Super El Nino event and its impacts on climate in China in spring and summer

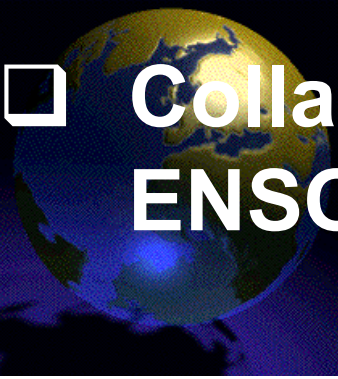
Yimin Liu, Anmin Duan, Jiangyu Mao,
Rongcai Ren, Yajun Hu

LASG, Institute of Atmospheric Physics (IAP), CAS, China

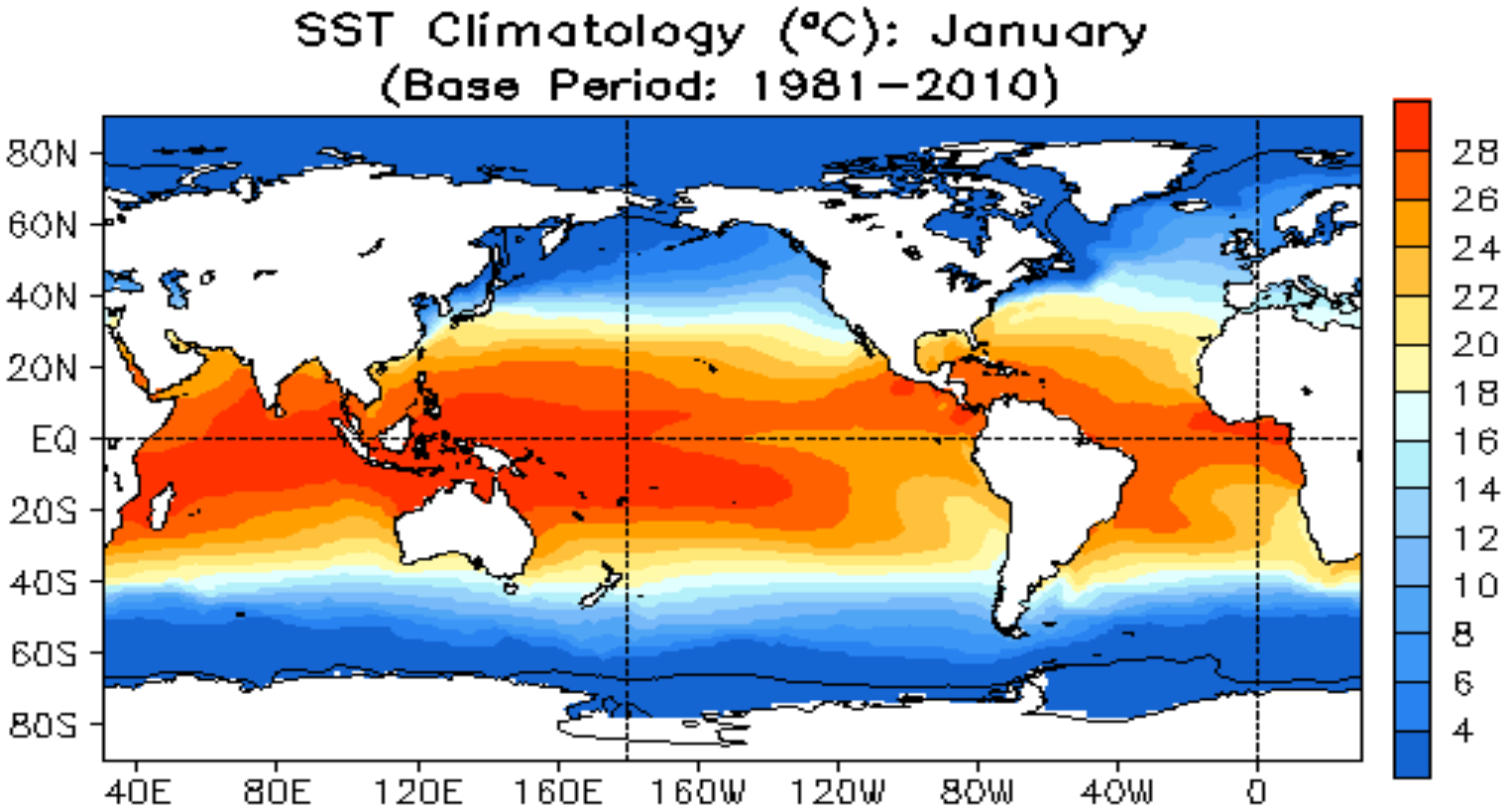
TTA, ITCP August 1 2017

Outline

- Introduction
- General physics of the ENSO Impacts on circulation
- Indian ocean SSTA associated with ENSO
- Impacts on the rainfall in spring in China
- Impacts on the rainfall in summer in China
- Collaborative influence of the PDO and ENSO

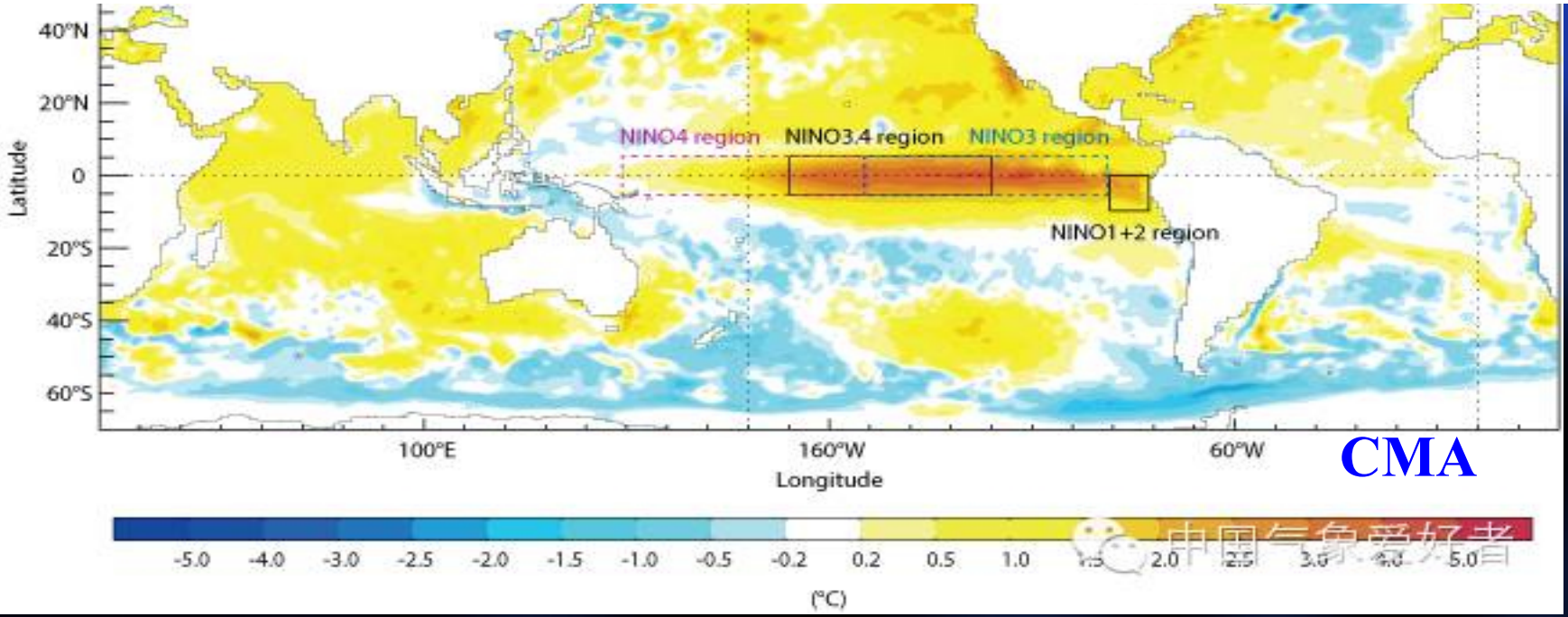


Introduction



El Nino in 2015/2016

SSTA, Nov. 2015 compared to 1981-2009 average

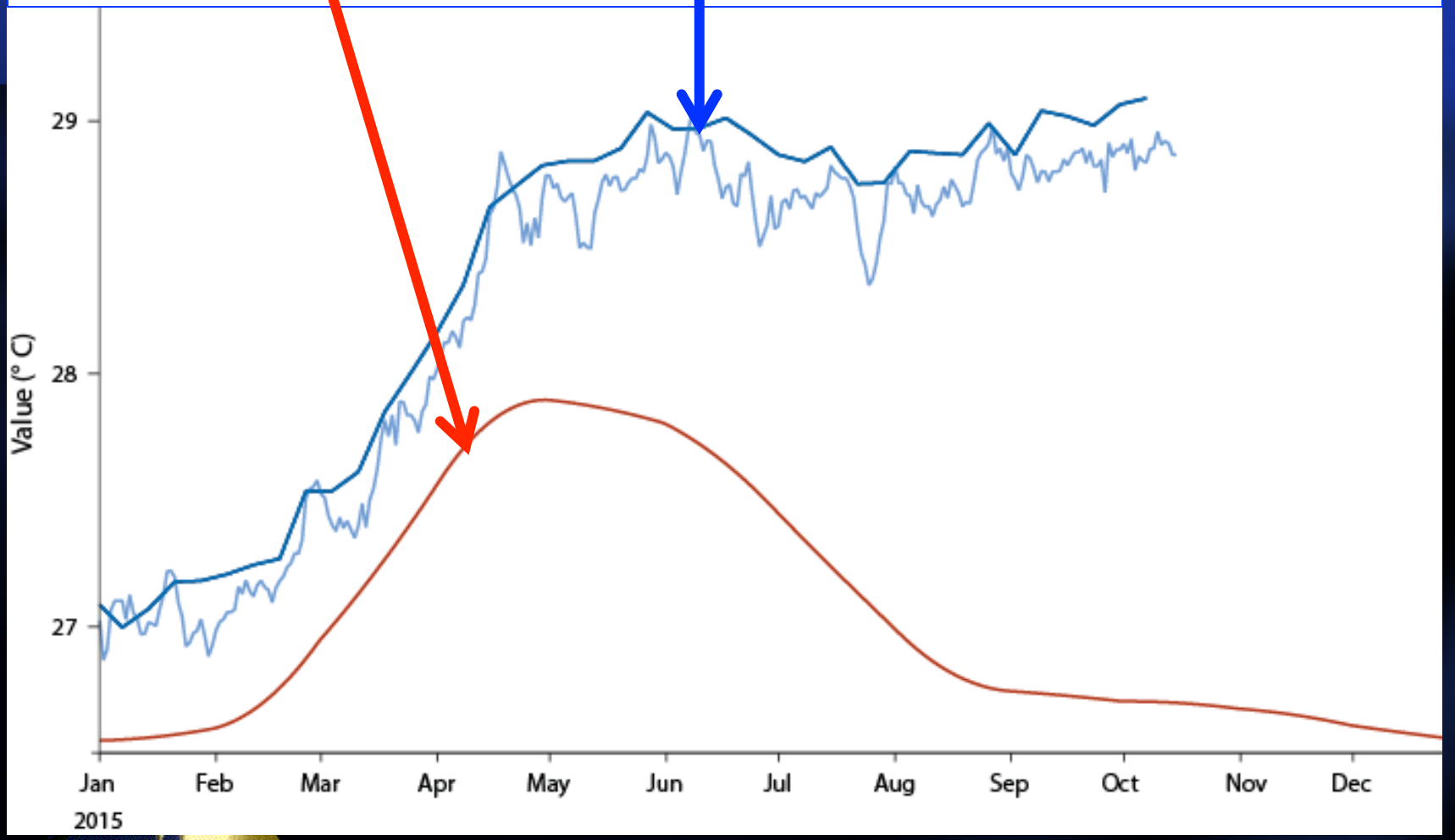


SSTA index for ENSO:

Mean of SSTA of 5N- 5S: NINO4 (160E-150W), NINO3.4（170W-120W), NINO3 (150W-90W)

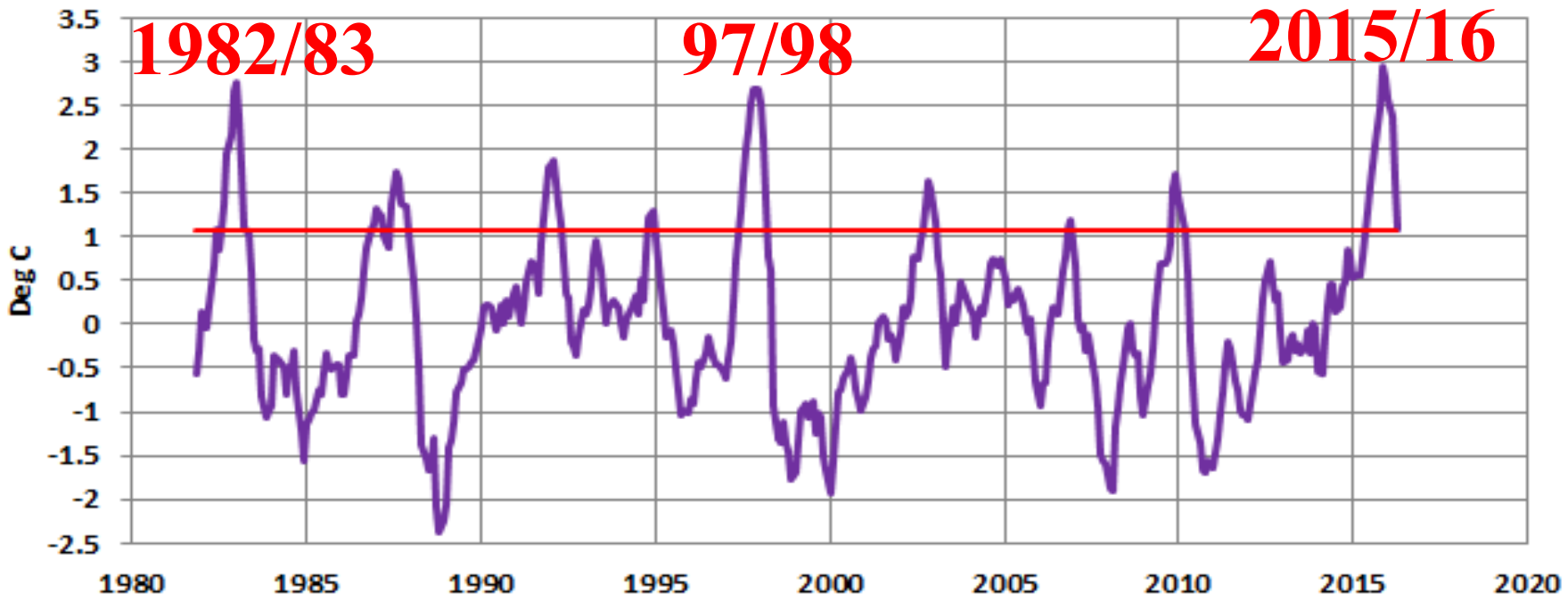
NINO1+2 (10S-EQ, 90W-80W)

1981-2010 SST & 2015 SST over NINO3.4 region



ECMWF

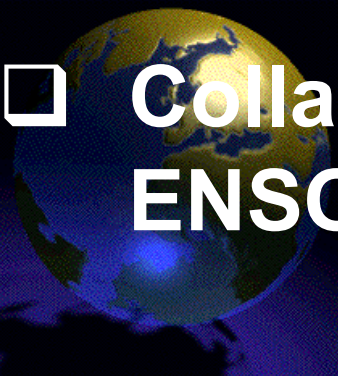
NINO3.4 Sea Surface Temperature Anomalies
(Reynolds OI.v2 through KNMI Climate Explorer)
Current Value = +1.08 Deg C
Nov 1981 to Apr 2016
Change: Apr 2016 Minus Mar 2016 = -0.59 Deg C

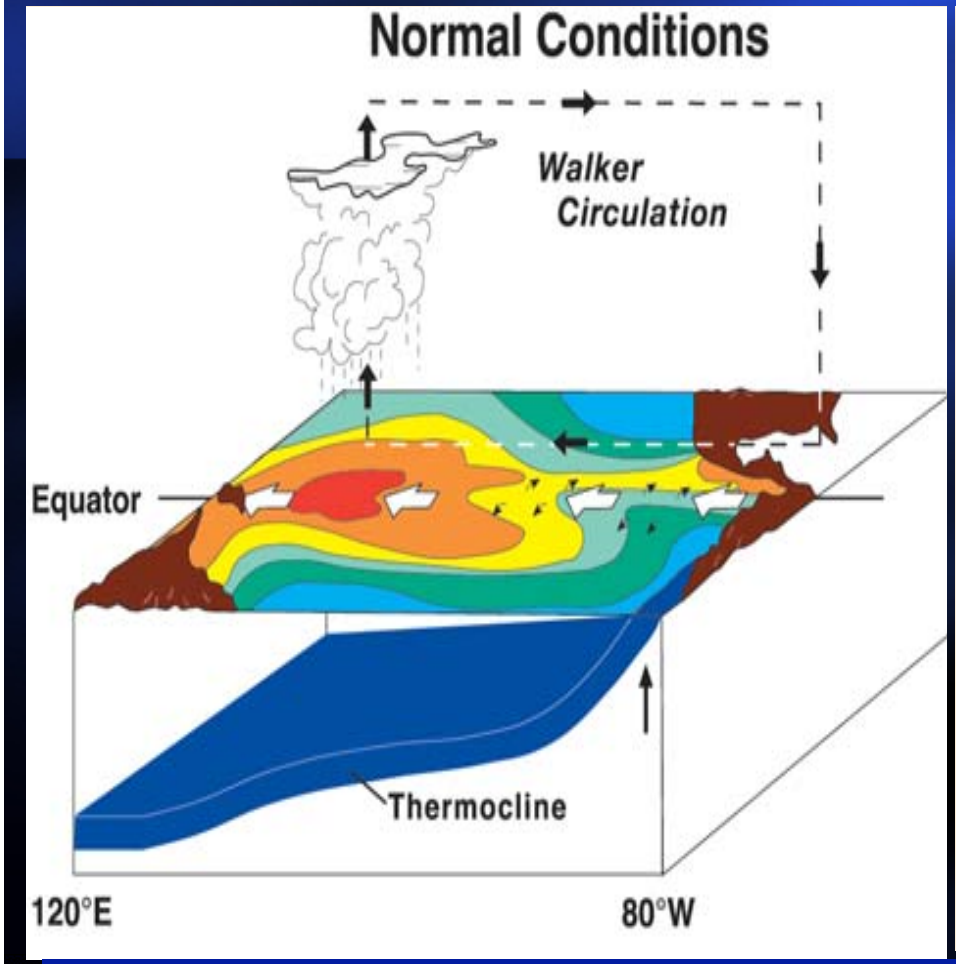


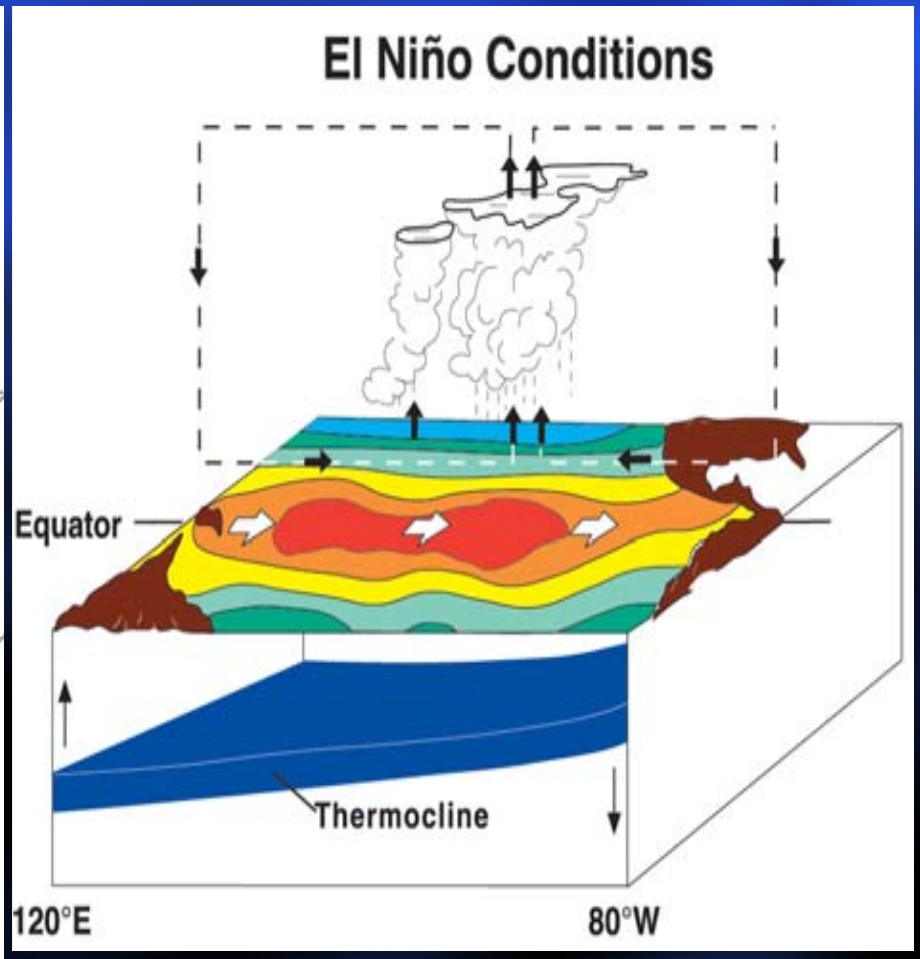
Bob Tisdale

Outline

- Introduction
- General physics of the ENSO Impacts on circulation
- Indian ocean SSTA associated with ENSO
- Impacts on the rainfall in spring in China
- Impacts on the rainfall in summer in China
- Collaborative influence of the PDO and ENSO

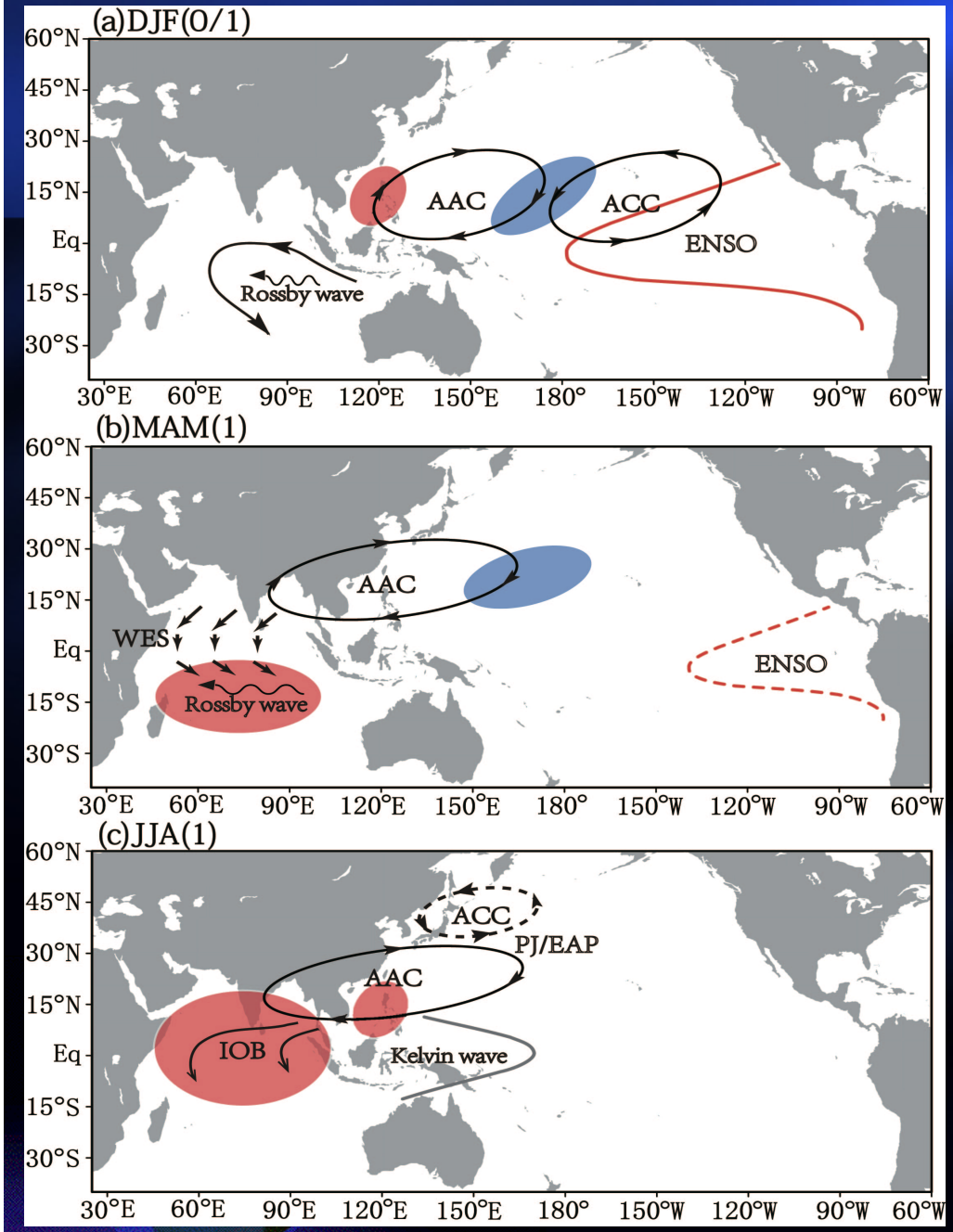






Thermocline: a thin but distinct layer in which the temperature changes more rapidly with depth that above and below

Wagg, Geography



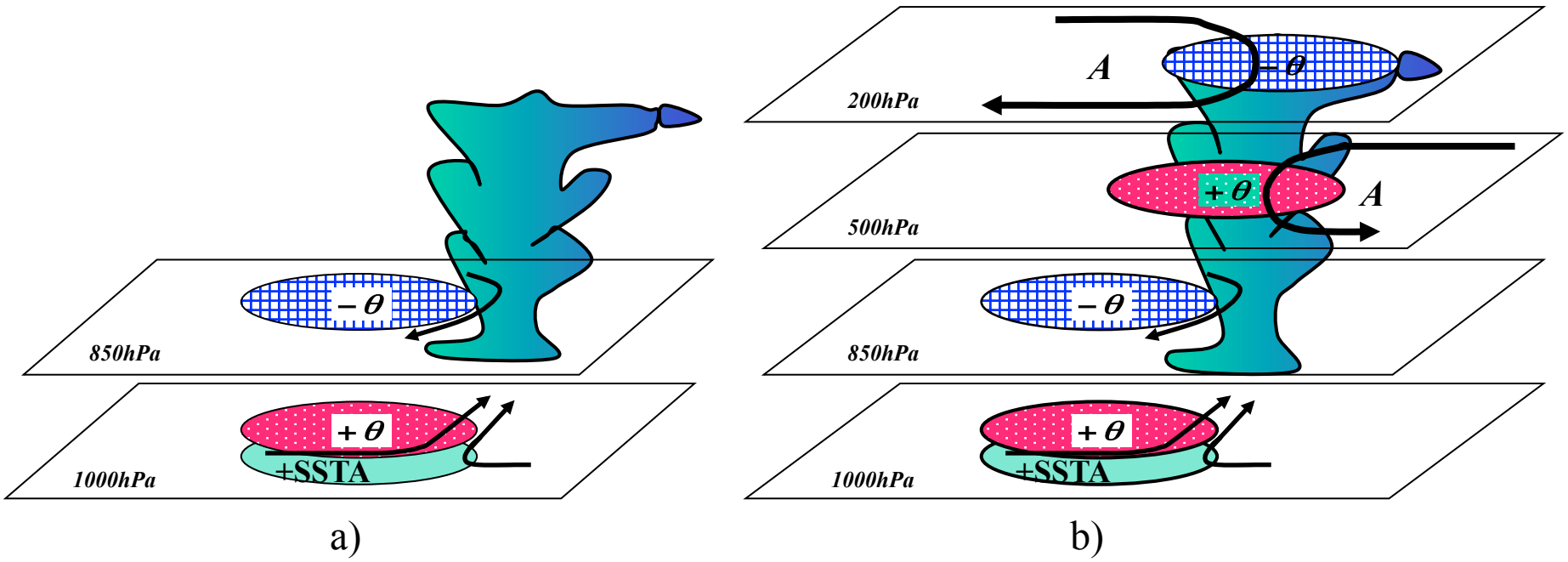
Schematic representation of atmospheric teleconnection

DJF: El Nino impacts on the South Indian Ocean (IO) through westward Rossby waves

MAM: Rossby waves inducing Southwest IO warming, which in turn induces an anti-symmetrical wind pattern over the tropical IO

JJA: 2nd IO warming exciting a tropospheric Kelvin wave propagating into the western Pacific, forcing the AAC and PJ/EAP pattern to affect East Asia during the following JJA

Xie et al (2016)



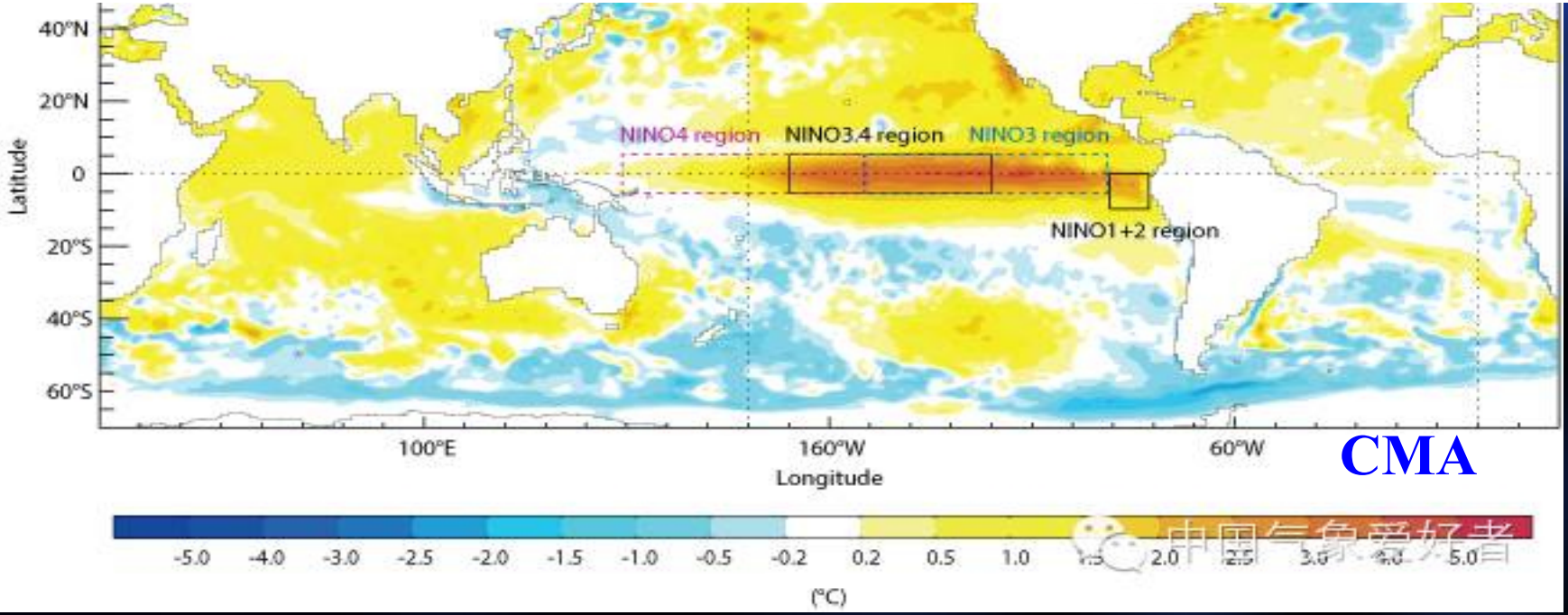
a) b)

“ Two-stage thermal adaptation” of the atmospheric circulation to the SSTA in the northern Indian Ocean

Wu et al. (2000)

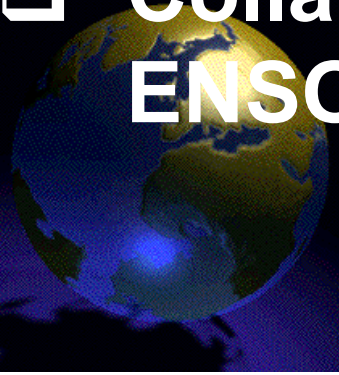
El Nino in 2015/2016

SSTA, Nov. 2015 compared to 1981-2009 average



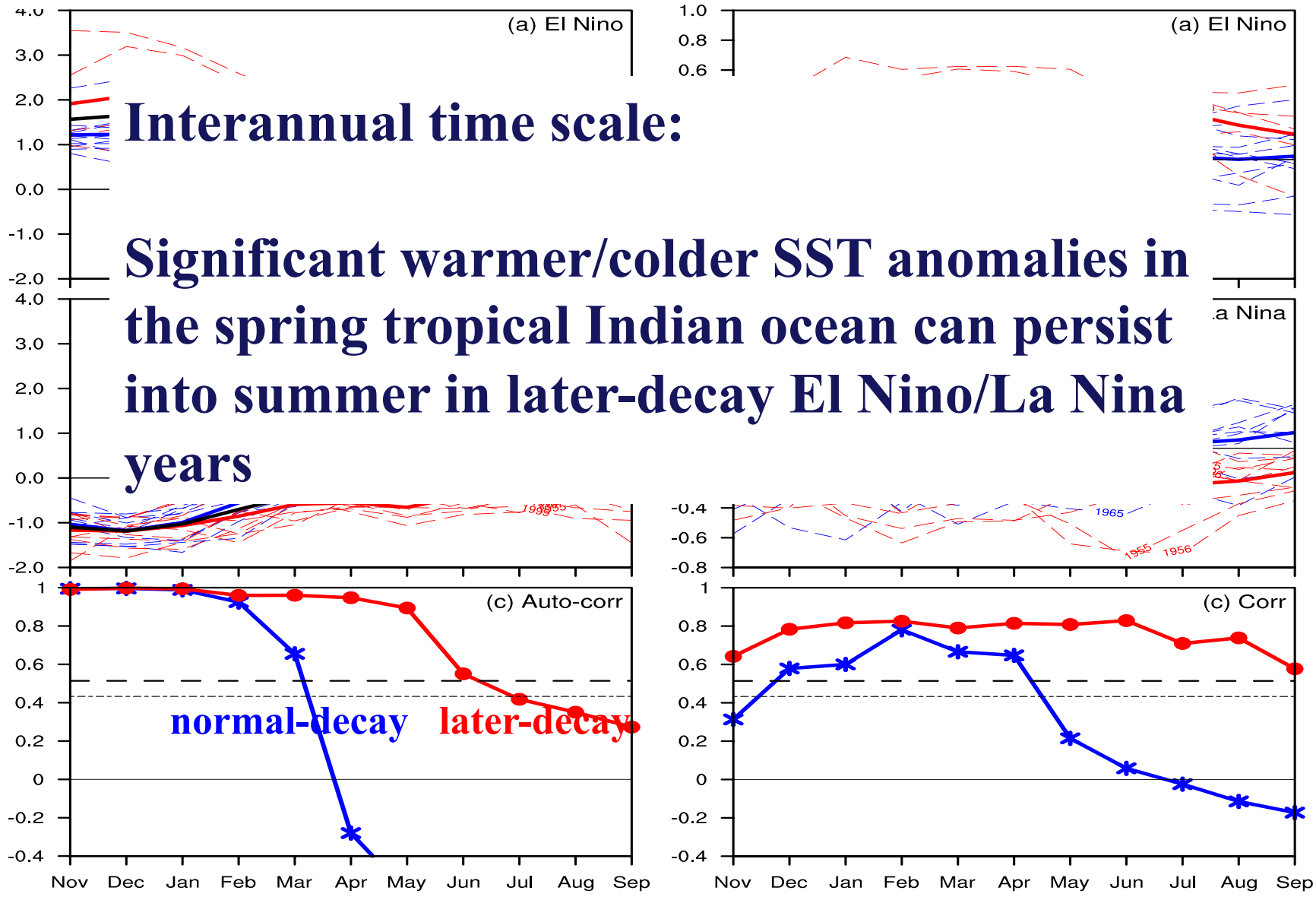
Outline

- Introduction to El Nino
- General physics of the ENSO Impacts on circulation
- Indian ocean SSTA associated with ENSO
- Impacts on the rainfall in spring in China
- Impacts on the rainfall in summer in China
- Collaborative influence of the PDO and ENSO



Nino3 index for normal-decay and later-decay

IOBI for ENSO normal-decay and later-decay



Interannual time scale:

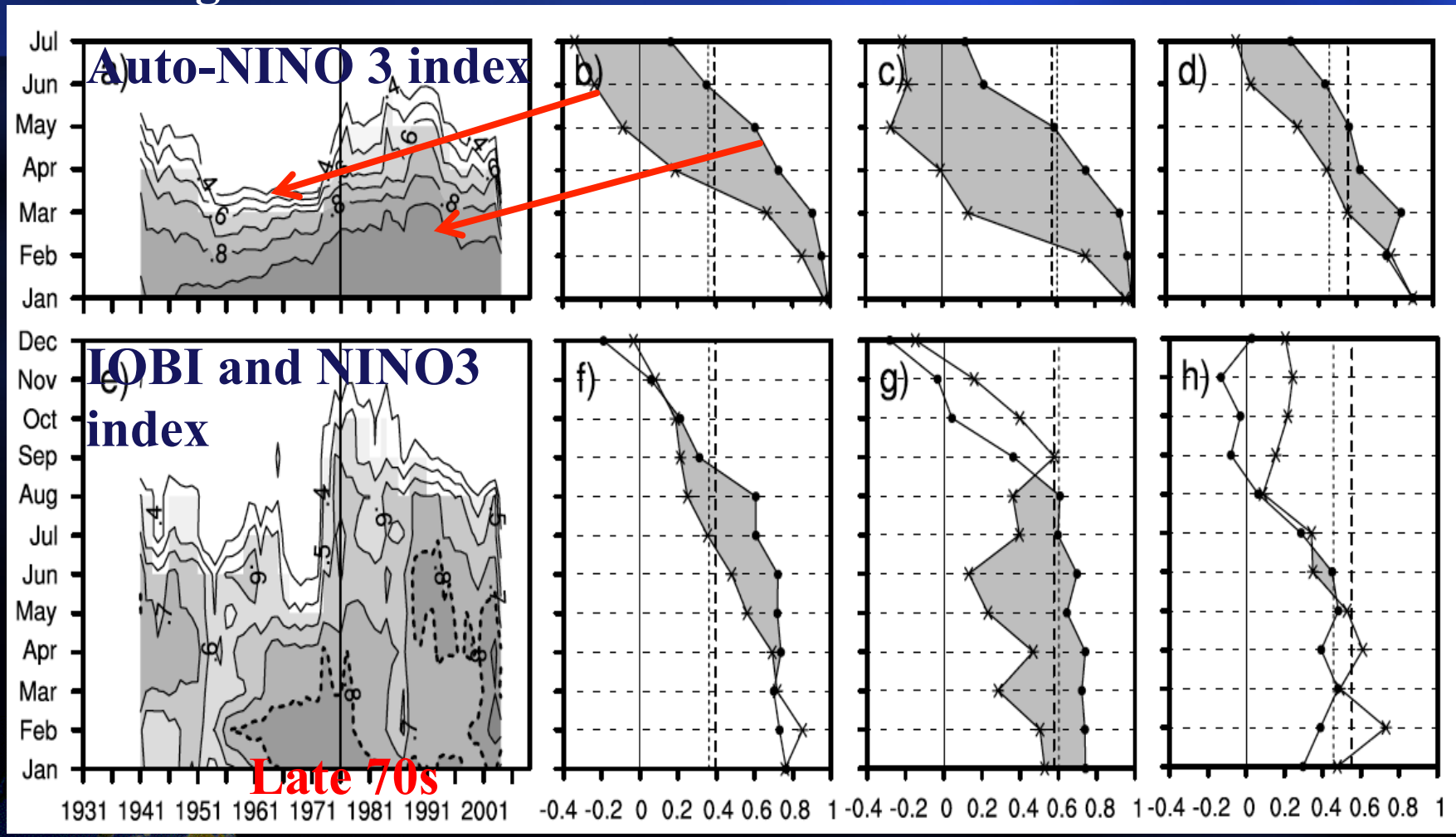
Significant warmer/colder SST anomalies in the spring tropical Indian ocean can persist into summer in later-decay El Nino/La Nina years

Ren et al., 2016

Decadal time scale

NINO 3 index
Running Correlation

All Years Warm Events Cold Events



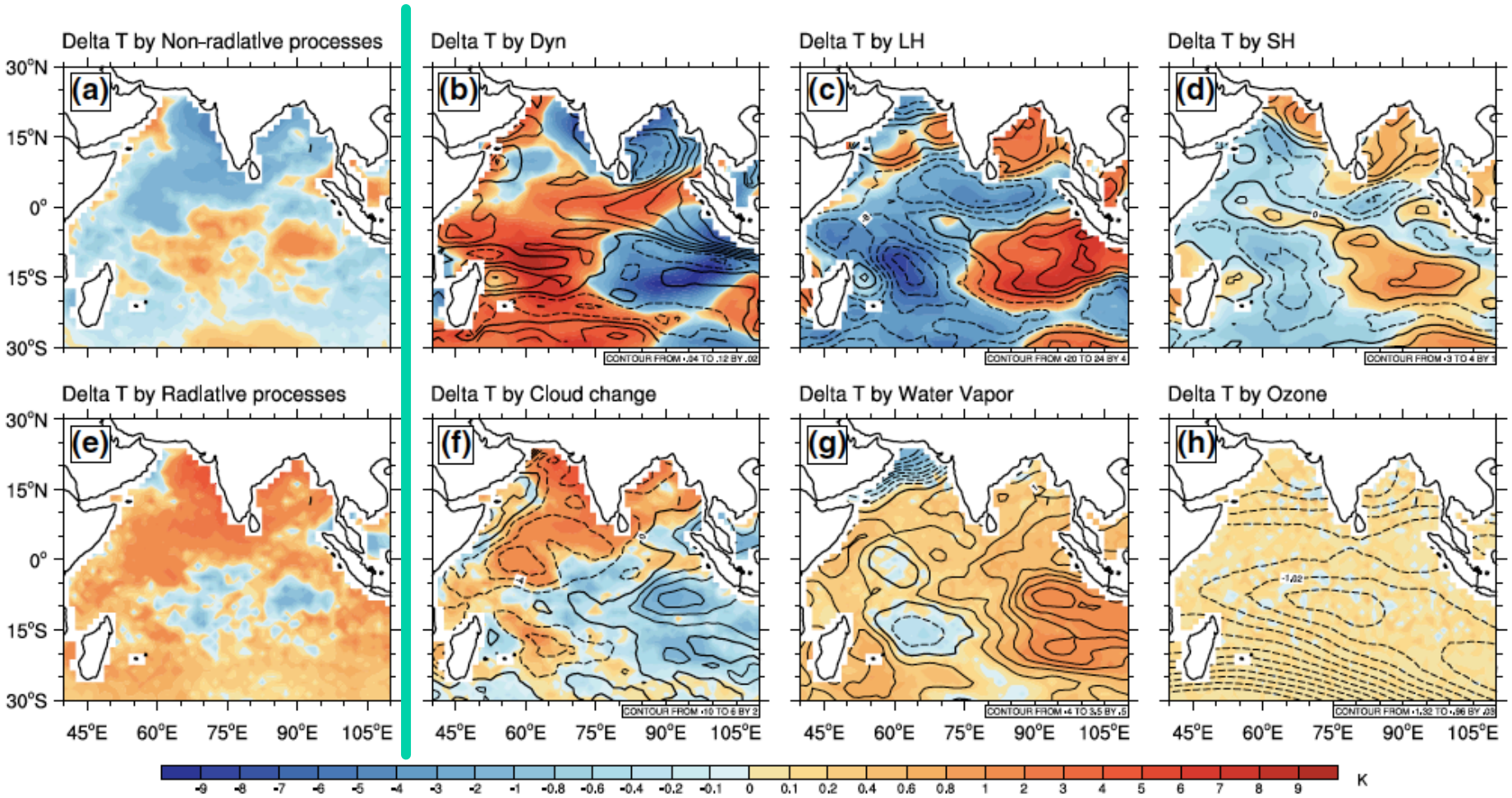
ENSO years

Correlation coefficient

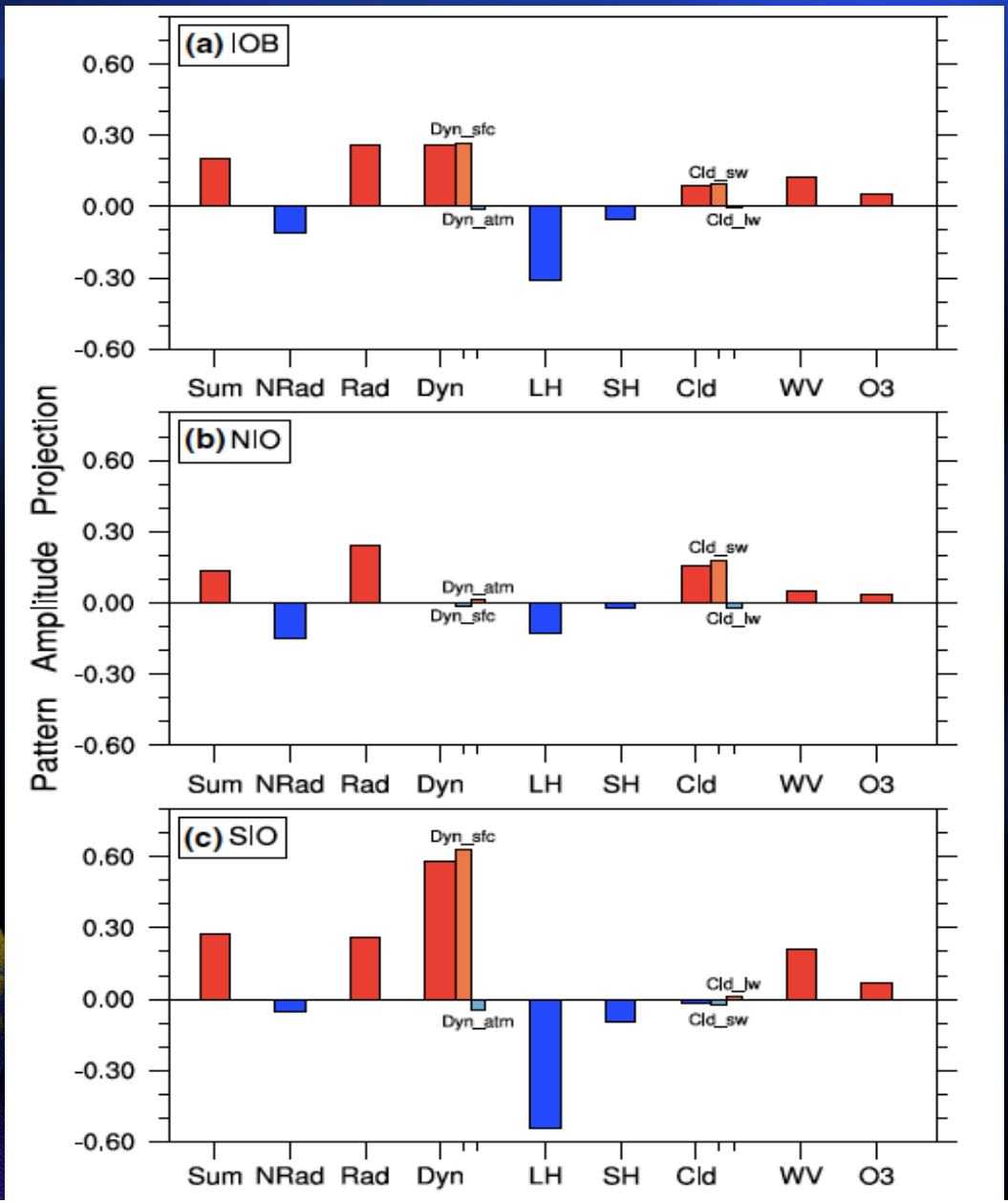
Ren et al., 2016

Quantitative attributing analysis of the interdecadal summer IOB warming in recent decades through the CFRAM

Partial contributions between later-decay and normal-decay El Nino years



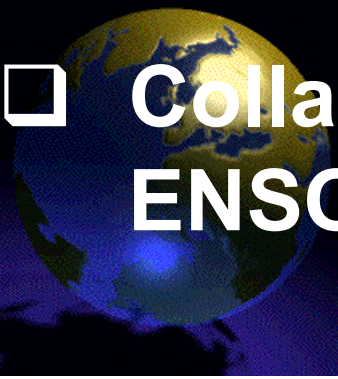
Partial contributions between later-decay and normal-decay El Nino years



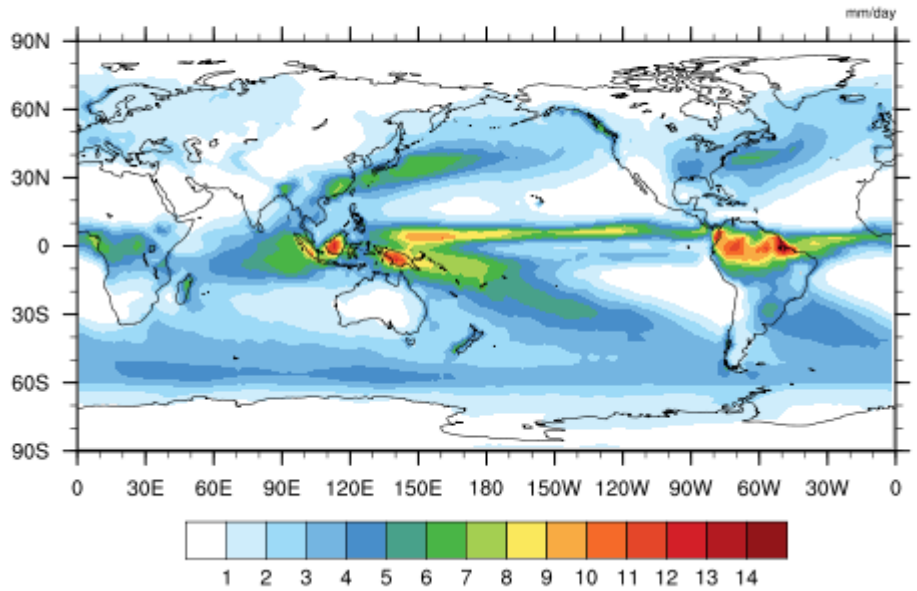
Ren et al., 2016

Outline

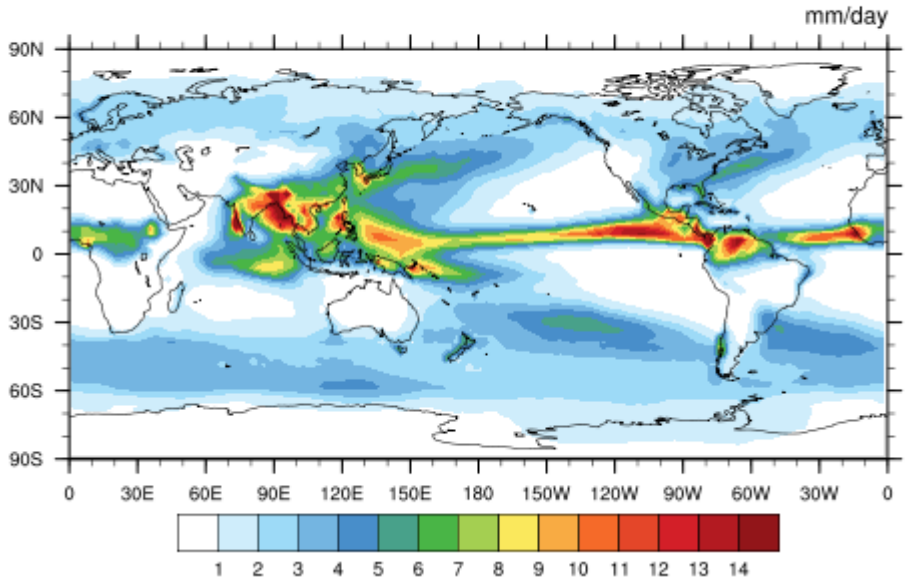
- Introduction to El Nino
- General physics of the ENSO Impacts on circulation
- Indian ocean SSTA associated with ENSO
- Impacts on the rainfall in spring in China
- Impacts on the rainfall in summer in China
- Collaborative influence of the PDO and ENSO



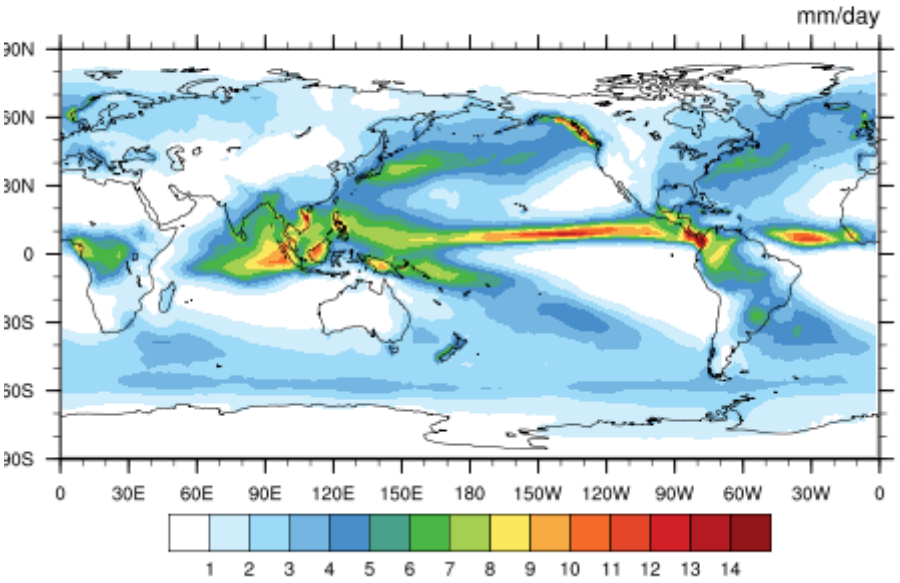
GPCP_MAM_1979-2010



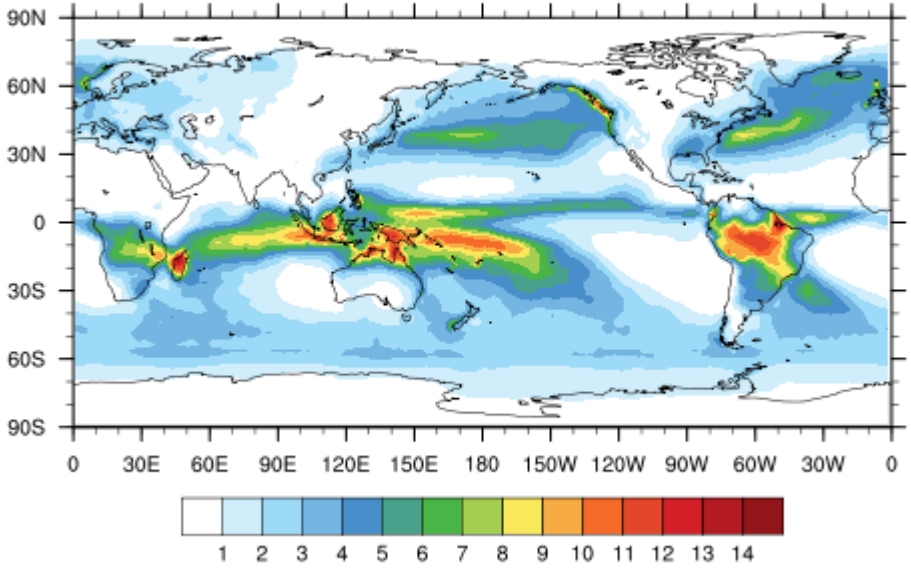
GPCP_JJA_1979-2010



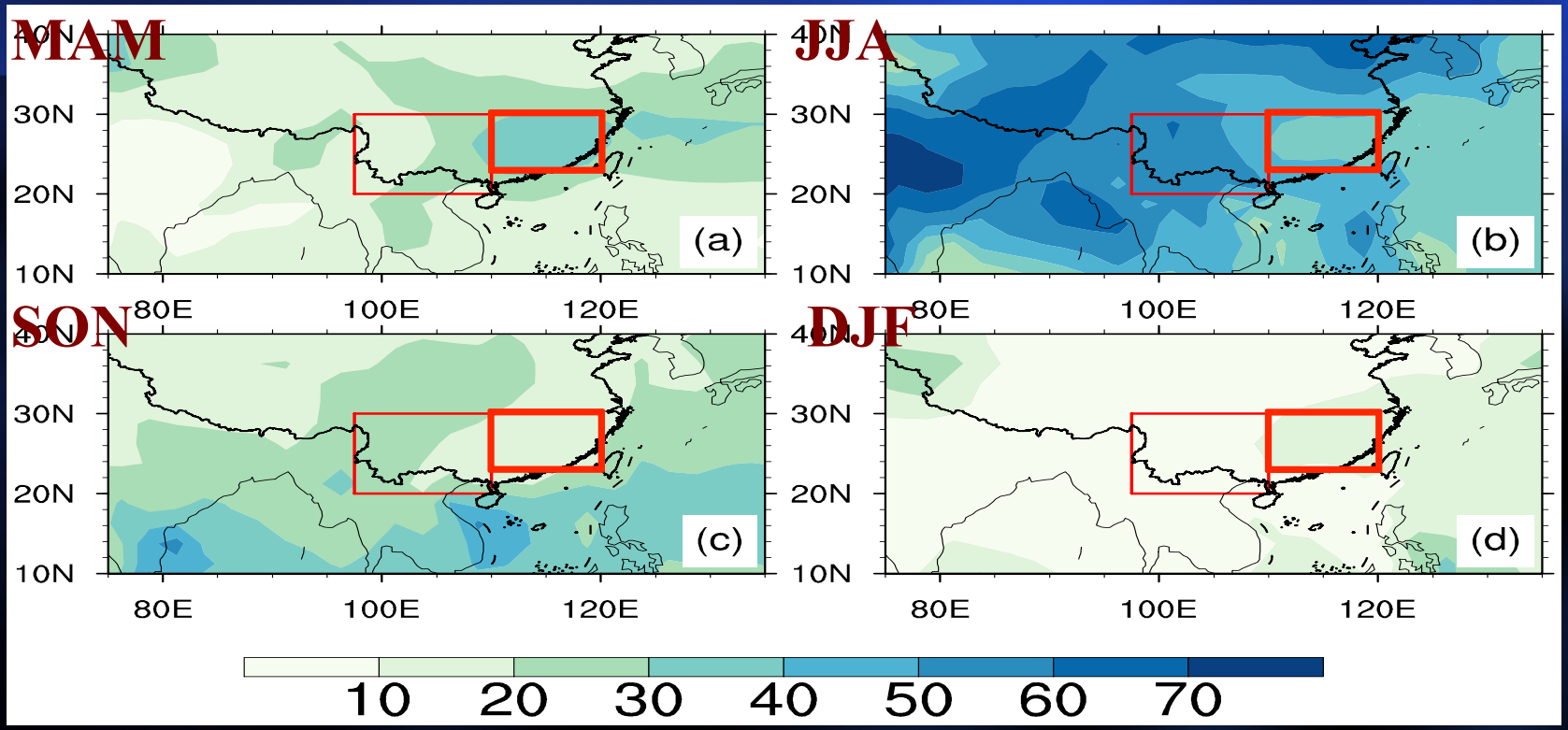
GPCP_SON_1979-2010



GPCP_DJF_1979-2010



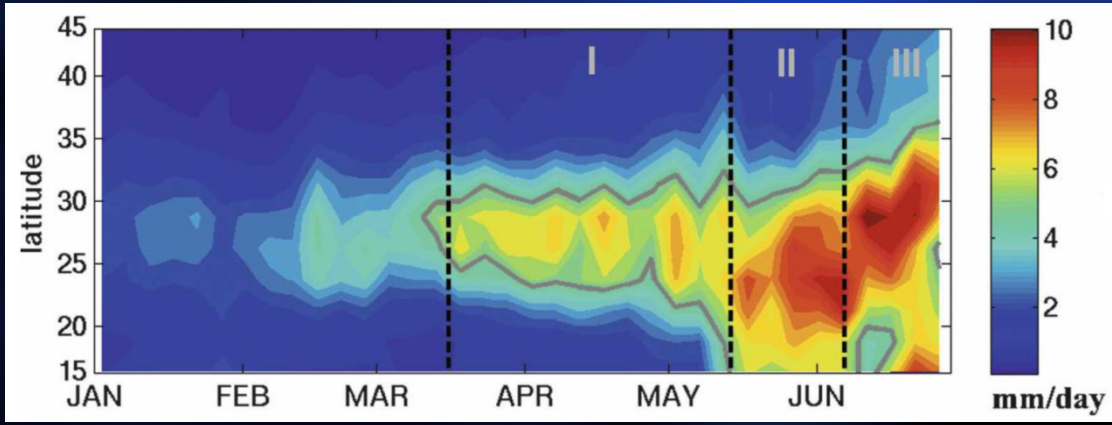
Percentage of rainfall amount



PRES: Persistence of rainfall in eastern China in spring

Hu, Liu, 2017

PRES: Persistence of rainfall in eastern China in spring



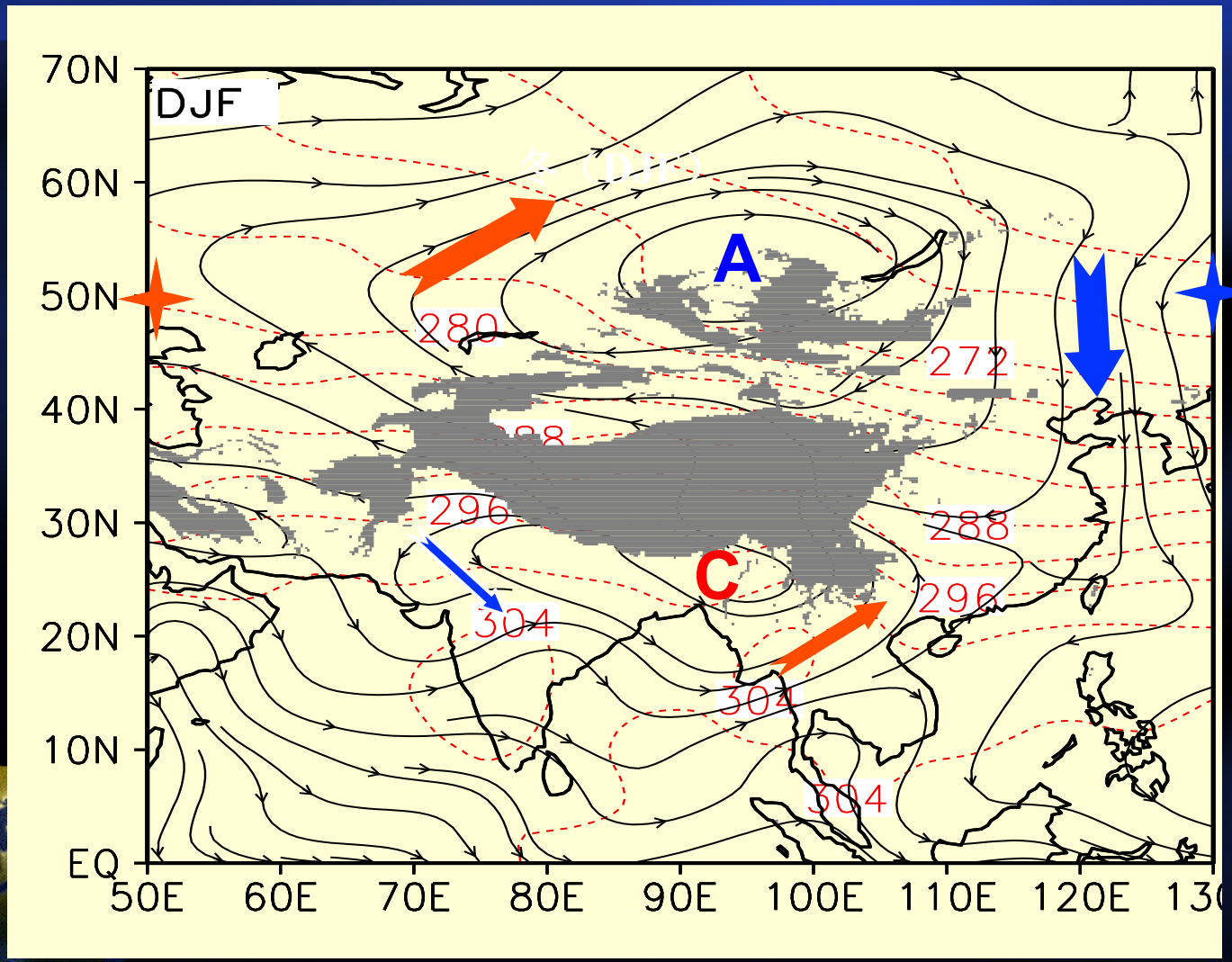
110-120E Pre
(LinHo et al. 2006)

Land-sea thermal contrast（Tian and Yasunari, 1998)

Tibetan Plateau impacts（Wu, Wan et al., 2007, 2008）

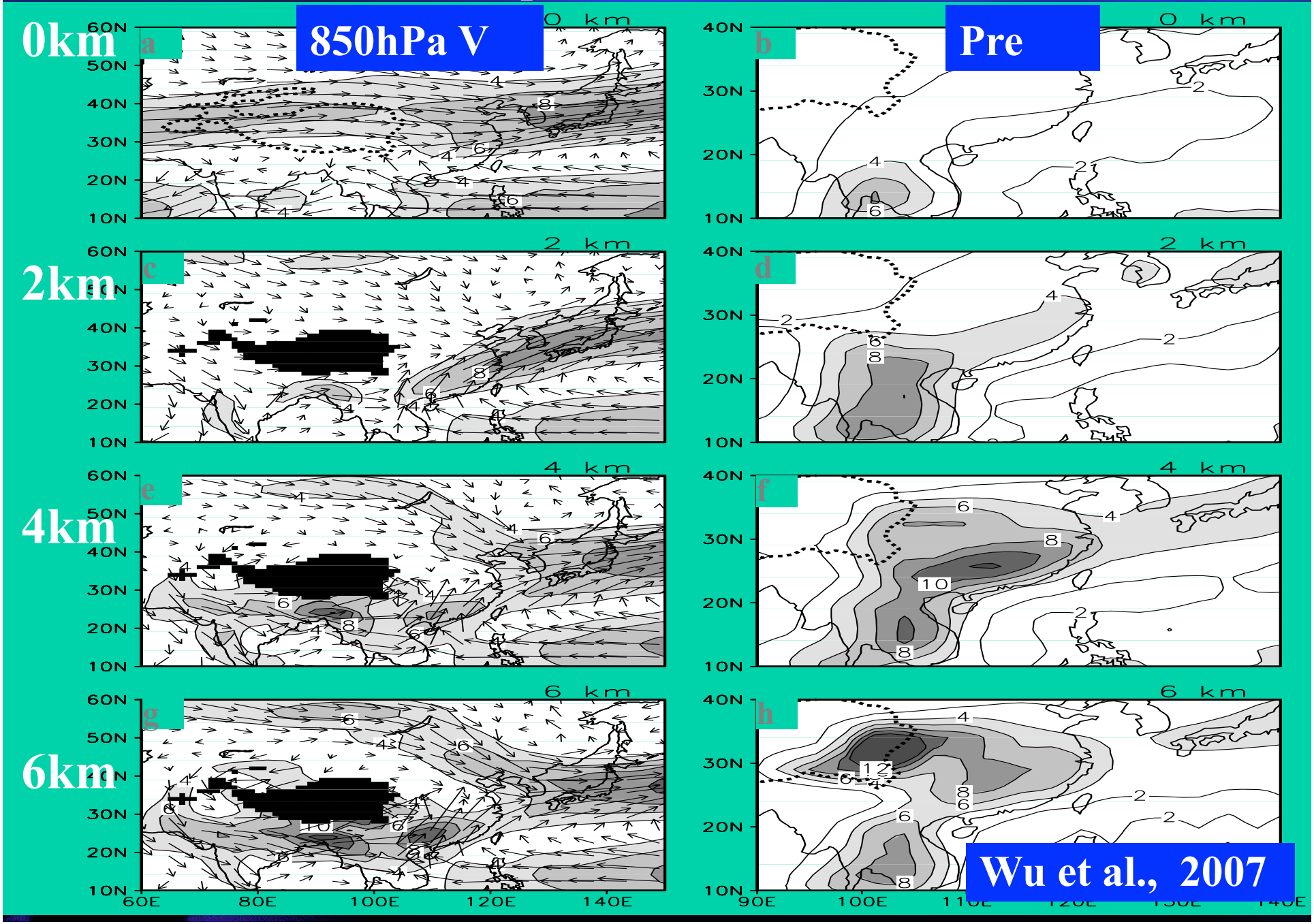
➢ Stationary wave patters in winter and spring

850hPa V^* and θ



Winter: Dipole Mode

PRES formation- TP's impacts

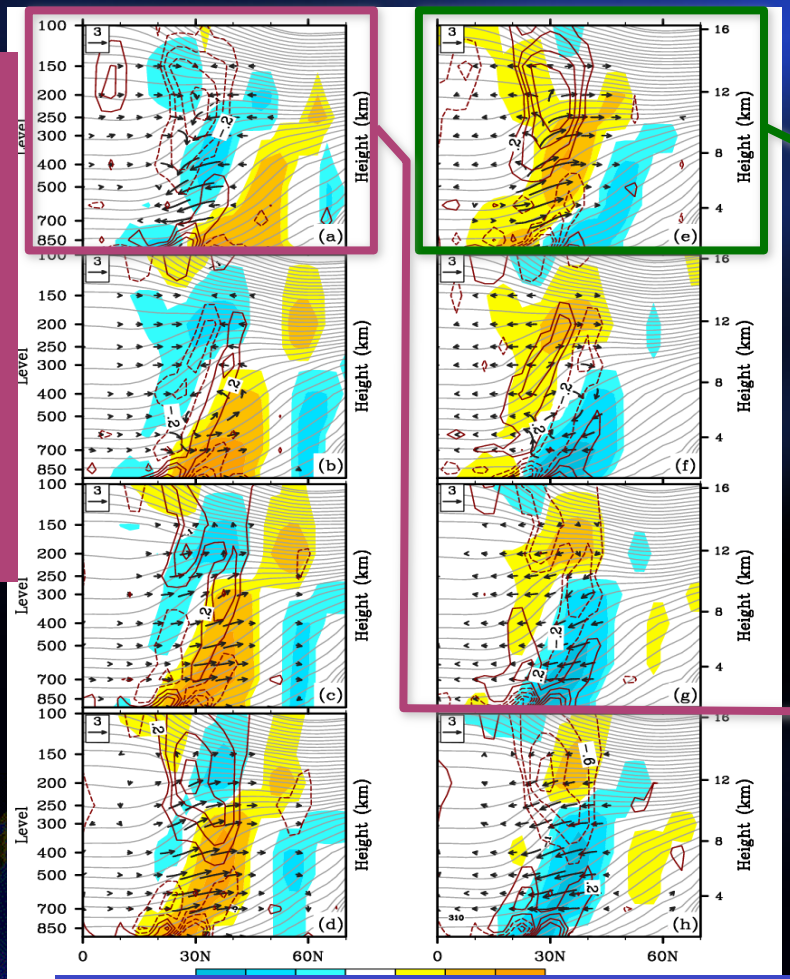


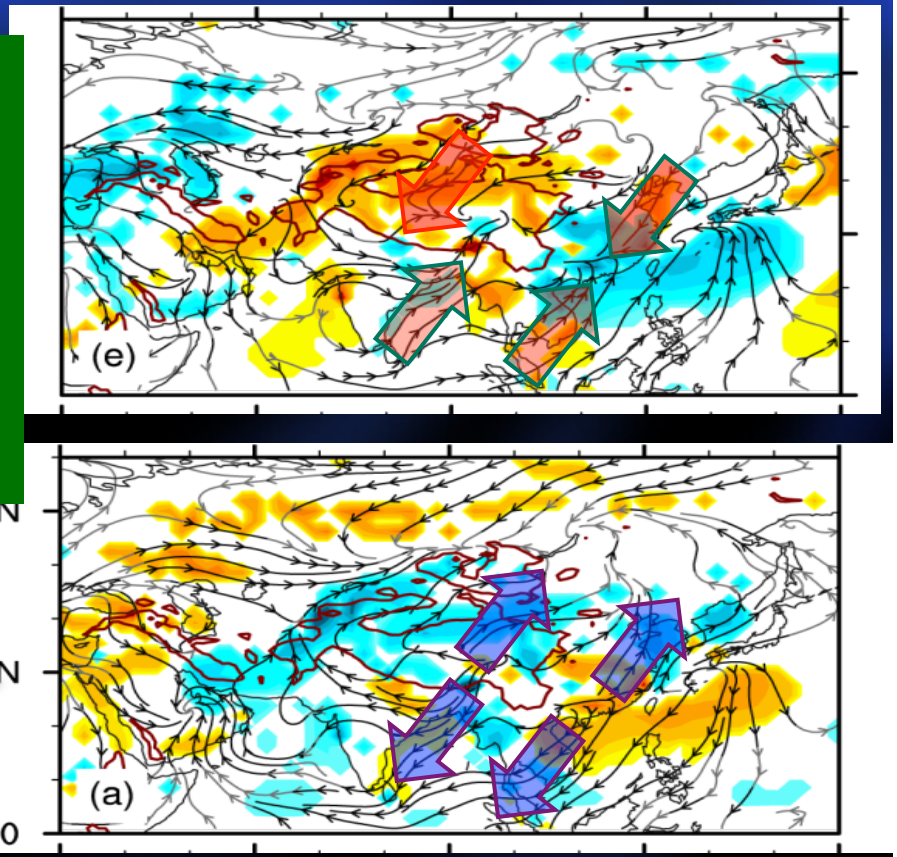
Bi-weekly Oscillation of the TP SH and its impacts on PRES

Div & -v ω

Dry Phase

Wet Phase





+SH: more PRES −SH: Less PRES

➢ PRES's interannual variability

Forecast?

Mostly on tropic oceans

ENSO	刘永强和丁一汇，1995；万日金等，2008；Feng and Li, 2011
SSTA in West Pac.	邓立平和王谦谦，2002；陈艺敏和钱永甫，2005；张博等，2011；
Heat content in West Pac.	尚可等，2013，2014
SSTA in Indian Ocean	陈丹等，2012；程慧萍和贾晓静，2014；Xie et al., 2016
AAO	郑菲和李建平，2012
Vegetation in	

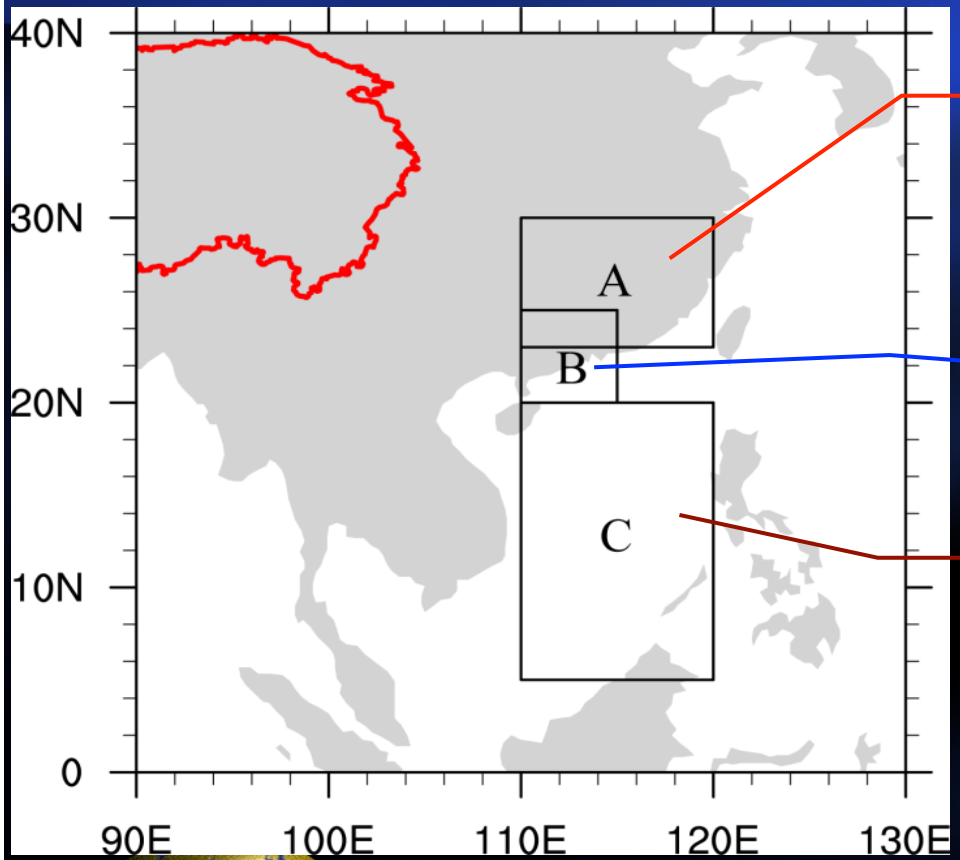
PRES's definition：13-27 P (Wu and Wan, 2007)

Q1：If fixed period of PRES is available?

Q2：PRES is not consistent for each factors, why?

Q3：Include multi-factors to improve the predictability?

➢ PRES definition



Pre>=4mm/d

850-hPa V >=4m/s

Start Pentad: Wan et al., 2008)

SCS monsoon onset (Mao et al., 2004)

End pentad: one pentad before SCS monsoon onset

PRES amount: Pre. From Start Pentad to End Pentad

PRES characters

START

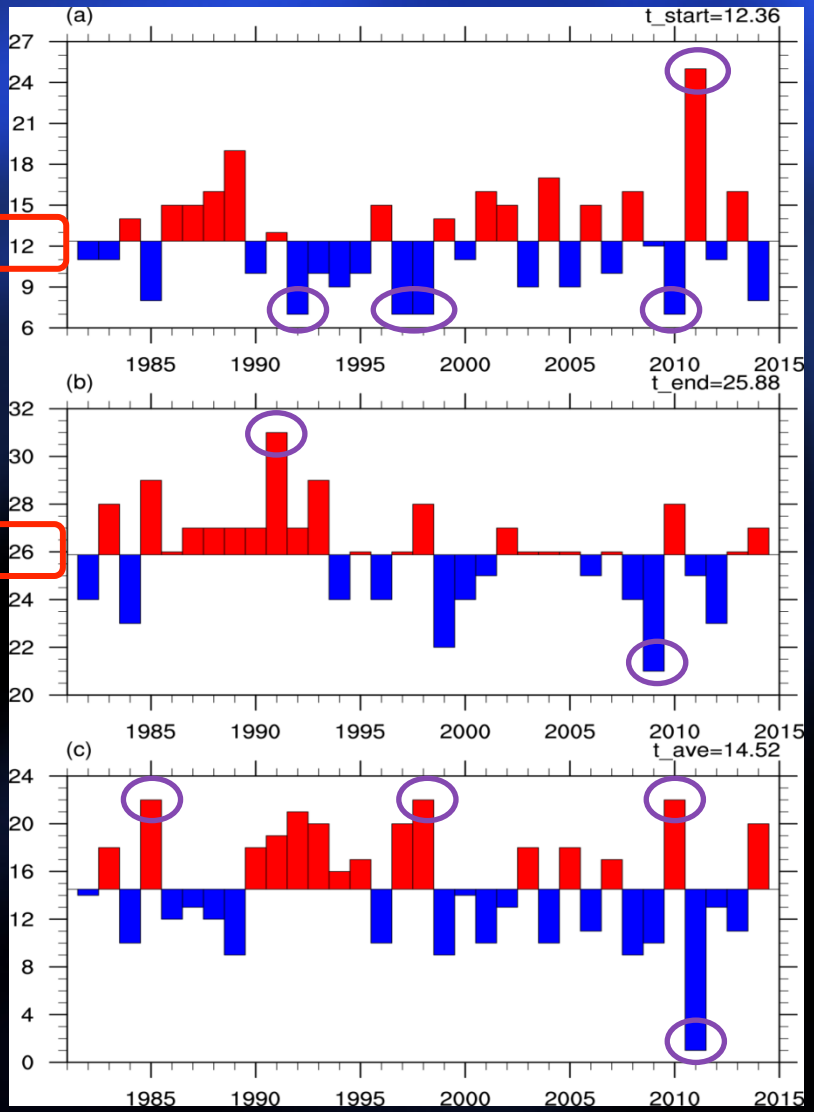
Earliest 7th P
Latest 25th (2011)
Mean :12.6~13rd P

END

Earliest 21st P (2009)
Latest 31st (1991)
Mean :25.3 P

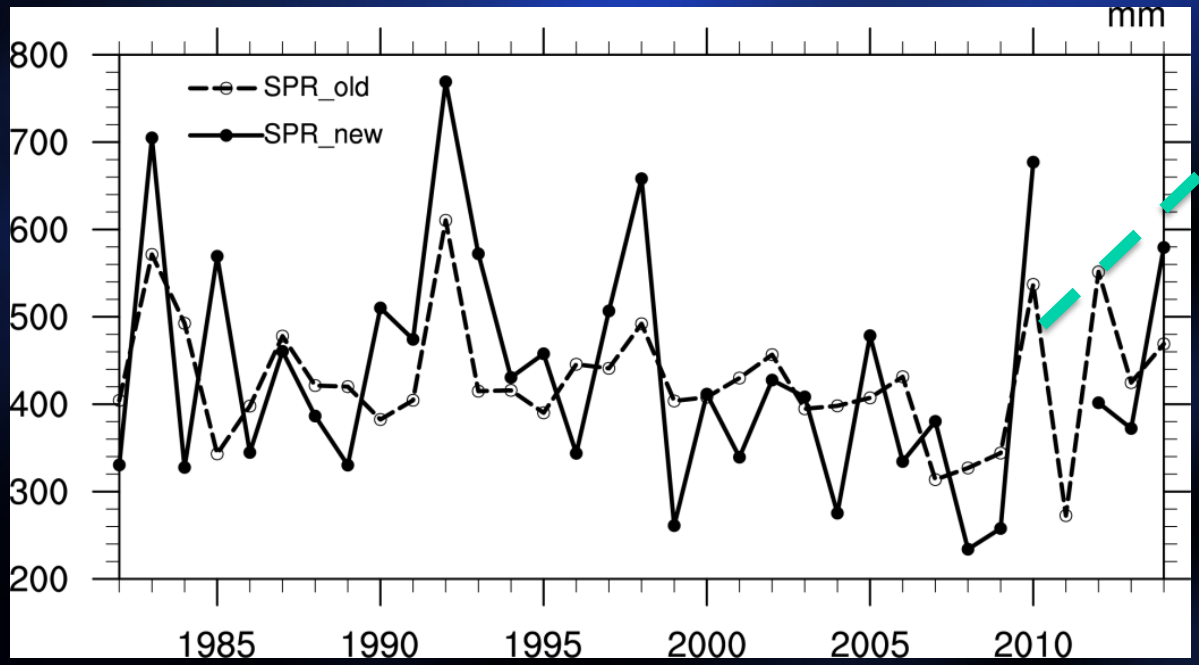
DURATION

Longest 22 Ps（85，98，10）
Shortest 1 P（2011）



➢ PRES amount

Pre.： Fixed dates & non-fixed dates



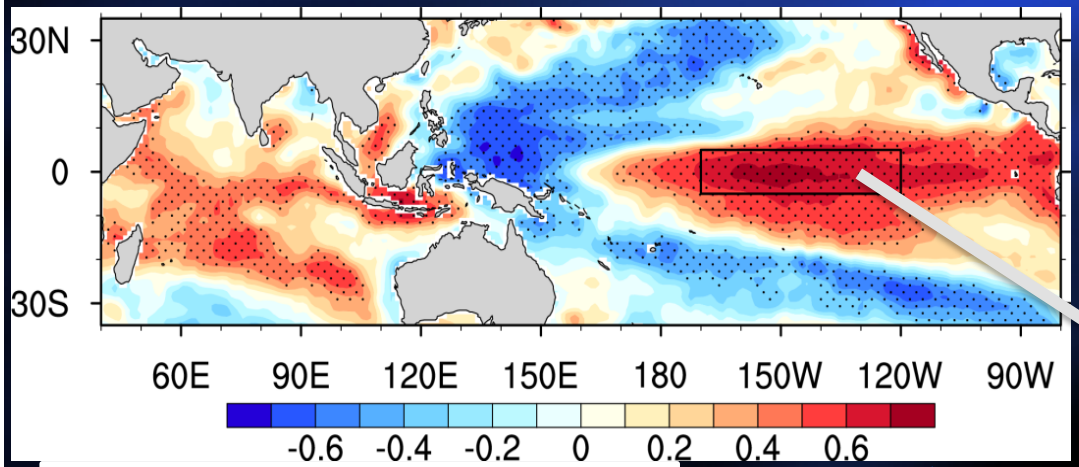
Fixed as 13–27 P

PRES	Fixed	Non-fixed
Mean (mm)	427.13	437.98
Stand.(mm)	71.99	136.10

Similar Mean
Larger St.

➢ Key SSTA area for the PRES variability

Correction bet. Pre & DJF-SSTA



Dotted : 0.05
Nino3.4

Larger corr. Areas:

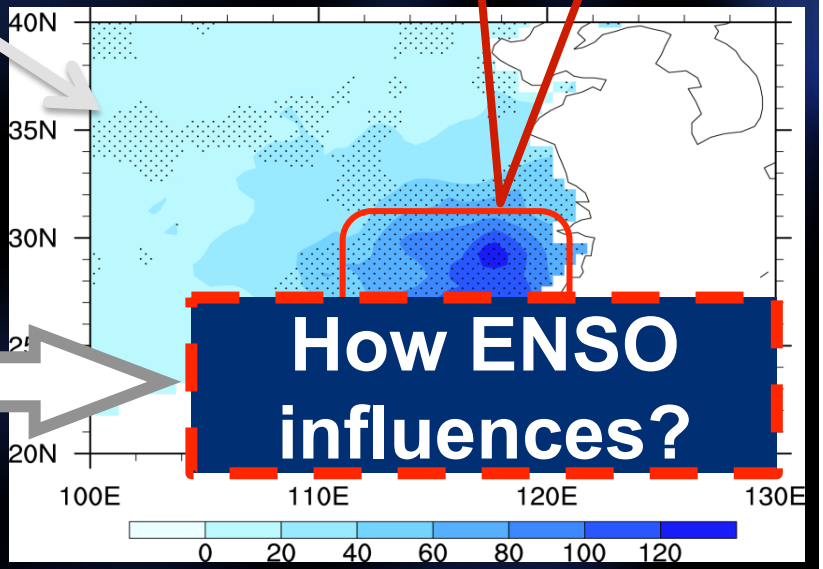
(1) Eastern P

(2) EQ of w (- corr)

(3) Tropical Indian Ocean

Key area: Nino3.4 region

Focus on South China in spring



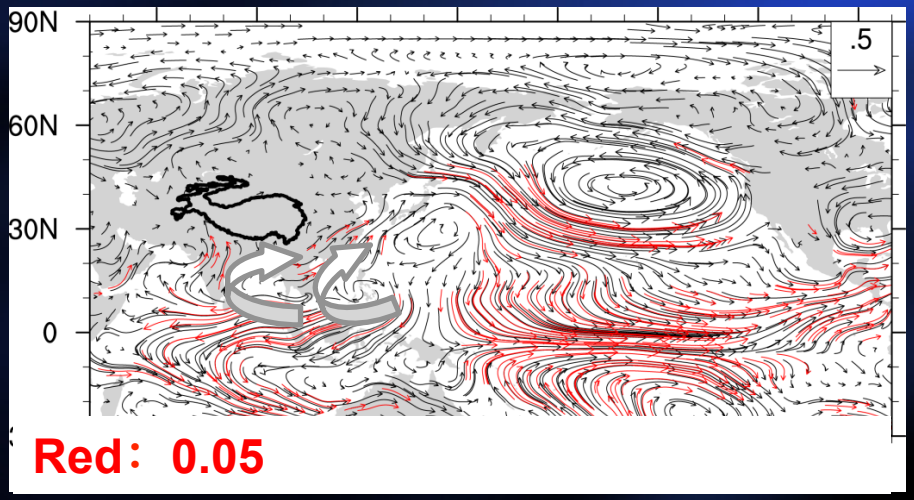
How ENSO influences?

Regression rainfall based 0-DJF Nino3.4 (mm/℃) ,
Dotted: 0.01

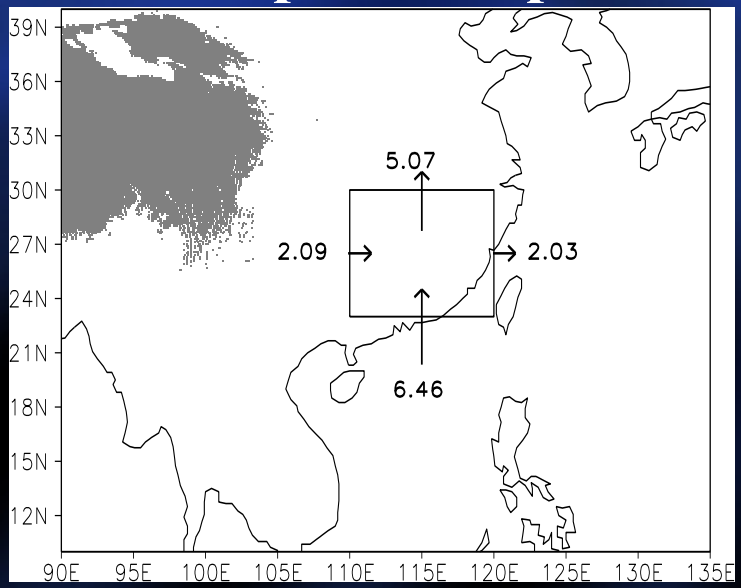
➢ Impacts of the ENSO

Regressed based NINO3.4

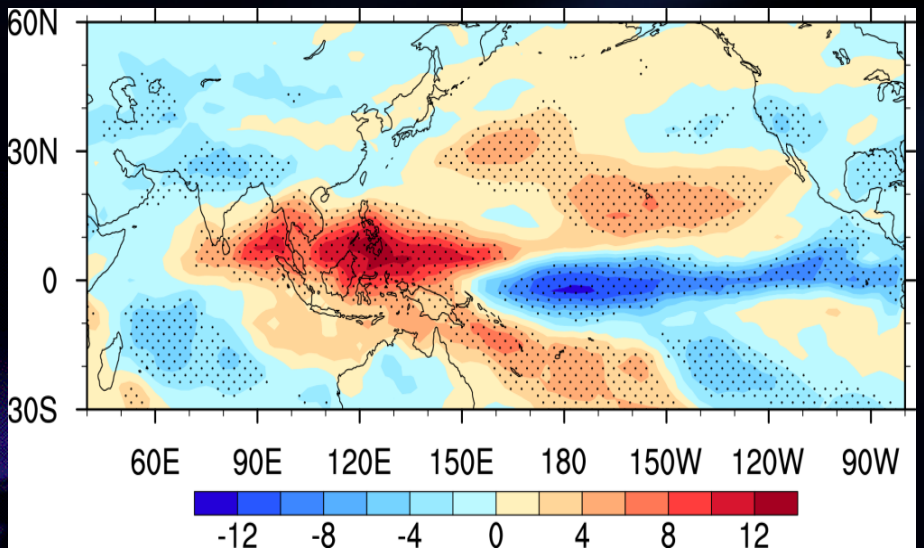
850-hPa V



Water vapor transport



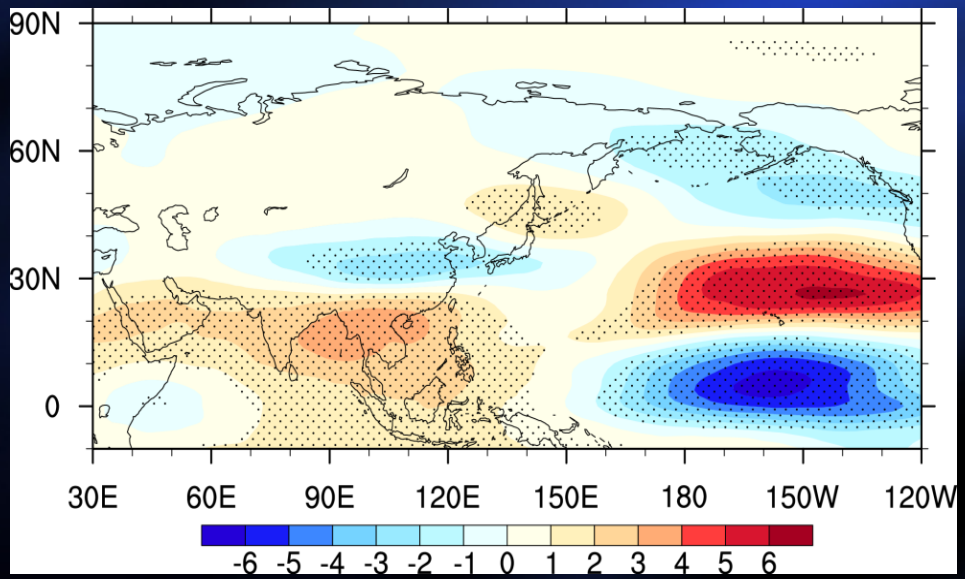
OLR



➢ Impacts of the ENSO

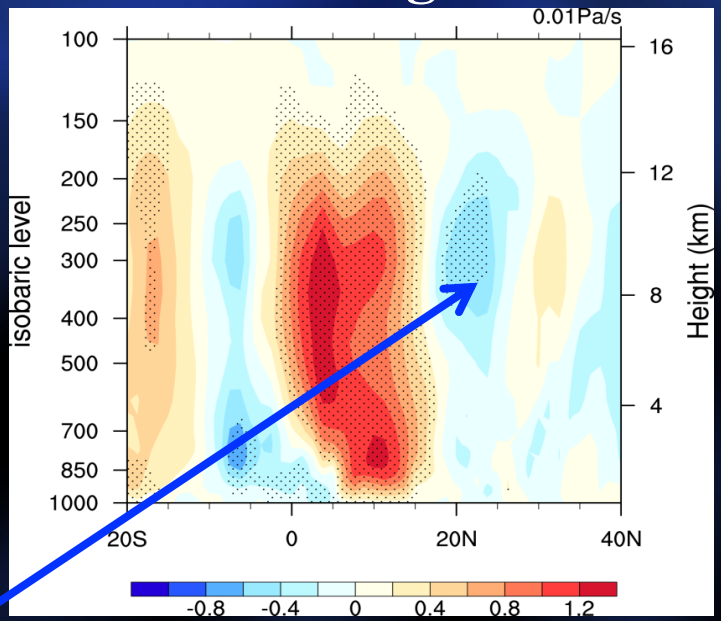
Regressed based NINO3.4

200-hPa u



Dotted: 0.05

110-120E Omega

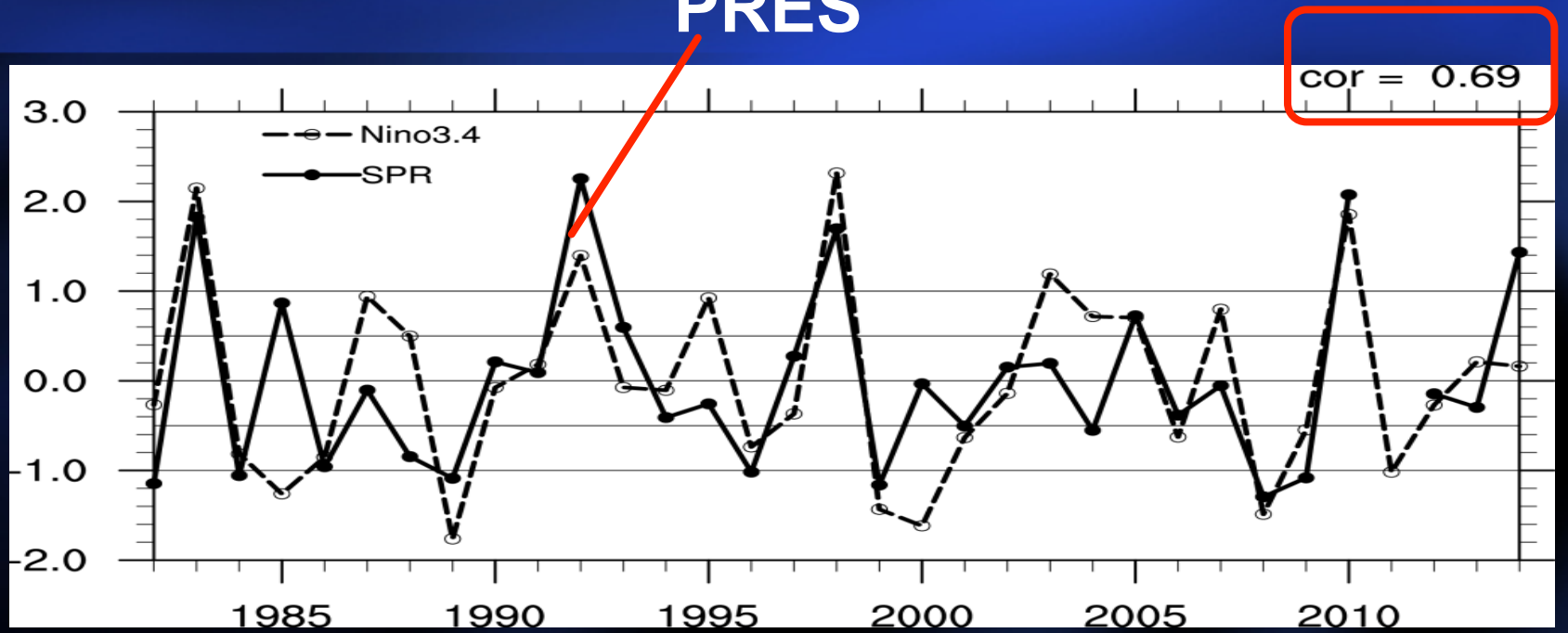


- **Divergence - ascent**
- **Moisture**

More Pre.

➢ Impacts of the ENSO: predictability?

PRES

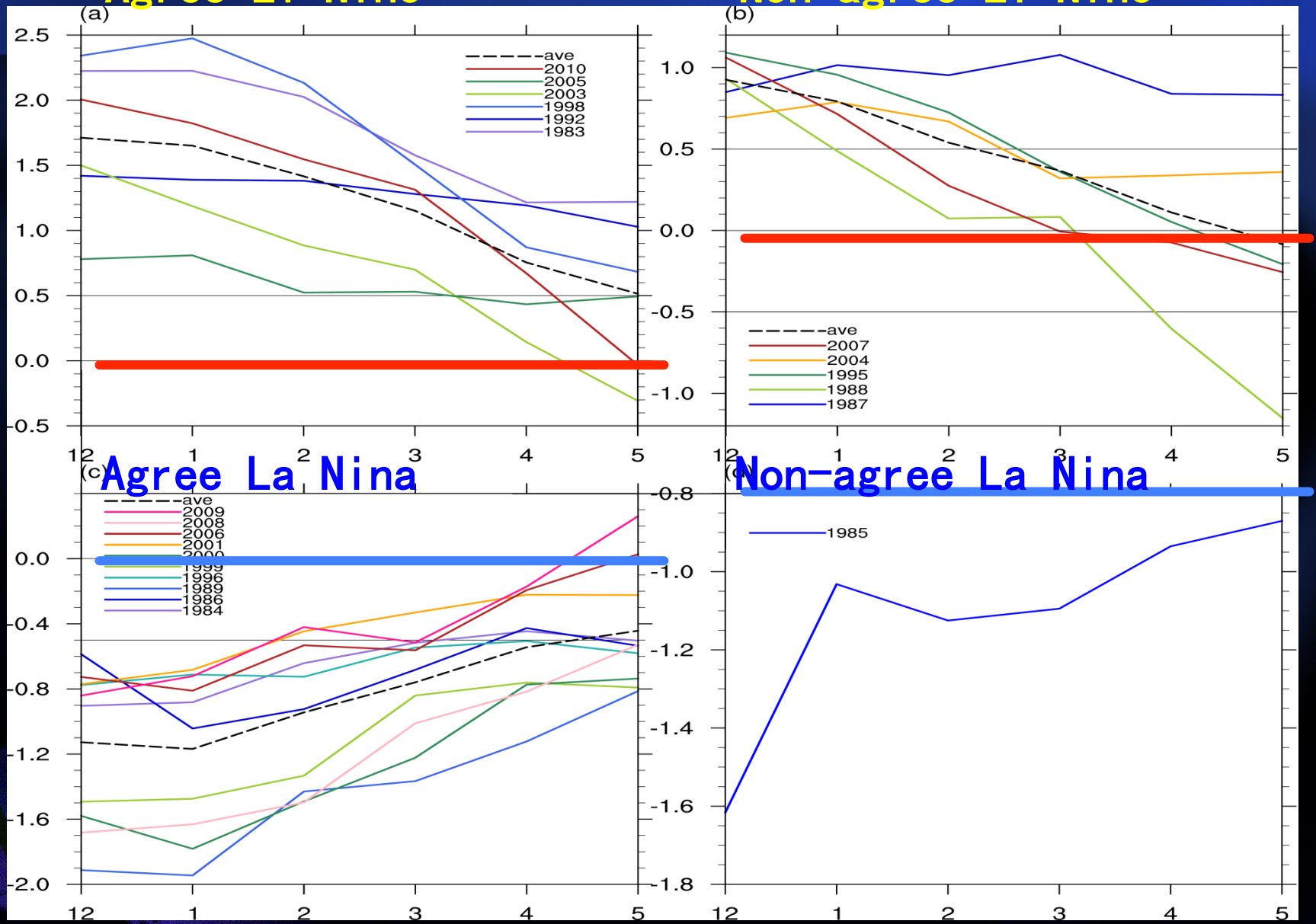


	El Niño 10	La Niña 7
Agree	1983,1992,1998, 2003,2005,2010	1989,1996,1999, 2000,2001, 2008
Non-agree	1987,1988,1995 2007	1985

Dec NINO3.4- Current May Nino3.4 Index

Agree El Nino

Non-agree El Nino

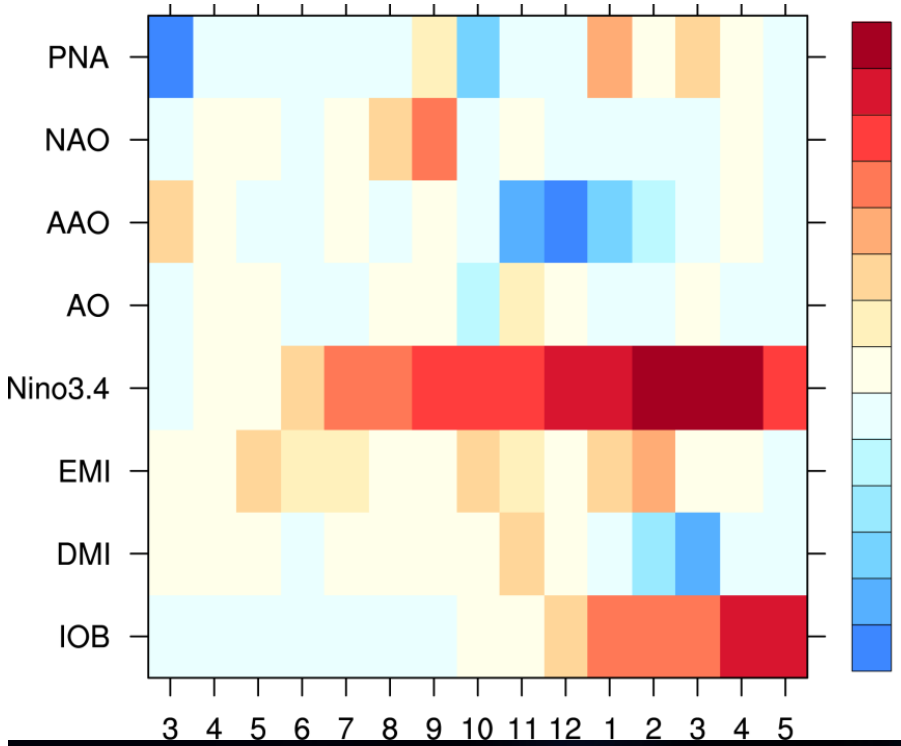


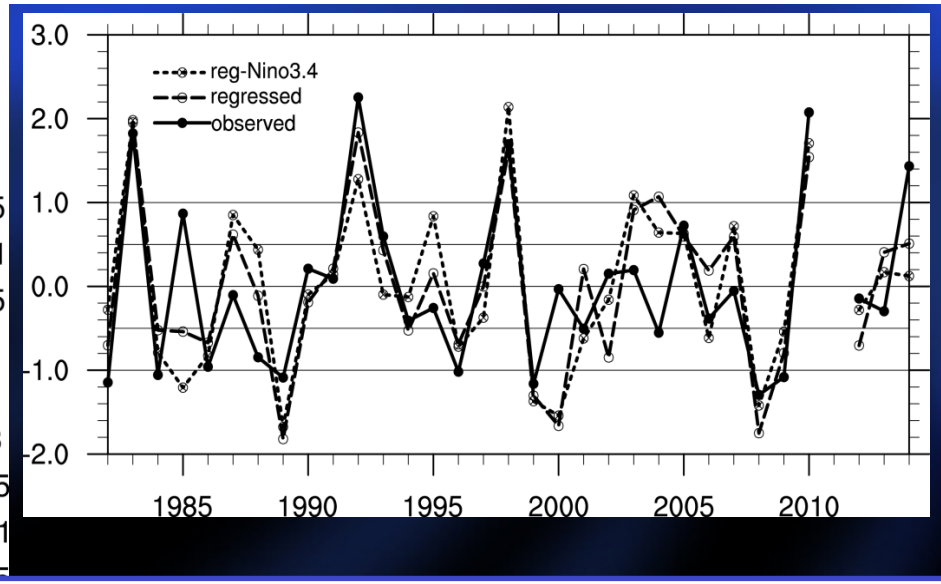
Agree La Nina

Non-agree La Nina

Multi-factors regression

$$y = -2.29 - 7.99 \times IOB + 67.67 \times Nino3.4 - 64.99 \times AAO$$





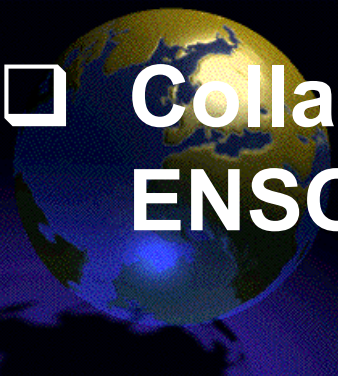
Corr. PRES and indexes

Nino3.4
AAO
IOB

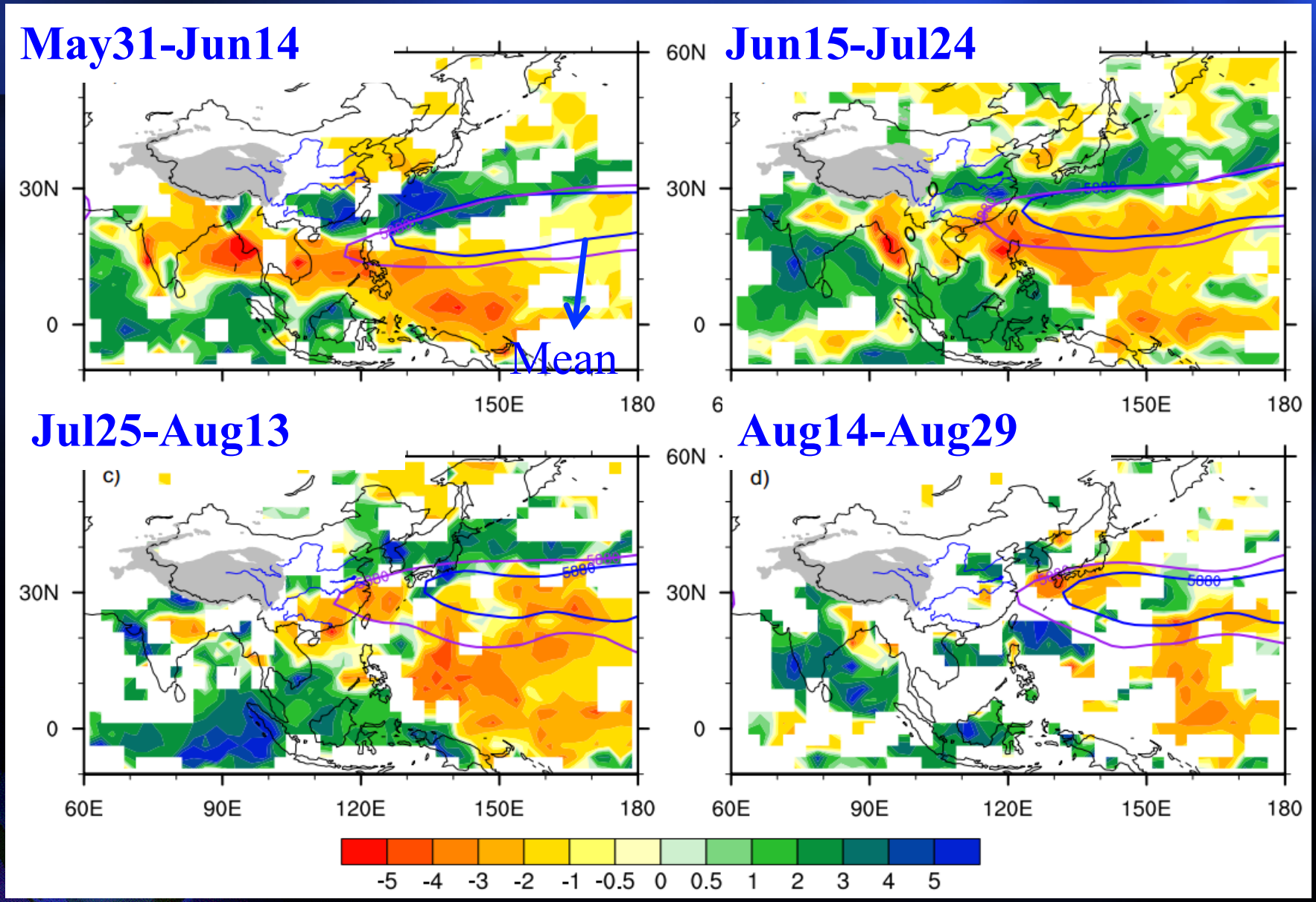
- **Corr. of New Pre & Pre: 0.76**
  Corr. Of Nino3.4 & Pre: 0.69
- **For extreme PRES year (1982, 2014), Stan. Of New Pre >±0.5**
- **Non-agree year (1985,87, 88,95,2007), better**

Outline

- Introduction to El Nino
- General physics of the ENSO Impacts on circulation
- Indian ocean SSTA associated with ENSO
- Impacts on the rainfall in spring in China
- Impacts on the rainfall in summer in China
- Collaborative influence of the PDO and ENSO

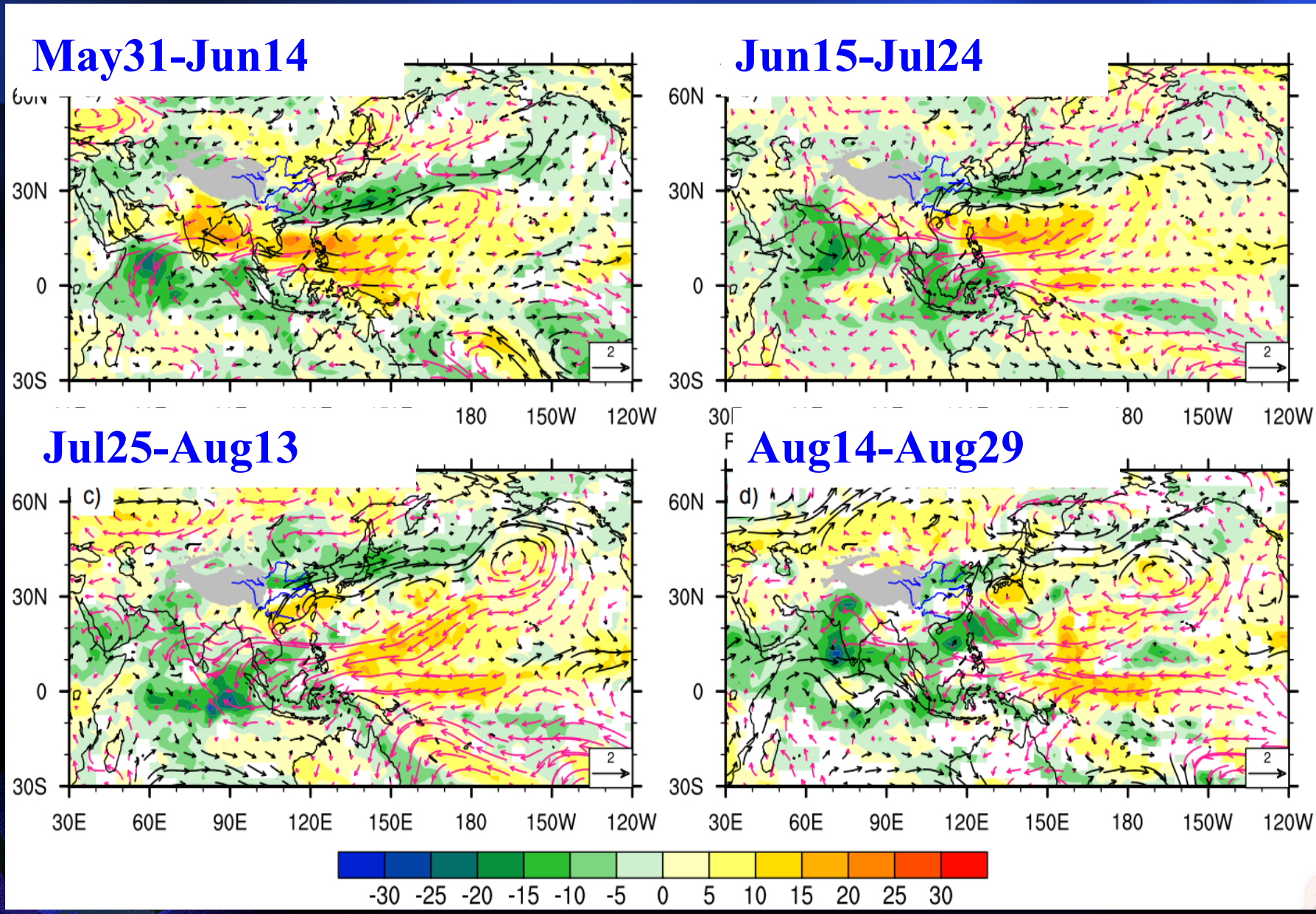


Pre* and 500-hPa H* (subtropical high) in JJA(+1) of El Nino



Duan et al., 2017

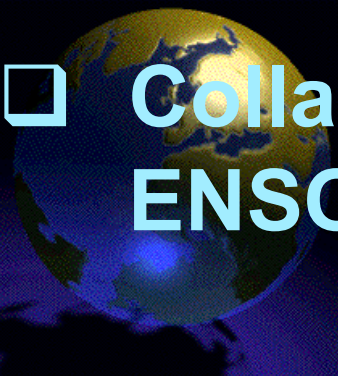
OLR* and 850-hPa V* in JJA(+1) of El Nino



Duan et al., 2017

Outline

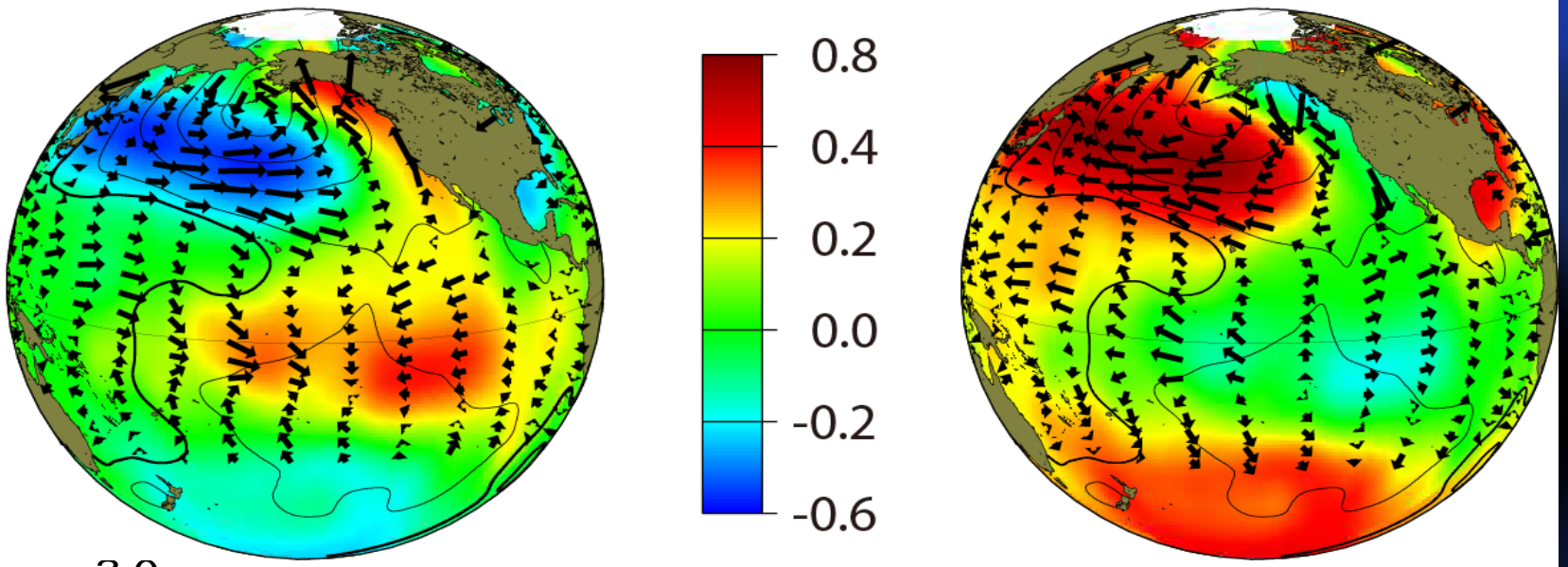
- Introduction to El Nino
- General physics of the ENSO Impacts on circulation
- Indian ocean SSTA associated with ENSO
- Impacts on the rainfall in spring in China
- Impacts on the rainfall in summer in China
- Collaborative influence of the PDO and ENSO

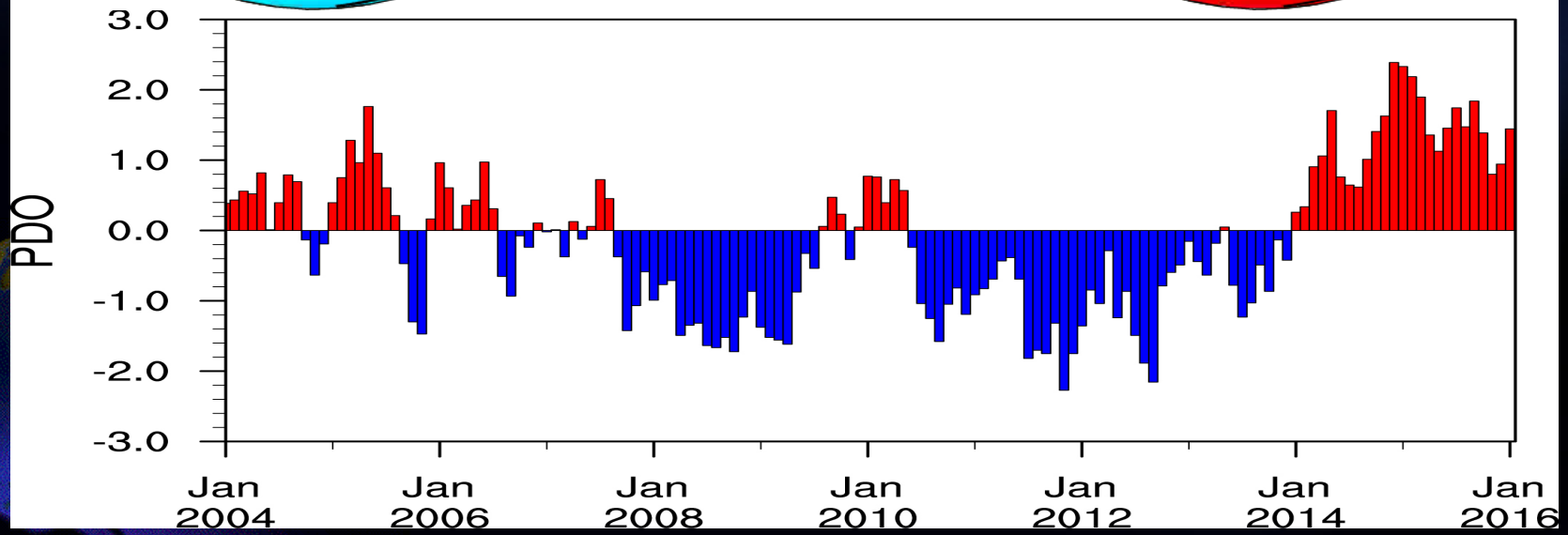


Pacific Decadal Oscillation

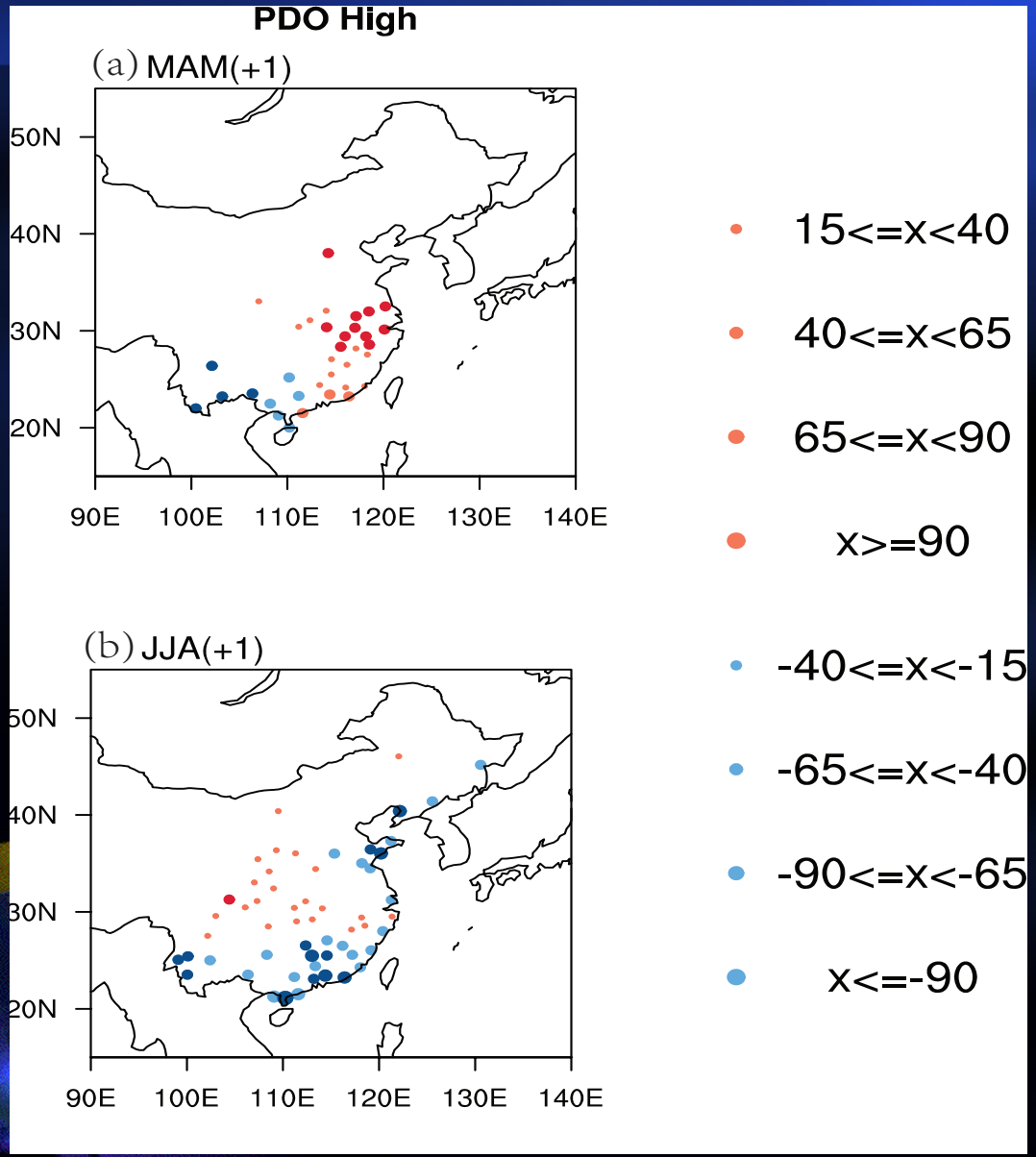
positive phase

negative phase





Pre anomaly (mm m^{-1}) in the following El Nino with positive PDO



Spring

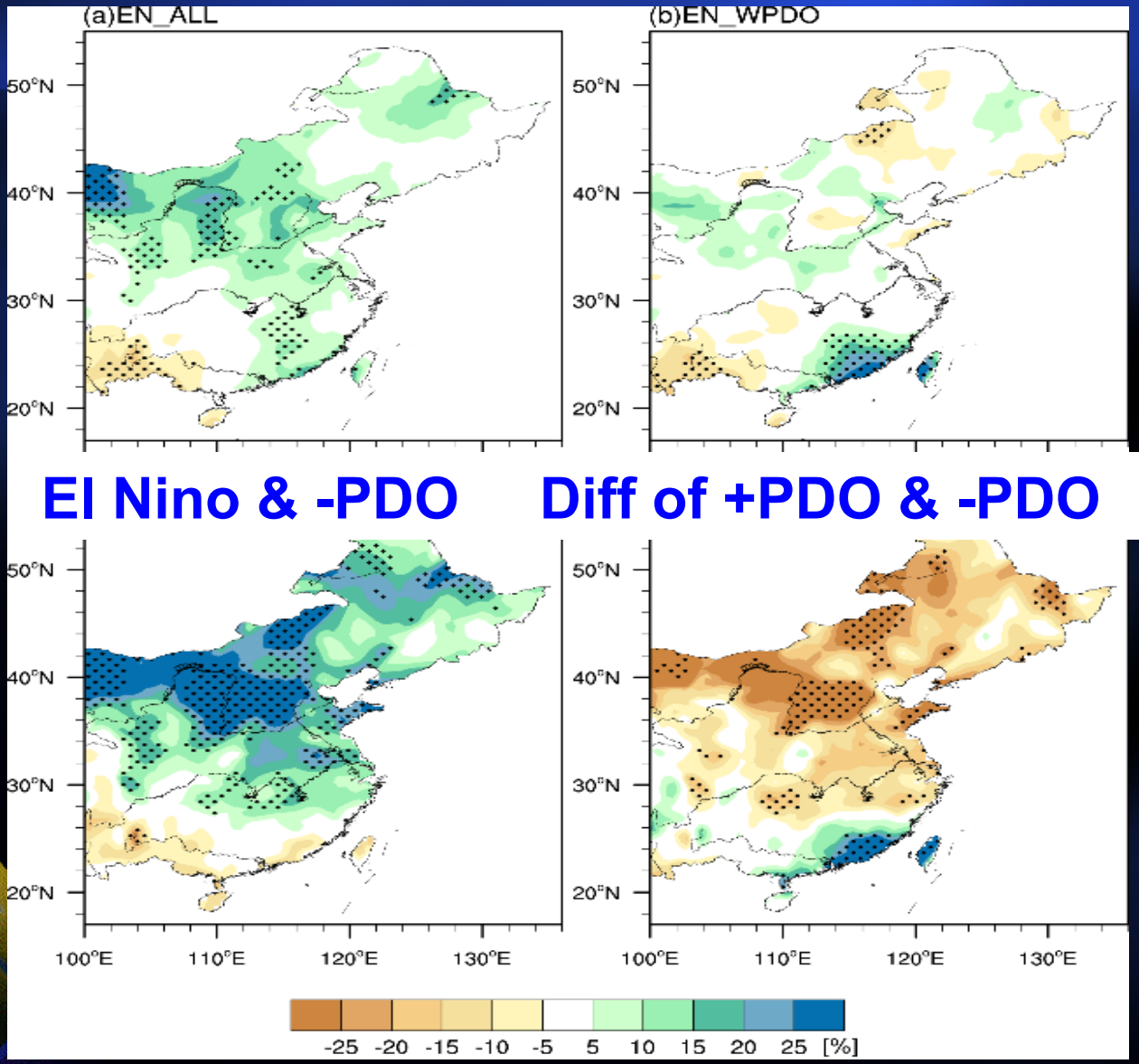
Summer

Mao et al., 2017

Pre anomaly percentage in spring

all El Nino

El Nino & +PDO



El Nino & -PDO

Diff of +PDO & -PDO

Mao et al., 2017

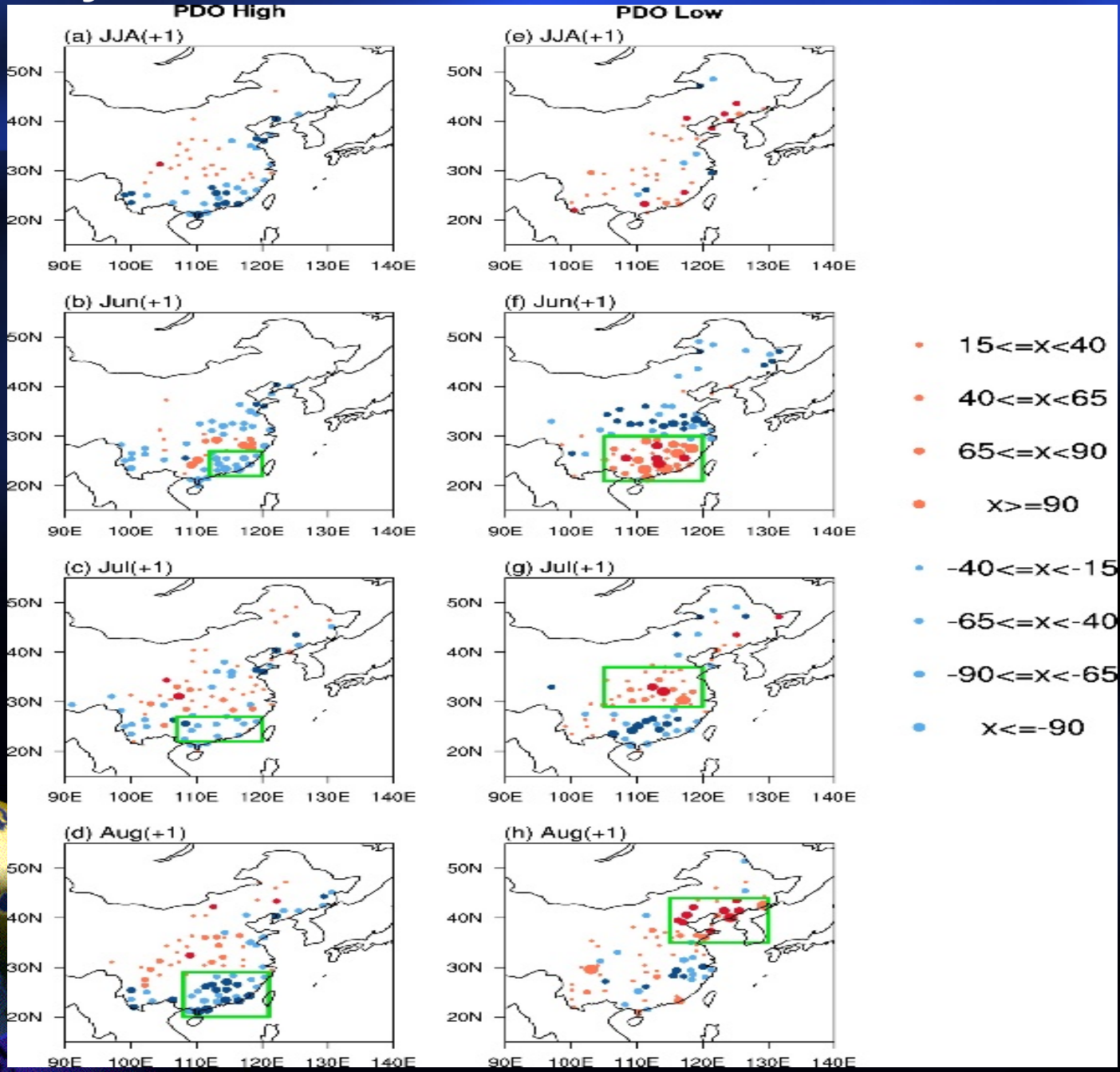
Pre anomaly +PDO -PDO After El Nino

JJA(+1)

Jun(+1)

Jul(+1)

Aug(+1)



Feng et al., 2014

Impacts of El Nino – beyond the precipitation: air pollution

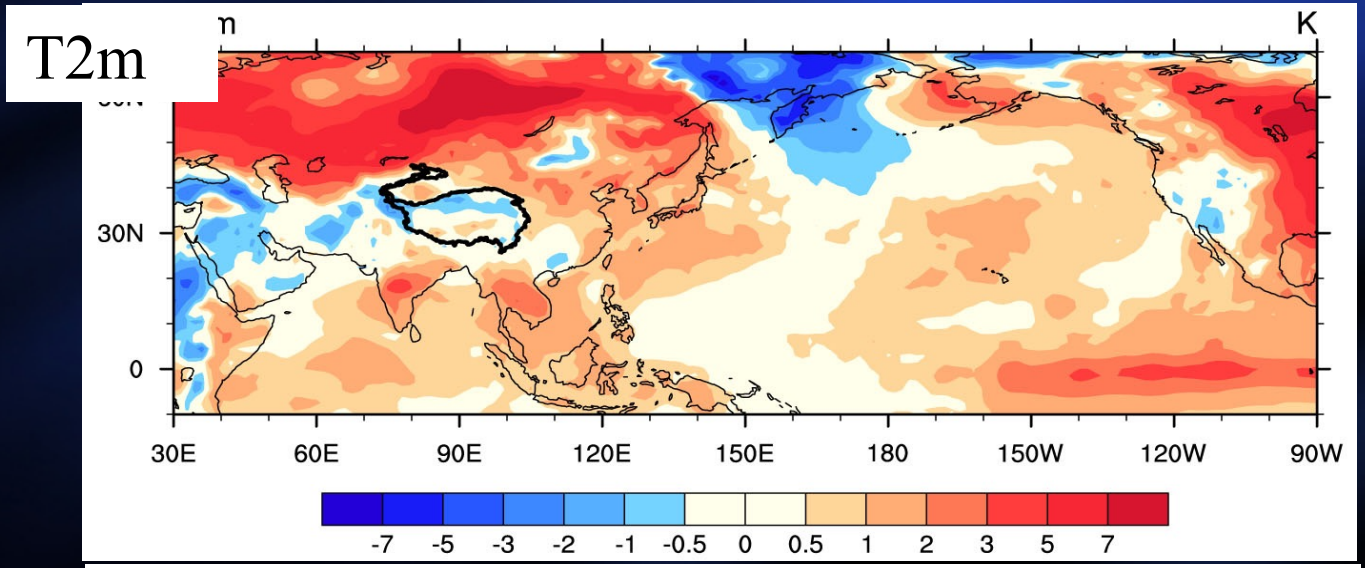
Extreme PM2.5 Beijing Dec 2015

http://bbs.qianlong.com/thread-9587819-1-1.html

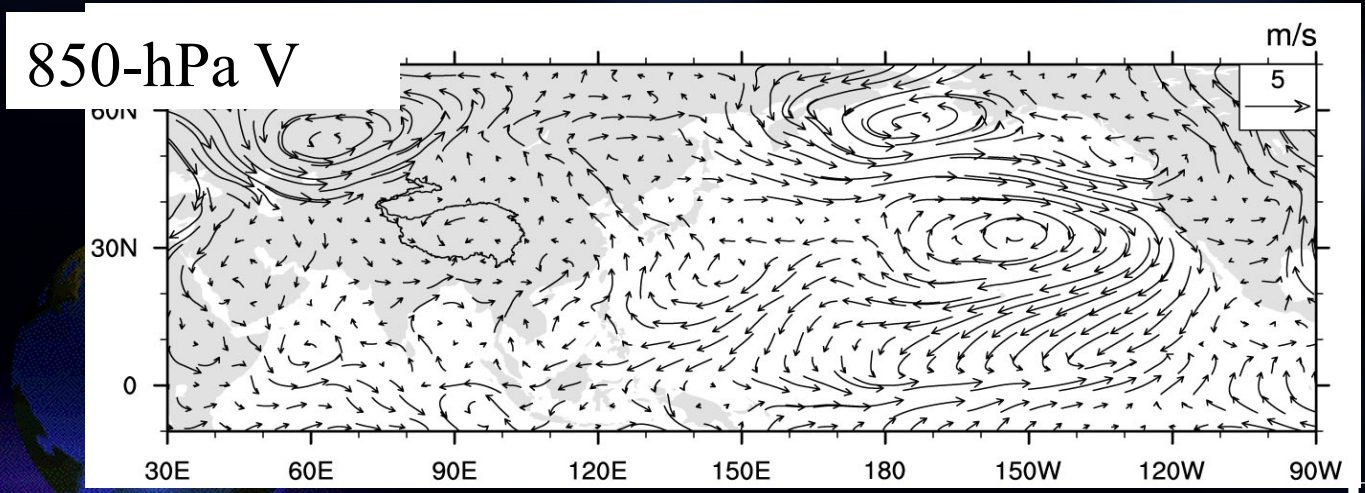
Impacts of El Nino – beyond the precipitation

air pollution

Anomaly in Dec. 2015



Higher land T: weaker winter monsoon



Anticyclonic circulation: More moisture

Liu et al., 2017


Thank You!