



# Effects of Global Warming, El Nino and other Climate Variations on Typhoon Activity in Asia

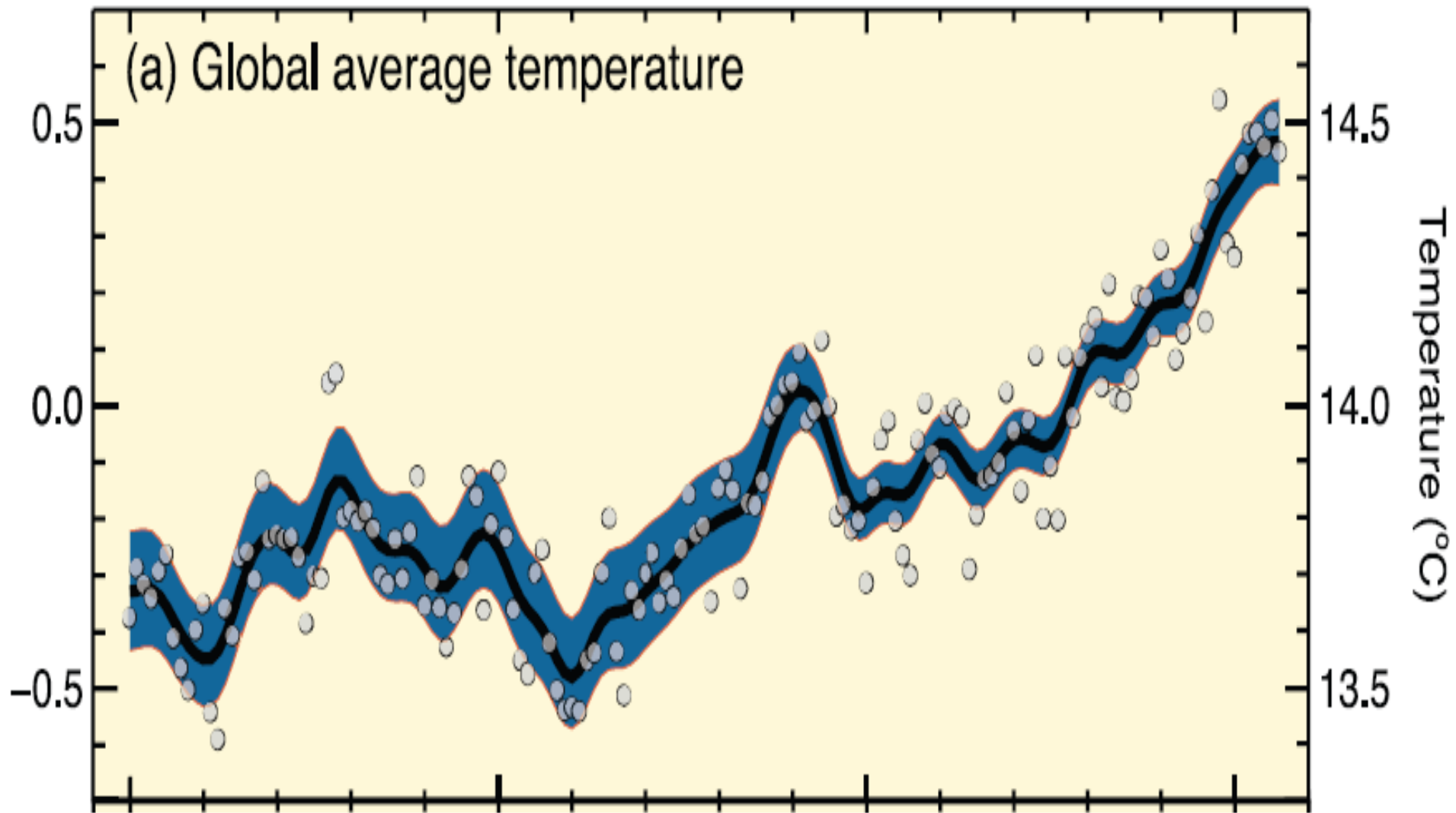
**Johnny Chan**

***Guy Carpenter Asia-Pacific Climate Impact Centre  
School of Energy and Environment  
City University of Hong Kong***

# Outline

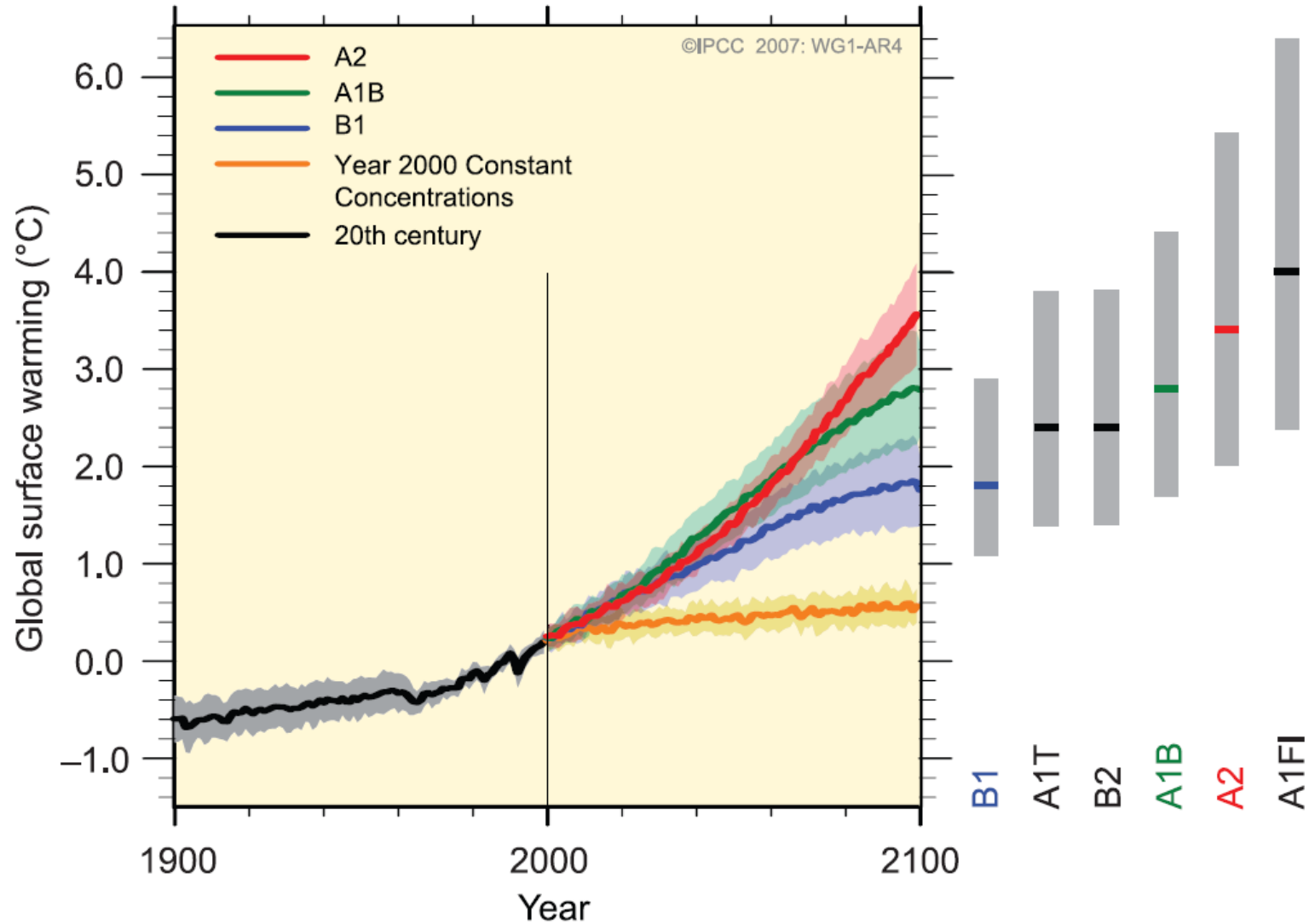
- **Crash course on global warming, El Niño and the Pacific Decadal Oscillation**
- **Crash course on typhoons**
- **Possible effects on typhoon activity**
- **Summary**

# Global warming – current temperatures



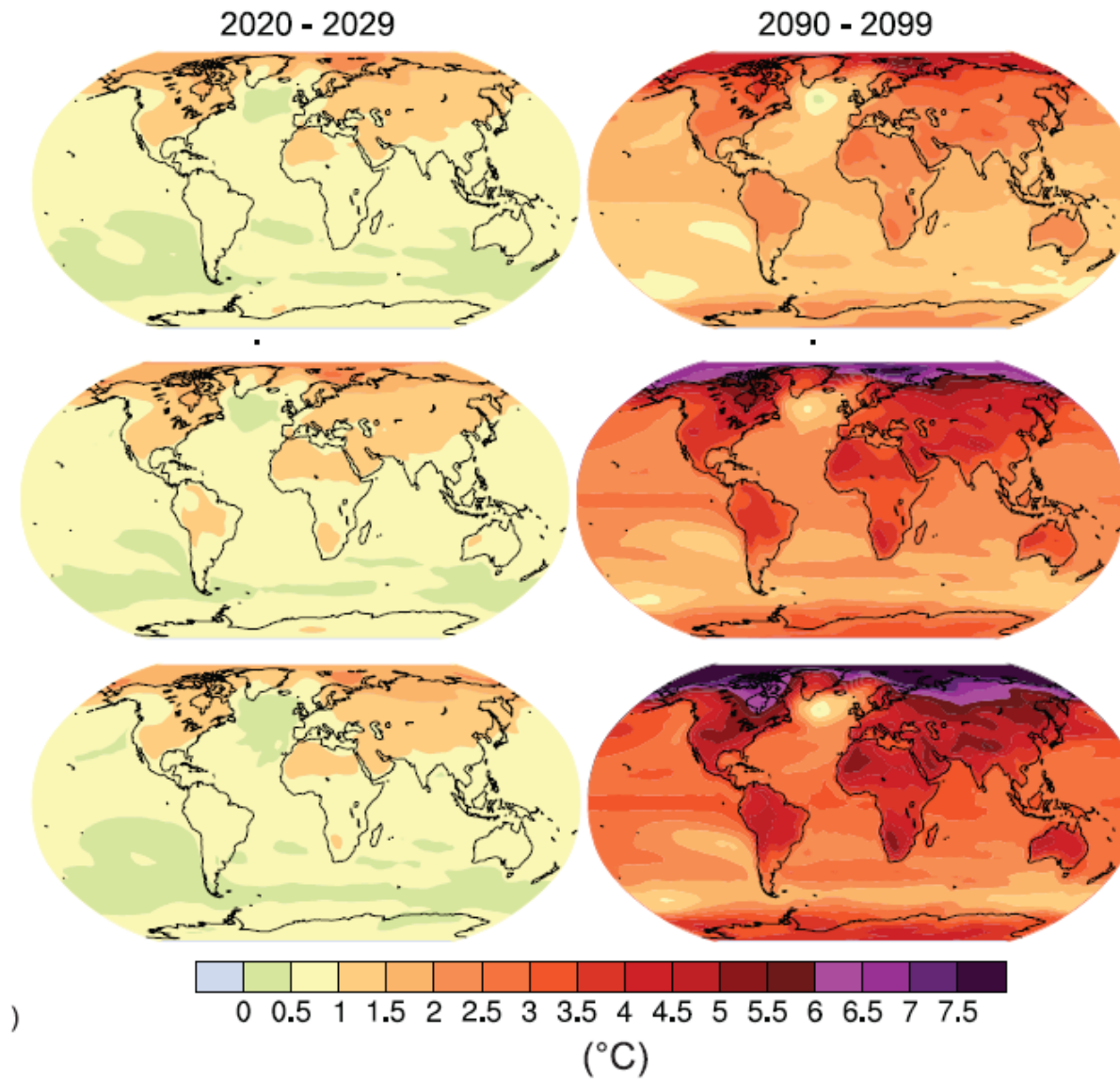
# Global warming – future projections

MULTI-MODEL AVERAGES AND ASSESSED RANGES FOR SURFACE WARMING





# Global warming – temperatures in the late 21st century

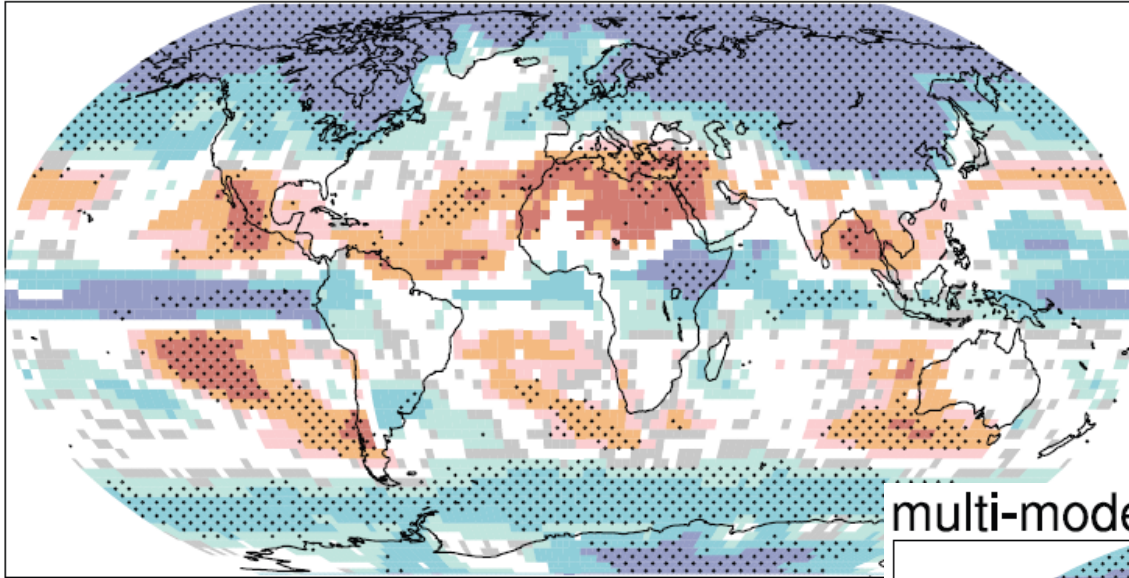


# Global warming – rainfall in the late 21st century

multi-model

A1B

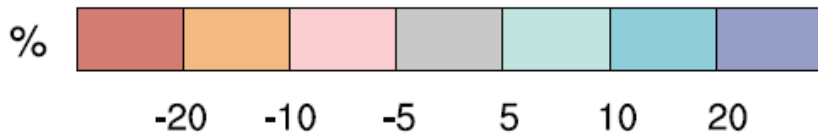
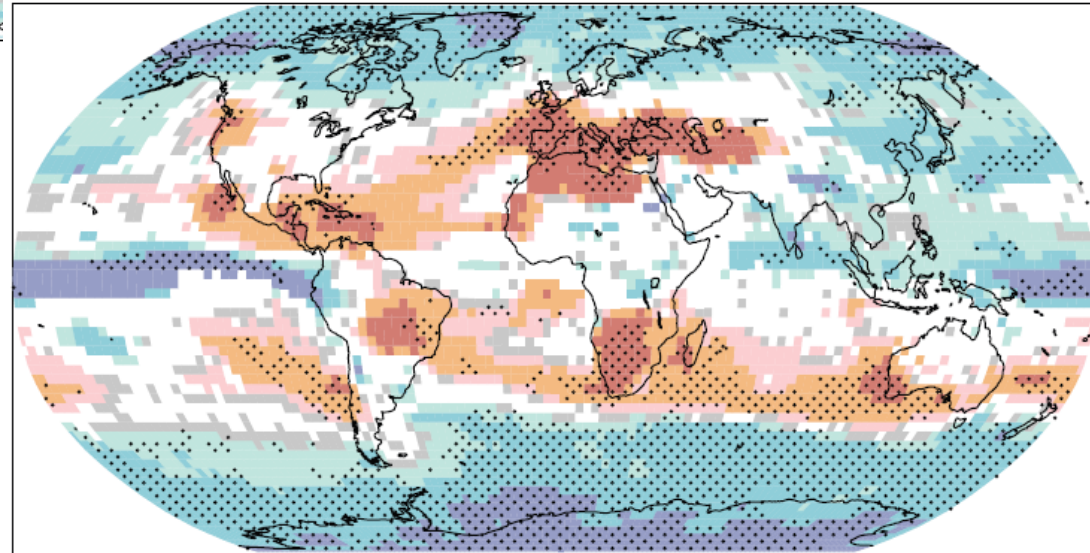
WINTER



multi-model

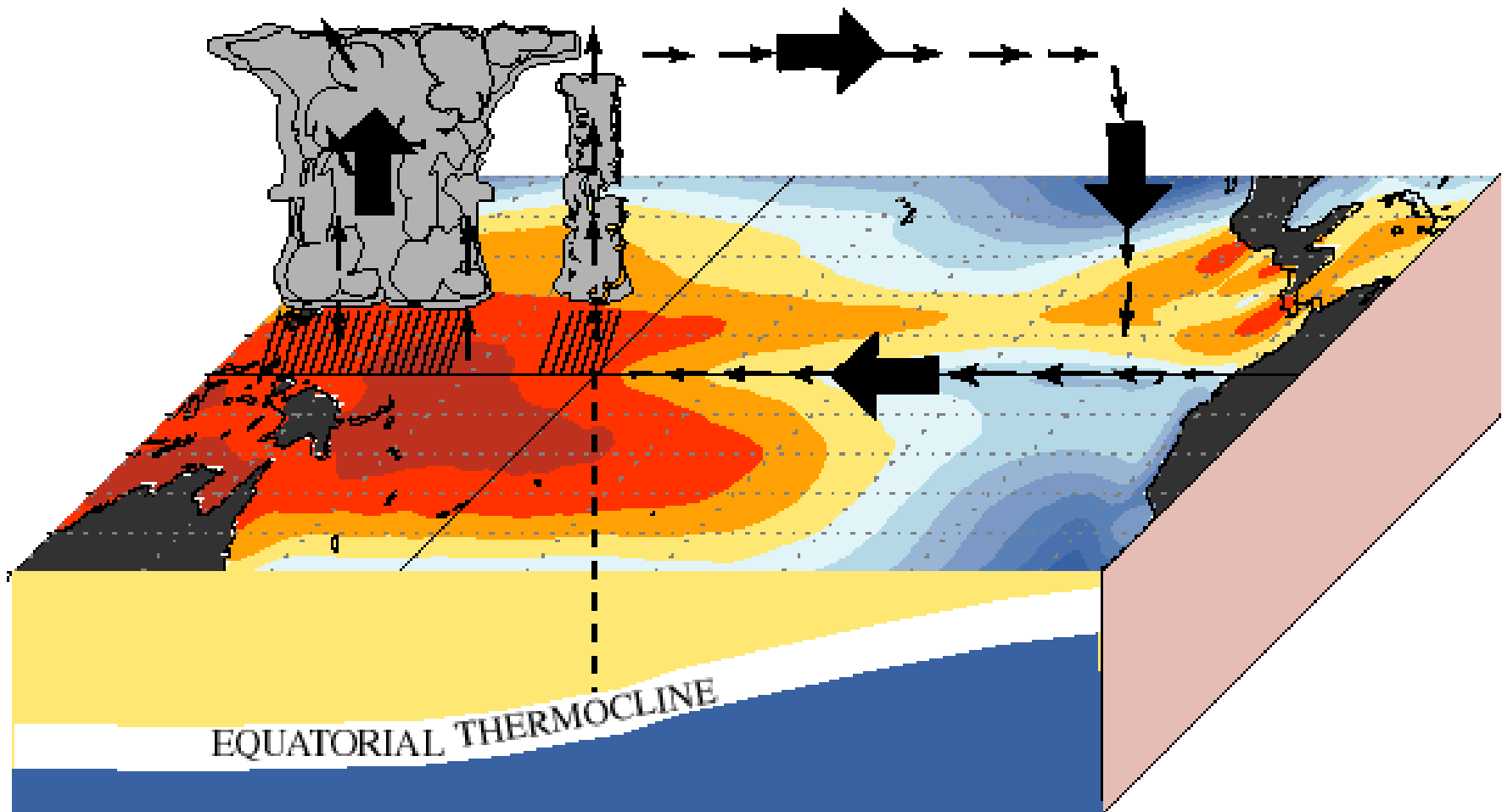
A1B

SUMMER



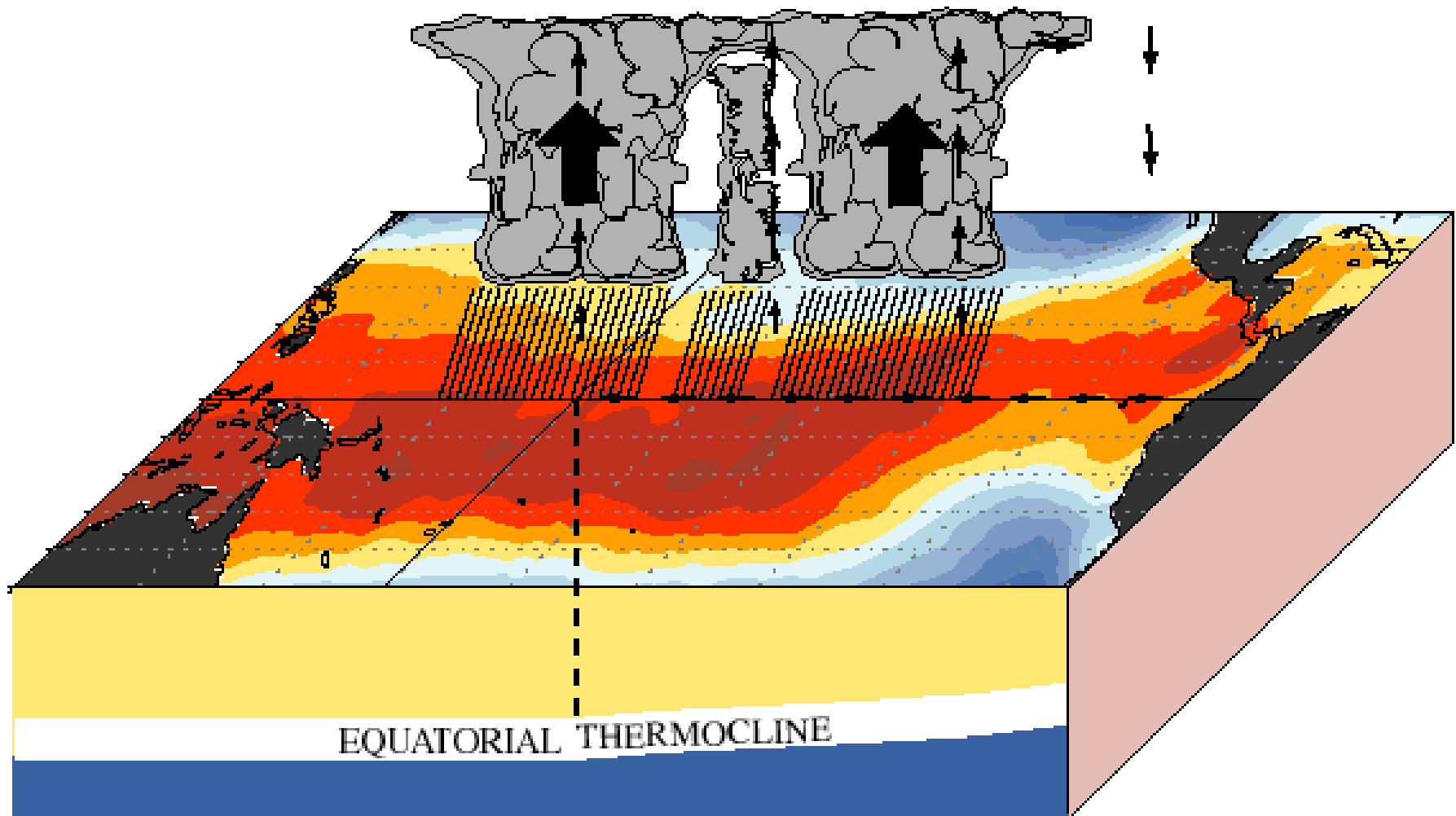
# El Niño/Southern Oscillation (ENSO)

## December - February Normal Conditions



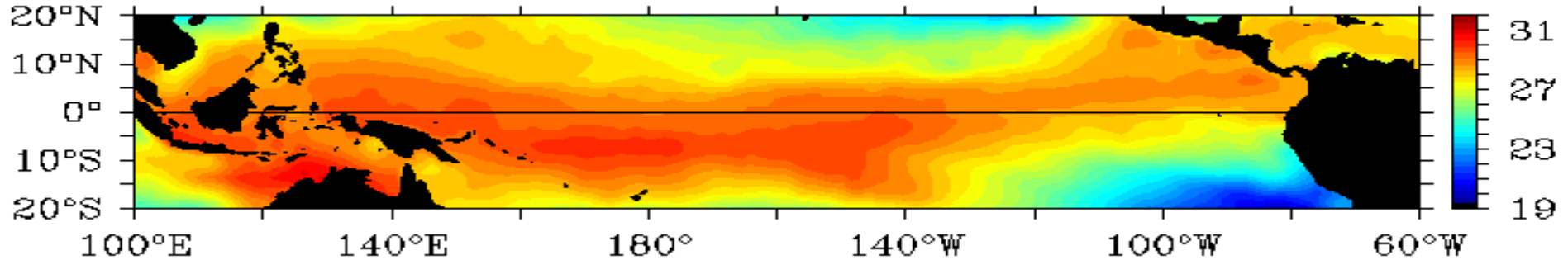
# El Niño/Southern Oscillation (ENSO)

## December - February ENSO Conditions

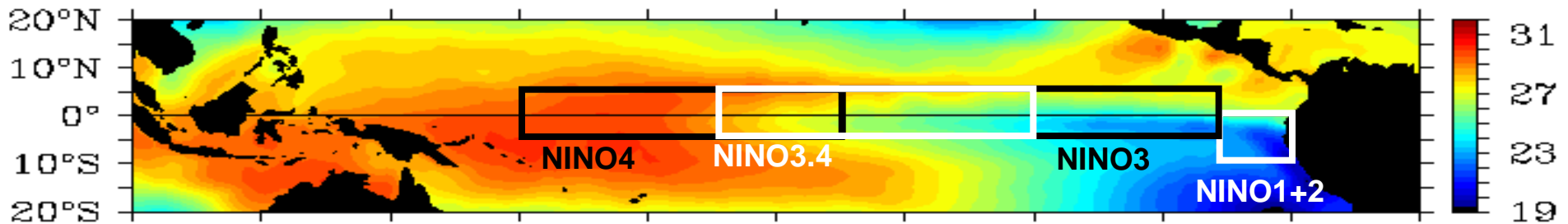


# El Niño/Southern Oscillation (ENSO)

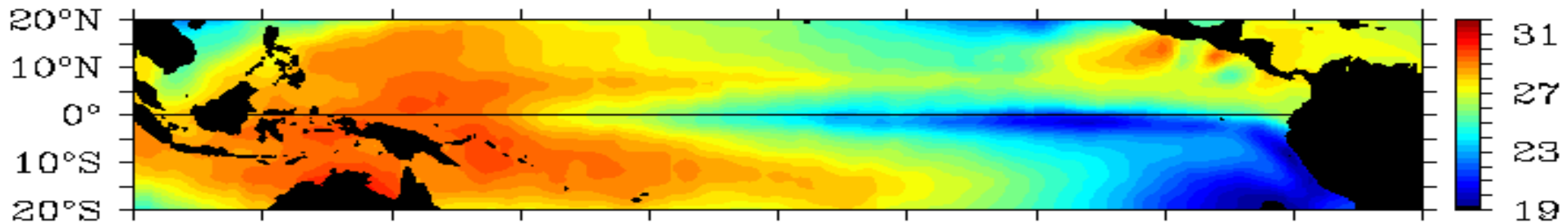
El Niño Conditions December 1997



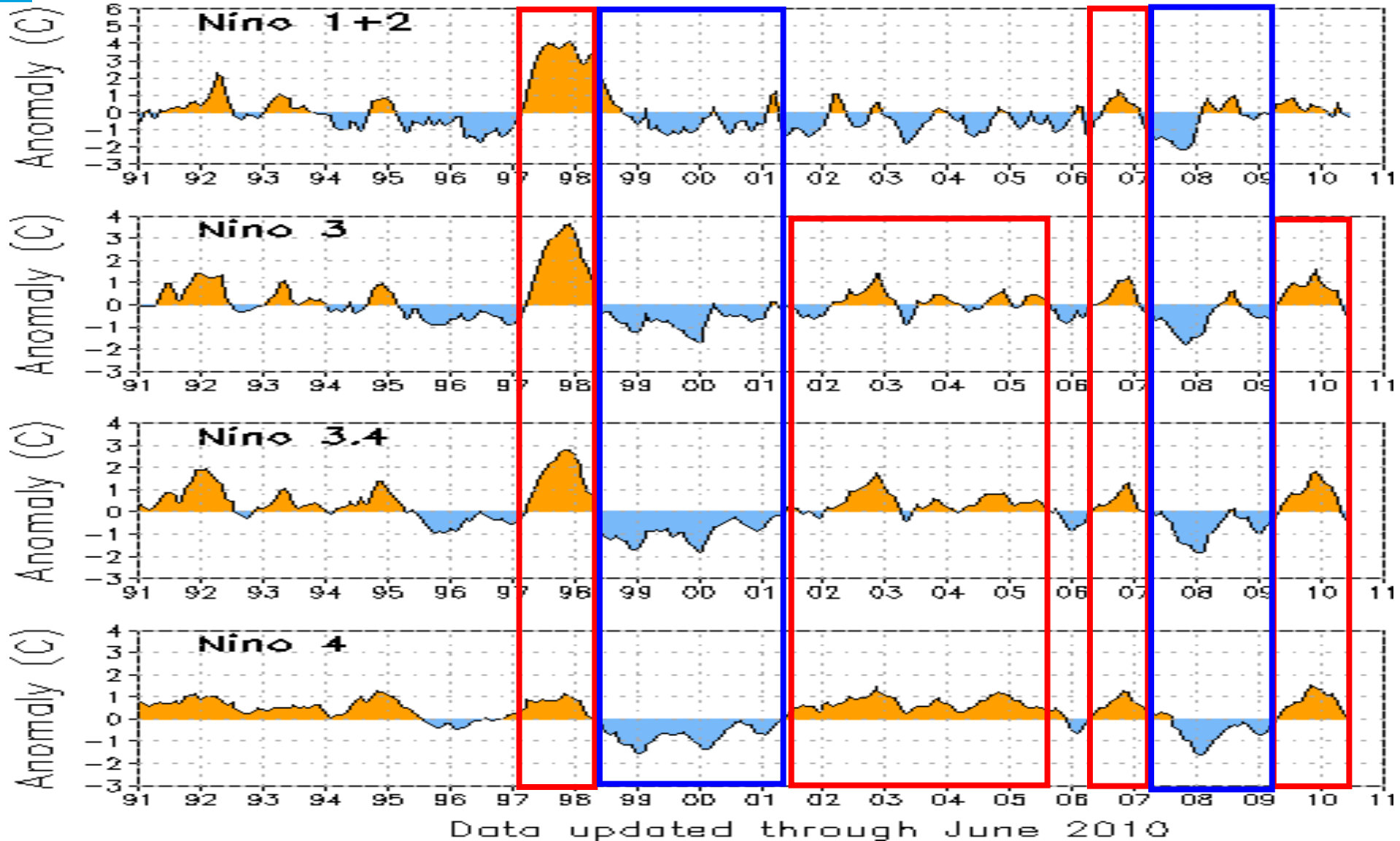
Normal Conditions December 1990



La Nina Conditions December 1988

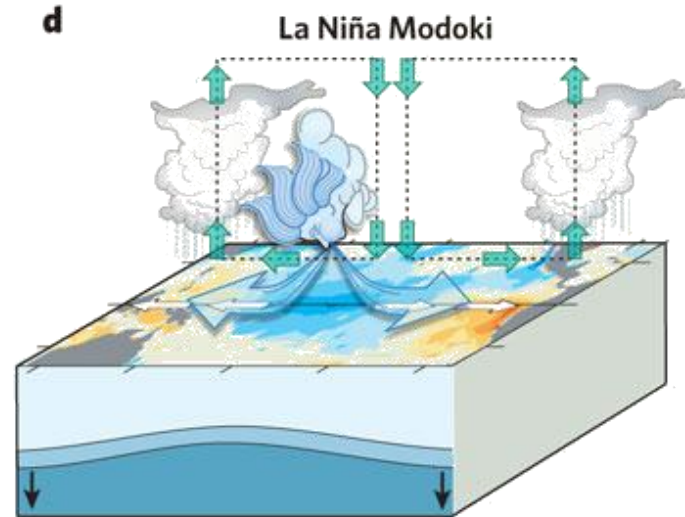
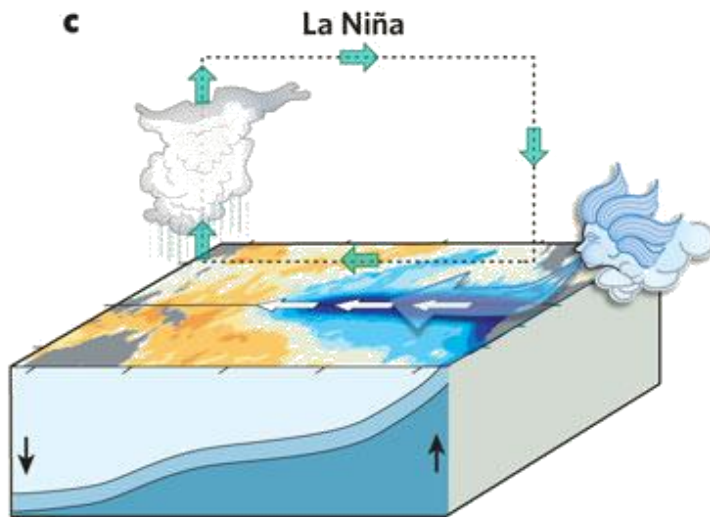
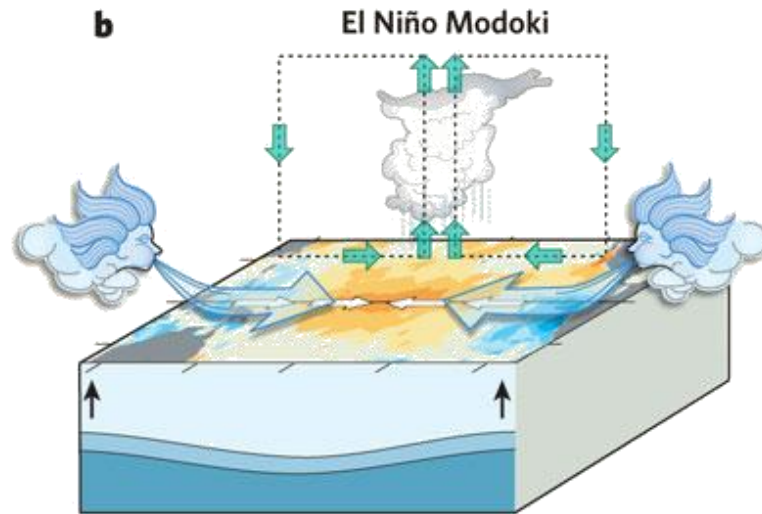
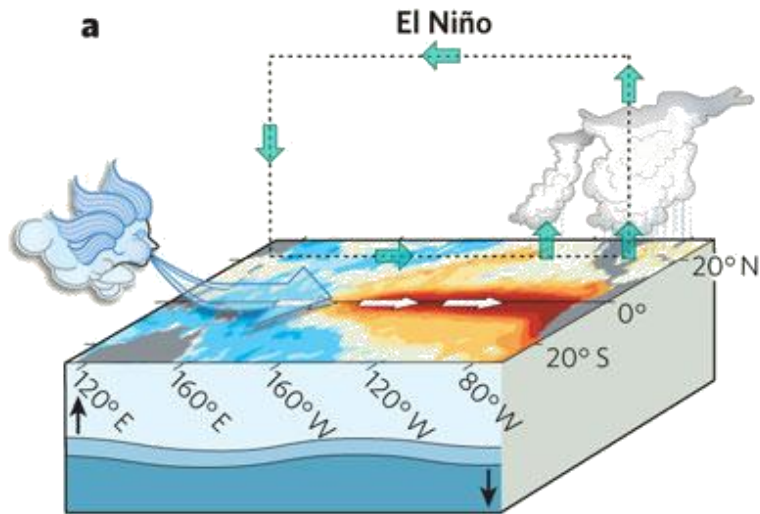


# El Niño/Southern Oscillation (ENSO)



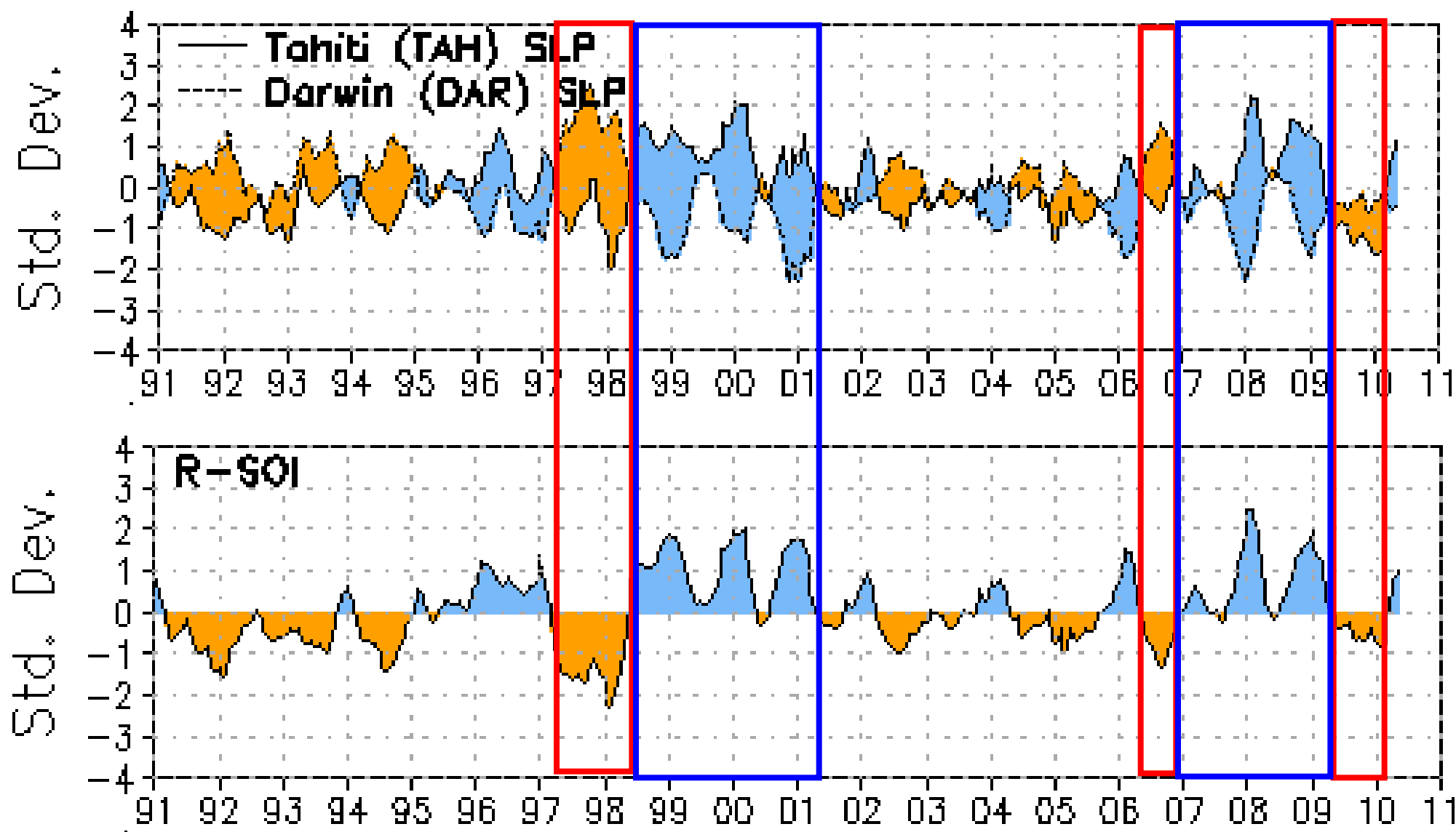


# El Niño Modoki

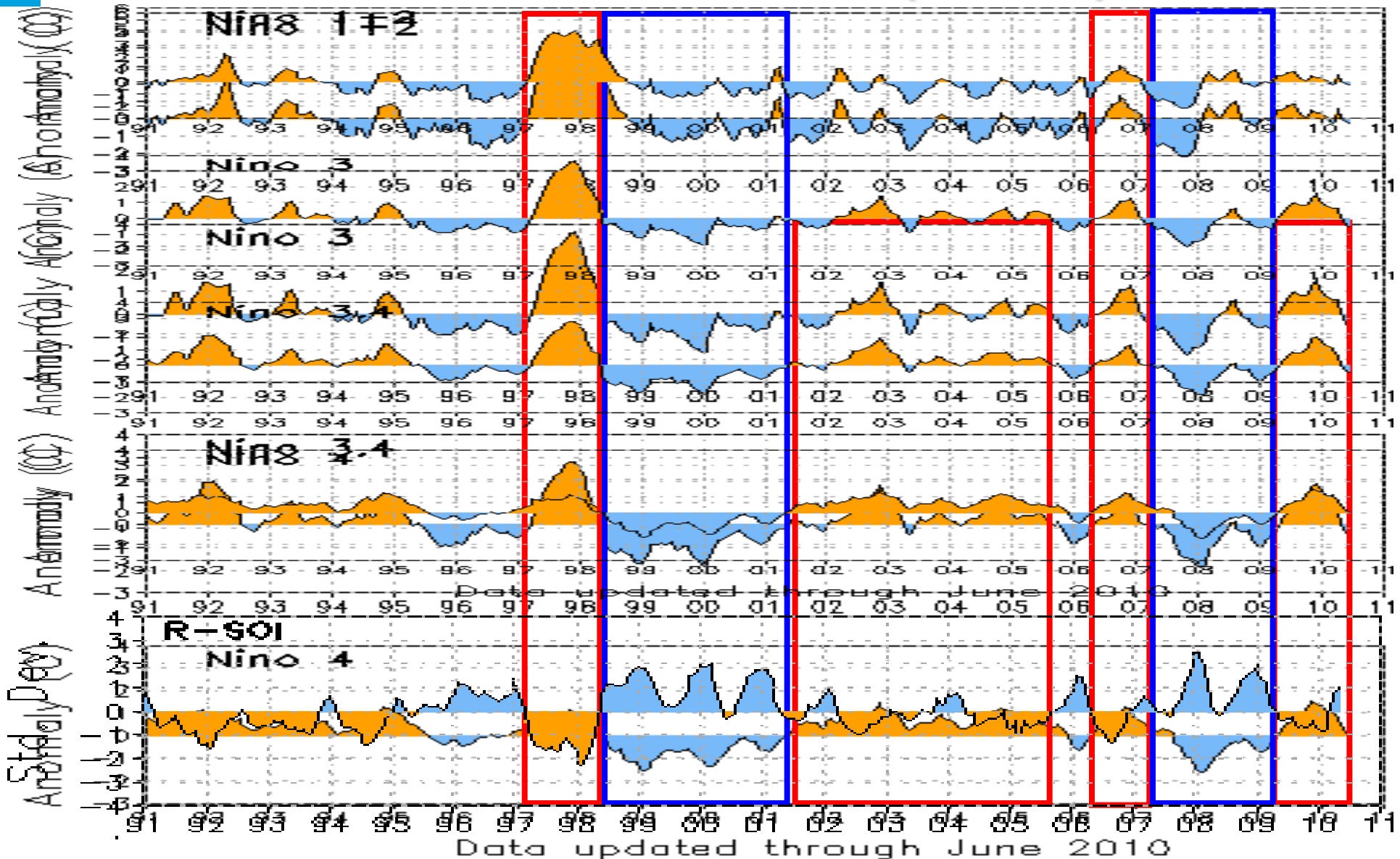




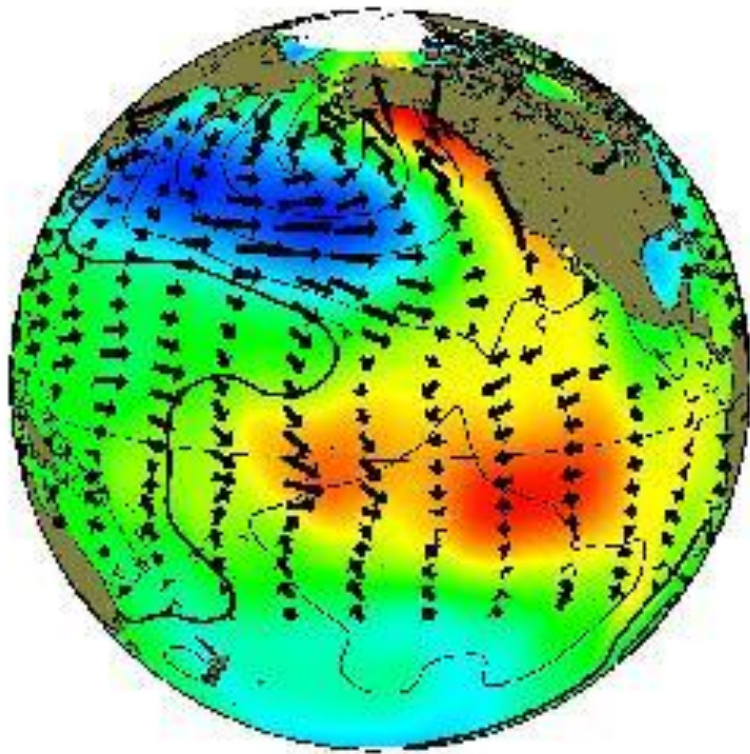
# El Niño – Southern Oscillation



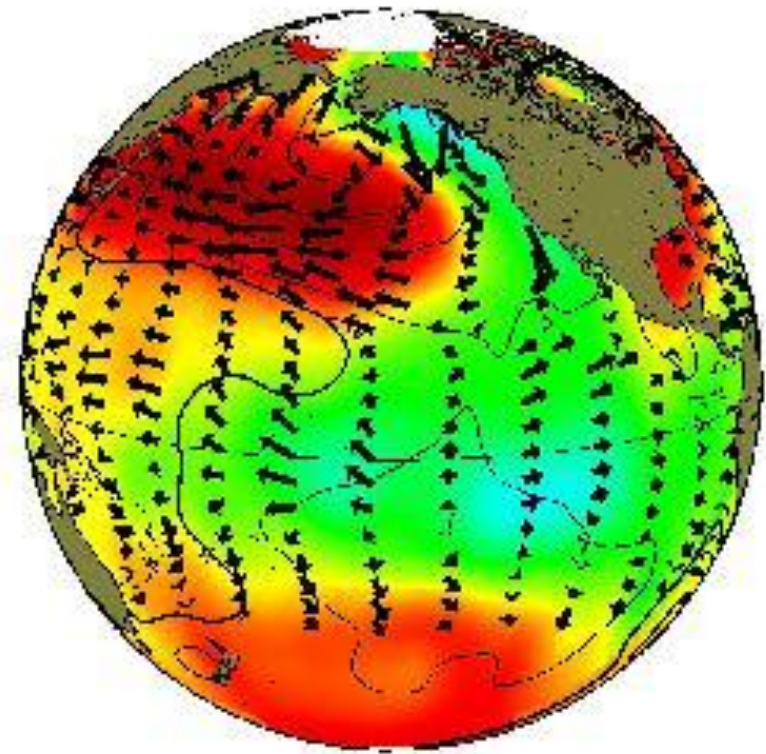
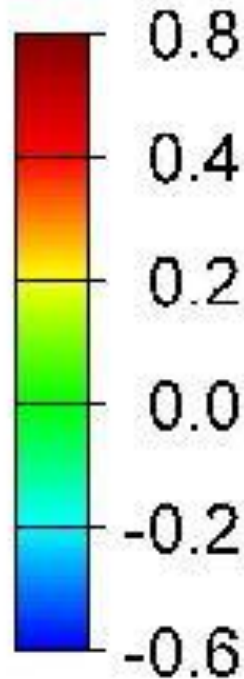
# El Niño/Southern Oscillation (ENSO)



# Pacific Decadal Oscillation



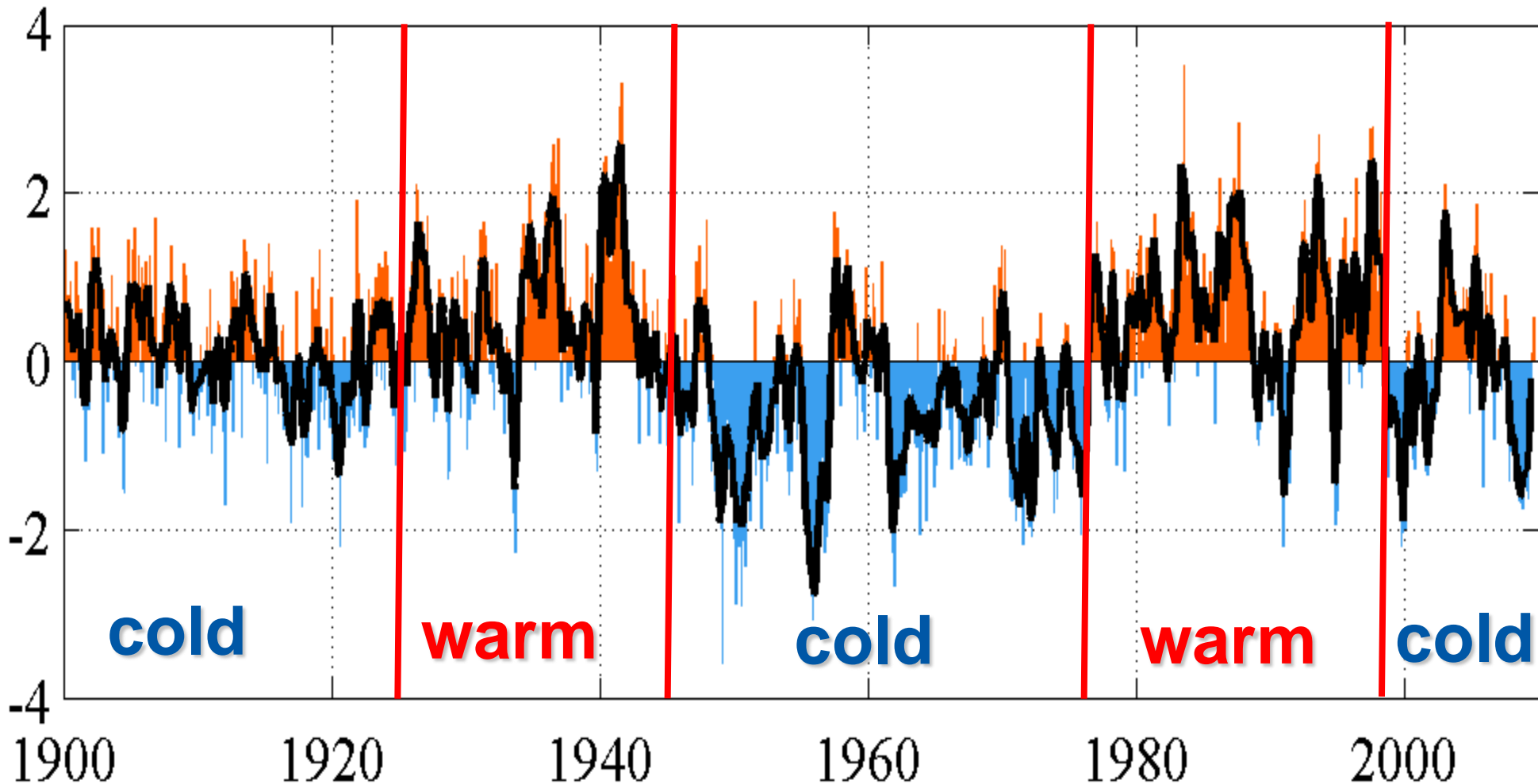
**warm phase**



**cold phase**

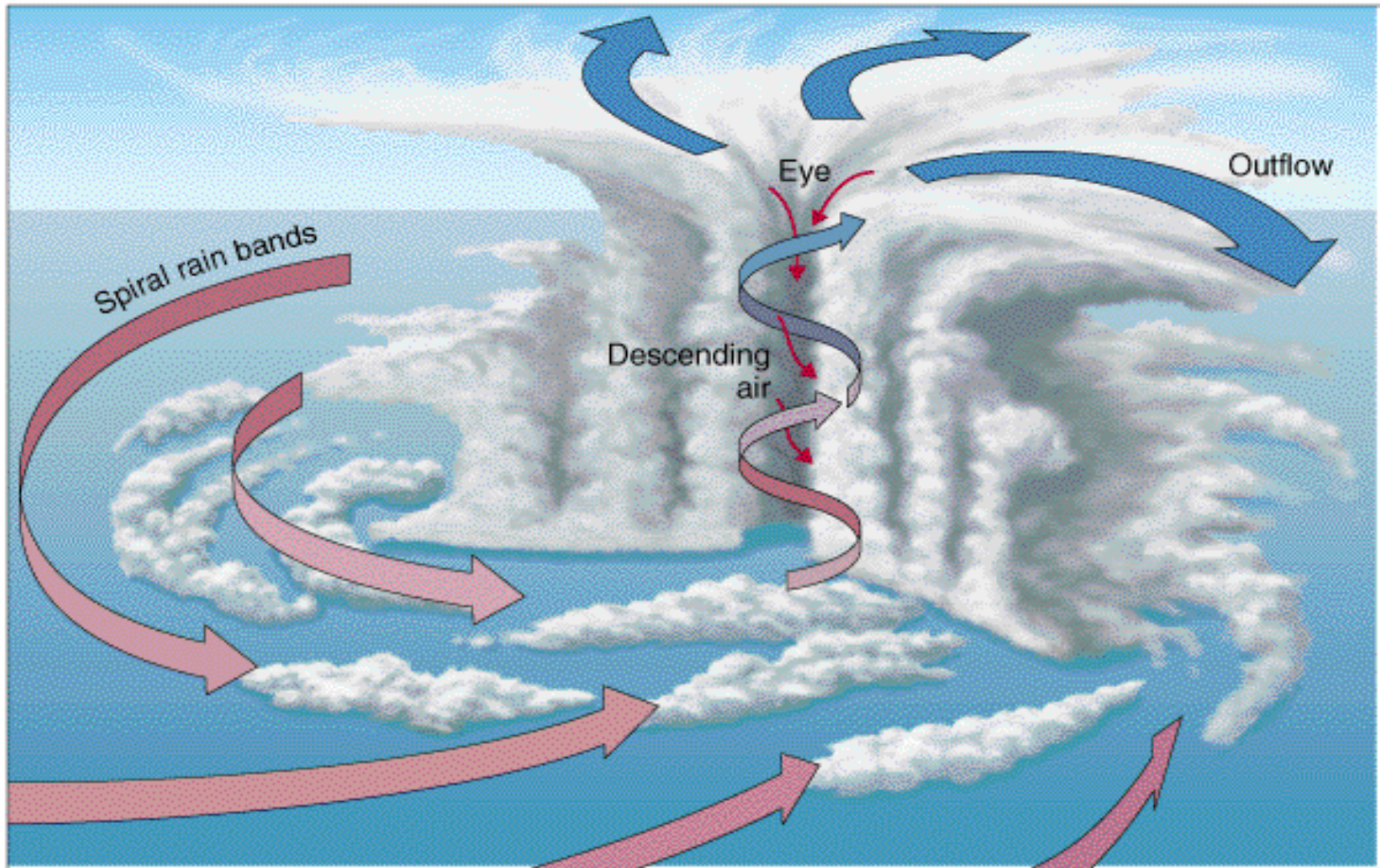
# Pacific Decadal Oscillation – PDO index

monthly values for the PDO index: 1900-September 2009





# Tropical Cyclones – Structure

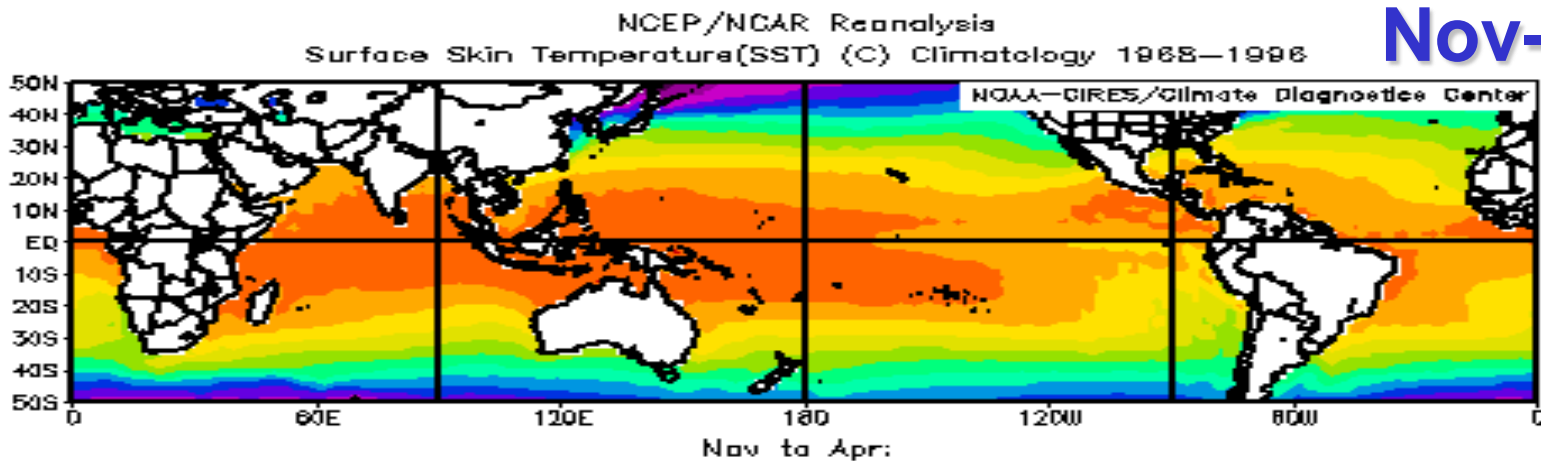
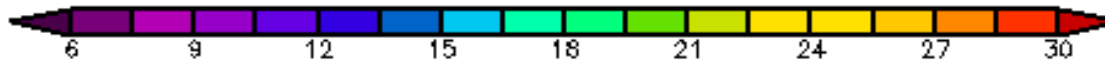
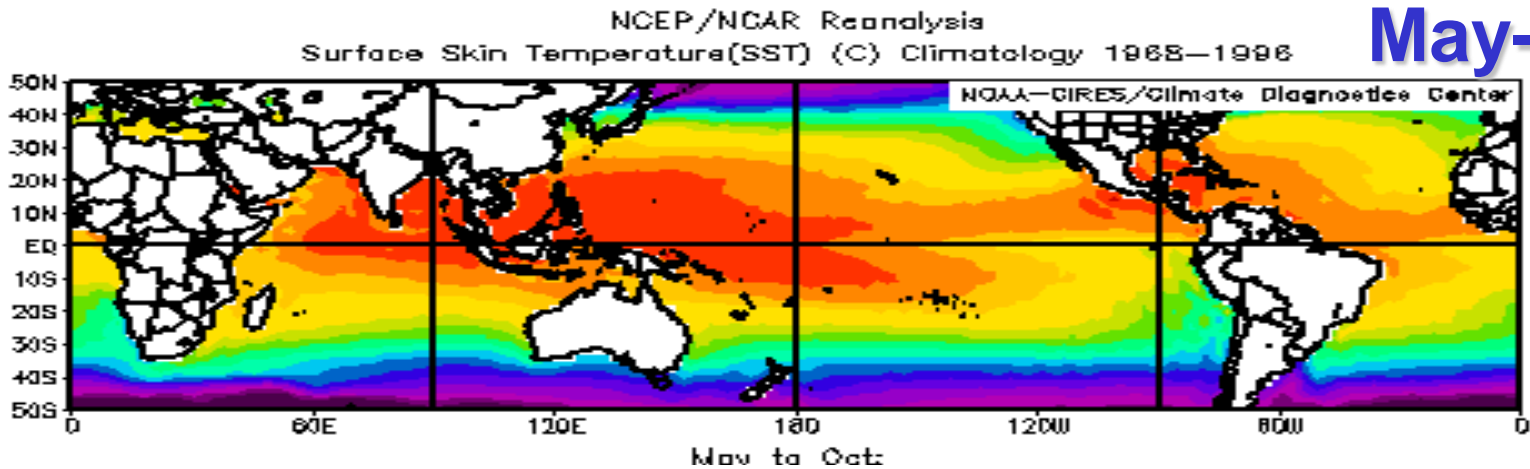


source: Aguado & Burt (1999) *Understanding Weather & Climate*

# Tropical Cyclone formation: Thermodynamic Conditions

1. sea-surface temperature  $> 26.5^{\circ}\text{C}$  - to provide enough moisture and thermal buoyancy for deep convection to occur
2. conditionally unstable atmosphere - to allow moist air to rise through a deep layer of the atmosphere
3. moist lower to mid troposphere - so that the condensed water will not evaporate and will continue its ascent

# Tropical Cyclone formation: Ocean surface temperature

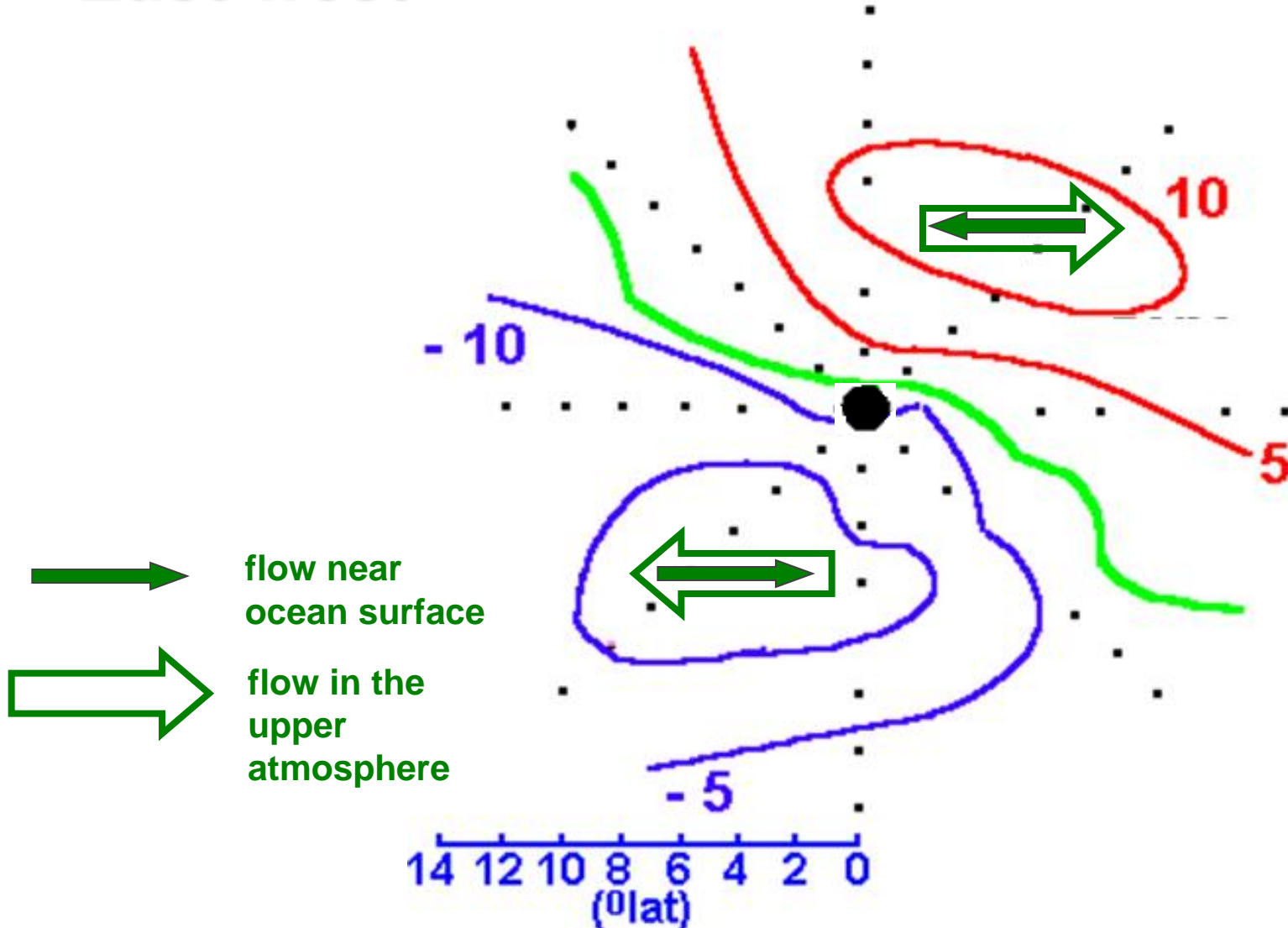




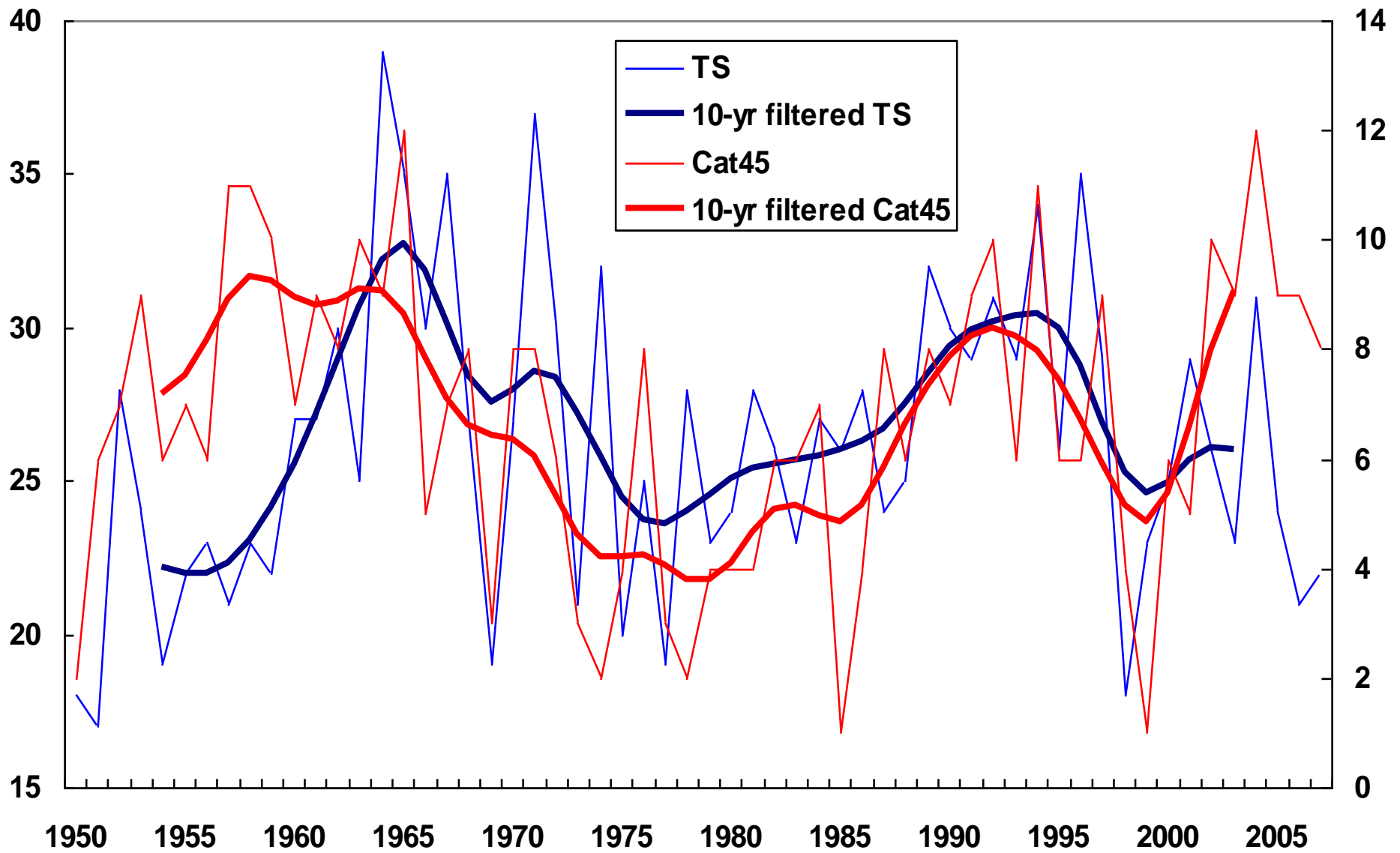
# Tropical Cyclone formation: Dynamic Conditions

1. *strong anticlockwise rotation near the ocean surface and clockwise rotation in the higher atmosphere* - to provide the necessary rotation in the low levels and allow outflow in the upper levels
2. *small vertical wind shear near the centre of the disturbance* - so that the convection will not be sheared off

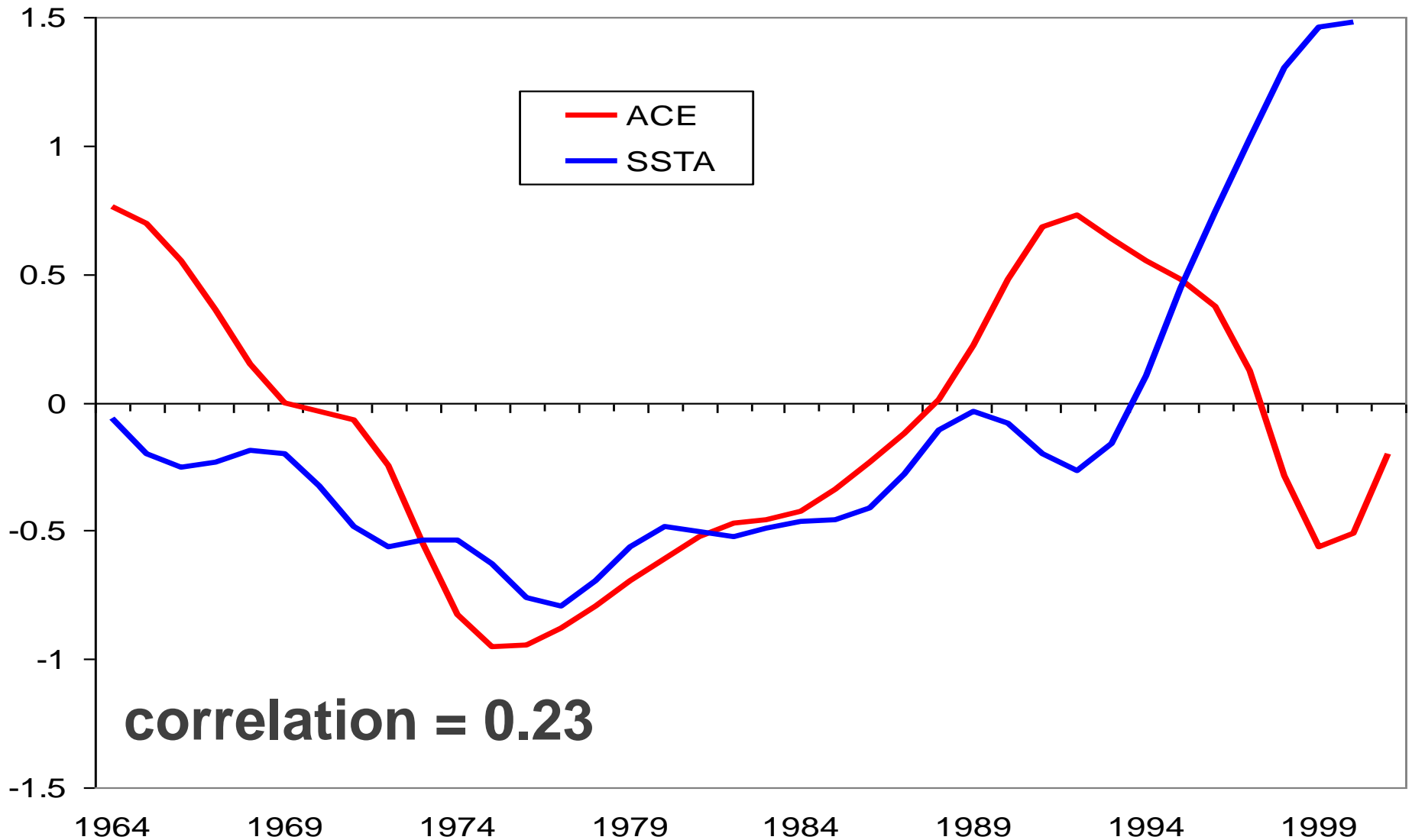
# Tropical Cyclone formation: East-west Winds and Shear



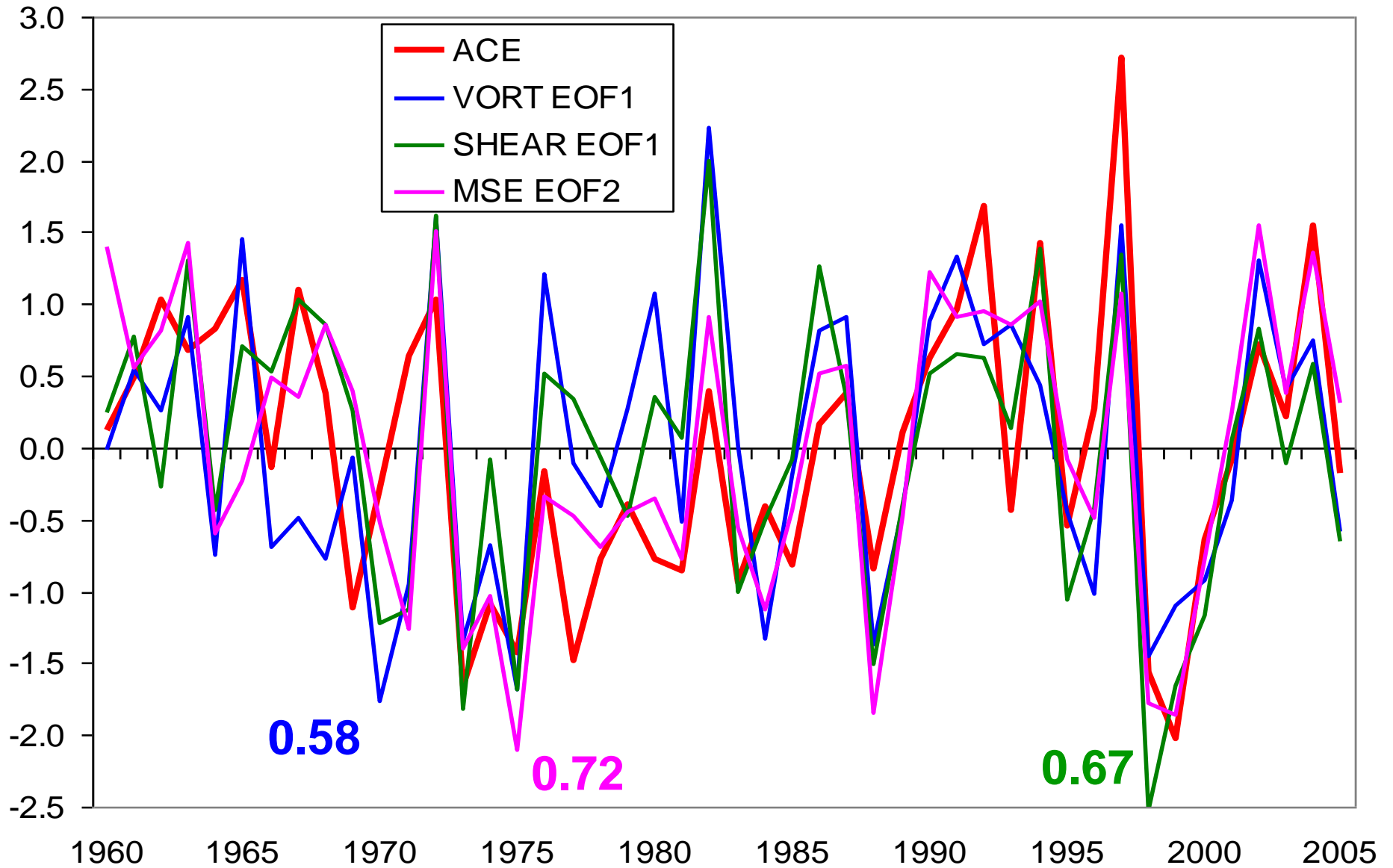
# Annual Number of TCs and intense TCs in WNP



# ACE vs. May-Nov SSTA (5-30°N, 120-180°E)



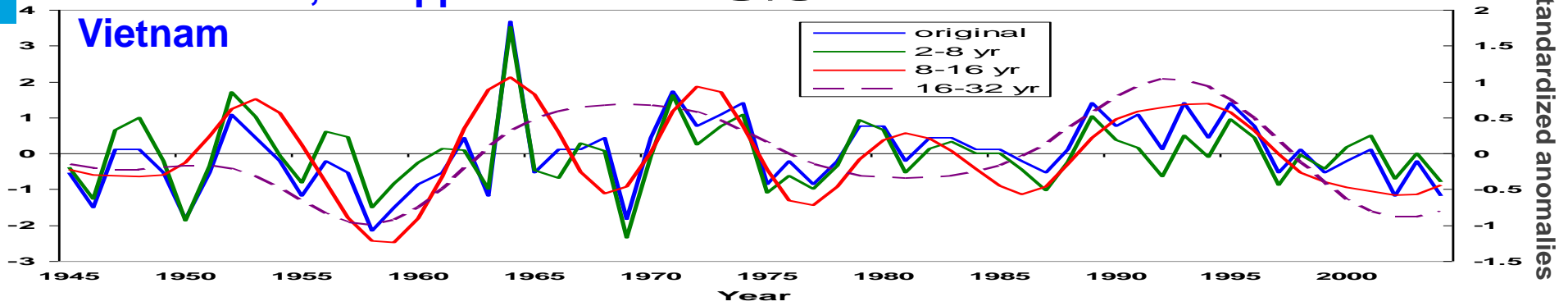
# ACE vs. VORT, SHEAR and MSE



# Variations of Landfall in Each Area at Various Oscillation Periods

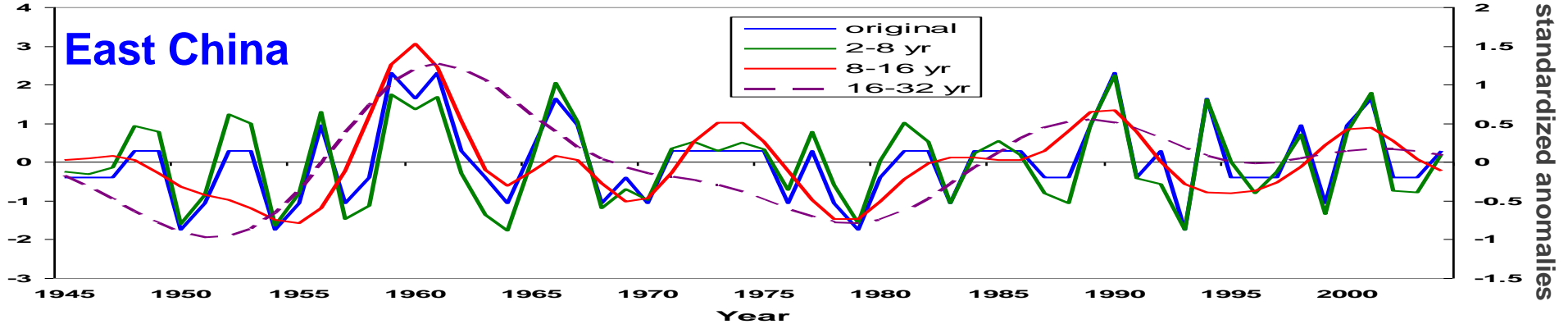
## South China, Philippines and Vietnam

STC



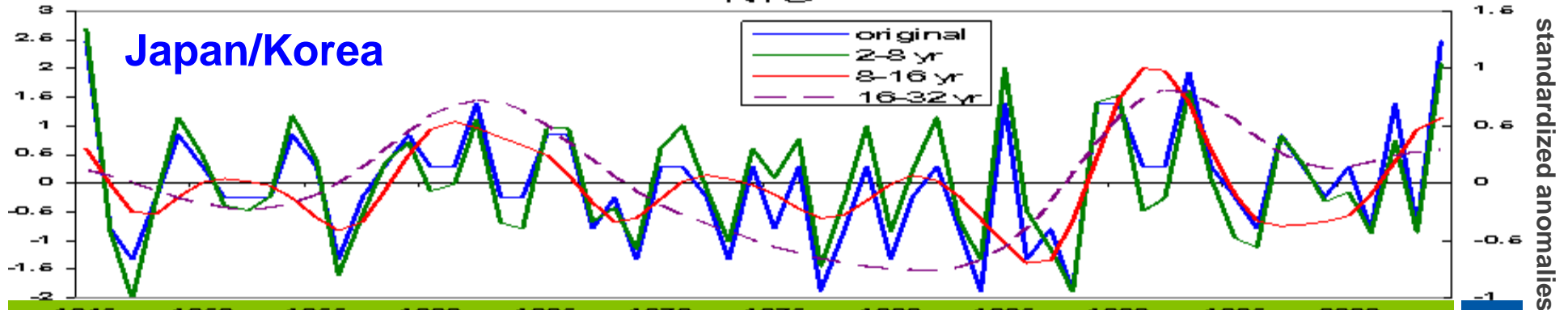
## East China

MTC



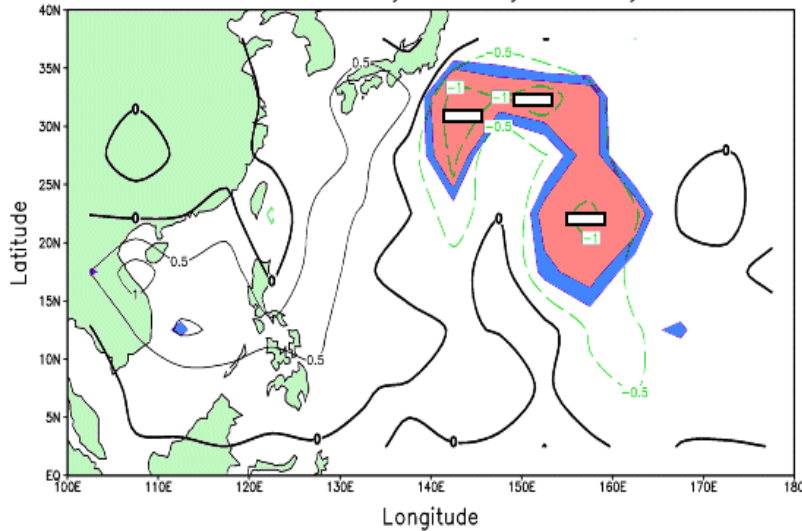
## Japan/Korea

NTC



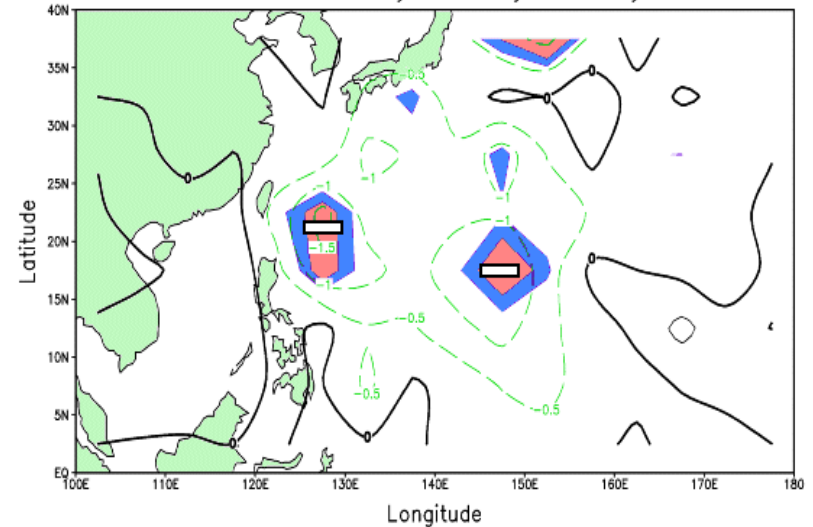
# El Niño effects on tropical cyclone activity

Annual TC activity anomaly, EN-1 year



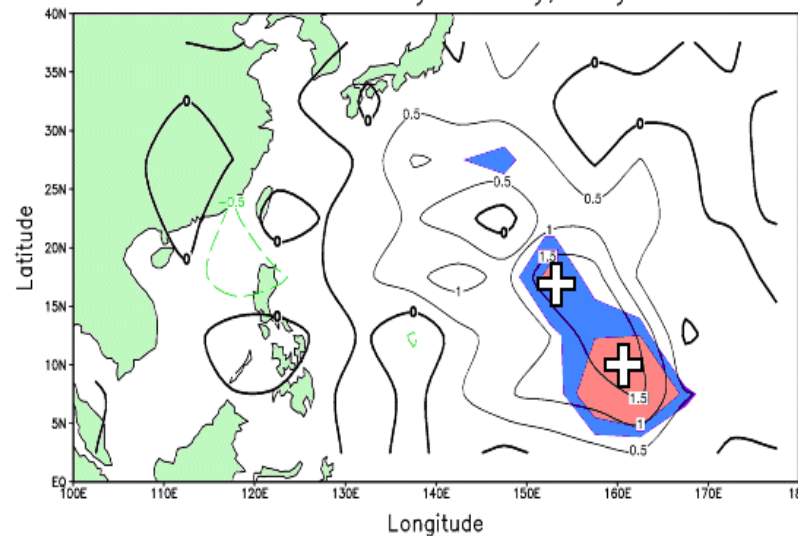
**Year before  
El Niño**

Annual TC activity anomaly, EN+1 year



**Year after  
El Niño**

Annual TC activity anomaly, EN year

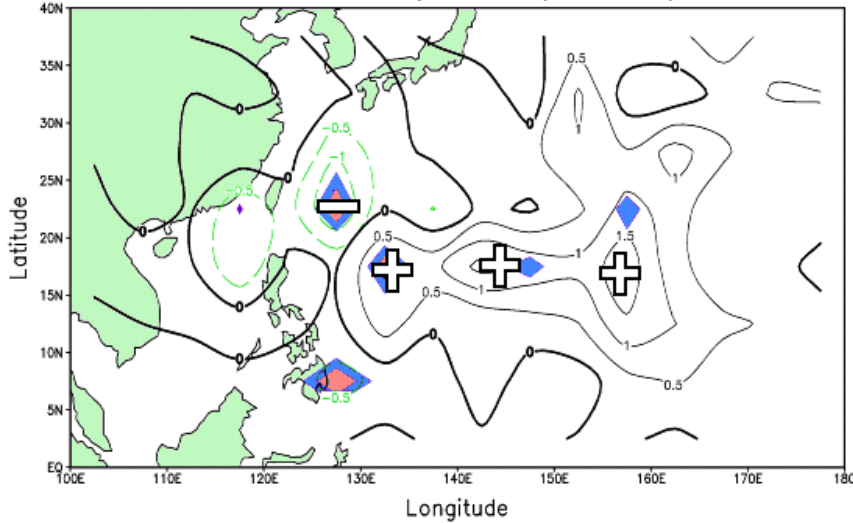


**El Niño Year**

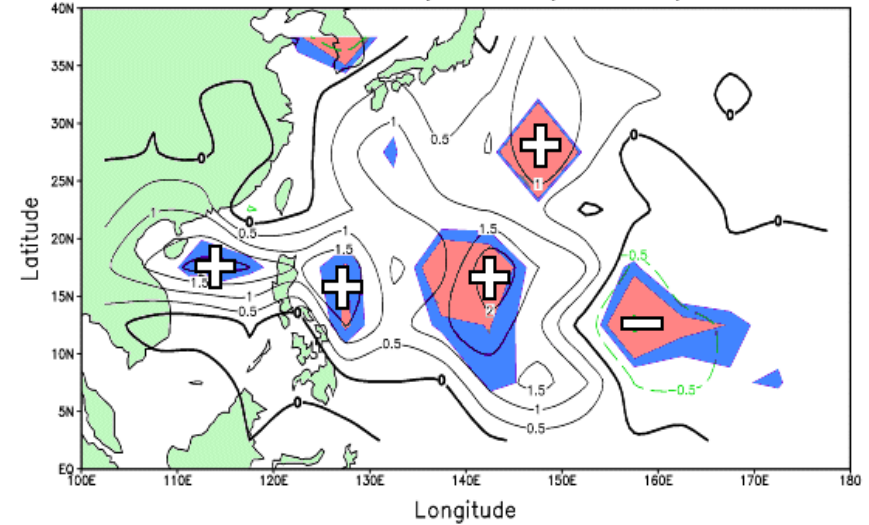


# La Niña effects on tropical cyclone activity

Annual TC activity anomaly, LN-1 year



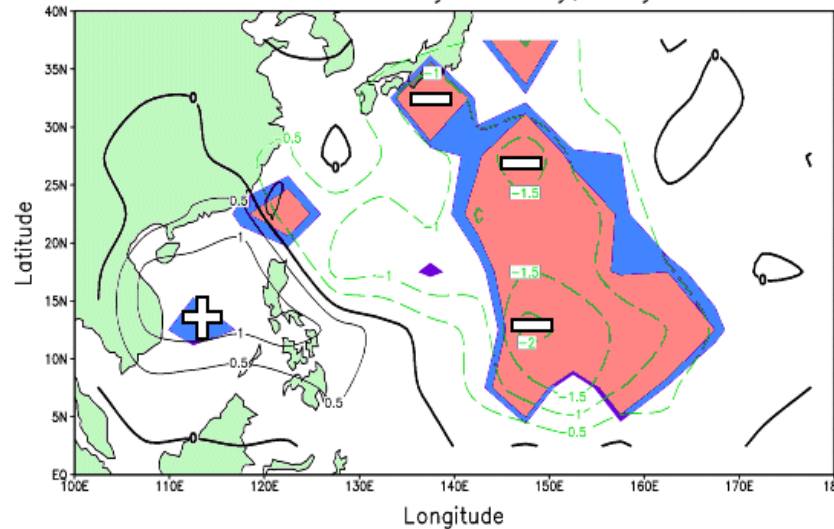
Annual TC activity anomaly, LN+1 year



Year before  
La Niña

Year after  
La Niña

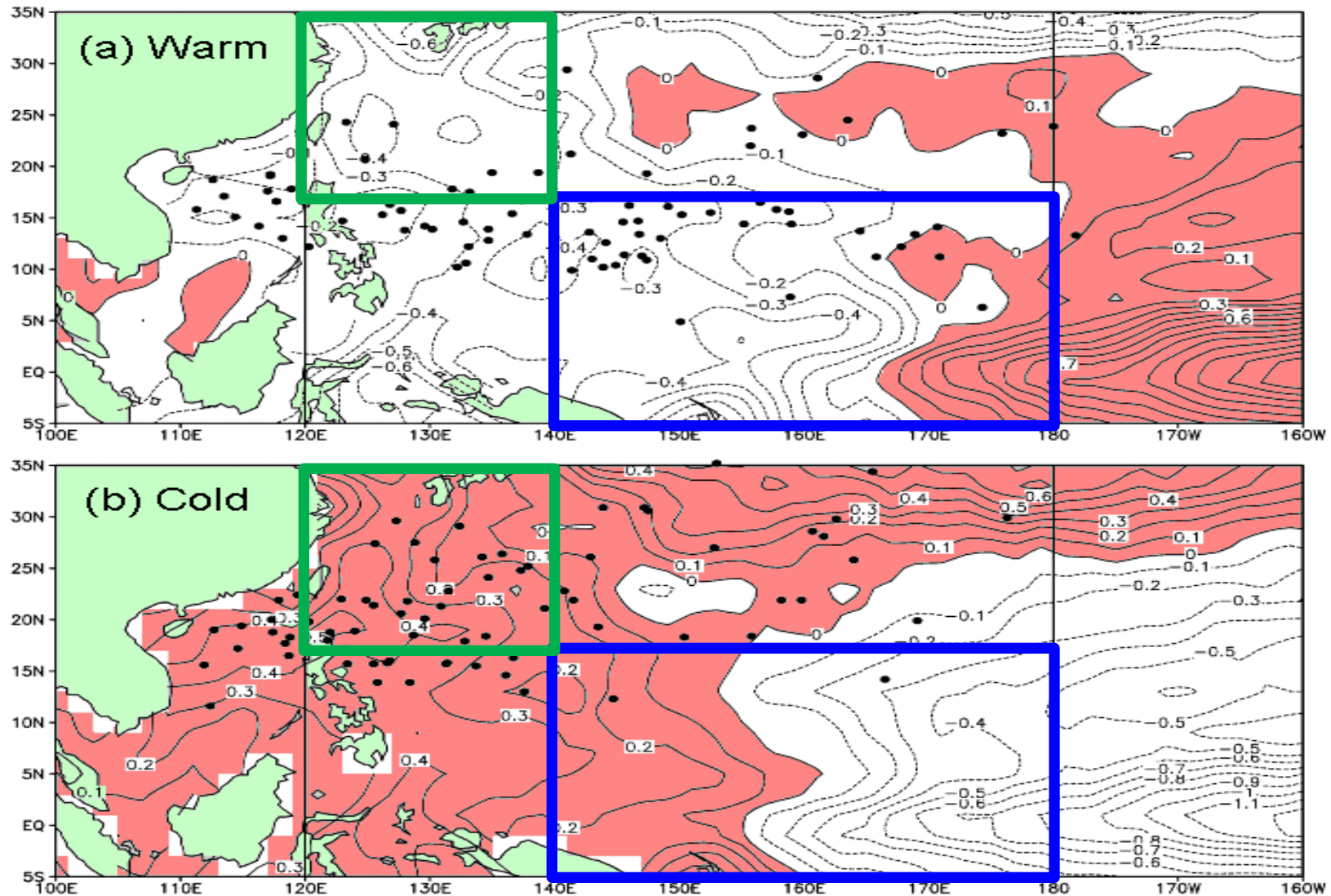
Annual TC activity anomaly, LN year



La Niña Year

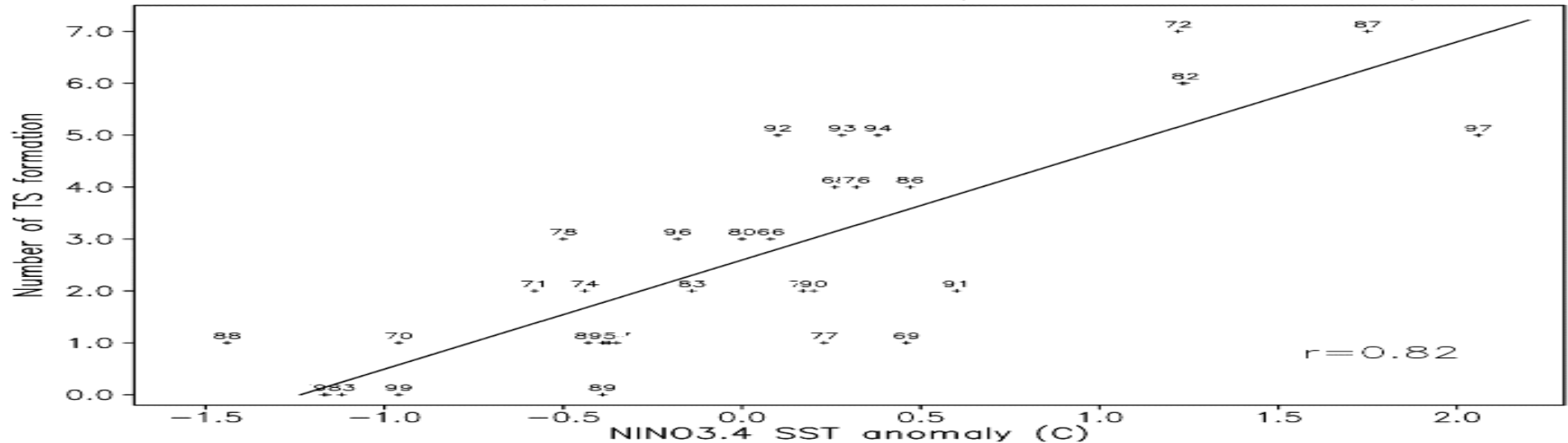
# El Niño effects on tropical cyclone activity

Locations of TS formation and SST anomalies in Jul - Sep

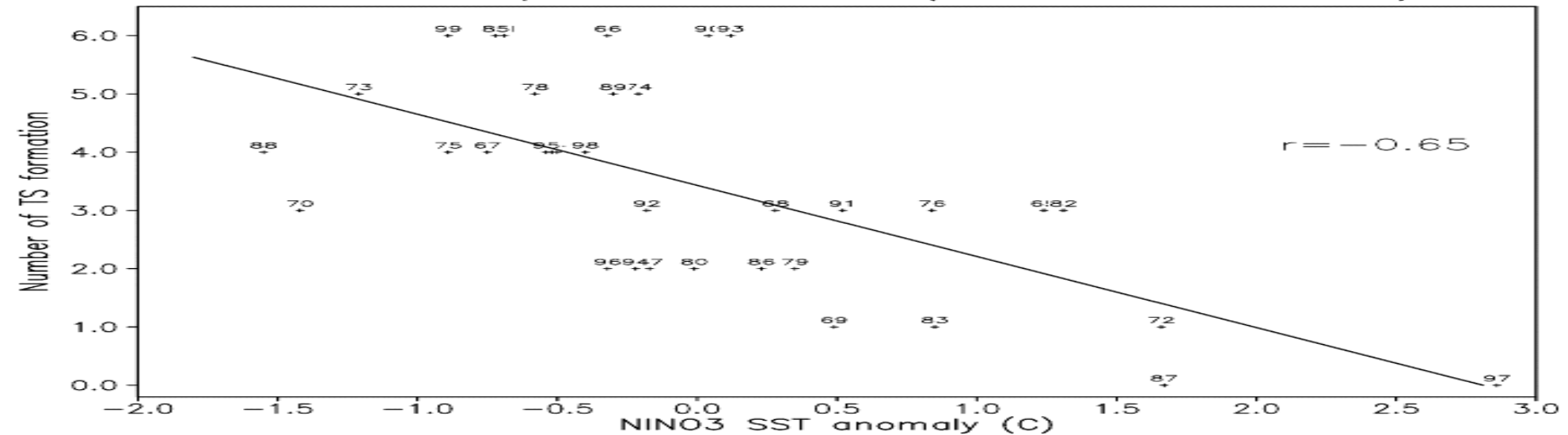


# El Niño effects on tropical cyclone activity

Southeast quadrant of WNP (5–17N, 140–180E)

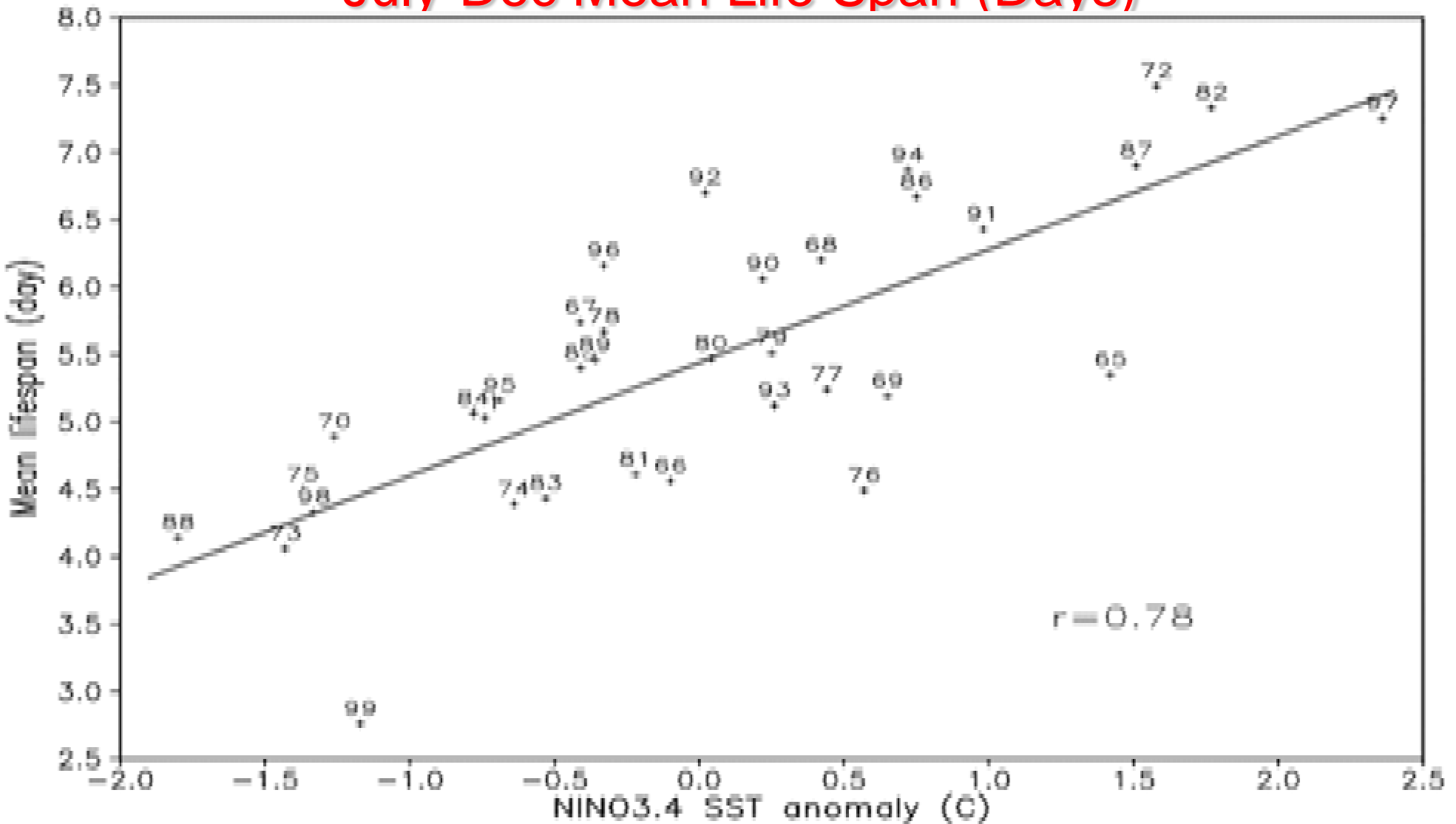


Northwest quadrant of WNP (17–30N, 120–140E)

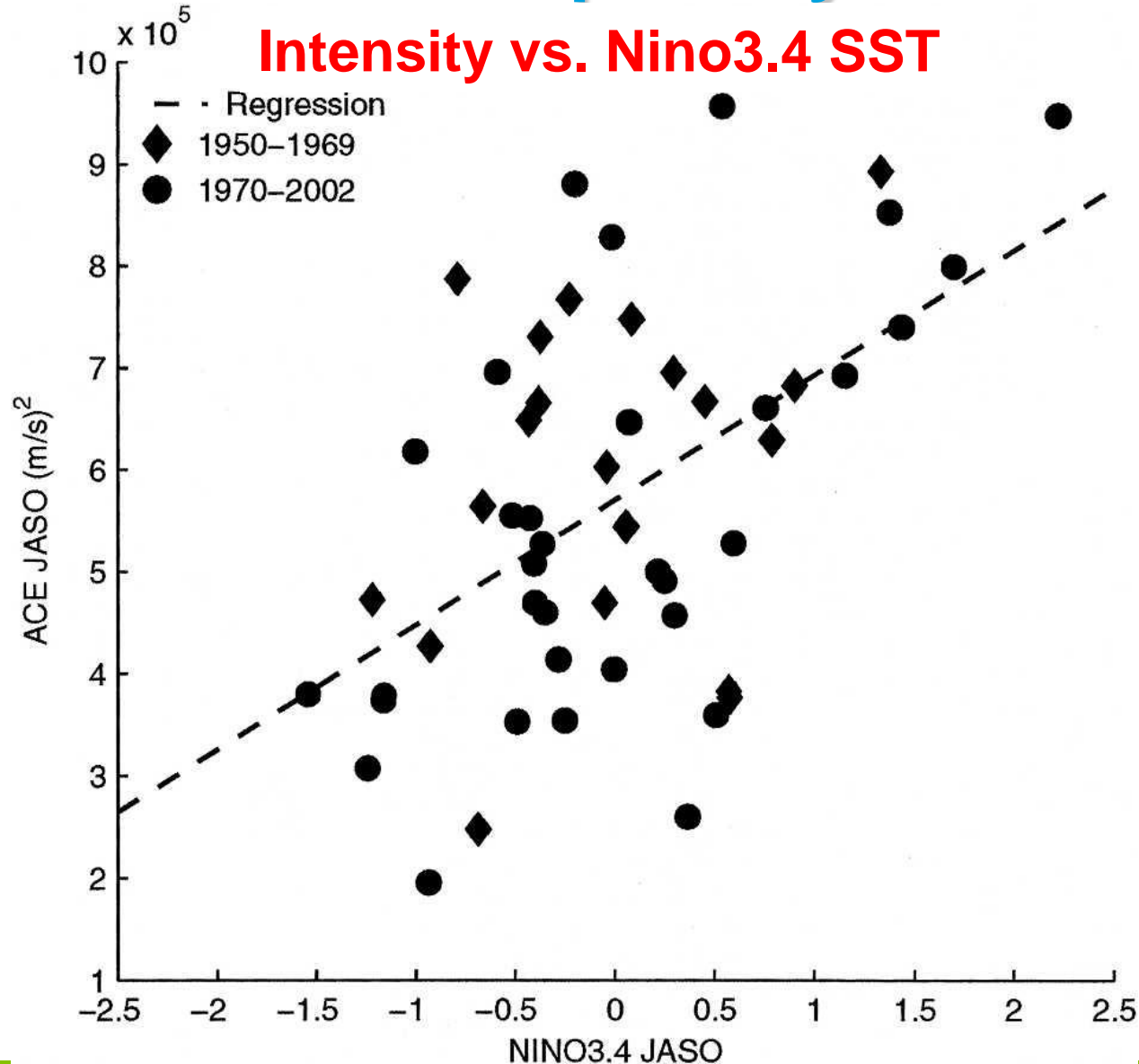


# El Niño effects on tropical cyclone activity

## July-Dec Mean Life Span (Days)

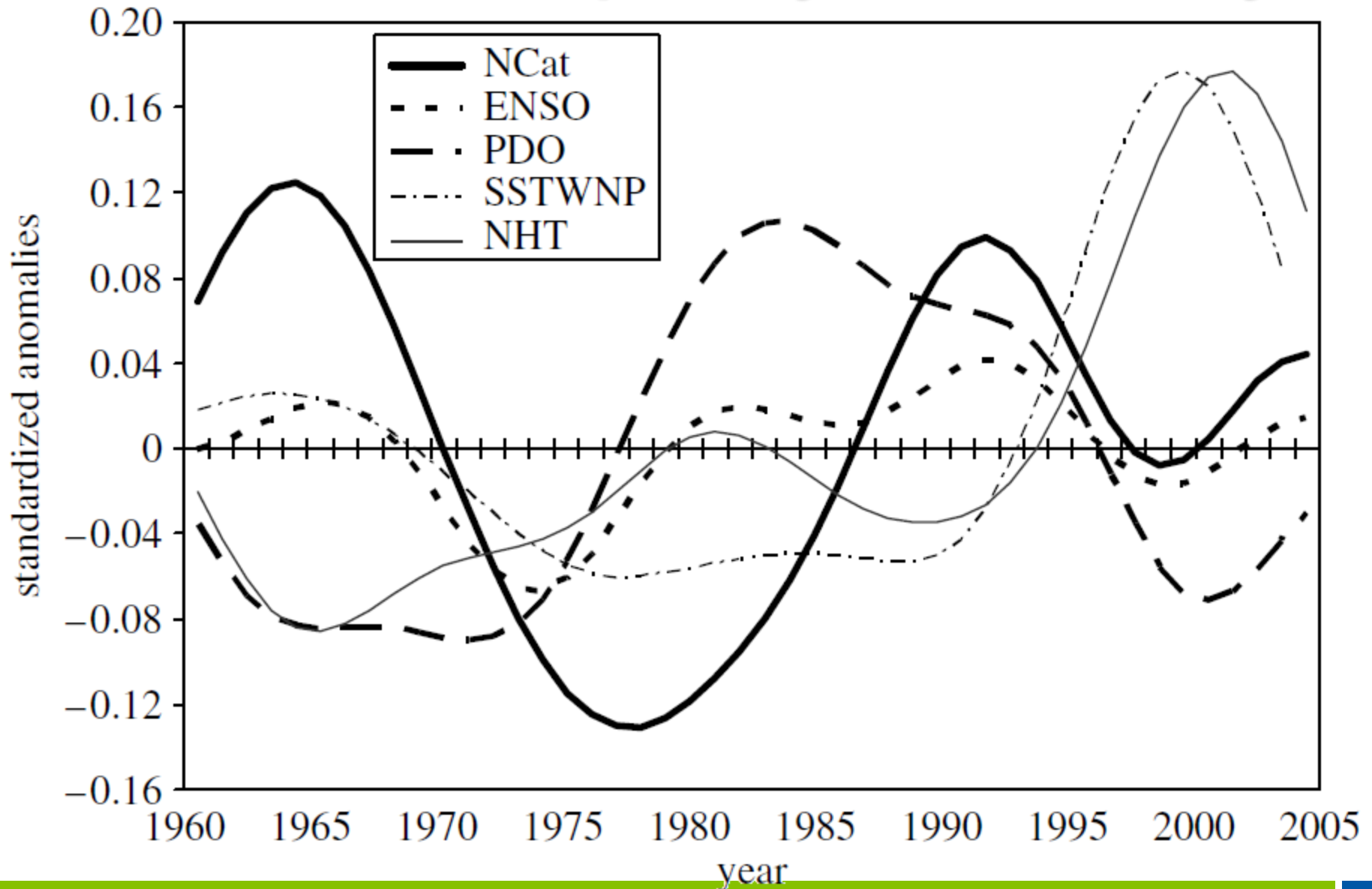


# El Niño effects on tropical cyclone intensity





# PDO effects on tropical cyclone intensity





# Summary

- **Global warming does not cause changes in typhoon activity (frequency of occurrence, intensity, landfall locations) in Asia.**
- **El Niño has a significant effect on typhoon activity through modifications of the atmospheric flow patterns that subsequently lead to changes in location of formation, and hence frequency of occurrence, intensity and locations of landfall.**

# Summary

- **Effects of the Pacific Decadal Oscillation apparently either collaborates with or modifies those of El Niño on a decadal or longer time scales. However, more research is necessary.**

# Conclusion and take-home message

- **In assessing typhoon risk on an annual time scale, the most important factor is El Niño. Better predictions of typhoon activity come from better predictions of the occurrence of El Niño.**
- **On longer time scales such as decades, other climate oscillations such as the Pacific Decadal Oscillation need to be considered. More research is necessary.**

# Conclusion and take-home message

- **The effect of global warming on typhoon activity is not obvious unless it can be shown that global warming will lead to changes in the frequency of occurrence of El Niño or other climate oscillations. The simple idea of an increase in ocean temperature due to global warming will enhance typhoon activity is incorrect.**