Investigate the influence of the Amazon rainfall on westerly wind anomalies and the 2002 Atlantic Nino using QuikScat, Altimeter and TRMM data

Rong Fu[1], Mike Young[1], Hui Wang[2], Weiqing Han[3]

[1]*School of Earth and Atmospheric Sciences, Georgia Institute of Technology*

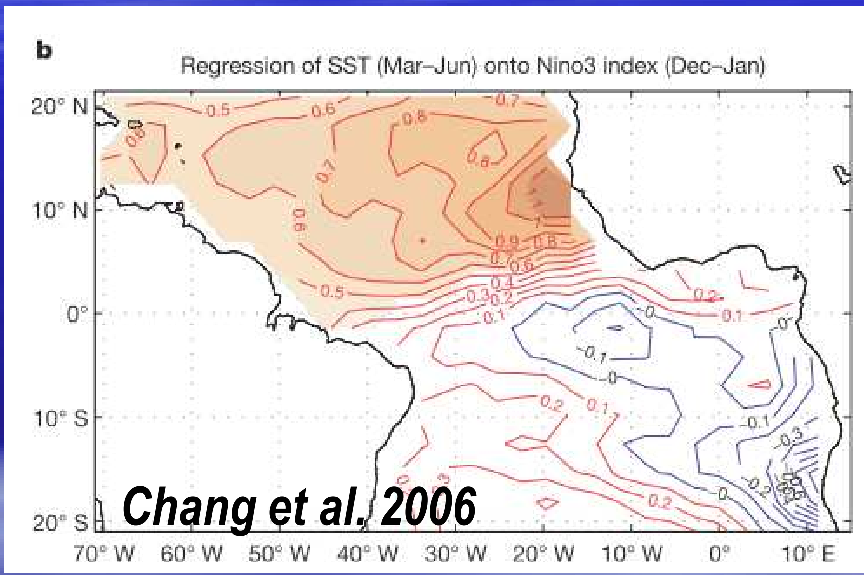
[2]*Cetern for Environmental Prediction, National Weather Service, NOAA*

[3]*Department of Atmospheric and Oceanic Sciences, University of Colorado*

The NASA OVWST 2007 Meeting, 2007 EUMETSAT Meteorological Satellite Conference and the 15th American Meteorological Society Satellite Meteorological & Oceanography Conference

Amsterdam, The Netherlands, September 28, 2007

What control the climate variability surface winds over the tropical Atlantic during boreal spring?



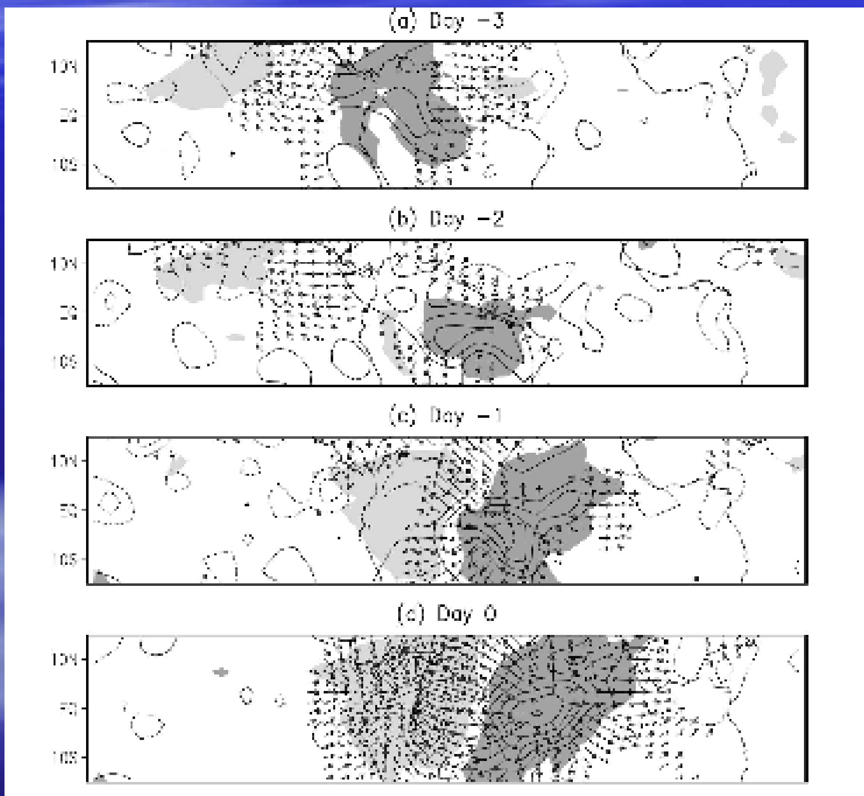
Zebiak 1993:

> *"The tropical Atlantic differs from the tropical Pacific in that it has proportionally more variability not attributable to the equatorial coupled mode. One aspect of this is the lower frequency, tropical basin-scale patterns. Additional contributors may be land surface interaction and global-scale forcing related to ENSO."*

Chang et al. 2006:

> *It is unclear what causes the winds in the western equatorial Atlantic to respond strongly to some El Niños, but not others.*

- ***The convective coupled Kelvin waves originated from the South and Central Americas dominate the synoptic variation of the atmospheric circulation in the equatorial Atlantic during the boreal spring season.***



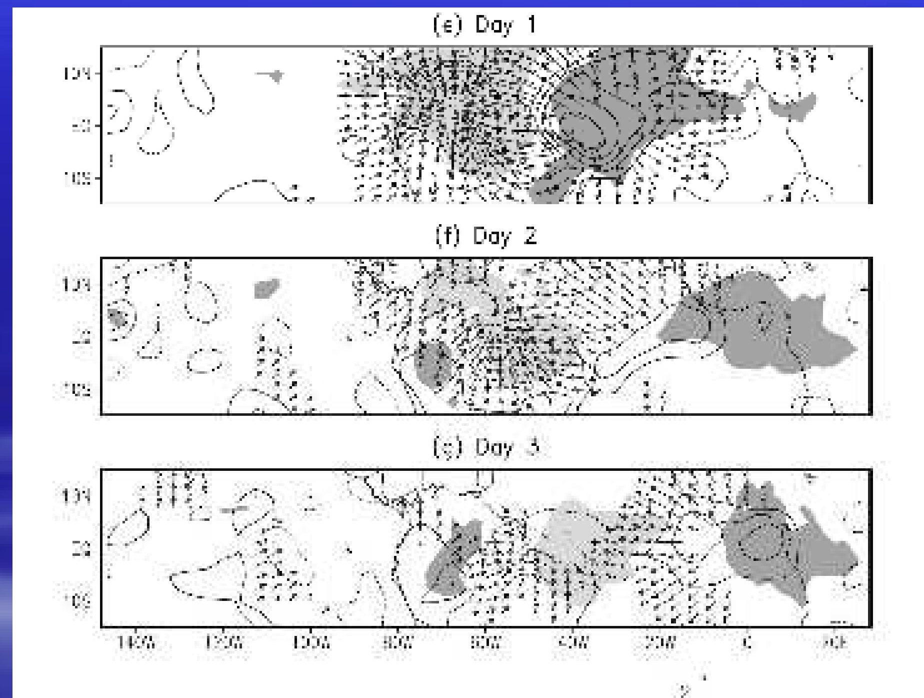
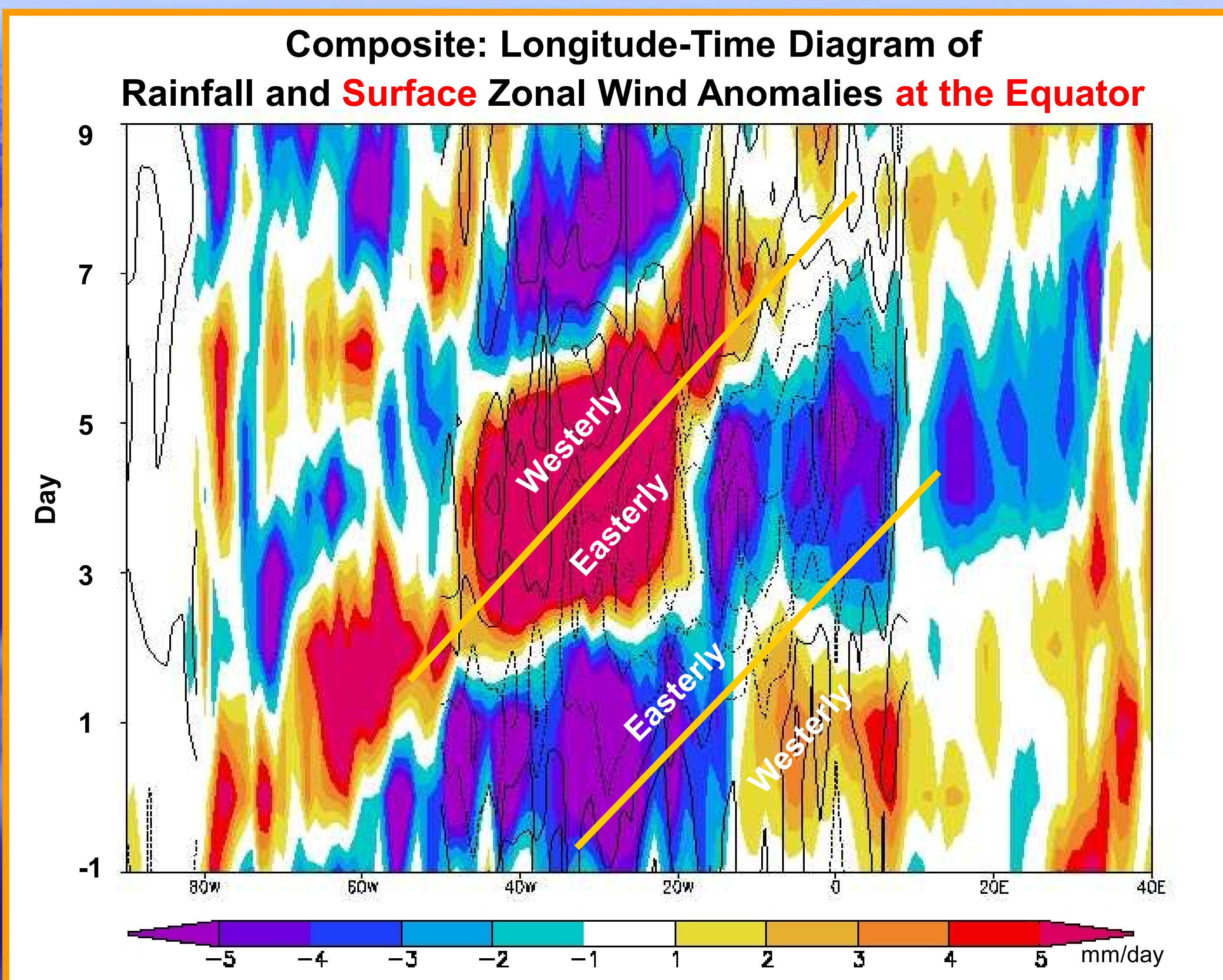


FIG. 8. Same as in Fig. 6 but for 200-hPa divergent wind (vectors) and divergence (contours). Contour interval is 0.5×10^{-6} s^{-1}. Negative contours are dashed and zero contours are omitted. Shadings are the same as in Fig. 6.

Wang and Fu 2007, J. Climate

Surface Zonal Wind Anomalies Induced by Convective Coupled Kelvin Waves in the Equatorial Waveguide:



Contour: wind
Shading: precip

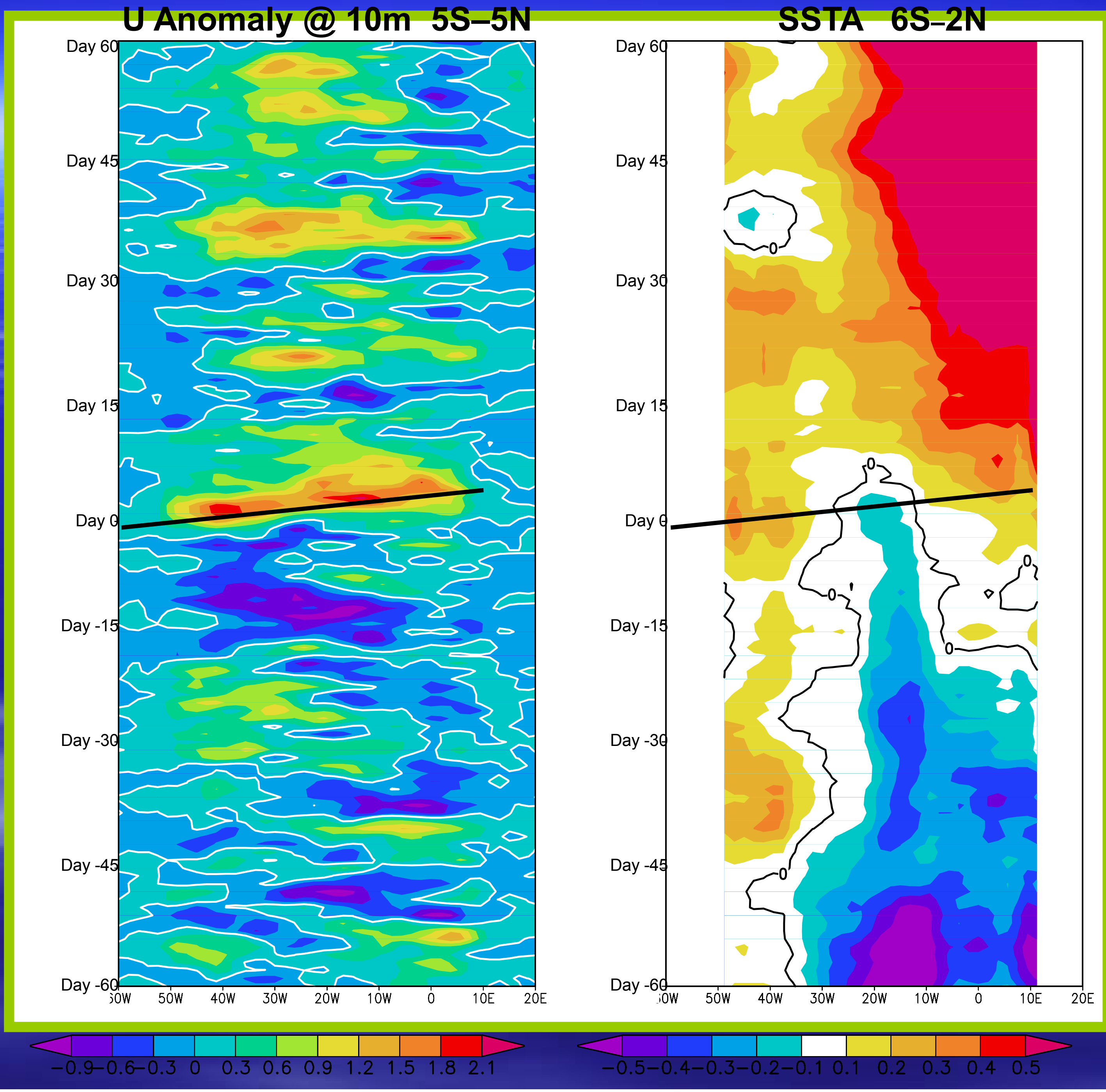
Atlantic Ocean

Data: TRMM & QSCAT

Composite

Day -60–Day 60 6 Atlantic Niños,

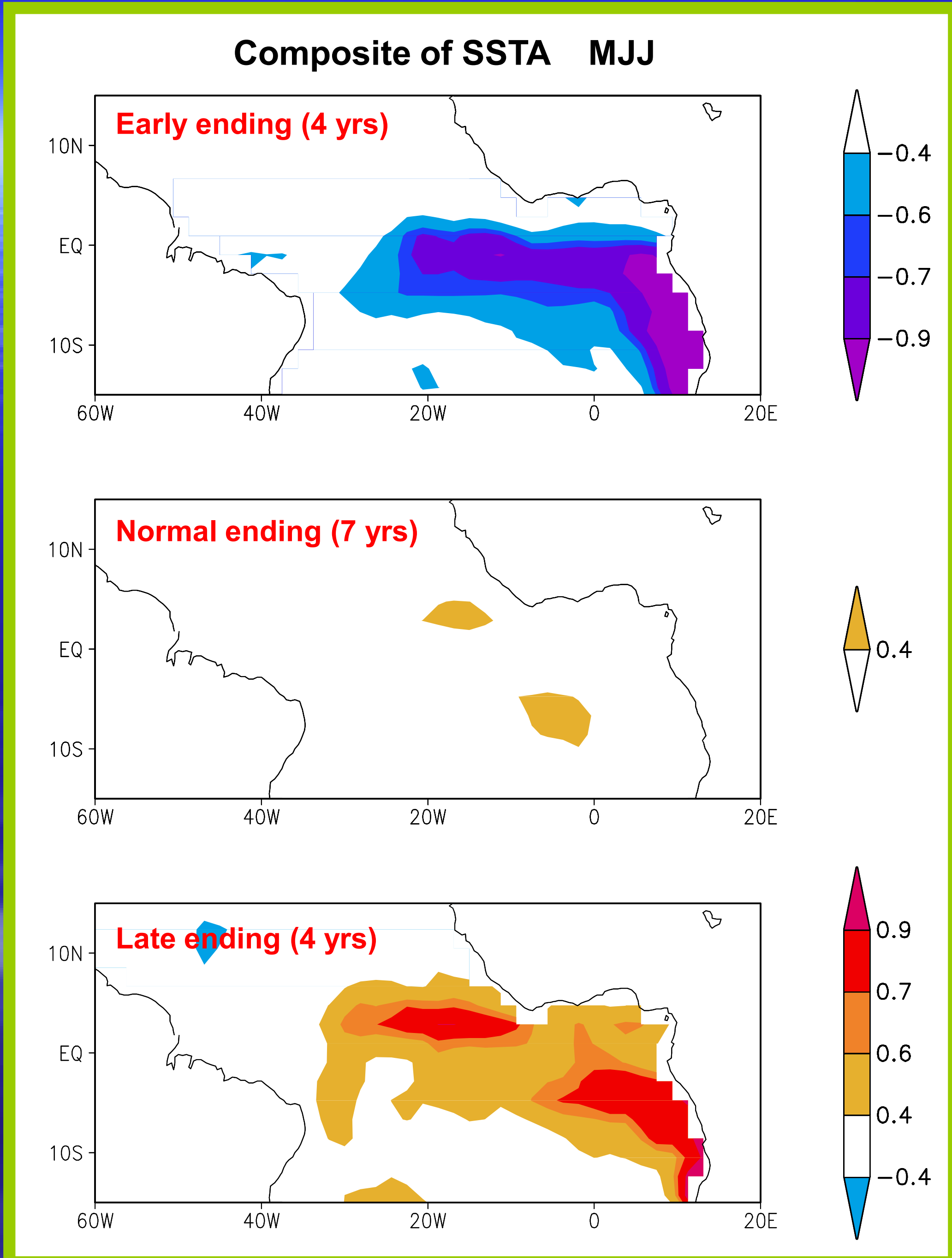
(1951, 1966, 1968, 1996, 2001, 2002)



Possible climate impact:

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



However, further clarification is needed:

Han et al. 2007:

- *The intraseasonal variations of sea level height and thermocline change in the equatorial Atlantic Ocean is dominated by 40-50 days spectrum peaks, especially during boreal spring. This variation is a result of ocean Kelvin waves excited by the zonal wind stress.*

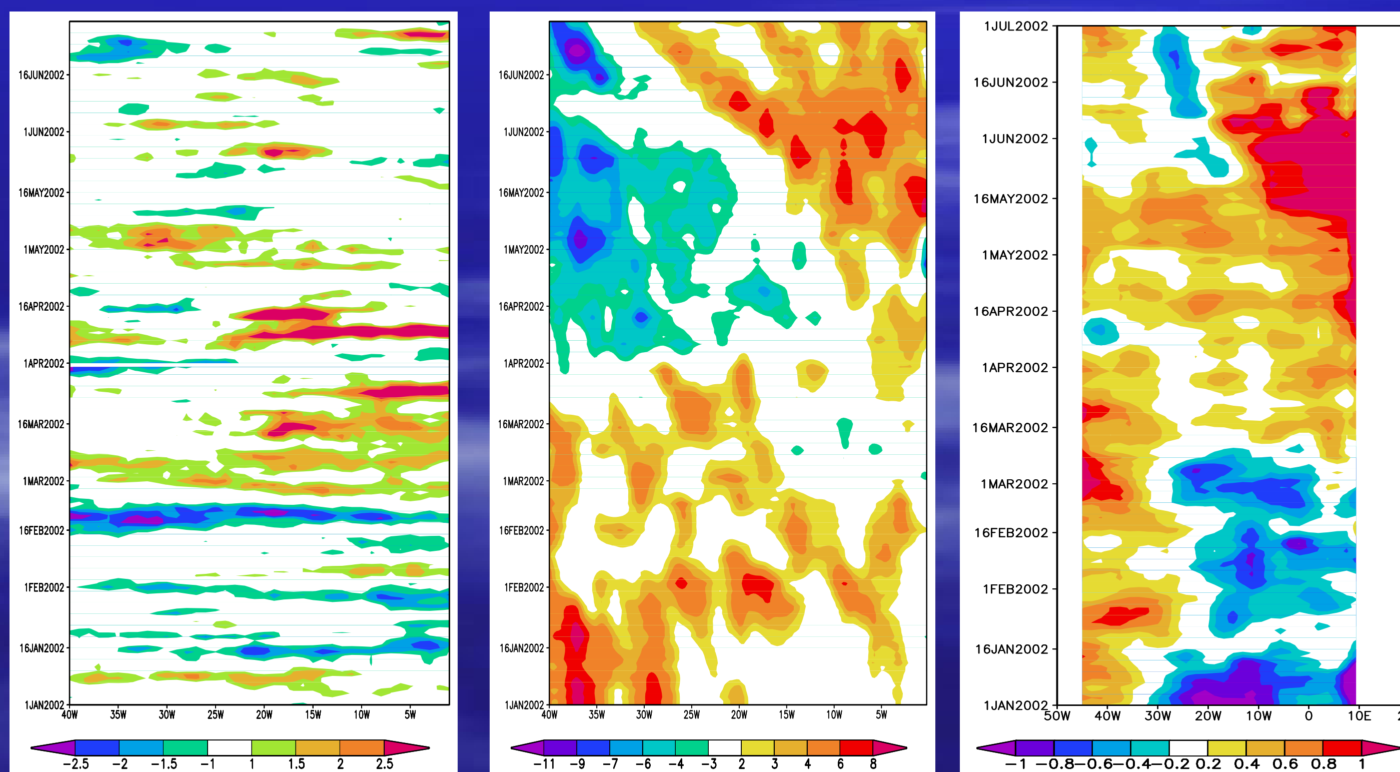
- *Could the convective coupled atmospheric Kelvin wave cause the 40-50 days zonal wind stress variations?*

Cross Wavelet transform and wavelet coherence

- ***Torrence and Compo (1998): Allows a objective identification of the relationship between two-time series in time-frequency space.***
- ***Applications on climate data: Torrence and Webster 1999; Grinsted et al. 2004***

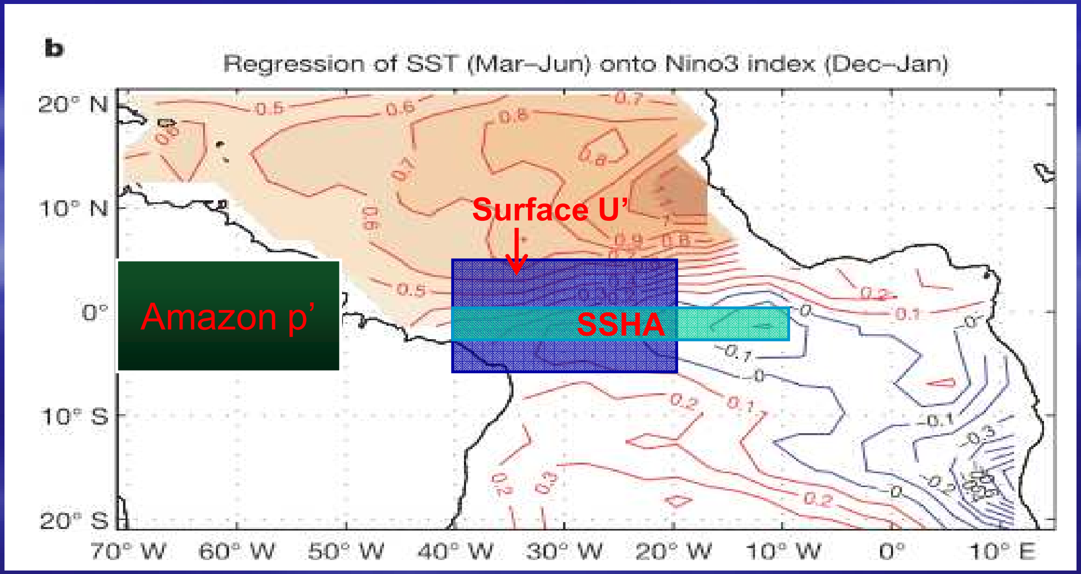
Frequency and intensity of the zonal wind anomalies vary strongly with time.

- **Left: QuikSCAT ocean surface wind anomalies (m/s) relative to their daily climatology average over 3º S - 3º N.**
- **Middle: 7-day running-mean-smoothed weekly SSHA (cm) averaged over 2º S - 2º N over the Atlantic basin.**
- **Right: Sea surface temperature anomaly (SSTA, ˚C) average from 6º S - 2º N.**



Data Sets :

- *QuikScat daily surface wind: daily ocean surface wind at 1° lat/lon resolution, 1999-2004;*
- *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.*

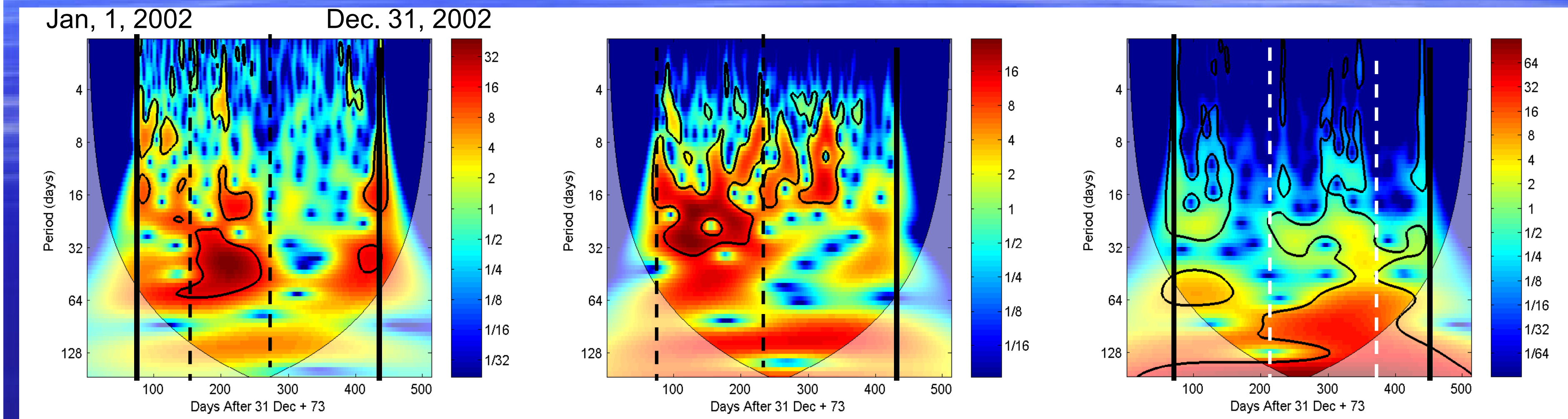


Wavelet spectra for 2002:

TRMM daily rainrate, the Amazon (5˚S-5˚N, 50˚-70˚W).

QuikSCAT daily u’, Atlantic (5˚S-5˚N, 20˚-40˚W).

DT-MSLA SSHA, Atlantic (2˚S-2˚N, 10˚-40˚W).



Late-Mar Mid-July

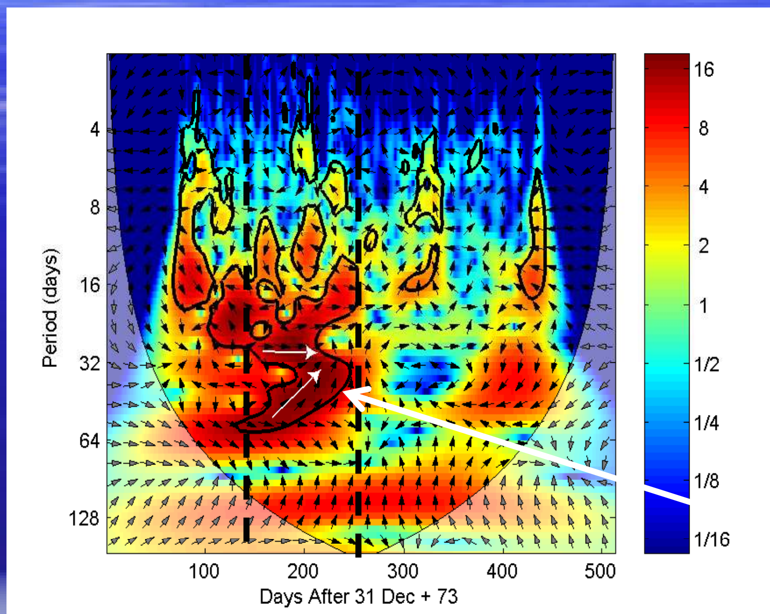
Jan Mid-Jun

Mid-May Late-Oct

- *Time series for the variables were generated by taking unique basin means for each variable, and each series has been normalized to have mean zero and unit variance.*
- *A spectrum peak in 30-60 day oscillation appears in TRMM daily rainrate over the Amazon and QuikSCAT zonal wind anomalies over the equatorial Atlantic in boreal spring when atmospheric convection reaches its annual peak in the equatorial Amazon.*
- *The SSHA shows a weaker but noticeable spectrum peak in the 30-60 day oscillation during late spring and summer in 2002.*
- ***Are these variations correlated?***

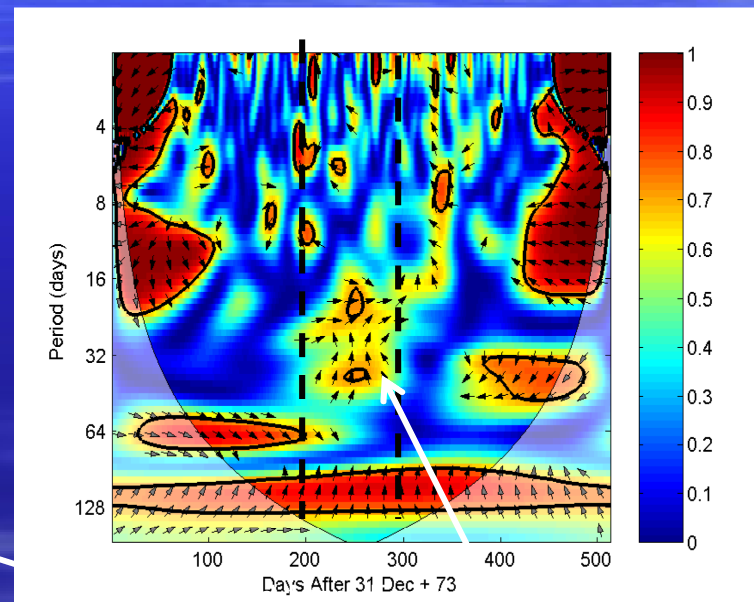
Daily rainrate anomalies over the equatorial Amazon vs. surface zonal wind anomalies over the equatorial Atlantic:

Common power

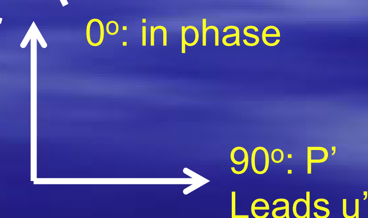


Mid-Mar Early-Jul

The wavelet coherence and phase relation



Early-Apr Mid-Aug

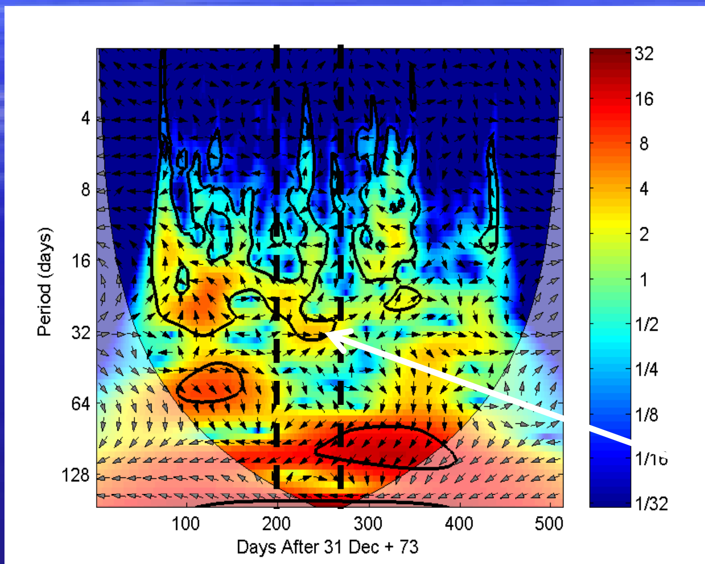


- ***Amazon daily rainrate anomalies and zonal wind anomalies in the equatorial Atlantic have common strong power and significant correlation in the 30-60 day frequency spectrum during spring-early summer, 2002.***

- ***Phase angles of 0-90º in late spring and summer also indicate that these variables are highly correlated, with precipitation leading zonal wind anomaly.***

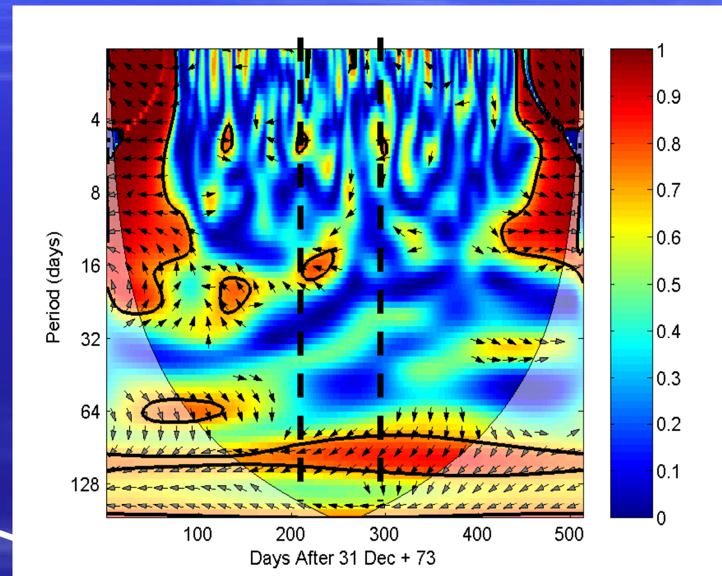
Surface zonal wind anomalies and SSHA over the equatorial Atlantic:

Common power

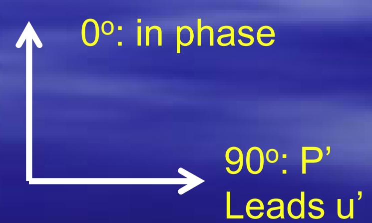


Early-Apr Early-Aug

The wavelet coherence and phase relation



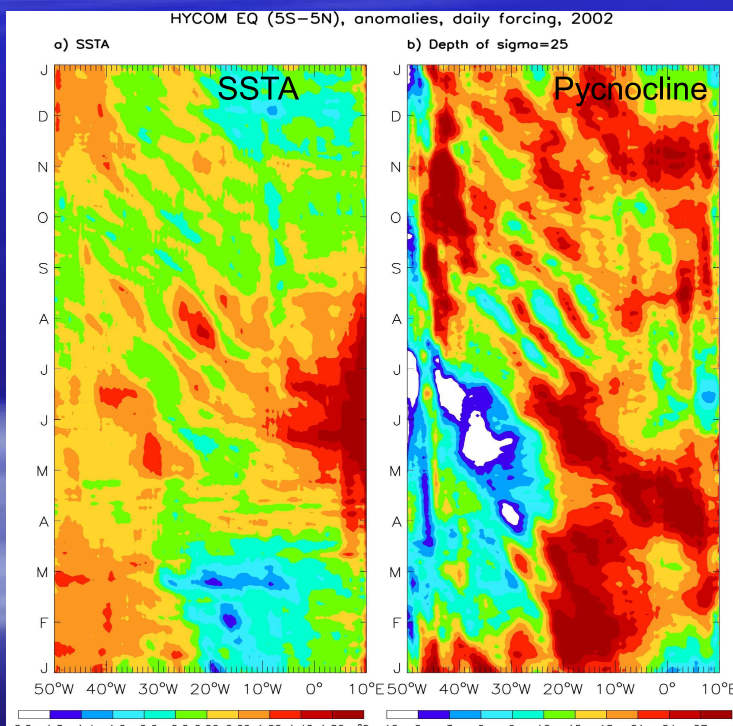
Early-Apr Mid-Aug



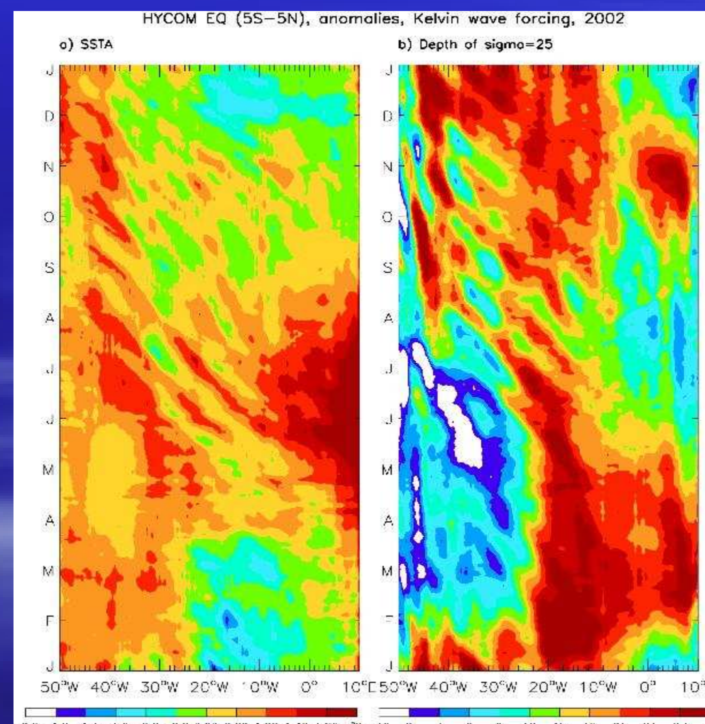
- *The surface zonal wind anomalies and SSHA in the equatorial Atlantic have common power above 70% confidence in the 30-50 day frequency spectrum during spring-early summer, 2002. The u' leads SSHA.*
- *However, the correlation between these two variables in the 30-50 days spectrum is insignificant.*

Ocean model simulation clearly shows that surface zonal wind anomalies associated with convective coupled Kelvin wave generate oceanic Kelvin waves, and trigger the 2002 Atlantic Nino:

HYCOM forced by daily wind in 2002:



HYCOM forced by U' of Convective Coupled Kelvin wave+daily climateological wind:



Han 2007

Summary:

- *Our cross-wavelet analysis suggests that precipitation over the Amazon appears to force the zonal wind anomalies in the equatorial Atlantic with 30-60 day frequency in spring and summer season.*
  - *Precipitation in the Amazon and the zonal wind anomalies in the equatorial Atlantic both exhibit strong signals in the 30-60 day frequency spectrum in spring and summer seasons. Within this time and spectrum space, they are significantly correlated with Amazon rainfall leads the Atlantic surface zonal wind anomalies.*

- *Given the importance of the zonal wind anomalies in forcing oceanic Kelvin wave and sea-level height anomalies shown by previous studies, our results provides a physical link for observed relationship between the Amazon rainfall, surface zonal wind and SST anomalies in the equatorial Atlantic on both intraseasonal and interannual scales.*