ENSO Diversity Working Group

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U.S members:

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Yan Xue (NCEP)
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Outline

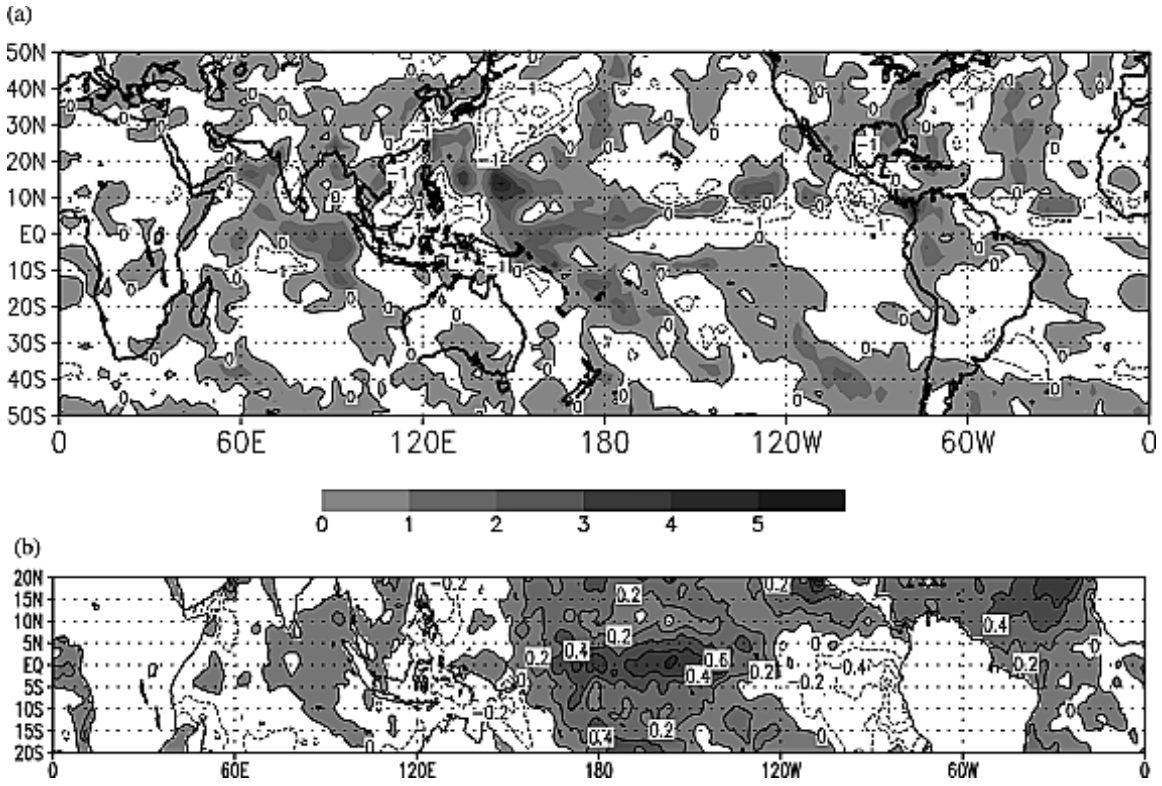
- Motivation
- Describe the scientific objectives
- First year activities
- Achievements and open questions
- Plans for the second year

What is ENSO diversity?

.....and why is it important?

El Niño "Modoki" ("Pseudo"), "two El Niños" idea (Ashok et al., 2007)

Anomalous conditions during JJAS 2004 based on 1979-2004 climatology



Precipitation (cm/month)
GPCP Version 2

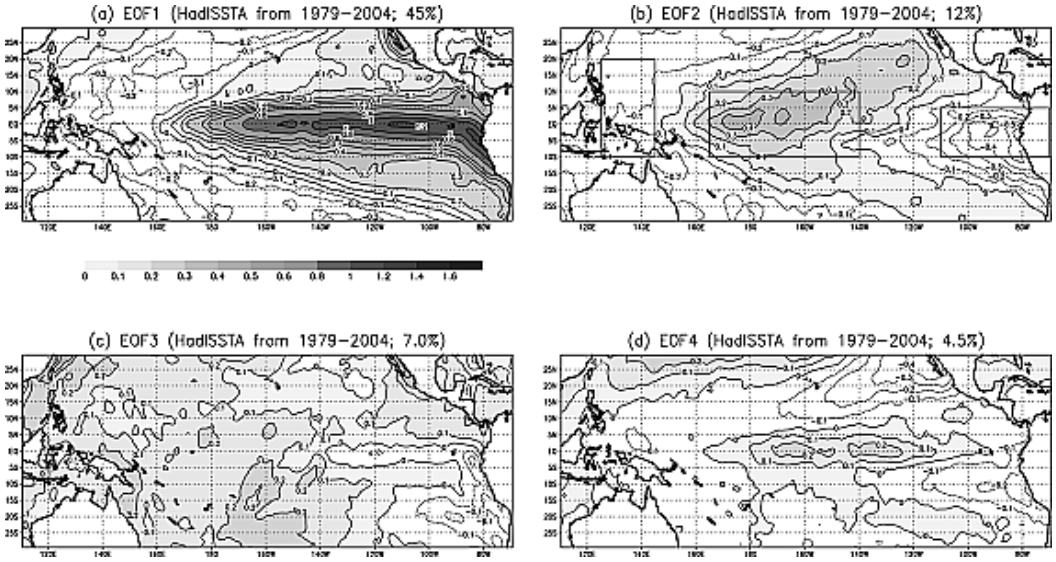
SST (°C) HadISST

El Niño “Modoki”

(Ashok et al, 2007)

SST EOFs (1979-2004)

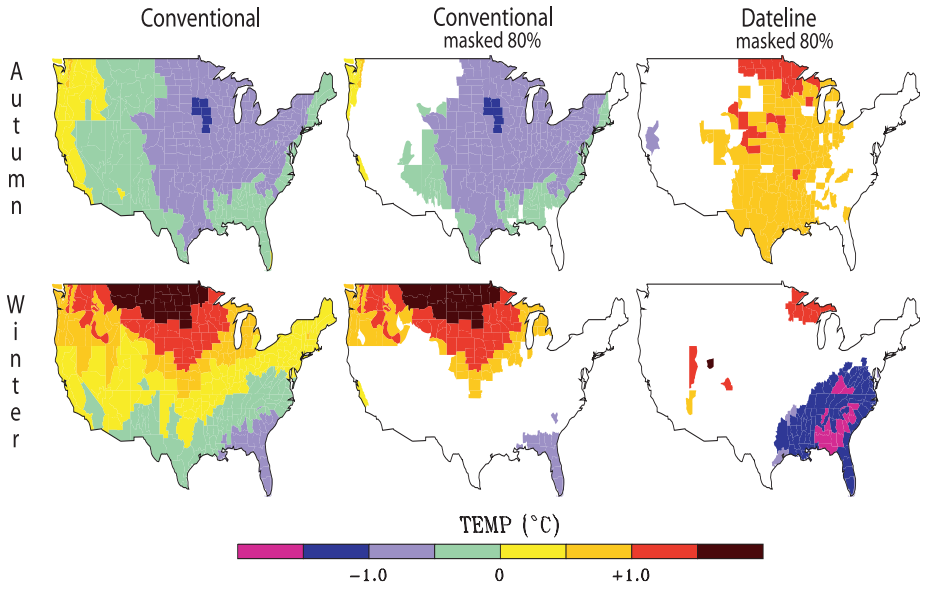
EOF1 (45%)



EOF2 (12%)

The connection between the Modoki SST pattern and the failure of the Indian Monsoon had already been noticed by K. Kumar et al. (Science, 2006)

Longitude of SST anomalies and T and Precip over the U.S.



Larkin and Harrison 2005

- Different ENSO flavors impact precipitation over Australia (Hendon et al. 2009)
- CP warming has been suggested as a forcing for the southernmost lobe of the NPO, which, in turn, appears to force the North Pacific Gyre Oscillation (NPGO, Di Lorenzo et al. 2008)
- It has been linked to changes in tropical cyclone activity (Kim et al. 2009), shifts in precipitation patterns (Weng et al. 2009), and warming in Antarctica (Lee et al. 2010, Ding et al. 2011)

Identification of ENSO flavors

Niño3 vs.Niño4 (Kug et al. 2009; Yeh et al. 2009)

CT&WP indices (Ren and Jin, 2011): rotation of Niño3 and Niño4

E and C-indices (Takahashi et al. 2011): rotation of Niño1+2&Niño4

Subsurface temperature method (Yu et al. 2011)

El Niño Modoki Index (EMI, Ashok et al. 2007)

EP/CP-Index (Kao and Yu 2009): PCs of leading EOF modes

Pattern correlation method (Yu and Kim 2011)

Definitions:

"Dateline El Niño" (Larkin and Harrison 2005)

"El Niño Modoki" (Ashok et al. 2007)

"Central Pacific El Niño" (Kao and Yu 2009)

"Warm Pool El Niño" (Kug et al. 2009)

Need to clarify, coordinate, and synthesize ENSO diversity research

Scientific Objectives

1. Examine the range of ENSO "flavors" with focus upon longitudinal variations of warming, identify basic surface and subsurface characteristics that are robust among different datasets, assess the existence of possible, and distinct precursors to the different flavors, and improve our understanding of how the interplay of different oceanic, atmospheric, and coupled processes drive different ENSO flavors and impact their predictability.

2. Examine the performance of the CMIP5 archive in reproducing the best observational estimate of ENSO diversity, and assess its projected changes.

First-year activities

1. Conference calls to discuss aspects of ENSO Diversity

2. AGU Fall 2012 Meeting session: **OS040: The El Niño – Southern Oscillation Continuum.** Conveners: Di Nezio, Capotondi, Kirtman, Newman

3. **Workshop**, February 6-8 2013, Boulder CO. Workshop included ~50 scientists involved in different aspects of ENSO diversity research, including: ENSO diversity in observations, Dynamical Processes, Predictability and Prediction, Teleconnections of different ENSO types, Insights from Paleoclimates. Ample time for discussion.

Bimodality or continuum?

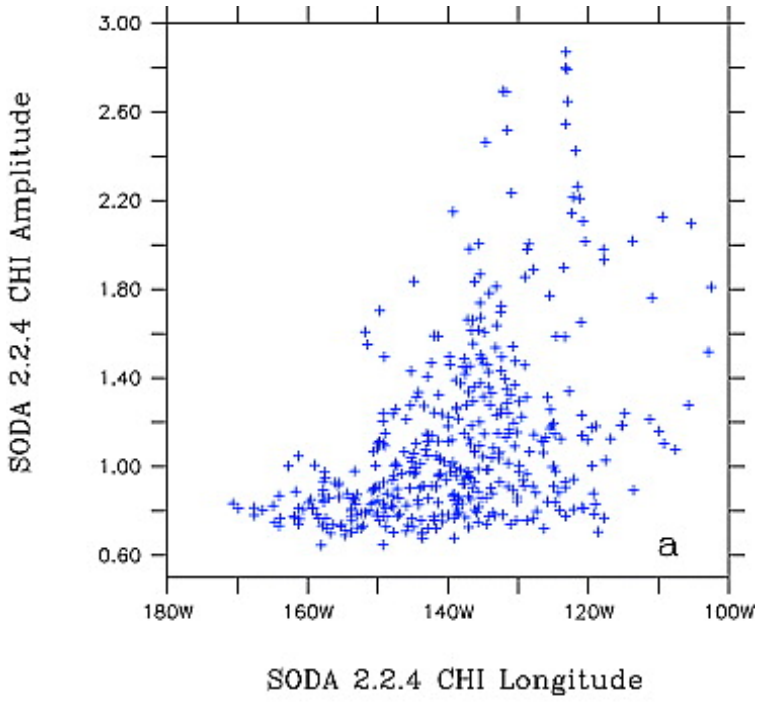
Choosing two different indices to identify events leads to two distinct patterns

Center of Heat Index (CHI) (Giese & Ray 2011)

$$CHI_{long} = \frac{\sum sst' \times long}{\sum sst'} \qquad CHI_{ampl} = \frac{\sum sst' \times area}{\sum area}$$

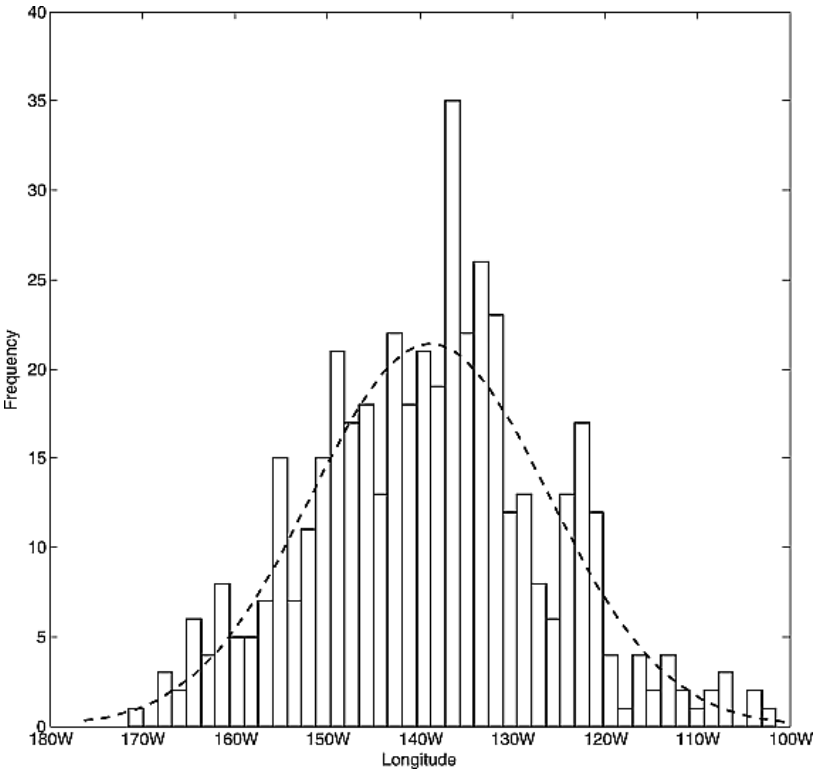
CHI statistics applied to 20th century SODA ocean reanalysis (1871-2008)

CHI amplitude



CHI longitude

Frequency

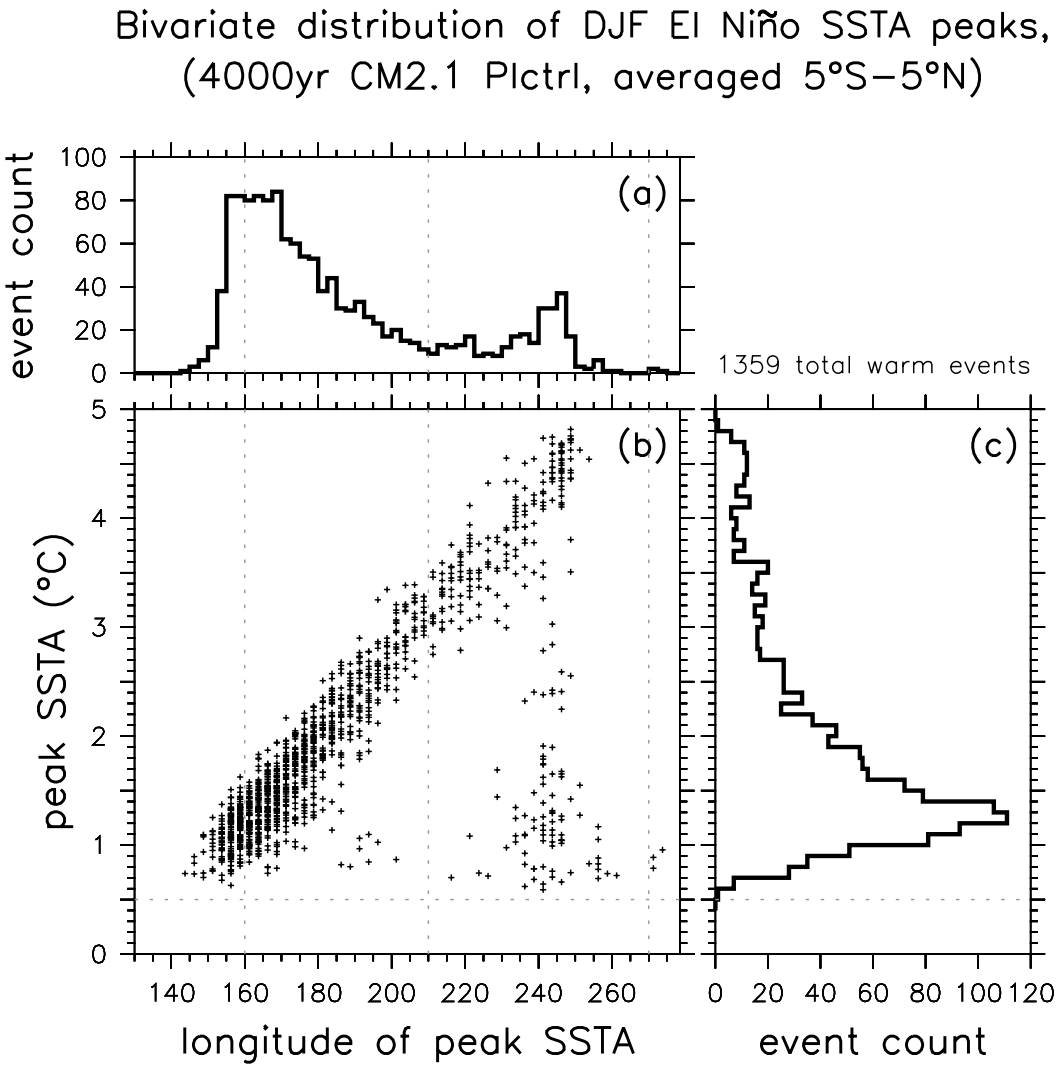


Longitude

This analysis does not support the idea of two preferred peak longitudes

Event structure in the GFDL CM2.1 model

From 4000 years of PI control simulation

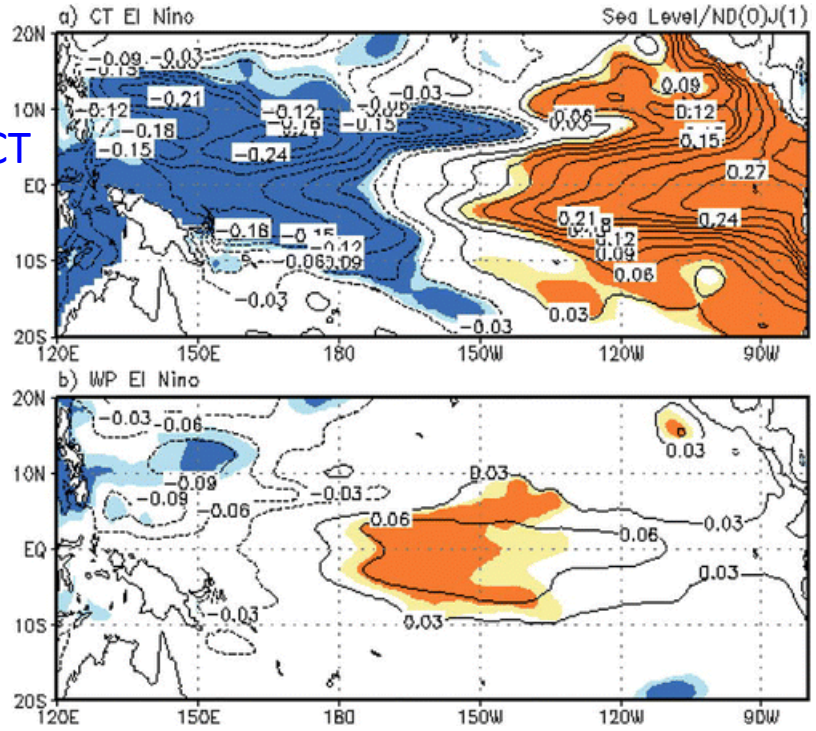


Wittenberg 2013
Workshop presentation

Dynamical processes (Observations)

Using Niño3 and Niño4 indices

Sea level, GODAS, 1980-2005



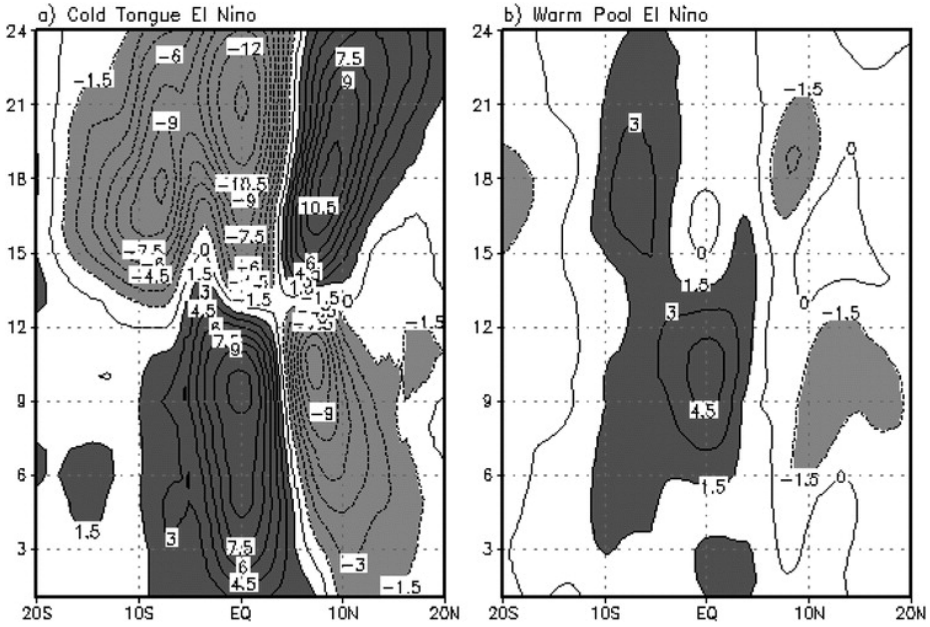
CT

WP

Composite sea level evolution

CT

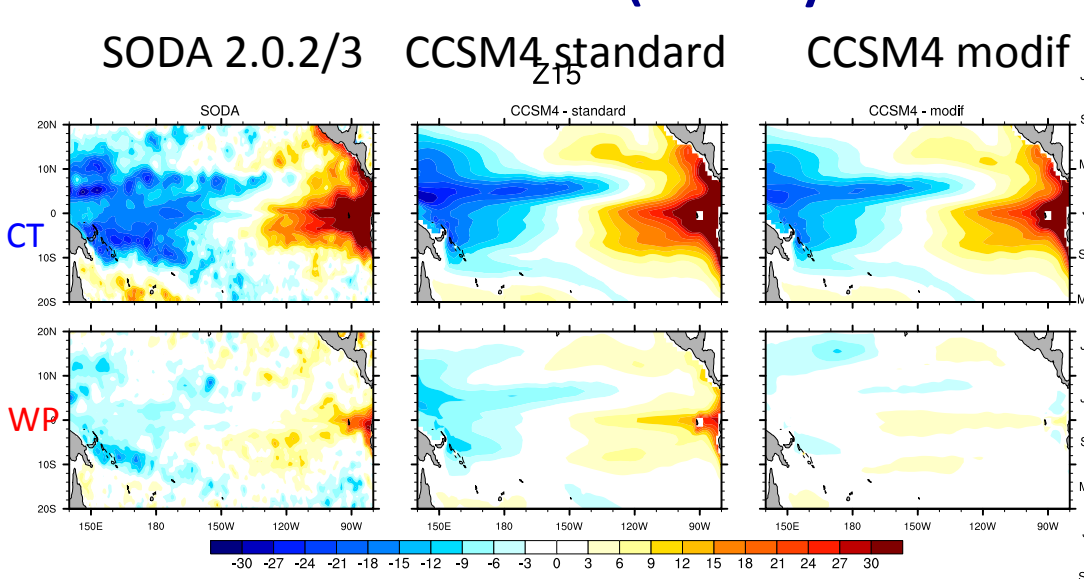
WP

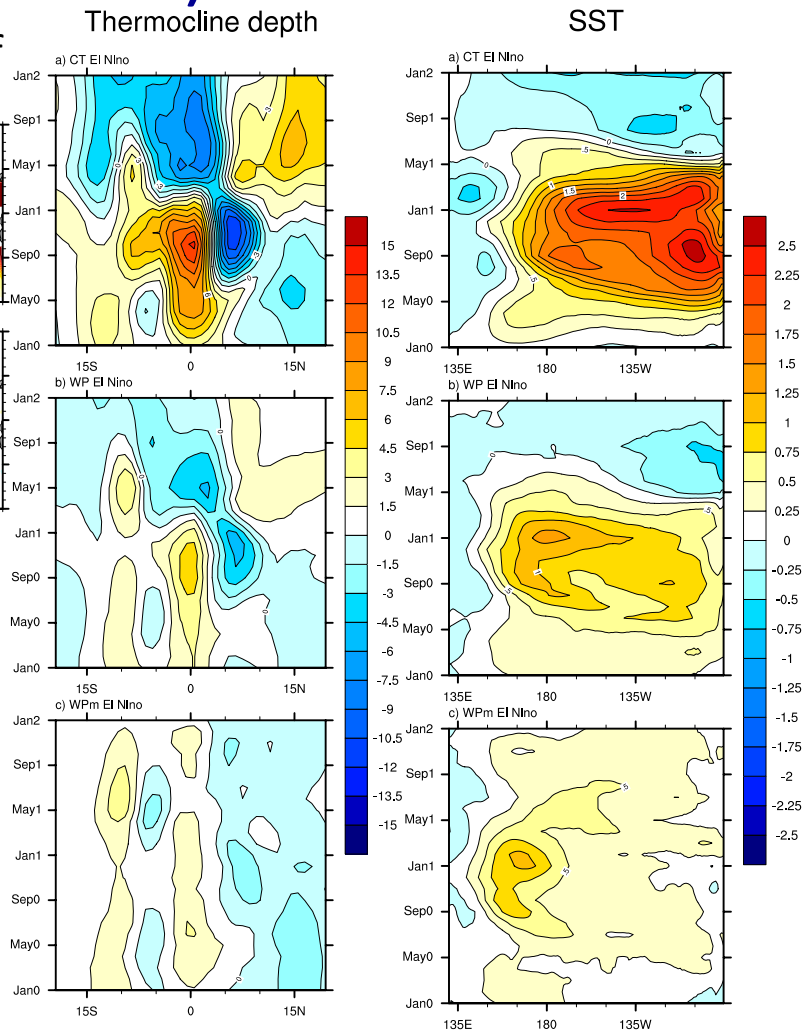


Kug et al. 2009

Dynamical processes (Models)

Thermocline depth (Z15) from the NCAR-CCSM4 (500 years PI-cntrl)





Capotondi 2013

Climate model analyses indicate a gradual change in the leading dynamical processes for events peaking at different longitudes. Vertical advection stronger in the east, zonal advection dominate in the central-western Pacific

Bimodality or continuum?

Neither. There may be different modes of variability of the equatorial ocean-atmosphere system (as suggested by EOF analysis and LIM studies), whose superposition can give rise to a multiplicity of flavors.

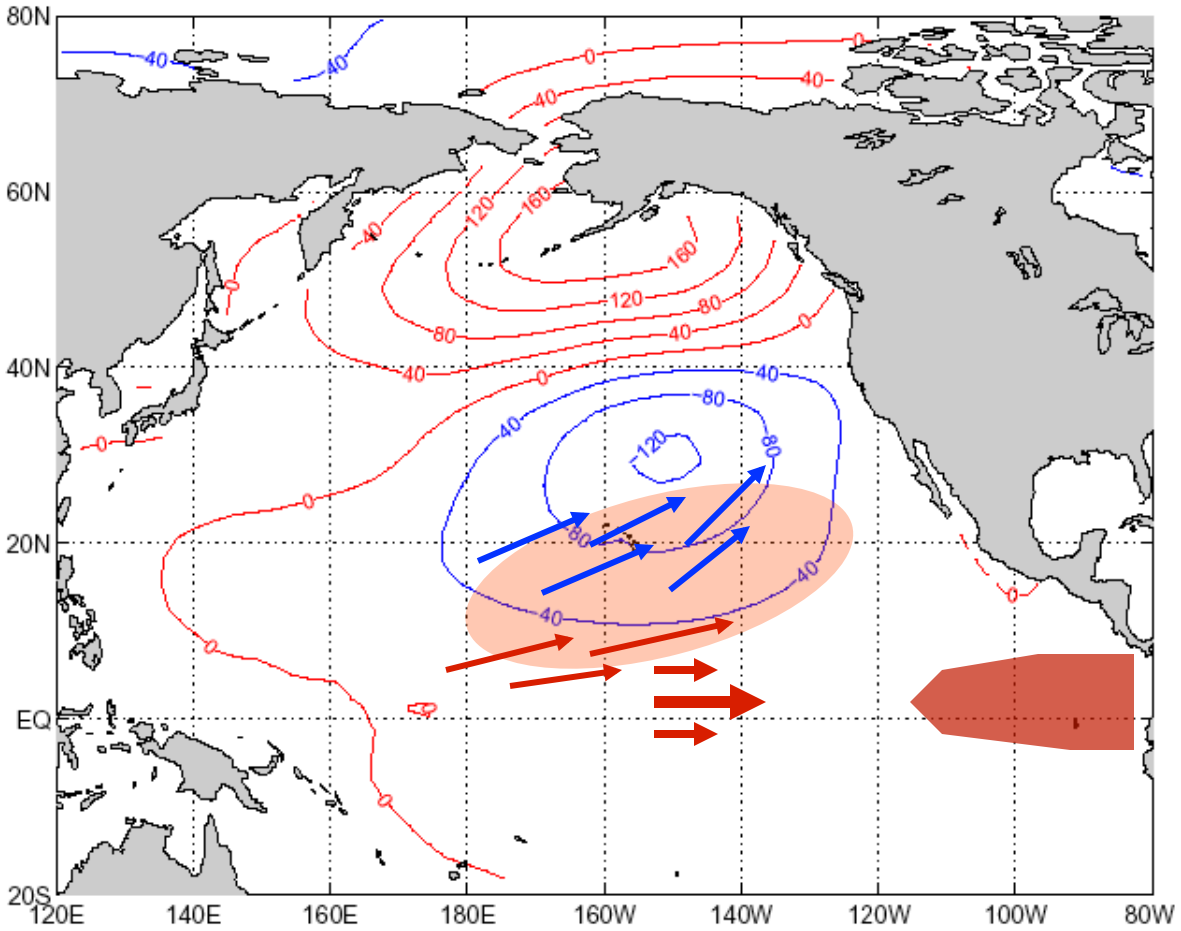
The concept of multiplicity rather than bimodality will be stressed in the BAMS article that the WG is preparing

Open questions:

- Origin of the different event types, and their predictability ("Precursors")
- Prediction of the different "flavors"
- Teleconnections
- Impacts

Precursors

Seasonal Foot Printing Mechanism (SFM)?



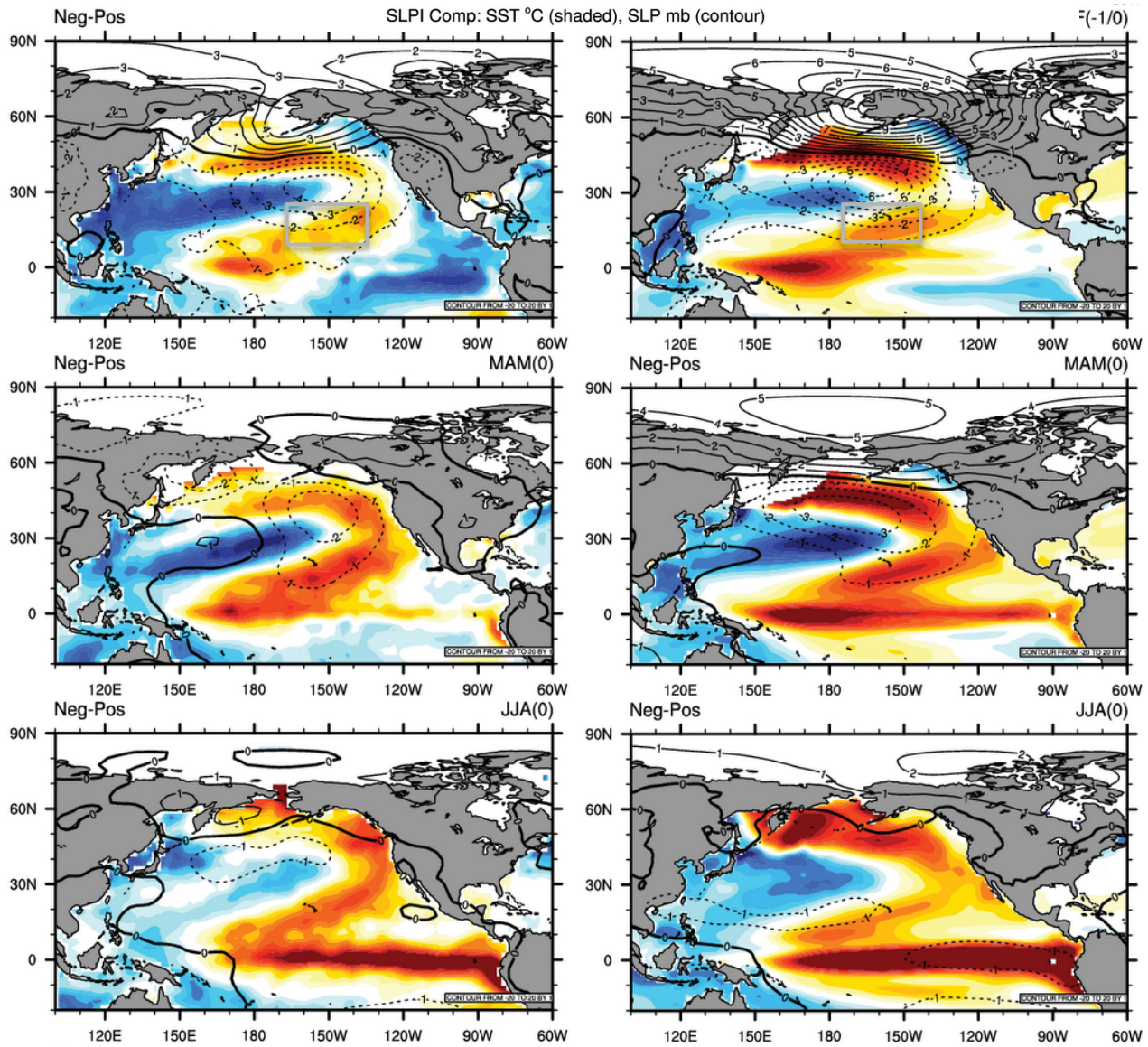
- *NPO in NDJ (-1)*
- ⇓
- *Winds & Heat Flux*
- ⇓
- *SST in FMA (0)*
- ⇓
- *Tropical Winds*
- *Feedback (e.g. WES) JJAS(0)*
- ⇓
- *El Nino in NDJ(0)*

Vimont et al. 2001, GRL; 2003a&b, J. Climate

SLP Index SST/SLP composite DJF(0)-JJA(0)

NDJFM(-1/0) SLP Index (175W-140W, 10N-25N) Composites (Neg-Pos)

NCEP Reanalysis

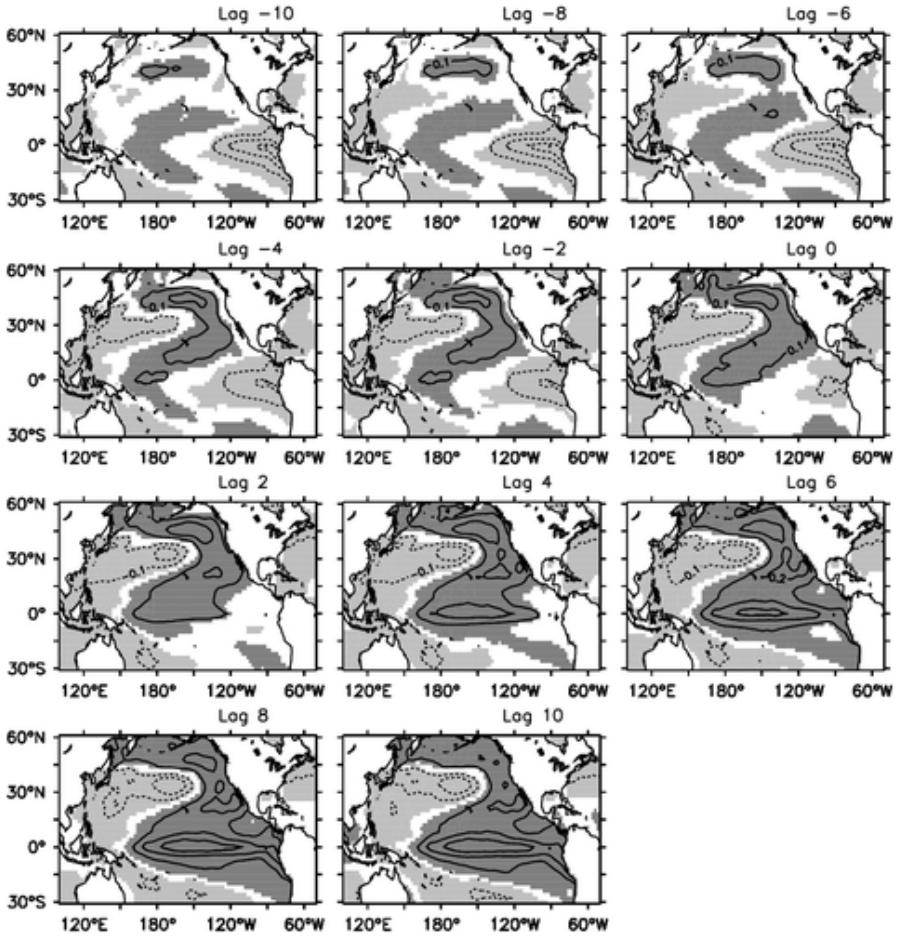


CCSM4

Correlation between SLPI and Niño3.4 SST Index in JFM(1) is 0.61 in nature (Anderson 2007) and 0.59 in the model

Deser et al., 2012

Open questions
"Precursors"



Yu and Kim 2011

Lag-regression of SST upon the North Pacific Oscillation (NPO) index, second EOF of winter SLP over the North Pacific

Is this mechanism a precursors only for Central Pacific events?

What is its efficiency?

A similar mechanism seems to operate in the Southern Hemisphere. What is the the relative importance of NH and SH?

What is the interplay between extratropical forcing and equatorial atmospheric noise (WWBs)?

What is the role of the oceanic backgound state? (Anderson 2007)

Publications to date

- Workshop report
- Summer issue of U.S. CLIVAR Newsletter *Variations*

Second-year activities

BAMS article to summarize our present state of knowledge, and open questions, as emerged from the workshop

Special issue of Climate Dynamics to spur further studies in the areas where answers are most needed.

Pursue second objective: *"Examine the performance of the CMIP5 archive in reproducing the best observational estimate of ENSO diversity, and assess its projected changes."*

Second-year activities (continued)

Pursue second objective: *"Examine the performance of the CMIP5 archive in reproducing the best observational estimate of ENSO diversity, and assess its projected changes."*

- Define metrics to characterize ENSO diversity in the CMIP5 model. This is in line with the broader activities of the International CLIVAR: 1)"ENSO in a warming world" has been identified as a "Research opportunity" by Scientific Steering Group, and 2) Ongoing work on metrics to evaluate climate models with the WGCM of WCRP.

- Expand the WG website to maintain an updated bibliography, and share articles and manuscripts for comparison and discussion in an interactive fashion

Deliverables

- BAMS article
- Climate Dynamics special collections
- ENSO diversity metrics and recommendation to the modeling community, also input to International CLIVAR (need for model analyses and model inter-comparison)
- ENSO Diversity website

These products and achievements will establish the WG legacy

Conclusions

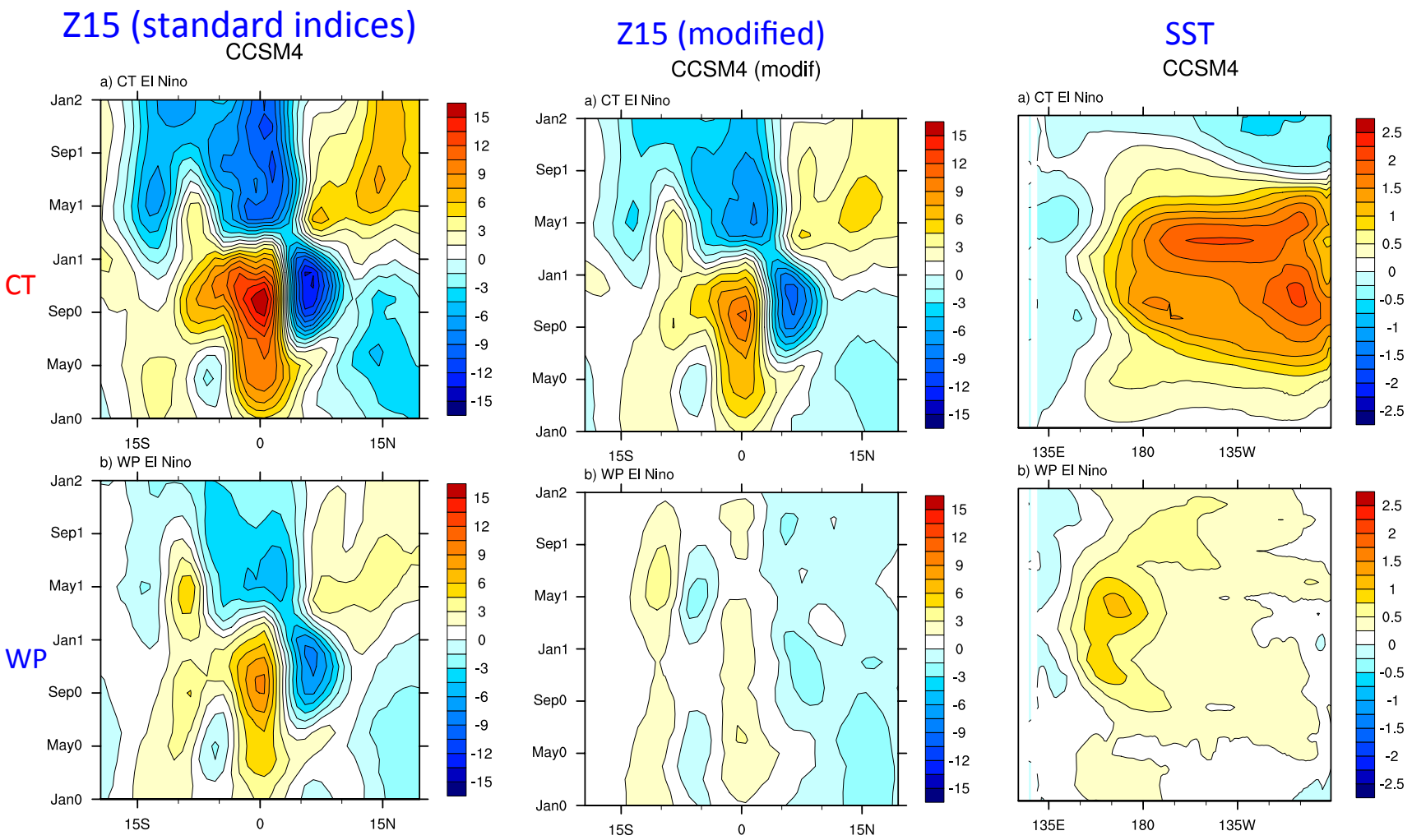
It is important to promote a systematic examination of observational data sets, reanalysis, and climate models simulations to identify robust features of ENSO diversity, and assess how well observations can define those features.

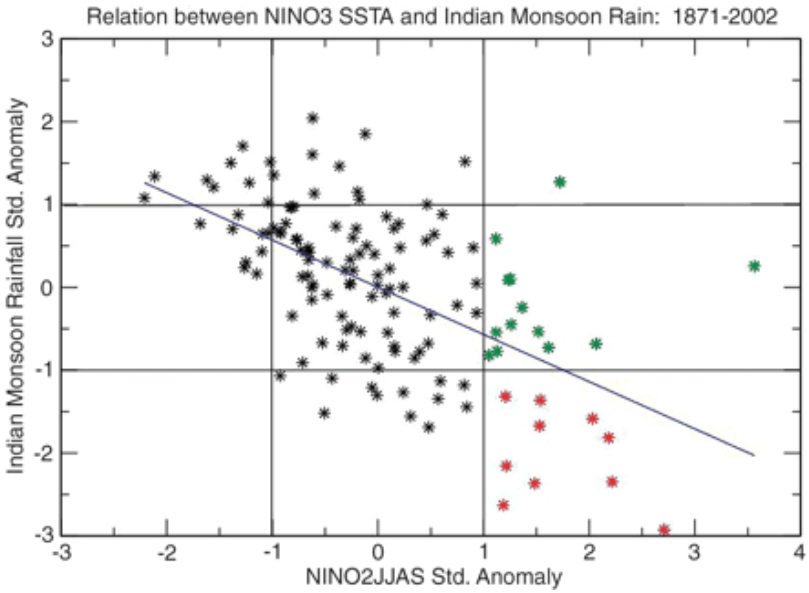
As climate models are becoming more realistic, we need to inter-compare them at a more refined level, and use several models.

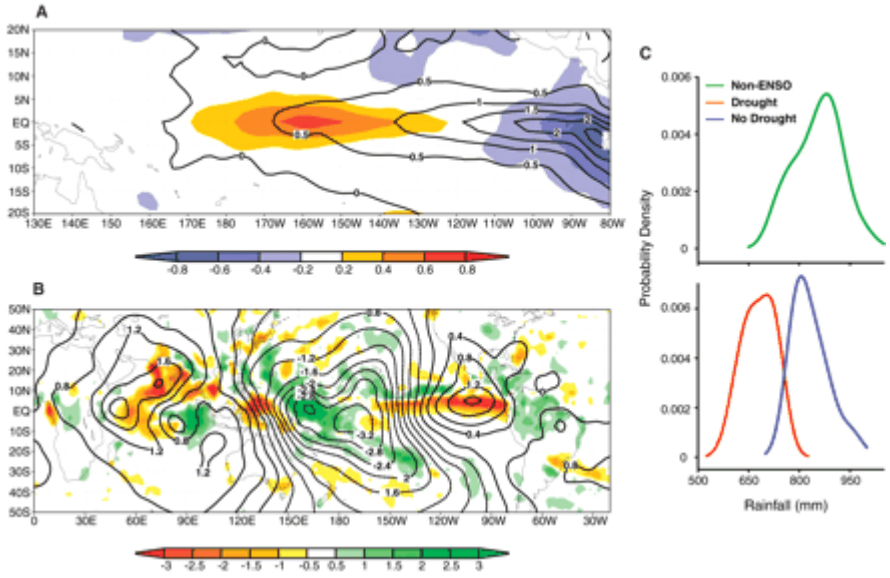
Metrics to evaluate ENSO in climate models need to account for the complexity and diversity of the phenomenon, including dynamical processes, patterns and evolution

NCAR-CCSM4

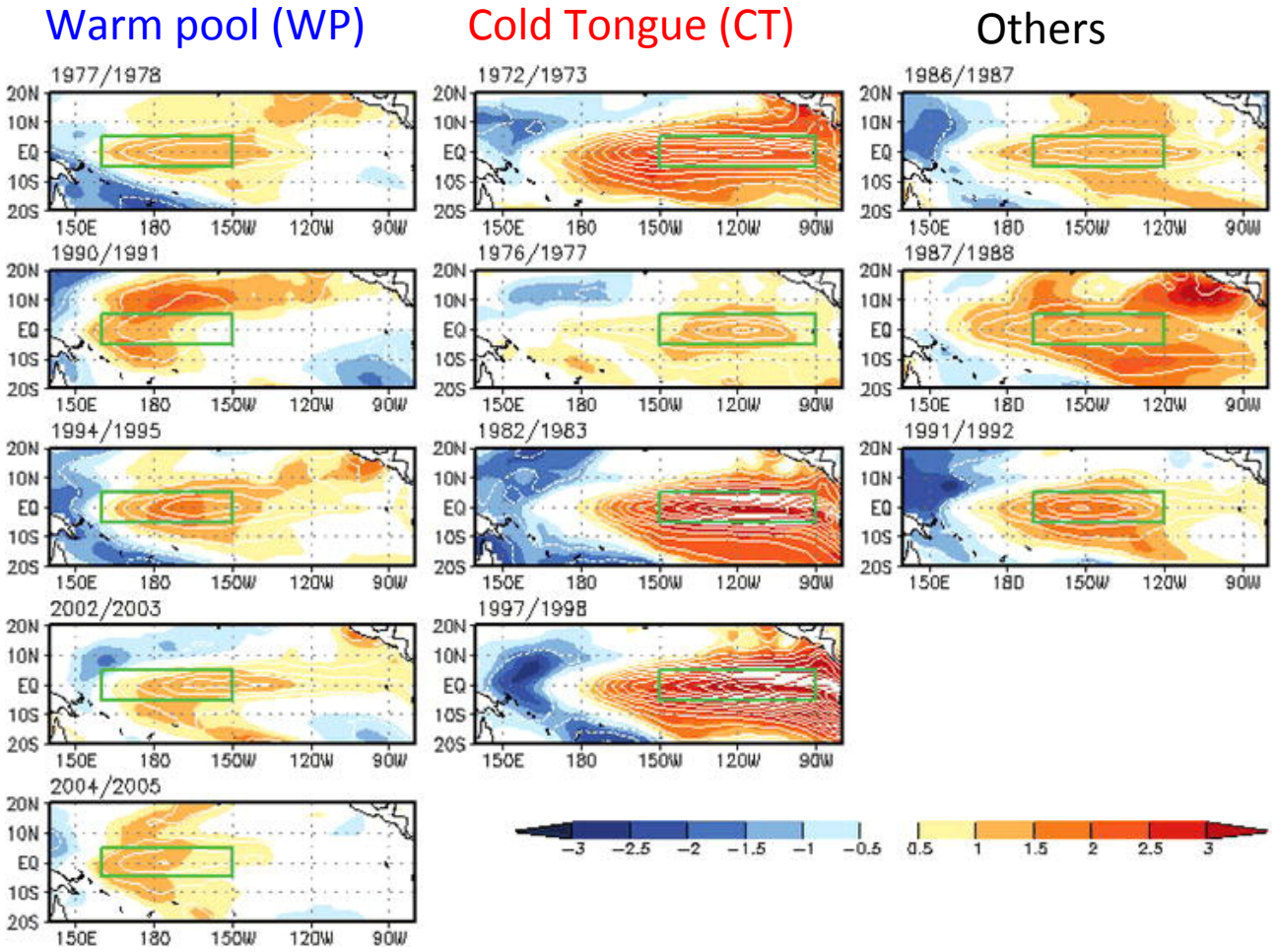
Evolution of thermocline depth (Z15)




Relation between NINO3 SSTA and Indian Monsoon Rain: 1871-2002
Indian Monsoon Rainfall Std. Anomaly
NINO2JJAS Std. Anomaly


A
B
C
Non-ENSO
Drought
No Drought
Probability Density
Rainfall (mm)

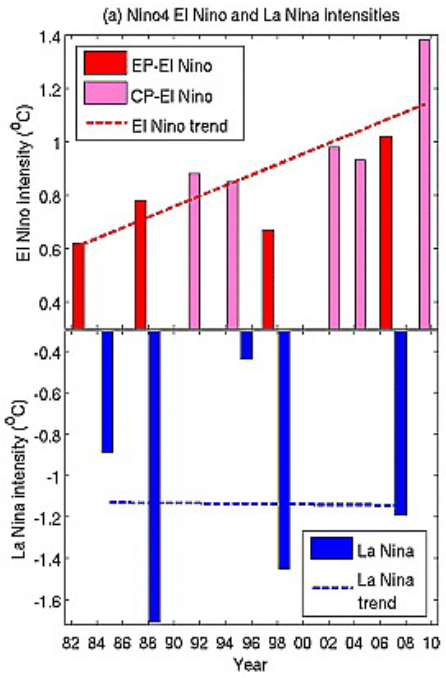
What do we mean with ENSO diversity?



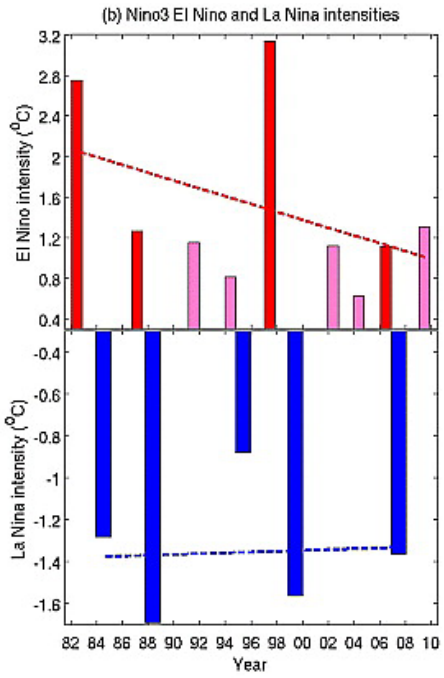
Kug et al. 2009: "Two types of El Niño: Cold Tongue El Niño and Warm Pool El Niño"
(NOAA-ERSST 1970-2005)
Selection of events based on Niño3 and Niño4 indices

Trend in El Niño types?

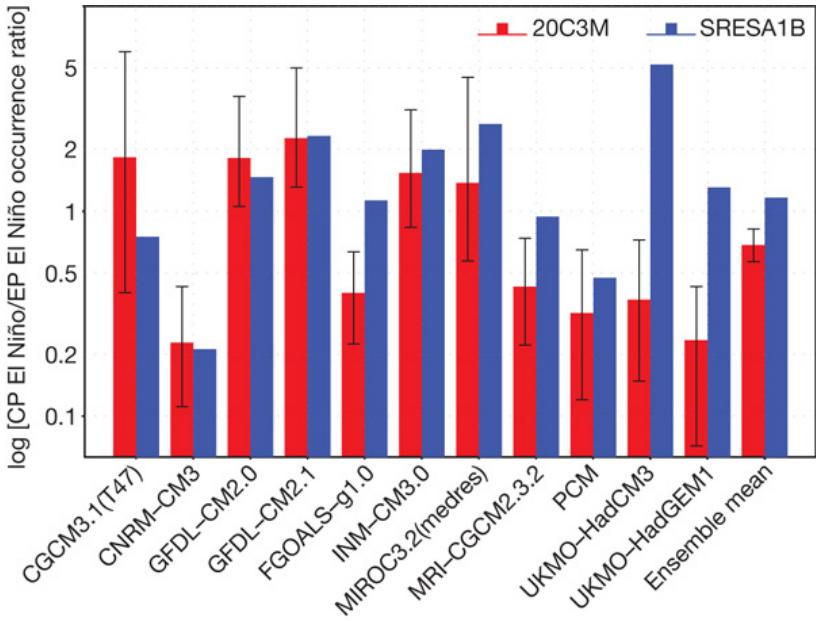
Niño4



Niño3



Lee and McPhaden, 2010



Yeh et al. 2009

Linear Inverse modeling approach