Indian Ocean Dipole Mode: A possible precursor for the East Asian Summer Monsoon

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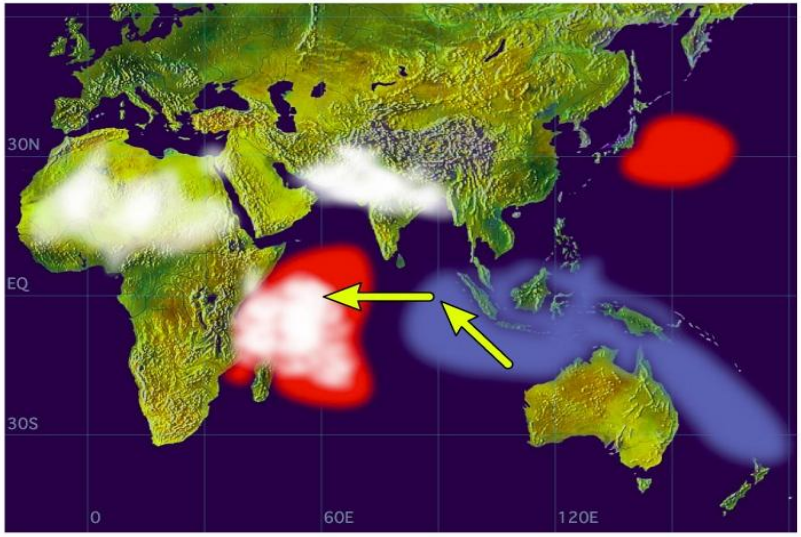
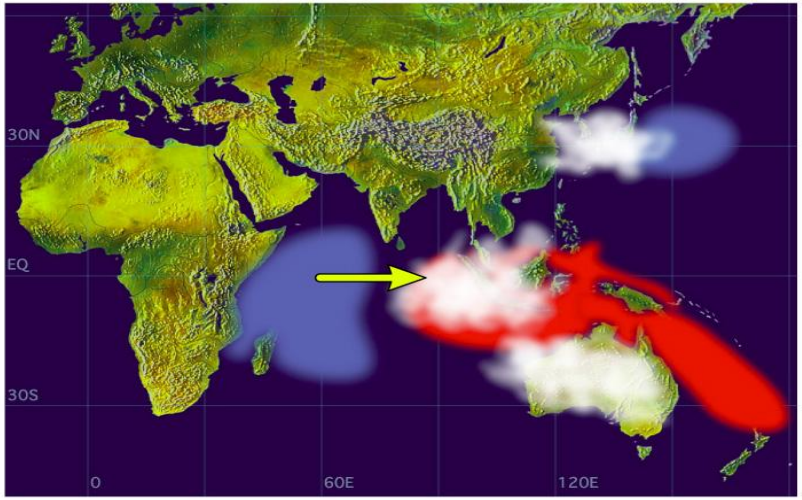
APEC Climate Symposium: 21-24 June 2010

Positive Dipole Mode



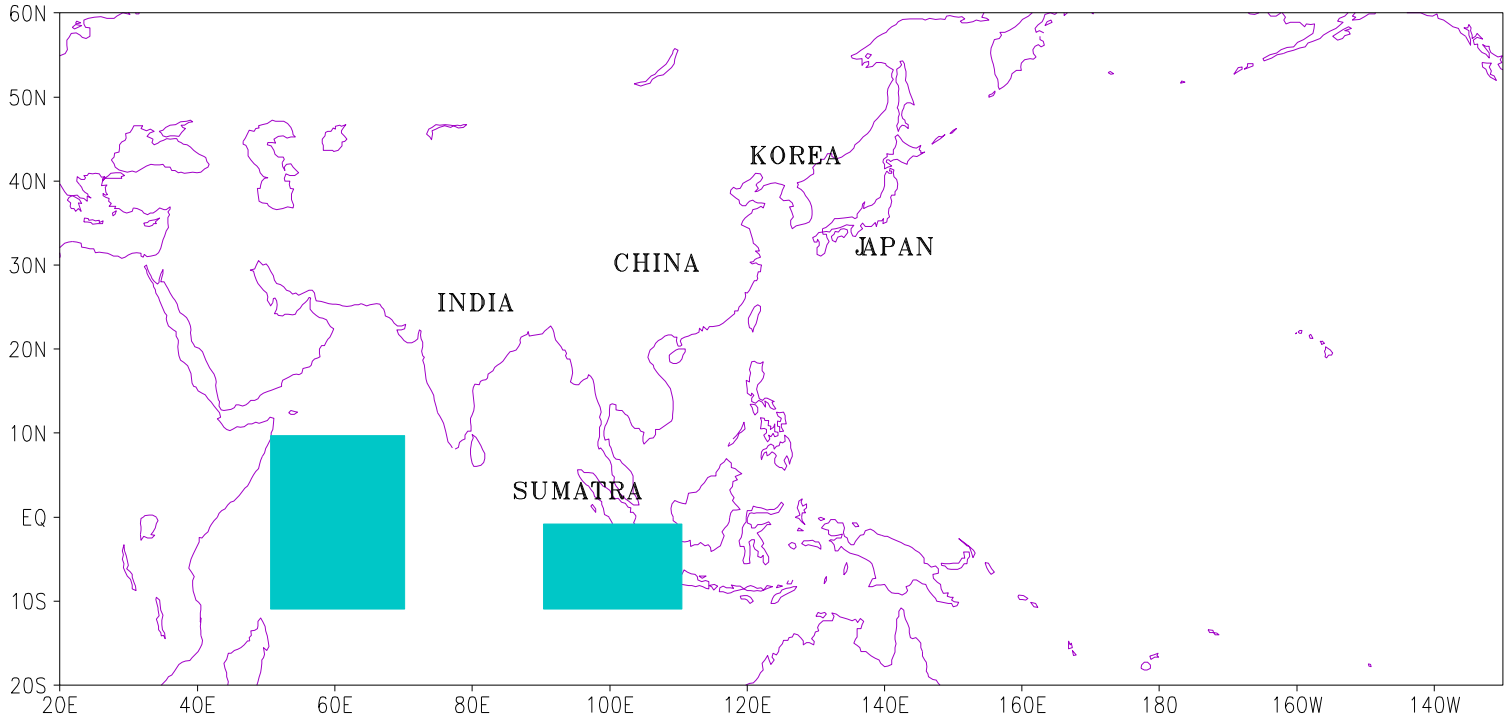
Negative Dipole Mode



Saji, Goswami, Vinaychandran, Yamagata

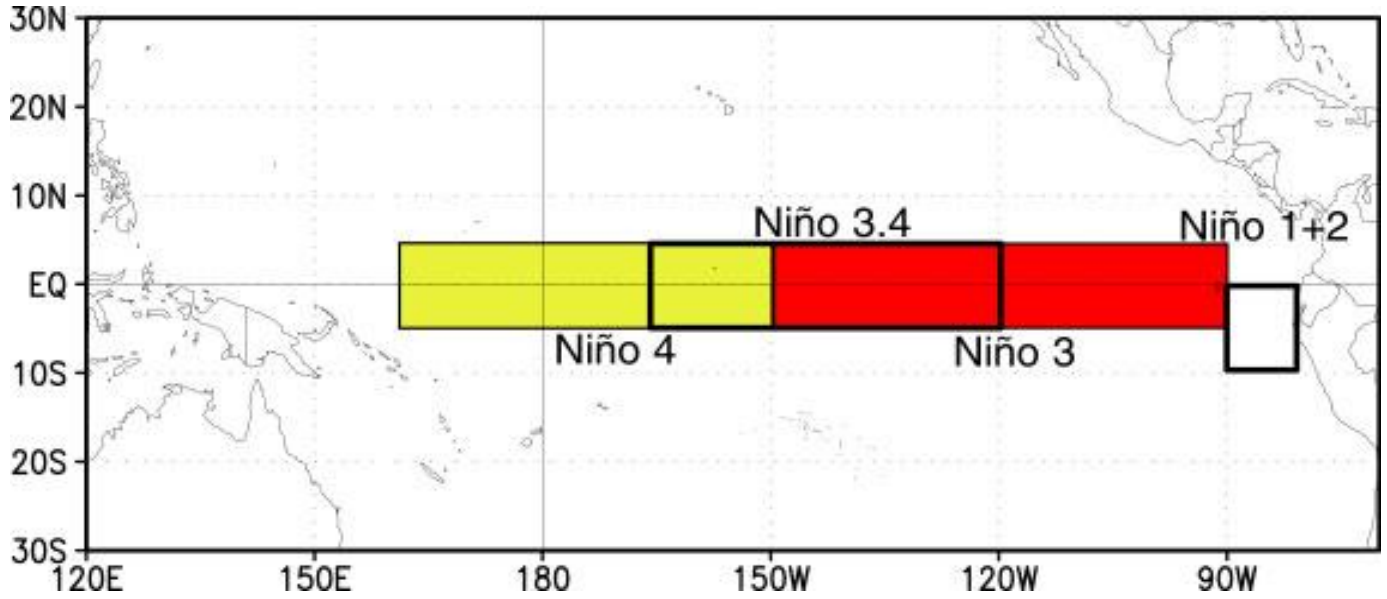
*Nature,*1999,401,360-363

Dipole Mode Index

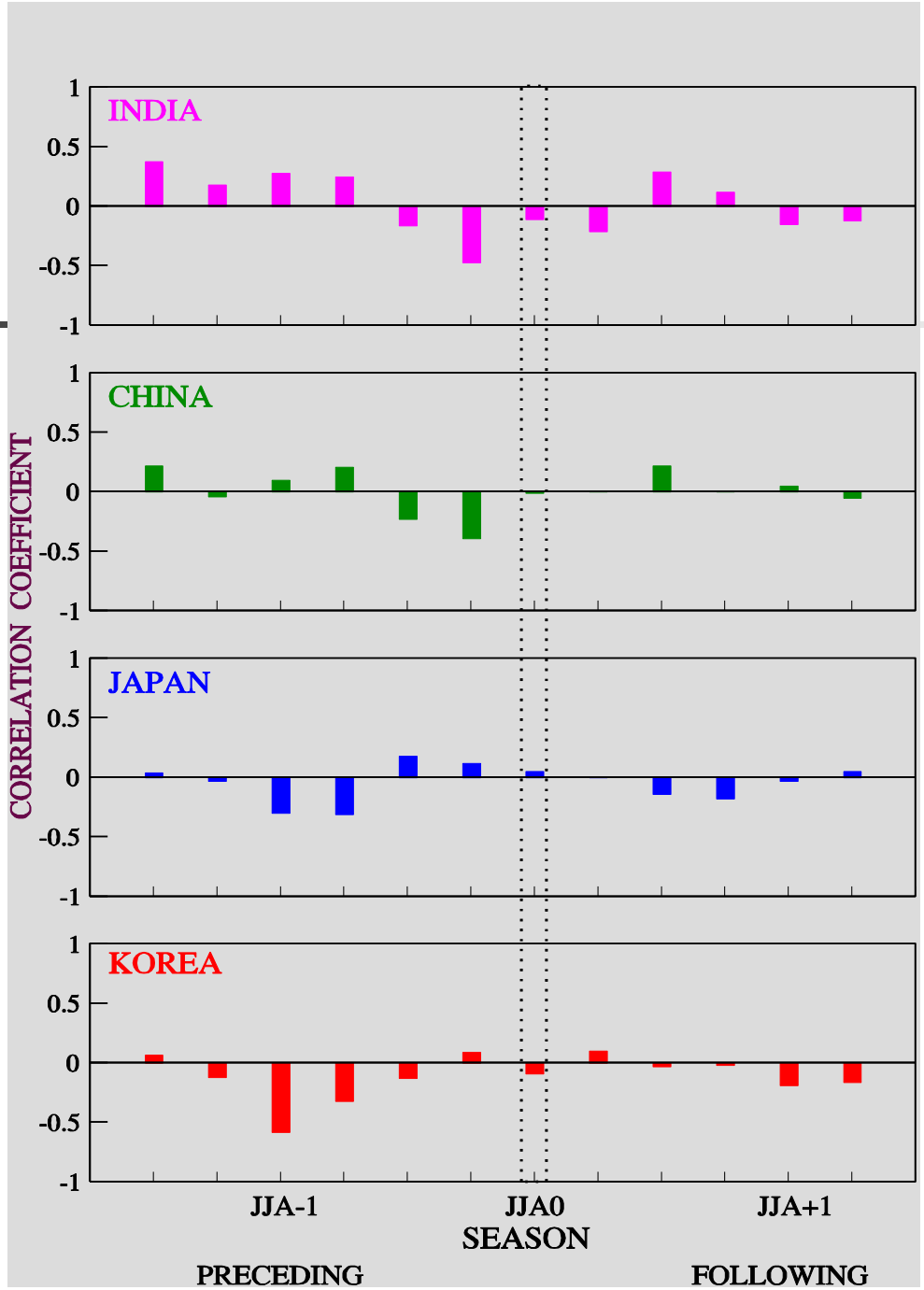


DMI: Standardized difference in SST anomalies between the above two blocks

Index for ENSO phenomenon



SST anomalies over Nino 3 region



Dipole Mode and summer rainfall

(i) No simultaneous relation

(ii) Significant negative relation with summer monsoon rainfall over Korea-Japan 3-4 seasons later

(Kripalani, Oh, Kang, Sabade, Kulkarni,2005, TAC, 82, 81-94)

Mean Seasonal Rainfall Following Extreme Dipole Events

- Positive Events: 1961 1972 1982 1994 1997
- Negative Events: 1960 1964 1992 1996 1998

For South Korea: Mean KMR: 648 mm

Following positive / negative events: 593 / 753 mm

Difference significant at 90% confidence level

For Japan: Mean JMR: 923 mm

Following positive / negative events: 885 / 1140 mm

Difference significant at 90% confidence level

(Kripalani,Oh,Kang,Sabade,Kulkarni,2005,TAC,82,81-94)

Main Inferences:

- Summer and Autumn Dipole Mode Index during the preceding year show significant negative relation with following summer monsoon rainfall over Korea and Japan

- Indian Ocean Dipole Mode influences East Asian Monsoon Variability 3 to 4 seasons later

- Delayed Impact ?

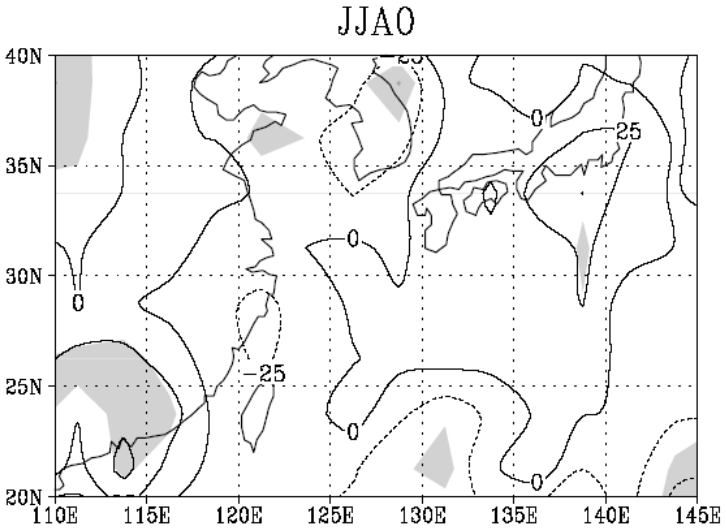
Detailed Analysis

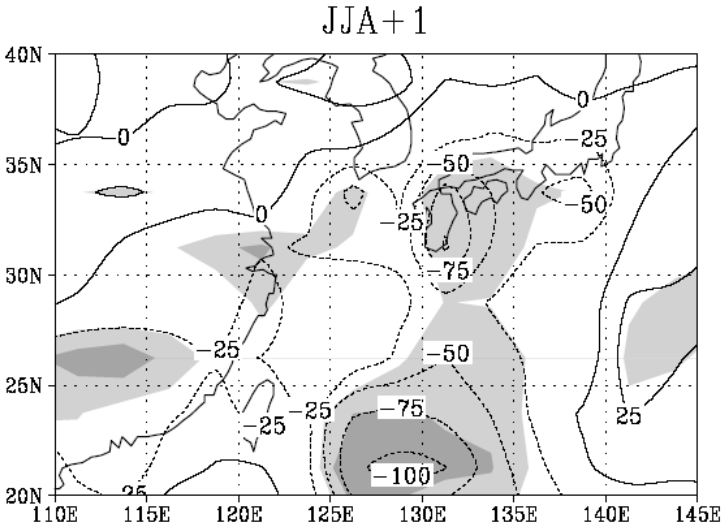
(International Journal of Climatology,2010,30,197-209)

- Historical Soviet Snow Depth Data (1884-1995)
- CMAP Precipitation
- NCEP-NCAR Reanalysis: 850 hPa winds, 500 hPa heights and SST
- HADCRUT3 SST and SAT
- Extreme Dipole /ENSO Events: 1961-2003

Positive:1961,1963,1967,1972,1982,1983,1991,1994,1997,2000
Negative:1964,1973,1974,1980,1981,1984,1989,1992,1996,1998
6 +ve events associated with El Nino: 1972,1982,1983,1991,1994,1997
5 –ve events associated with La Nina: 1964,1973,1974,1984,1998

CMAP Precipitation Difference
Positive minus Negative ZMI





For events between 1979-2003

EAWNP: 15-35^{0}N,120-140^{0}E

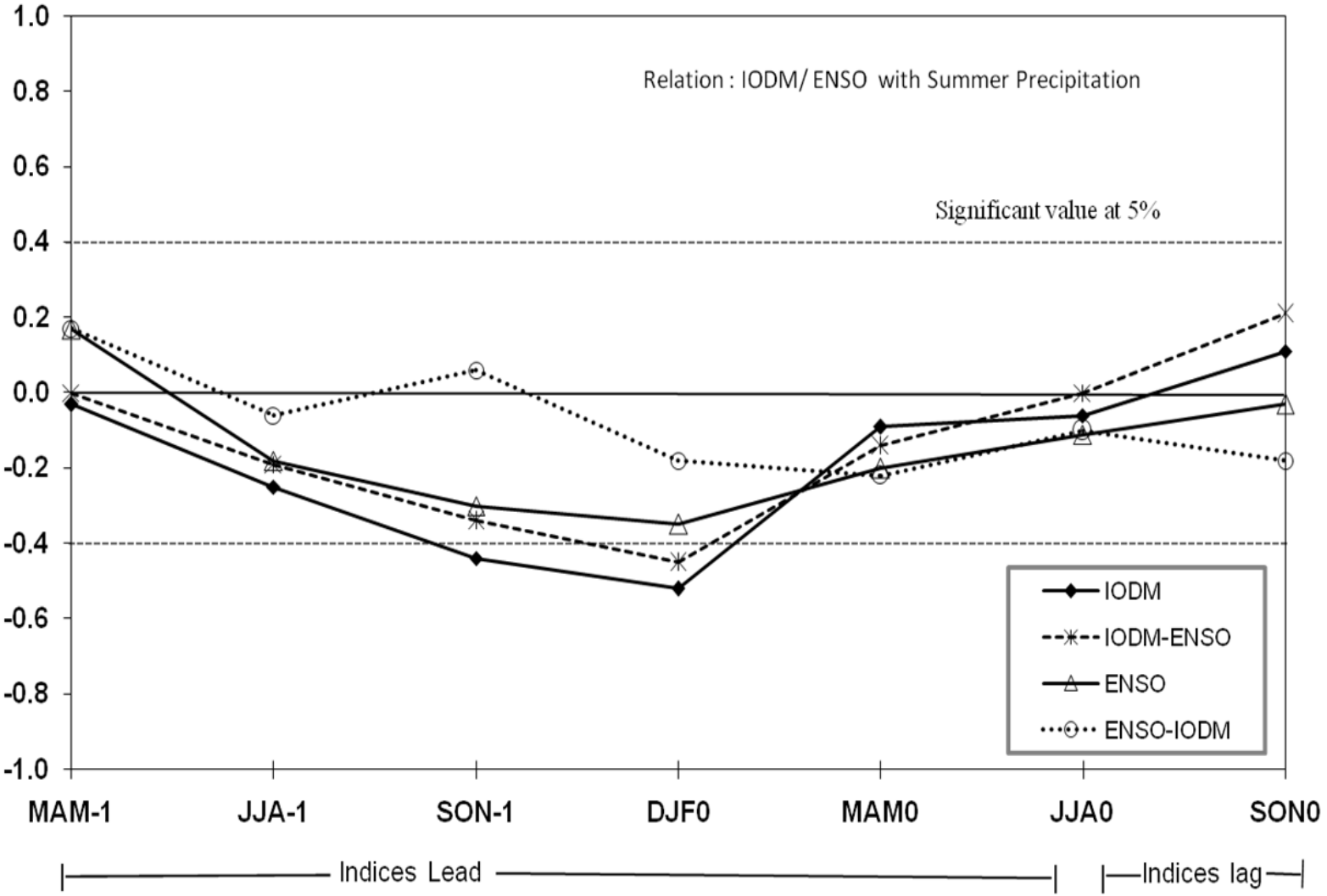
(Kripalani,Oh,Chaudhari,2010, IJOC, 30, 197-209)

Partial Correlation Analysis

$$r12.3 = \frac{r12 - r13\ r23}{sqrt(1-r13**2)\ sqrt(1-r23**2)}$$

Relation between EAWNP precipitation with IODM (ENSO) index removing ENSO(IODM) effect

Relation with EAWNP precipitation
Data period: 1979-2003

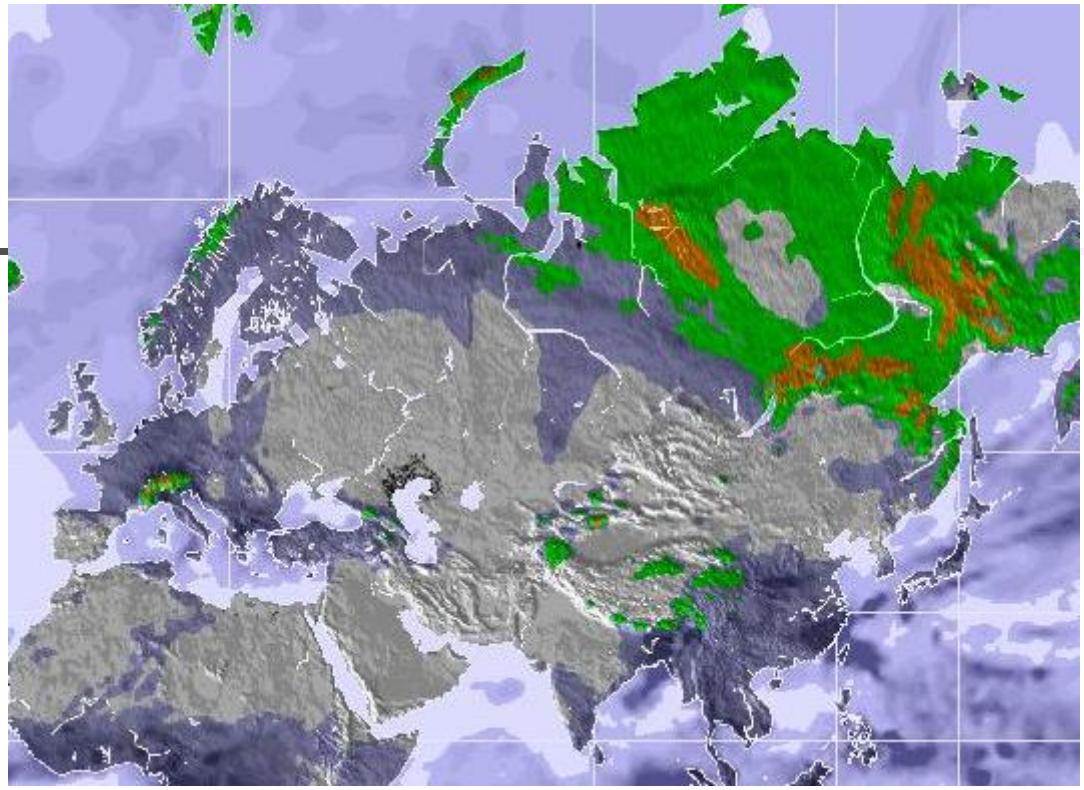


(Kripalani,Oh,Chaudhari,2010,IJOC, 30, 197-209)

Inferences:

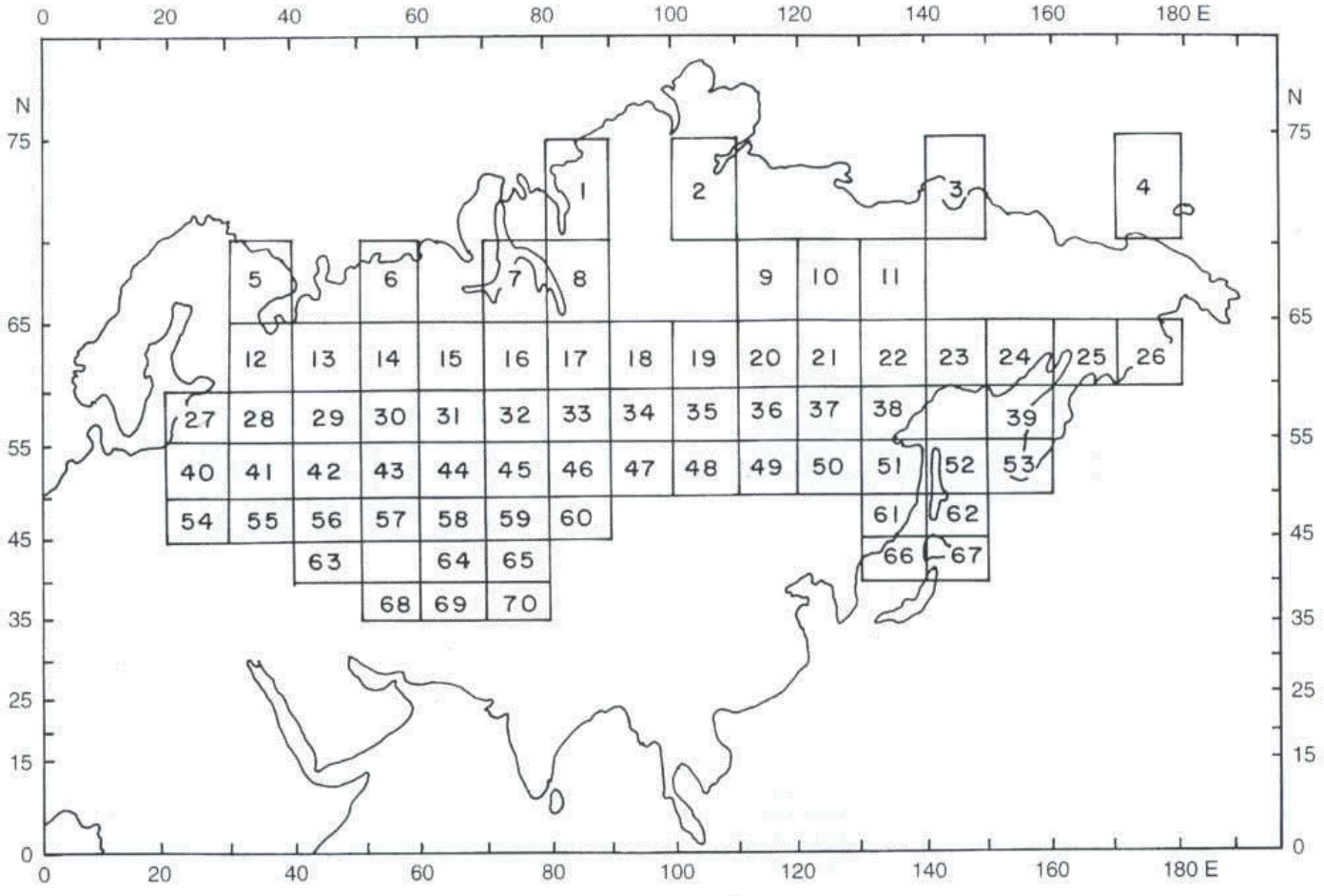
- CC suggests EAWNP precipitation has stronger relationship with preceding IODM than with ENSO

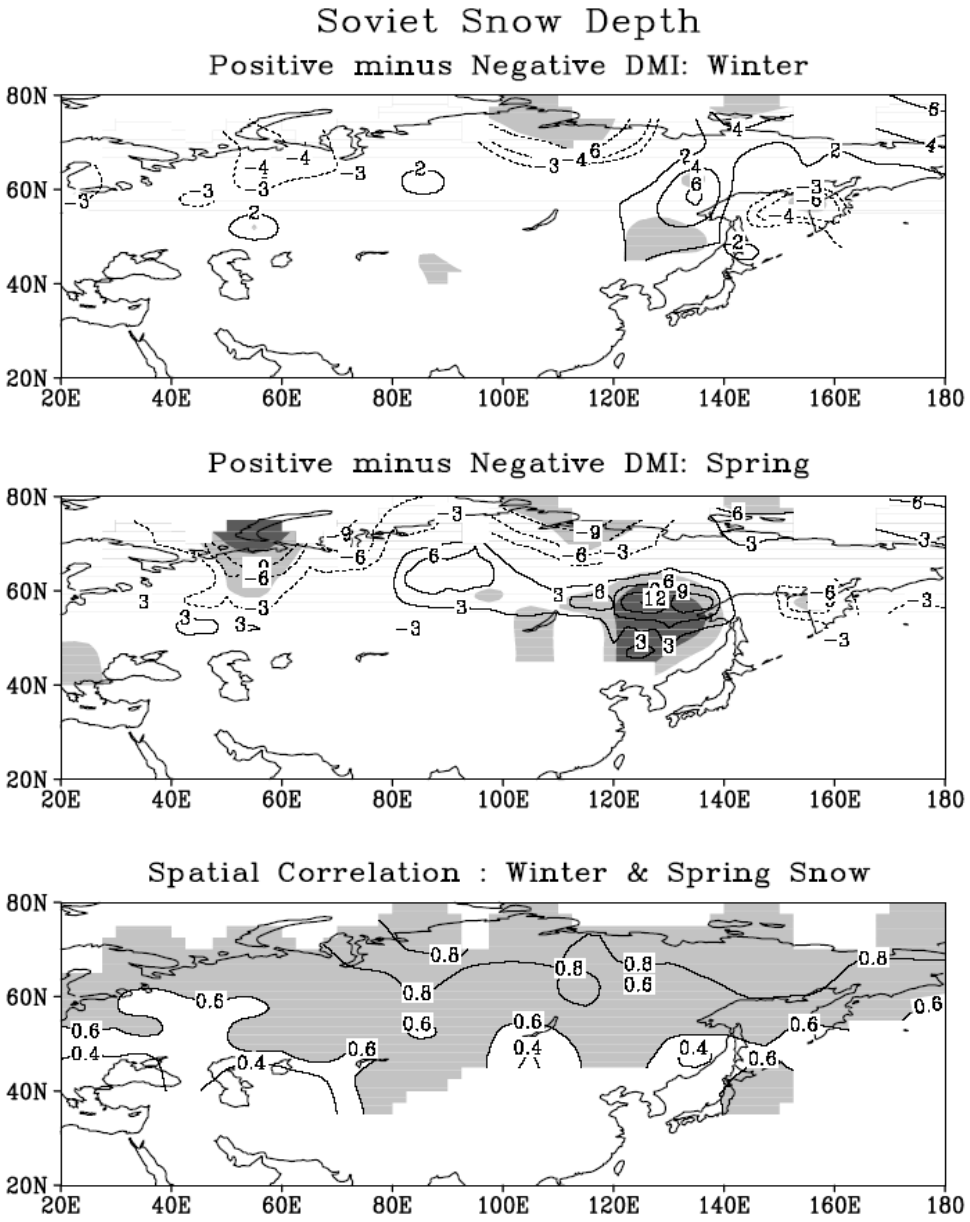
- PCC suggests both IODM and ENSO co-operate for summer monsoon rainfall anomalies over EAWNP



- **Memory for delayed impact : Eurasian Snow ?**

Soviet Snow Depth Data: NSIDC, Boulder, Co, USA
Data for 284 stations 1884-1995
Converted to 70 blocks 5 lat x 10 long
(Kripalani and Kulkarni, Climate Dynamics,1999,15,475-489)



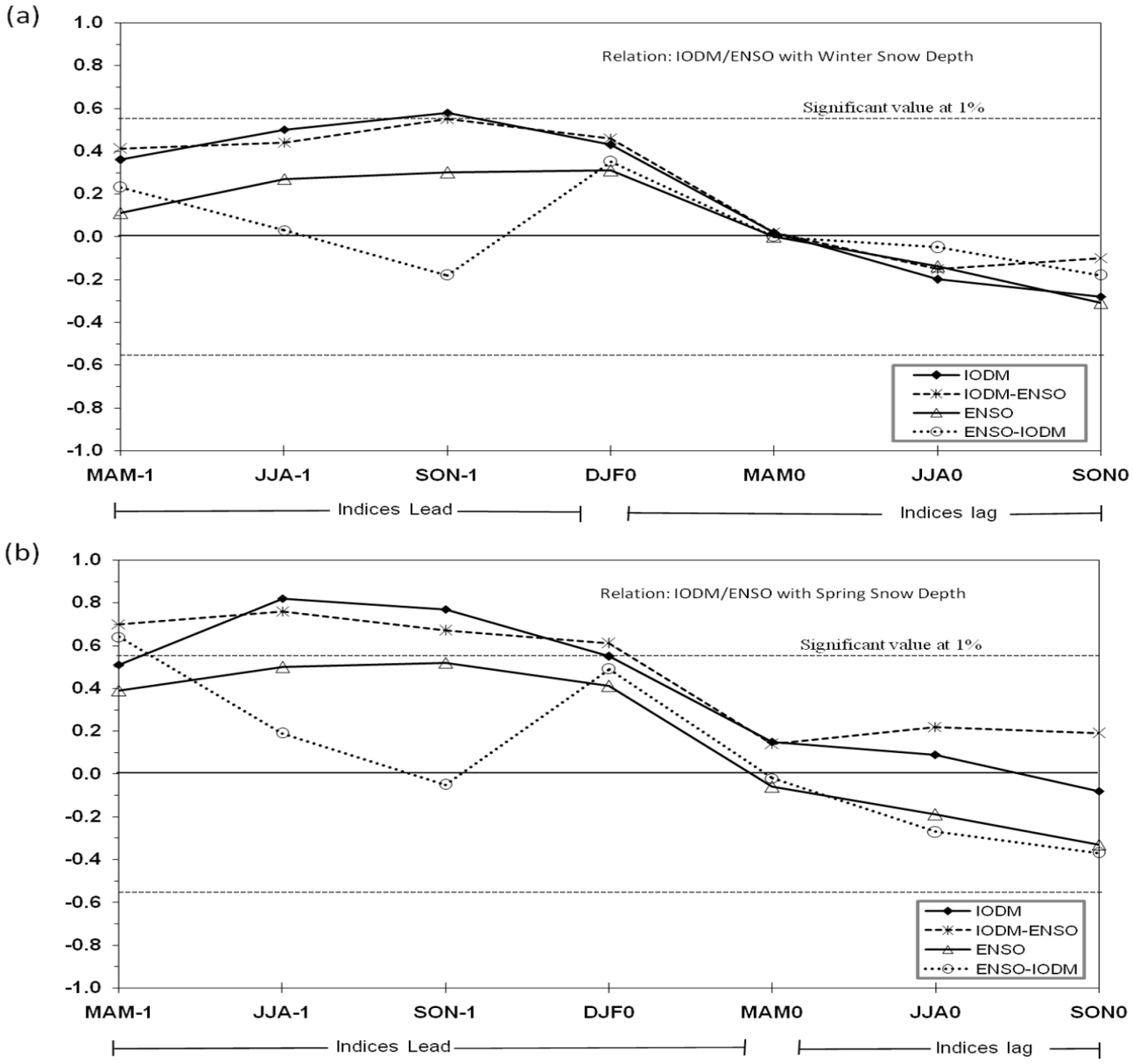


For Events Between 1961-1995

EENKJ: 45-60^{0}N,120-140^{0}E

(Kripalani,Oh,Chaudhari,2010, IJOC, 30, 197-209)

Relation with EENKJ snow: 1976-1995



(Kripalani,Oh,Chaudhari,2010,IJOC, 30, 197-209)

The above analysis suggests :

Positive phase of the dipole during autumn could induce heavy snow during the following winter and spring just North of the Korea-Japan sector

Snow has stronger relation with IODM than with ENSO

IODM can preserve its footprints via snow

Mechanism: North Pacific Subtropical High

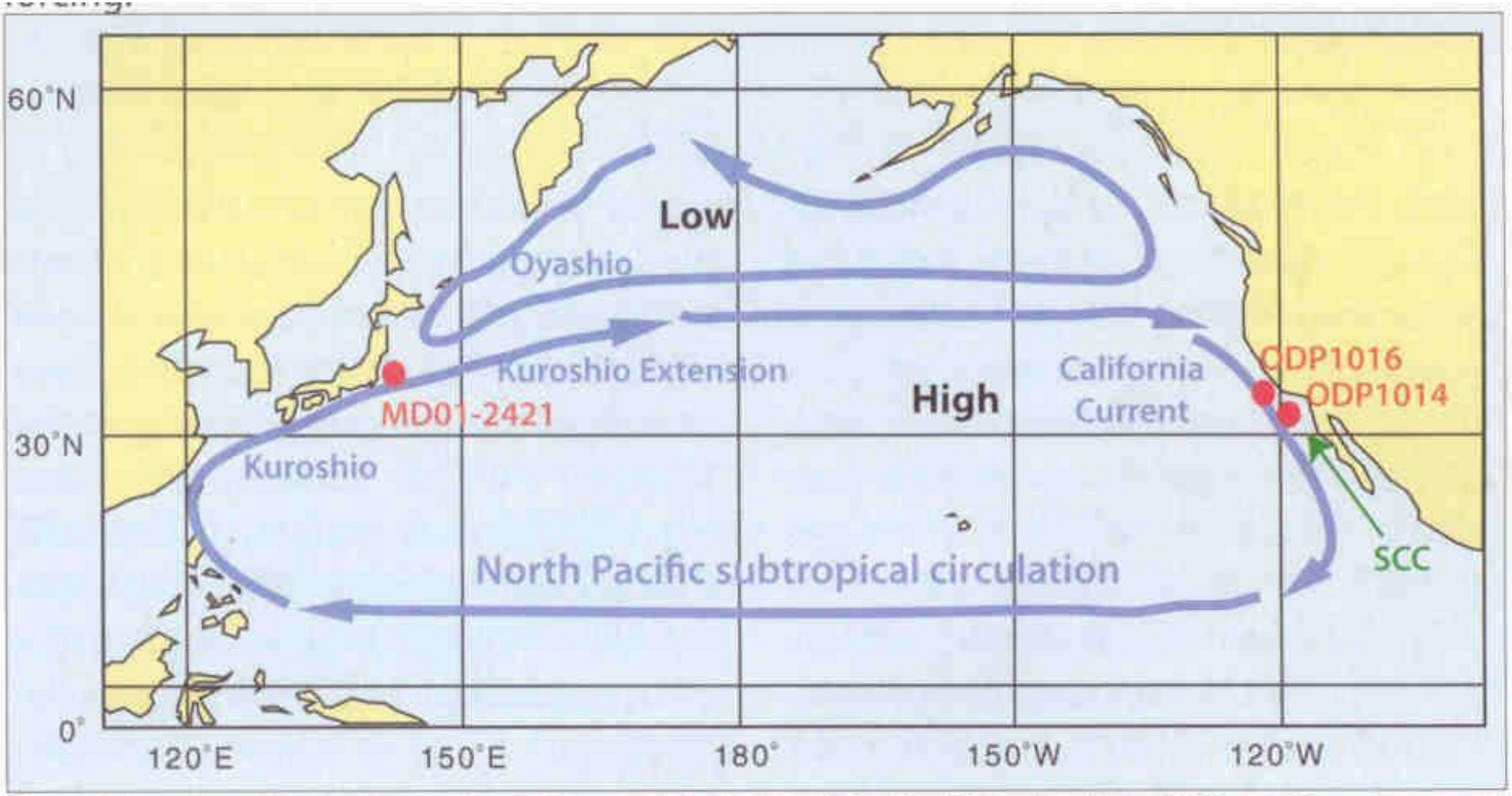


Figure 1: Location of study sites and surface currents in the North Pacific (SCC = Southern California Countercurrent). Local atmospheric cells are also indicated: ***High*** *= North Pacific High,* ***Low*** *= Aleutian Low.*

Through Northern Hemisphere

- Circulation features associated with Extreme
  - Dipole phases (TAC,2005,82,81-94)

  - Snow phases
  - Snow depth over EENKJ region

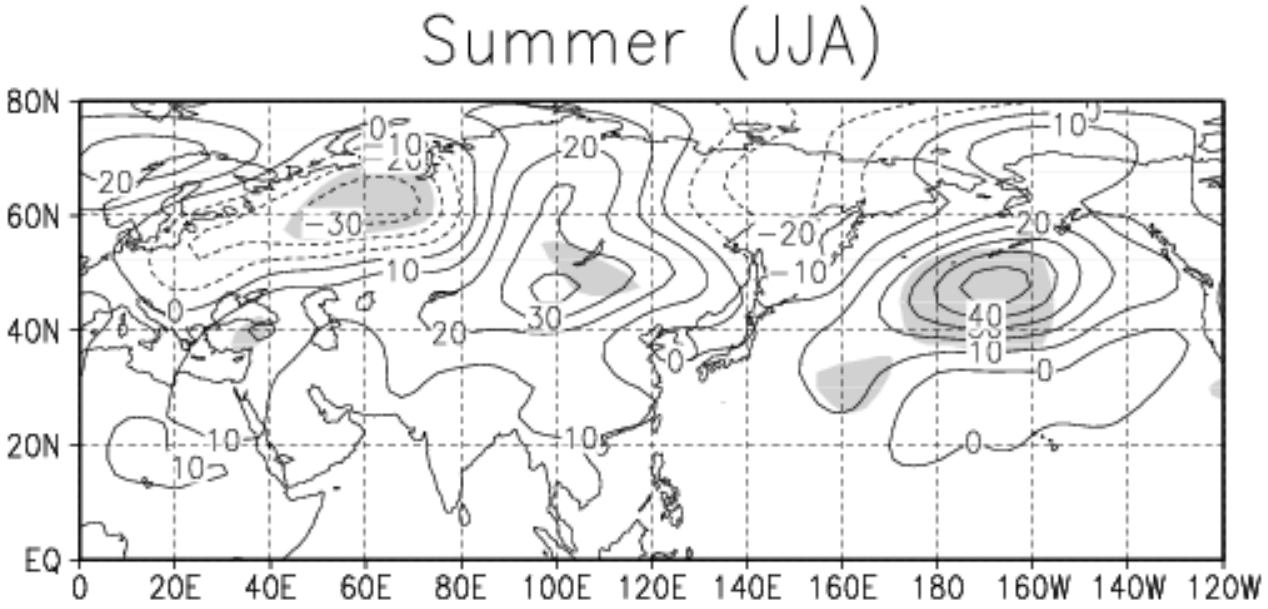
- Heavy snow: 1962,1970,1978,1979,1980

Standardized snow depth: Winter (DJF) +1.6, Spring (MAM) +1.1

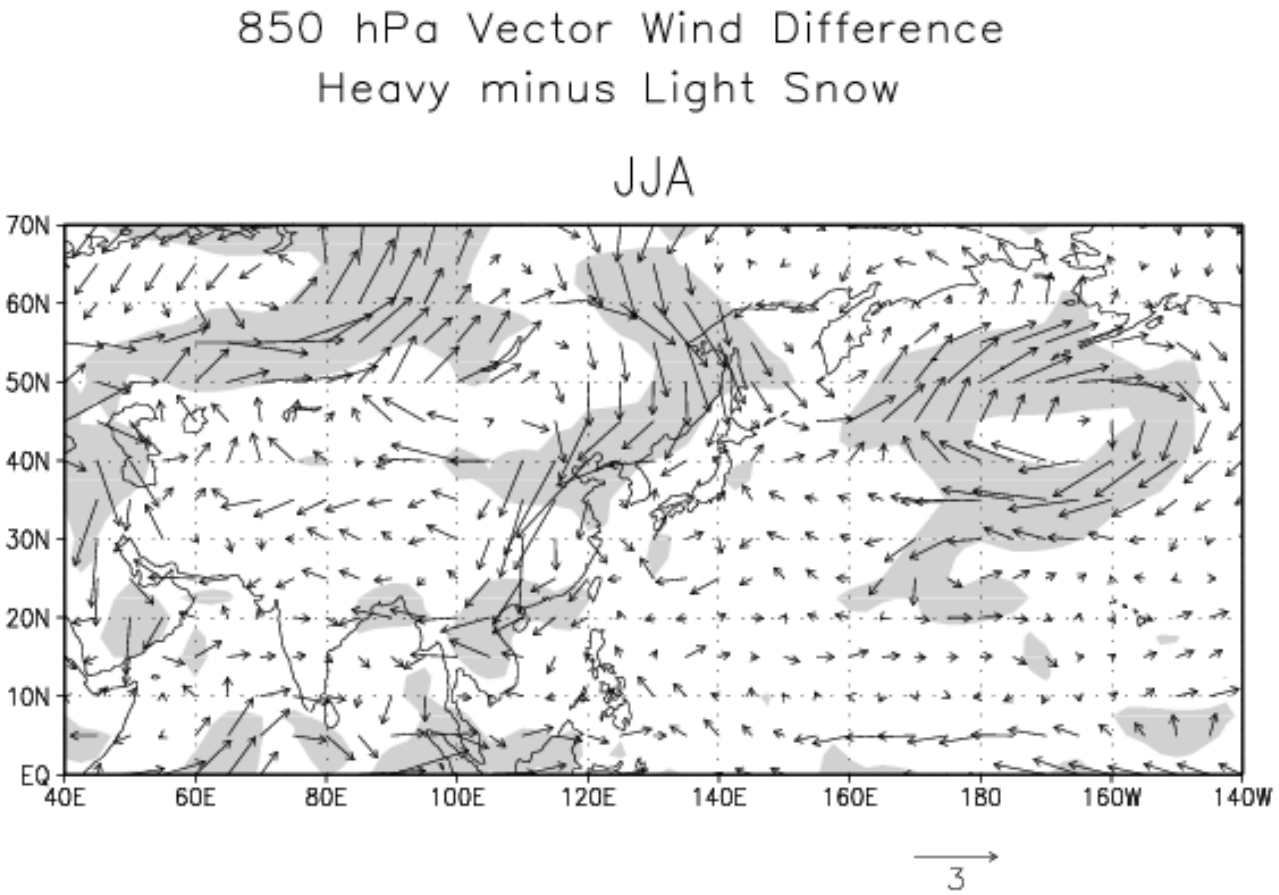
- Light snow: 1961,1963,1966,1973,1987

Standardized snow depth: Winter (DJF) -1.5, Spring (MAM) -0.6

500 hPa Geopotential Height Difference
Heavy minus Light Snow



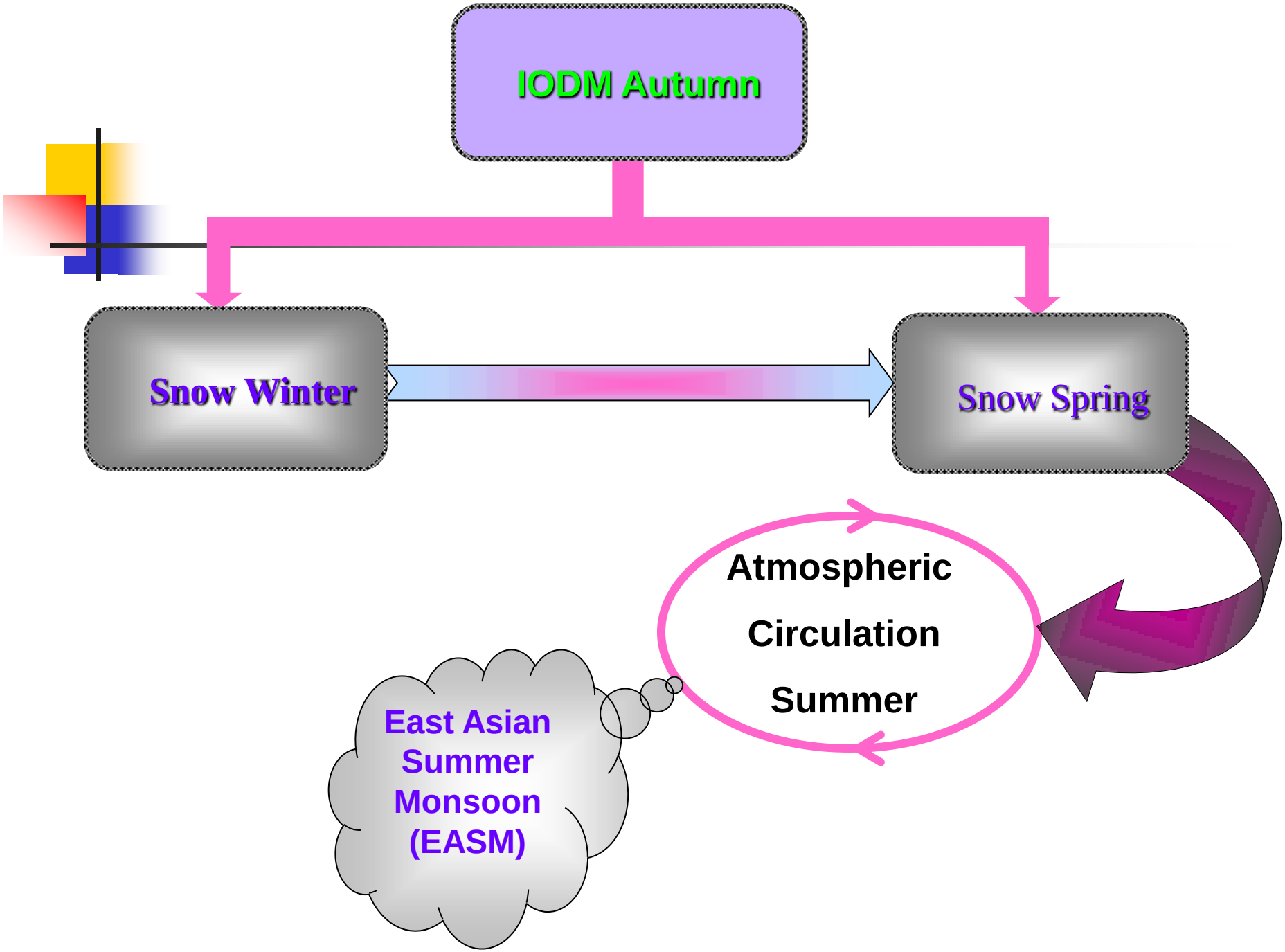
(Kripalani,Oh,Chaudhari,2010,IJOC, 30, 197-209)

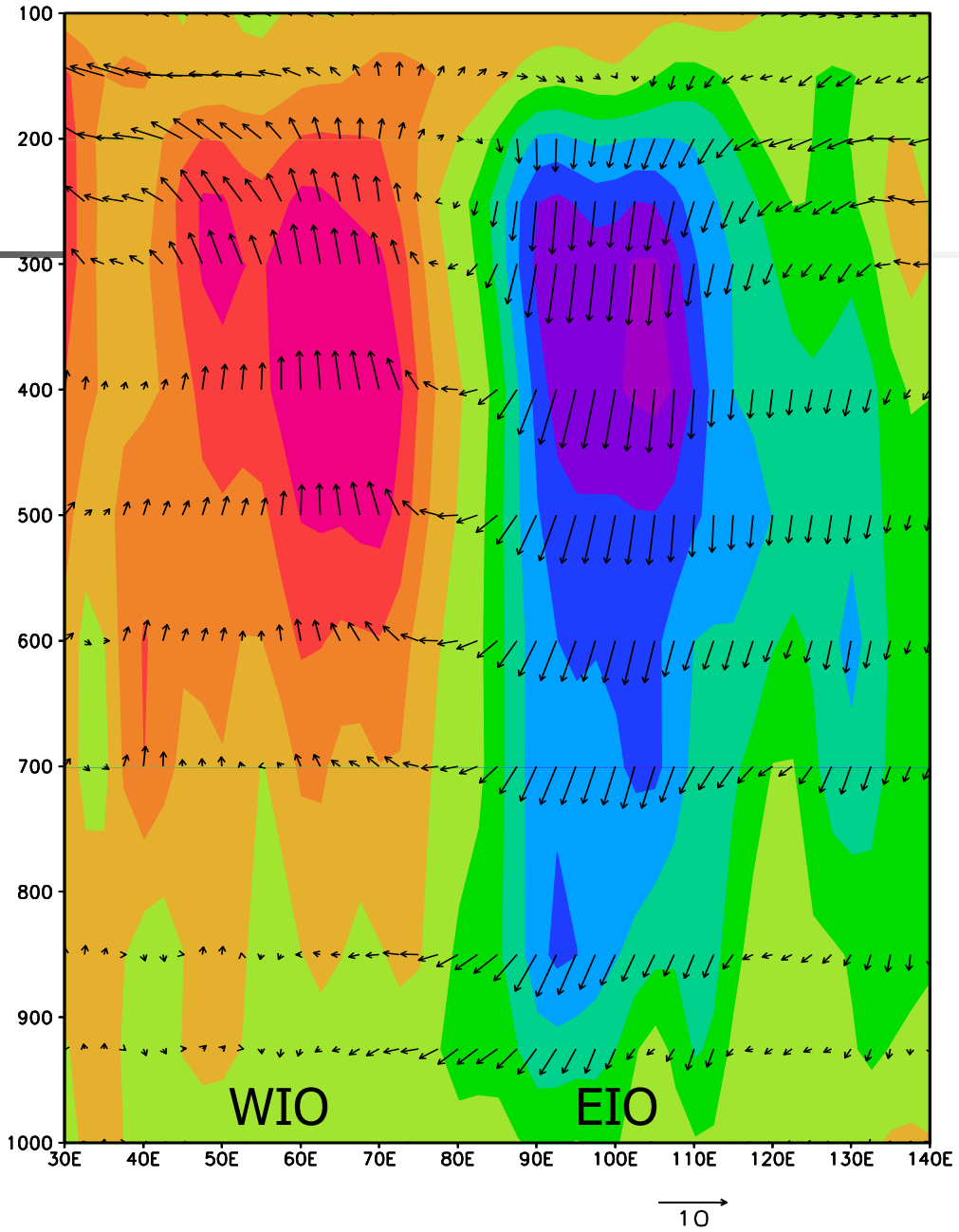


(Kripalani,Oh,Chaudhari,2010,IJOC, 30, 197-209)

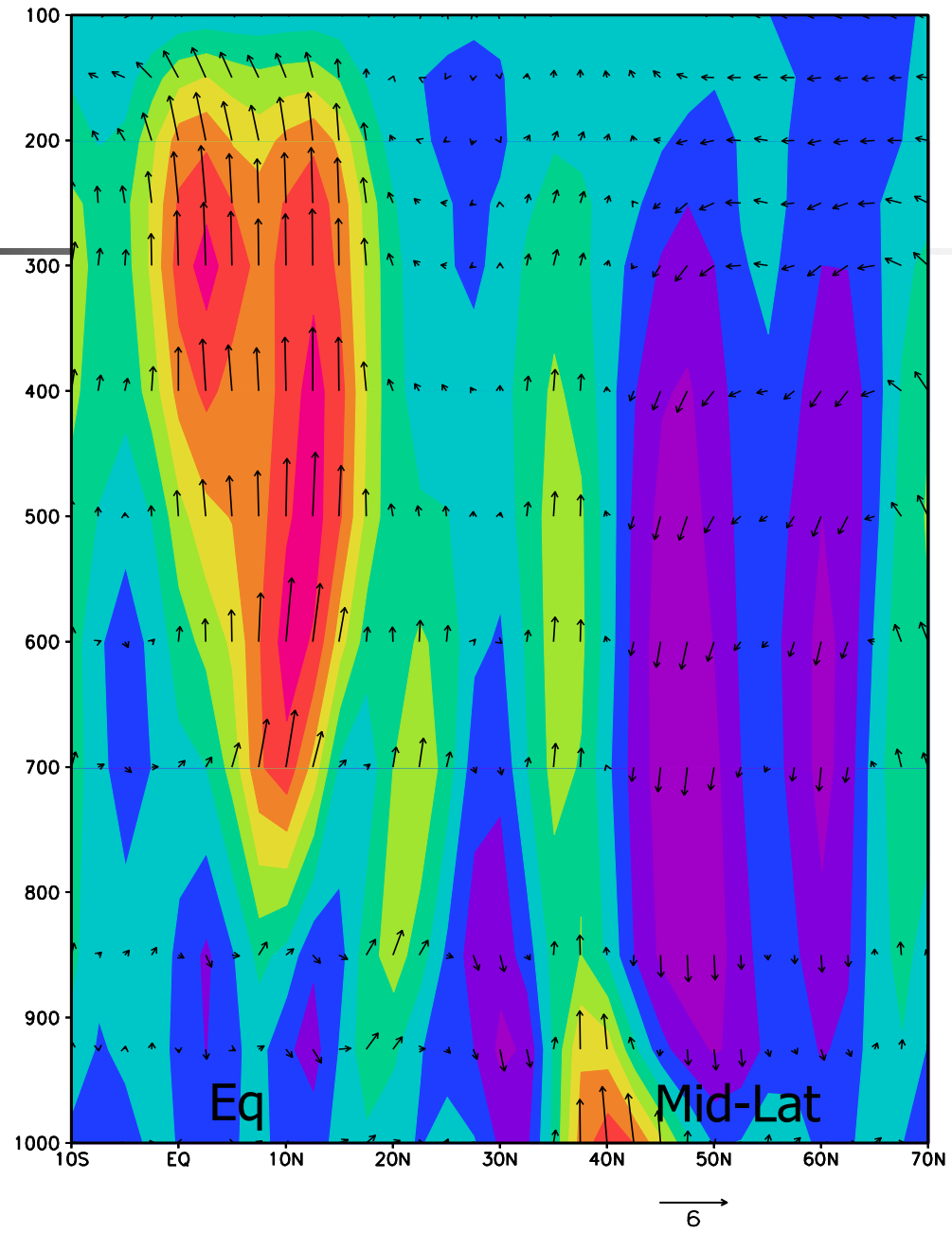
Inferences

- NPSH displaced northeastwards due to anomalous northerly flow
- Weakening cross-equatorial flow and low-level jet
- Less moisture supply from Pacific towards South China-Korea-Japan-West Pacific
- Subdued Rainfall Activity


IODM Autumn
Snow Winter
Snow Spring
Atmospheric
Circulation
Summer
East Asian
Summer
Monsoon
(EASM)


Walker Cell (w+u) 10S–10N Autumn (SON)
Positive minus Negative IODM: Only IODM cases
100
200
300
400
500
600
700
800
900
1000
30E
40E
50E
60E
70E
80E
90E
100E
110E
120E
130E
140E
WIO
EIO
10

Walker Cell


Hadley Cell (w+v) 10E–60E Autumn (SON)
Positive minus Negative IODM: only IODM cases
100
200
300
400
500
600
700
800
900
1000
10S
EQ
10N
20N
30N
40N
50N
60N
70N
Eq
Mid-Lat
6

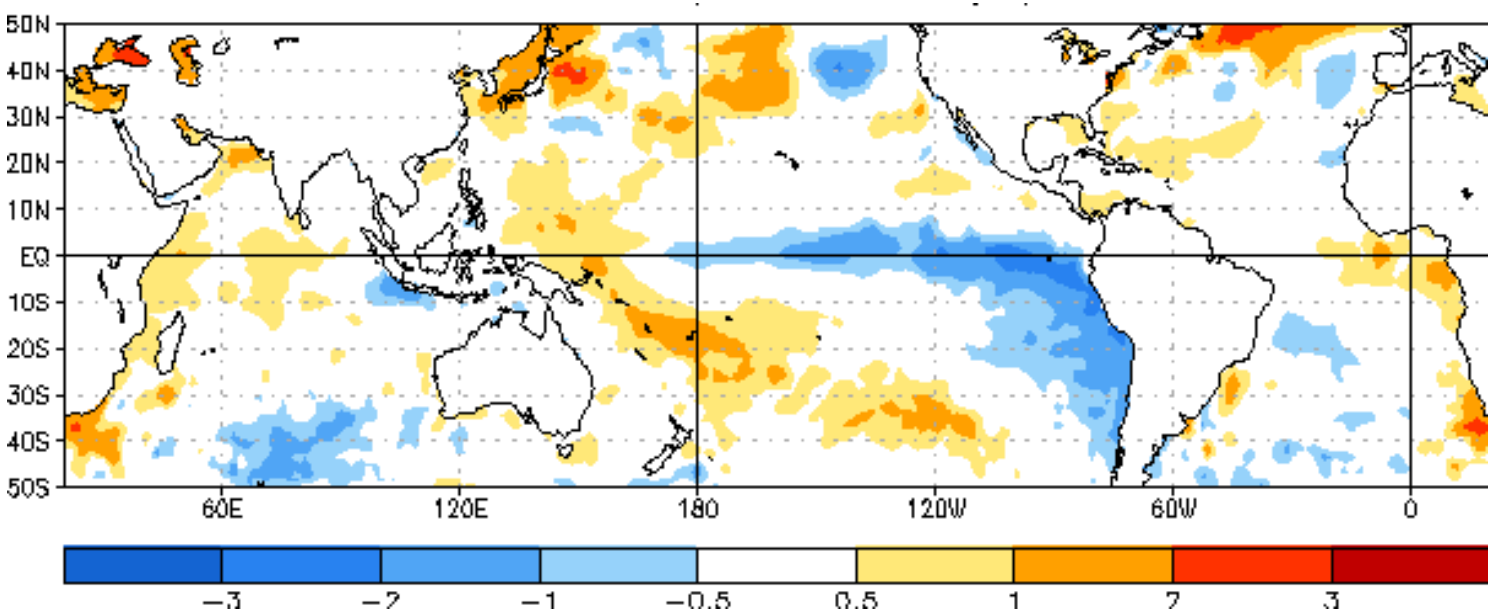
Hadley Cell

Unusual IOD event of 2007

(Behera, Luo, Yamagata, GRL, 2008;

Rao, Luo, Behera, Yamagata, Clim Dyn, 2009)

SST Anomalies September 2007



Outlook for summer monsoon rainfall 2008 over Korea-Japan peninsular: Below Normal

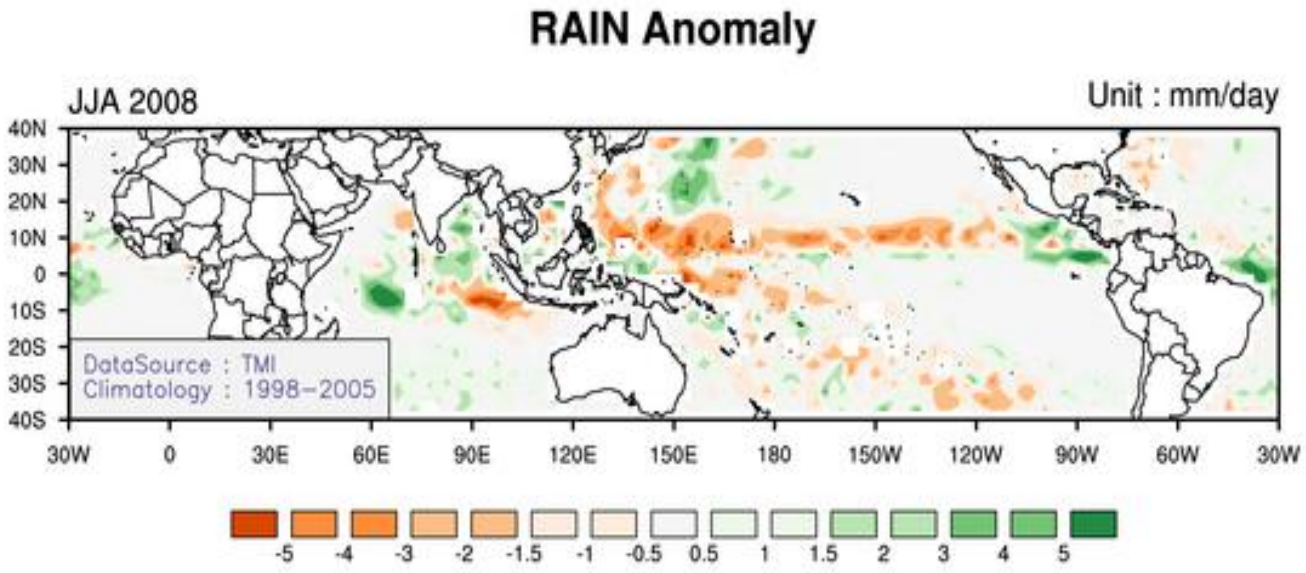
(Kripalani, APEC Newsletter, Vol 2 No 4, Dec 2007, pp 4-6, www.apcc21.net)

China's snow disaster in 2008, who is the principal player?
Gao Hui

- International Journal of Climatology, 2009,
  doi: 10.1002/joc.1859

Unprecedented snow disaster in January 2008 brought serious human and economic losses to China

Rather than the La Nina event, the abnormal circulation at the high latitudes may play a more crucial role in making this snow disaster

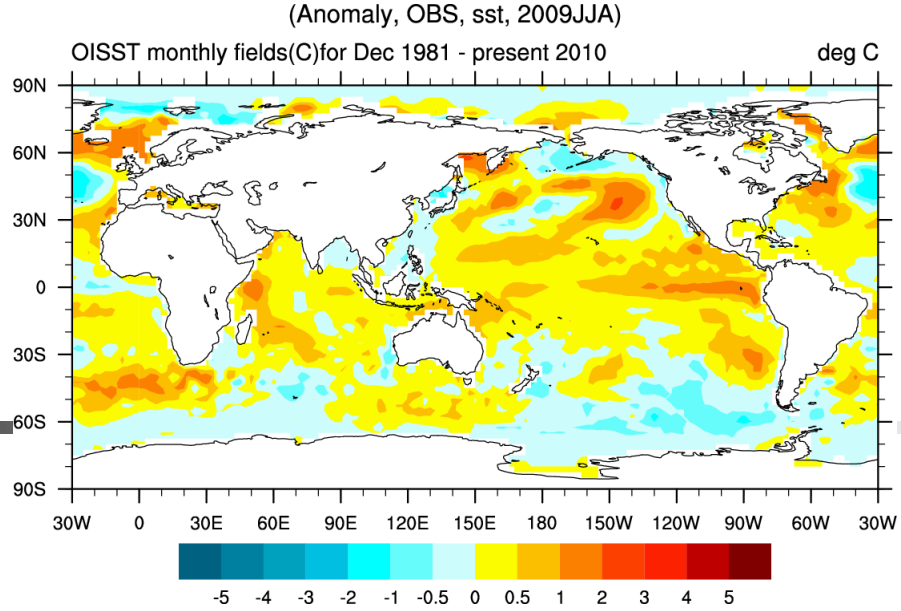


Severe Drought South Korea Summer 2008

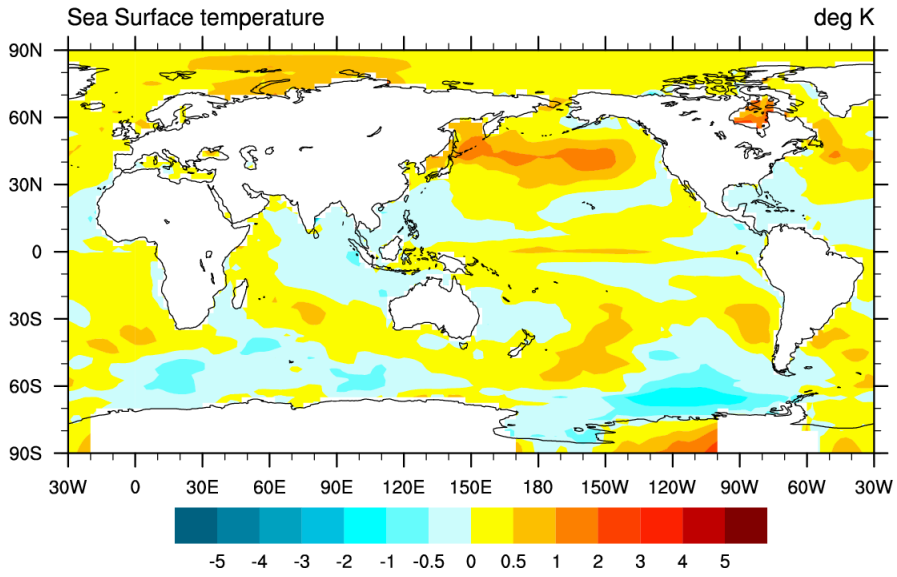
 created:09/10/08

2009 JJA

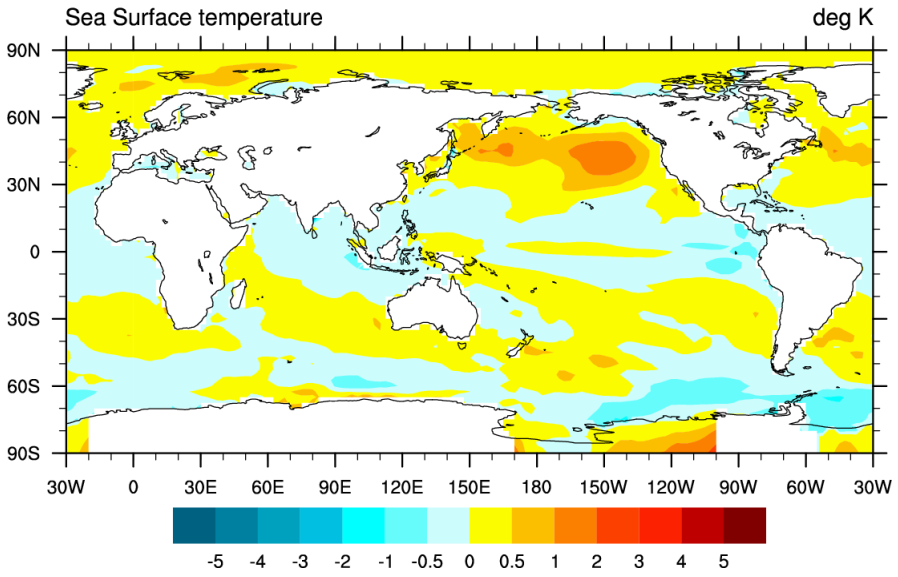
Observation



1-M lead SCM

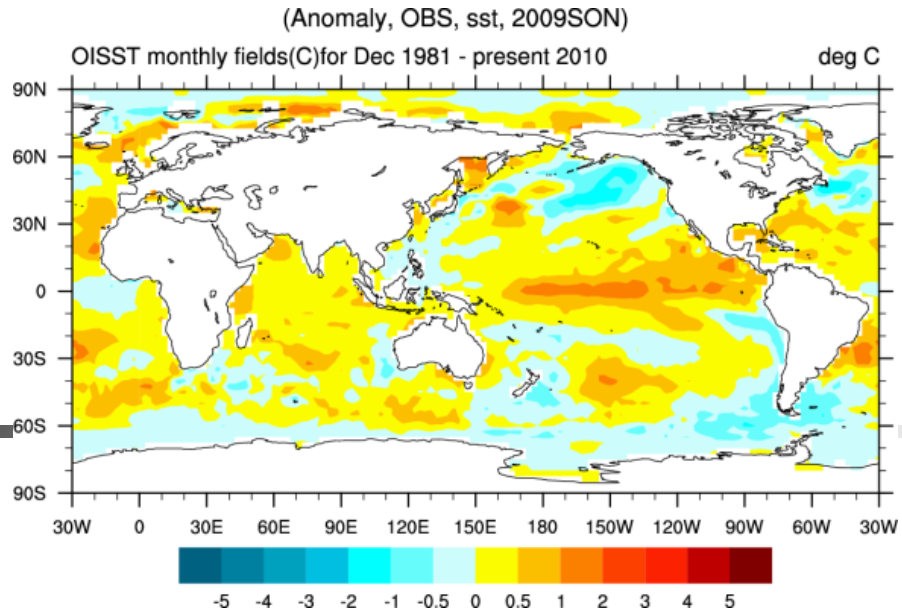


4-M lead SCM

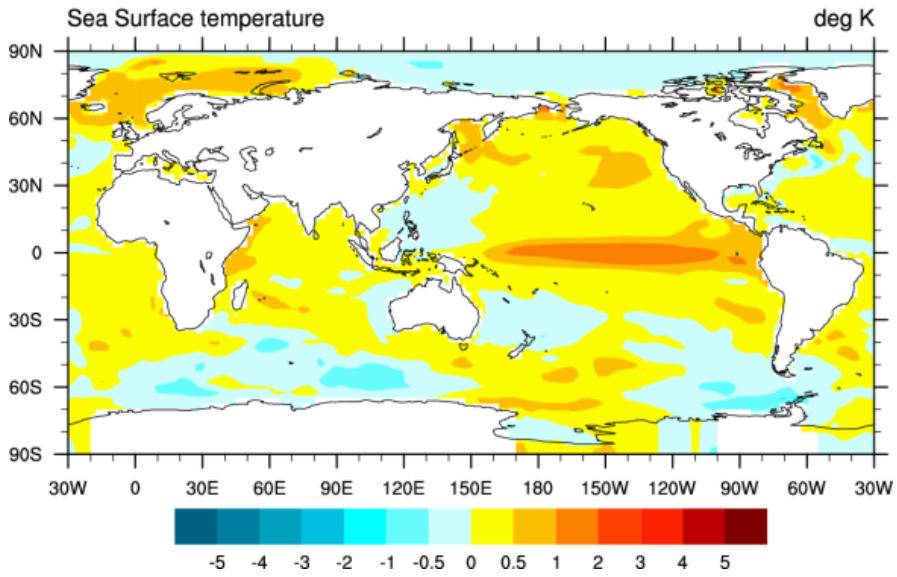


2009 SON

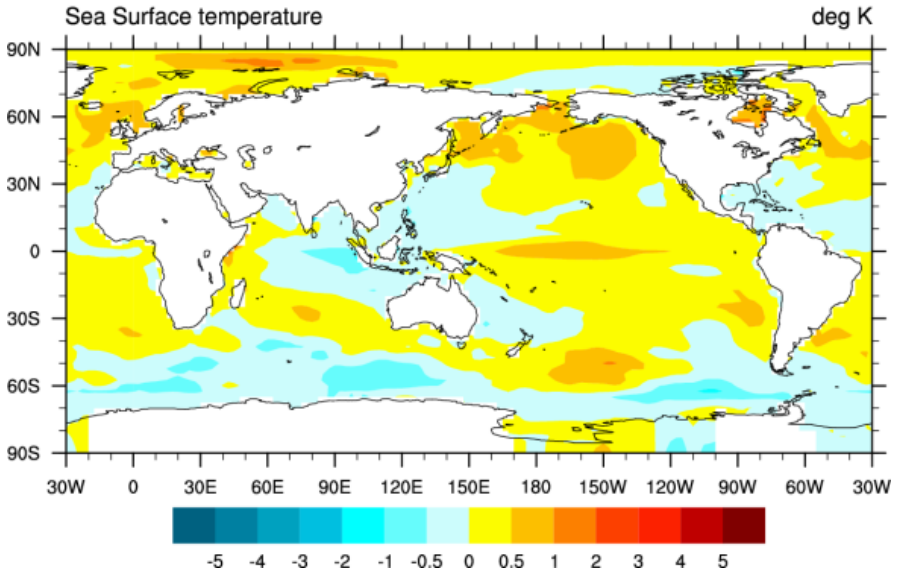
Observation



1-M lead SCM

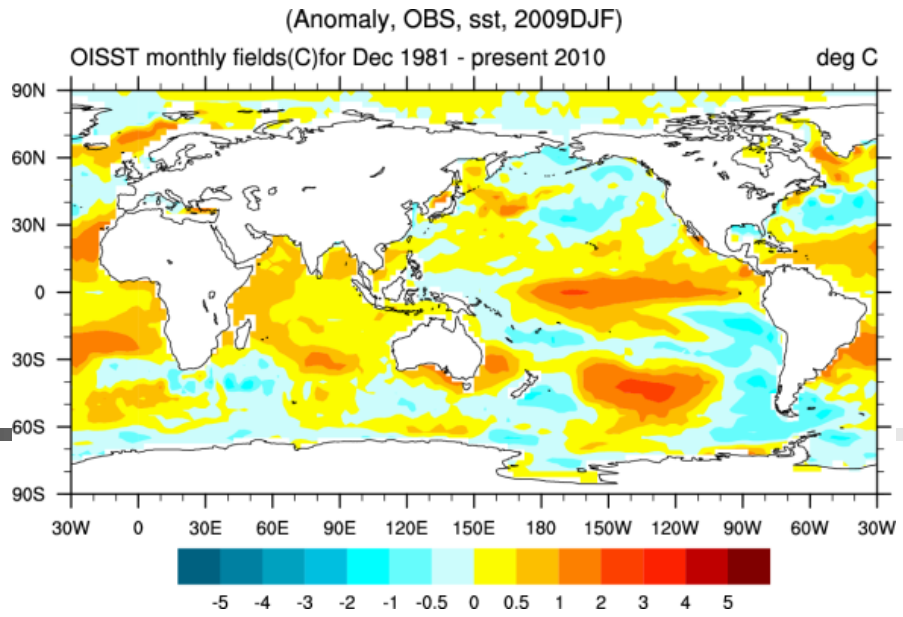


4-M lead SCM

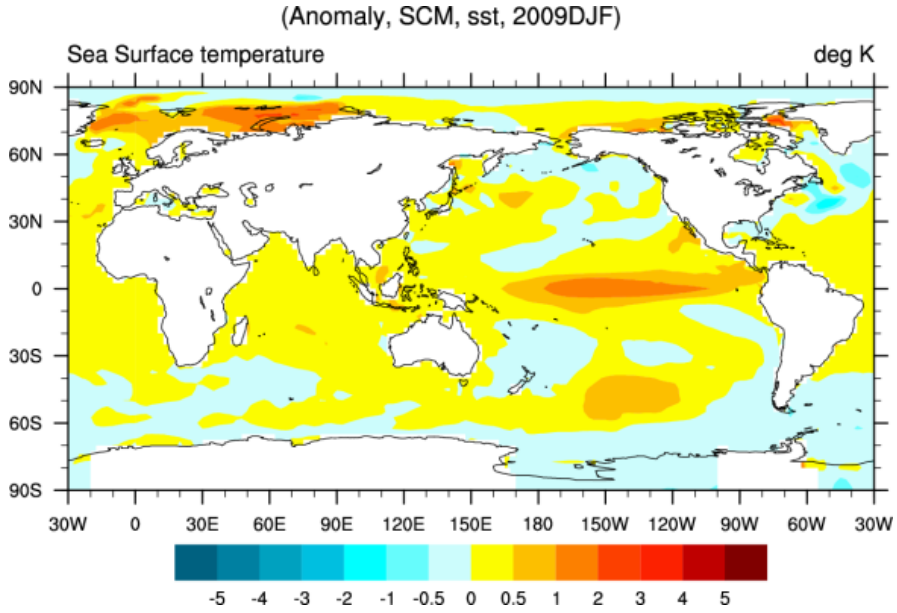


2009-2010 DJF

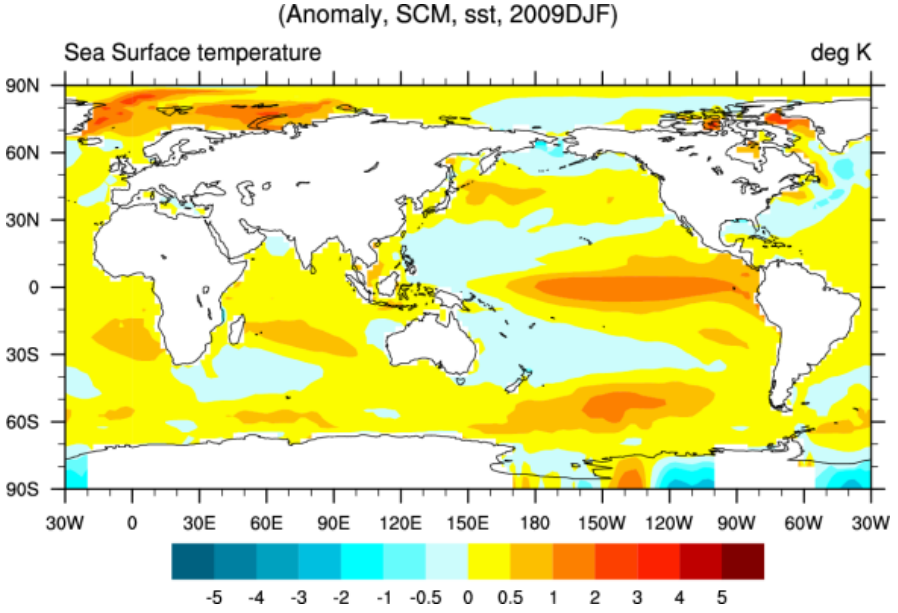
Observation



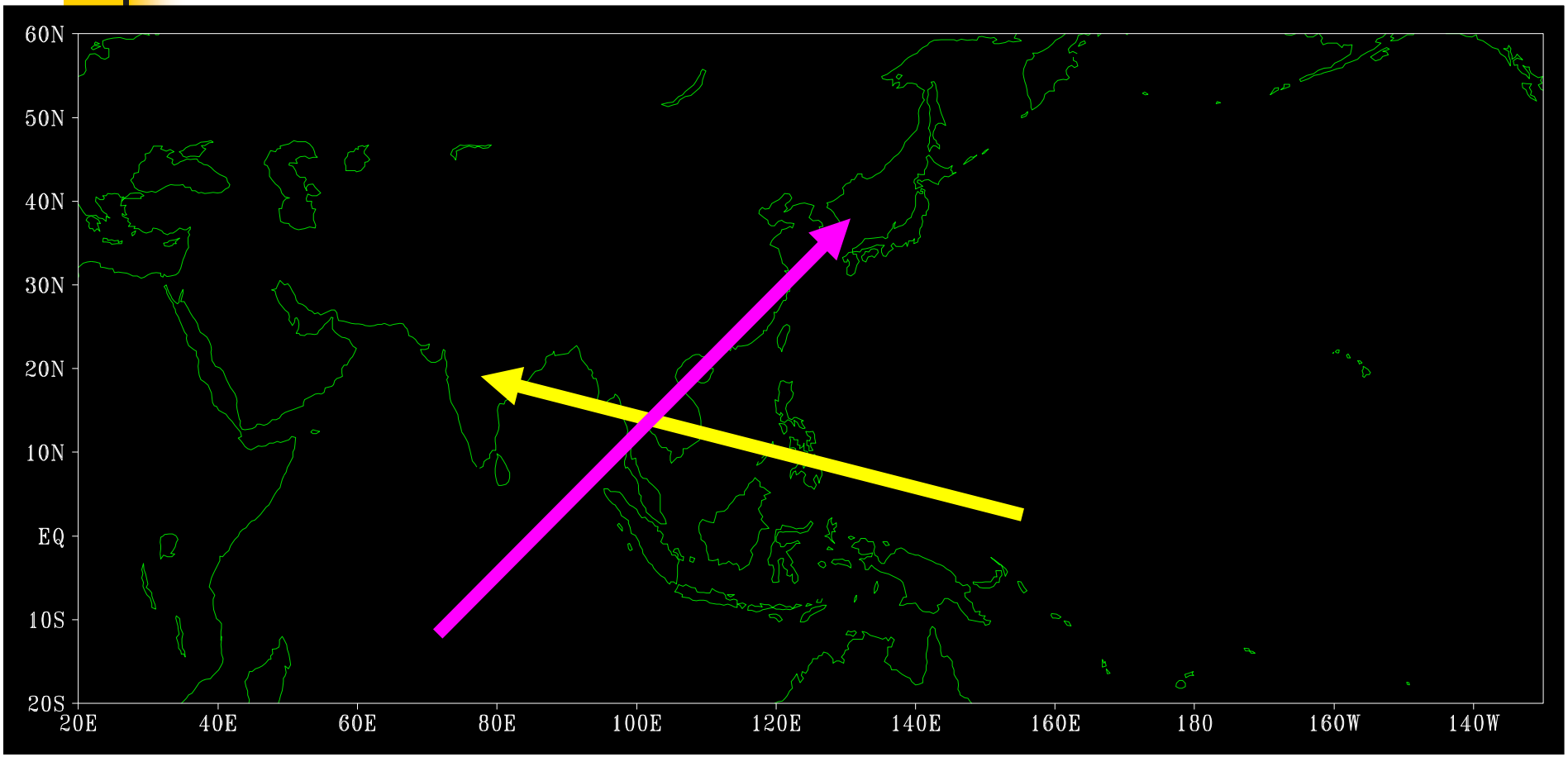
1-M lead SCM



4-M lead SCM



CROSS DIAGONAL EFFECT



--Thank You--