

Large-Scale Circulation: Three Big Ideas

1) Meridional Temperature and Momentum Transport (Mean Meridional Circulation)

- Stationary and Transient Eddies

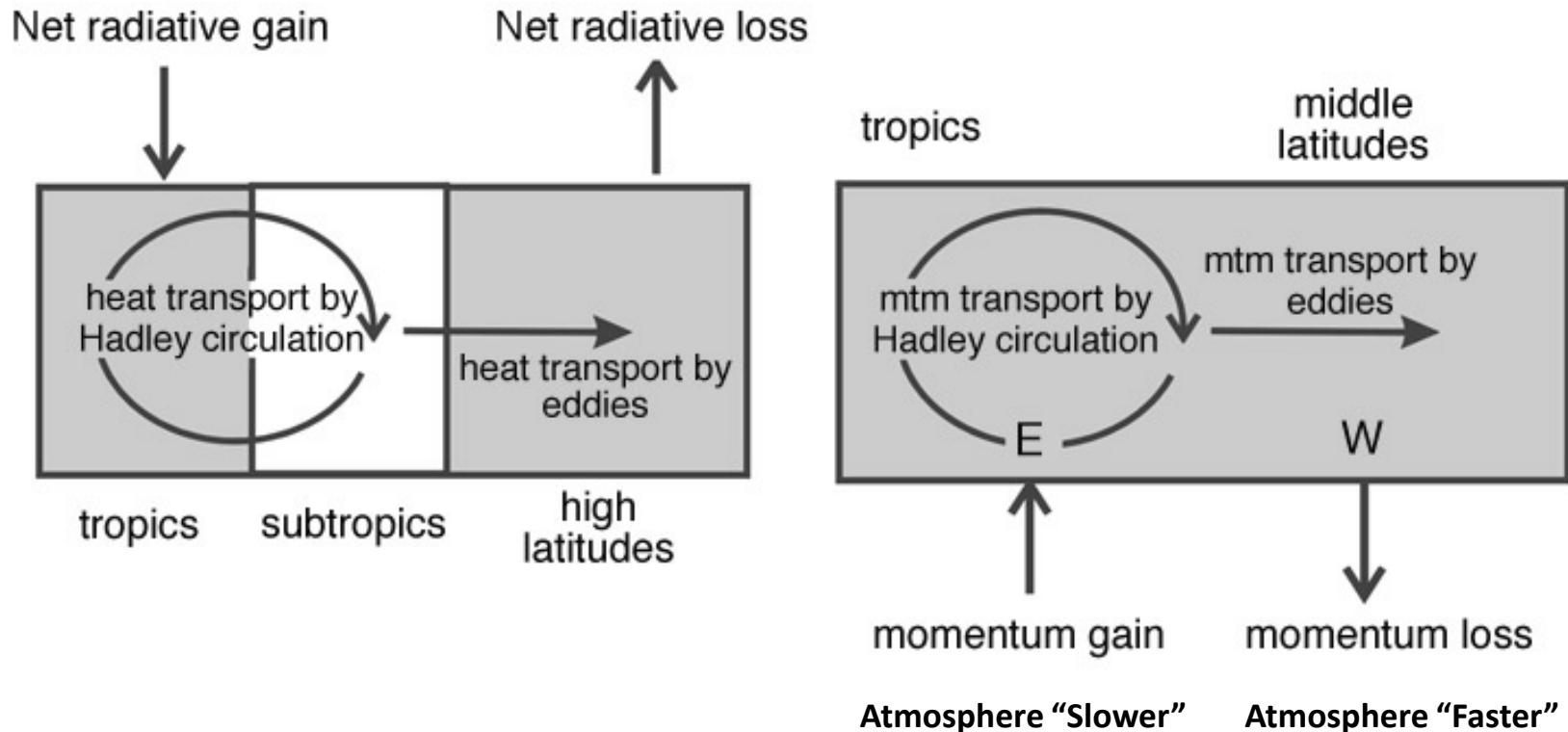
2) Large-Scale Tropics

- ENSO

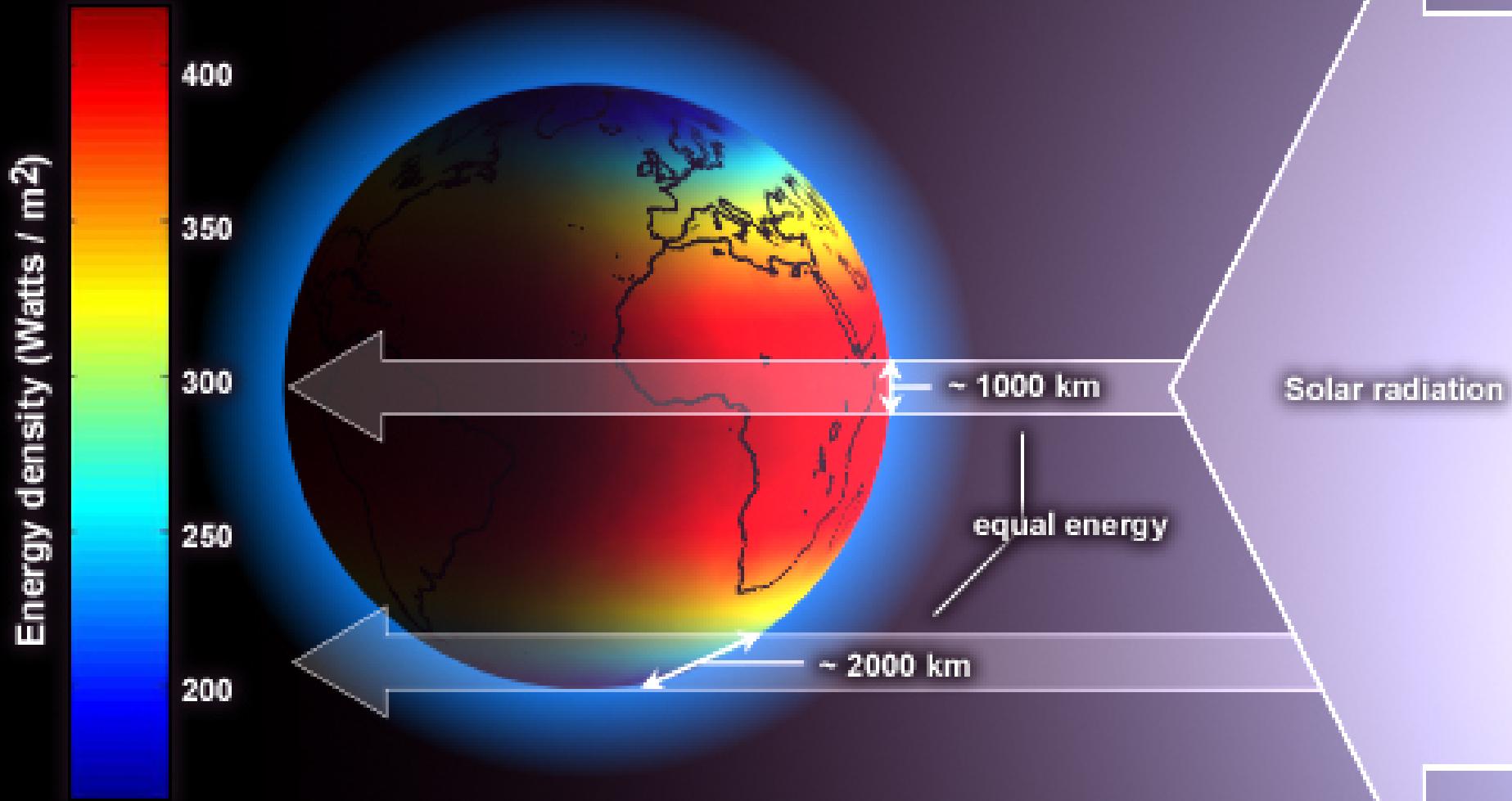
3) Climate Change

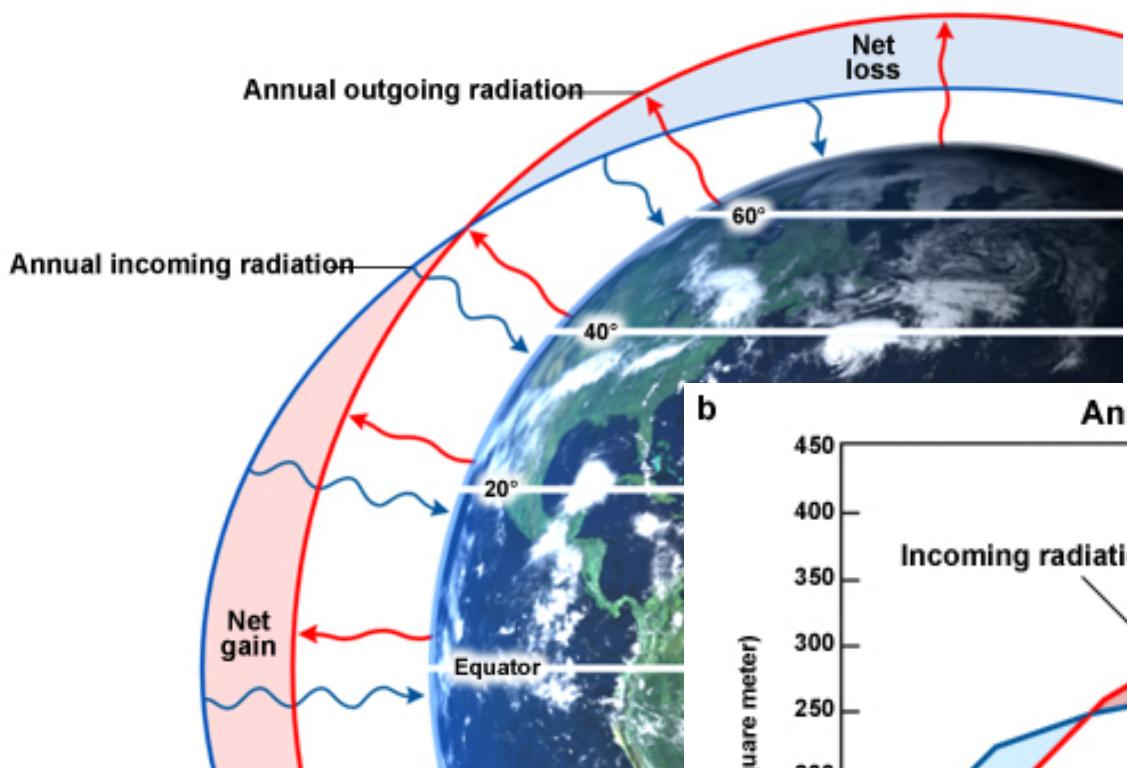
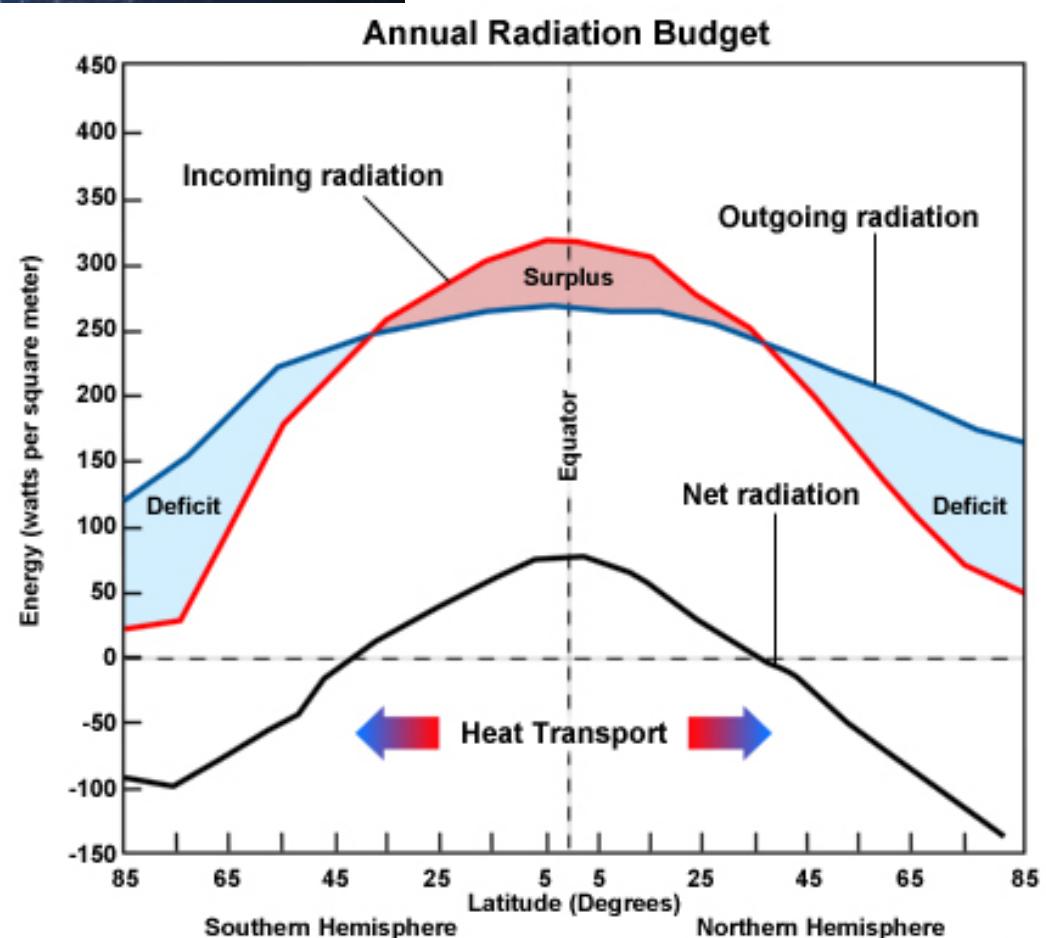
- Weaker Overturning Circulation

1) Meridional Temperature and Momentum Transport

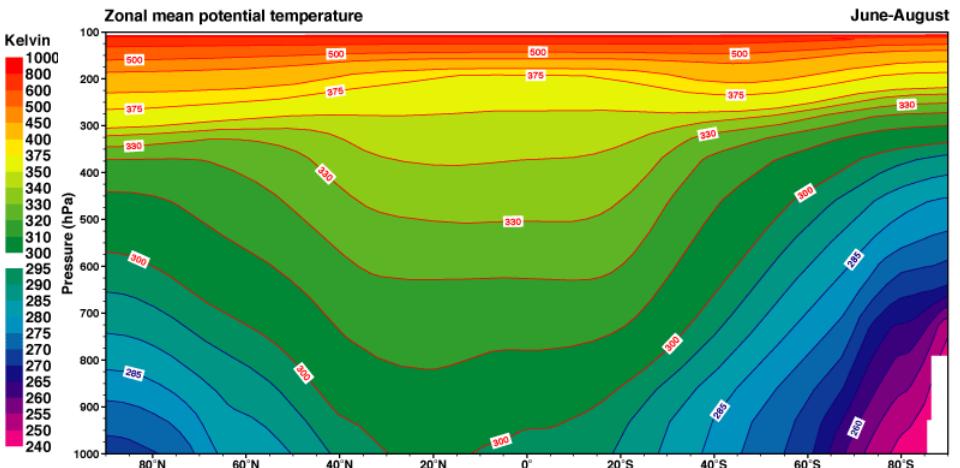
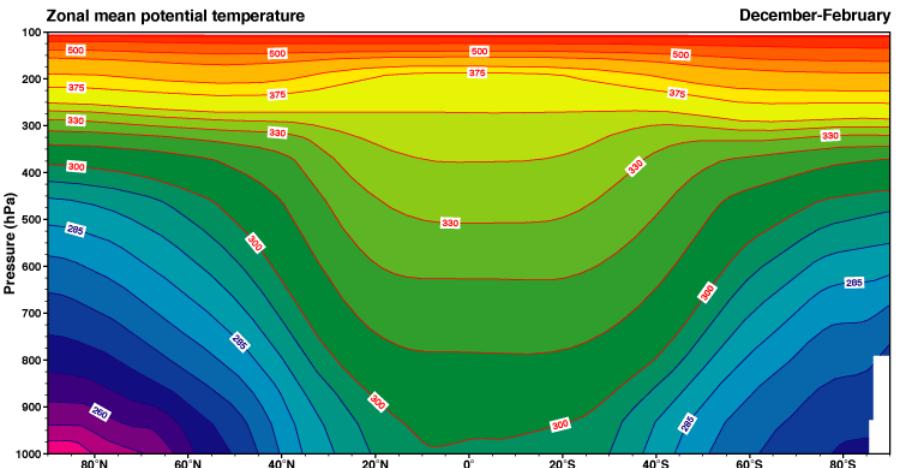
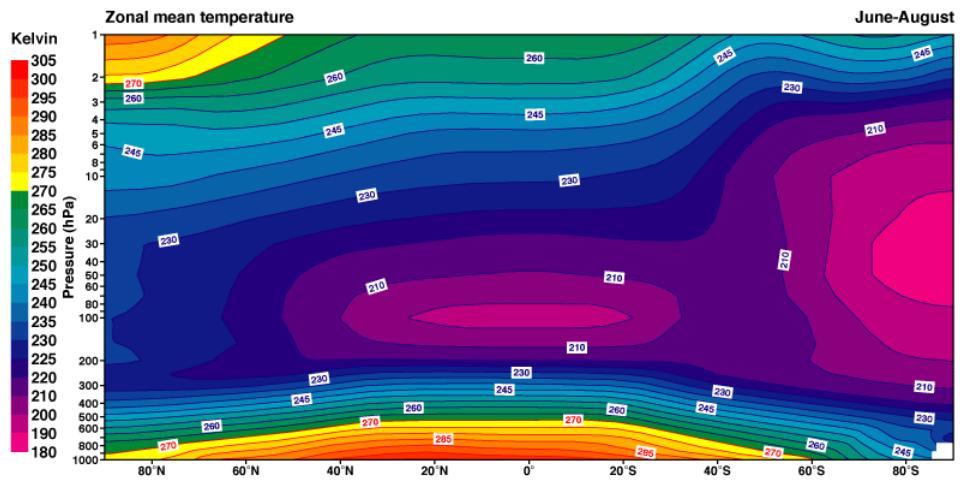
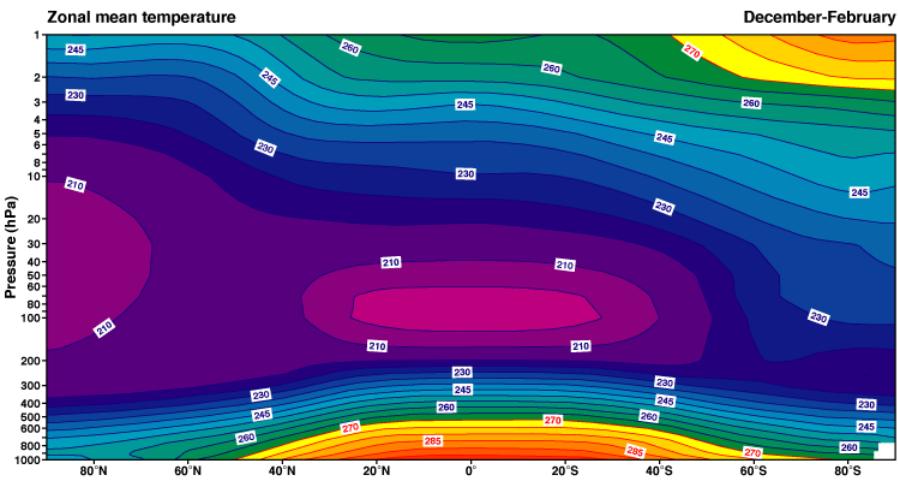


Mean Annual Global Insolation

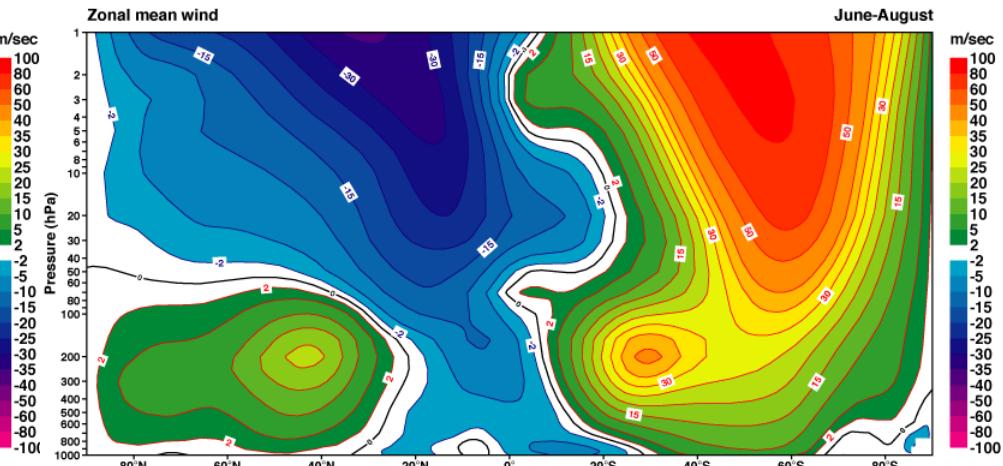
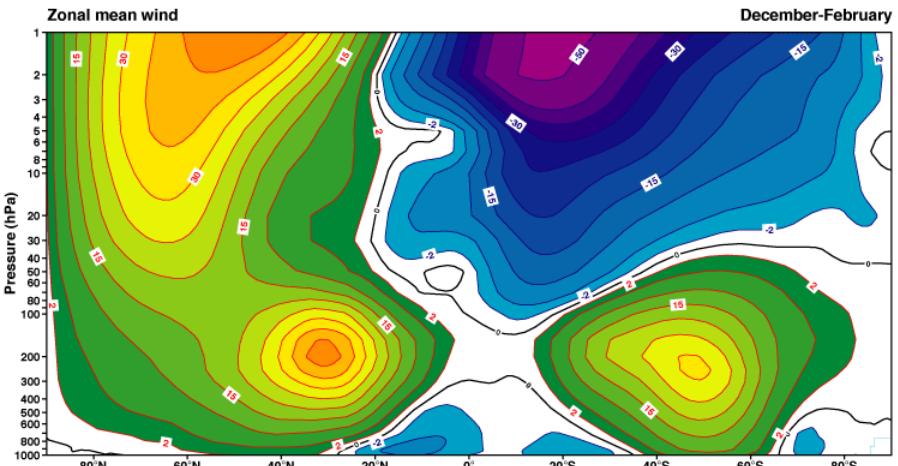
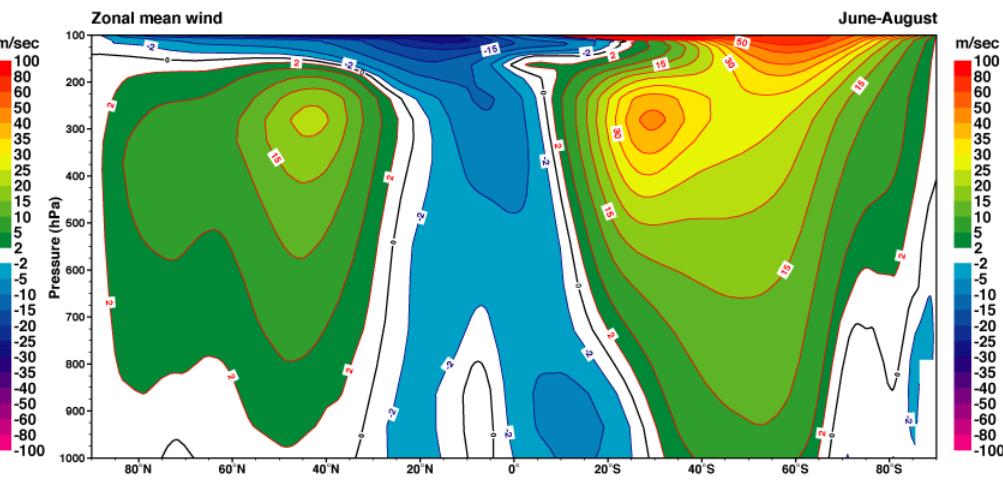
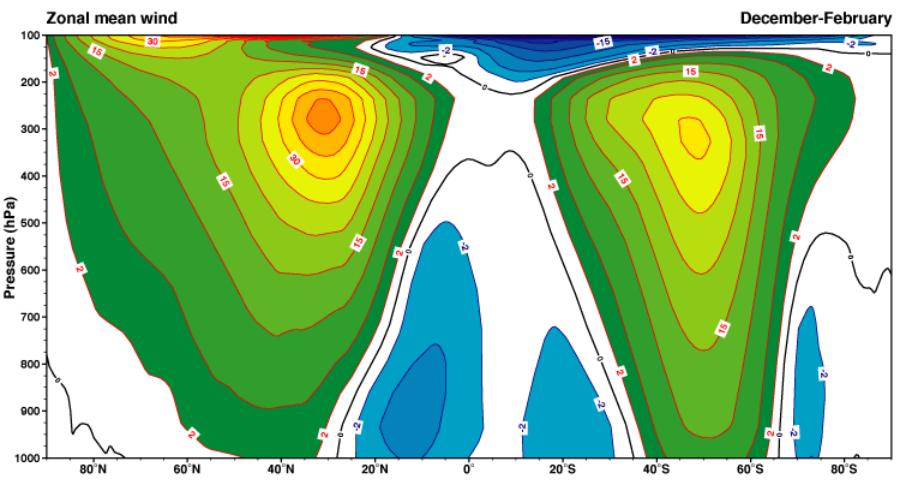


a**b**

Temperature and Potential Temperature Structure of the Atmosphere



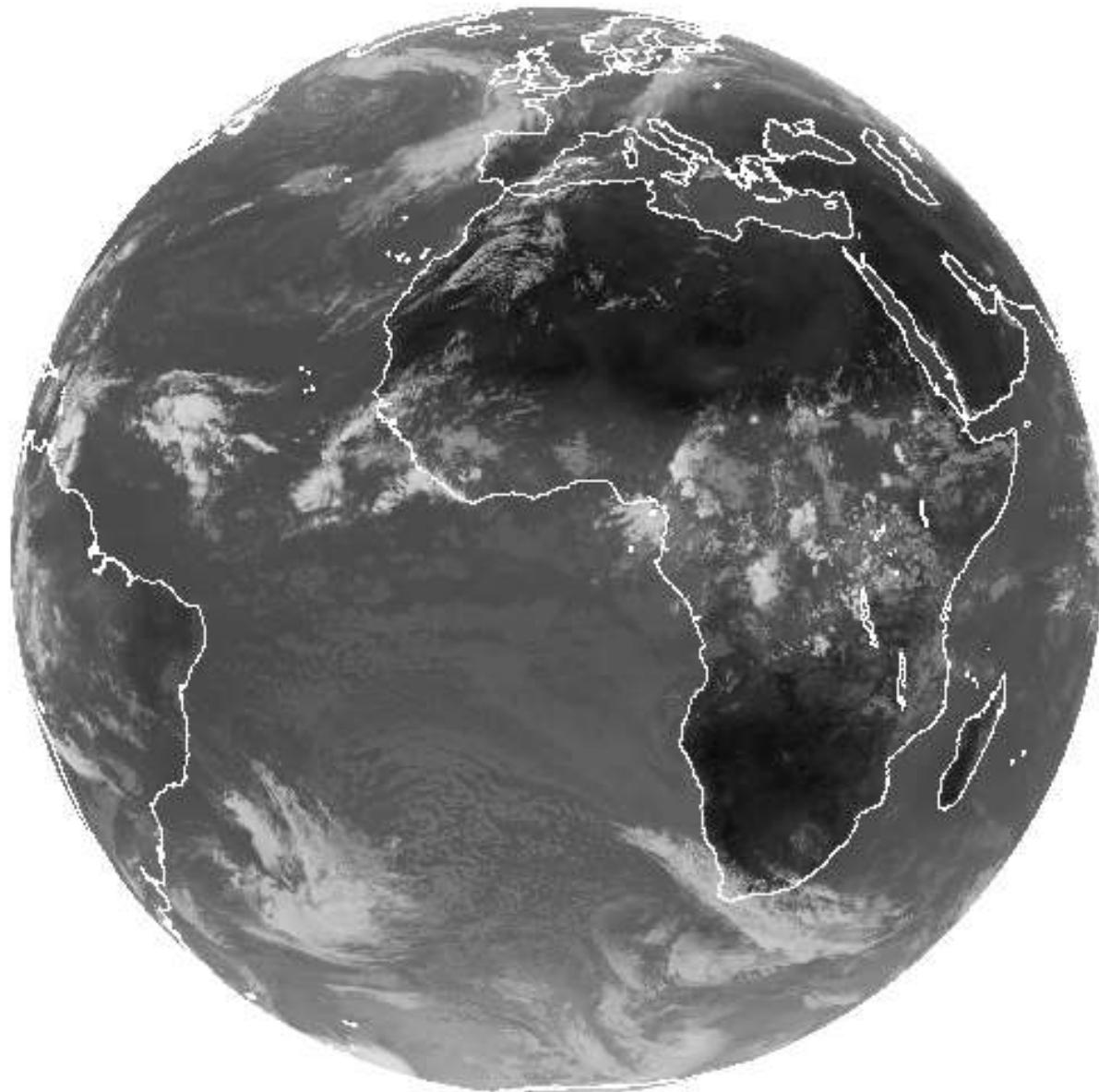
Zonal Wind Structure Structure of the Atmosphere



ITCZ Intertropical Convergence Zone

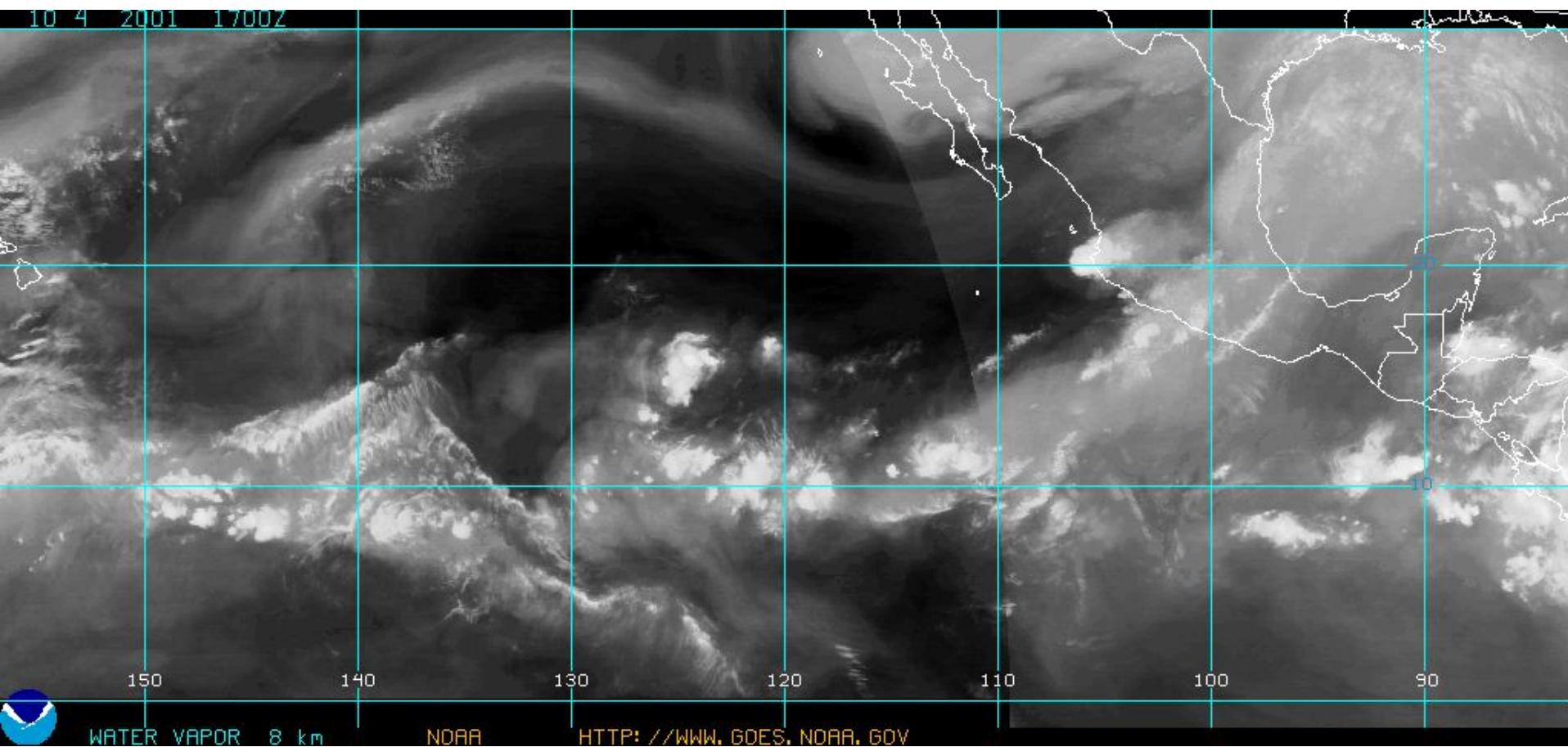
- Latitude of Tropical Precipitation Maximum
- Not Necessarily Latitude of Maximum Rising Motion

10 4 2001 1200Z



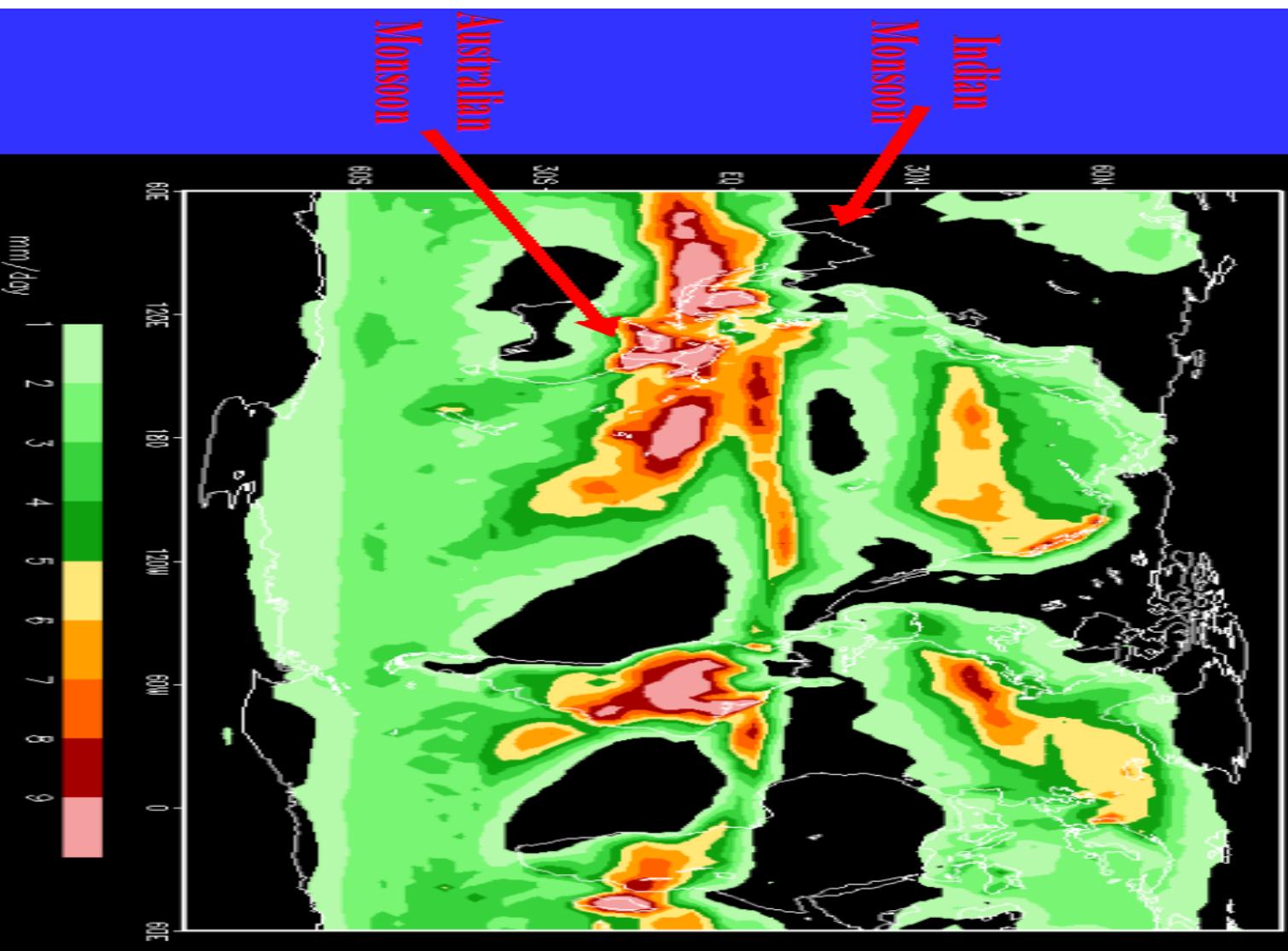
IR

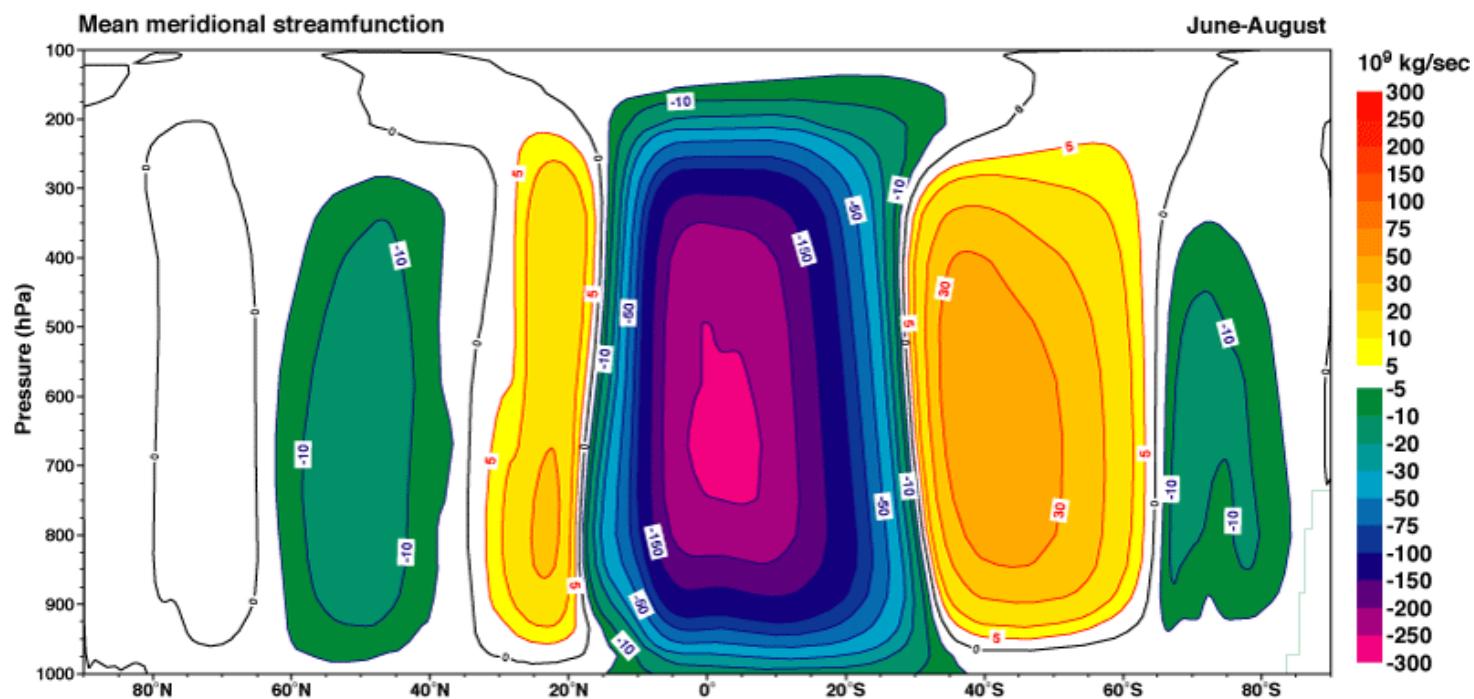
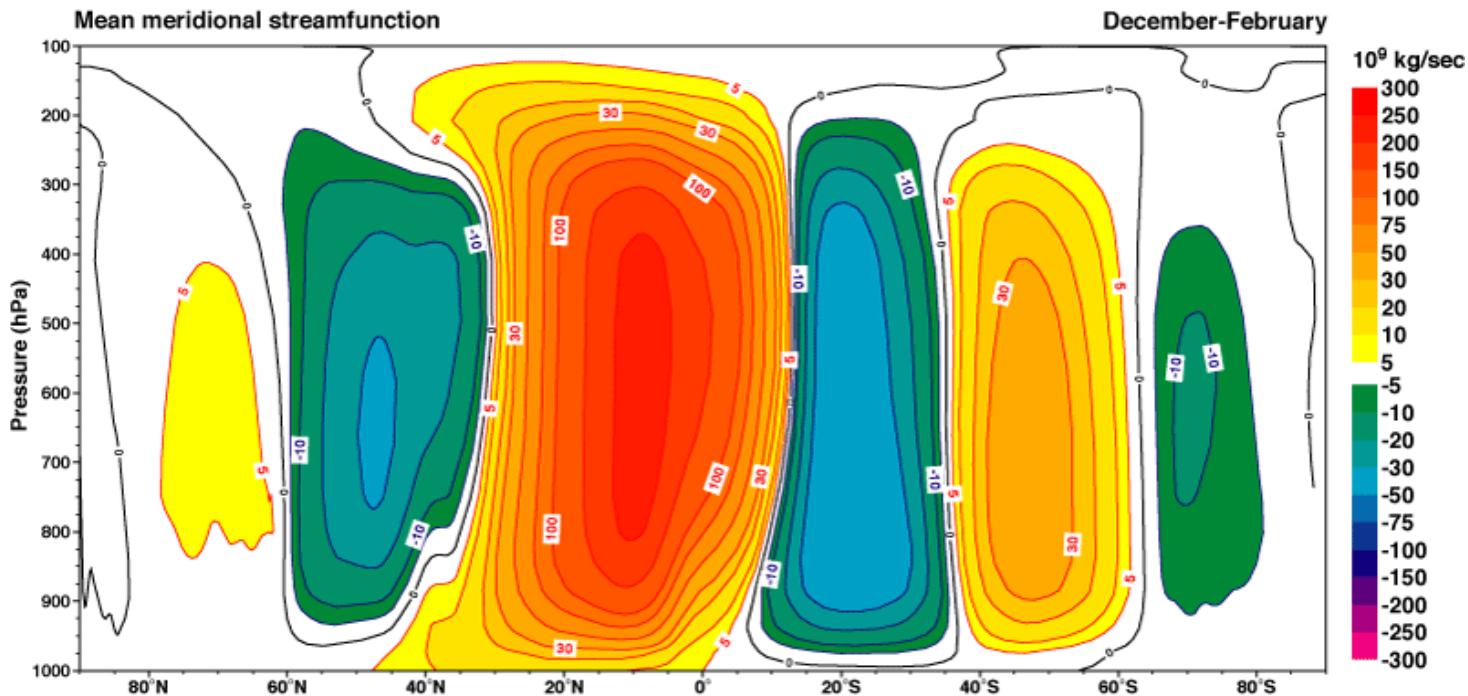
METEOSAT

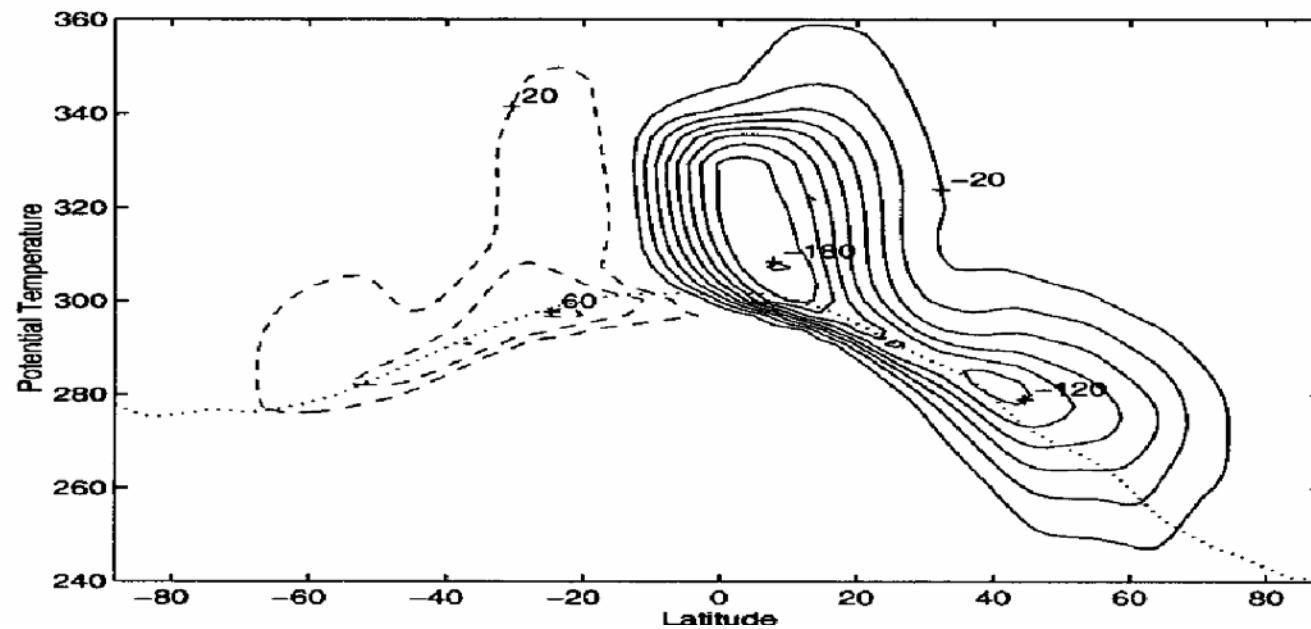
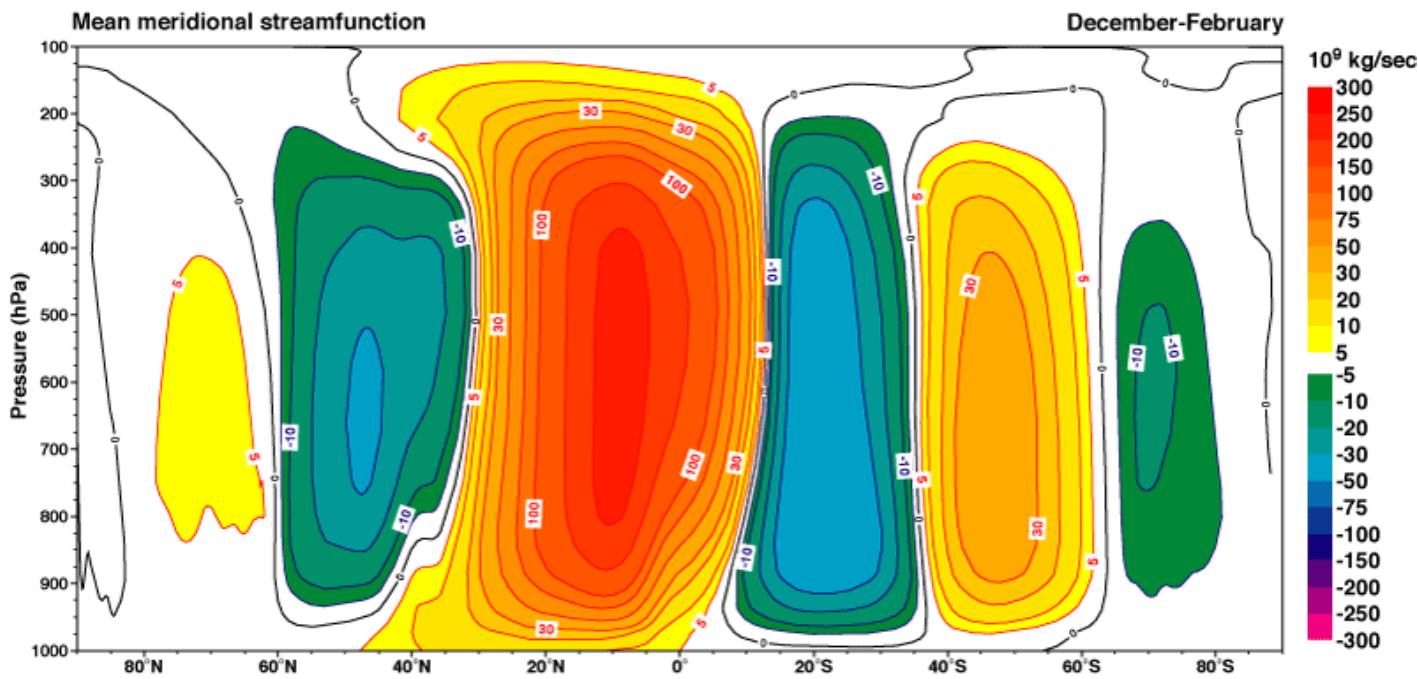


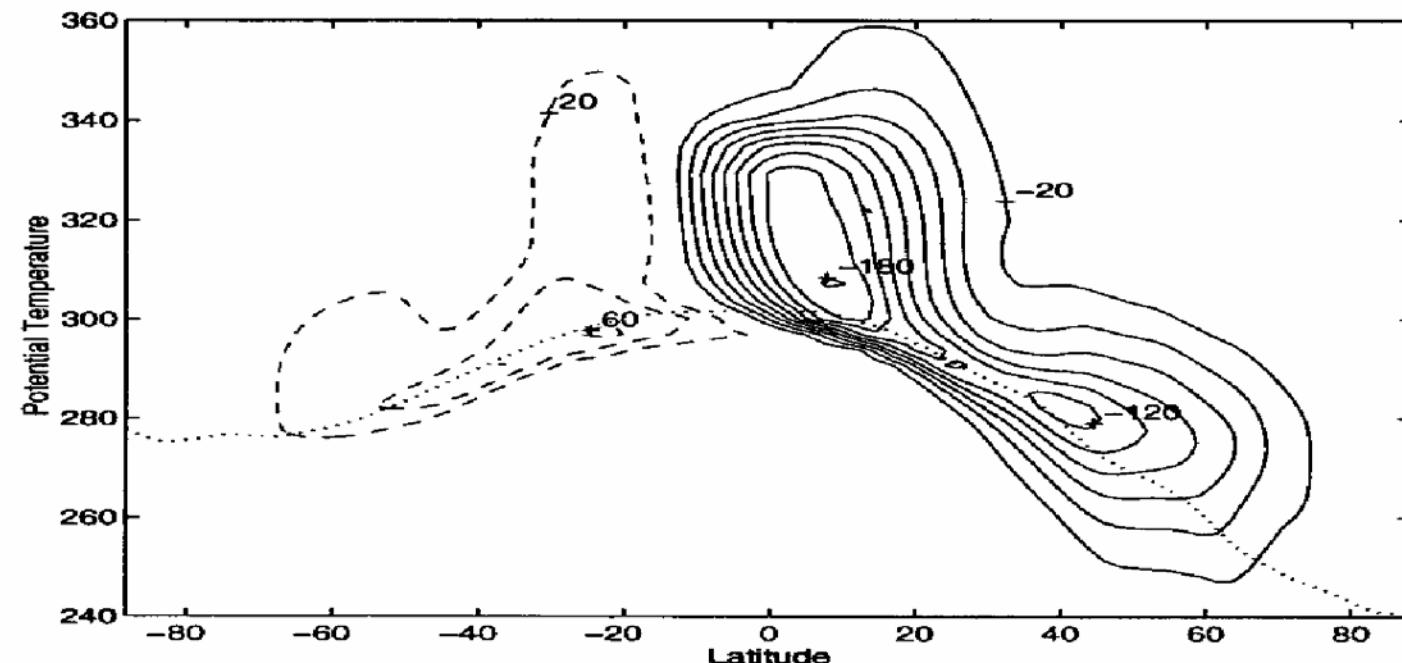
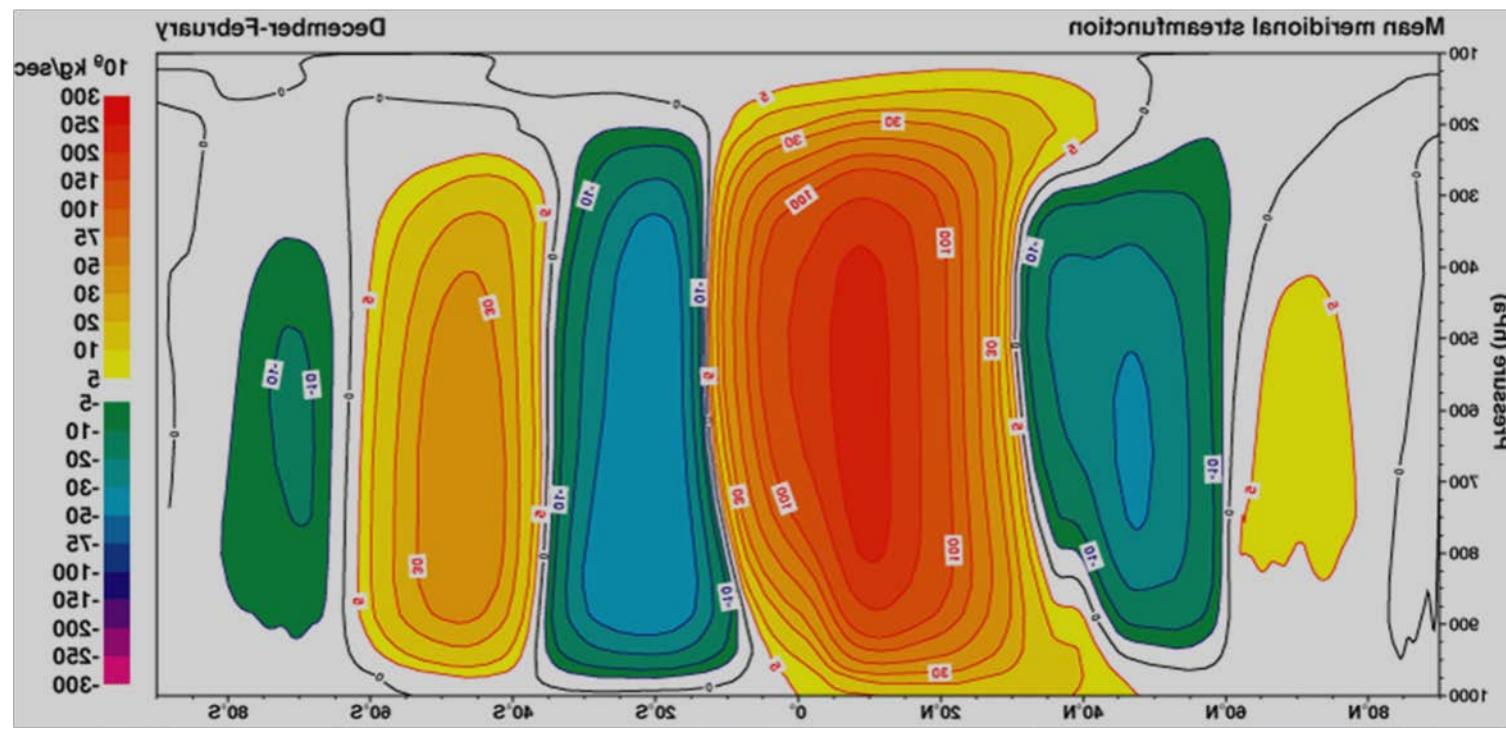
(from IRI)

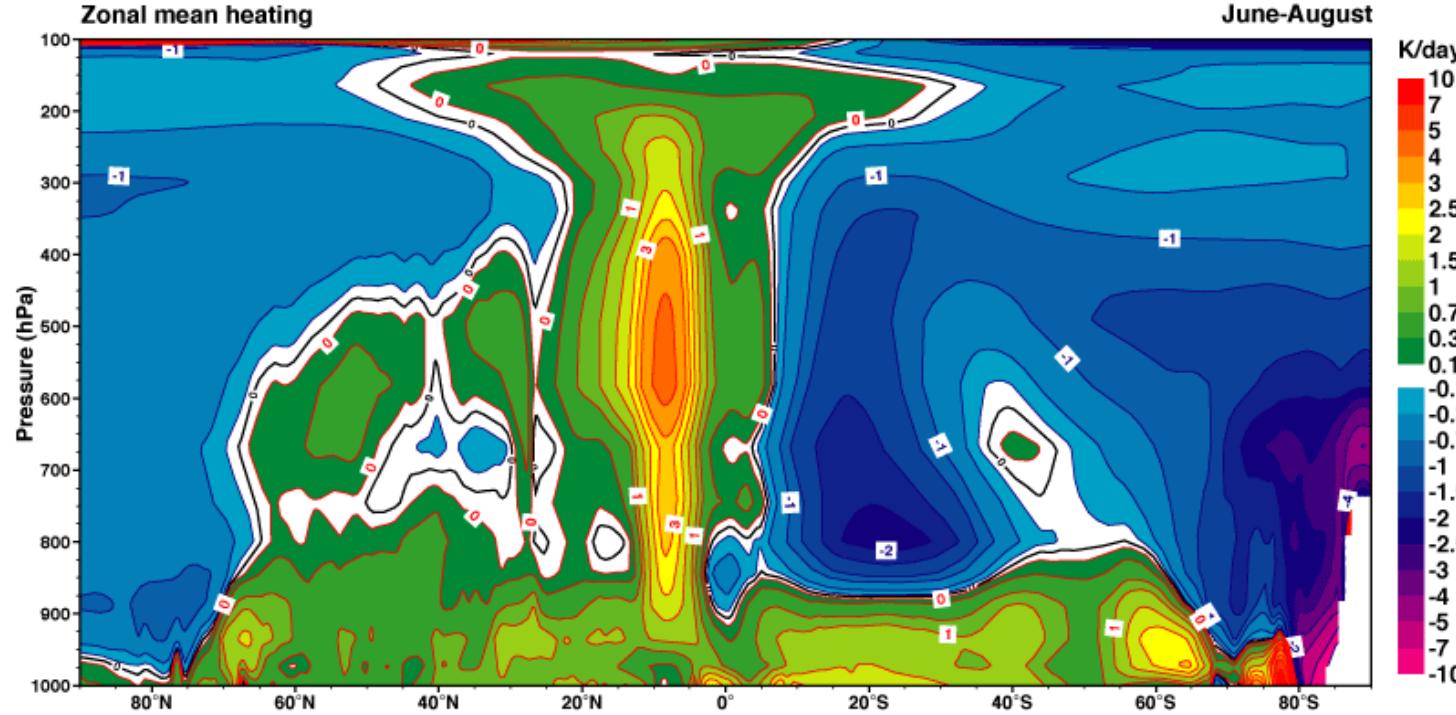
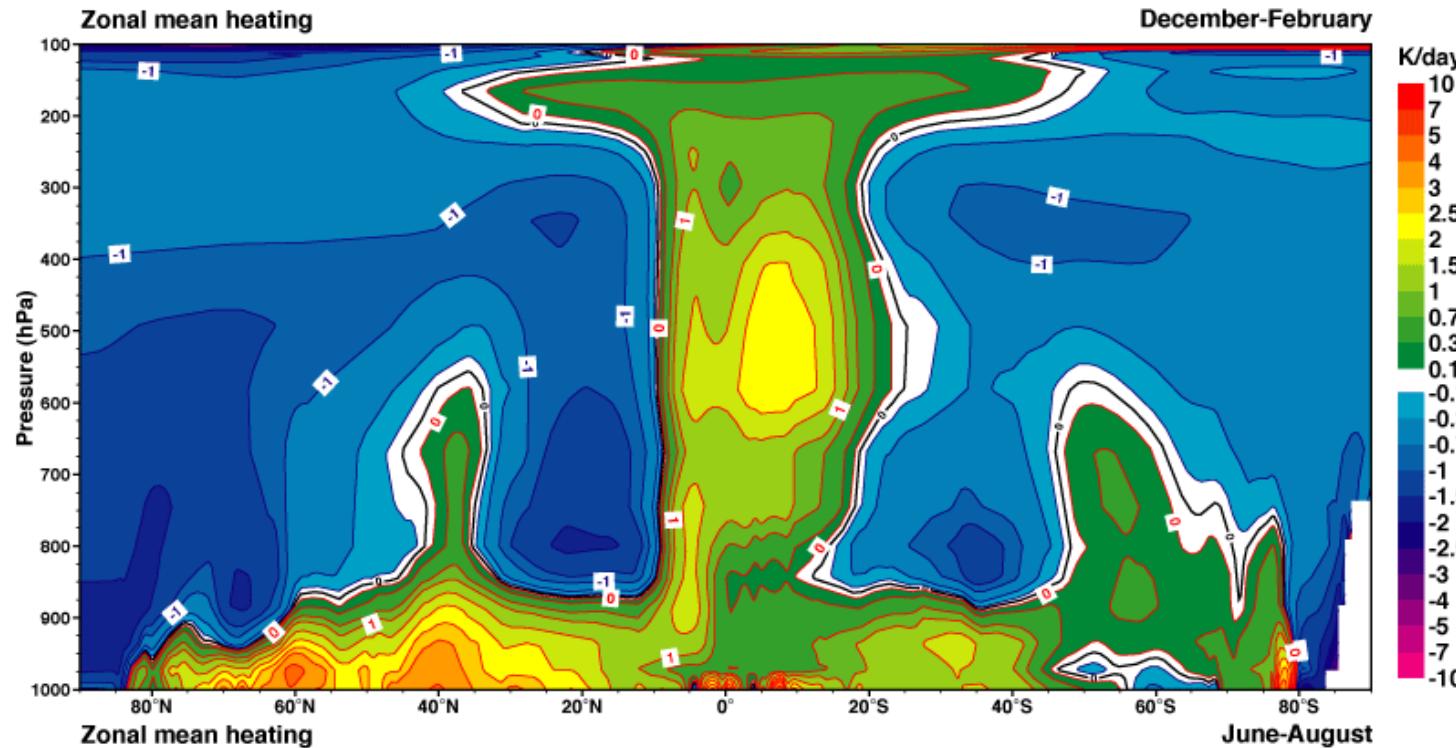
Mean Jan GPCC Precipitation (79-03)

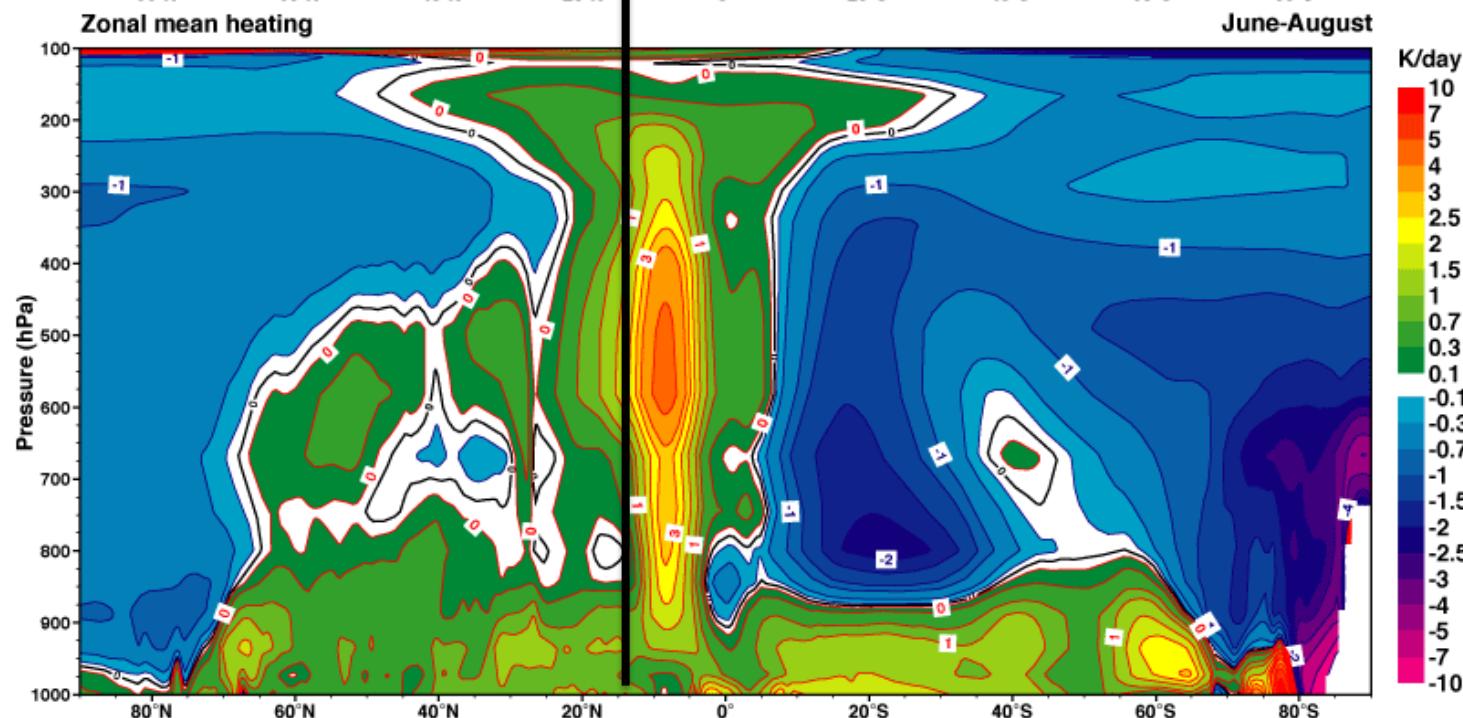
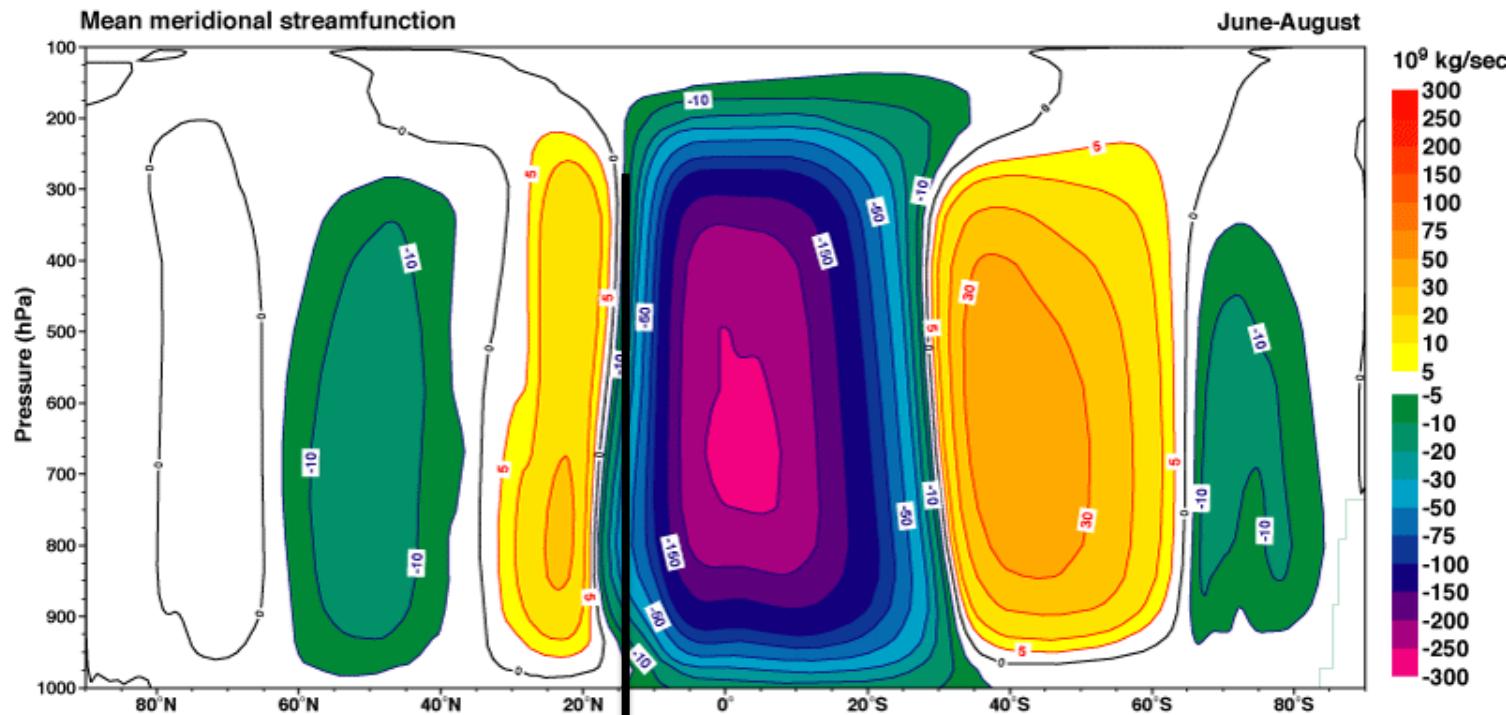




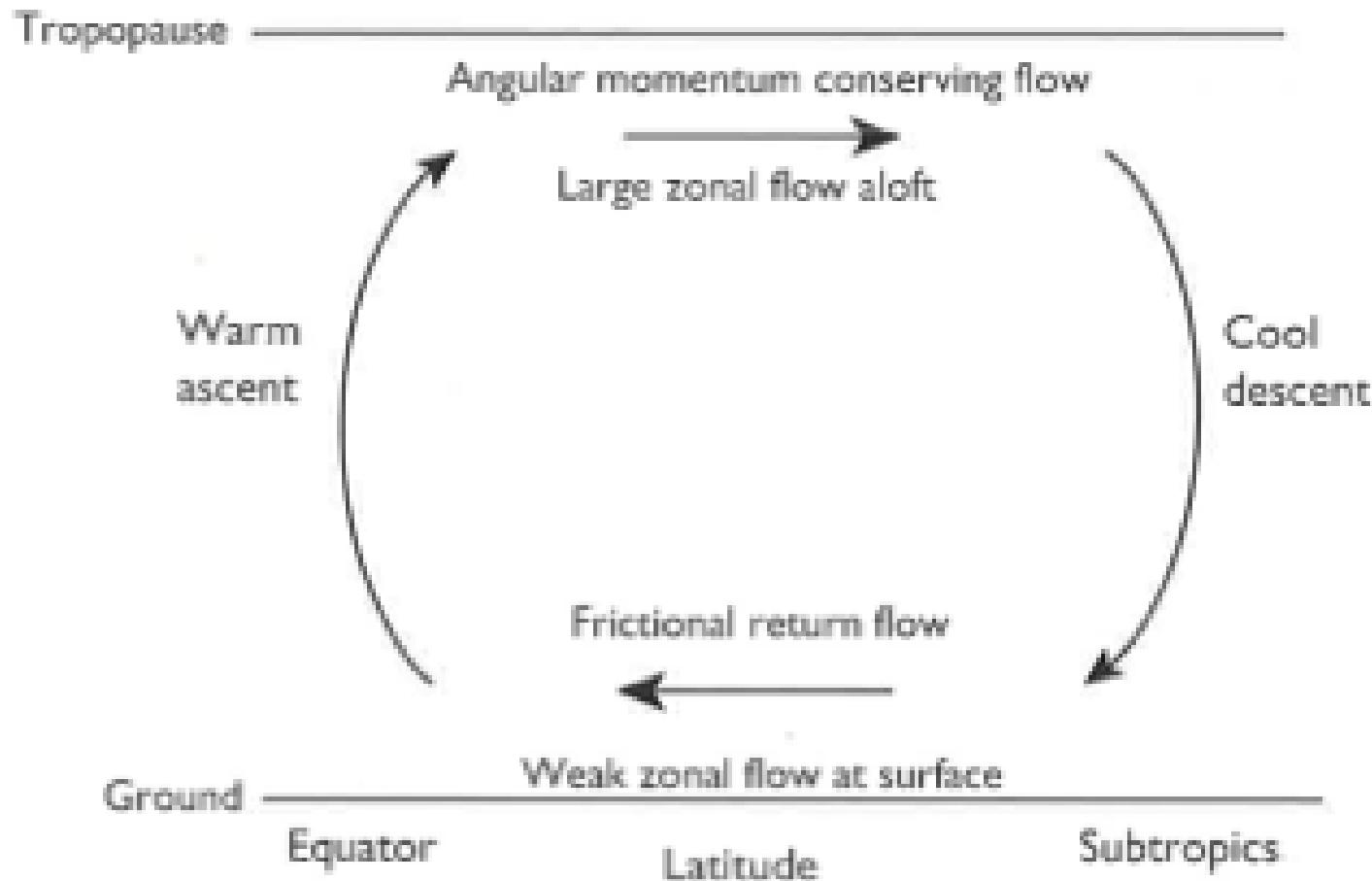




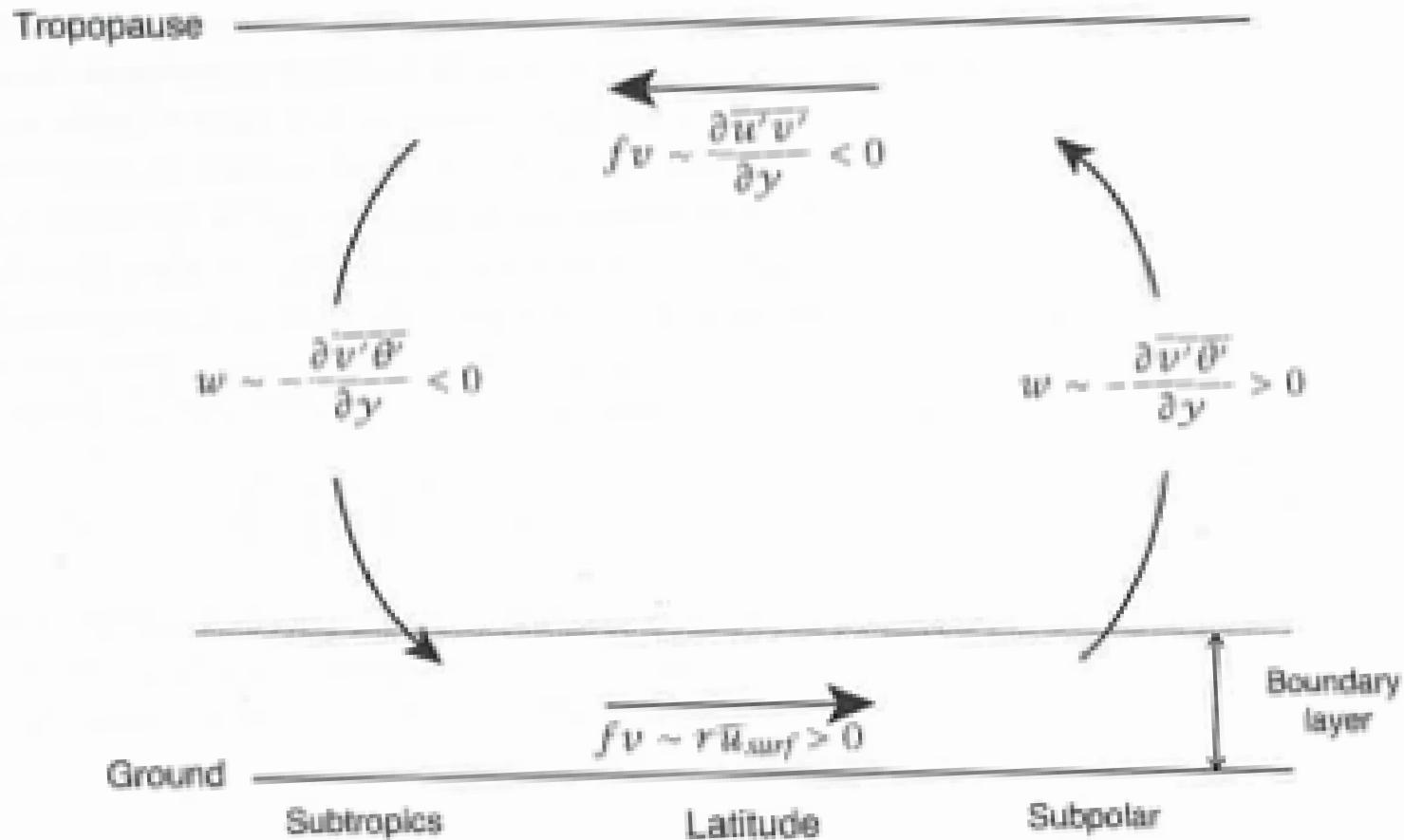




Hadley Circulation: Transporting Heat and Momentum Poleward

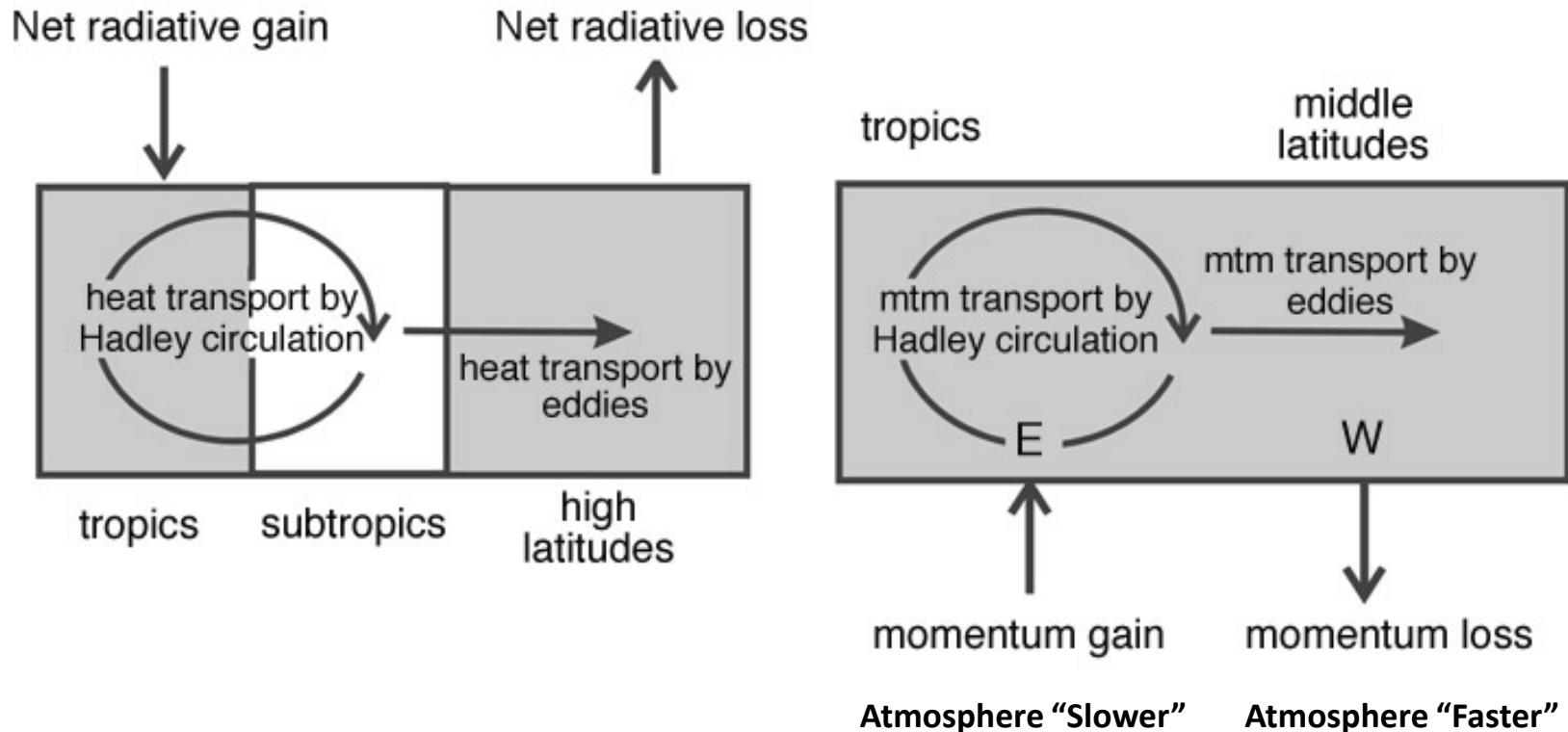


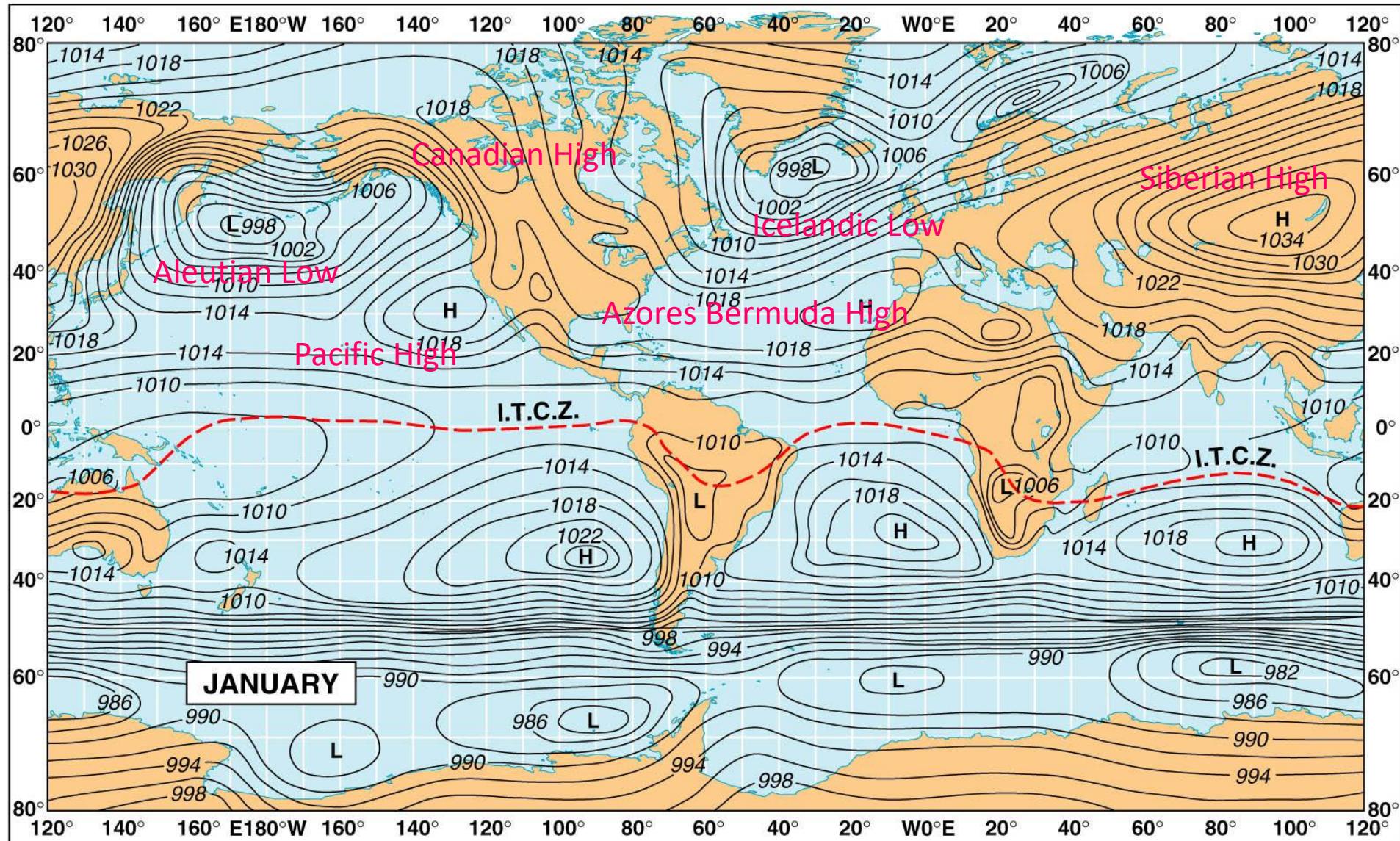
Ferrell Circulation



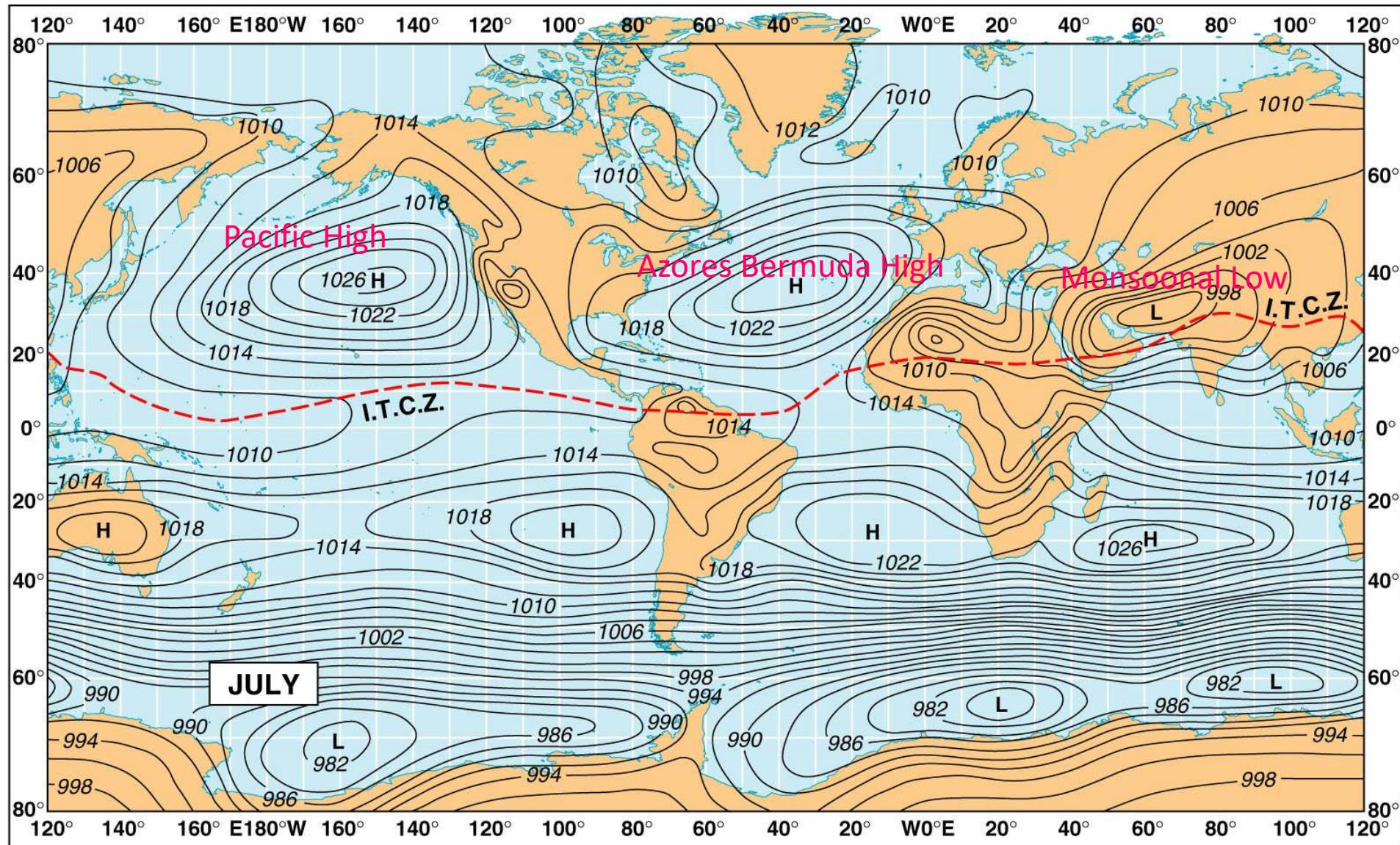
1) Meridional Temperature and Momentum Transport

- Stationary Eddies and Transient Eddies





(a)



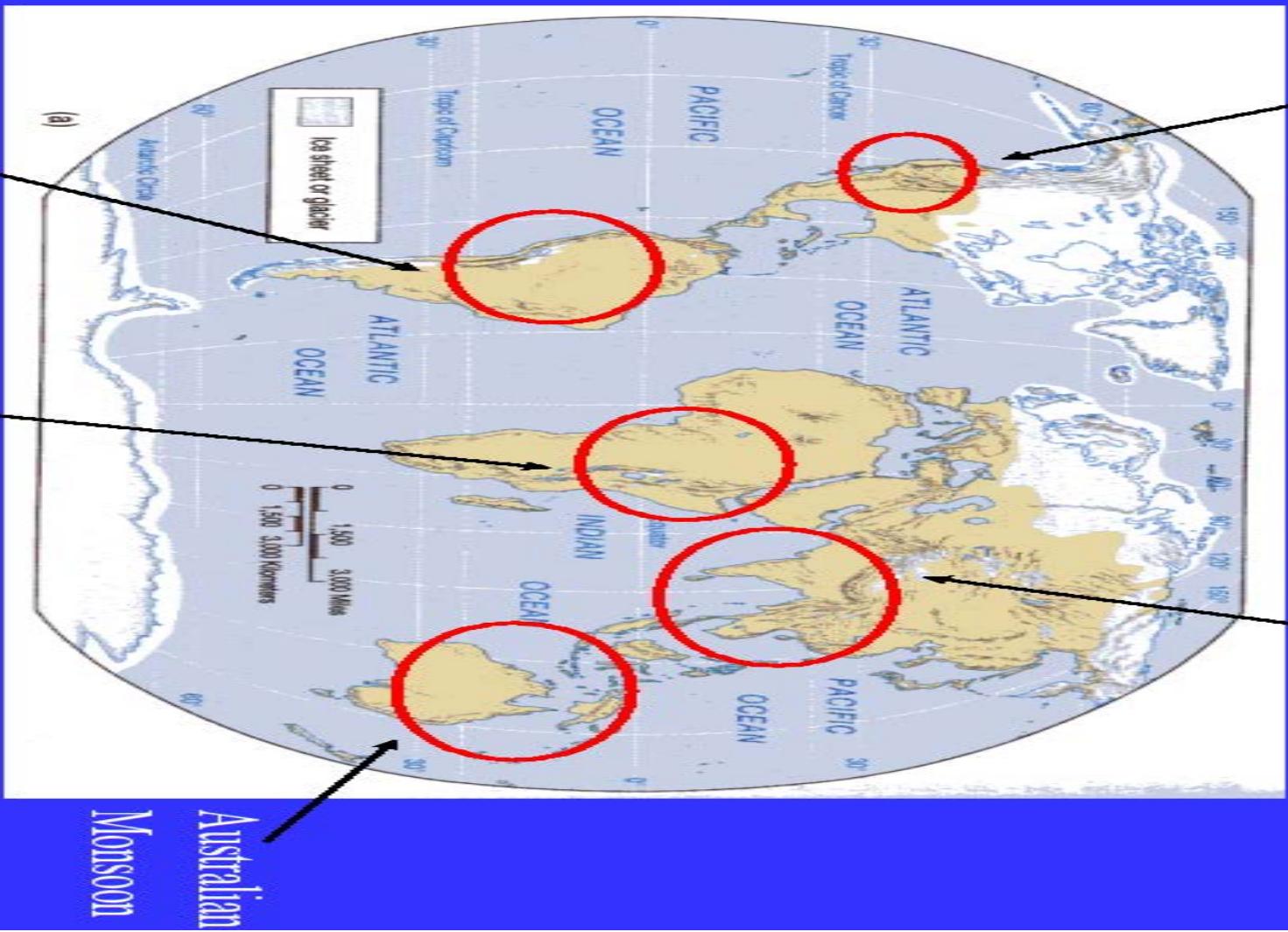
(b)

Global Deserts



North America Monsoon

Asian Monsoon



South America Monsoon

Africa Monsoon

Australian
Monsoon

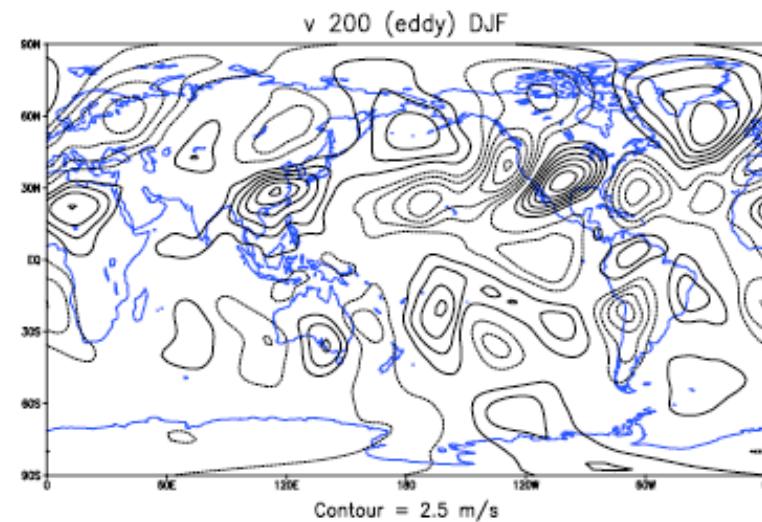
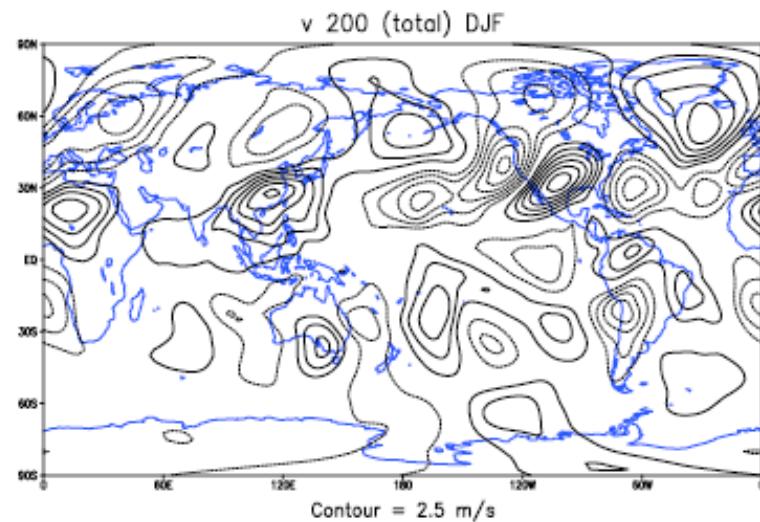
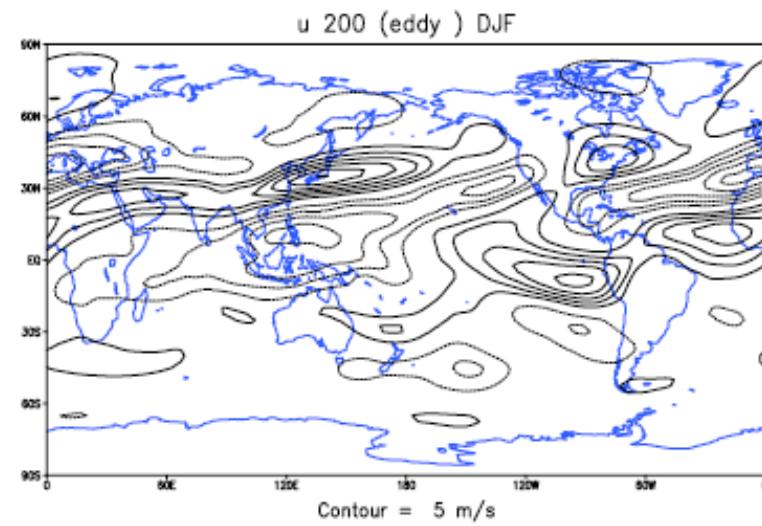
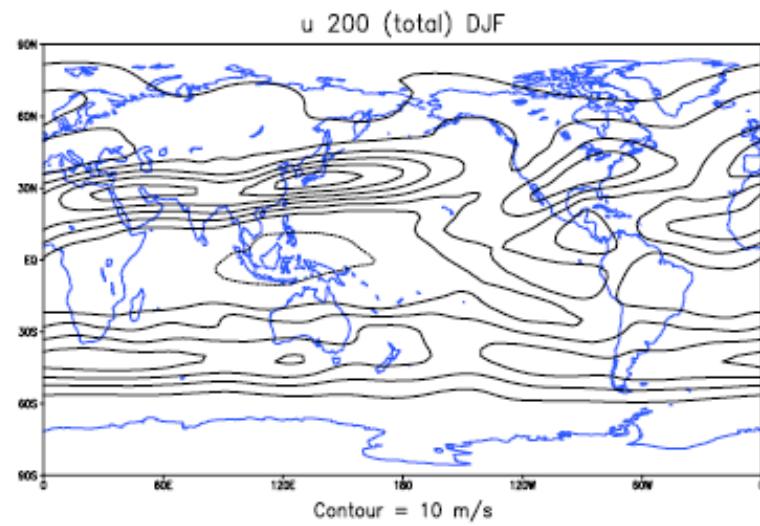


Figure 1: DJF 200 hPa u and v wind, total and eddy.

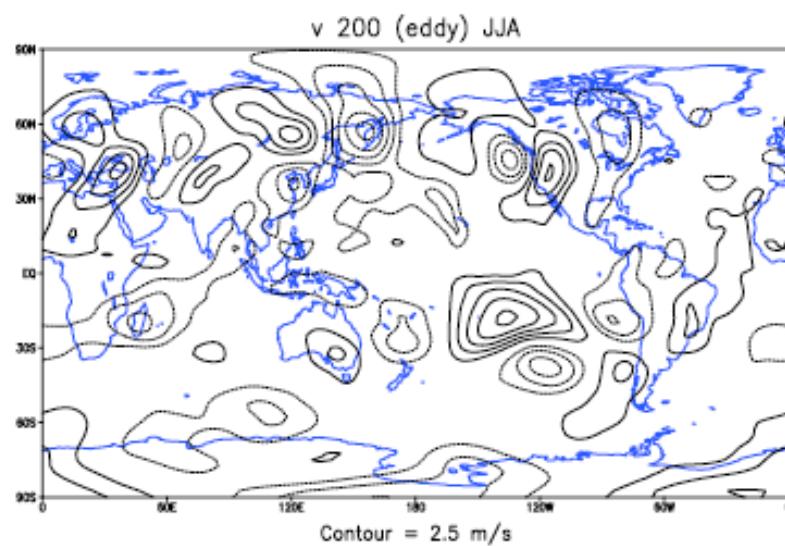
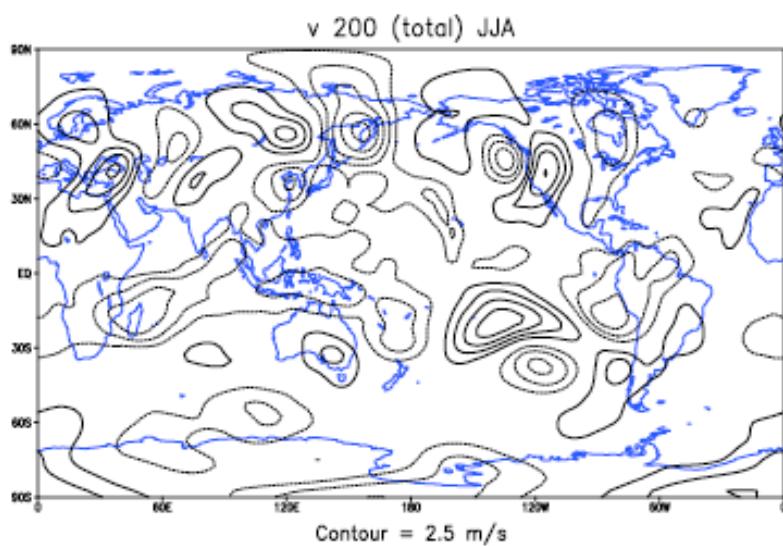
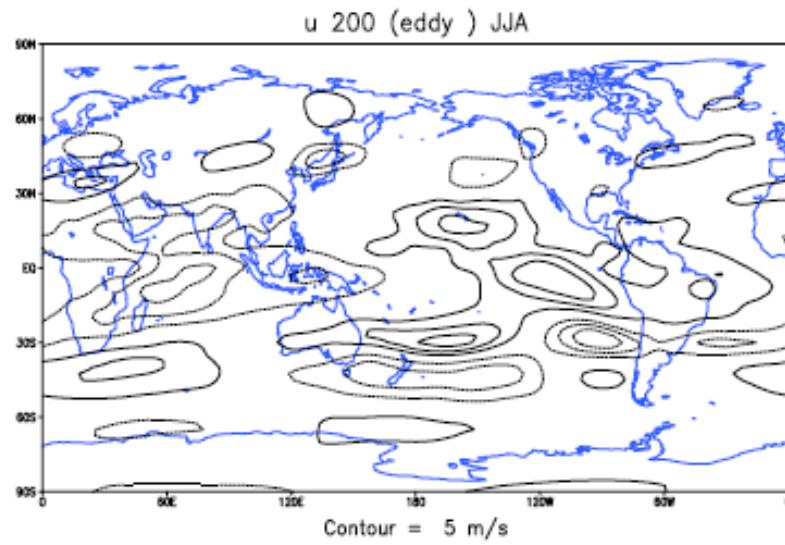
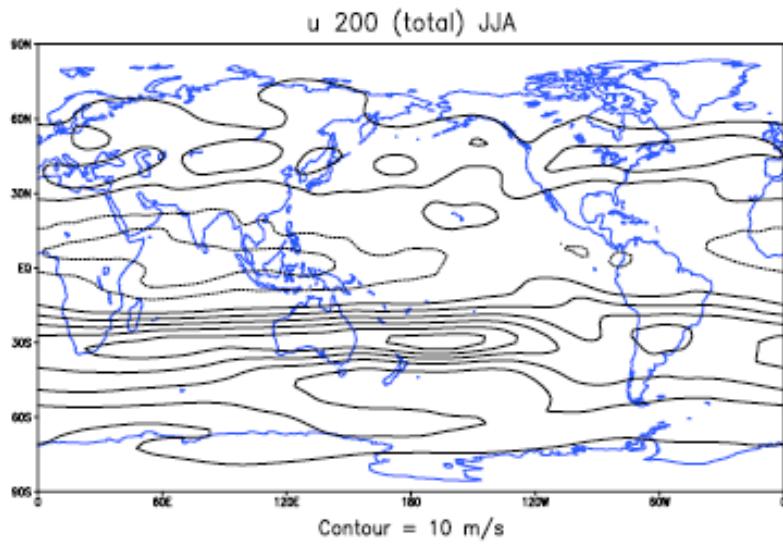


Figure 2: JJA 200 hPa u and v wind, total and eddy.

z 200 (eddy) DJF

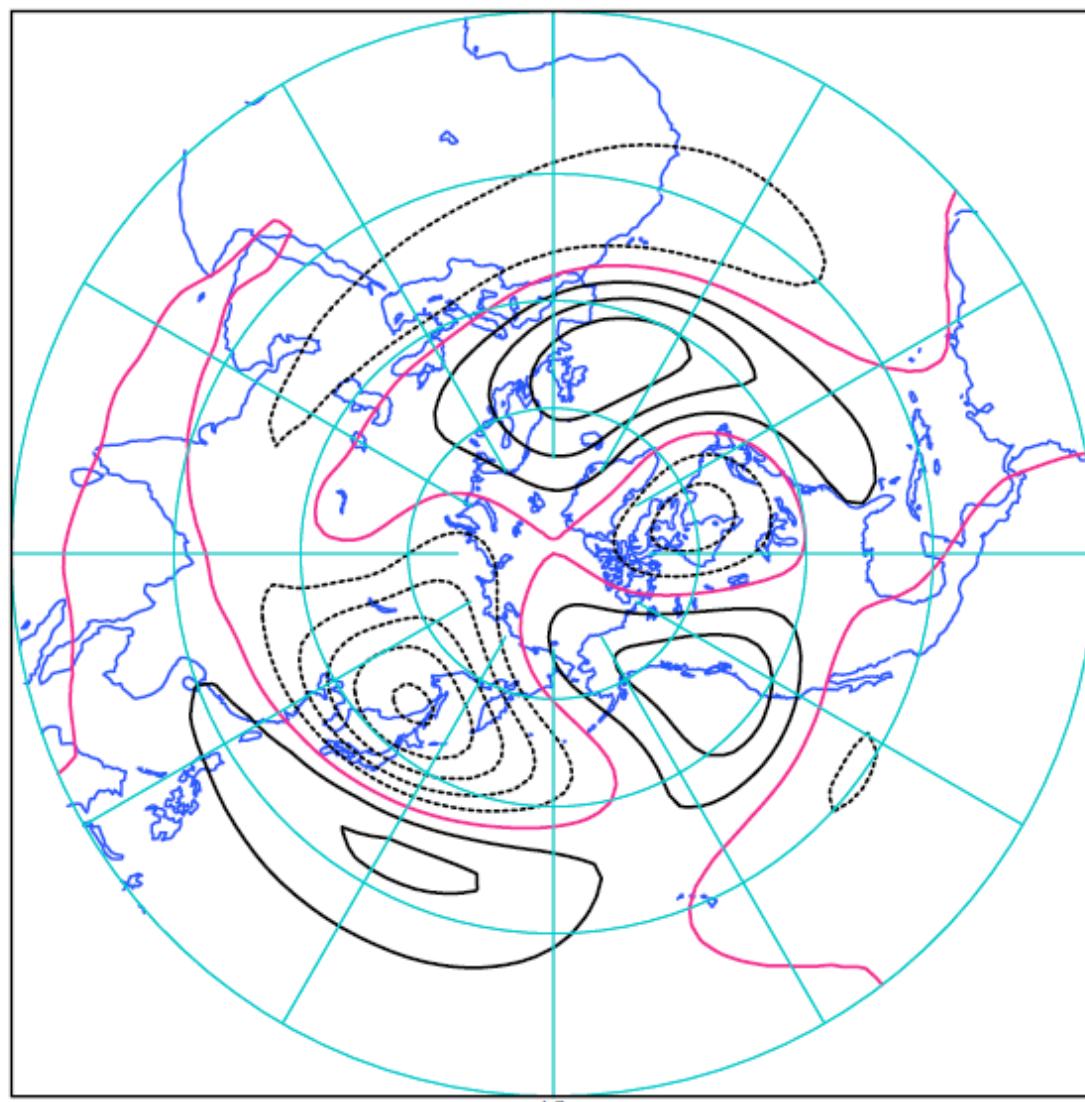


Figure 3: DJF 200 hPa Z eddy.

z^* DJF 60N(top), 45N(mid), 25N(bot)

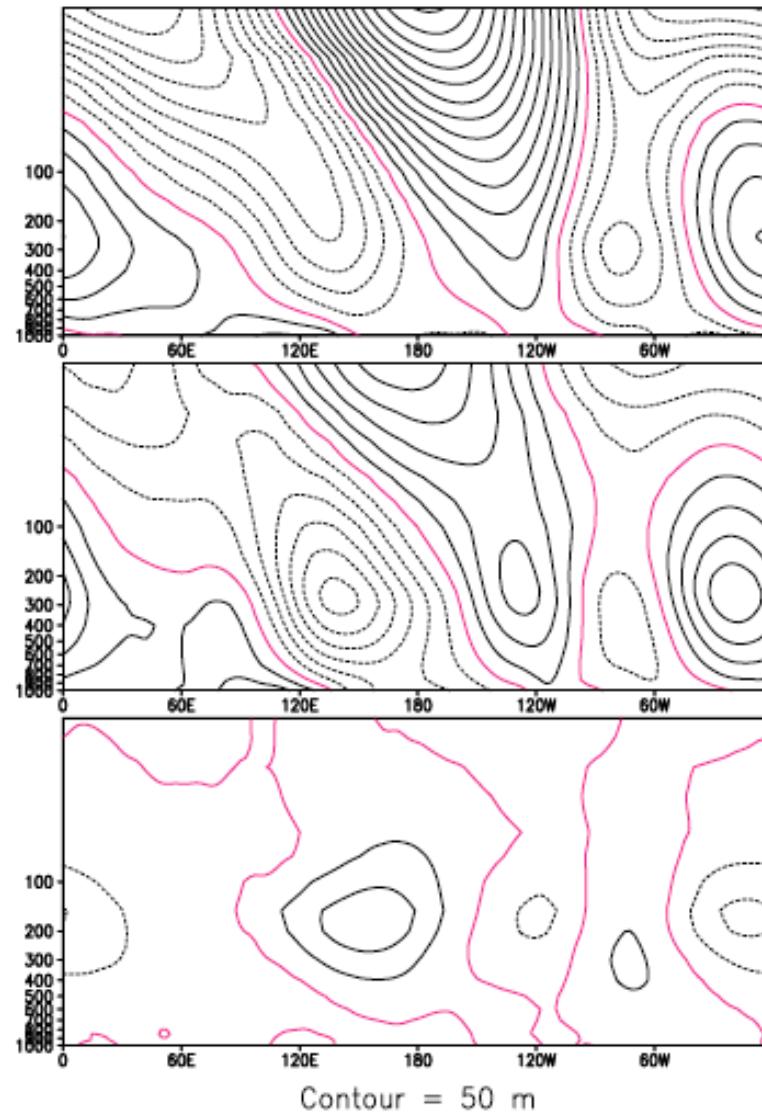
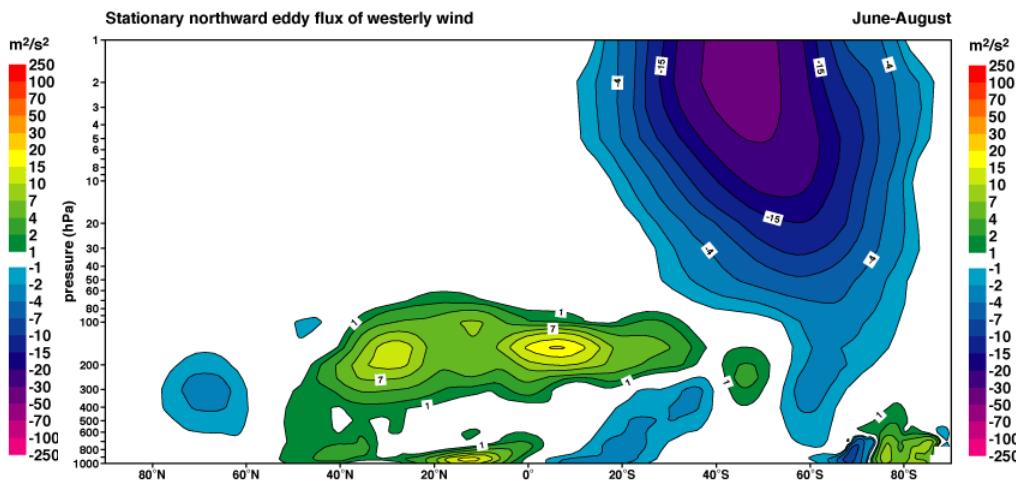
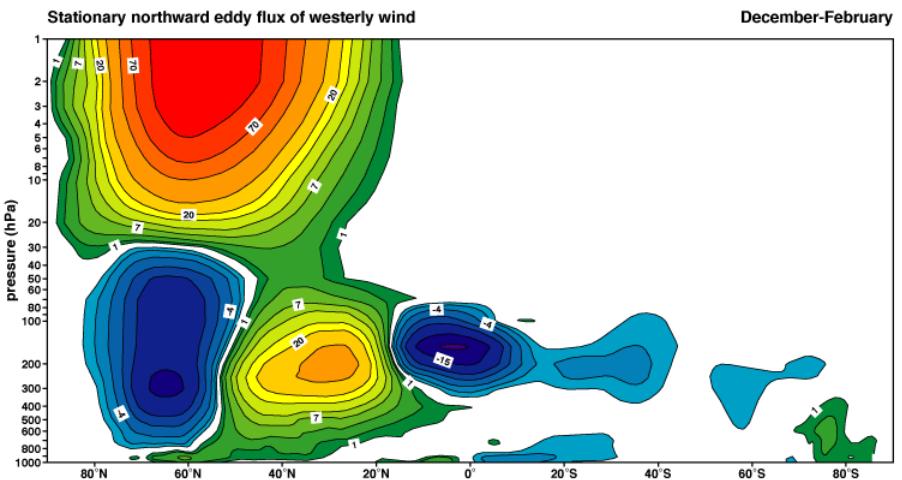
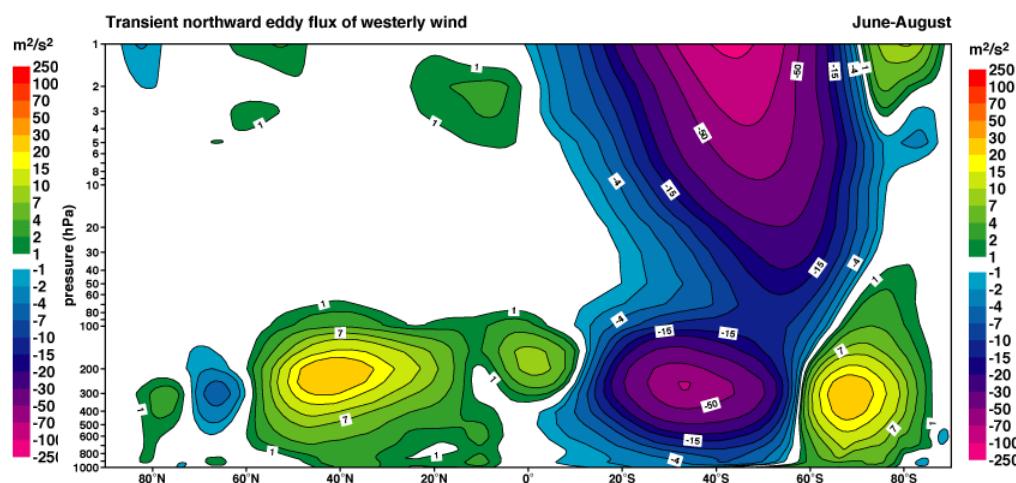
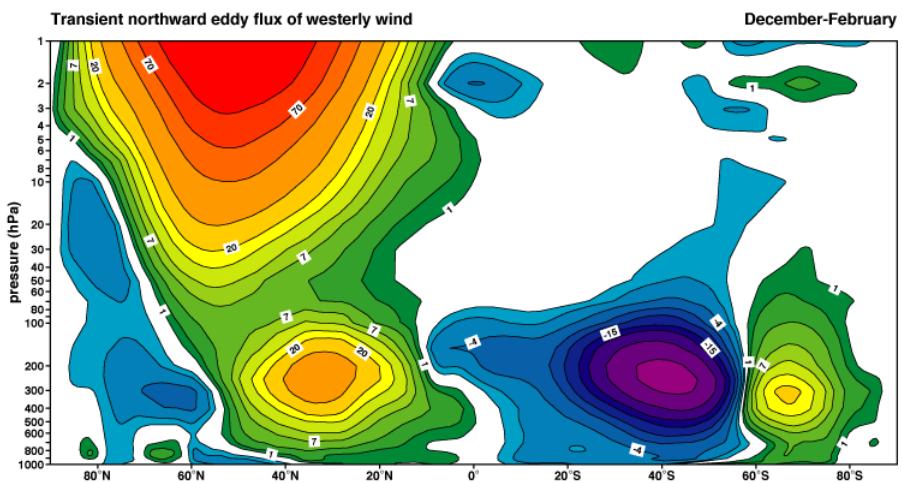
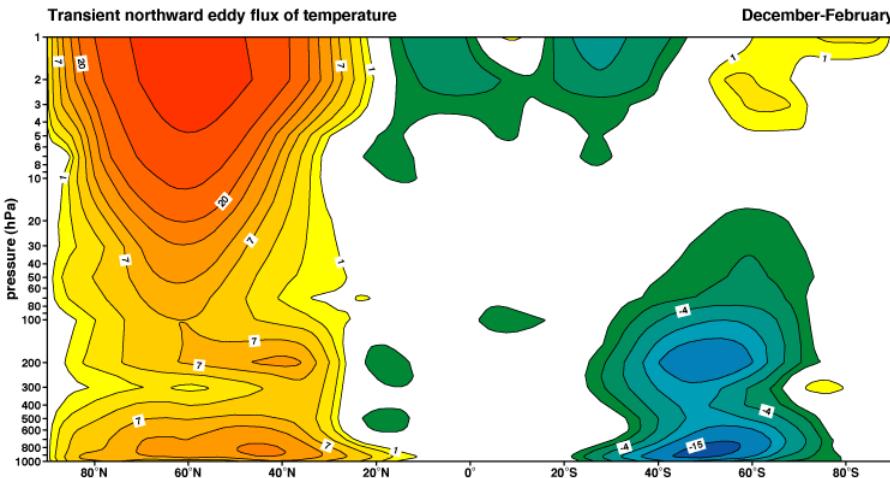


Figure 4: Longitude/Pressure sections of DJF Z^* at 60N (top), 45N(mid), and 25N(lower) .

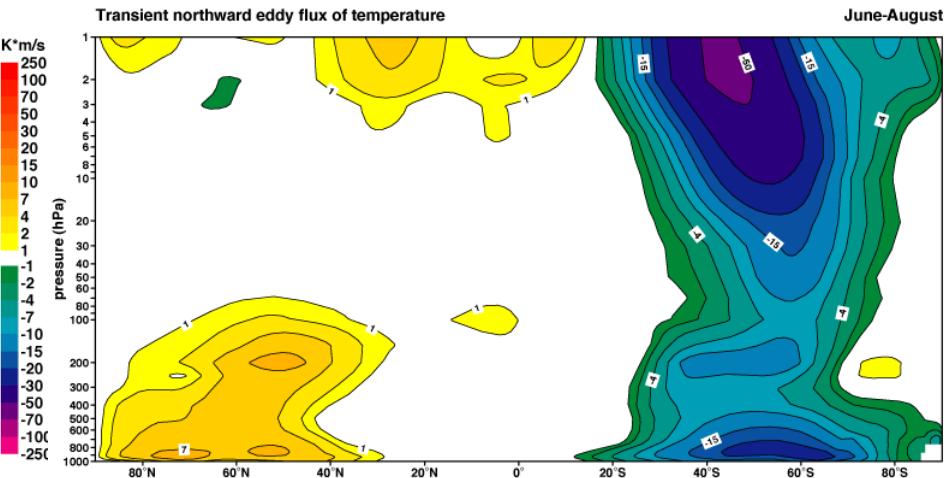
Transient and Stationary Eddy Flux of Westerly Momentum



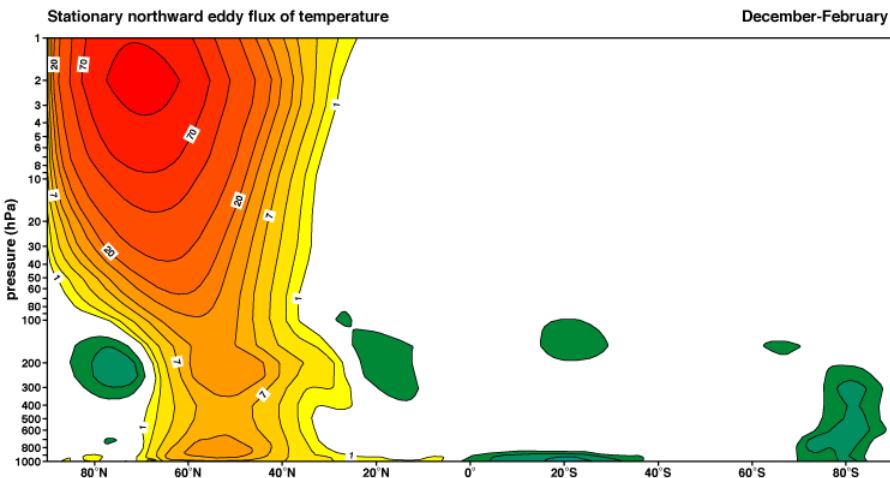
Transient and Stationary Eddy Flux of Temperature



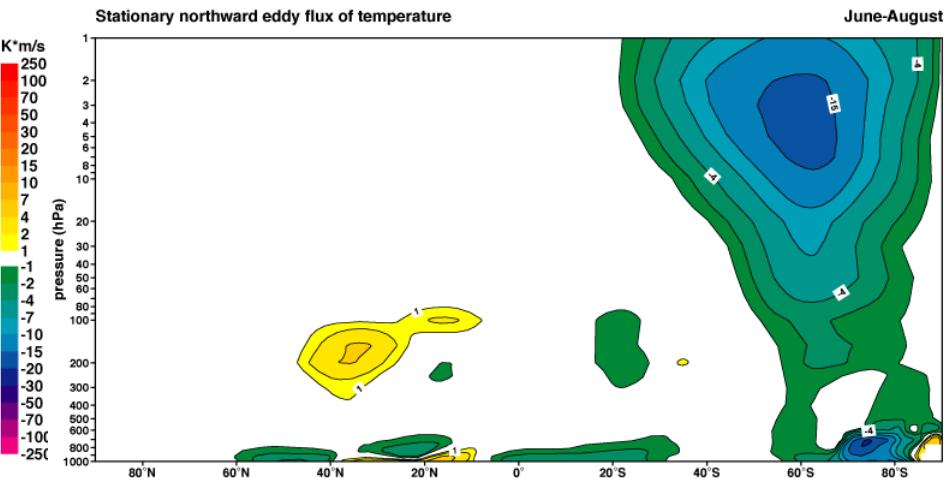
December-February



June-August



December-February



June-August

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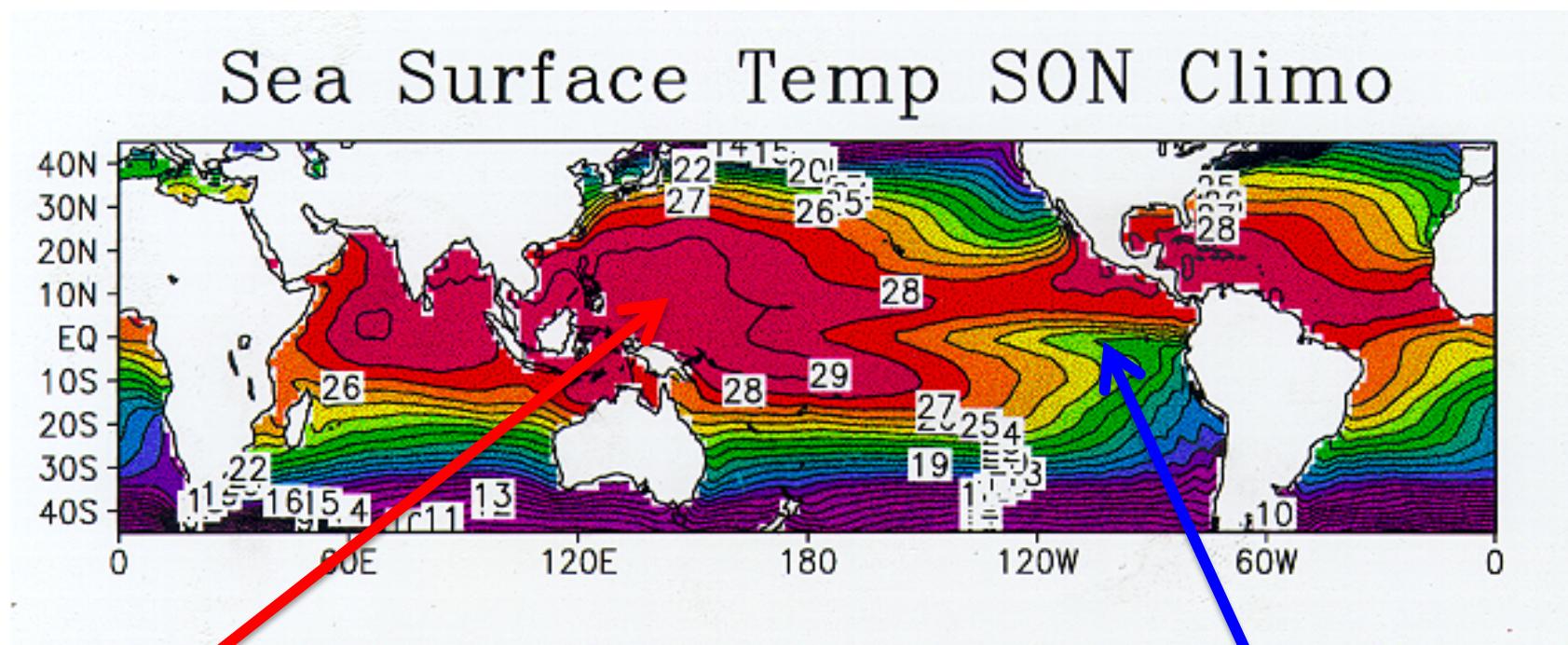
2) Large-Scale Tropics

- ENSO

3) Climate Change

- Weaker Overturning Circulation

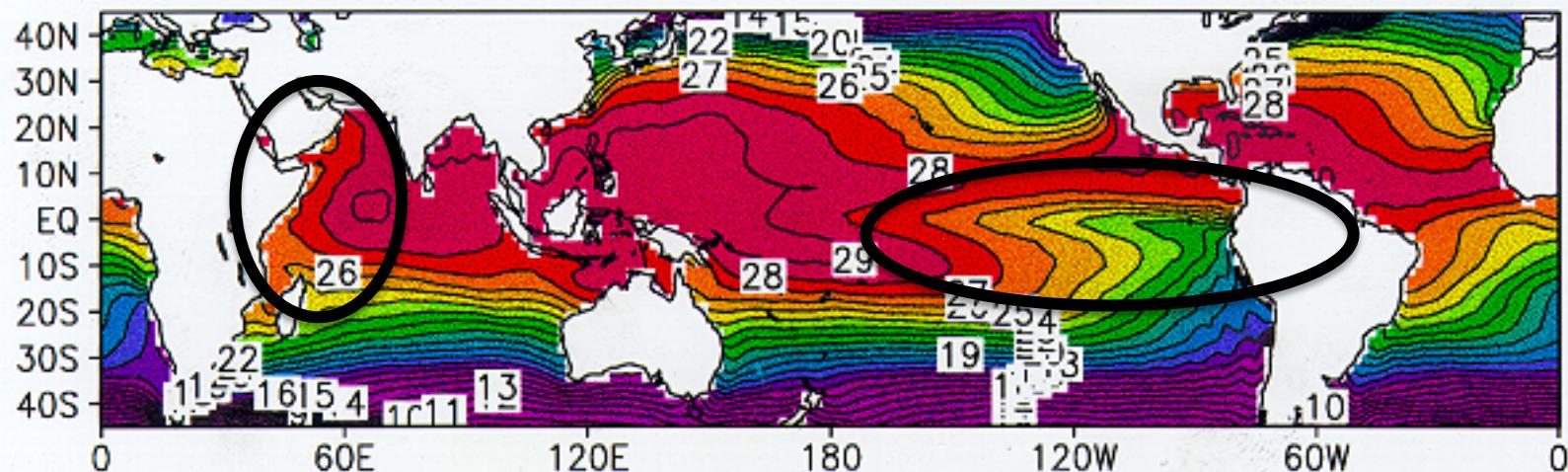
September-October-November Sea Surface Temperature Climatology



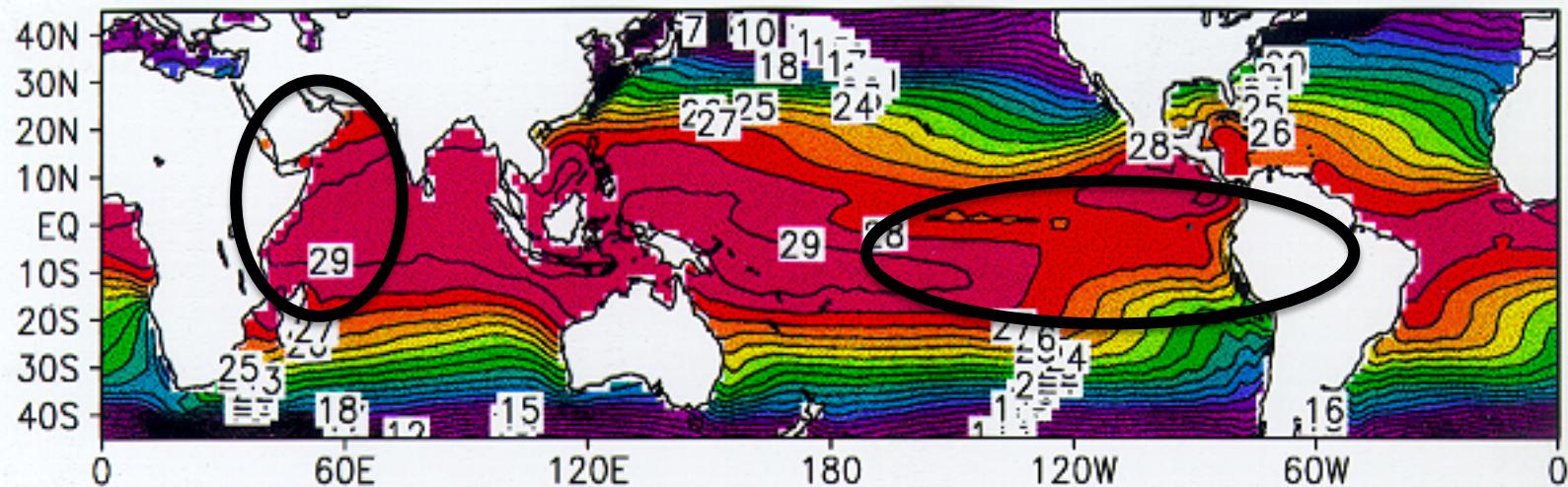
Warm Pool

Cold Tongue

Sea Surface Temp SON Climo



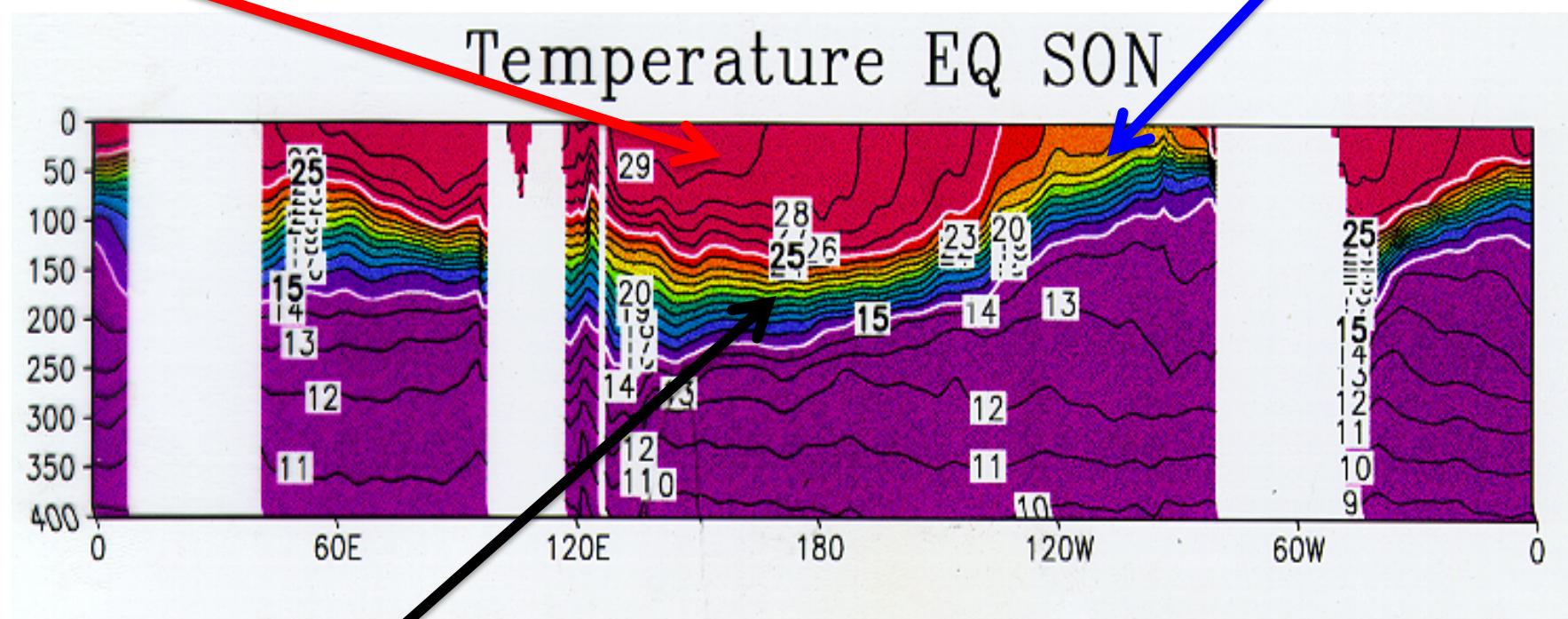
Sea Surface Temp MAM Climo



September-October-November Equatorial Temperature Climatology

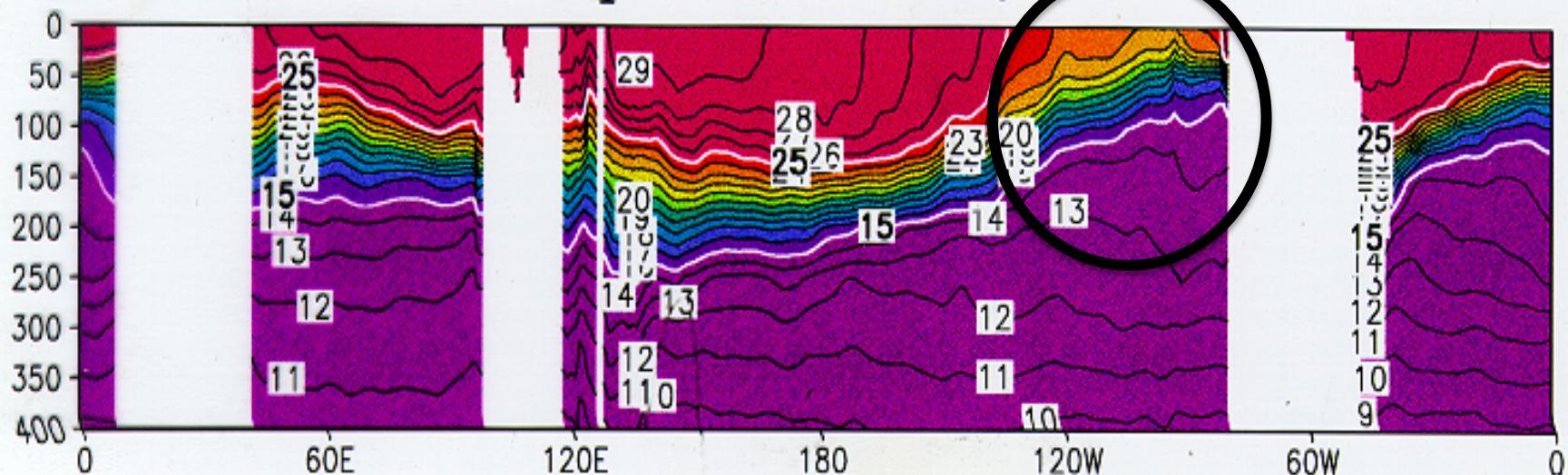
Warm Pool

Cold Tongue

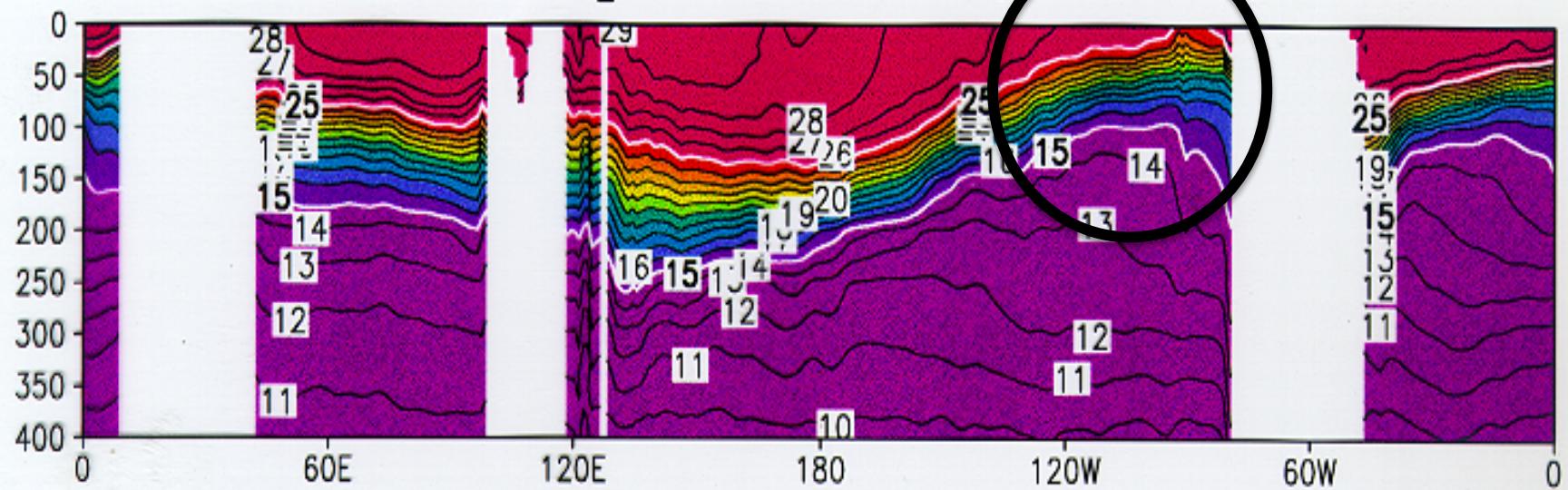


Thermocline

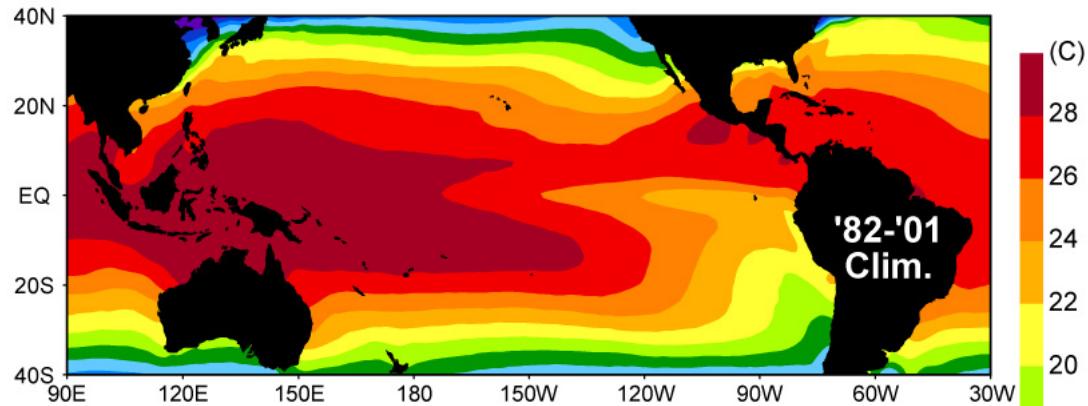
Temperature EQ SON



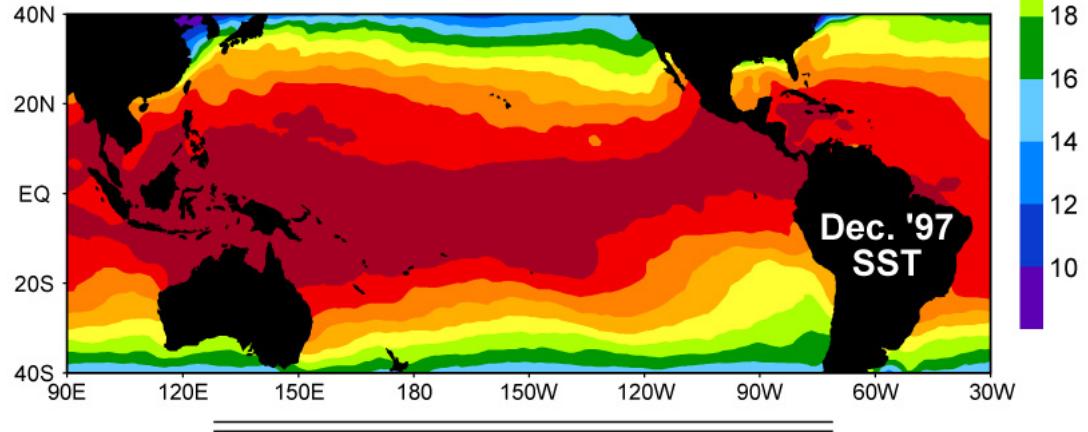
Temperature EQ MAM



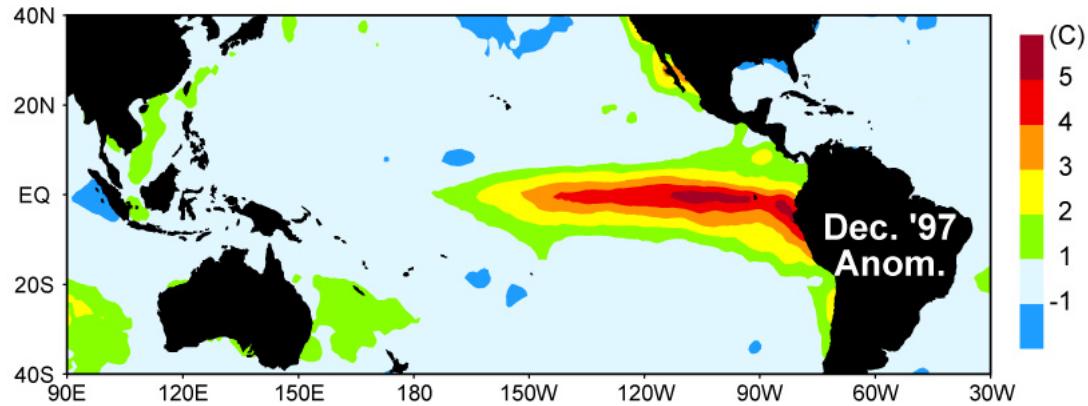
December 1982-2001 SST Climatology



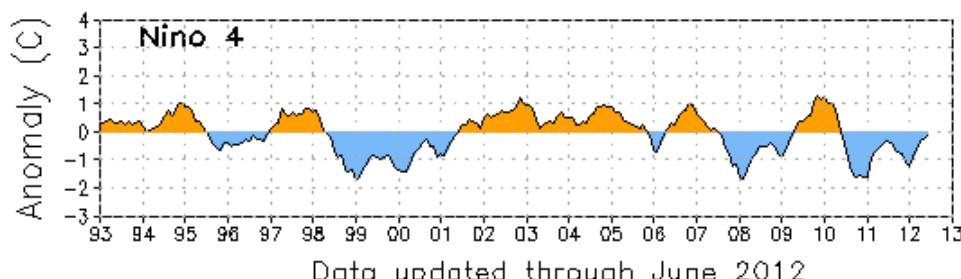
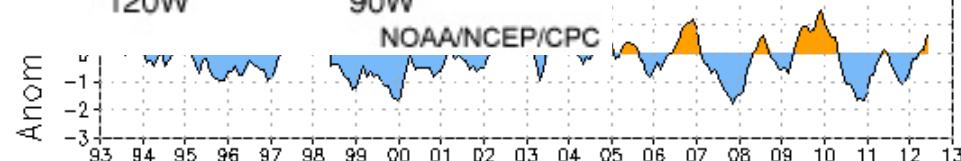
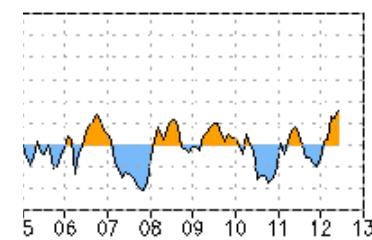
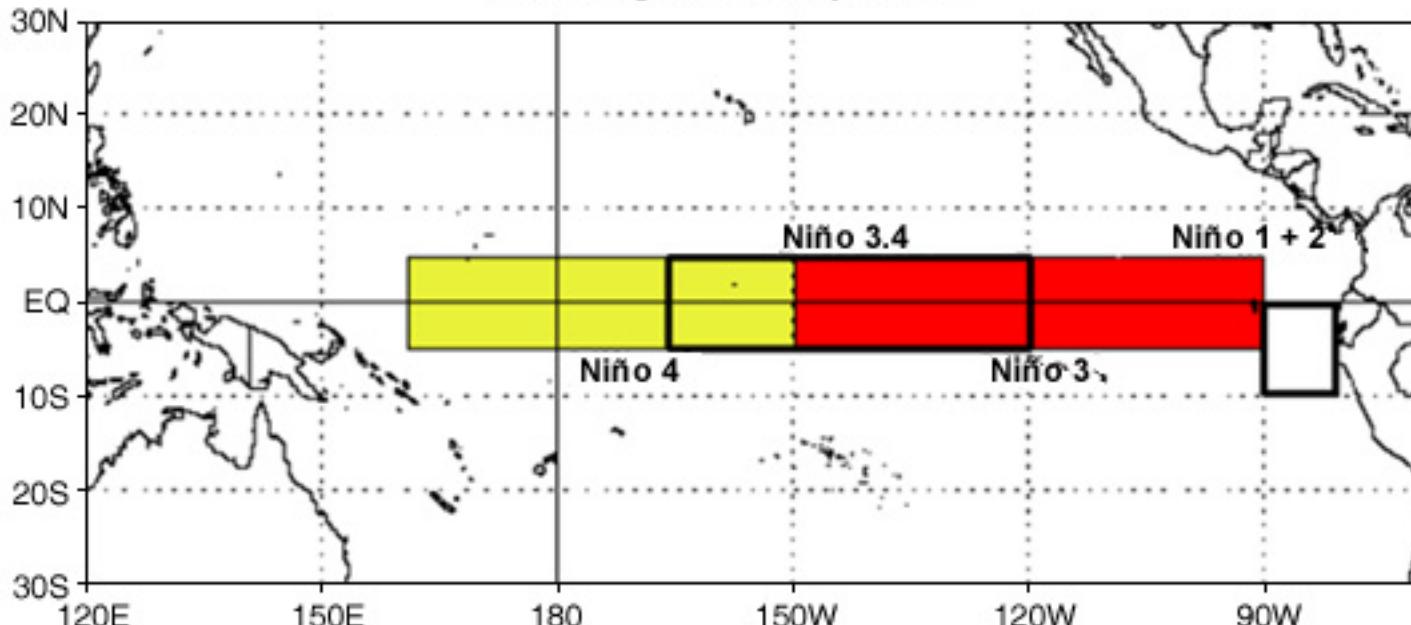
December 1997 Total SST



December 1997 SST Anomaly

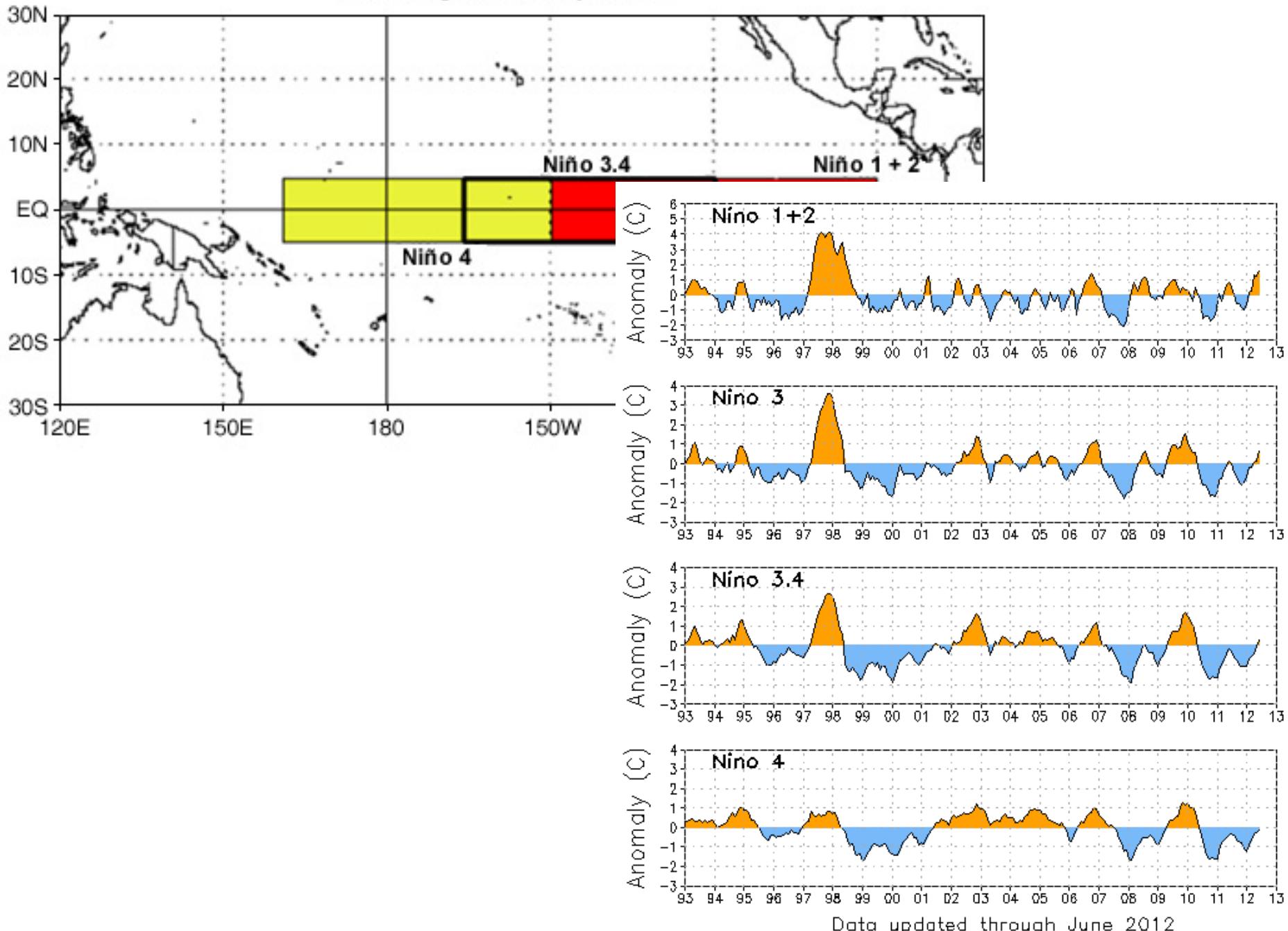


Monitoring Ocean Temperature

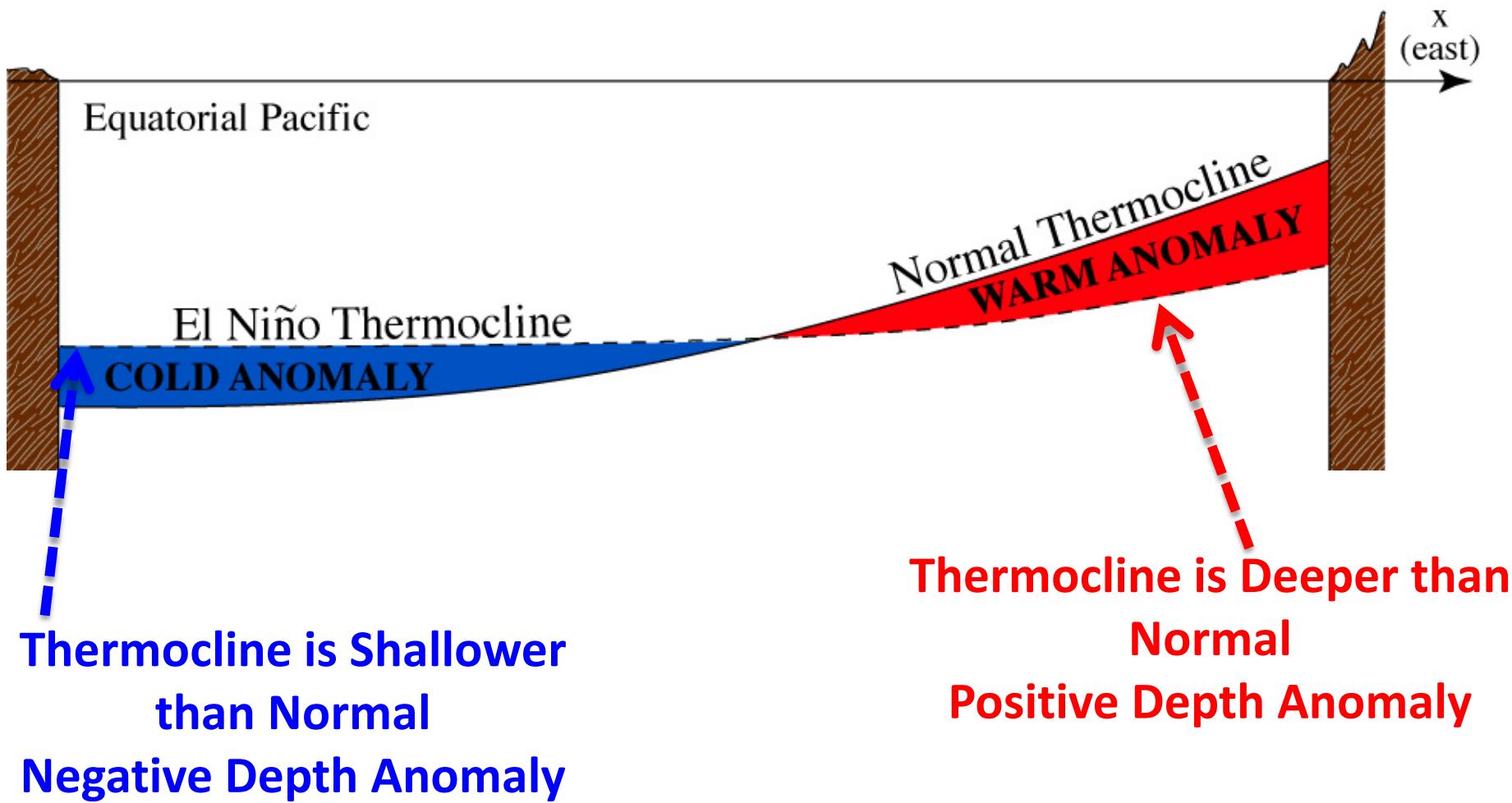


Data updated through June 2012

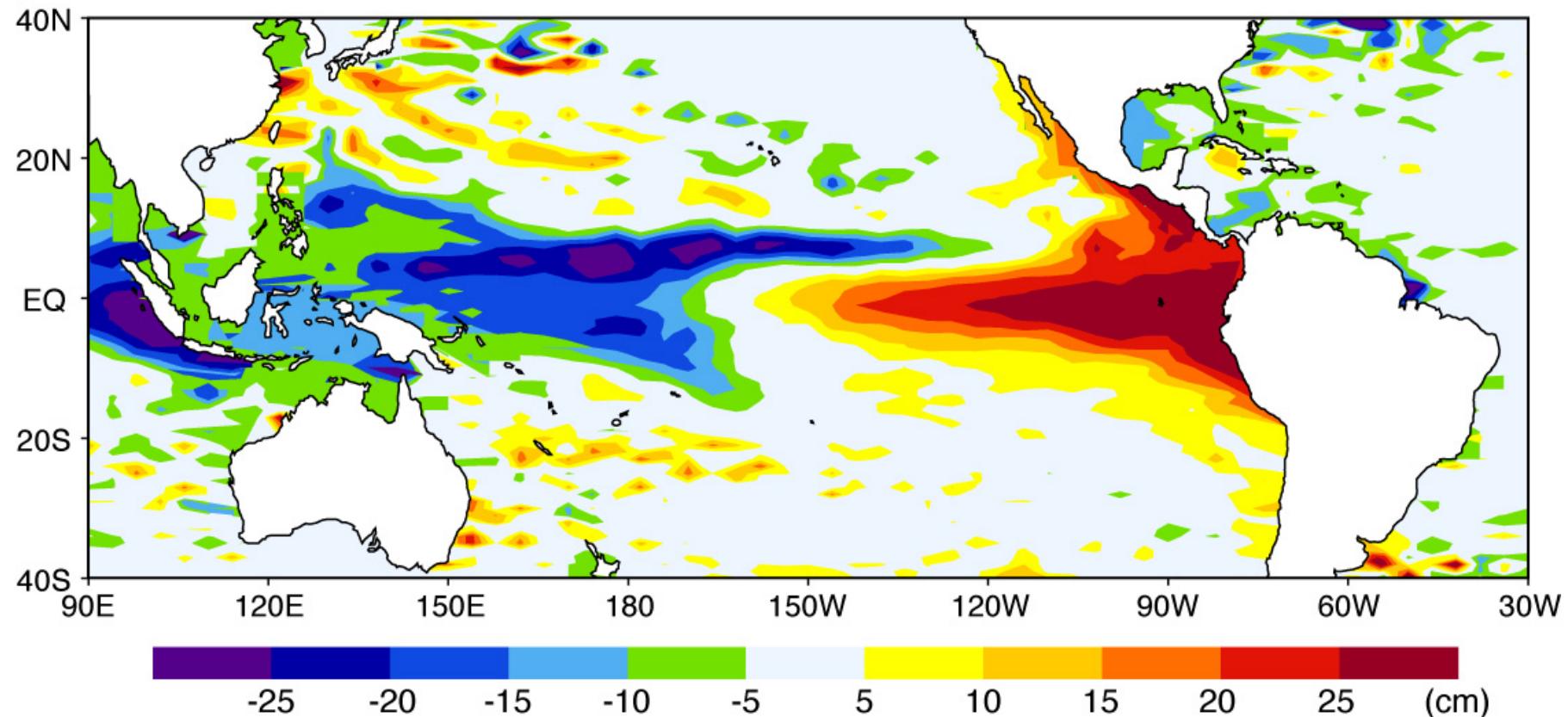
Monitoring Ocean Temperature

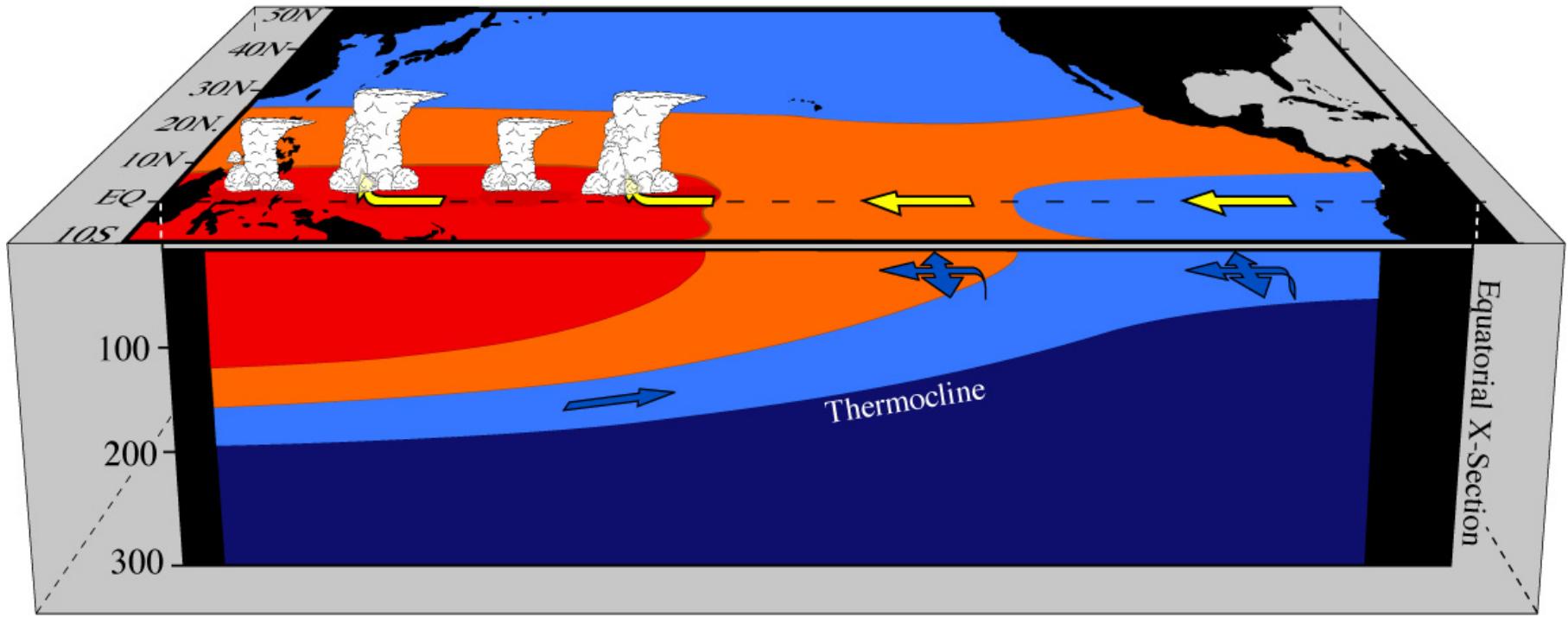


El Niño vs. Normal Thermocline Depth

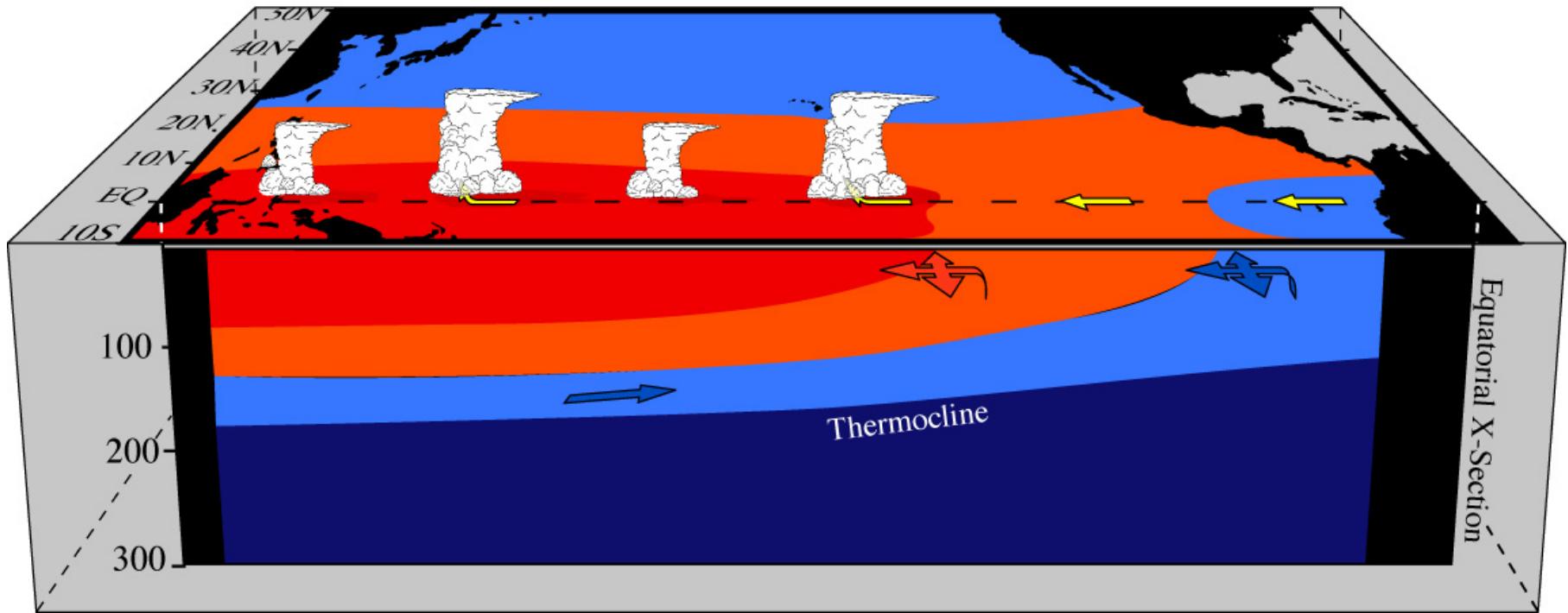


December 1997 (El Nino) Thermocline Depth Anomalies)

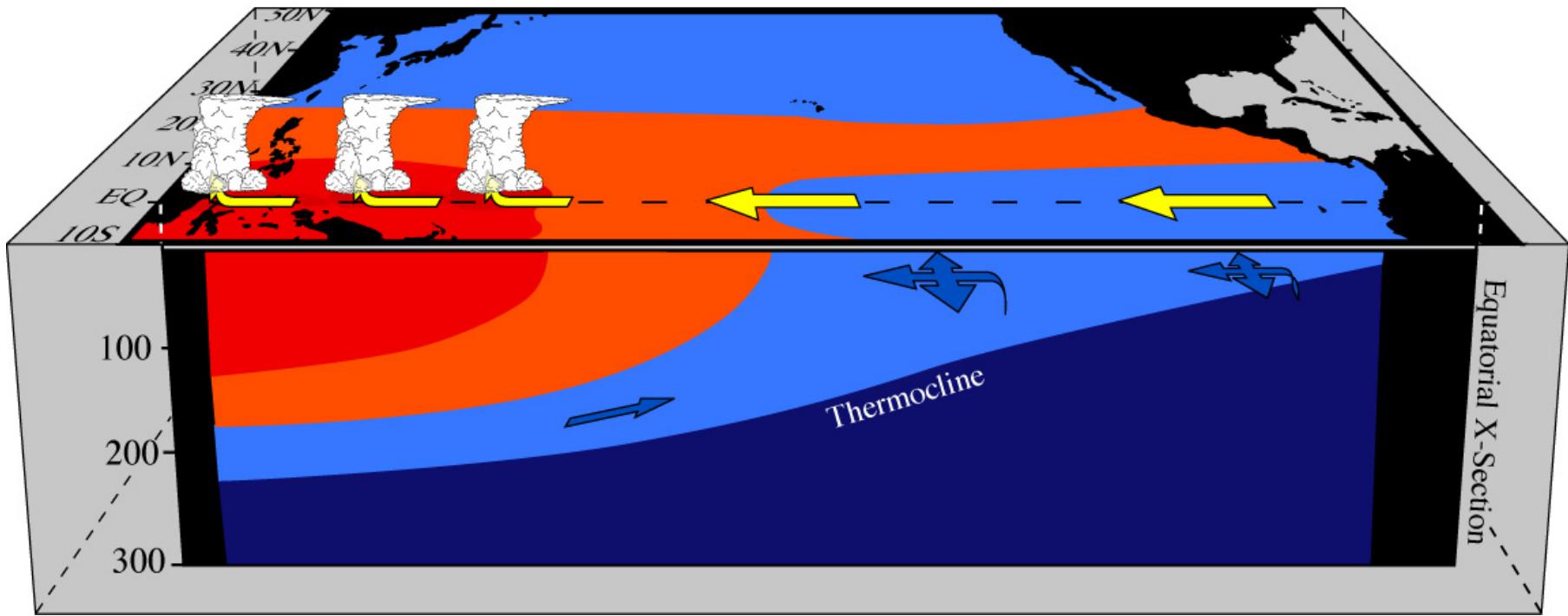




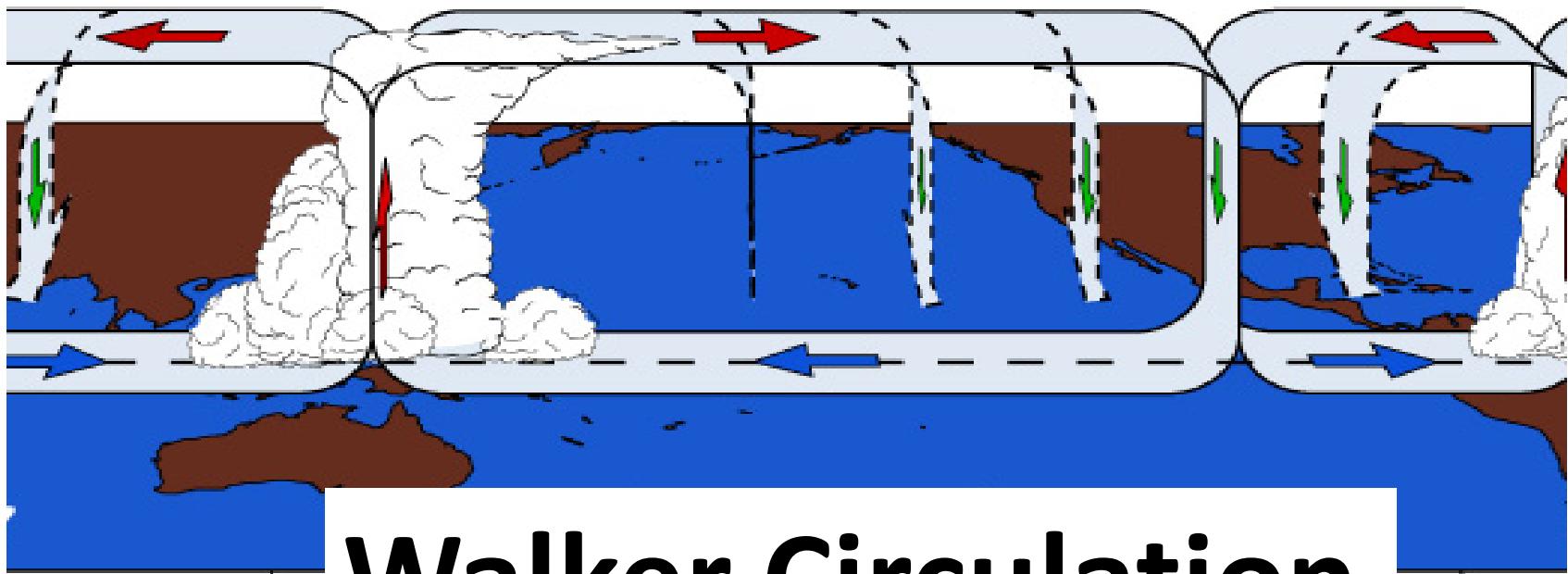
Normal Conditions in the Tropical Pacific



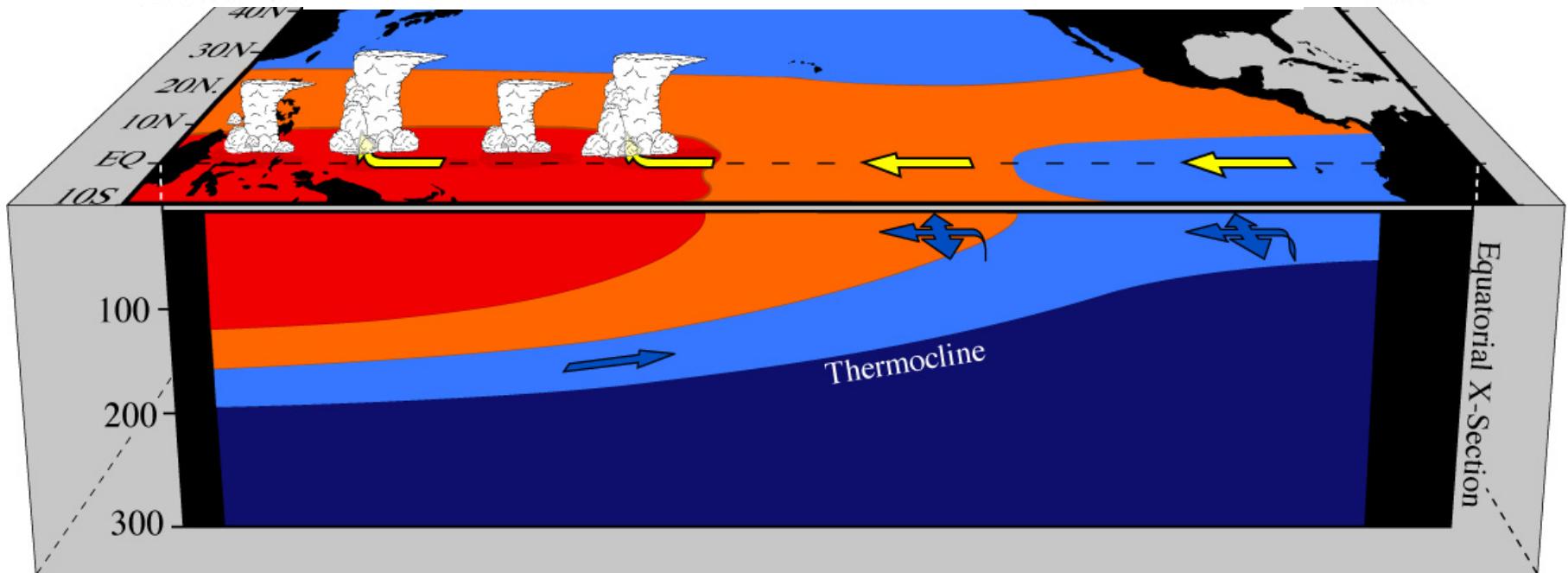
Warm (El Niño) Conditions in the Tropical Pacific

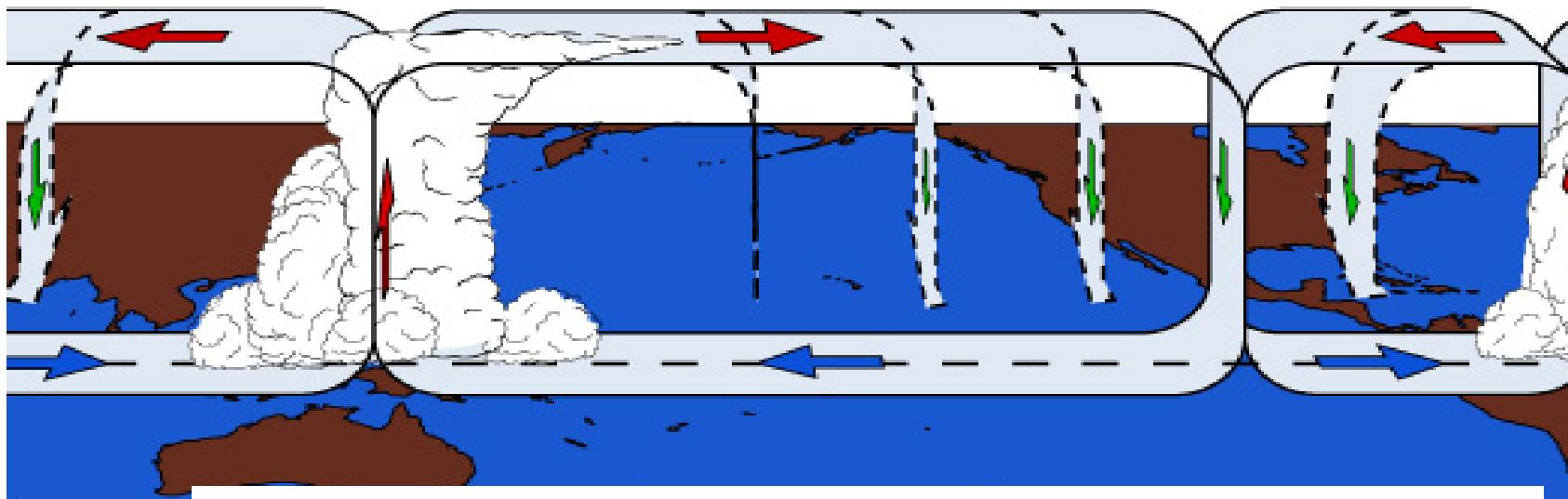


Cold (La Niña) Conditions in the Tropical Pacific

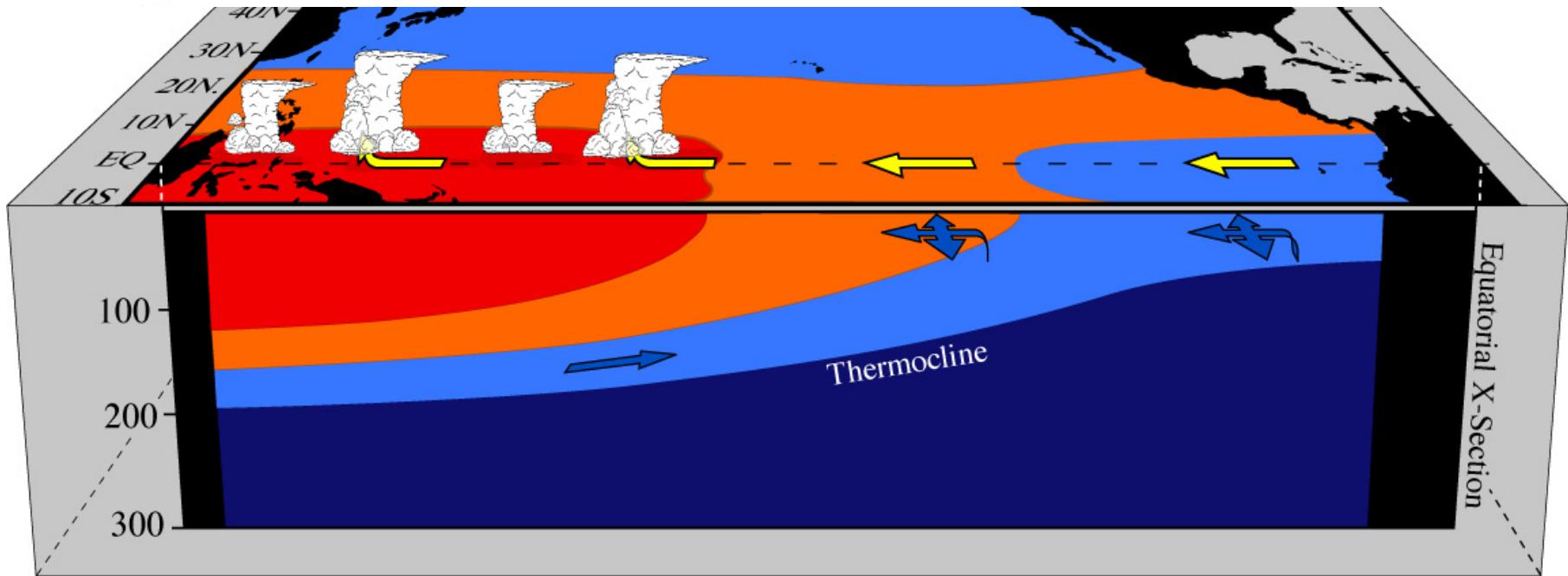


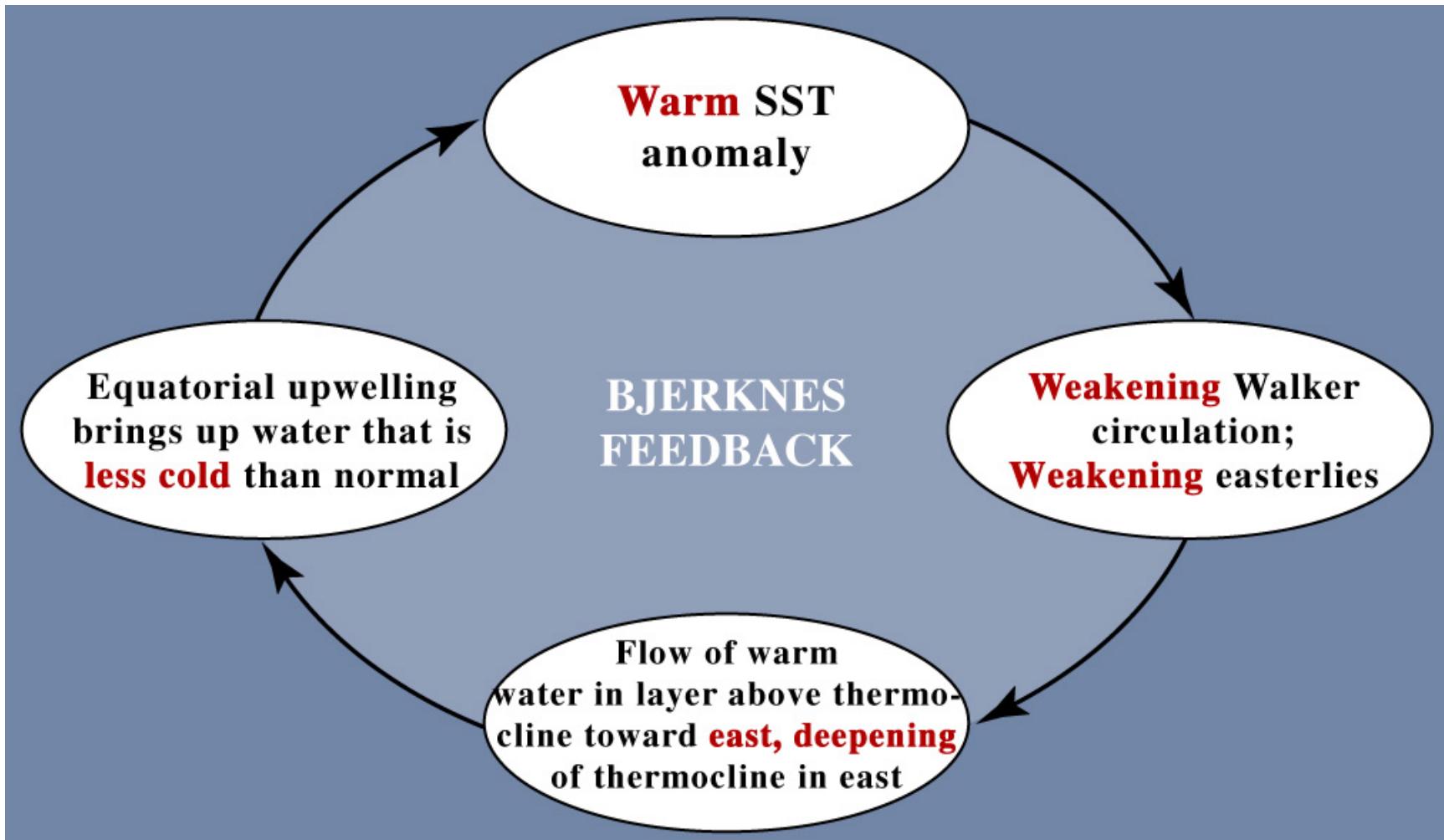
Walker Circulation

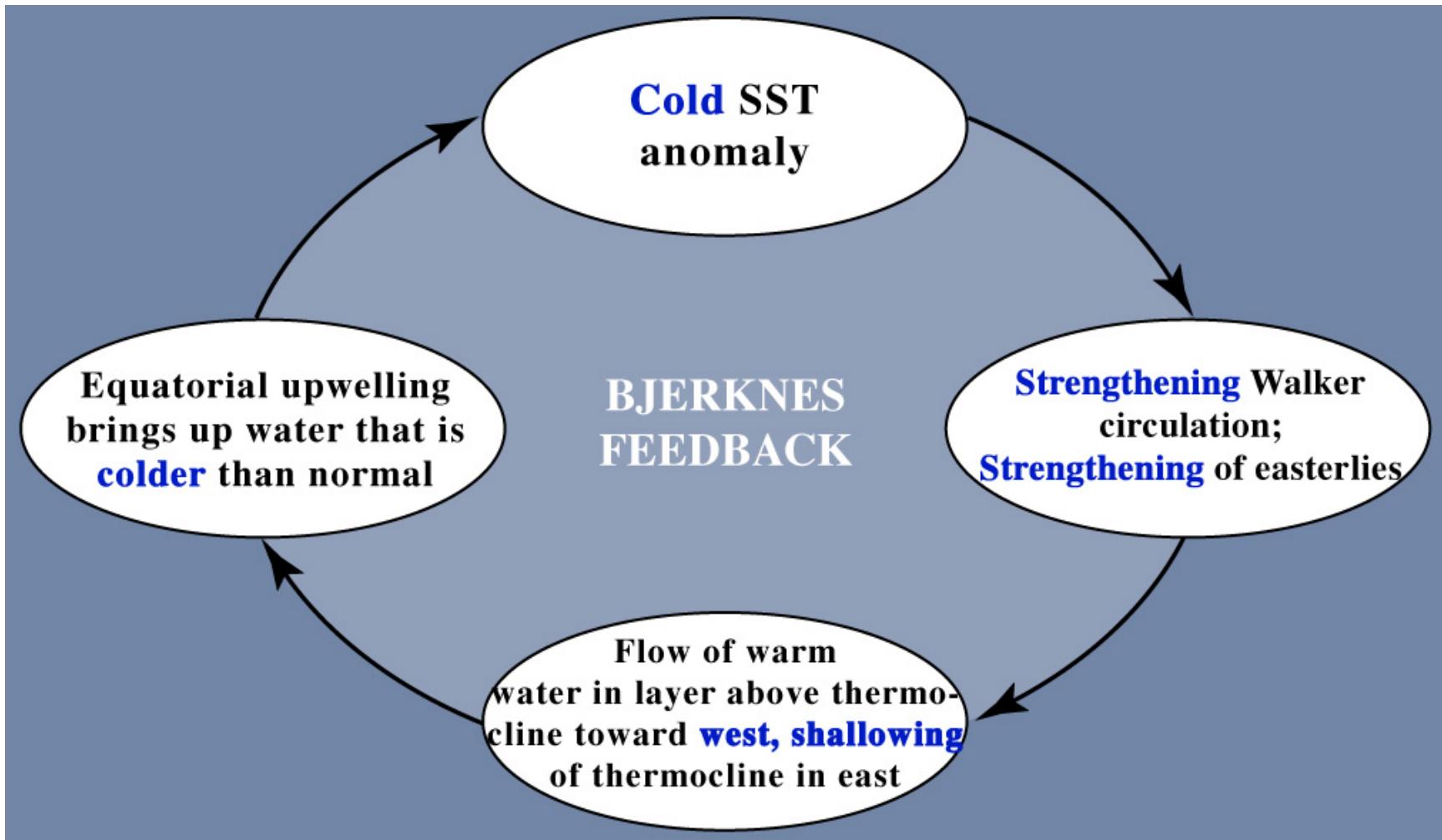




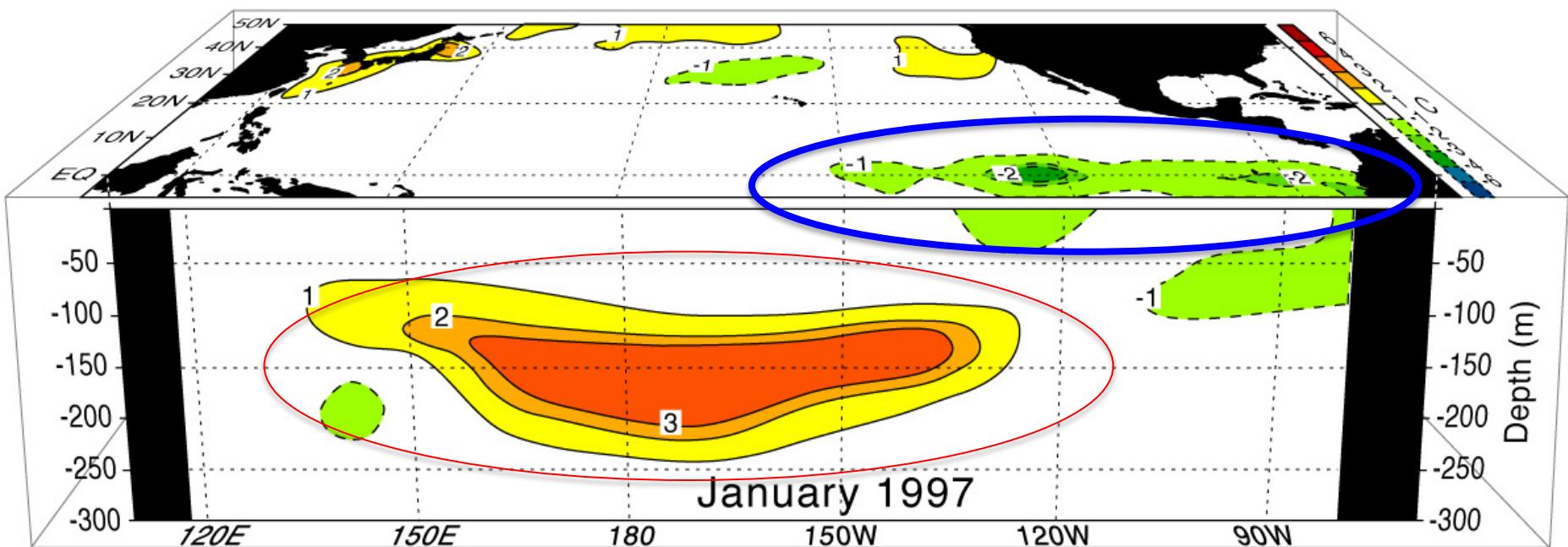
1 Overturning Circulation



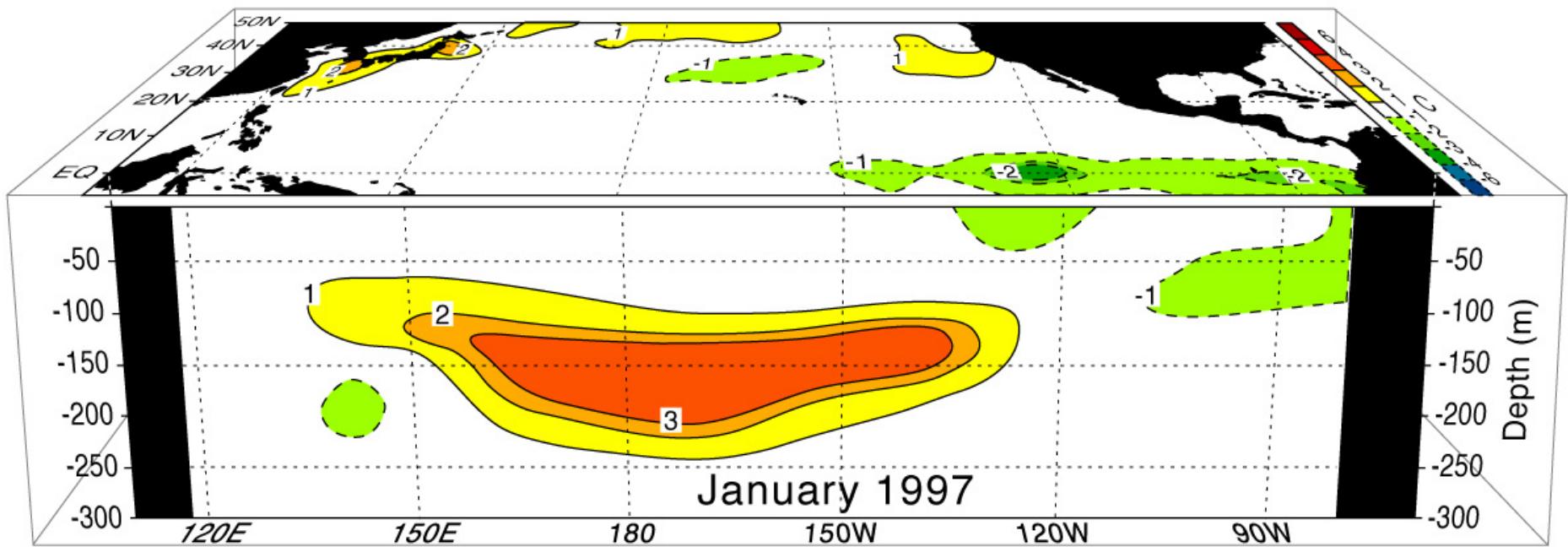


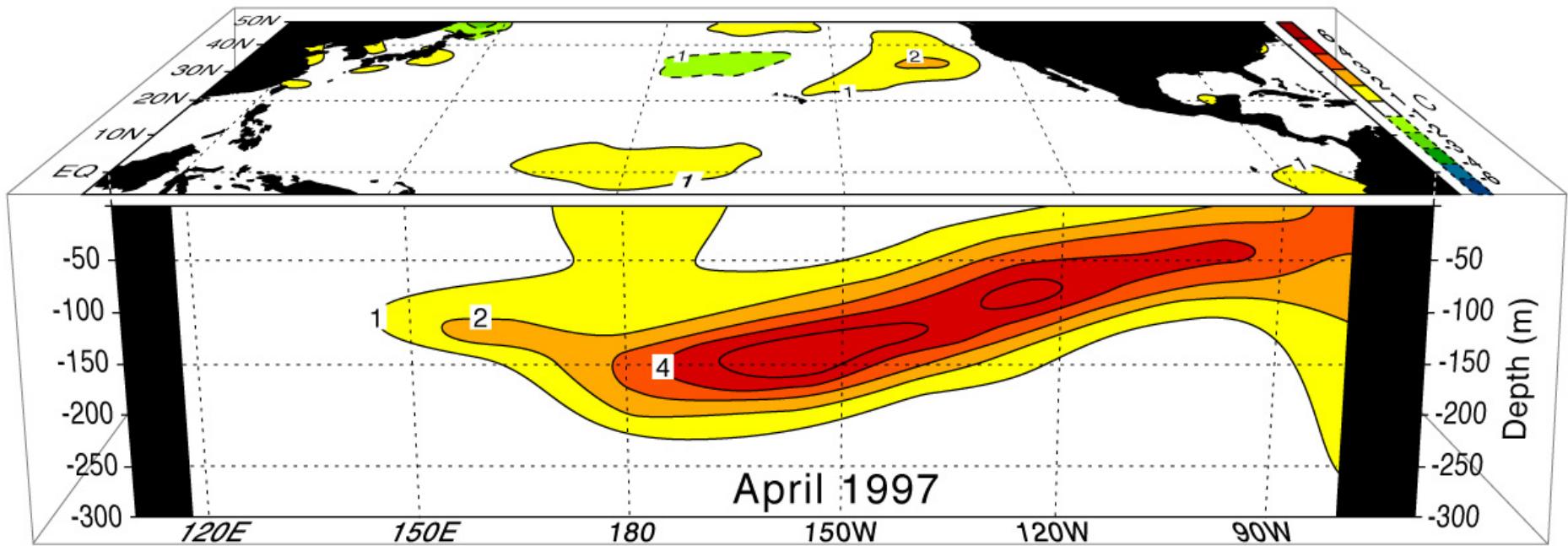


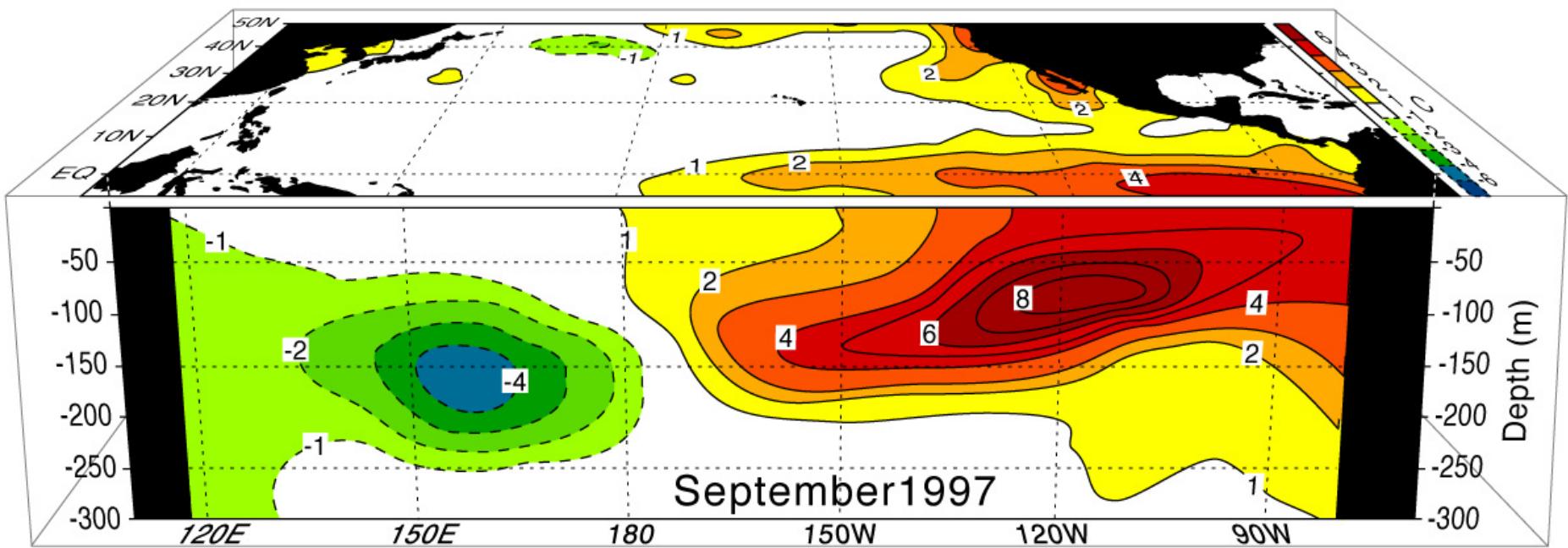
Evolution of the 1997-98 ENSO Event



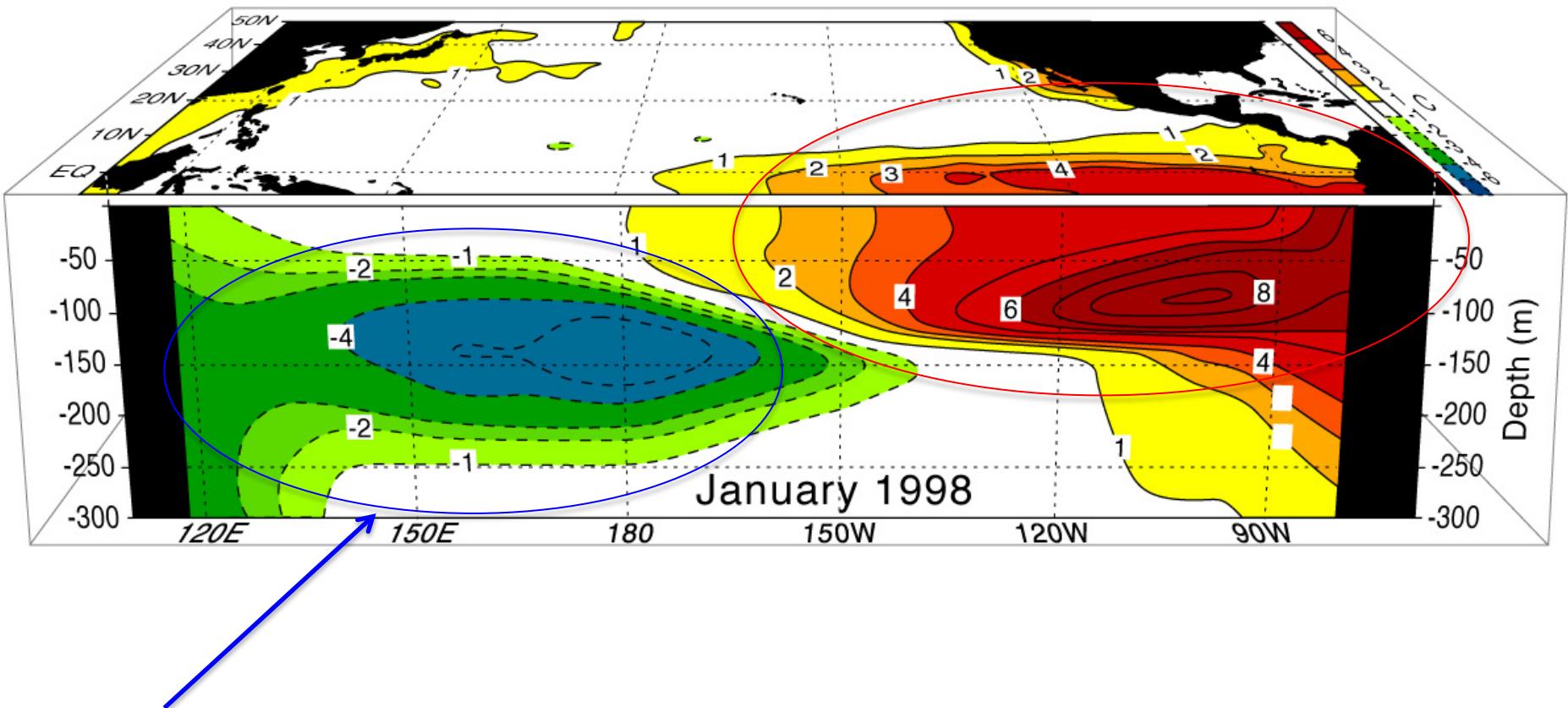
Warm Sub-Surface Temperature (Deeper Thermocline) Anomaly is the Precursor of the Coming Warm Event – Why We Can Predict



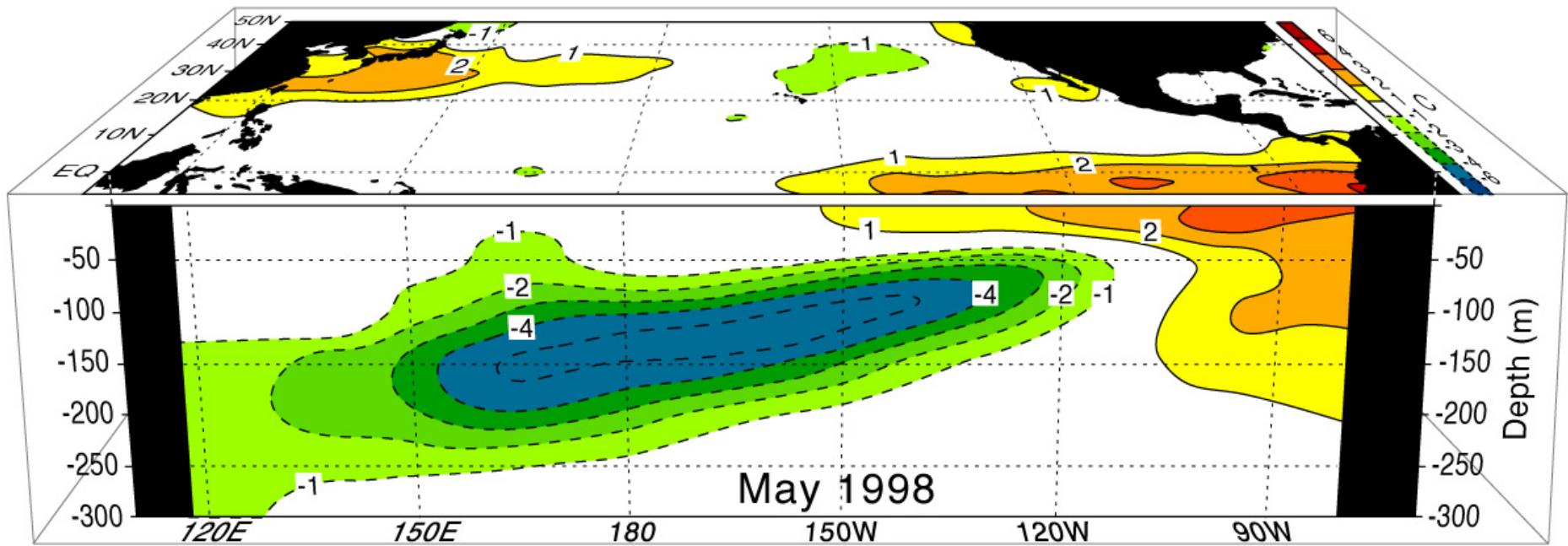


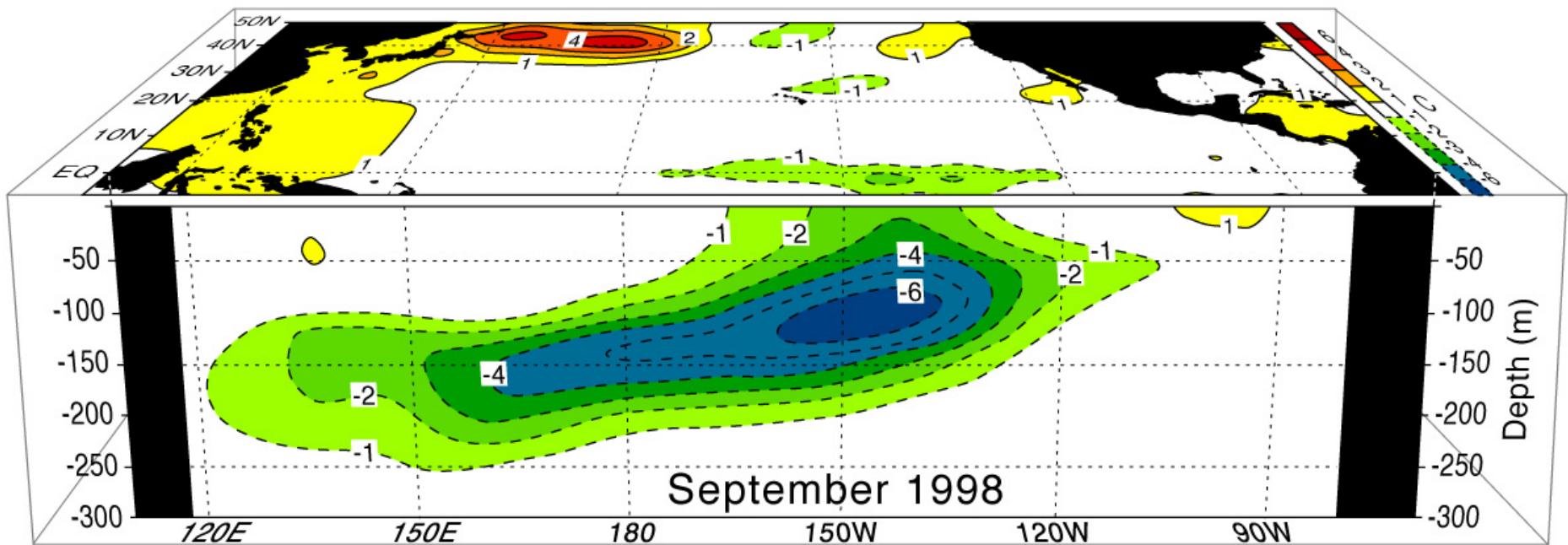


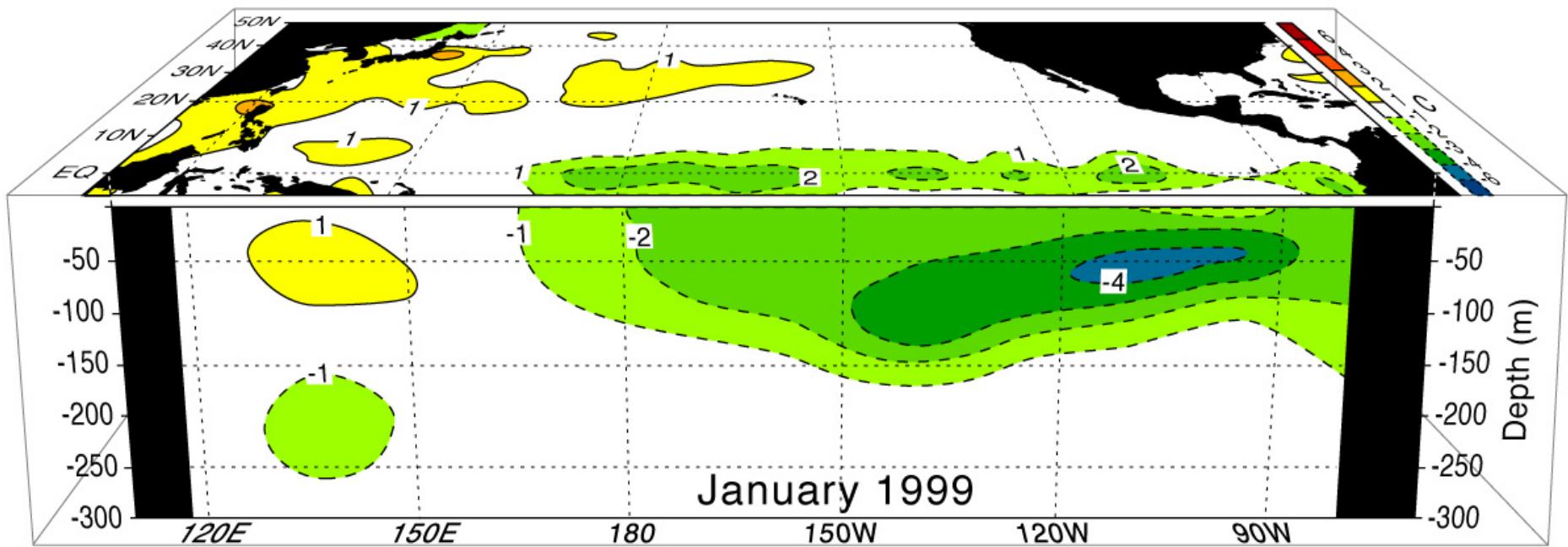
Mature Warm Event



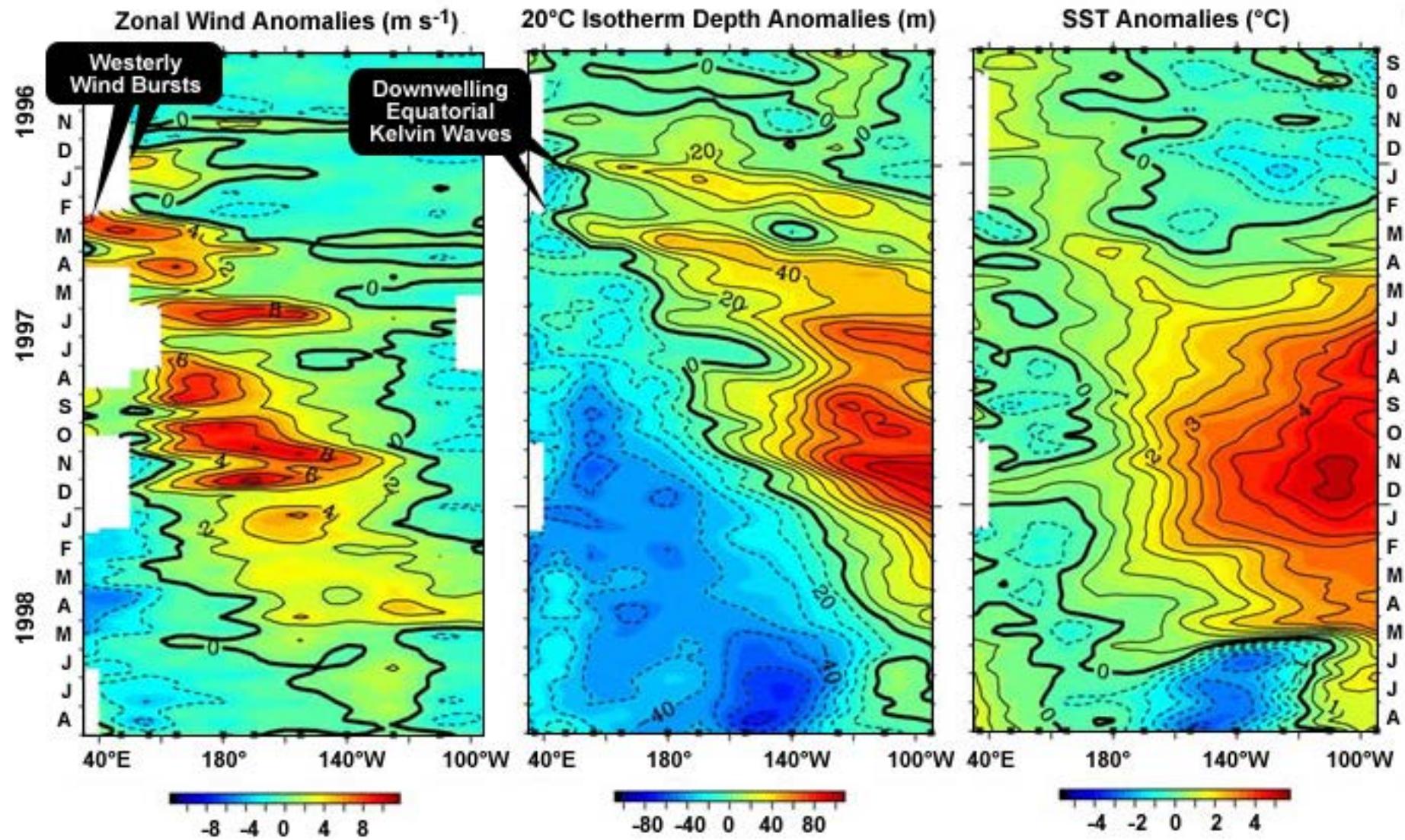
The Precursor of the Coming Cold Event





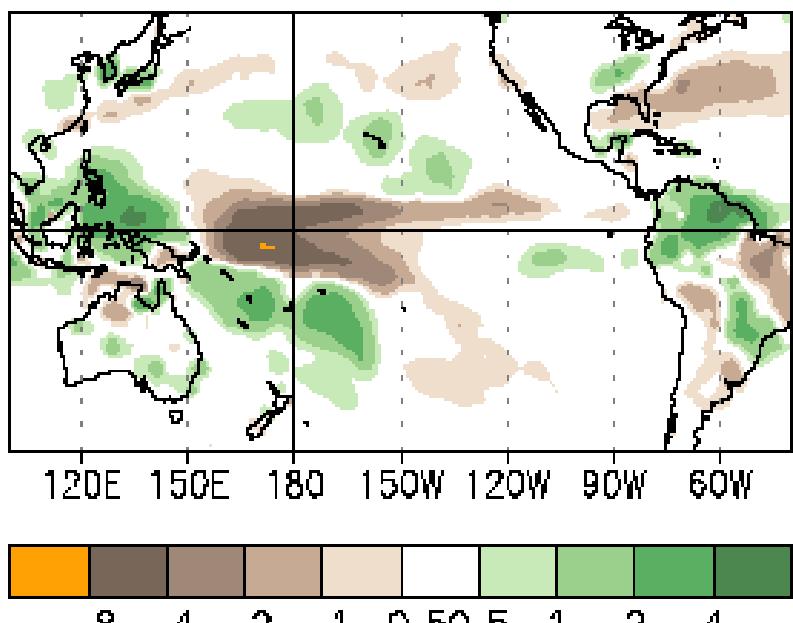
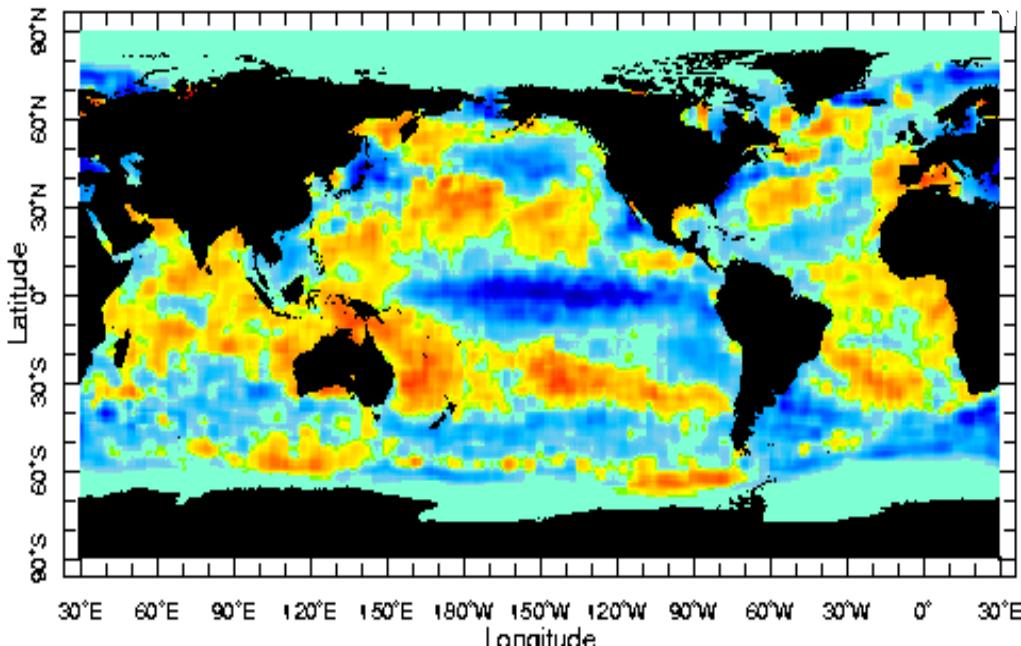
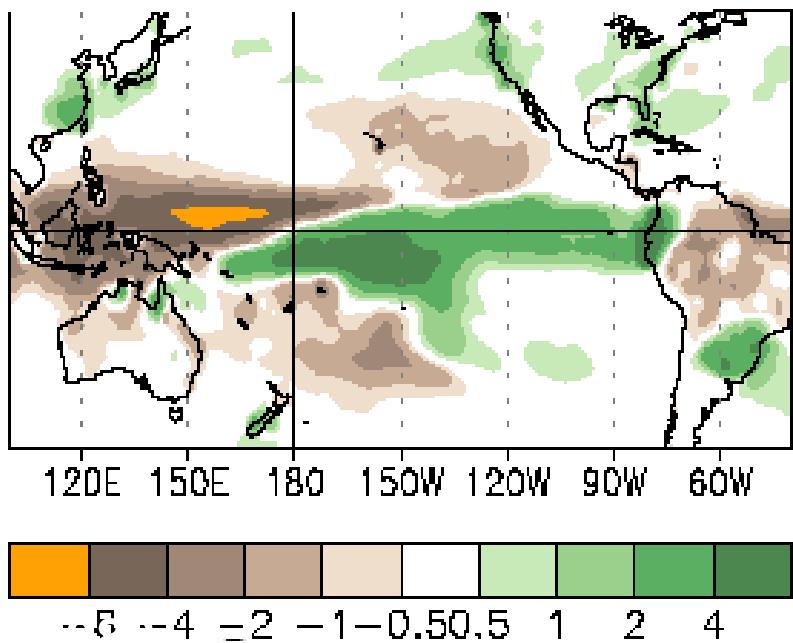
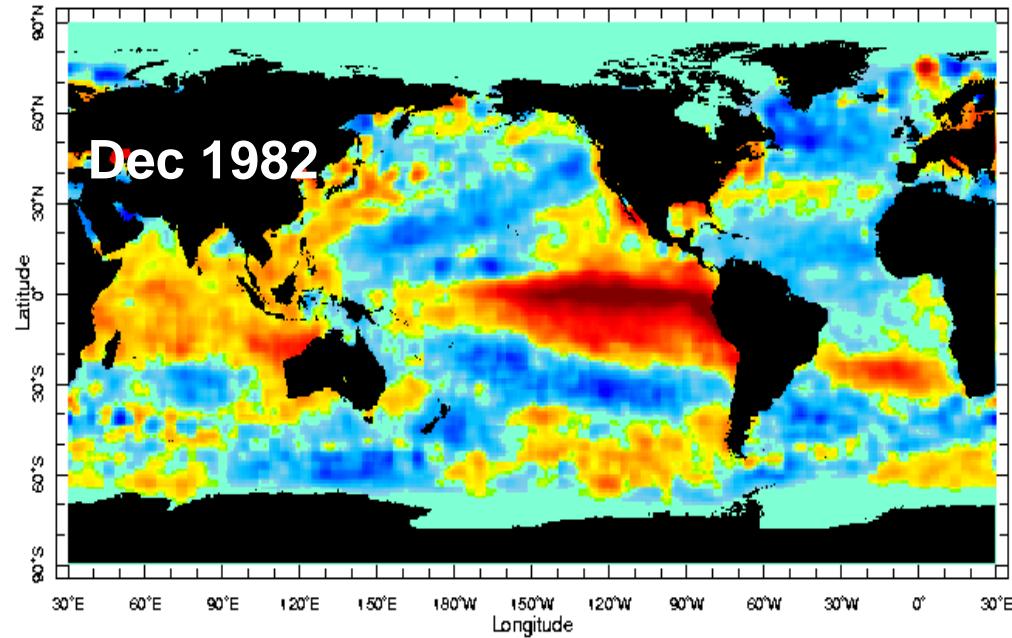


Evolution of the 1997-98 ENSO (2°S-2°N Averages)



Teleconnections

SST \Rightarrow Rainfall

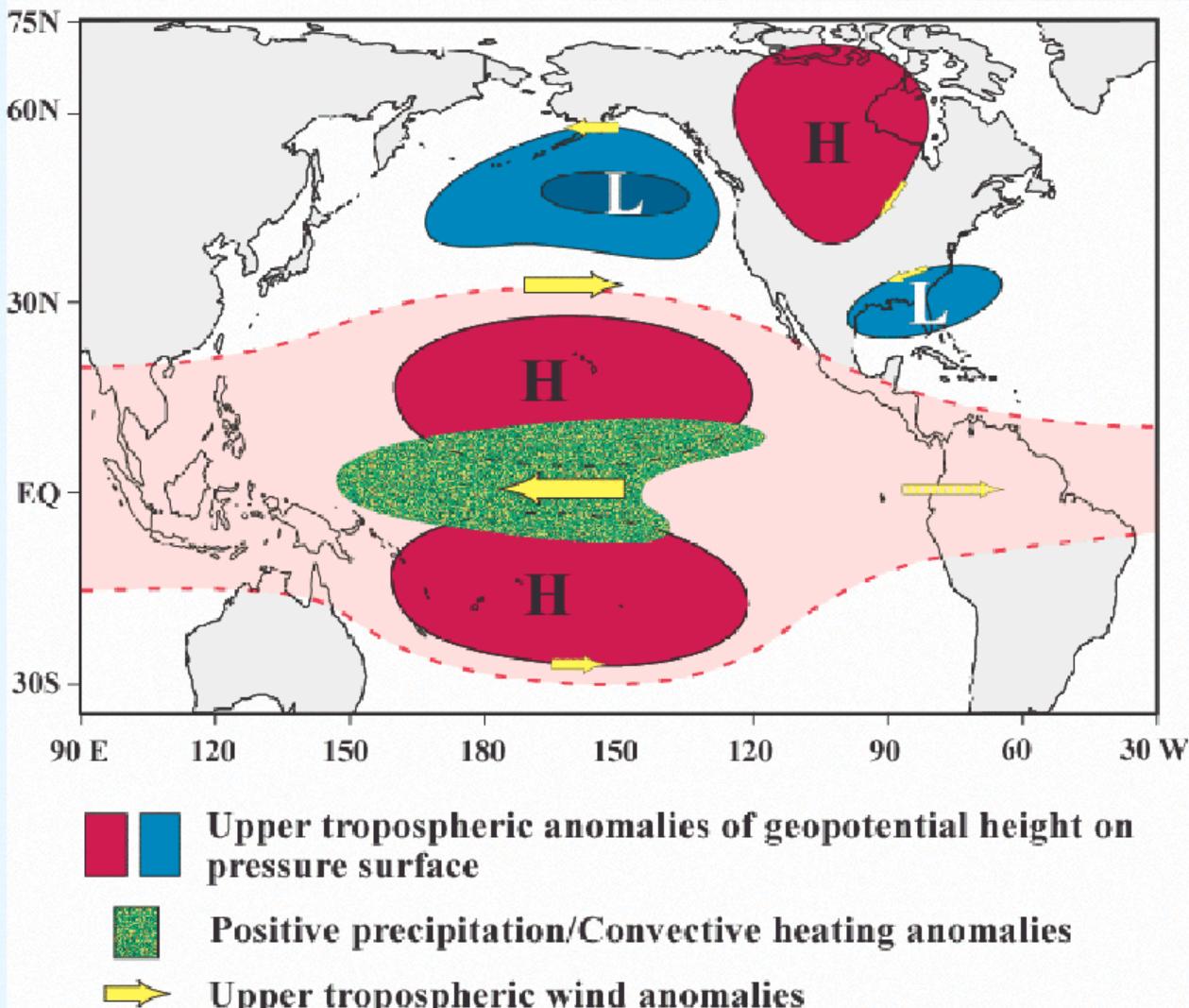


Pacific - North American sector Response to El Niño

La Niña: opposite sign to a first approximation
(but weaker, esp. over N. America)

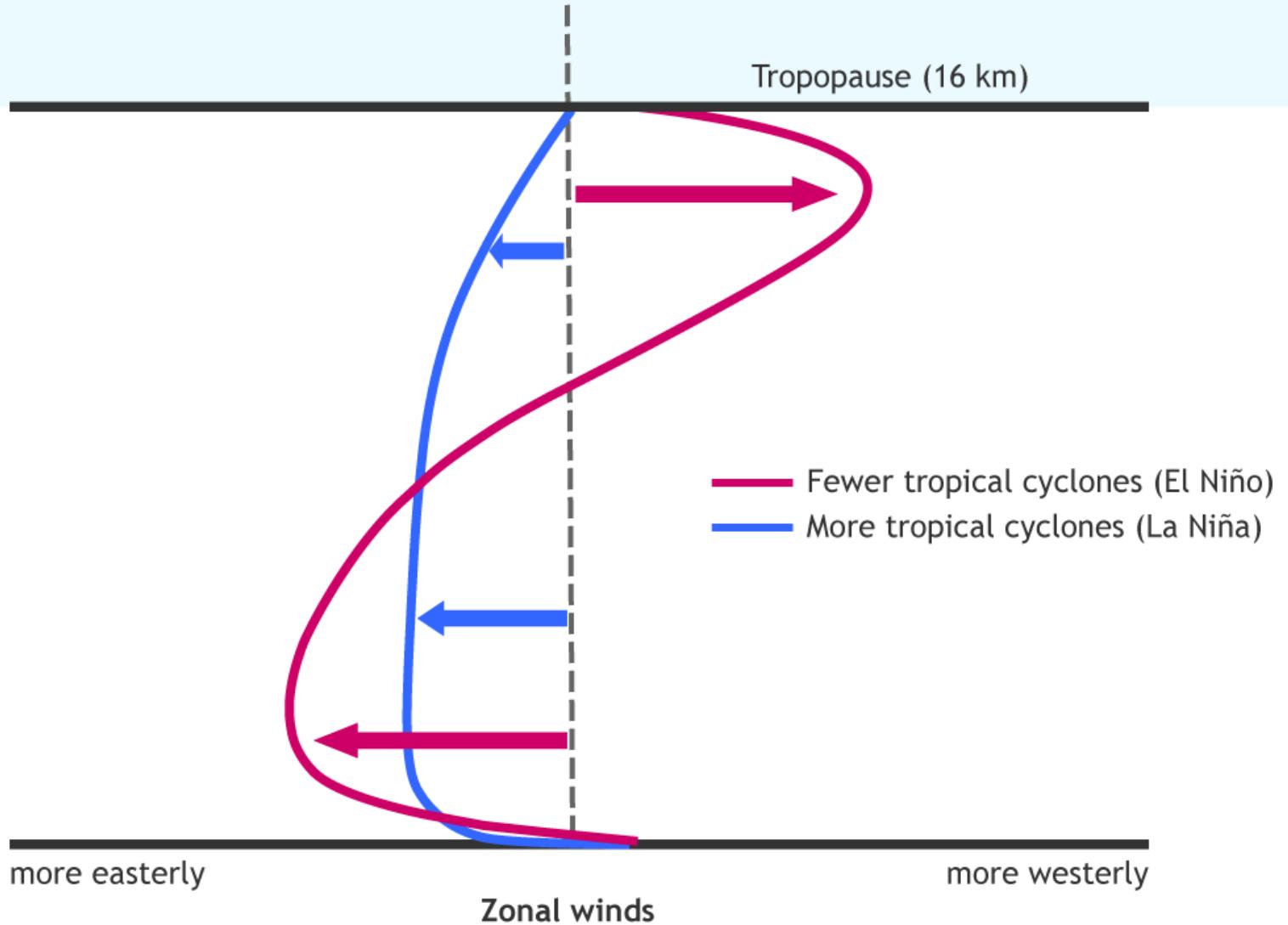
Mid-latitude response:
barotropic, same sign
through depth of
troposphere

Tropical response:
baroclinic, opposite sign
at low levels



Refs: J.M. Wallace et al 1998,
K. Trenberth et al 1998

Vertical wind profile in the western tropical Atlantic



Large-Scale Circulation: Three Big Ideas

1) Meridional Temperature and Momentum Transport (Mean Meridional Circulation)

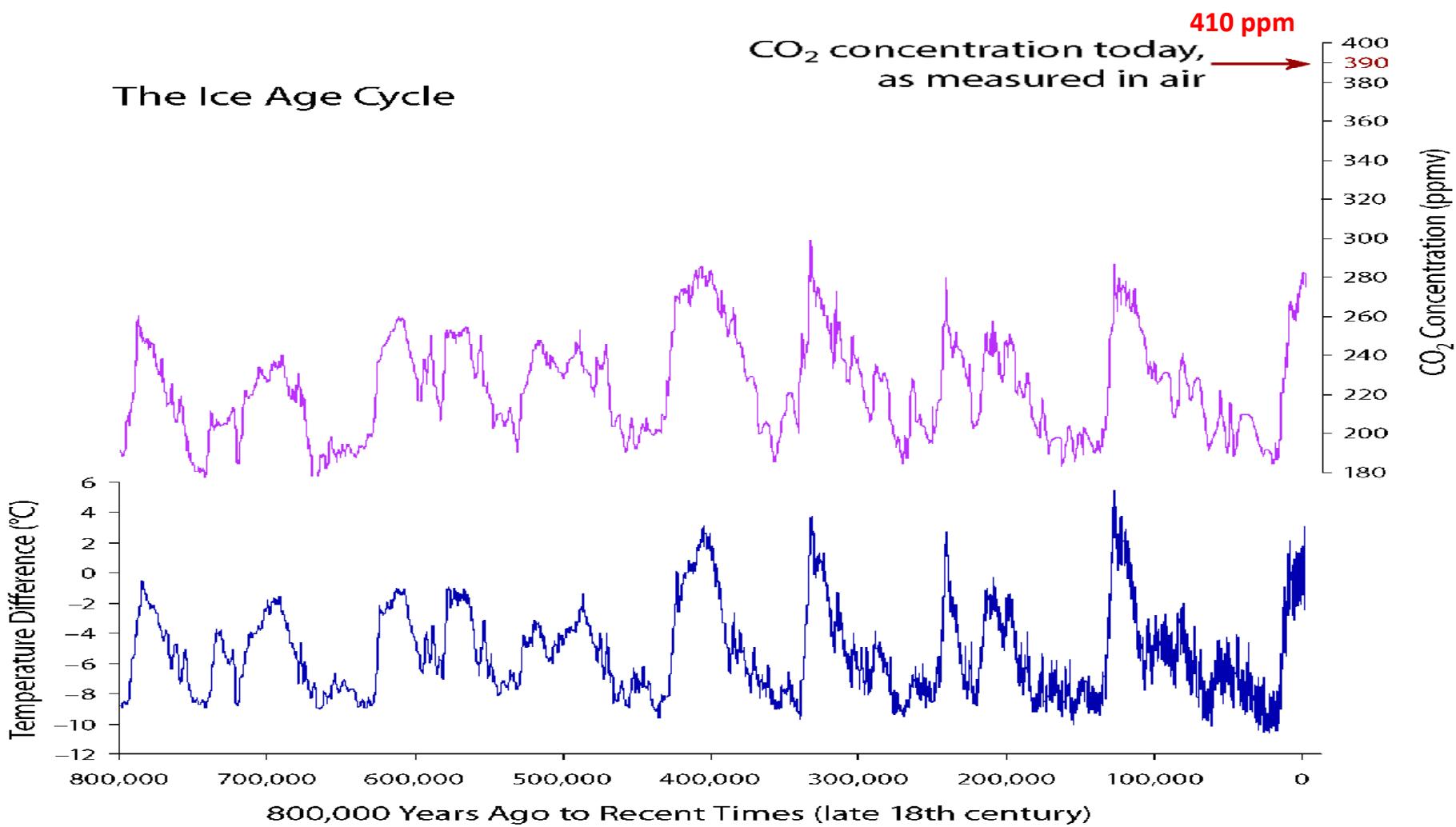
- Stationary and Transient Eddies

2) Large-Scale Tropics

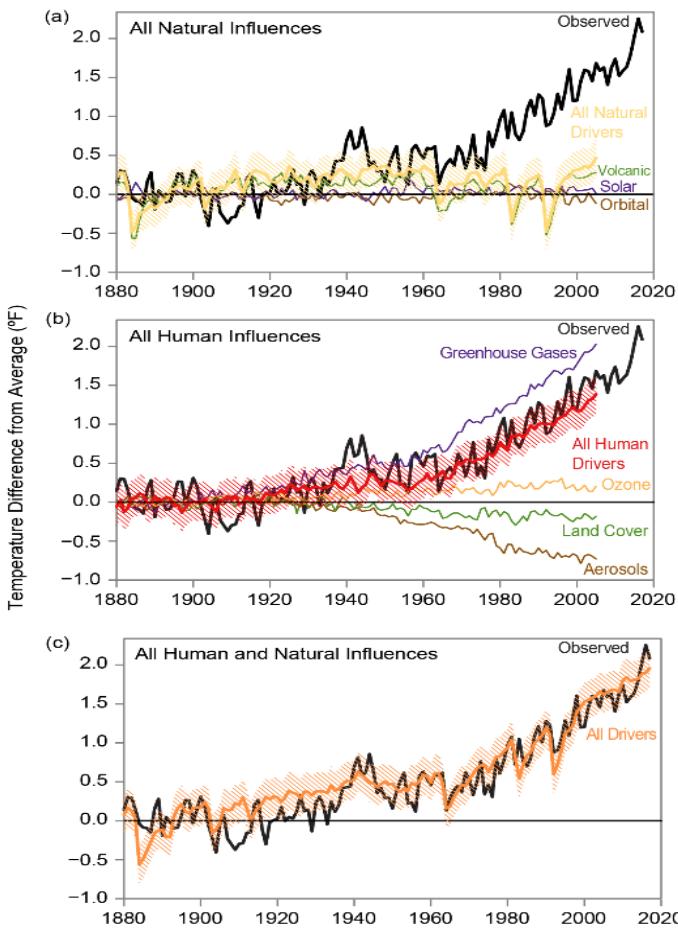
- ENSO

3) Climate Change

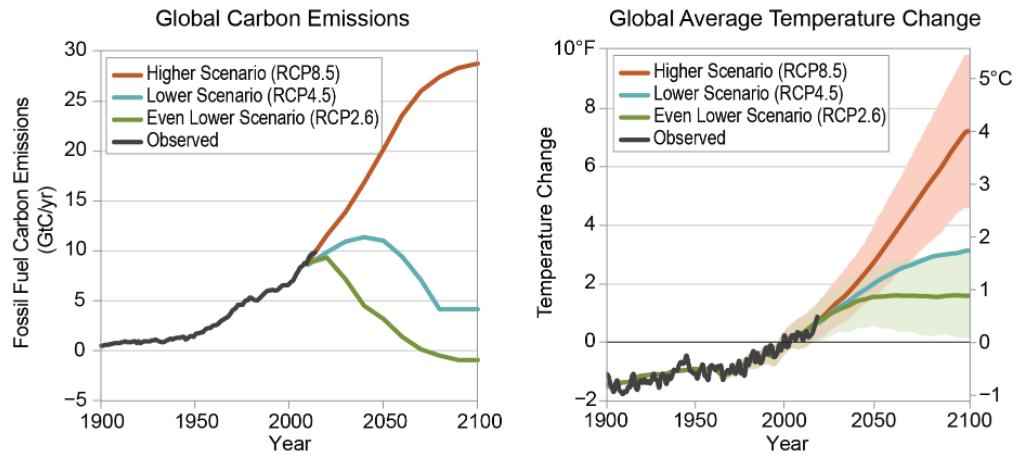
- Weaker Overturning Circulation



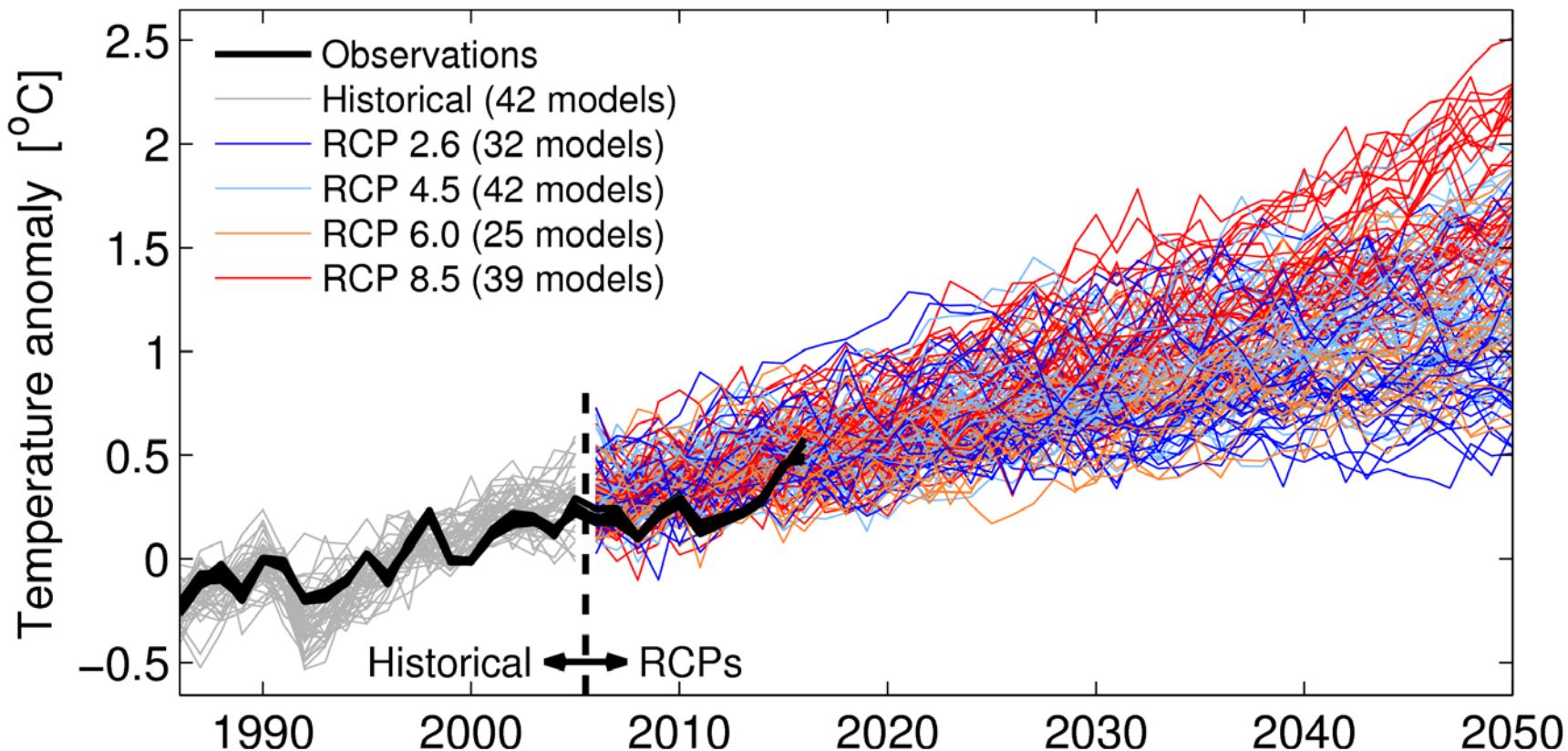
How We Understand Human Influence on Climate



Projections of Future Human Influence on Climate

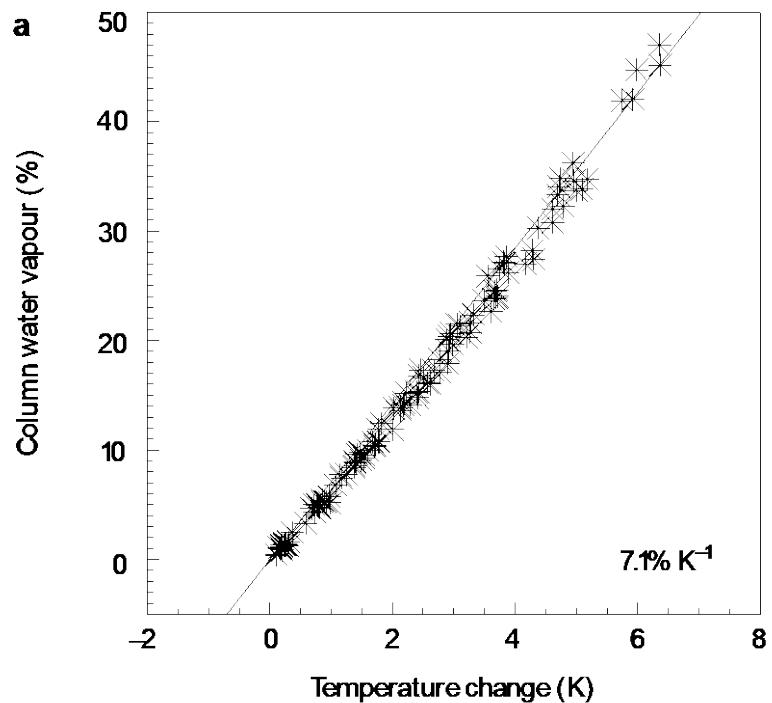


Global mean temperature near-term projections relative to 1986–2005



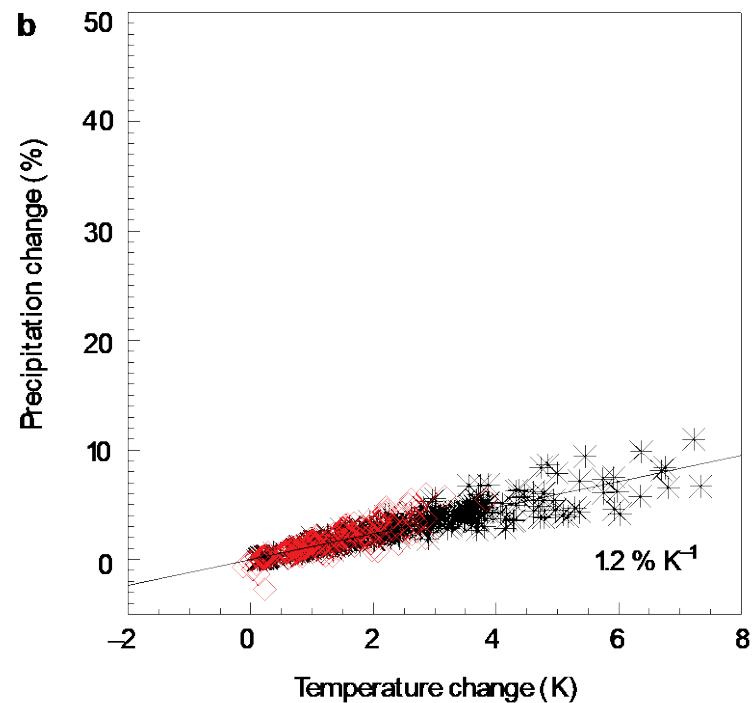
Global Changes with Warming

Increase in Water Vapor



Expected From Clausius-Clapeyron

Changes in Precipitation



Smaller than Expected ->
Decrease in Overturning
Circulation

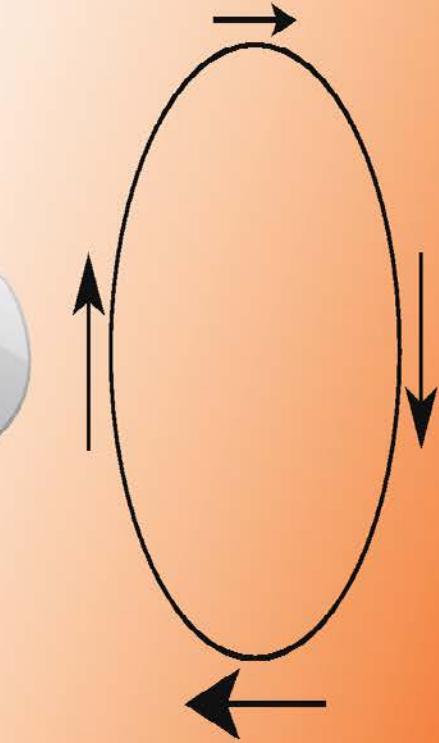
(a) present

solar radiation



land use

warm



moisture

cool

(b) future

solar radiation



in aerosols

more rain

land use

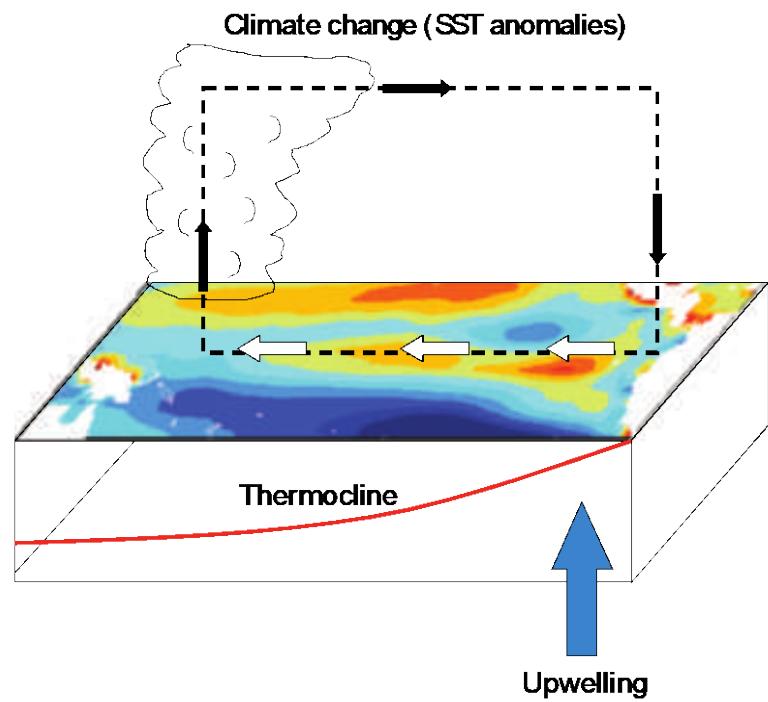
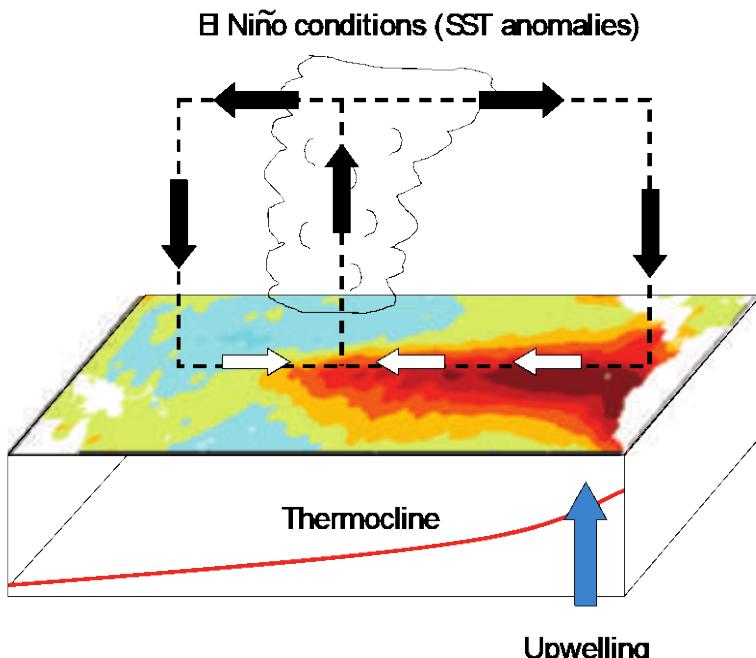
warmer

weaker
circulation



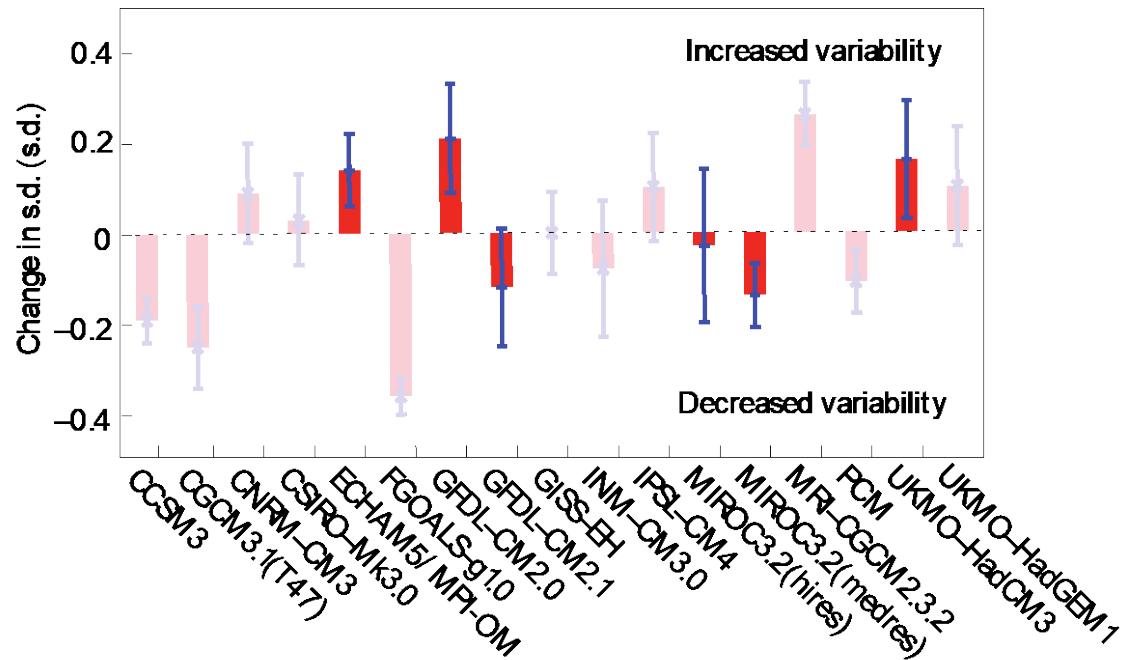
enhanced moisture

warm

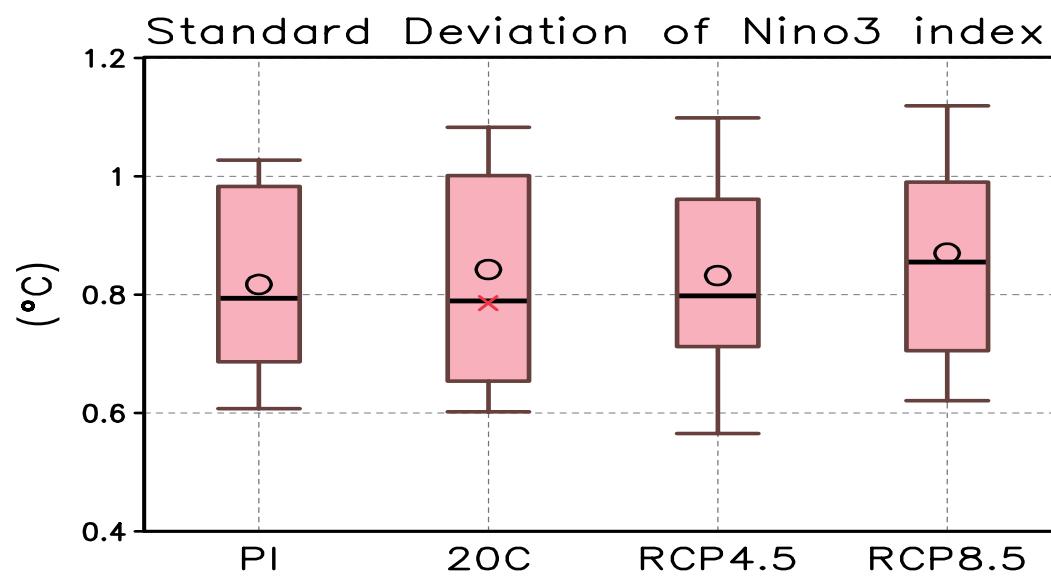


Not El Niño-Like

CMIP3



CMIP5



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- Weaker Overturning Circulation