SEA SURFACE TEMPERATURE ANOMALIES OFF BAJA CALIFORNIA:

A POSSIBLE TRIGGER FOR ENSO

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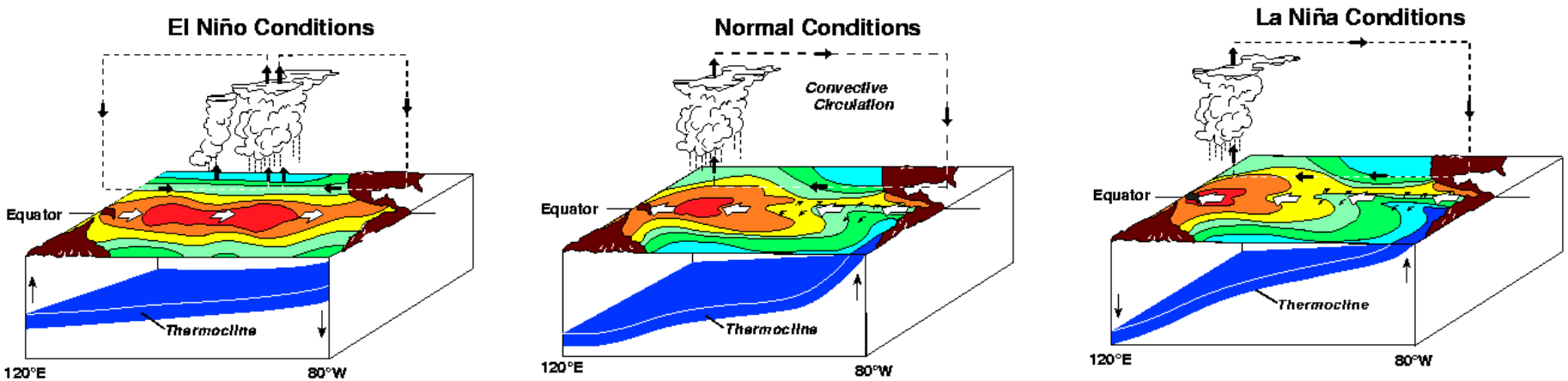
OUTLINE

- El Nino and Southern Oscillations (ENSOs)
- ENSO Index
- “Footprints” of ENSOs
- Triggering of Central Pacific ENSO

ENSO – DESCRIPTIVE VIEW

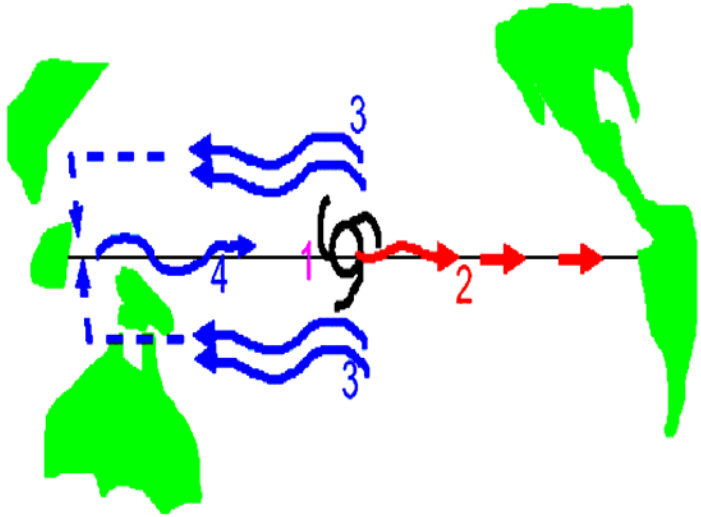
• El Niño-Southern Oscillation (ENSO) is a quasi-periodic climate phenomenon of an abnormal warming and/or cooling of surface ocean waters in the eastern tropical Pacific. ENSO owe its existence to coupled ocean-atmosphere interaction and typically has a varying period of 2-7years.

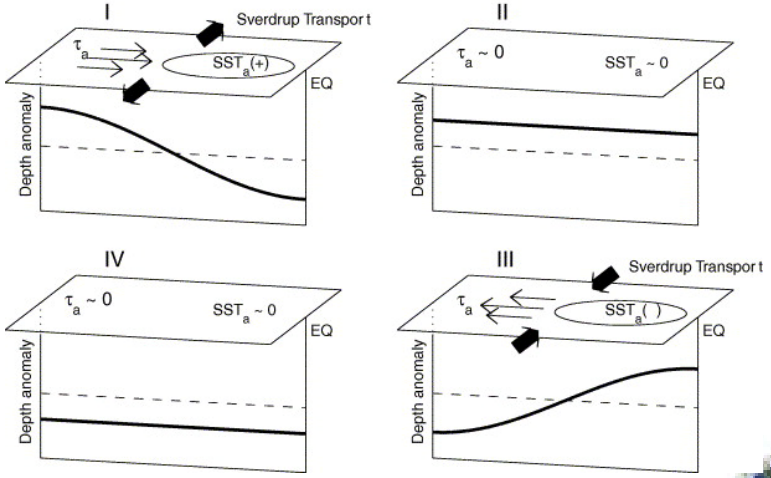


ENSO AS A SLEF-SUSTAINED OSCILLATOR

- The delayed oscillator theory (e.g., *Schopf and Suarez* 1988; *Suarez and Schopf* 1988; and *Battisti and Hirst* 1988) was proposed during the Tropical Ocean-Global Atmosphere (TOGA) program.

- The recharge-discharge oscillator (*Jin* 1997a and b) indicated that the equatorial heat content results in oscillating coupled system.

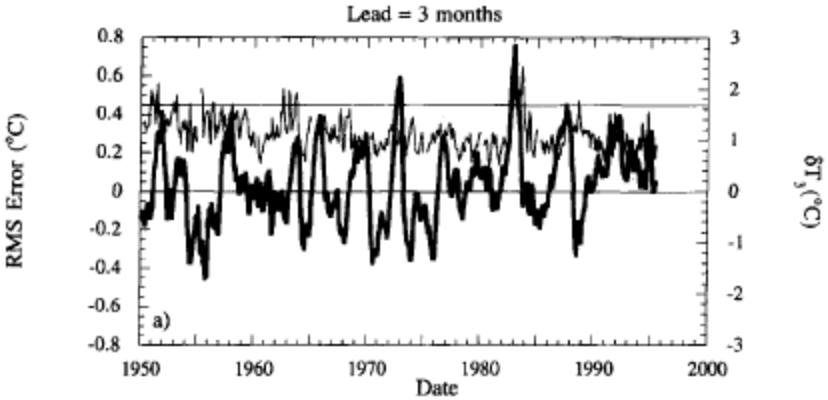


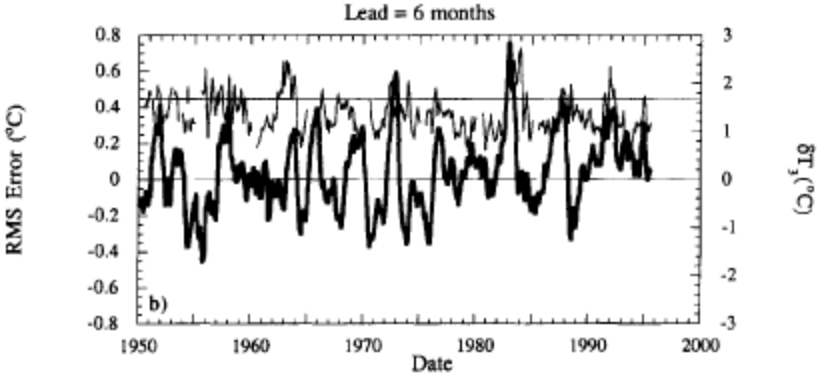


ENSO AS A STOCHASTICALLY DRIVEN OSCILLATOR

- ENSO sea surface temperature anomalies (SSTAs) can be represented as a stable linear process driven by spatially coherent stochastic forcing (Xue et al. 1994, Penlend 1996, Thompson and Battisti 2000).

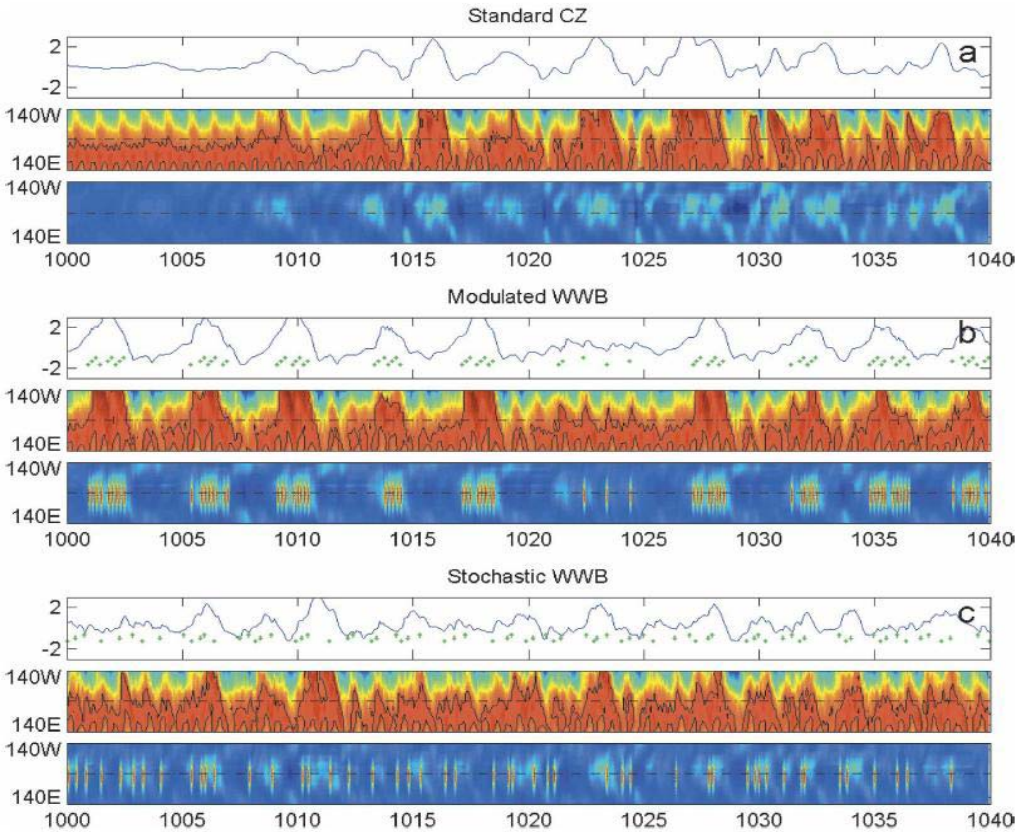
$$\frac{dT_a(x,y,t)}{dt} = \mathbf{B}(x,y)T_a(x,y,t) + \mathbf{S}(x,y)w(t)$$





ENSO TRIGGERED BY WEST WIND BURST

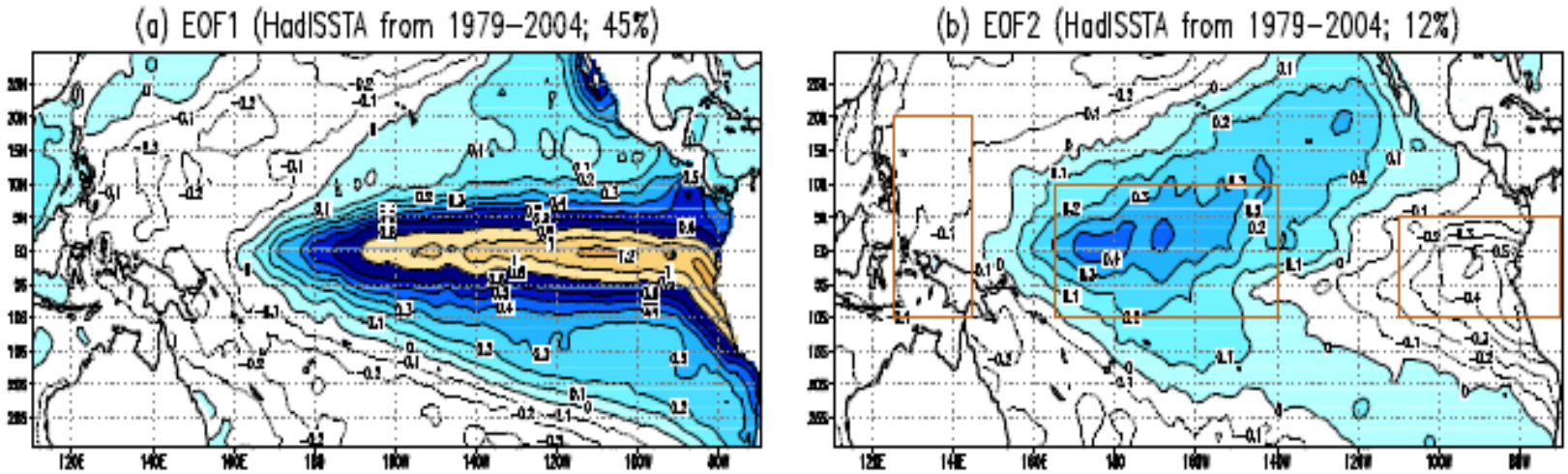
- It is observable in buoy data that westerly wind bursts (WWBs) on synoptic scale cause downwelling Kelvin waves that propagate eastward. WWBs are believed to be involved with the onset of El Niño events (e.g., *Kerr* 1987; *McPhaden et al.* 1988; *Lengaigne et al*. 2004, Tziperman et al. 2007).



ENSO DIVERSITY

- More recently, a new type of ENSO has been frequently observed, which is called ENSO Modoki[1] (*Ashok et al*. 2007), Central Pacific (CP) El Niño (*Kao and Yu* 2009), or Dateline El Niño (*Larkin and Harrison* 2005).

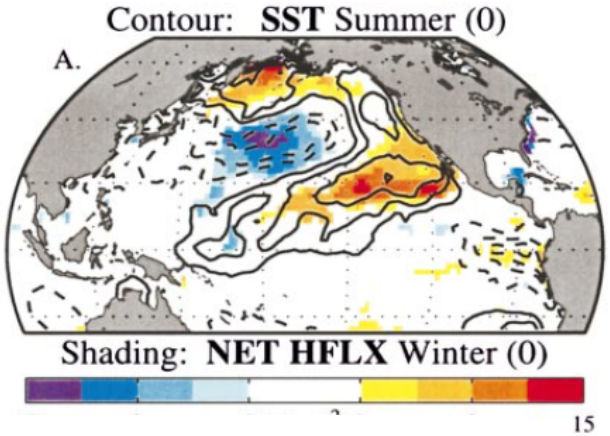
- In a CP ENSO event, the initial SST anomalies arise in central Pacific near the dateline instead of the South America coast.



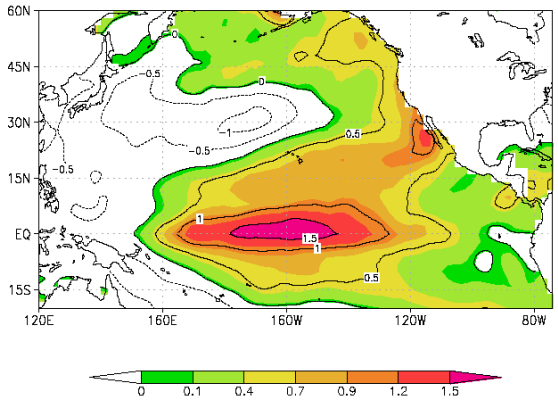
Ashok et al. 2007

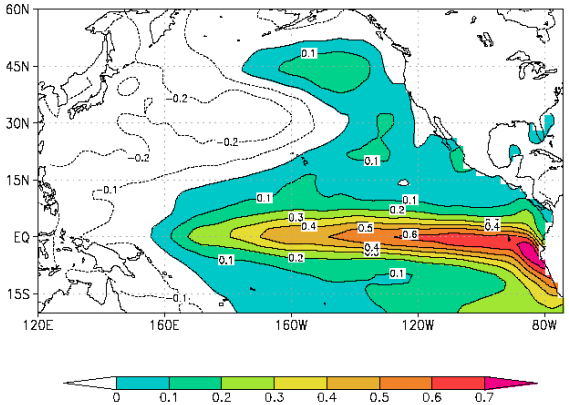
[1] “Modoki” is a classical Japanese word which means “similar but different”.

ENSO TROPICAL - HIGH LATITUDE CONNECTION



Vimont et al. 2001, 2003.



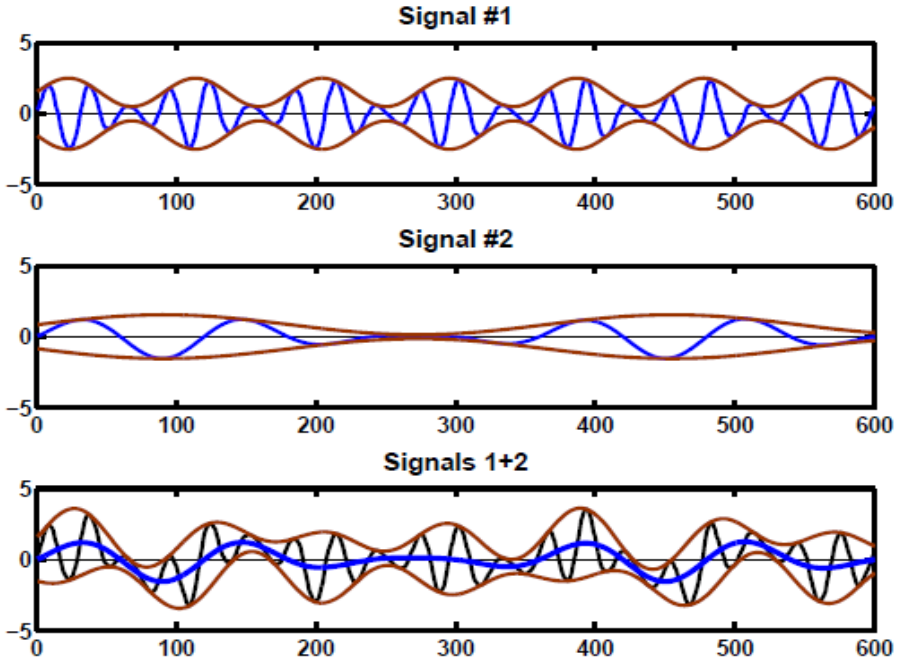


DATA

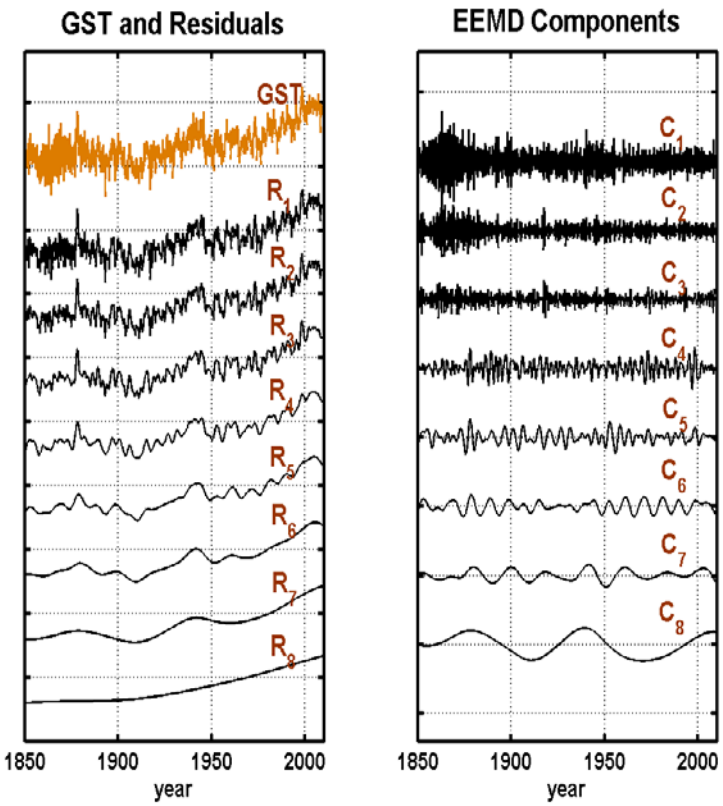
- Monthly analysis of the Extended Reconstructed Sea Surface Temperature version 3b dataset (ERSST.v3b, Smith et al. 2008) over the tropical Pacific Ocean (120° E–74° W, 30° S–30° N) is analyzed.
- International Comprehensive Ocean-Atmosphere Data Set (ICOADS) release 2.4; statistical methods; Satellite data are not included.
- The dataset has 2° ×2° spatial resolution. Data from January 1880 through December 2009 (130 yr) are used.
- We computed the anomalies by removing the long term mean with respect to the period of 1880–2009.

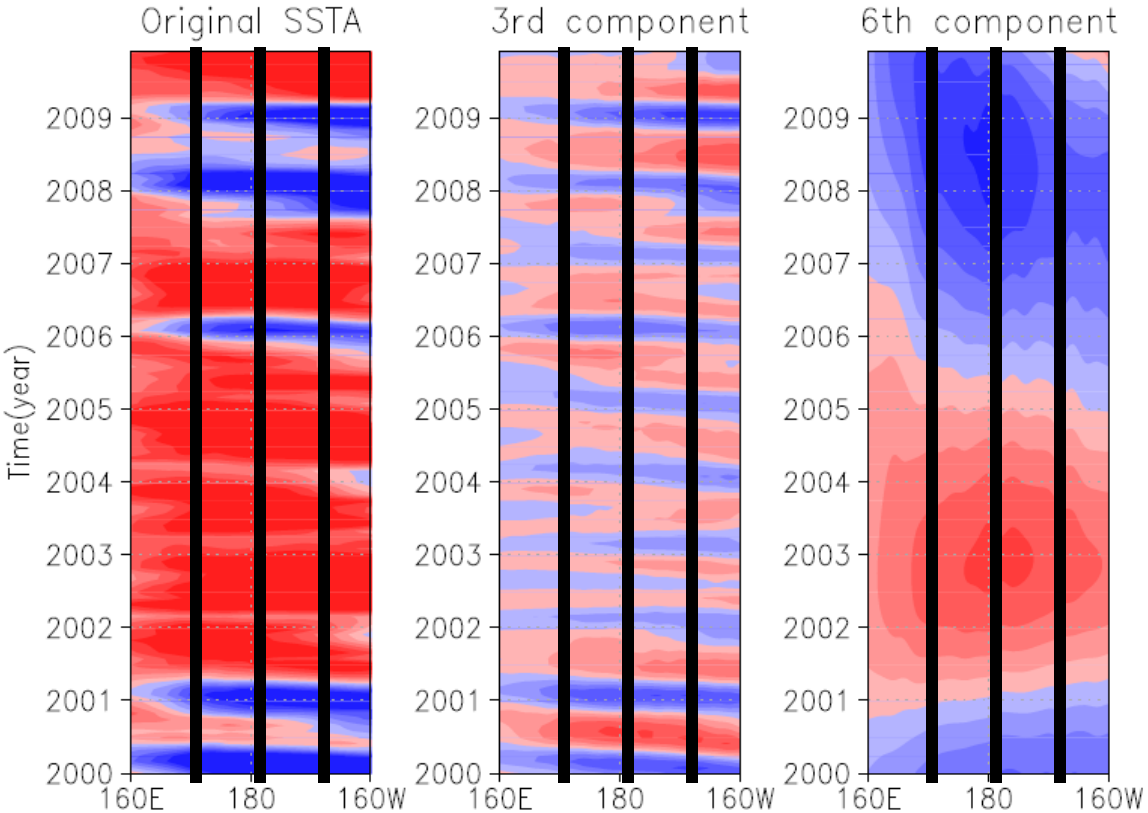
METHOD

- “Natural” waveforms need not be of Fourier (or wavelet, or curvelet, ...) type and should allow amplitude-frequency modulation
- Nevertheless, it can still be useful to decompose signals into more elementary waveforms
- Such a decomposition should be adaptive and local
- Should produce meaningful components
- Should also be robust to noisee period of 1880–2009.



METHODS


GST and Residuals
GST
R1
R2
R3
R4
R5
R6
R7
R8
1850
1900
1950
2000
year
EEMD Components
C1
C2
C3
C4
C5
C6
C7
C8
1850
1900
1950
2000
year

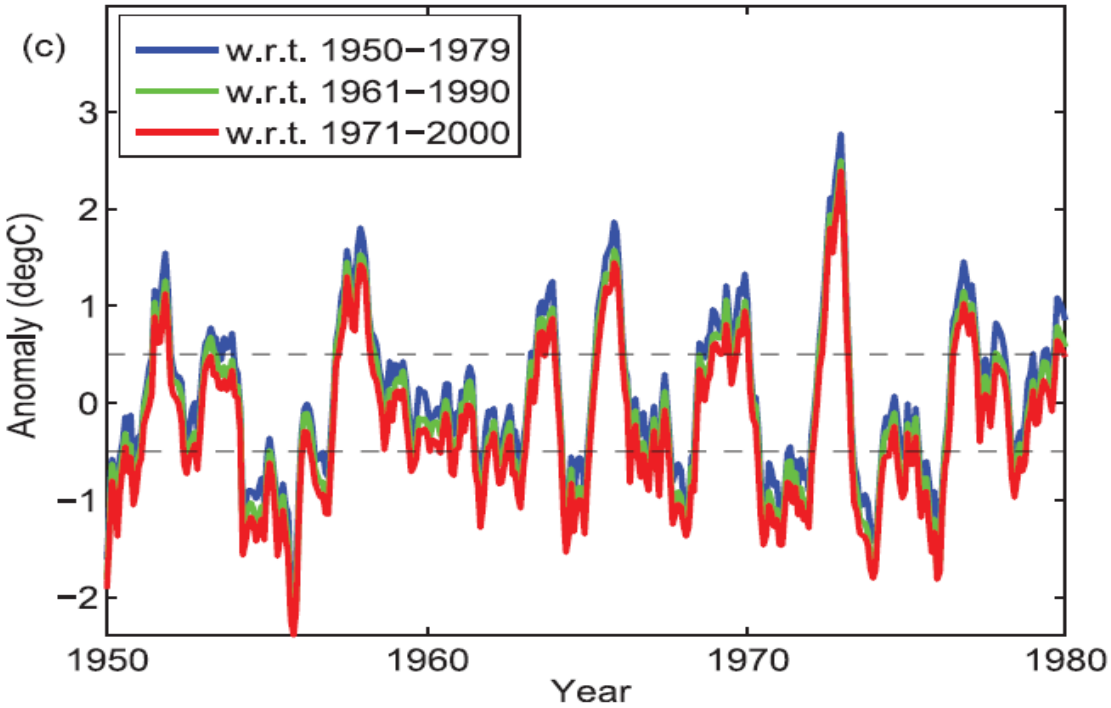

Original SSTA
3rd component
6th component
Time(year)
2009
2008
2007
2006
2005
2004
2003
2002
2001
2000
160E
180
160W

MULTI-DIMENSIONAL ENSEMBLE EMPIRICAL MODE DECOMPOSITION

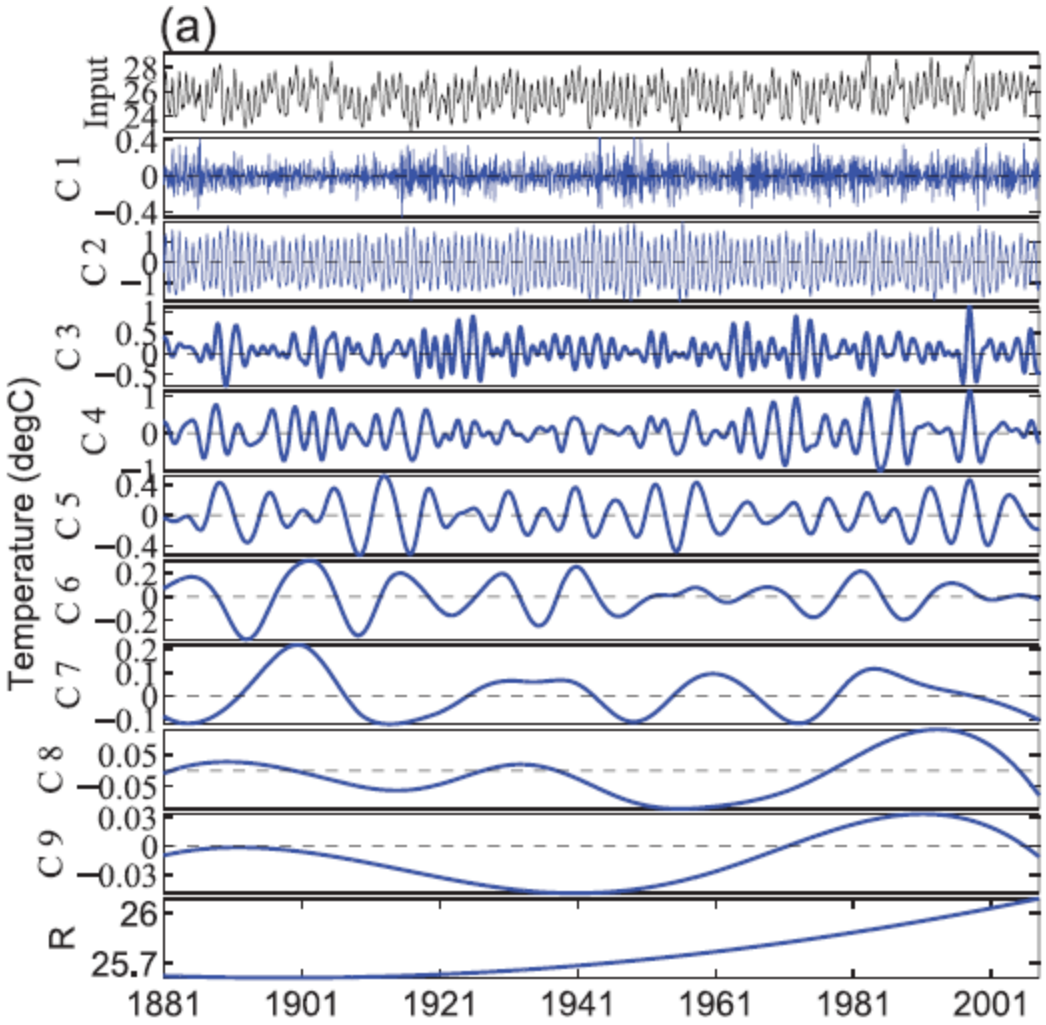
1998	Huang, M. L. Wu, S. R. Long, S. S. Shen, W. D. Qu, P. Gloersen, and K. L. Fan (1998) **The empirical mode decomposition and the Hilbert spectrum for nonlinear and non-stationary time series analysis**. *Proc. Roy. Soc. Lond.*, 454A, 903-993. **Citations: 6694**
2004	Wu, Z., and N. E. Huang (2004) **A study of the characteristics of white noise using the empirical mode decomposition method**. *Proc. Roy. Soc. London*, 460A, 1597-1611. **Citations: 571**
2007	Wu, Z., Huang, N. E, S. R. Long, and C.-K. Peng (2007) **On the trend, detrending, and the variability of nonlinear and non-stationary time series**. *Proc. Natl. Acad. Sci. USA*., 104, 14889-14894. **Citations: 153**
2009	Wu, Z., and N. E Huang (2009) **Ensemble Empirical Mode Decomposition: a noise-assisted data analysis method**. *Advances in Adaptive Data Analysis*. Vol.1, No.1. 1-41. **Citations: 663**
2009	Wu. Z., Huang N. E. and X. Chen (2009) **The Multi-Dimensional Ensemble Empirical Mode Decomposition Method**. *Advance in Adaptive Data Analysis*, Vol. 1, No. 3, 339–372. **Citations: 59**

STATIONARY ENSO INDEX

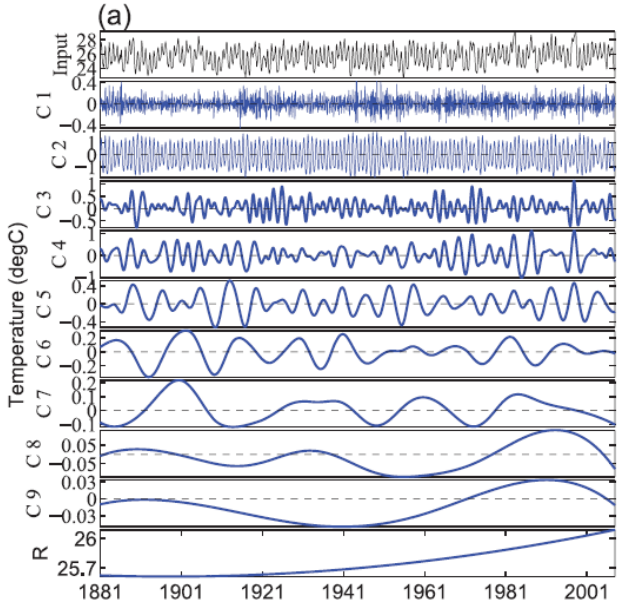
- Some commonly used indices subjectively partition the data into 30-yr base periods, on which the anomalies are calculated.

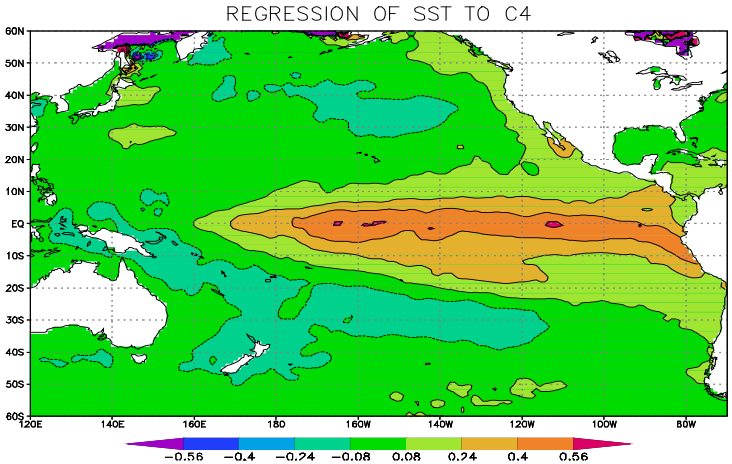


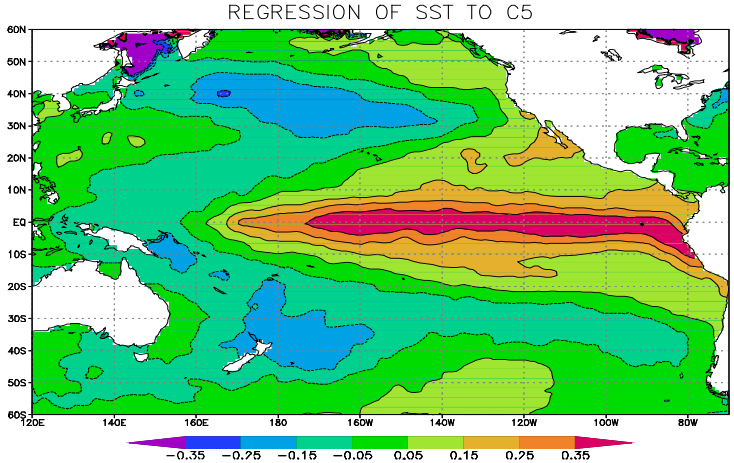
NATURAL COMPONENTS OF SST IN NINO.3 AREA

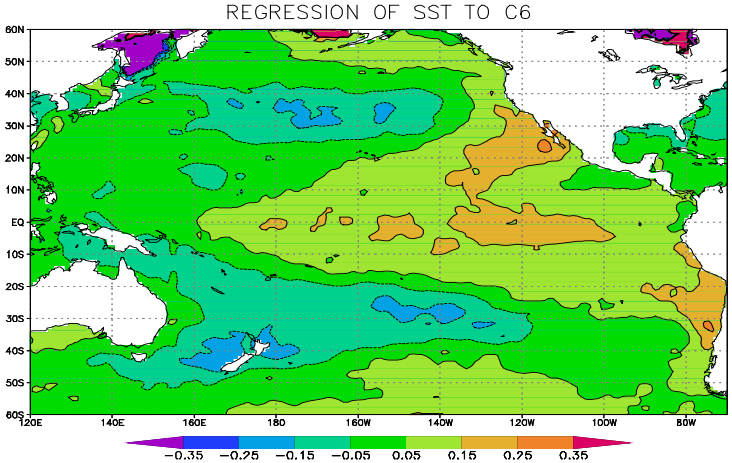


PHYSICAPABILTY









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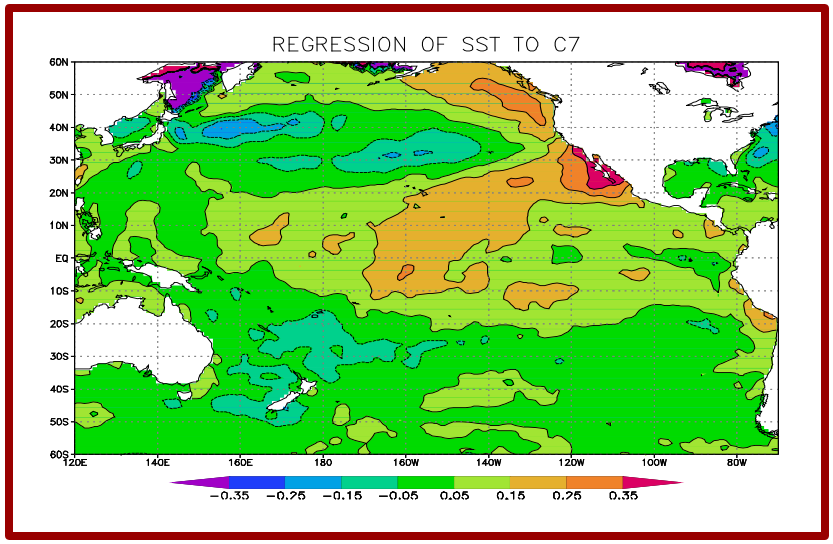
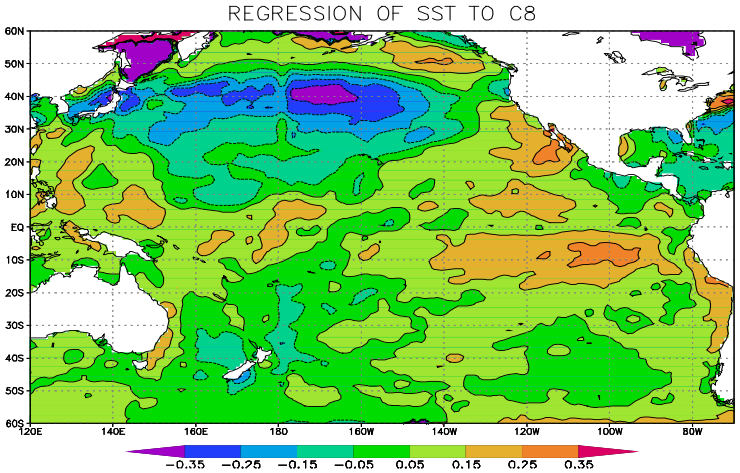
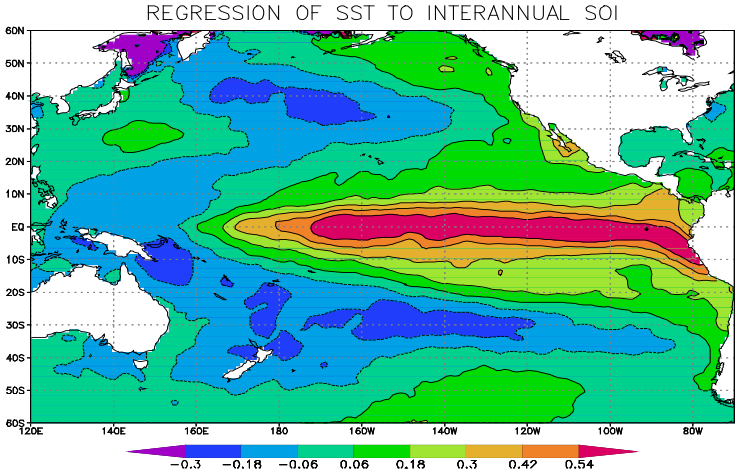
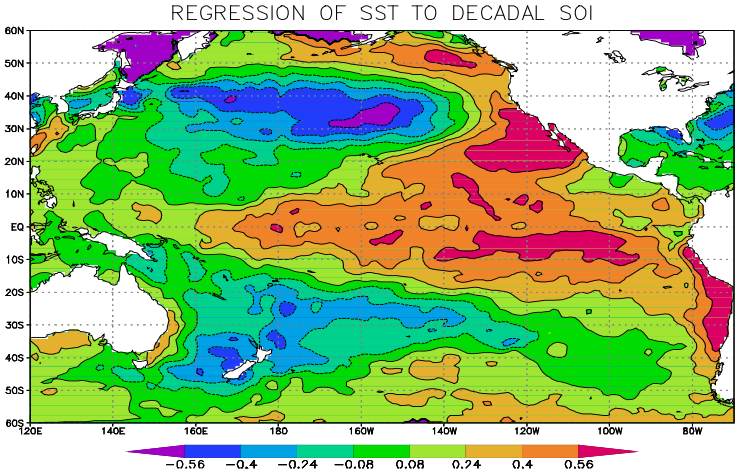
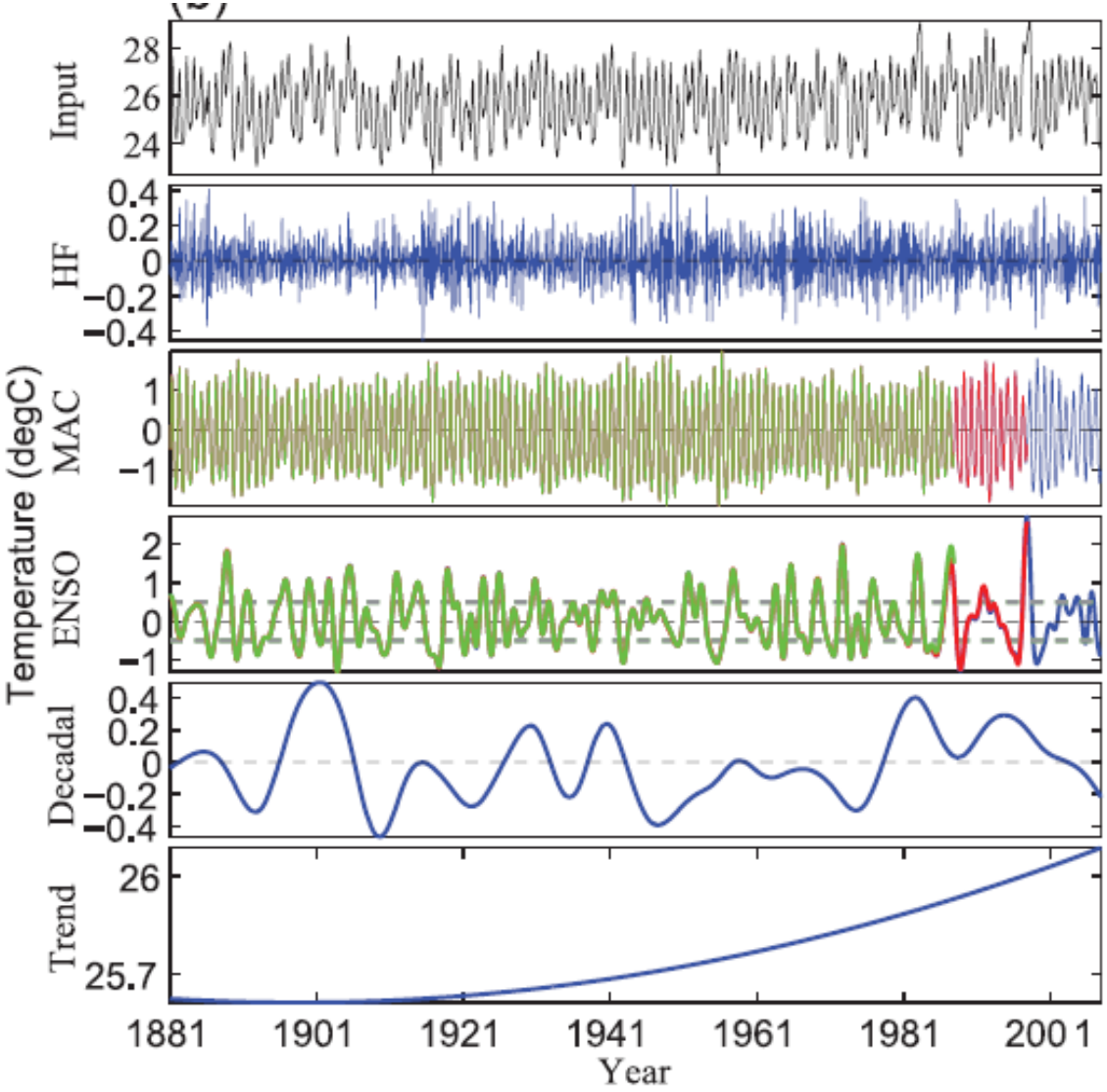






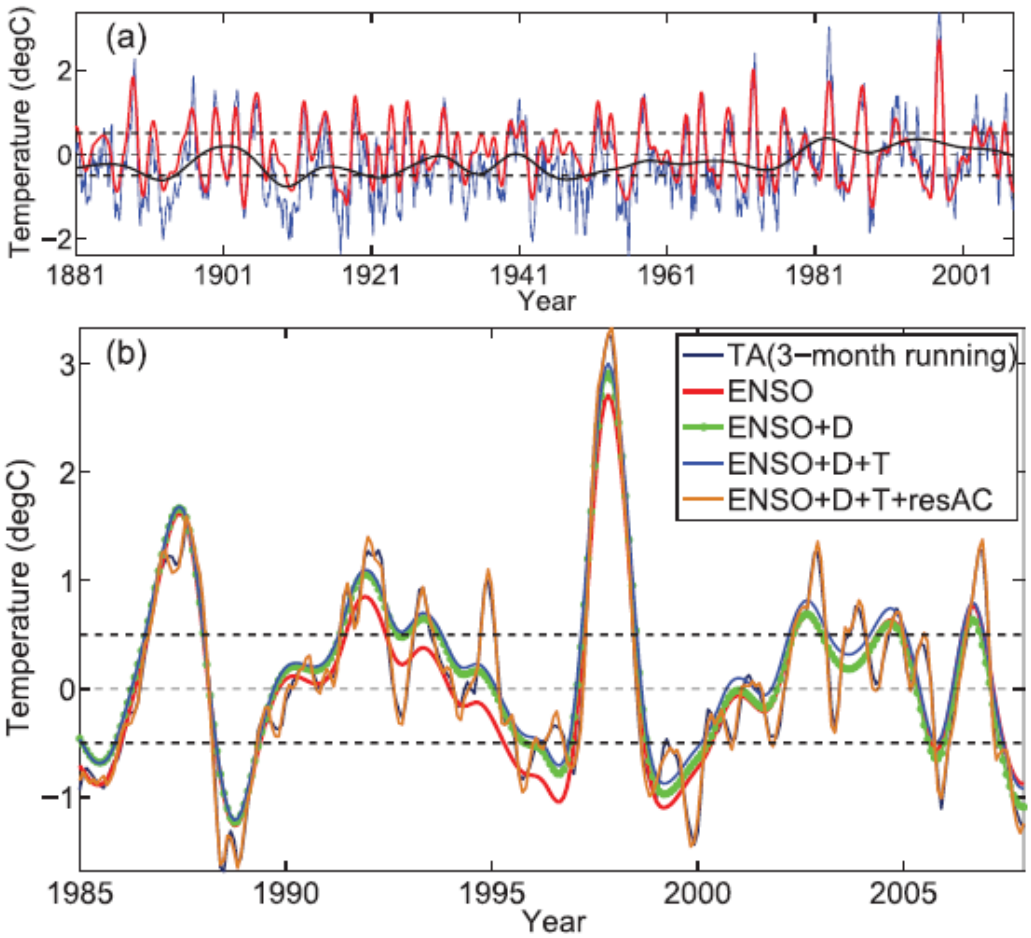


TEMPORAL LOCALITY

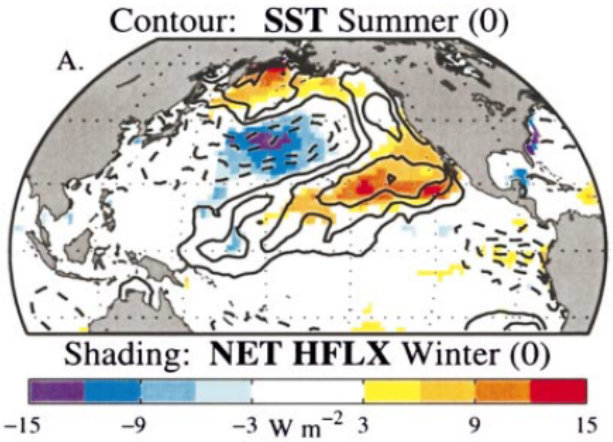


AN ALTERNATIVE ENSO INDEX

- No presumed base periods for the anomaly.
- The defined anomaly does not change as new data come in.
- Narrowed timescales, probably leading to clear physics explanation



“FOOTPRINT” APPROACH



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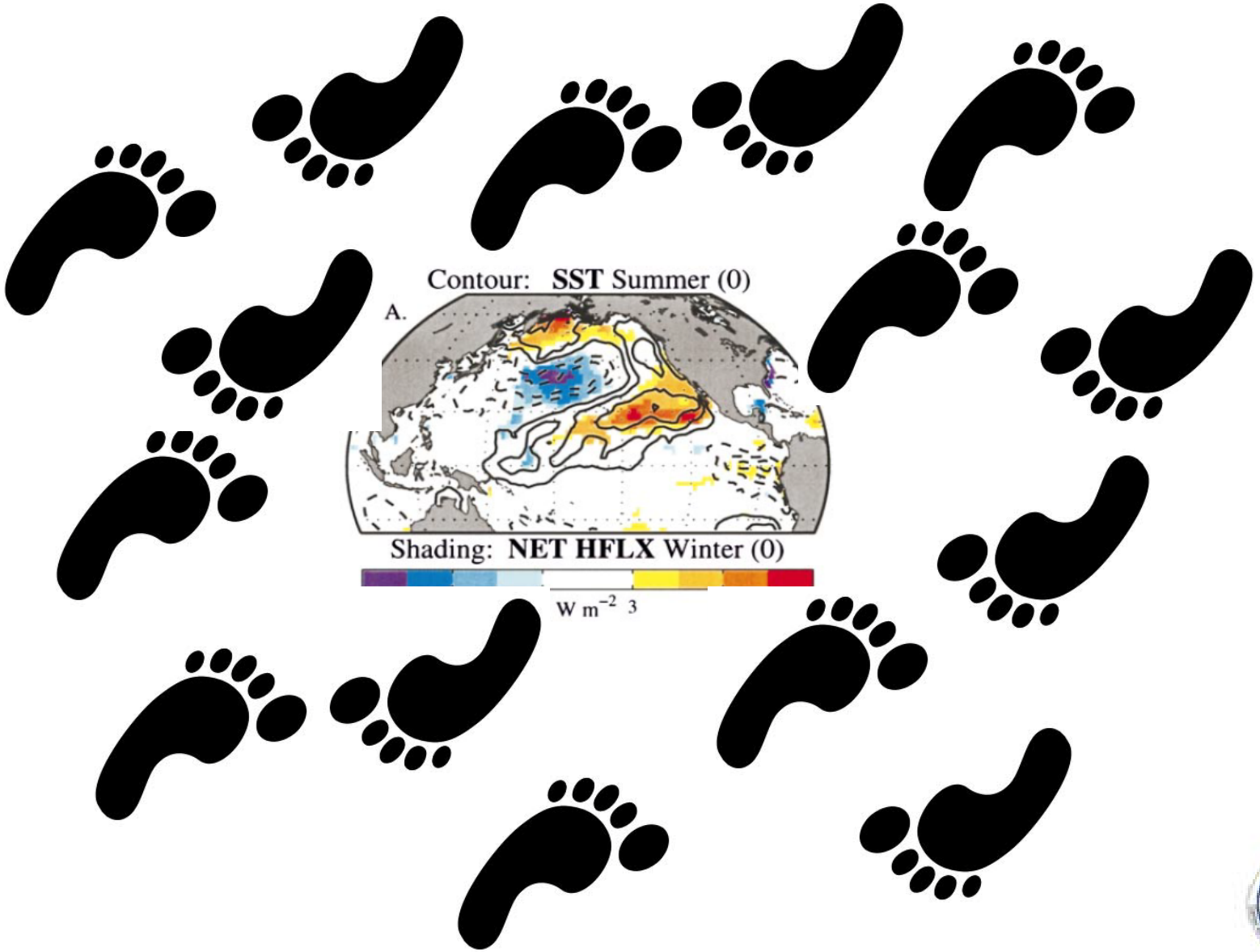
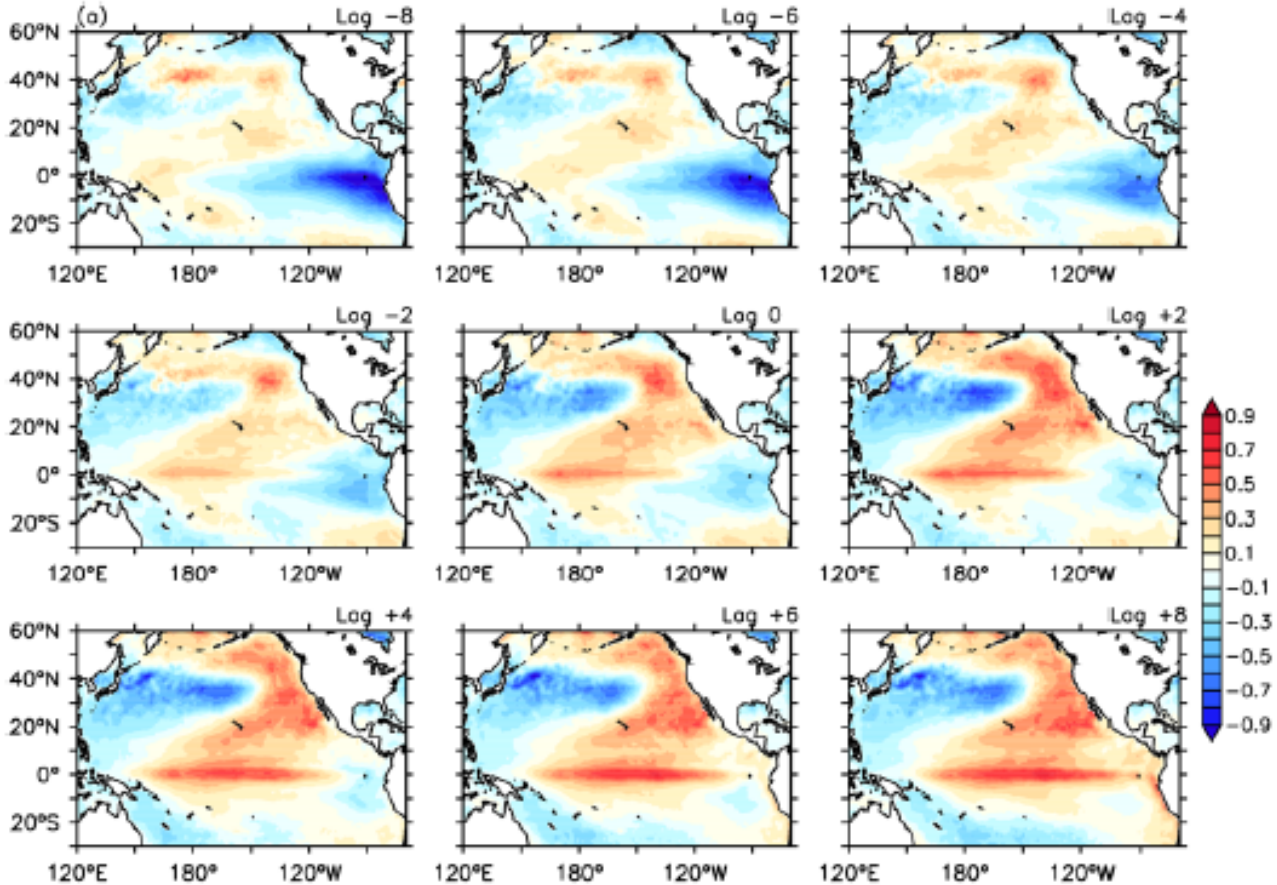


SOME POINTS ON "FOOTPRINT" APPROACH

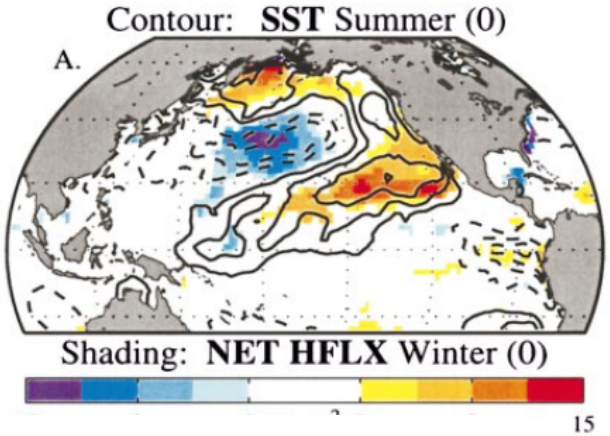
- "Footprints" are accumulated signatures of many events occurred over time.
- "Footprint" approach can not directly provide information of the sequential of different signals.
- "Footprint" approach in general requires a pre-selected time series (such as ENSO index) to serve as a weights, therefore, dependent on the index selected.
- "Footprint" approach can reveal some information of evolution through examination of lead-lagged footprints.
- When statistical property of the "footprints" changes, this approach may lead to severe misinterpretation.

LEAD-LAGGED FOOTPRINTS

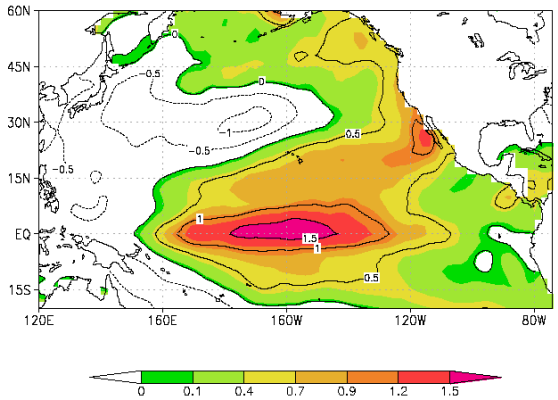


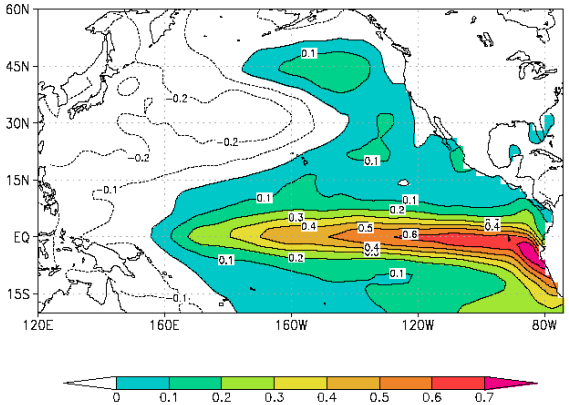
Yu et al. 2012

CENTROL PACIFIC ENSO: DECADAL OR INTERANNUAL ENSO?



Vimont et al. 2001, 2003.

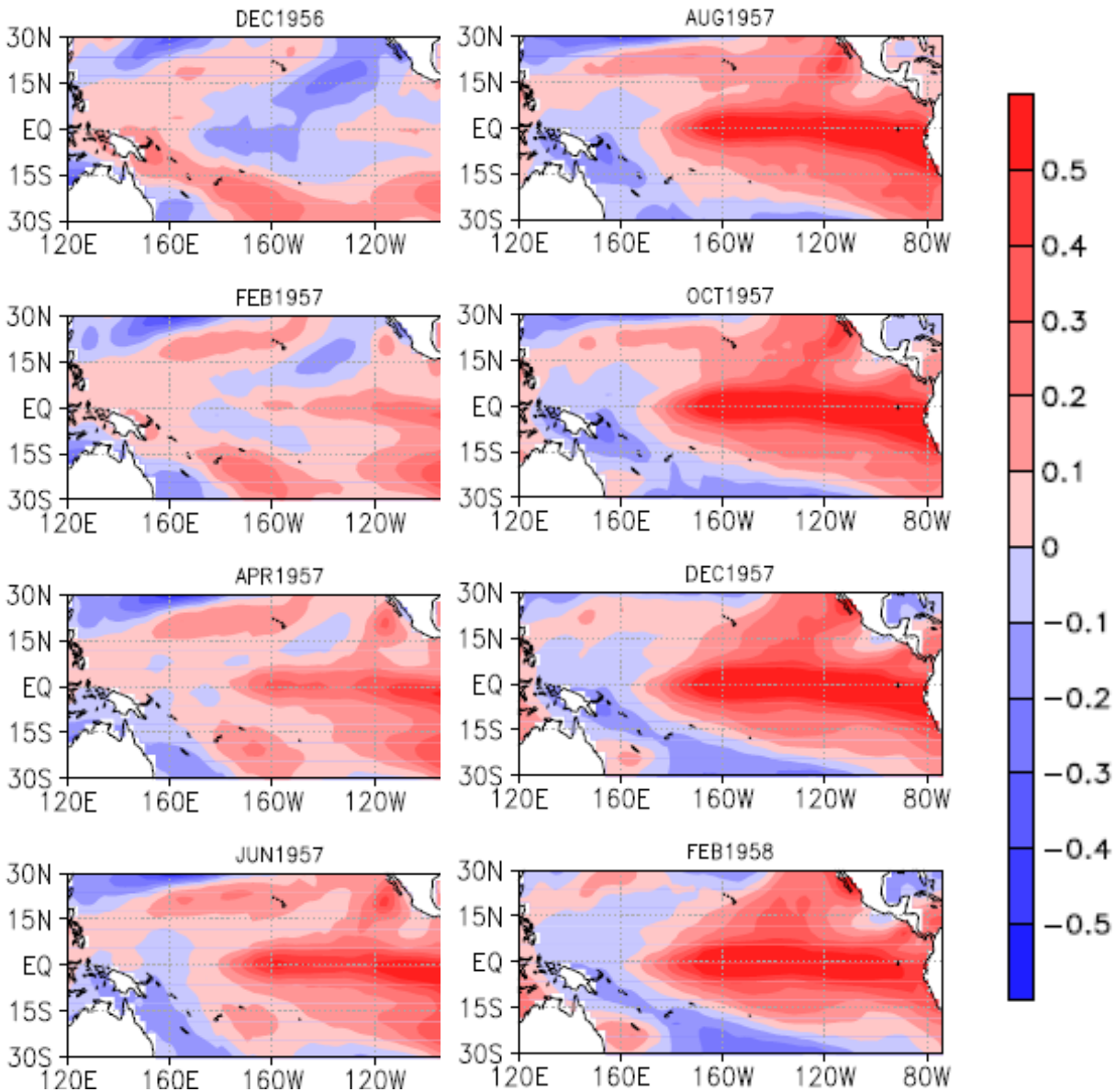




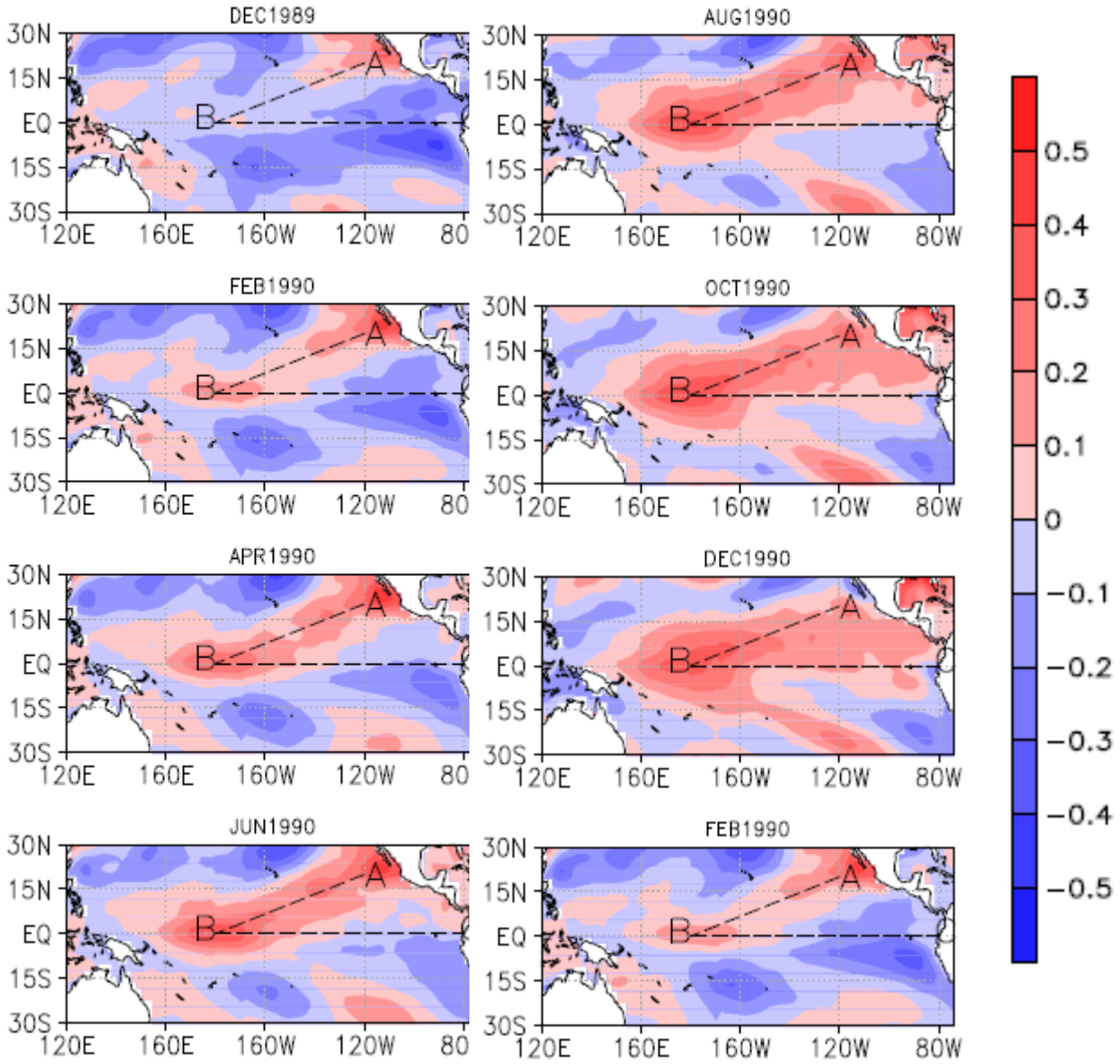
OUR APPROACH

Watching evolution

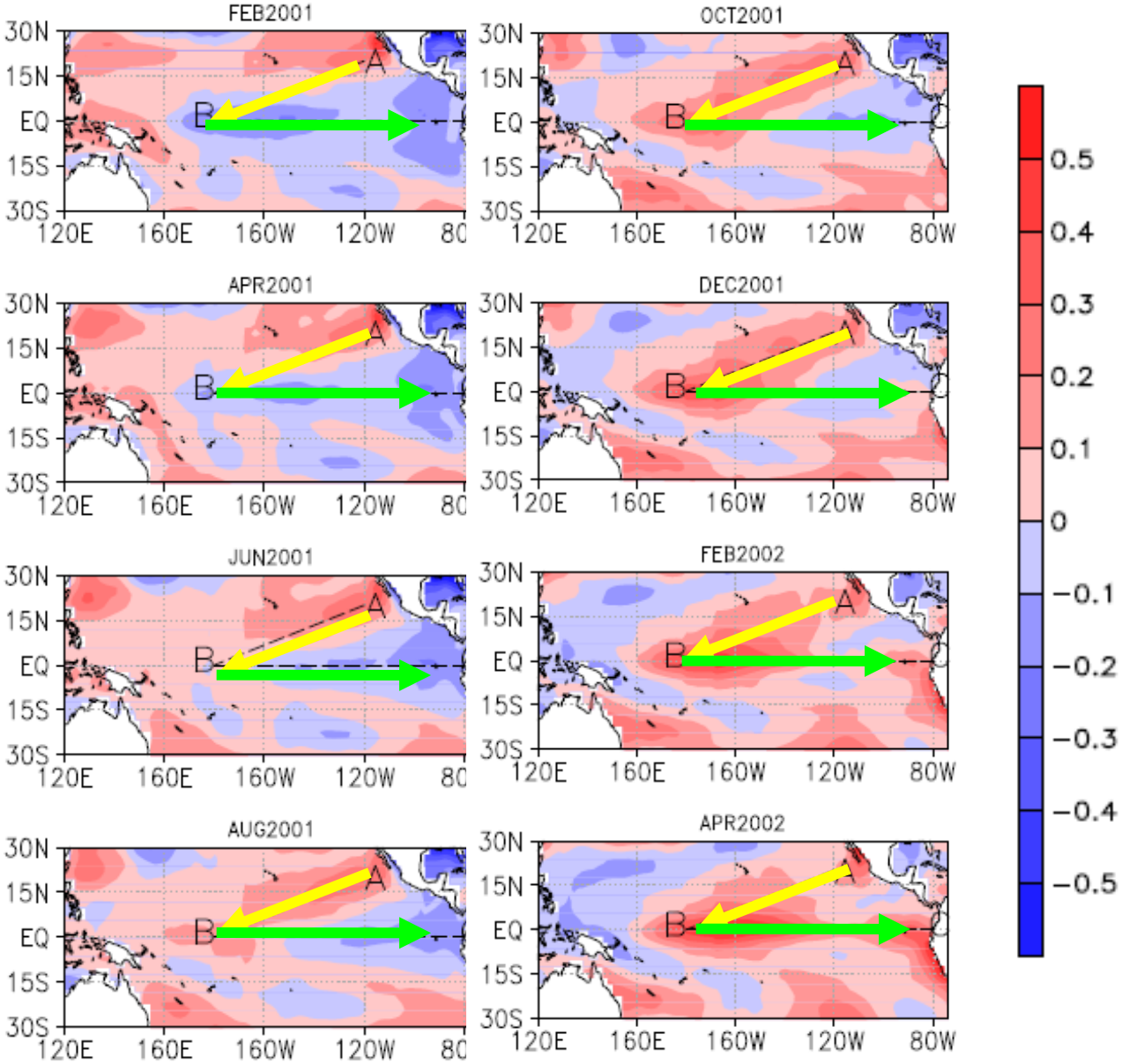
TRADITIONAL ENSO



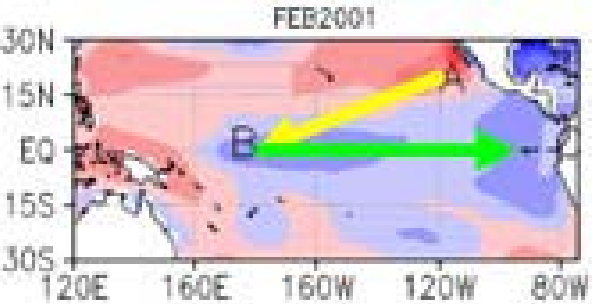
CENTRAL PACIFIC ENSO



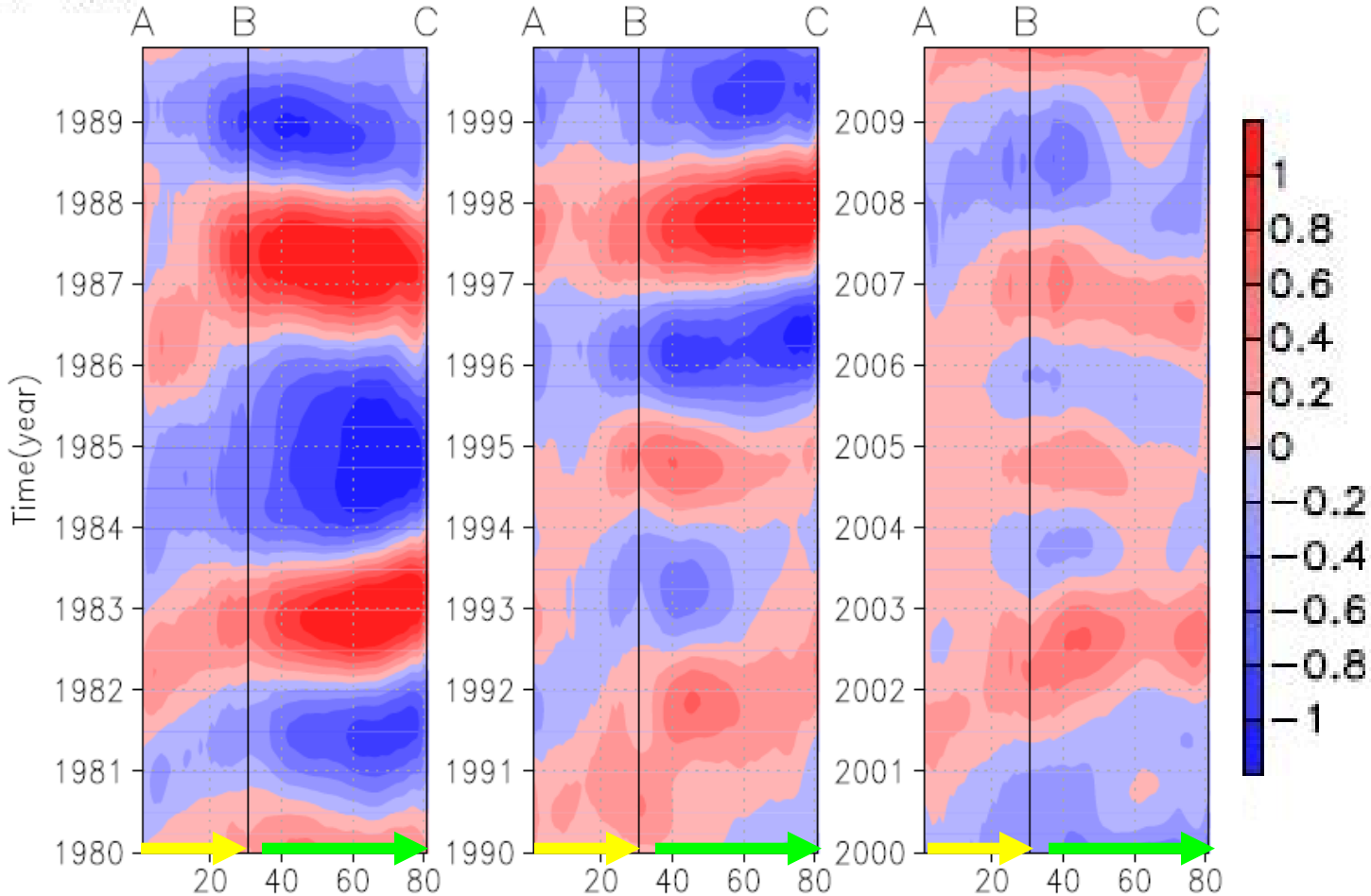
A POSSIBLE TRIGGER



A POSSIBLE TRIGGER

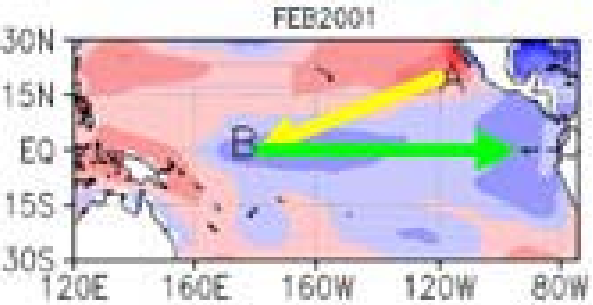


First Interannual Component (2-3yr)

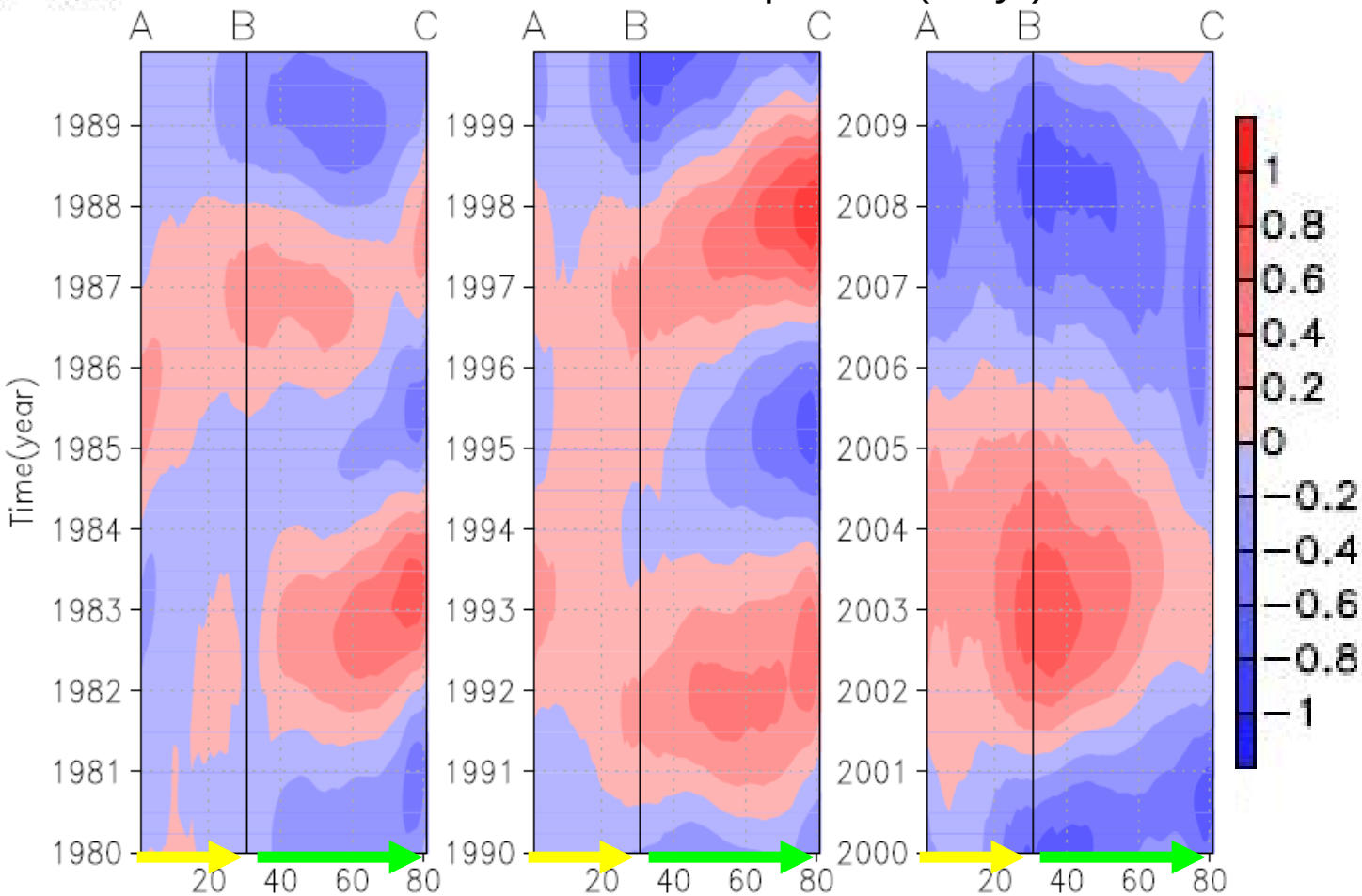


Order of grid points along the path

A POSSIBLE TRIGGER



Second Interannual Component (4-6yr)



Order of grid points along the path

SOME SATISTICS

Frequency of El Niño events pre- and post-1980.

	Total number of El Niño events	*Number of El Niño events associated with the warm signal from Baja California*	*Number of CP El Niño-like events*
1880-1979	21	8	2
1980-2009	10	6	6

SUMMARY

- The SSTAs off Baja California appears instrumental to some ENSO warm events, especially those recently discovered CP El Niño. In these events, warm anomalies occur off Baja California and propagate southwestward, arriving at the equator after about one year. This possibly triggers the subsequent warm event in the central Pacific and the warm anomalies then tends to extend eastward at a faster speed, eventually reaching a mature stage.

Mathematics are well and good but nature keeps dragging us around by the nose.

Albert Einstein

CONCLUSION

Mathematics are well and good but nature keeps dragging us around by the nose.

Albert Einstein