ENSO Residuals and Asymmetry: Interactions between ENSO Amplitude and the Decadal Mean

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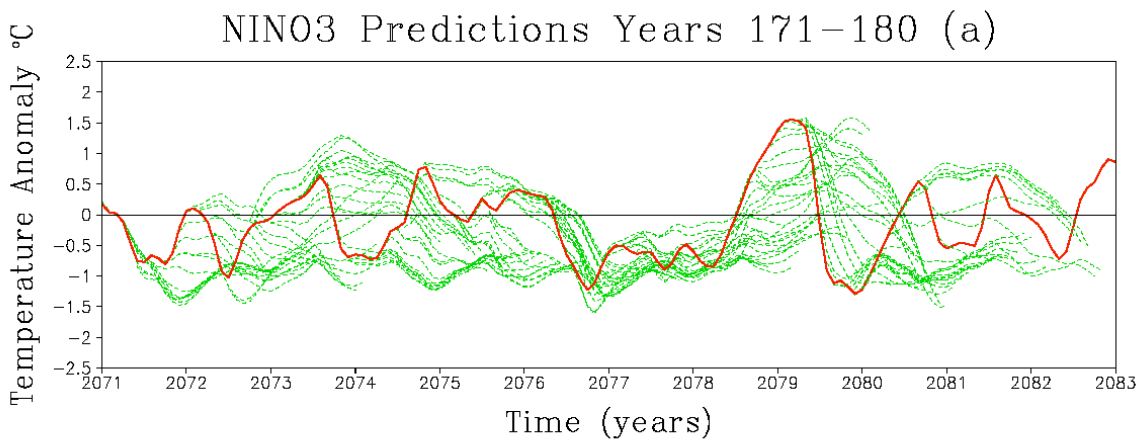
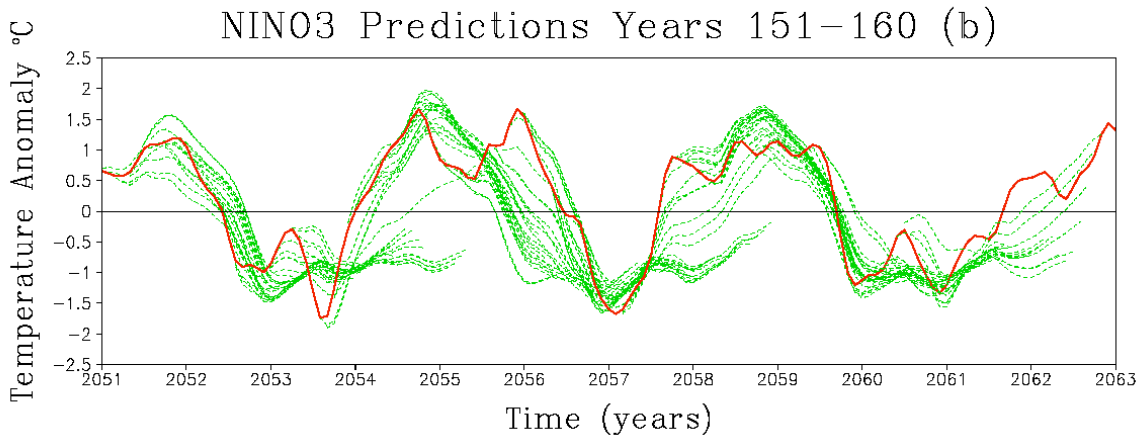
Questions

- What causes decadal scale changes in ENSO?
  - Internal chaotic nature of ENSO?
  - Perturbations to background state?
  - Changes in projection of noise onto stochastic optimals?

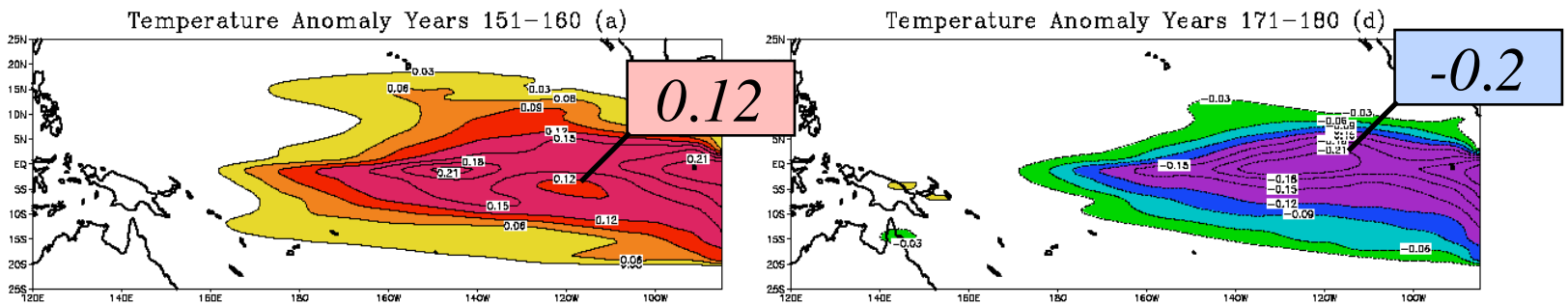
Predictable and non-Predictable Decades



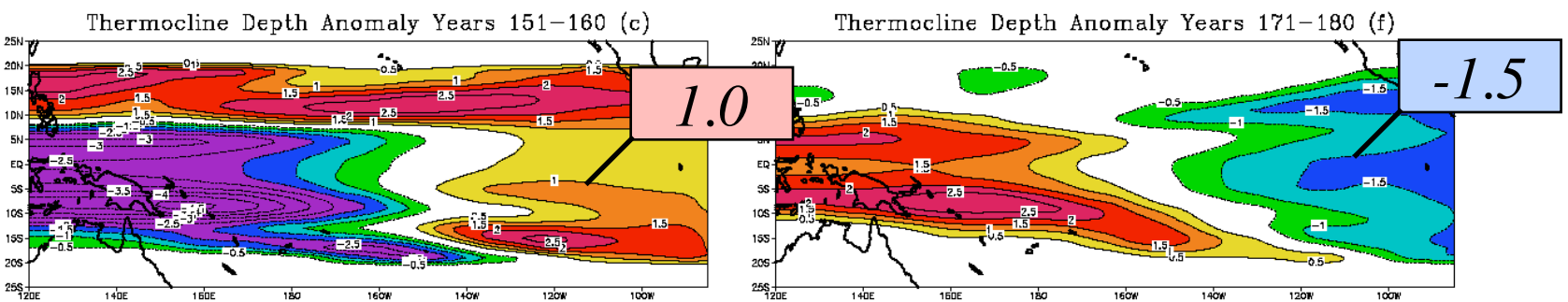


Differences

SST

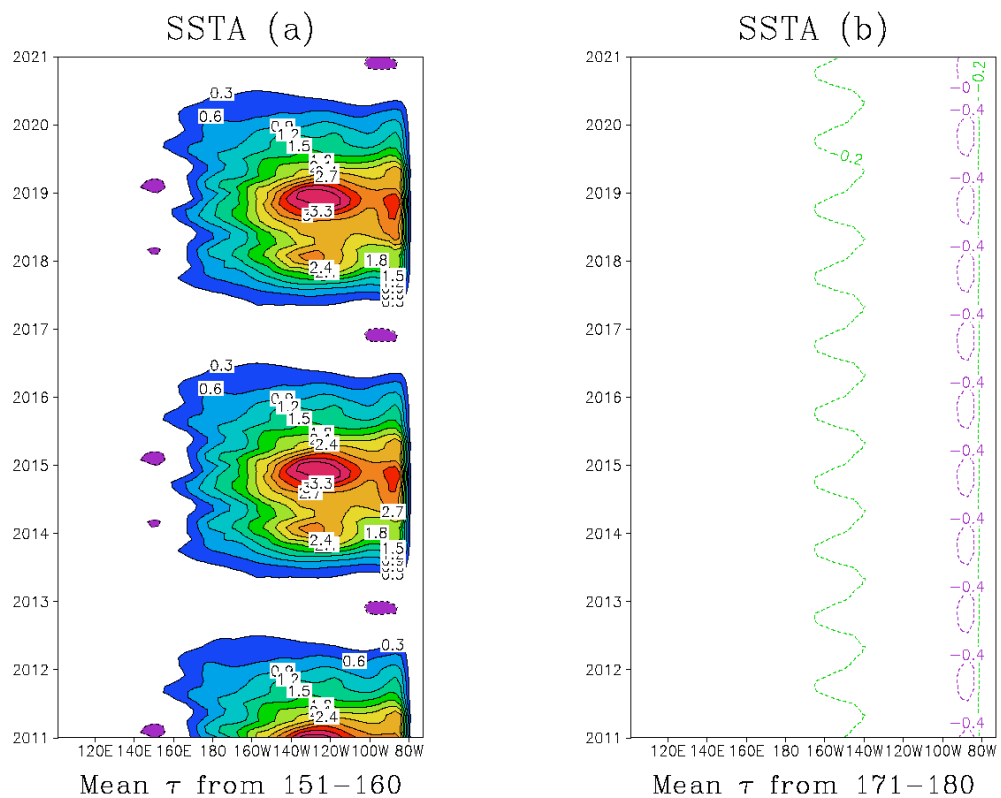


H_{20}



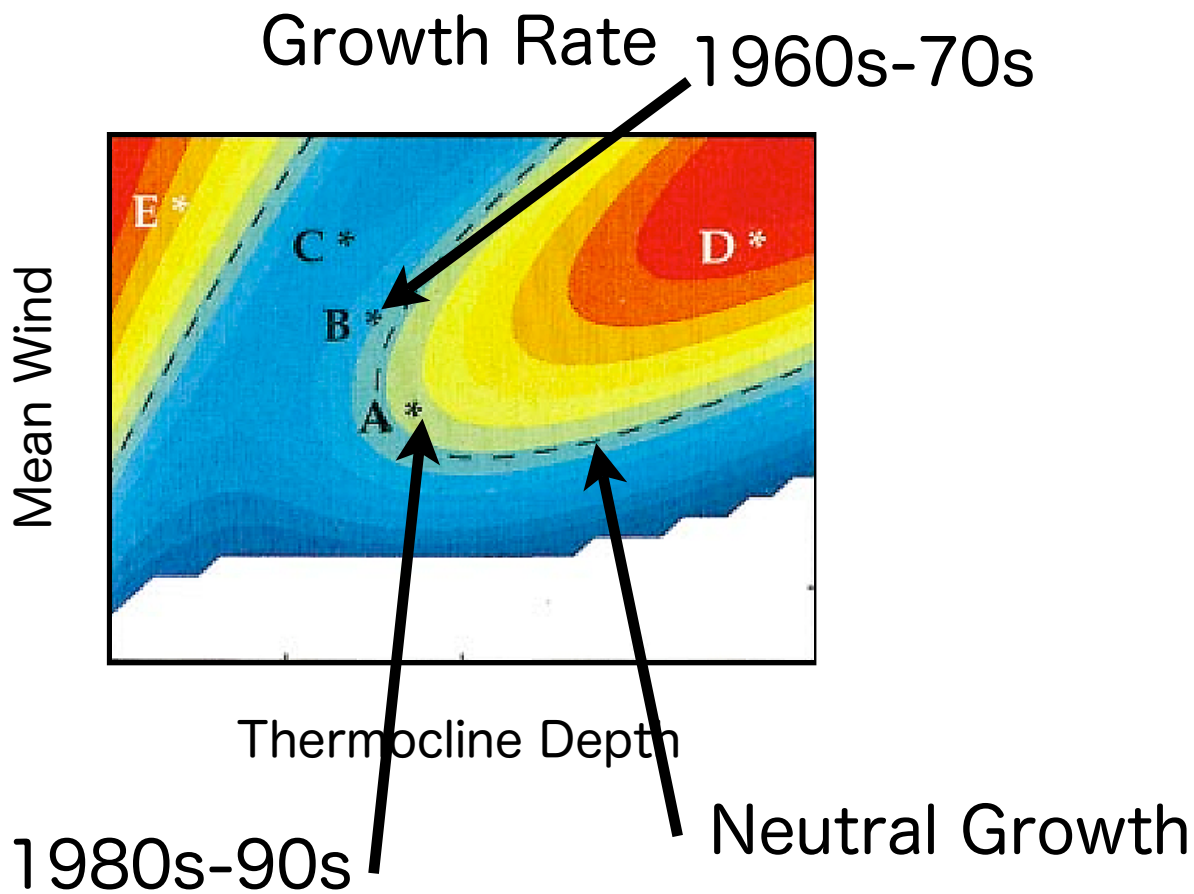
Hi ENSO *Low ENSO*

Crossing the Bifurcation

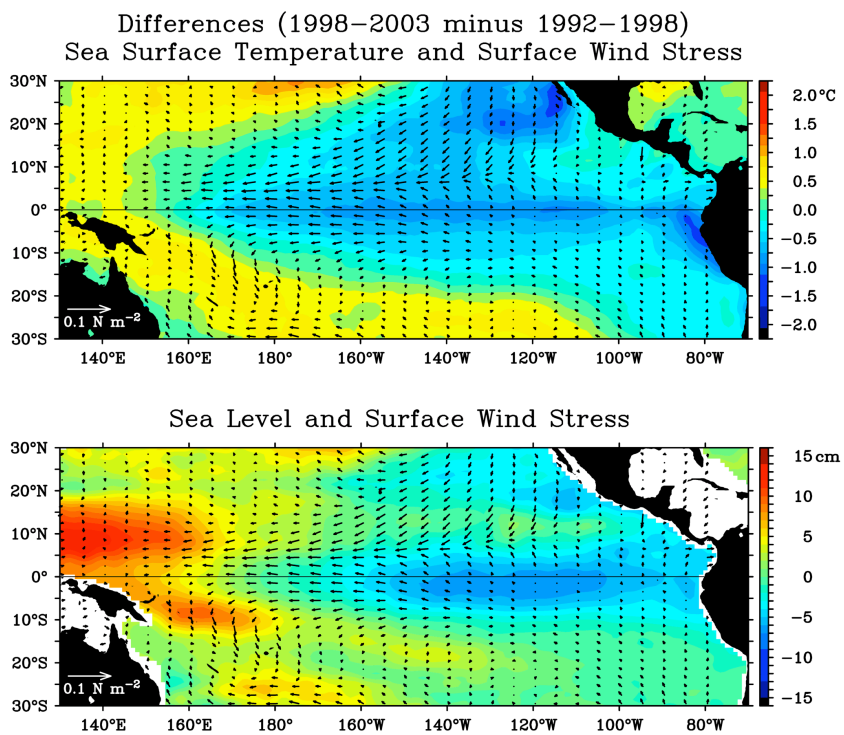


When noise is removed, but slight wind bias exists, predictable decade is seen to be oscillatory unpredictable decade is damped

Fedorov & Philander Analysis

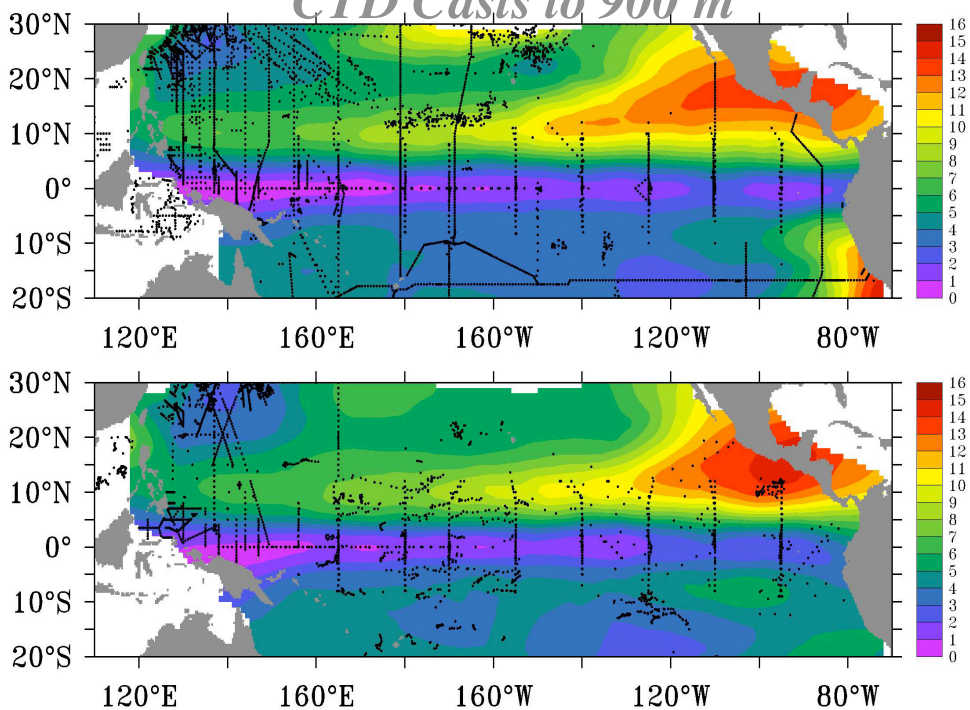


McPhaden Zhang SST differences



Potential Vorticity ***($\sigma\theta$ = 25 kg m^{-3})***

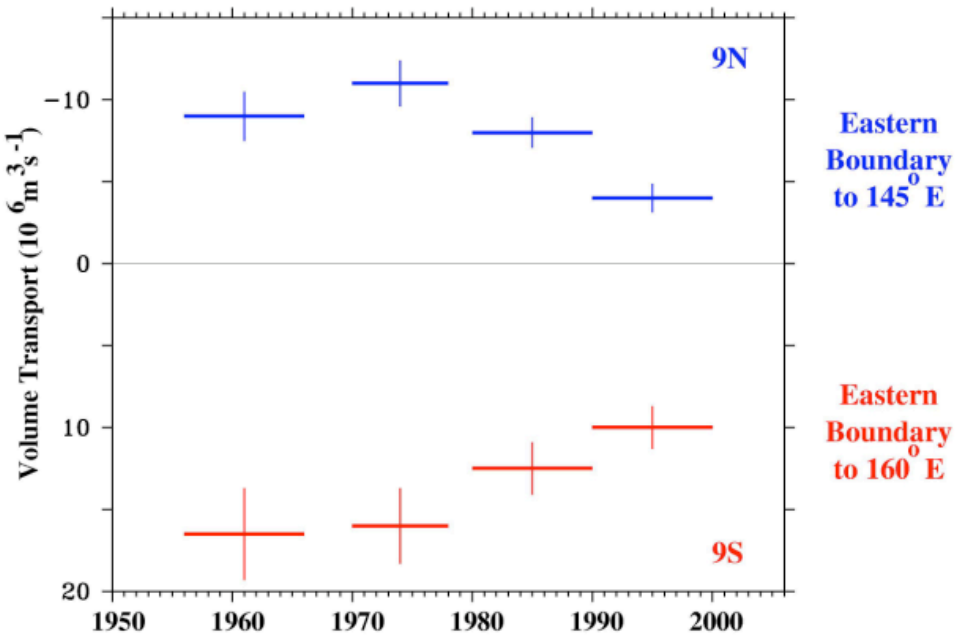
CTD Casts to 900 m

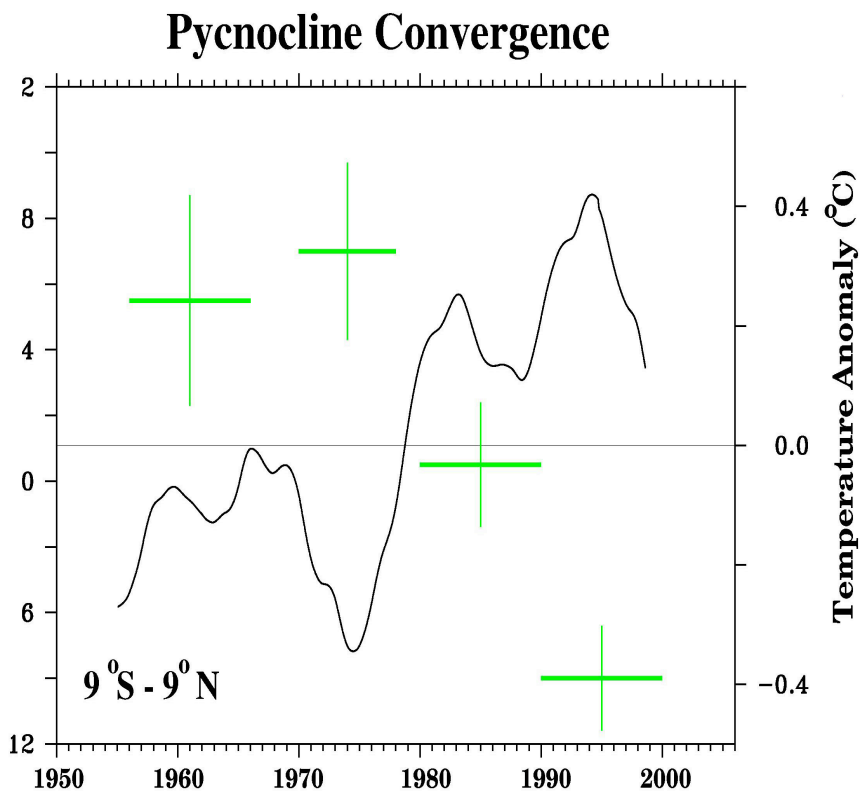


Reynolds SST; ERS & Quikscat wind stress, TOPEX/ Poseidon & Jason sea level

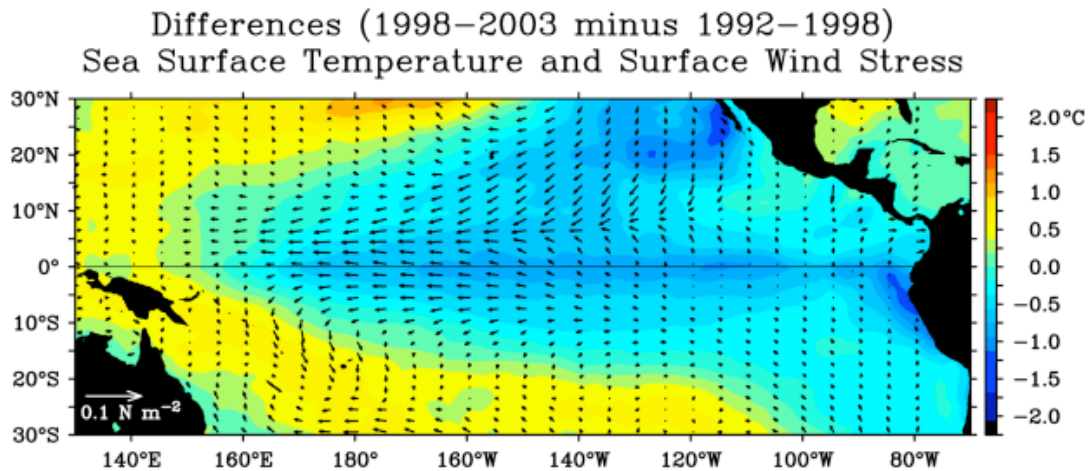
McPhaden & Zhang, 2004

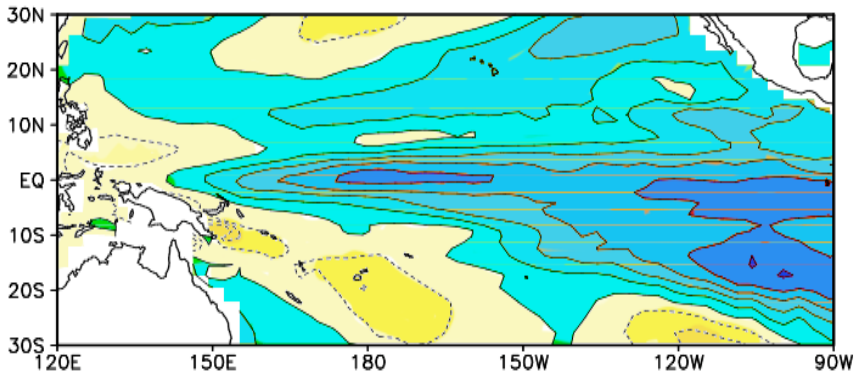
Spindown of Pacific STCs

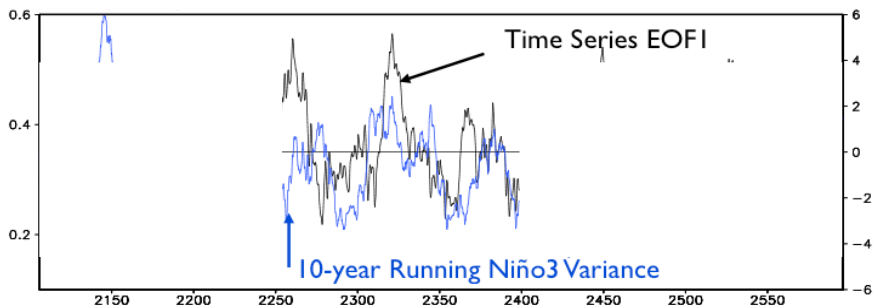


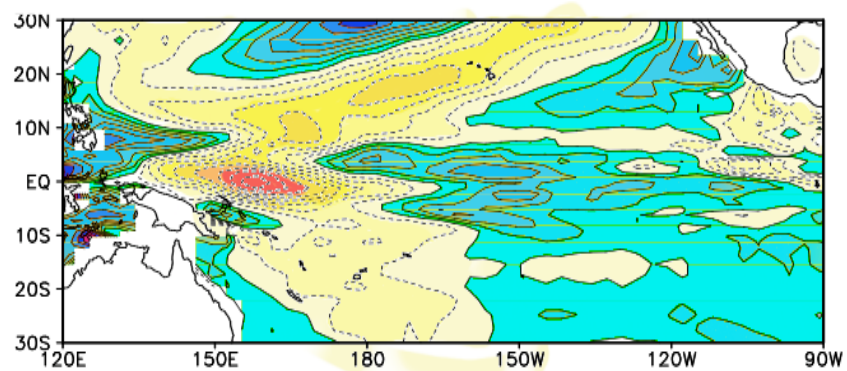


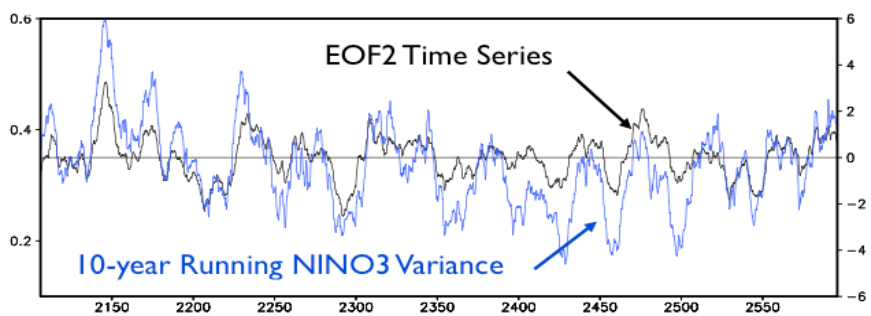
McPhaden & Zhang, 2004











(Yeh and Kirtman, 2004)

Questions

- Rodgers, Fredrich & Latif identify EOF2 as “residual” of ENSO
- Is decadal change in background the CAUSE or RESULT of changes in ENSO?

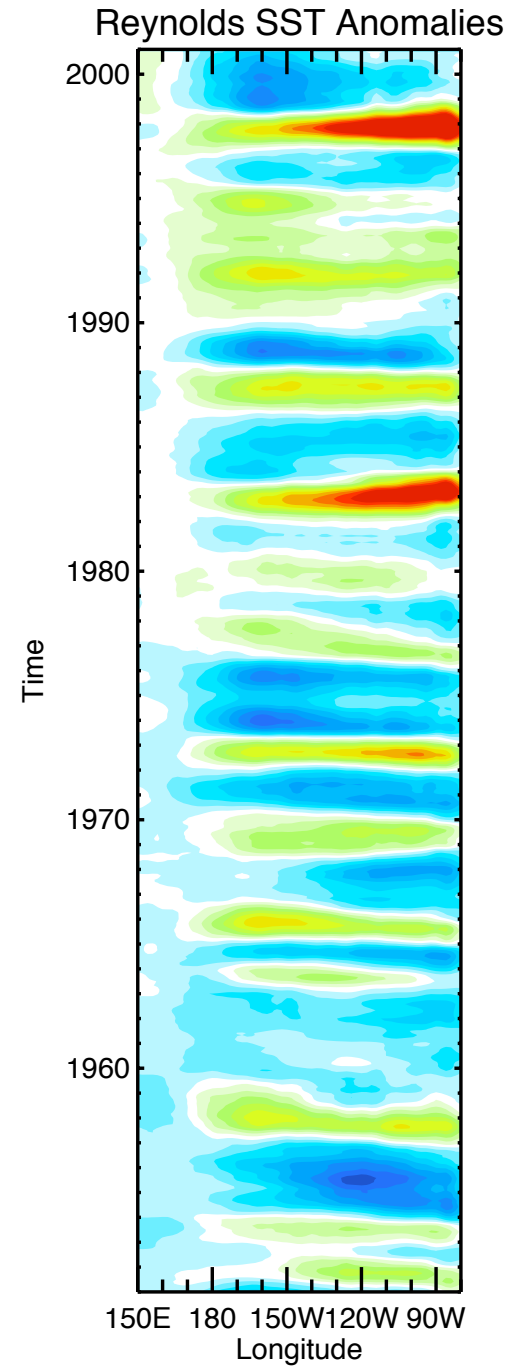
Other Features of ENSO

- El Nino big, La Nina smaller (is La Nina "normal")
- Warm SST anomalies larger in east, cold anomalies seem found to west

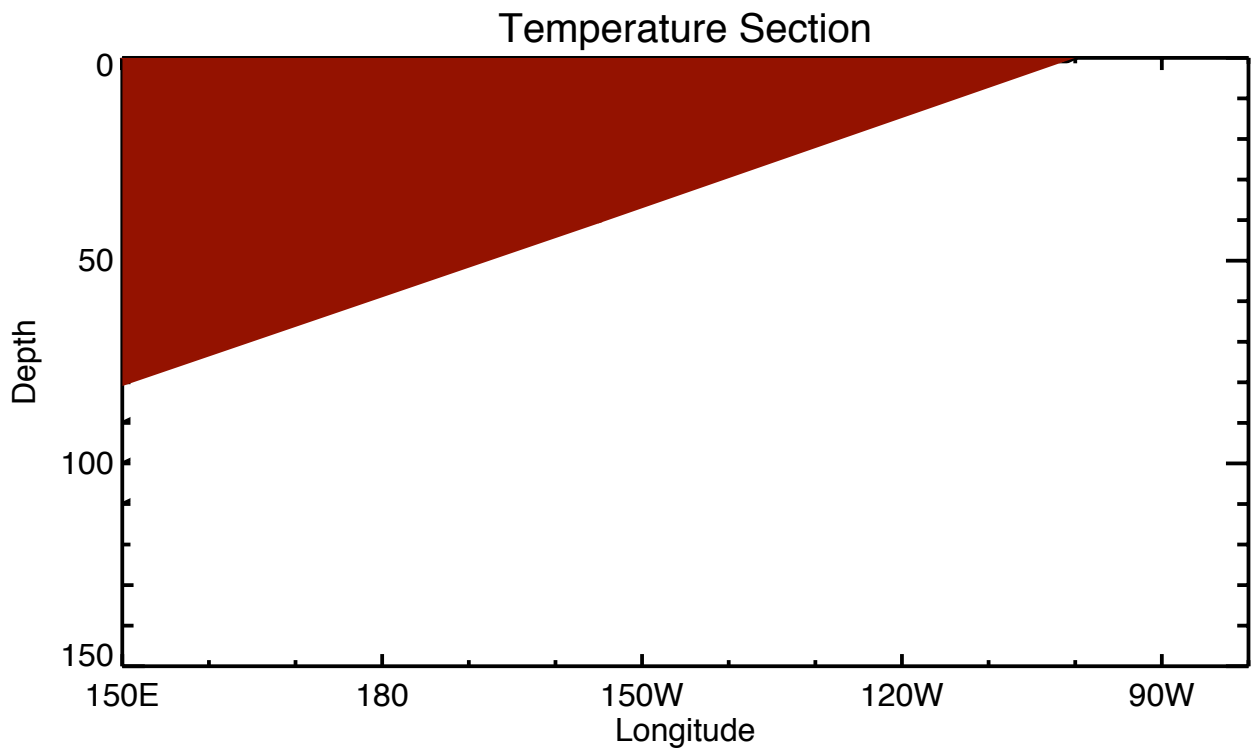
SST Asymmetry

Anomalies from 1-year running means

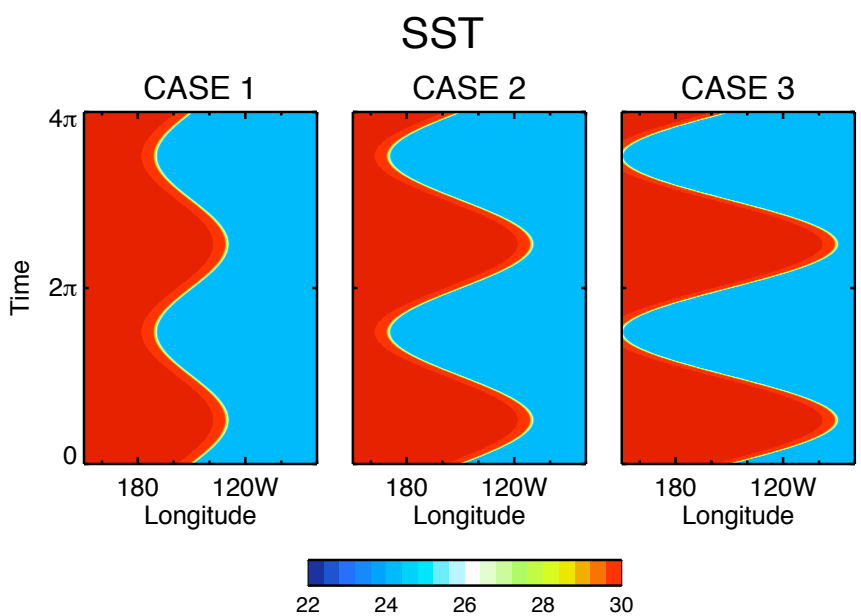
Skewed statistics:
Warm anomalies in east, cold to west.

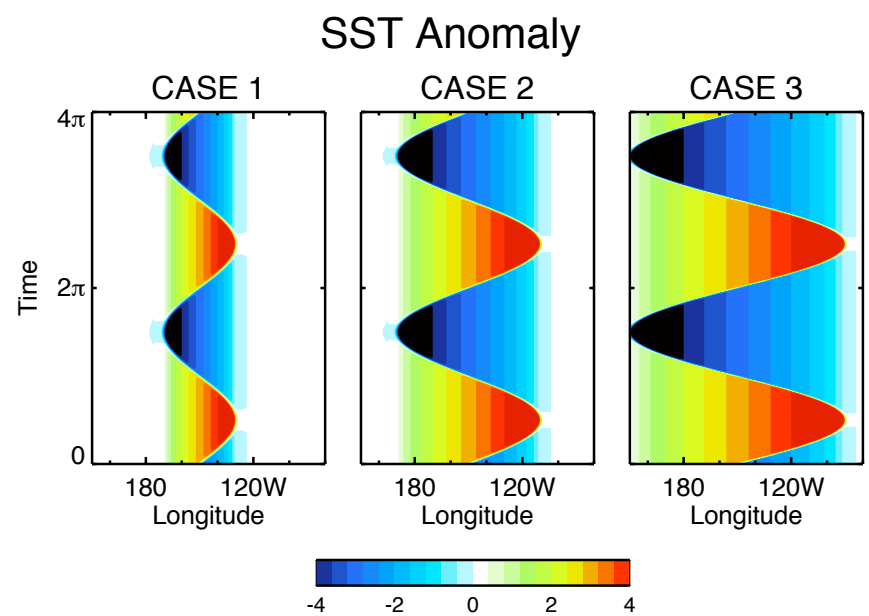


A Mechanism for Asymmetry

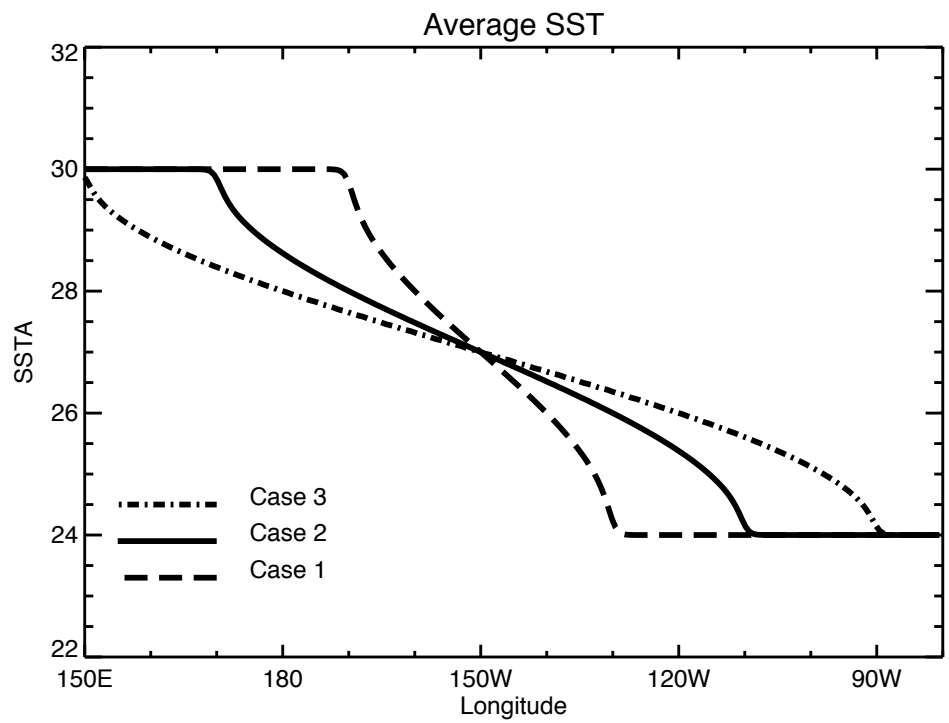


SST


SST
CASE 1
CASE 2
CASE 3
Time
4π
2π
0
180
120W
Longitude
22
24
26
28
30


SST Anomaly
CASE 1
CASE 2
CASE 3
Time
4π
2π
0
180
120W
Longitude
-4
-2
0
2
4

Time Mean SST



$$\frac{\partial \overline{T}}{\partial A} = -\frac{b}{2\pi}\int_0^{2\pi} \delta(x + A\sin t)\cos t \; dt$$

Generalizing

$$T(x,t) = f(x - AX(t))$$

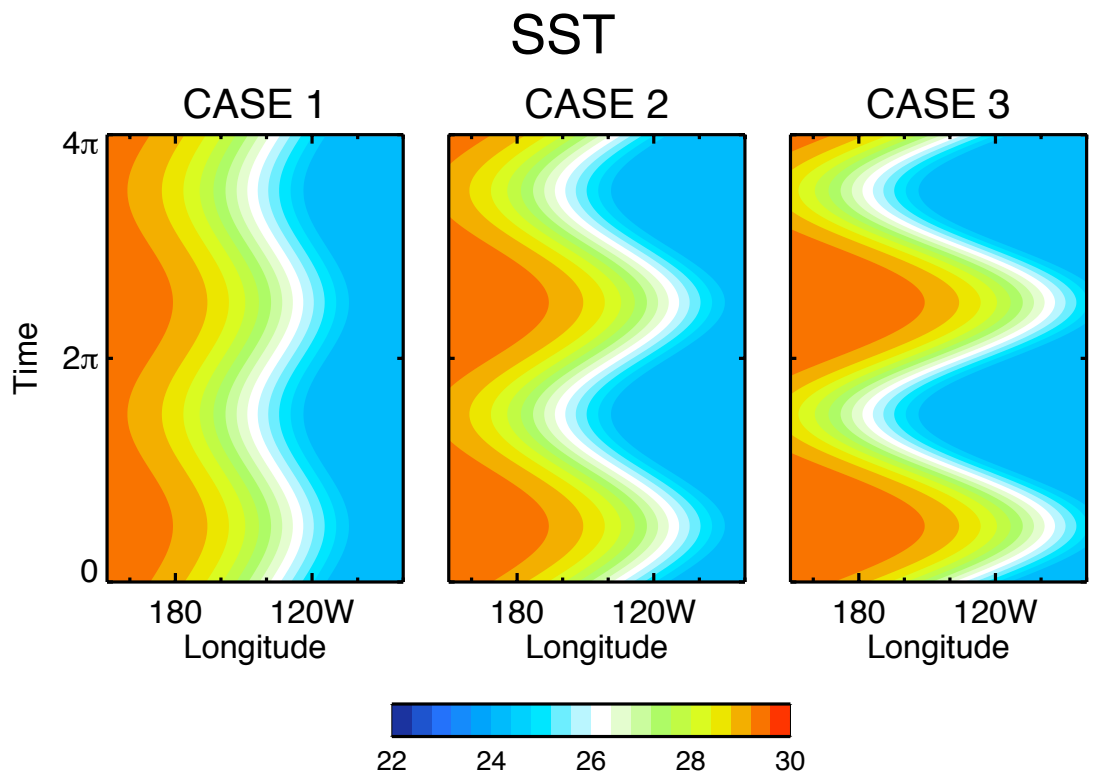
Simplest nonlinearity:

$$f(y) = a_o + a_1 y + a_2 y^2$$

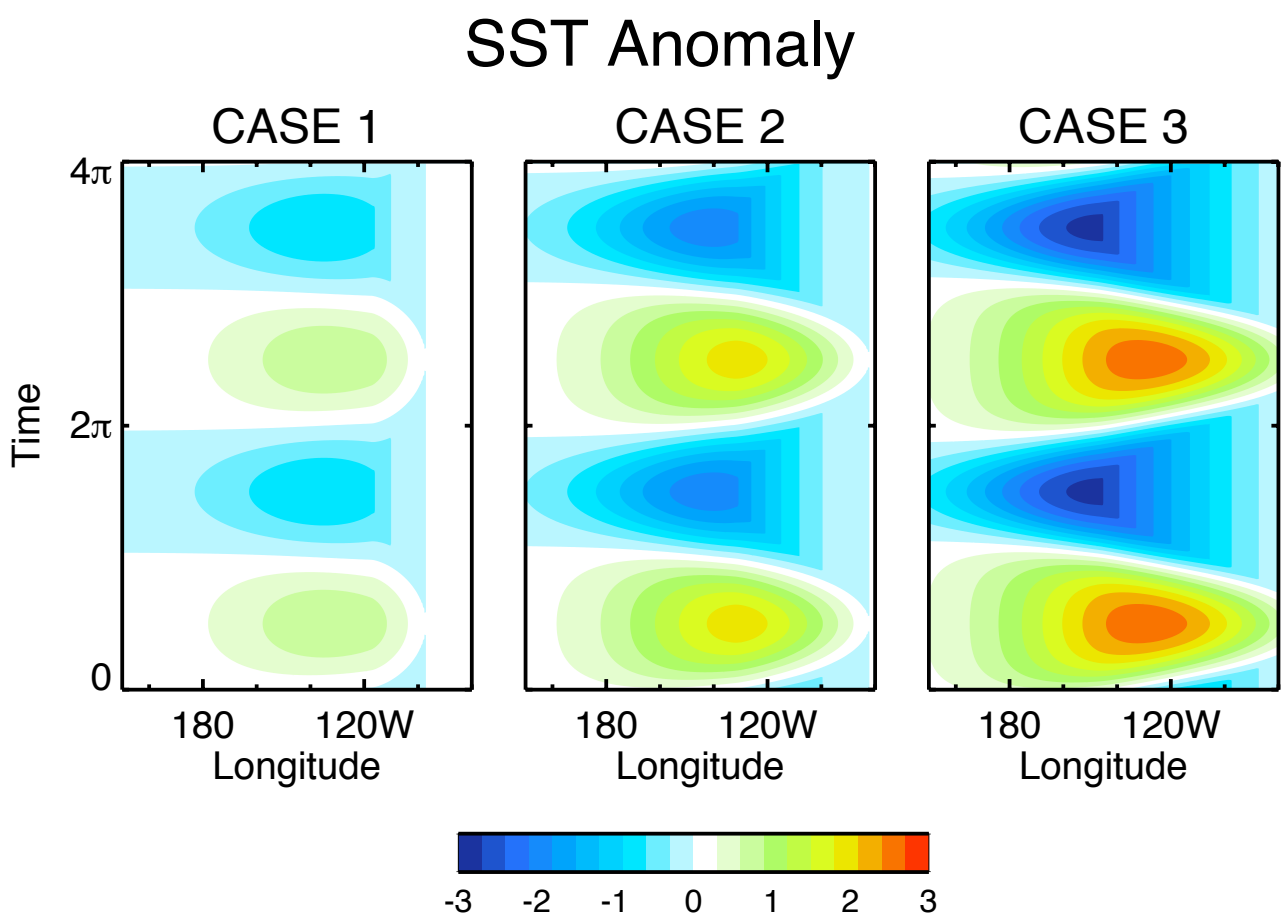
$$y = x - A\sin t$$

$$\frac{\partial \overline{T}}{\partial A} = a_2 A$$

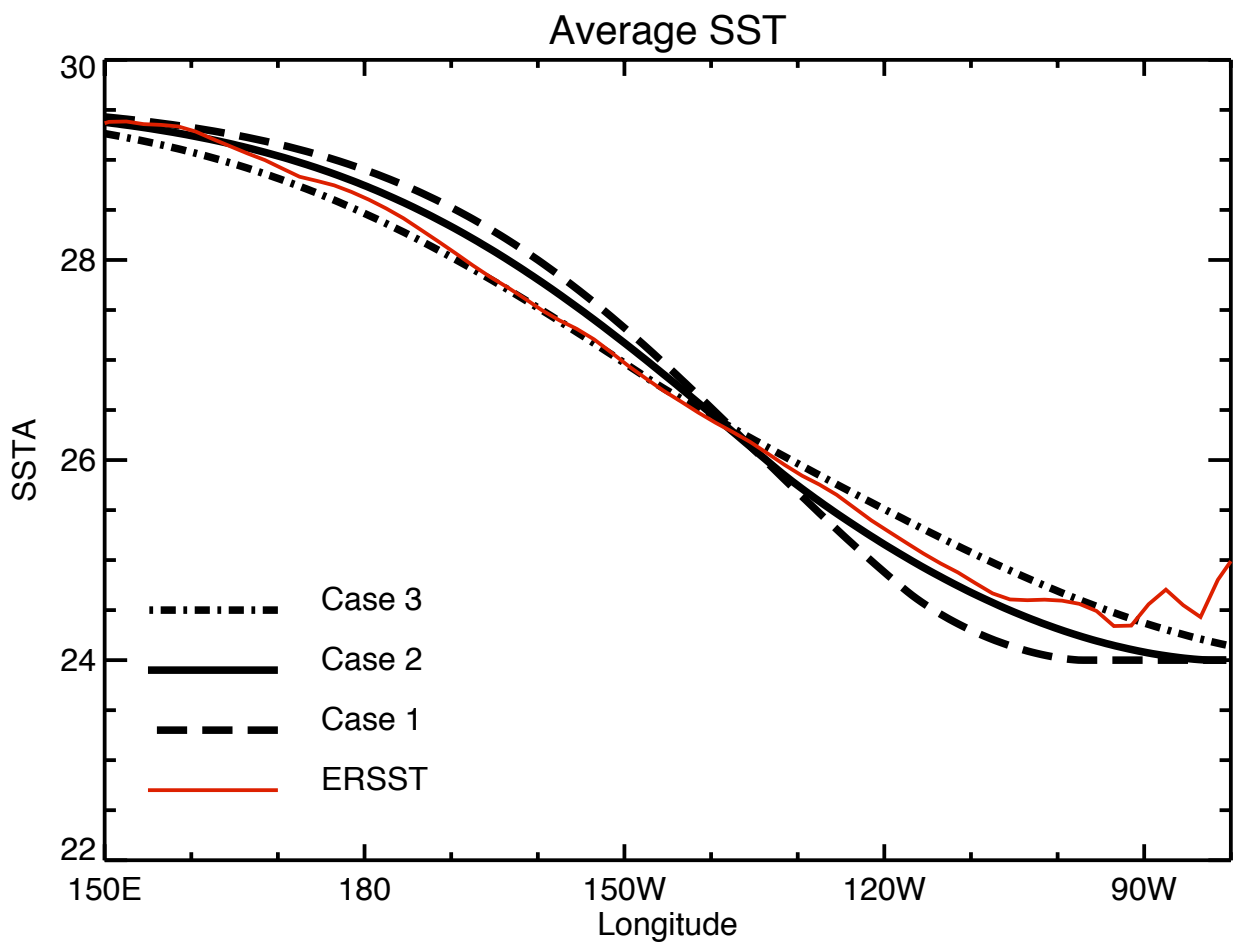
tanh() Profile

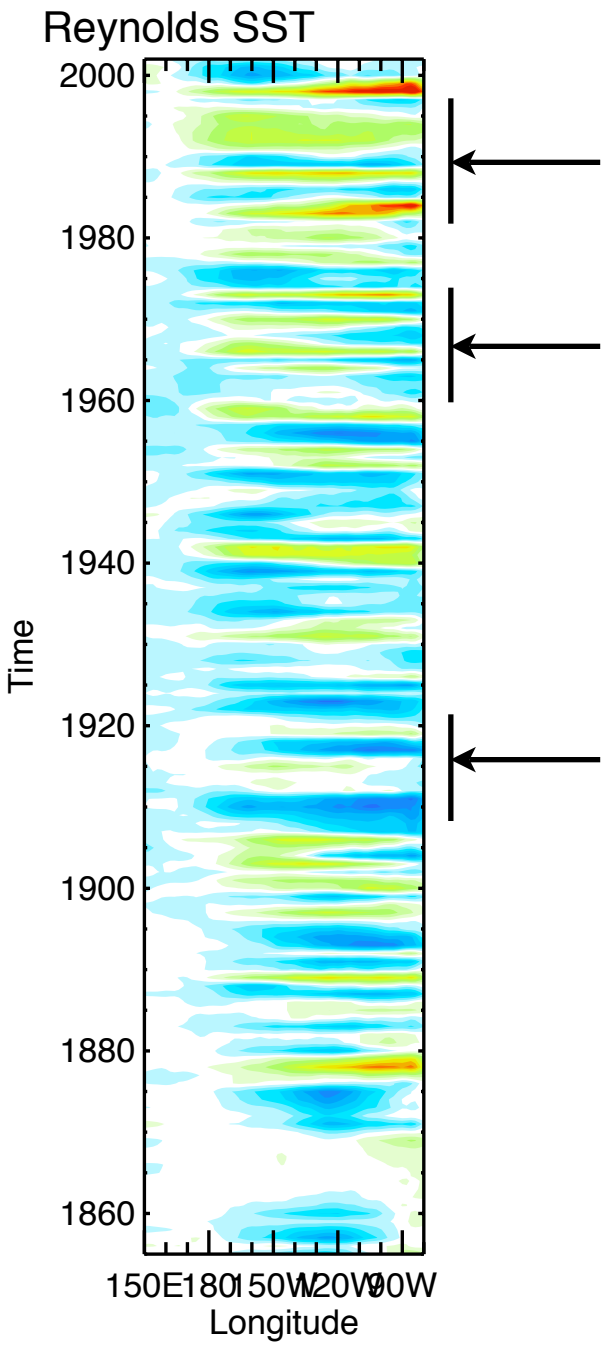


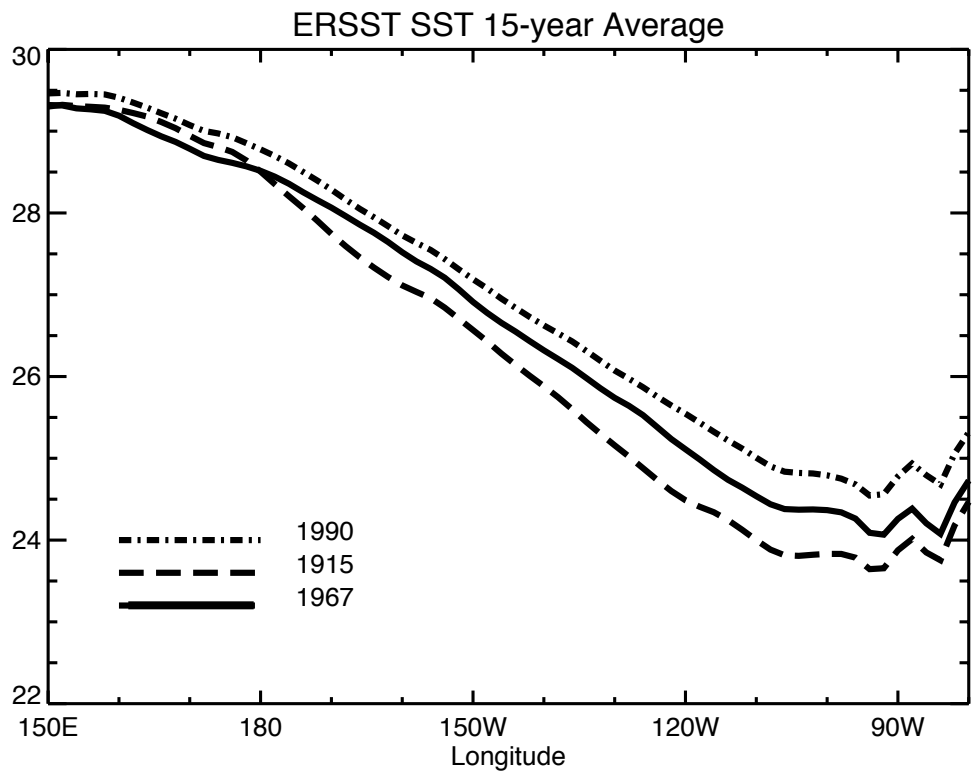
Anomalies


SST Anomaly
CASE 1
CASE 2
CASE 3
4π
2π
0
Time
180
120W
Longitude
-3
-2
-1
0
1
2
3

Means

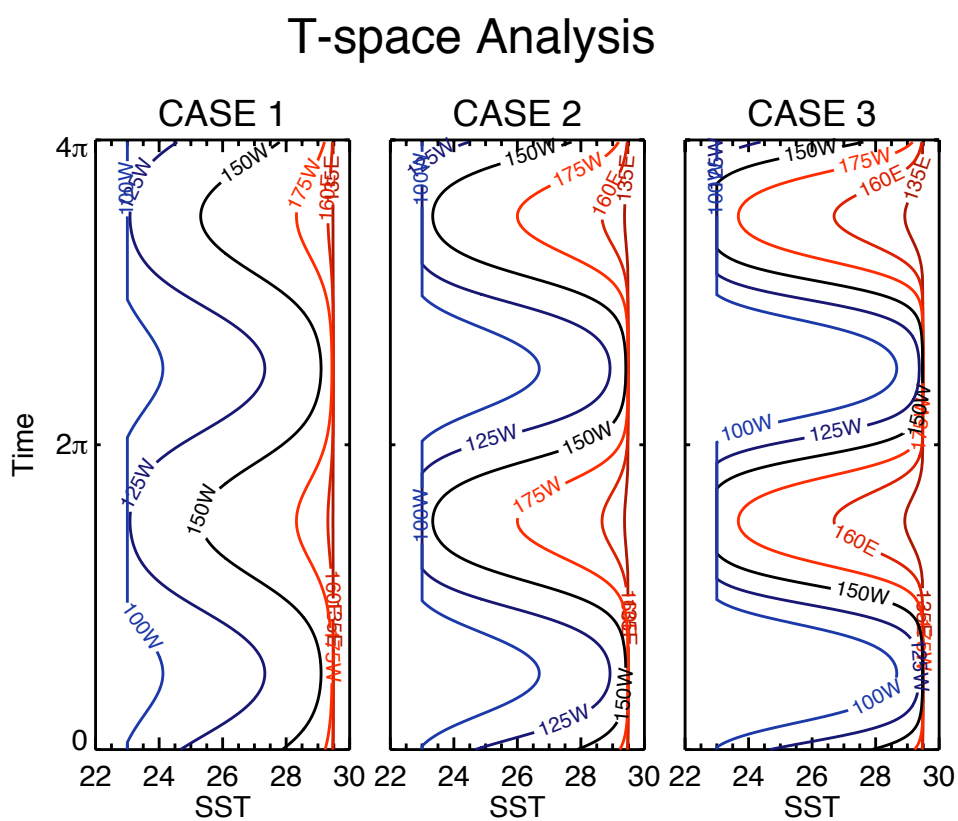

Average SST
30
28
26
24
22
SSTA
150E
180
150W
120W
90W
Longitude
Case 3
Case 2
Case 1
ERSST

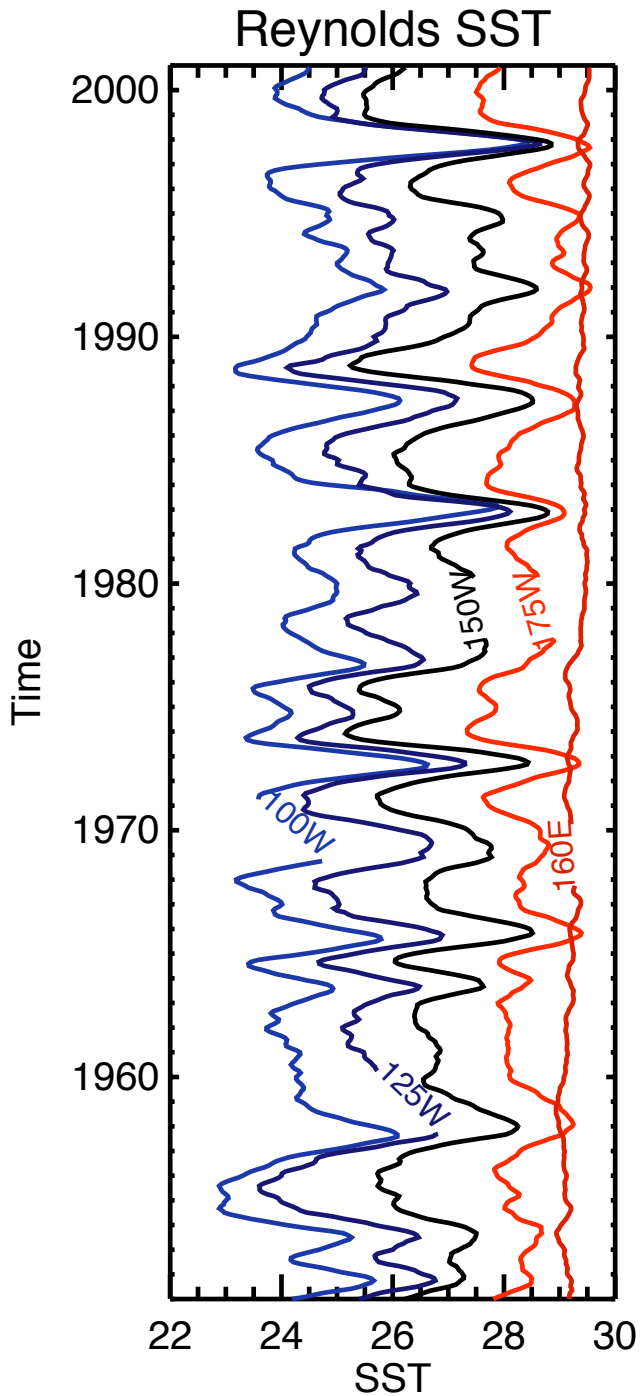

Reynolds SST
2000
1980
1960
1940
1920
1900
1880
1860
Time
150E
180
150W
120W
90W
Longitude


ERSST SST 15-year Average
30
28
26
24
22
150E
180
150W
120W
90W
Longitude
1990
1915
1967

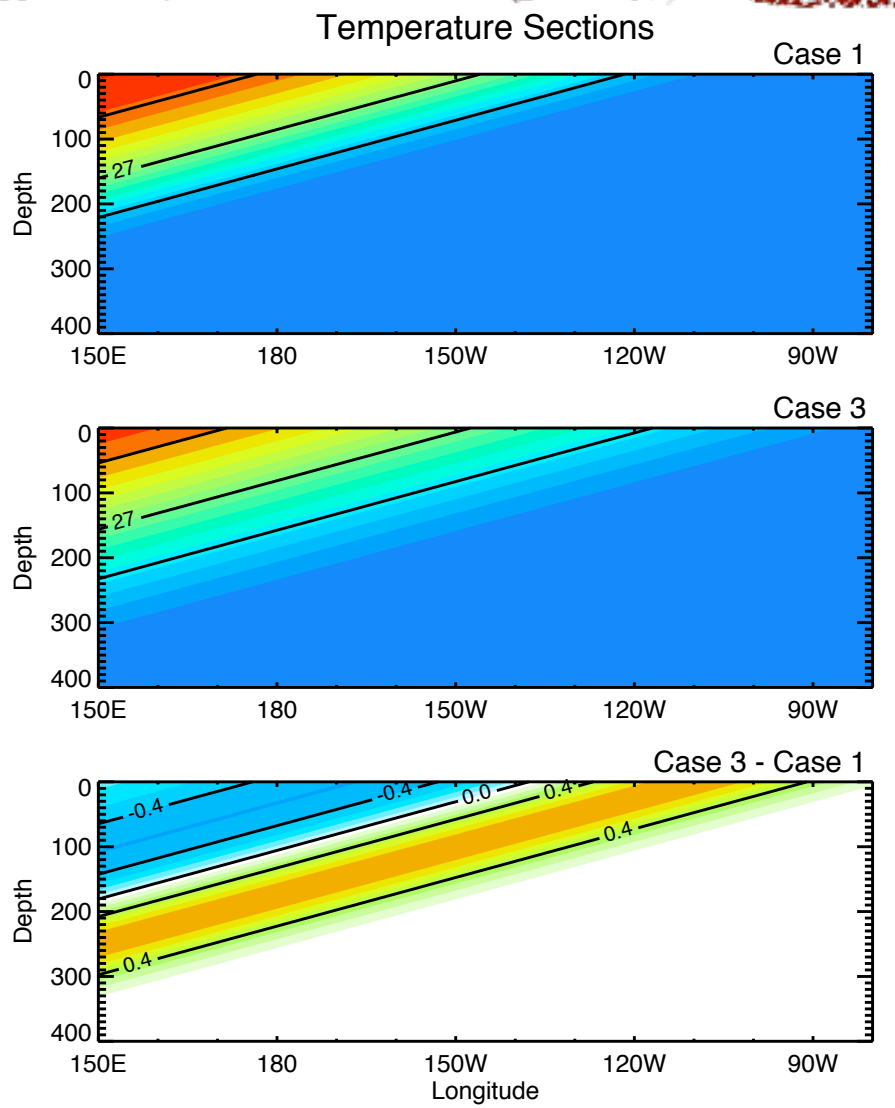
Temperature Space

$$x(T,t) = AX(t) + L\tanh^{-1}\left(\frac{a-T}{b}\right)$$

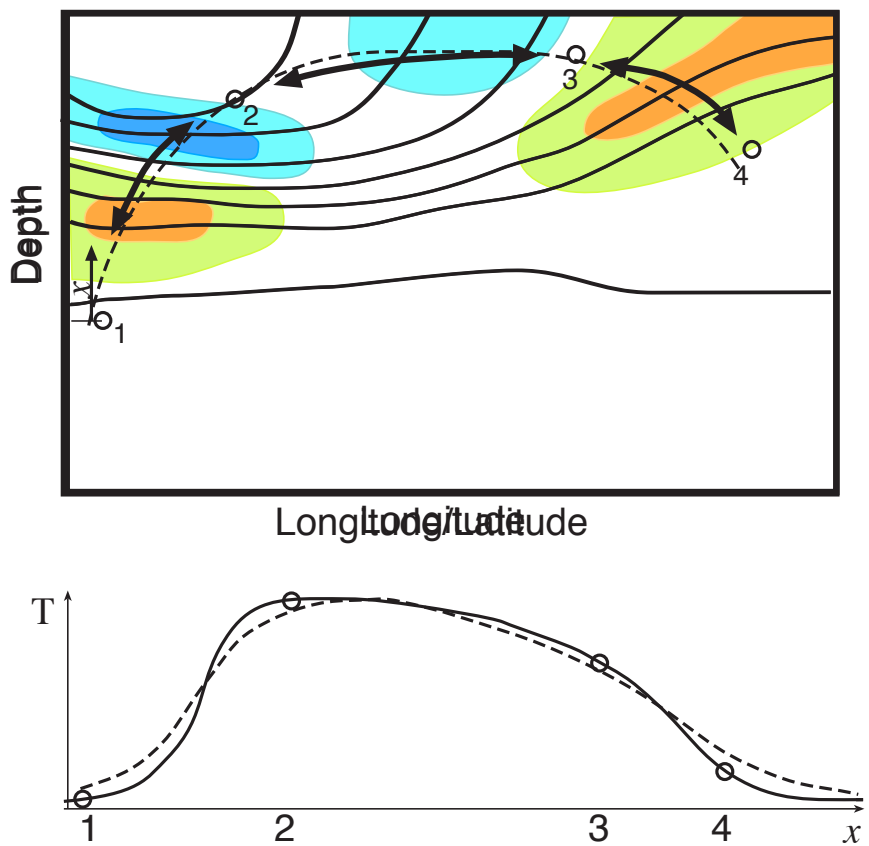



Reynolds SST
Time
2000
1990
1980
1970
1960
22
24
26
28
30
SST
100W
125W
150W
175W
160E

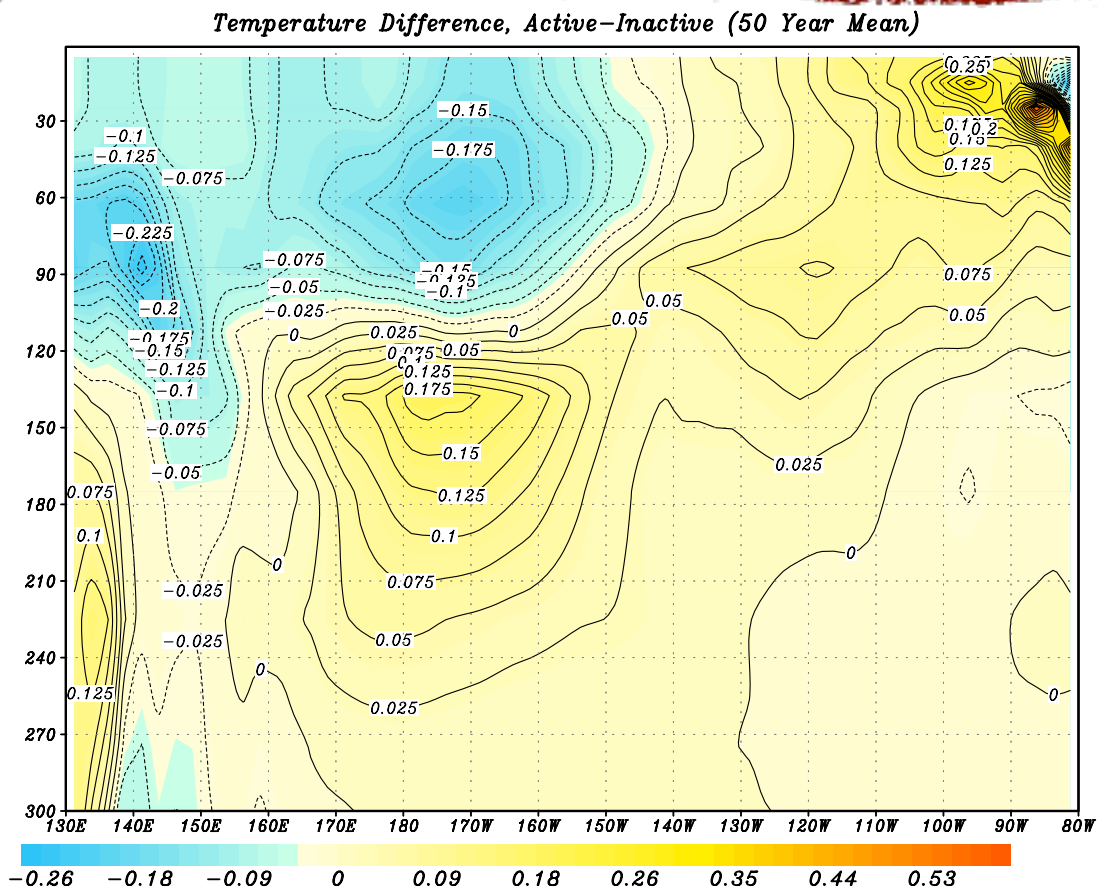
Effects on Thermocline



Alternate Effects on Thermocline



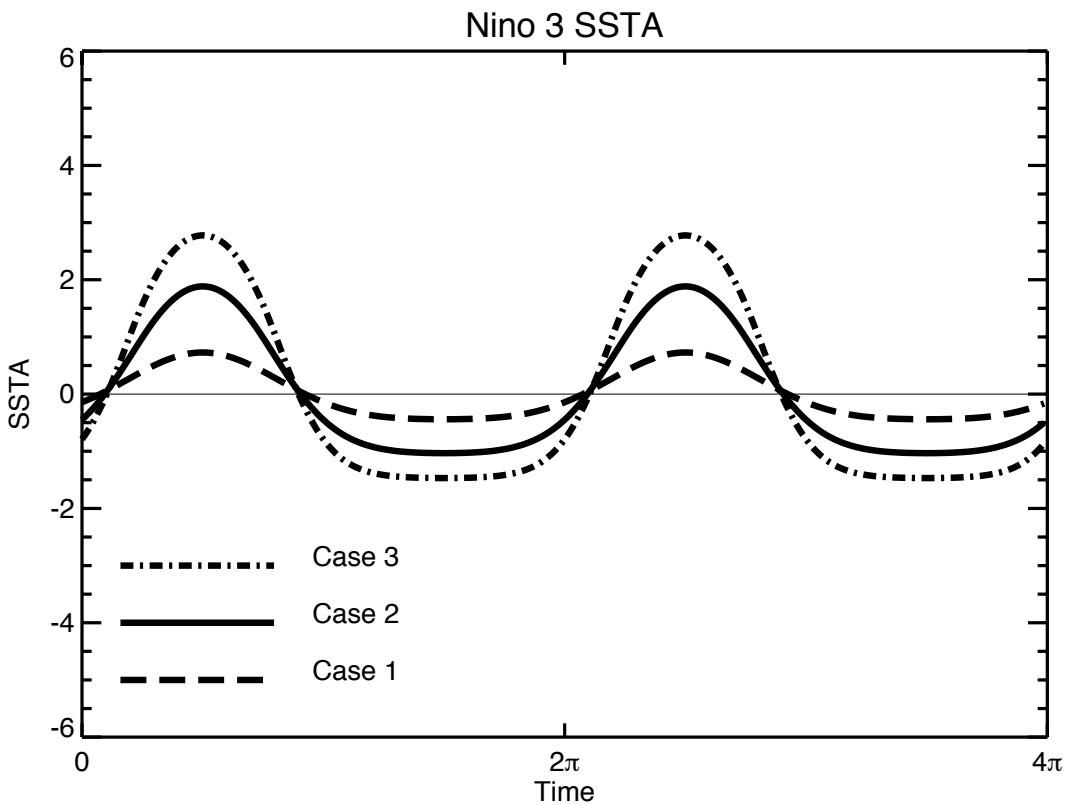
Thermocline Differences

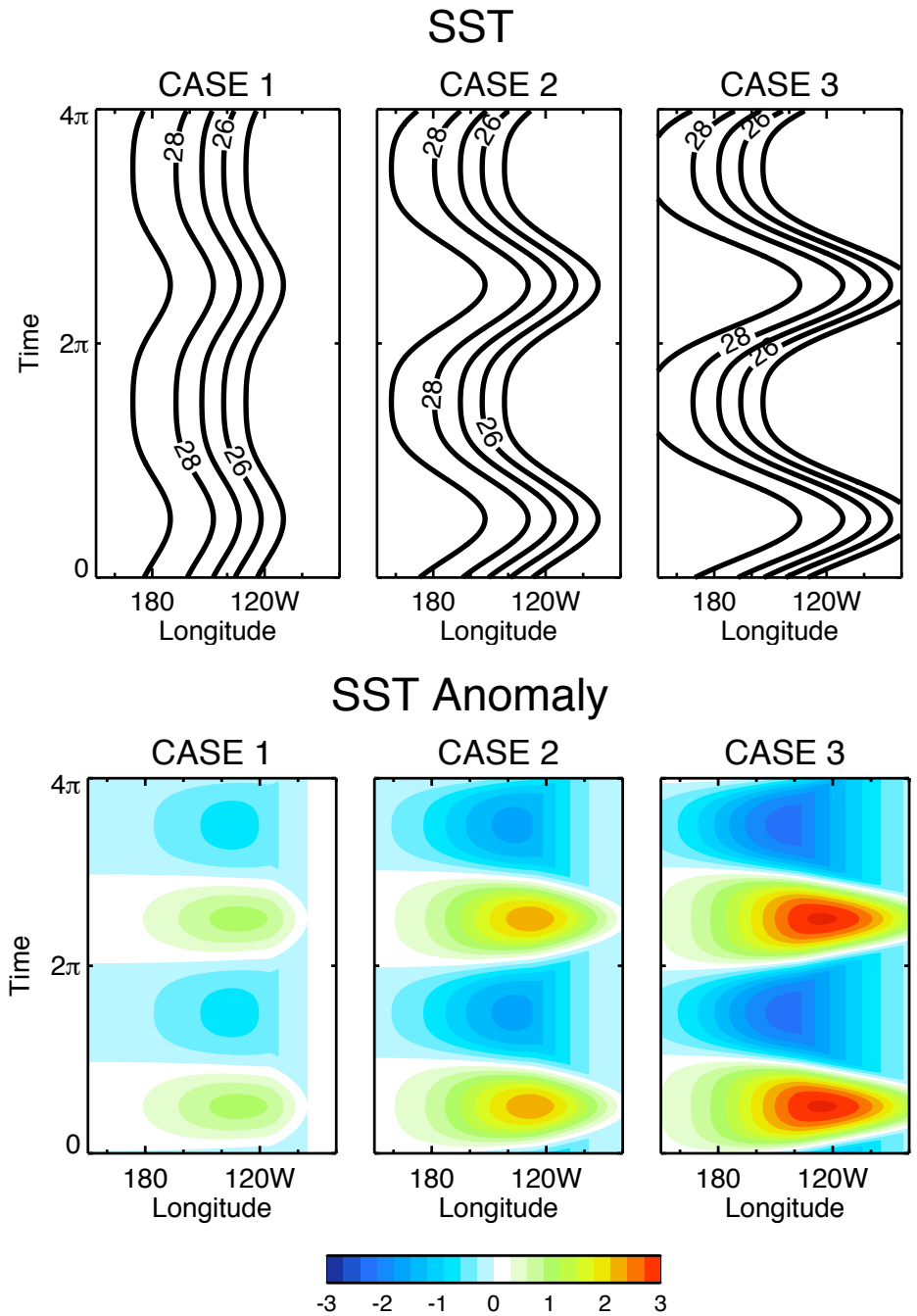


Predictable v. non-Predictable, Poseidon hybrid run

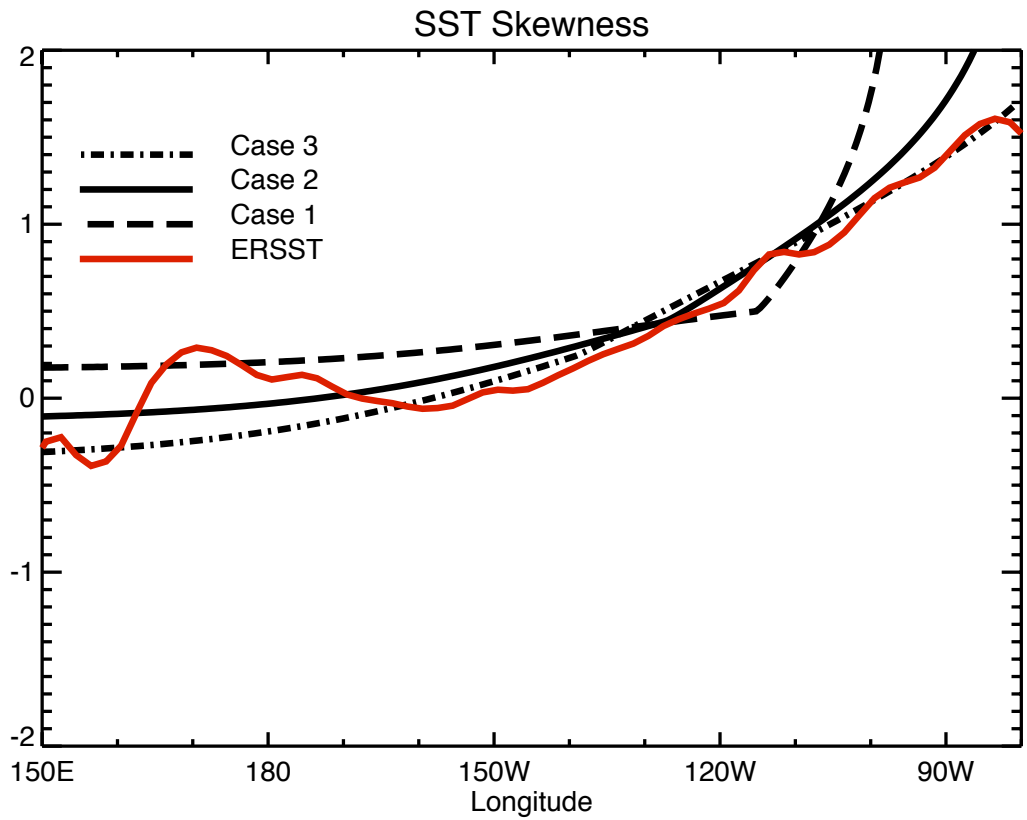
Skewness of ENSO Statistics

$$X(t) = \sin(t) - r\cos(2t)$$




SST
CASE 1
CASE 2
CASE 3
4π
2π
0
Time
28
26
180
120W
Longitude
SST Anomaly
-3
-2
-1
0
1
2
3

Skewness

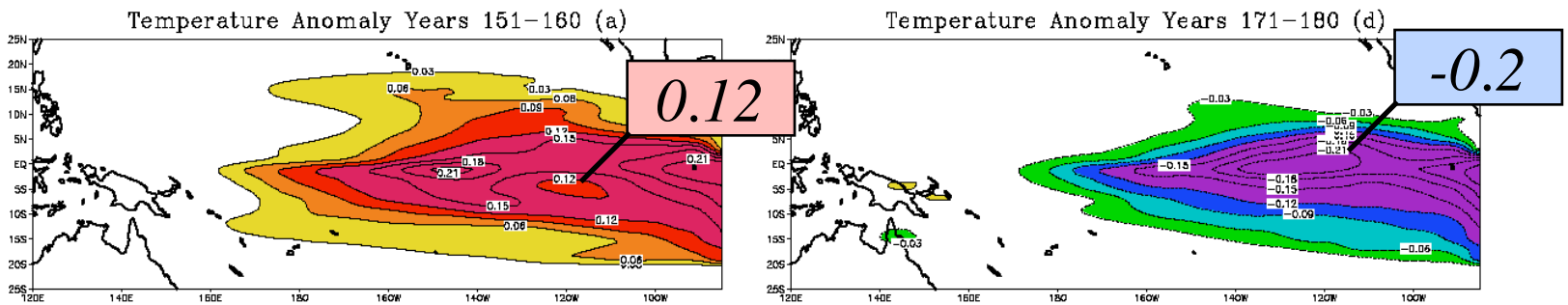

SST Skewness
Case 3
Case 2
Case 1
ERSST
2
1
0
-1
-2
150E
180
150W
120W
90W
Longitude

Some Conclusions

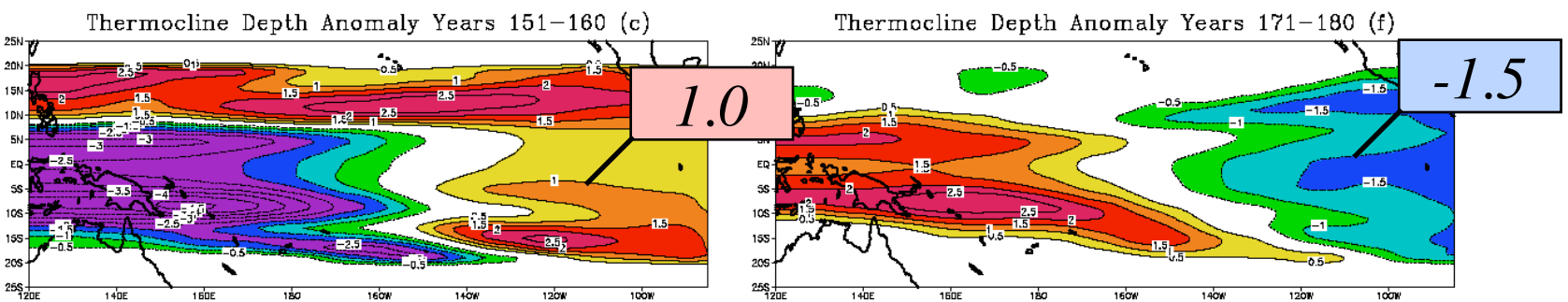
- ENSO amplitude affects the Eulerian time mean statistic
- We have excluded the possibility of simple “counting” problems
- Larger amplitude -> warmer SST in east

Kirtman-Schopf

SST

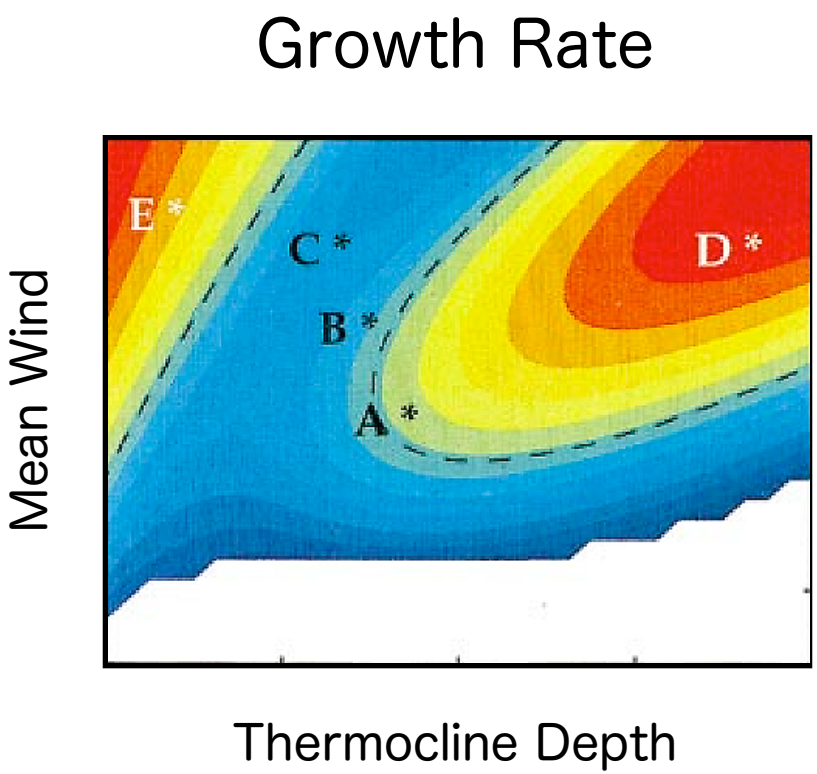


H_{20}



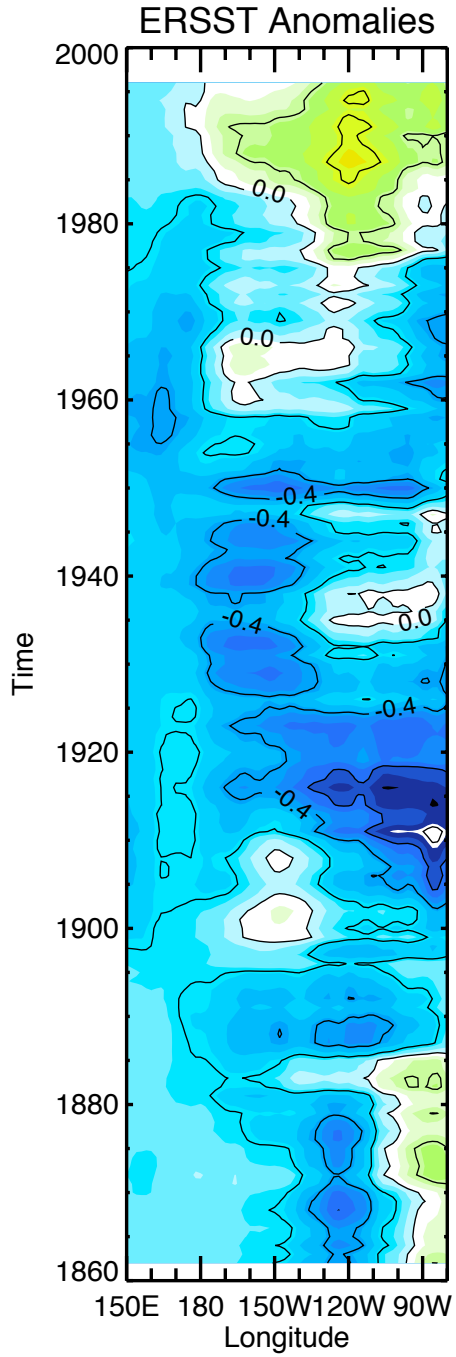
Hi ENSO *Low ENSO*

Fedorov & Philander Analysis



"We do indeed find that the changes in the properties of El Nino from the 1960s to the 1990s ... are consistent with the presence of a decadal fluctuation that was observed to deepen the thermocline in the eastern tropical Pacific, and to weaken the trade winds."

15 year Running Means



On the Mean and Predictability

- Because we just oscillate a fixed profile the instantaneous state during a decade with large oscillations looks just like the state during a decade with small.
- How does the system know to produce different size ENSO?

Conclusion

- Eulerian time means are fairly useless for predicting ENSO amplitude
- ENSO residuals are likely to be a dominant EOF of low frequency SST
- Other sources of change may well exist -- we just have to change how we look
- Fluegel, et al may be right, except essential nonlinearity.
- STC decadal variability may be 2nd mode