ENSO Diversity Working Group

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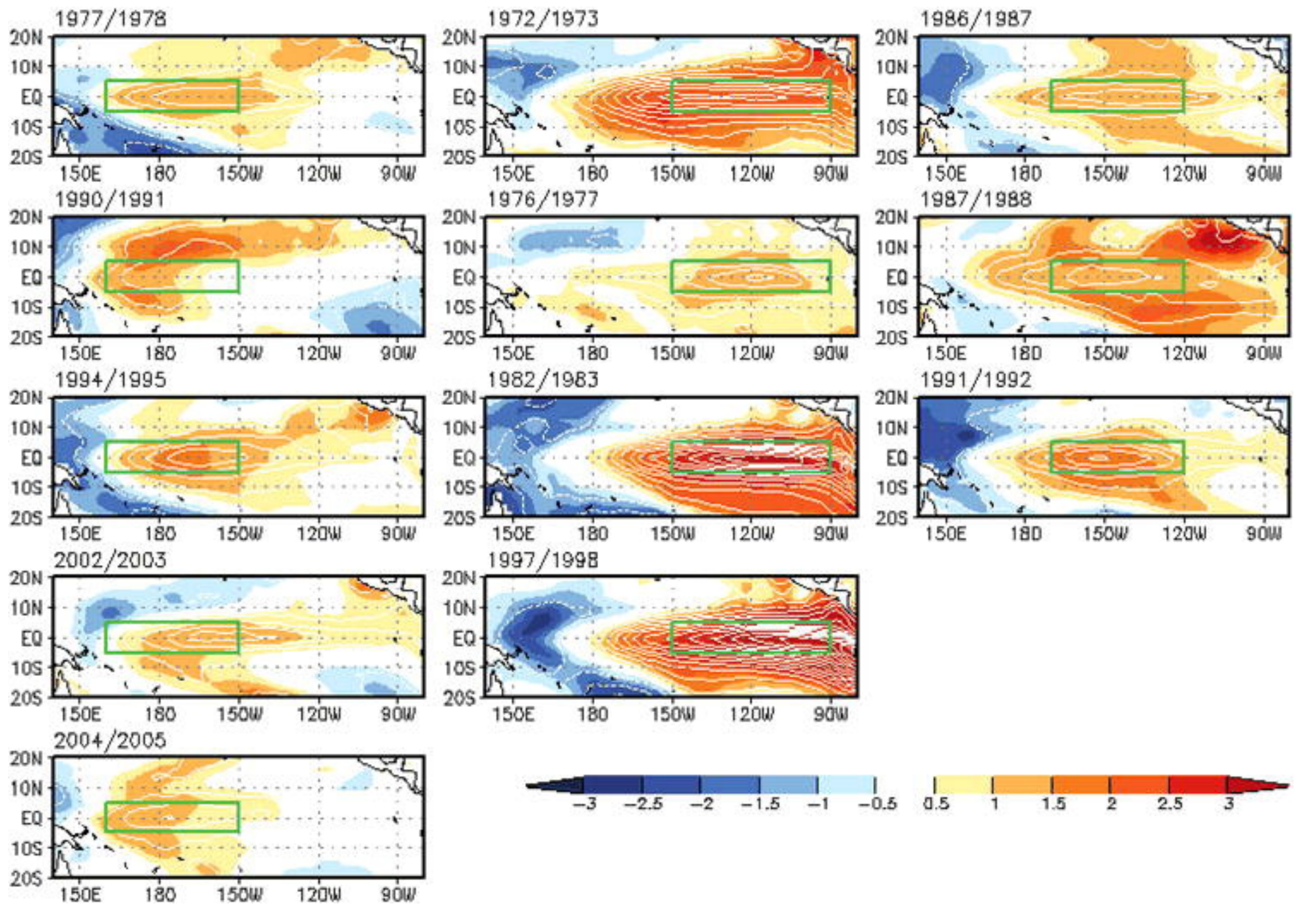
What do we mean with ENSO diversity?

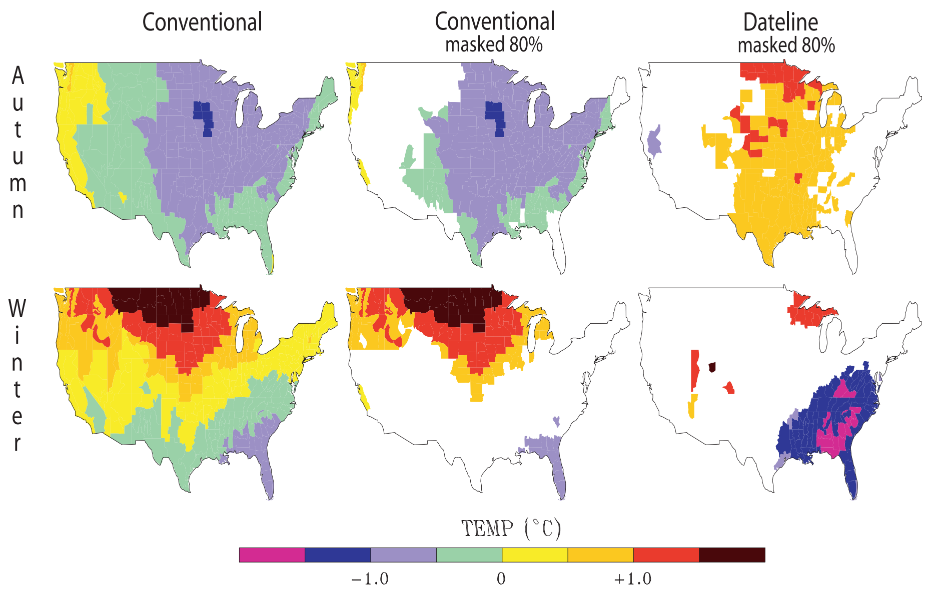
Warm pool (WP) | Cold Tongue (CT) | Others



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

Why is ENSO diversity important?



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

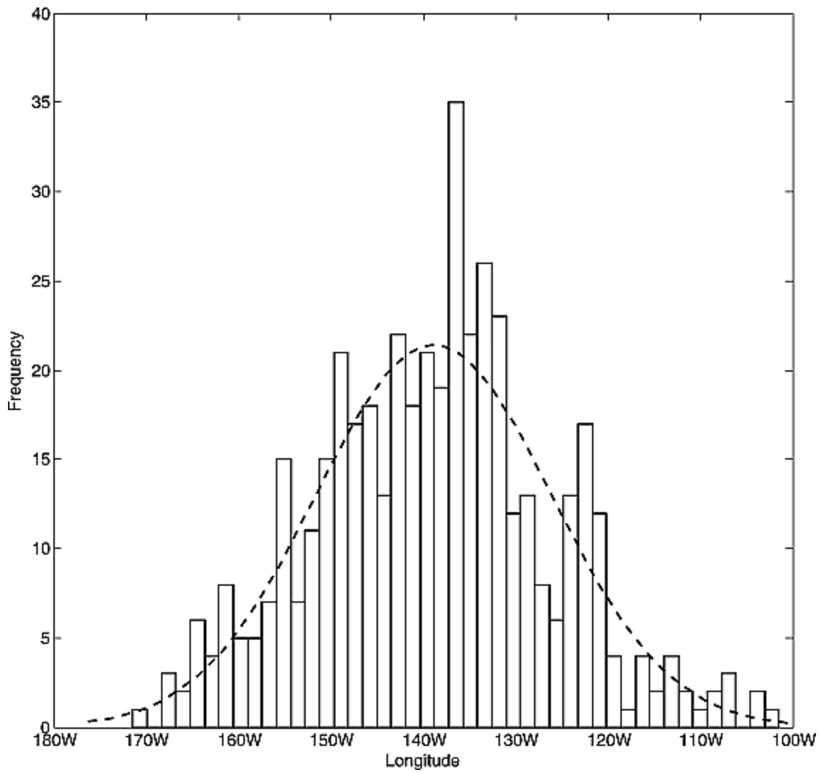
Are there two El Niño types, as assumed by most of the earlier studies ……… or rather a continuum of flavors?

Choosing specific indices to identify events creates the dicothomy

Center of Heat Index (CHI, Giese and 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)



Frequency

Longitude

Giese and Ray 2011

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.

Specific plans

During its first year, the WG is charged with establishing the ability of "observational" data sets to reveal a range of ENSO types, and the ability of models to simulate the types revealed. "Observational" data sets will include reconstructions (HadISST, NOAA-ERSST), reanalysis, paleoclimate.

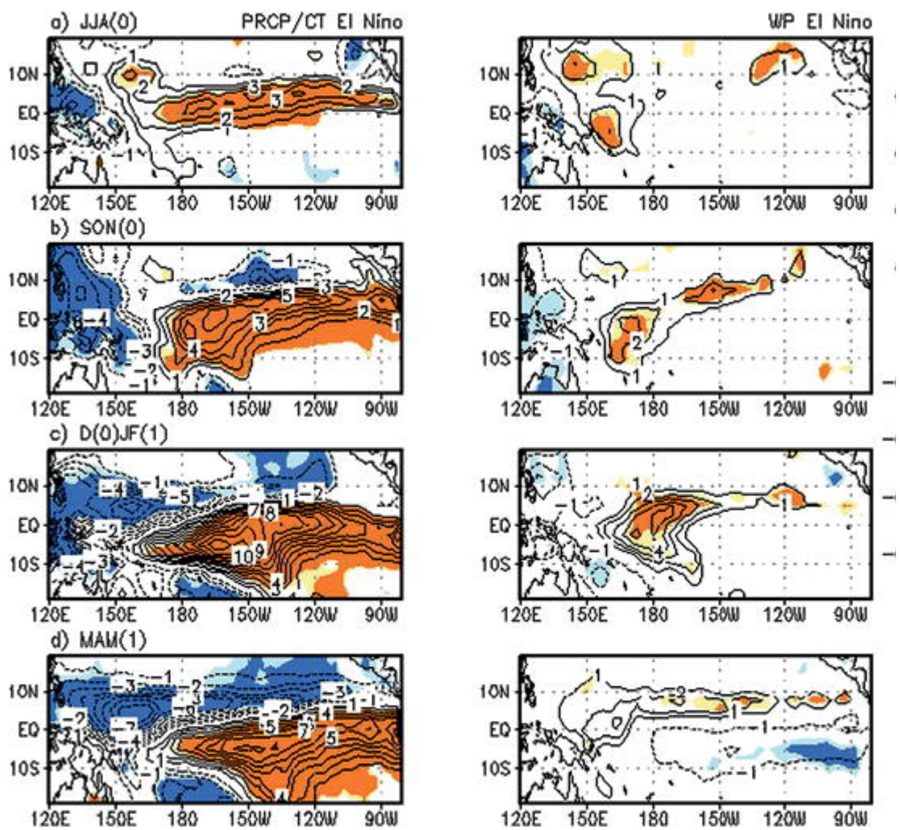
A community workshop is being planned for fall 2012 to review the

- representation of ENSO diversity in observational data sets,
- model analyses of ENSO diversity and basic characteristics of different ENSO types, and
- extra-tropical influences on ENSO diversity, and remote impacts of different ENSO flavors

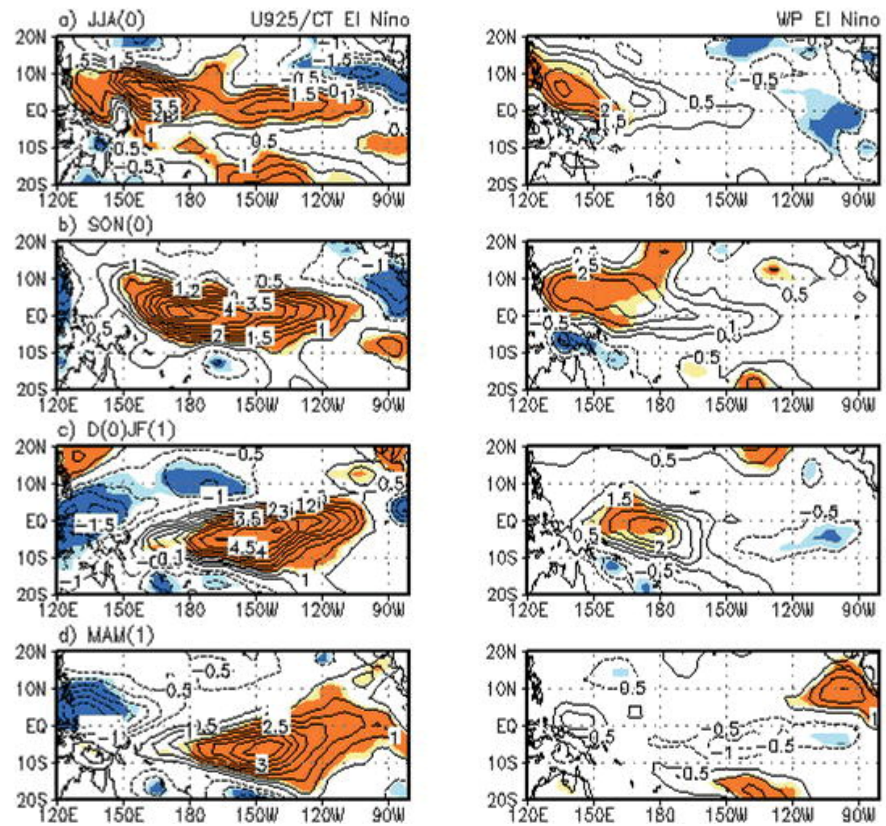
AGU Fall Meeting session: **OS040: The El Nino – Southern Oscillation Continuum**
Conveners: Di Nezio, Capotondi, Kirtman, Newman

What do we know from observations?

Precipitation, CPC –CMAP (1981-2001)



Zonal wind stress, NCEP-NCAR reanalysis



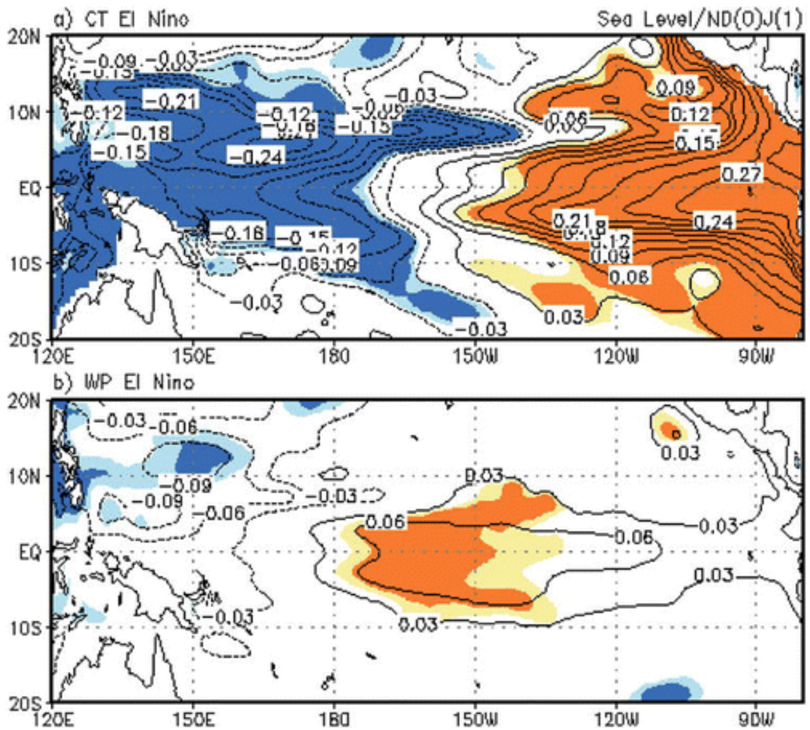
Kug et al. 2009: "Two types of El Niño: Cold Tongue El Niño and Warm Pool El Niño"

What do we know from observations? dynamical processes

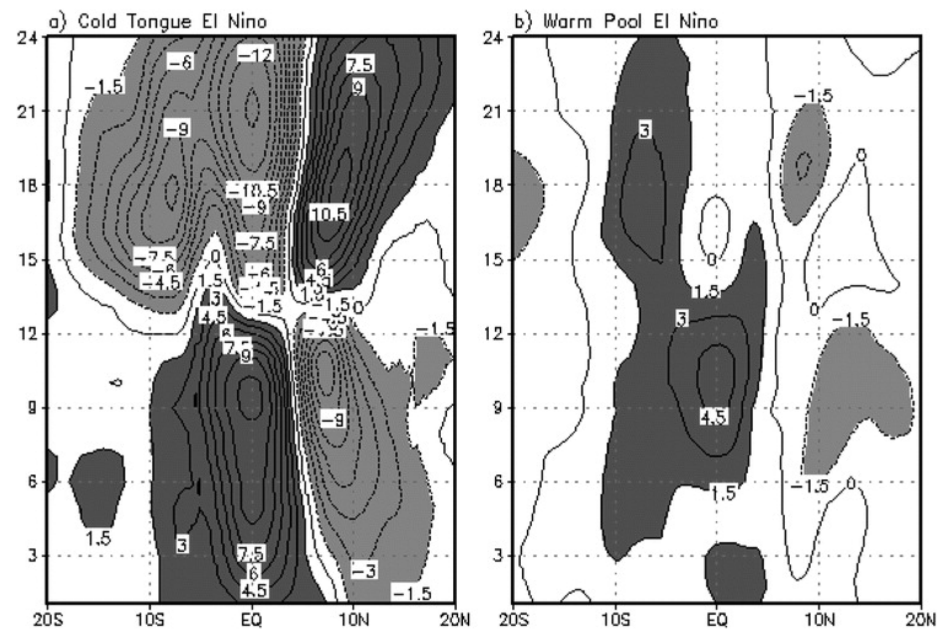
Sea level, GODAS, 1980-2005

CT

WP



Sea level (proxy for thermocline depth) evolution



Kug et al. 2009

Composite CM2.1 events (NDJ anomalies)

SST

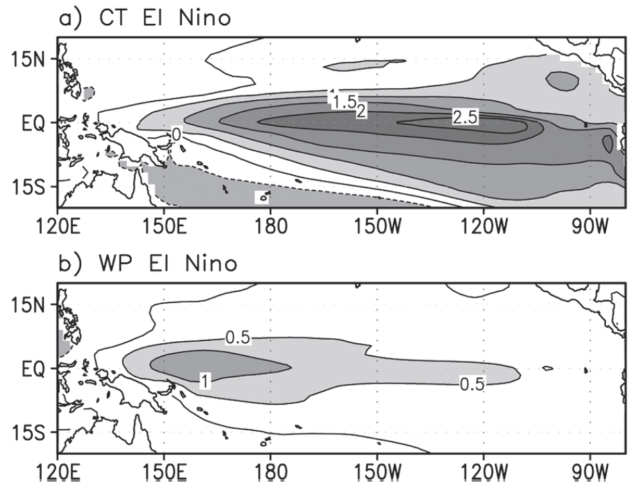


FIG. 3. SST anomaly (°C) composite of the (a) CT El Niño and (b) WP El Niño during ND(0)J(1).

precip

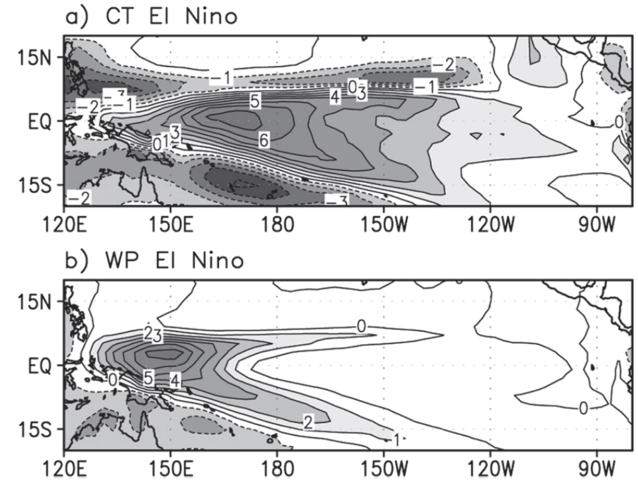


FIG. 4. As in Fig. 3, except for precipitation (mm day^{-1}).

zonal wind (925mb)

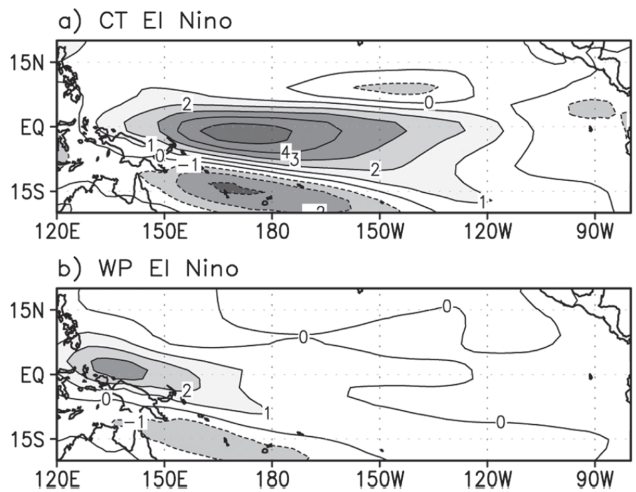


FIG. 5. As in Fig. 3, except for zonal wind at 925 hPa (m s^{-1}).

heat content (top 300m)

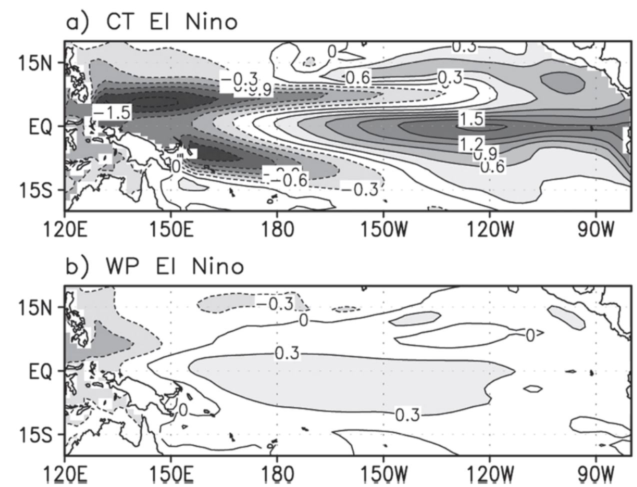
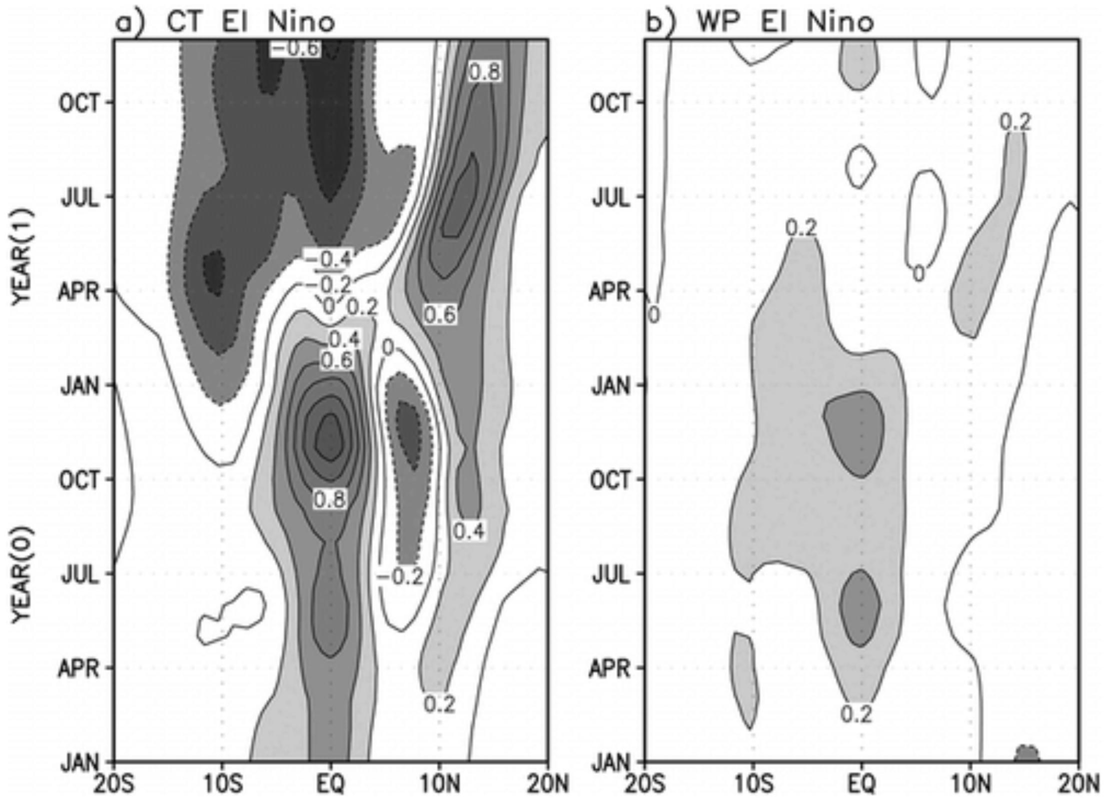


FIG. 6. As in Fig. 3, except for heat content (K).

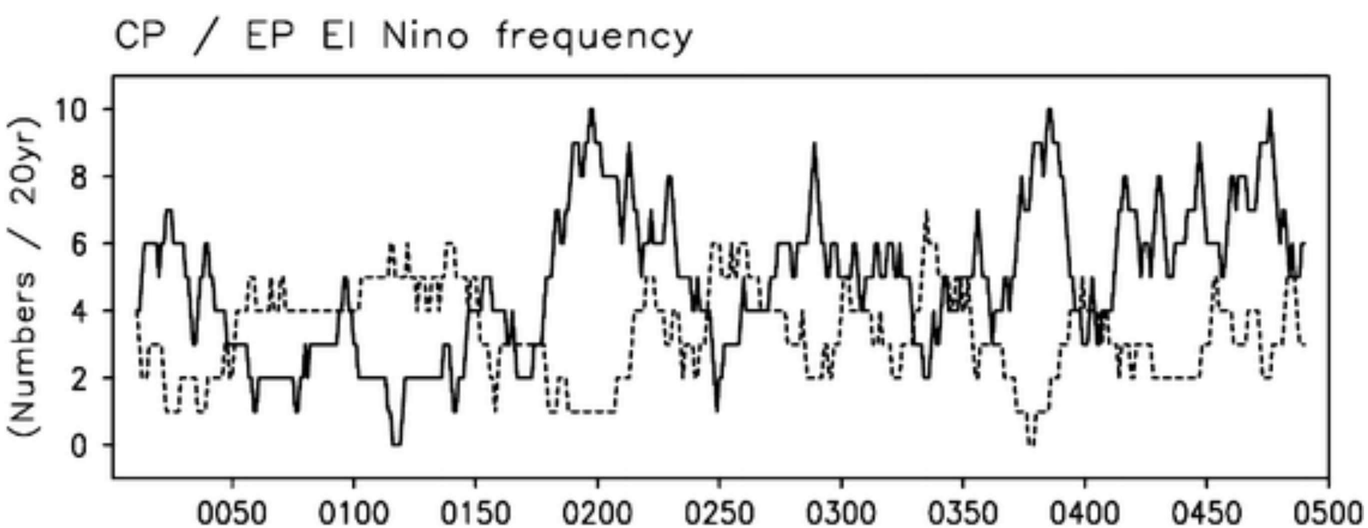
Kug et al. (JC 2010)

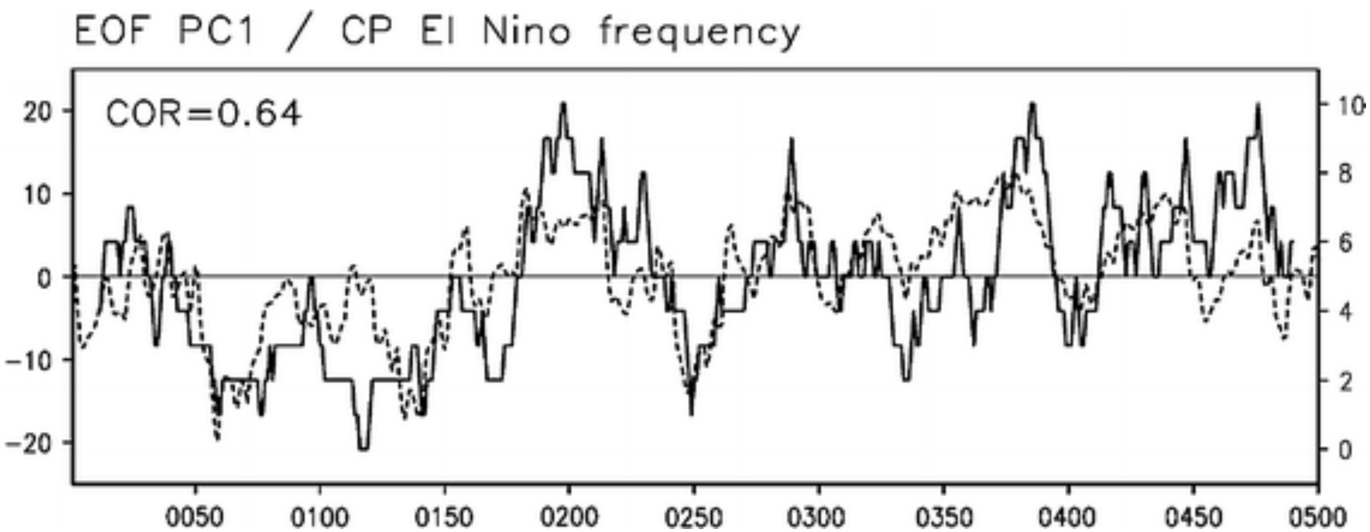
What do models show? GFDL_CM2.1 Evolution of thermocline depth



Kug et al. (JC 2010)

Decadal modulation in the frequency of WP events (GFDL_CM2.1)





Solid line: Number of WP events in 20-yrs sliding window

Dashed line: Number of CT events

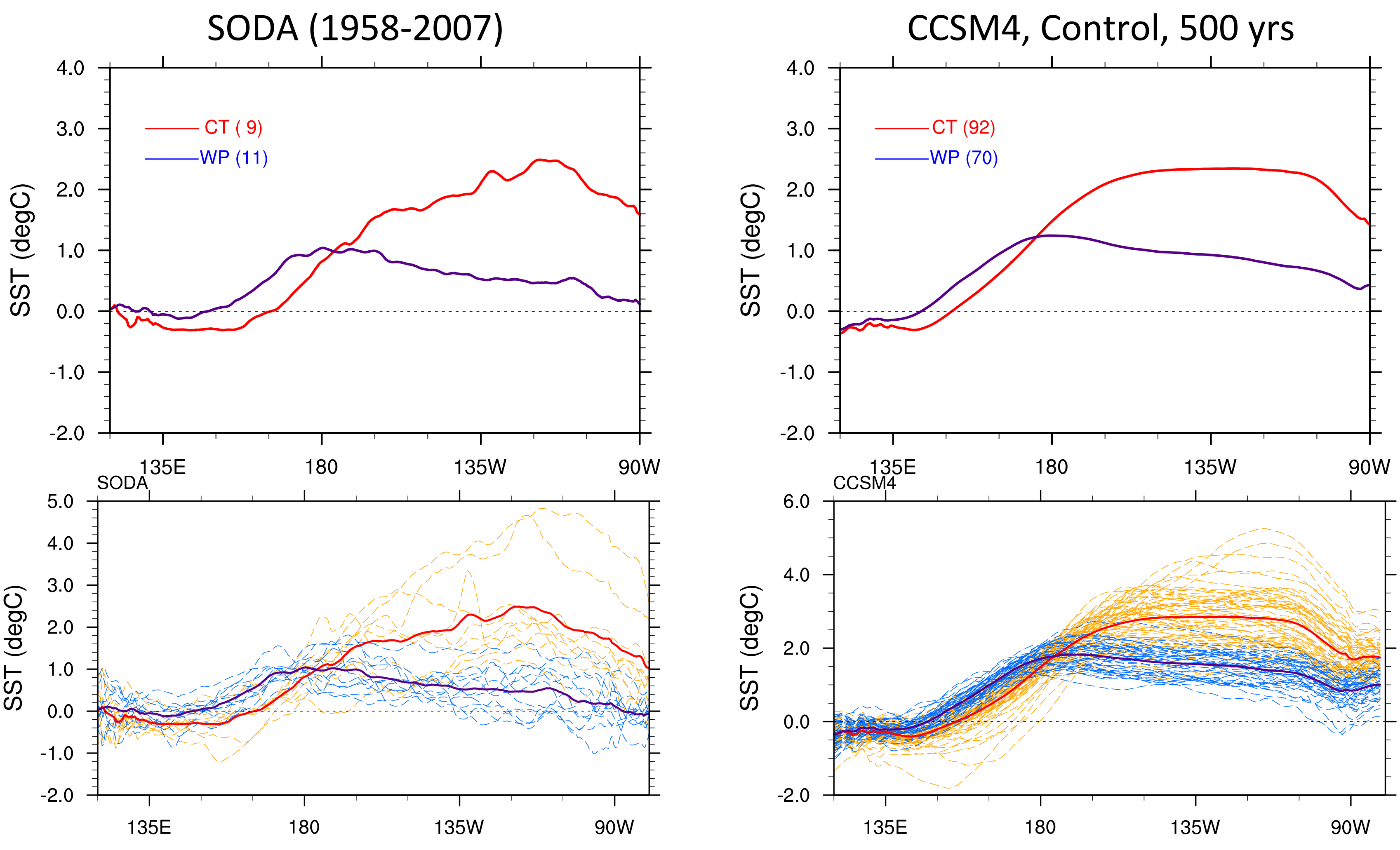
Corr. Coeff.=-0.65

WP no.=121
CT no. =84

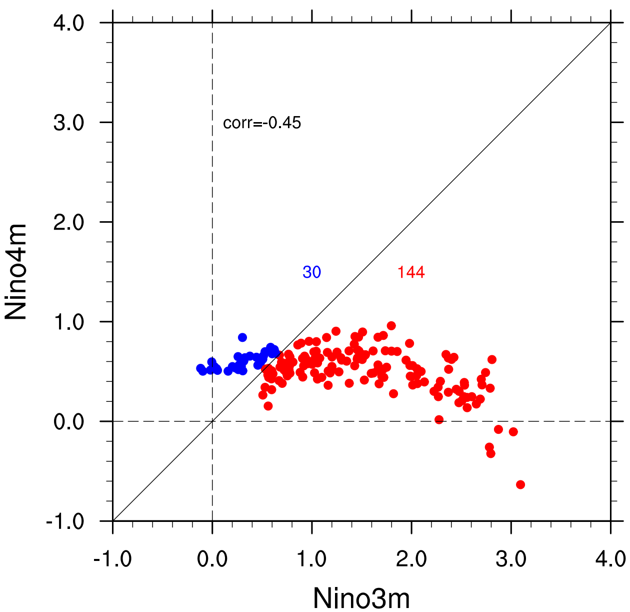
Choi et al. , *Climate Dyn*. 2011

NCAR-CCSM4

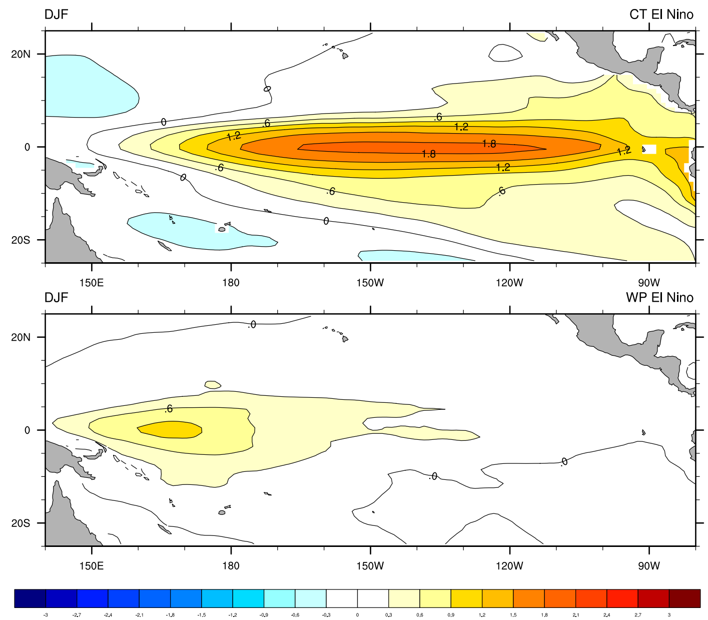
Standard Niño3 and Niño4 indices



(CCSM4 - Modified Niño3 and Niño4 indices
(centers of Niño3 and Niño4 regions displaced 20° westward)



SST spatial patterns



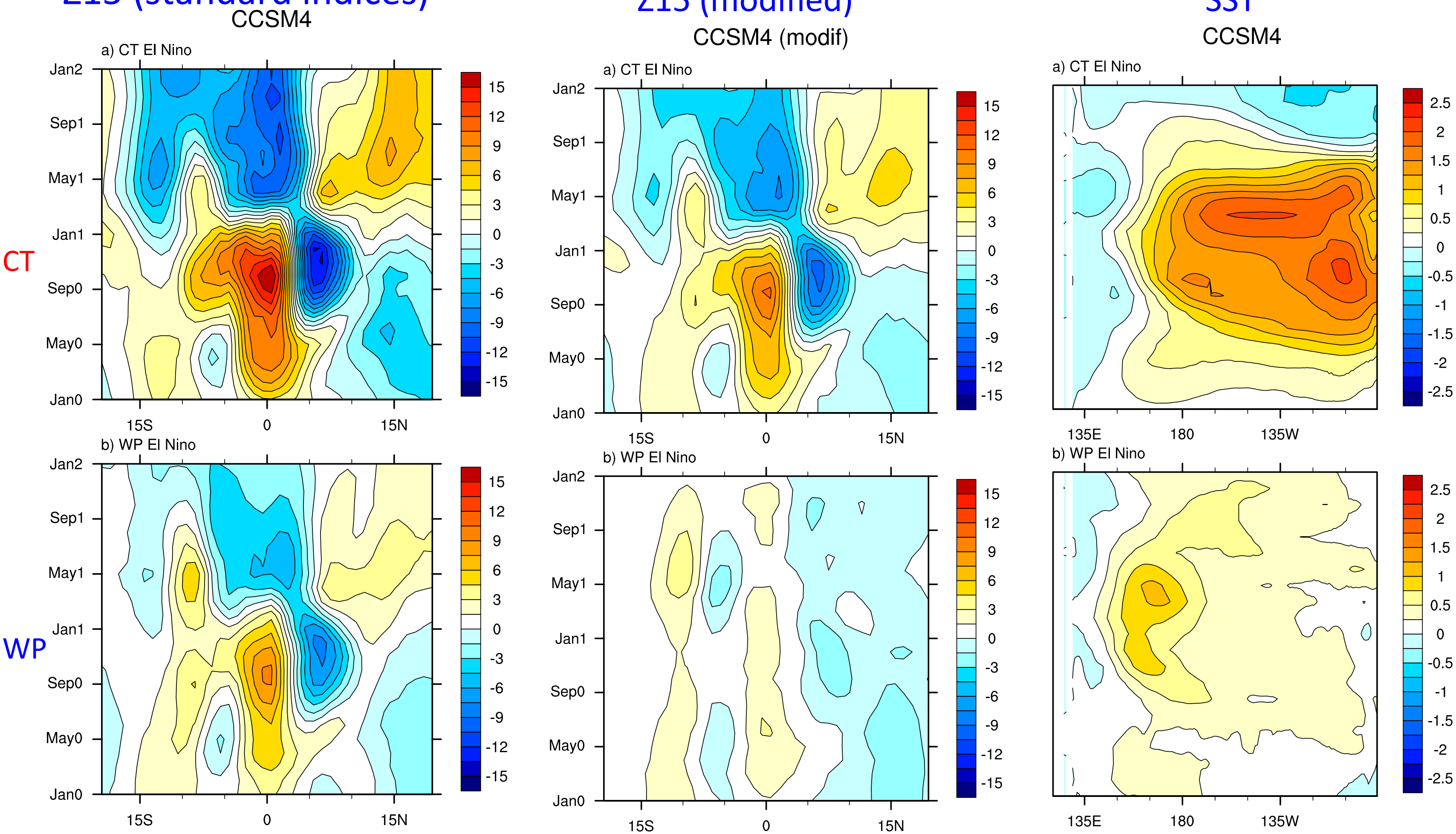
CTm

WPm

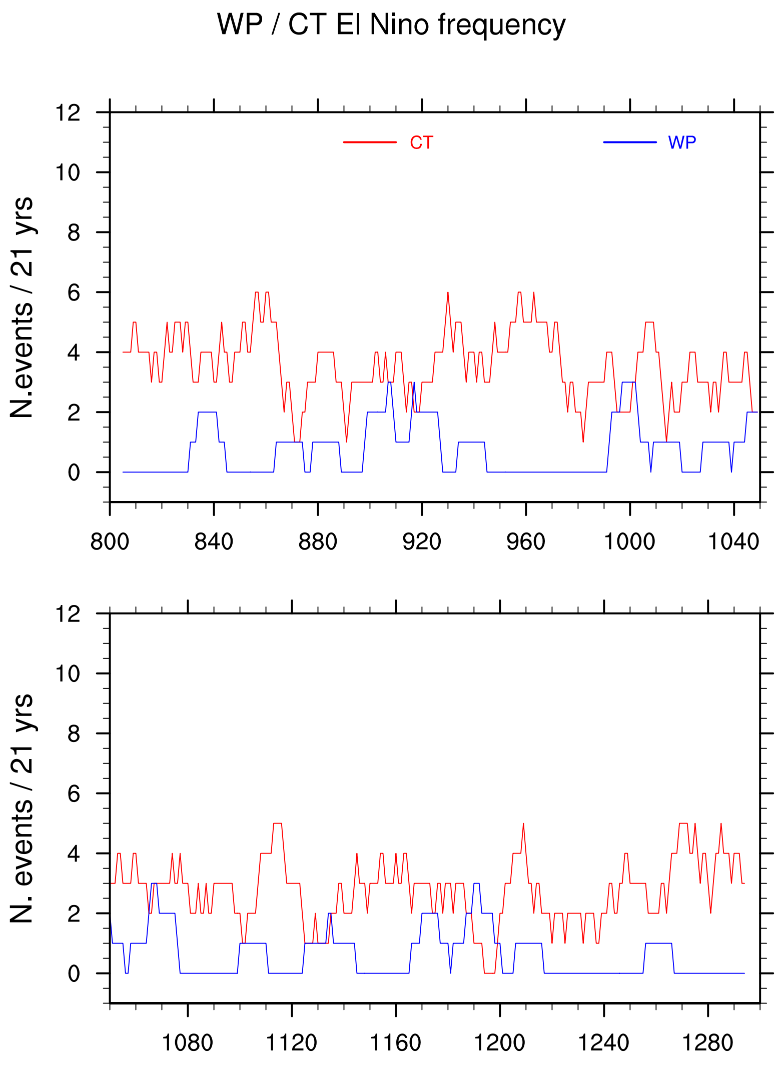
NCAR-CCSM4

Evolution of thermocline depth (Z15)

Z15 (standard indices) | Z15 (modified) | SST



Decadal modulation of event frequency (CCSM4)



Corr. Coeff.=-0.29

WP events = 30

CT events = 144

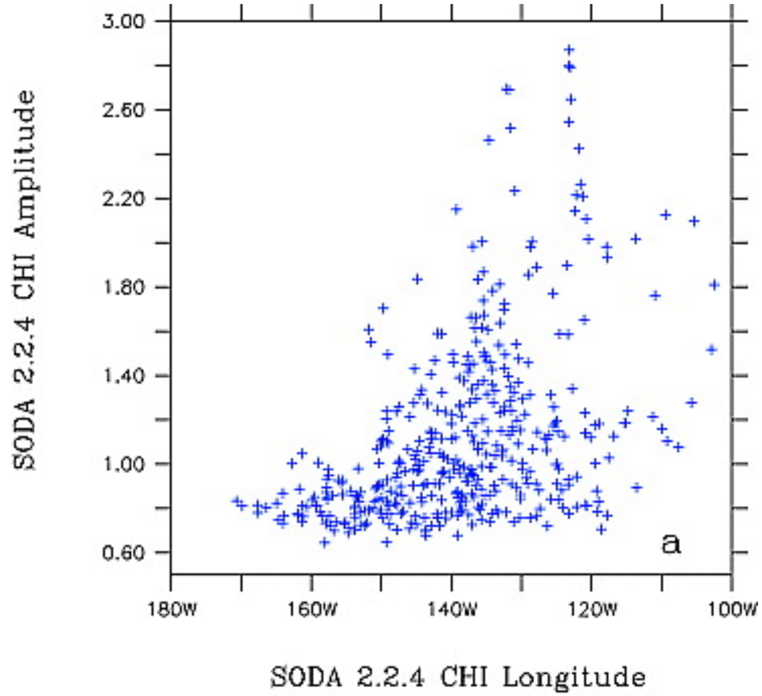
Conclusions

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

Extras



CHI amplitude

CHI longitude

CM2.1 SSTA tendency terms

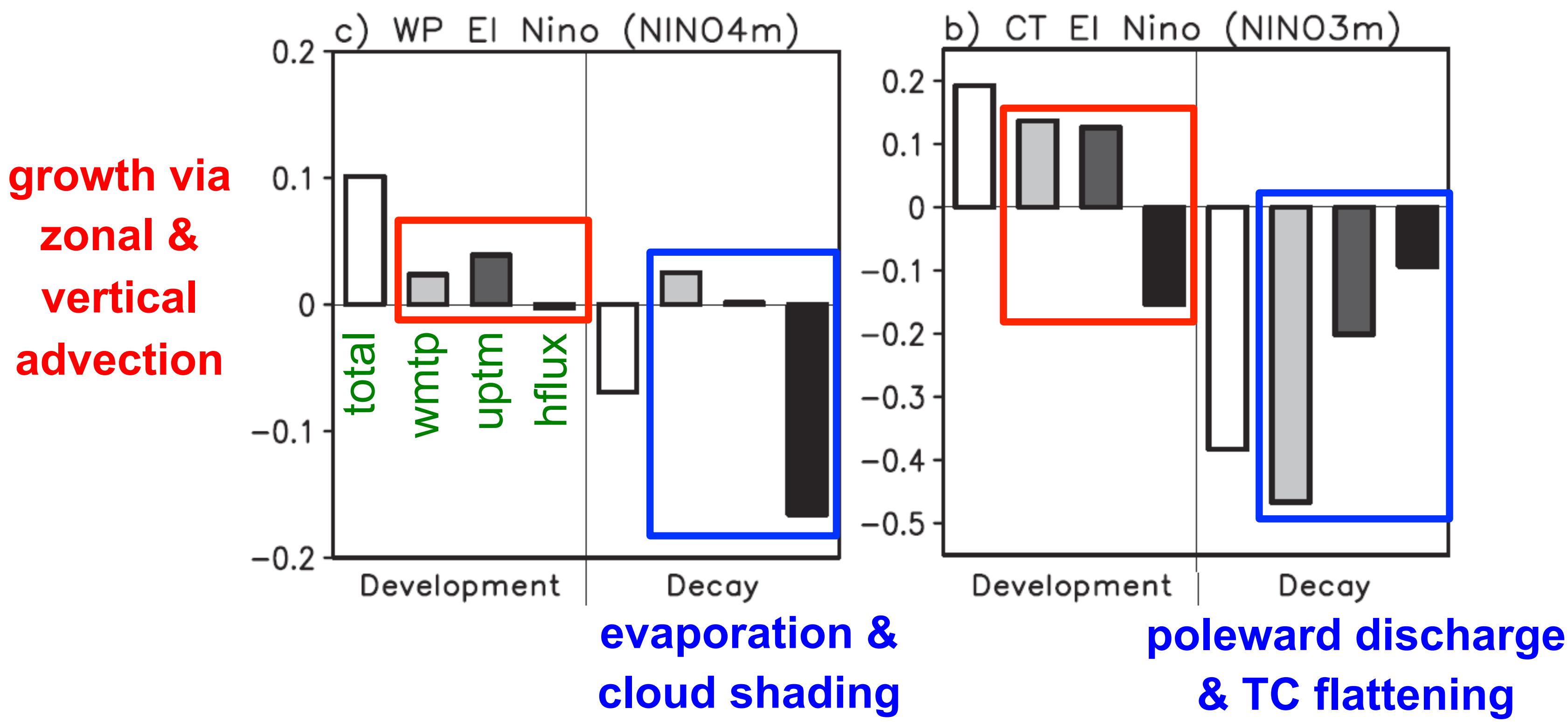


FIG. 11. SST tendency (open bar), SST tendency according to the thermocline feedback (light-gray bar), the zonal advective feedback (dark-gray bar), and net flux (black bar) for (a),(b) CT El Niño and (c),(d) WP El Niño (K month^{-1}). Each magnitude is calculated over 2°S–2°N, 170°–110°W [(b),(d) Niño-3m region] or 2°S–2°N, 140°E–170°W [(a),(c) Niño-4m region]. Period of development (decay) is defined from March (0) to November (0) [from February (1) to October (1)].

Kug et al. (JC 2010)