

Diagnosics of tropical cyclone activity and associated environmental conditions in observations and models.

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ICTP Workshop on High Resolution Climate Modeling,
August 10 – 14, 2009, Trieste, Italy

Outline

- Genesis Potential Index (GPI)
 - GPI in climate models
 - GPI and MJO
- Tropical Cyclones and QBO
- Potential Intensity trends
- Summary

Genesis Potential Index (GPI)

- Refinement of Gray's tropical cyclone genesis index using Reanalysis data

$$GP = |10^5 \eta|^{3/2} (H/50)^3 (PI/70)^3 (1 + 0.1 V_{\text{shear}})^{-2}$$

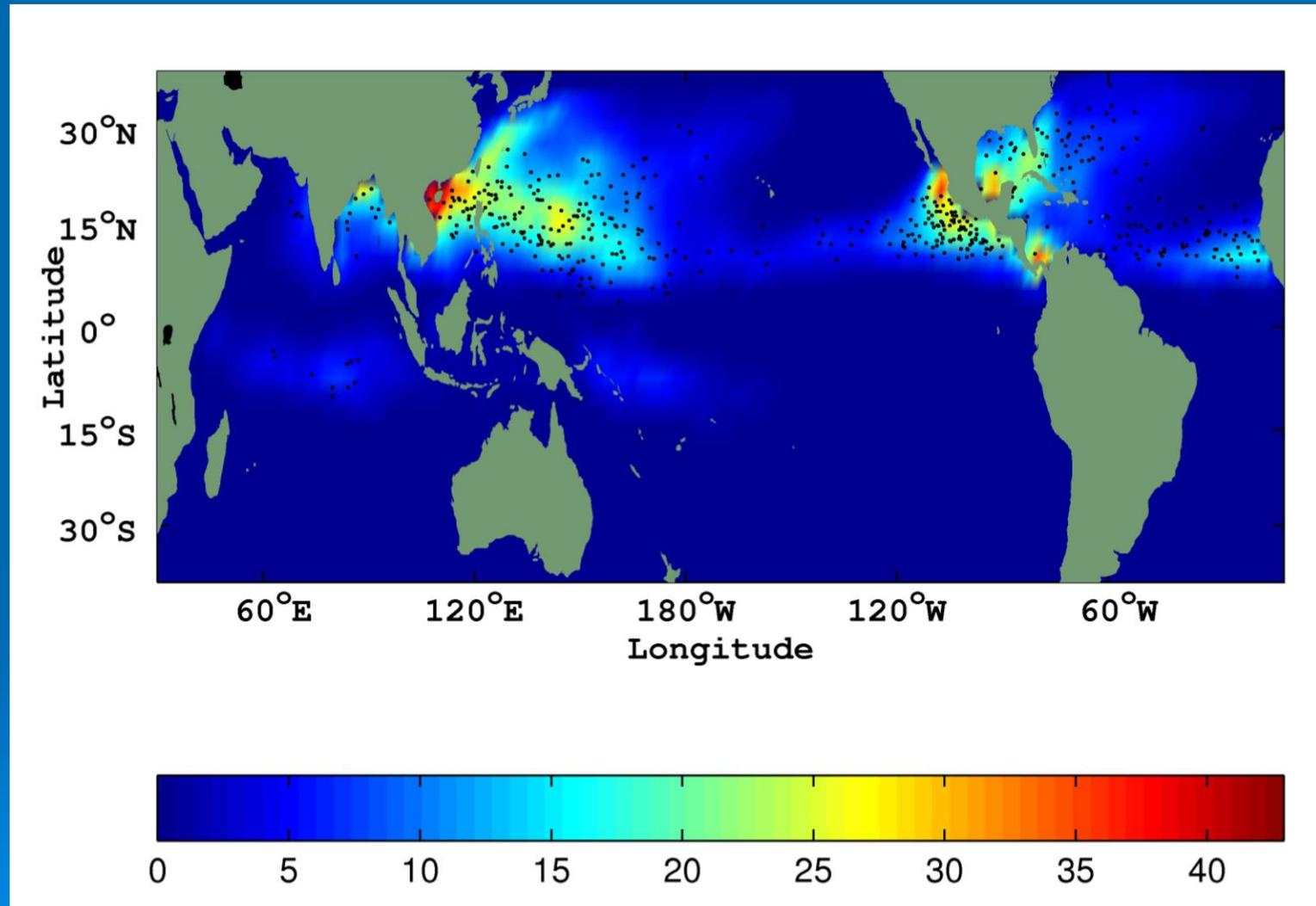
η = absolute vorticity at 850hPa (s^{-1})

H = relative humidity at 600hPa (%)

PI = potential intensity (m/s)

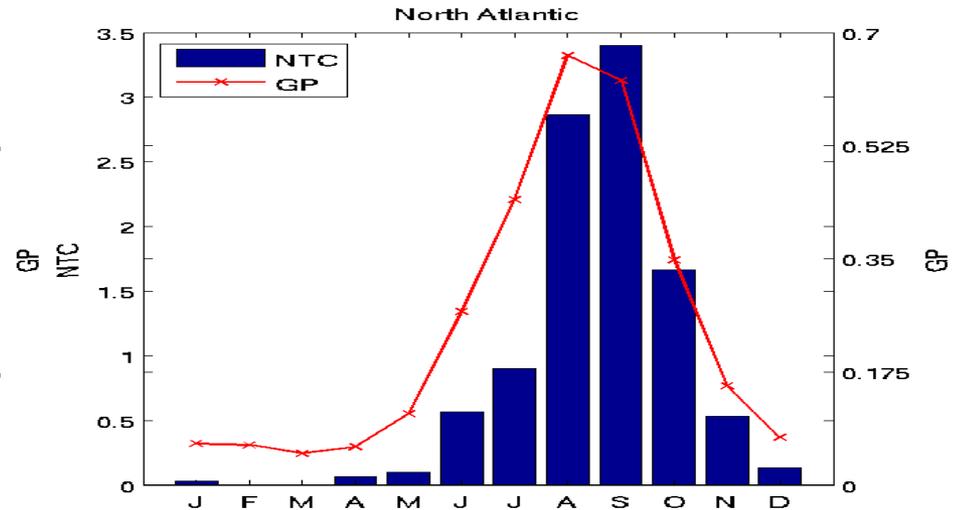
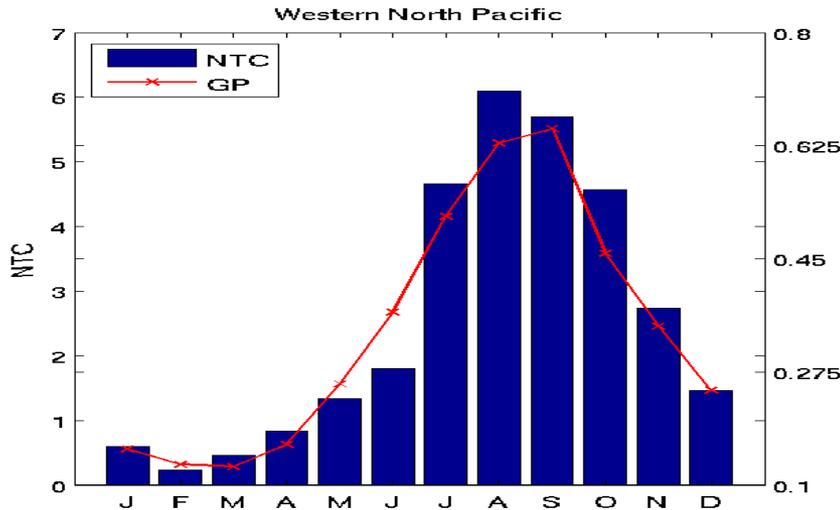
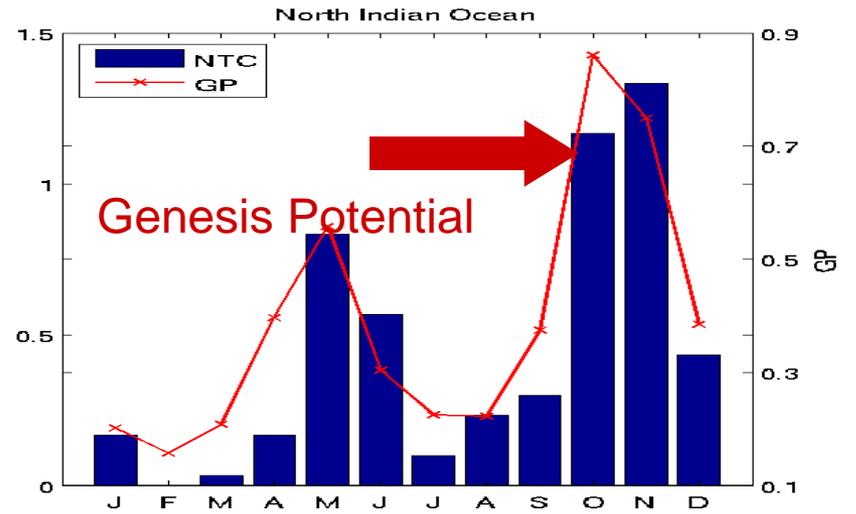
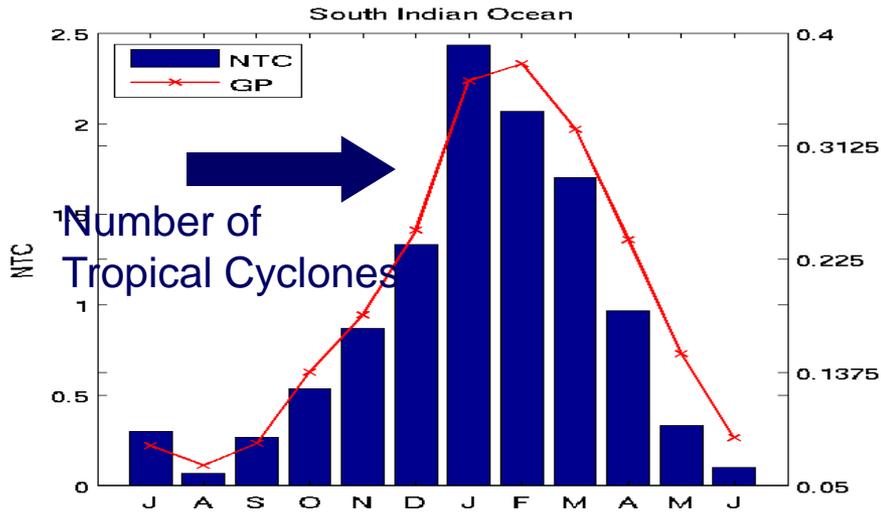
V_{shear} = magnitude of the vertical wind shear between 200 and 850hPa (m/s).

GPI Climatology - September



Camargo, Emanuel and Sobel, J. Climate (2007).

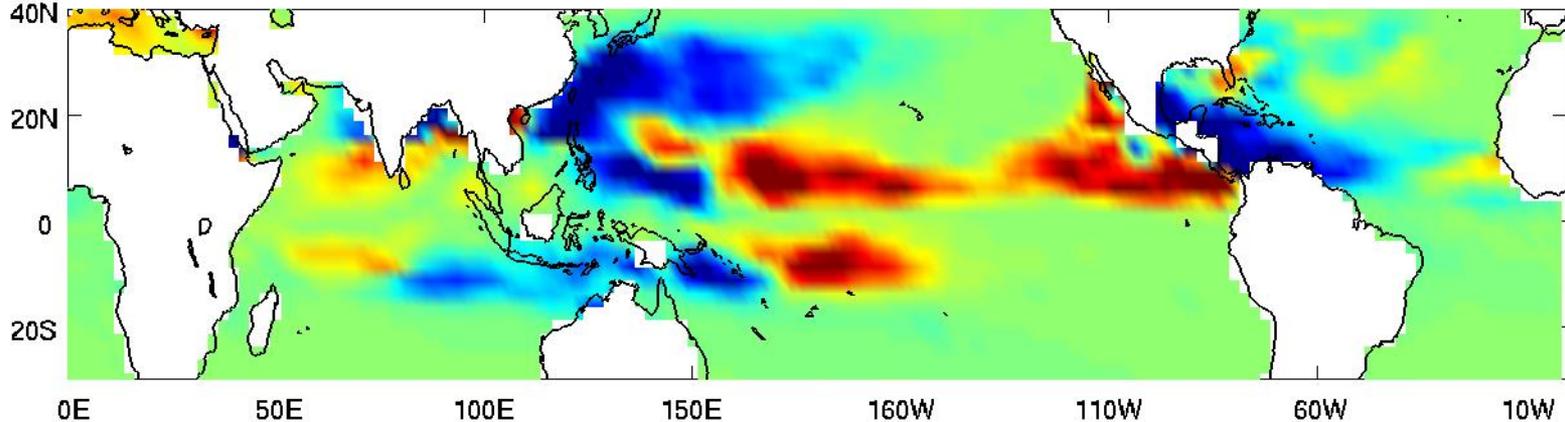
Climatology - Basins



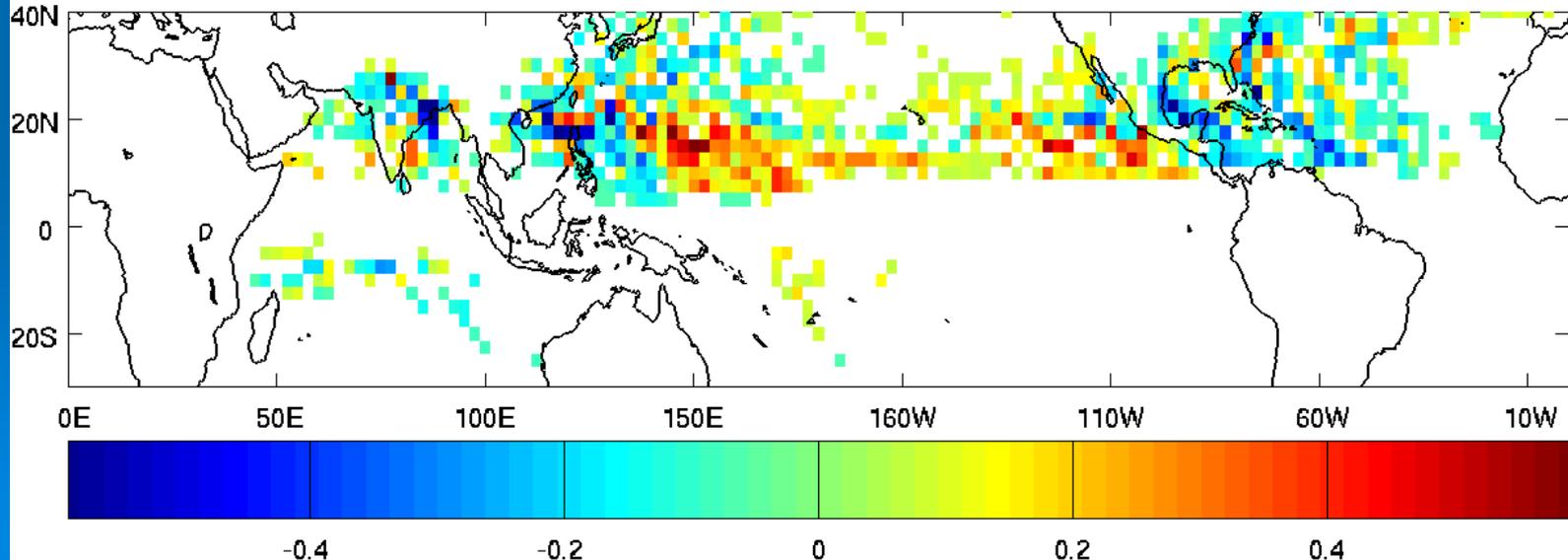
Genesis Potential Index and Observations

Difference: **El Niño** and **La Niña** – ASO

Genesis
Potential
Index

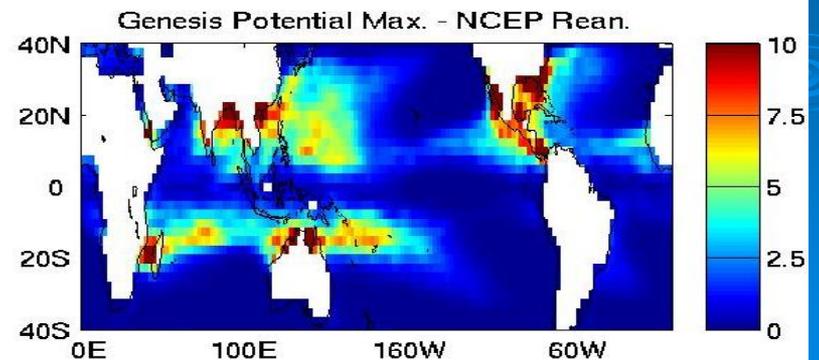
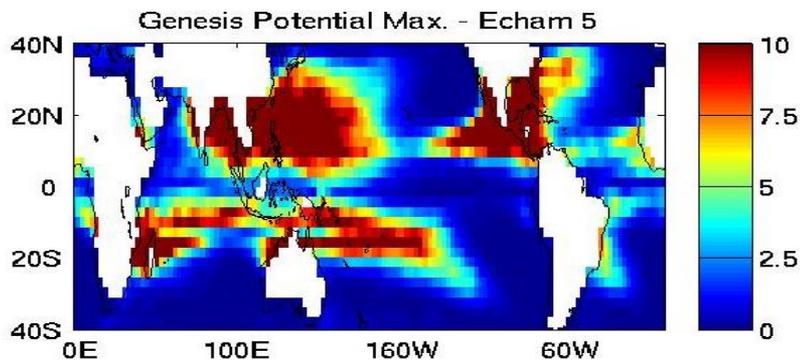
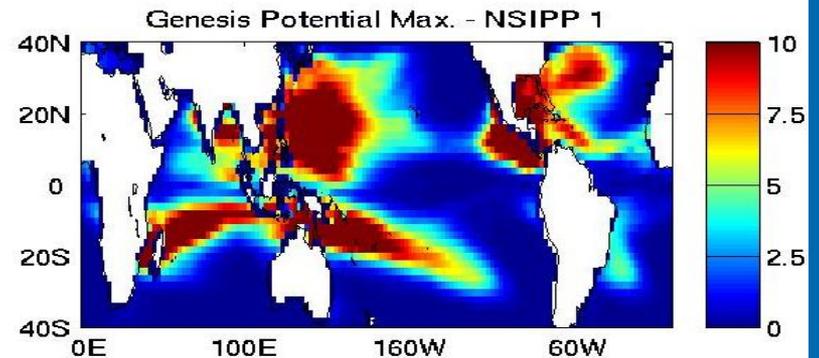
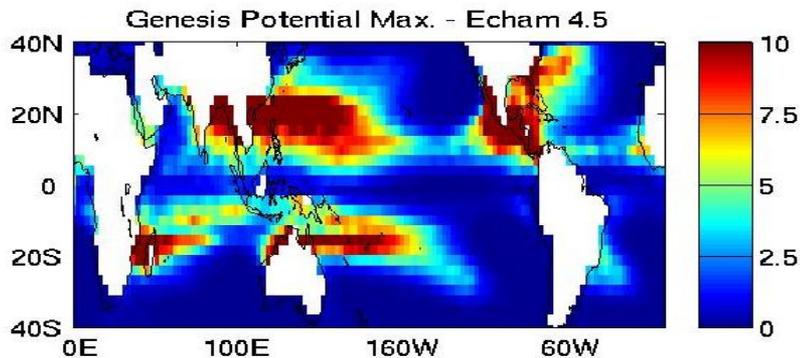
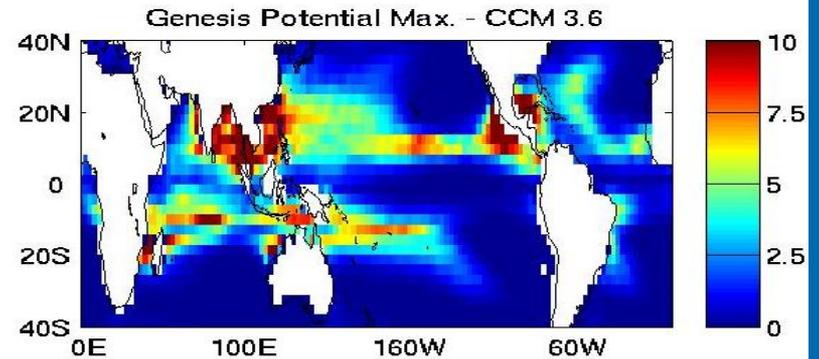
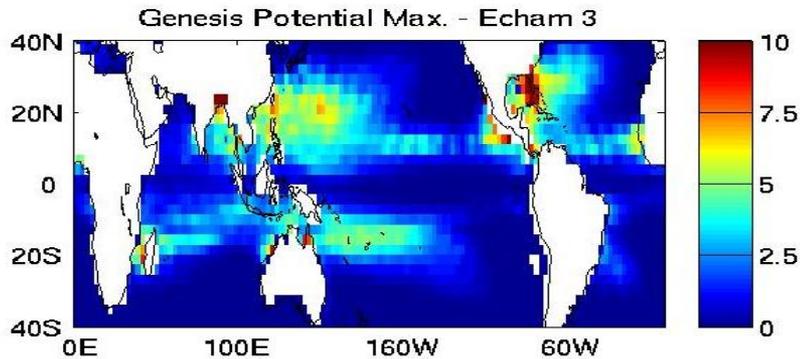


Observed
Track
Density

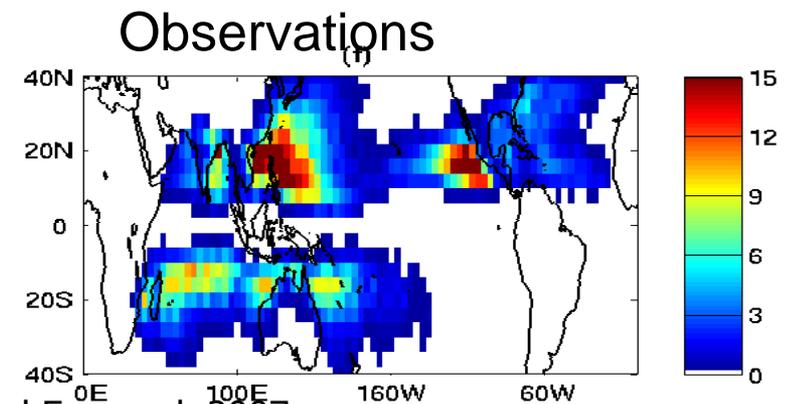
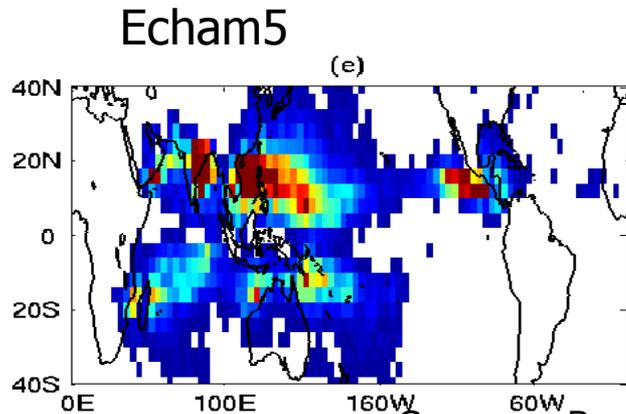
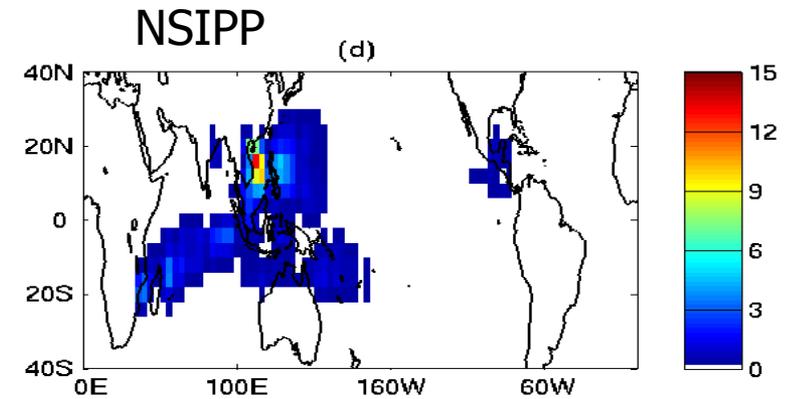
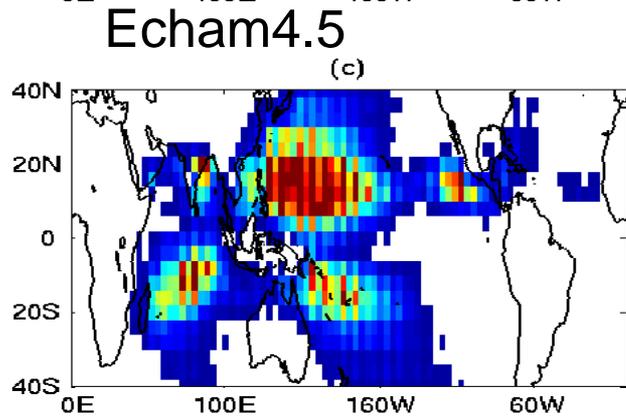
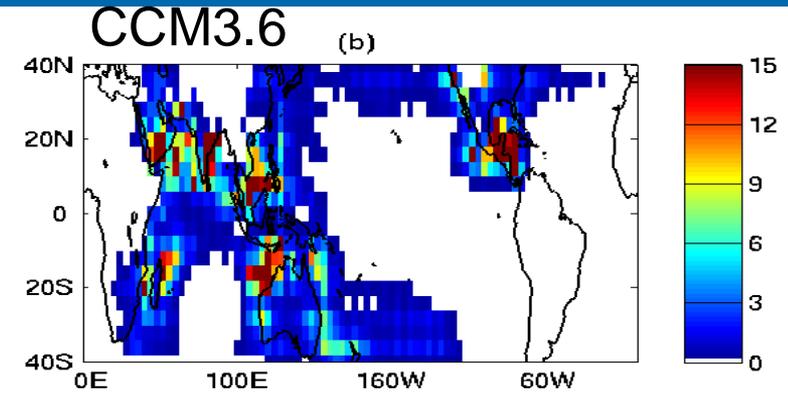
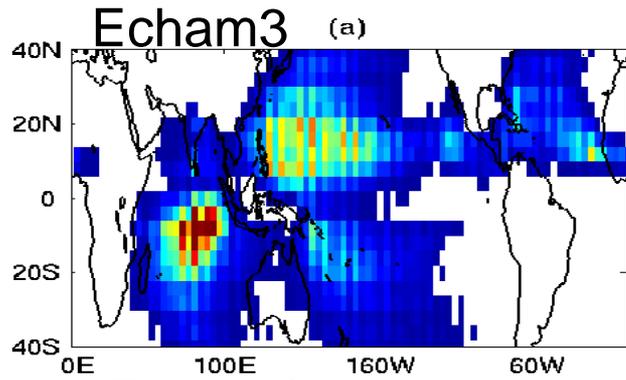


Camargo, Emanuel and Sobel (2007)

Models' GPI Climatology: annual maximum



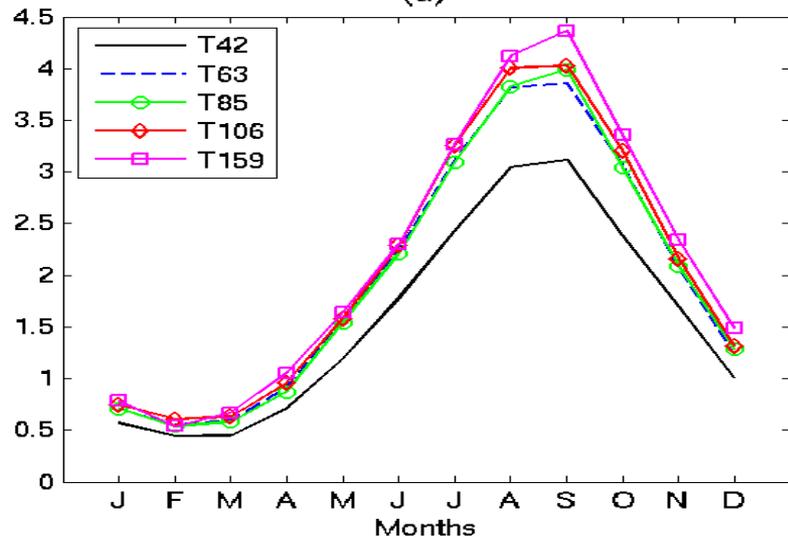
Track Density in Climate Models



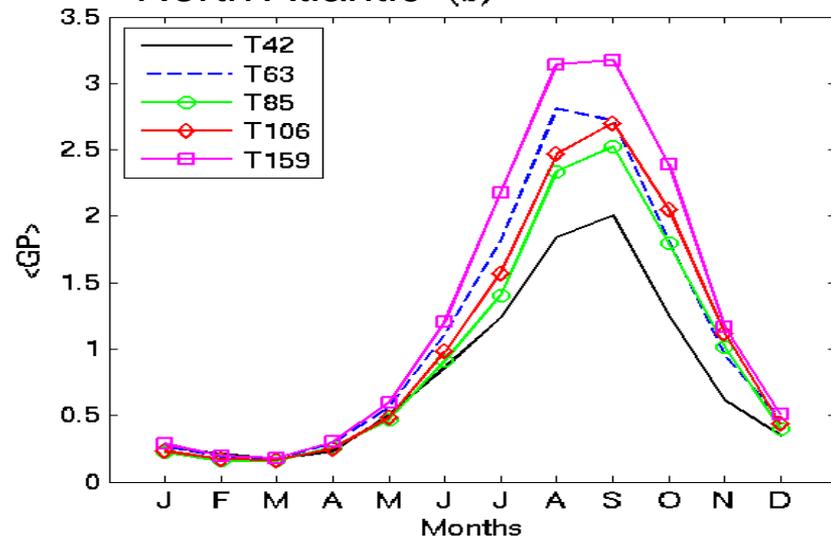
Camargo, Barnston, Sobel and Emanuel, 2007.

GPI and Horizontal Resolution - Basins

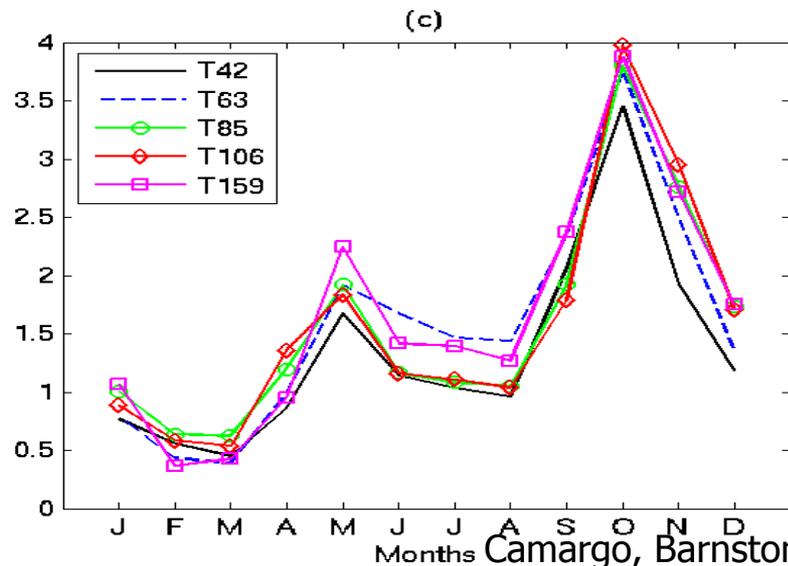
Western North Pacific (a)



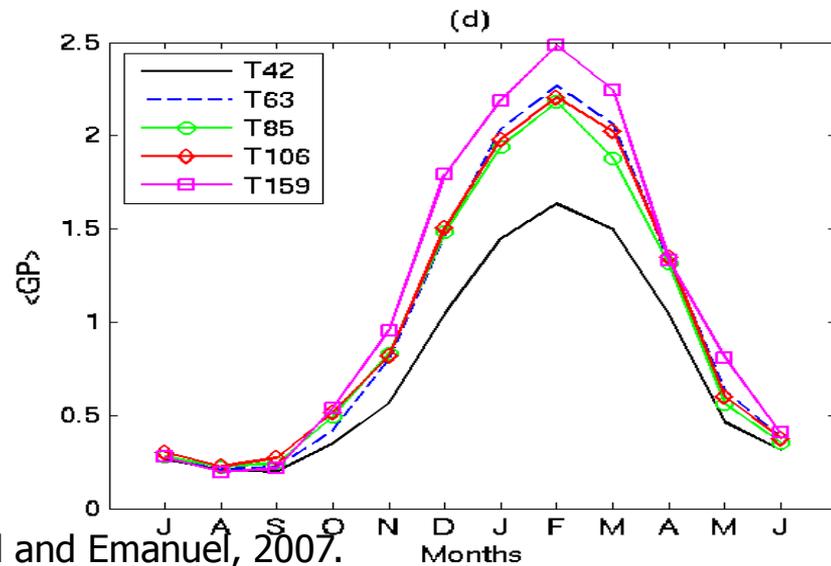
North Atlantic (b)



North Indian (c)



South Indian (d)

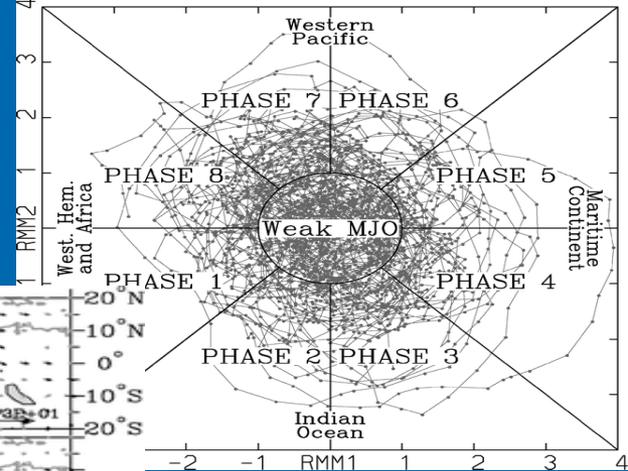
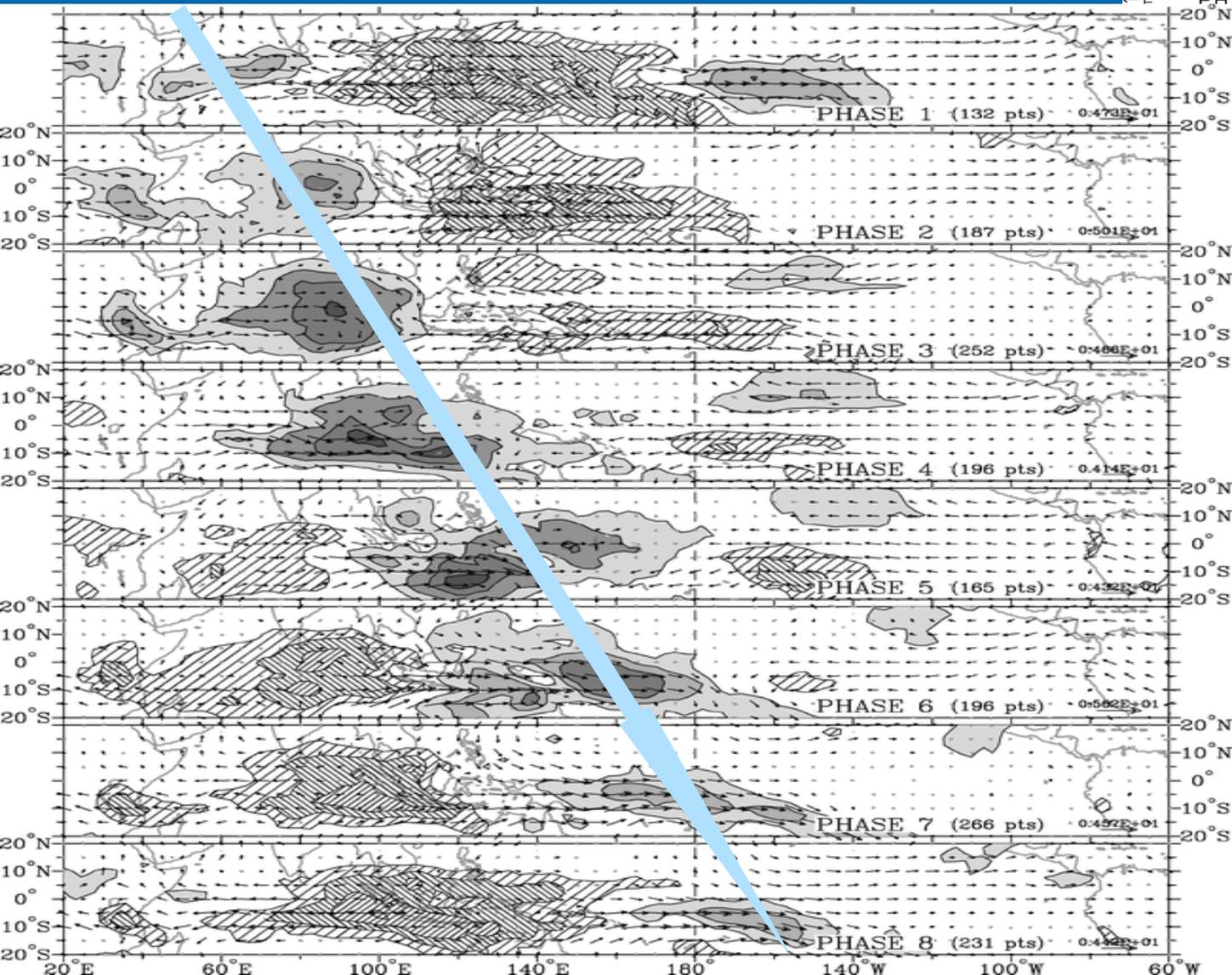


Genesis Potential Index and MJO

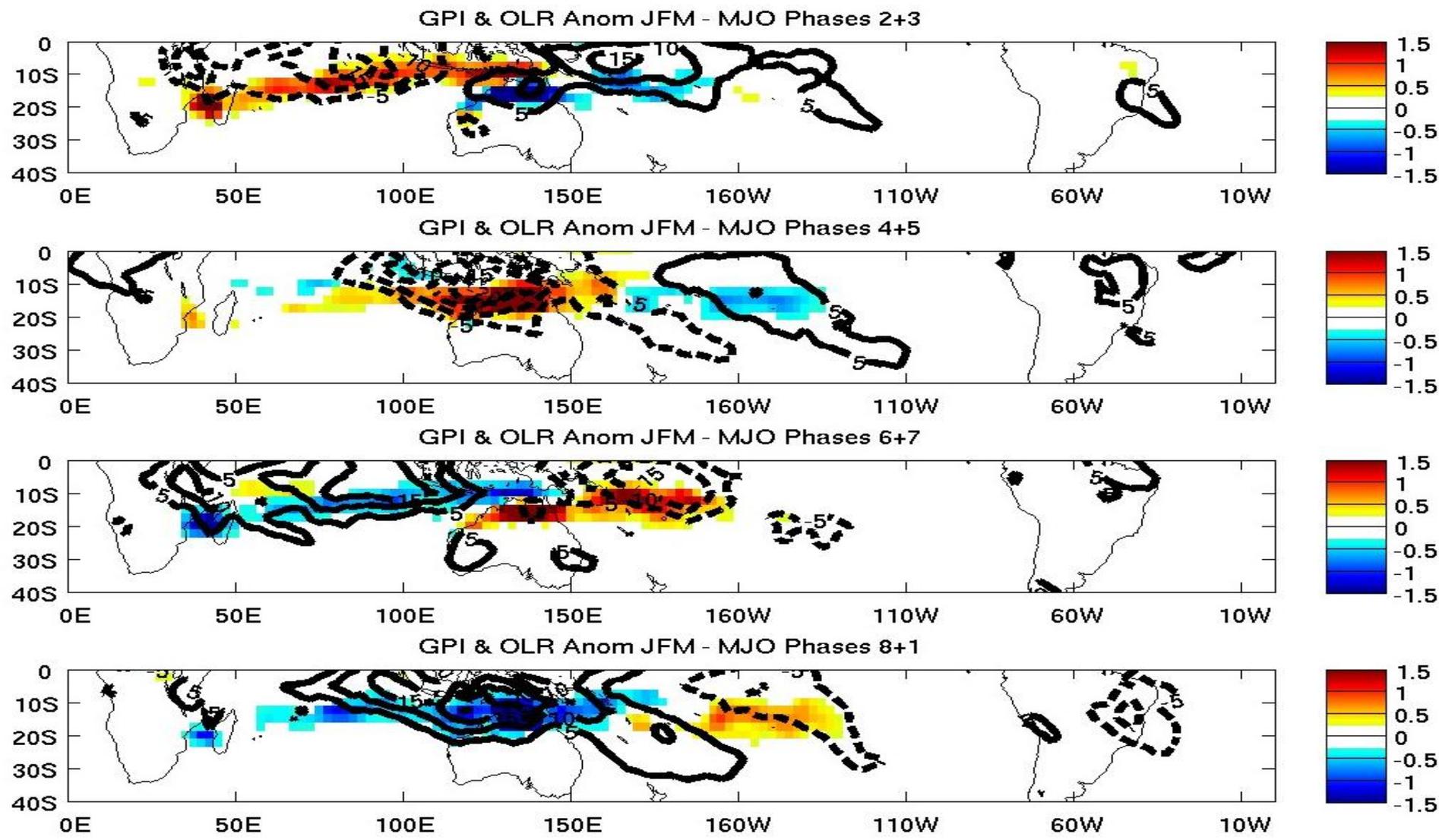
Camargo, Wheeler, and Sobel, *J. Atmos. Sci.*, in press, (2009)

MJO index

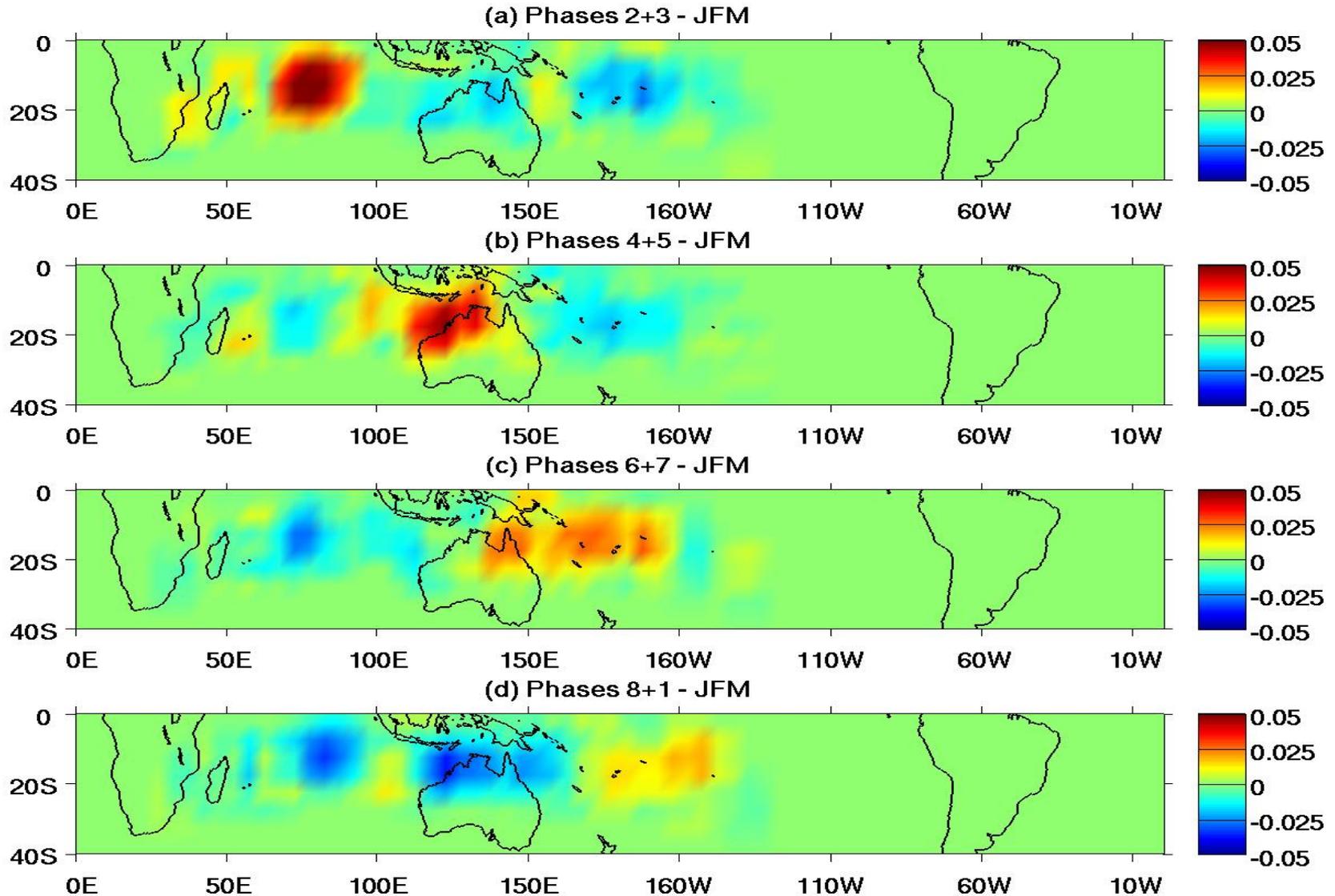
Wheeler and Hendon (2004)



GPI and OLR Anom. Composites - JFM

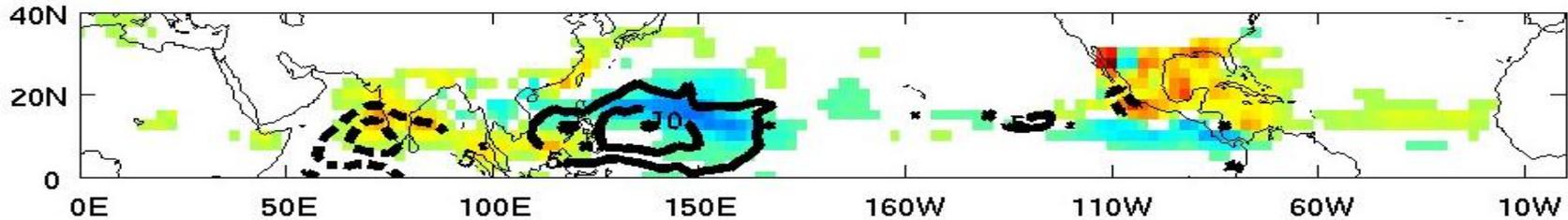


First Position Anomaly Composites - JFM

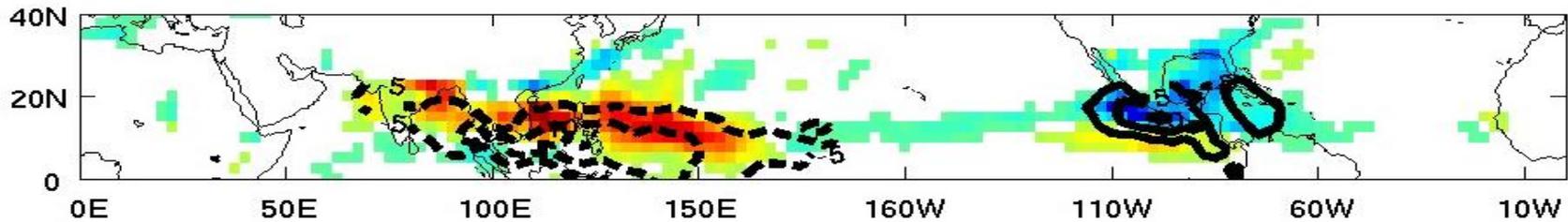


GPI & OLR Anom. Composites ASO

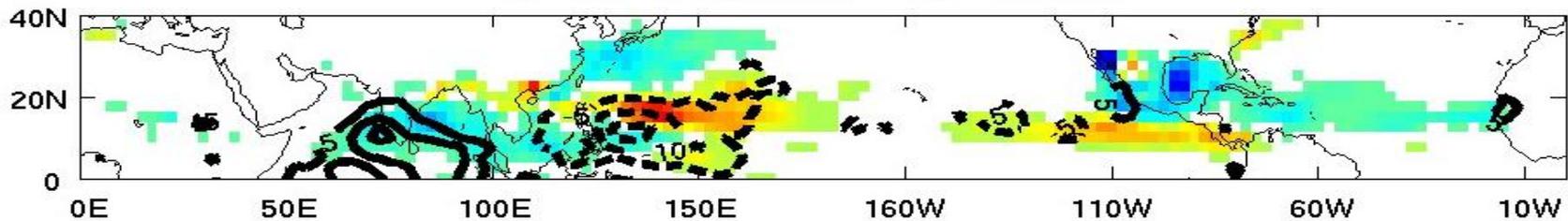
GPI & OLR Anom ASO - MJO Phases 2+3



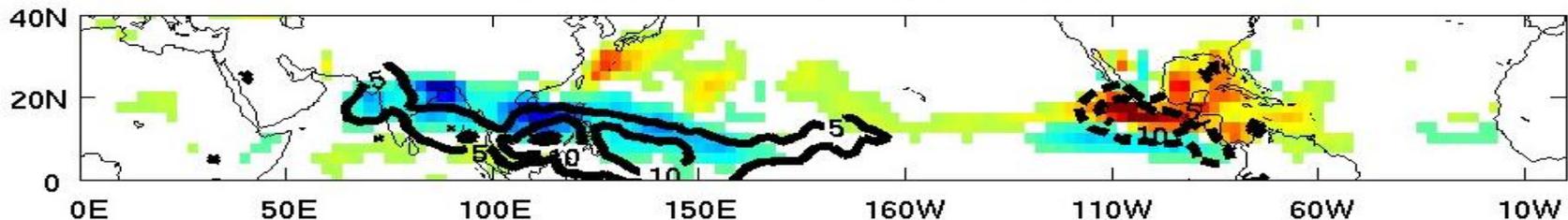
GPI & OLR Anom ASO - MJO Phases 4+5



GPI & OLR Anom ASO - MJO Phases 6+7

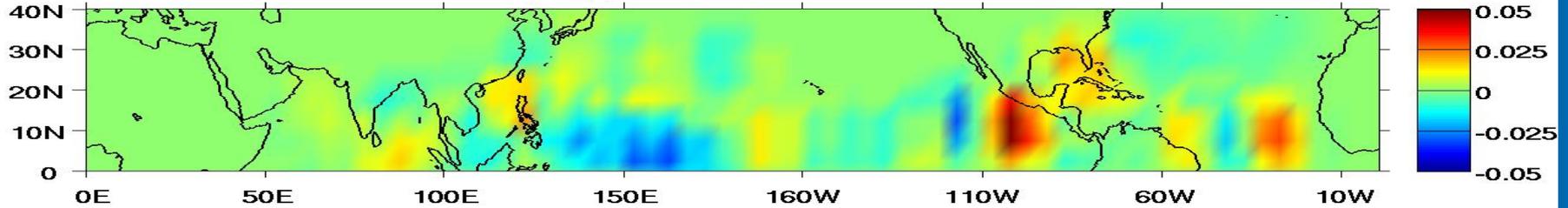


GPI & OLR Anom ASO - MJO Phases 8+1

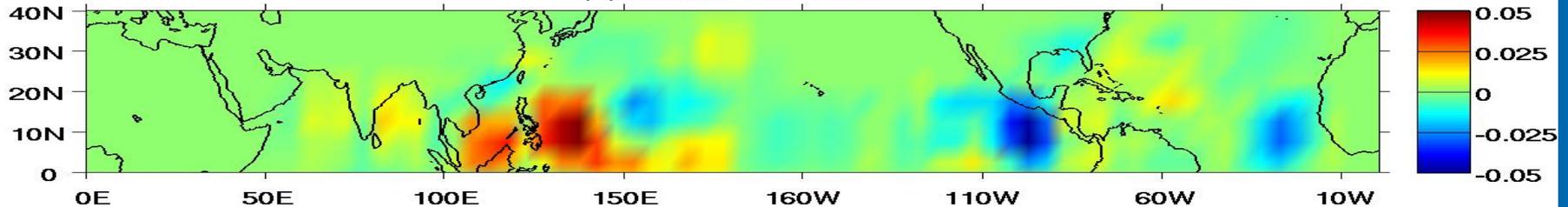


First Position Anomaly Composites - ASO

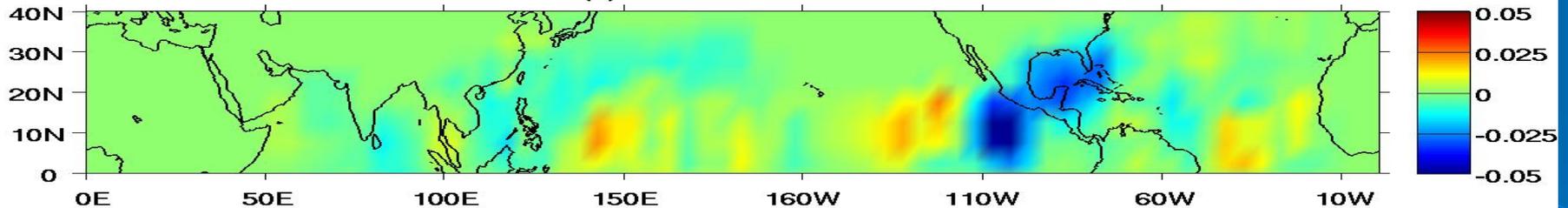
(a) Phases 2+3 - ASO



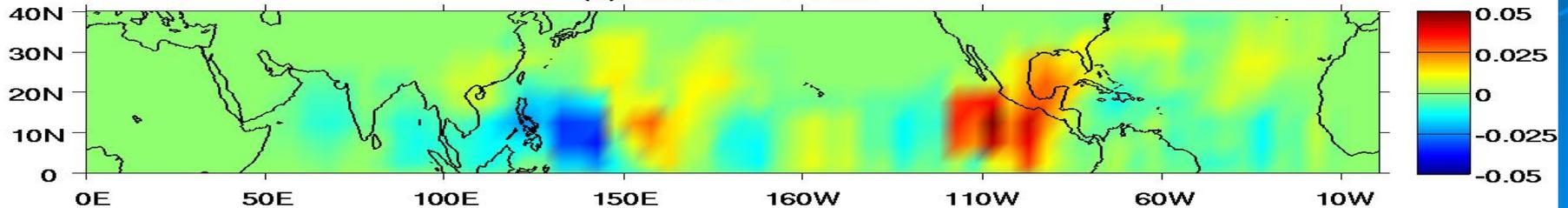
(b) Phases 4+5 - ASO



(c) Phases 6+7 - ASO



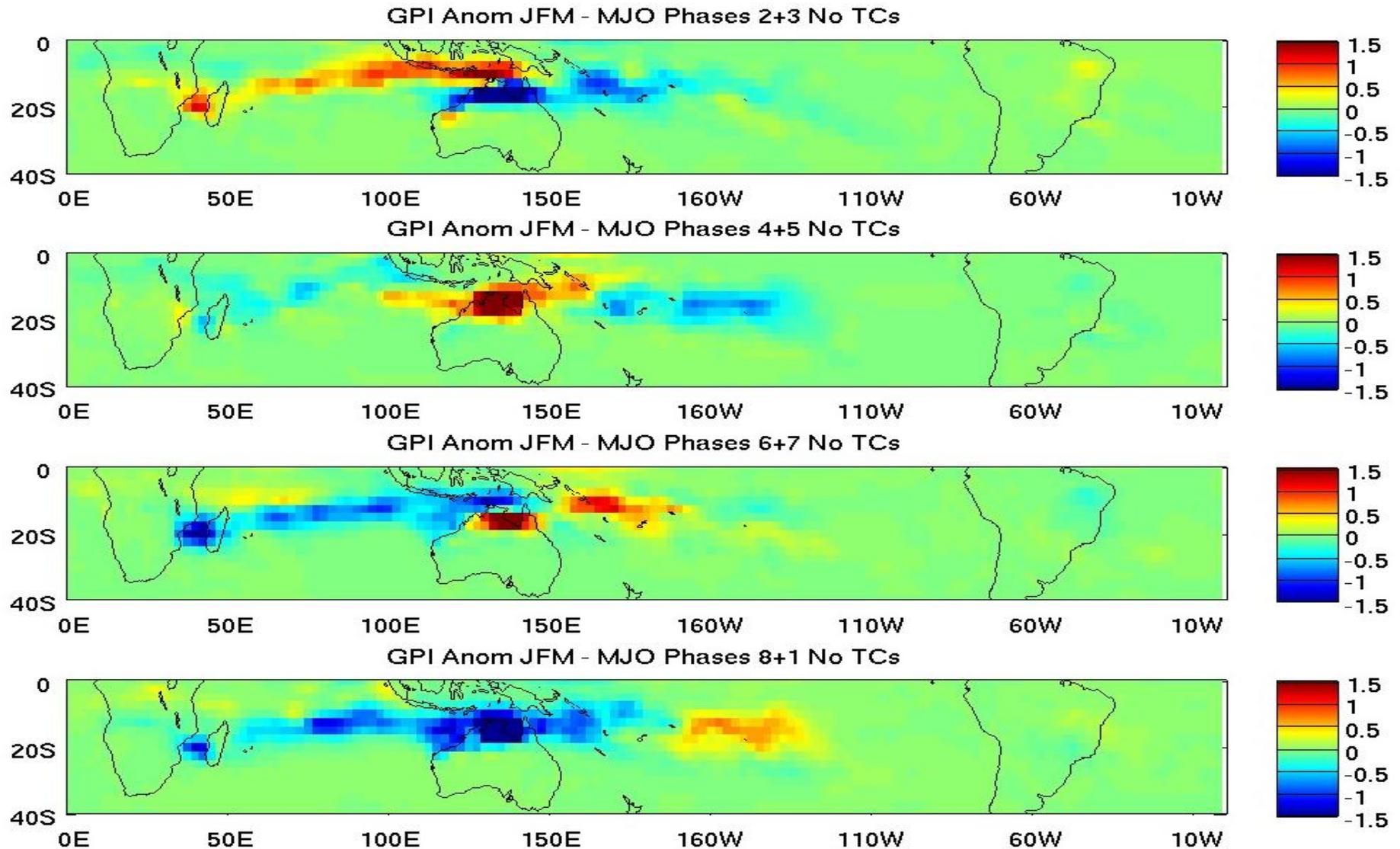
(d) Phases 8+1 - ASO



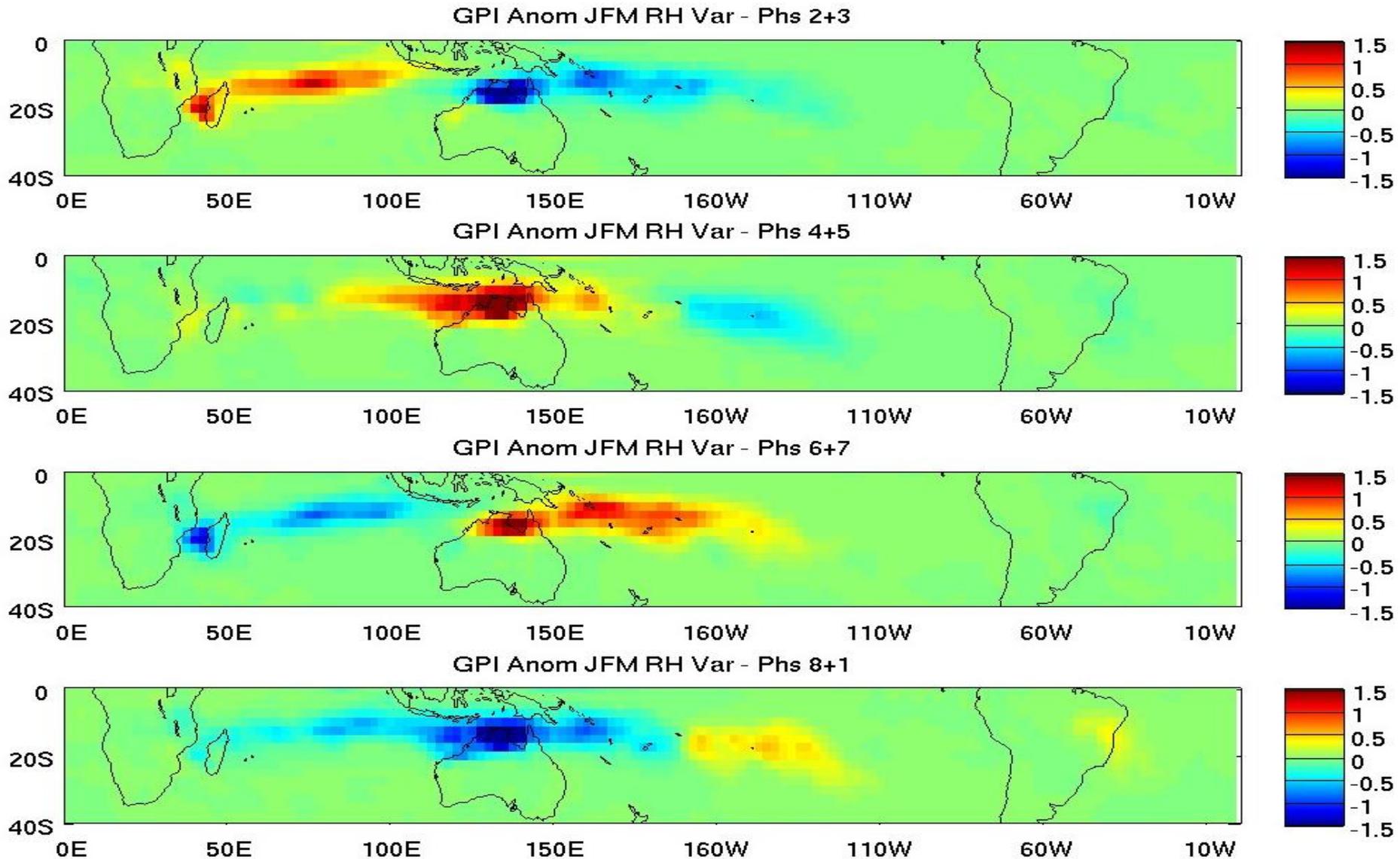
Influence of TCs in the MJO - GPI composites

- Excluding TCs from MJO composites:
 - When there is an active TC:
 - In the region (12.5 degrees around the TC) of the TC - substitute in the GPI for that day the climatological GPI.
 - Recalculate the MJO composites using the GPI with NO TCs.

GPI Anom. - no TCs - JFM

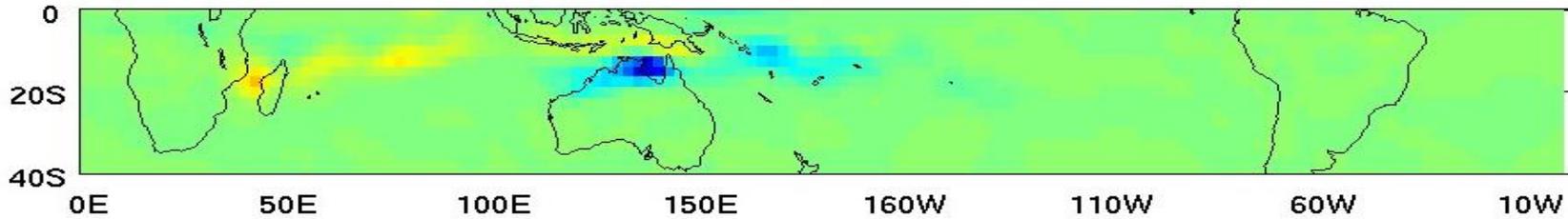


Relative Humidity varying - JFM

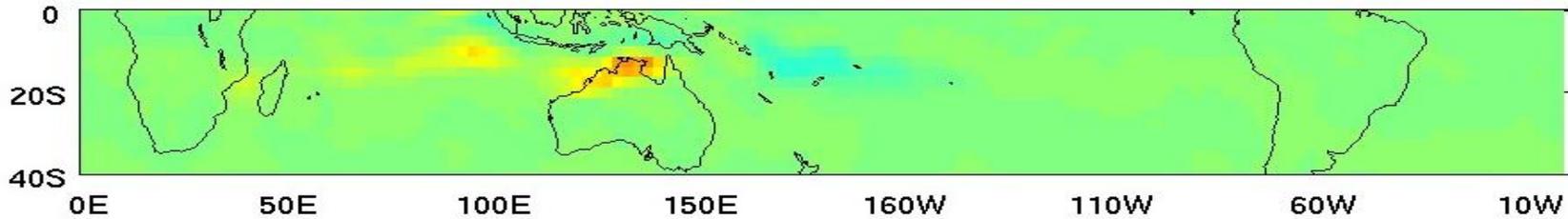


Vorticity varying - JFM

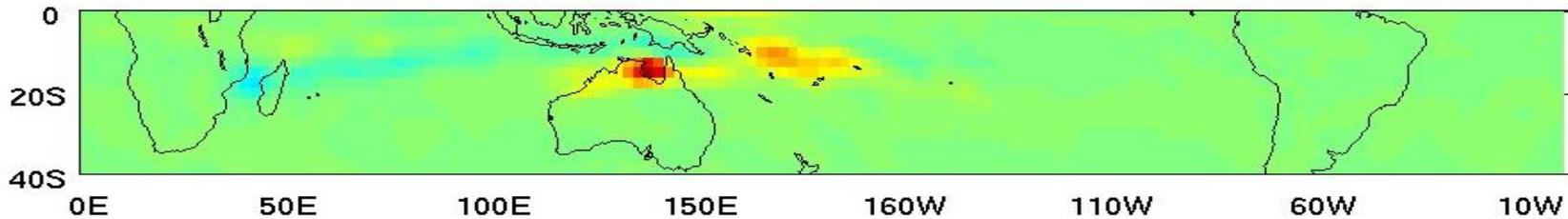
GPI Anom JFM Vort Var - Phs 2+3



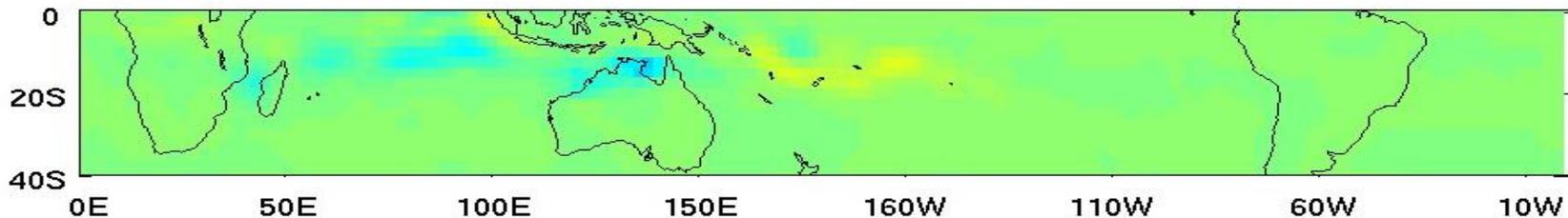
GPI Anom JFM Vort Var - Phs 4+5



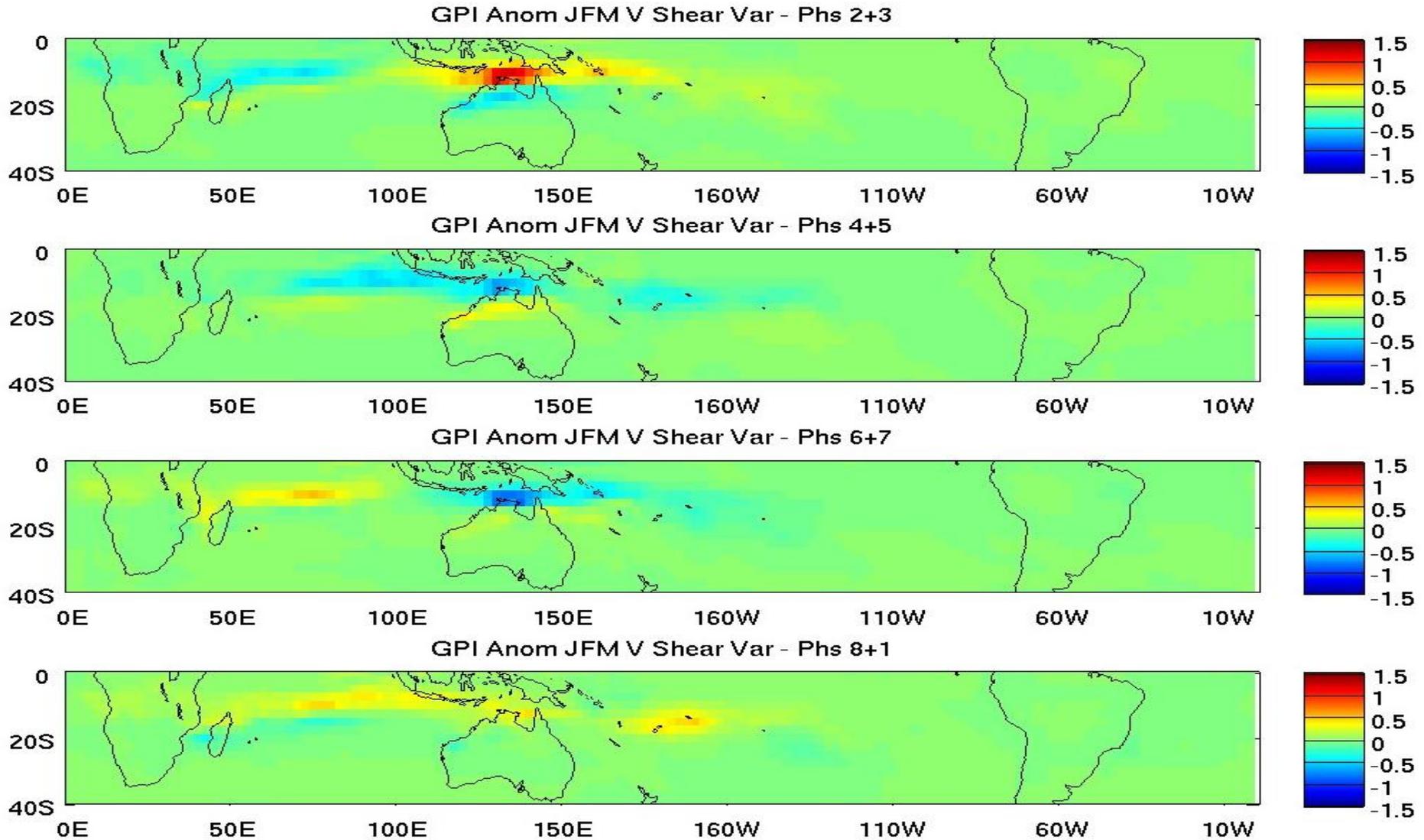
GPI Anom JFM Vort Var - Phs 6+7



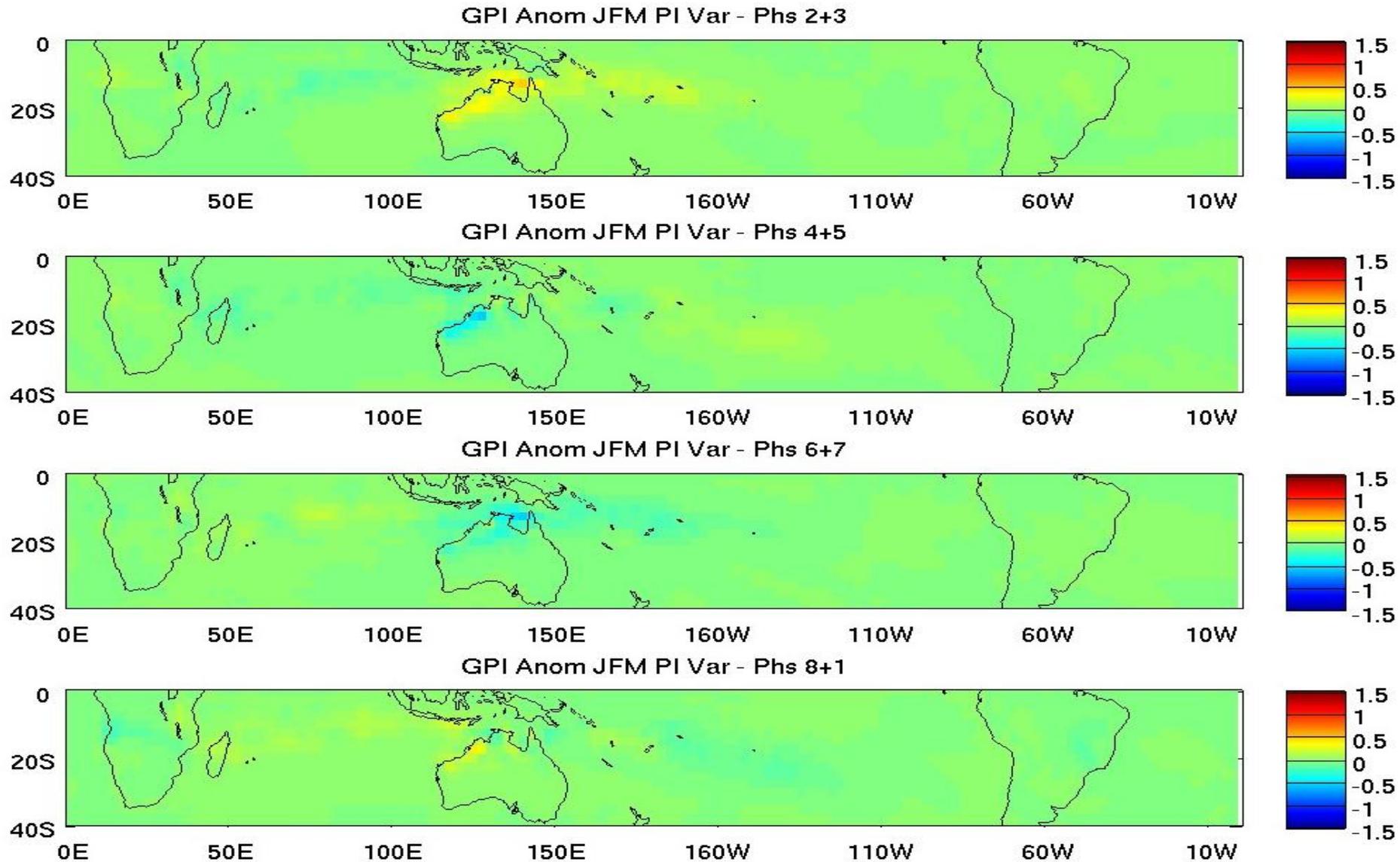
GPI Anom JFM Vort Var - Phs 8+1



Vertical Shear varying - JFM



Potential Intensity Varying - JFM



GPI - summary

- GPI reproduces ENSO and MJO TC modulation.
- Humidity main responsible for MJO variability.
- Models can reproduce the GPI climatology and ENSO response.

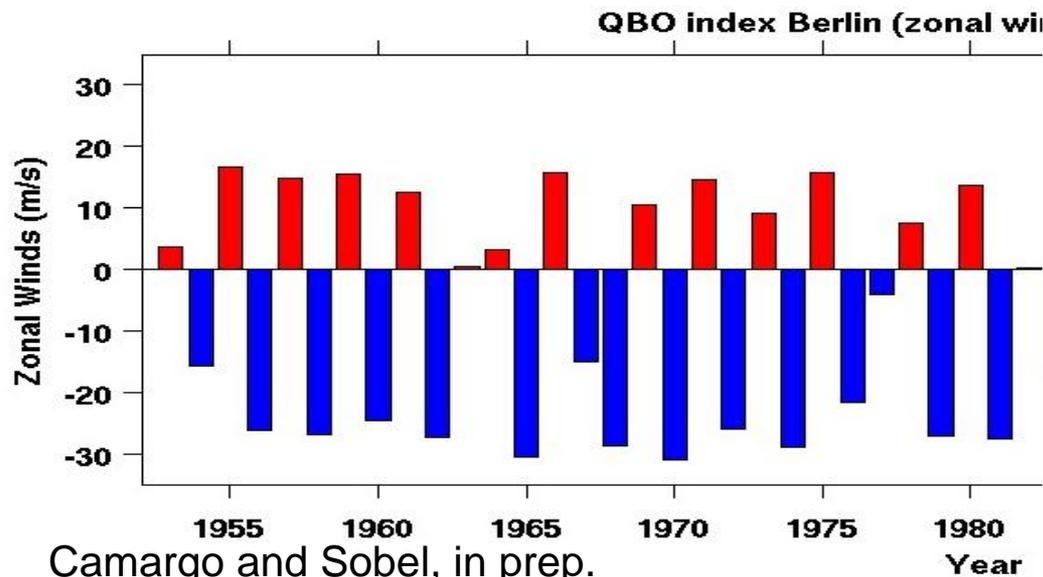
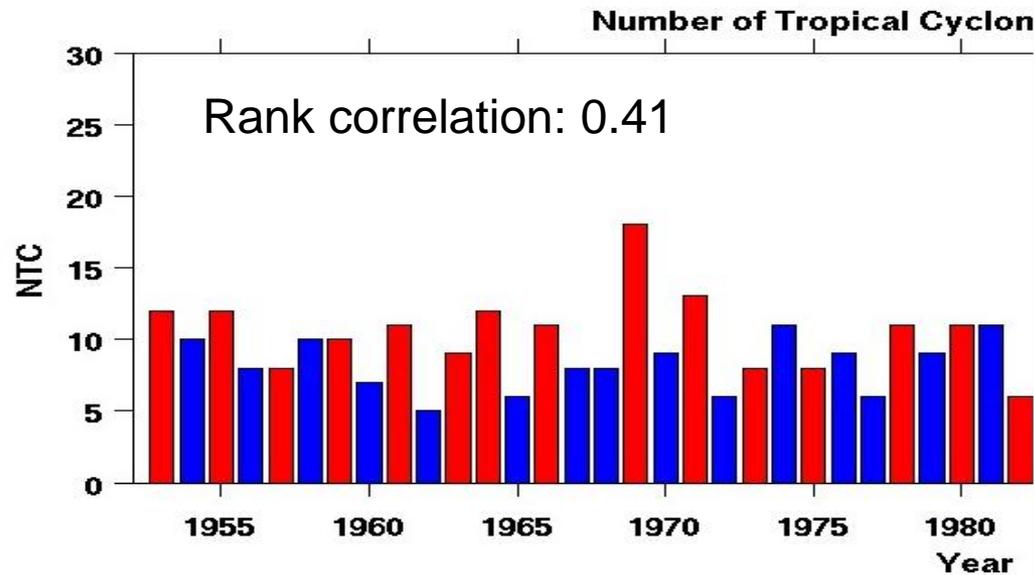
Tropical Cyclones and Quasi Biennial Oscillation (QBO)

Collaboration with
Adam H. Sobel (Columbia University)

Camargo and Sobel, in preparation.

Atlantic NTC and QBO

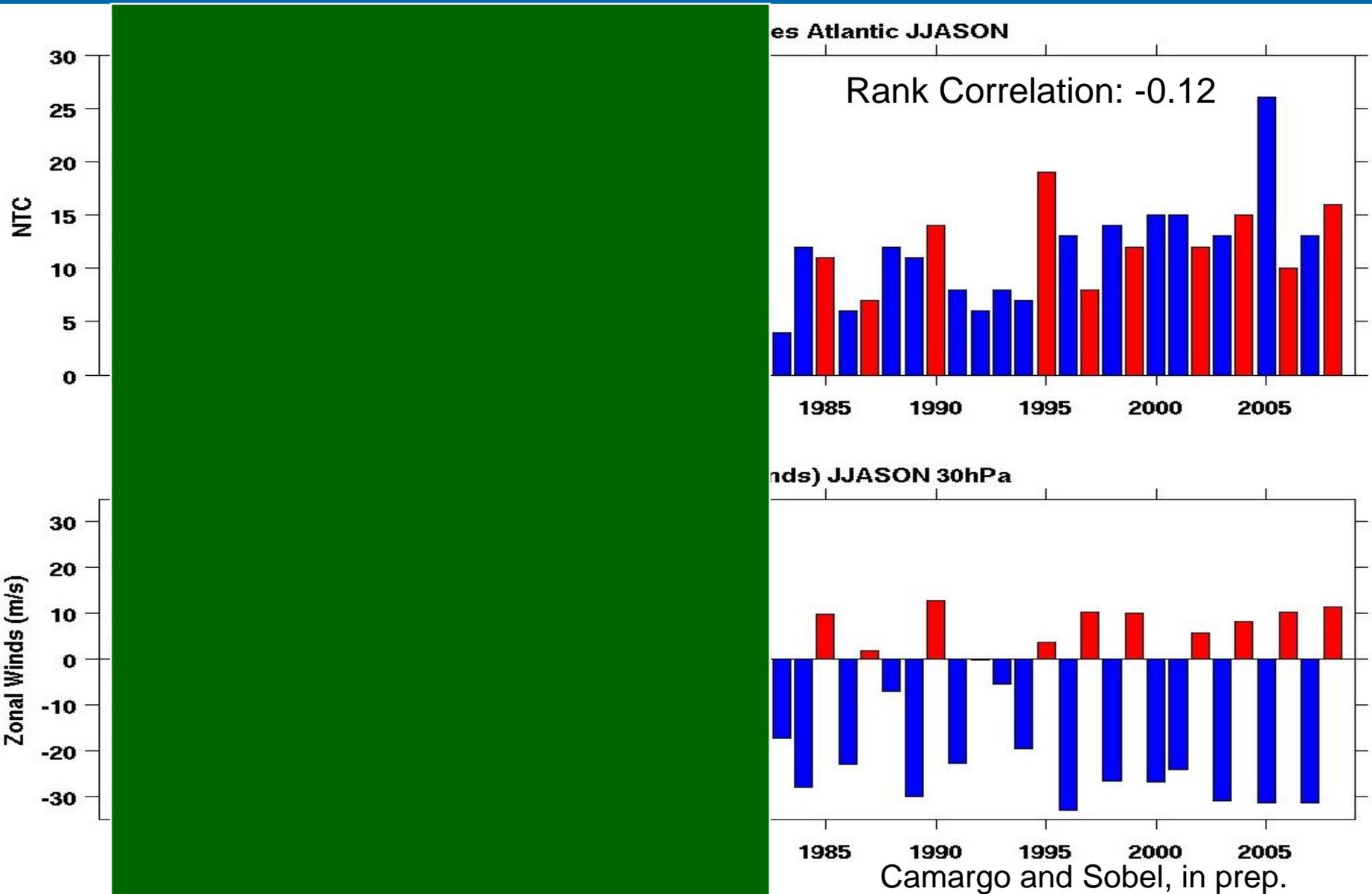
Correlation 1953-1982: 0.44 (significant 95% level)



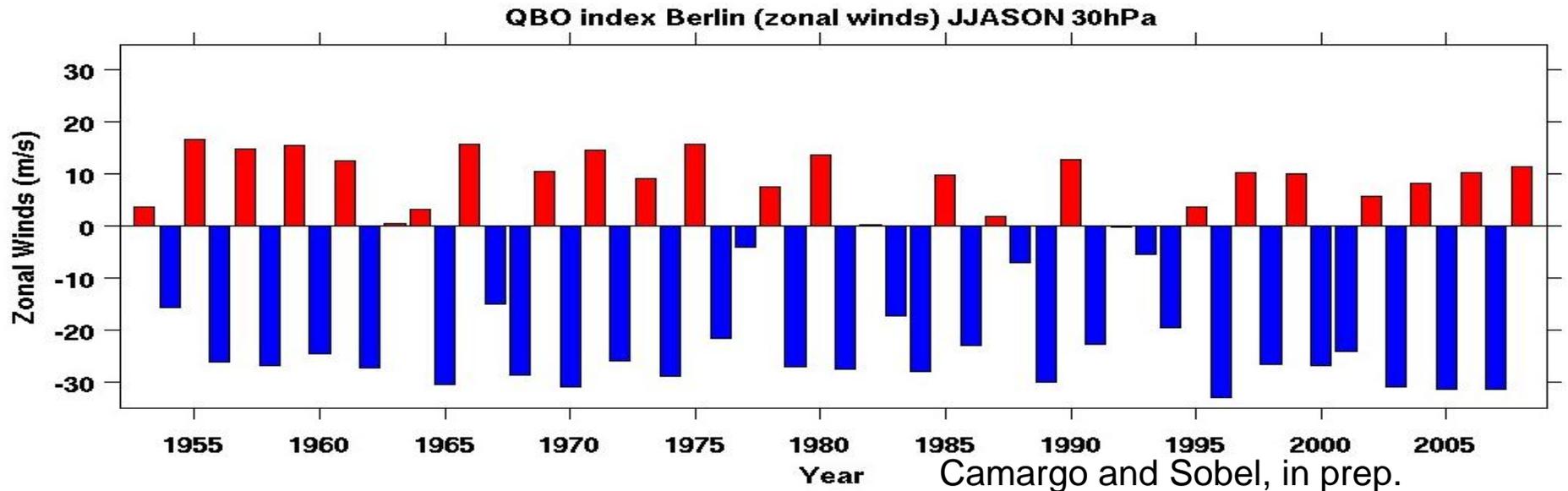
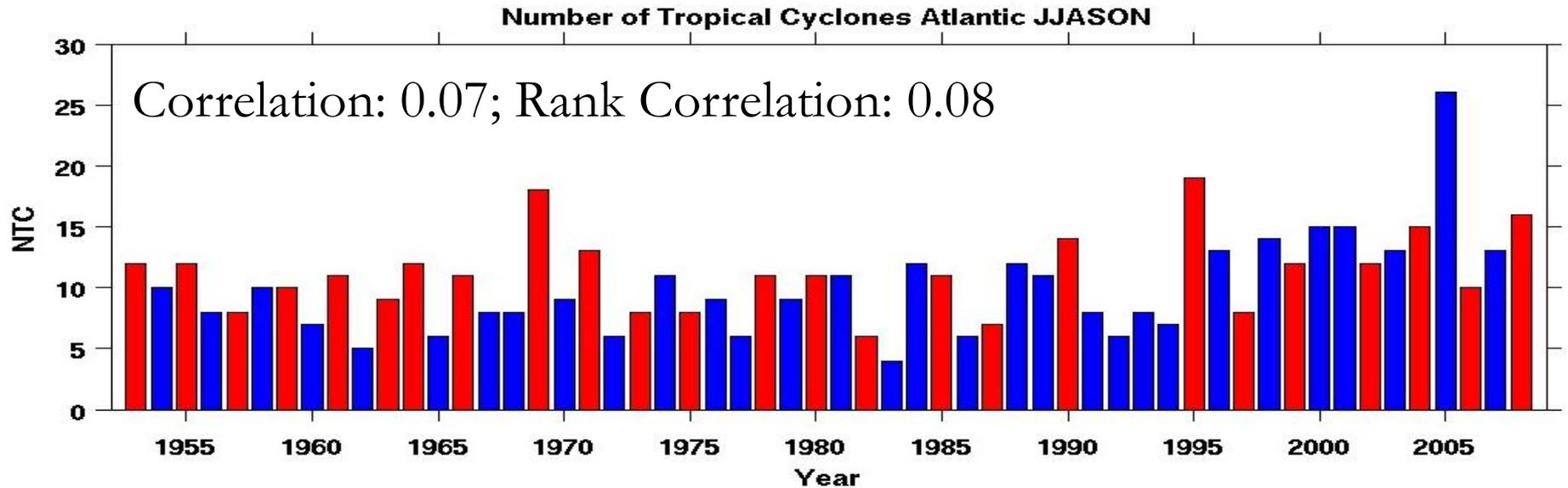
Camargo and Sobel, in prep.

Atlantic NTC and QBO

Correlation 1983-2008: -0.12



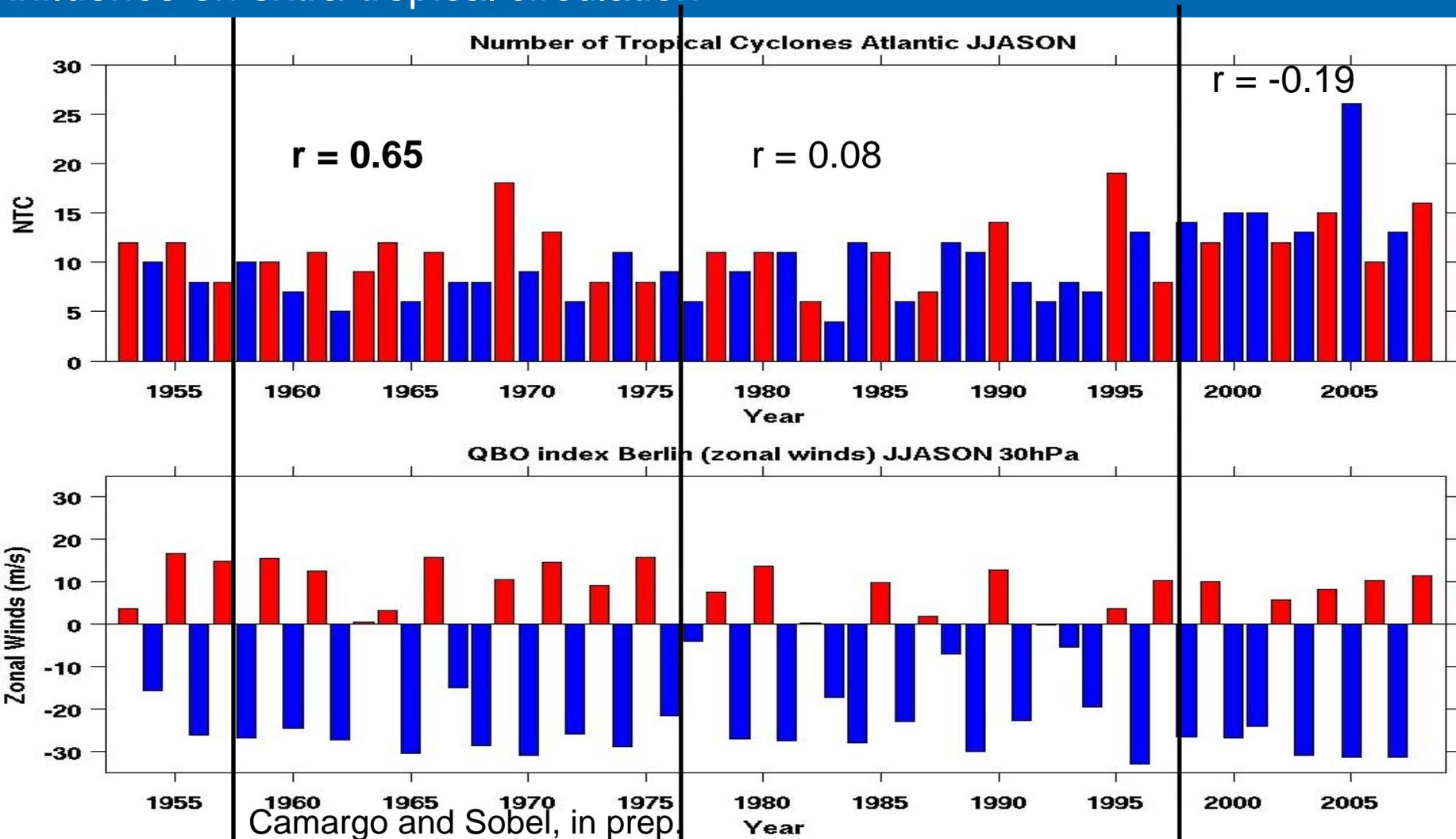
Atlantic NTC and QBO



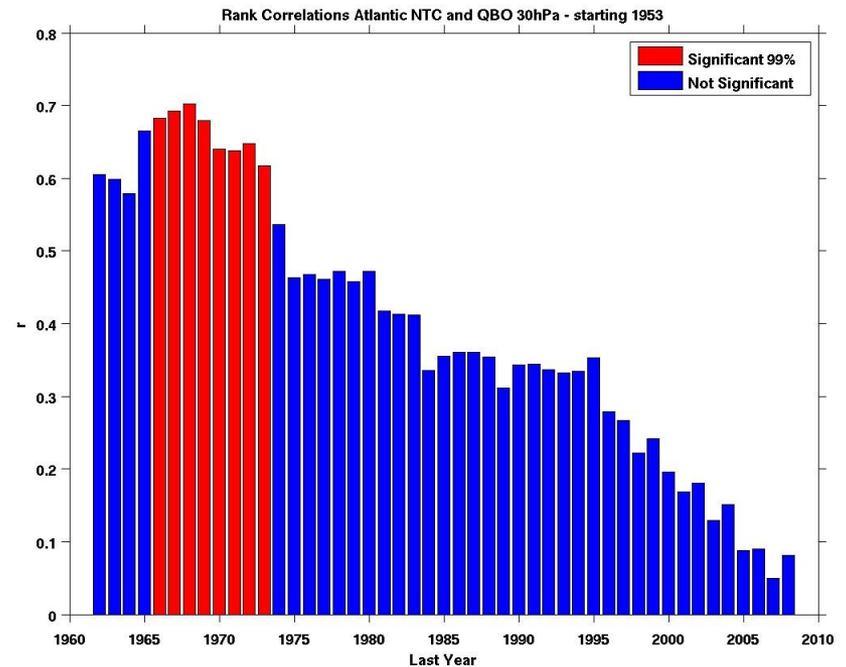
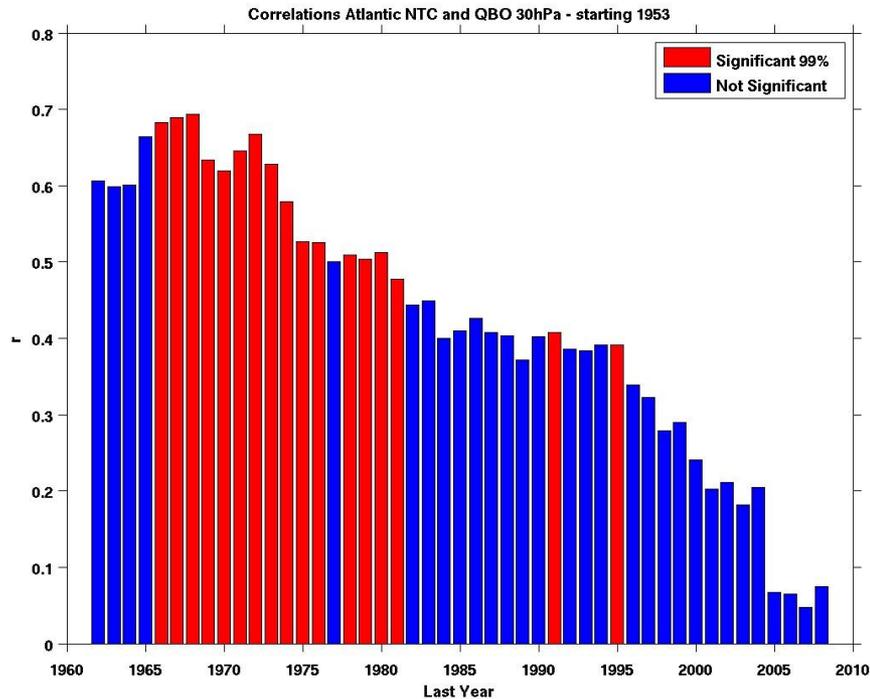
Camargo and Sobel, in prep.

QBO decadal variability

- Lu, Baldwin, Gray and Jarvis, 2008: Decadal changes in the effect of the QBO on the northern stratospheric polar vortex.
- Structural change of the QBO from mid-1970s to mid or late 1990s: weaker influence on extra-tropical circulation.



Correlations NTC x QBO



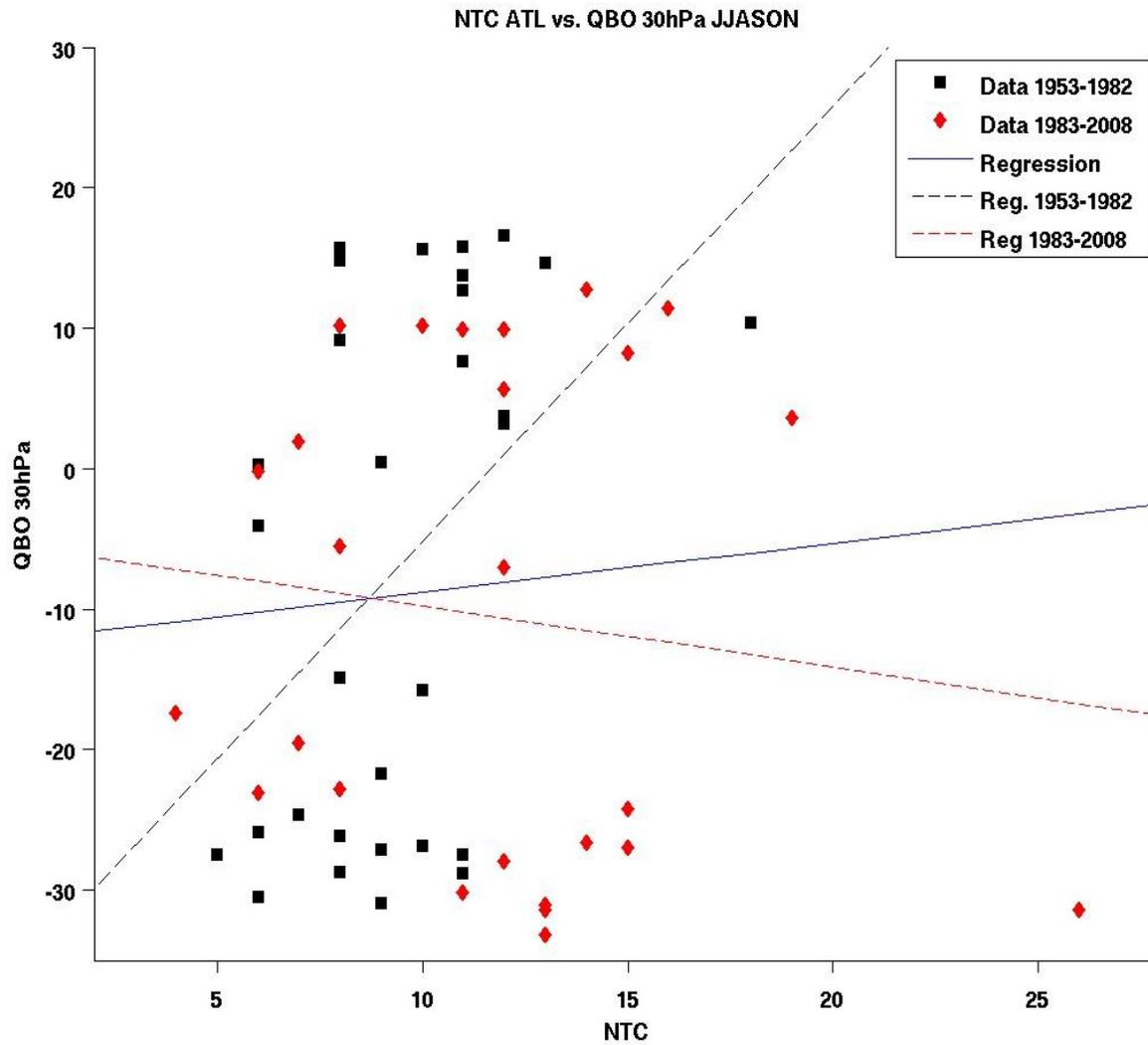
Rank Correlations

Camargo and Sobel, in prep.

Robust results:

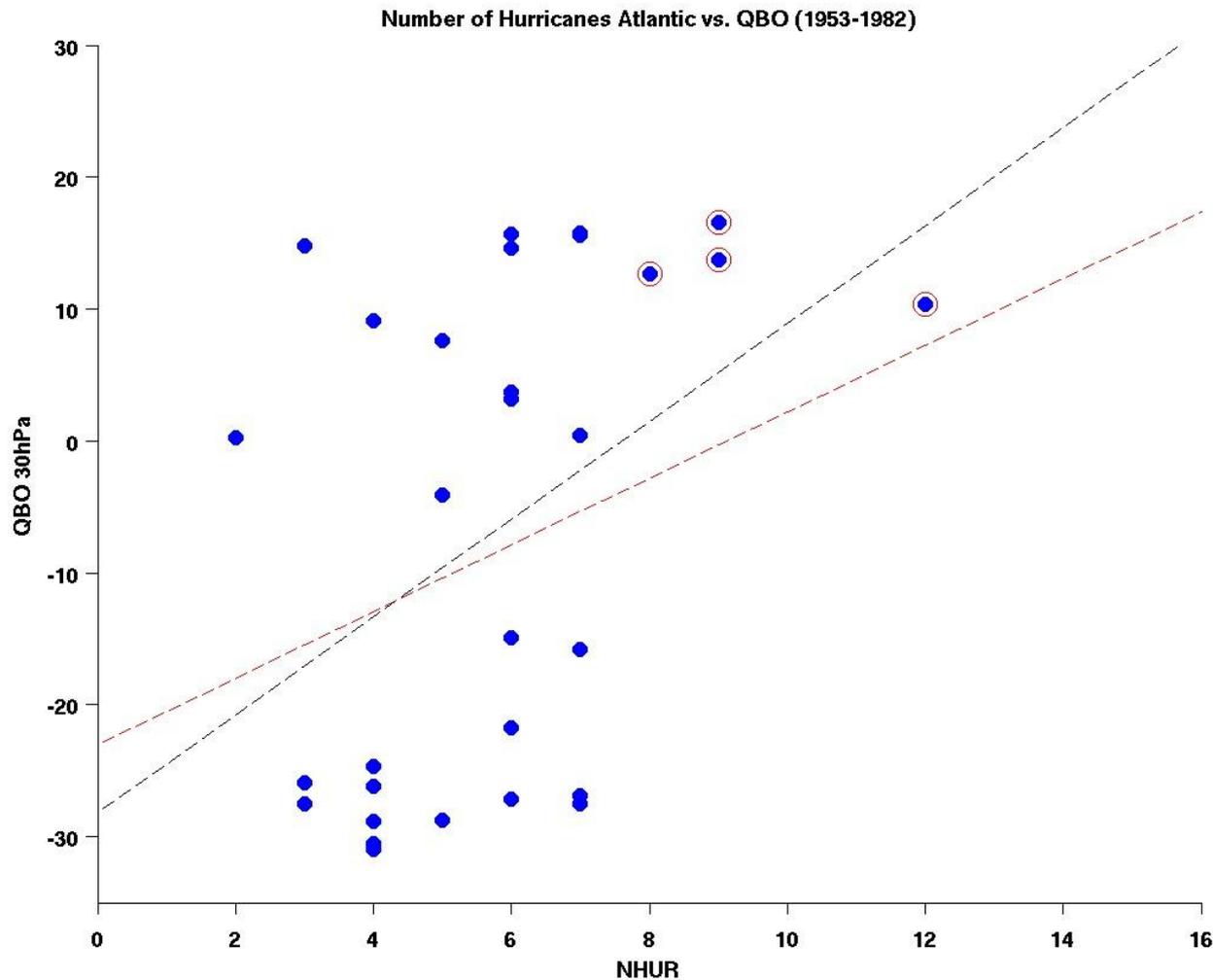
- - Significance: Monte Carlo
- - Different QBO indices
- - Different levels for the QBO index
- - Various tropical cyclone variables:
 - Number of tropical cyclones
 - Number of hurricanes
 - Number of hurricane days
 - ACE (accumulated cyclone energy)²⁹
- - NHC and IBTRACS datasets

NTC x QBO



Number of Hurricanes and QBO

1953 - 1982



All years:
 $R = 0.42$

Without outliers:
 $R = 0.21$

Outlier years:
1955 (LN),
1961 (neut),
1969 (EN), 1980
(neut)

Excluding ENSO years

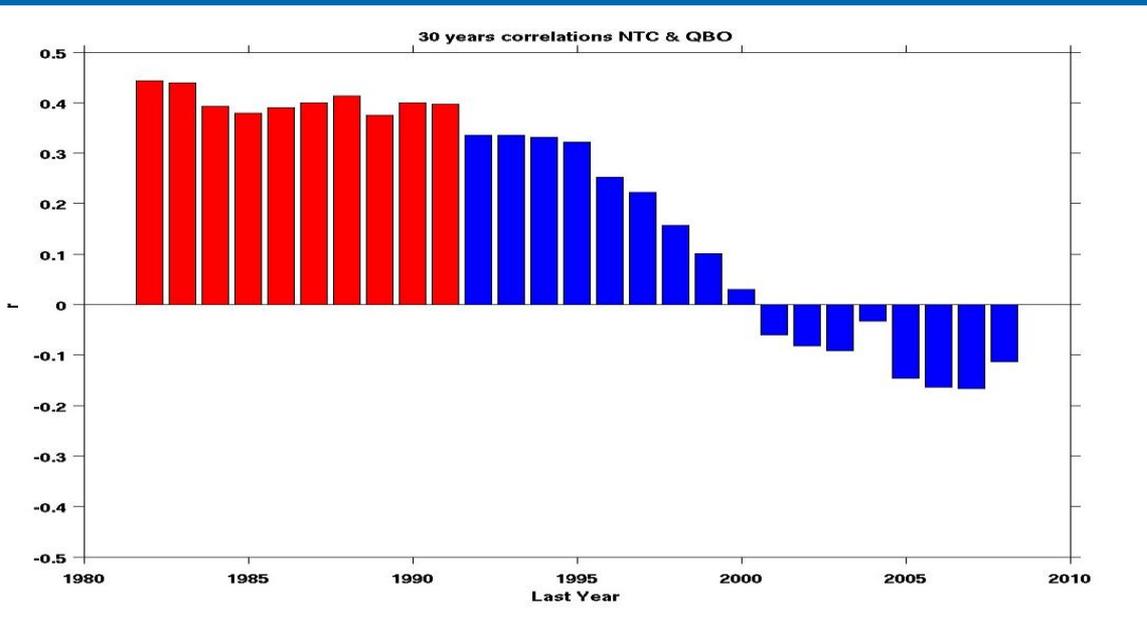
■ No El Niño years

Period	r
1953 - 2008	0.00
1953 - 1982	0.51
1983 - 2008	-0.11

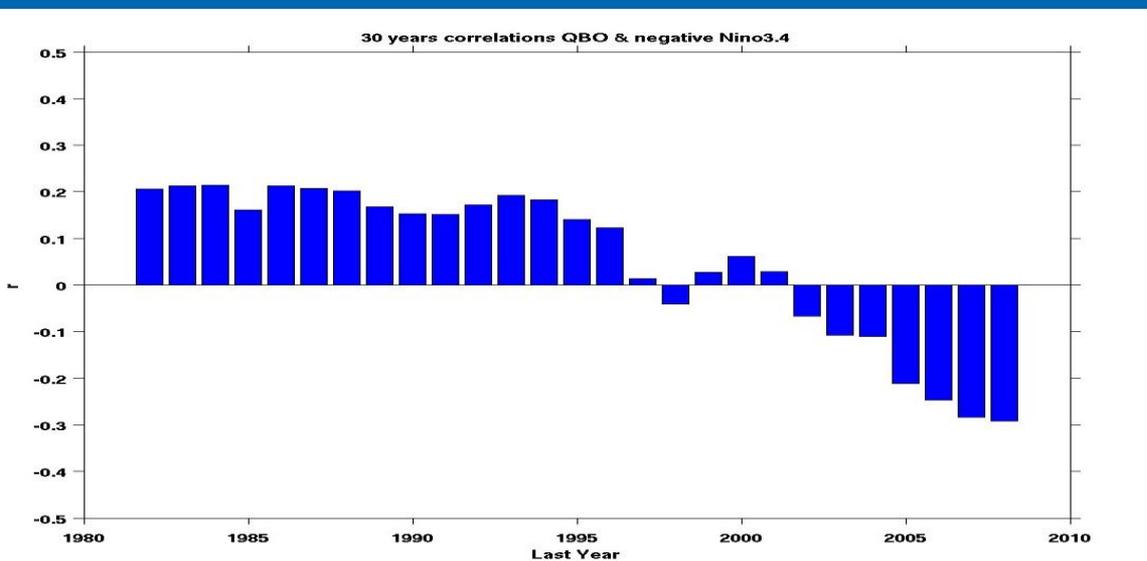
■ Neutral years only

Period	r
1953 - 2008	-0.05
1953 - 1982	0.46
1983 - 2008	-0.21

Correlations – 30 years



NTC and QBO



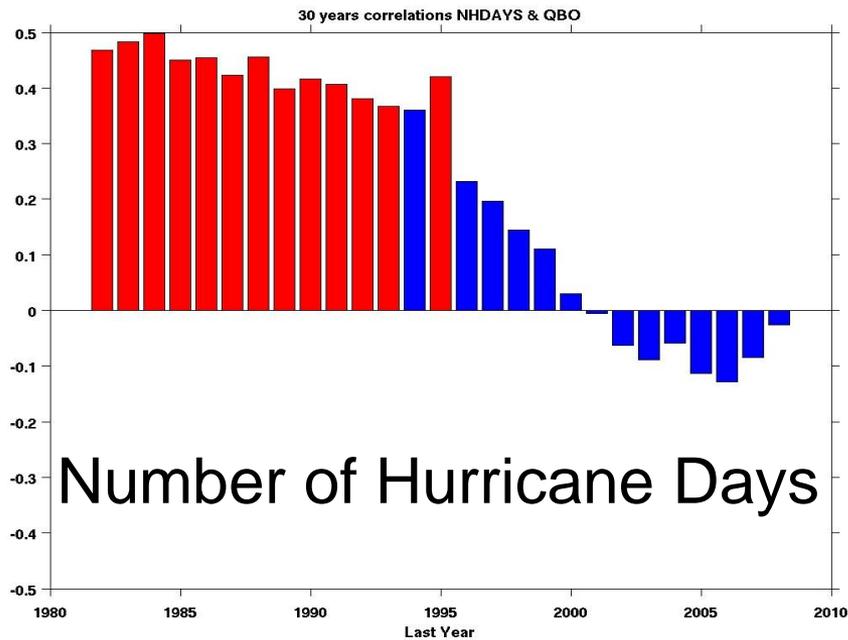
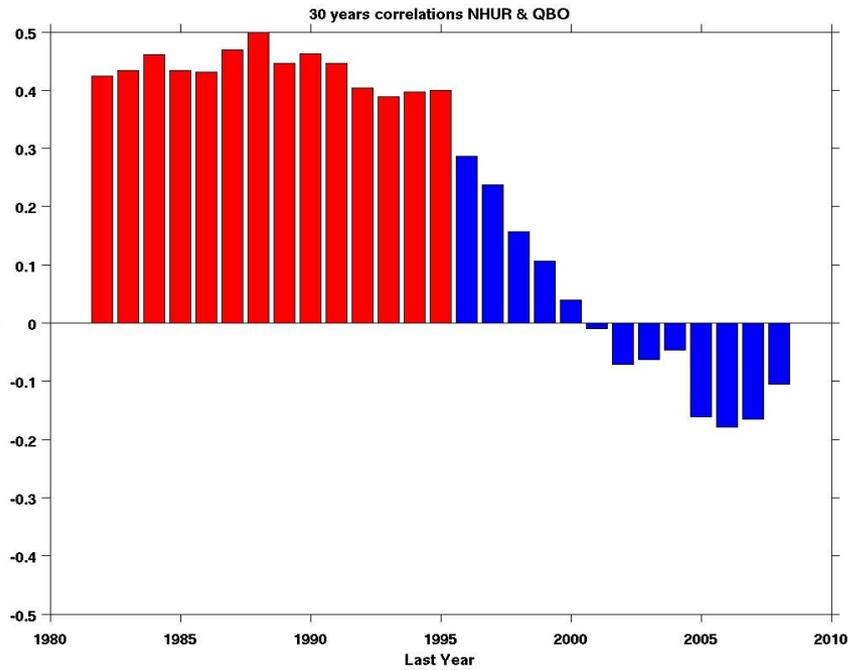
Nino3.4 and QBO

Camargo and Sobel, in prep.

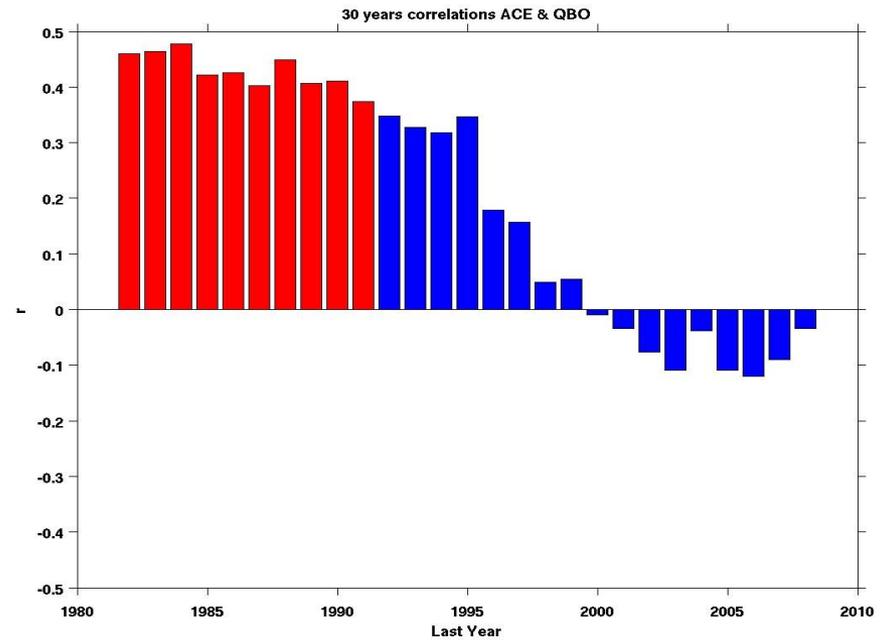
Correlations 30 years

Number of Hurricanes

ACE



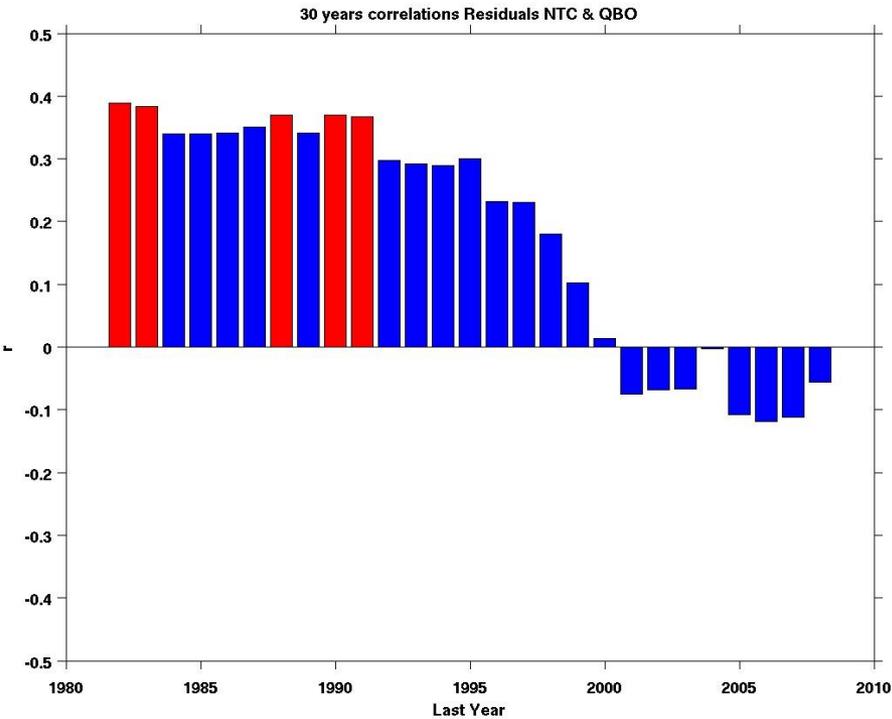
Number of Hurricane Days



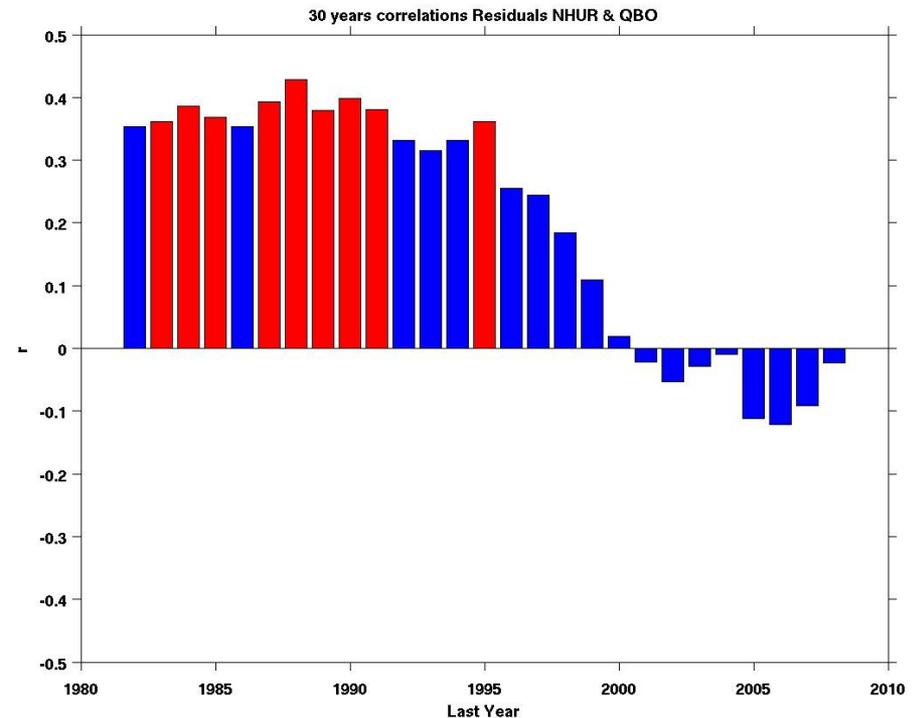
Camargo and Sobel, in prep.

Correlations of Residuals: (subtracting Nino3.4 regressions)

Residuals NTC & QBO

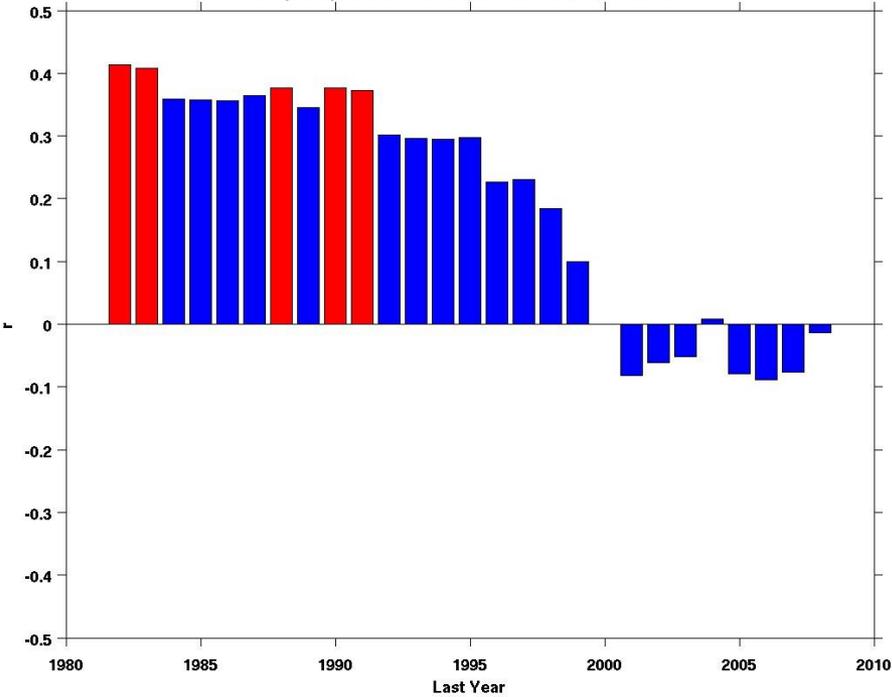


Residuals Number of Hurricanes and QBO



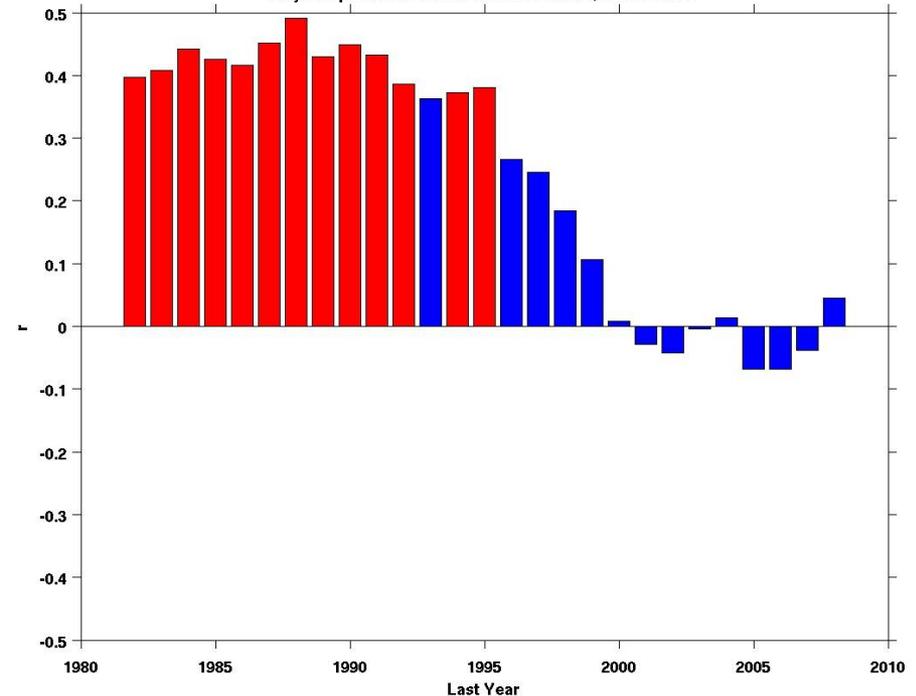
Partial Correlations with QBO & Nino3.4

30 years partial correlations NTC & QBO, with Nino3.4



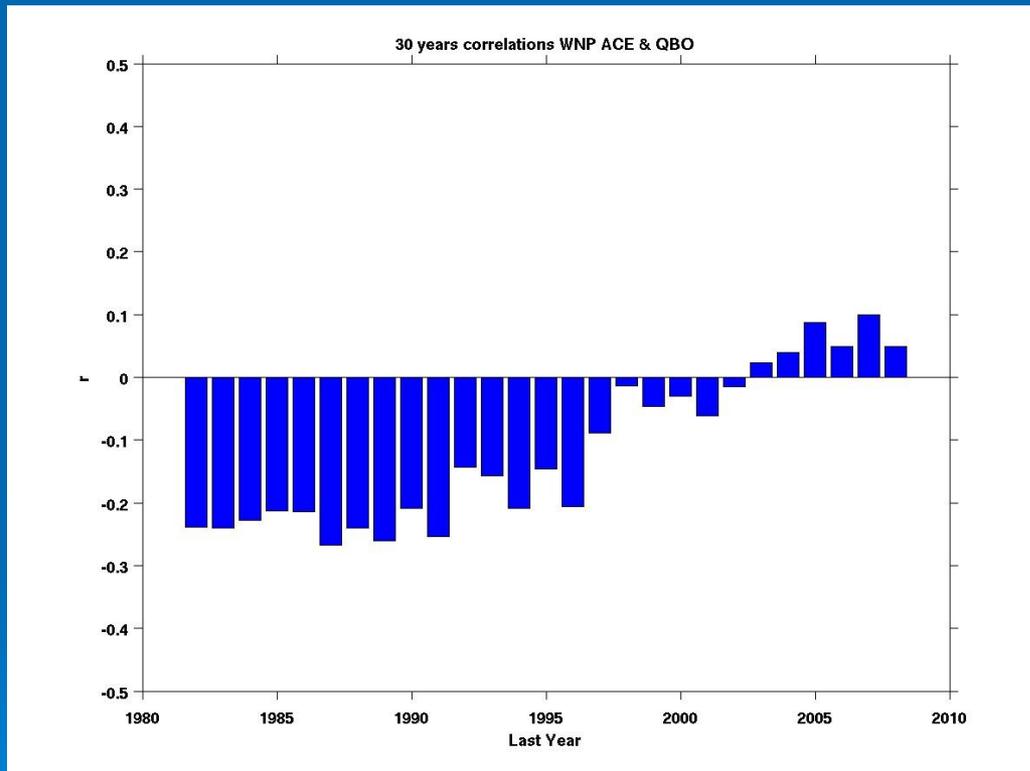
NTC & QBO

30 years partial correlations NHUR & QBO, with Nino3.4



Number of Hurricanes & QBO

Western North Pacific TCs and QBO



TC & QBO: Summary

- QBO relationship with Atlantic hurricane activity until 1980s robust.
- Relationship disappeared in more recent years.
- Suggestive of ENSO influence in QBO & Atlantic TC relationship.
- Other basins: very weak or not significant relationship with QBO
- ENSO could also be playing a role in the other basins

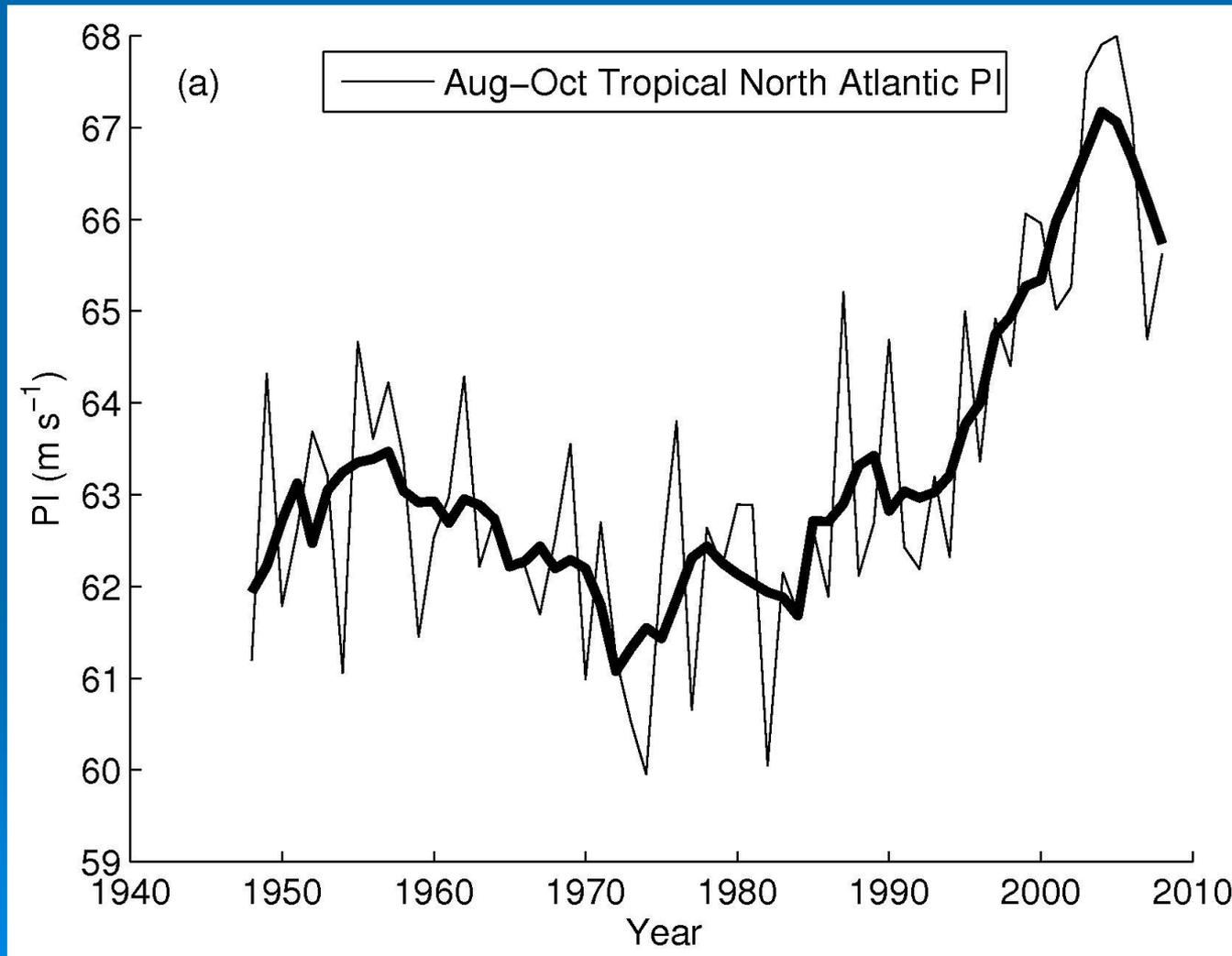
Hurricane Track Variability and Secular Potential Intensity Trends

In collaboration with
James Kossin

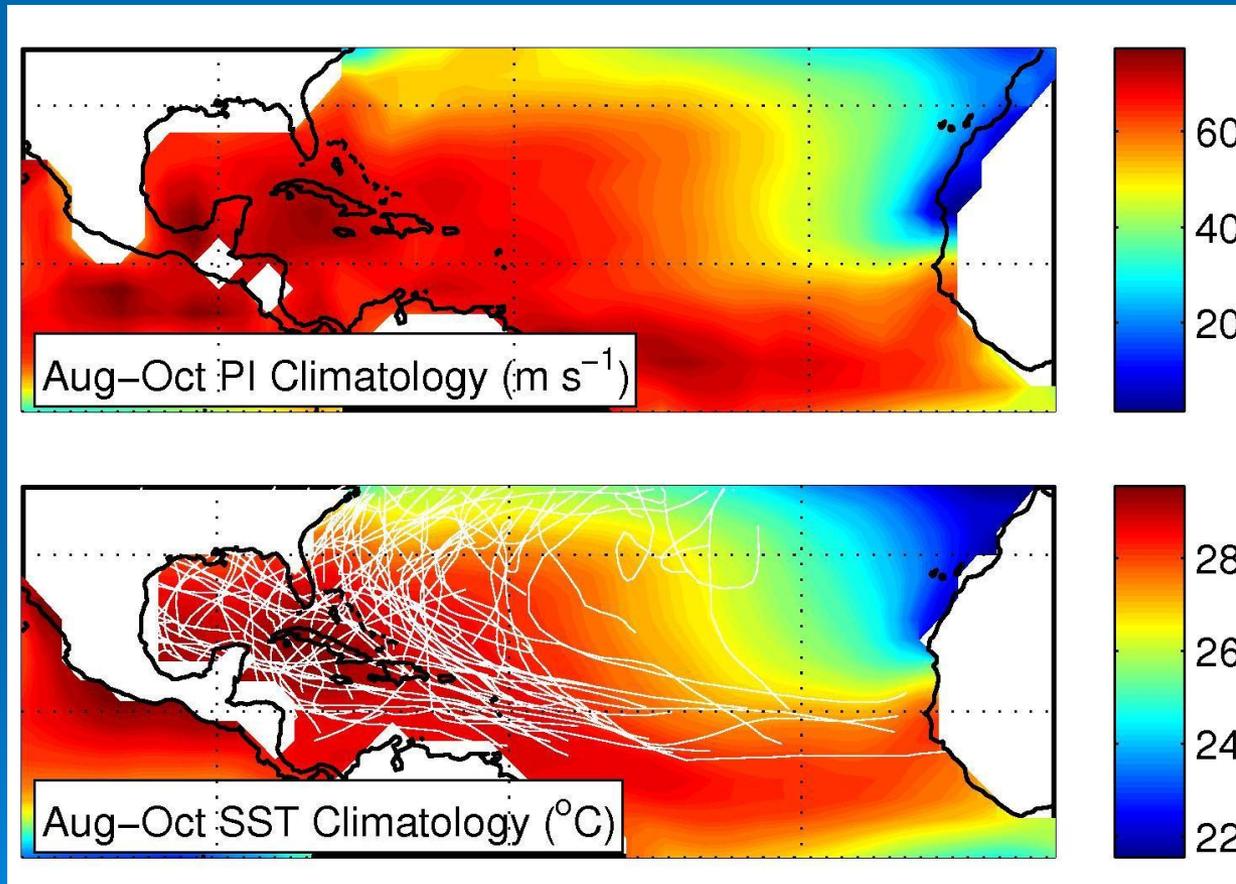
NOAA's National Climatic Data Center
University of Wisconsin–Madison

Kossin and Camargo, 2009, in review

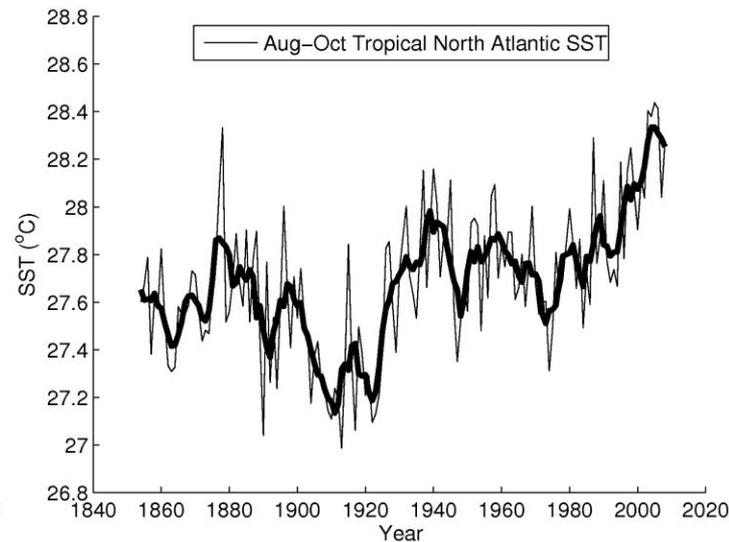
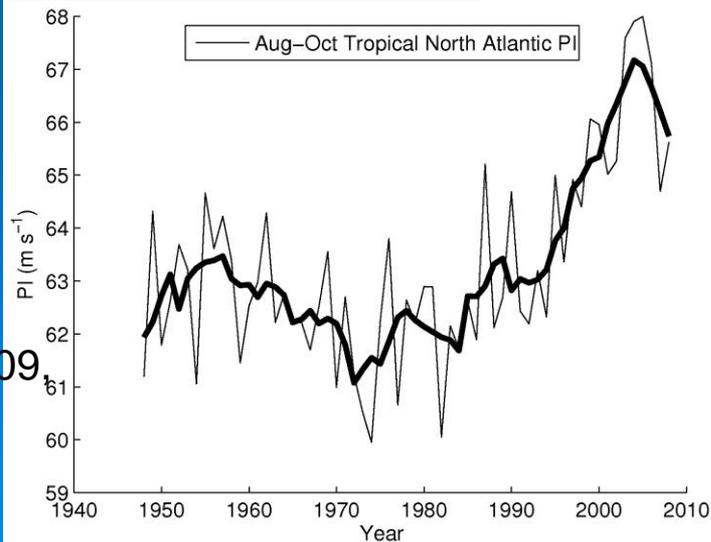
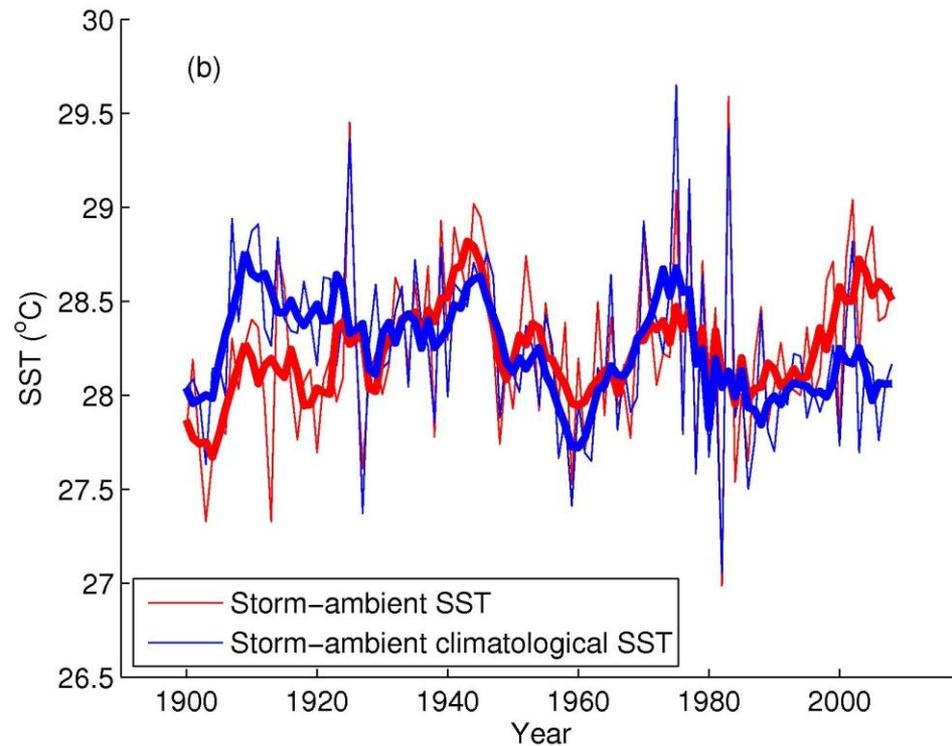
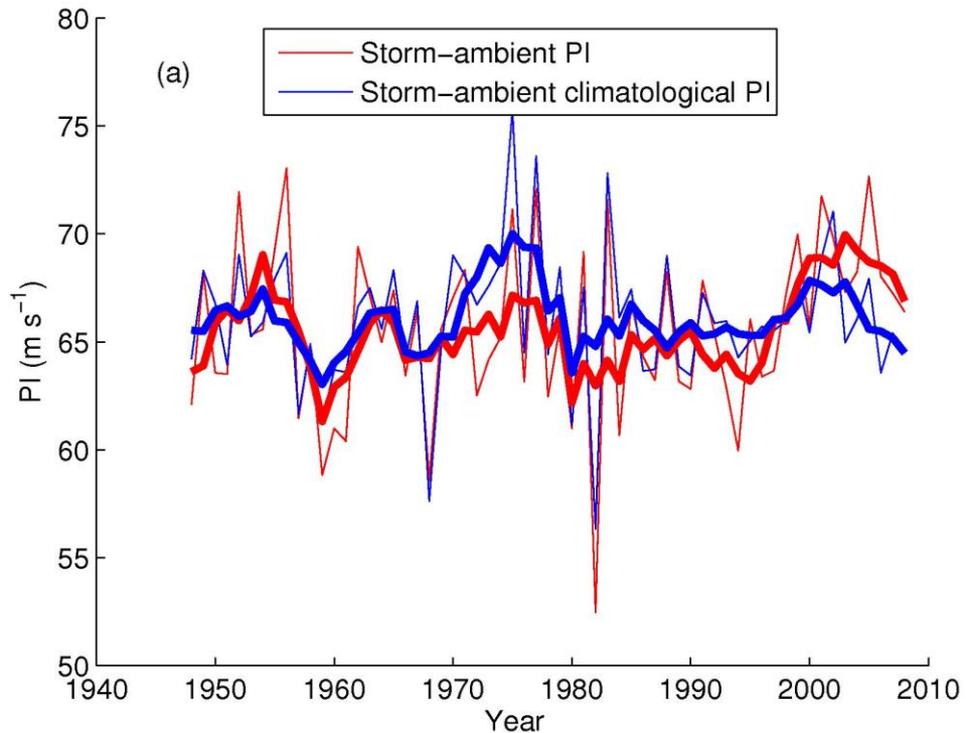
Potential intensity ASO tropical North Atlantic



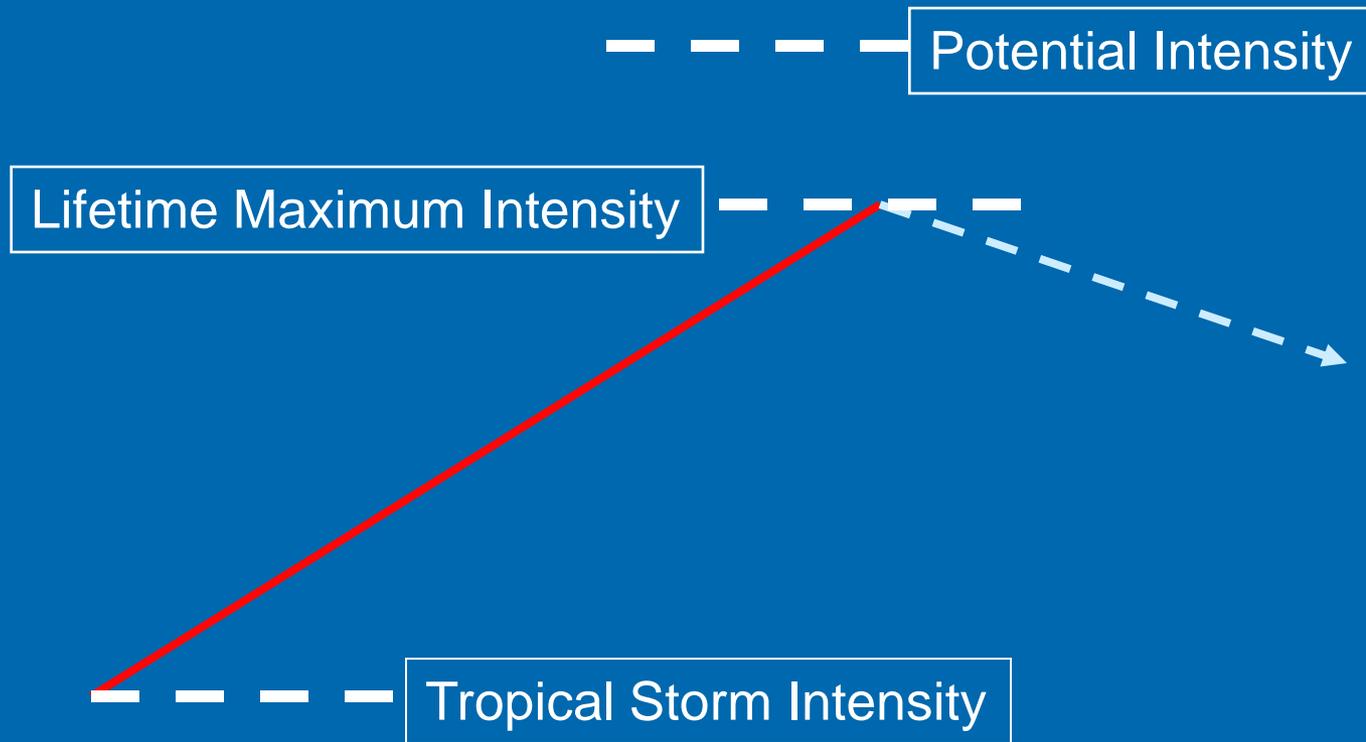
Potential intensity theory is strictly based on local thermodynamics.
How does hurricane track variability contribute to PI variability?



Variability and trend of local storm-ambient conditions



Kossin and Camargo 2009
in review



Three distinct pathways to an intensity trend:

1. trend in PI
2. trend in duration
3. trend in intensification rate

Summary – PI trends

Inclusion of hurricane track variability leads to storm-ambient PI and SST variability that is markedly different than regionally & temporally averaged values.

The observed trends in regionally-averaged climate in the North Atlantic are not found in the more relevant storm-ambient conditions.

Potential intensity theory can not explain the secular trends in measures of “hurricane activity” and no formal theory is in place to understand frequency and track changes.



Summary

- GPI is able to reproduce the modulation of tropical cyclones by ENSO and MJO.
- QBO & TC relationship: not valid any since 1980s.
- PI trends in the Atlantic not as strong, if the ambient PI and not the basin PI is considered.