Exploring relationships between regional climate and Atlantic Hurricanes

Mark R. Jury

Physics Department
University of Puerto Rico - Mayagüez
Mayaguez, PR, 00681

Data employed:

- **hurricane index: 1850-2004 (60-80W,15-35N)**
- **monthly NCEP atmospheric and oceanic variables 1948-2004**

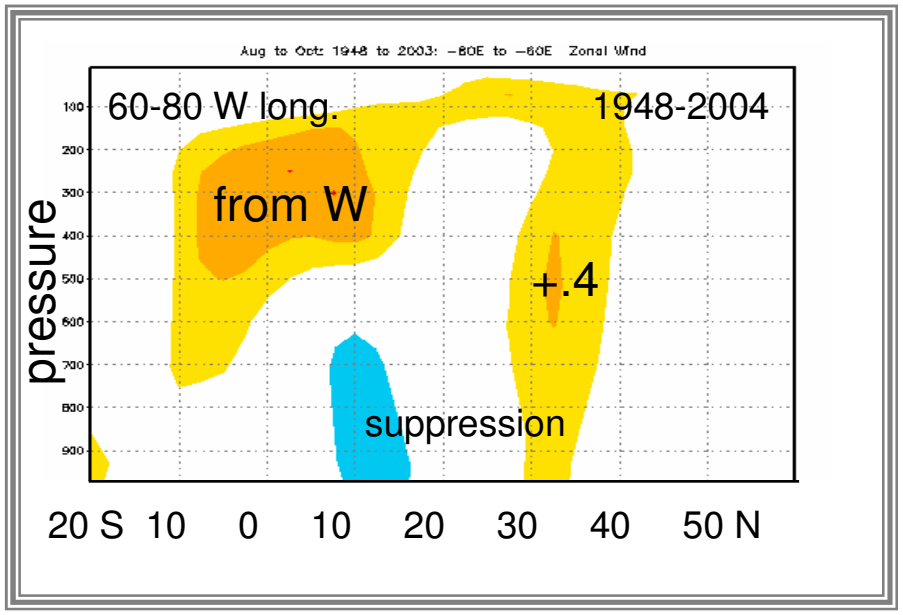
Methods of Analysis:

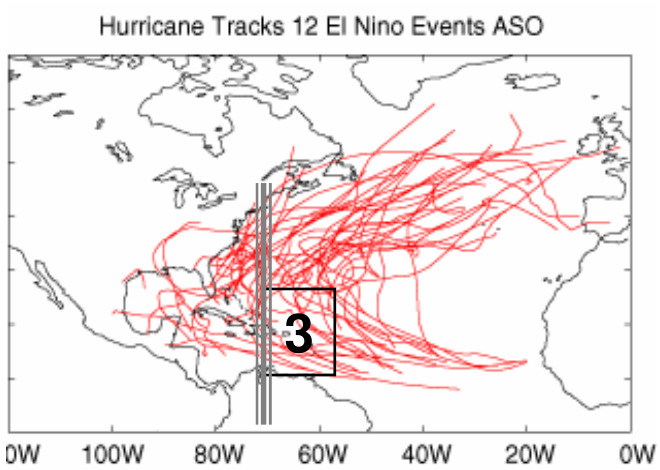
- **wavelet spectrum of 150 yr record**
- **correlation to evaluate regional indices**
- **composite patterns for high and low years (50,55,61,95,04 & 72,77,82,83,94)**
- **hovmoller analysis to study zonal propagation**

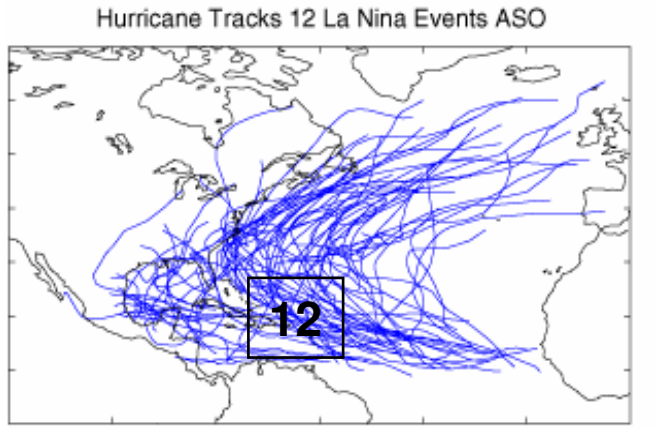
The aim is to find predictable interactions.

Earlier studies have revealed links between Pacific ENSO and Atlantic hurricanes

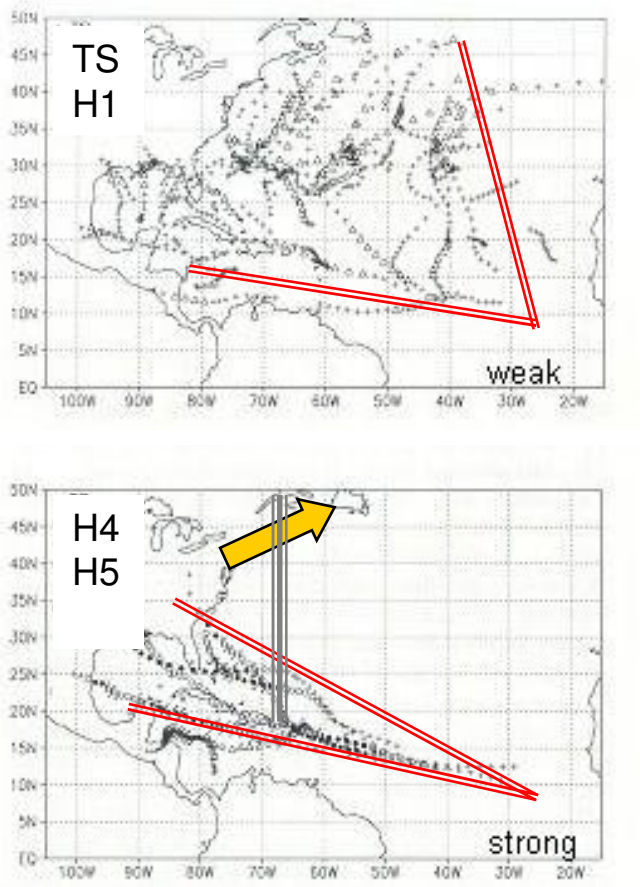
N-S correlation: Nino3 vs zonal wind

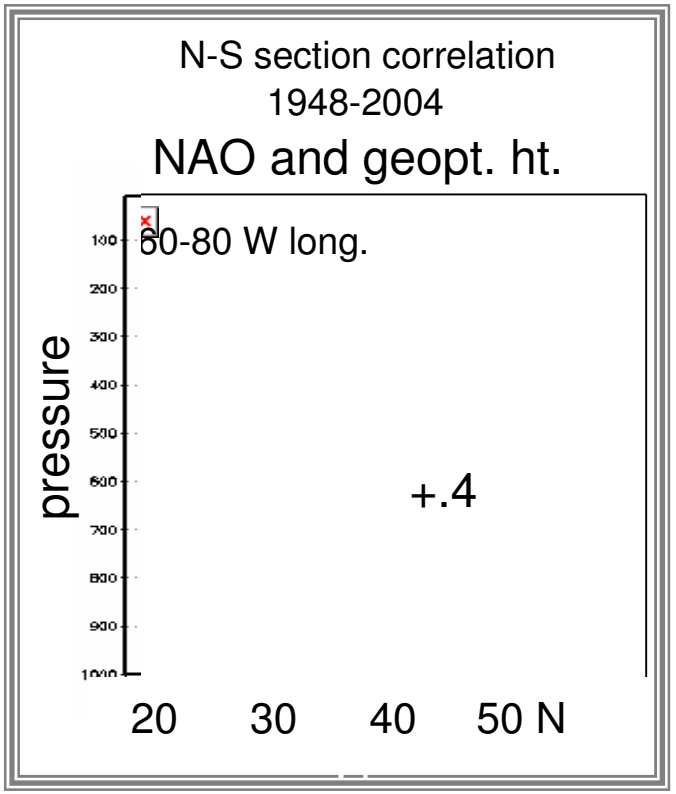






Hurricane tracks are concentrated as intensity increases

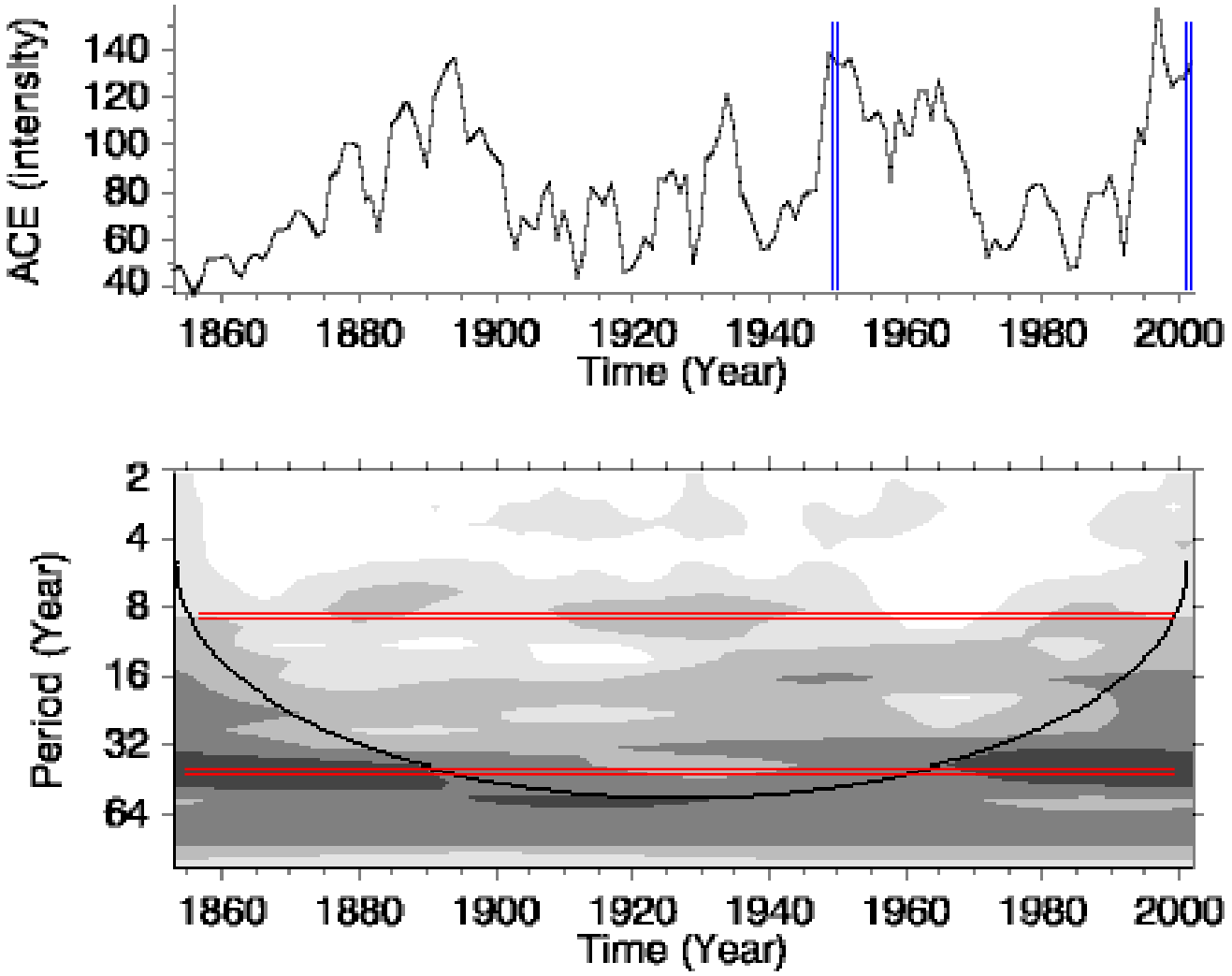




N. Atlantic High strengthens in +NAO phase: deflects the jet stream.

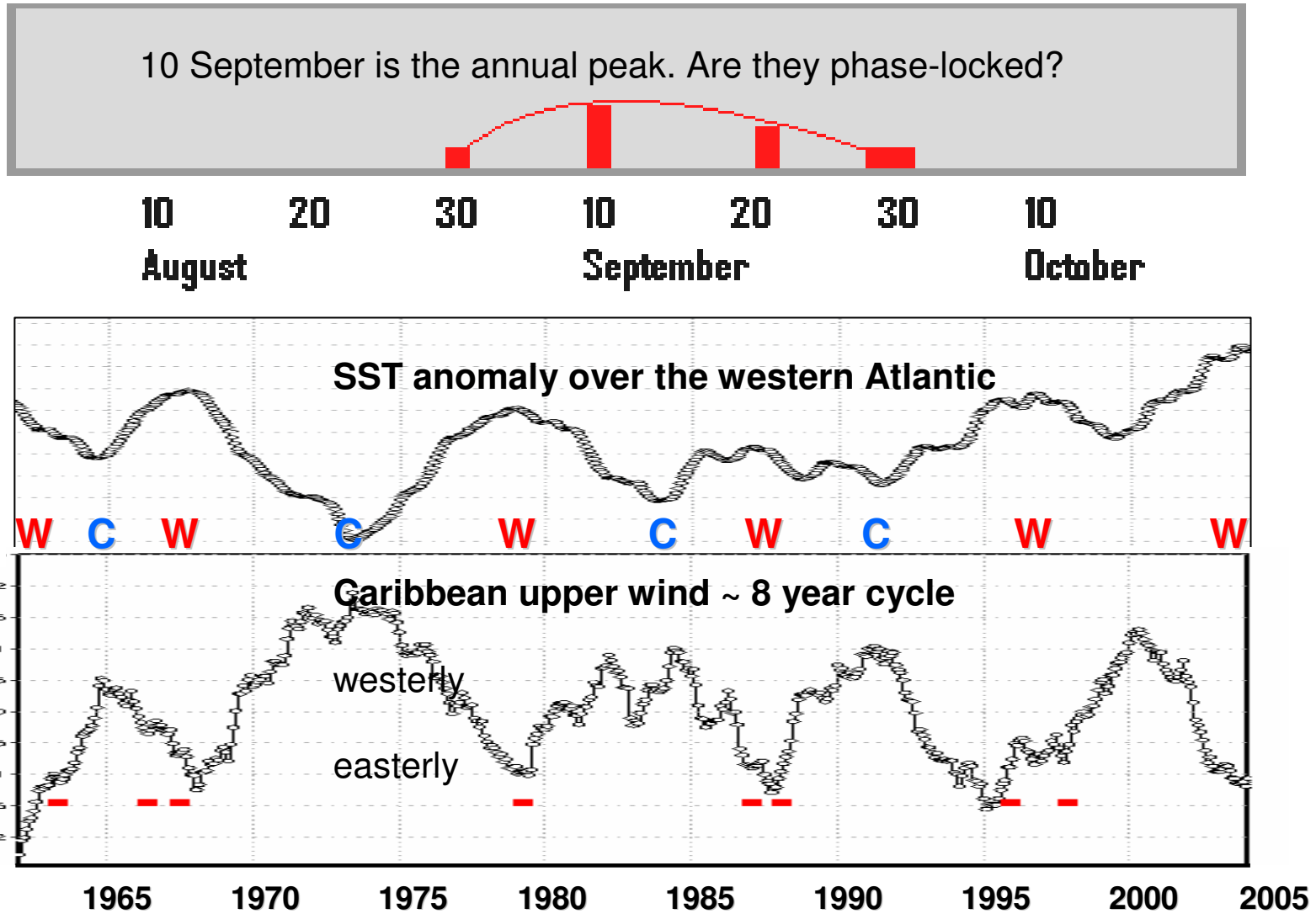
Result : westward tracks for the most intense hurricanes

Wavelet analysis



Wavelet analysis of smoothed hurricane index: 8 and 50 year cycles.

Hurricane cycles and seasonal timing



Correlation of Atlantic hurricanes and climate indices

1948-2004, r ≥ |0.27| : 95%.

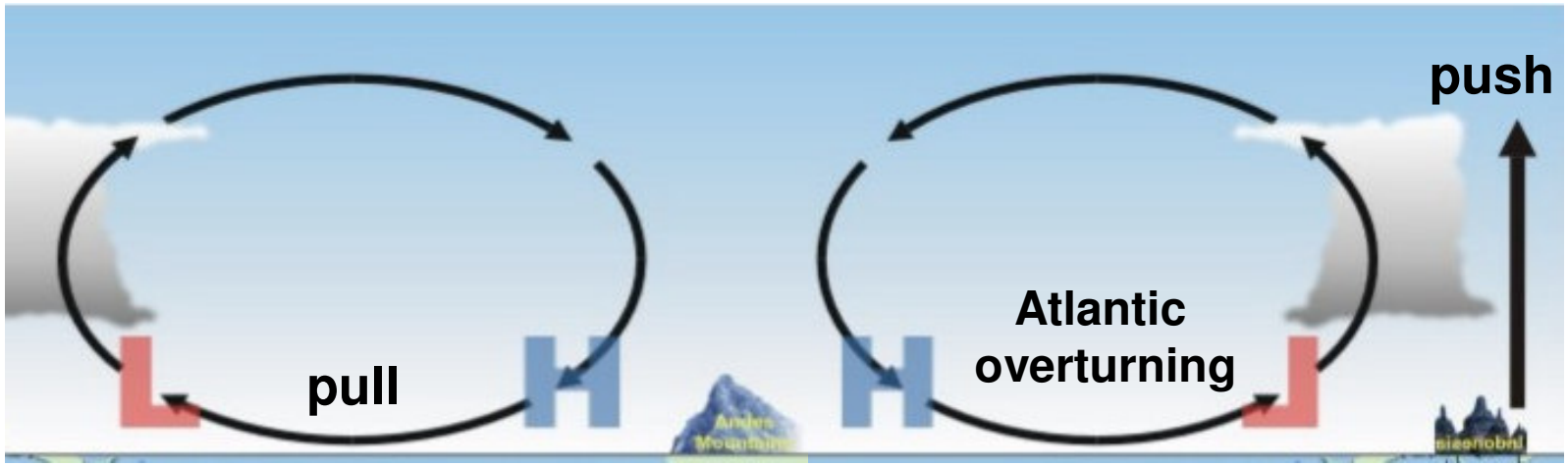
soi	pna	nao	nino3	nino1	wp	qbo	nino4	censo	pdo	npac
0.08	0.06	0.04	**-0.41**	**-0.58**	-0.03	-0.03	0.04	-0.08	-0.03	**0.28**

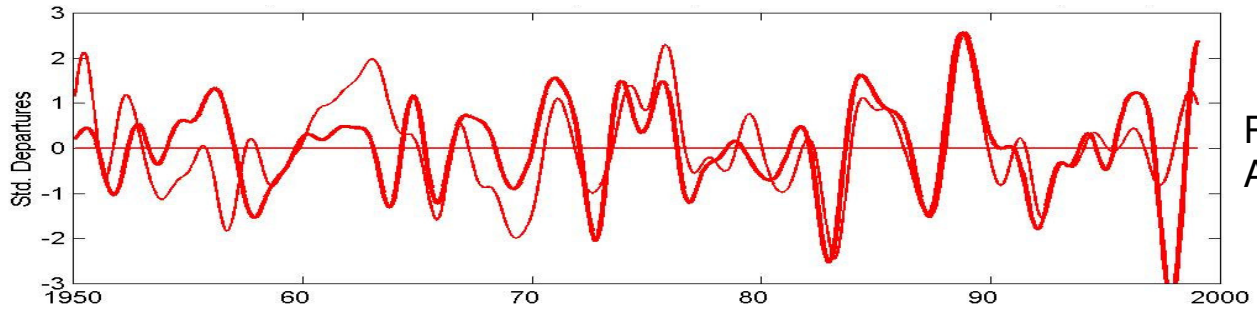
ao	trend	tni	pacw	eofpa	atlt	solar	mjo	indm	sahl	braz
0.04	0.03	-0.07	0.05	-0.07	0.05	-0.01	**-0.27**	**0.50**	-0.01	-0.02

mei	swus	gmst	epo	tnh	amo	noi	esp	aao
-0.07	**0.30**	0.01	0.01	0.01	0.00	0.00	-0.10	-0.04

Six indices are significant:
Pacific SSTs: nino1, nino3 and north.
Indian monsoon rainfall, SW US rainfall,
Madden-Julian Oscillation

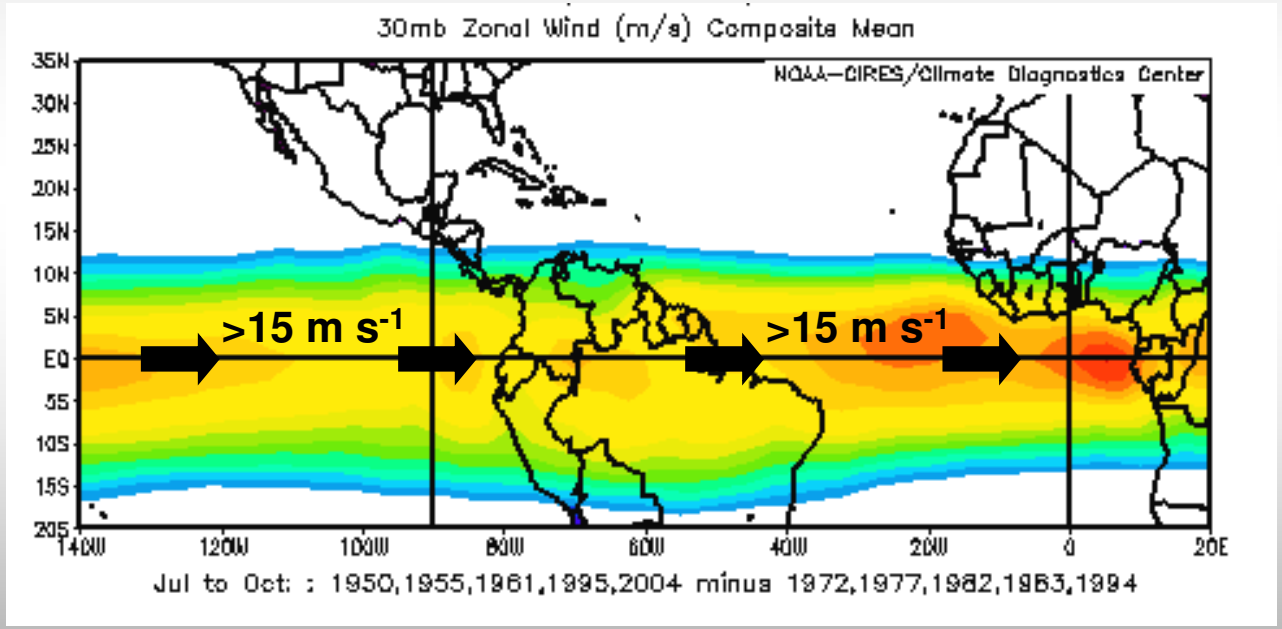
Links between Pacific Ocean and equatorial Atlantic atmosphere





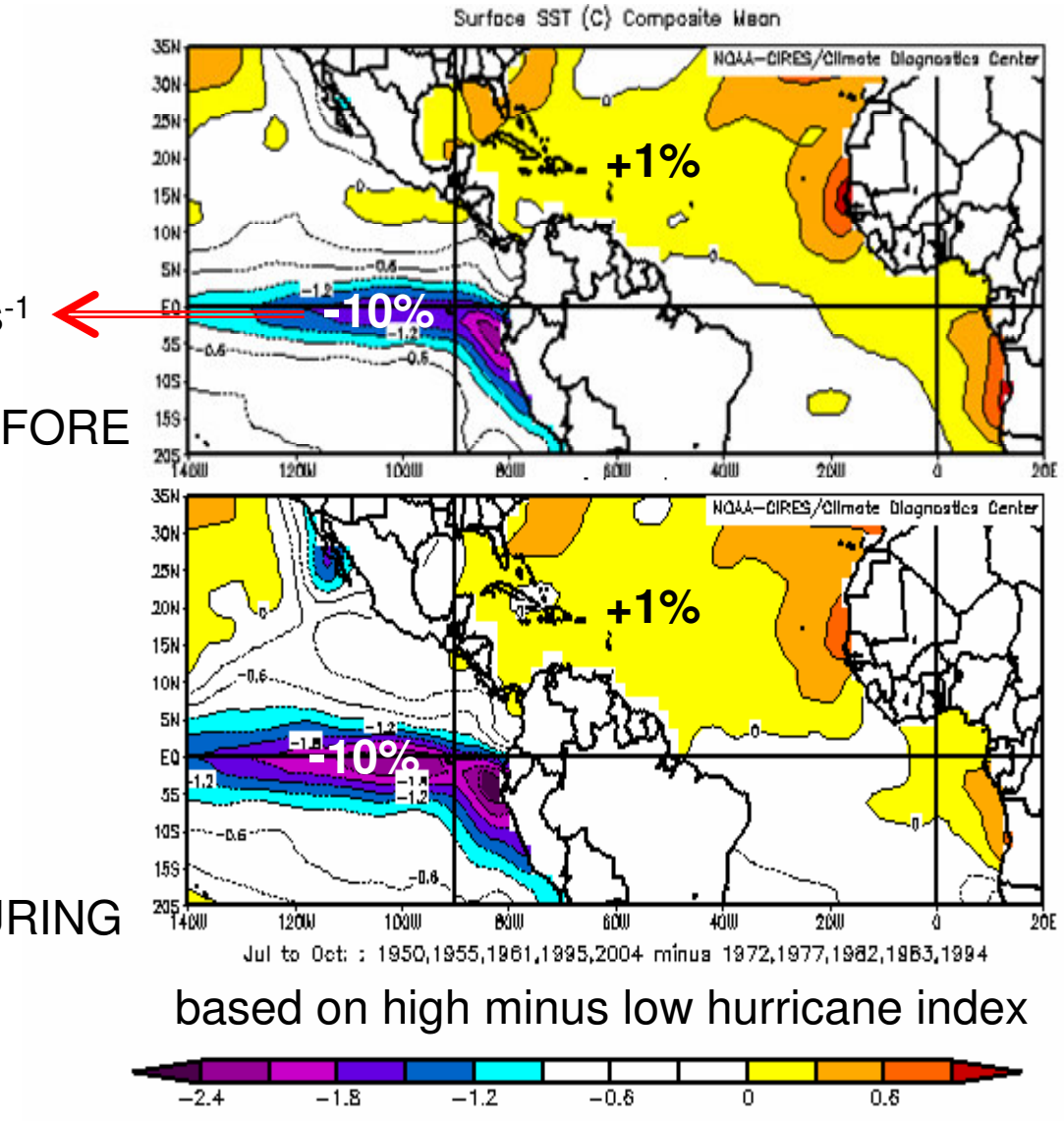
Pacific thermocline – bold
Atlantic zonal wind – thin

Is the ocean-atmosphere coupling transient?
Are changes abrupt or wave-driven?
Which oscillations are relevant to Atlantic hurricanes and which occur naturally?
Is upper level forcing evident?



One signal in the composite analysis : the stratospheric wind

Composite SST pattern favoring Atlantic hurricanes: pre-La Niña



$c = - 0.27 \text{ m s}^{-1}$

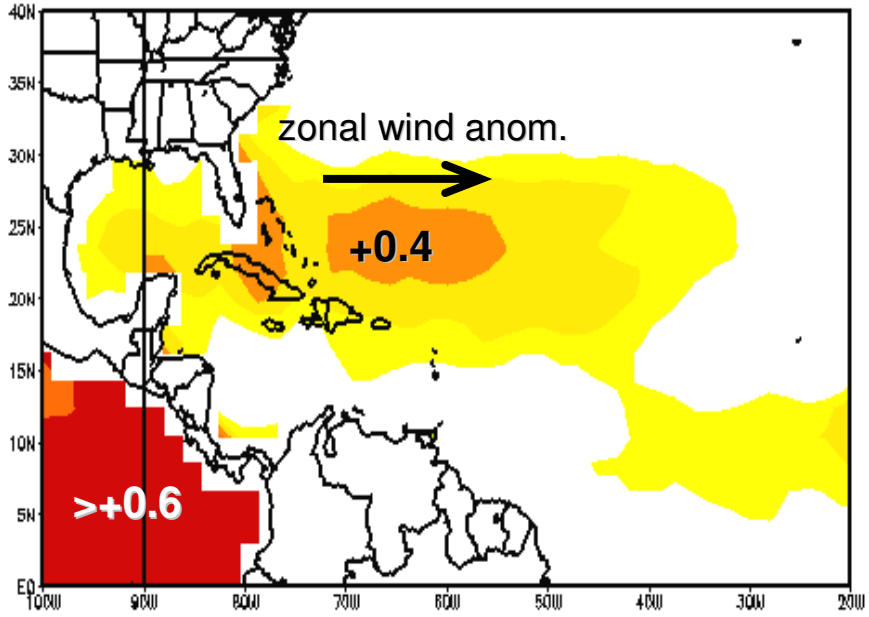
BEFORE

DURING

based on high minus low hurricane index

Usually, a Pacific El Niño causes warming in the tropical North Atlantic through the reduction of trade winds.

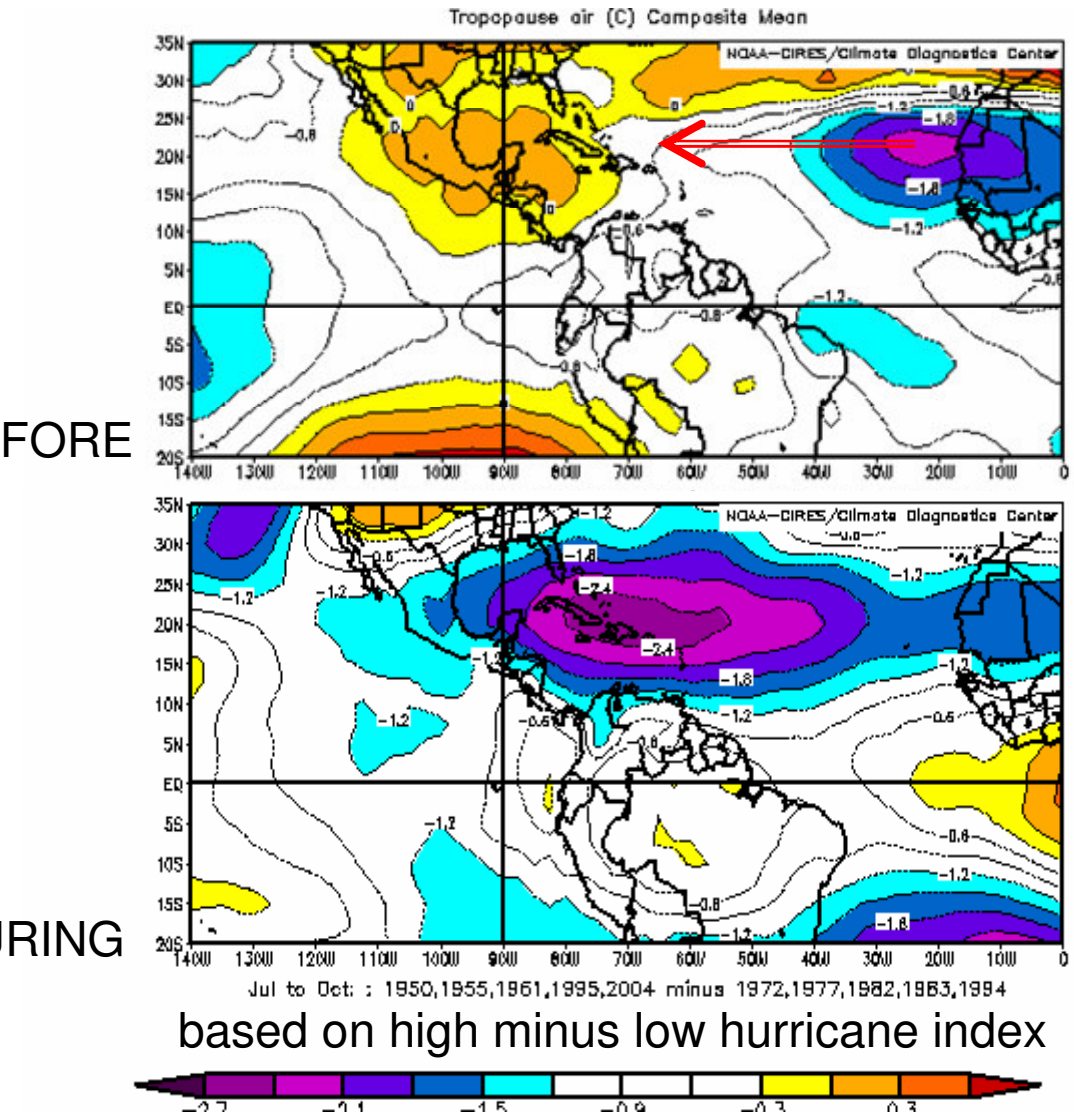
Pacific Niño3 -3 month correlation with SST, 1948-2004, r |0.27| sig. at 95%



Here the hurricane composite SST pattern indicates that Pacific La Niña precedes Atlantic warming

The anti-phase relation is a valuable predictor

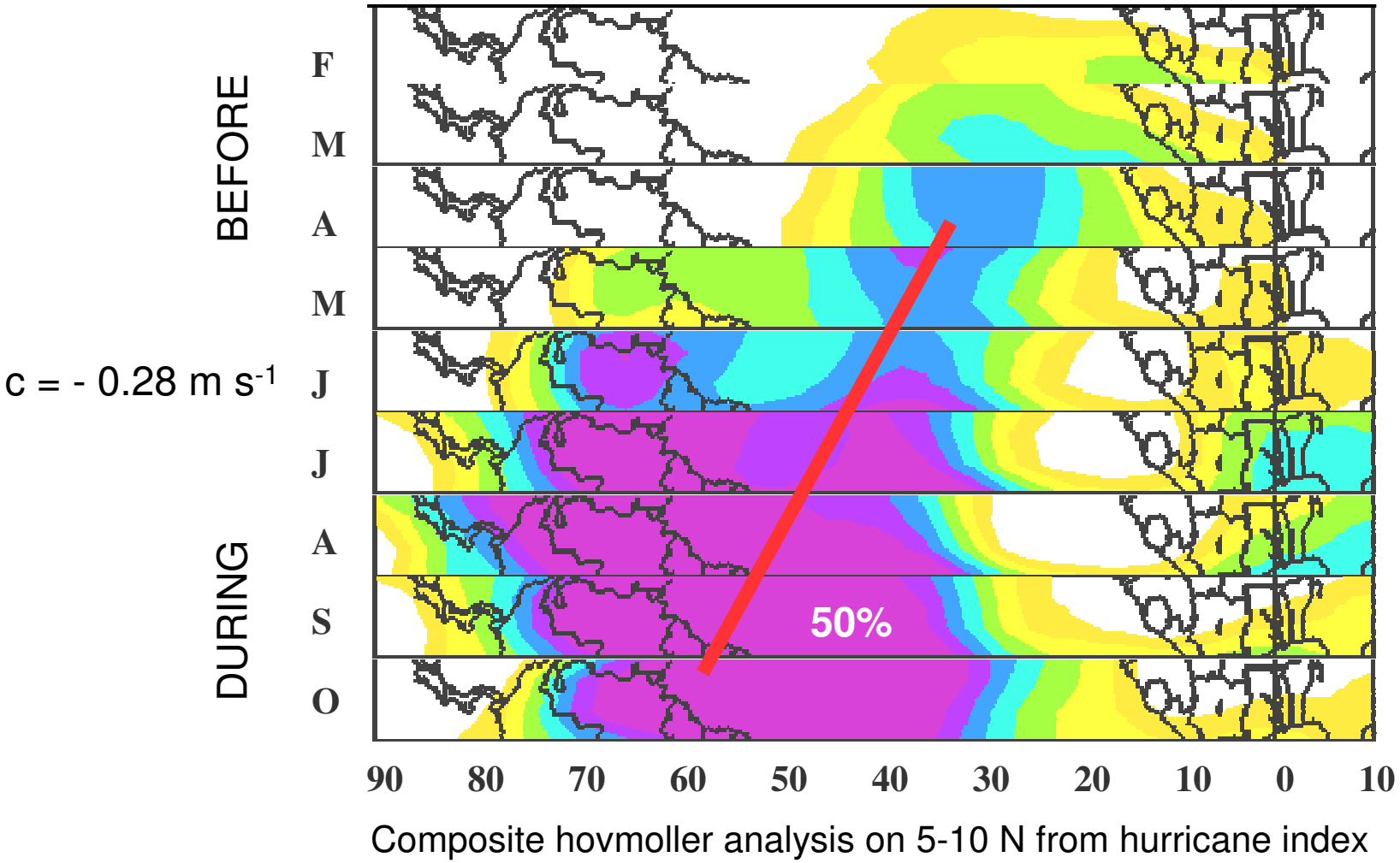
Composite tropopause temperature: westward movement



$c = - 0.26 \text{ m s}^{-1}$

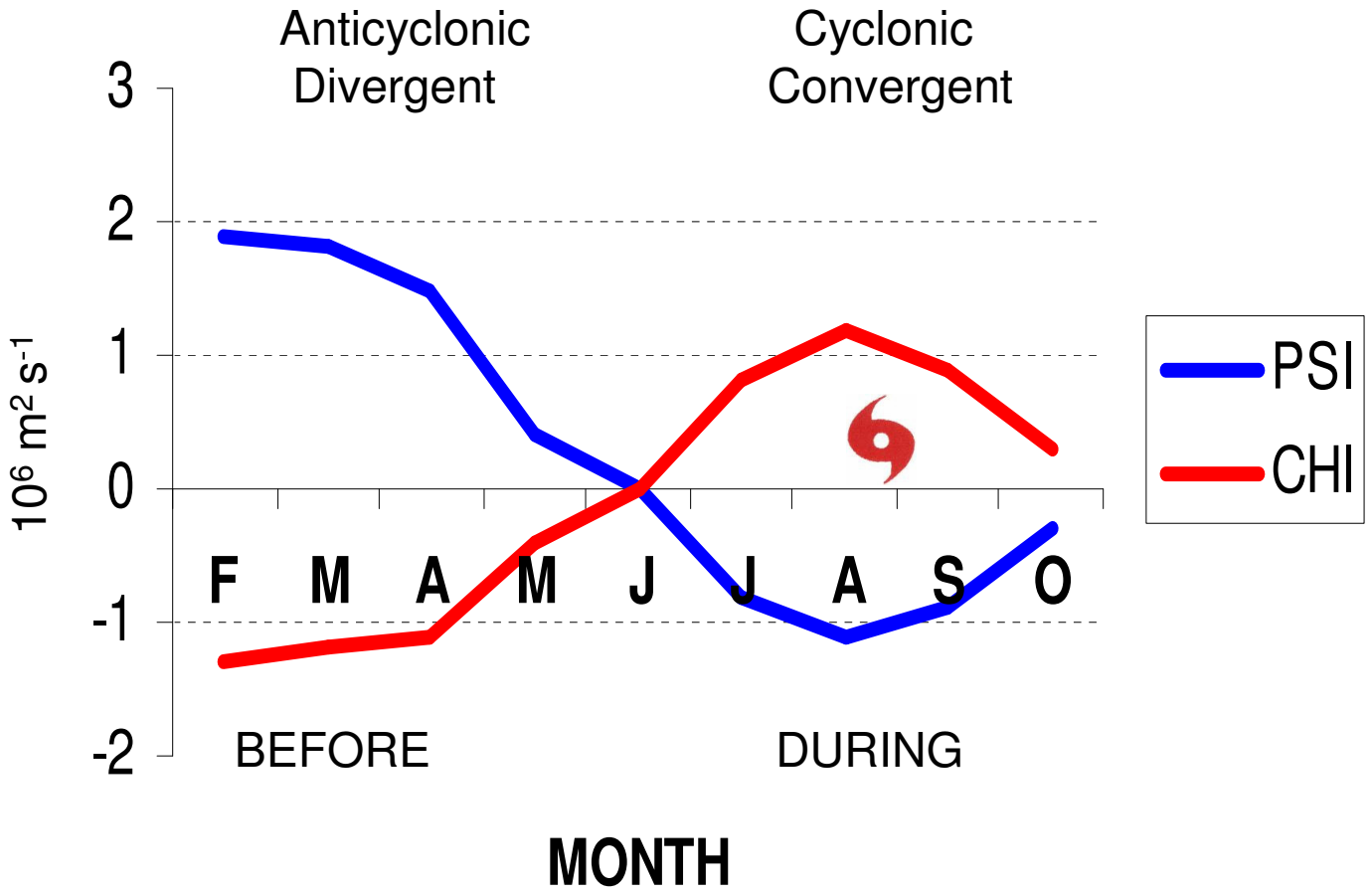
based on high minus low hurricane index

Upper level zonal winds shift across the tropical Atlantic



Composite hovmoller analysis on 5-10 N from hurricane index

Abrupt change of low level circulation northwest of Puerto Rico



Discussion: transient evolution

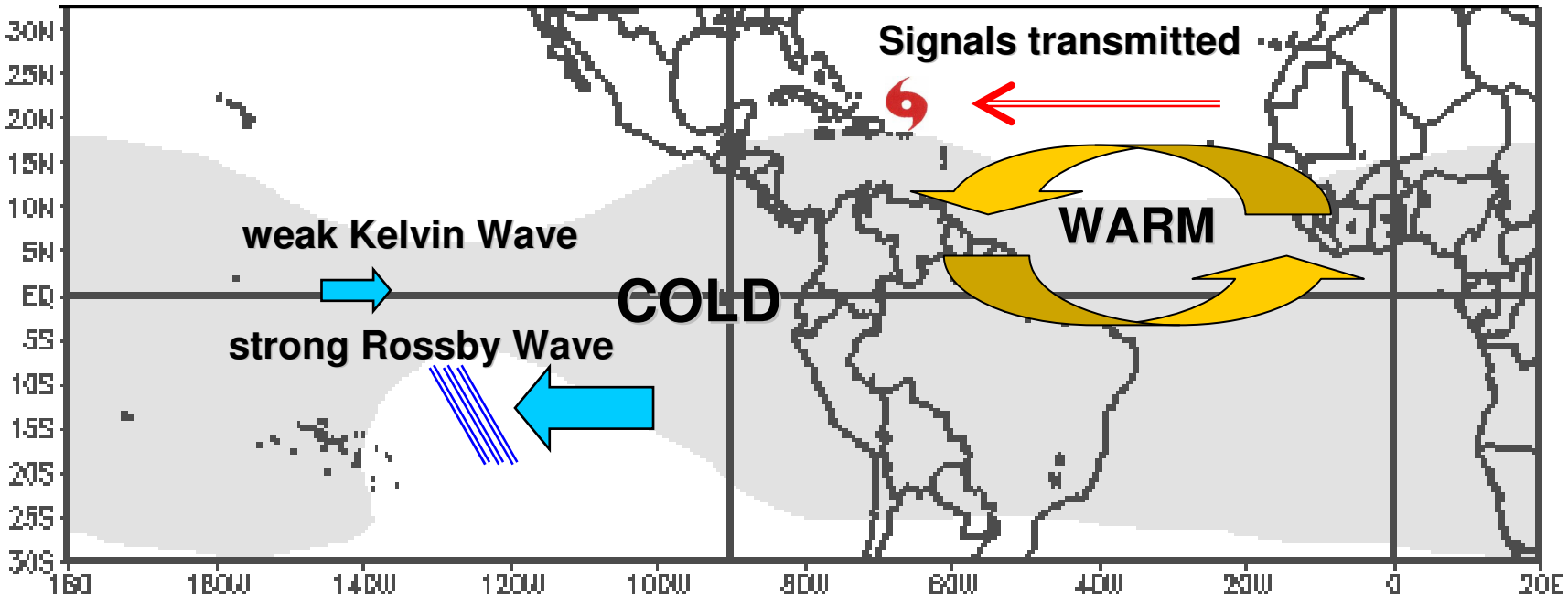
Atlantic hurricanes enhanced by:

- **Anti-phase Atlantic - Pacific SST pattern.**
- **Pacific upwelling and Atlantic upper winds spreading westward prior to La Niña.**

Propagation is consistent with a Pacific ocean Rossby wave:

$$c = \beta g' H / f^2 = -0.27 \text{ m s}^{-1}$$ **uncoupled, at 10˚S**

Conceptual model of Pacific – Atlantic interaction



Westward spreading ENSO and Atlantic circulation

Discussion: predictor signals

Hurricane region SST and SLP change only 1%
East Pacific and West Africa SST change 10% Upwelling Regions

Tropical Atlantic tropospheric and stratospheric wind change 50%
Hurricane region low level Ψ and *X* change 100% from Feb ↓ to Aug ↑

Using this knowledge a group of predictors were assembled, keeping in mind the need to limit co-linearity and artificial skill

Ensuring the training period is 3 x greater than the number of candidate predictors

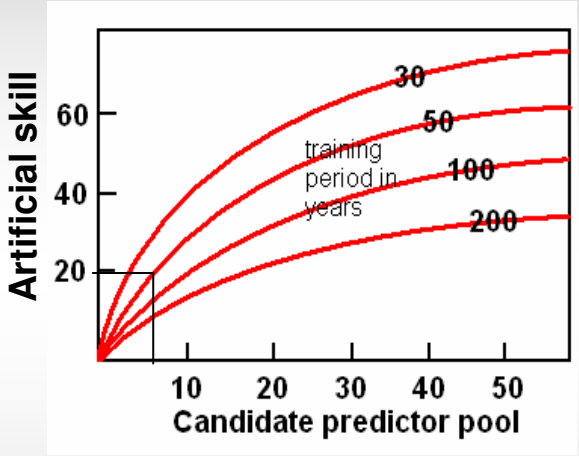
The predictors: NAO, QBO, Au2, a-pSLP, a-pSST where a=Atlantic
Preceding March-April-May p=Pacific

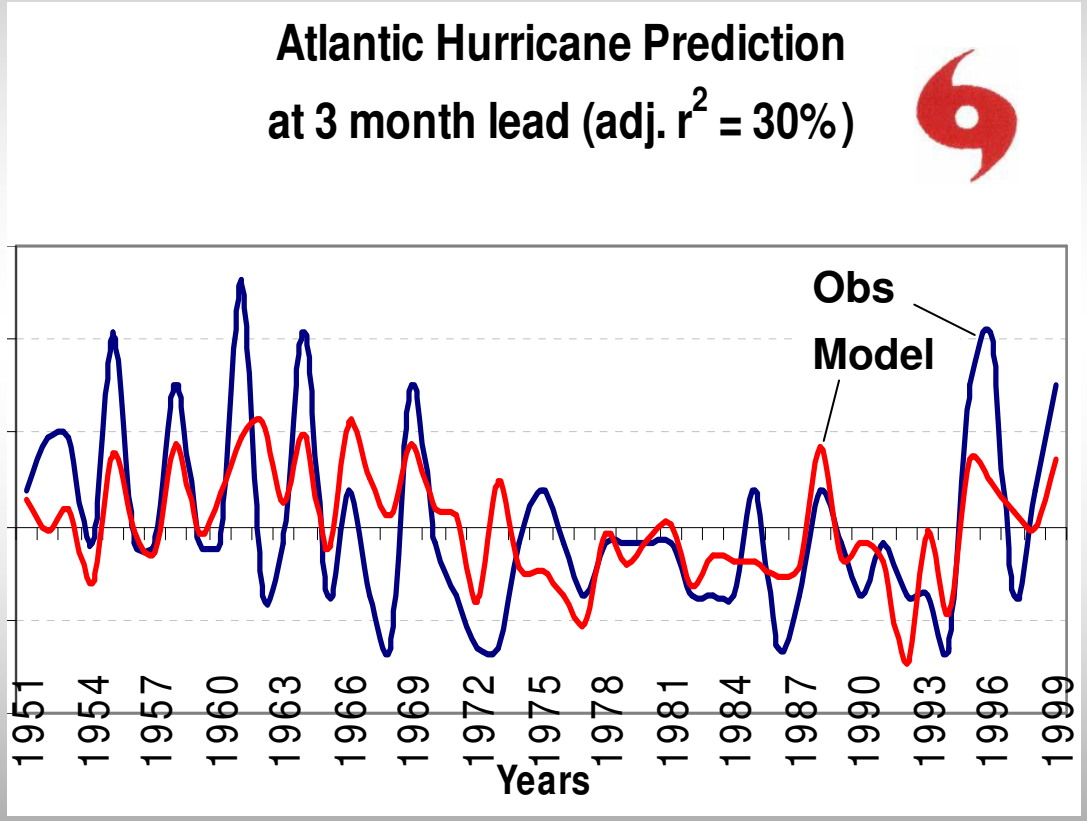
The targets: #Hur1-5, #Hur3-5, ACE

Multi-variate step-wise regression is performed…

Model outcome:

+.3(QBO)+.3(a-pSST) = #Hur3-5





Preliminary findings are useful, further research is needed!