ENSO Diversity Working Group

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U.S members:

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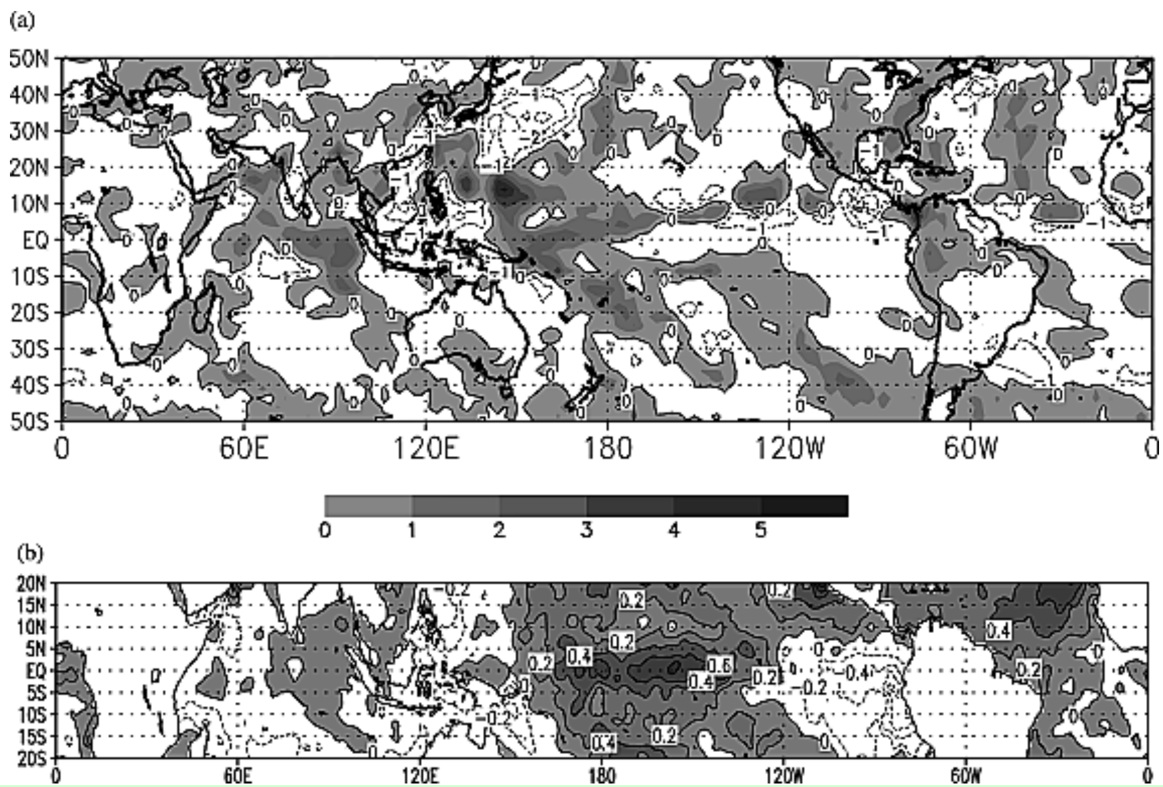
Outline

- Motivation
- Describe the scientific objectives
- Achievements to date
- Open questions
- Plans for the second year

El Niño “Modoki” (“Similar but different”) (Ashok et al., 2007)

Anomalous conditions during JJAS 2004
based on 1979-2004 climatology



Precipitation (cm/month)
GPCP Version 2

SST (°C) HadISST

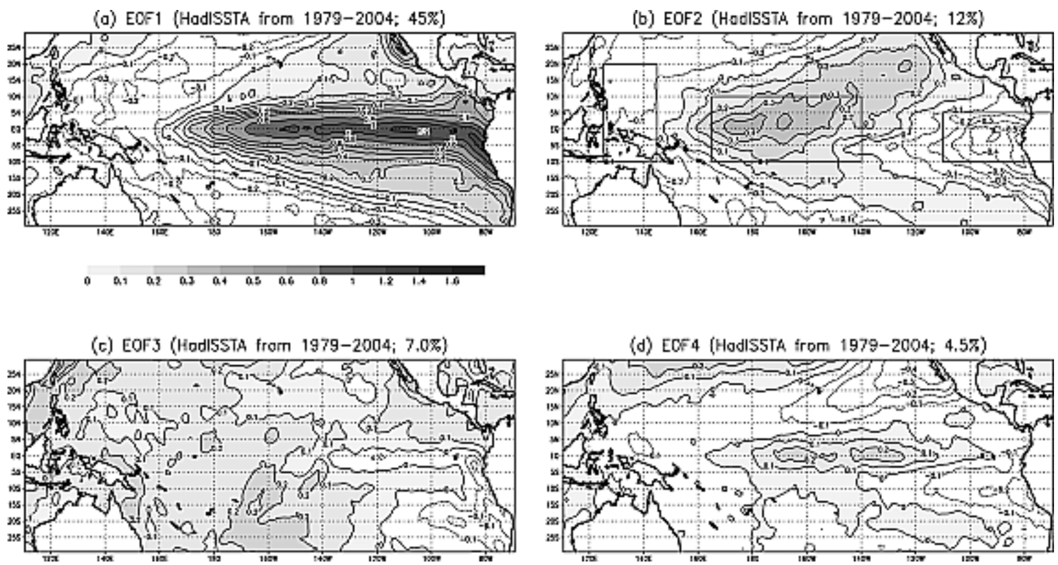
“We believe that identifying a unique phenomenon with the most appropriate definition, just as new species in biology, is important to promote further research”

El Niño "Modoki" (Ashok et al, 2007)

SST EOFs (1979-2004)

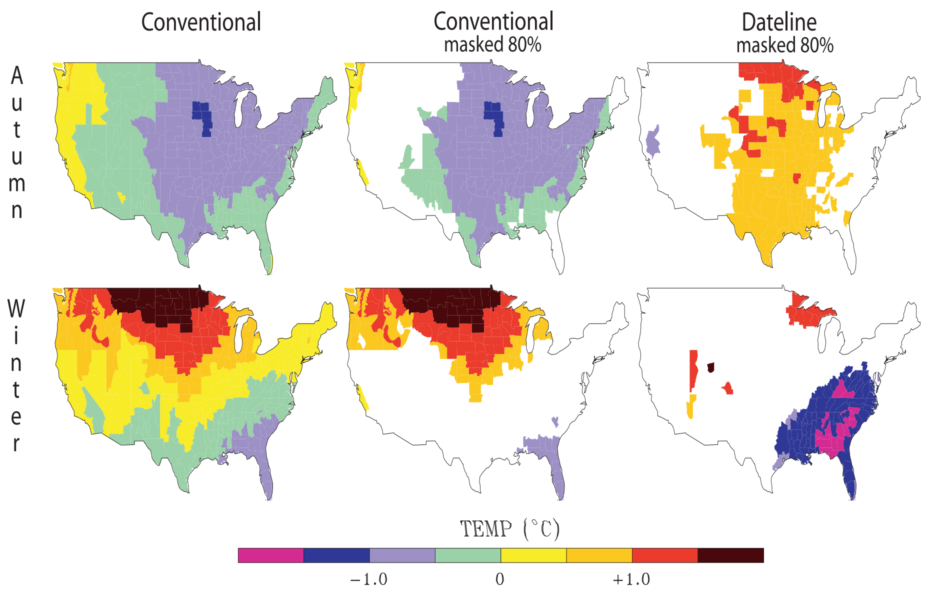
EOF1 (45%)

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)

Details of SSTA pattern affect Temp and Precip over the U.S.



Larkin and Harrison 2005

- Different ENSO types impact precipitation over Australia (Wang and Hendon 2007)
- 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)

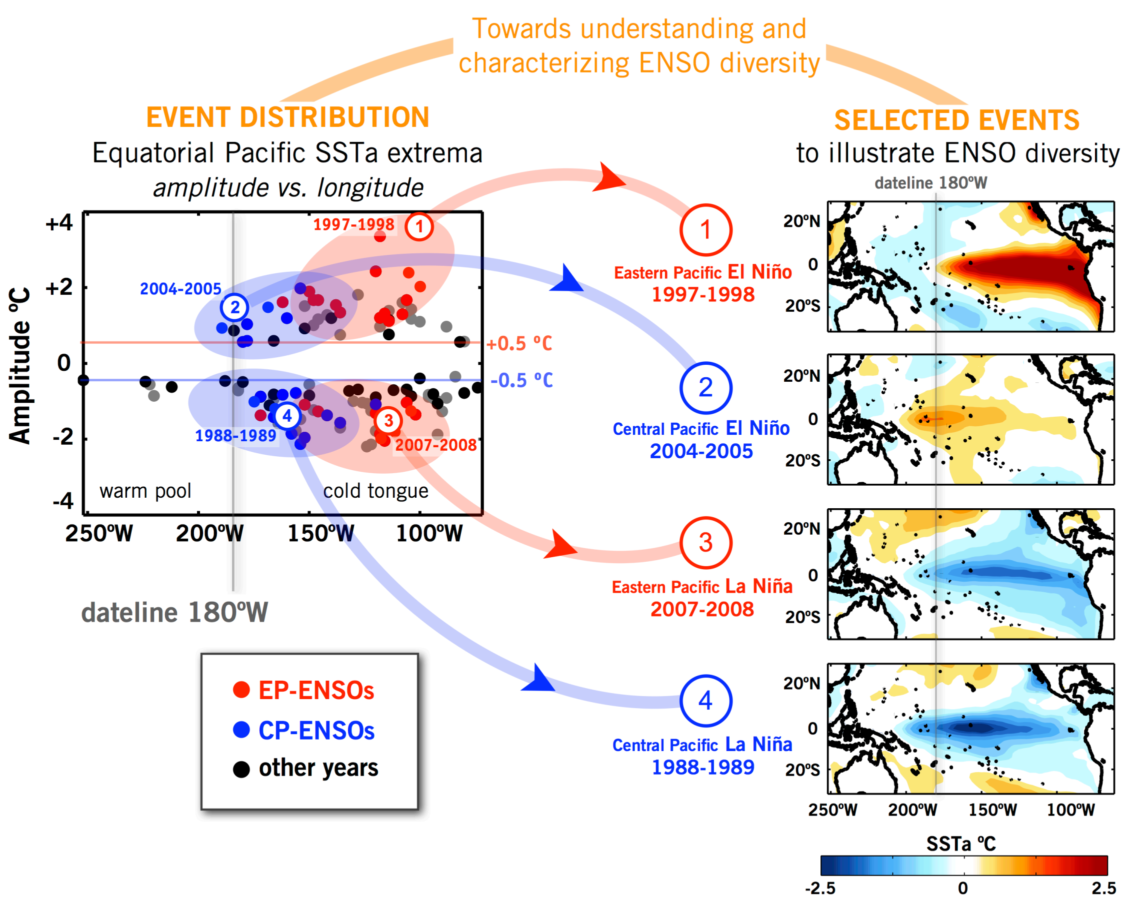
Need to clarify, coordinate, and synthesize ENSO diversity research

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.

Bimodality or Continuum?



NDJ extreme equatorial (2°S-2°N, 110°E-90°W) SST values over 1900-2013 relative to the 1945-2013 climatology

EP : Niño3 > 1 std

CP : PC of leading SST EOF > 1 std

Figure by E. Di Lorenzo

CHI statistics characterizes longitudinal distribution of ENSO events without using specific indices

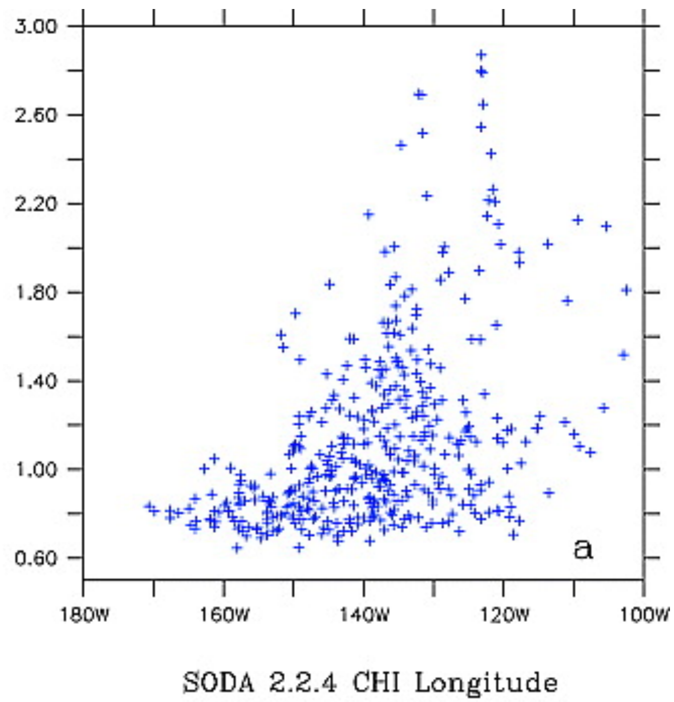
Choosing two different indices to identify events leads to two distinct patterns

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

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

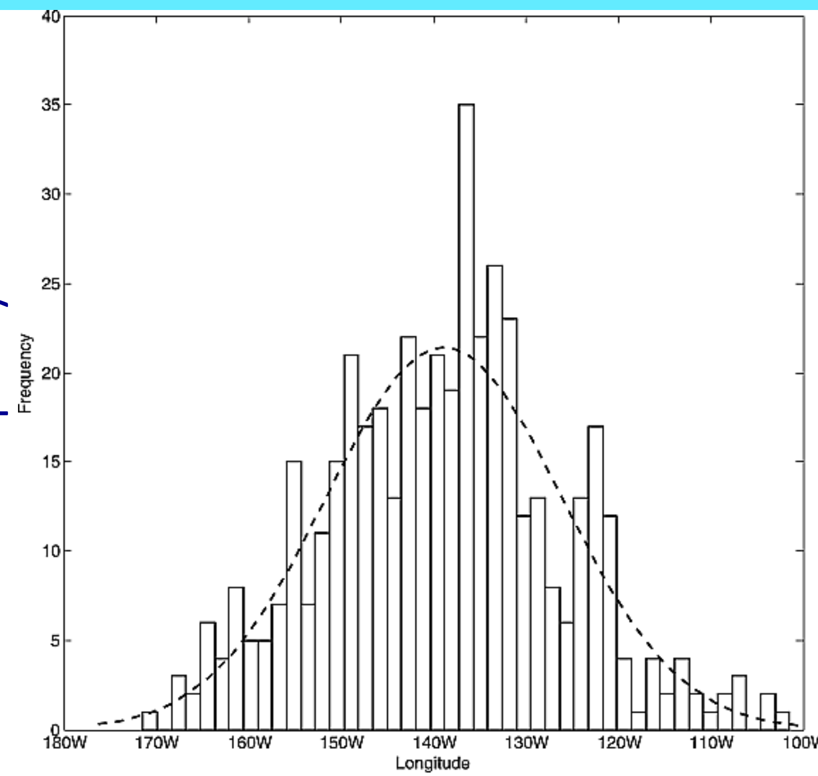
CHI statistics applied to 20th century SODA ocean reanalysis (1871-2008) shows “smooth” event distribution

CHI amplitude



CHI longitude

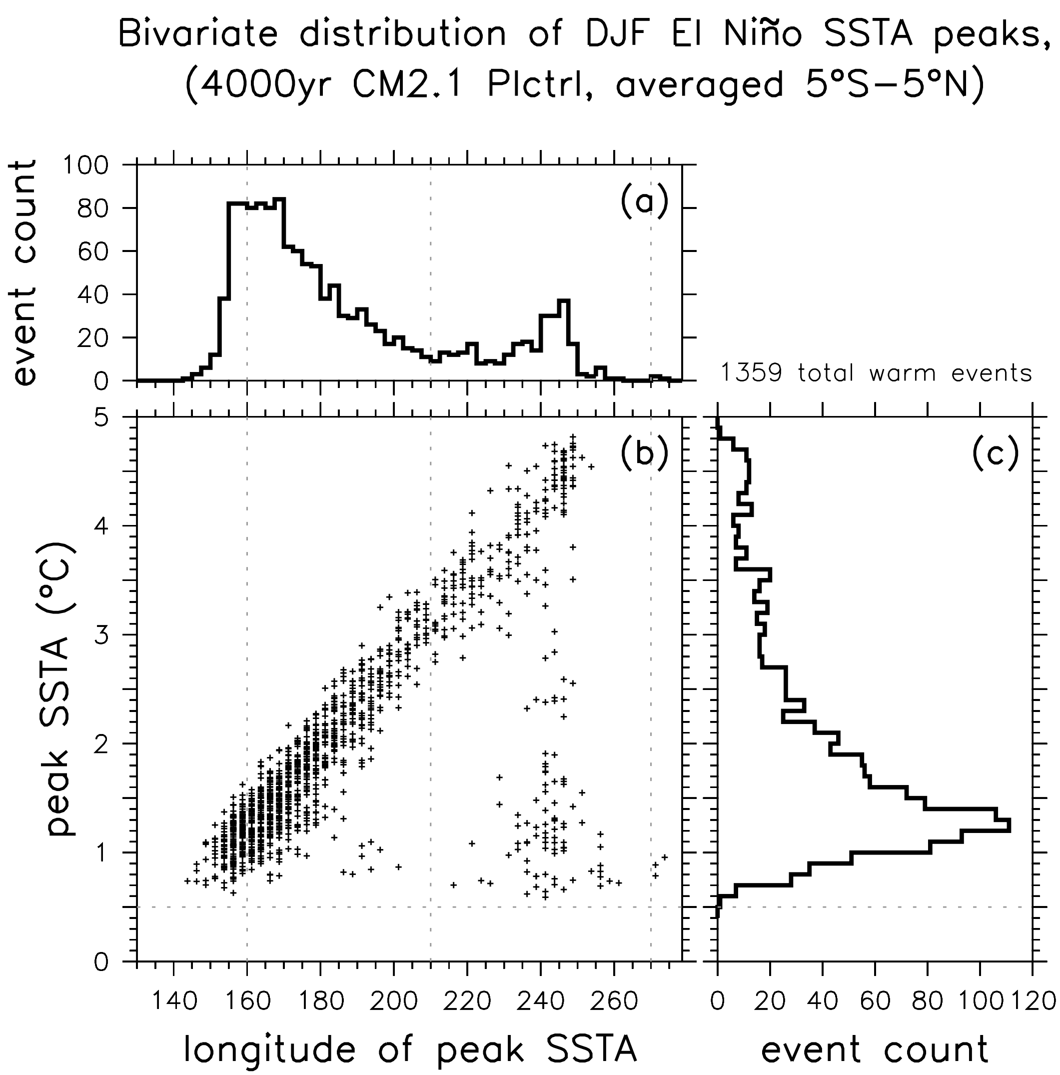
Frequency



Longitude

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

Event distribution in the GFDL CM2.1 model
From 4000 years of PI control simulation



Wittenberg 2013
Workshop presentation

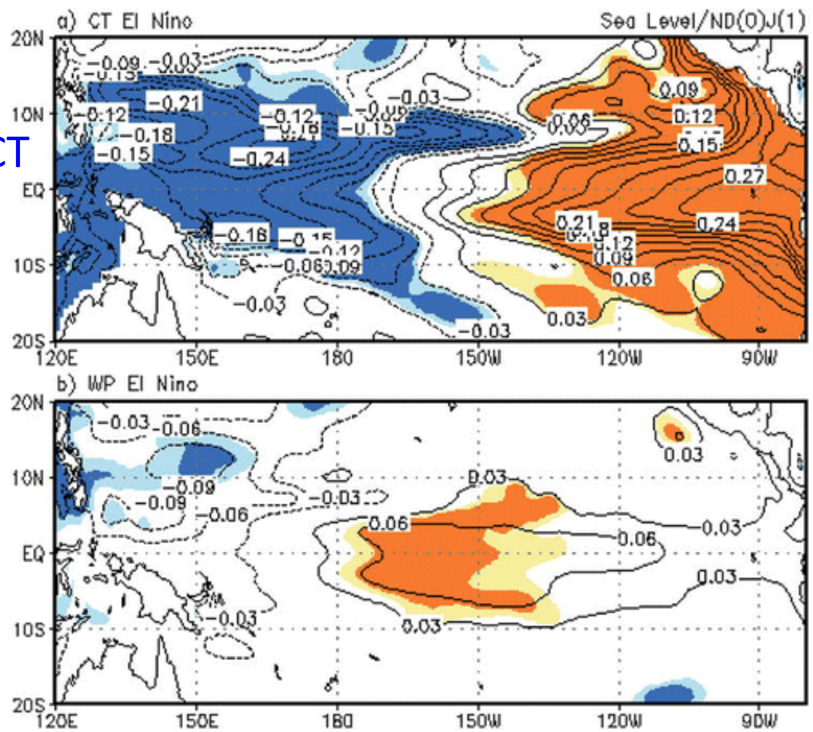
Do Dynamical Processes Differ for Different Event Types?

Observational study using Niño3 and Niño4 indices

Sea level, GODAS, 1980-2005

CT

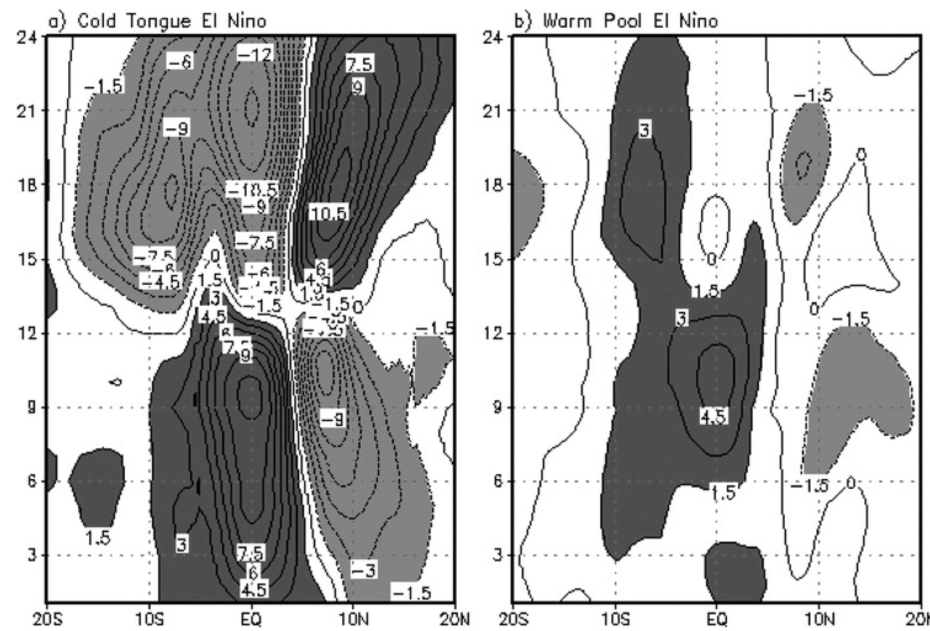
WP



Sea level (proxy for thermocline depth) evolution

CT

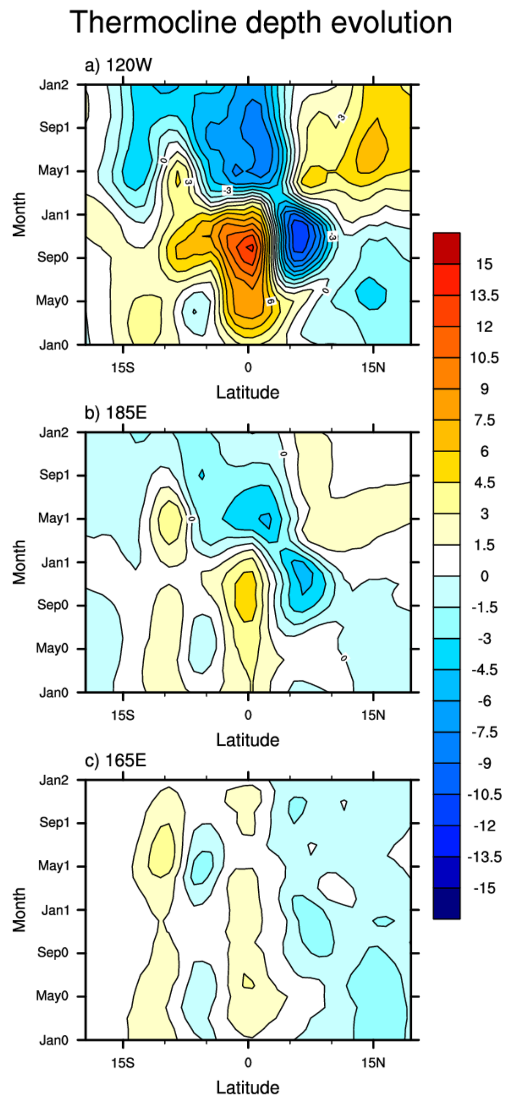
WP



From Kug et al. 2009

What do models say?

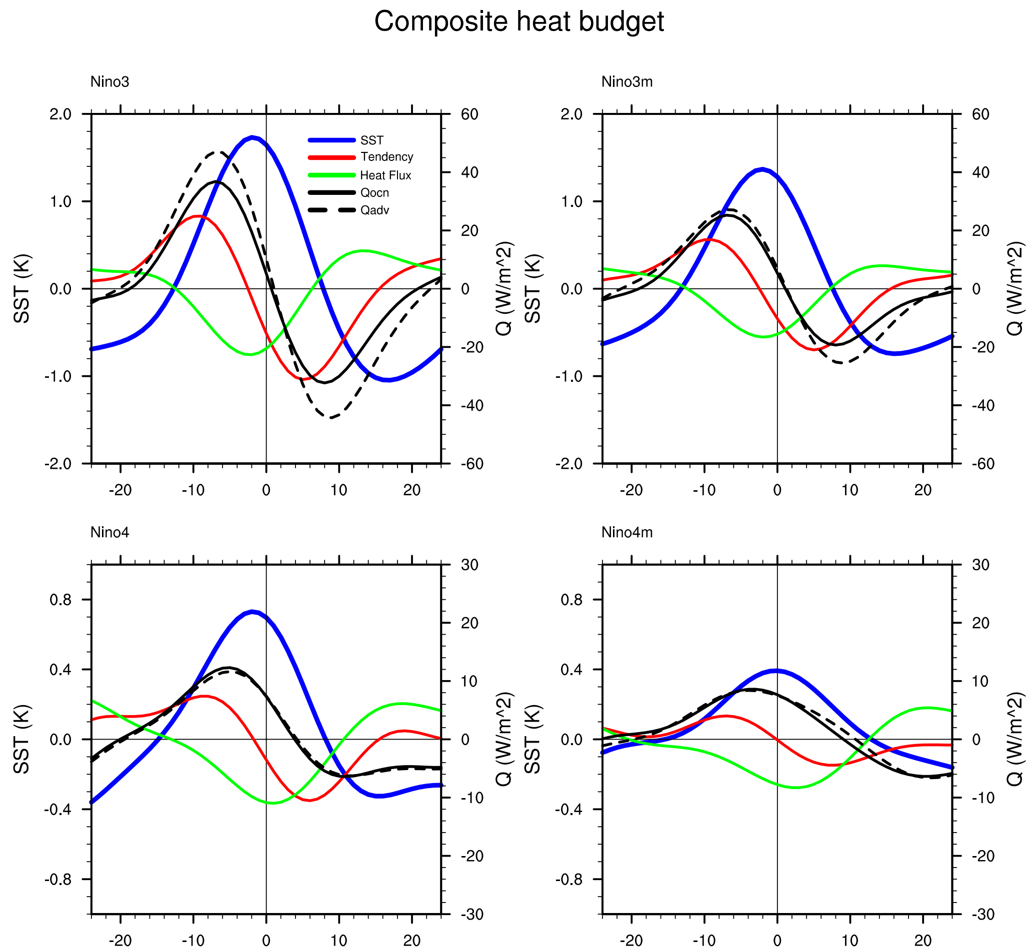
Thermocline depth (Z15) variations from the NCAR-CCSM4 (500 years PI-cntrl)



Recharge-discharge processes become progressively weaker for events peaking further west

From Capotondi 2013

Heat budget of the NCAR-CCSM4



Surface Heat flux damping becomes increasing more important further west

Detailed budget analysis shows that zonal advection dominates dynamical terms in the central Pacific, while vertical advection controls SSTAs in the eastern Pacific

Basic processes are the same. Their relative influence is geographical dependent

Bimodality or Continuum?

"ENSO can be described as a coupled atmosphere-ocean phenomenon that exhibits substantial variations with regionally different feedbacks, leading to a diverse continuum of realized ENSO events."

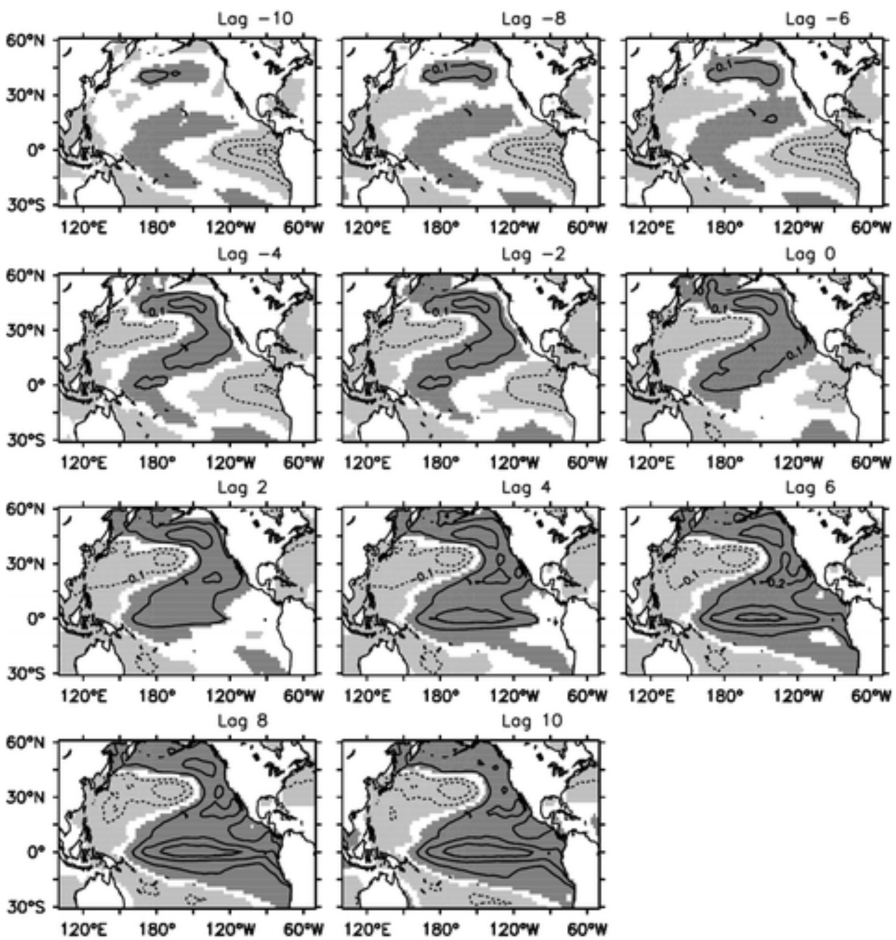
Open Questions

Origin of the different event types and their predictability
"Precursors" need to be better understood

Predictions of different ENSO types (model, data for initialization/assimilation)

Teleconnections and impacts

Extra-tropical 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

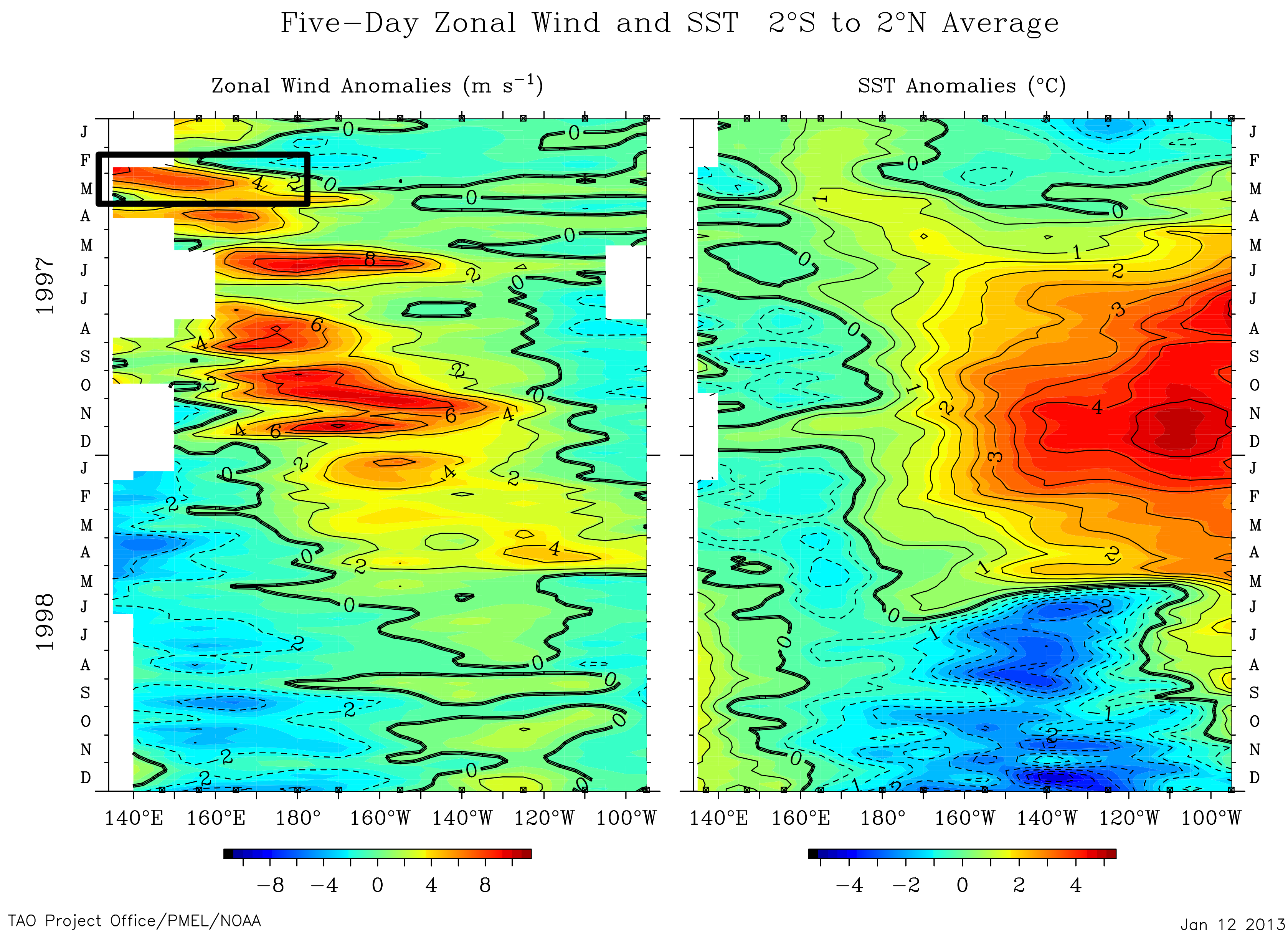
Is this mechanism a precursors only for Central Pacific events?

What is its efficiency?

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

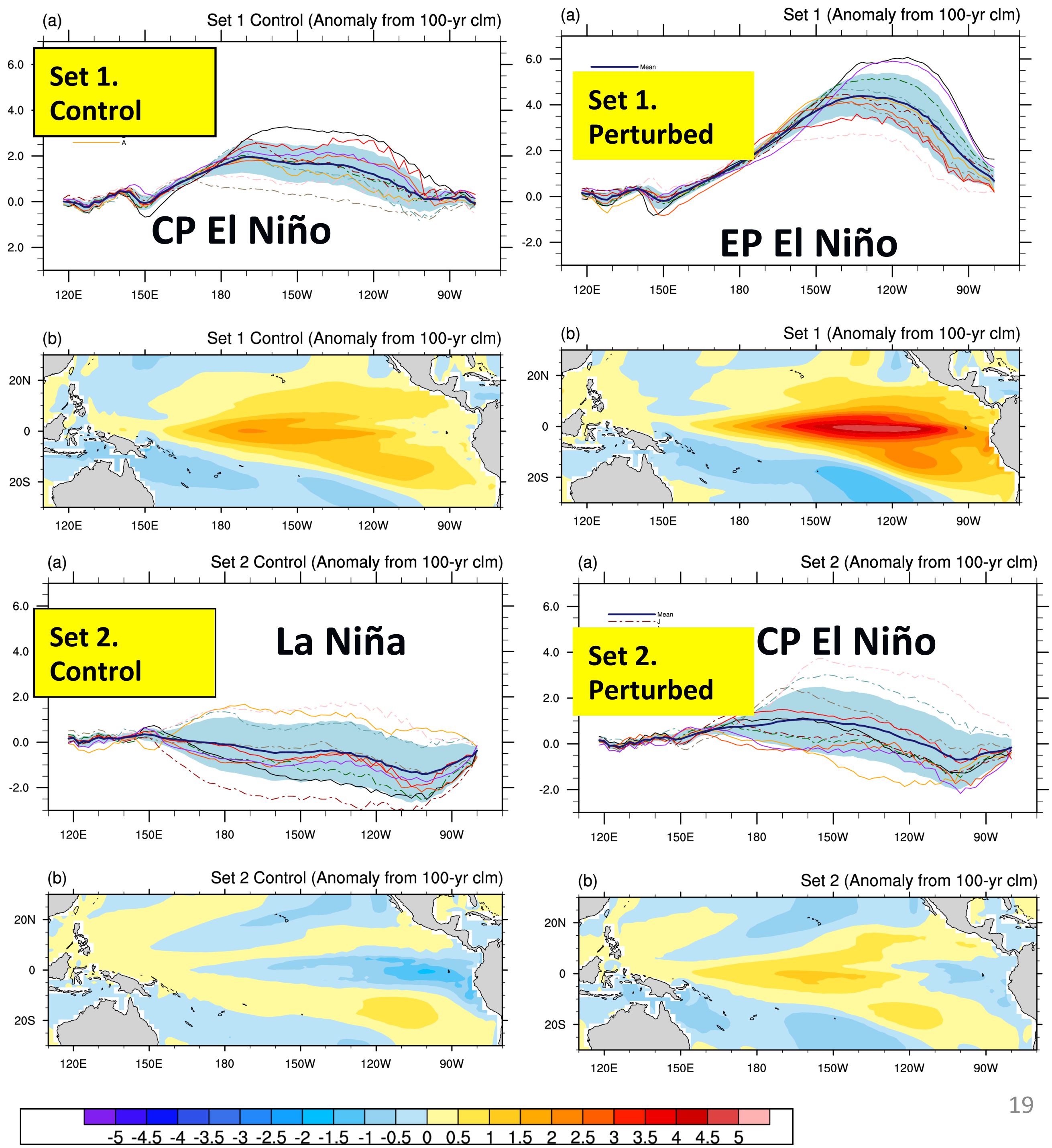
What is the role of the oceanic backgound state? (Anderson 2007)

Westerly Wind Burst (WWB) in Feb-Mar 1997, preceding El Niño



Events at their peak (SST along the equator)

Fedorov et al. (2014)



Activities to date

1. Conference calls to discuss aspects of ENSO Diversity, included presentations

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.

Publications to date

- Workshop report
- Summer 2013 issue of US CLIVAR Newsletter *Variations*
- BAMS article (in revision)

Future activities

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."*

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.

Deliverables

- BAMS article
- Climate Dynamics special collections
- ENSO diversity metrics and recommendation to the modeling community, also input to International CLIVAR

These products and achievements will establish the WG legacy

Conclusions

It is important to continue systematically examining observational data sets, reanalysis, paleoclimate records and climate model simulations to improve our understanding of the origin of ENSO diversity and its predictability

Sustained and enhanced observations are imperative for more reliable ENSO monitoring and prediction in a changing climate

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