Optimum Observation Sites over the Tibetan Plateau for Understanding the Asian Monsoon and Its Impacts

WU Guoxiong

LIU Yimin, LIU Xin , MAO Jianyu and DUAN Anmin

State Key Lab of Atmospheric Sciences and Geophysical Fluid Dynamics (LASG)

Institute of Atmospheric Physics (IAP)

Chinese Academy of Sciences (CAS)

ICTP, Trieste, June 10-15, 2001

References:

1. Wu Guoxiong, Yongsheng Zhang, 1998: Tibetan Plateau Forcing and monsoon onset in South Asia and Southern China Sea. *Mon. Wea. Rev*. 1998, 126(4): 913-927.

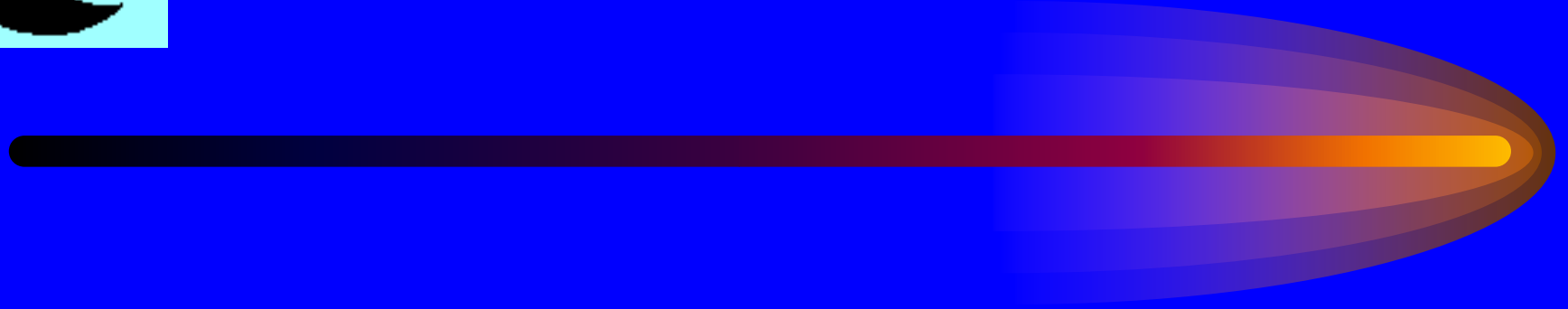
2. Wu, Guoxiong and Yimin Liu, 2003: Summertime quadruplet heating pattern in the subtropics and the associated atmospheric circulation. *Geophys. Res. Lett.,* **30(5)**, 1201, 5_1-4.

3. YIMIN LIU, GUOXIONG WU, AND RONGCAI REN, 2004: Relationship between the Subtropical Anticyclone and Diabatic Heating. *J. Climate*, 2004, **17**: 682-698.

4. Wu, Guoxiong, Yimin Liu, Jianyu Mao, Xin Liu and Weiping Li. 2004: Adaptation of the atmospheric circulation to thermal forcing over the tibetan plateau. *Obseervation, Theory And Modeling Of The Atmospheric Variability. Selected Papers Of Nanjing Institute Of Mateorology Alumni In Commemoration Of Professor Jijia Zhang*, Edited By Xun Zhu Etc.World Scientific 92-114.

5. Yanai, M, and Wu Guoxiong, 2005: Effects of the Tibetan Plateau . To appear as Chapter 13 in *Asian Monsoon*, Edited By Bin Wang Etc.World Scientific.

Atmospheric Thermal adaptation



(i) *PV*-θ View- Latent heating

(ii) Friction impact- Surface sensible heating

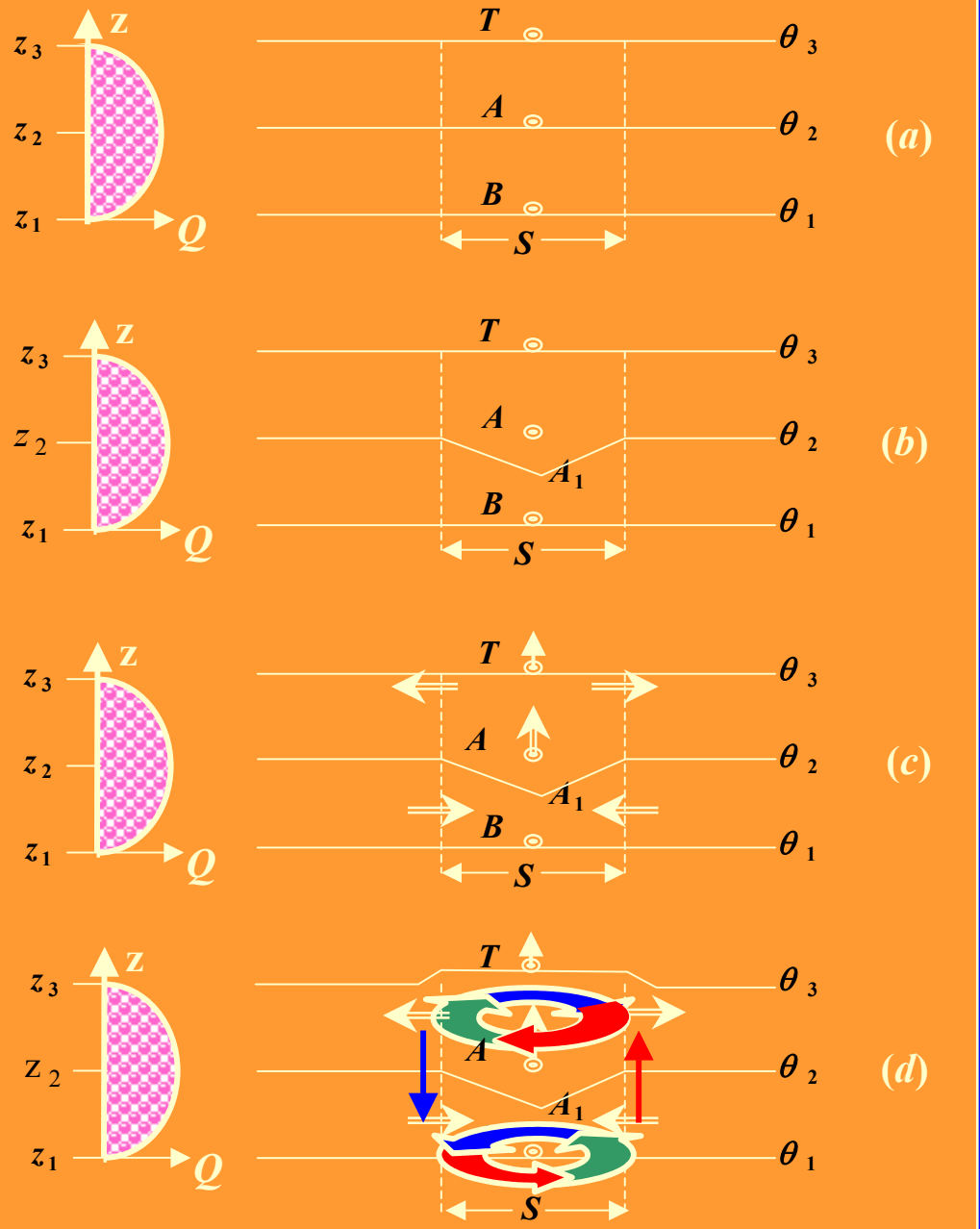
(iii) Sensible heat driven air-pump over TP (SHAP)

$$P = \frac{1}{\rho}\vec{\zeta}_a \cdot \vec{n}\,\frac{\partial \theta}{\partial z}$$

$$\frac{\mathrm{D}P}{\mathrm{D}t} = \frac{1}{\rho}\vec{F}_\zeta \cdot \nabla\theta + \frac{1}{\rho}\vec{\zeta}_a \cdot \nabla Q$$

$$N^2 W \cong Q$$

$$\frac{1}{S}\int P dm = \int_{\theta_B}^{\theta_T} \zeta_{an}\, d\theta$$

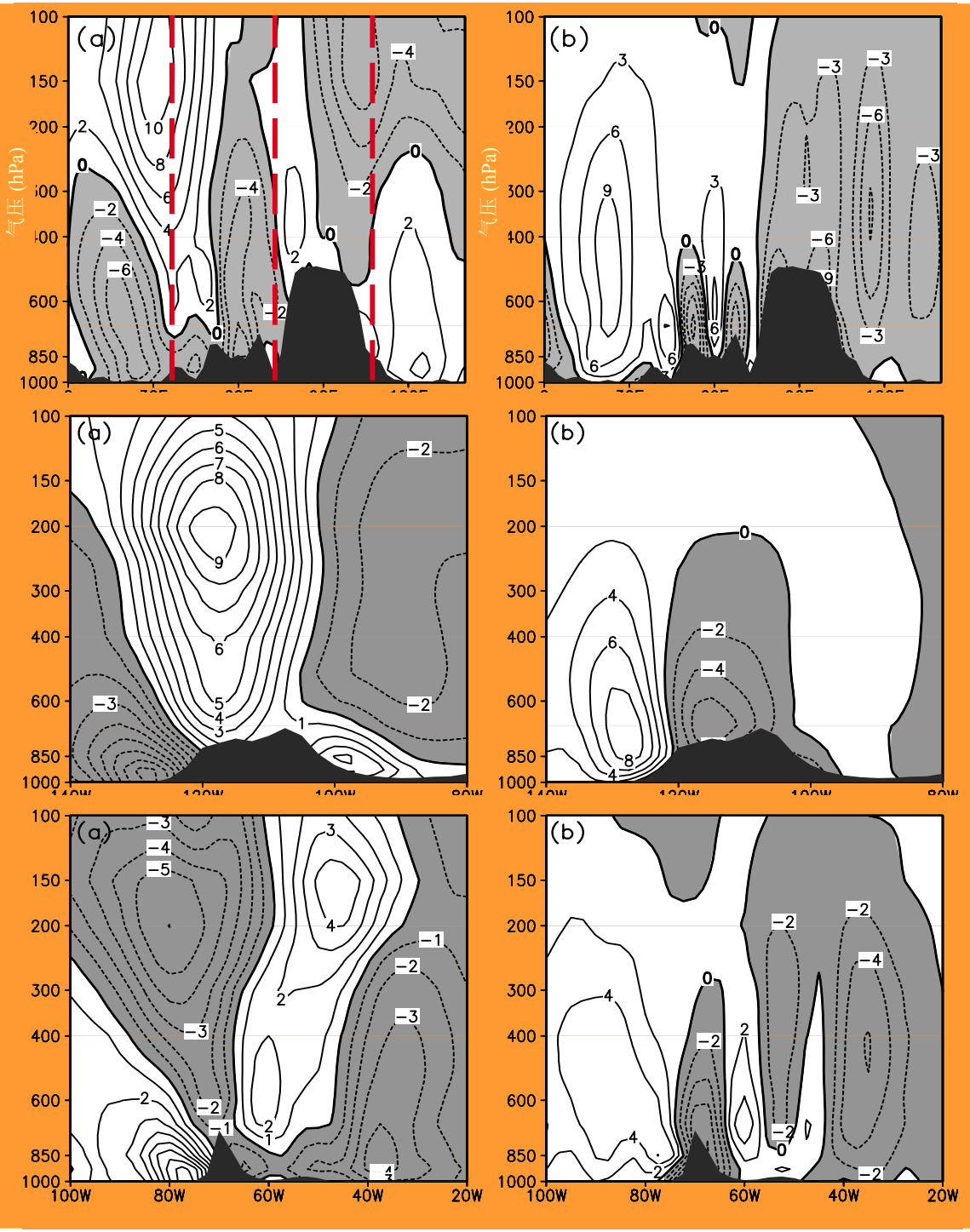


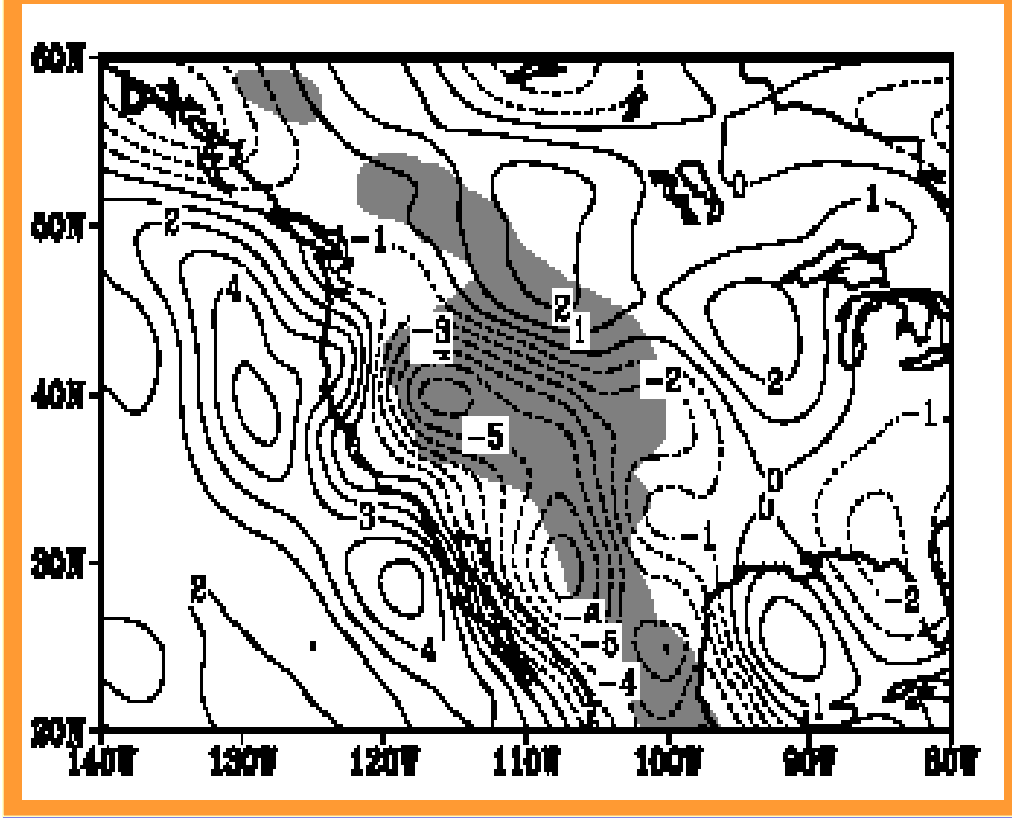
Summertime Eurasian Continental Heating and Tibetan Plateau LOCAL Heating

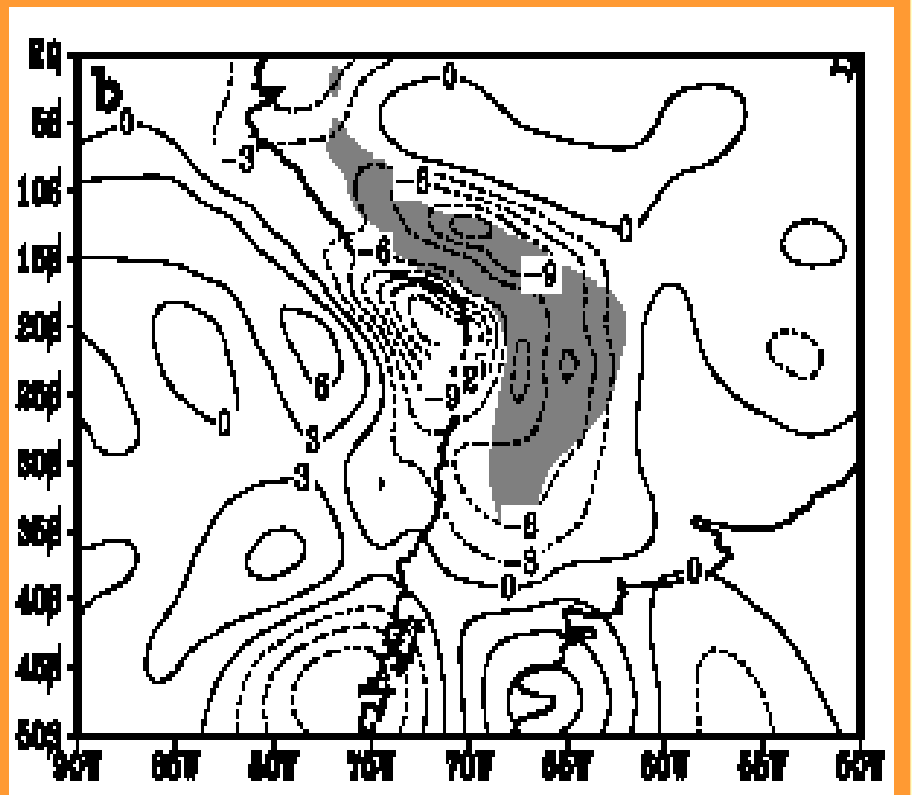
Tibetan July

Rockies July

Andes January



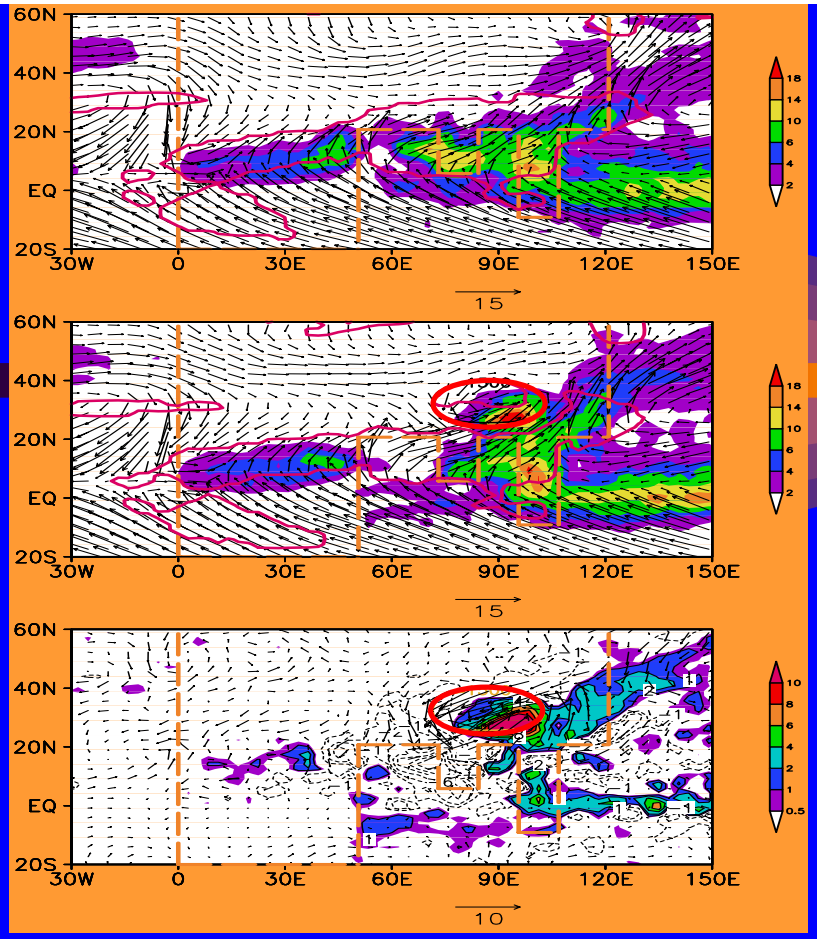

b
60N
50N
40N
30N
20N
140W
130W
120W
110W
100W
90W
80W

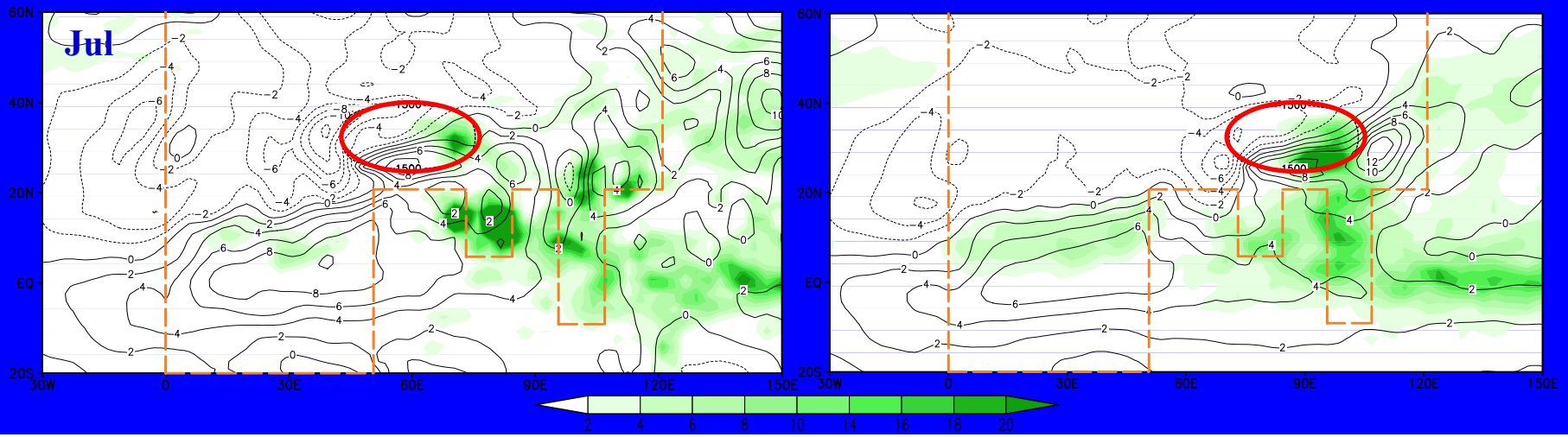

b
EQ
10S
20S
30S
40S
50S
90W
85W
80W
75W
70W
65W
60W
55W
50W

a) Without mountain

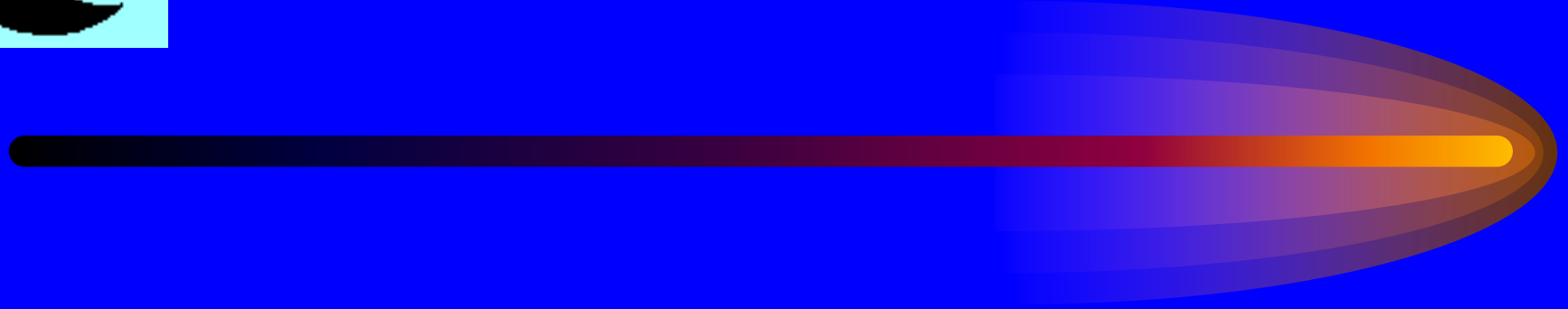
b) With mountain

b) –a)





Atmospheric Thermal adaptation



(i) *PV*-θ View- Latent heating

(ii) Friction impact- Surface sensible heating

(iii) Sensible heat driven air-pump over TP

Ertel Potential Vorticity Equation

PV:

$$P = \alpha \vec{\zeta}_a \cdot \nabla \theta ; \qquad (1)$$

$$W = \rho P = \vec{\zeta}_a \cdot \nabla \theta . \qquad (2)$$

PV equation:

Advection form:

$$\dot{P} = \frac{\partial P}{\partial t} + \vec{V} \cdot \nabla P = \alpha \vec{F} \cdot \nabla \theta + \alpha \vec{\zeta}_a \cdot \nabla Q . \qquad (3)$$

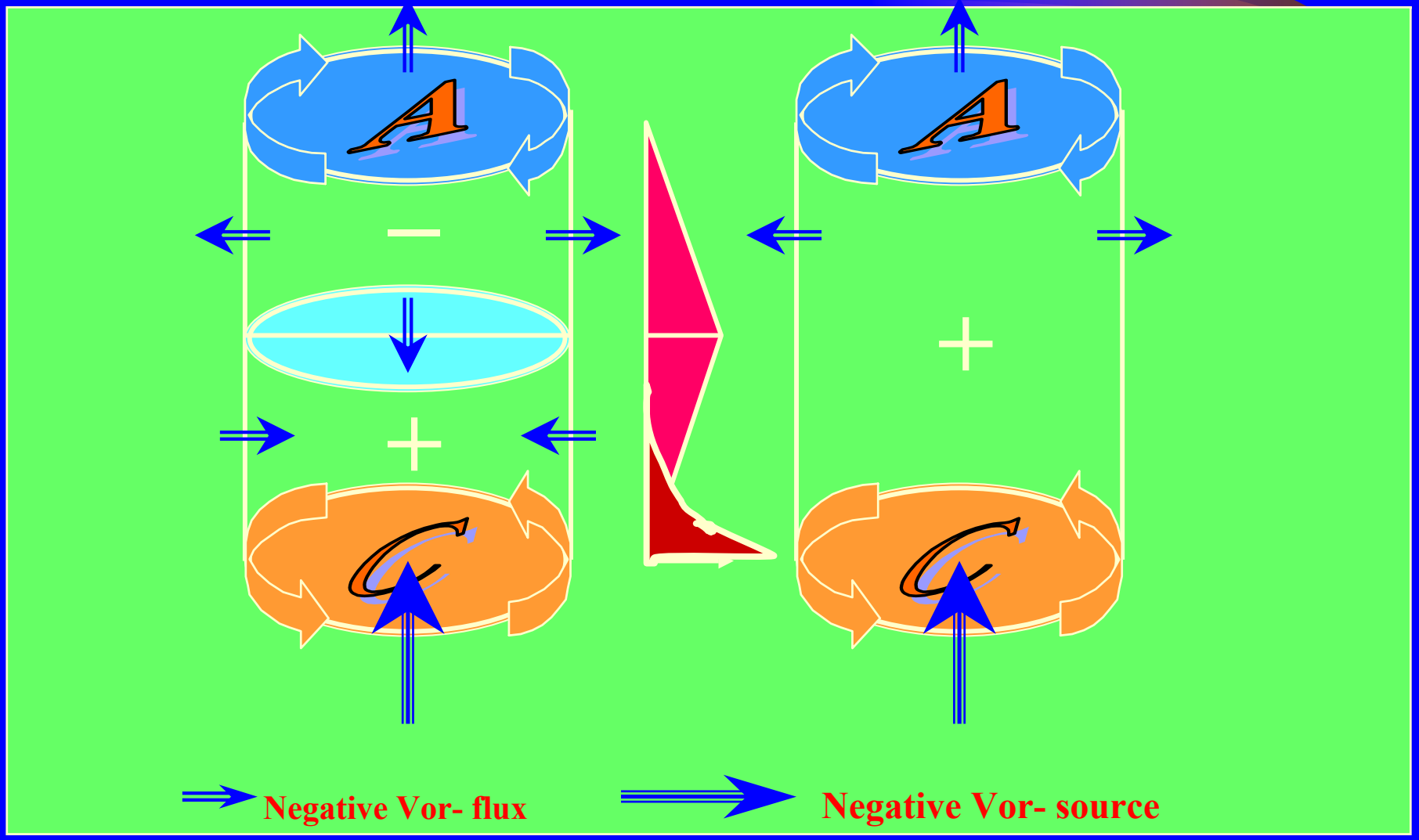
Divergence form:

$$\frac{dW}{dt} = \frac{\partial W}{\partial t} + \nabla \cdot \vec{V} W = \vec{F} \cdot \nabla \theta + \vec{\zeta}_a \cdot \nabla Q . \qquad (4)$$

Dissipation

Heating

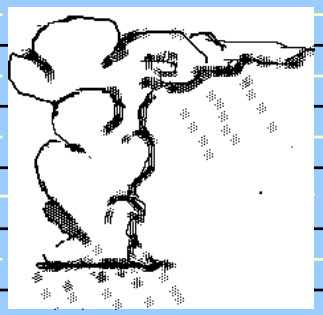
Atmospheric Thermal Adaptation



LASG

Sun

Atmosphere



Land

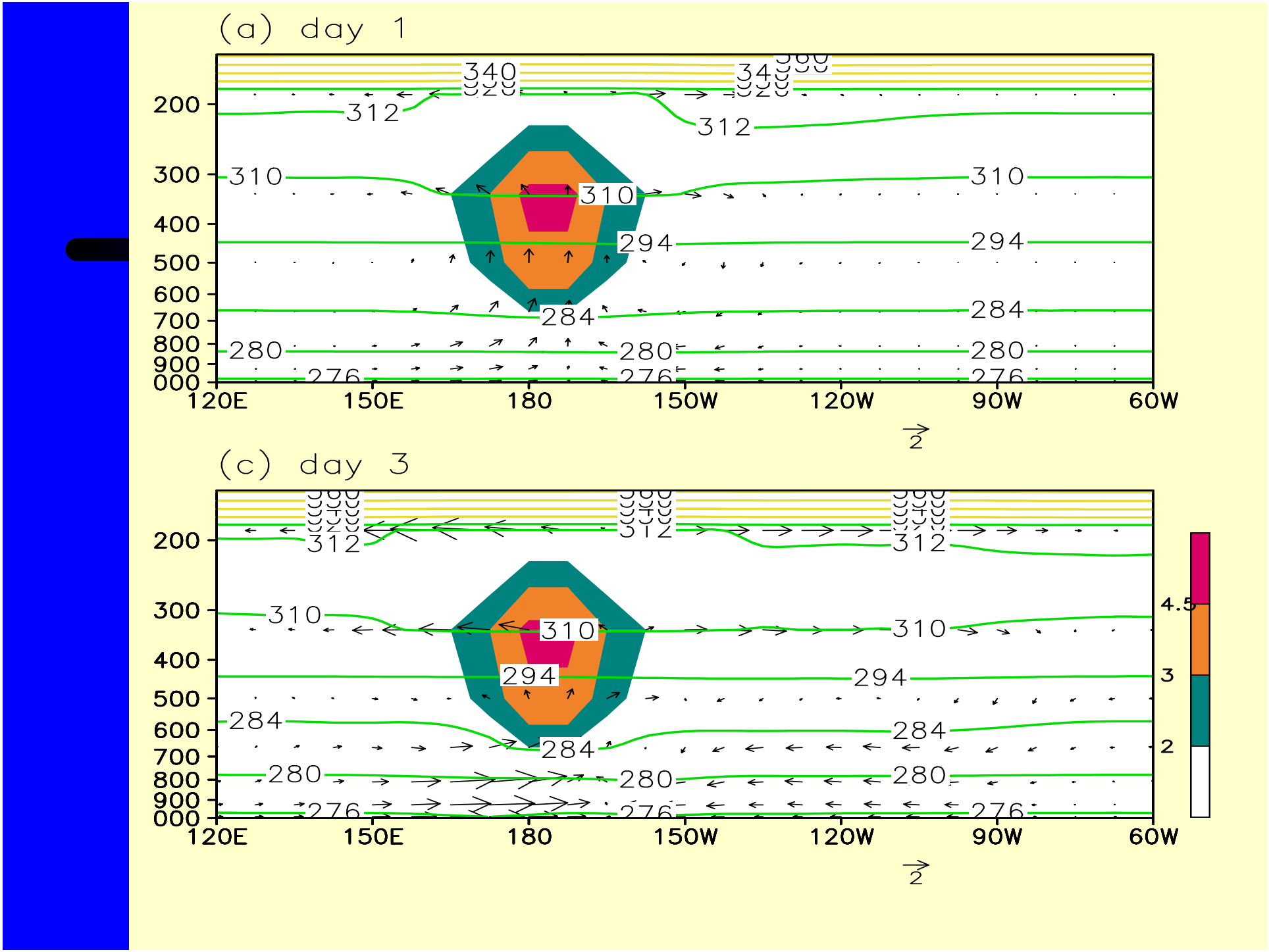
Sea Ice

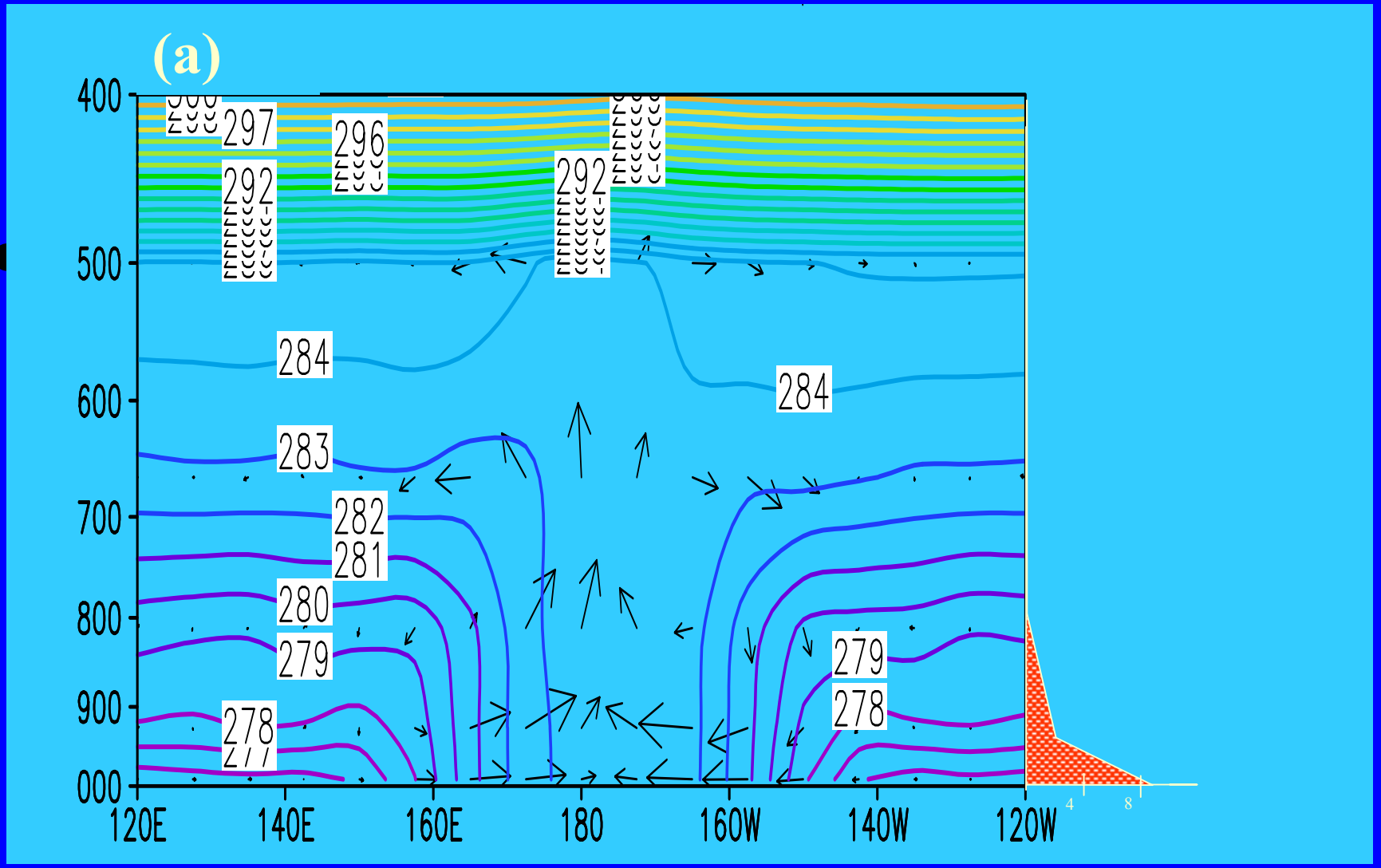
Ocean

	.008916
	.074074
7	.188615
	.336077
5	.500000
	.663923
3	.811385
	.925926
1	.991084

1	25
	75
3	125
	180
5	255
	360
7	500
	680
9	900
	1160
11	1455
	1775
13	2115
	2475
15	2850
	3235
17	3625
	4015
19	4405
	4800

GOALS/LASG.IAP CLIMATE MODEL


(a) day 1
340
312
310
294
284
280
276
200
300
400
500
600
700
800
900
000
120E
150E
180
150W
120W
90W
60W
2
(c) day 3
312
310
294
284
280
276
4.5
3
2



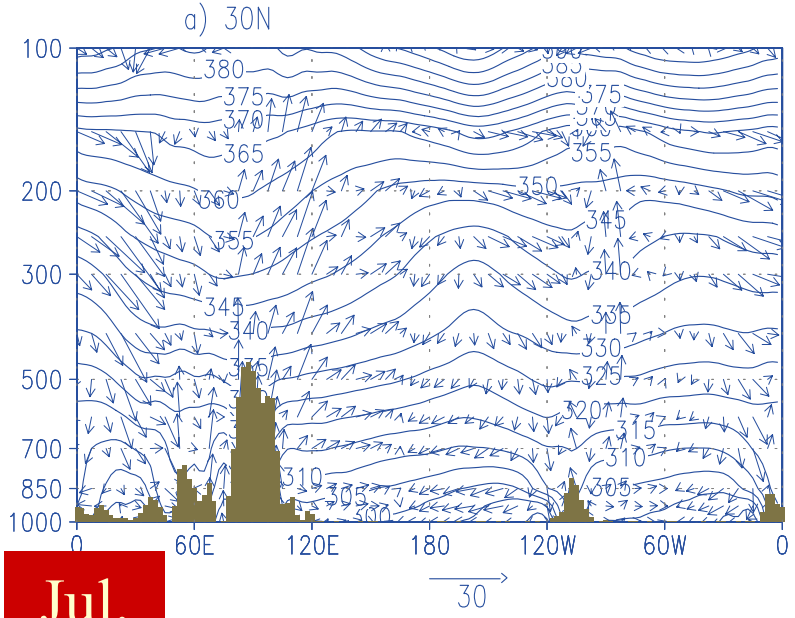
Surface sensible heating results in negative vorticity input into the atmospheric volume from the underlying ground surface.

Atmospheric Thermal adaptation

(i) *PV*-θ View- Latent heating

(ii) Friction impact- Surface sensible heating

(iii) Sensible heat driven air-pump over TP (SHAP)



Jul.

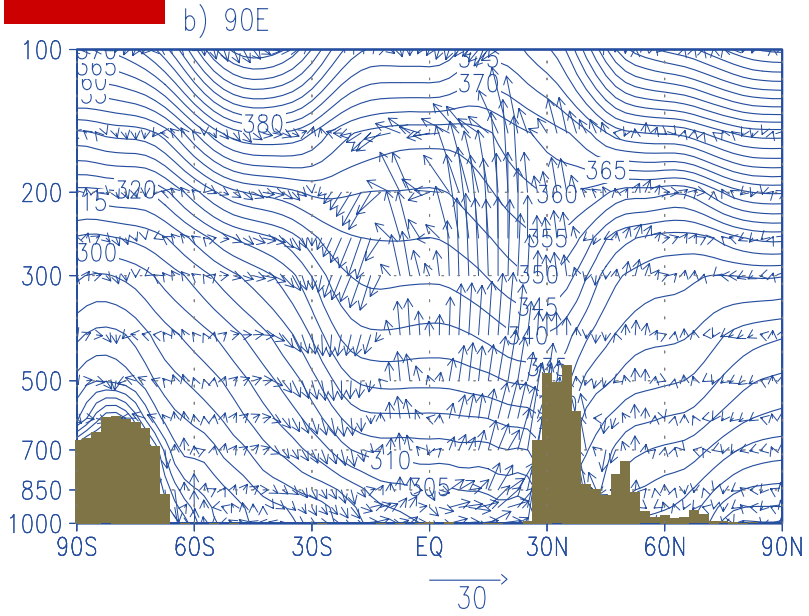
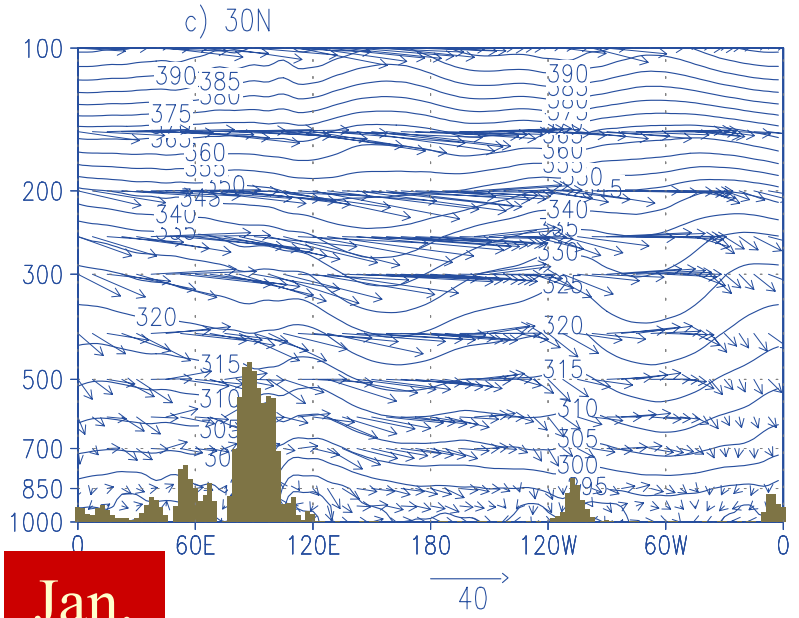
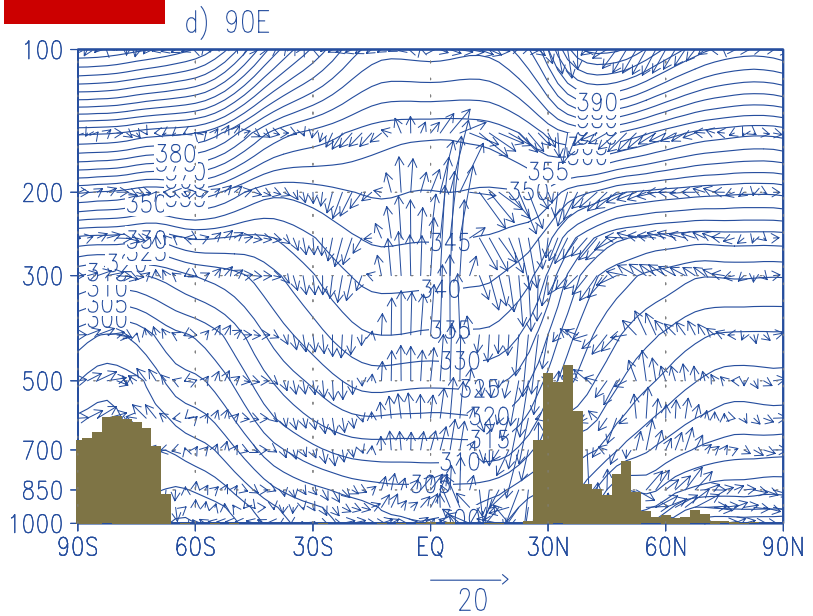


fig. 4; 1986–1995 10 years mean Jul. potential temperature and wind vector cross-section; theta(K) Wind(m/s)

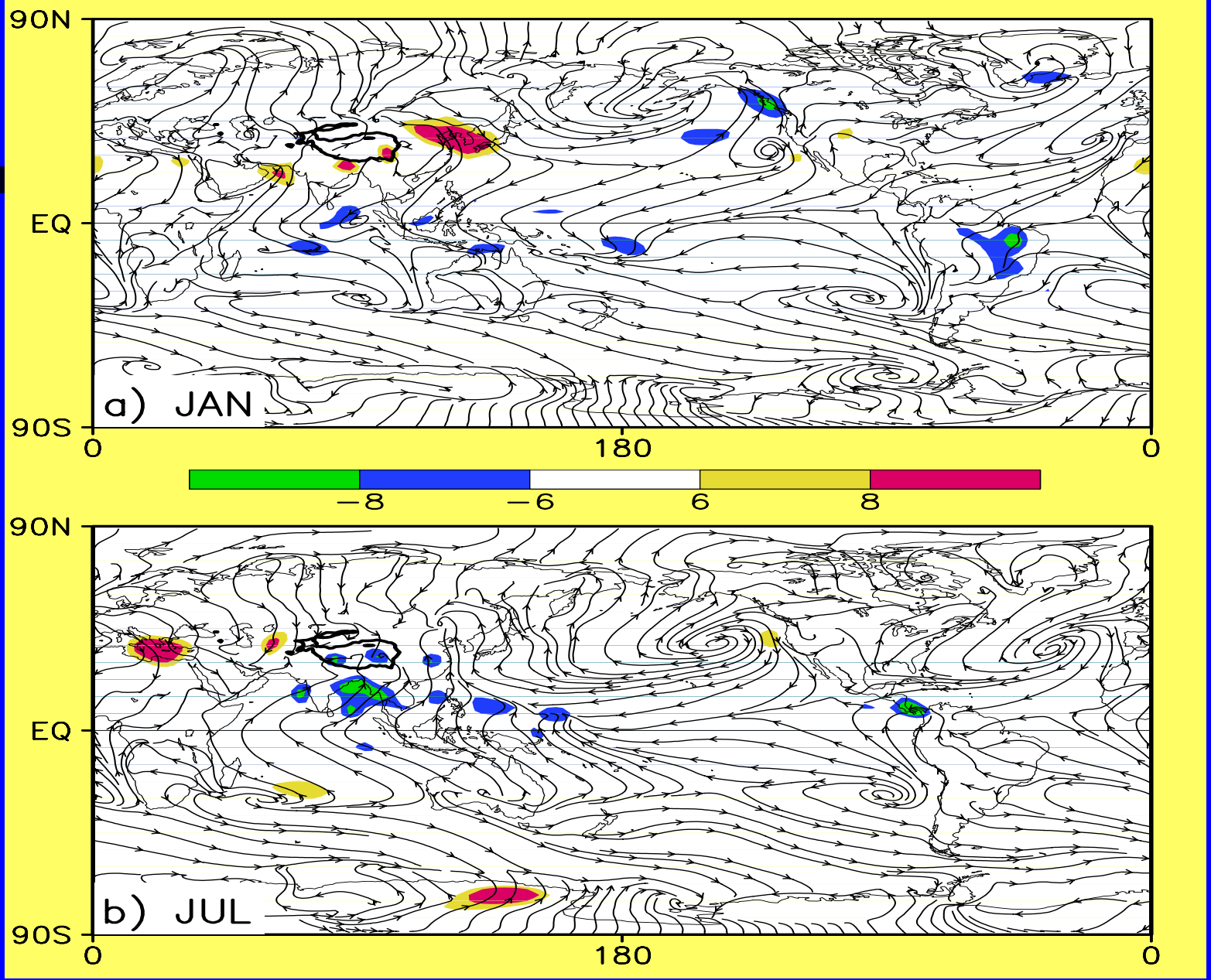


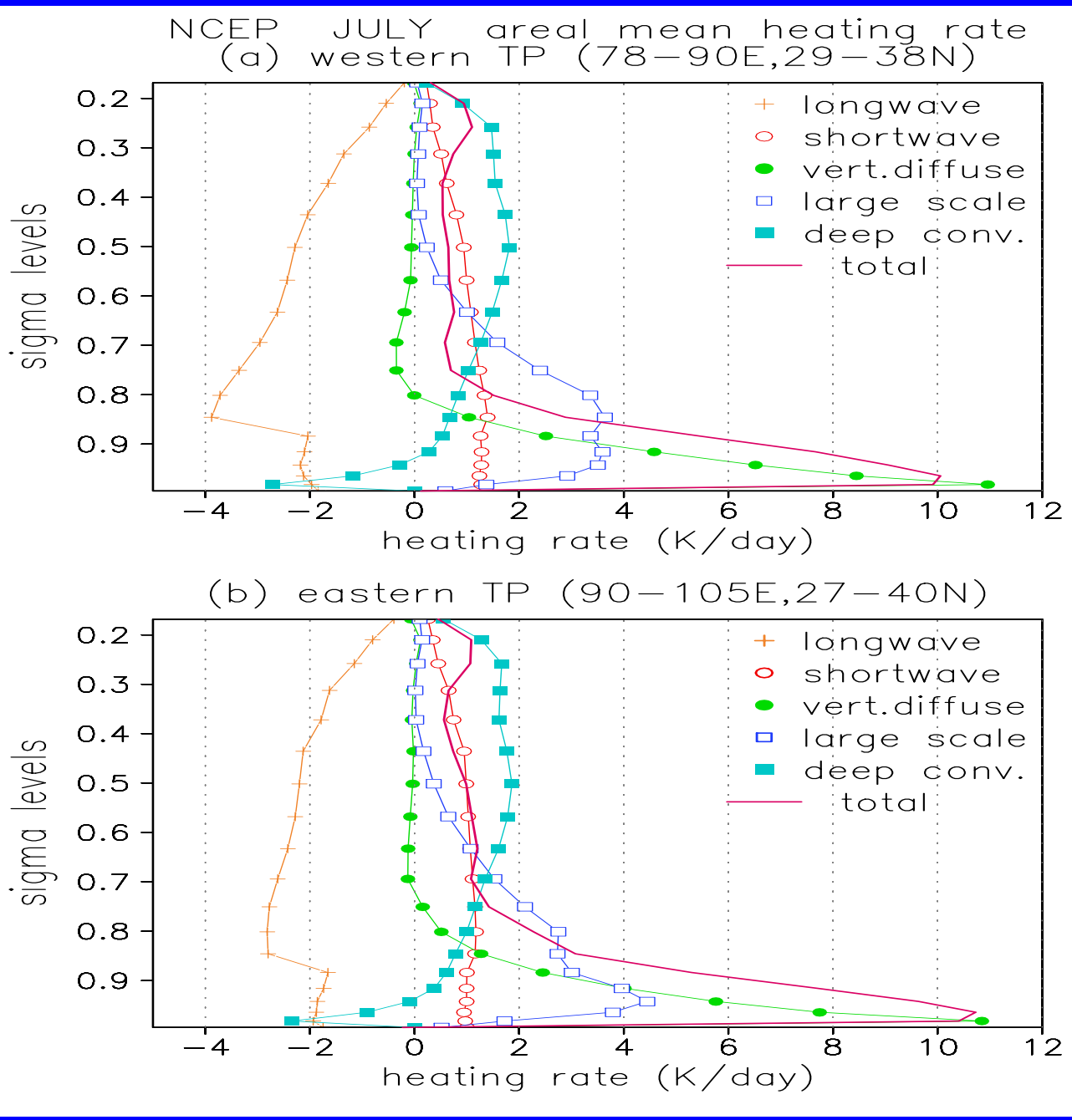
Jan.

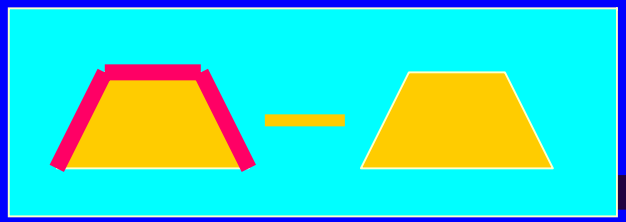


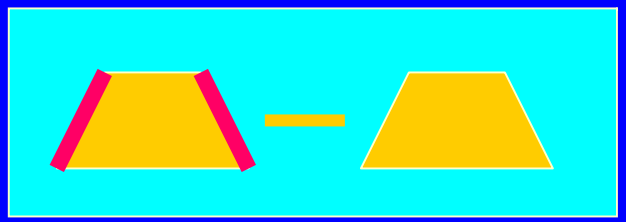
1986–1995 10 years mean Jan. potential temperature and wind vector cross-section; theta(K) Wind(m/s)

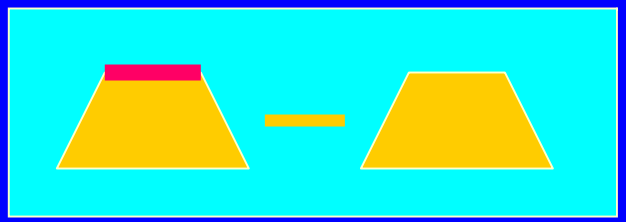
NCEP monthly mean of 10m wind & 500 hPa ω

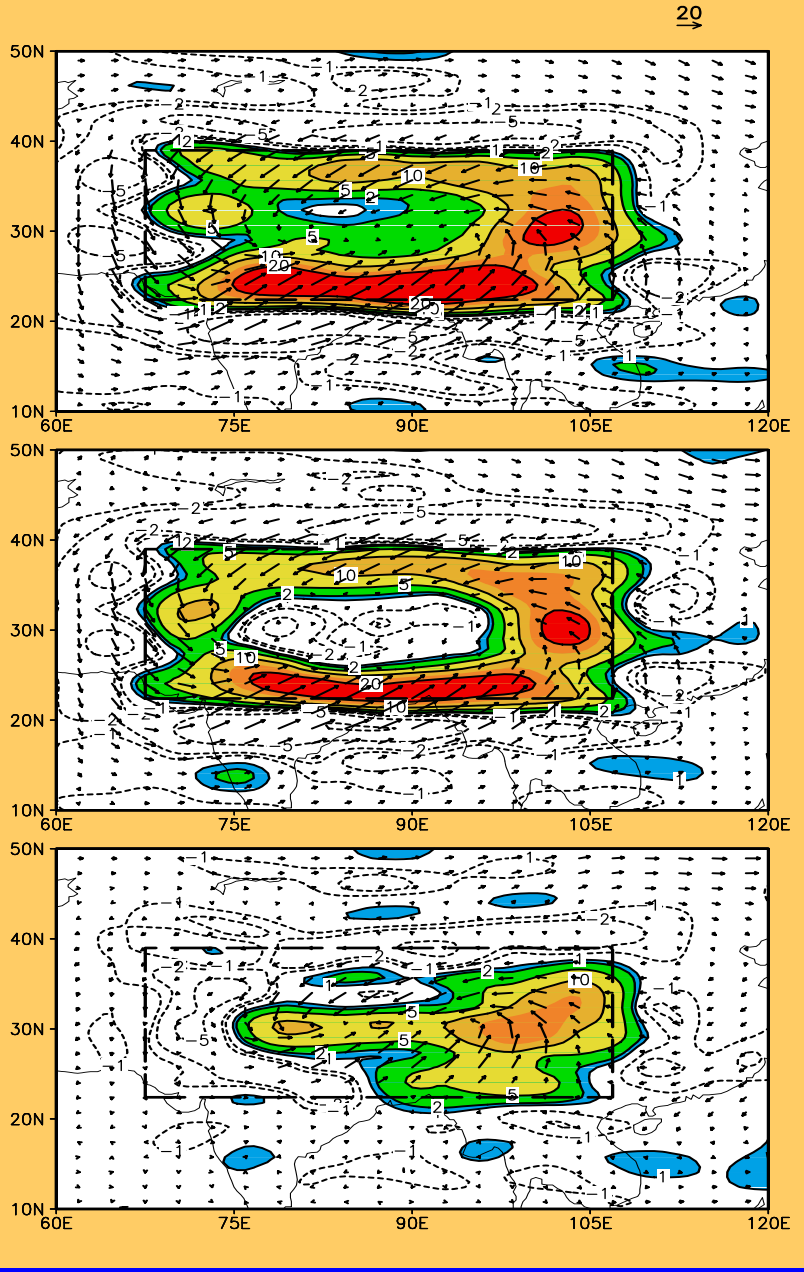



NCEP JULY areal mean heating rate
(a) western TP (78−90E,29−38N)
sigma levels
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
−4
−2
0
2
4
6
8
10
12
heating rate (K/day)
longwave
shortwave
vert.diffuse
large scale
deep conv.
total
(b) eastern TP (90−105E,27−40N)
sigma levels
heating rate (K/day)
longwave
shortwave
vert.diffuse
large scale
deep conv.
total

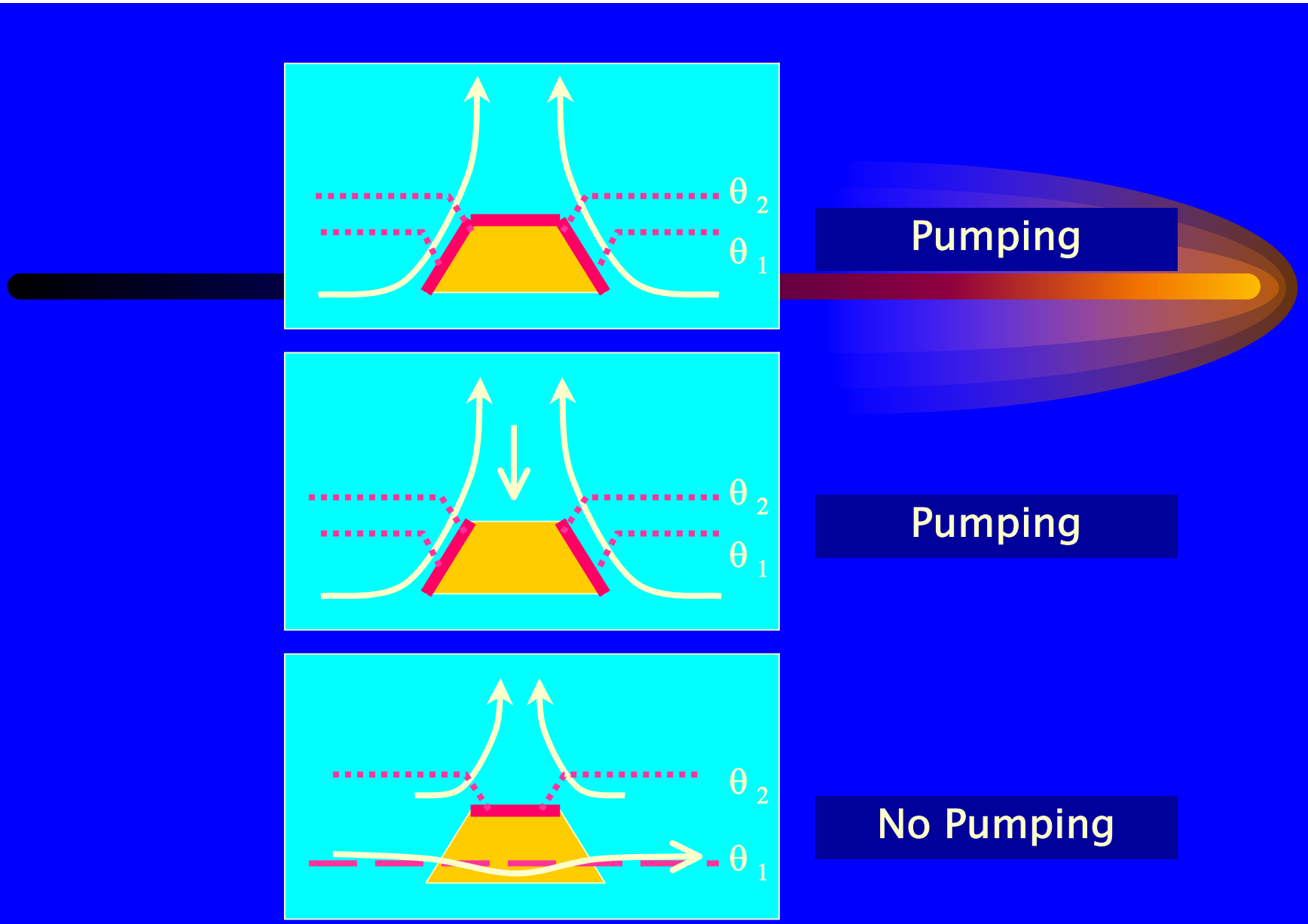








V and w at σ=0.991

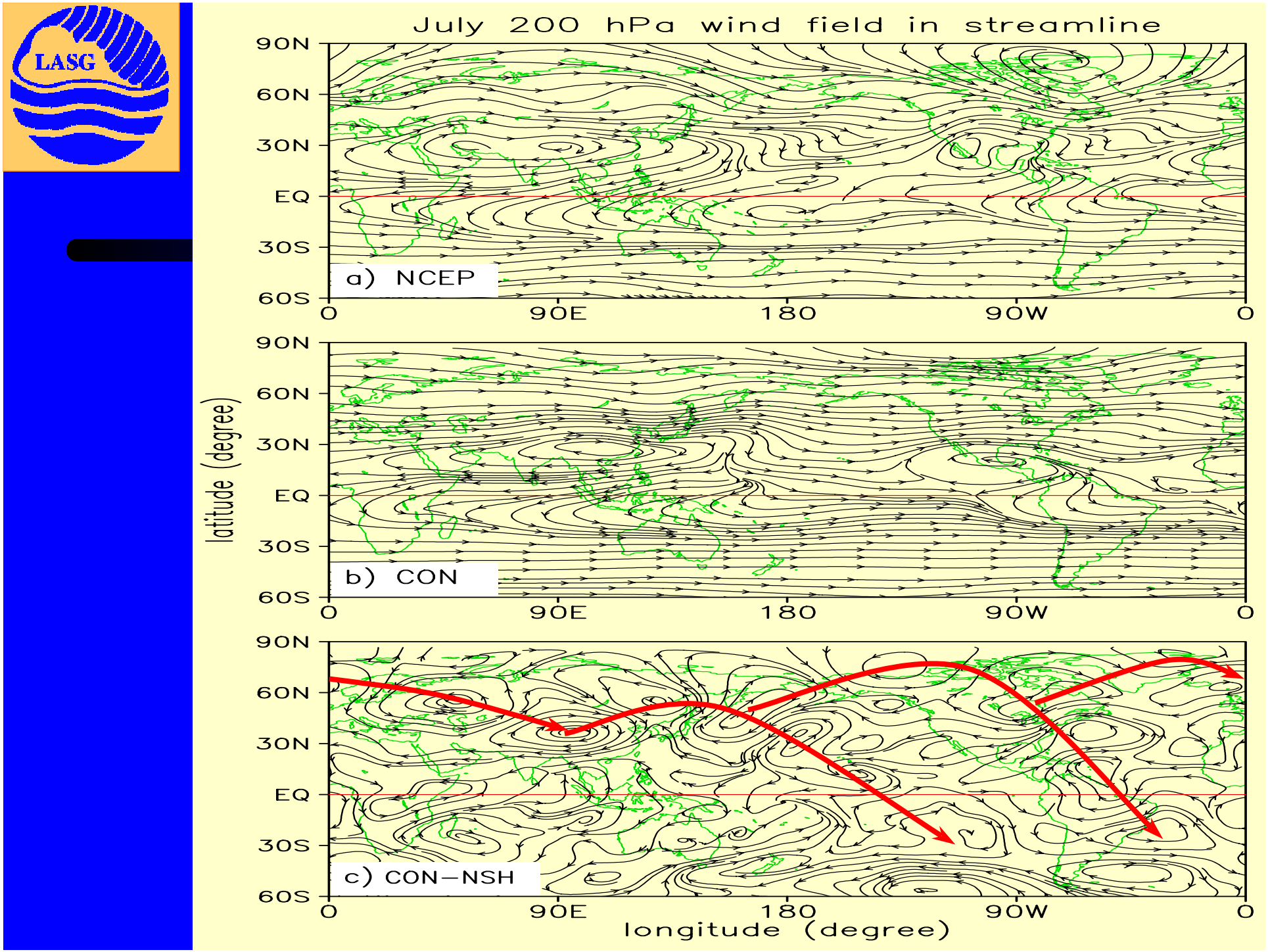


U , W and θ vertical cross- section

Impacts of SHAP

on

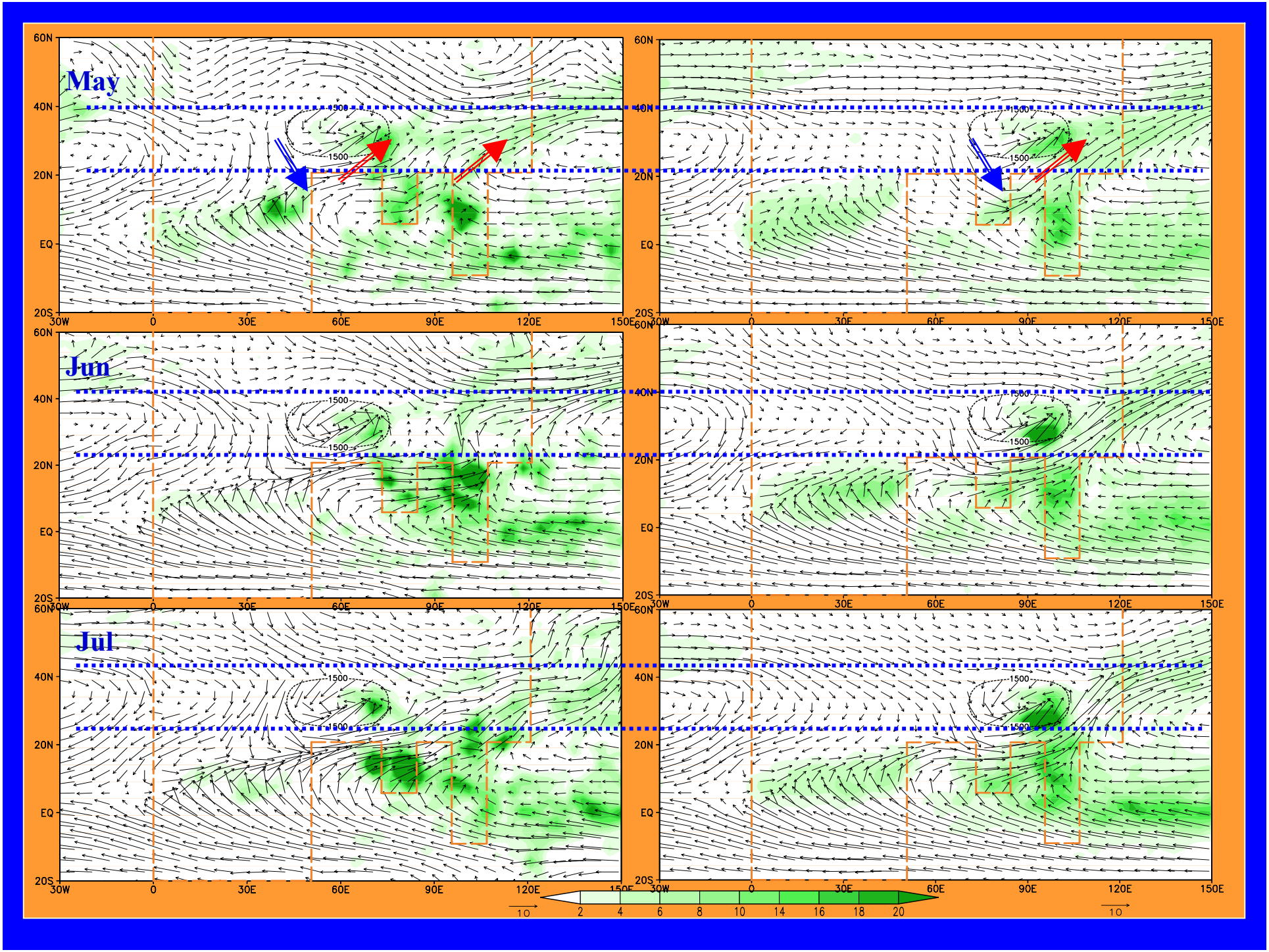
Summertime Circulation


July 200 hPa wind field in streamline
90N
60N
30N
EQ
30S
60S
0
90E
180
90W
0
a) NCEP
b) CON
c) CON—NSH
latitude (degree)
longitude (degree)

Impacts of SHAP

on

Asian Monsoon Onset


May
Jun
Jul
60N
40N
20N
EQ
20S
30W
0
30E
60E
90E
120E
150E
1500
10
2
4
6
8
10
14
16
18
20
10

V. Concluding remarks

1. The circulations forced by TP local thermal forcing and by continental scale heating in summer are in phase. Wet monsoon to the east and dry climate to the west of the Continent are therefore intensified by TP.

2. TP in summer is a huge source of negative vorticity.

3. TP Air- Pump is driven by surface sensible heating (SHAP), which regulates the surrounding climate and affects the world circulation

4. One of the functions of the TP SHAP is to anchor the Asian summer monsoon onset over the region from eastern Bay of Bengal (BOB) to western Indochina Peninsula.

5. The Optimum observation sites should be on the slopes, particularly the S- and SE- slopes, of the Tibetan Plateau.

THE END

THANK YOU!