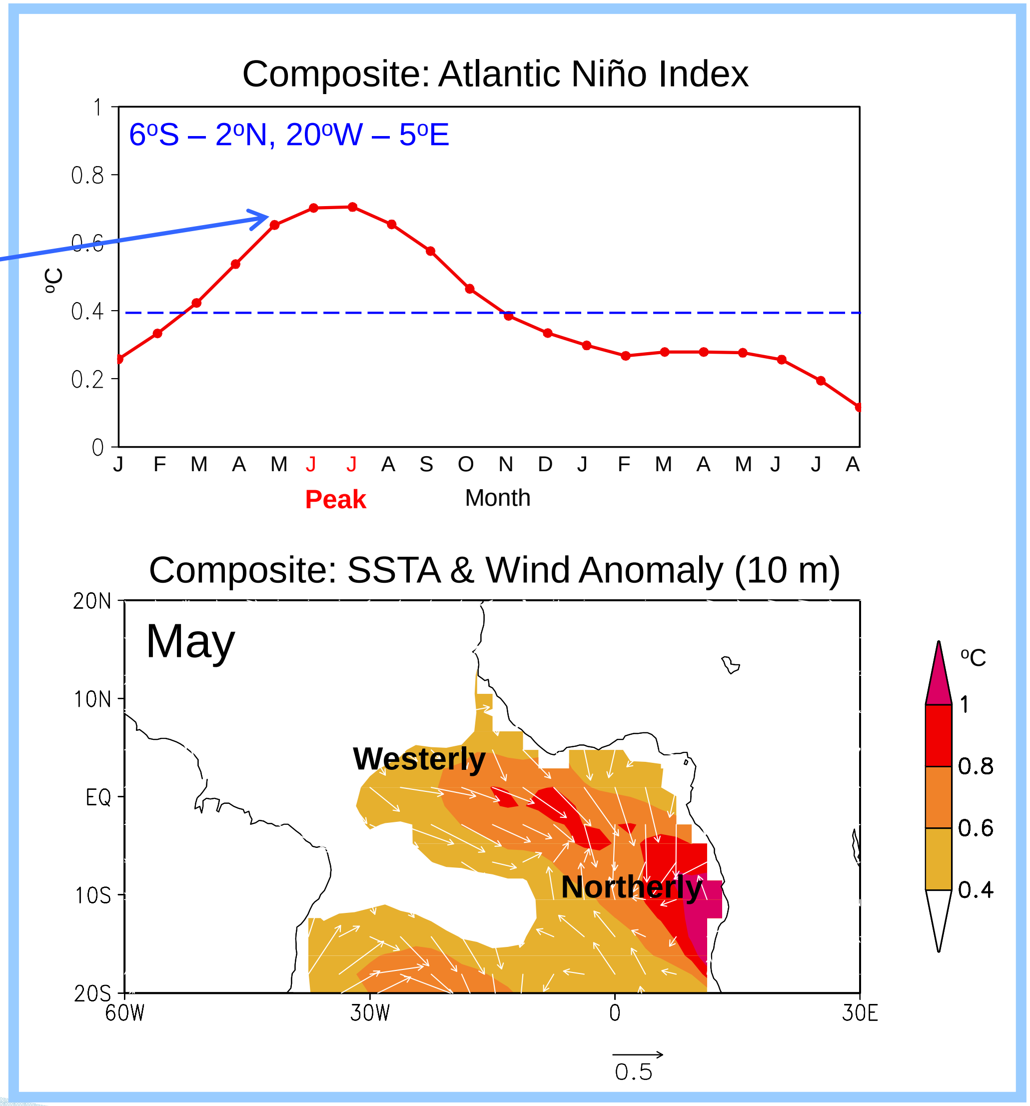
NASA OVWST – Scatterometry and Climate Meeting
Arlington, Virginia, 19 – 21 August 2009

Atlantic Niño starts during March–May season:

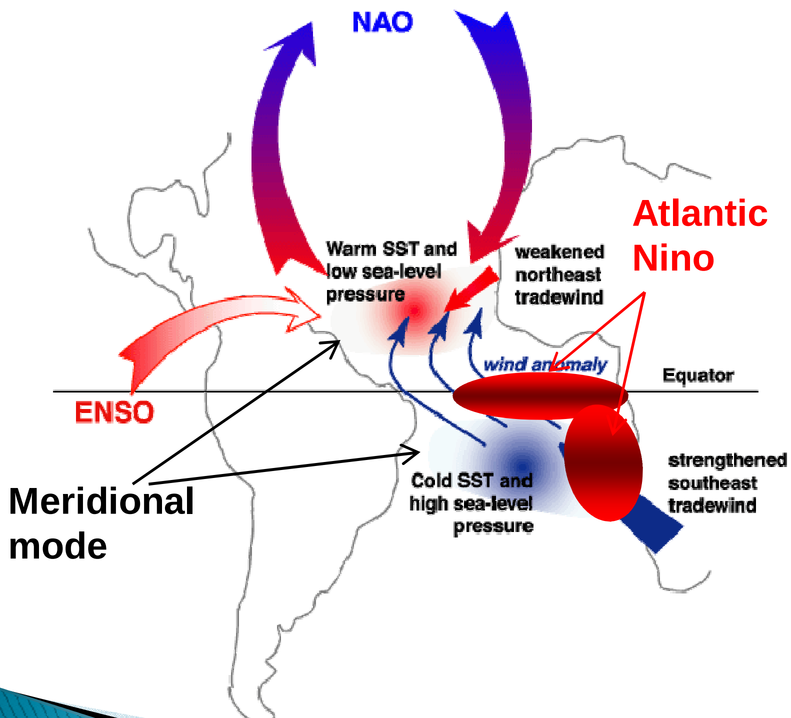


SST Composite
11 warm events
1948–2005



What process might bridge the temporal gap between ENSO influence and Atlantic Niño on seasonal scale?

- ENSO influence peaks in boreal winter, whereas Atlantic Niño peaks in boreal summer.
- Okumura & Xie 2006: the meridional mode of Atlantic SST anomalies.



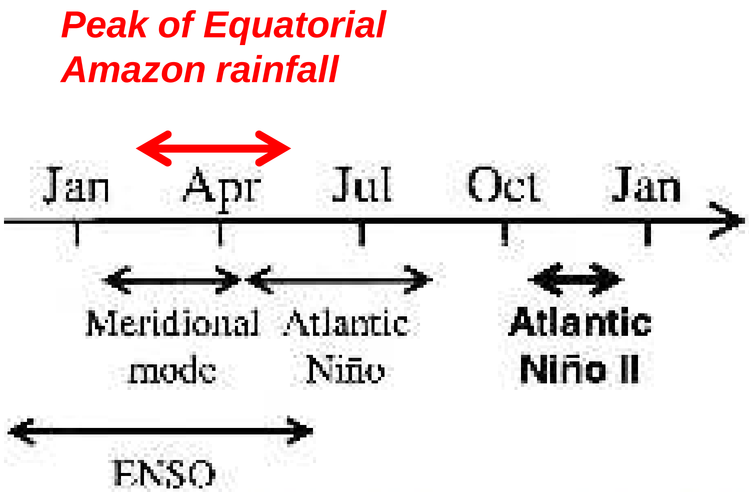
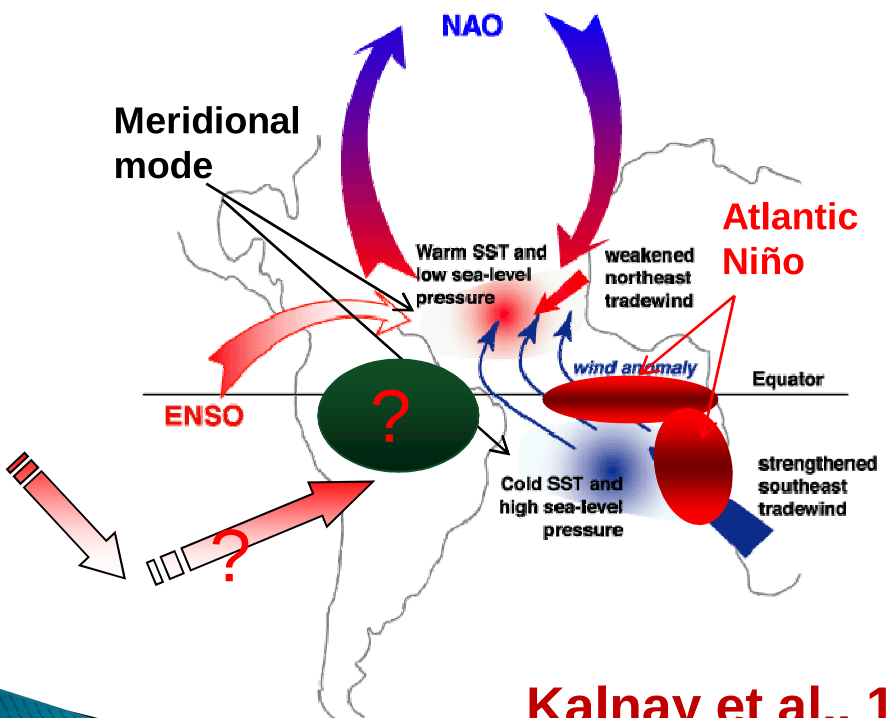


FIG. 16. Seasonality of the dominant modes of climate variability in the tropical Atlantic, modified after Sutton et al. (2000). The present study shows that the Atlantic Niño II fills an important gap in early boreal winter.

Okumura and Xie, 2006

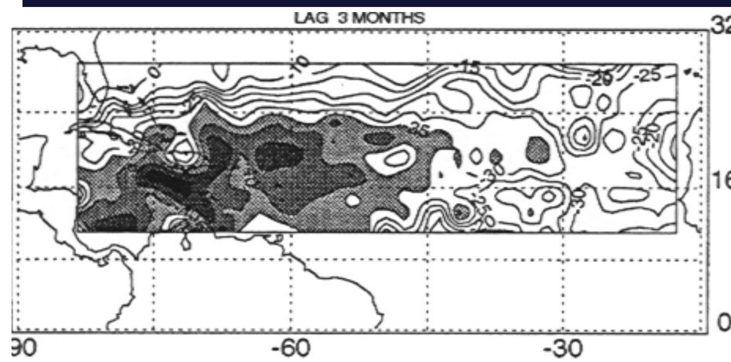
Potential role of South American Continent:

- *The SSTA in the N. tropical Atlantic is better correlated with river flow in the S. America than with ENSO index.*
- *Are there other pathways, esp. through change of S. American rainfall, for ENSO to influence Atlantic Nino?*

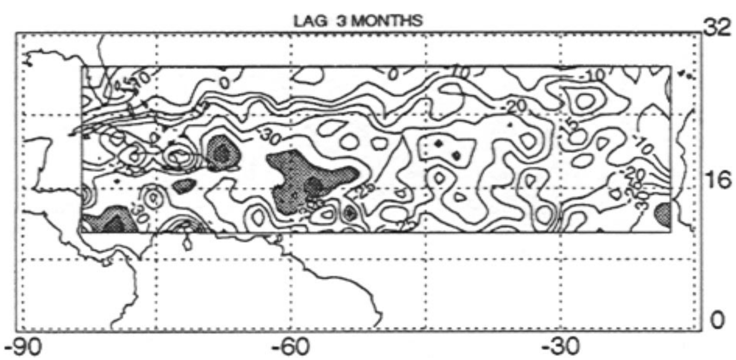


Kalnay et al., 1988

Colombia Rivers vs. Atlantic SST



Niño3 vs. Atlantic SST

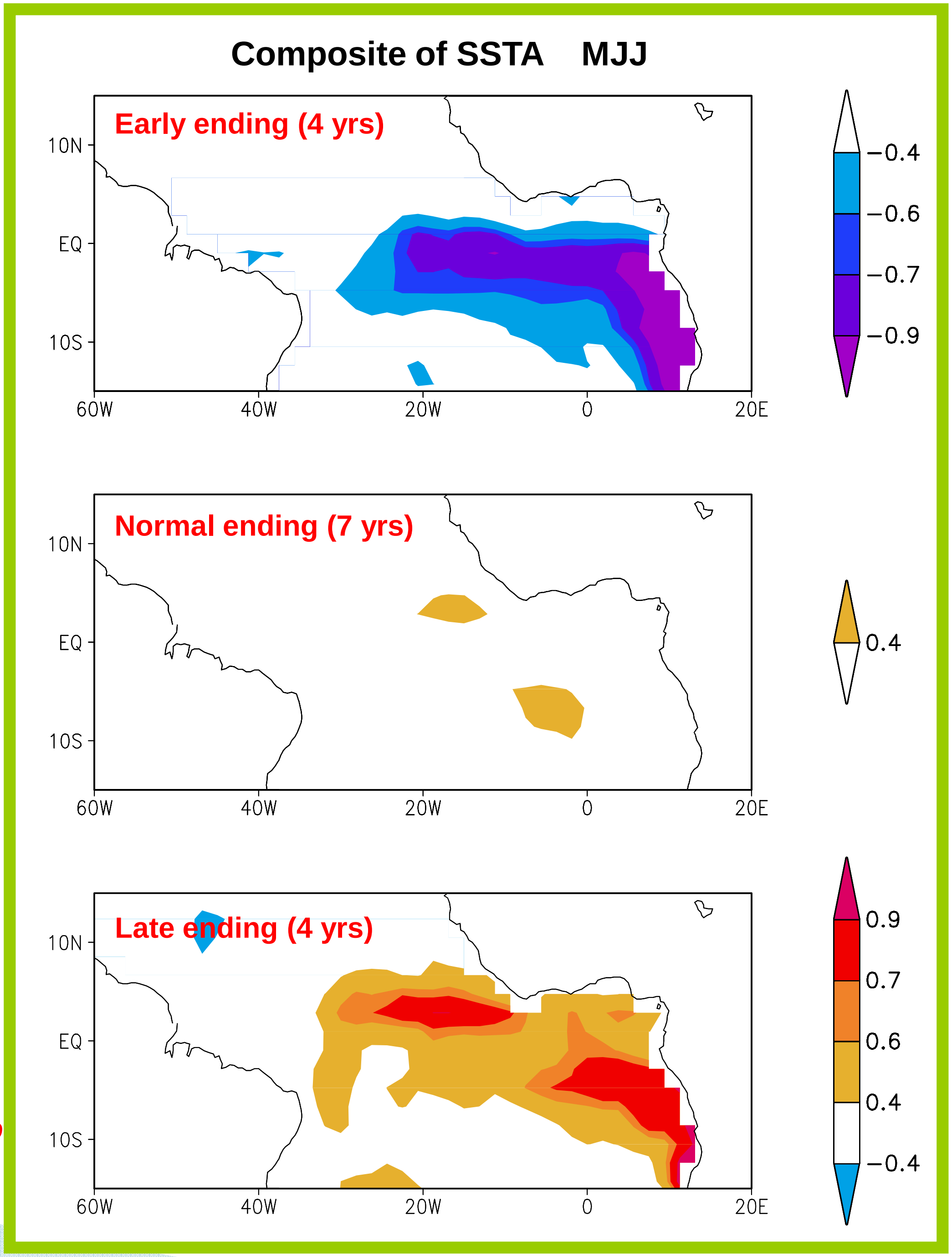


Poveda & Mesa (1997): Atlantic SST anomalies, anomalies of Colombia River flow, Niño3 (1946-95).

Link between changes in wet season ending in the Amazon and Atlantic Niño:

Amazon Wet season	*Atlantic Niño*
Early ending in spring Weak Kelvin wave	*cold phase in summer*
Late ending in spring Strong Kelvin wave	*warm phase in summer*

Data: 1979–1997
Ending date: Marengo



Data Sets :

- *QuikSCAT daily surface wind: daily ocean surface wind at 1° lat/lon resolution, 1999-2007;*

- *DT-MSLA merged altimeter data: 7-day running mean of sea-level height anomalies at 1/3° resolution. A merged product of Topex/Poseidon, Jason-1, and European Research Satellite (ERS) altimeter data produced by the French Archiving, Validation, and Interpolation of Satellite Oceanographic Data (AVISO) project;*

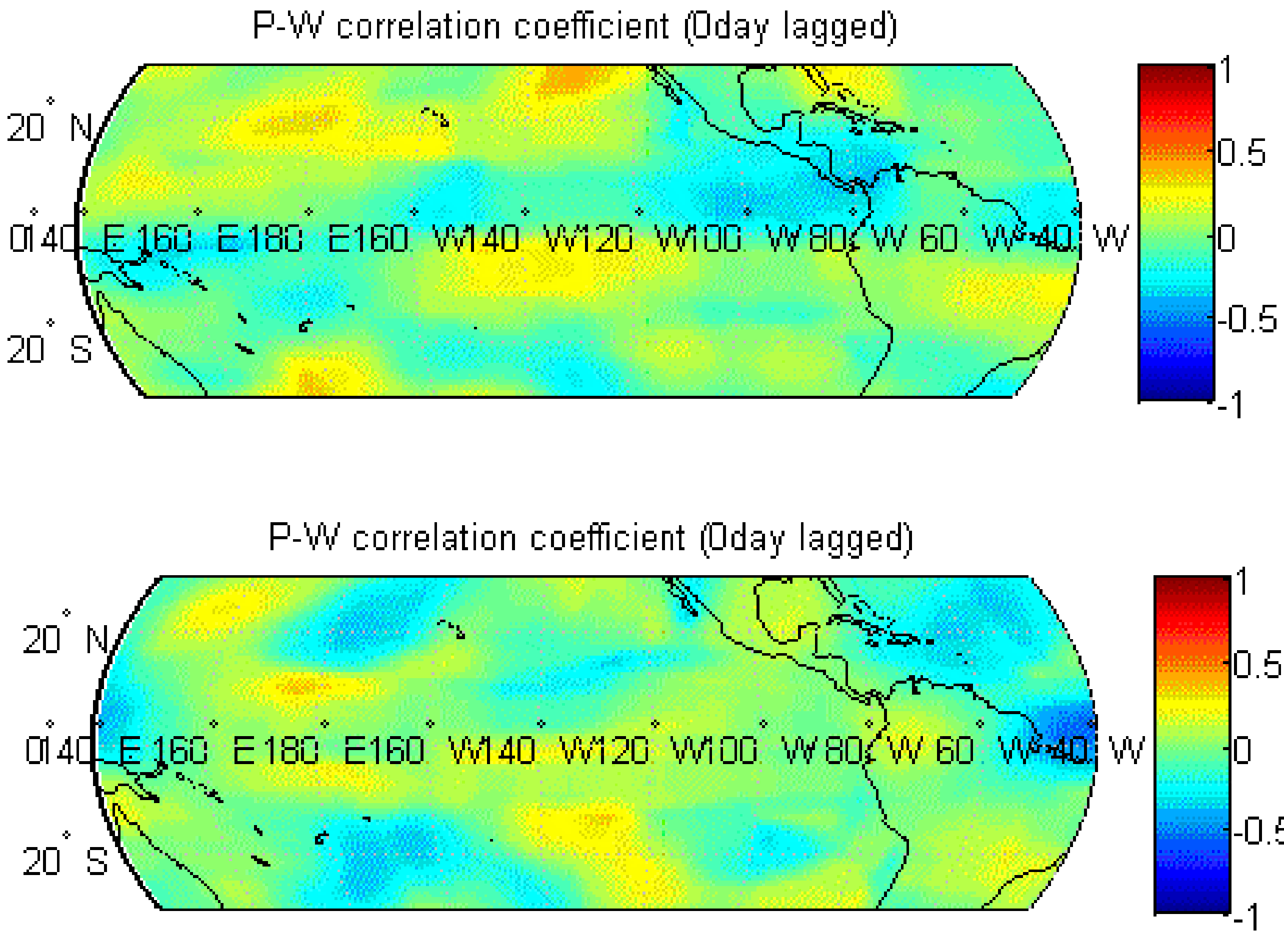
- *TRMM daily rainrate data (3B42): 1° lat/lon resolution;*

- *NCEP Reanalysis: Sea surface Temperature (SST), winds above the surface, 6 hrs, 2.5° lat/lon resolution.*

Two pathways for ENSO to influence winds to influence Atlantic Niño through changes of S. American rainfall:

2002, March-May Equatorial pathway

2007, March-May Subtropical pathway



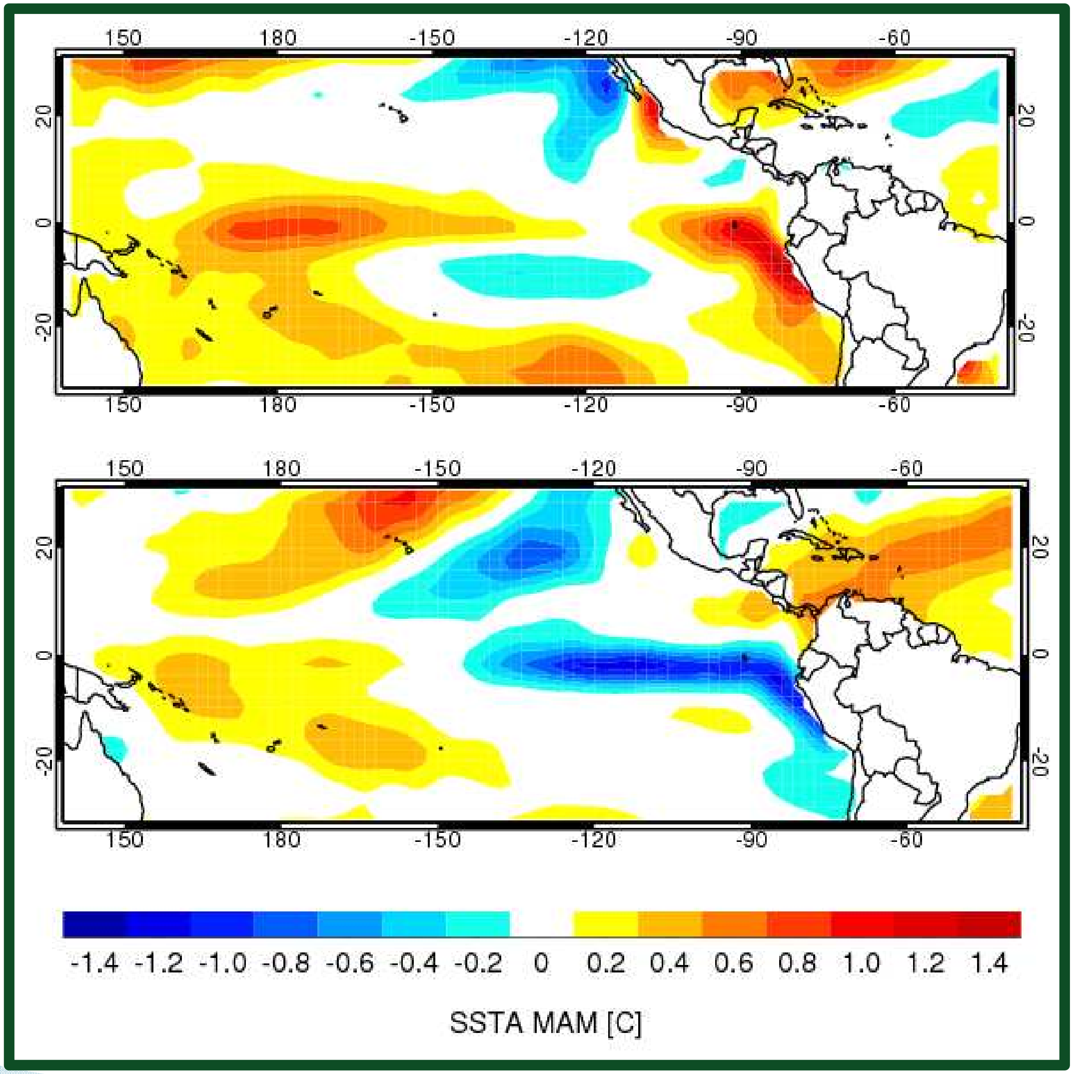
Lead correlation between rainfall anomalies in the pacific and S. America and zonal wind anomalies in the equatorial W. Atlantic ocean.

Two pathways for ENSO to influence winds to influence Atlantic Niño through changes of S. American rainfall:

SST Anomalies

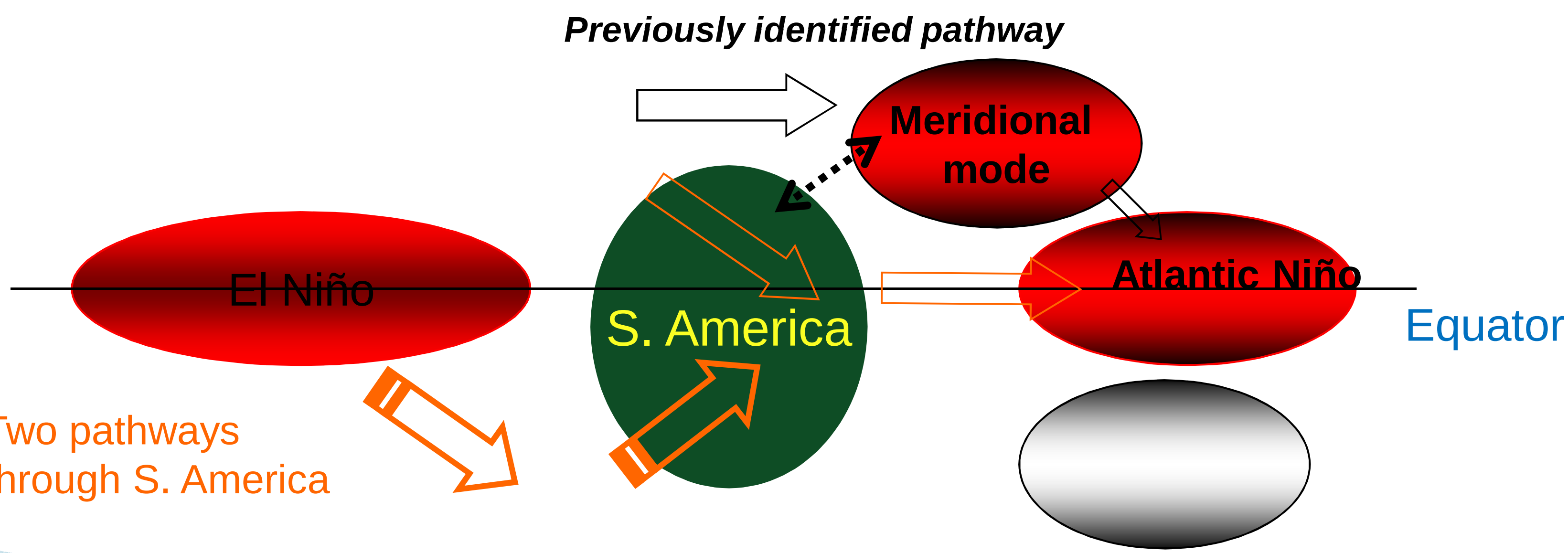
2002, March-May Eastern Pacific warming

2007, March-May Western/Central Pacific warming



Hypothesis:

- **ENSO influences can be carried out through two additional pathways using S. America as a sprint board.**



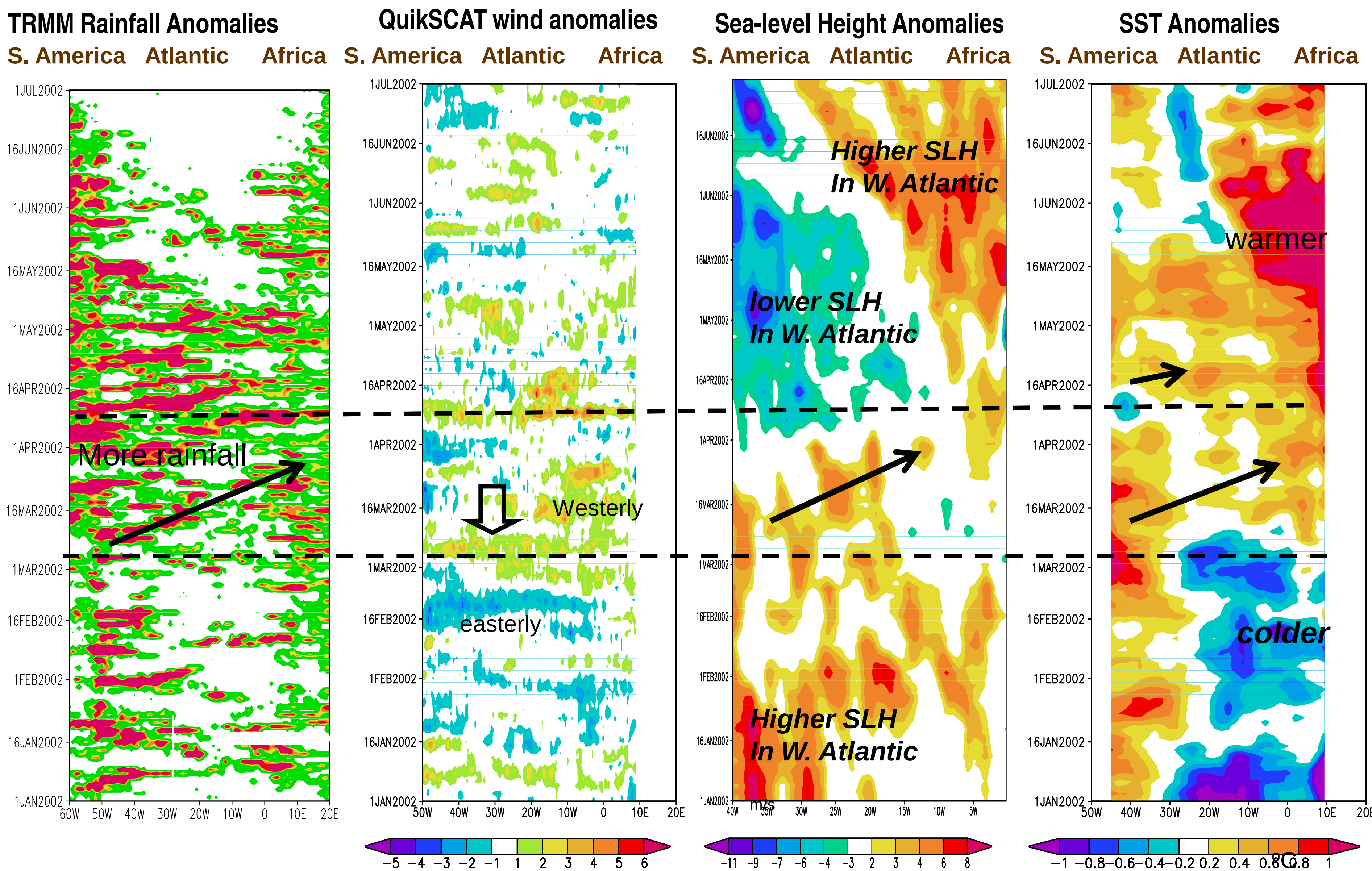
What are the underlying physical processes?

- *What triggers onset of the Atlantic Niño?*

- *What cause convective coupled Kelvin waves in the equatorial Atlantic Ocean?*

- *What might control the pathway ENSO influence on Atlantic Niño?*

Kelvin wave originated from S. America ⇒ westerly surface wind anomalies ⇒ Oceanic Kelvin waves increase SLH in E. Atlantic ⇒ warmer SSTA in the E. Atlantic



Convective coupled Kelvin waves propagated from Amazon generate oceanic Kelvin wave in the equatorial Atlantic. Thus, they are an important trigger for onset of Atlantic Niño.

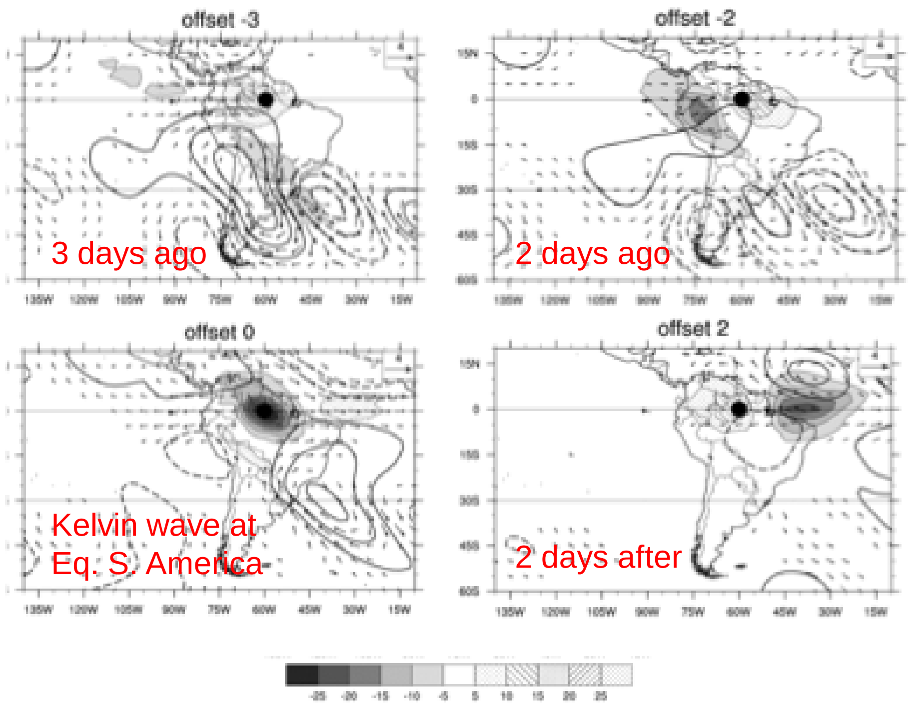
What cause convective Kelvin waves in Amazon?

What control the variability of the convective coupled Kelvin waves in S. America?

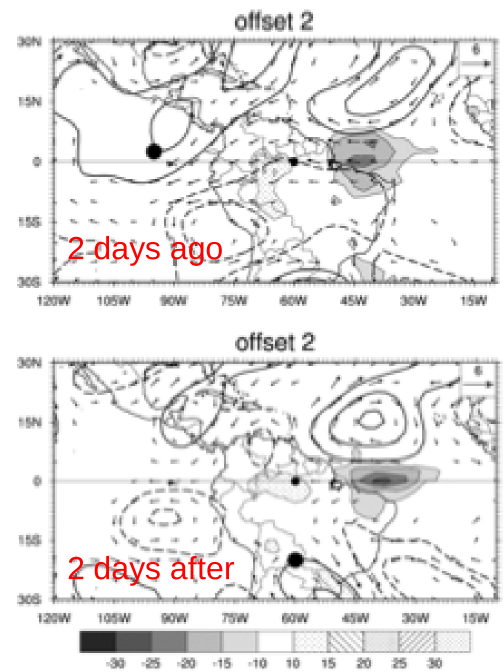
- Liebmann et al. 2008: Convective Kelvin waves in S. America are forced by Rosbby waves from two sources:

Composite OLR (shades), the 200 mb geopotential height anomalies (contours), and wind anomalies (vectors) associated with the convective coupled Kelvin wave in the Equatorial S. America (based on OLR anomalies at the location of the black dot) for those generated by Rossby waves propagated from extratropical S. America (E. Pacific / C. America). Period: November to May season during 1979-2006.

1. The extratropical S. America

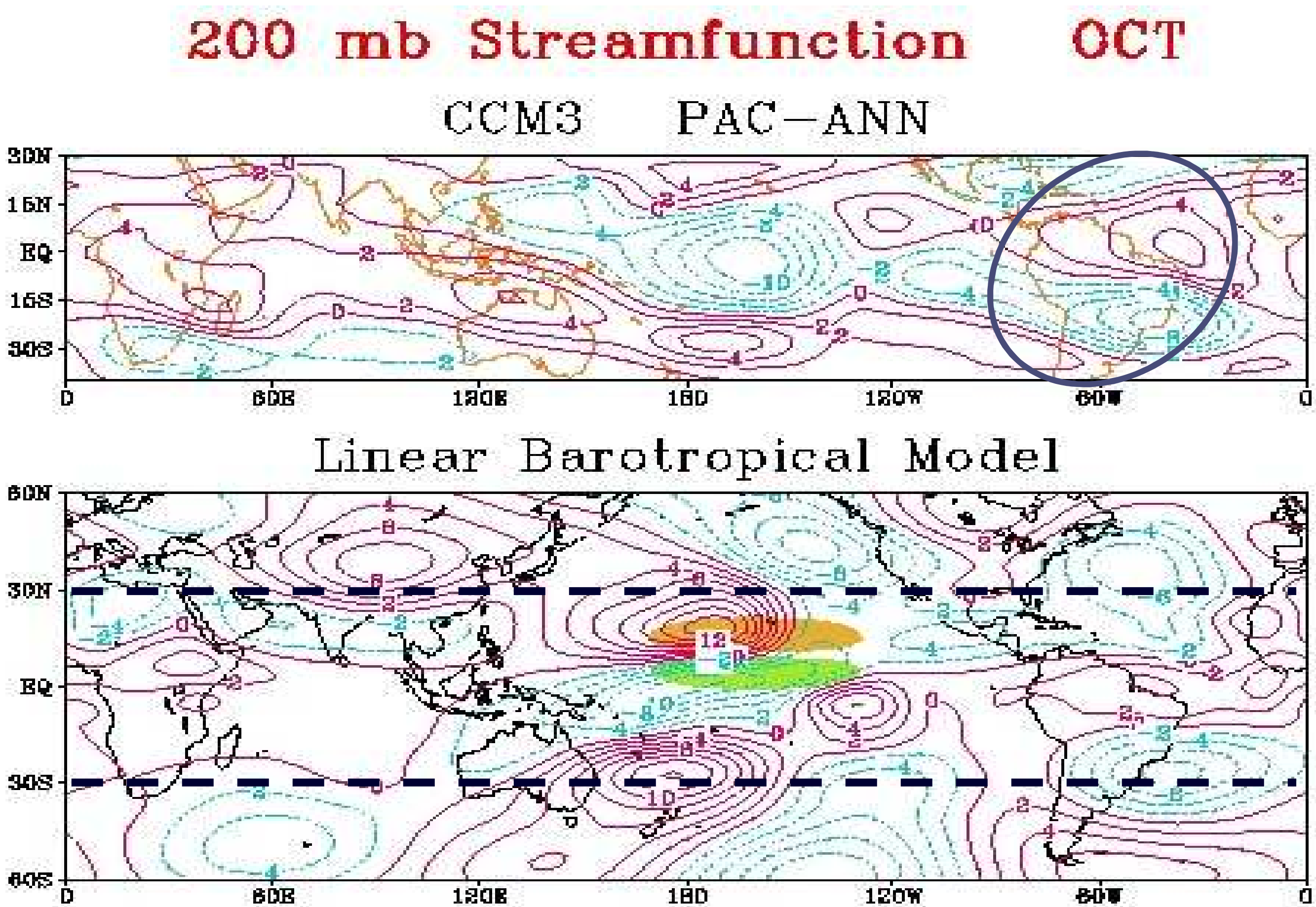


2. The Central America



How does ENSO influence South American atmospheric circulation?

Modeled Influence of Pacific SST anomalies on South American upper troposphere circulation:

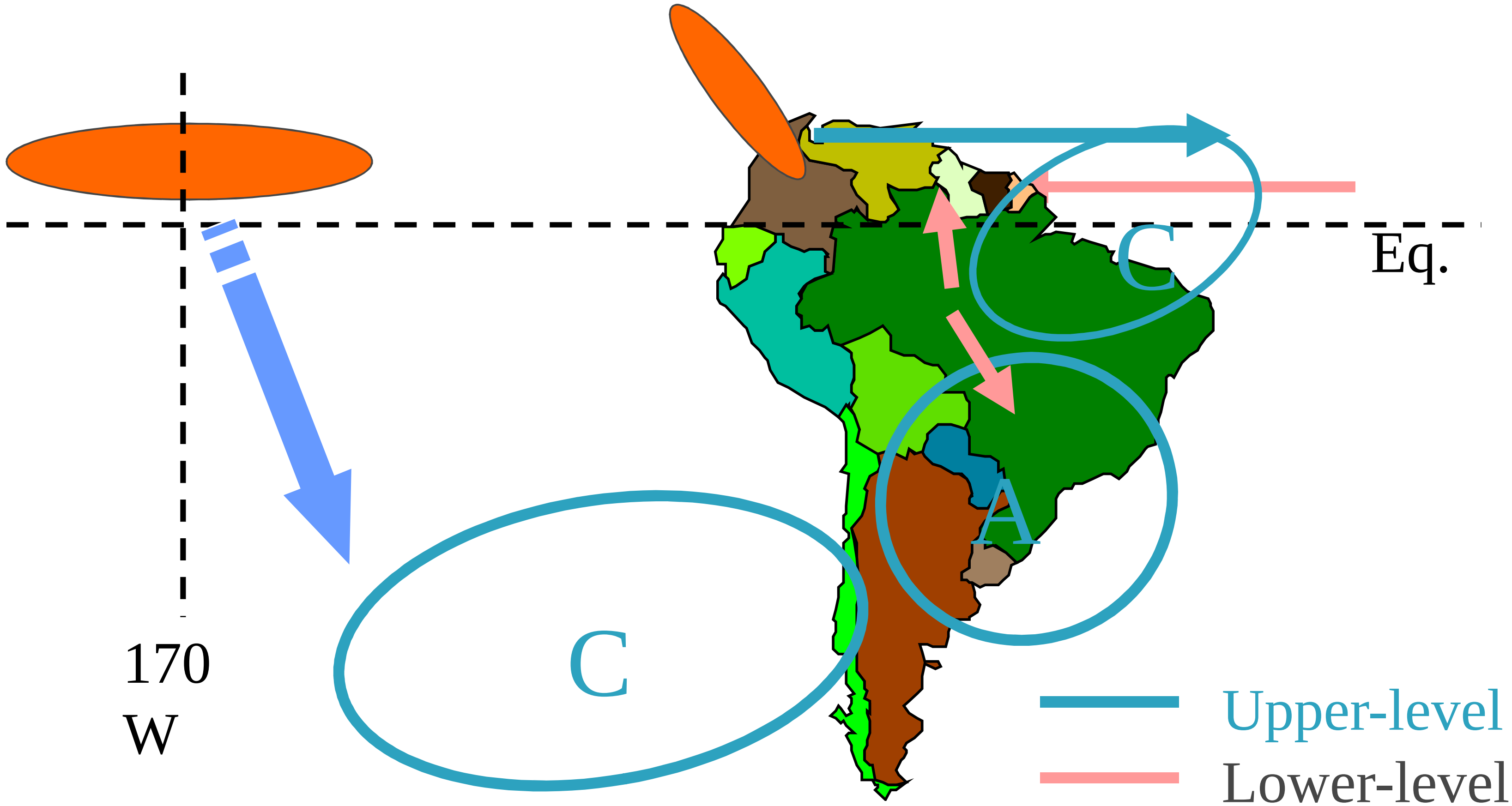


Wave train anomaly in the South Pacific and American sector, extending from the tropics to the extratropics.

Upper level cyclone in turn can suppress precipitation in the eastern Amazon.

Fu et al. 2001, J. Climate

Pacific Influence:

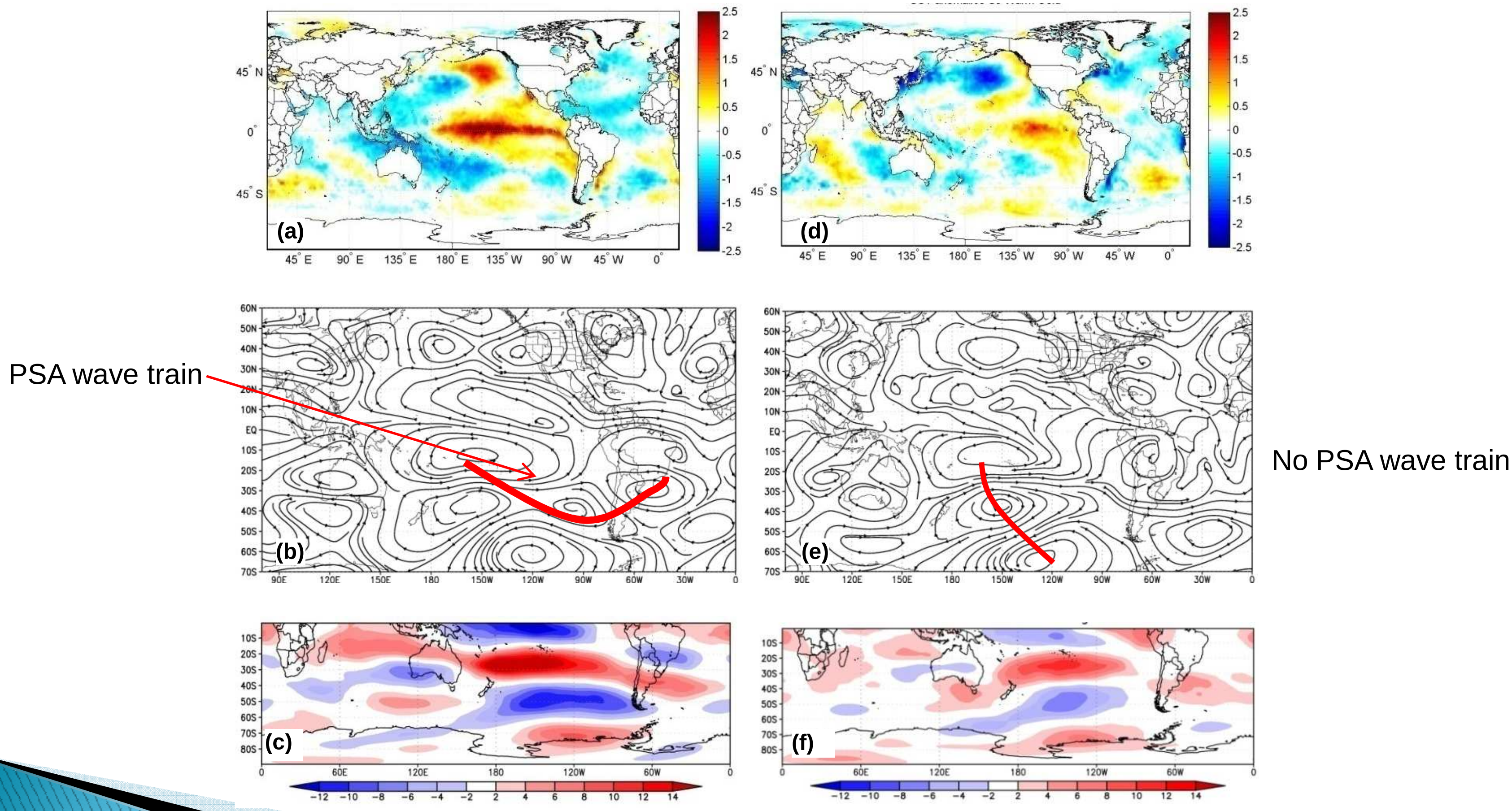


N. Eastern Pacific → Direct circulation
C. Pacific → Rossby wave train

Fu et al. 2001, J. Climate
Wang and Fu, 2007, J. Climate

What might determine the pathway of ENSO Influence on Convective coupled waves in South America?

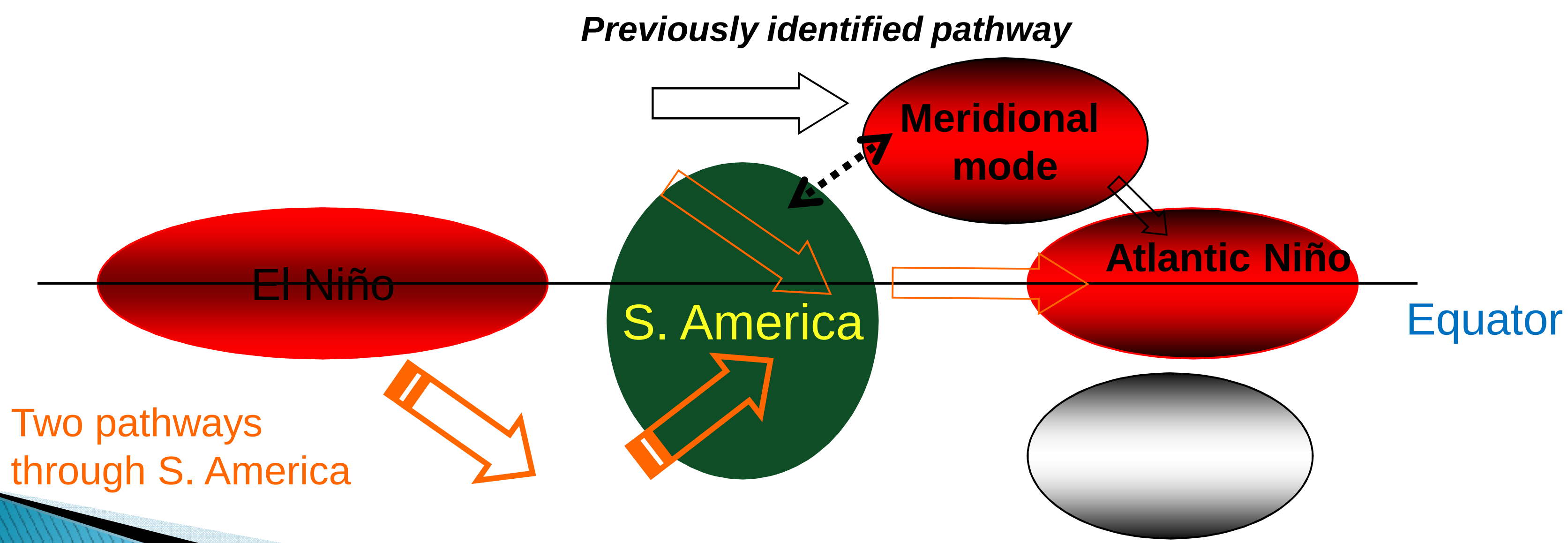
- Central and Eastern Pacific warming have different impact on Pacific-South American (PSA) wave train response.



Fernandes & Fu, 2009

Summary:

- Peak rainfall in the equatorial S. America during MAM and its variability appear to play an important role in bridge the ENSO influence on Atlantic Niño through its influence on convective coupled atmospheric Kelvin waves in the equatorial Atlantic Ocean;
- Variation of the pathway through which ENSO influences S. America may be linked to variation of ENSO SSTA pattern.



Questions?

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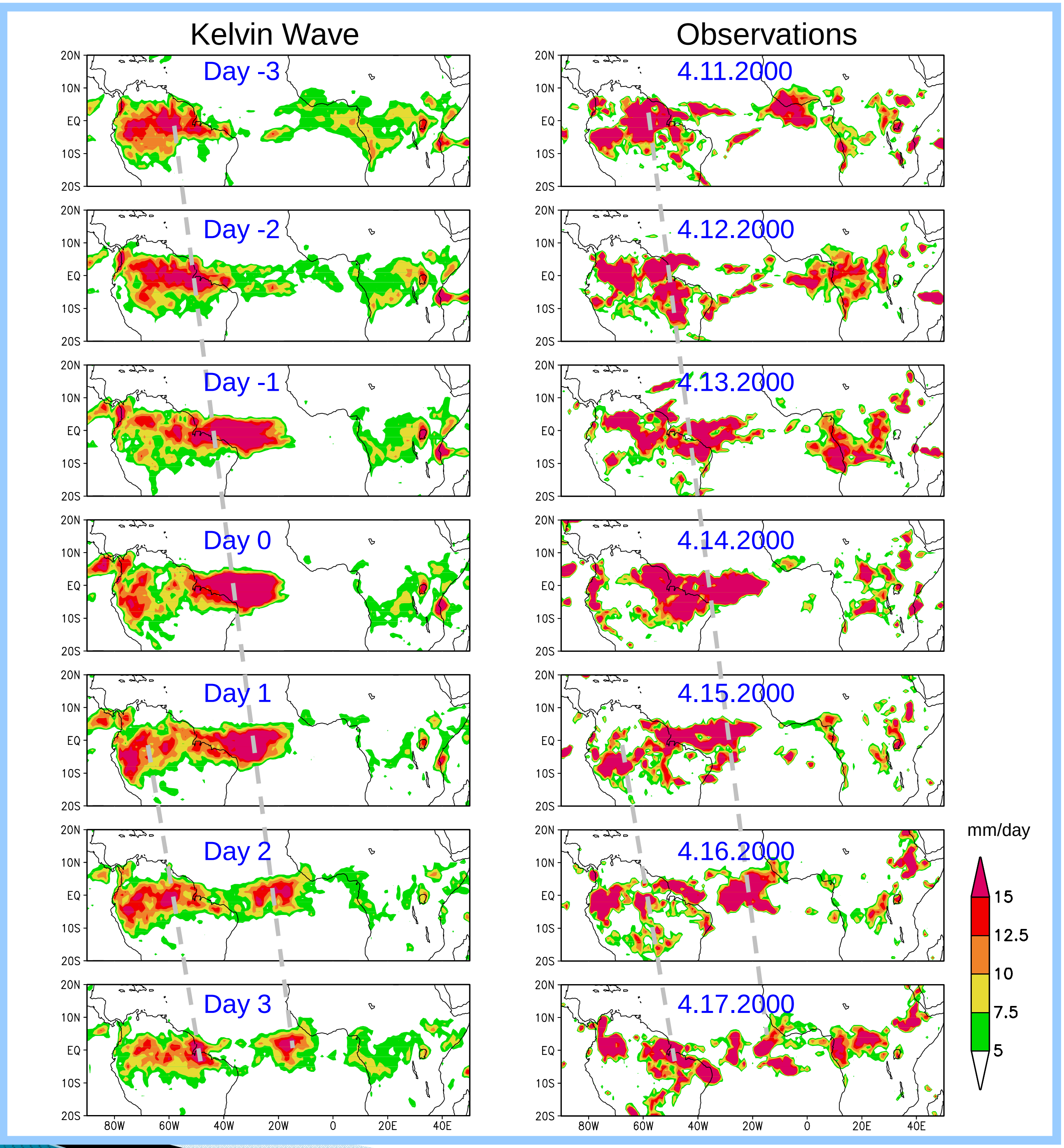
- *The leading EOF mode capture the convective coupled Kelvin Wave:*

- **Eastward propagating**
- **Phase speed: 15 m/s**
- **Zonal wavenumber 6**
- **Period: 6–7 days**

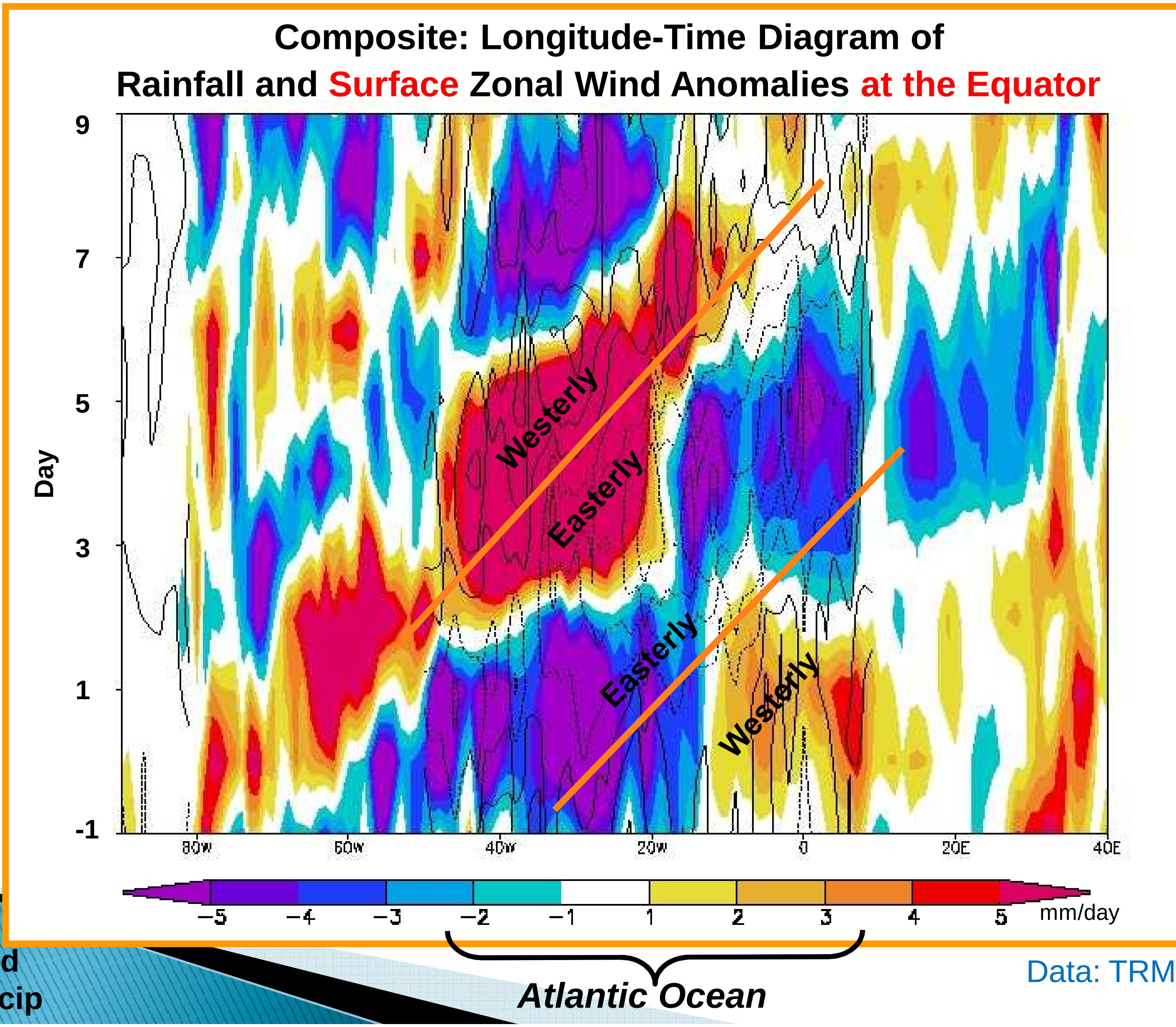
- Kelvin wave captures the major feature of the ITCZ

Wang & Fu 2007

TRMM data
2000–2003



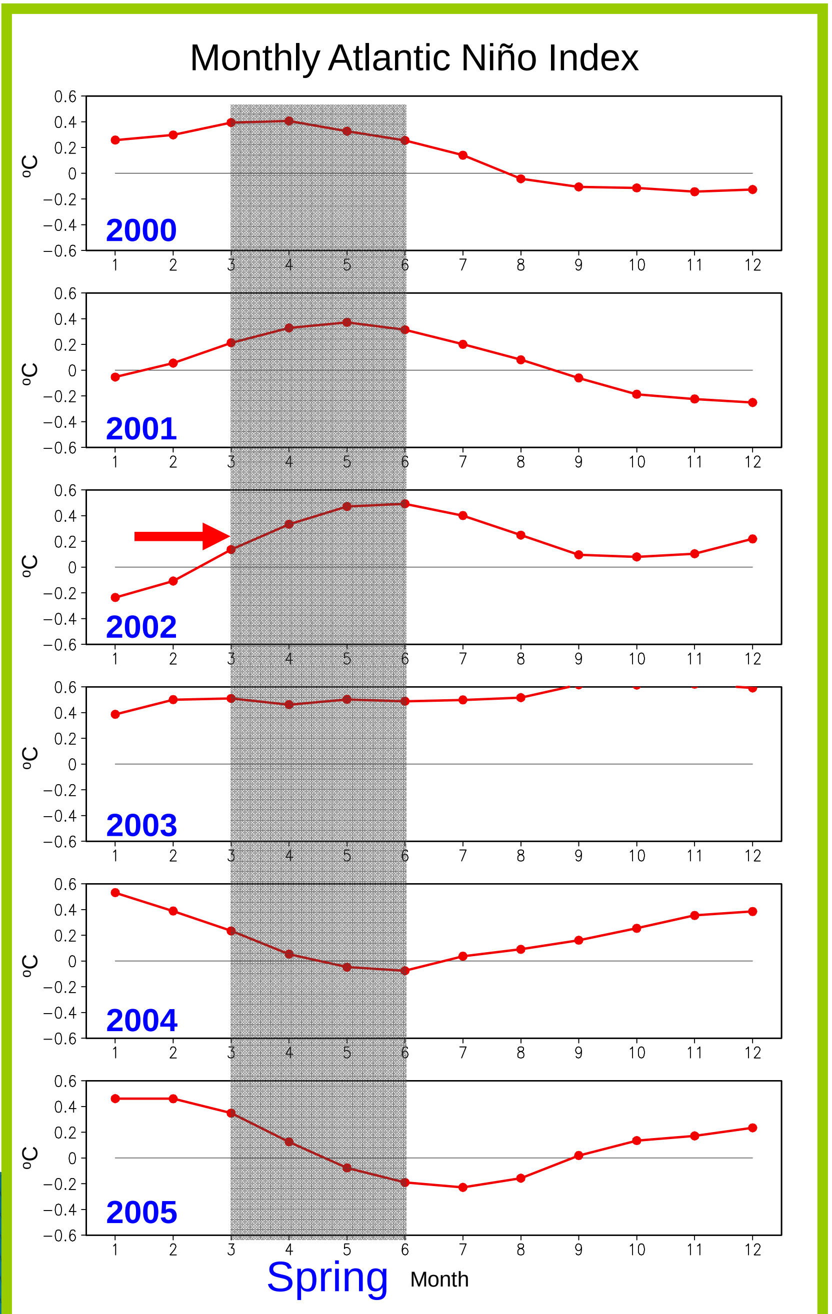
Zonal Surface Wind Anomalies Induced by Convective Coupled Kelvin Waves over the Equatorial Atlantic Ocean

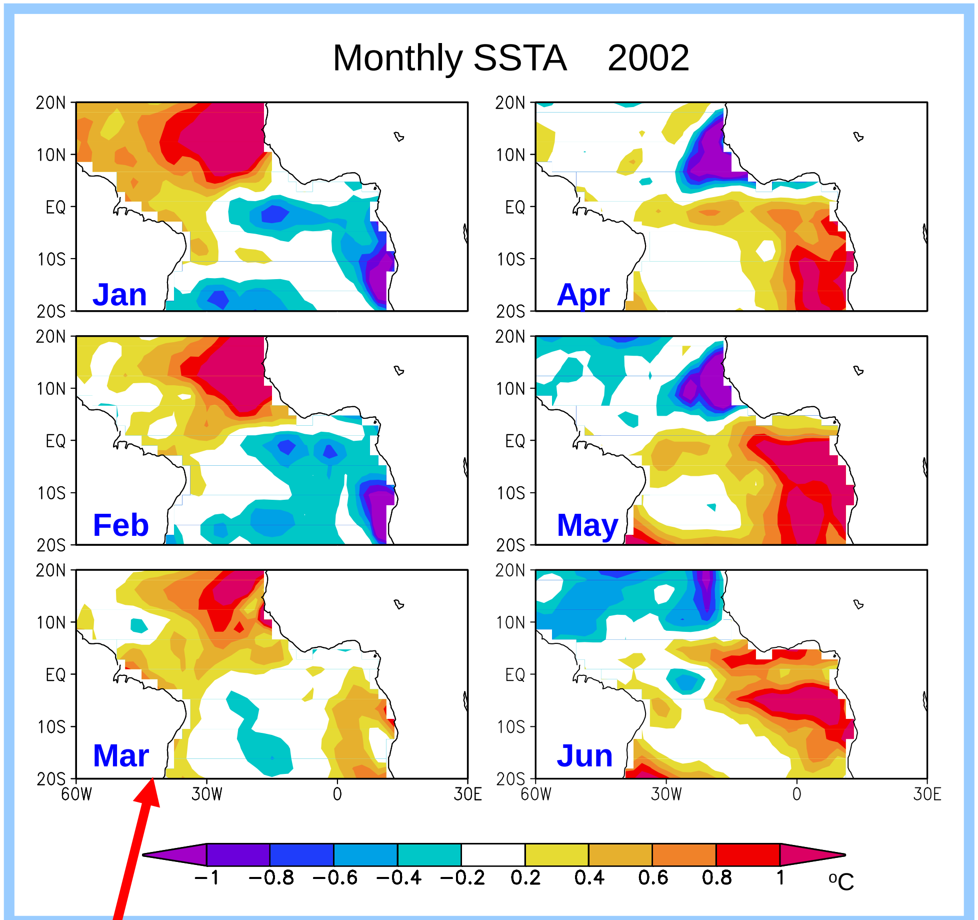


Contour: wind
Shading: precip

Data: TRMM & QSCAT

2002 Warm Event





Cold to warm transition occurred in March.