Climate Variability

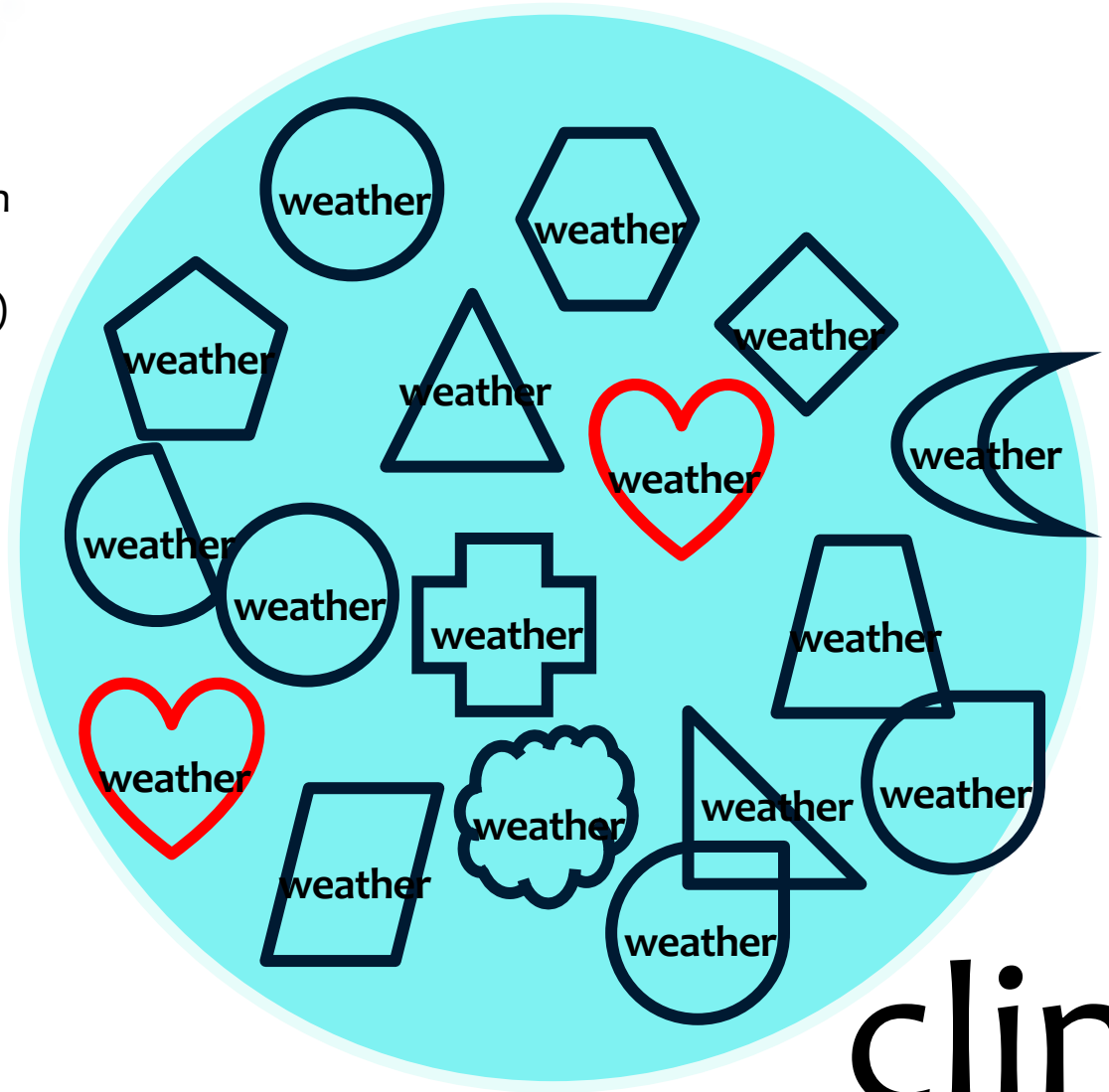
Yun-Young Lee

APCC APEC CLIMATE CENTER

CLIMATE?

Weather summary = Climate

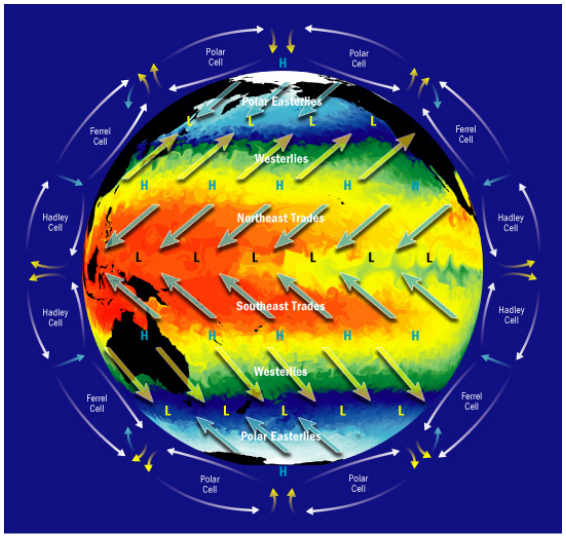
Expectation= mean condition of atmosphere (temp. & Prcp.)



Weather is what we ***get,***

Climate is what we ***expect*!**

Climate = Expectation



CLIMATE VARIABILITY?

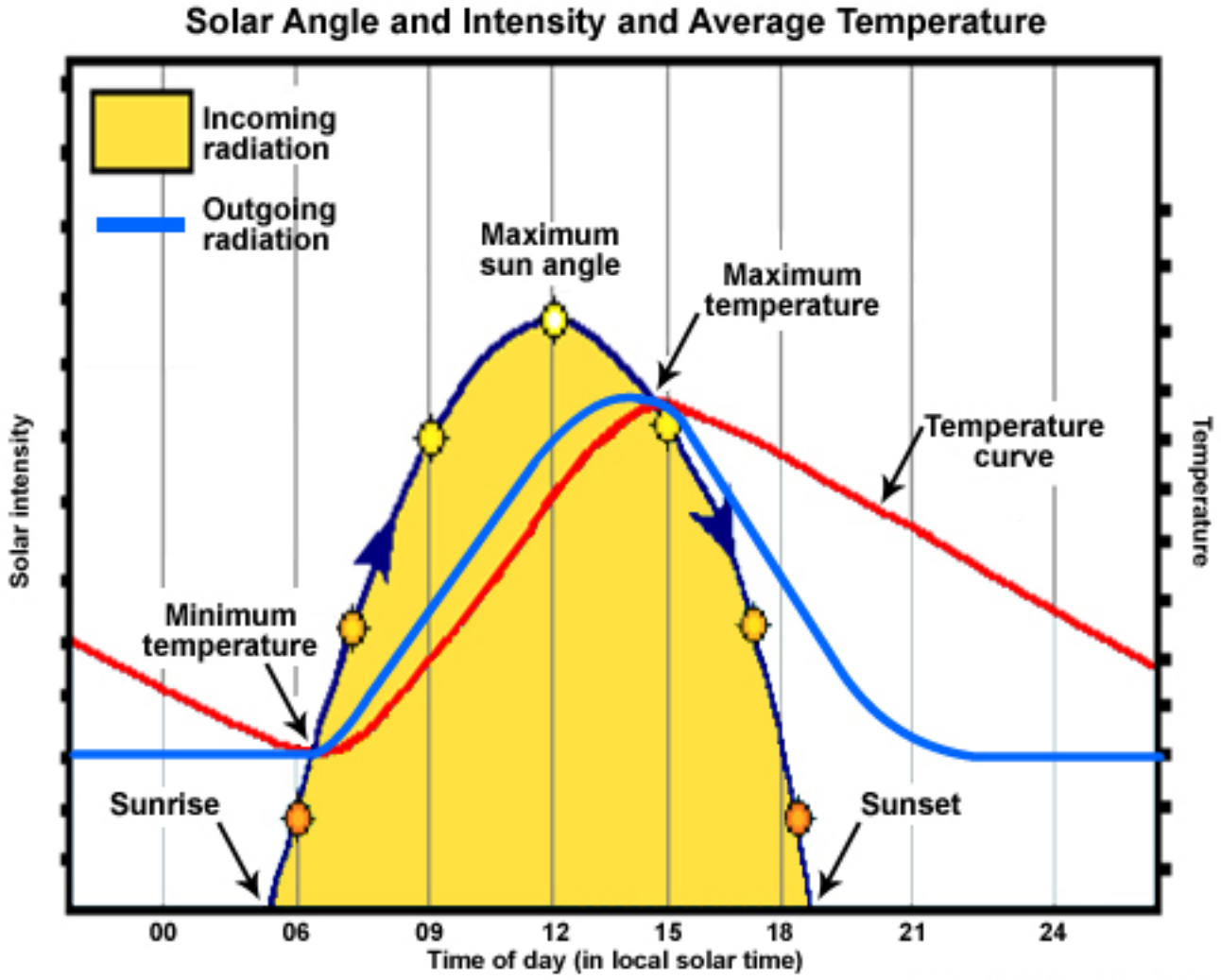
Climate Variability

Climate variability = (variability of expectation)

= spatiotemporal fluctuations (oscillations) of mean atmospheric condition associated with dynamical atmospheric/oceanic systems

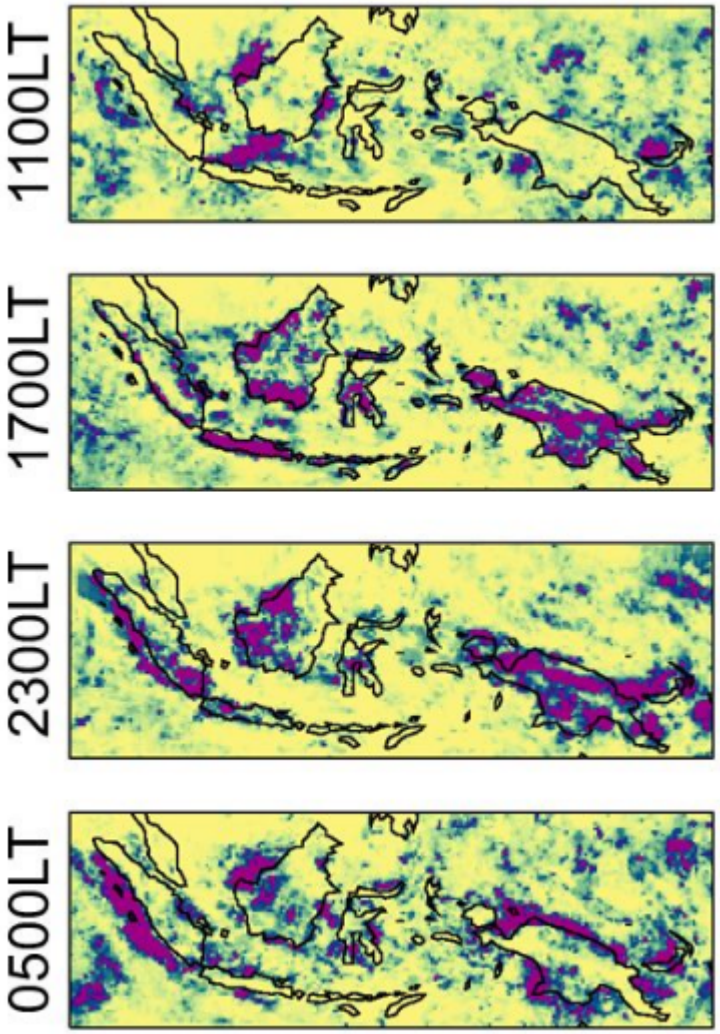
What are they?

Diurnal cycle



- ✓ Humidity
- ✓ Cloudiness
- ✓ Wind

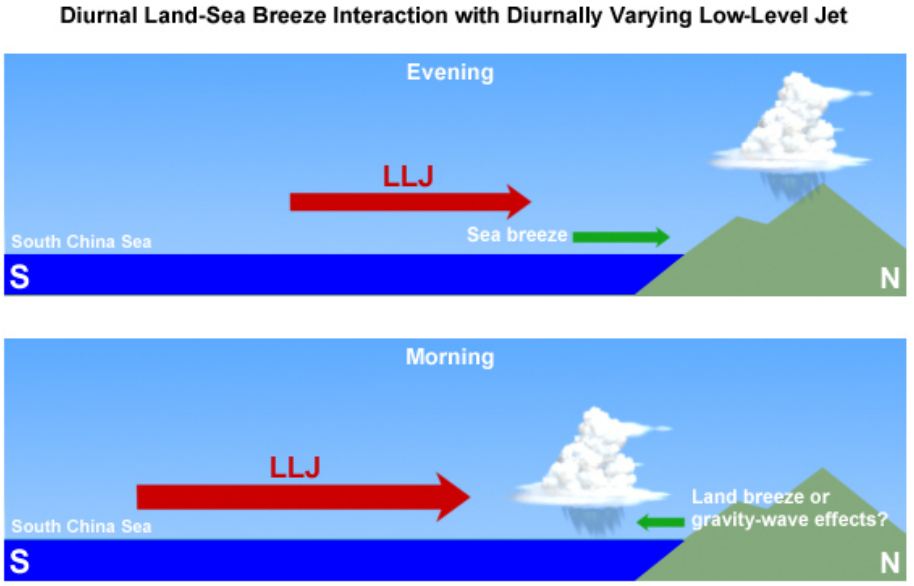
Diurnal cycle



From Jane Strachan

Land-sea breeze

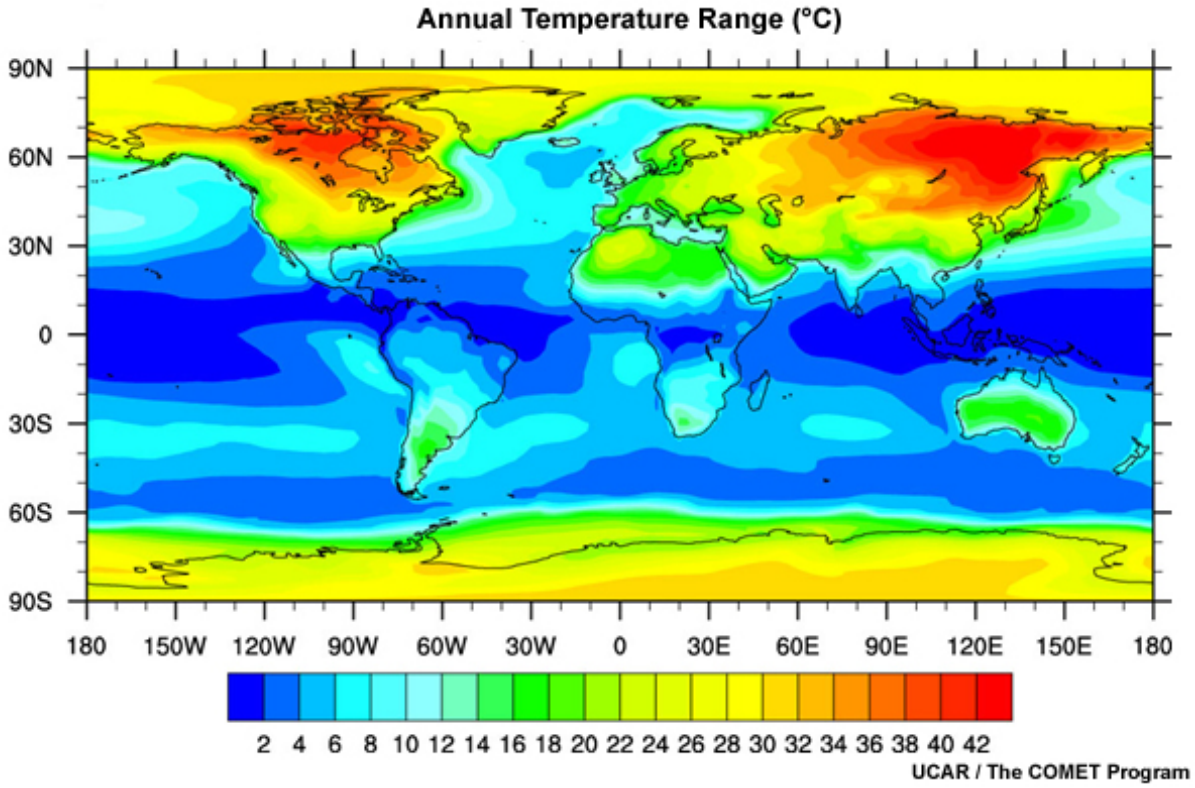
Mountain-Valley circulation

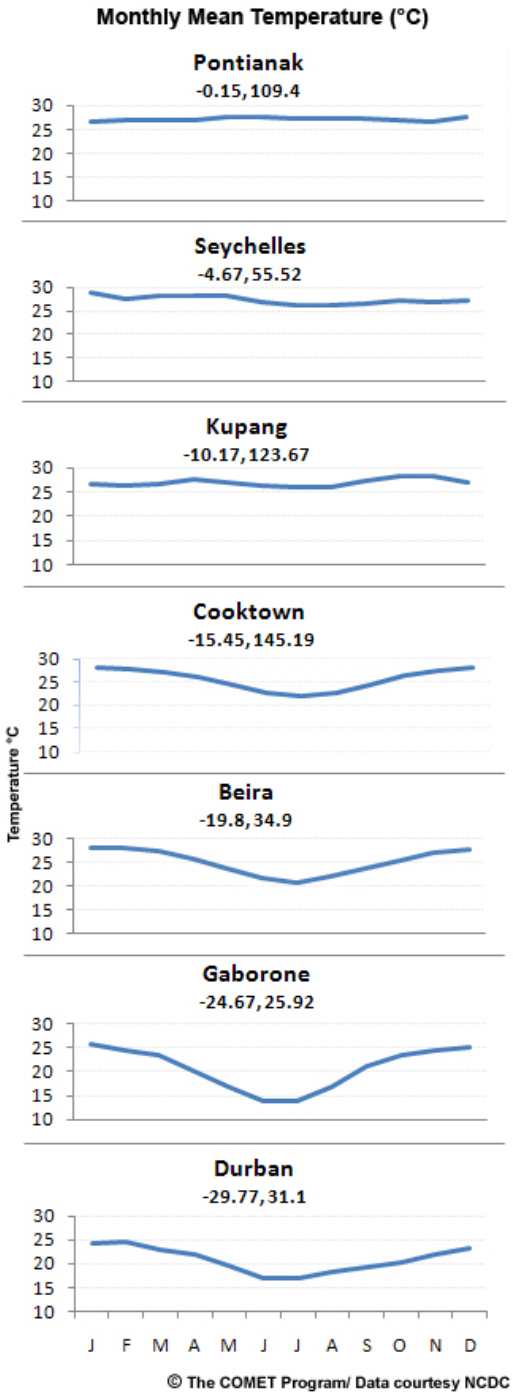


From R. Johnson

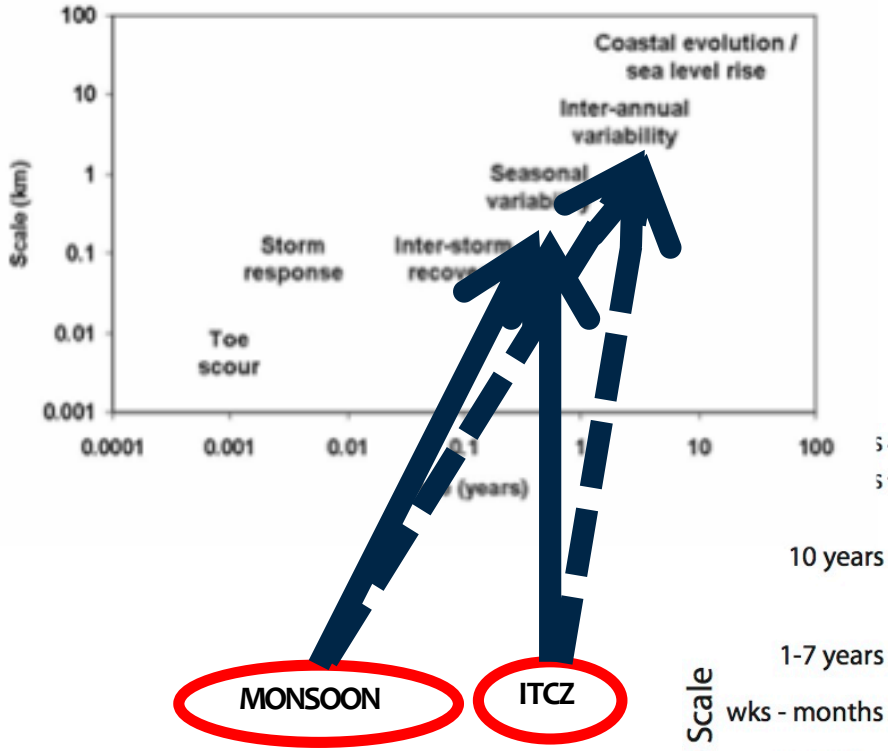
Seasonal cycle

- ✓ Latitude
- ✓ Continentality
- ✓ Clouds and Precipitation
- ✓ Albedo



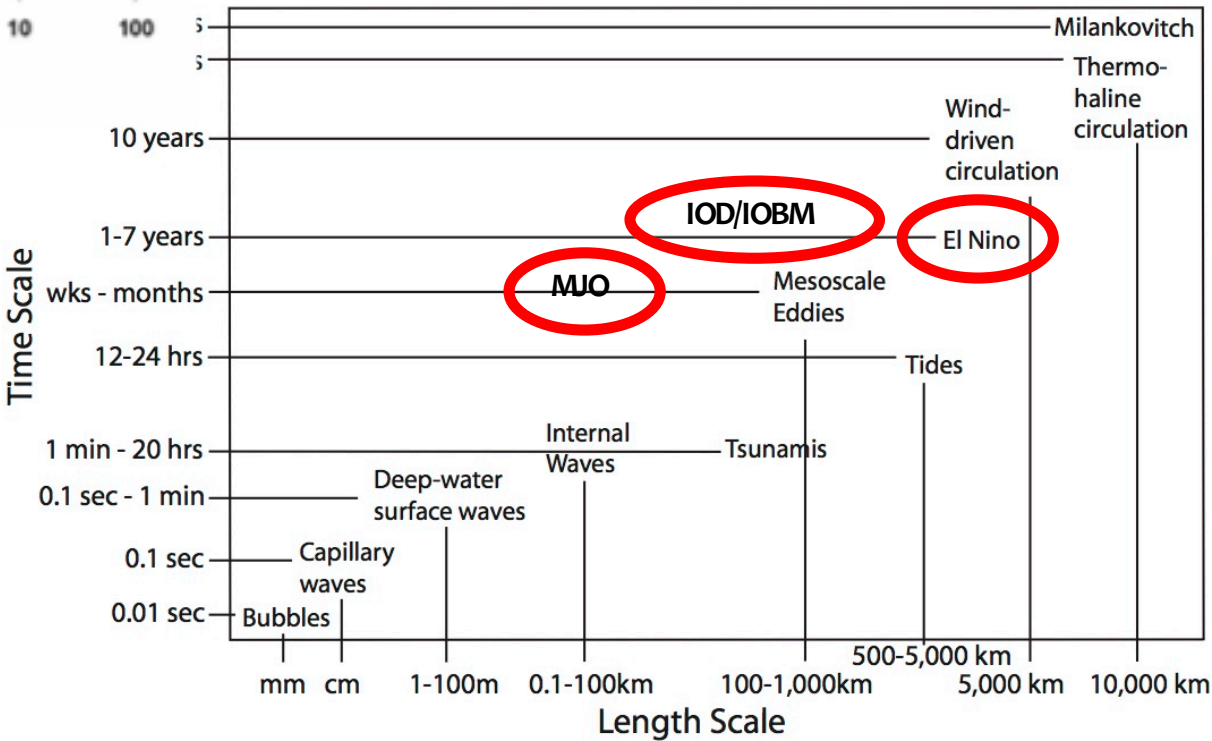


Climate Variability



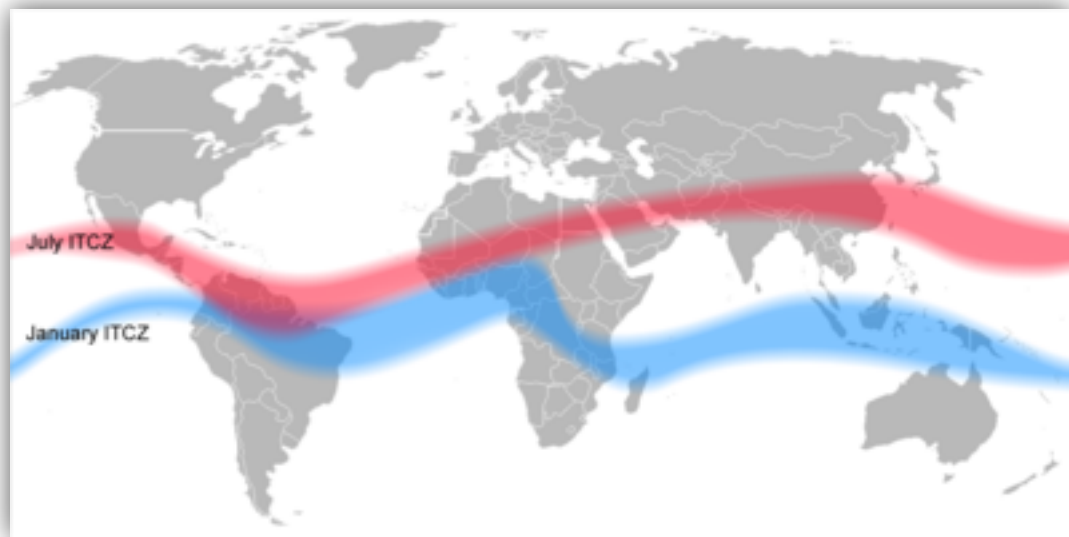
Energy Source: Solar radiation

Very obvious diurnal and seasonal cycle (oscillation) due to earth rotation & resolution (relative to the Sun)

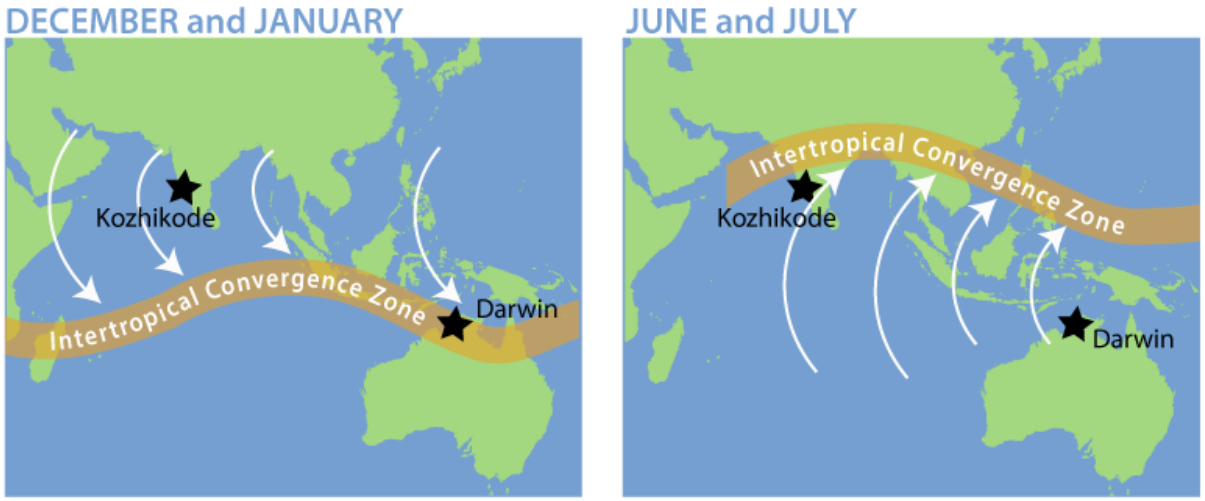


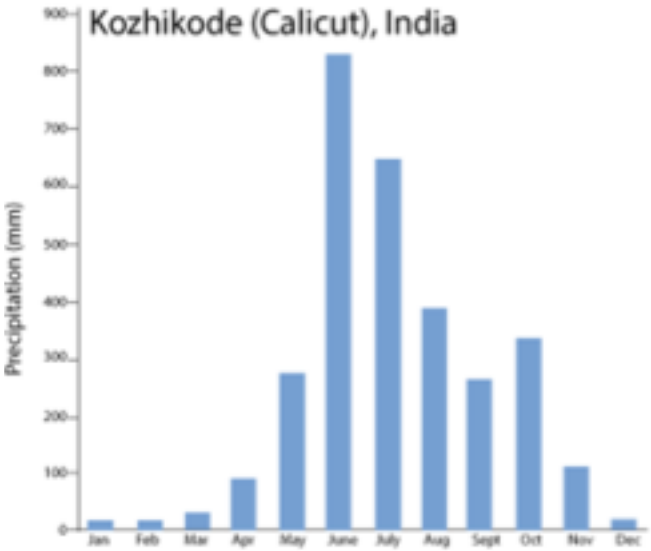
Inter Tropical Convergence Zone (ITCZ)

https://earthobservatory.nasa.gov/IOTD/view.php?id=703



Inter Tropical Convergence Zone (ITCZ)





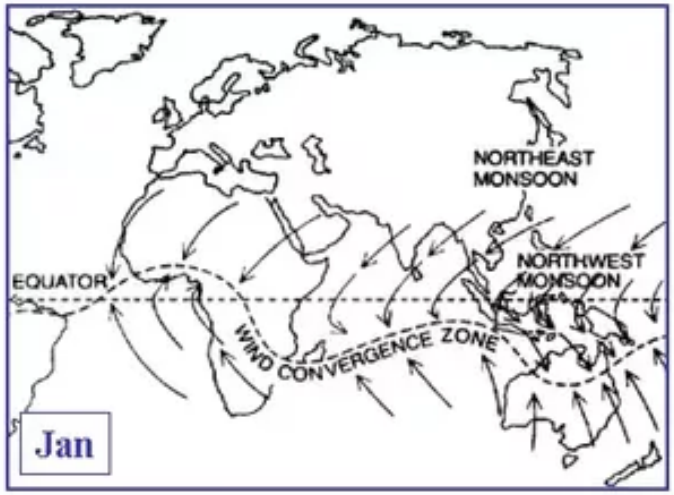
As the Intertropical Convergence Zone (ITCZ) changes location through the year, the winds, rains, and the location of wet monsoon weather changes, too. In this example from Asia and Australia, the ITCZ moves from the Southern Hemisphere (left map) to the Northern Hemisphere (right map). (Images: UCAR)

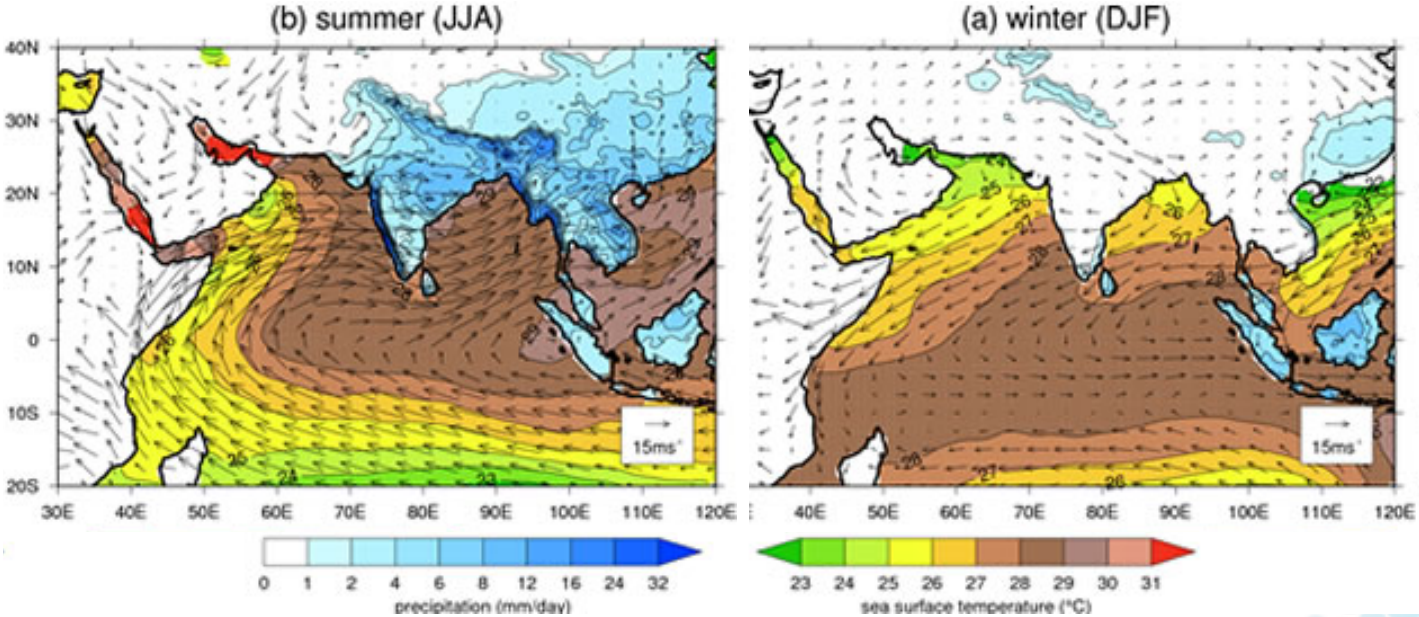
As the ITCZ swings north during the summer months, it brings monsoon rains to Kozhikode, India. As the ITCZ drops south during summer in the Southern Hemisphere, it brings monsoon rains to Darwin, Australia. (Images: UCAR)

http://monsoon.yale.edu/why-monsoons-happen/

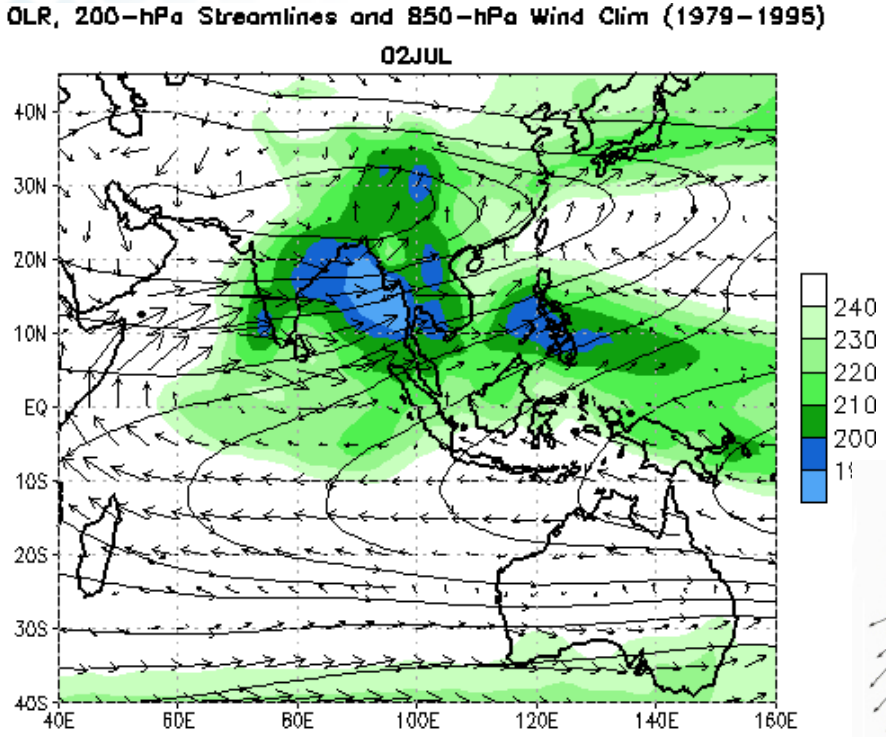
Monsoon


WIND CONVERGENCE ZONE
SOUTHWEST MONSOON
AFRICAN SOUTHWEST MONSOON
SOUTHEAST MONSOON
July

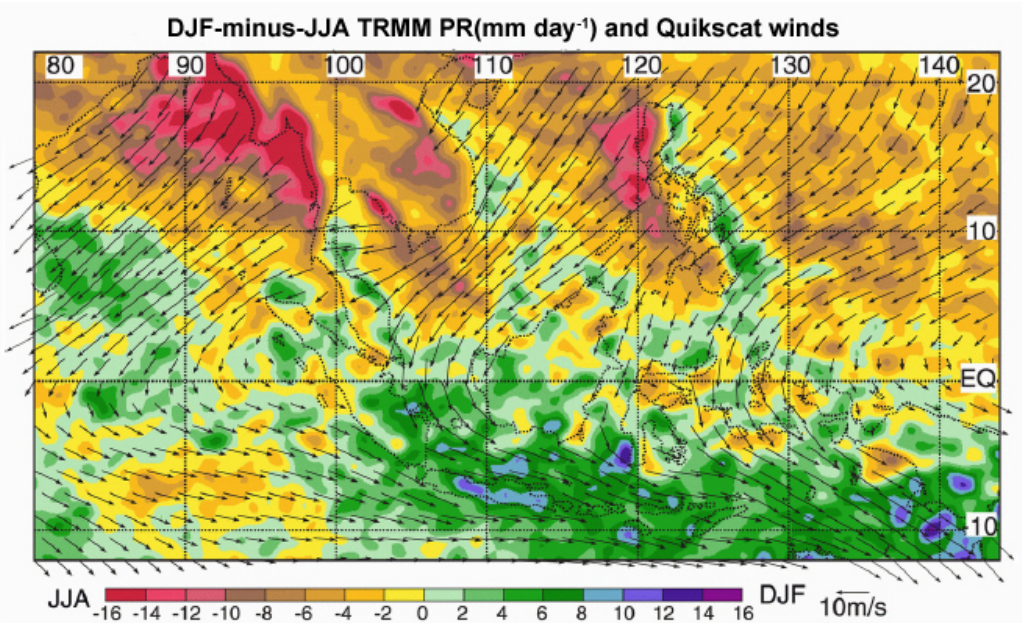

NORTHEAST MONSOON
EQUATOR
NORTHWEST MONSOON
WIND CONVERGENCE ZONE
Jan


(b) summer (JJA)
(a) winter (DJF)
40N
30N
20N
10N
0
10S
20S
30E
40E
50E
60E
70E
80E
90E
100E
110E
120E
15ms⁻¹
0 1 2 4 6 8 12 16 24 32
precipitation (mm/day)
23 24 25 26 27 28 29 30 31
sea surface temperature (°C)

Monsoon



Data Sources: OLR – NESDIS/ORA, Winds – NCEP CDAS/ Reanalysis



Chang et al. 2005

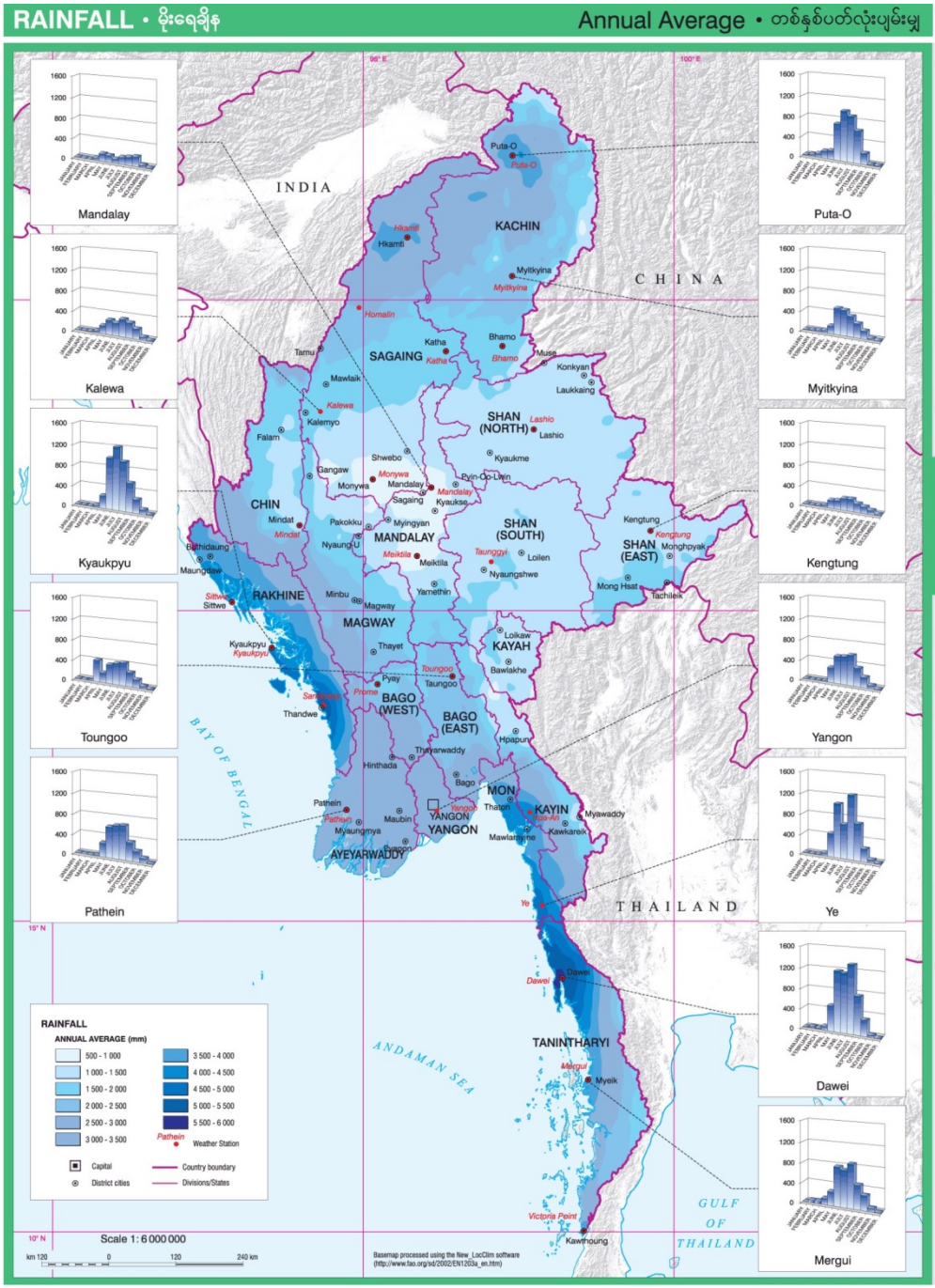
Monsoon Climate (Myanmar)

Regional Difference:

Delta region is approximately 2,500 mm (Yangon 2700 mm)

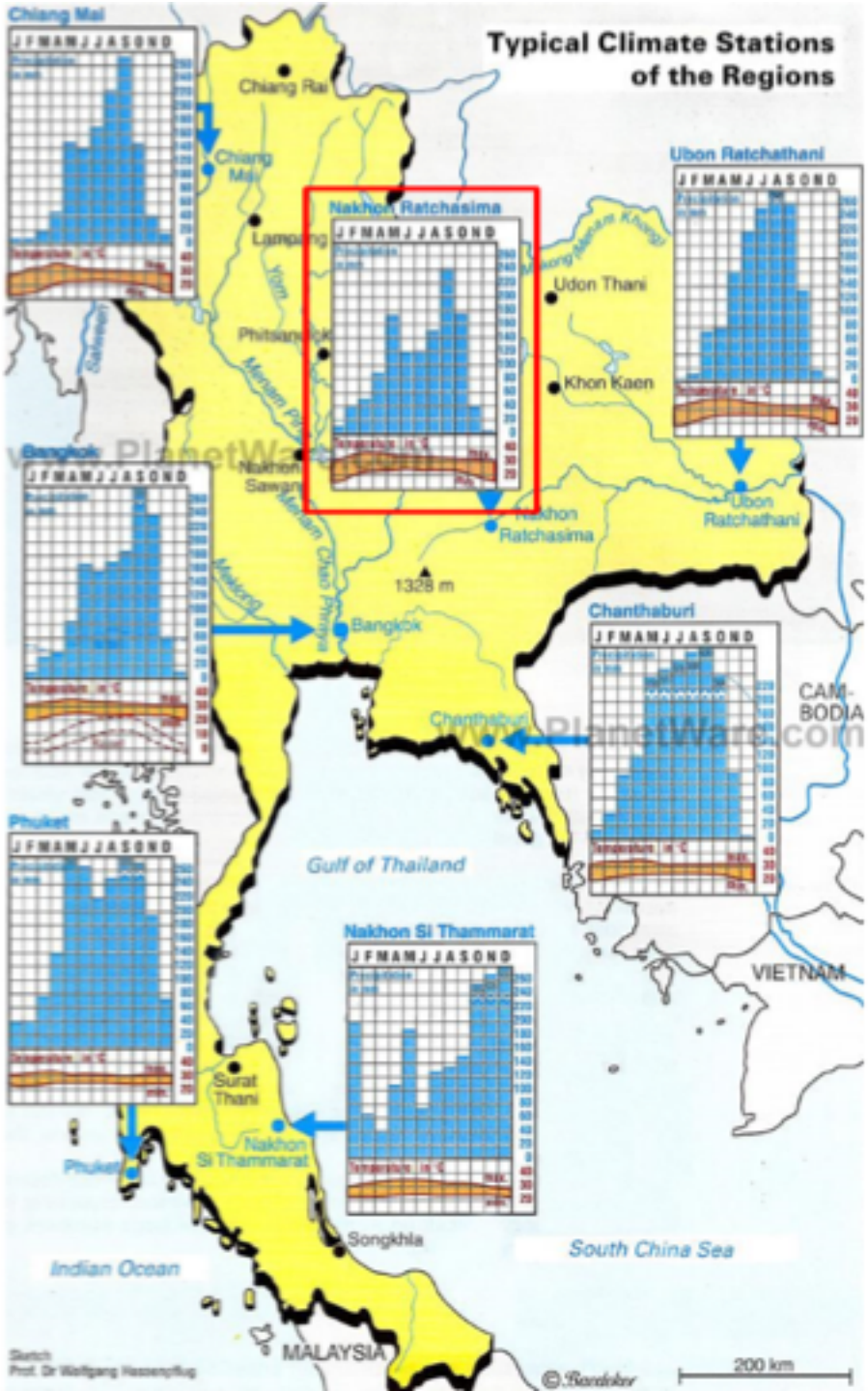
Dry Zone is less than 1,000 mm (Mandalay 840 mm)

Coastal regions receiving over 5,000 mm



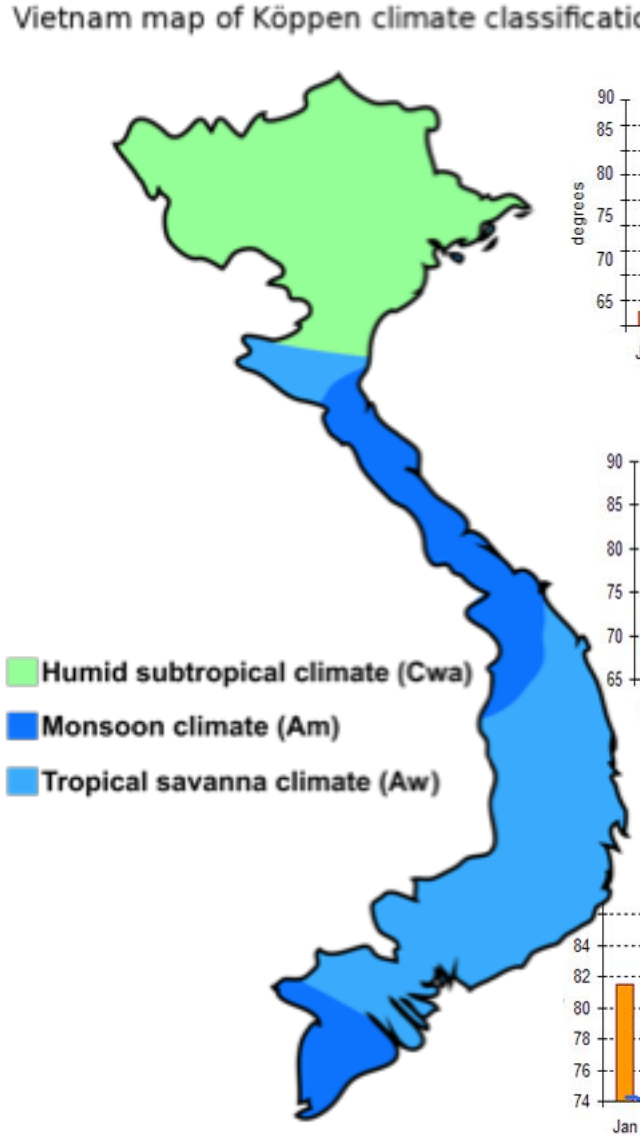
Regional difference (Thailand)

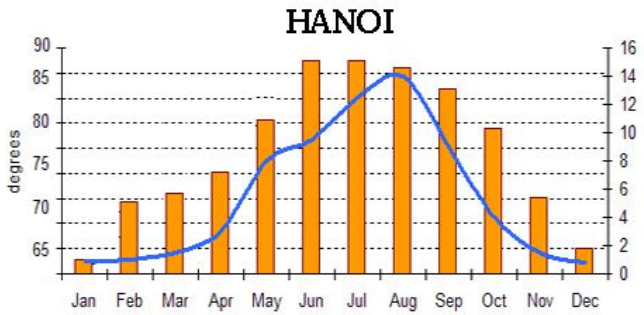
Coastal area vs Inland

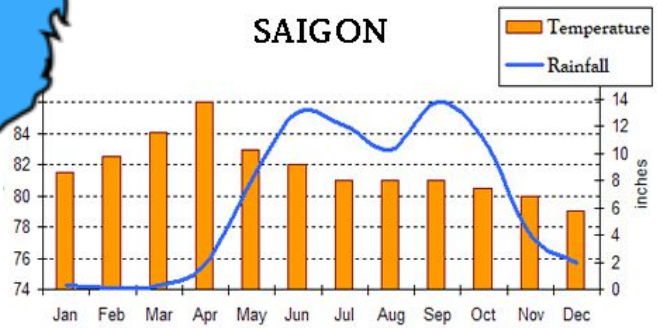


Regional difference (Vietnam)

North
& Central
& South

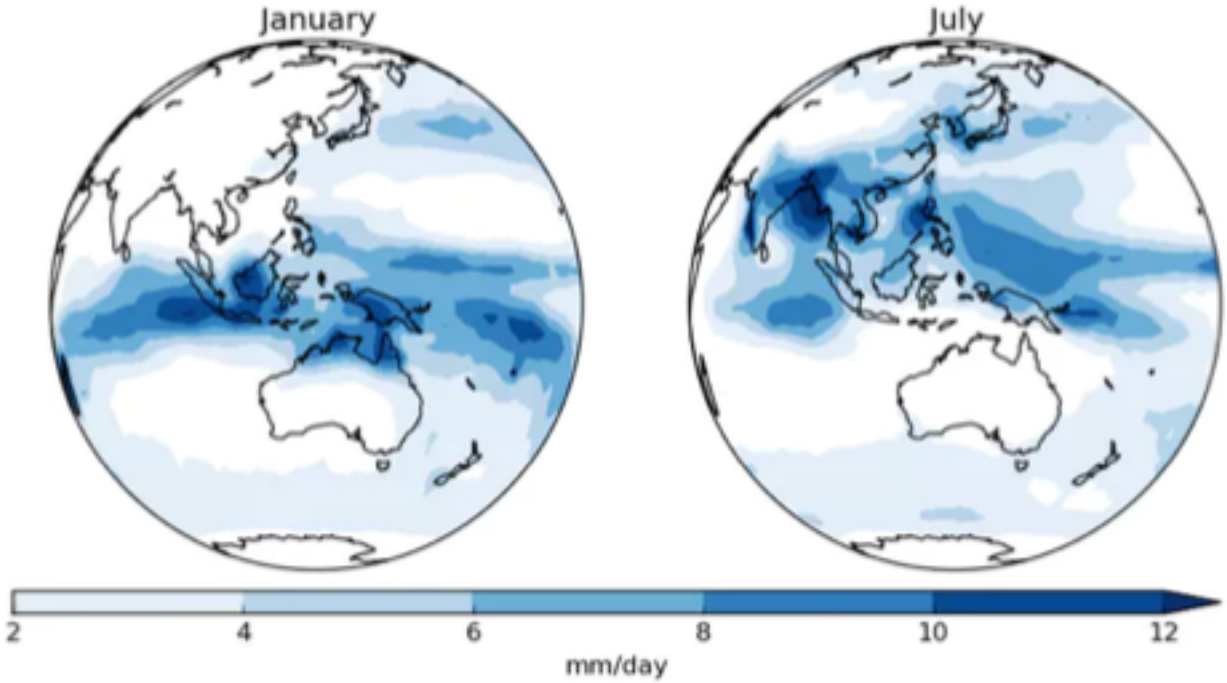






https://www.fareastour.asia/when-is-the-best-time-to-visit-Vietnam/

Australian Monsoon

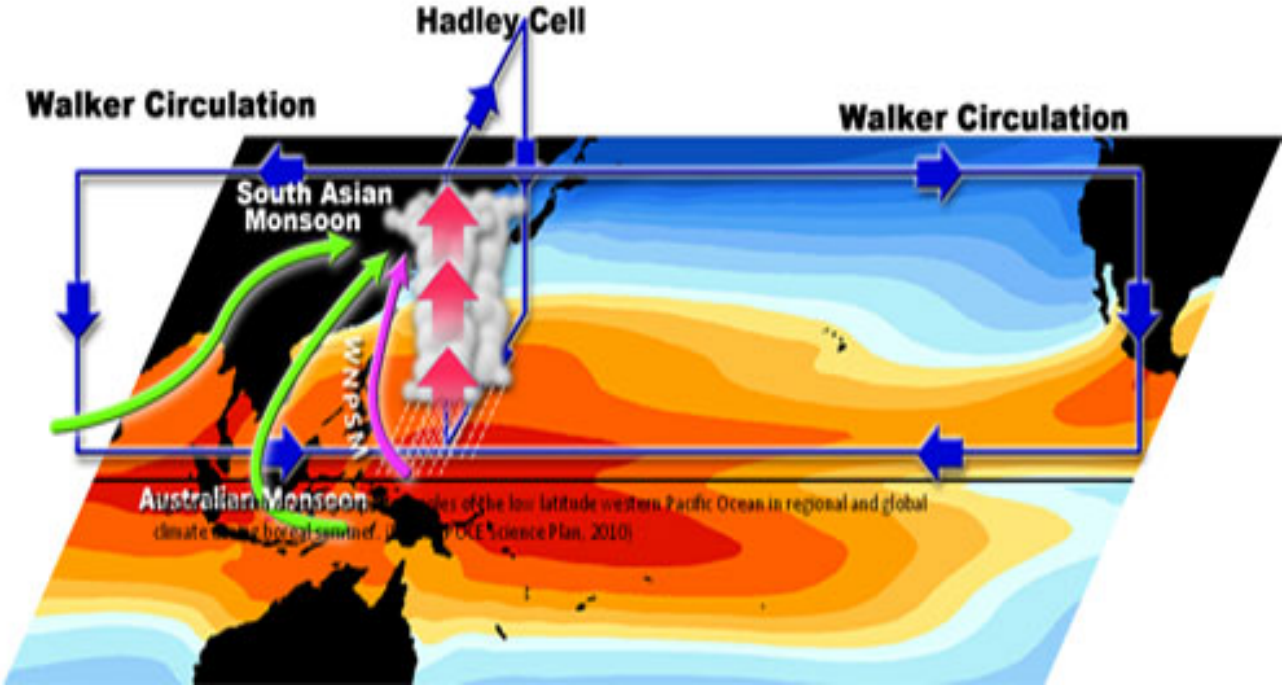


Global rainfall daily averages (1979-2008) for the months of January (left) and July (right). The monsoon trough is positioned over northern Australia in the southern summer, and moves northward during the southern winter. NOAA/OAR/ESRL PSD (http://www.esrl.noaa.gov/psd/)

Western Pacific Warm Pool (WPWP)

- Climate Engine : remember "mean" feature

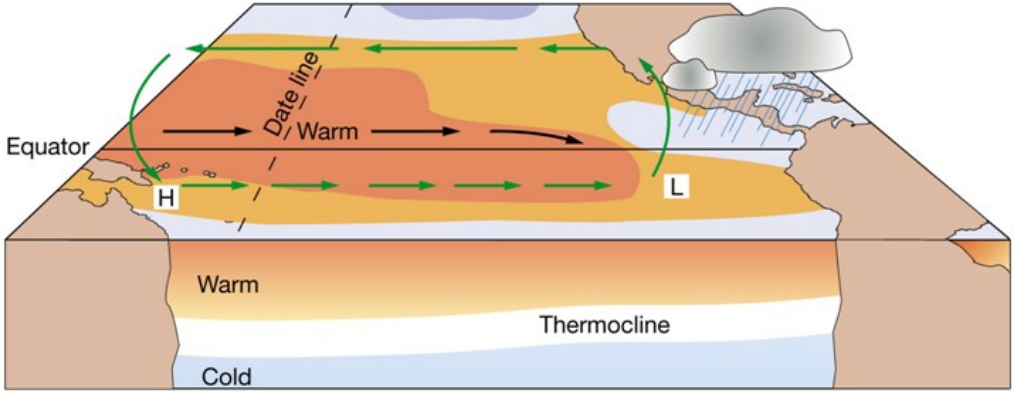
SST > 28.5° C



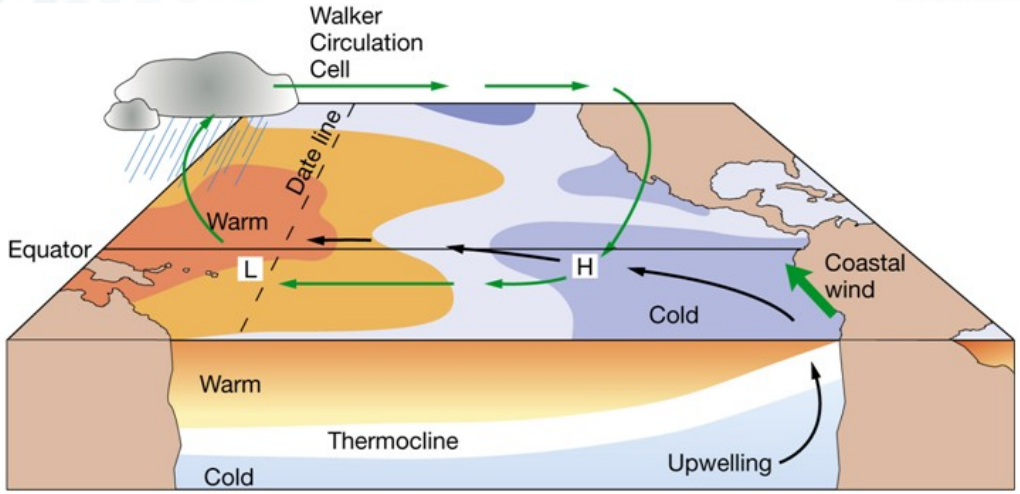
http://npoce.qdio.ac.cn/background

ENSO

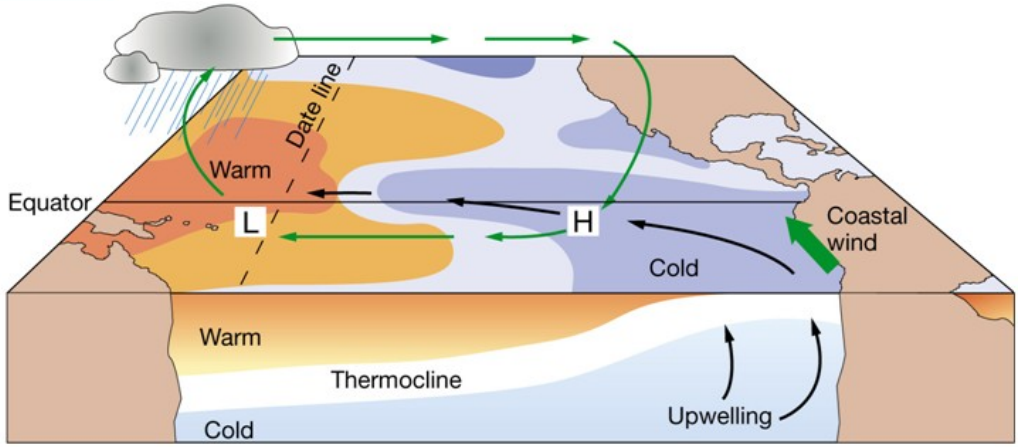
- A Big Ocean Swing



(b) El Niño conditions

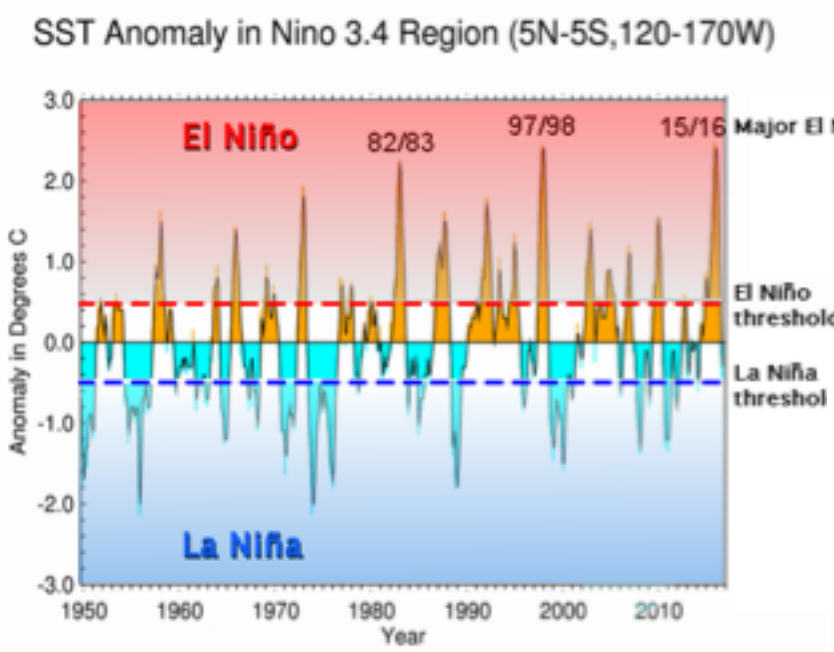


(a) Normal conditions



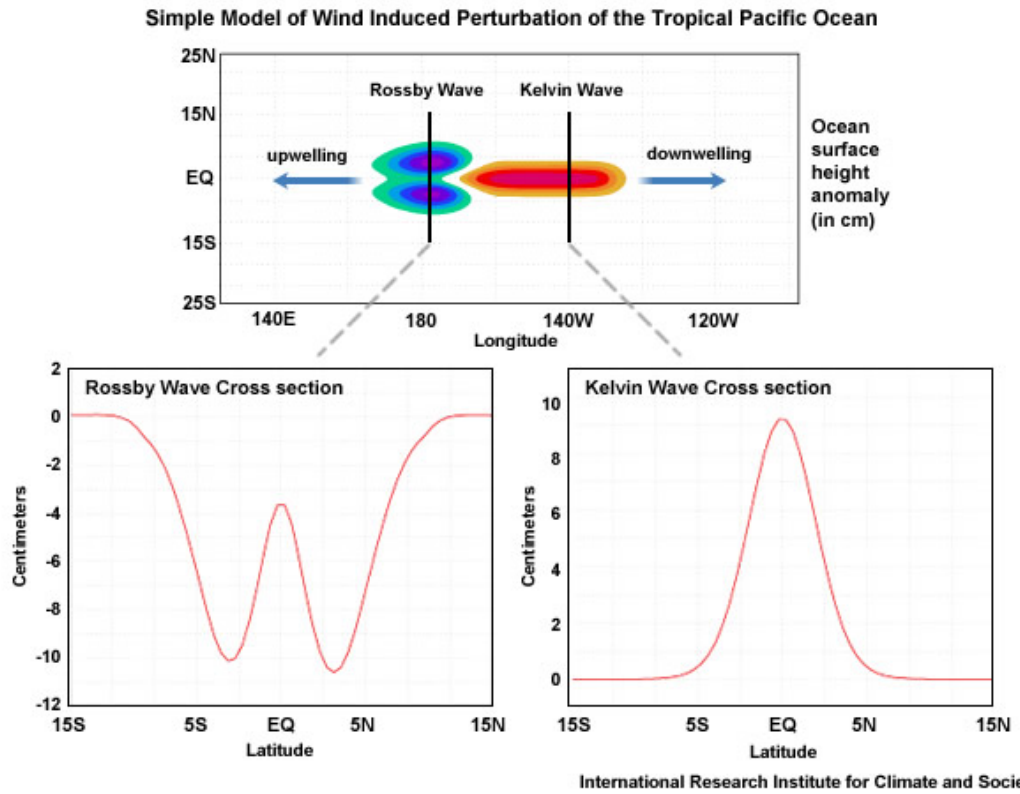
(c) La Niña conditions

ENSO, why it oscillates?

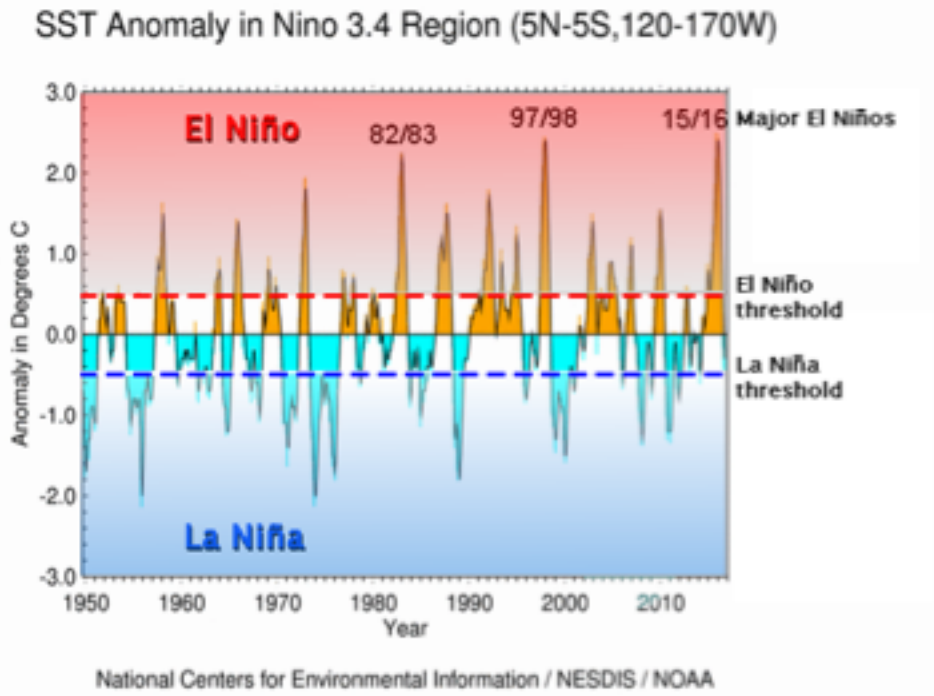


The period/cycle of 2 -7 years

Delayed Oscillator

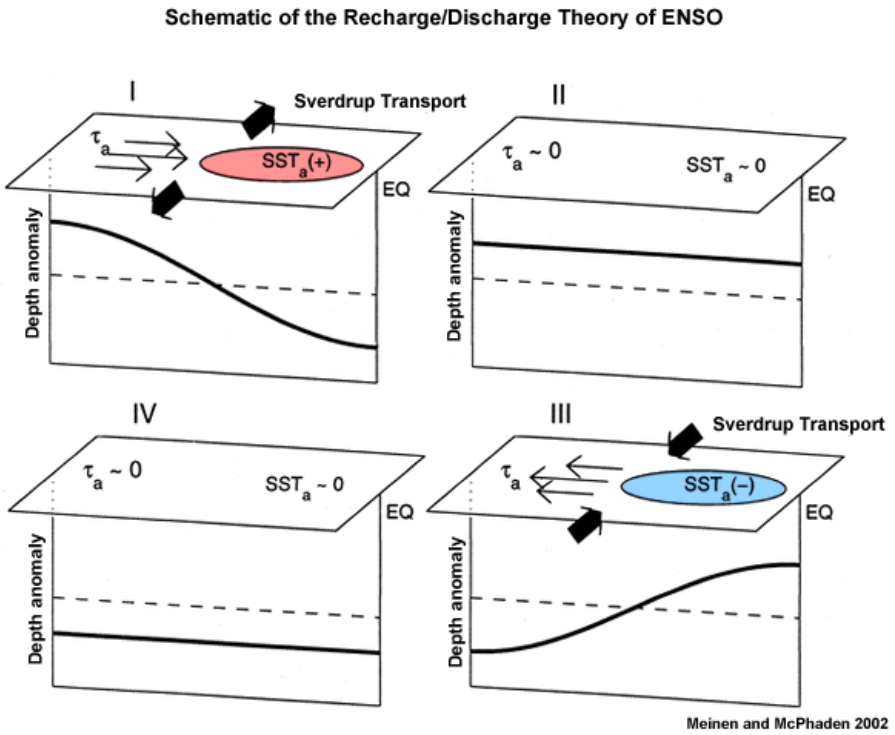


ENSO, why it oscillates?

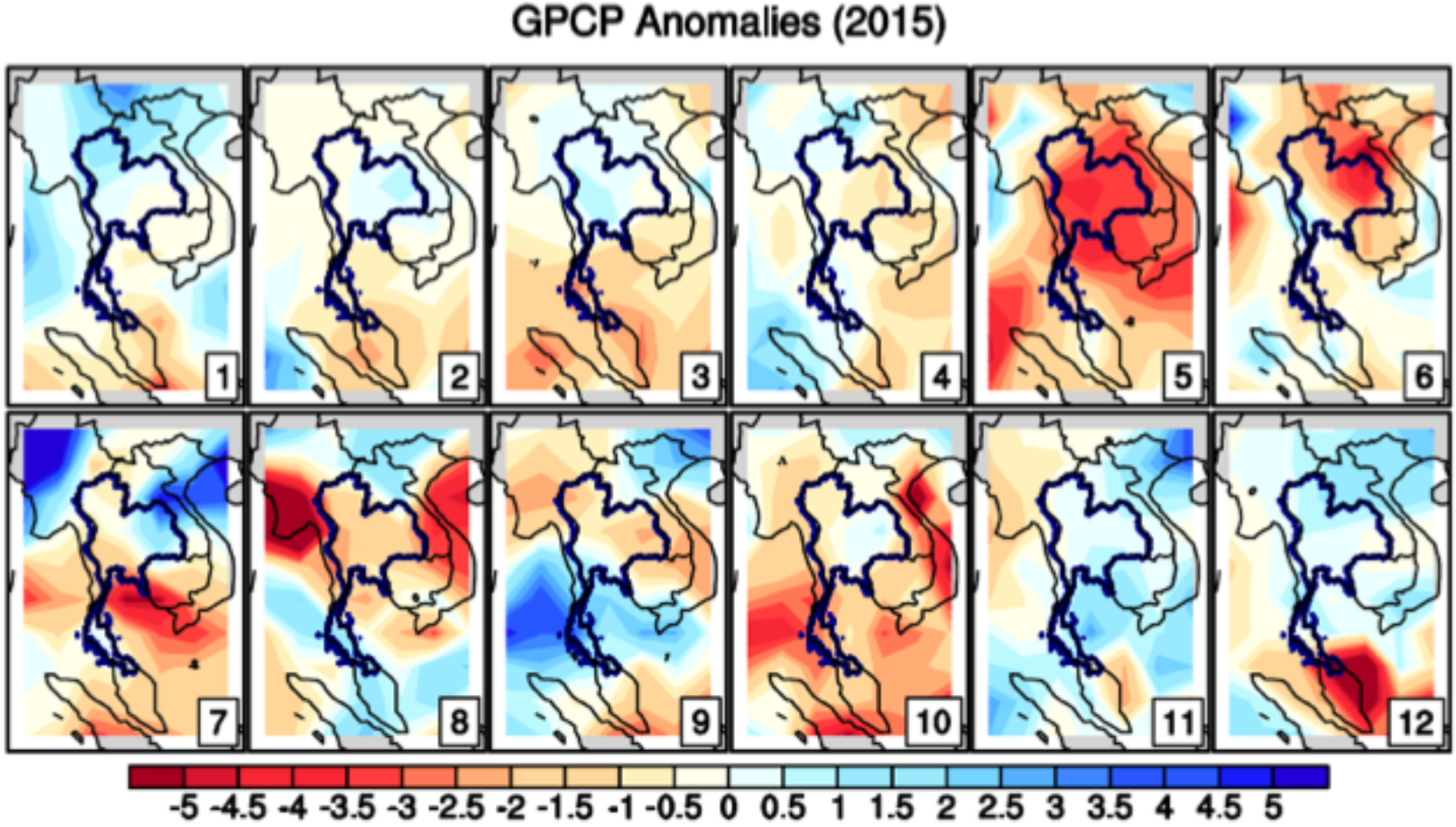


The period/cycle of 2 -7 years

Recharge-discharge Oscillator



What happen in Southeast Asia during 15-16 prolonged El Nino?



By Ji-Hyun Oh (APCC)

2016 Drought in Vietnam

10,302 views | May 25, 2016, 01:39am

Why Vietnam Is Running Dry, Worst Drought In Nearly 100 Years

Tim Daiss Contributor ⓘ

Oil markets analyst, journalist and author based in Southeast Asia

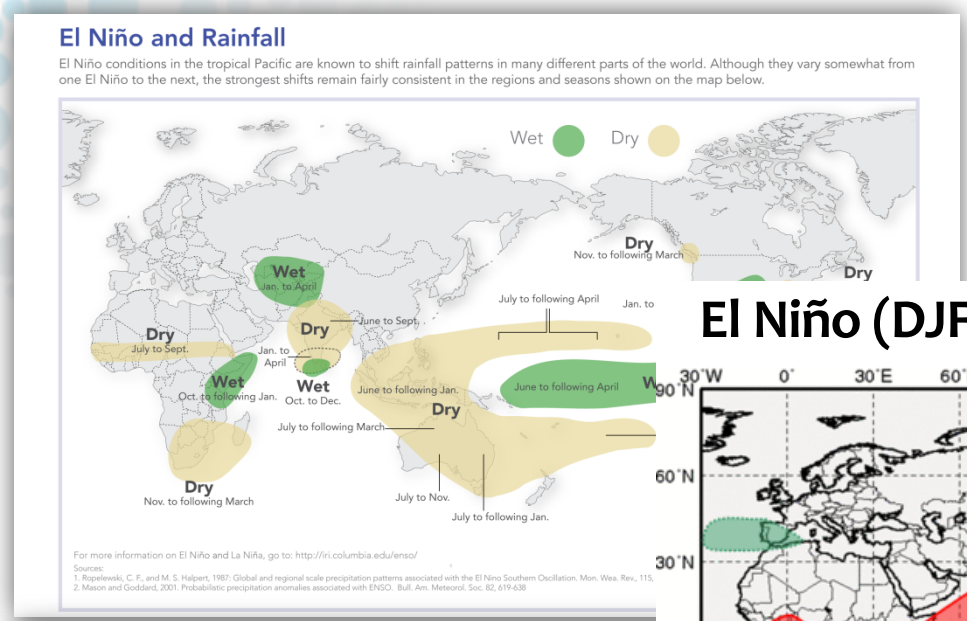
TWEET THIS

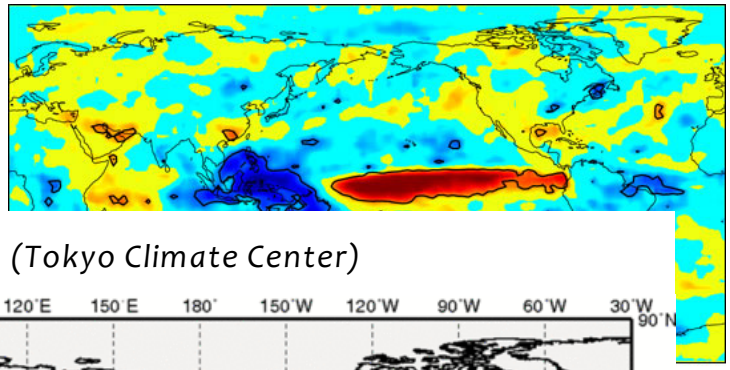
Vietnam's Mekong Delta is suffering from its worst drought in nearly a century, and the effects have been devastating.

this year's drought could also lead to a serious reduction in exports of major goods produced in the region, including rice, seafood, and coffee.

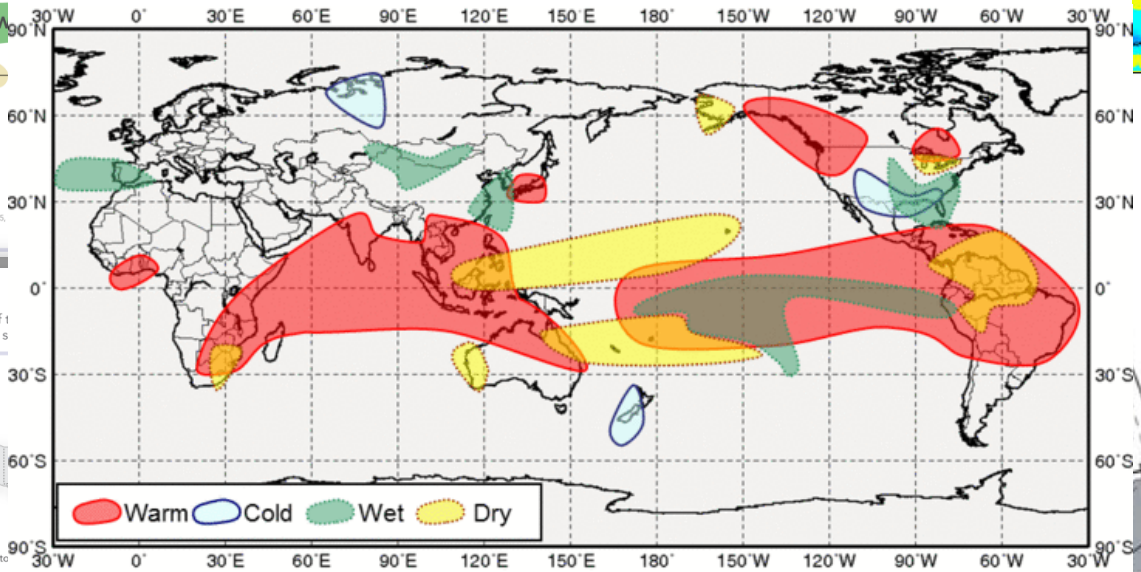
https://www.forbes.com/sites/timdaiss/2016/05/25/why-vietnam-is-running-dry-worst-drought-in-nearly-100-years/#35d4df0874b3

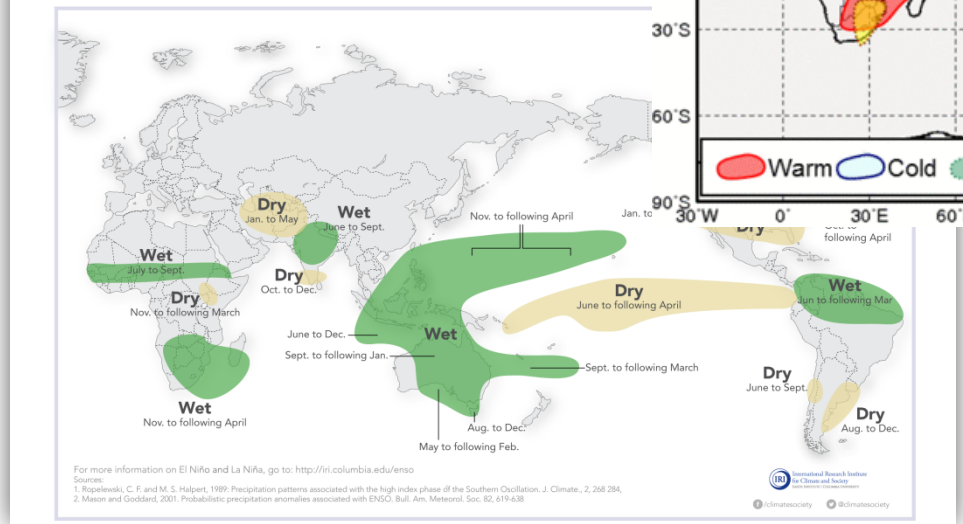
ENSO impact

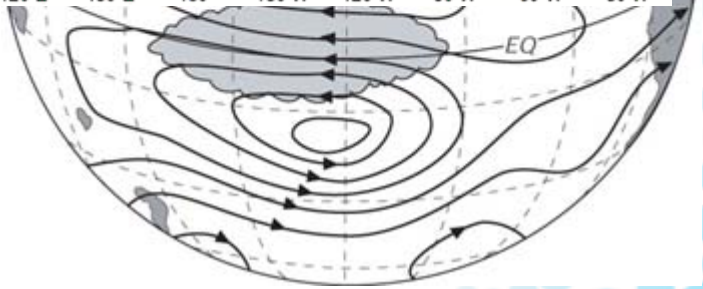




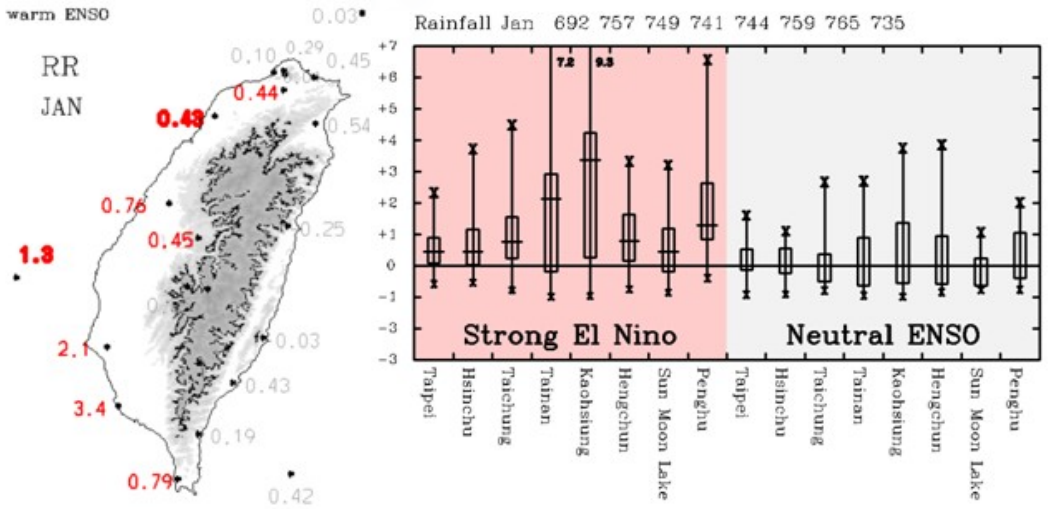
El Niño (DJF) by TCC (*Tokyo Climate Center*)

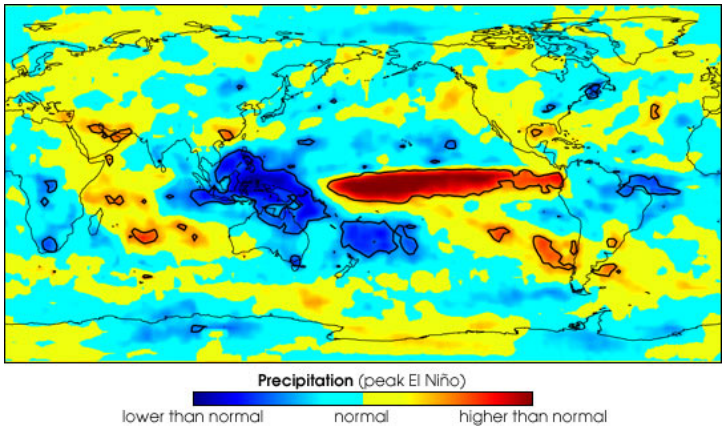




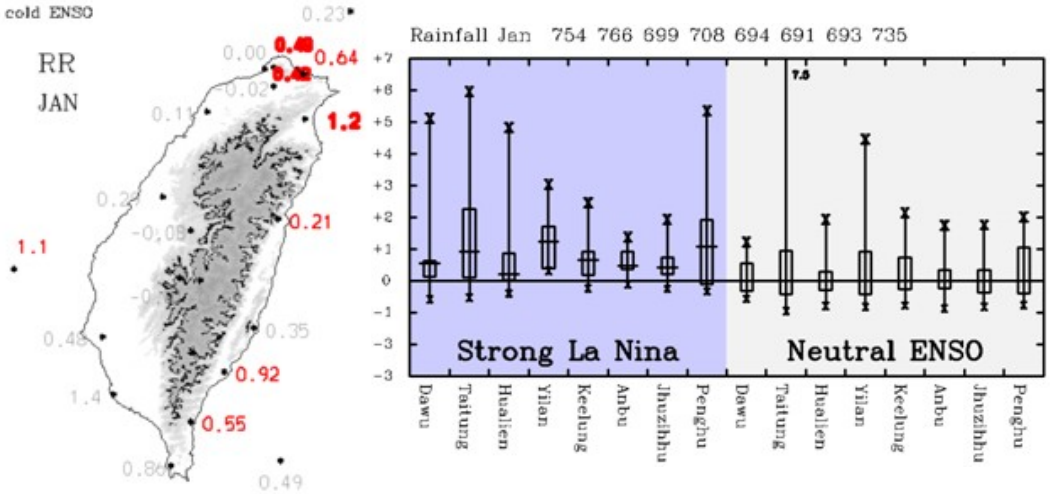


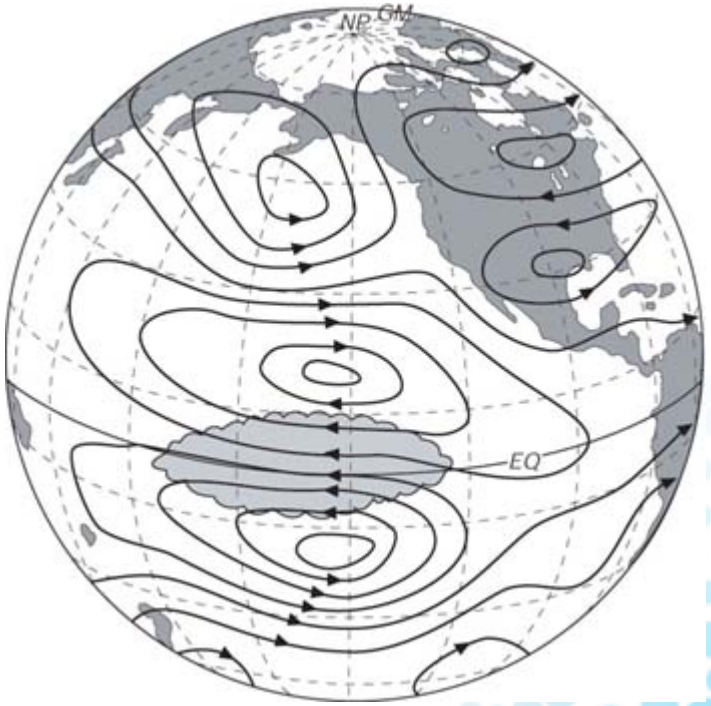
ENSO impact (Taiwan)





Difference between two ENSO phases

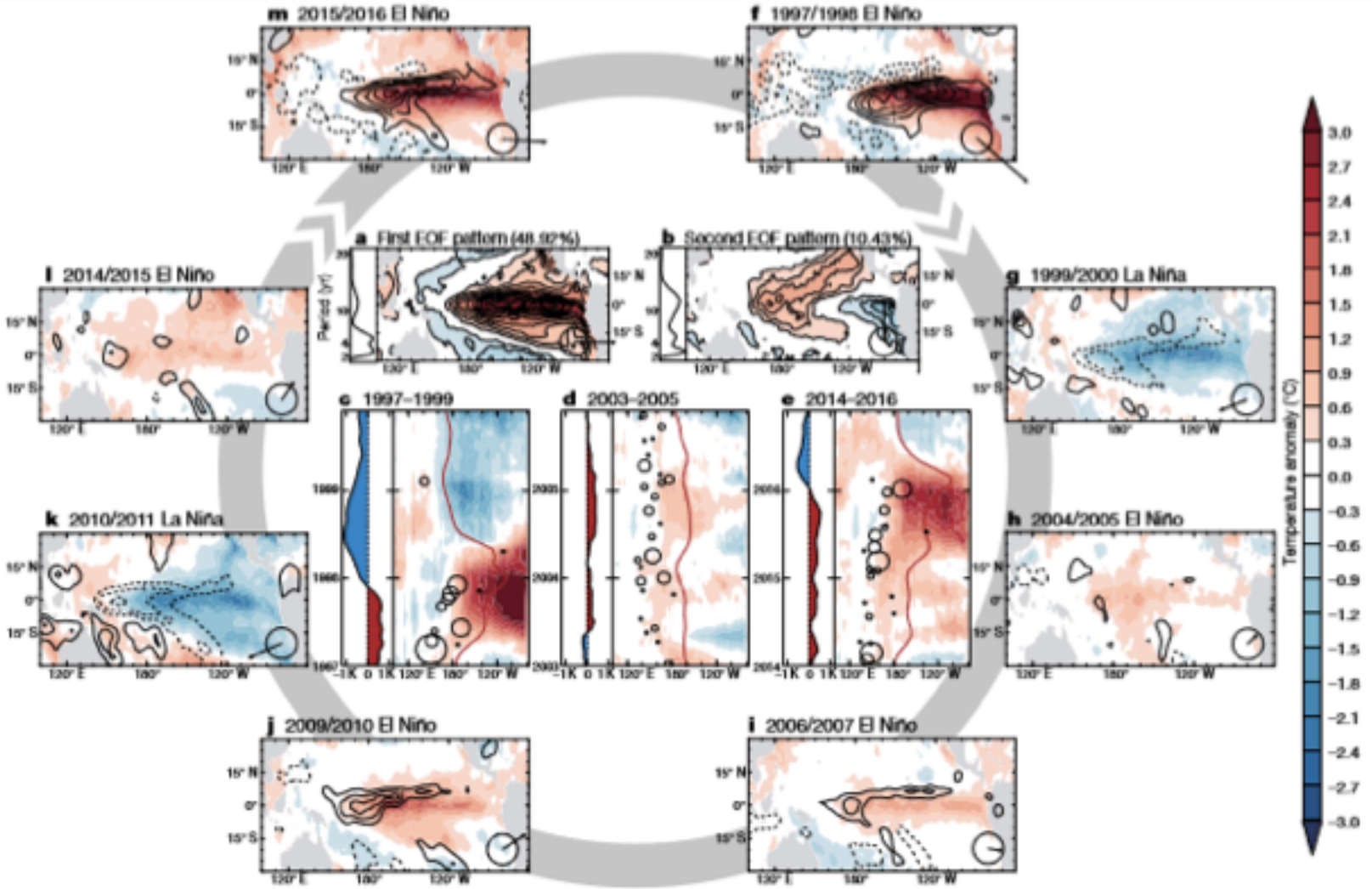




https://slideplayer.com/slide/8505484/

ENSO Complexity

In Time & Space



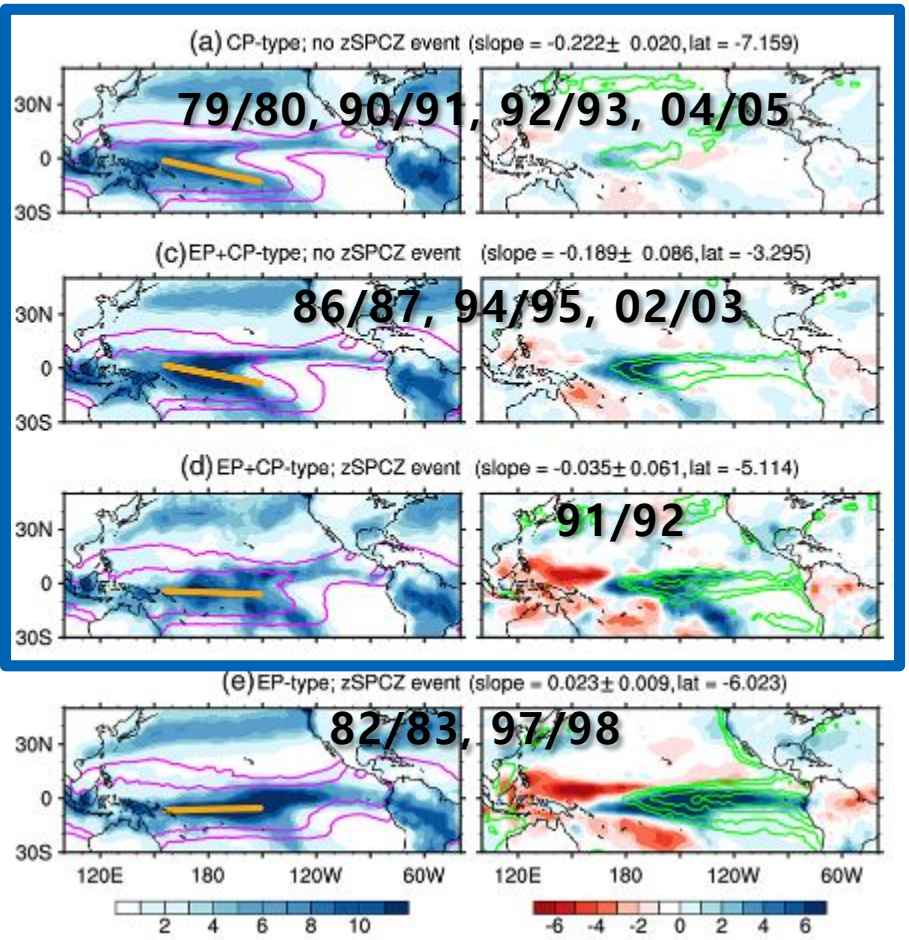
Timmermann, A., An, S. I., Kug, J. S., Jin, F. F., Cai, W., Capotondi, A., ... & Stein, K. (2018). El Niño–Southern Oscillation complexity. *Nature*, *559*(7715), 535.

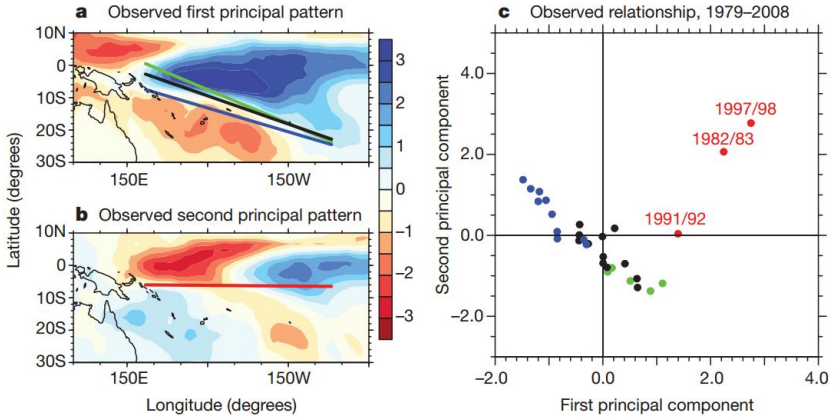
Extreme Swing of SPCZ

Cai et al (2012) & Borlace et al (2014)

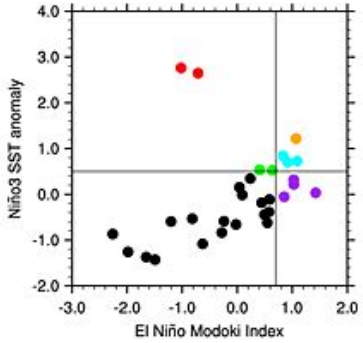
-Strong (Super) EP type El Nino (82/83, 97/98) → **zonal SPCZ**

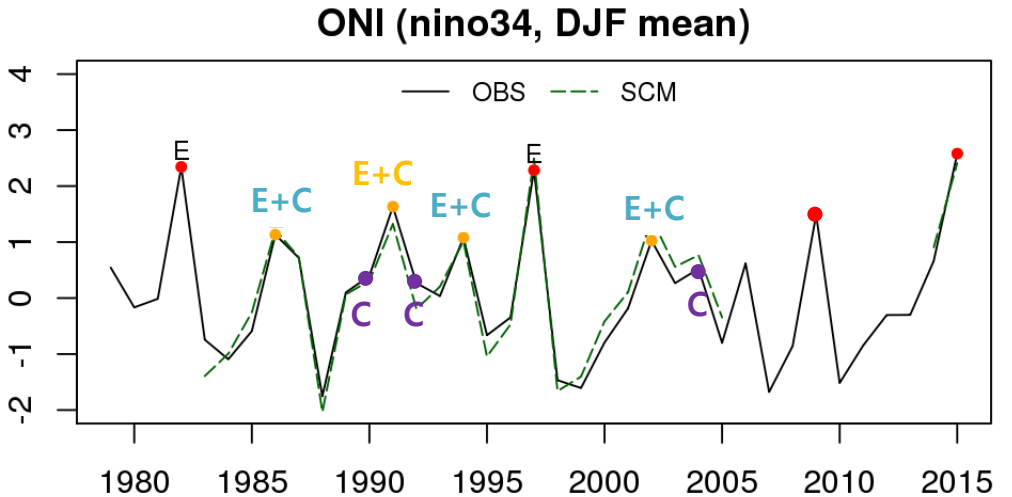
-EP/CP (91/92) El Nino → **Zonal SPCZ**





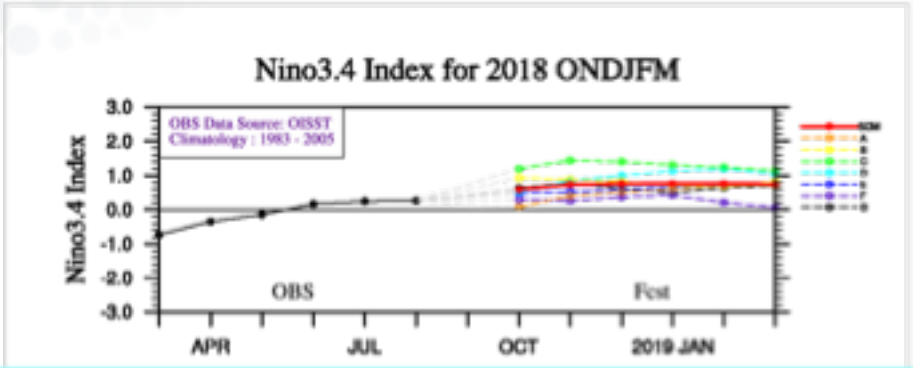
How about 2018/19?

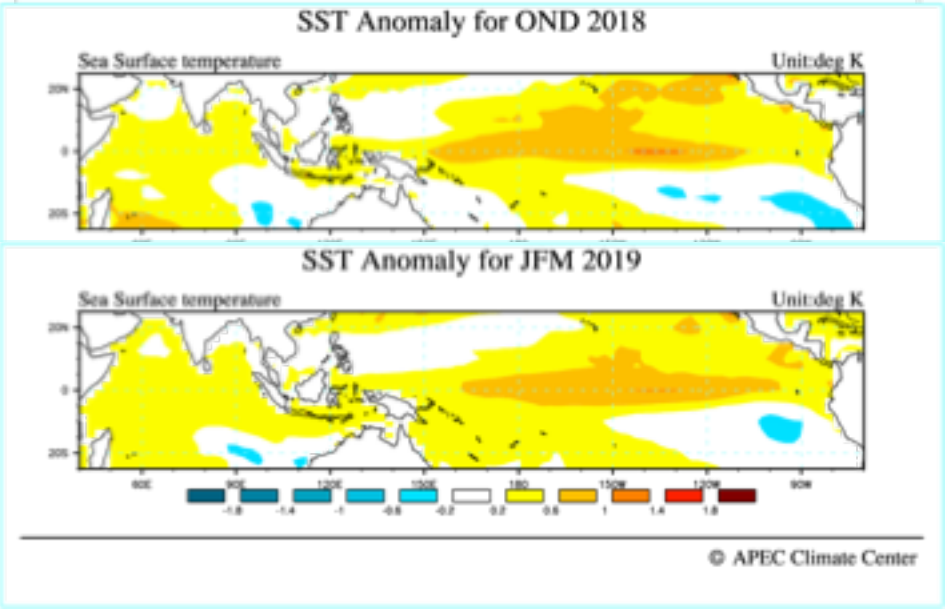


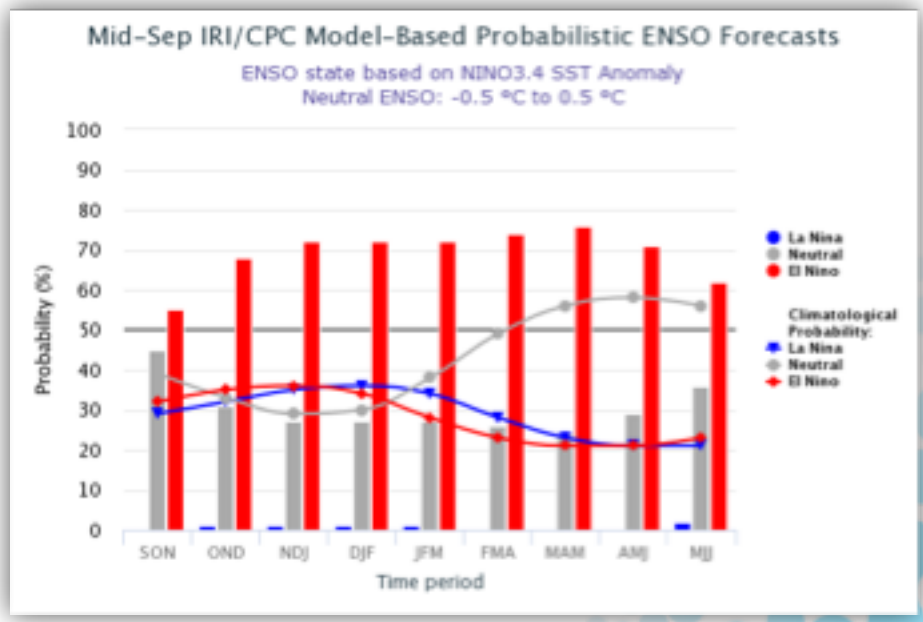


Weak CP-type El Nino expected in 2018/19???

- Heatwave & drought expected in Vietnam?
- Rainfall increase in the west coast in Taiwan?
- Different regional impacts of CP-type should be explored!

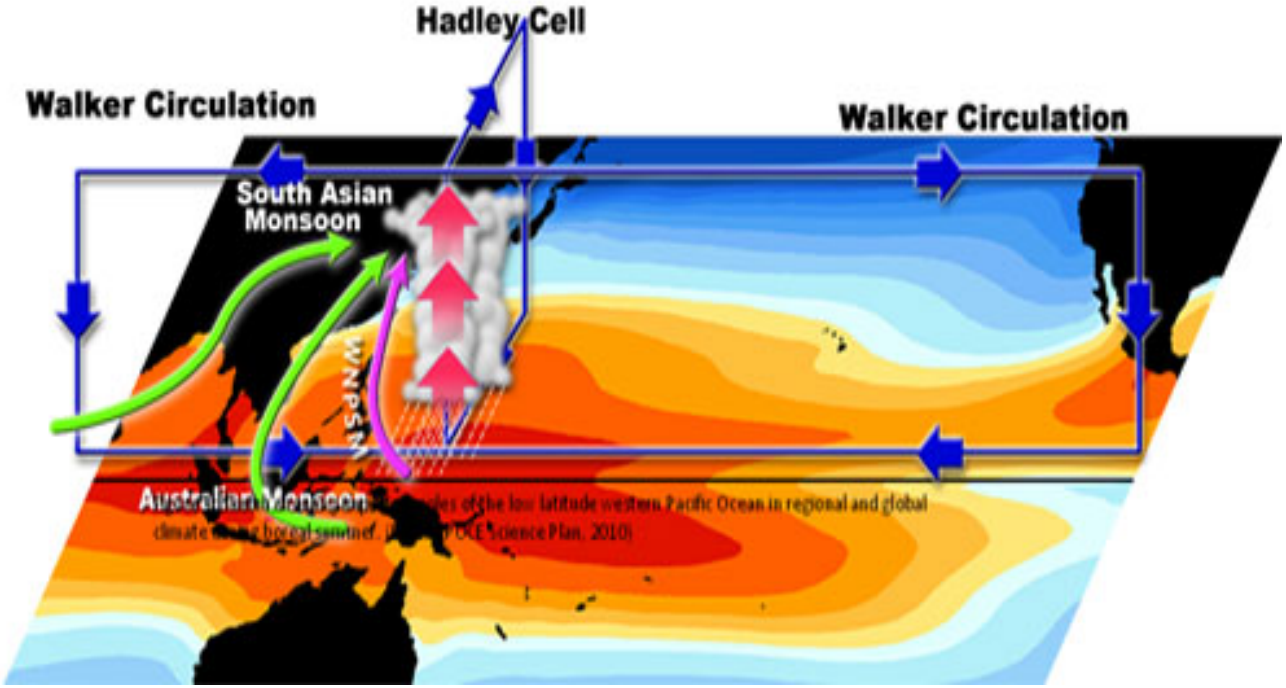






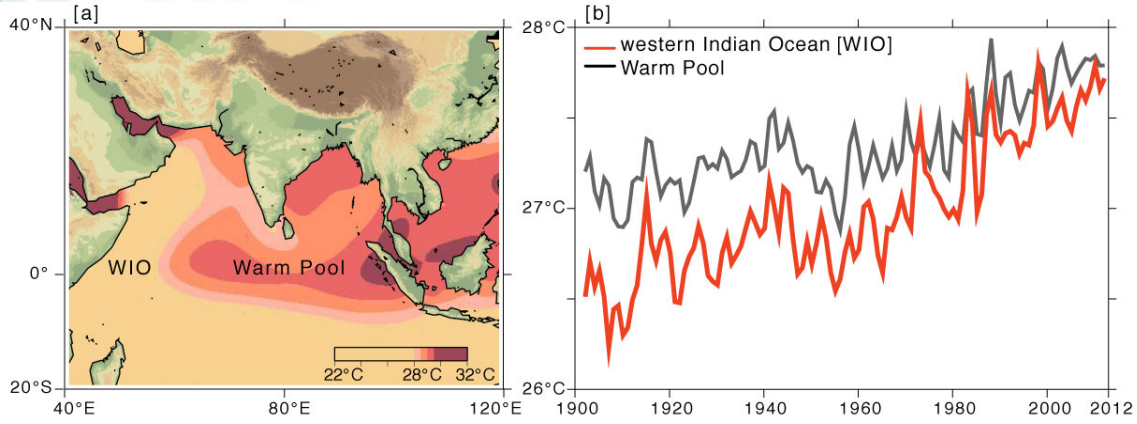
Western Pacific Warm Pool (WPWP)

- Climate Engine : remember “mean” feature



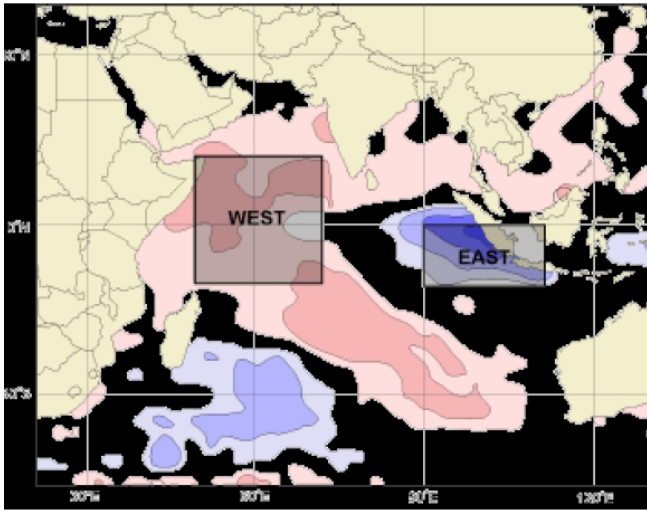
http://npoce.qdio.ac.cn/background

Don’t forget Indian Ocean



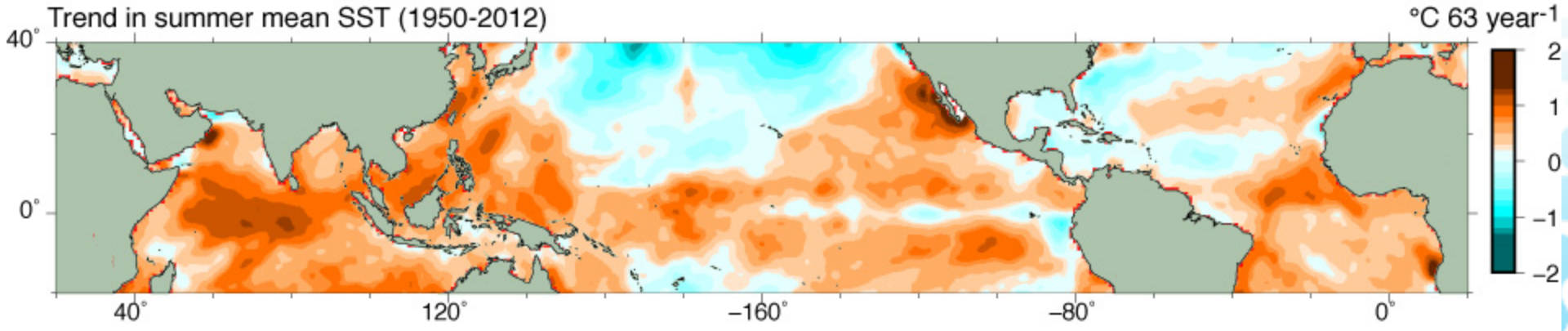
Source: http://www.climate.rocksea.org/research/indian-ocean-warming/

Indian Ocean Dipole



http://devconsultancygroup.blogspot.kr/2010/08/la-nina-disasters-much-worst-probably.html

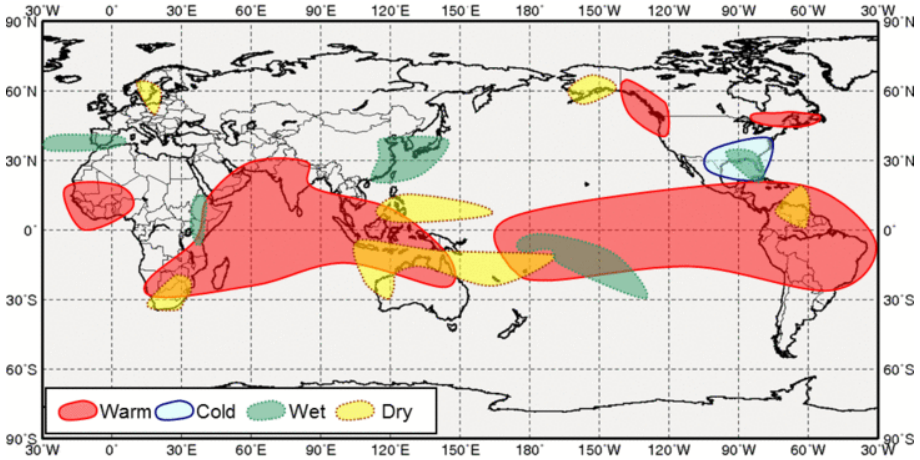
Indian Ocean Basin Mode



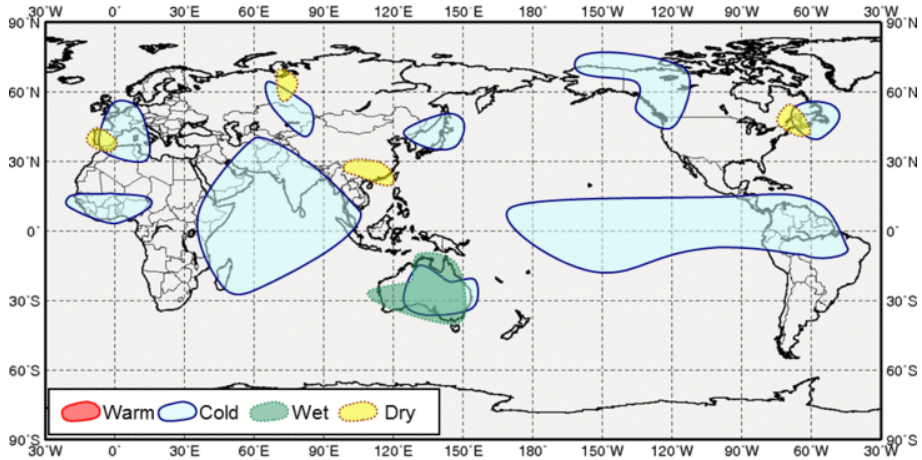
Indian Ocean Basin-wide Mode (IOBM)

Source: TCC, JMA

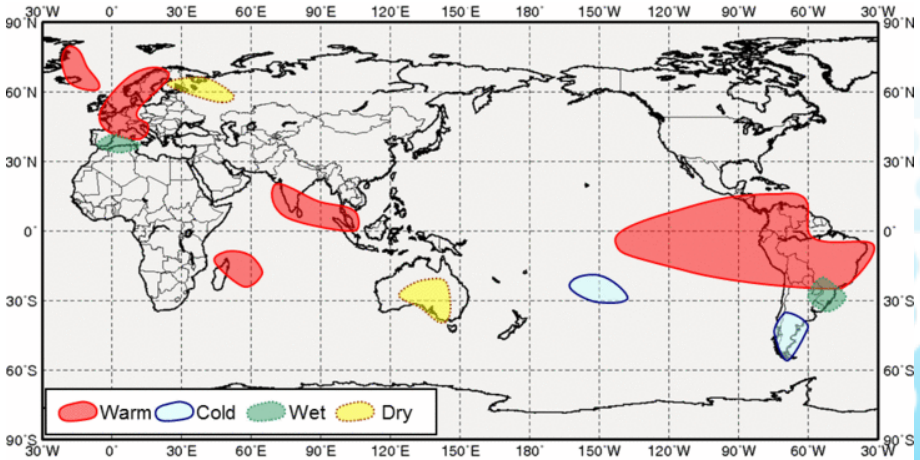
Positive IOBW, DJF



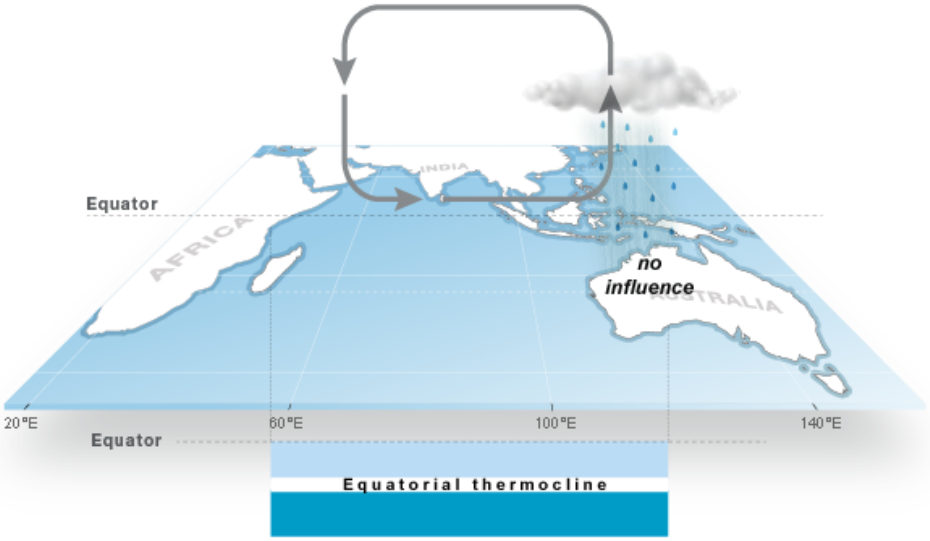
Negative IOBW, SON



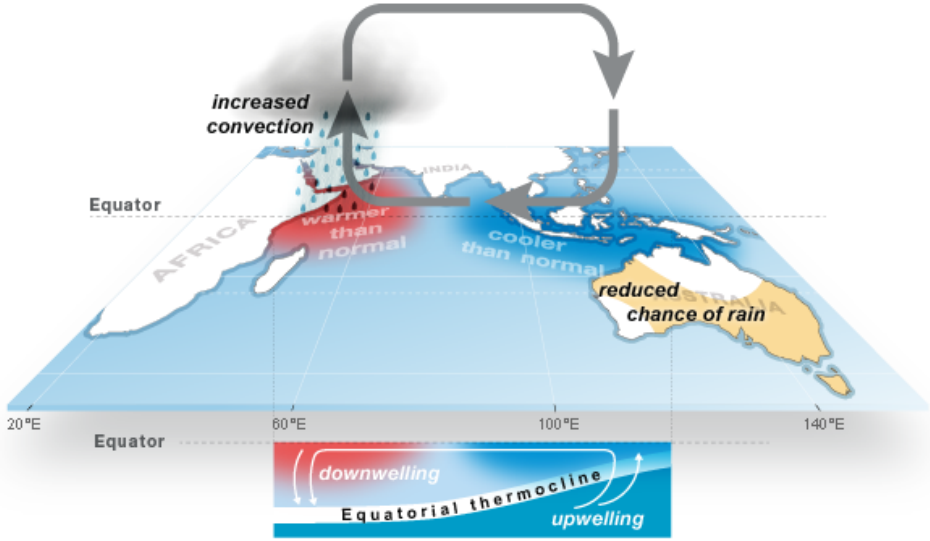
Positive IOBW, SON



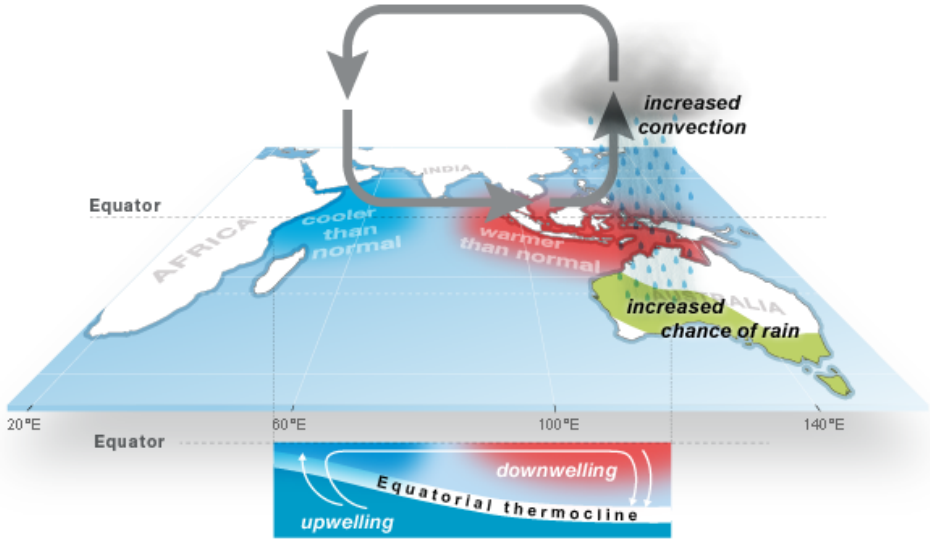
Indian Ocean Dipole (IOD)



Indian Ocean Dipole (IOD): **Neutral phase**



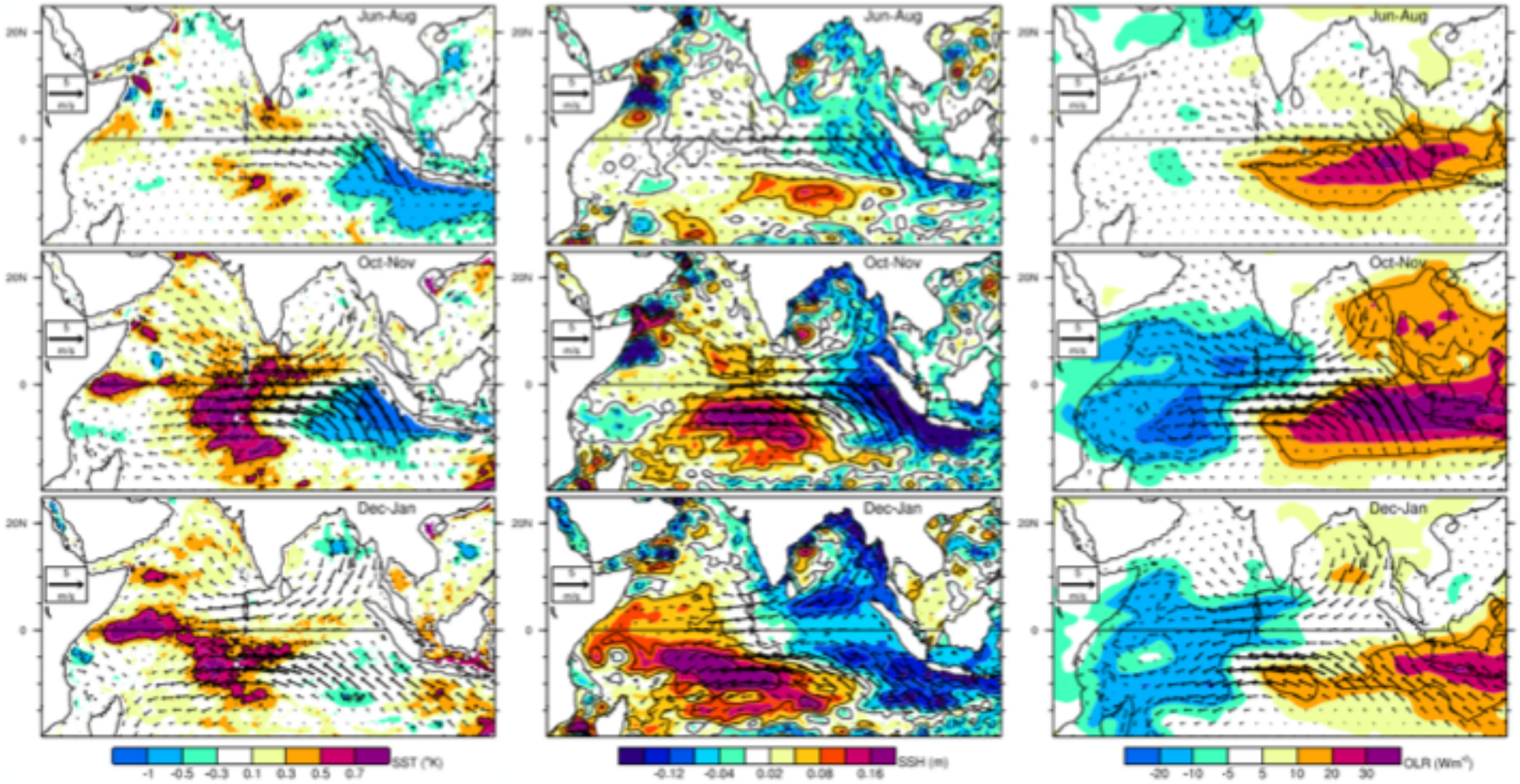
Indian Ocean Dipole (IOD): **Positive phase**



Indian Ocean Dipole (IOD): **Negative phase**

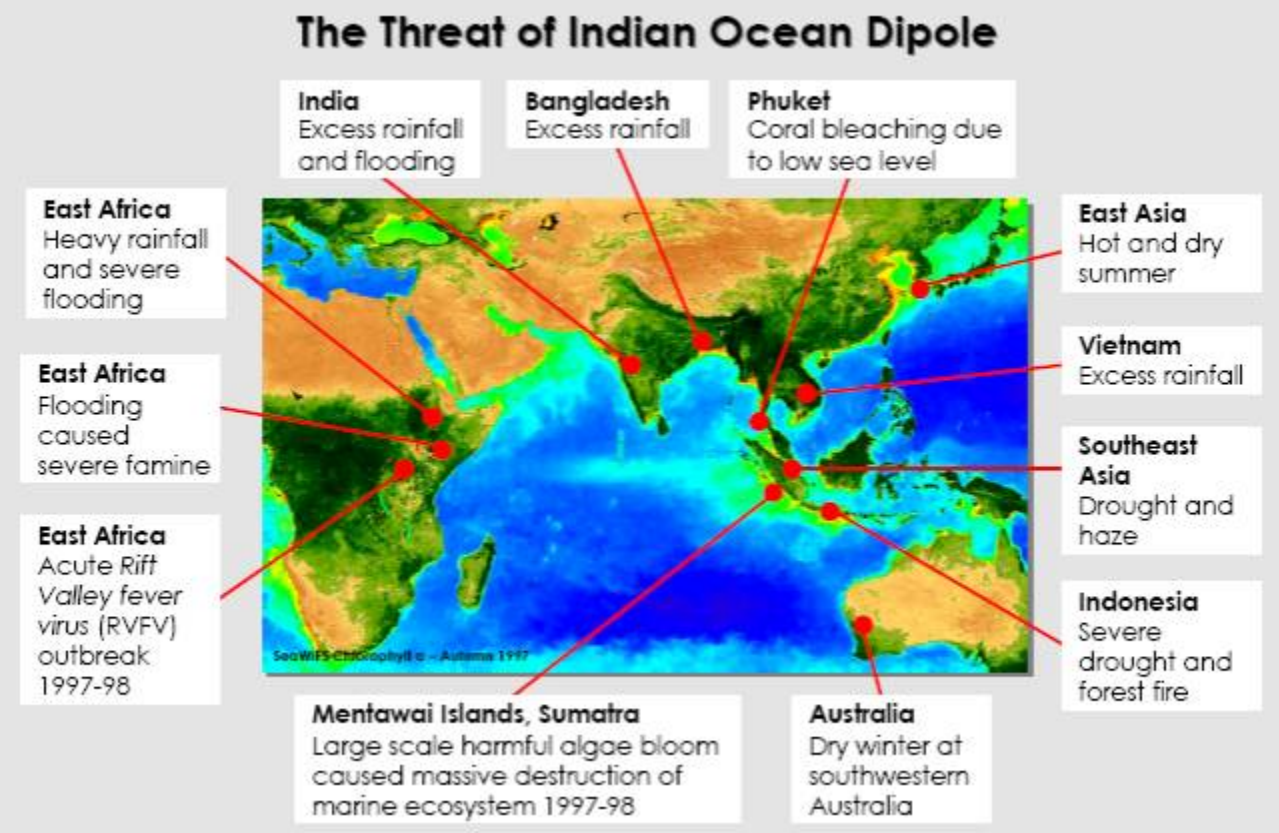
Development of Positive IOD

By Saji N Hameed



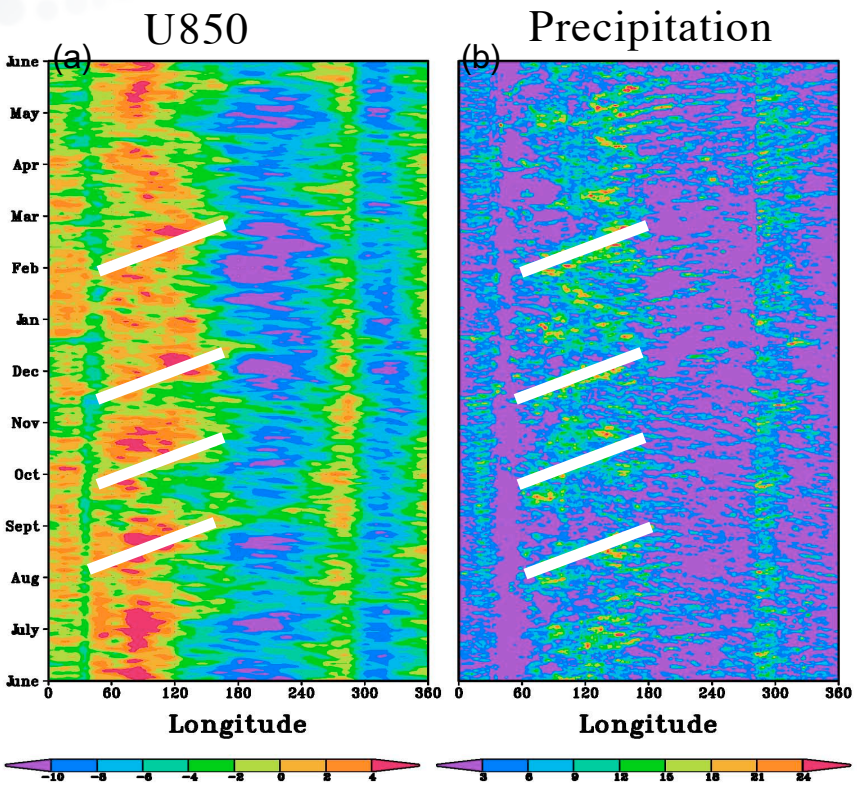
(a) SST (b) SSH (c) OLR

Indian Ocean Dipole (IOD)



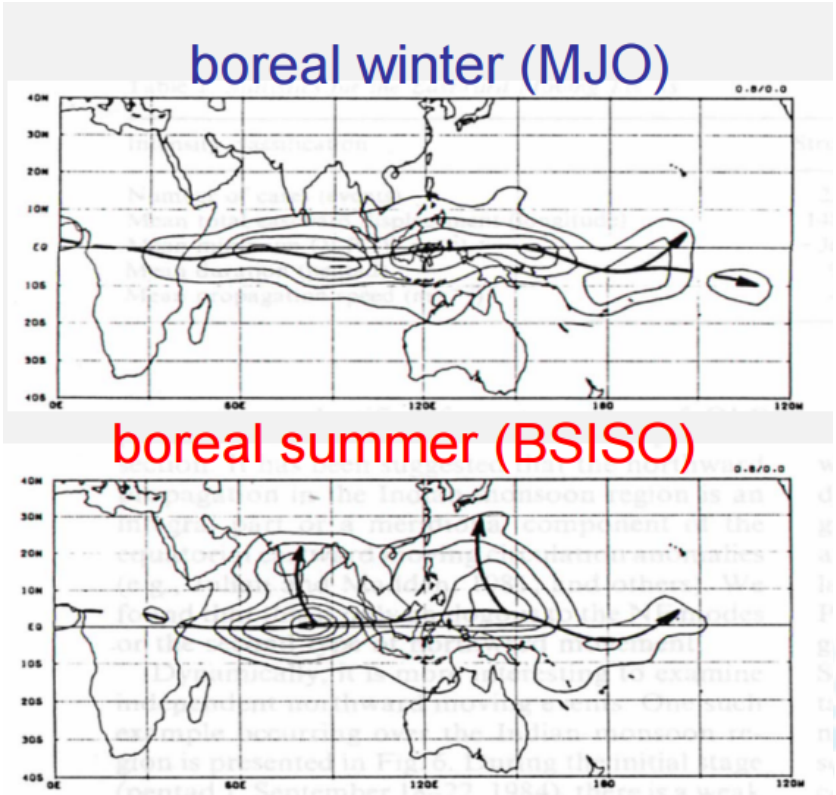
Intra-Seasonal Oscillation (ISO)

Intraseasonal : 20-90



By Ji-Hyun Oh

Northward & Eastward propagation

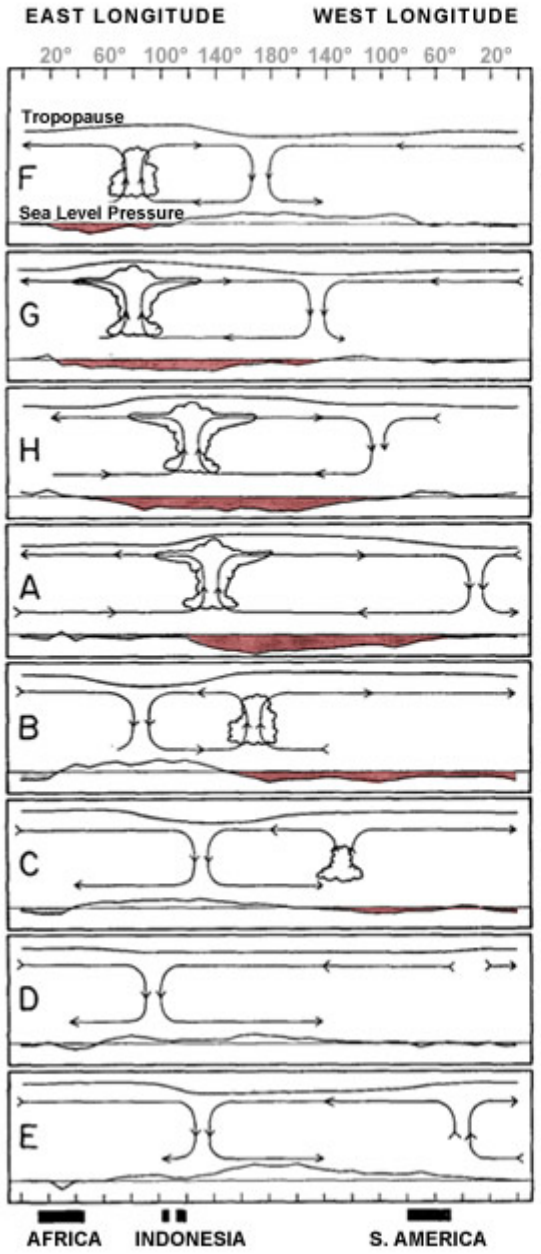


Wang and Rui 1990

Madden Julian Oscillation

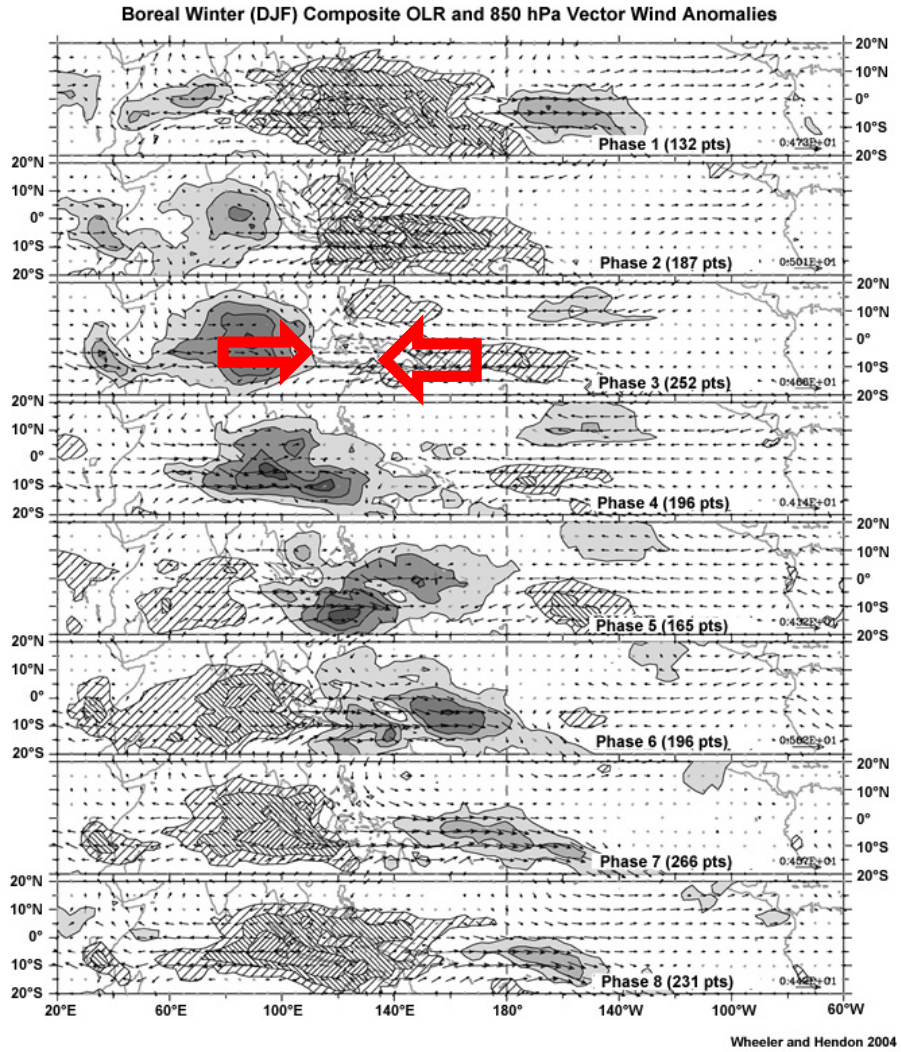
Intraseasonal Oscillation (ISO)
during boreal winter

Intraseasonal: 20-90

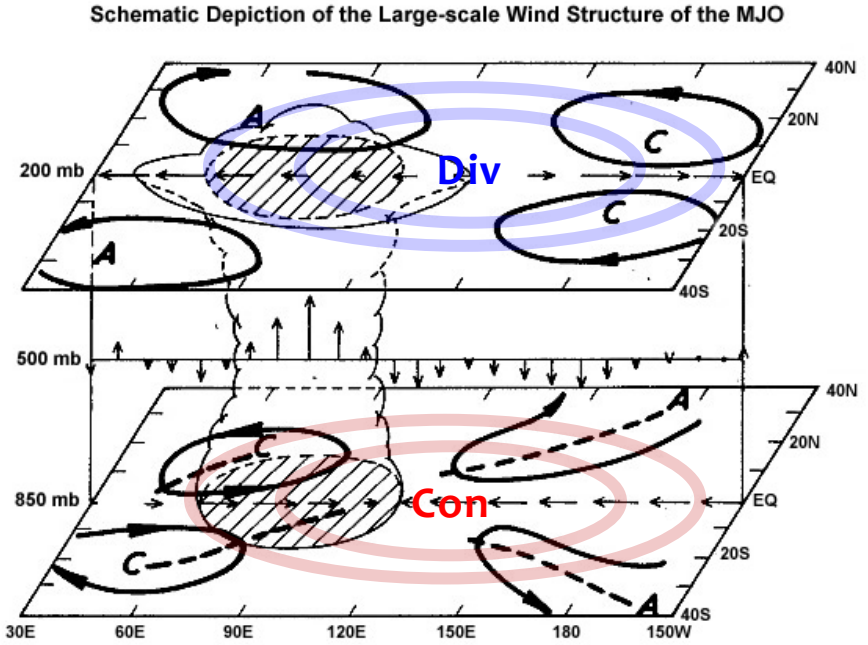


Madden and Julian 1972

MJO (Madden Julian Oscillation)

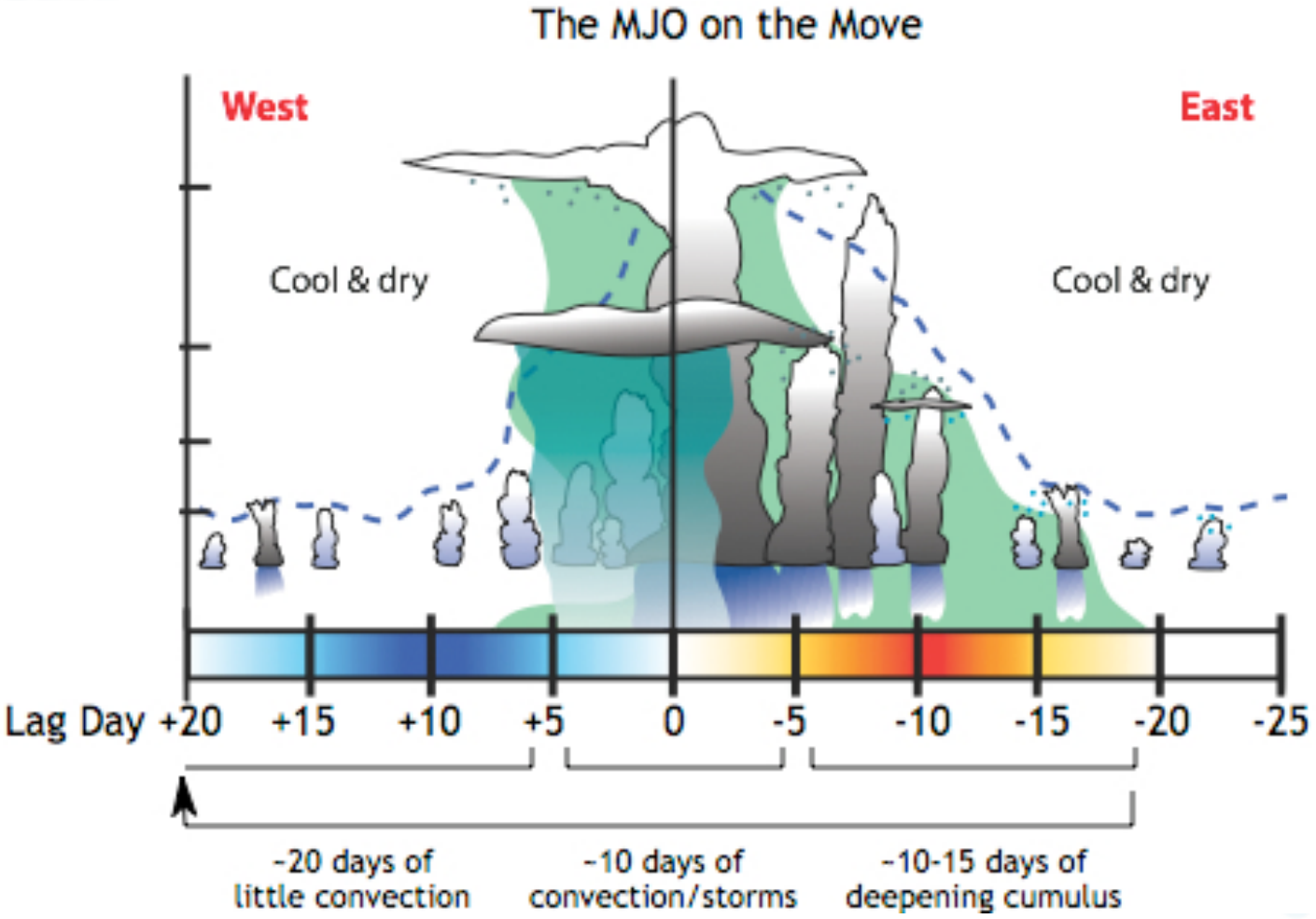


Wheeler and Hendon 2004



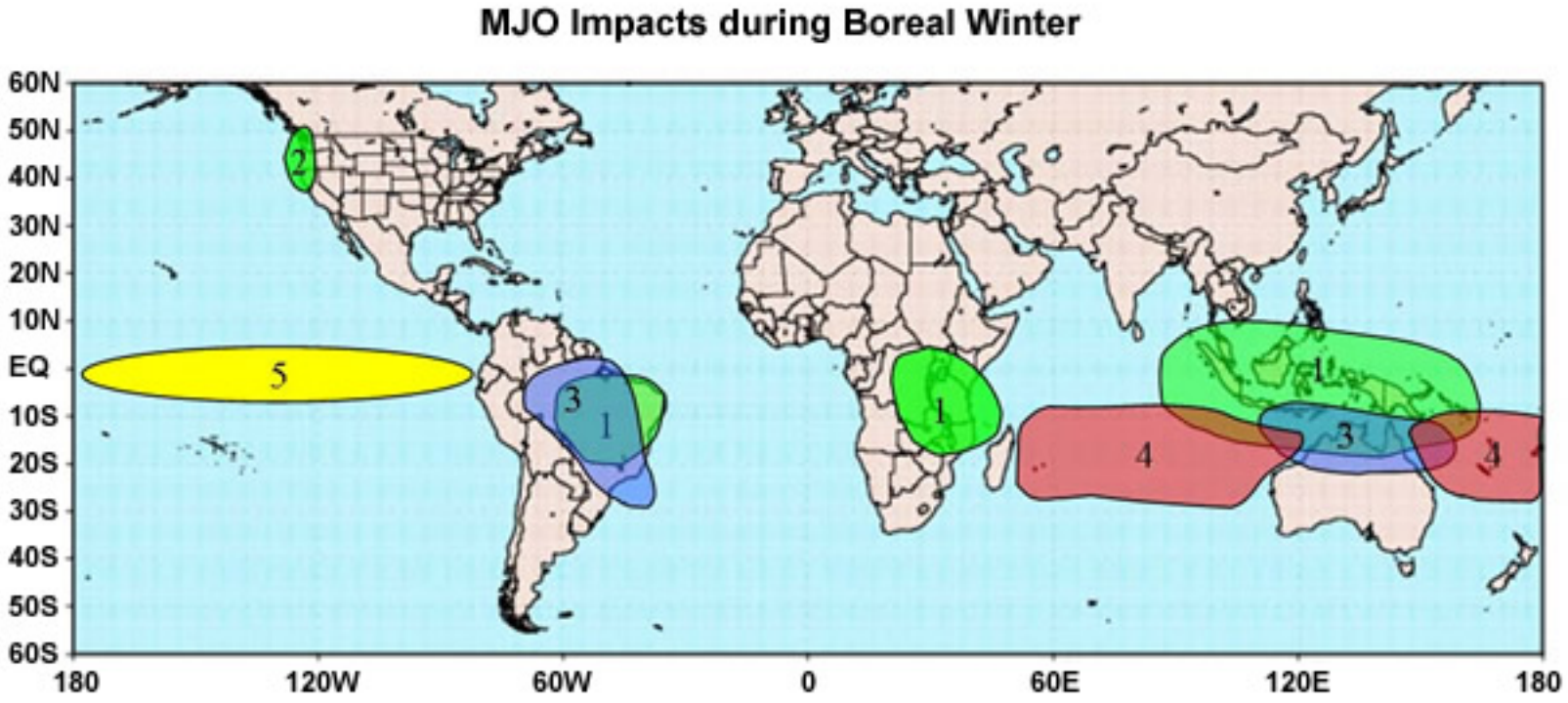
Rui and Wang 1990

MJO (Madden Julian Oscillation)



A schematic of the MJO from cmmap.org

MJO impacts

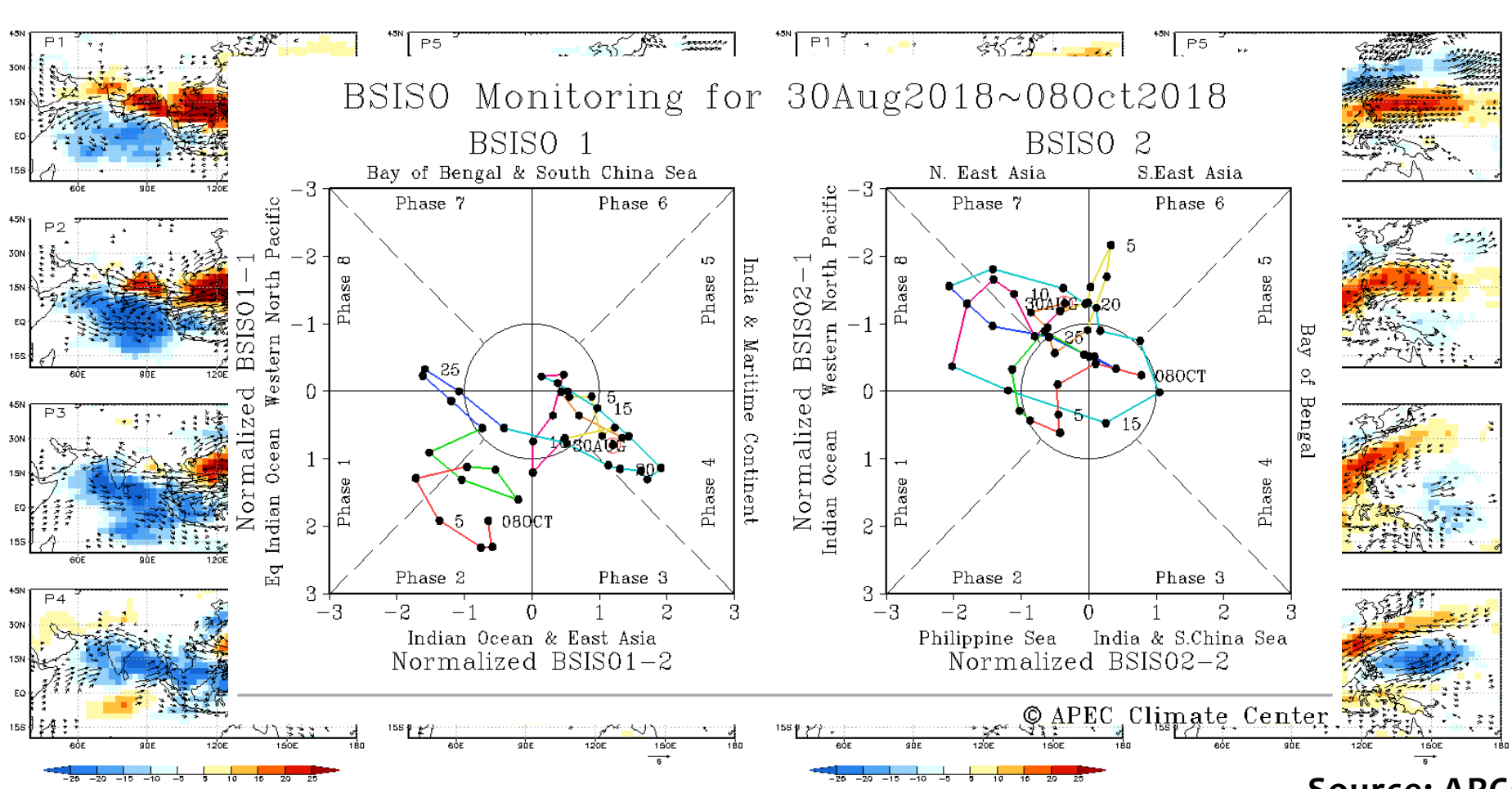


1 - Alternating wet/dry conditions
2 - Tropical moisture plume to higher latitudes
3 - Modulation of monsoon systems
4 - Modulation of tropical cyclone activity
5 - Modulation of ENSO through oceanic Kelvin waves

NOAA / CPC / NCEP / NWS

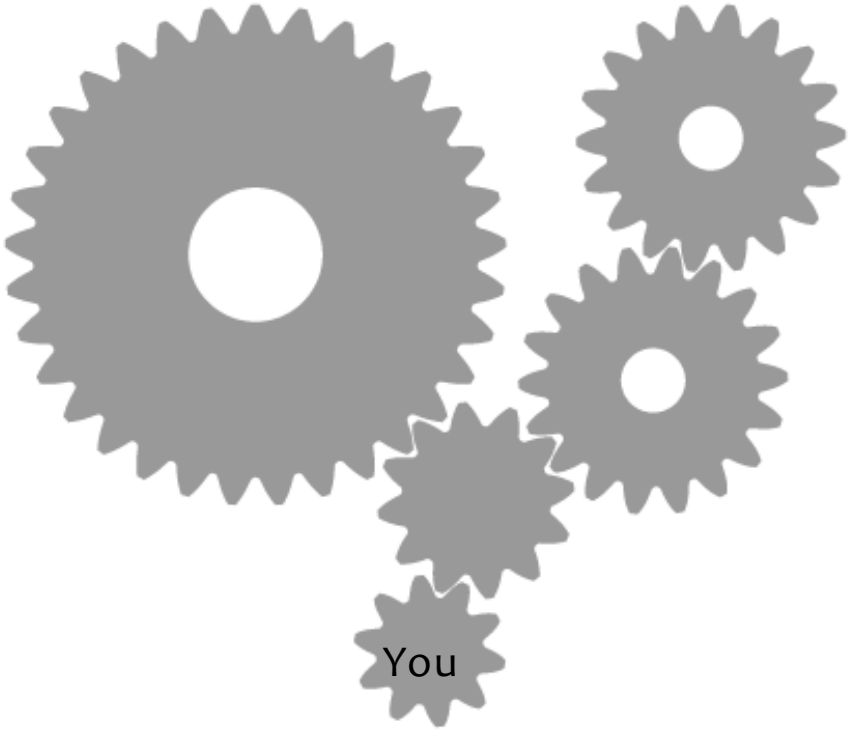
BSISO (Boreal Summer ISO)

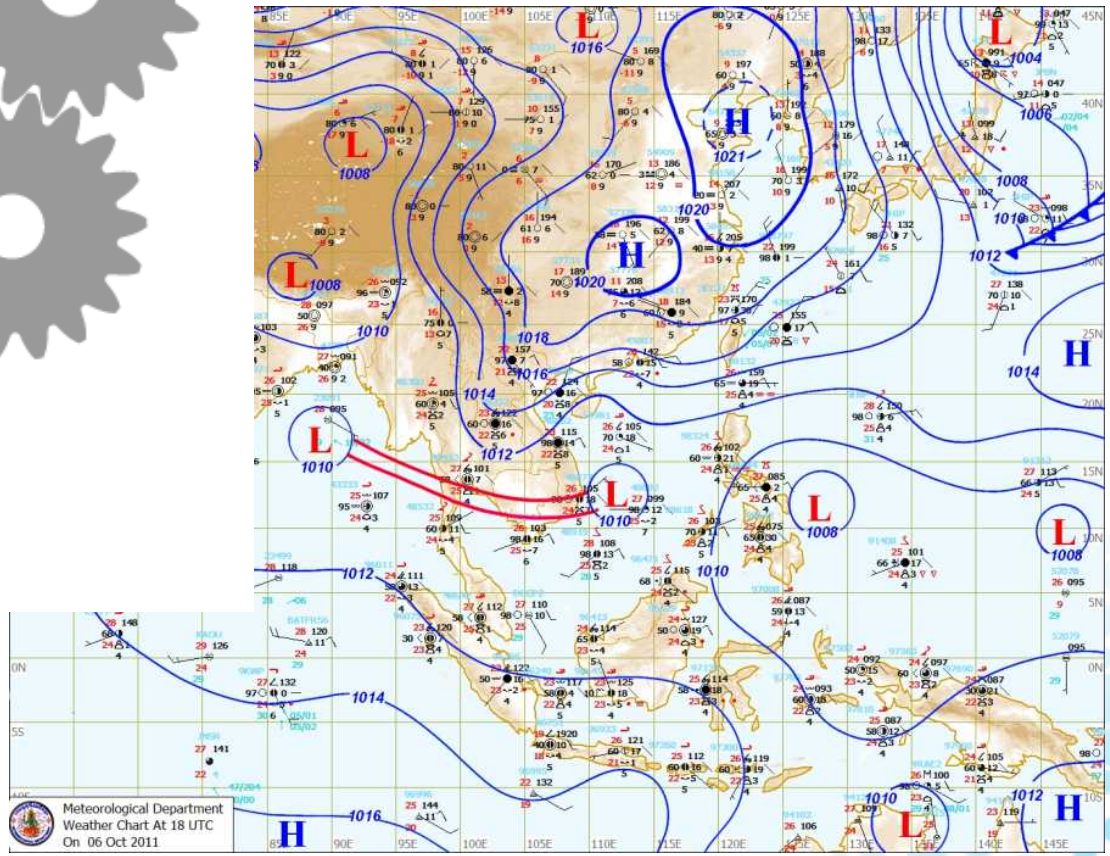
Intraseasonal Oscillation ISO during boreal summer



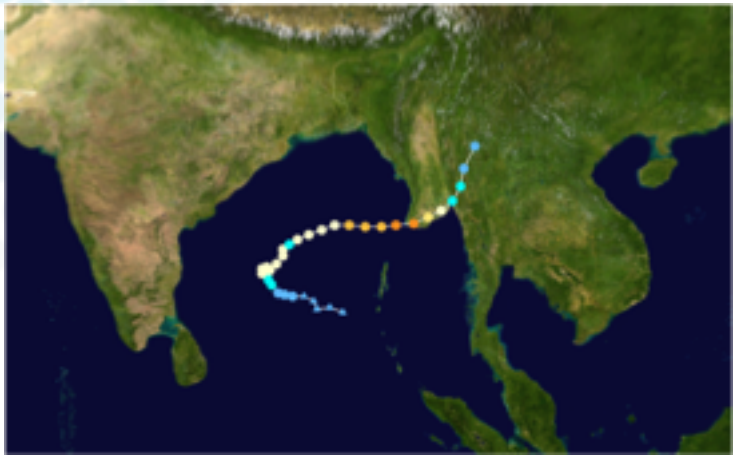
Source: APCC

How they change weather?



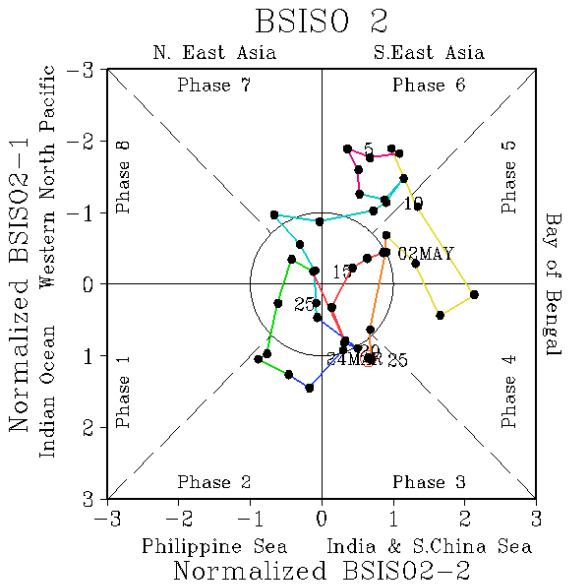


Extreme rainfall (flood)



https://en.wikipedia.org/wiki/Cyclone_Nargis

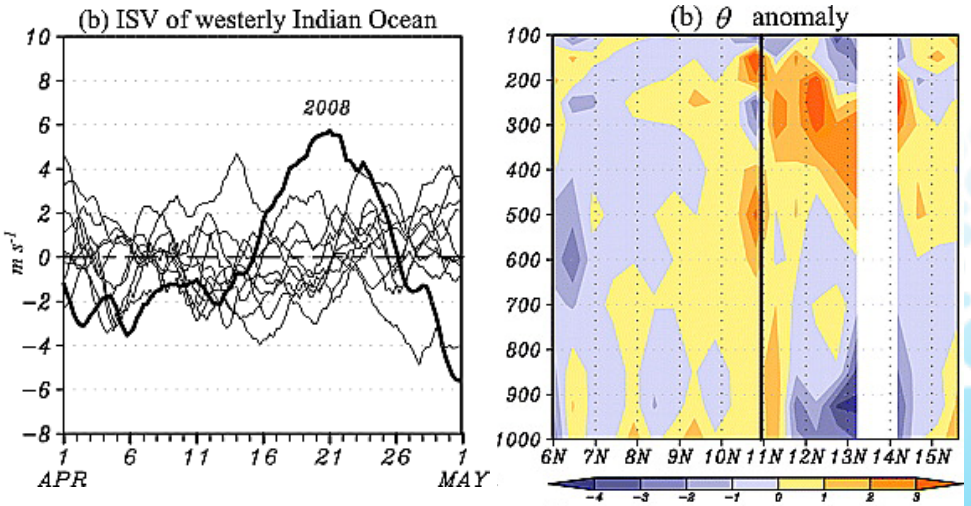
- Tragic Myanmar flood associated with **Cyclone Nargis**!



Source: APCC BSISO monitoring

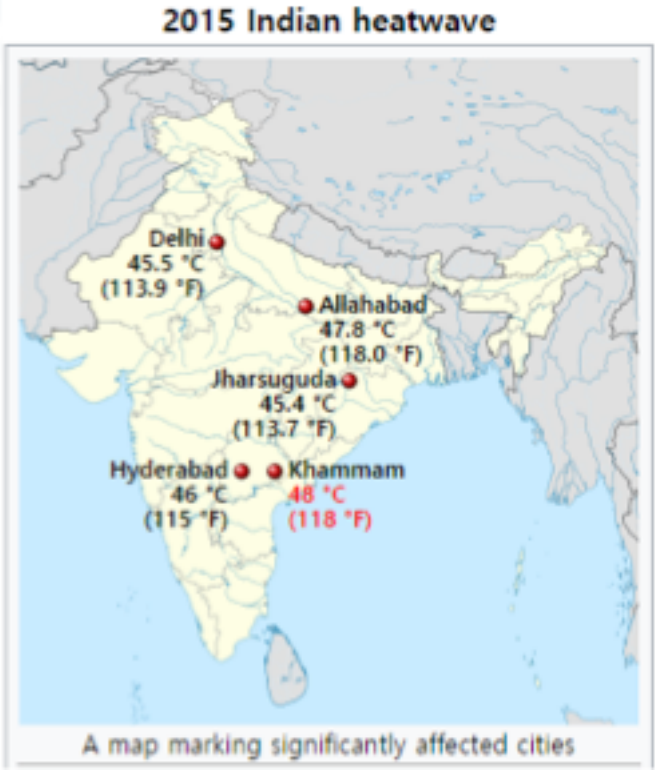
✓ Northward movement of **MJO convection**

Kikuchi, K., B. Wang, and H. Fudeyasu (2009), Genesis of tropical cyclone Nargis revealed by multiple satellite observations, Geophys. Res. Lett., 36, L06811, doi:10.1029/2009GL037296.

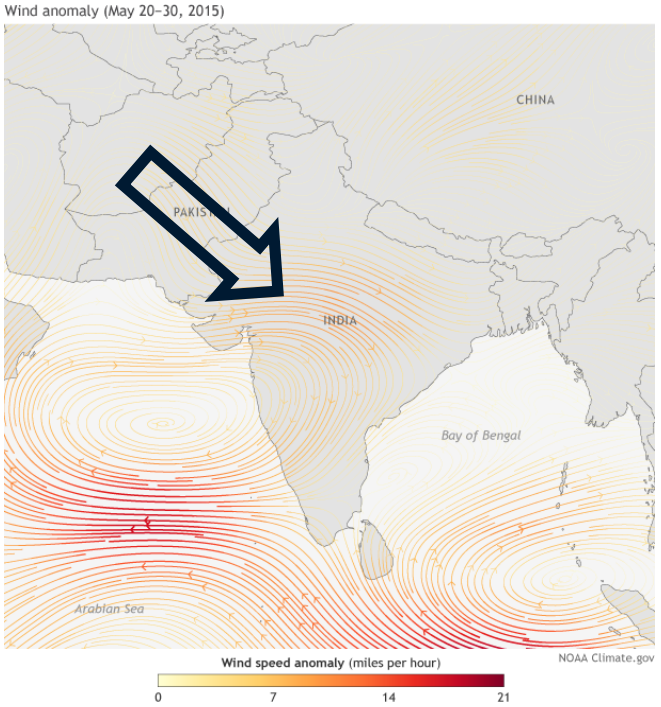


Heat waves

- 2015 India heat wave



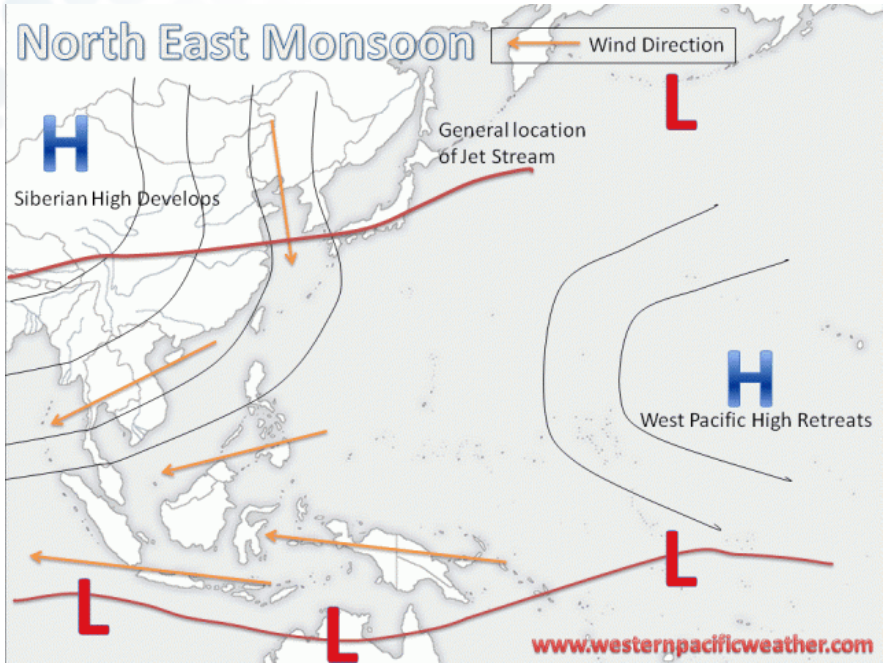
-“**Heat Bomb**” : unusual northwesteries → sparse showers and their sudden end during pre-monsoon season (before June)



- El Nino effect?

Cold surge

- Outbreak of Siberian cold air



The Extreme Cold Anomaly over Southeast Asia in February 2008: Roles of ISO and ENSO*

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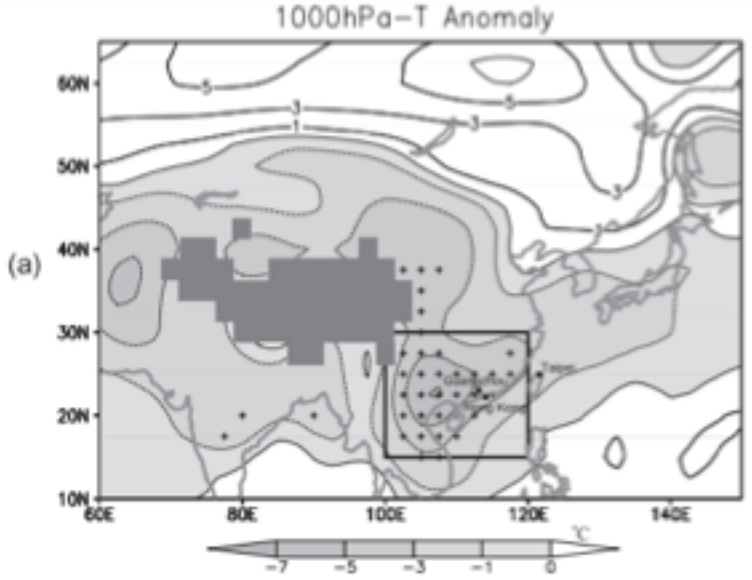
TIM LI

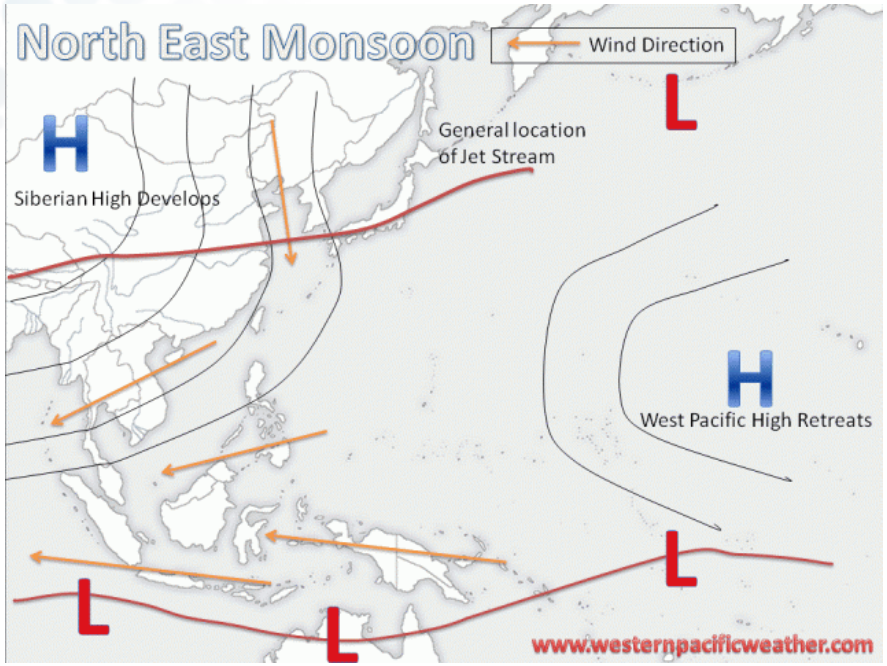
International Pacific Research Center/School of Ocean and Earth Science and Technology, University of Hawaii at Manoa, Honolulu, Hawaii

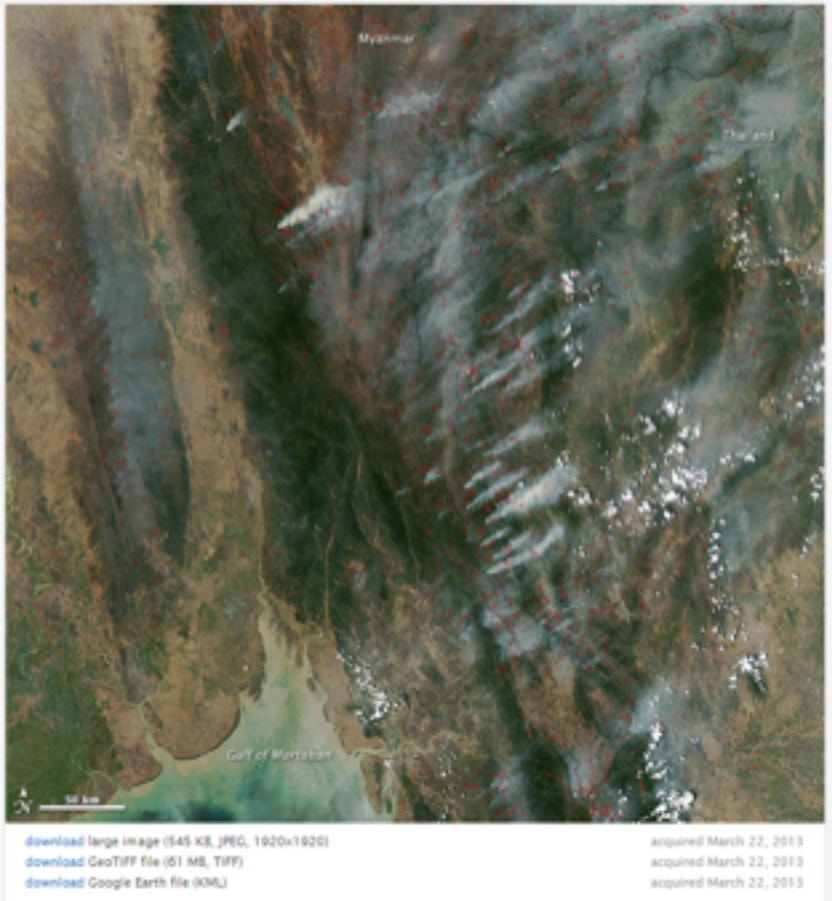
(Manuscript received 30 September 2008, in final form 12 January 2009)



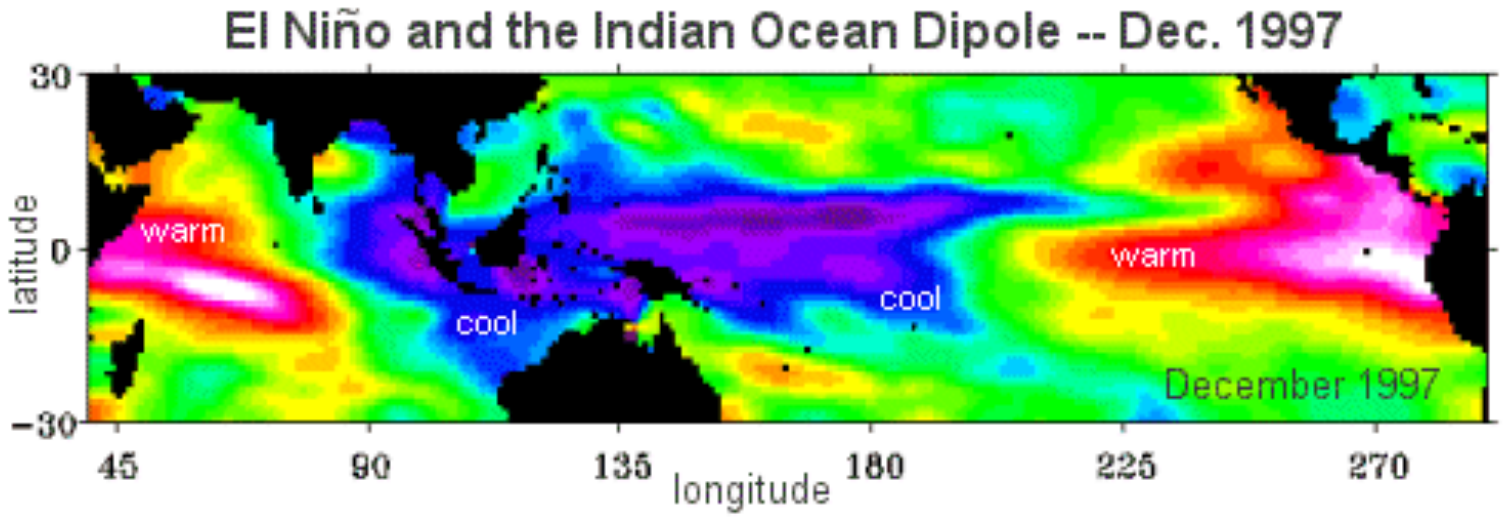
Dry spell (wildfire)

- Outbreak of Siberian dry air + dry monsoon (Nov-Mar)

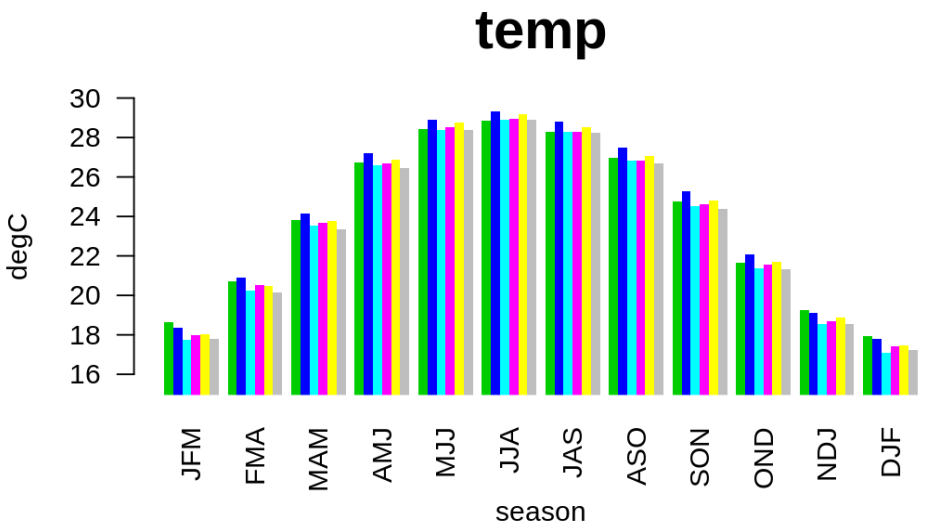


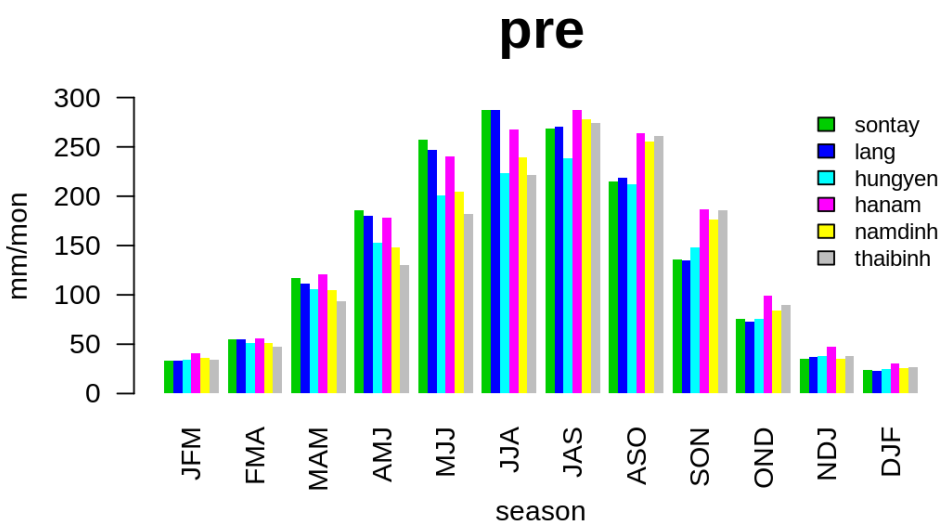


ENSO + IOD

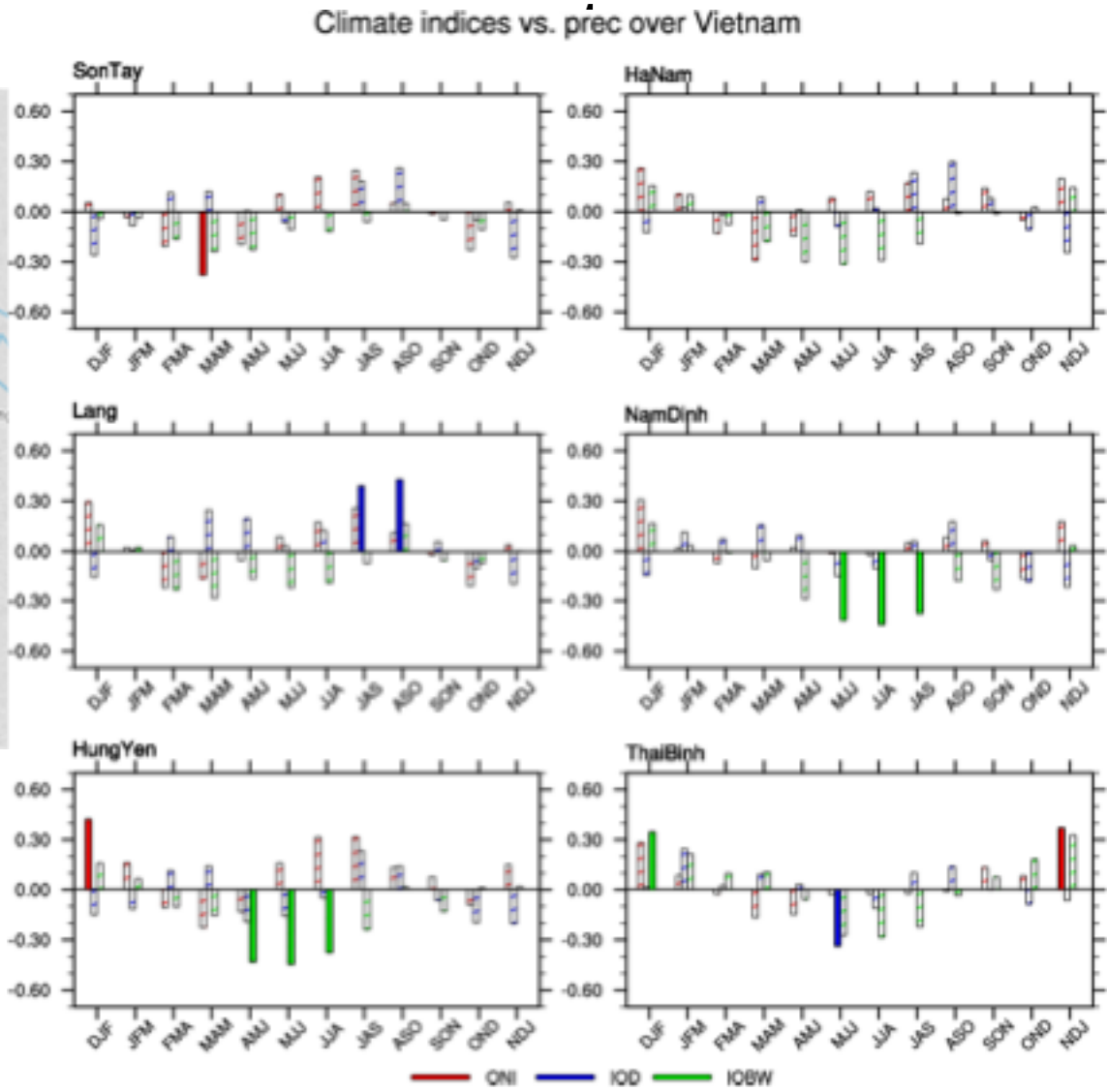

El Niño and the Indian Ocean Dipole -- Dec. 1997
30
0
−30
latitude
warm
cool
cool
warm
December 1997
45
90
135
180
225
270
longitude

Northern Vietnam



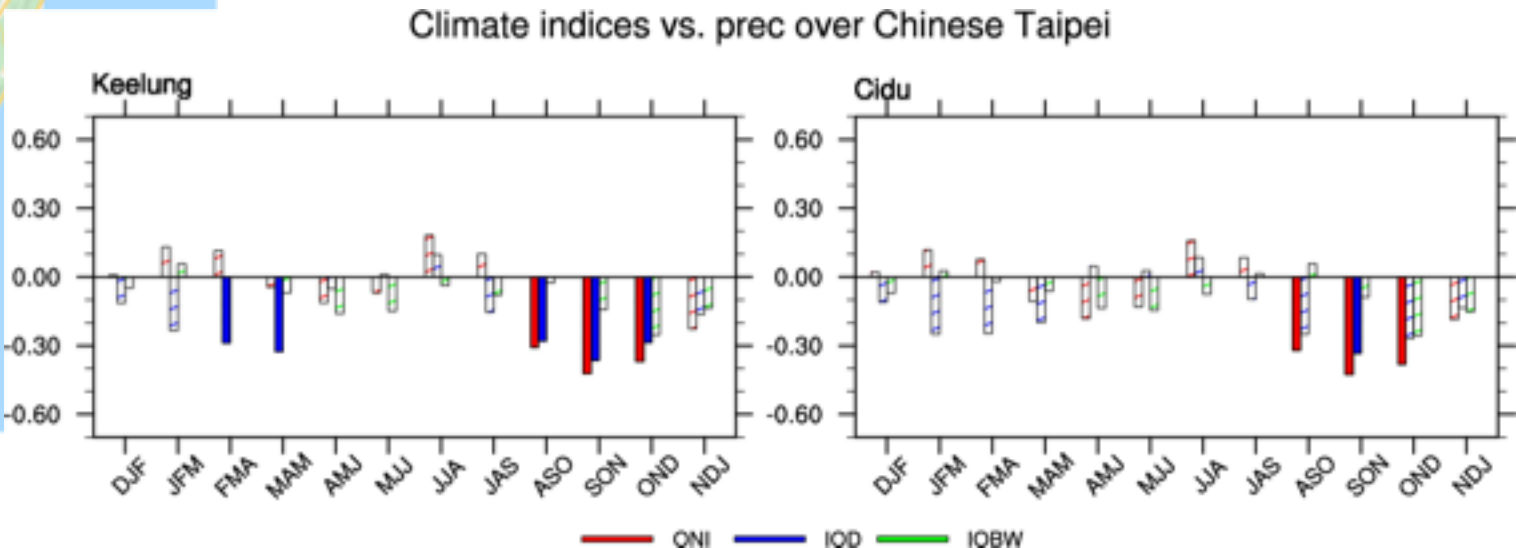


Northern Vietnam



TAIWAN


Taipei
台北
Hsinchu City
新竹市
Taichung City
Taiwan
臺灣
Hualien
County
花蓮縣
Taiwan
Tainan City
Kaohsiung
City


Climate indices vs. prec over Chinese Taipei
Keelung
Cidu
0.60
0.30
0.00
-0.30
-0.60
DJF
JFM
FMA
MAM
AMJ
MJJ
JJA
JAS
ASO
SON
OND
NDJ
ONI
IOD
IOBW