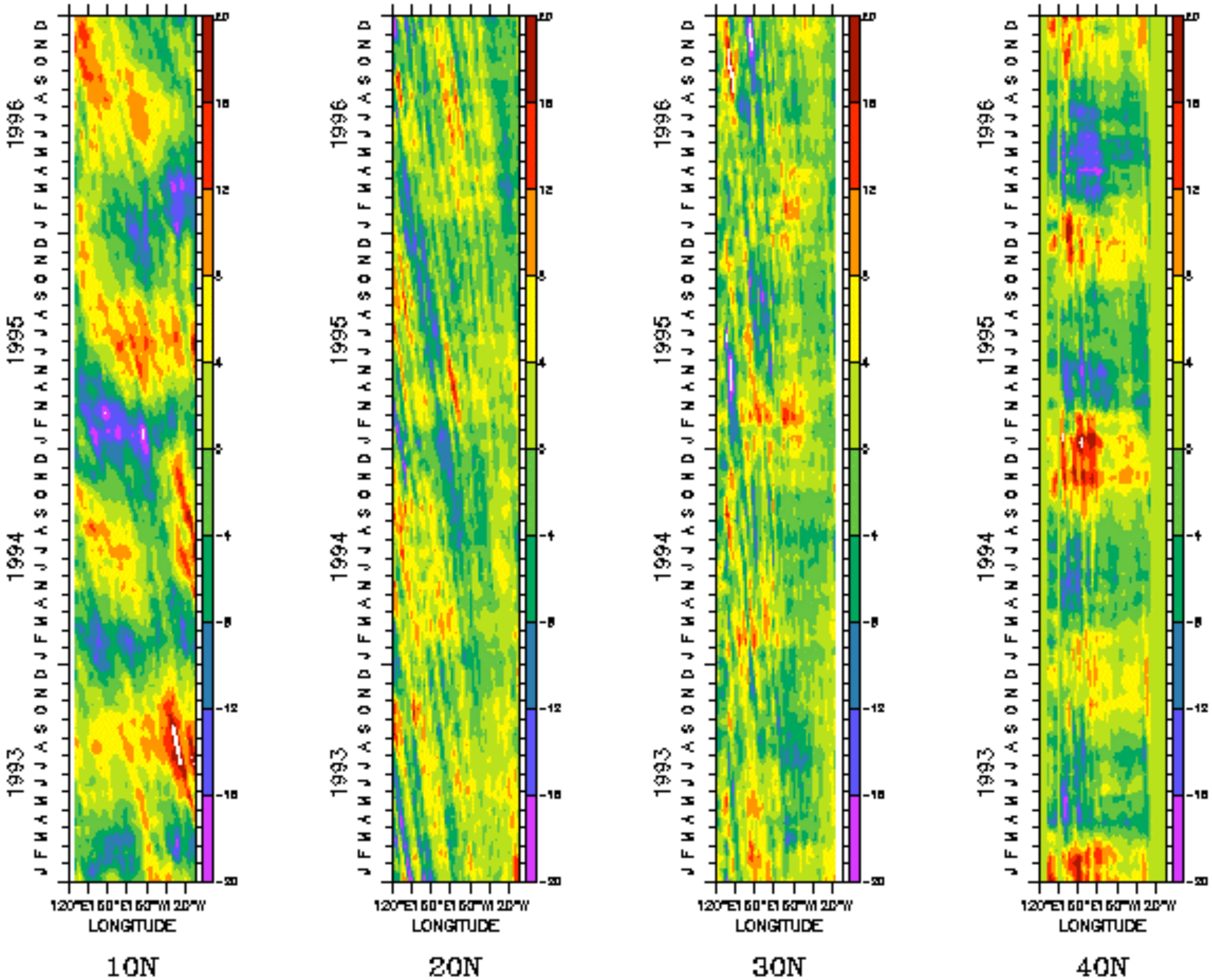
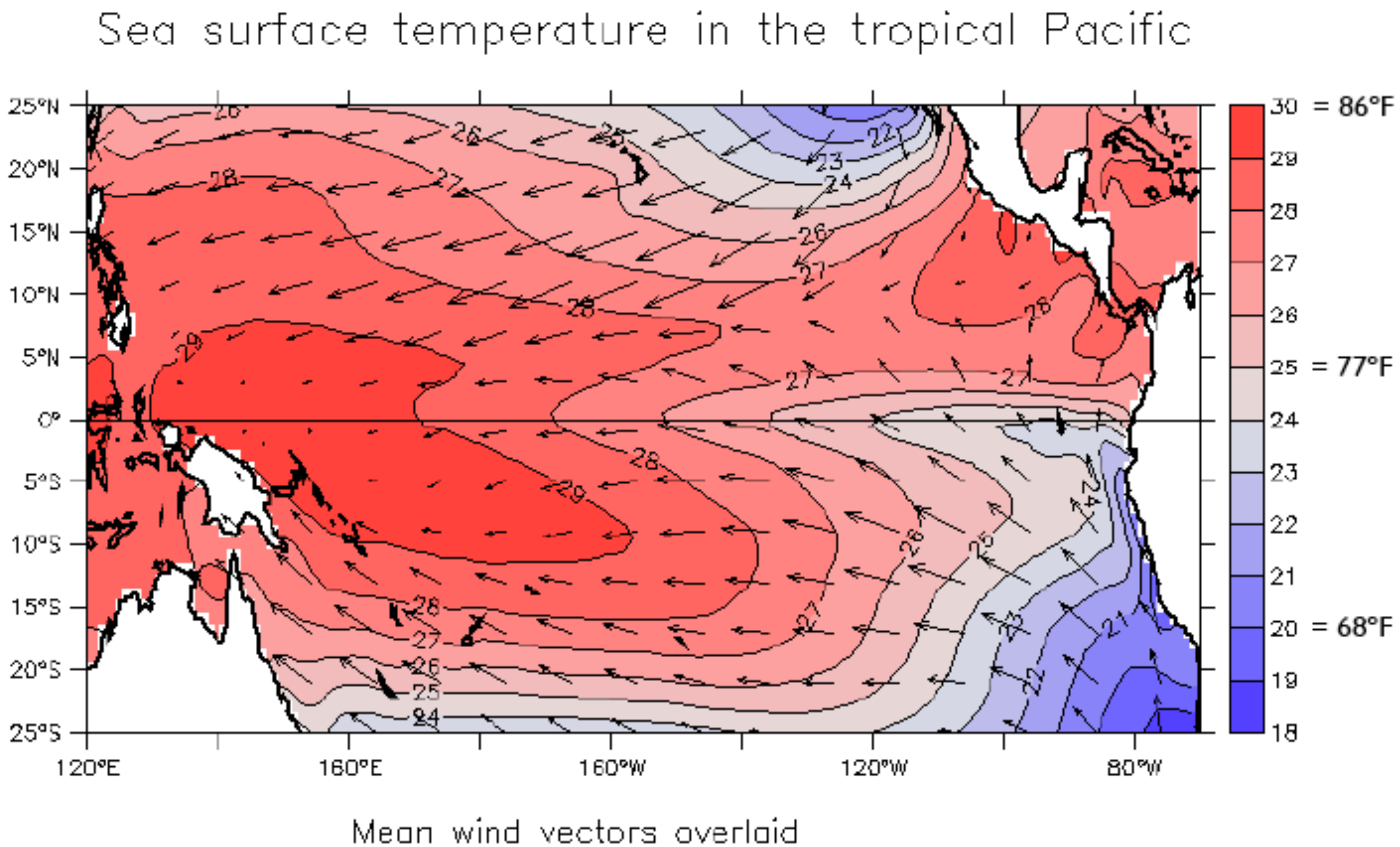
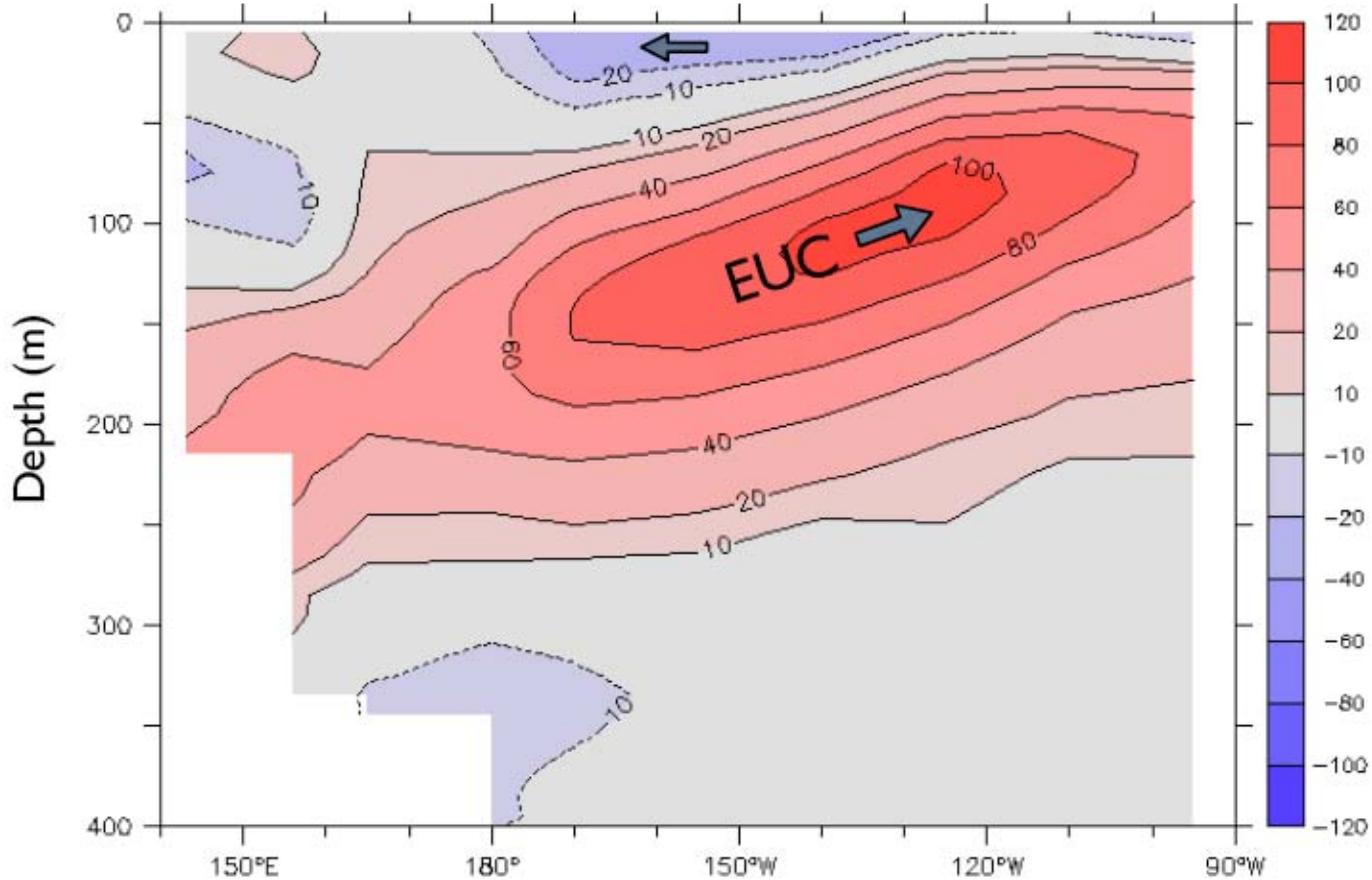
SSH anomalies from satellite

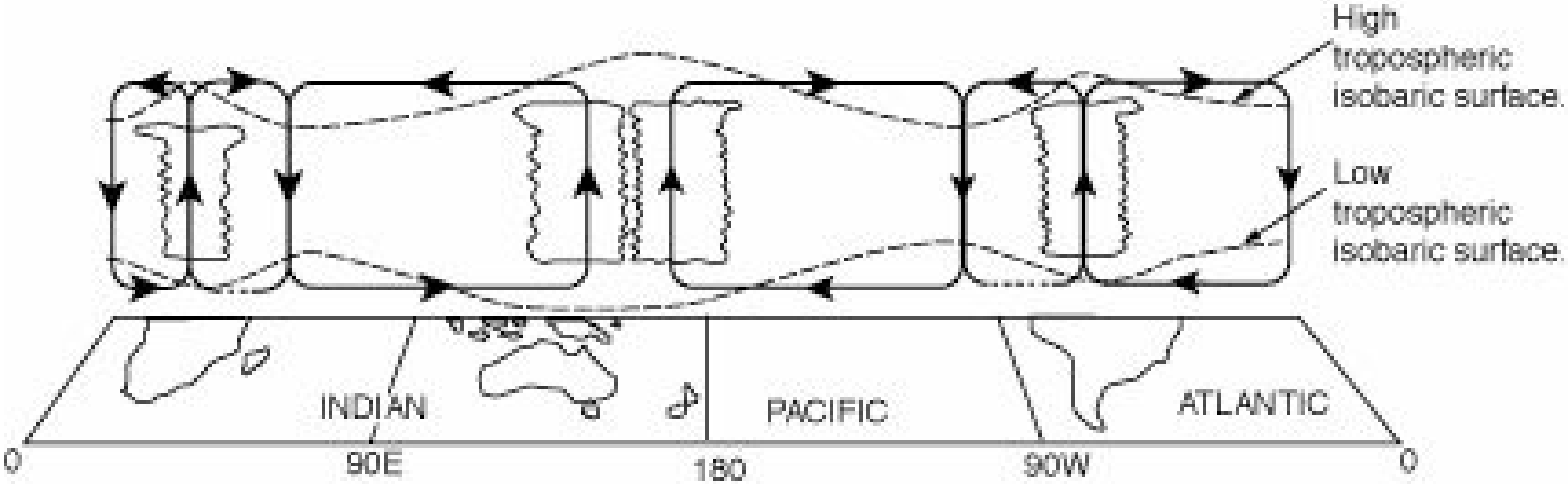


Mean SST

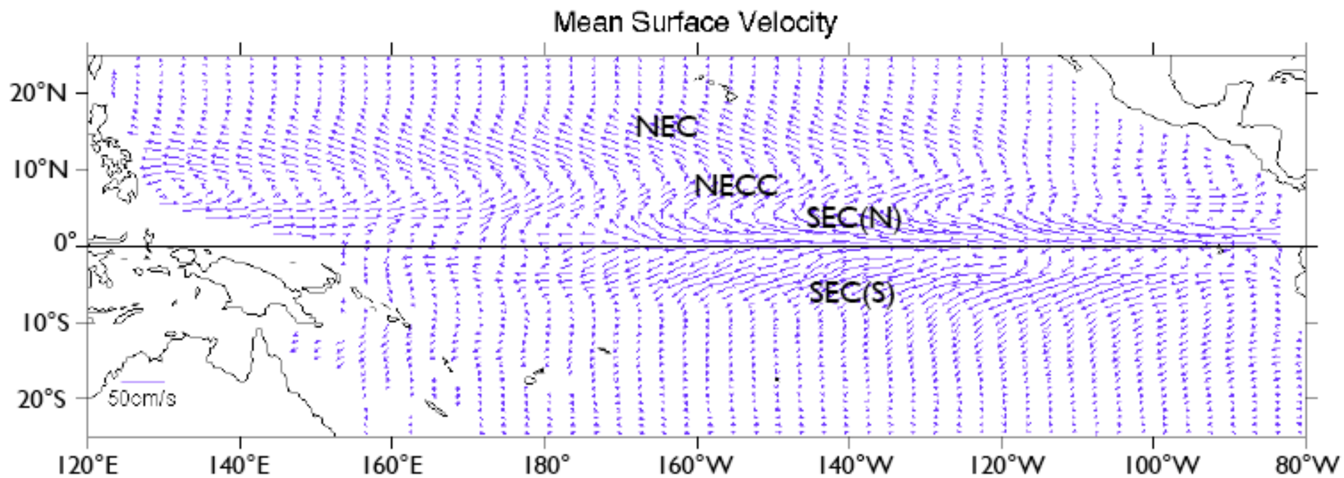

Sea surface temperature in the tropical Pacific
25°N
20°N
15°N
10°N
5°N
0°
5°S
10°S
15°S
20°S
25°S
120°E
160°E
160°W
120°W
80°W
30 = 86°F
29
28
27
26
25 = 77°F
24
23
22
21
20 = 68°F
19
18
Mean wind vectors overlaid

Zonal currents along the equator



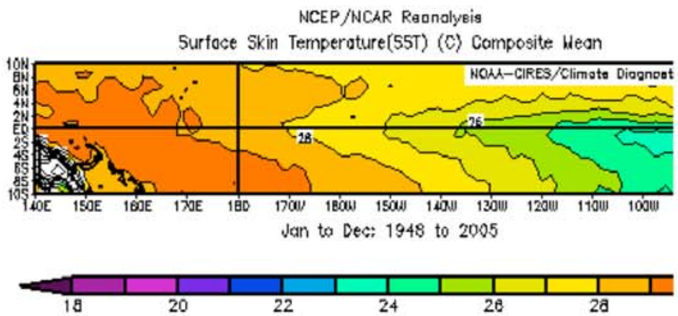

High
tropospheric
isobaric surface.
Low
tropospheric
isobaric surface.
INDIAN
PACIFIC
ATLANTIC
0
90E
180
90W
0

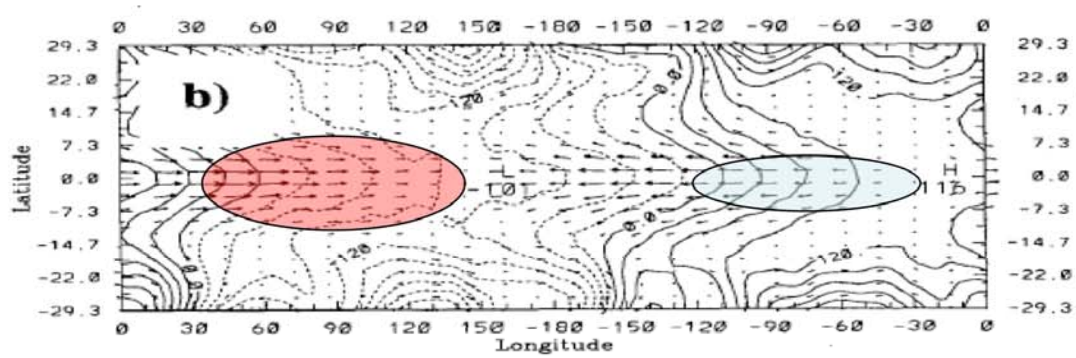
Currents from Topex altimetry and surface drifters

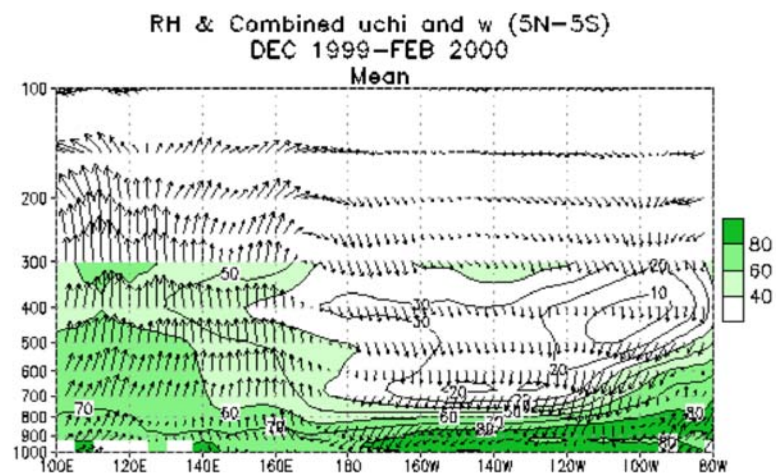


Lagerloef and Bonjean

East-West SST Gradient -> Walker Circulation

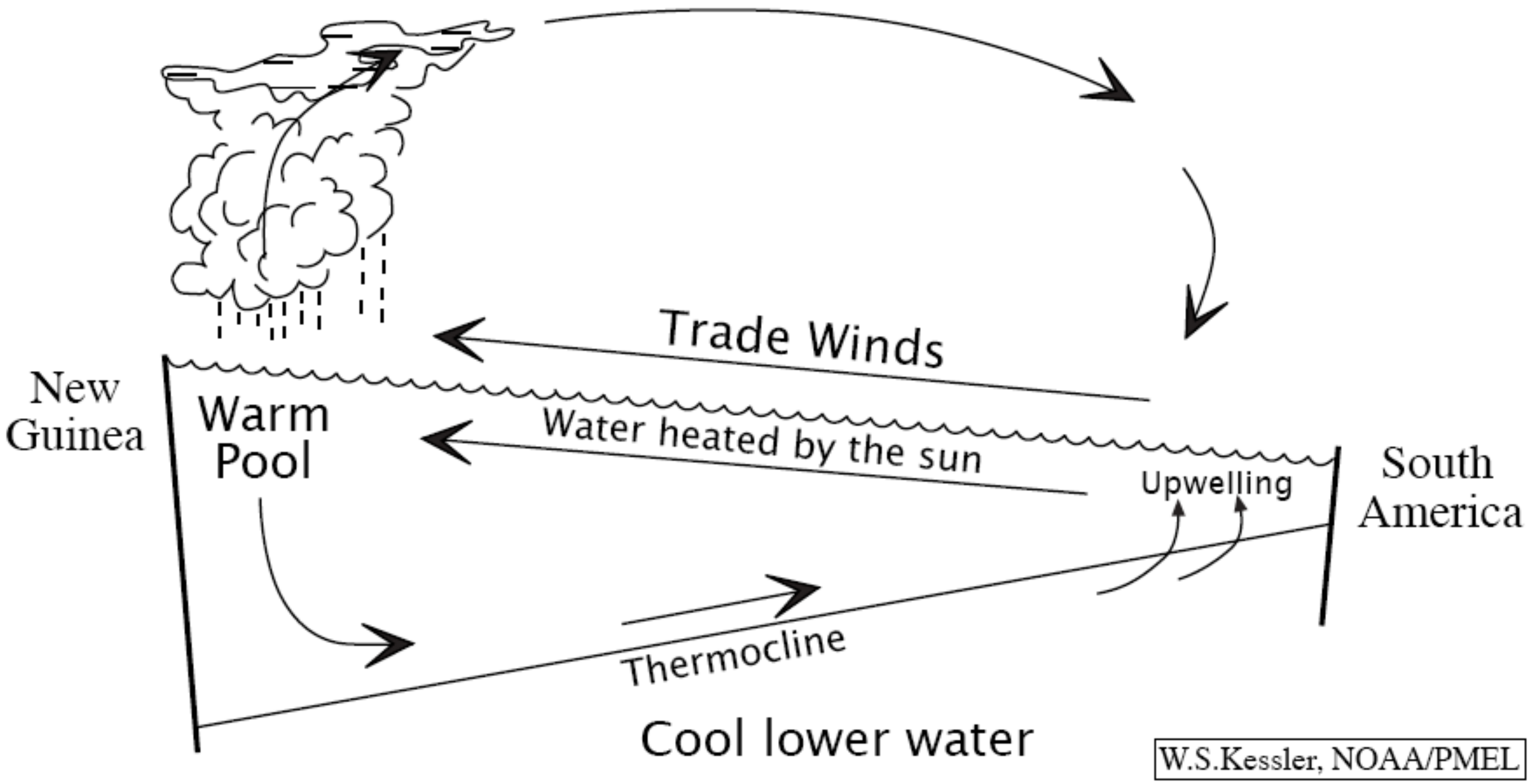




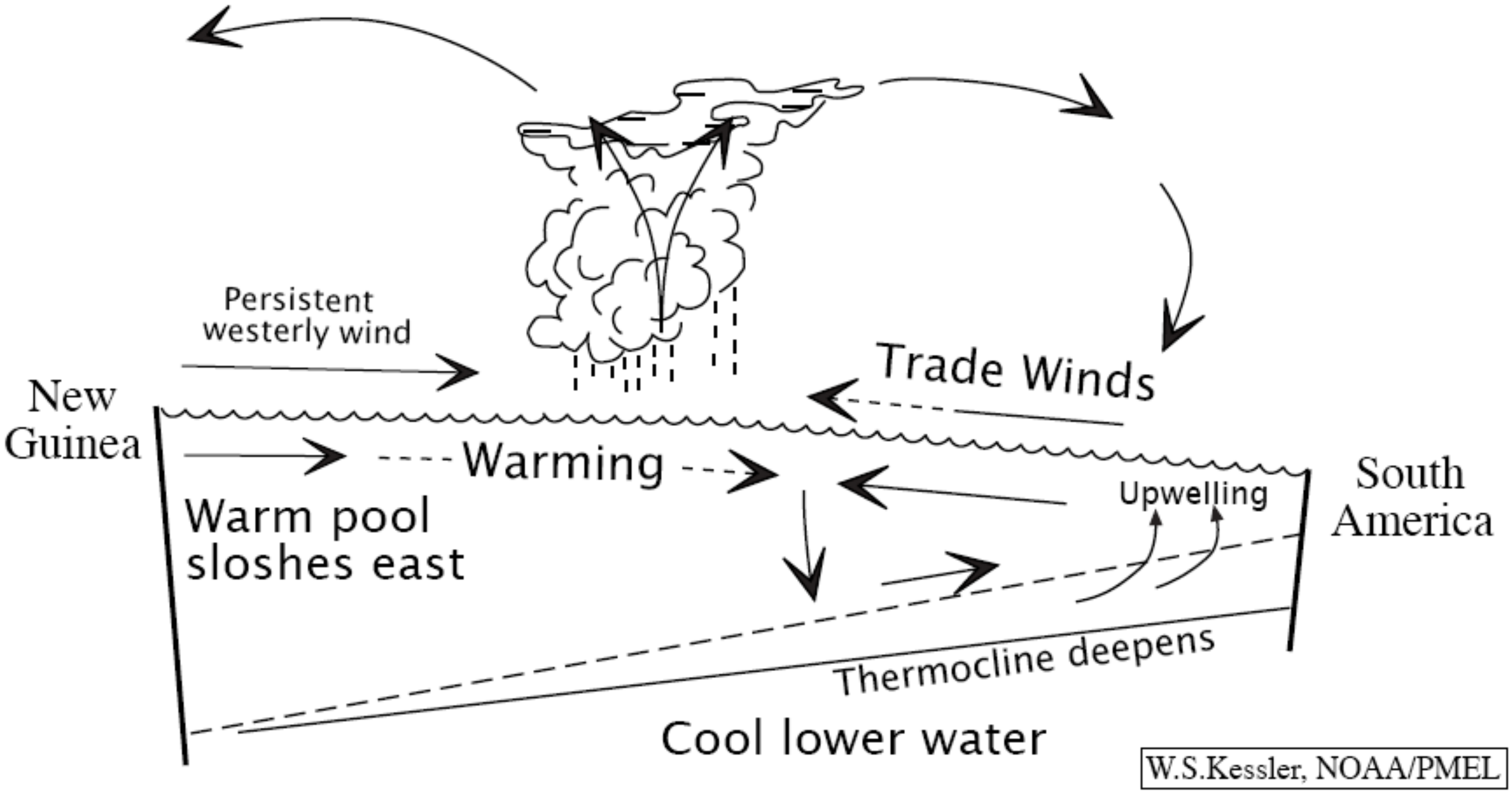


Positive (Bjerknes) feedback amplifies SST gradient and Walker Circulation

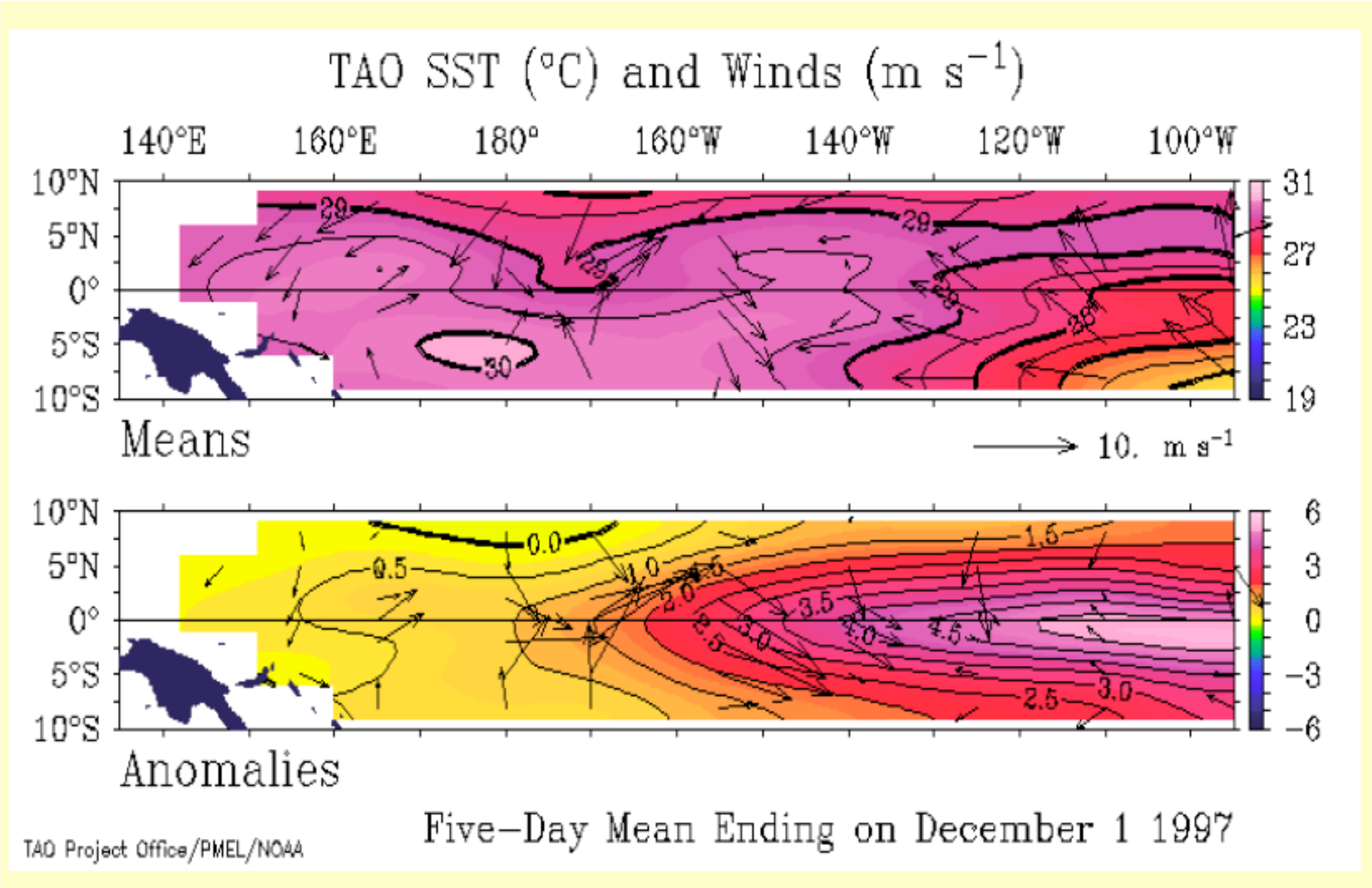
Normal conditions

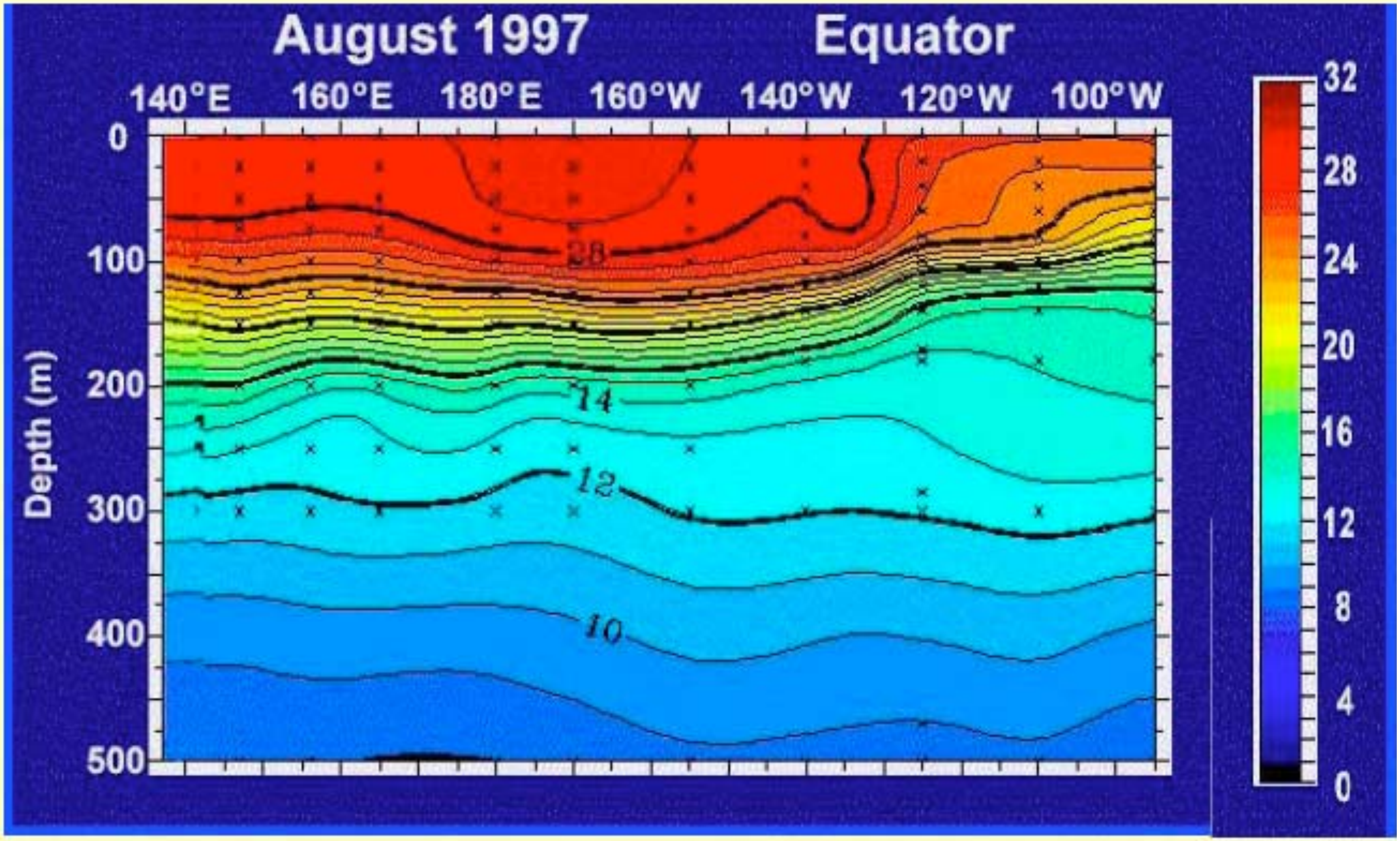


El Nino conditions

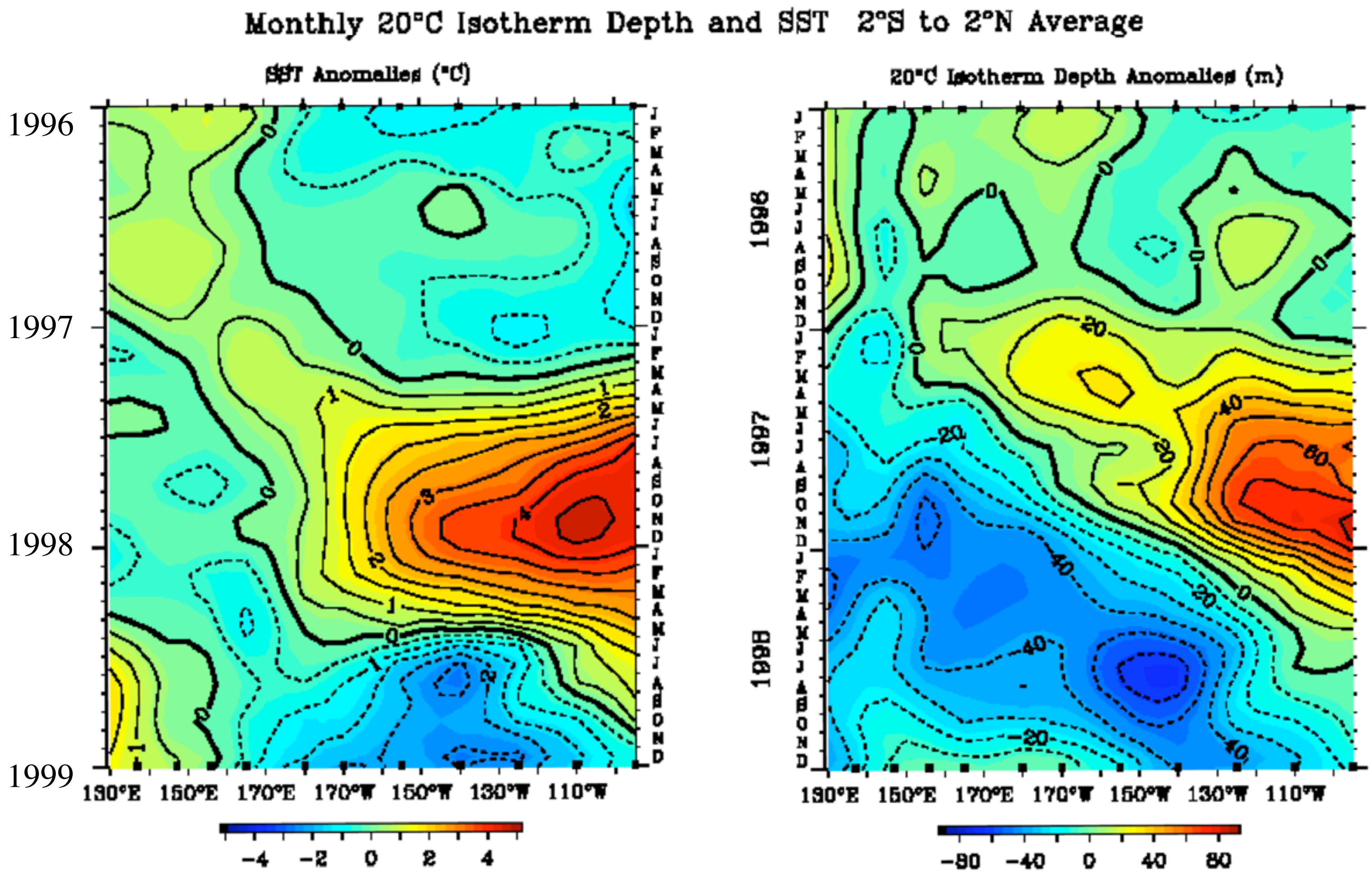


ENSO Wind and SST



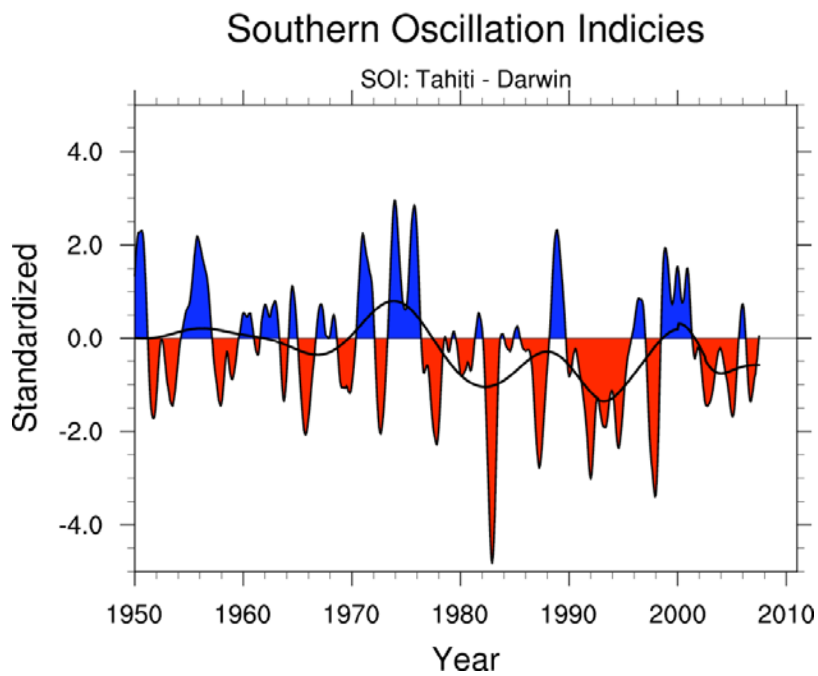


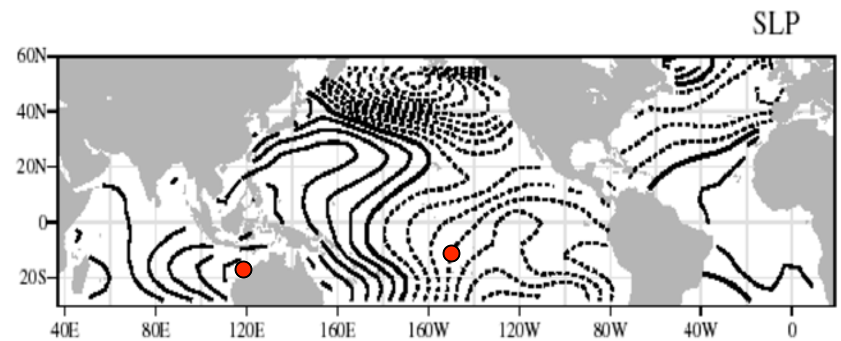
August 1997
Equator
140°E
160°E
180°E
160°W
140°W
120°W
100°W
Depth (m)
0
100
200
300
400
500
28
14
12
10
32
28
24
20
16
12
8
4
0



Sea surface temperature (SST) and zonal wind anomalies vary in a quasi-stationary fashion.

Thermocline anomalies along the equator show a systematic space and time evolution relative to SST anomalies.





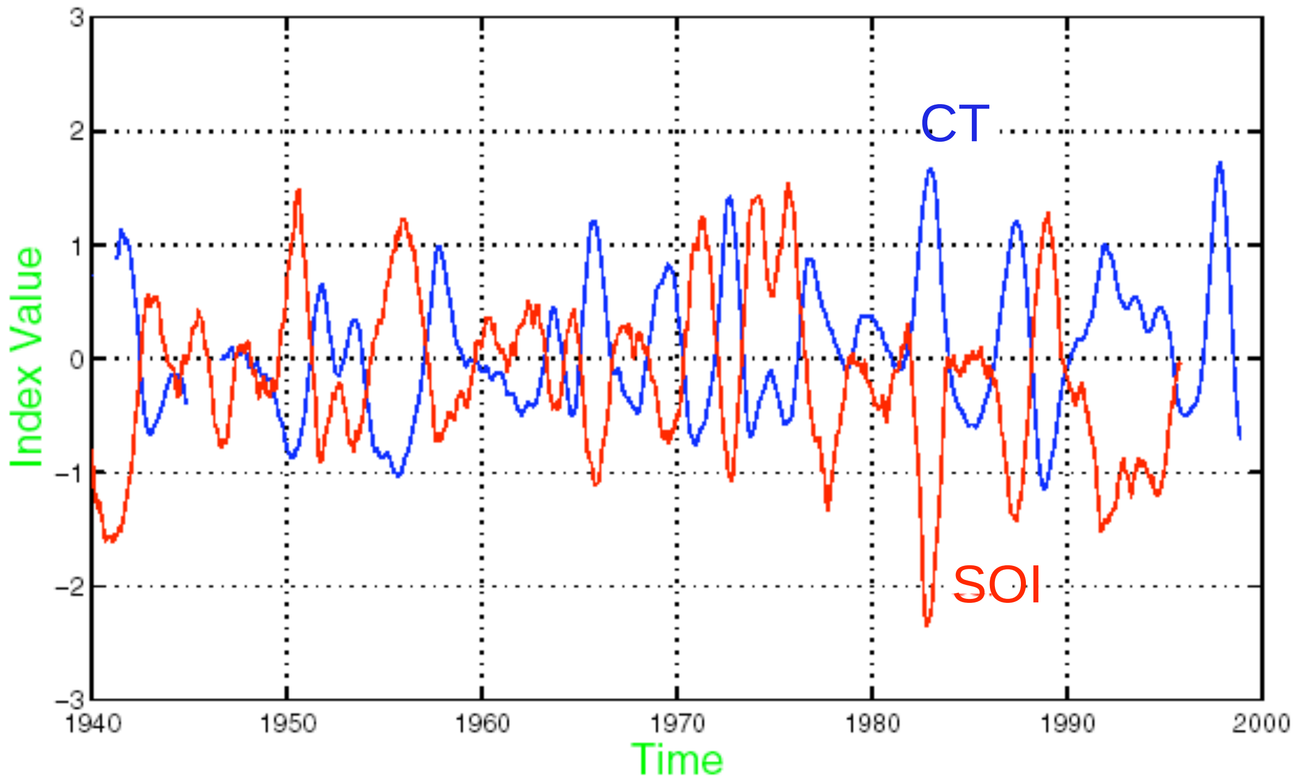
$$SOI = 10\frac{\left(P_{diff} - P_{diffav}\right)}{SD(P_{diff})}$$

$$P_{diff} = P_{Tahiti} - P_{Darwin}$$

Mean P Tahiti>P Darwin. Negative SOI is weakening of trades

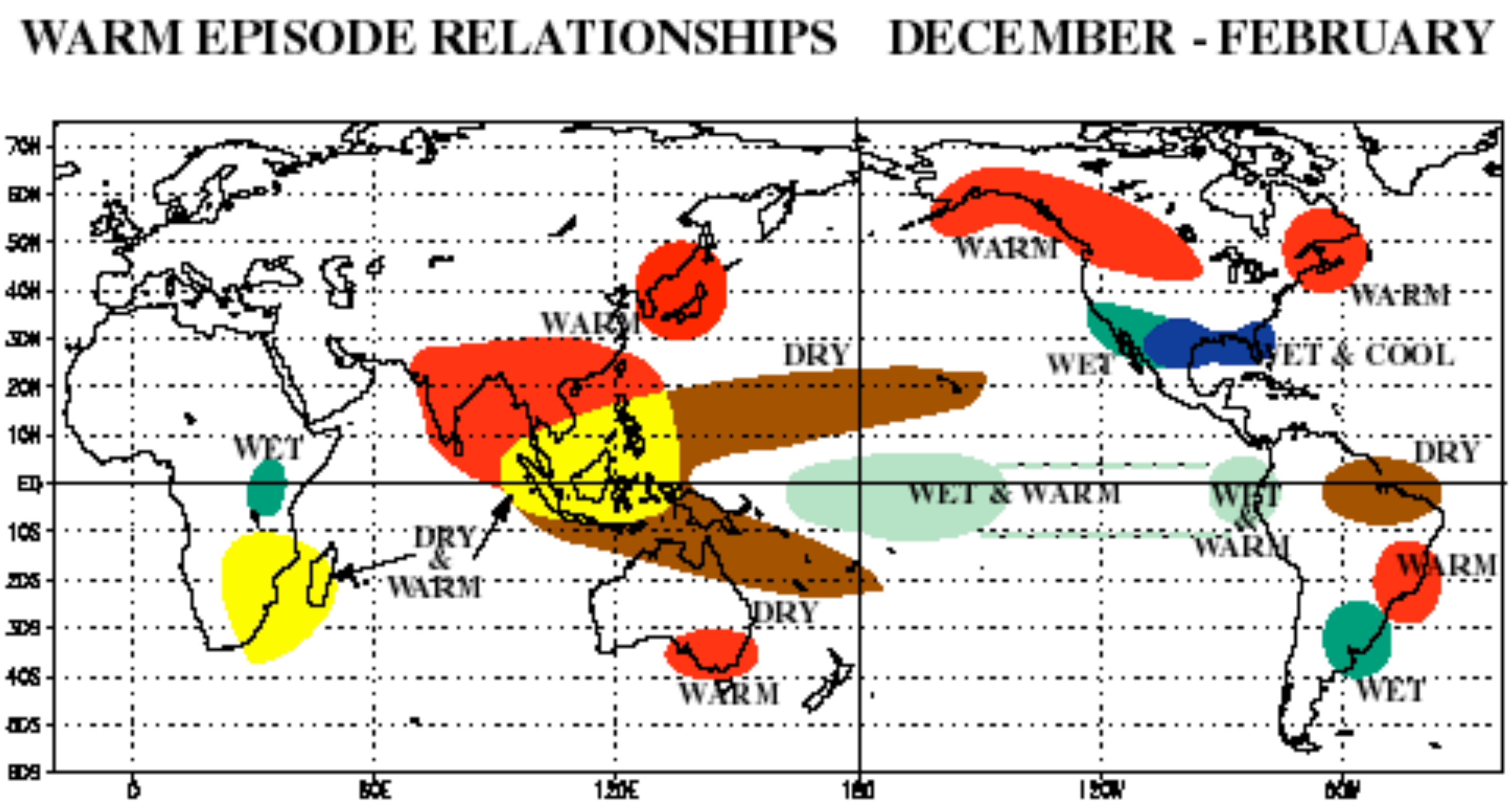
There is a tight coupling between the atmosphere & ocean.

Sea Surface Temperature and Sea Level Pressure



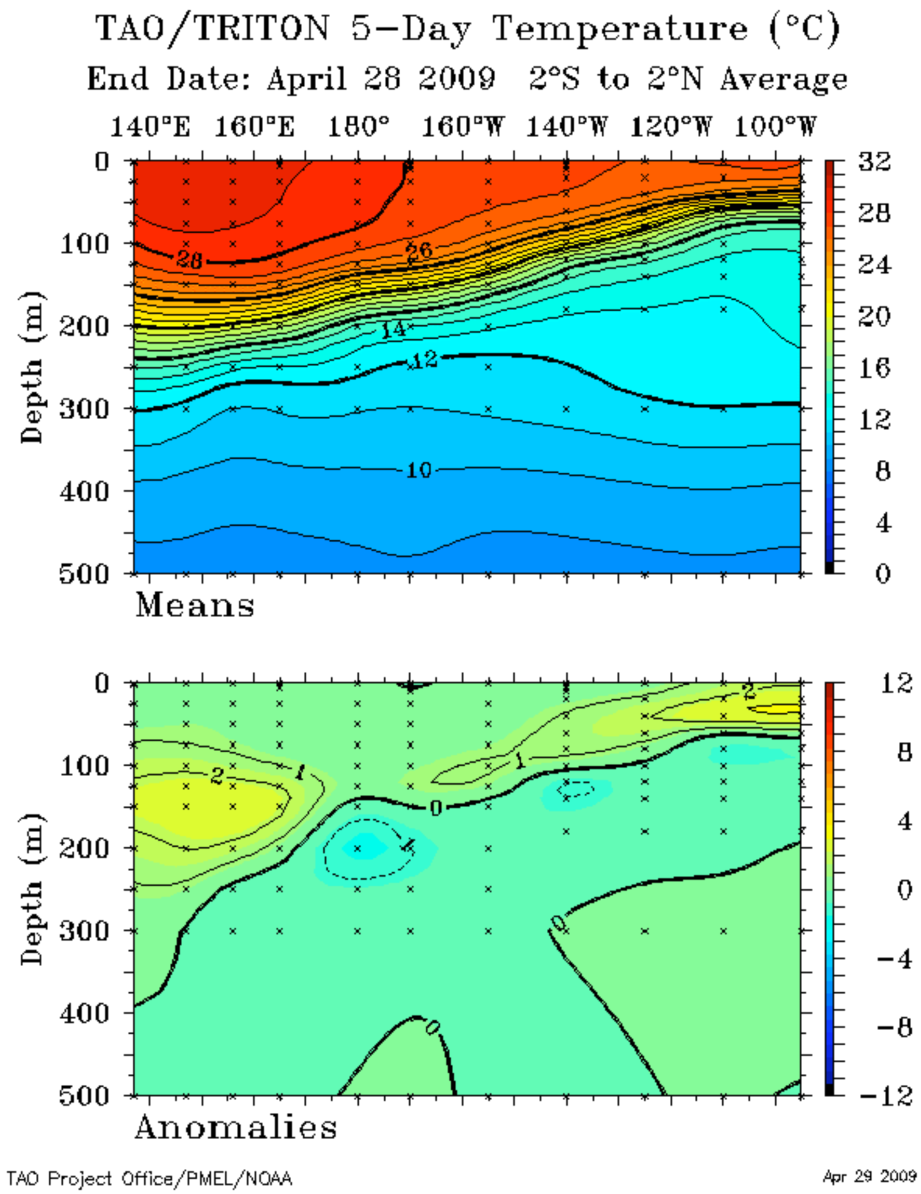
r = 0.93

The impacts of ENSO (cont).

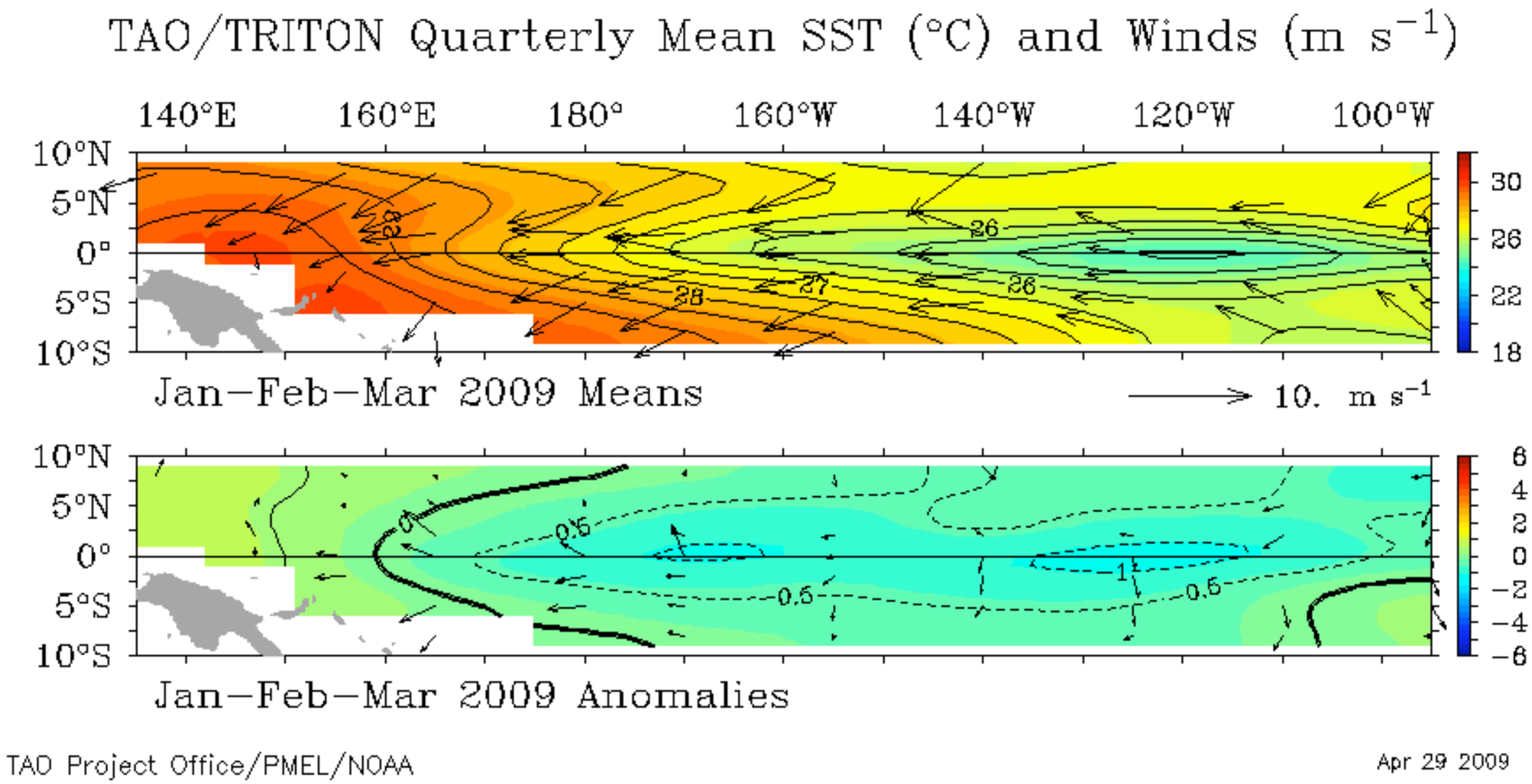


- ENSO alters the Pacific storm tracks, and the probabilities of extreme weather events on a global scale.

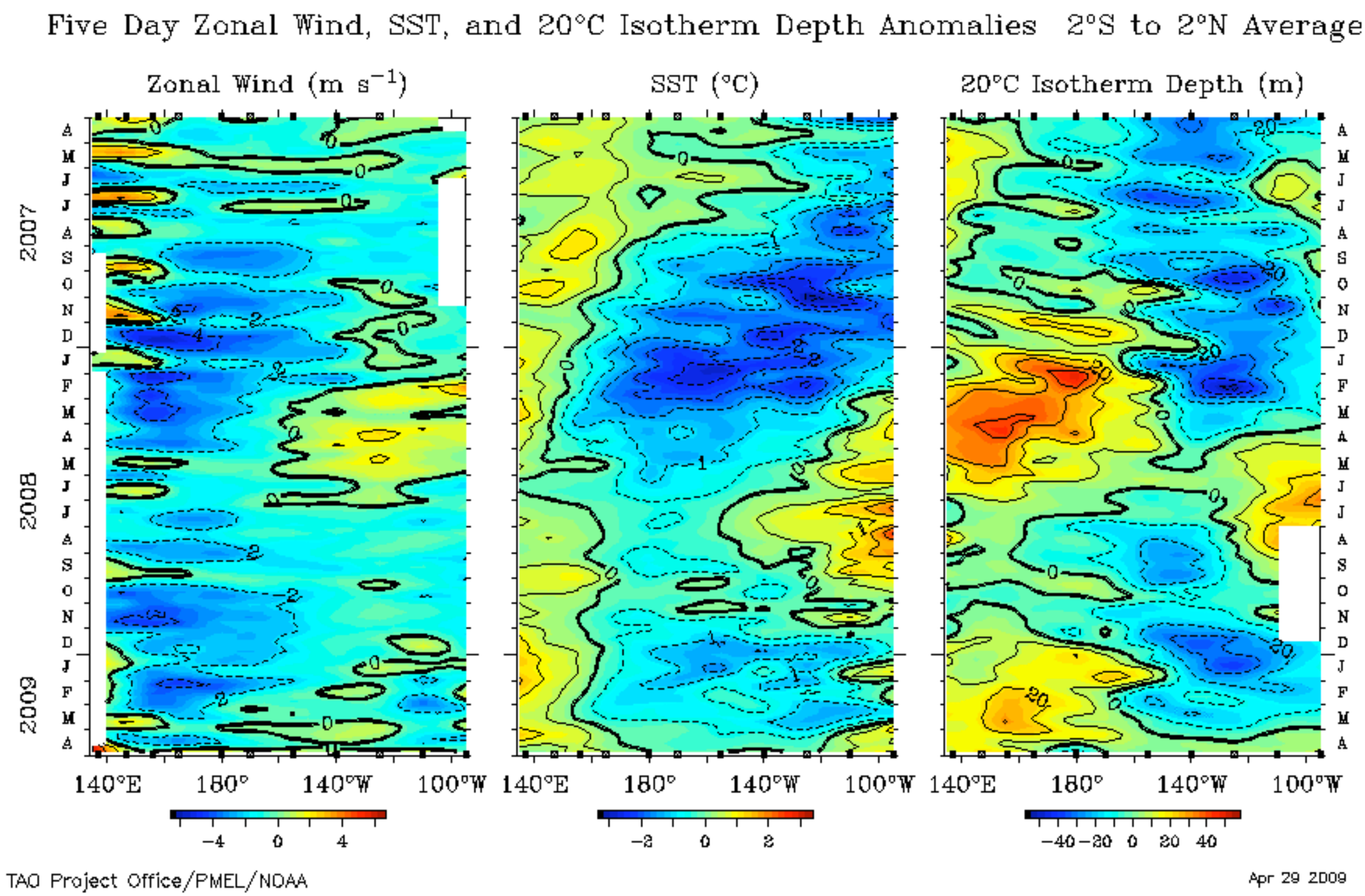
State of the tropical Pacific today



State of the tropical Pacific today



State of the tropical Pacific today

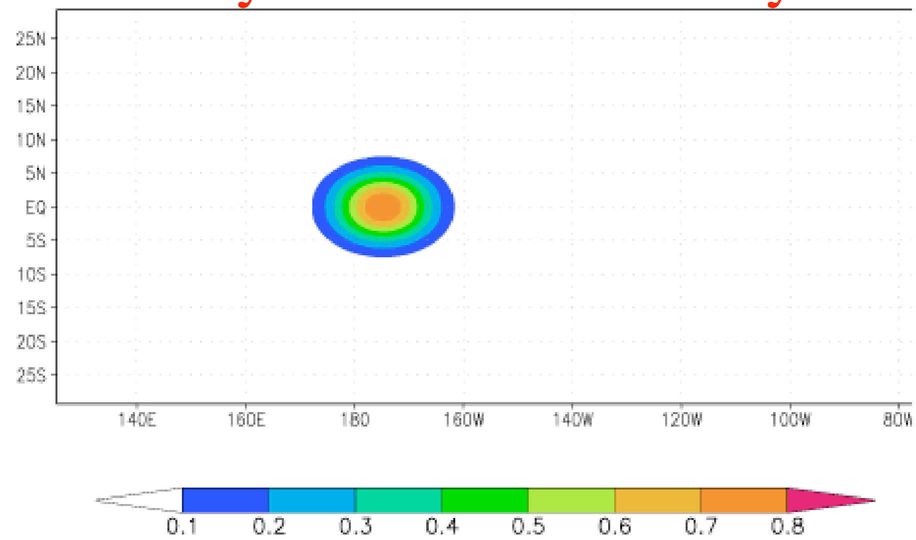


Delayed Oscillator Theory: introduction to KW and RW

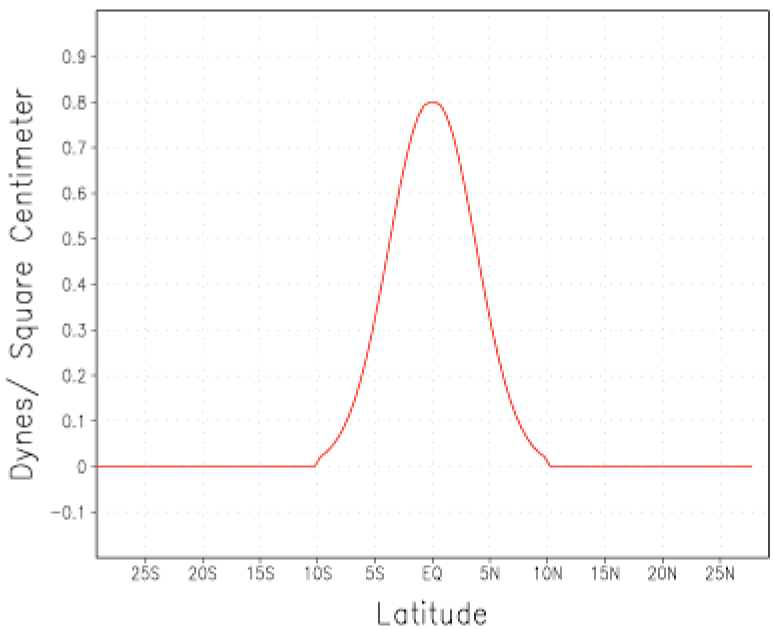
1. Kelvin wave: travels as a first baroclinic mode gravity wave with speed sqrt(g'h) to the east, about 3 m/s to the EAST. Crosses the Pacific in about 2 months.

2. Rossby wave (first meridional mode) travels as a first baroclinic mode with phase speed equal to sqrt(g'h)/3, about 1 m/s to the WEST Cross the Pacific in 6 months. In oceanic Rossby waves, meridional advection of planetary vorticity is balanced by stretching not relative vorticity

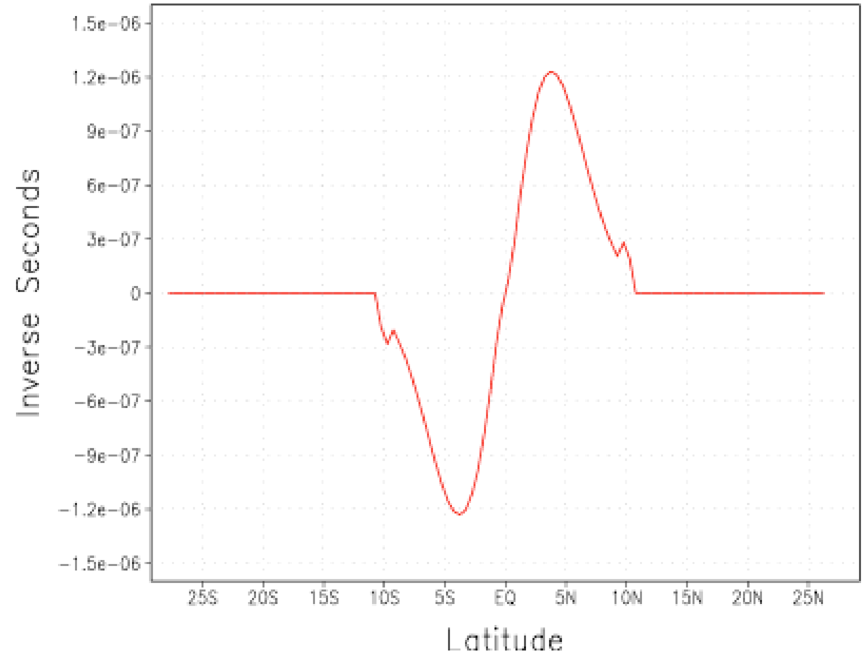
Delayed Oscillator Theory: a model of SSH evolution



Zonal wind anomaly on the Equator (westerly)

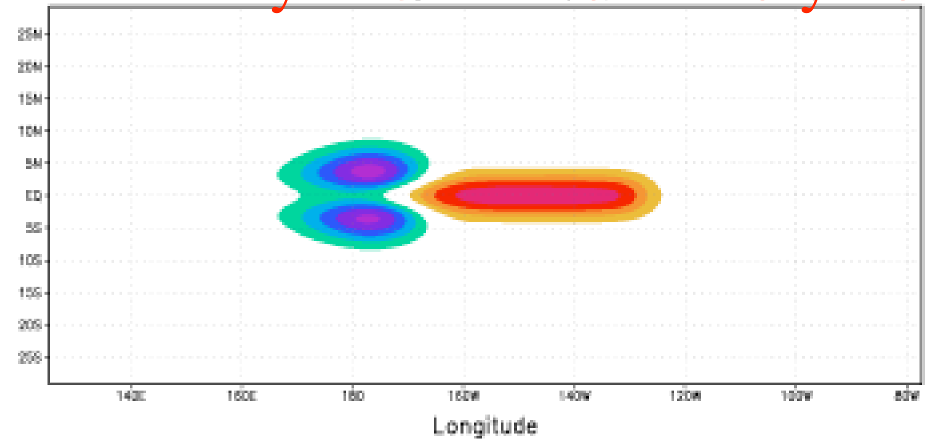


Wind stress at 175W

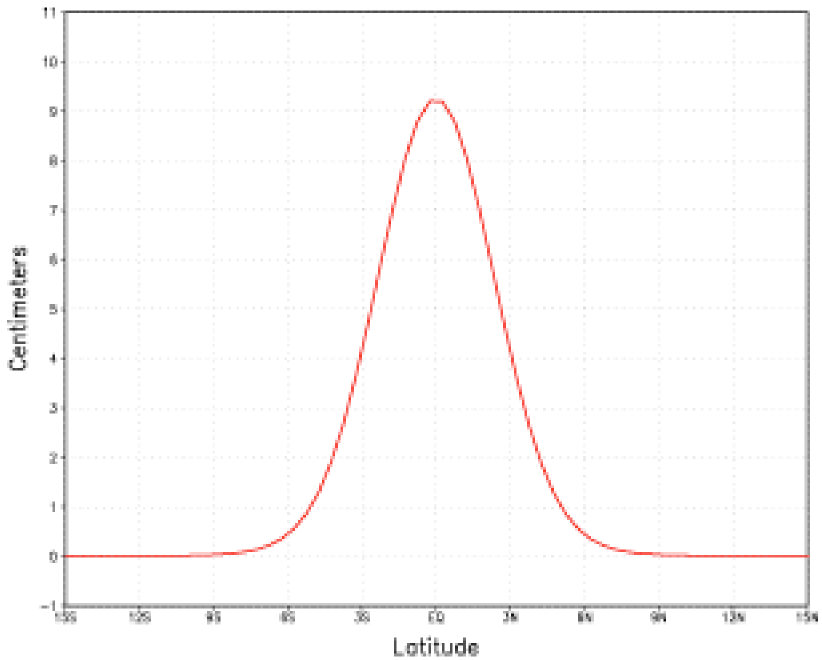


Wind stress curl at 175W

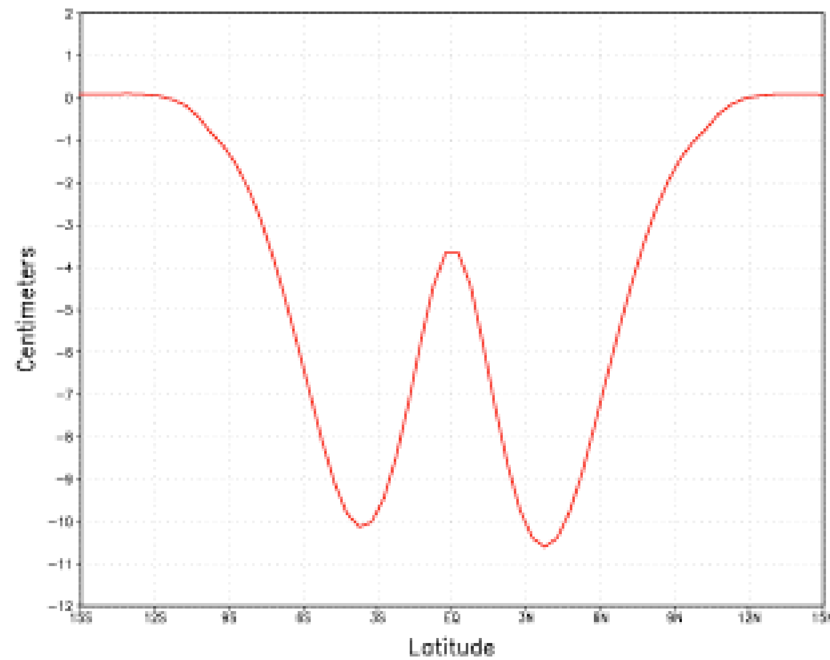
Delayed Oscillator Theory: forcing of RW and KW



Ocean sea surface
Height anomaly
(remember thermocline
is opposite)

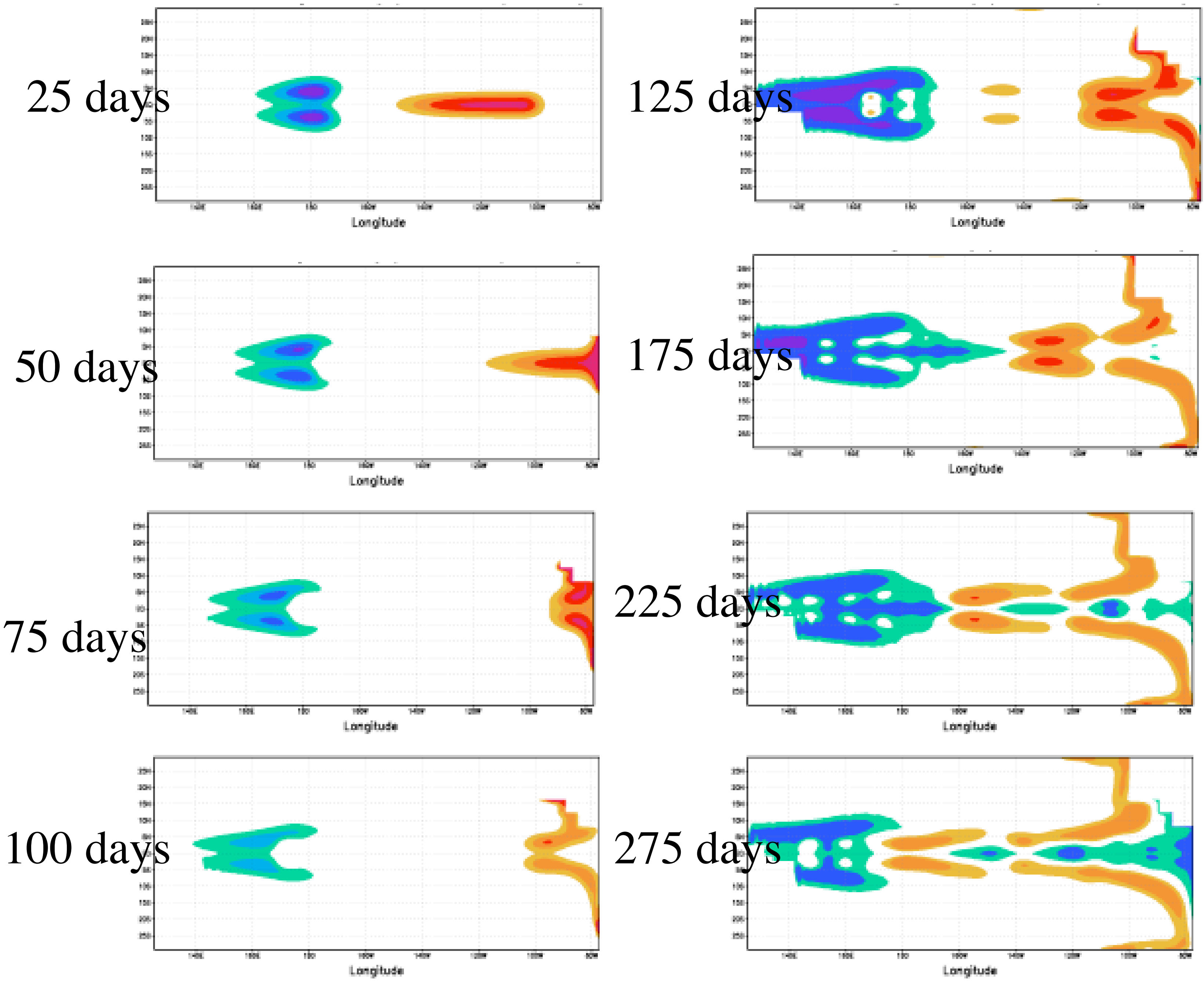


Ocean sea surface height
anomaly along 140W
Downwelling Kelvin Wave

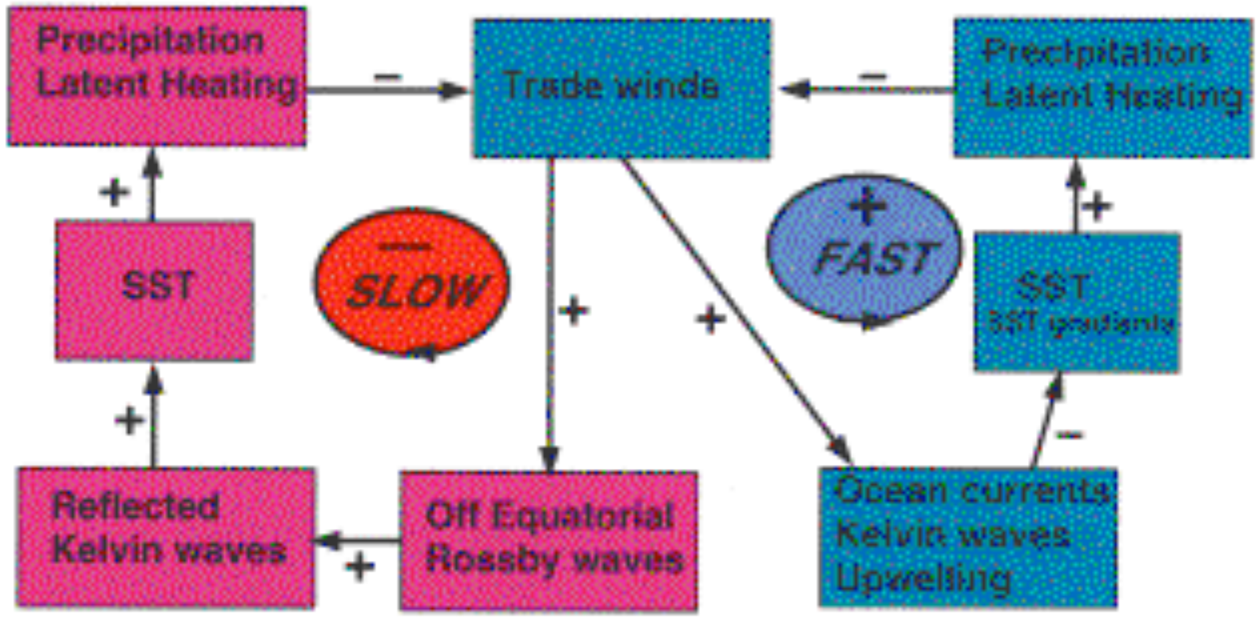


Ocean sea surface height
anomaly along 180E, upwelling
Rossby wave

Delayed Oscillator Theory: evolution of RW and KW



ENSO Feedback (Delayed Oscillator)



Ocean circulation changes from weaker tradewinds include weaker equatorial currents, weaker upwelling, and downwelling Kelvin waves, which lead to higher SSTs in the central and eastern Pacific. The off equatorial Rossby waves propagate westward and eventually trigger upwelling Kelvin waves, which reverse the process a year or so later.