Dominant Heating, Water Transport, and Climate Pattern

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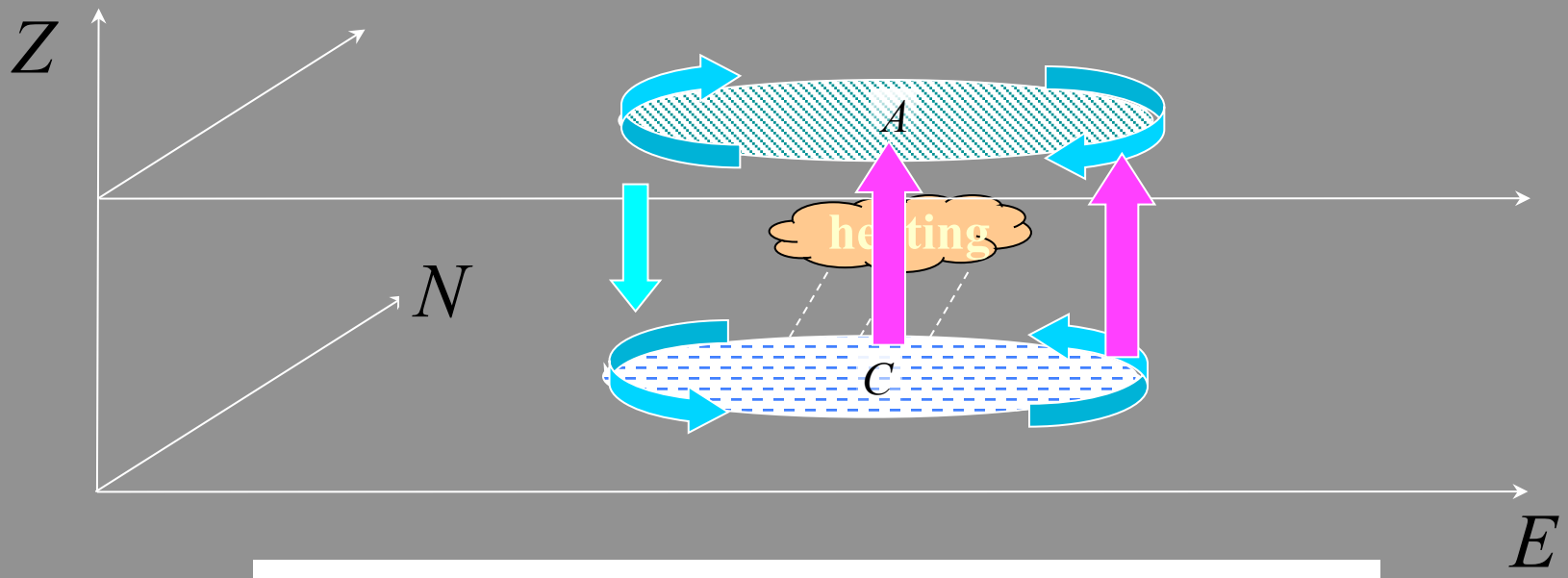
Outline

1. Introduction- Thermal adaptation
2. Summertime subtropical dominant heating and circulation
3. Water transport due to Tibetan Plateau and climate pattern
4. An important GEWEX activity in China
5. Conclusion

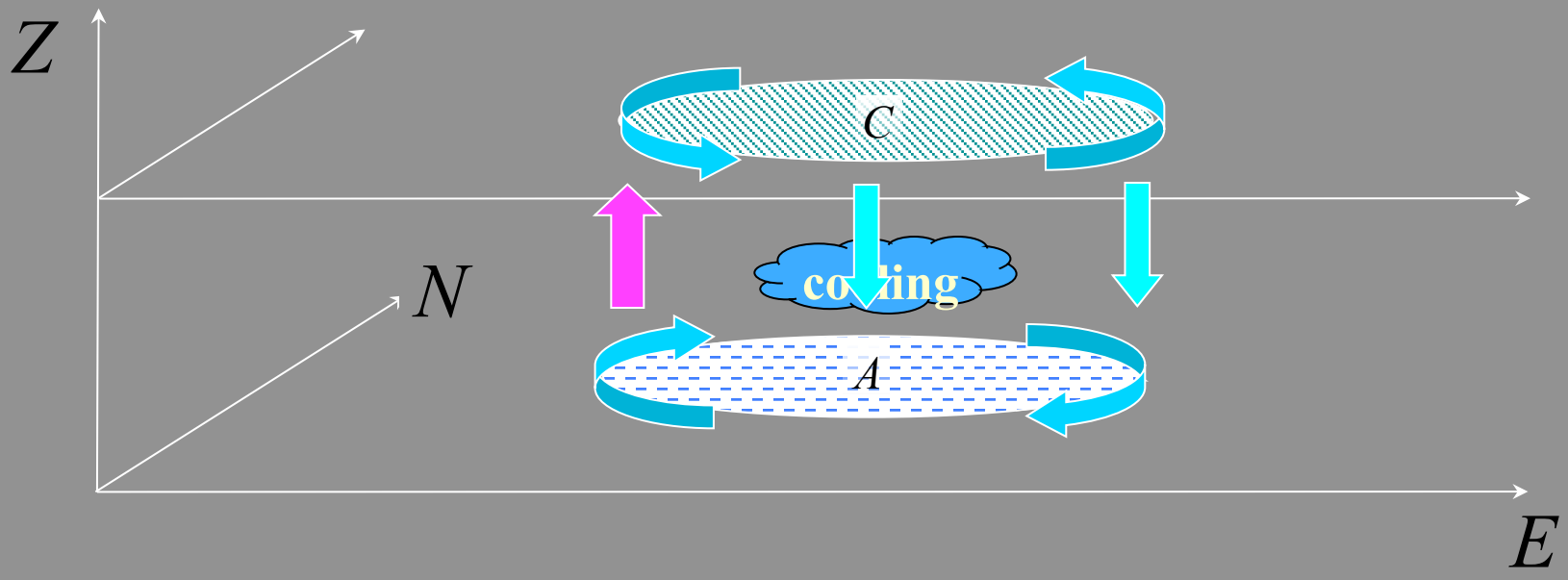
Thermal Adaptation in Subtropics - heating



$$-\beta v - f\nabla \cdot \vec{V} \approx 0$$

$$w \propto -\beta \frac{\partial v}{\partial z}$$

Thermal Adaptation in Subtropics - cooling



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Multi-scale forcing

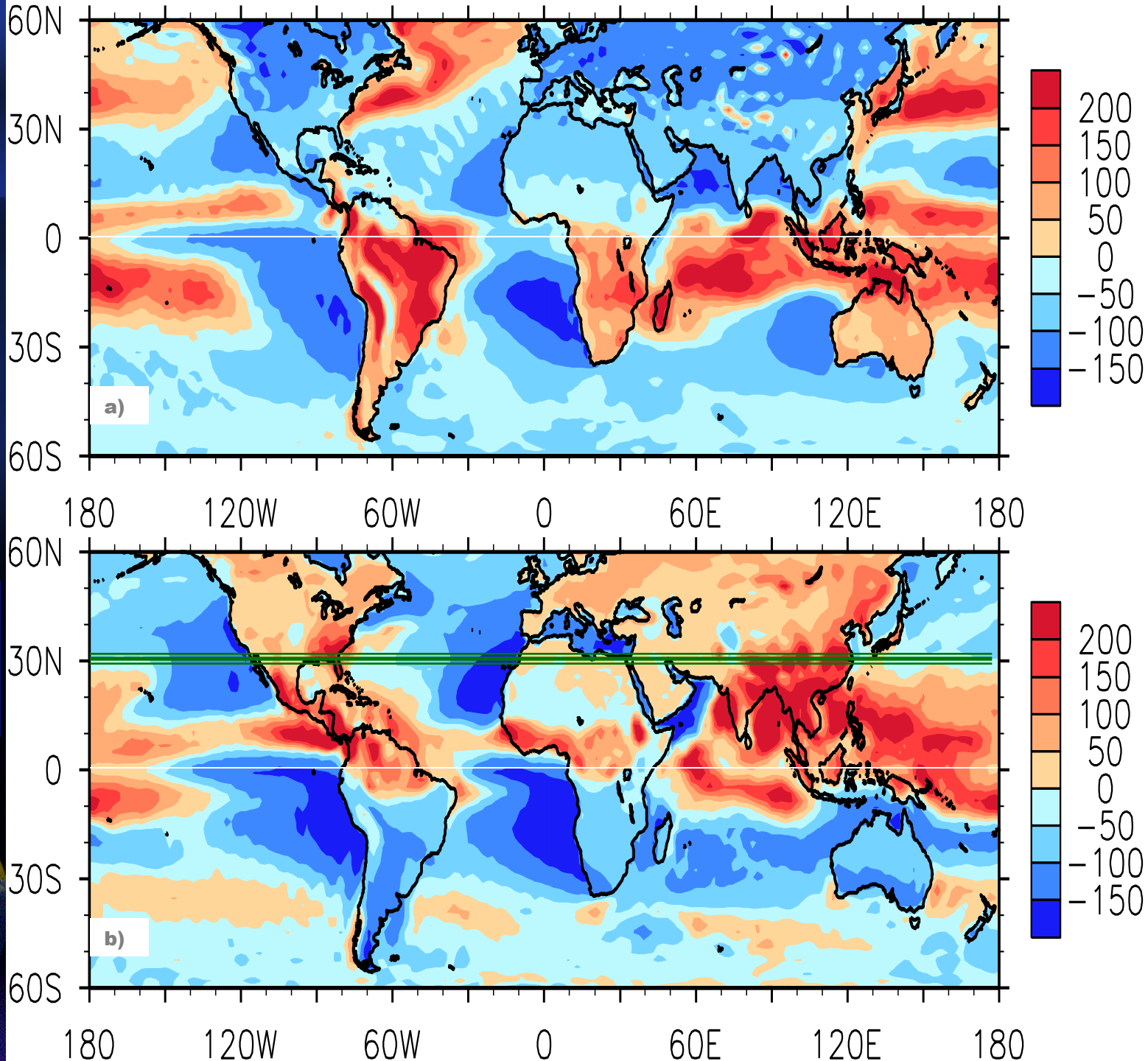
1. Land-Sea Distribution and Continental-Scale Thermal Forcing
2. Coastal Local- Scale Sea-breeze Forcing and Formation of "LOSECOD" Quadruplet Heating
3. Tibetan Plateau Regional- Scale Forcing and Formation of Desert and Monsoon

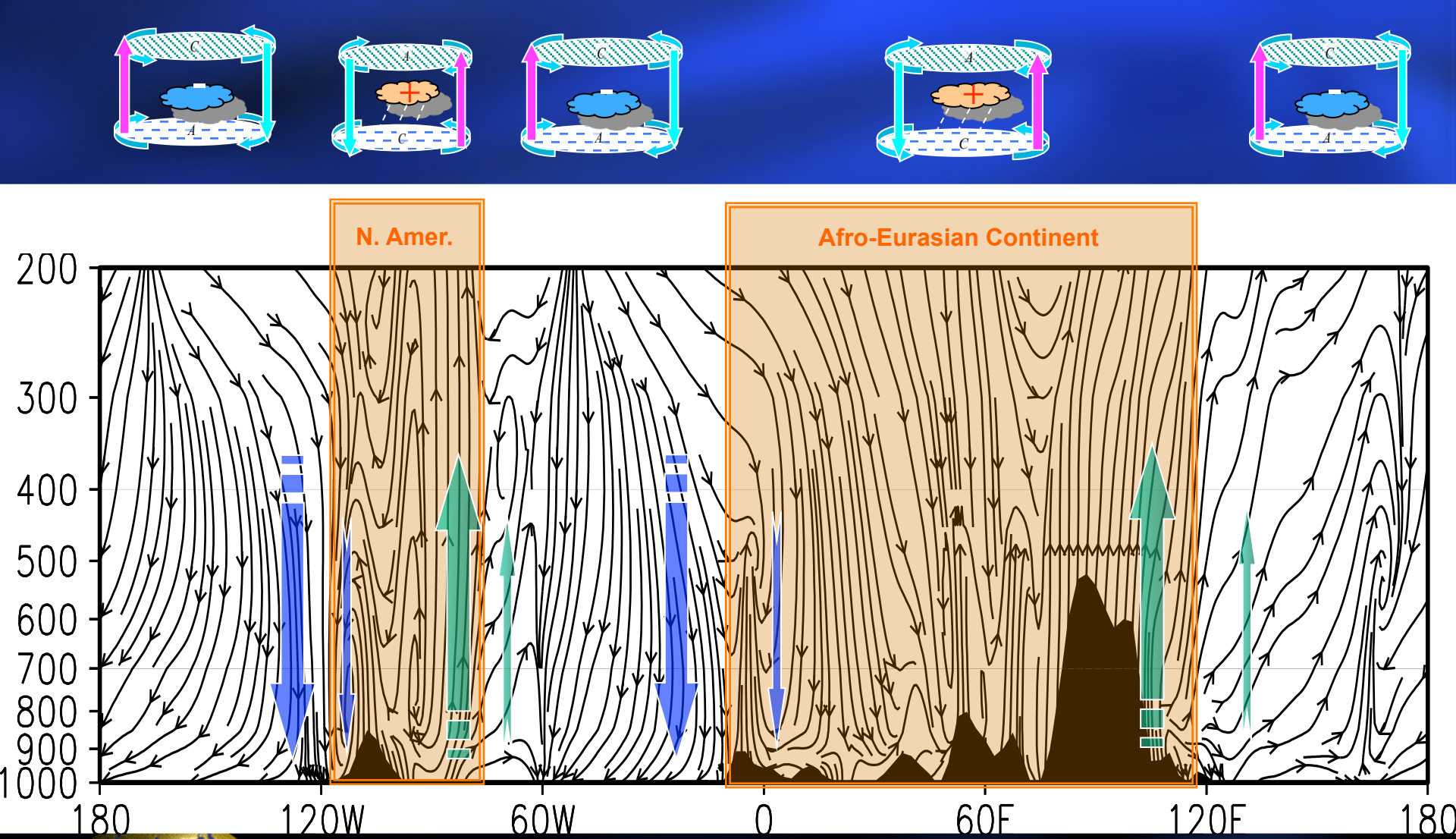
N. Winter:

Source-ocean; sink-land

N. Summer:

Source-land; sink-ocean





Asymmetry：ascent/decent on the west is always stronger than on its east

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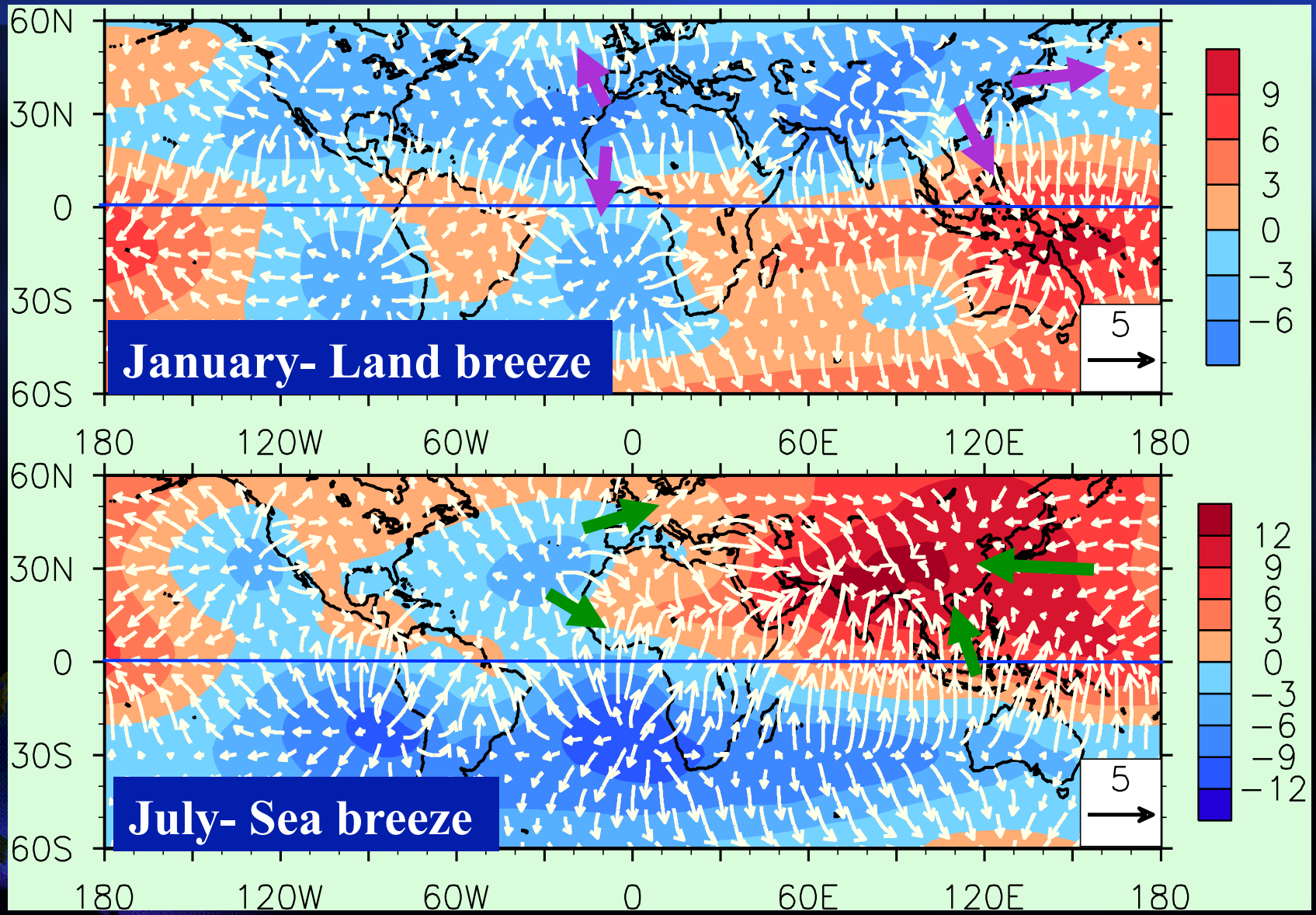
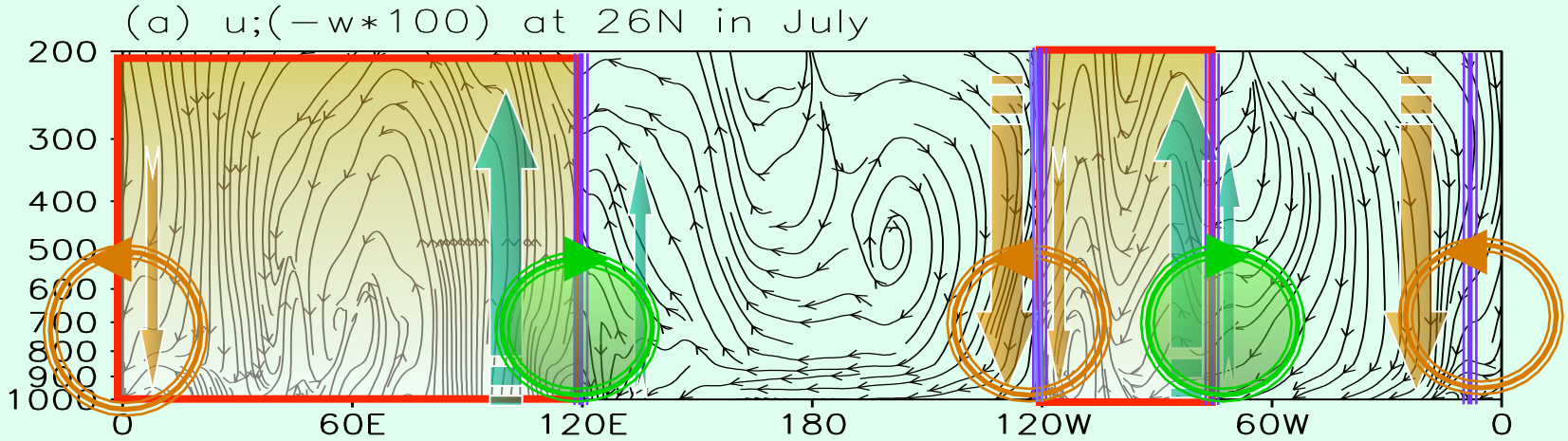
1000 hPa velocity potential (shaded) in unit of 10^6 m^2/s and divergent wind component (arrow) in unit of m/s (1980-1997)



LO SE CO D LO SE CO D LO

Eurasian-C N.Pacific-O N.Amer-C N.Atlan-O



LO

$$\int_0^{p_0} Q\frac{dp}{g} < 0;$$

Free Atm $\vec{V}\cdot\nabla\theta = Q < 0.$

D

$$\int_0^{p_0} Q\frac{dp}{g} < 0;$$

Free Atm $\vec{V}\cdot\nabla\theta = Q > 0.$

SE

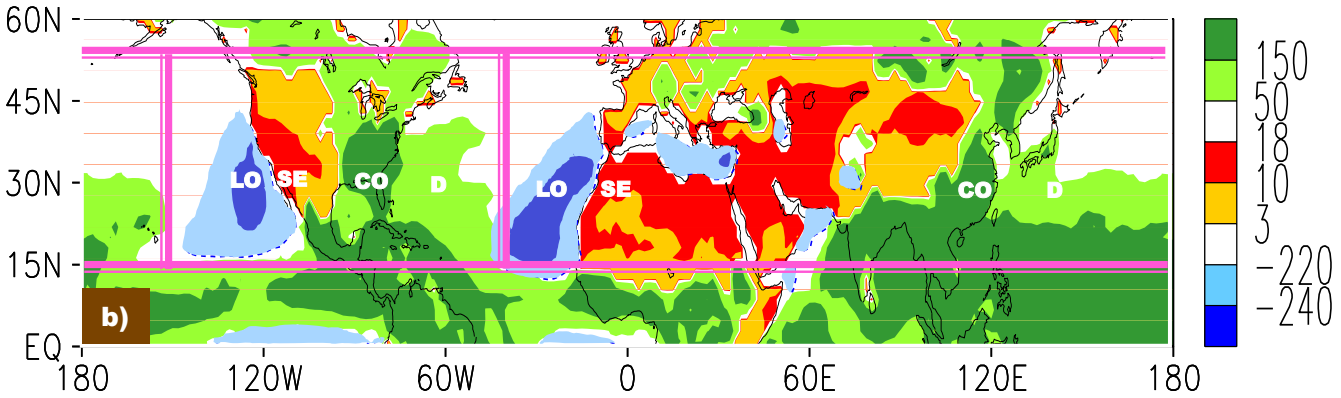
$$\int_0^{p_0} Q\frac{dp}{g} > 0;$$

Free Atm $\vec{V}\cdot\nabla\theta = Q < 0.$

CO

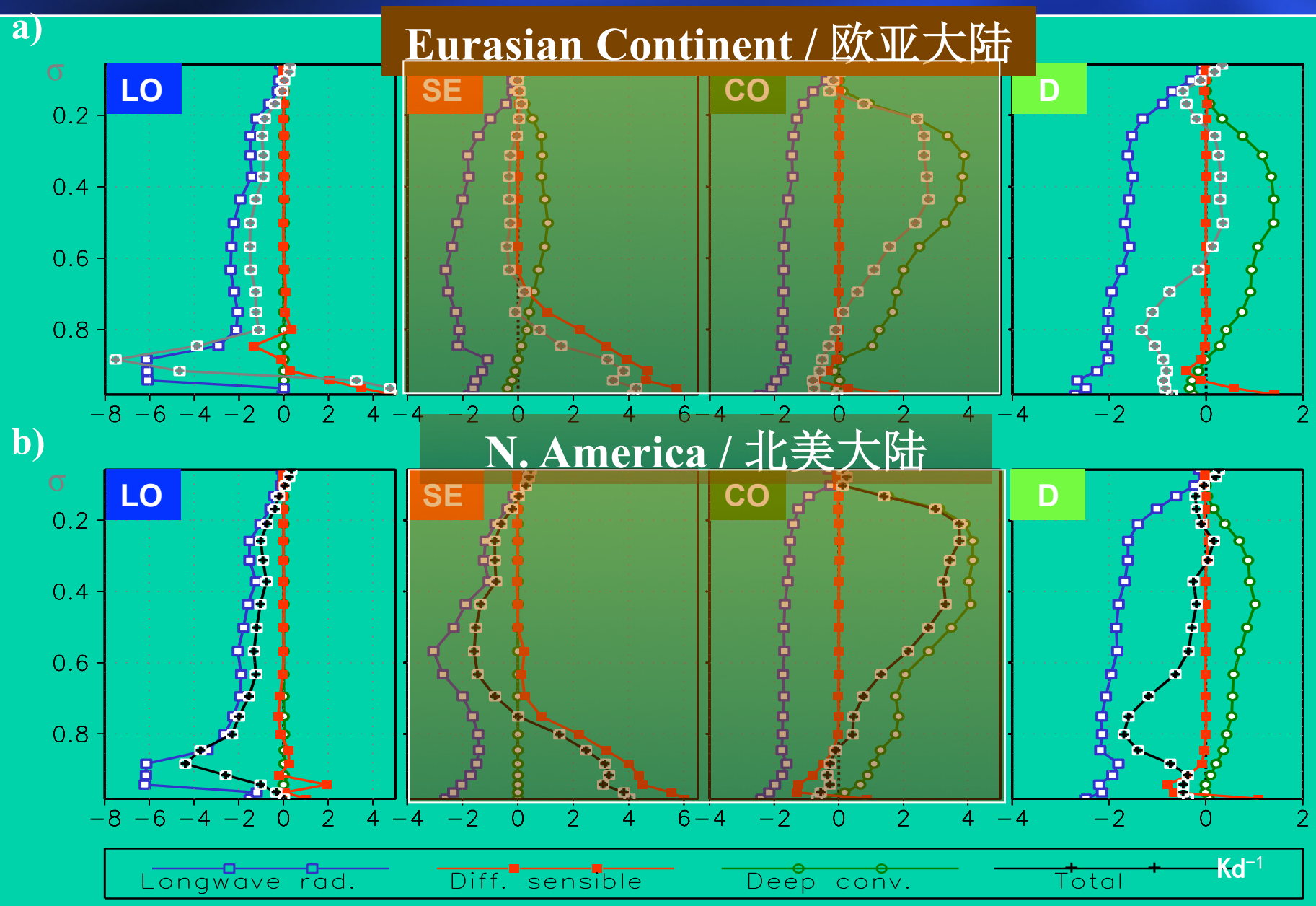
$$\int_0^{p_0} Q\frac{dp}{g} > 0;$$

Free Atm $\vec{V}\cdot\nabla\theta = Q > 0.$


60N
45N
30N
15N
EQ
180
120W
60W
0
60E
120E
180
LO
SE
CO
D
LO
SE
CO
D
b)
150
50
18
10
3
-220
-240

LOSECOD

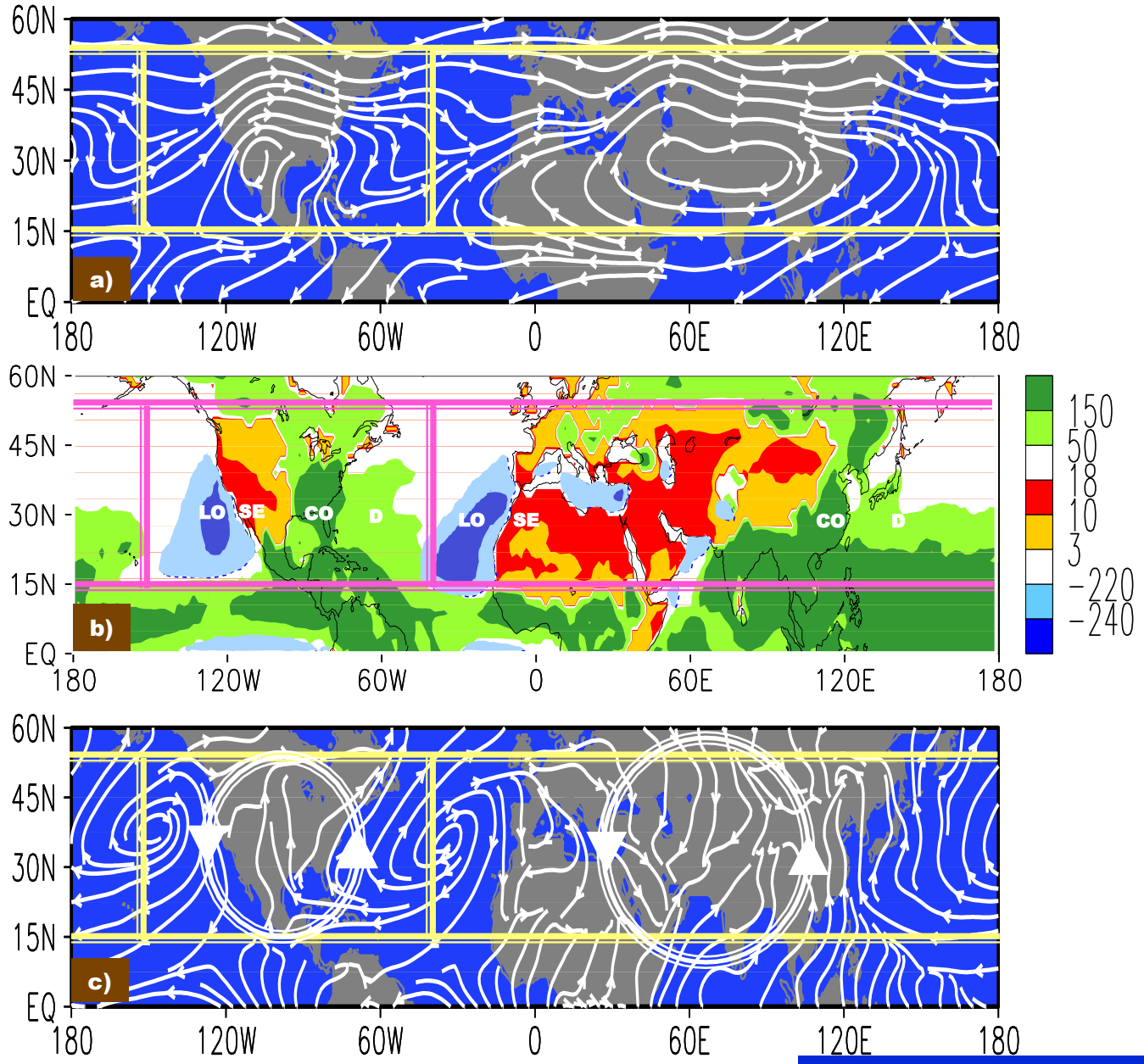
LOSECOD Quadruplet Heating Vertical Profiles

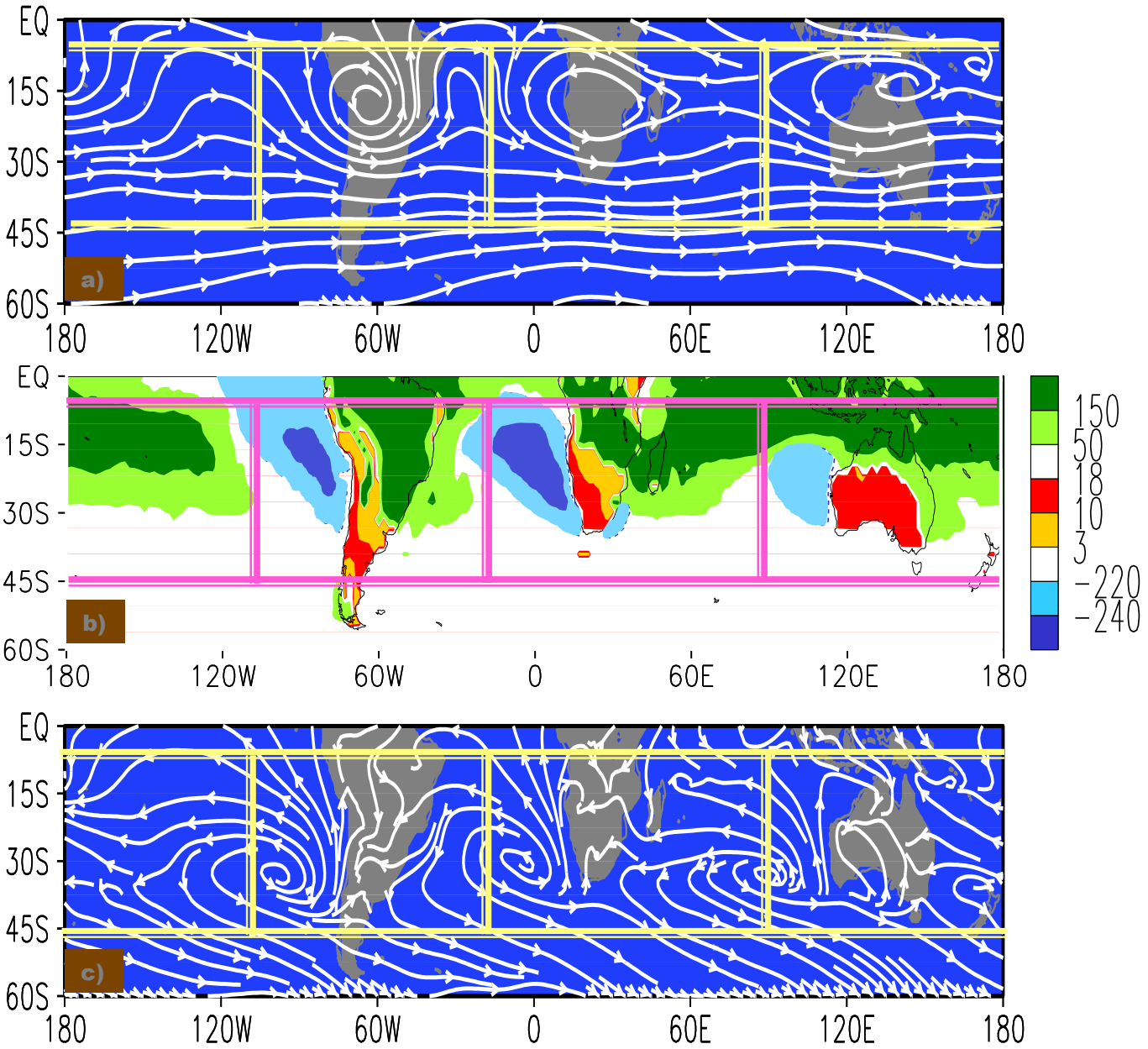


Thermal Adaptation

- Sverdrup balance

$$\nu \approx \beta^{-1}\theta_z^{-1}(f+\zeta)Q_z \begin{cases} <0 & (z > Z_M) \\ >0 & (z < Z_M) \end{cases} \quad (\theta_z \neq 0).$$


60N
45N
30N
15N
EQ
180
120W
60W
0
60E
120E
180
a)
b)
LO
SE
CO
D
LO
SE
CO
D
150
50
18
10
3
−220
−240
c)


EQ
15S
30S
45S
60S
180
120W
60W
0
60E
120E
180
a)
b)
c)
150
50
18
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−240

LOSECOD

Multi-scale forcing

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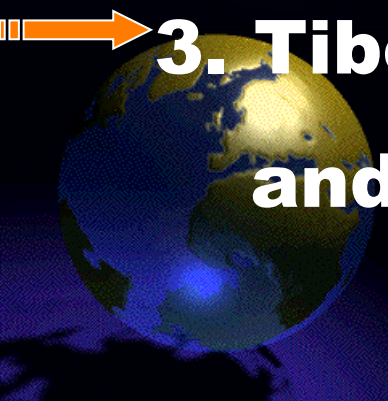
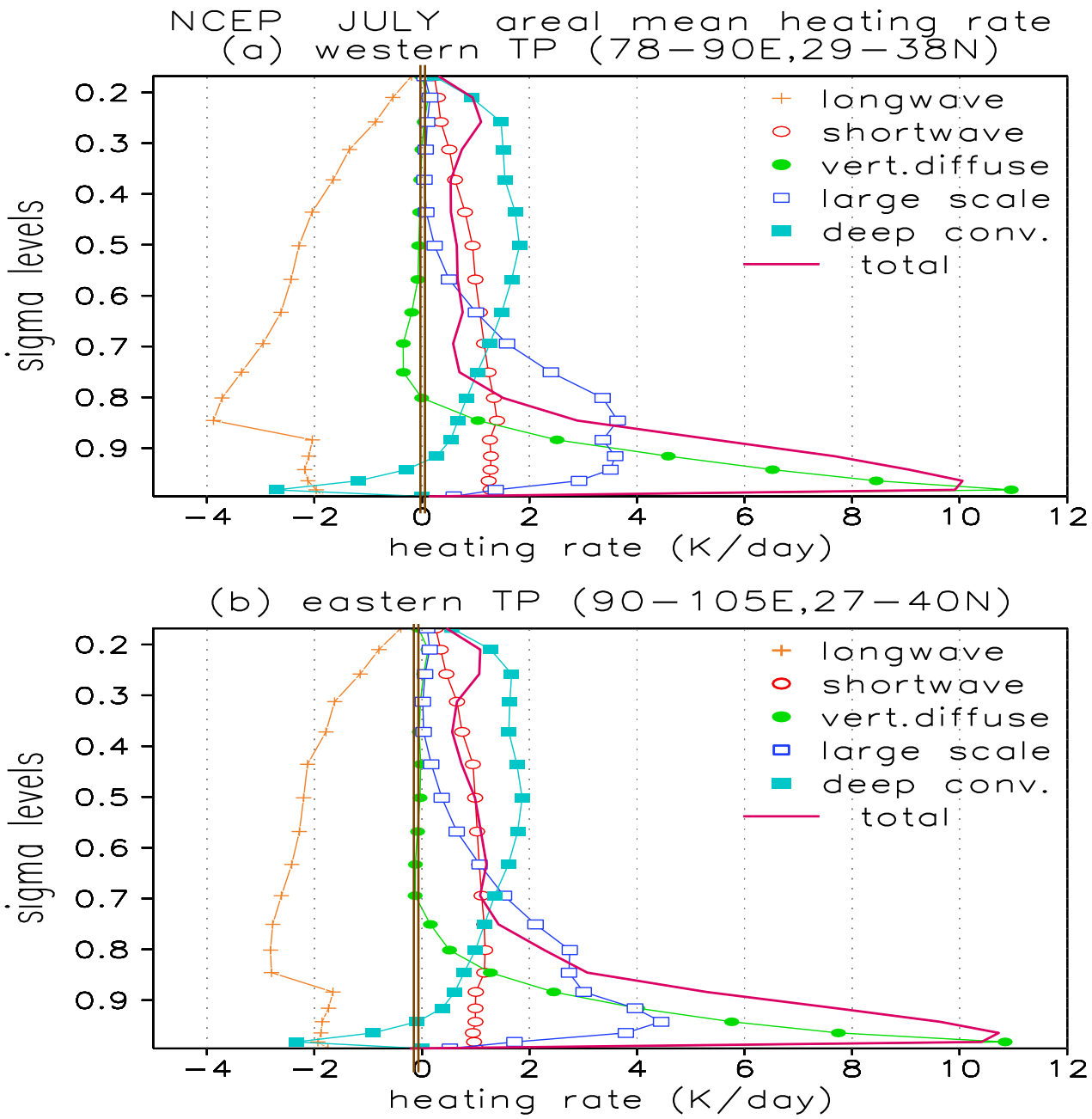
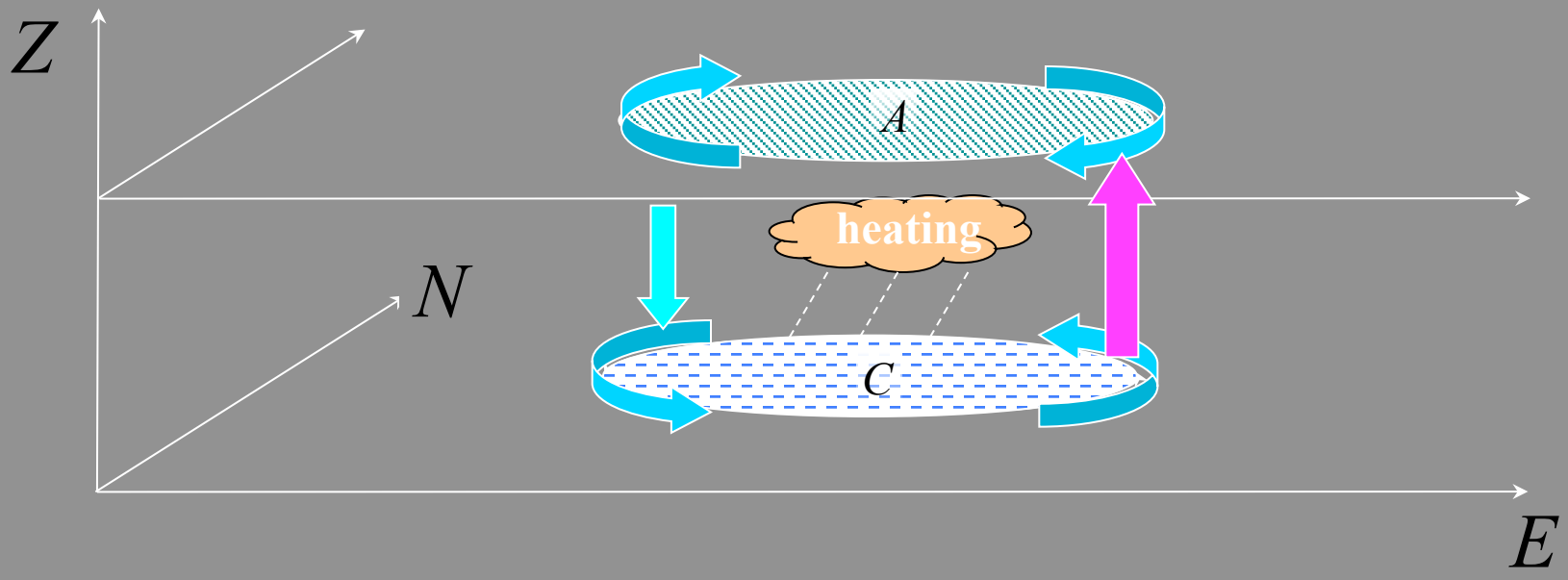


Tibetan Plateau heating profiles in July



Thermal Adaptation- heating

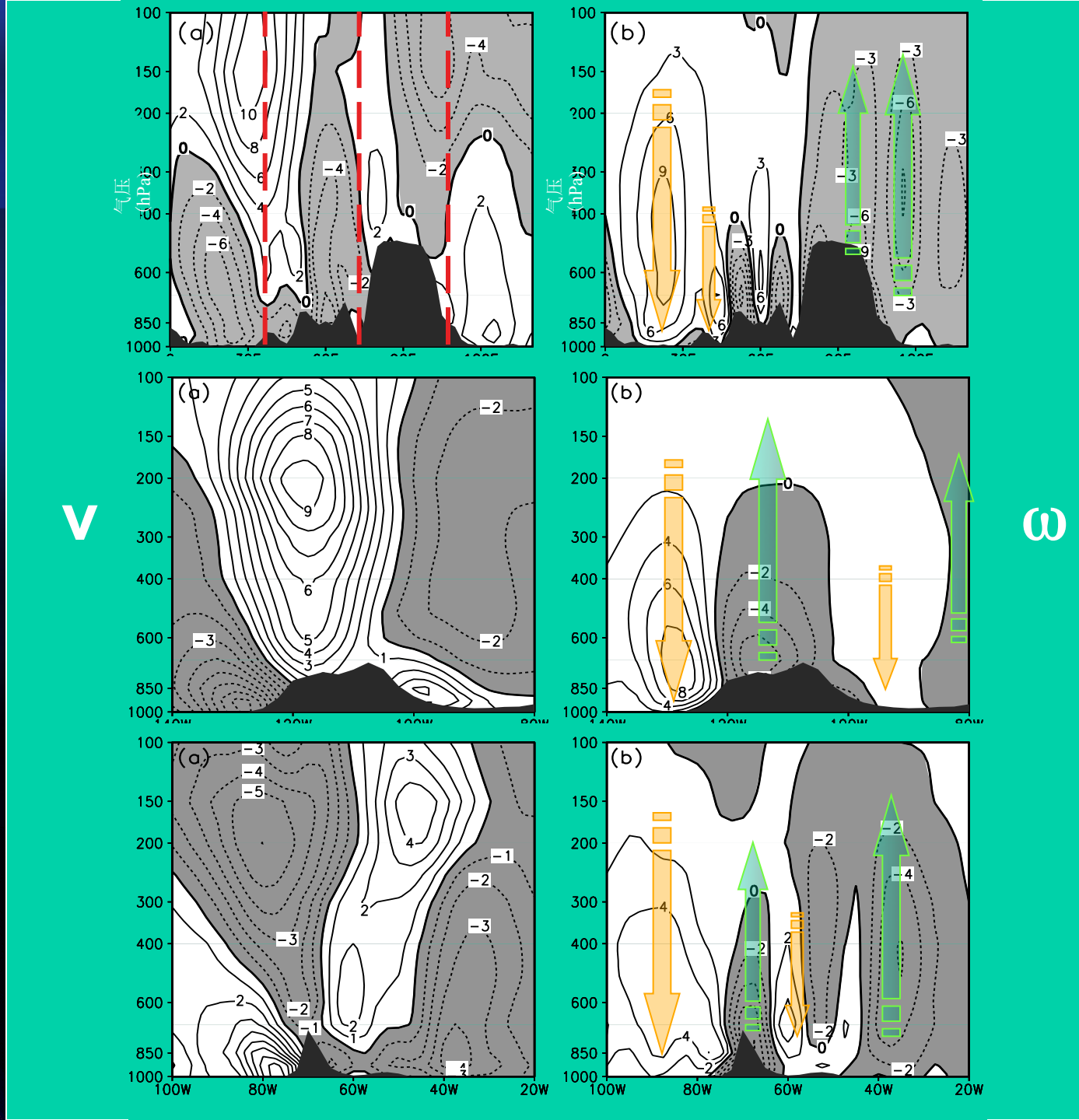


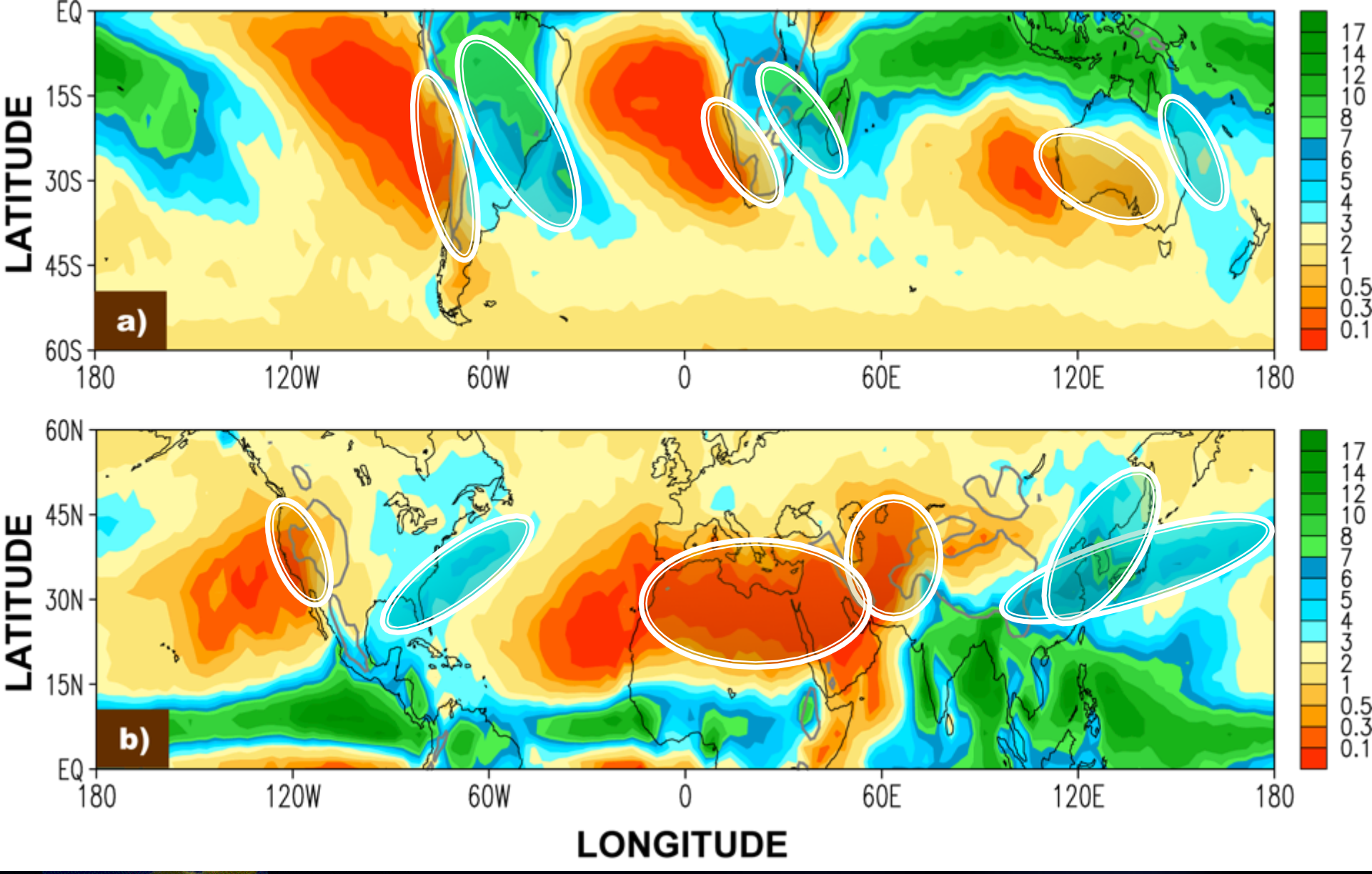
$$w \propto -\beta \frac{\partial \mathrm{v}}{\partial \mathrm{z}}$$

Tibetan
July

Rockies
July

Andes
January





Desert and Monsoon are Formed!

Summary

- Atmospheric Energy/heating and circulation are well coupled
- Desert and Monsoon coexist and are formed due to the atmospheric thermal adaptation to Continental-Scale "LOSECOD" forcing, Local-scale sea-breeze forcing and Regional-scale topography Forcing

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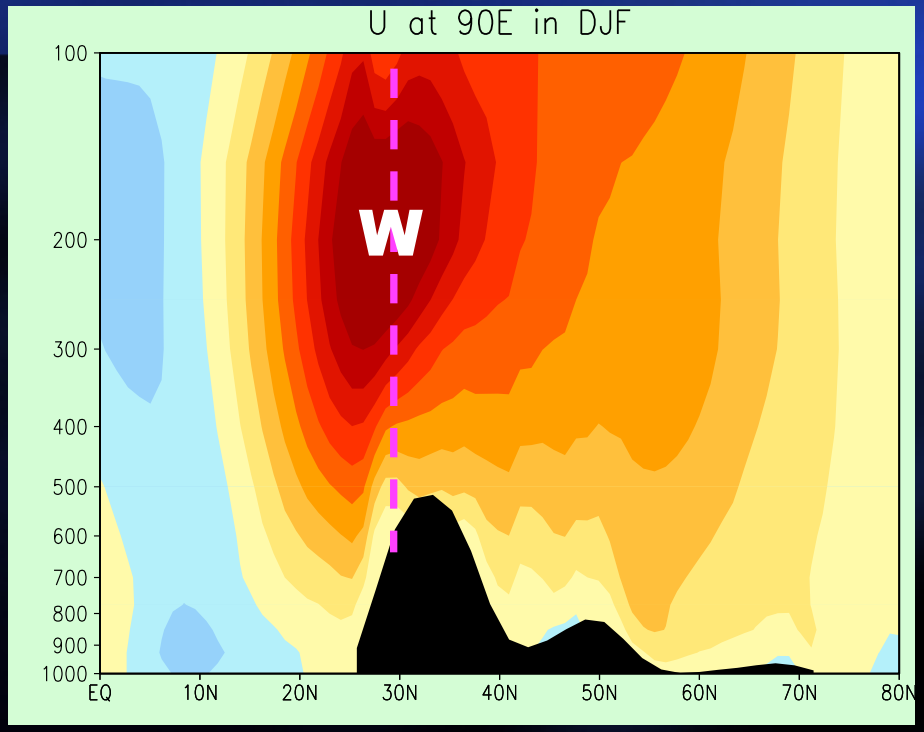
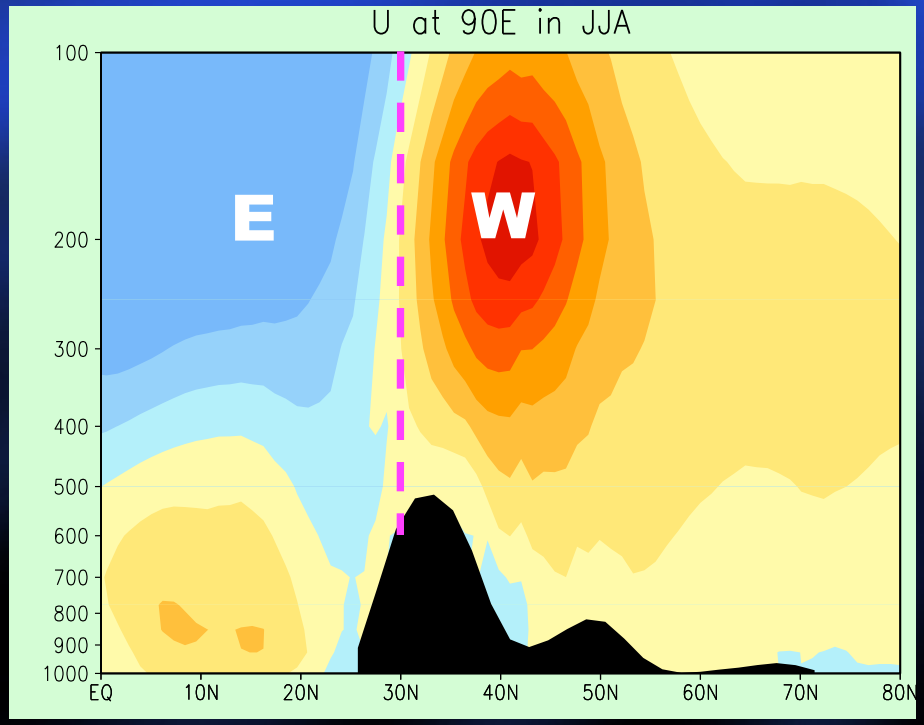
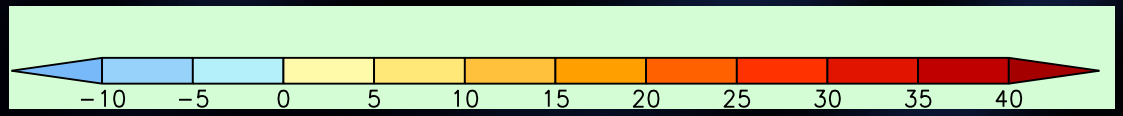
Zonal Wind $\overline{u}$

Winter



Summer





TP locates below westerly jet

horizontal advection is strong

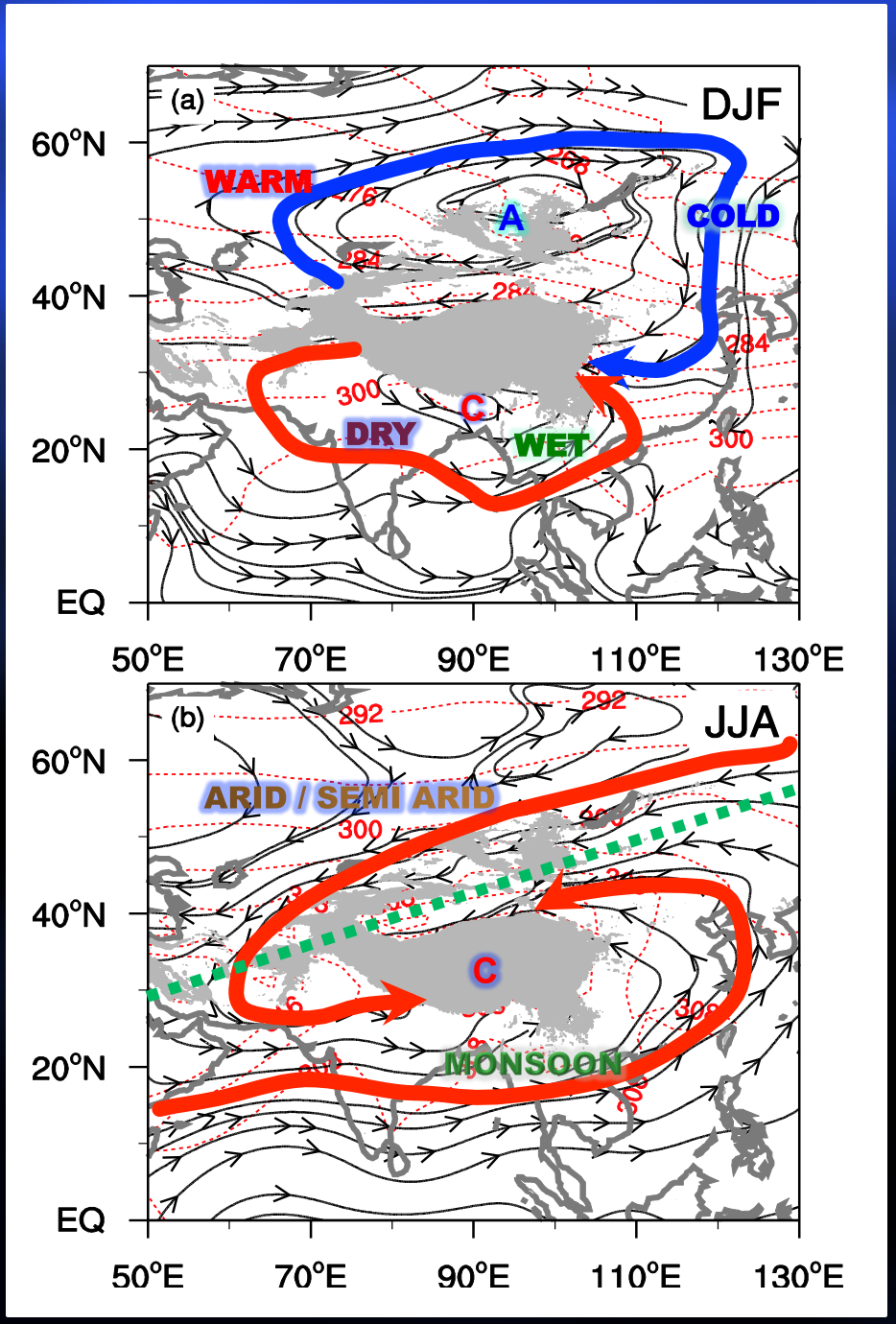
TP locates in the boundary of westerly and easterly

horizontal advection is small

V*

Winter: impinging westerly generates negative mountain torque and an asymmetric stationary wave circulation patter, influencing temperature and moisture advection

Summer: thermal pumping of the TP generates convergence spiral stationary wave pattern, influencing moisture advection

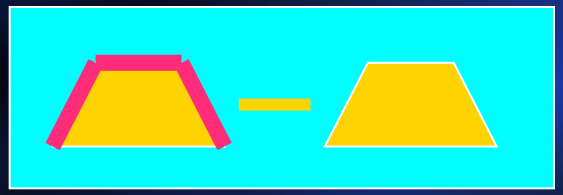


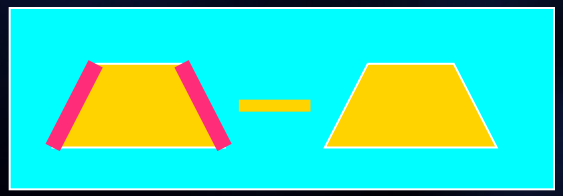
Tibetan Plateau-Sensible Heat driven Air-Pump (TP-SHAP-vertical)

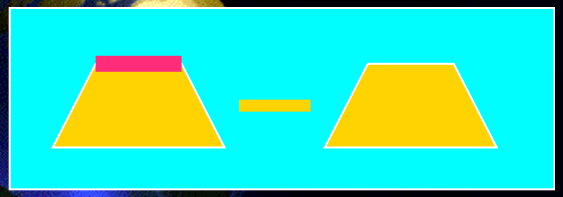
Heating on the mountain slope surface is crucial for uplifting water vapor from the surface to free atmosphere to form monsoon cloud and precipitation!

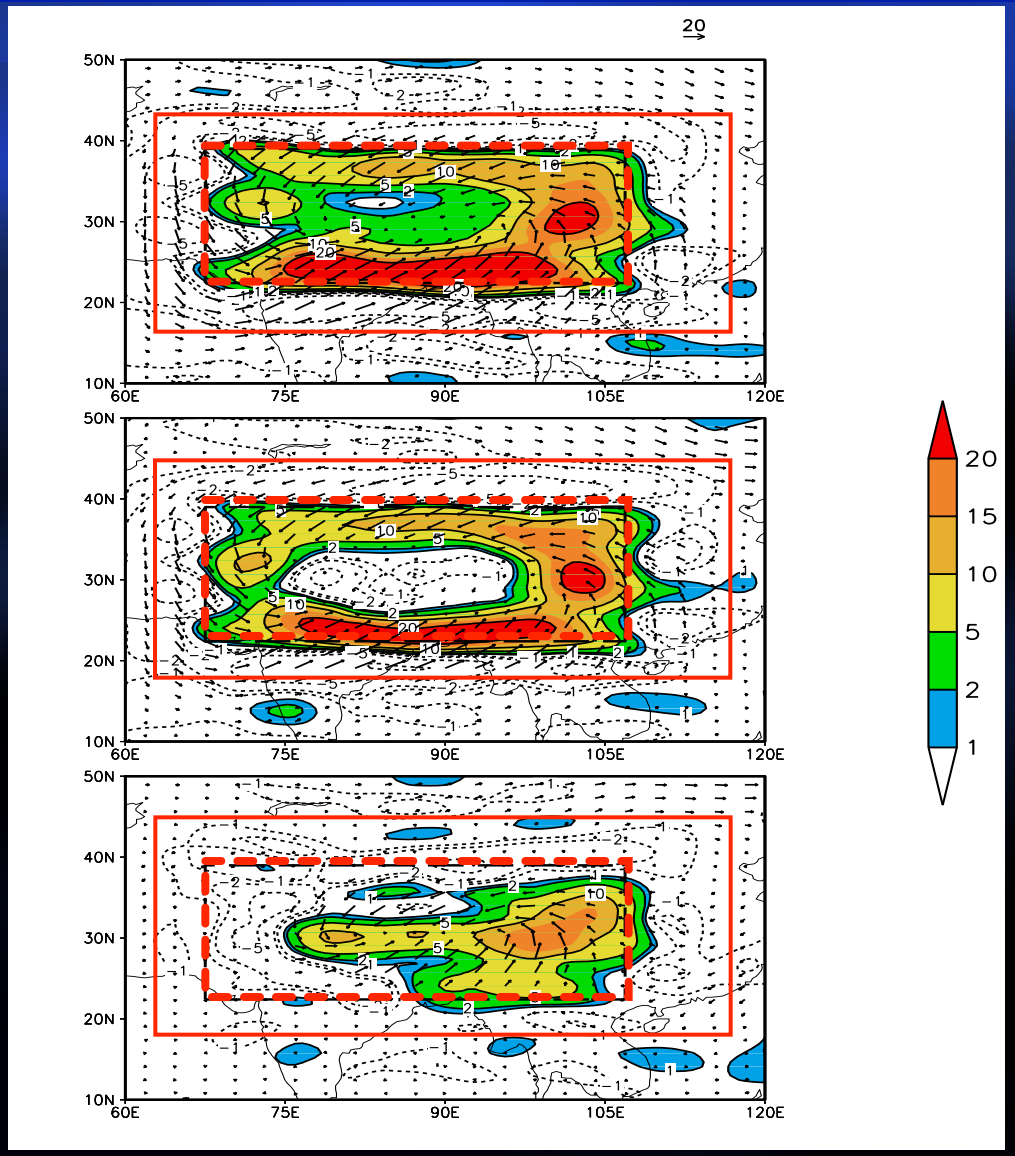
Vertical pumping

Aqua-Planet Experiment (APE): Diff of V and w at s=0.991







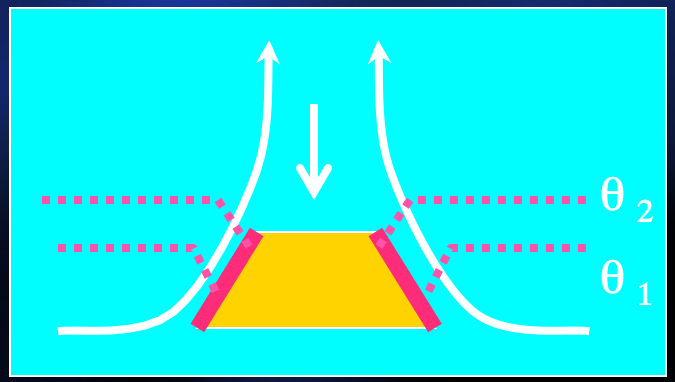


Wu et al., JHM, 2007

TP Sensible Heat Driven Air-Pump (TP SHAP) mainly happens on the slopes

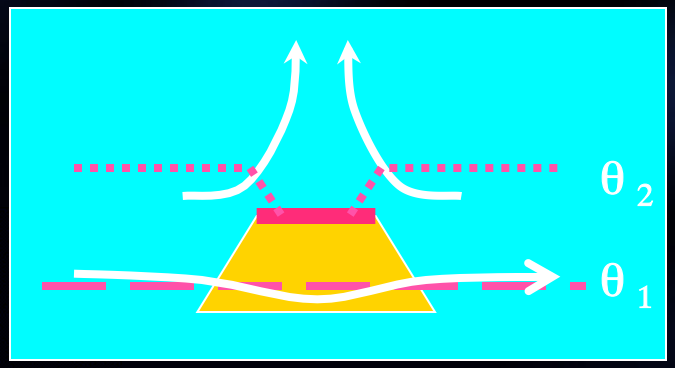
Pumping

$\vec{V} \cdot \nabla\theta = Q > 0$



Pumping

$\vec{V} \cdot \nabla\theta = Q = 0$



No Pumping

U , W and θ vertical cross- section

Wu et al., JHM, 2007

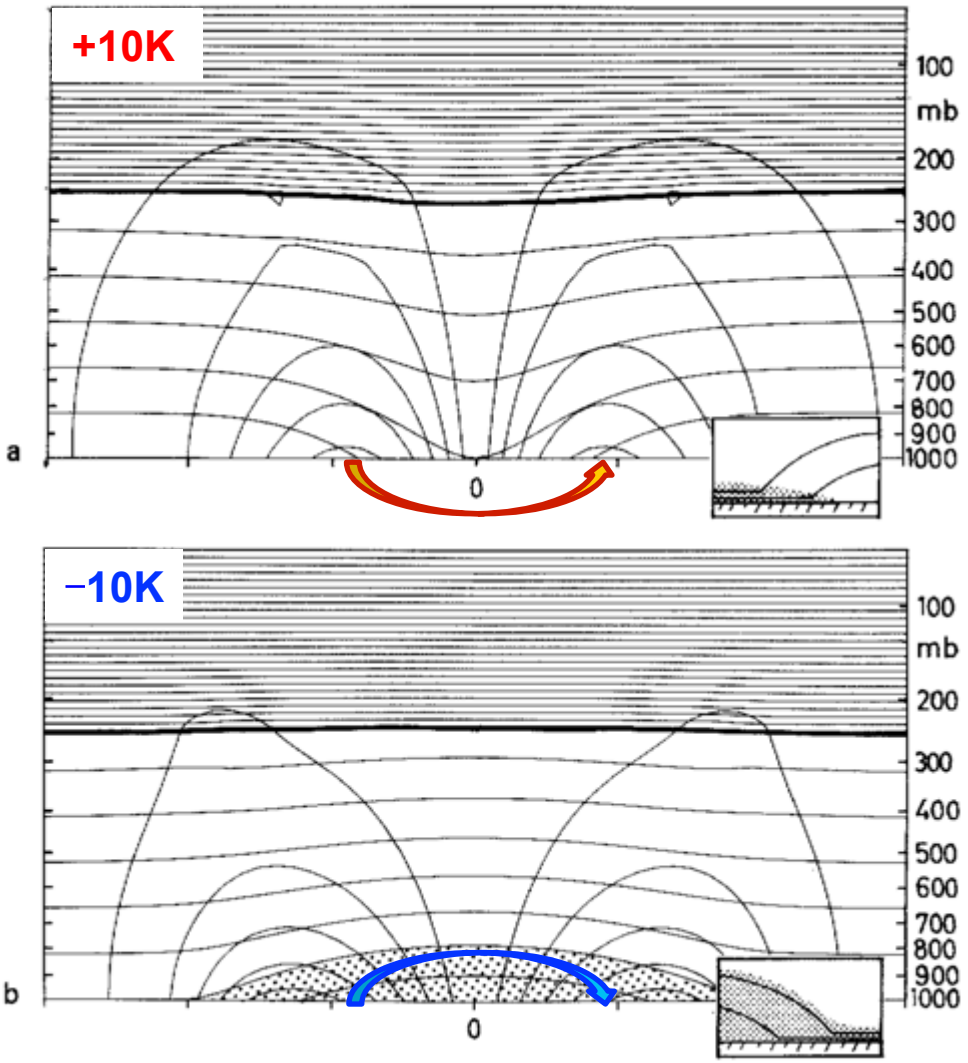
Tibetan Plateau-Sensible Heat driven Air-Pump (TP-SHAP-horizontal)

TP Surface sensible heating is crucial for transporting water vapor from sea to land to breed monsoon cloud and precipitation!

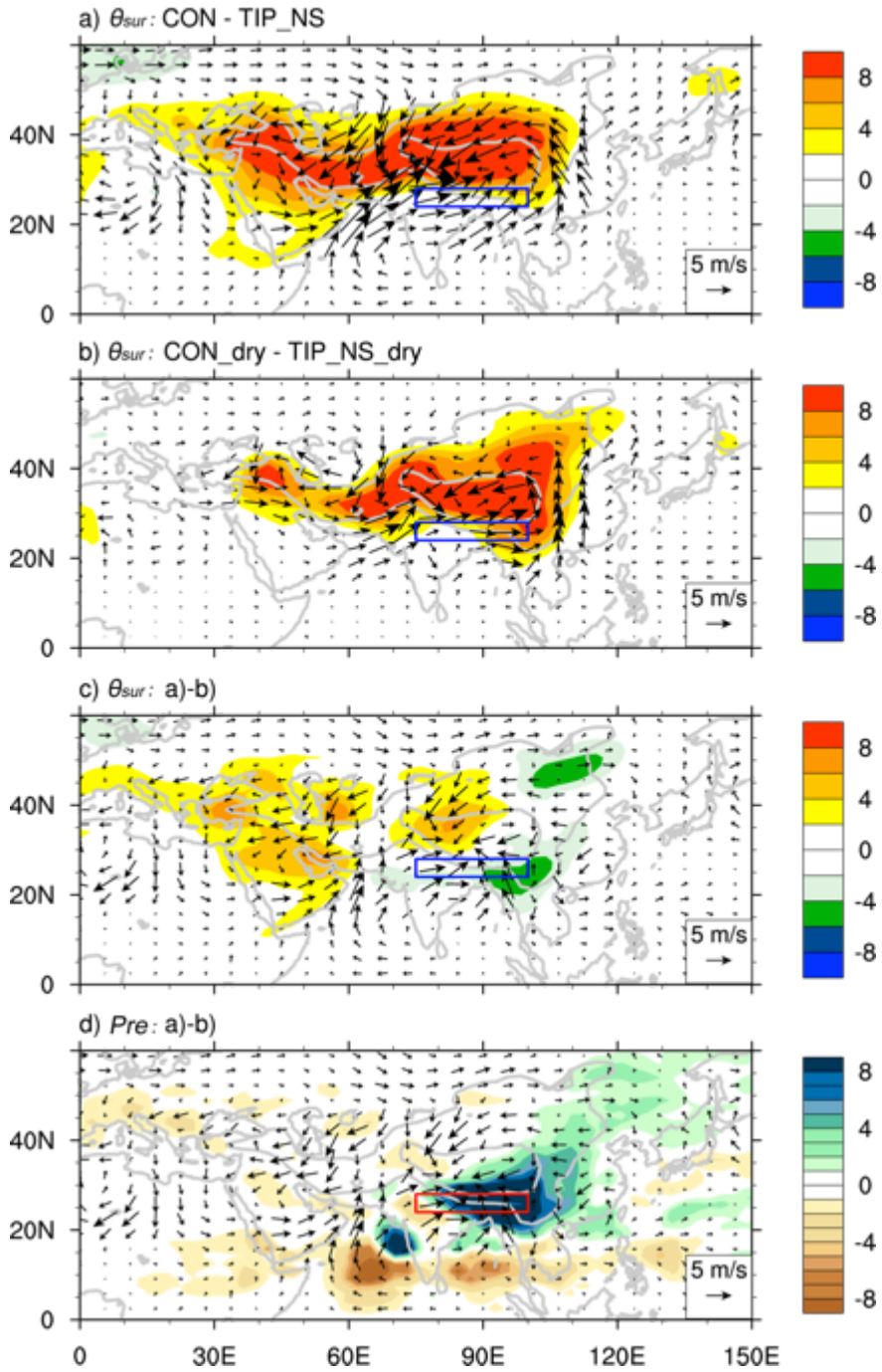
Horizontal pumping

Circulation symmetric flows induced by boundary temperature anomalies

***PV*-constrain**



Thorpe AJ (1985) Diagnosis of balanced vortex structure using potential vorticity. *J Atmos Sci* 42(4): 397-406.



MOIST

DRY

Fig. 6 JJA-mean differences of θ_{sur} (shading, K) and circulation (vectors, m s^{-1}) between

(a) CON and TIP_NS,

(b) CON_dry and TIP_NS_dry,

(c) difference between (a) and (b);

(d) is the same as (c) but for precipitation (mm d^{-1}). The square indicates the SASM region of (24–28°N, 75–100°E).