ENSO Multiplicity and Regime Sensitivity

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DOE Project: ASSESSING ENSO REGIME CHANGES IN A CHANGING CLIMATE

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11/9/2011

(i)Two Types of El Niño

2009

2006

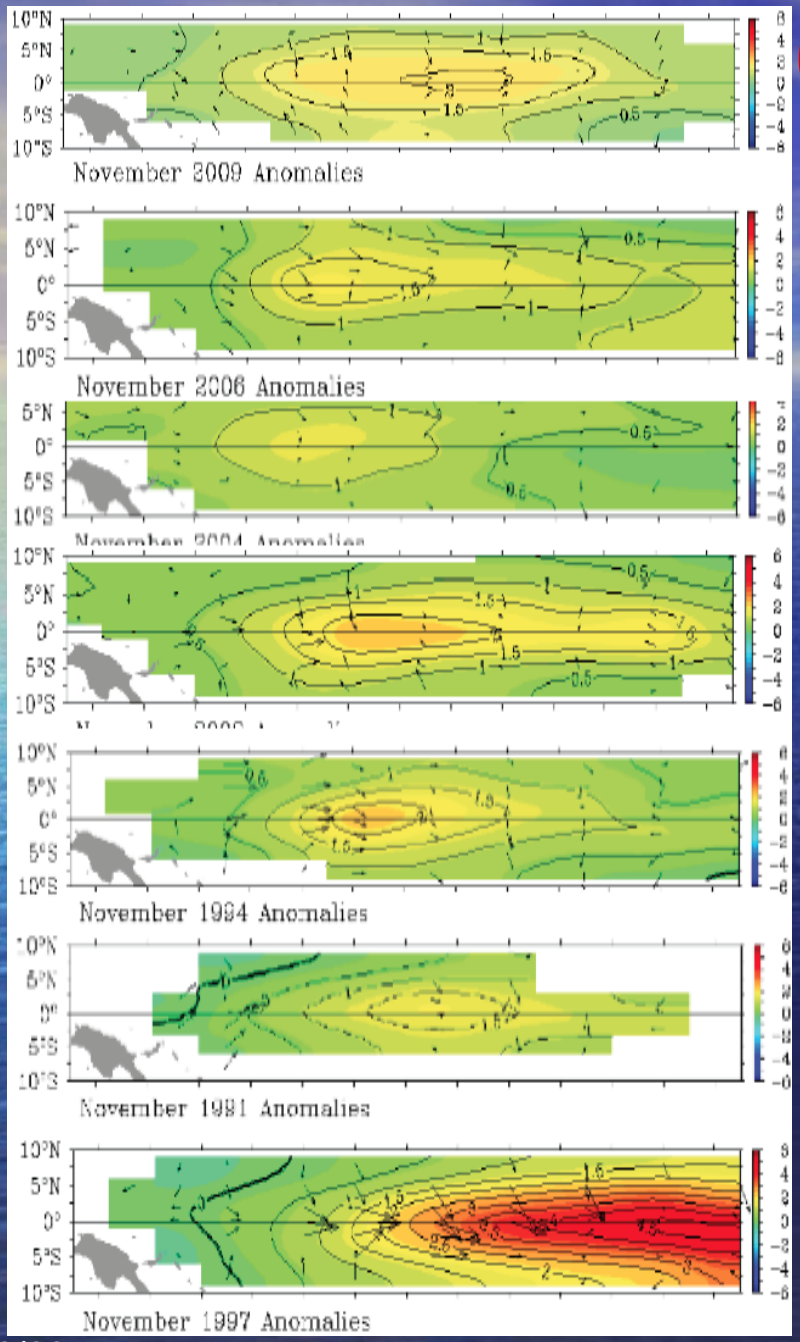
2004

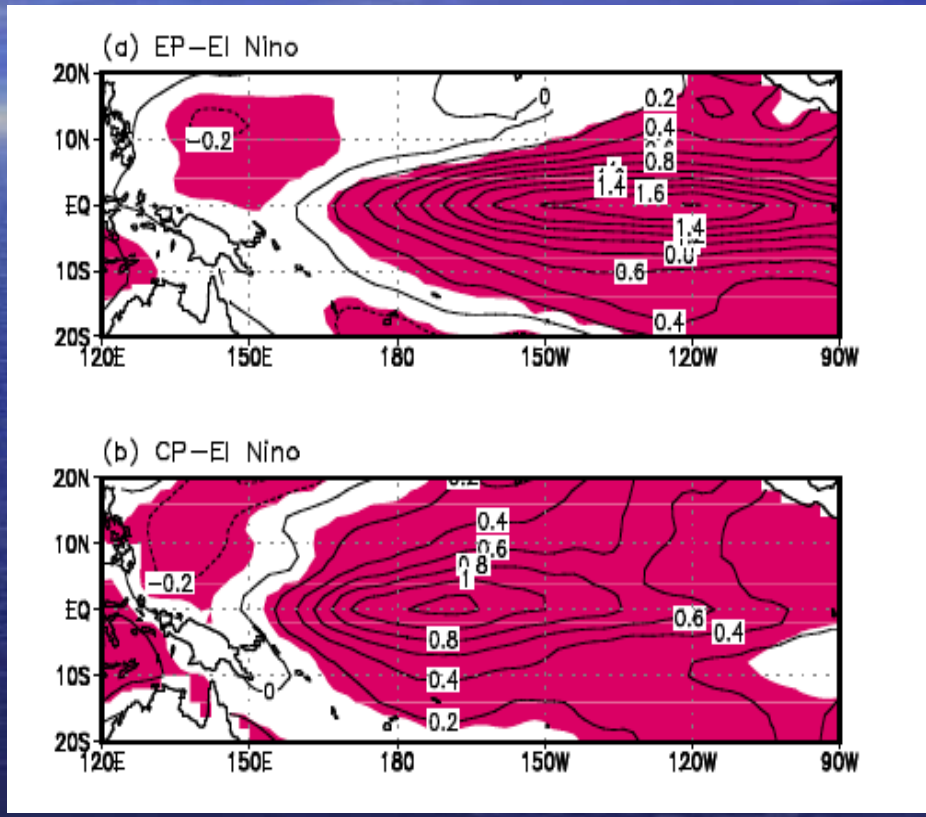
2002

1994

1991

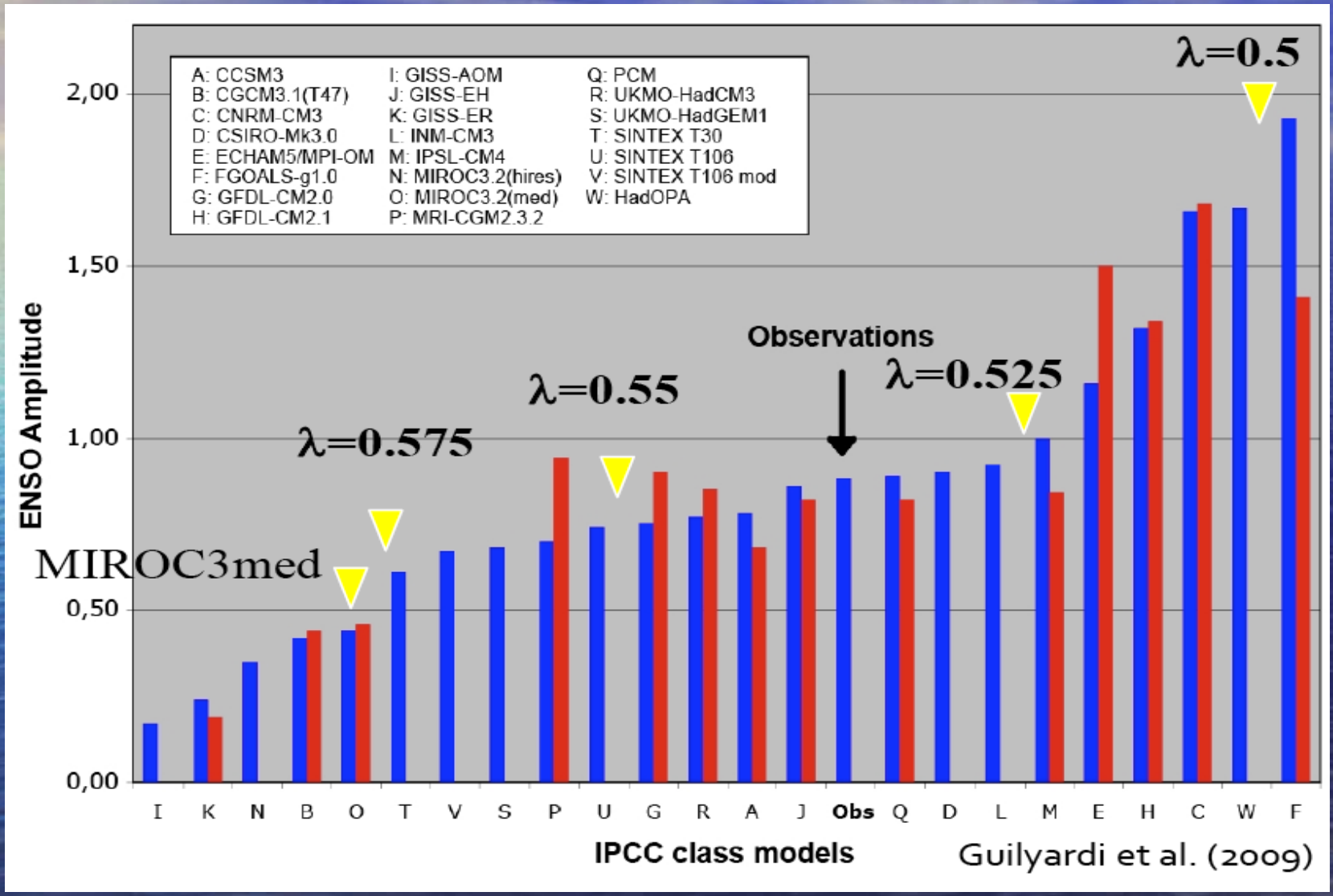
1997





Yeh et al (2009)

(ii) ENSO Amplitude

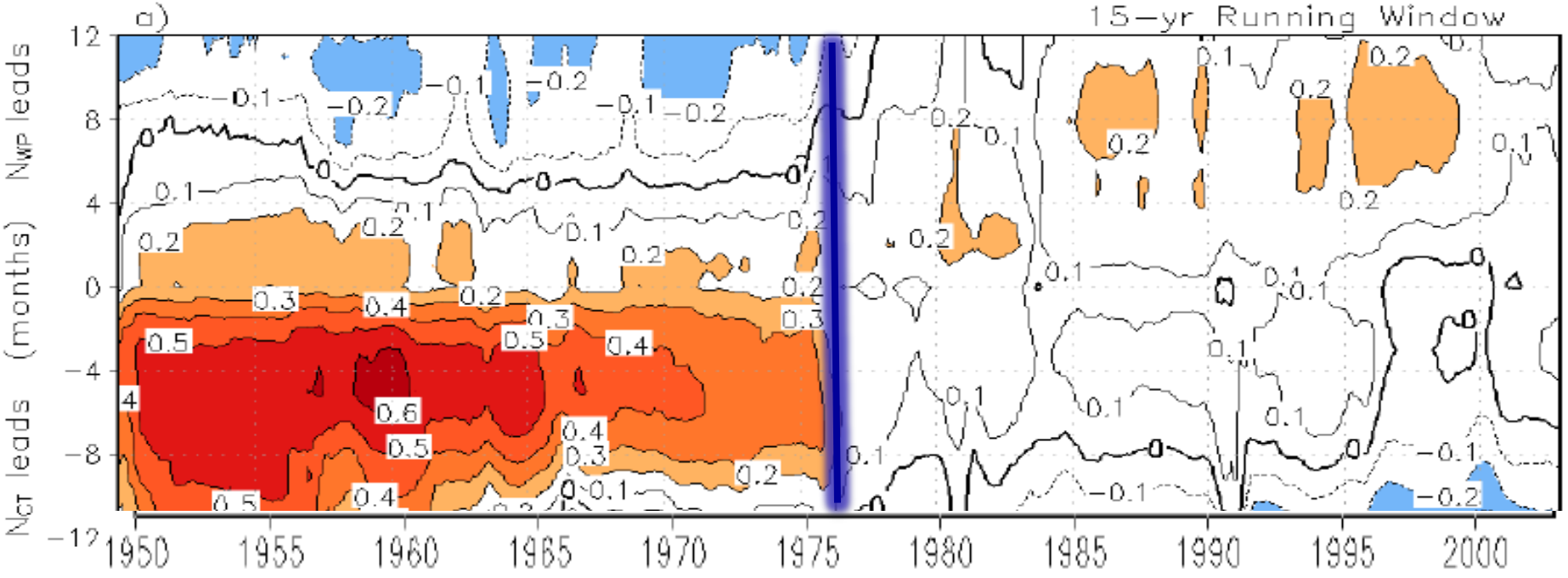


i) Multiplicity of ENSO: Two types of El Niño and ENSO Regime Change in terms of Patterns

WP and CT ENSO Indices (Ren and Jin 2010)

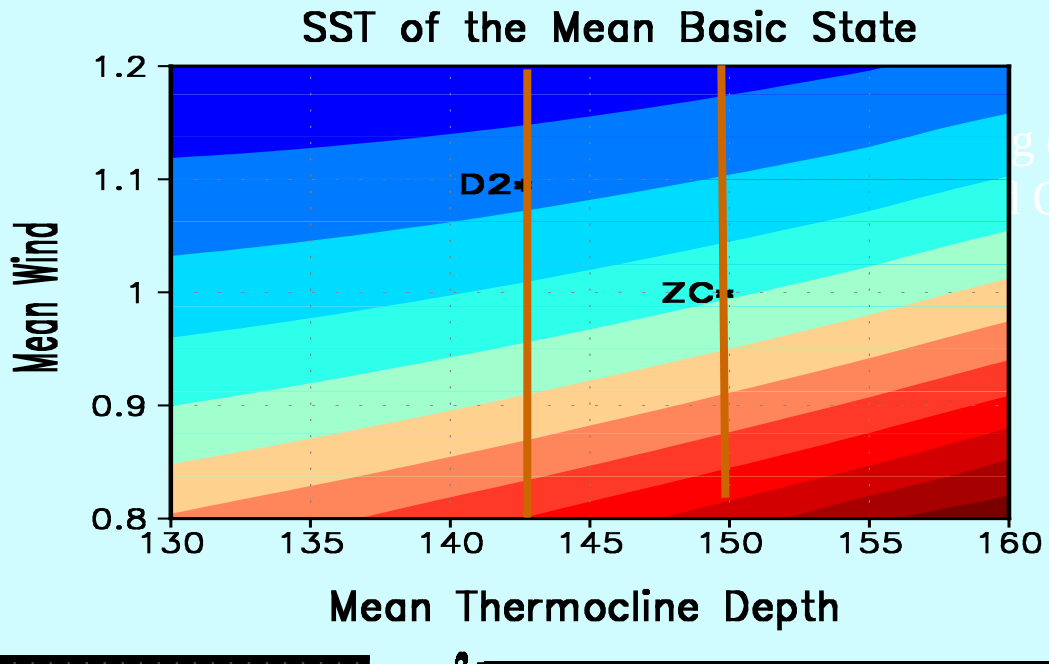
$$\begin{cases} N_{CT} = N_3 - \alpha N_4 \\ N_{WP} = N_4 - \alpha N_3, \end{cases} \qquad \alpha = \begin{cases} 2/5, & N_3 N_4 > 0 \\ 0, & \text{otherwise.} \end{cases}$$

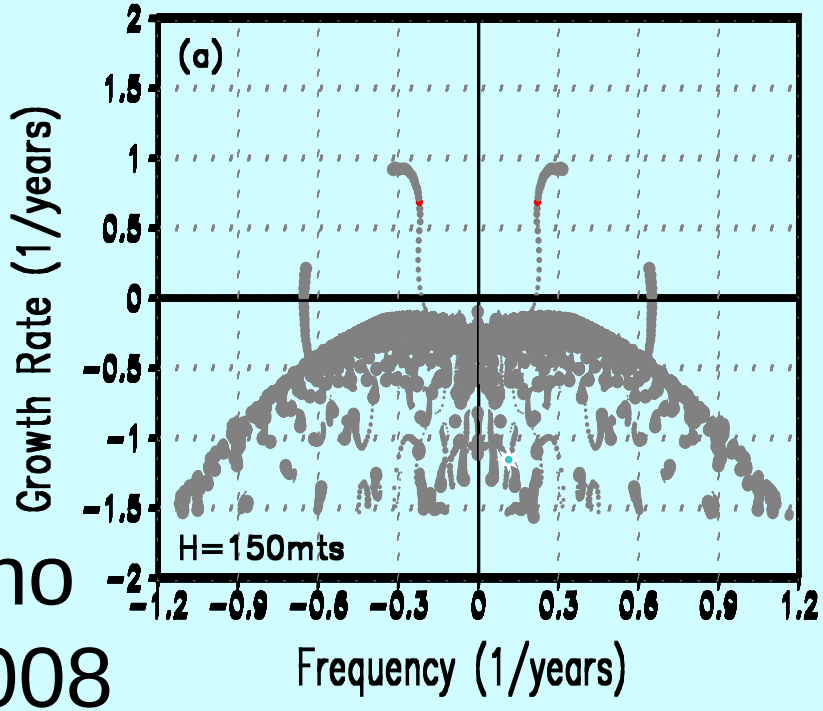
ENSO Regime Change

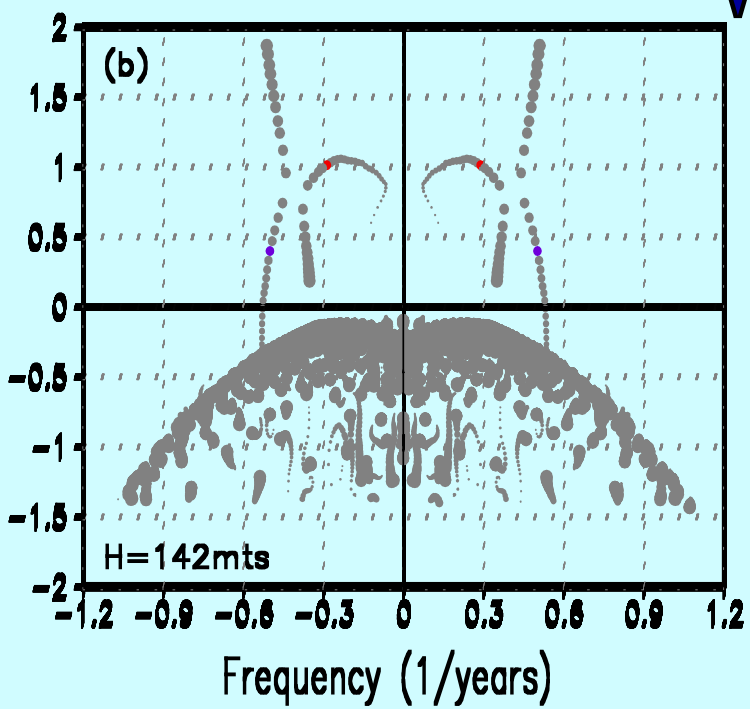


(i) 76 Climate mean state shift. (ii) ENSO regime change

Eigen-modes in ZC model under different different climate conditions

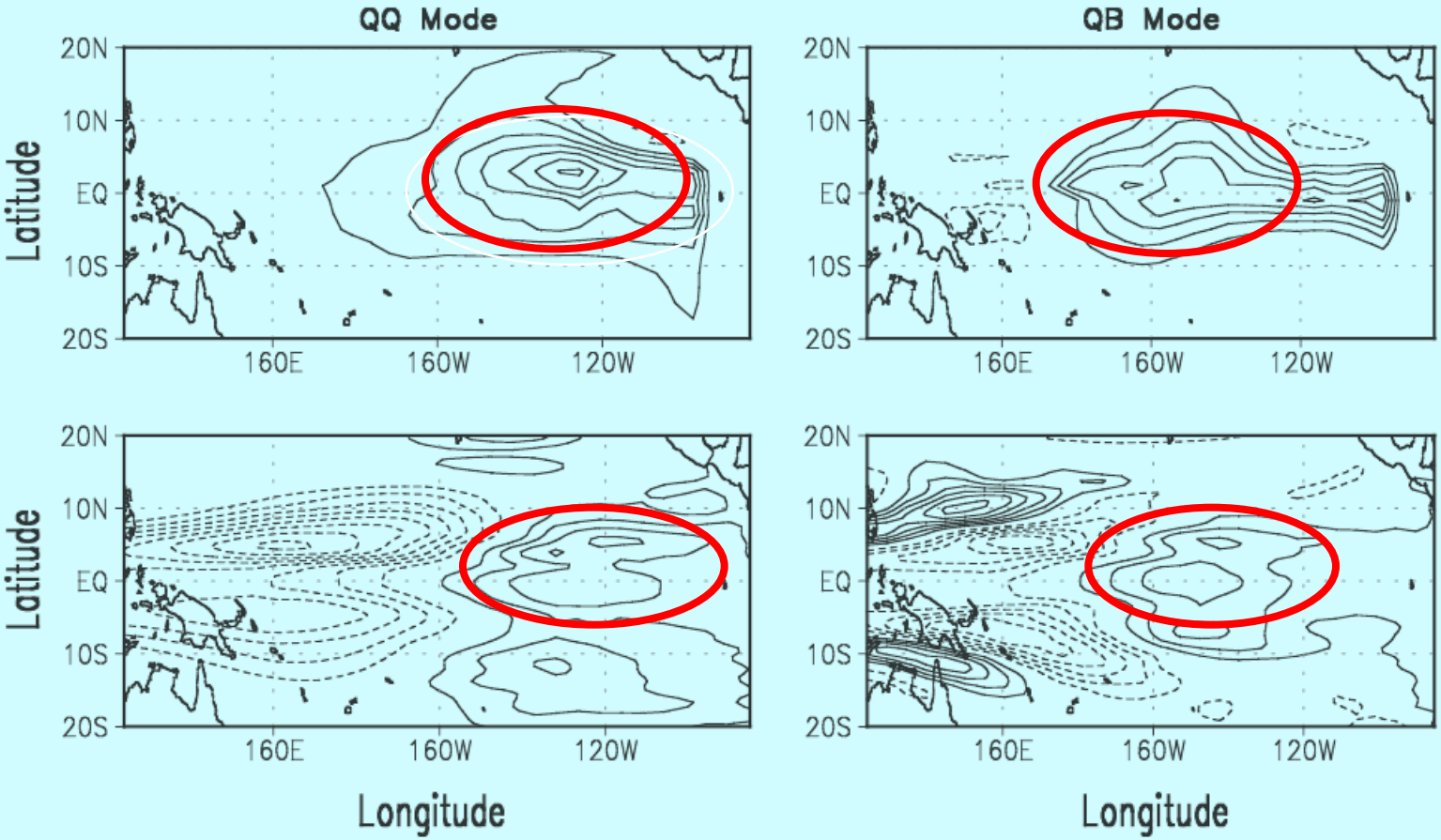




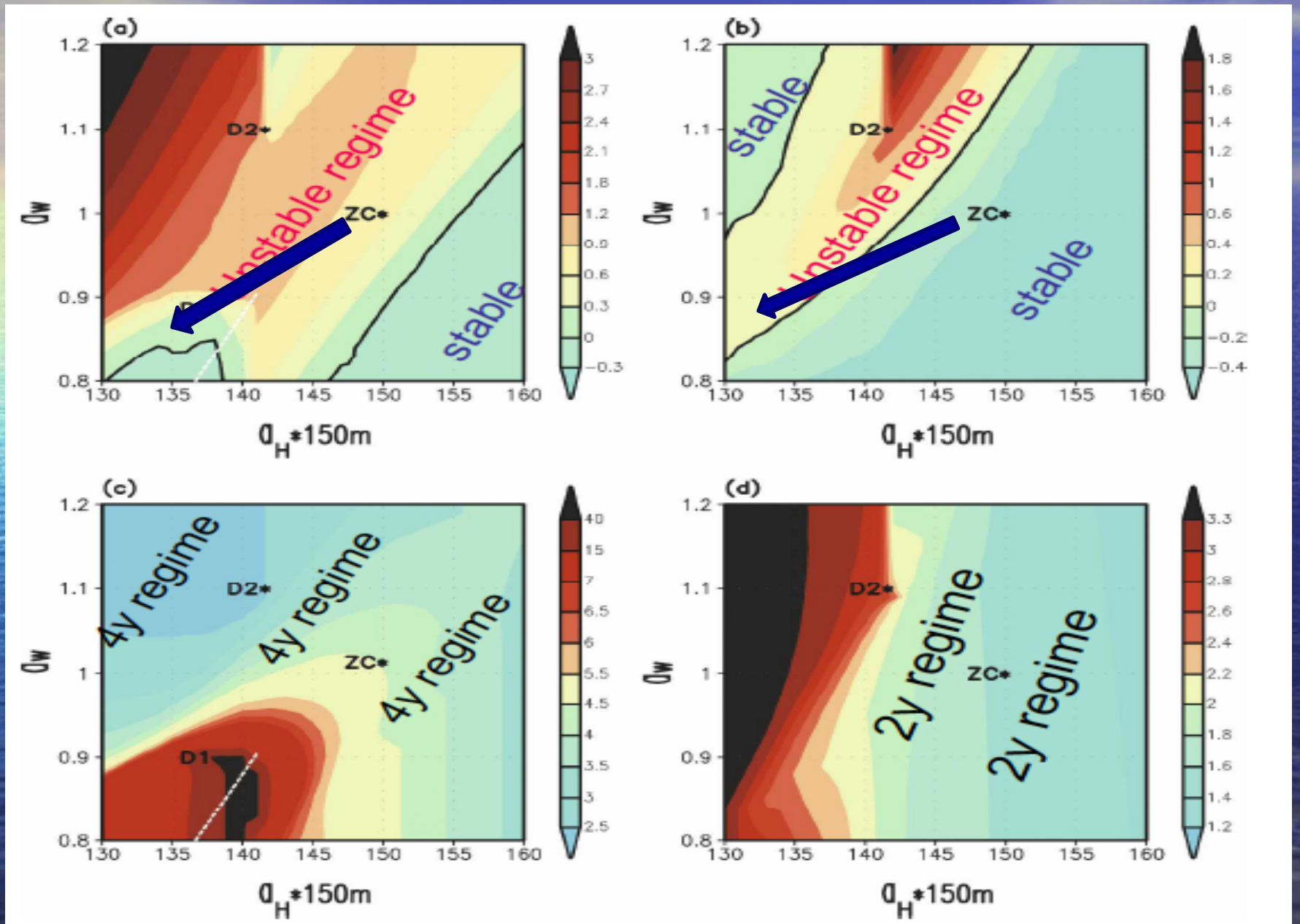


Bejarano &Jin 2008

CT- and WP ENSO like Eigen-vectors



Regimes for CT-ENSO-like and CT-ENSO-like modes



(ii) ENSO Amplitude Sensitivity Near Criticality

Near criticality, ENSO amplitude depends on 3 factors: linear growth rate, noise forcing, and nonlinearity:

$$\lambda A^2 - eA^4 = -\sigma^2$$

A : *ENSO amplitude*

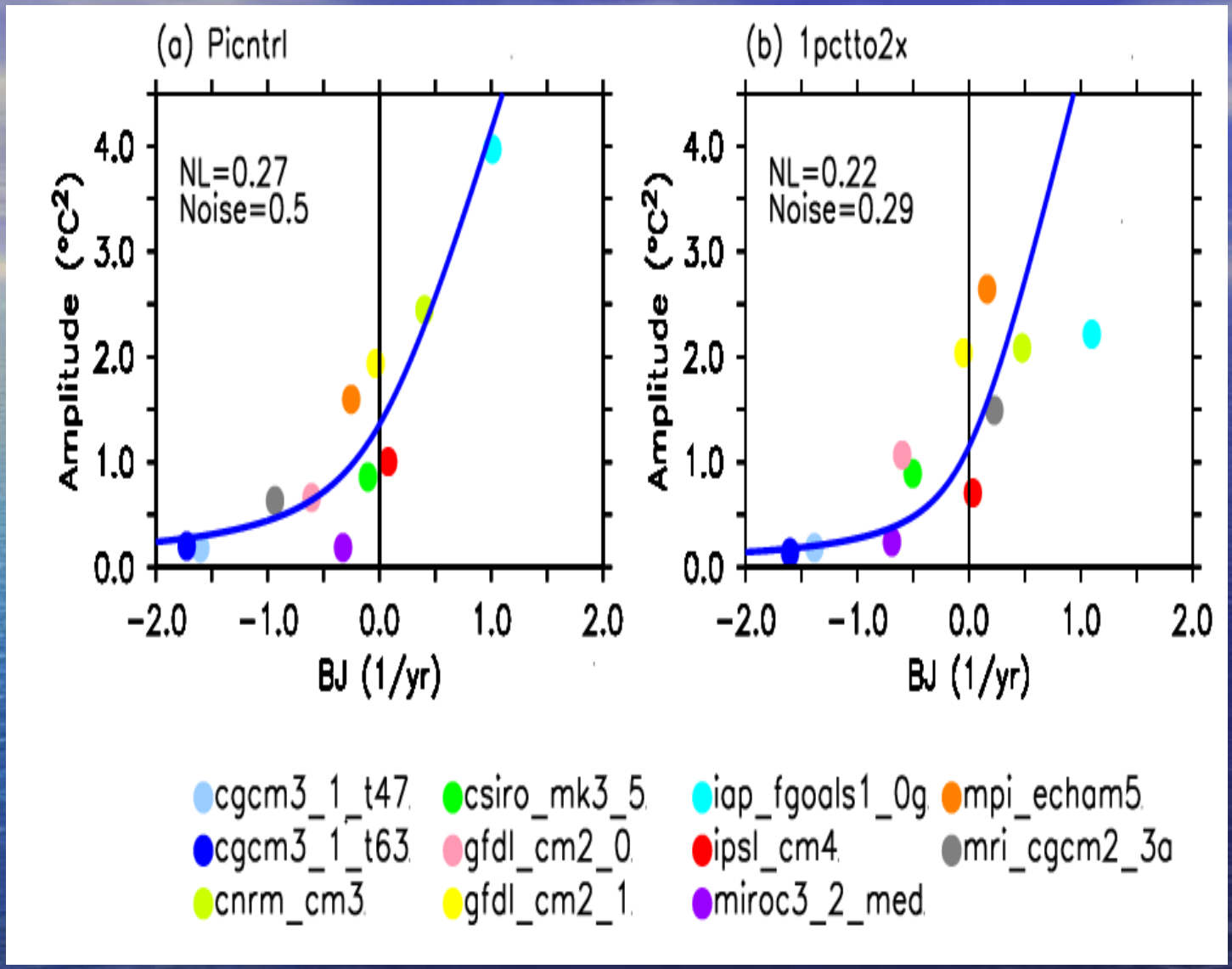
λ : *ENSO growth rate*

σ^2 : *Variance of Noise forcing*

e : *Effect of nonlinearity*

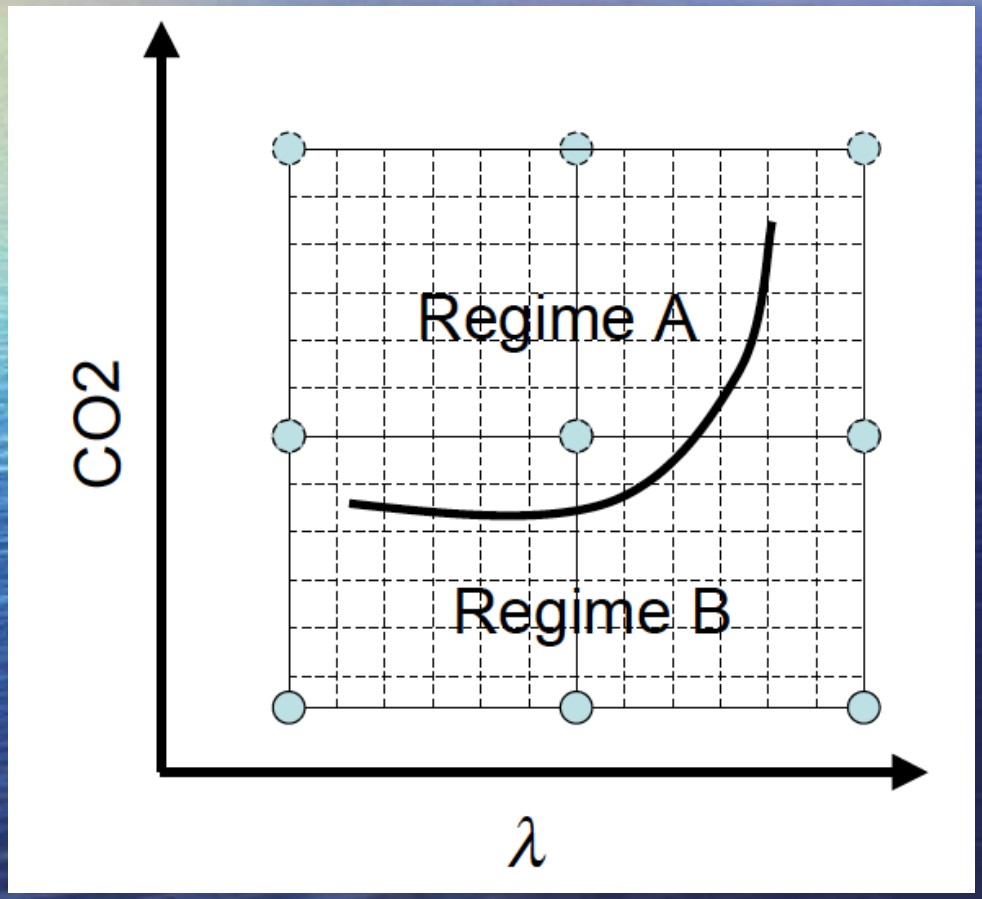
or

$$A^2 = (\lambda + \sqrt{\lambda^2 + 4e\sigma^2}) / 2e$$



The blue curves represent nonlinear fits following the theoretical formula for ENSO variance as the function of the BJ indexes.

Work in progress: Assessing the potential changes in ENSO Regime and/or criticality due to GW



(1) Developing a simpler diagnostic method for estimating ENSO growth rates and frequency from CGCM outputs.

(2) Analyzing the runs from NCAR and GFDL runs and arrays of runs with these models in 2-parameter space.

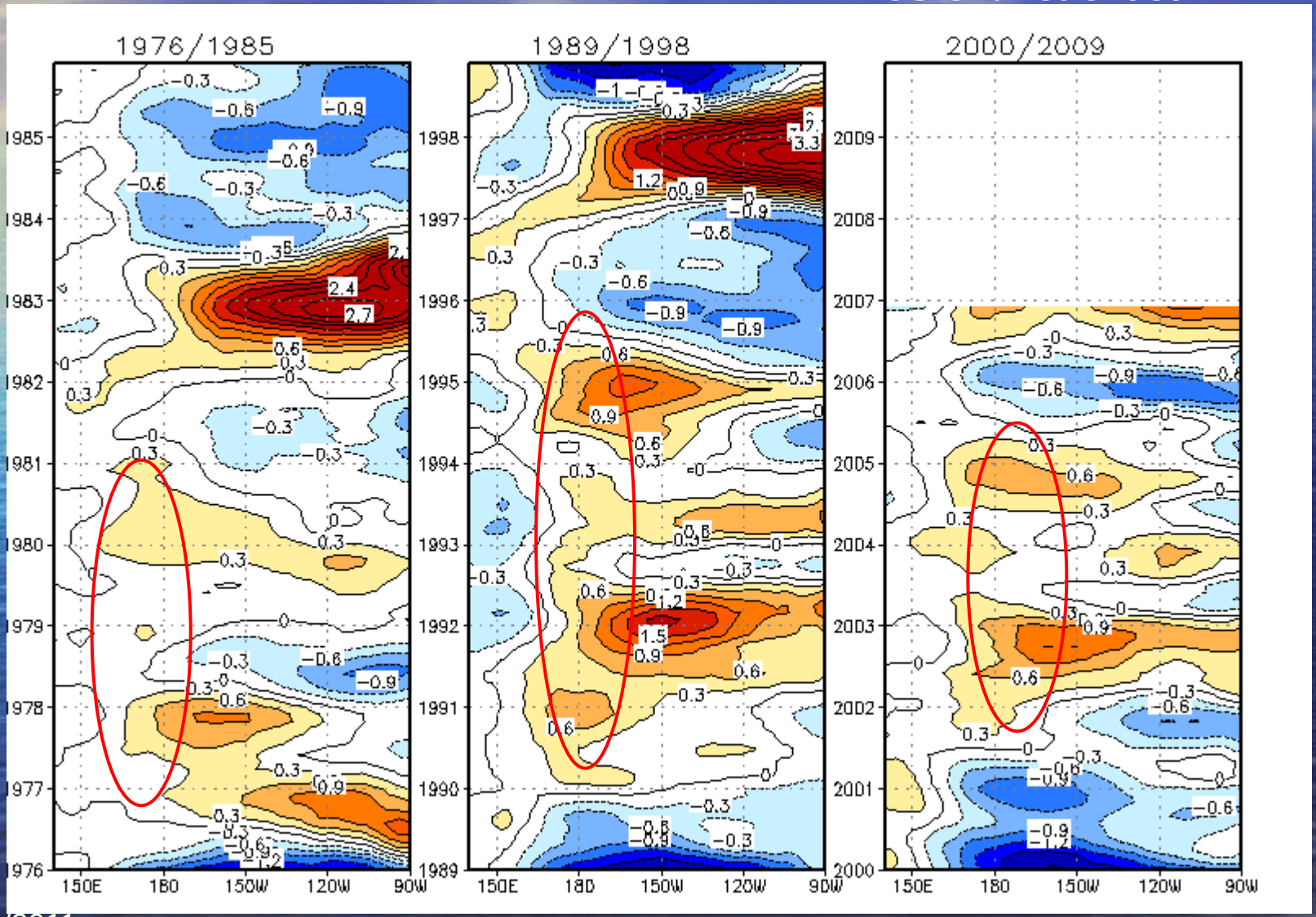
Summary

- Current climate state supports ENSO multiplicity, thus the co-existences of two-type ENSO modes. This ENSO regime is sensitively to relatively small changes in climate mean state.
- Current climate state supports ENSO whose stability is near criticality. Thus ENSO amplitude is sensitive to small changes of climate state as well.
- Interaction of two types of ENSO may lead to large internal ENSO modulation.

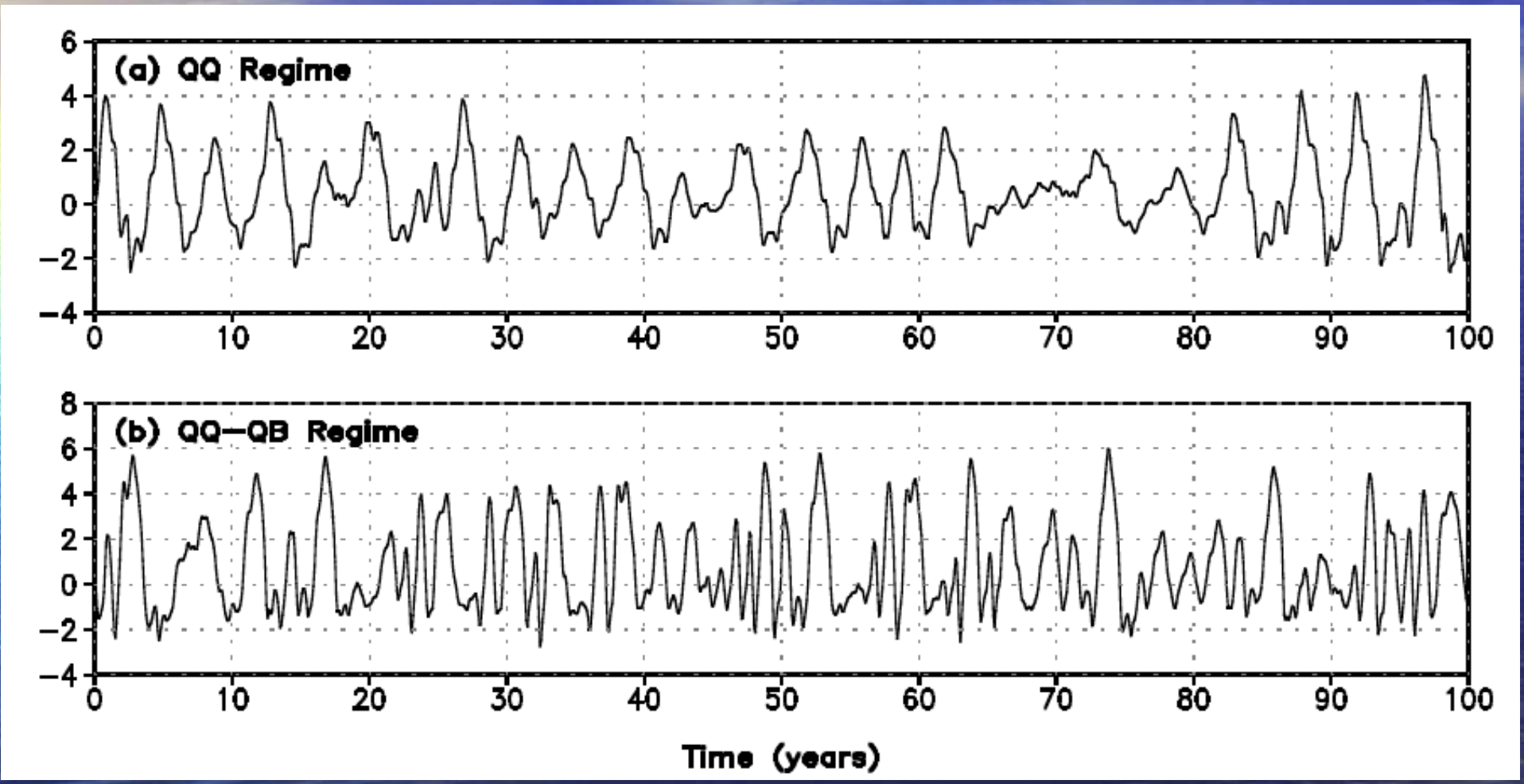
- Further study will focus on understanding and assessing ENSO potential regime changes due to GW using a number CGCMs.

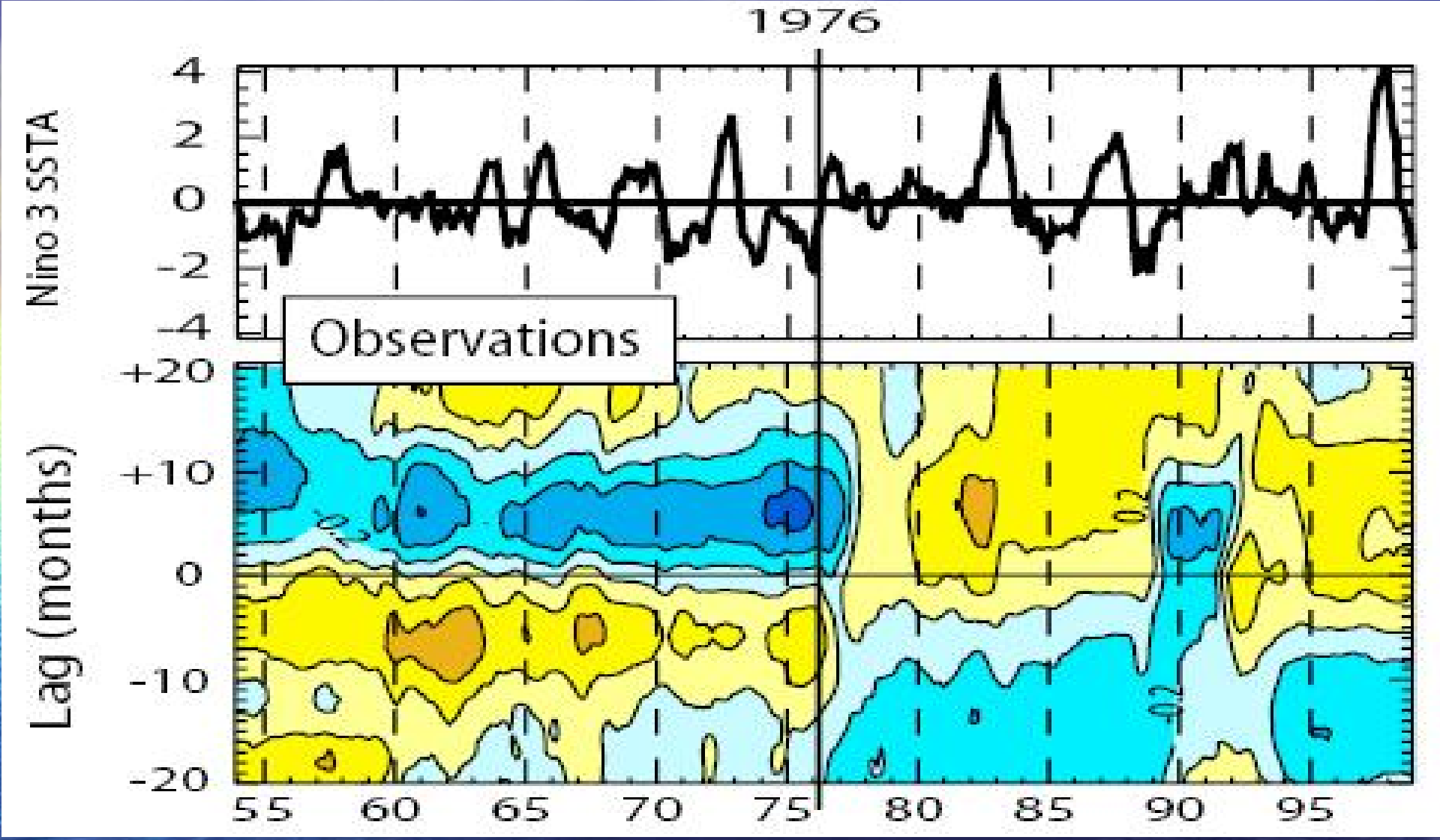
SST Anomalies along the Equator

5S-5N/Detrended



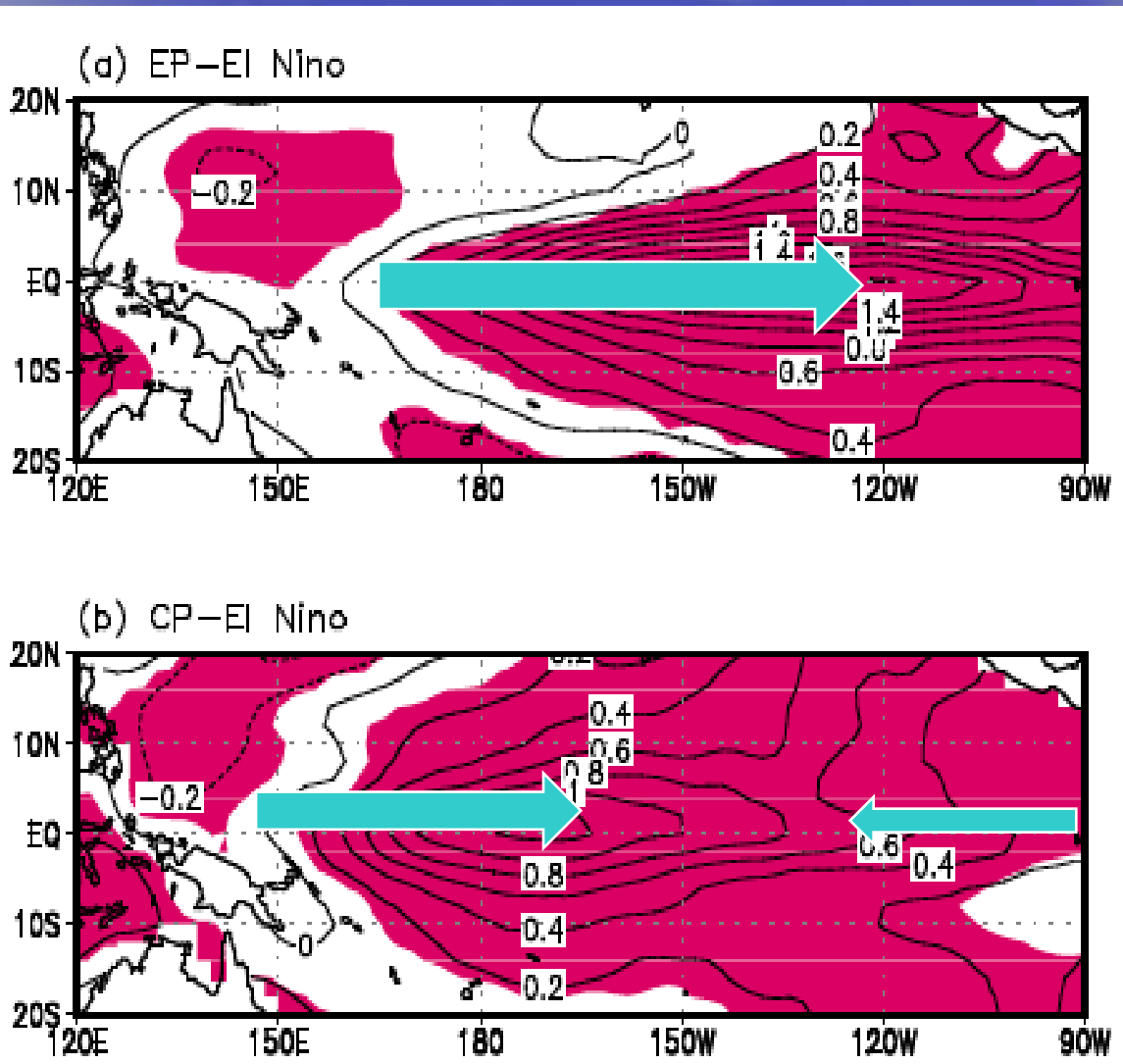
Bursting behavior of ENSO in QQ-QB regime:

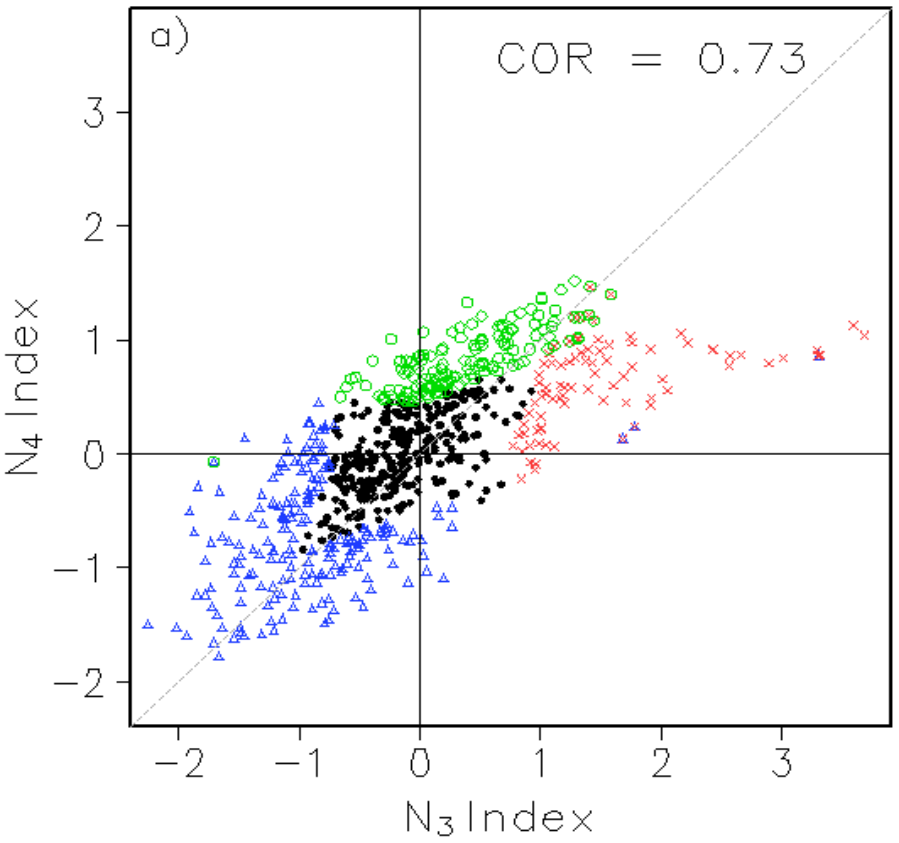


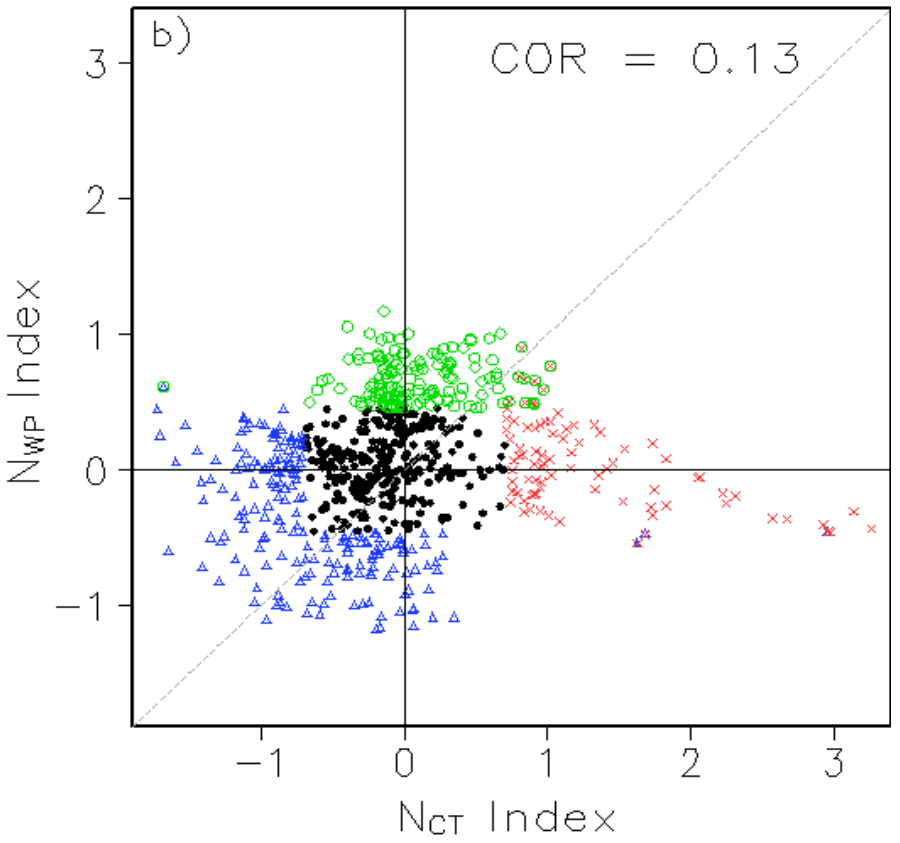


Westward propagating before 76, eastward or standing after 76

ENSO regime changed !


(a) EP−El Nino
20N
10N
EQ
10S
20S
120E
150E
180
150W
120W
90W
0
0.2
0.4
0.8
−0.2
1.4
0.6
0.4
(b) CP−El Nino
20N
10N
EQ
10S
20S
120E
150E
180
150W
120W
90W
0.4
0.6
0.8
−0.2
0.8
0.4
0
0.2
0.6
0.4





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ENSO Regime & Multiplicity

Jin et al 1993

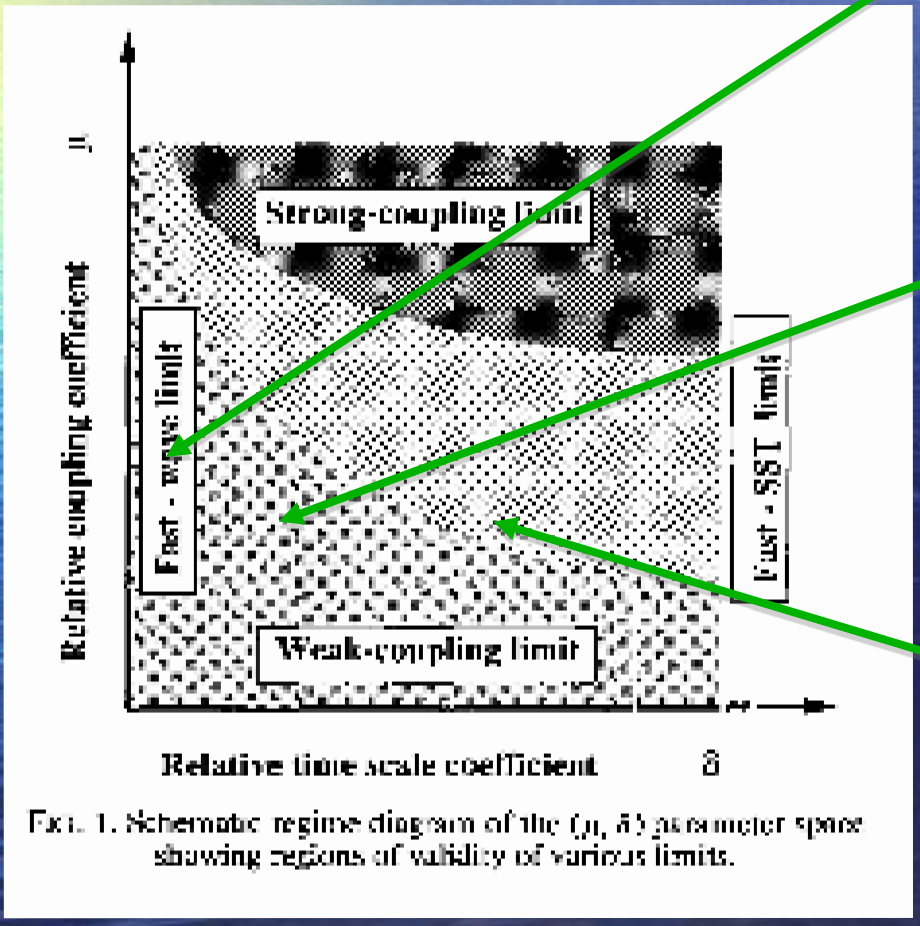

FIG. 1. Schematic regime diagram of the (μ, δ) parameter space showing regions of validity of various limits.