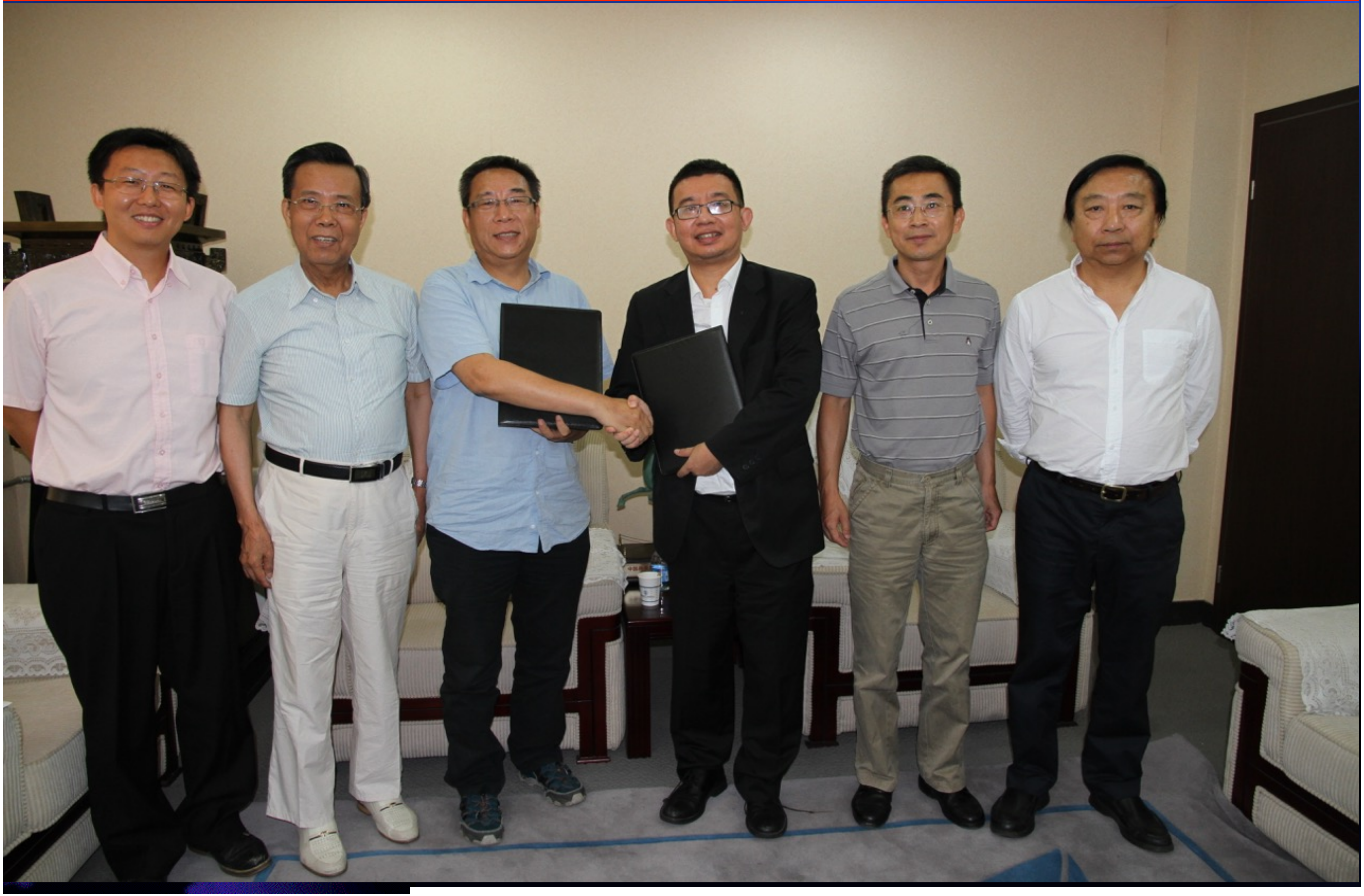
LASG/IAP and ICES partnership

Himalayas = Third Pole

- The Himalaya Project has been conceived by ICES to improve communication and collaboration among governments, academic and commercial organizations in the 16 nations that are either bordering, exercising jurisdiction or directly impacted by events occurring in the Himalayan region,

Signature of Cooperation Agreement between LASG/IAP and ICES, Aug 19, 2015, Beijing



Introduction of the

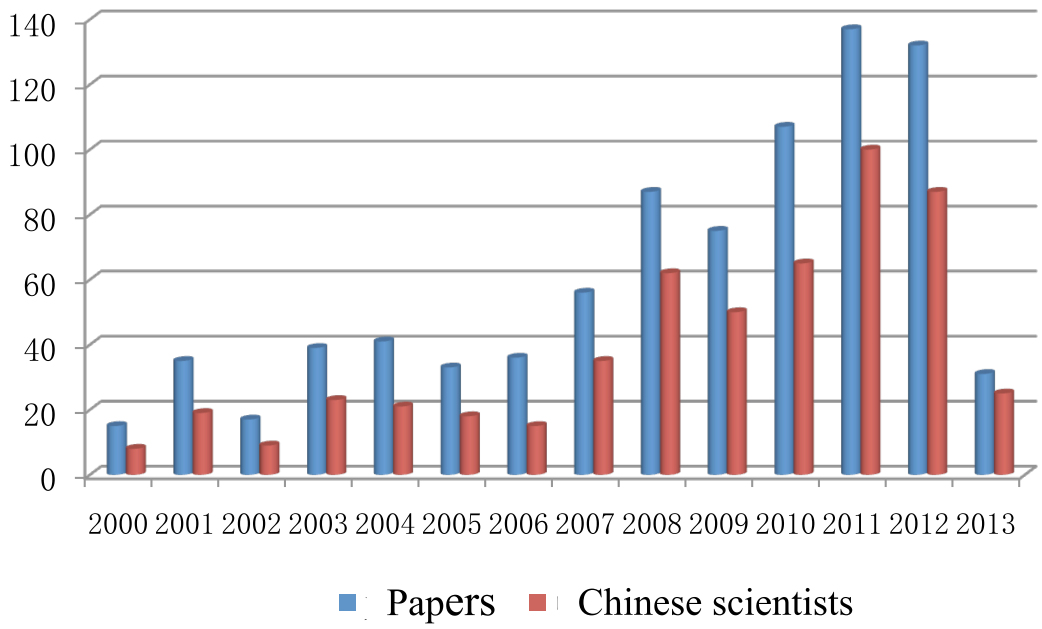
Asian Centre for Earth System Simulation" ("ACESS")

And the Himalaya sub-Projects

Guoxiong Wu, Bob Bishop and Aaron Xue

Funding： 200 Million RMB

Period： Jan. 2014- Dec. 2023



Year	Annual Papers	Chinese scientists	Ratio(China/total)
2000	15	8	0.5333333
2001	35	19	0.5428571
2002	17	9	0.5294118
2003	39	23	0.5897436
2004	41	21	0.5121951
2005	33	18	0.5454545
2006	36	15	0.4166667
2007	56	35	0.625
2008	87	62	0.7126437
2009	75	50	0.6666667
2010	107	65	0.6074766
2011	137	100	0.729927
2012	132	87	0.6590909
2013	31	25	0.8064516

Annual Publications related to TP impacts in the past 10 years

（From： Web of Science， International Mainstream SCIs （IF>1.8））

Outline

1. Science significance
2. Current issues, Obs Infrastructure
3. Research content, implement plans
4. Why ACESS Himalaya projects

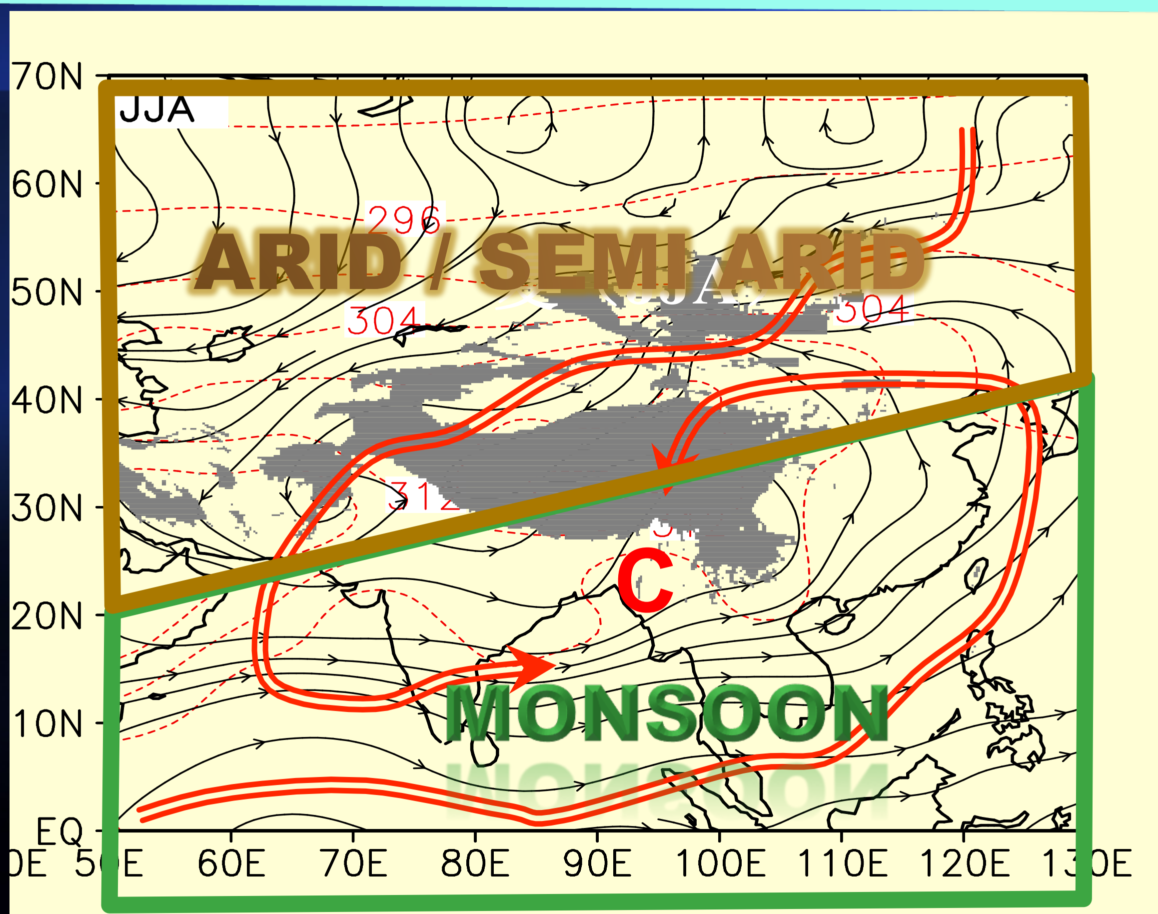
I. Science significance

Scale- crossing the Eurasian continent, one quarter of China's territory

亚洲地形图

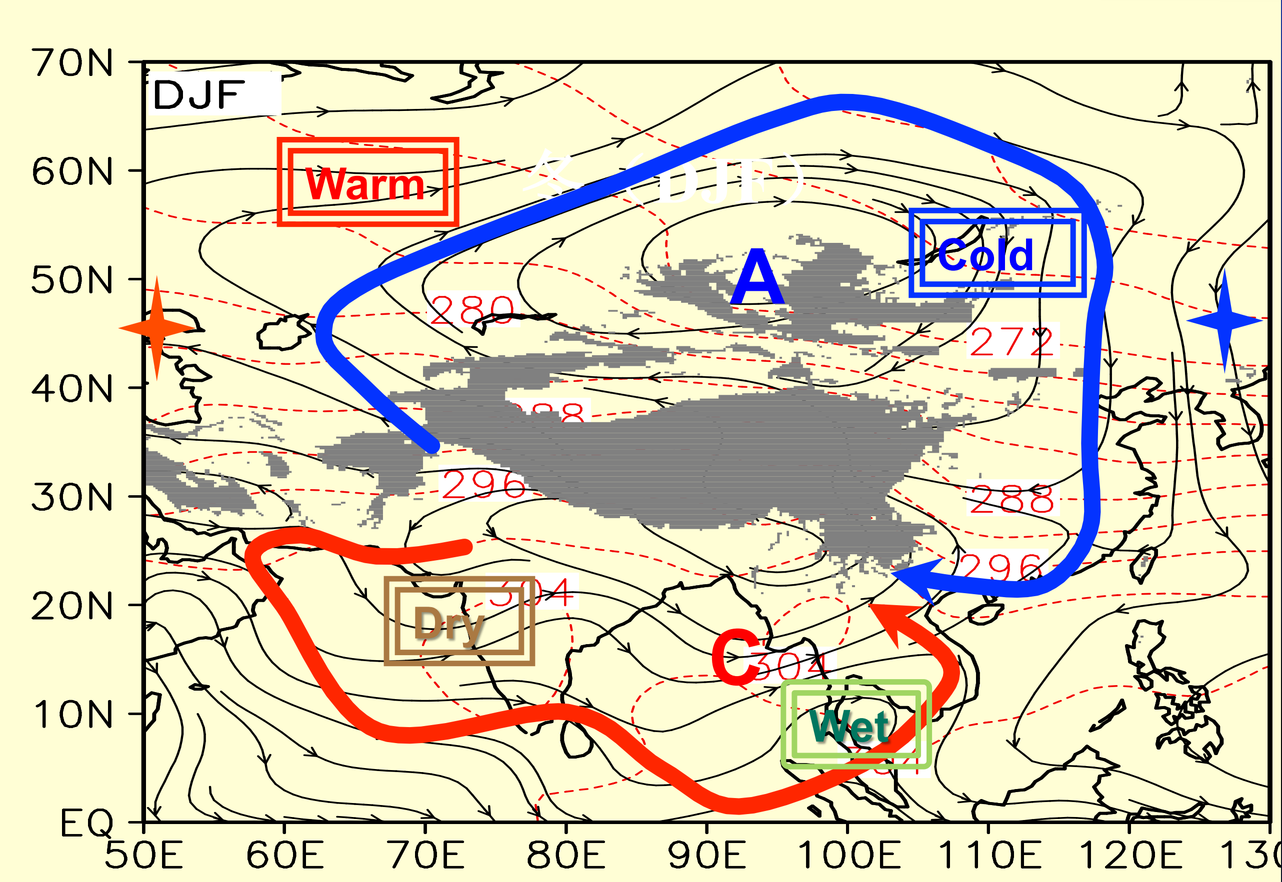
- generates continental- scale stationary waves

TP and Asian Climate- Summer



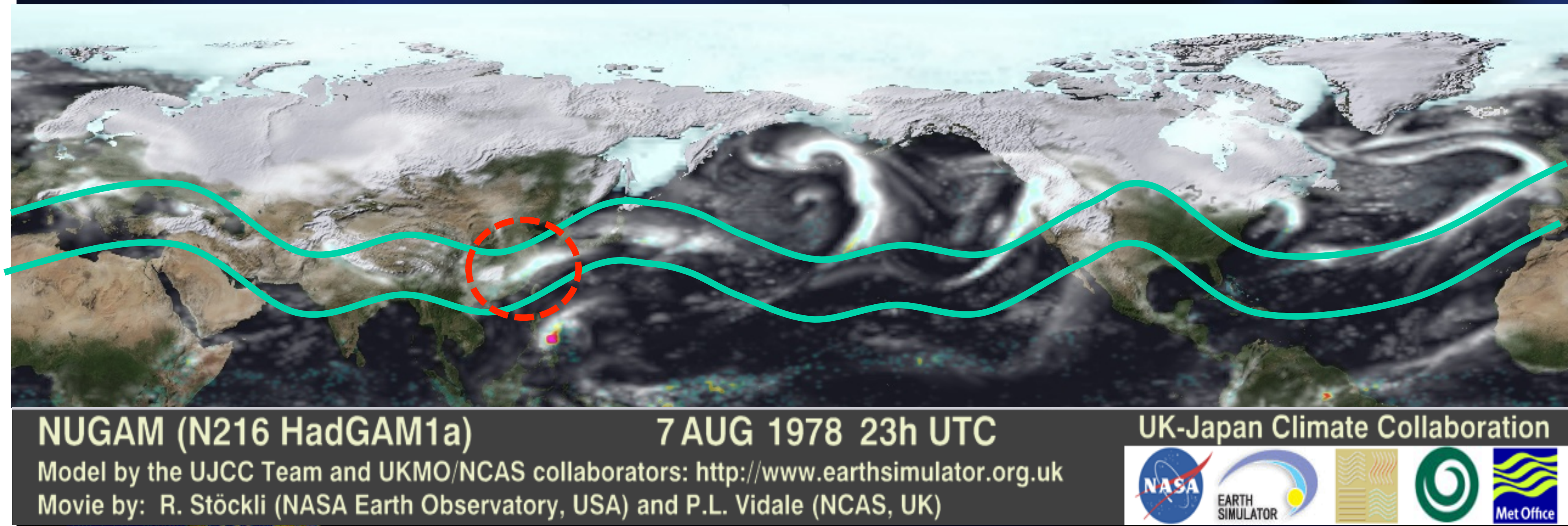
- Summer: generates continental-scale stationary waves

TP and Asian Climate- Winter



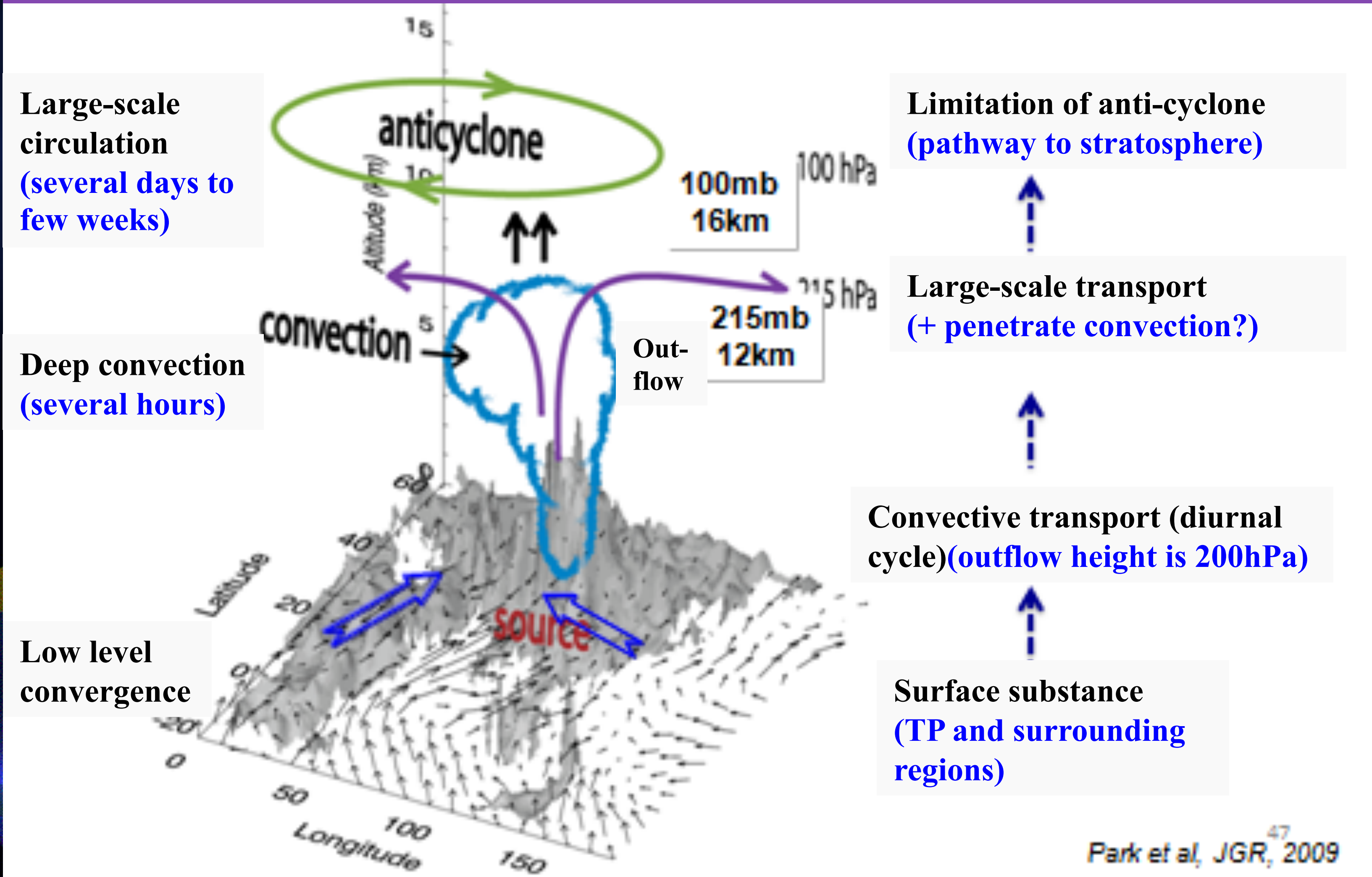
➢ **Winter: generates continental-scale stationary waves**

Tibetan Plateau affects boreal circulation and climate via Rossby-wave propagation



Height- above 8km in the upper troposphere

TP is the main path for pollutants being transported into the stratosphere in summer

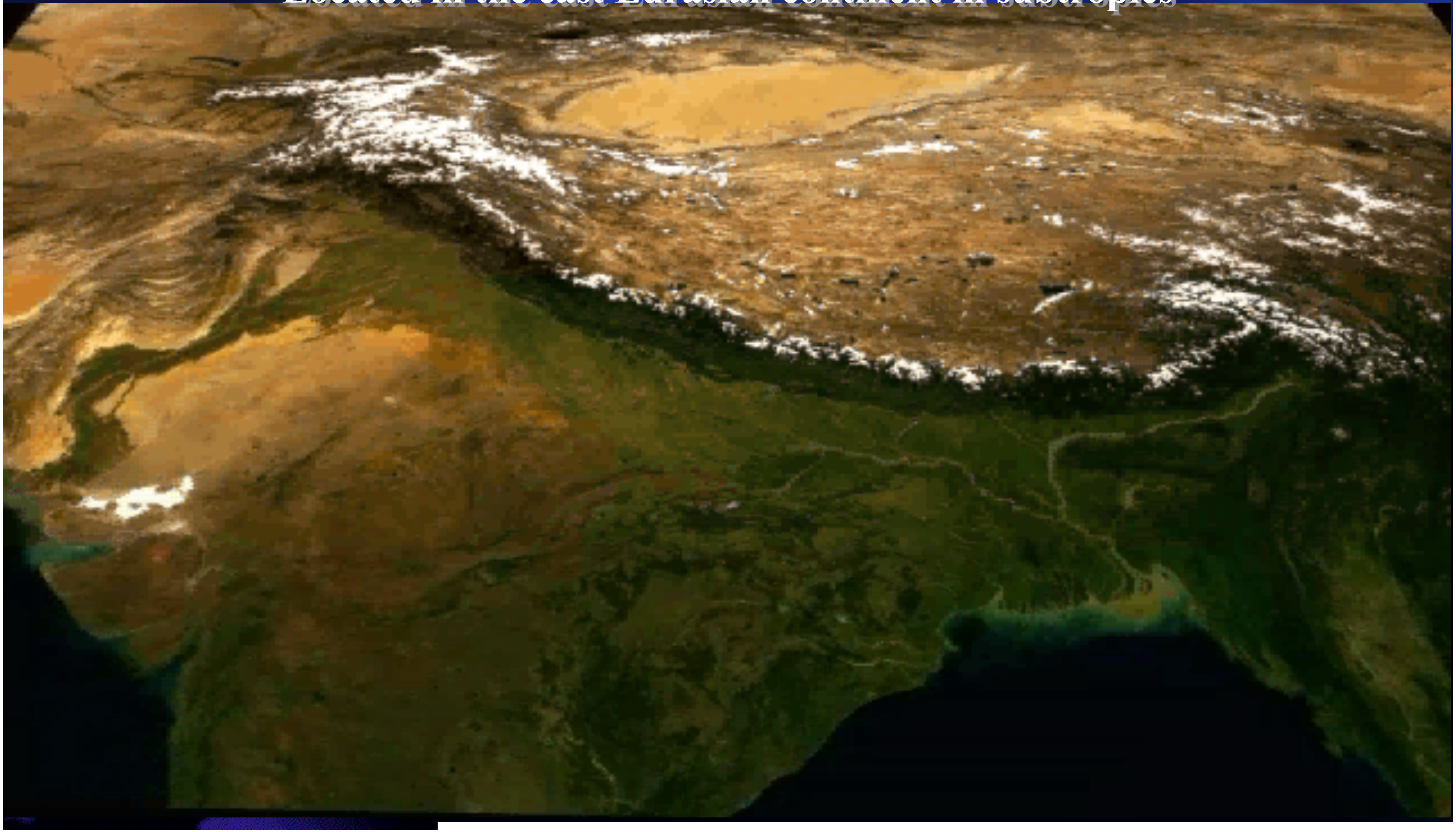


Park et al, JGR, 2009

Slope－Steeper topography in the southern and eastern flanks

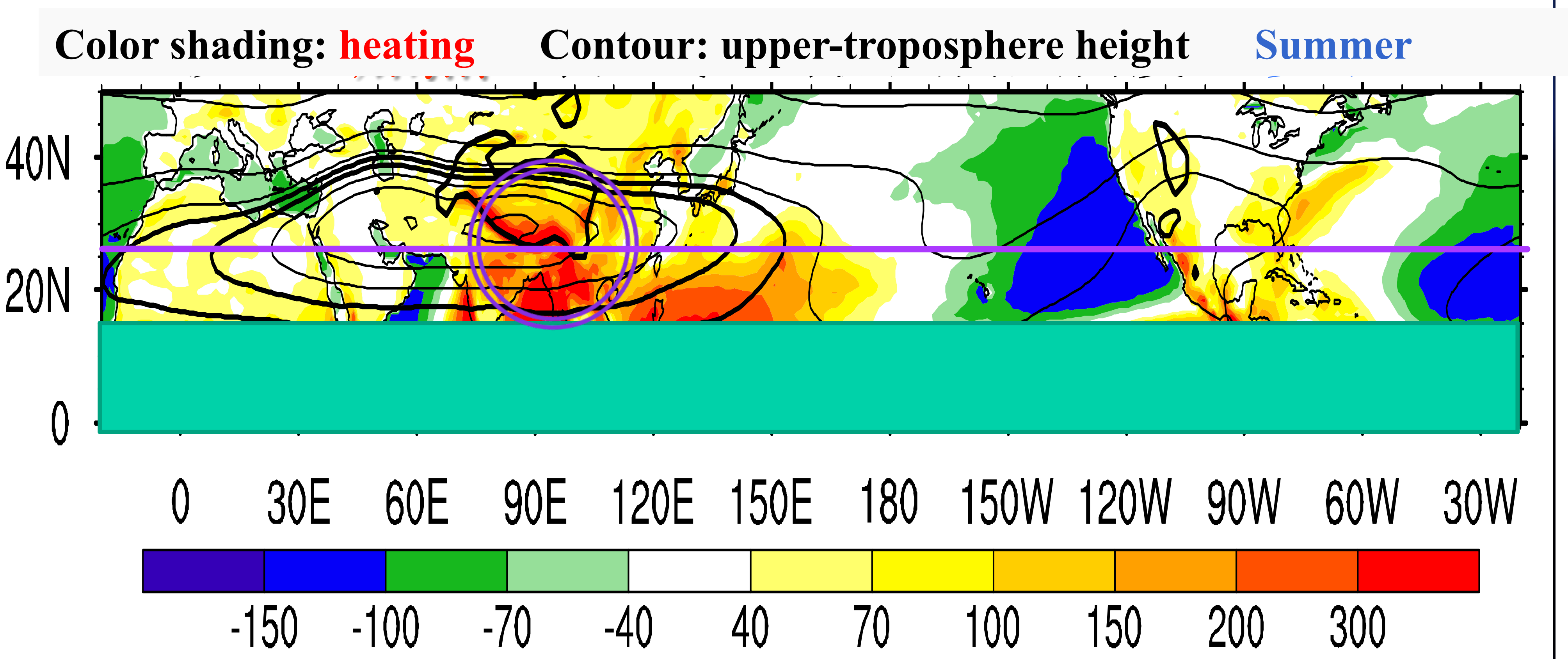
Averaged height is 4 km; Area is 1/4 ~ 2.5 m km^2 of China territory

Located in the east Eurasian continent in subtropics



Slope—steep in the south and east flanks

The strongest subtropical heating locates over south slope of TP and Bay of Bengal in boreal summer, and the South Asian High dominates the Eurasian continent; the heating influences the north hemisphere.



Liu YM et al., 2004, J Climate

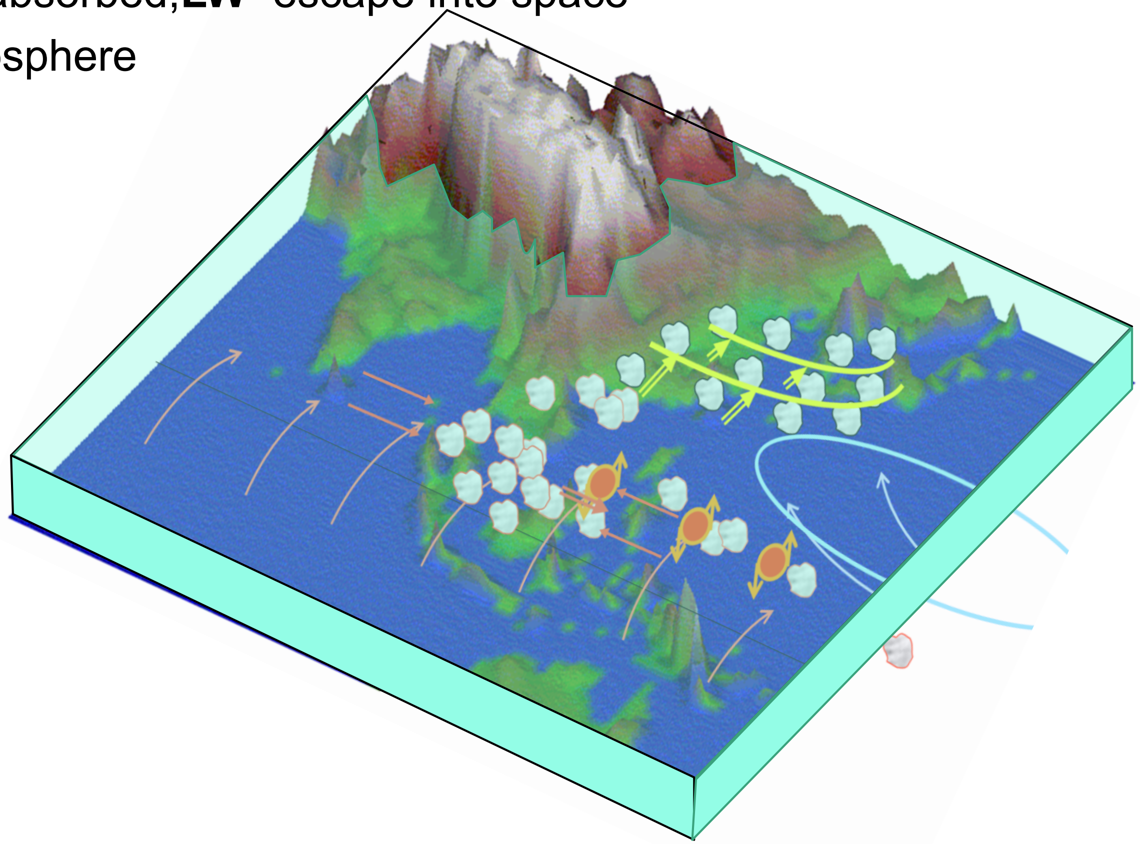
TP Sensible heating drive air pump (SHAP)—water vapor lifted—Asian monsoon

A. **Monsoon- water vapor:** 85% resides bellow 700mb

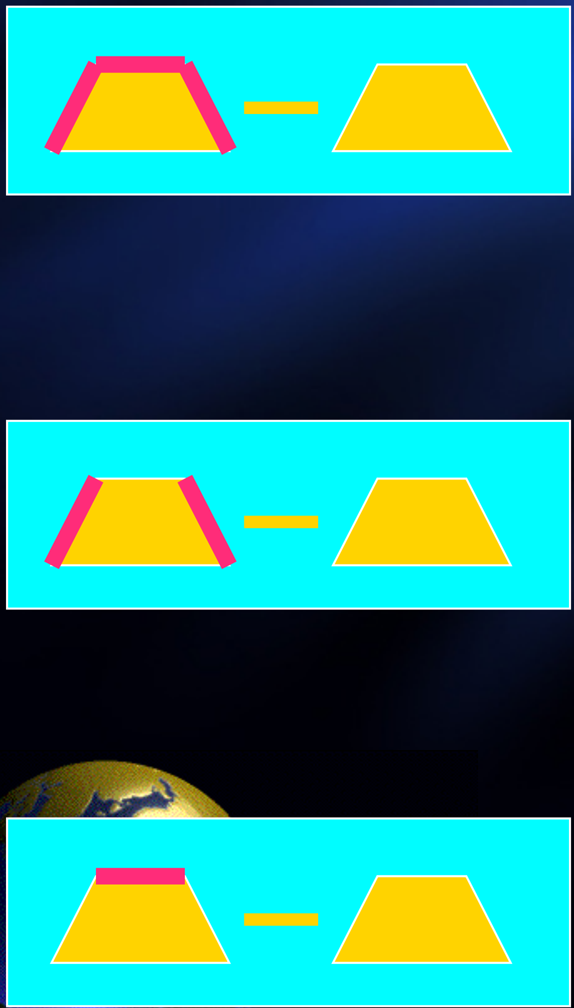
B. **Lifting:**

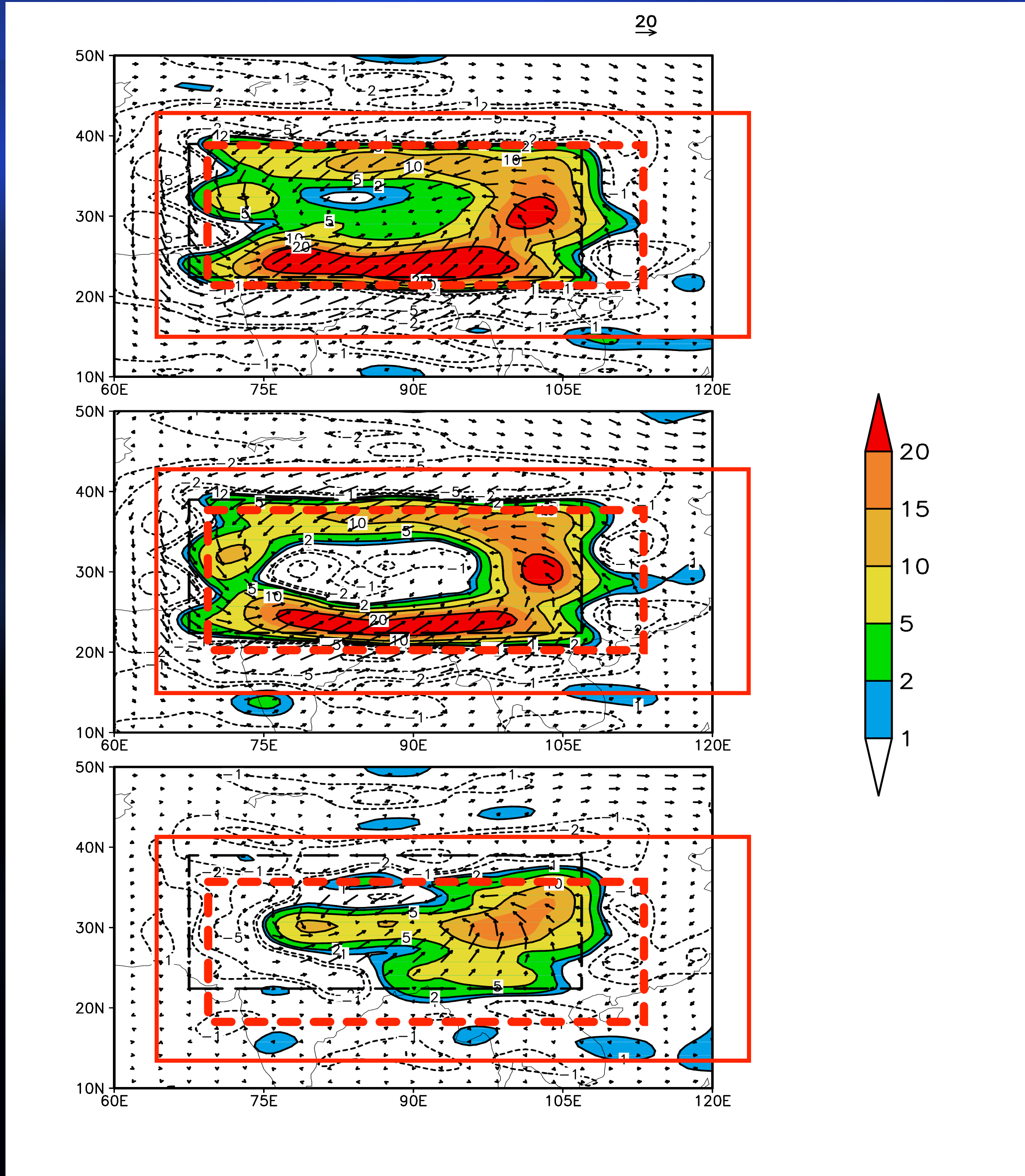
- **Internal- baroclinity:** winter and extratropics
- **External- mechanical:** deflected or lifted <1km
- **External- thermal: SW-** hardly absorbed;**LW-** escape into space
- **Latent heating-** in the free atmosphere
- **Surface Sensible heating**

  - effective!---mountain slope



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





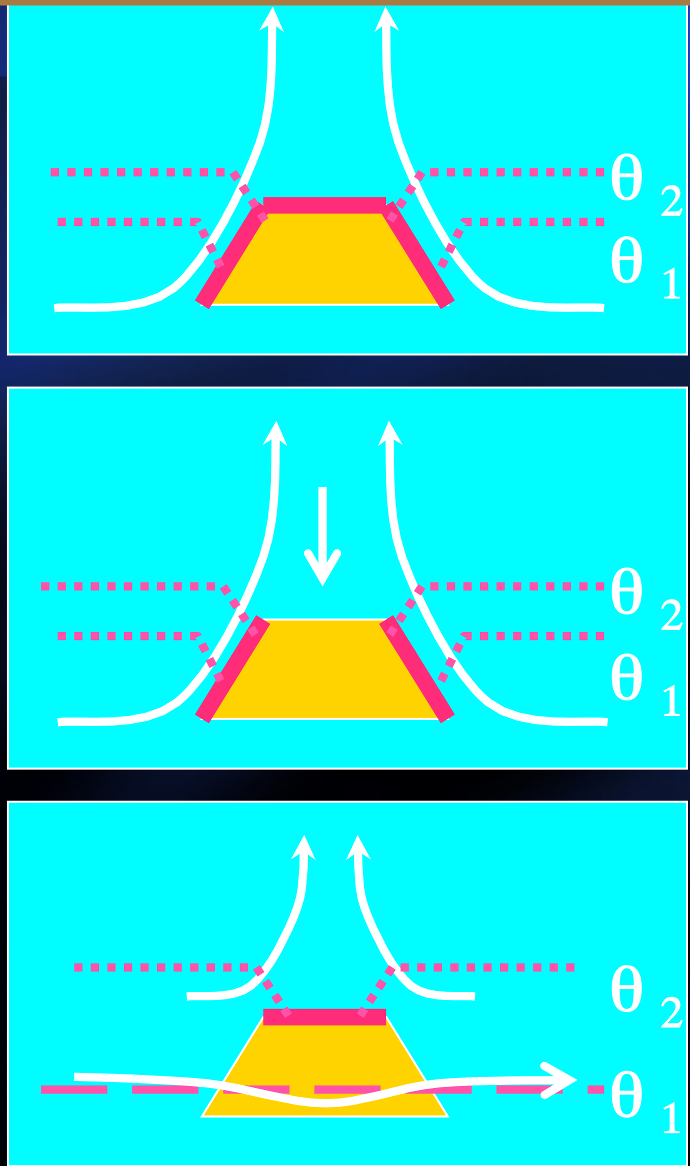
Wu et al., JHM, 2007

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

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

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

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



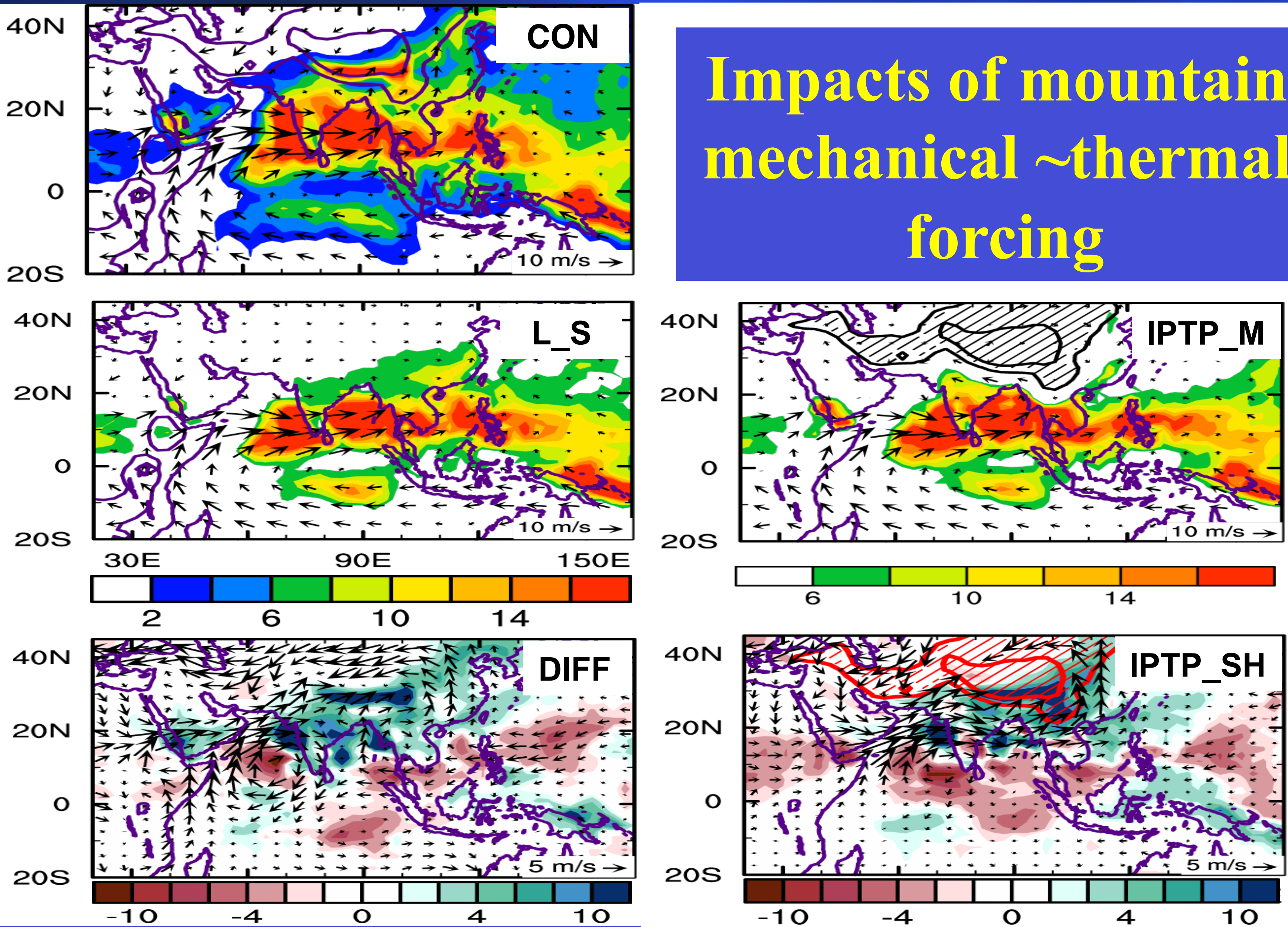
Pumping

Pumping

No Pumping

U , W and θ vertical cross- section

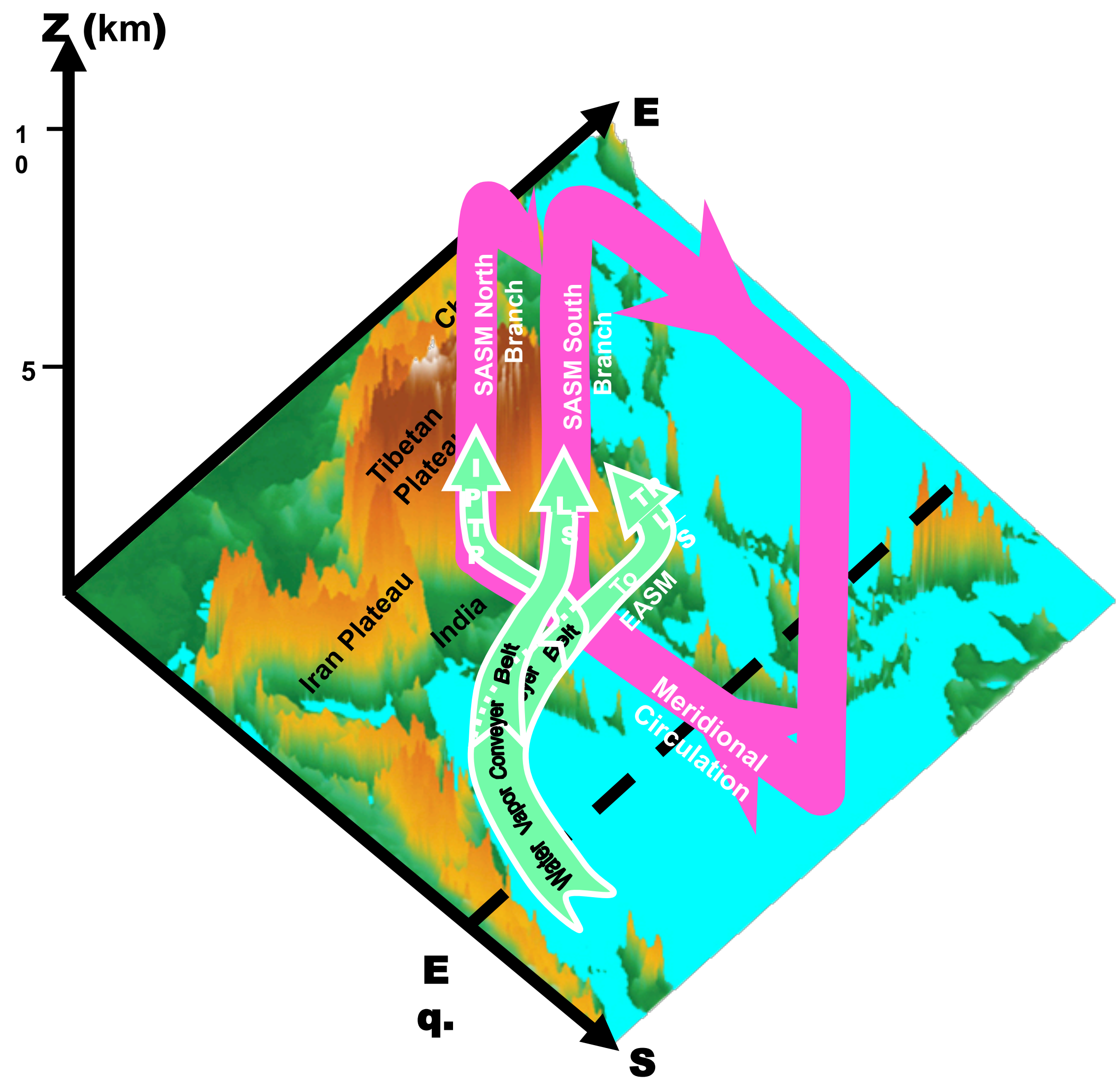
Impacts of mountain mechanical ~thermal forcing



Required Circul. and Precip. to make up the Asian summer monsoon

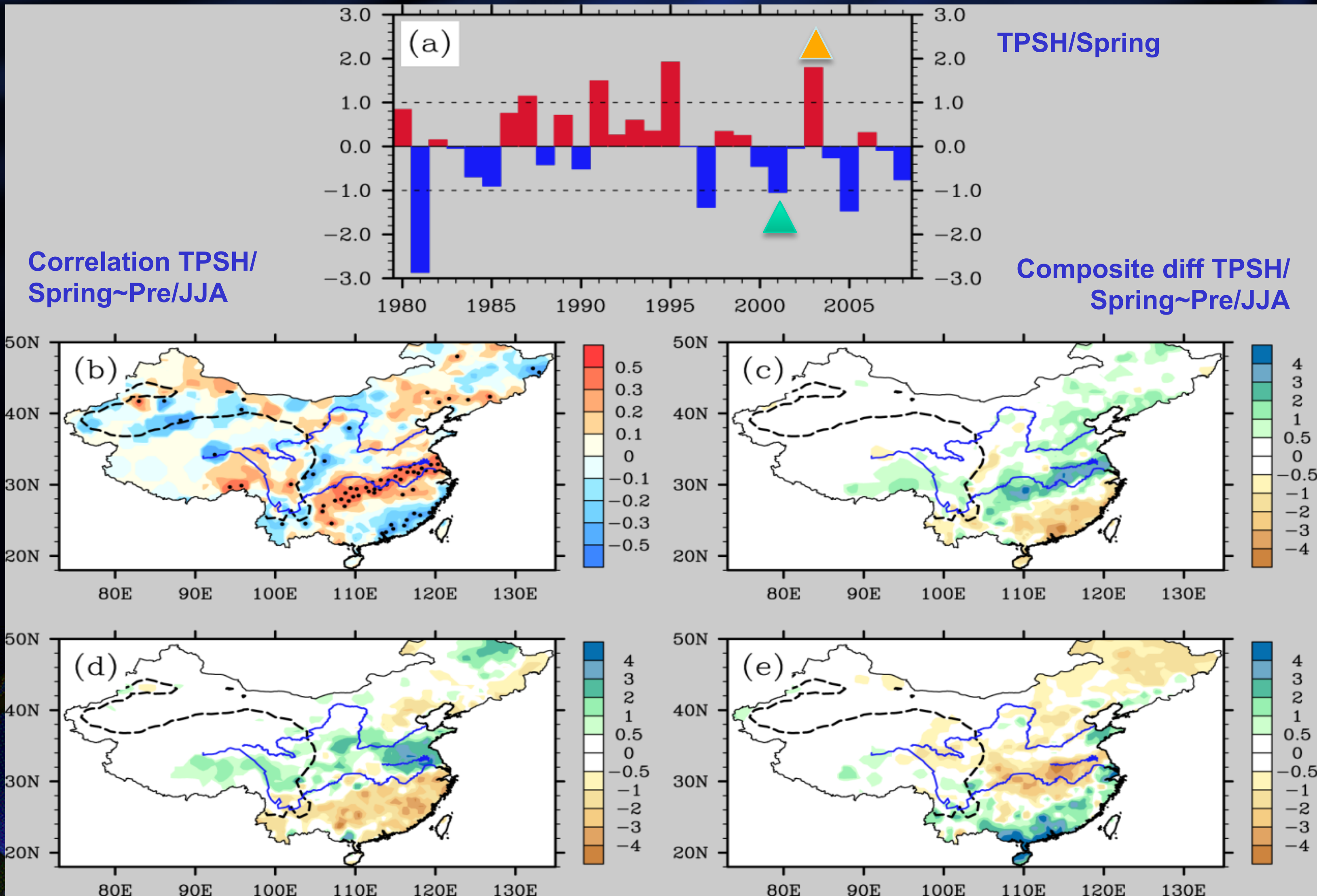
TP thermal control of the Asian summer monsoon

The thermally driven Asian summer monsoon circulation descending in the Southern Hemisphere, and thereby influence the Southern Hemisphere climate change.



Interannual variability

高原春季感热对我国夏季降水年际变率的影响

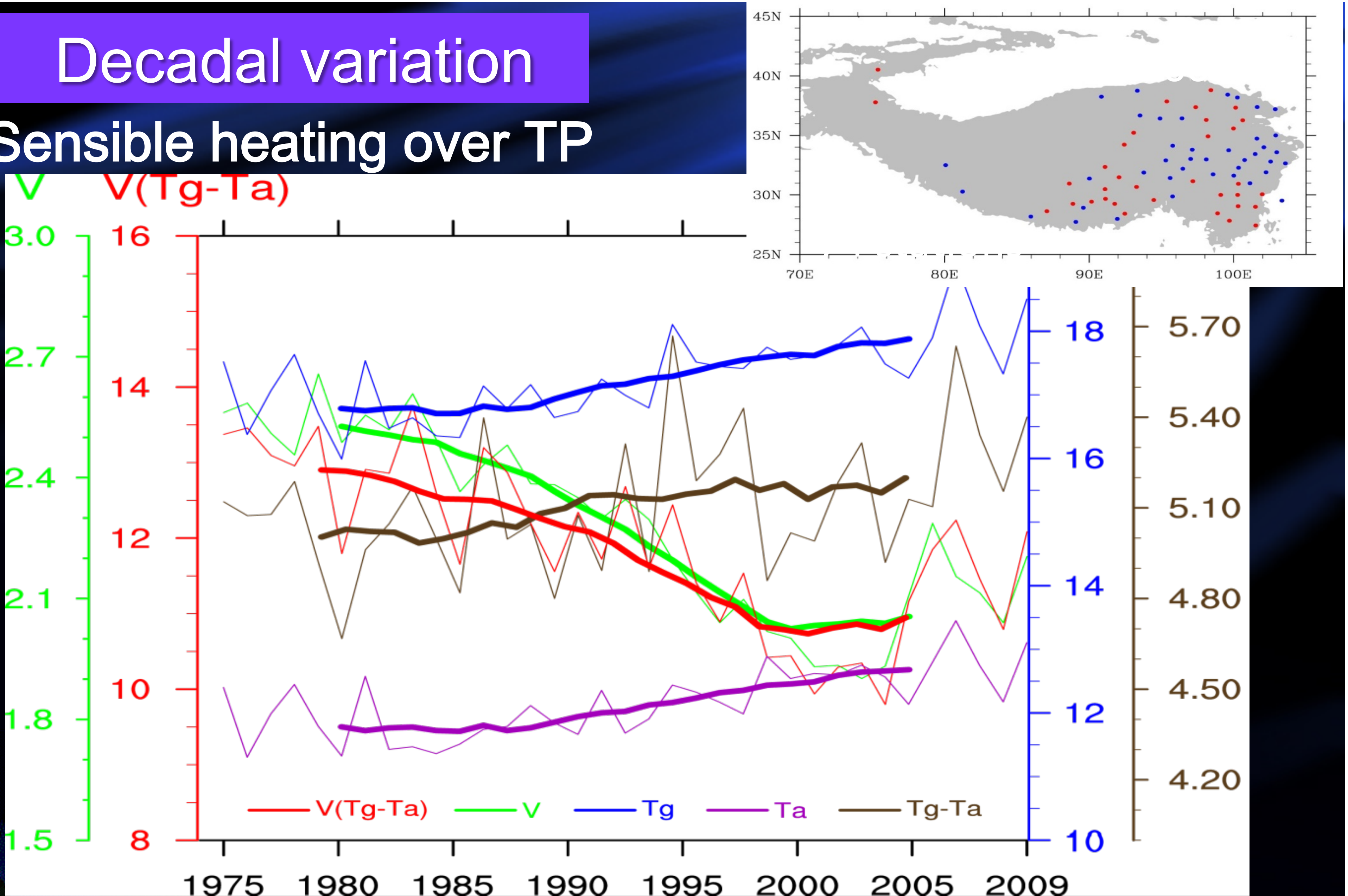


Pre/JJA 2003 **Pre/JJA 2001**

(Wang et al., 2013)

Decadal variation

Sensible heating over TP

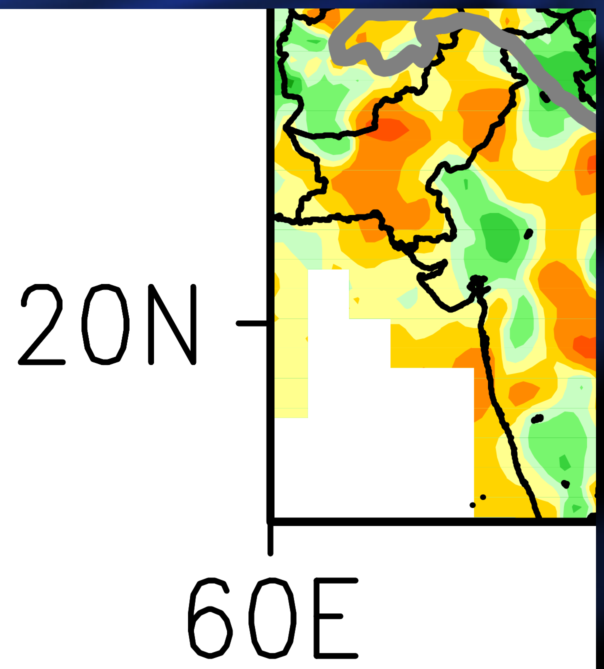


Mean over the TP, JJA

$$\frac{\Delta SH}{SH} = \frac{\Delta V}{V} + \frac{\Delta(T_g - T_a)}{T_g - T_a} \approx \frac{\Delta V}{V}$$

Liu etal. Cli. Dyn 2012

TP heating and "Wet in South and Dry in North"



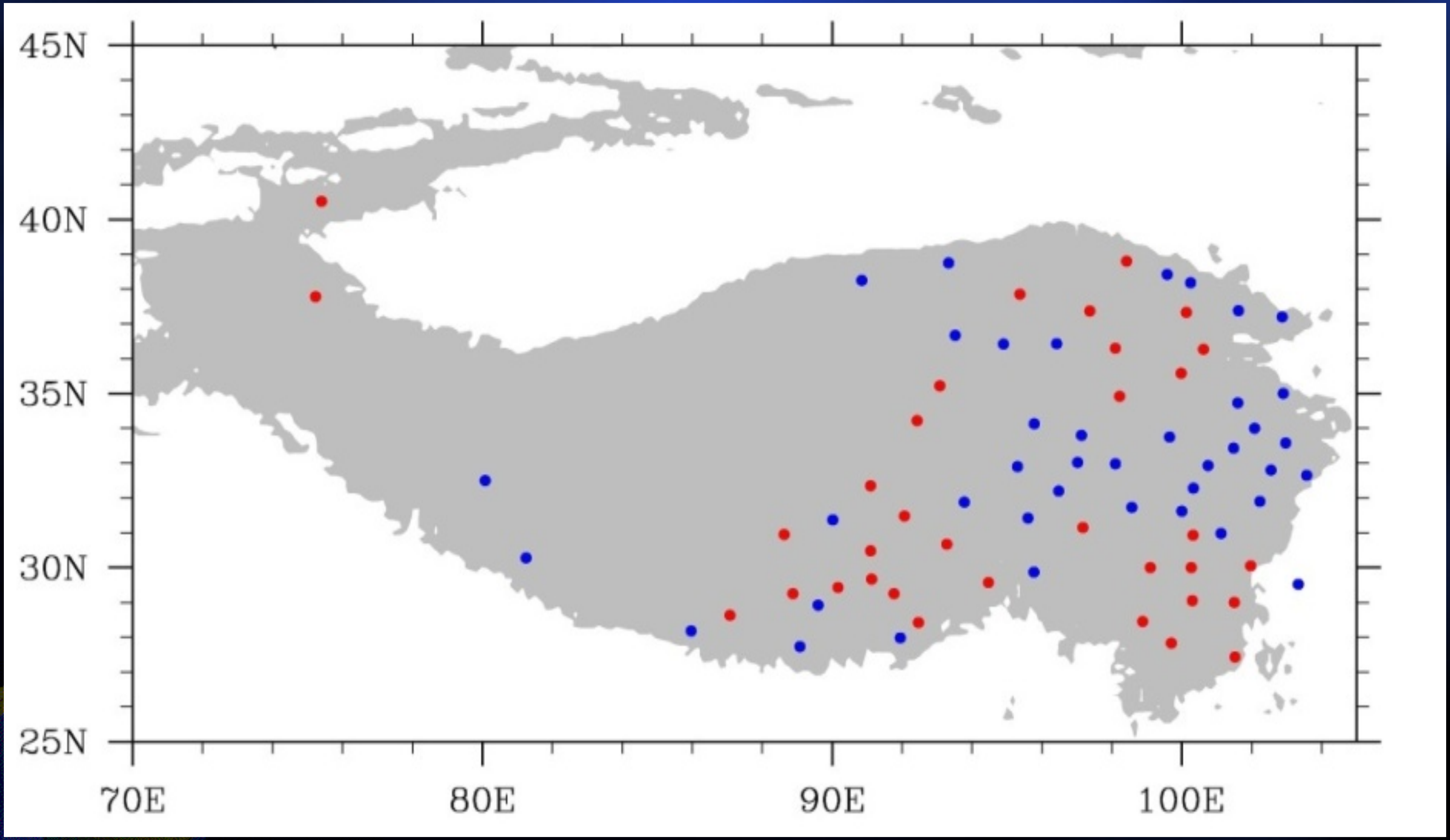
Correlation of SH averaged over TP and Pre_Land, 11-year running mean

SH=(Tg-Ta)V

Outline

1. Science significance
2. Current issues, Obs Infrastructure
3. Research content, implement plans
4. Why ACESS Himalaya projects

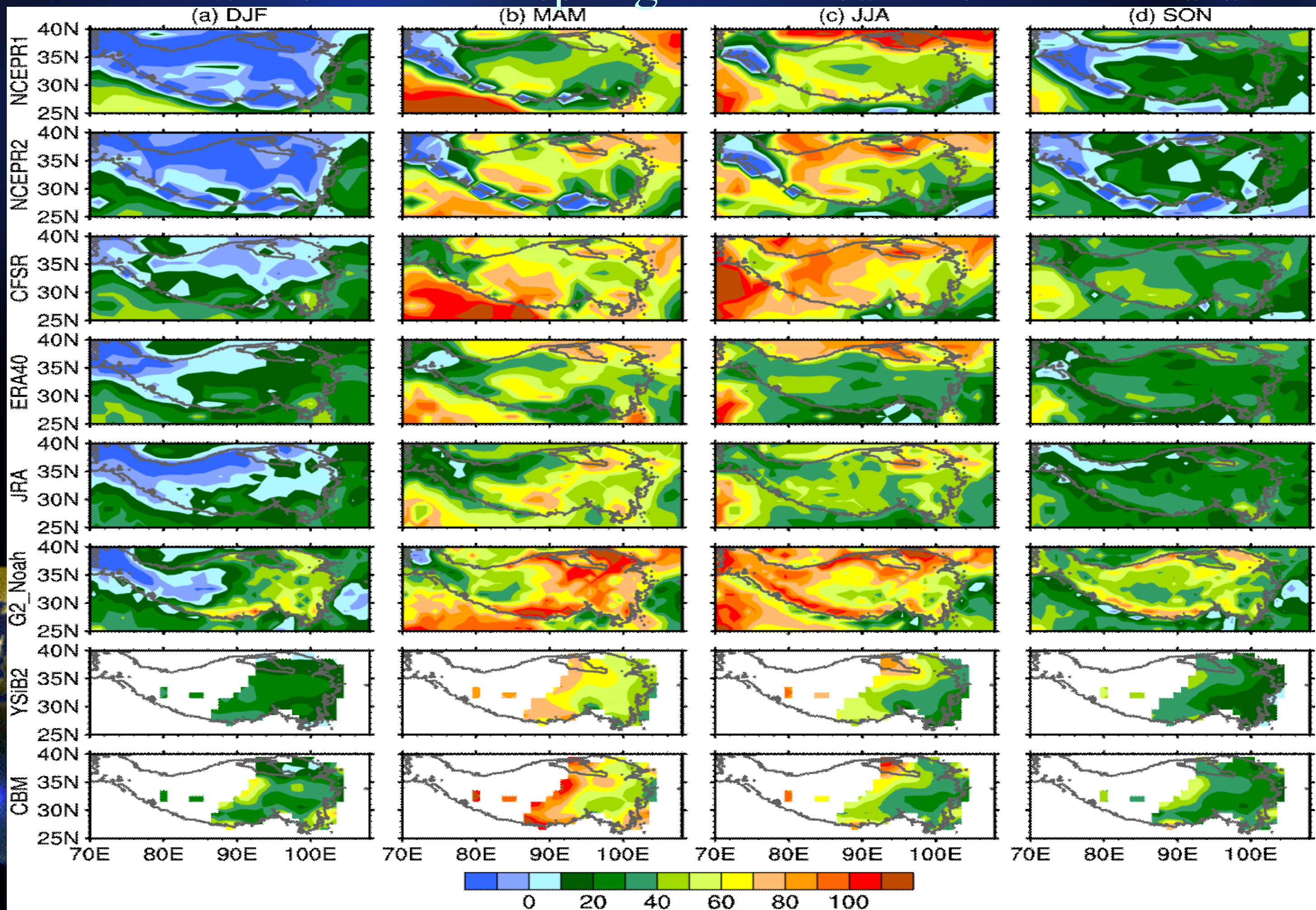
1. Observation: density, accuracy, content



3. Reanalysis has larger bias over the TP

Surface sensible heating in different reanalysis

winter spring summer autumn

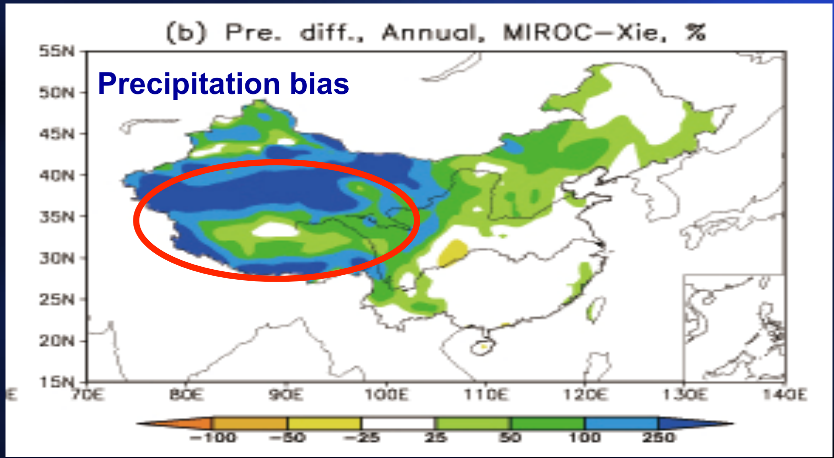


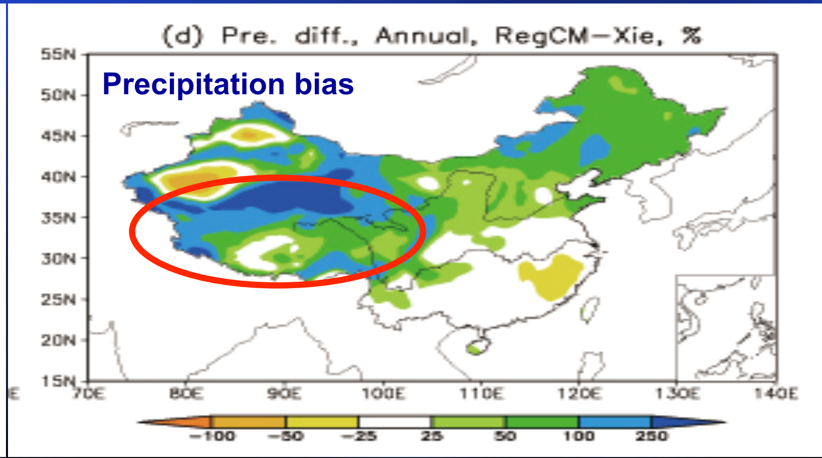
Zhu et al., 2012 SCI China

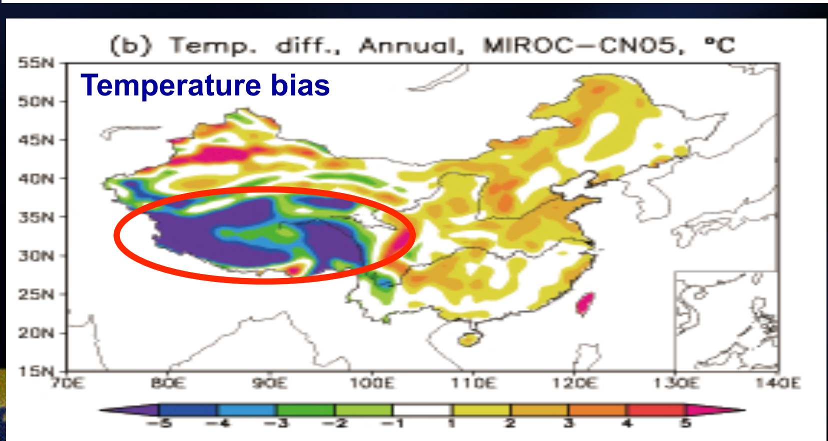
4.Big bias on TP in both regional and global models

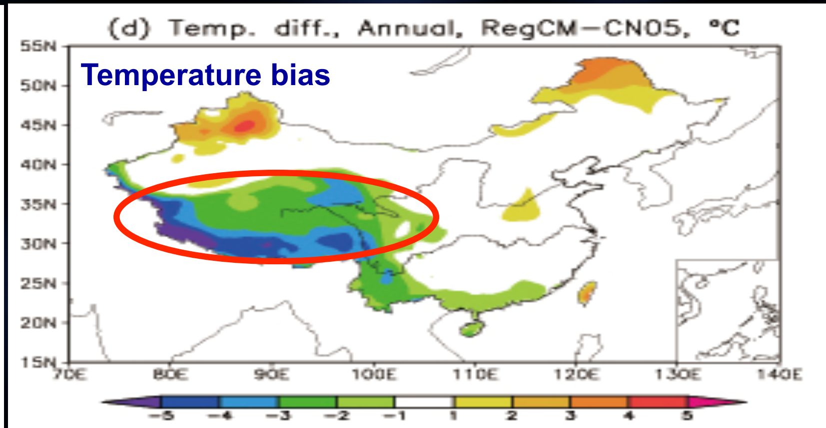
Global model

Regional model









Shi Xiaoying, et al. *Geophysical Research Letter,2008*

Big bias of precipitation and surface temperature on TP region!

CMA TP Observation Network Development (2014-2023)

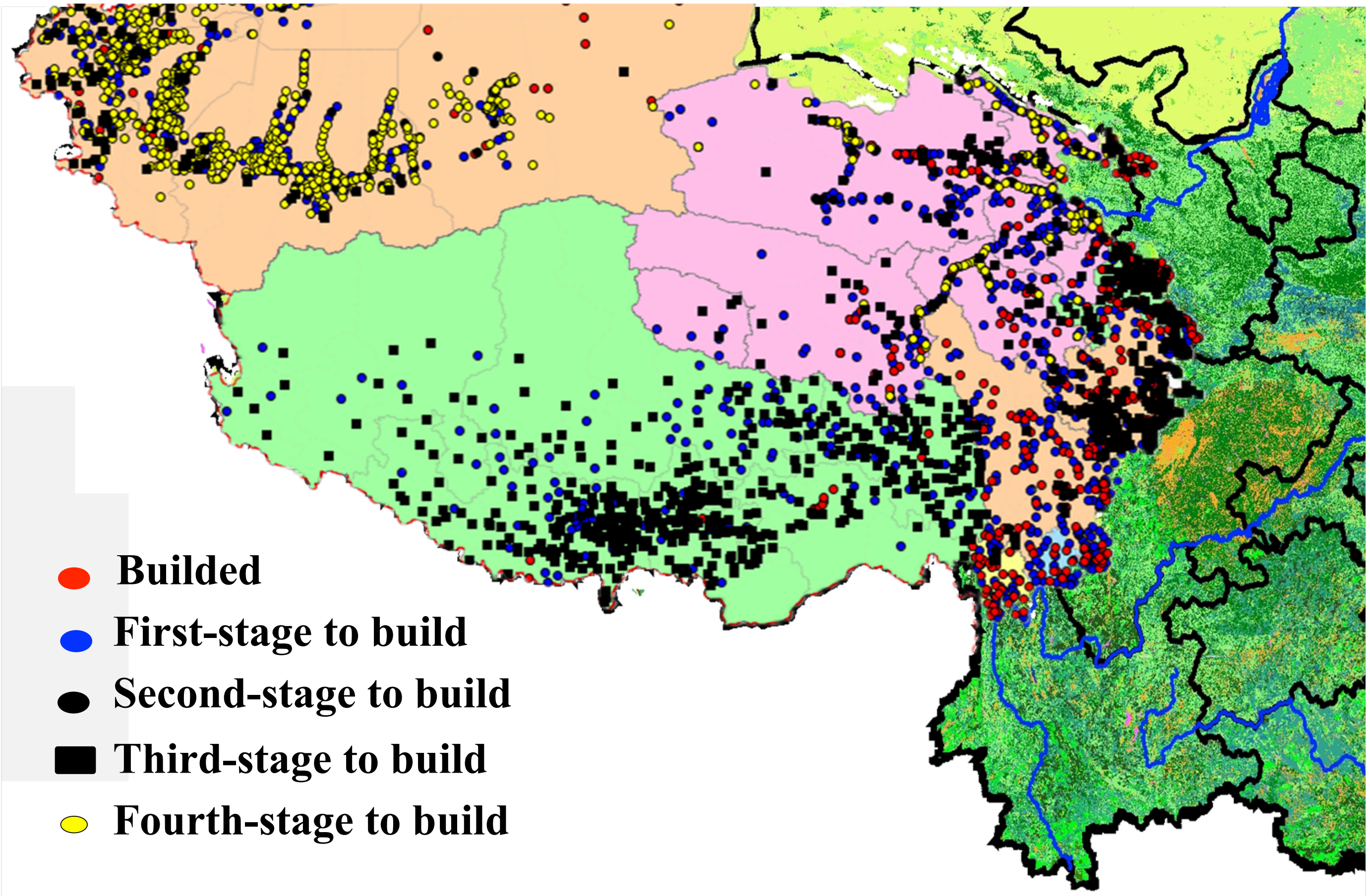
（2.0 Billion Yuan）

1、Ground station (453 points)

Tibet		Si Chuan		Yun Nan		Gan Su		Qing Hai	
Builded	Add	Builded	Add	Builded	Add	Builded	Add	Builded	Add
39	0	156	0	125	0	81	0	52	0

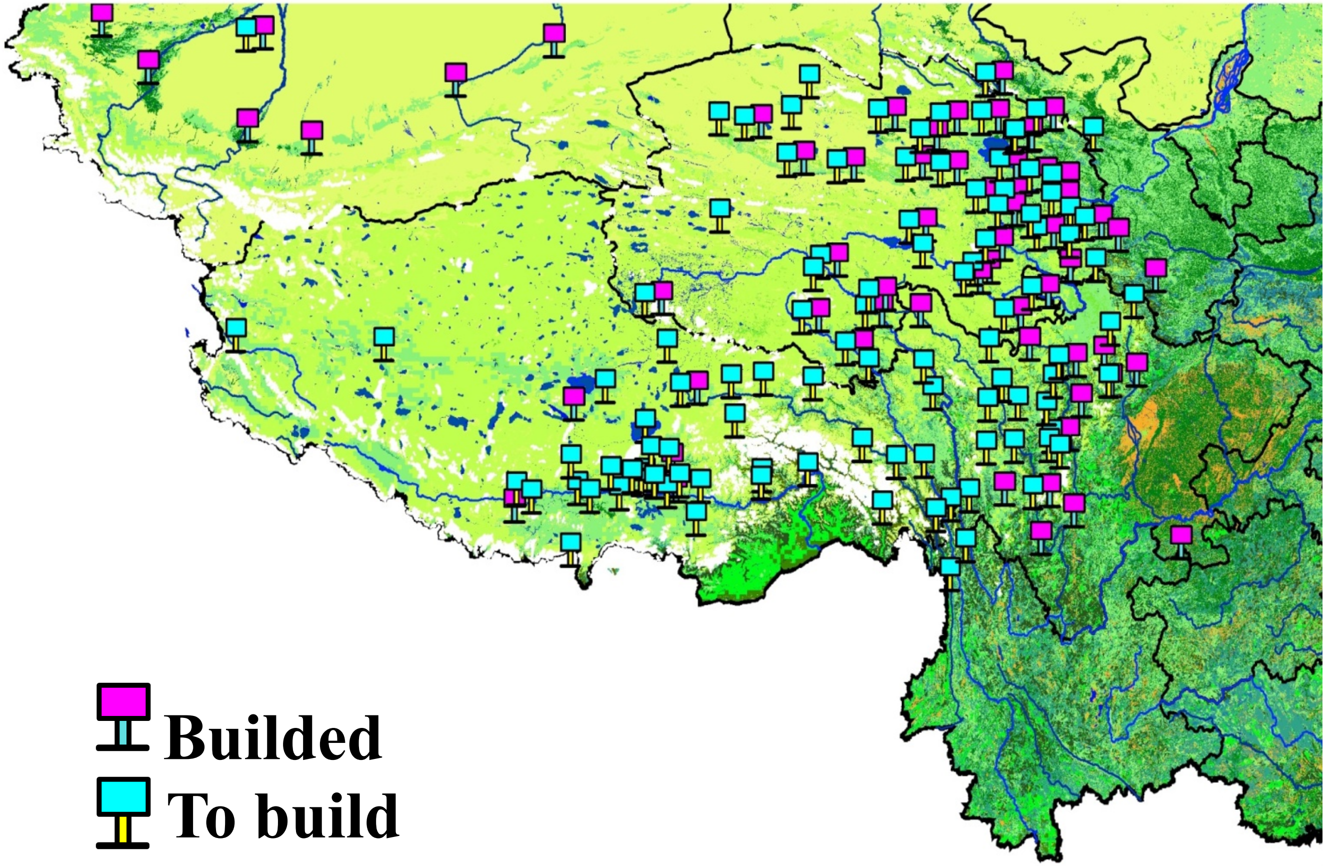
AWS (6754 points)

Tibet		Si Chuan		Yun Nan		Gan Su		Qing Hai	
Builded	To build	Builded	To build	Builded	To build	Builded	To build	Builded	To build
17	580	2110	581	1627	23	900	135	101	680

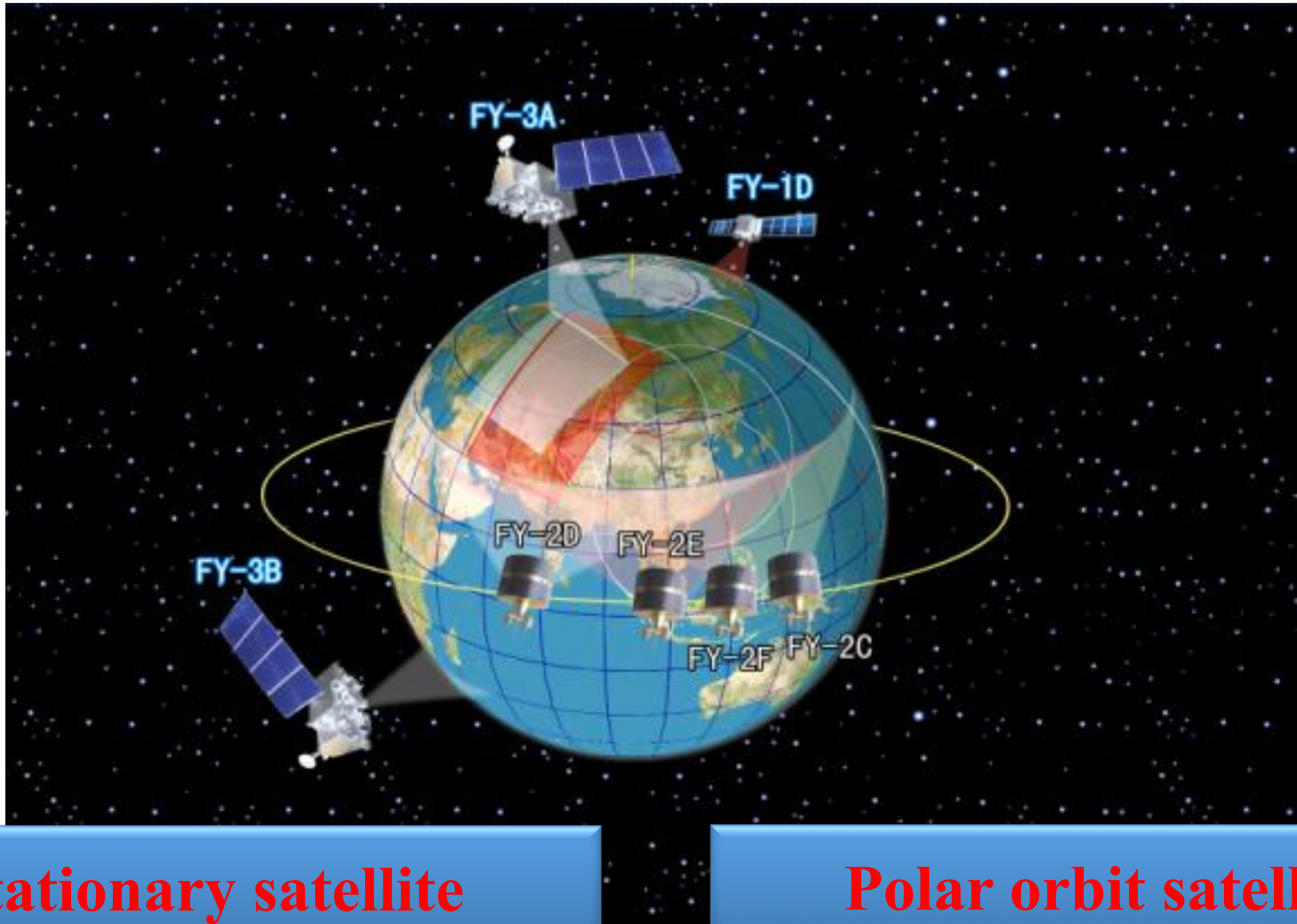


Soil moisture station (460 points)

Tibet		Si Chuan		Yun Nan		Gan Su		Qing Hai	
Builded	To build	Builded	To build	Builded	To build	Builded	To build	Builded	To build
8	41	197	20	20	3	61	5	55	50



FY Meteorology Satellite (7 satellites)

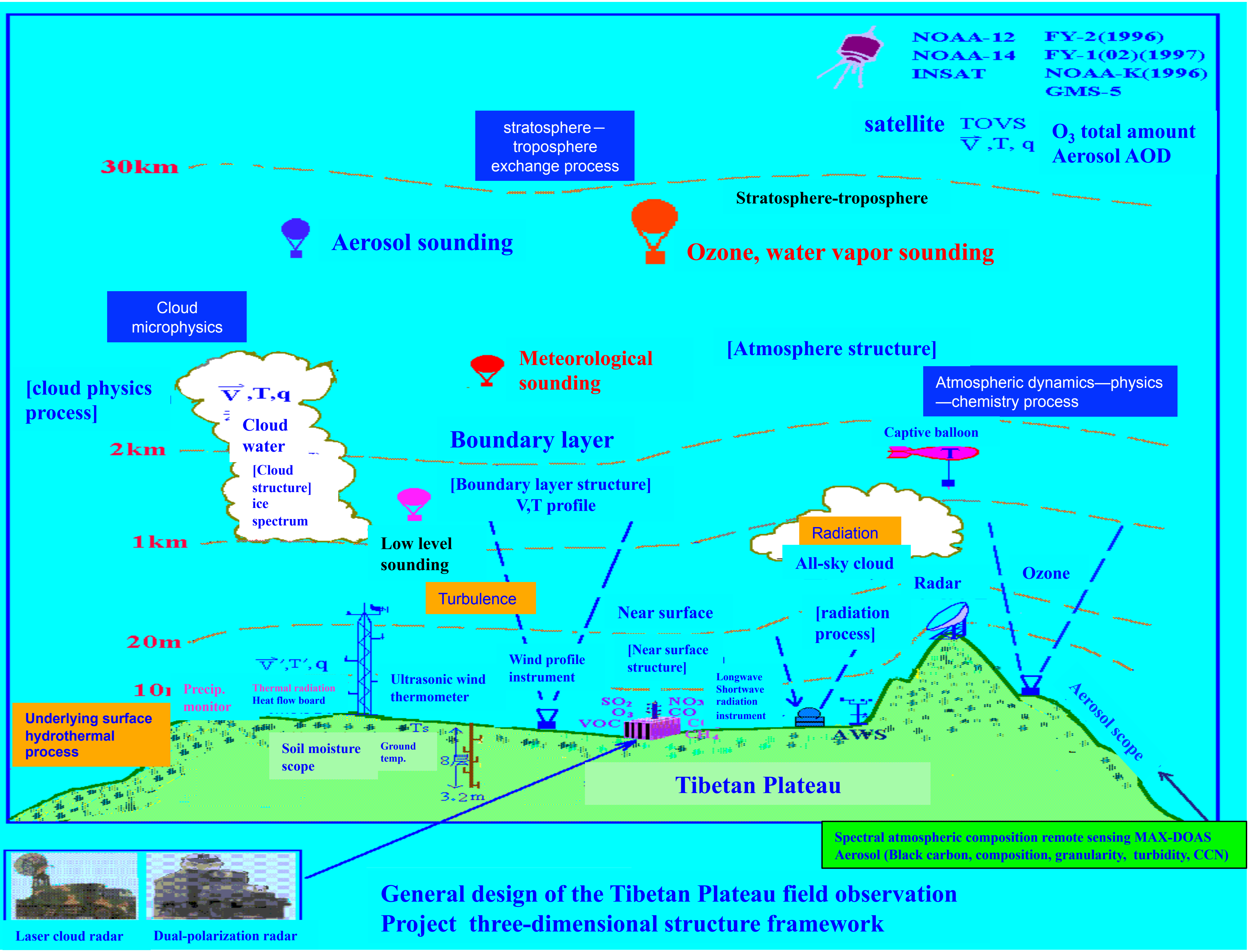


Stationary satellite

- 28 cloud pictures are captured by each satellite everyday, 48 cloud pictures can be got when intensively observed
- Observed by double satellites can get one cloud picture every 15 minutes

Polar orbit satellite

- Move across the South and North Pole, the period is about 102 minutes, 14 circles across the earth everyday
- Observe the same place under the satellite point twice, and can get a global merged map



General design of the Tibetan Plateau field observation Project three-dimensional structure framework

Outline

1. Science significance
2. Current issues, Obs Infrastructure
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A Co- Design example--

NSFC Key Research Program

(国家自然科学基金委员会重大研究计划)

Land-air Coupling over the Tibetan Plateau and Its Climate Impact

(青藏高原地- 气耦合系统变化及其全球气候效应)

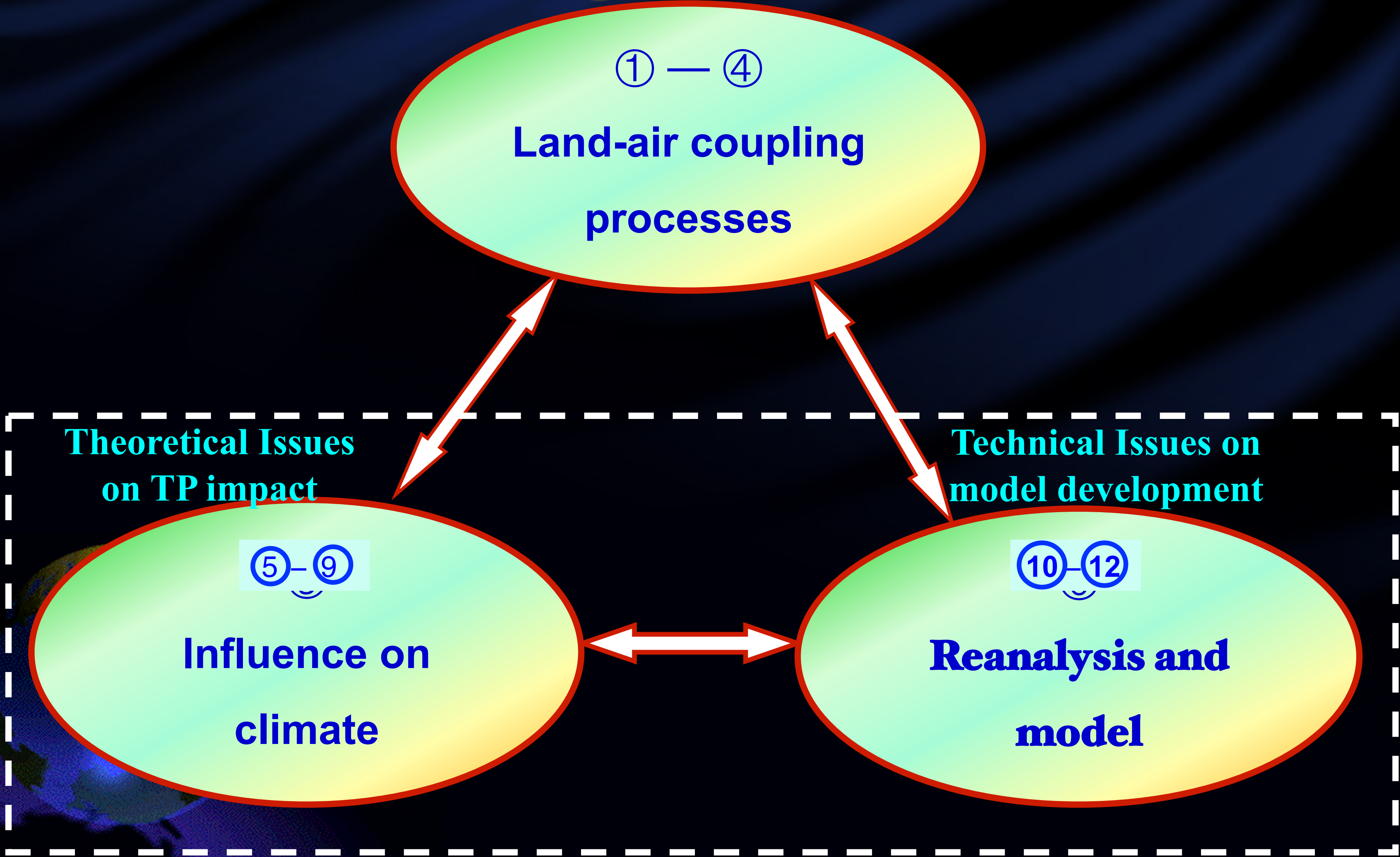
Guoxiong Wu

Funding： 200 Million RMB

Period： Jan. 2014- Dec. 2023

Program Main Framework

Co- Design Co- Produce



Core research directions

(I) Land-air coupling over the Tibetan Plateau

1. Tibetan Plateau complex multi-scale topographical atmospheric dynamics process
2. Tibetan Plateau land process and land-air interactions
3. Tibetan Plateau cloud precipitation physics and hydrological cycle
4. Tibetan Plateau troposphere-stratosphere interactions

(2) Influence on climate of the physical processes over the TP

1. The mechanism and prediction method of the influence on TP surrounding regions by TP process
2. The influence of air-sea interaction on TP land-air coupling effect
3. The connection between TP energy and hydrological cycle and its influence on Asian climate
4. The influence of TP on the coexist of Asian monsoon and desert
5. The influence and response of TP on global climate formation and changes

(3) Observation, data assimilation and model development for the TP area

1. The scientific issue of synthetically observation on TP
2. Multi-data sources re-analyze and development of assimilation
3. The research of model development

Program General Goals

- Understand the influence of TP on global climate;
- Foster young scientists;
- Contribute to the global sustainable development!

- **Mountains Play important roles in global climate changes and need to be studied in depth!**

Outline

- 1. Science significance
- 2. Current issues, Obs Infrastructure
- 3. Research content, implement plans
- 4. Why ACESS Himalaya projects

- Protect TP environment can protect the TP heat source.
- We should focus on the TP thermal status and reveal how its variation can affect climate anomaly, so as to improve climate prediction and risk mitigation

ACCES Key Projects

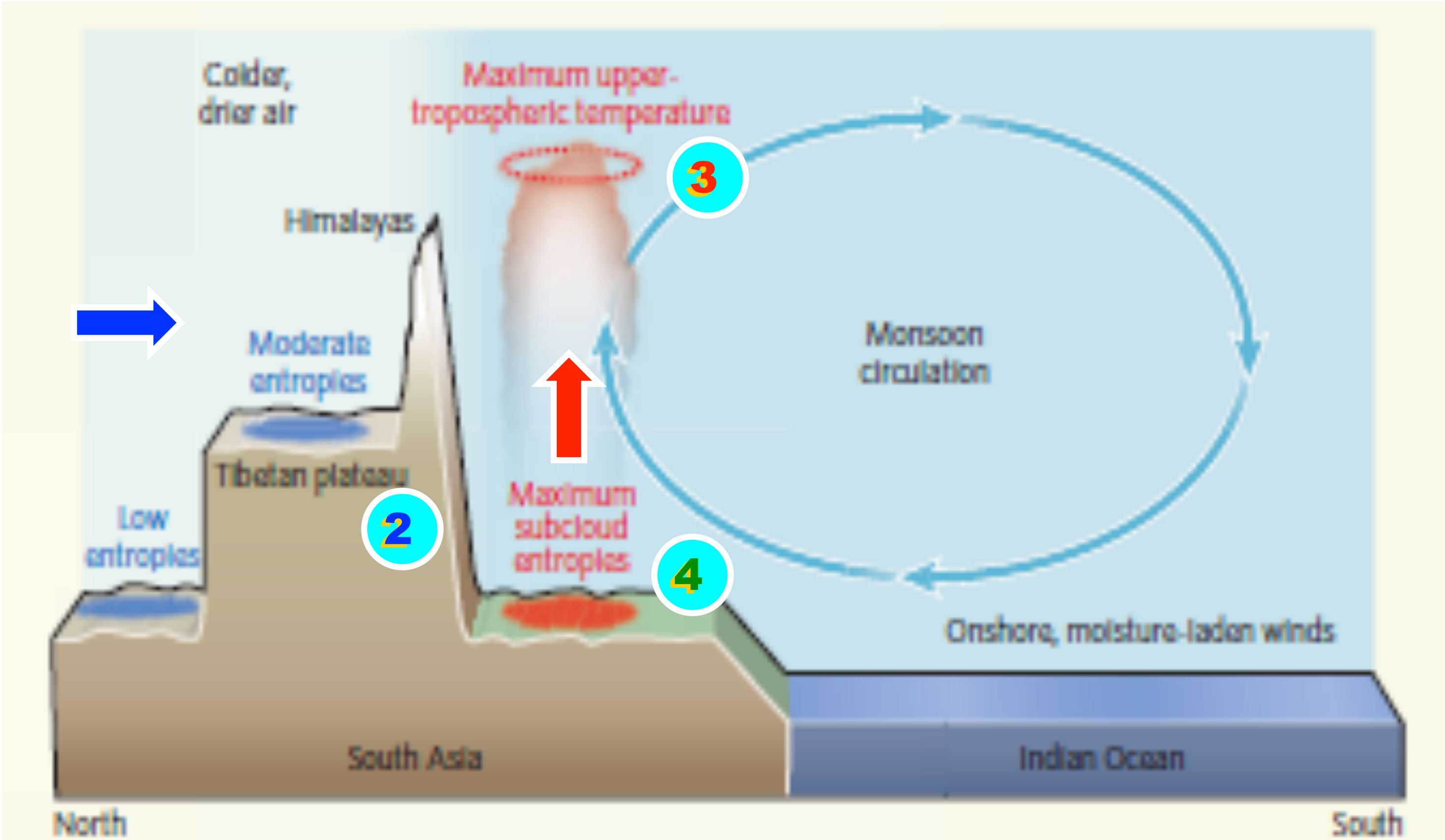
- **Project A1:** The Regional and Global Influences of the Giant Mountains in Asia on Climate and Environment

- **Project A2:** Himalayas climate modeling: development of a high resolution Earth System Model and Asian climate change risk assessment

Mechanical forcing hypothesis: blocking impact of the TP :

1. Shield the India from cold and dry advection

2. High surface energy and UTTM are coupled by monsoon convection



Boos and Kuang, 2010, Nature
Cane, 2010, Nature

Outline

1. Introduction- TIP_ SHAP
2. TIP mechanical blocking effect?
3. Maintenance of UTTM
4. Water vapor- continental monsoon
5. *PV-θ* perspective of ASM
6. Outlook

Does there exist the TP Shielding of India from cold and dry advection?

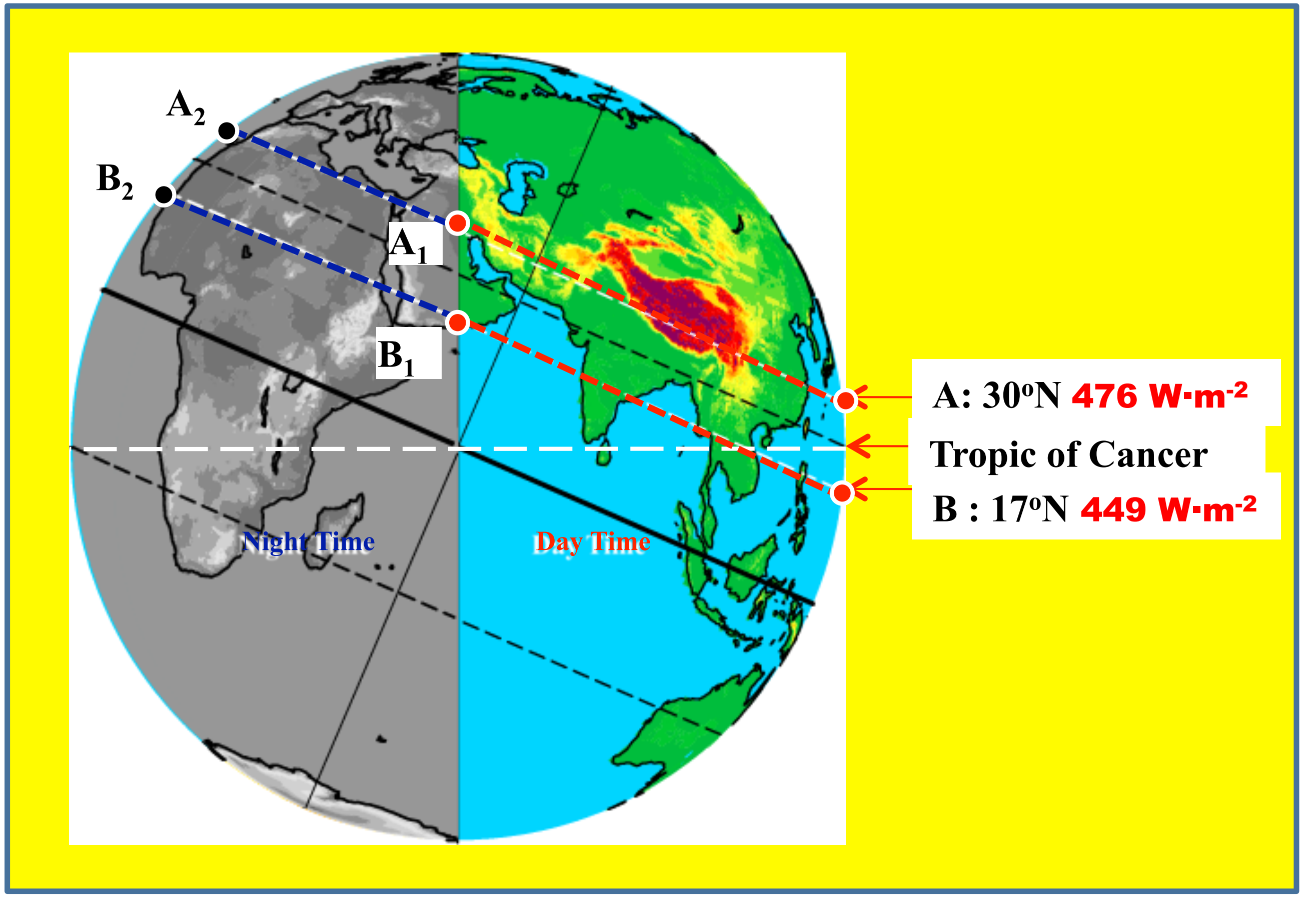


Fig. 1 (a) At the summer solstice, the solar zenith angle at noon is zero at the Tropic of Cancer (ϕ= 23.5°N). At the top of the atmosphere (TOA), the intensity of solar radiation (SR) at latitude A (30°N) in the subtropics is the same as that at latitude B (17°N) in the tropics. **However, the length of day (LOD) at A (AA_1/AA_2) is about one hour longer than the LOD at B (BB_1/BB_2). Thus the daily solar radiation (DSR) at 30°N is more than that at 17°N**

Nature _Scientific Reports, 2015

Summer months Daily solar radiation (DSR) in Wm^{-2}

	17°N	30°N
Jun	444	474
Jul	443	466
AUG	438	436
JJA	442	458

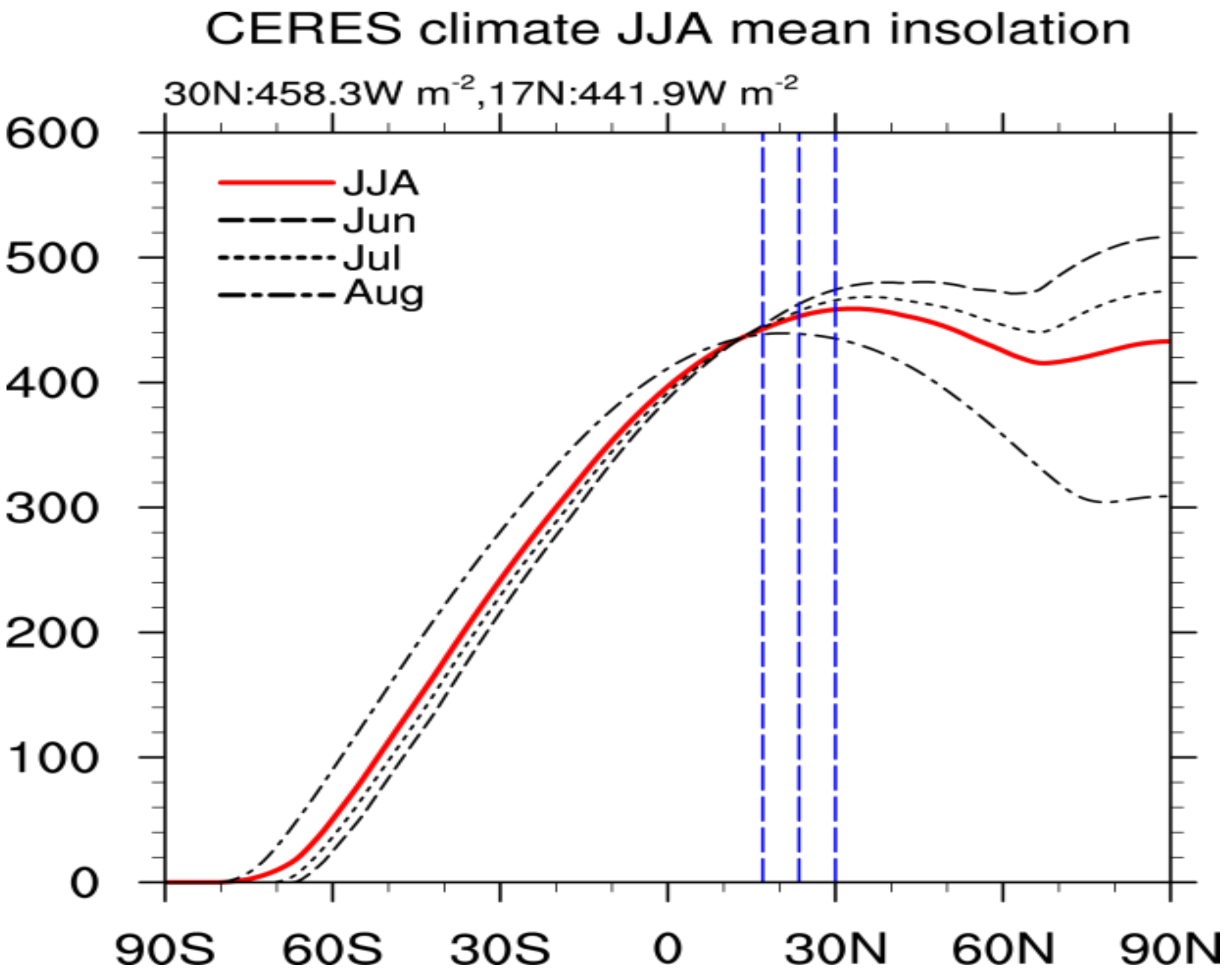


Fig. 1 (b) The climate mean latitude distributions of DSR in summer months are calculated from the CERES reanalysis

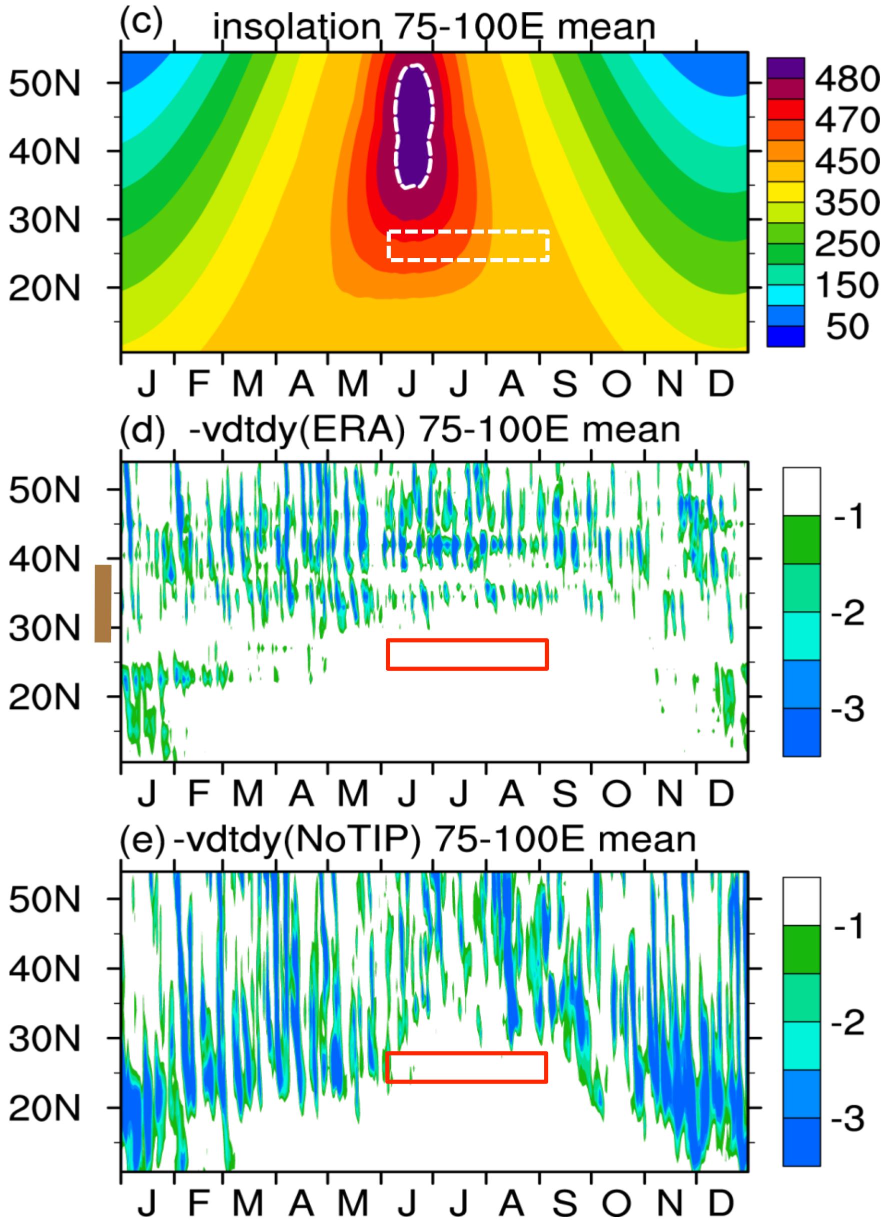
Nature _Scientific Reports, 2015

the daily evolutions in 2001 across the longitude domain 75–100°E of

(c) DSR (W m^{-2}), with the white dashed curve denoting the 480 W m^{-2} contour,

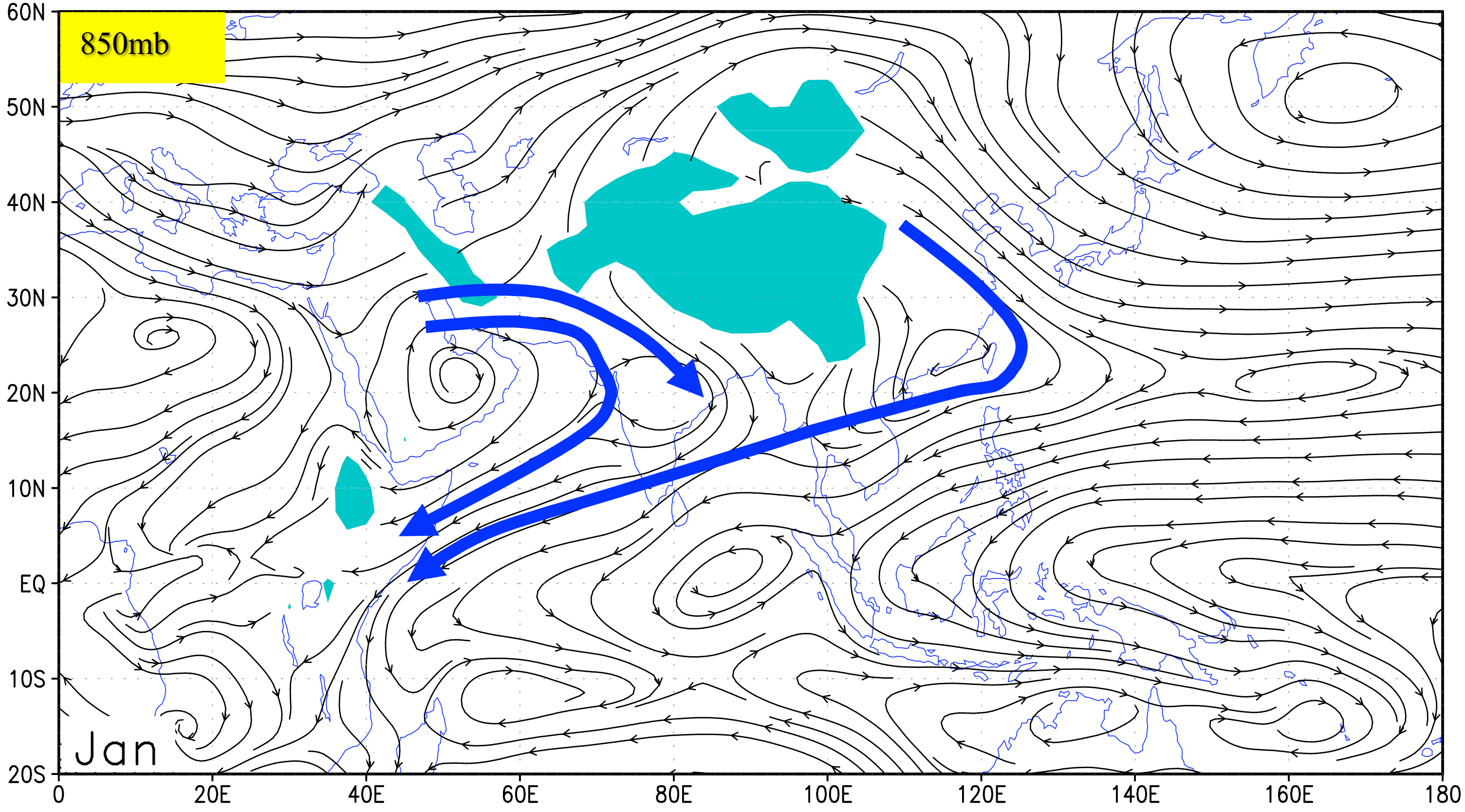
(d) the cold temperature advection (v<0) at the surface (sigma=0.99) from ERA-interim and

(e) from the NoTIP experiment, which is driven with the SST in 2001 and with the removal of the mountain range TIP. The square in (c-e) indicates the South Asian summer monsoon region between 24 °N and 28°N and during June to August.

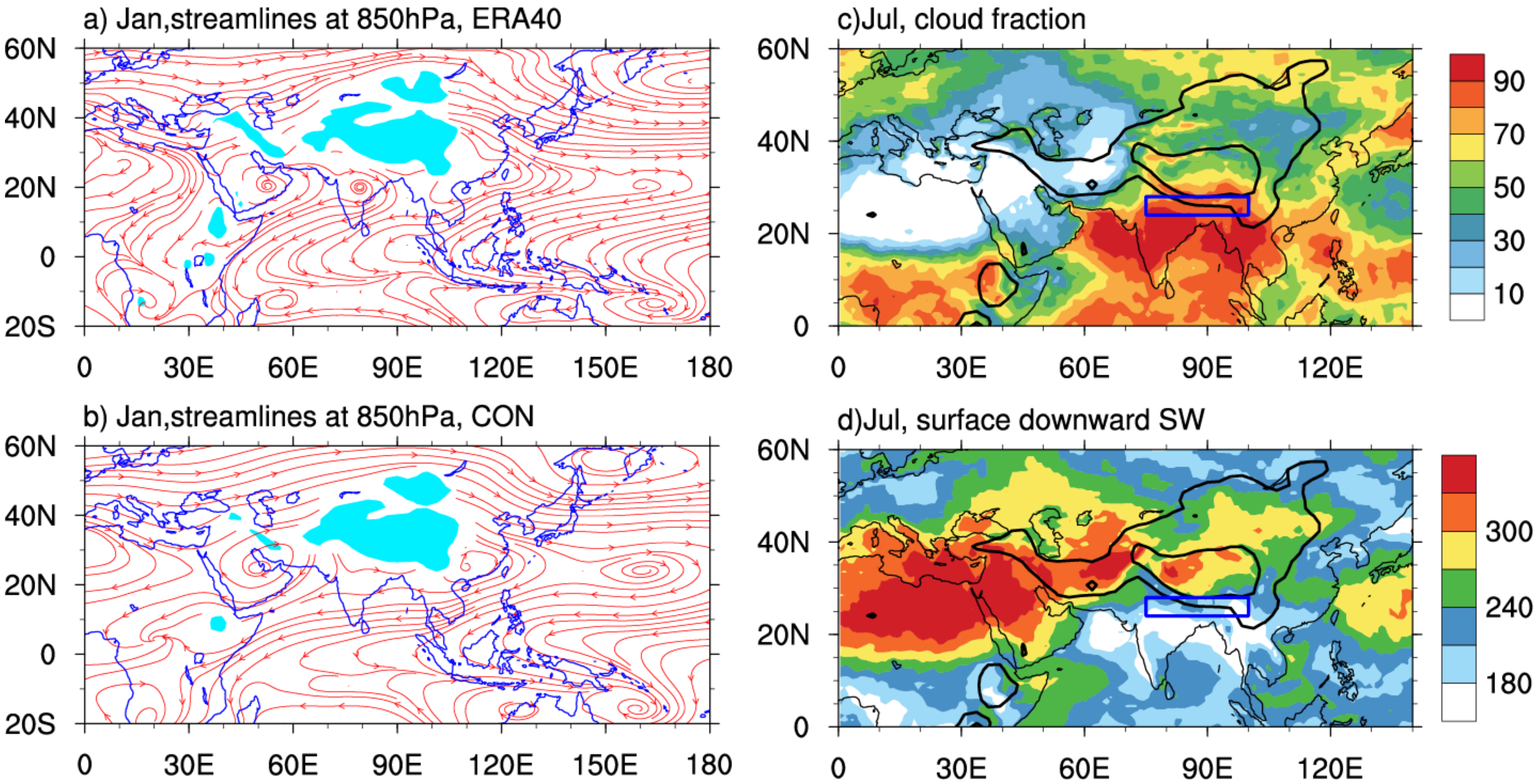


Summer: Shielding not need!

Winter: TP cannot block cold advection!



Jan mean streamline at 850 hPa



Climatological mean January streamfield at 850 hPa produced from (a) ERA40 and (b) CON Experiment; and the monthly mean of July, 2001 of (c) cloud fraction in persentage and (d) downward shortwave radiation at the surface (Wm^{-2})produced from CERES.

Nature _Scientific Reports, 2015

Conclusion

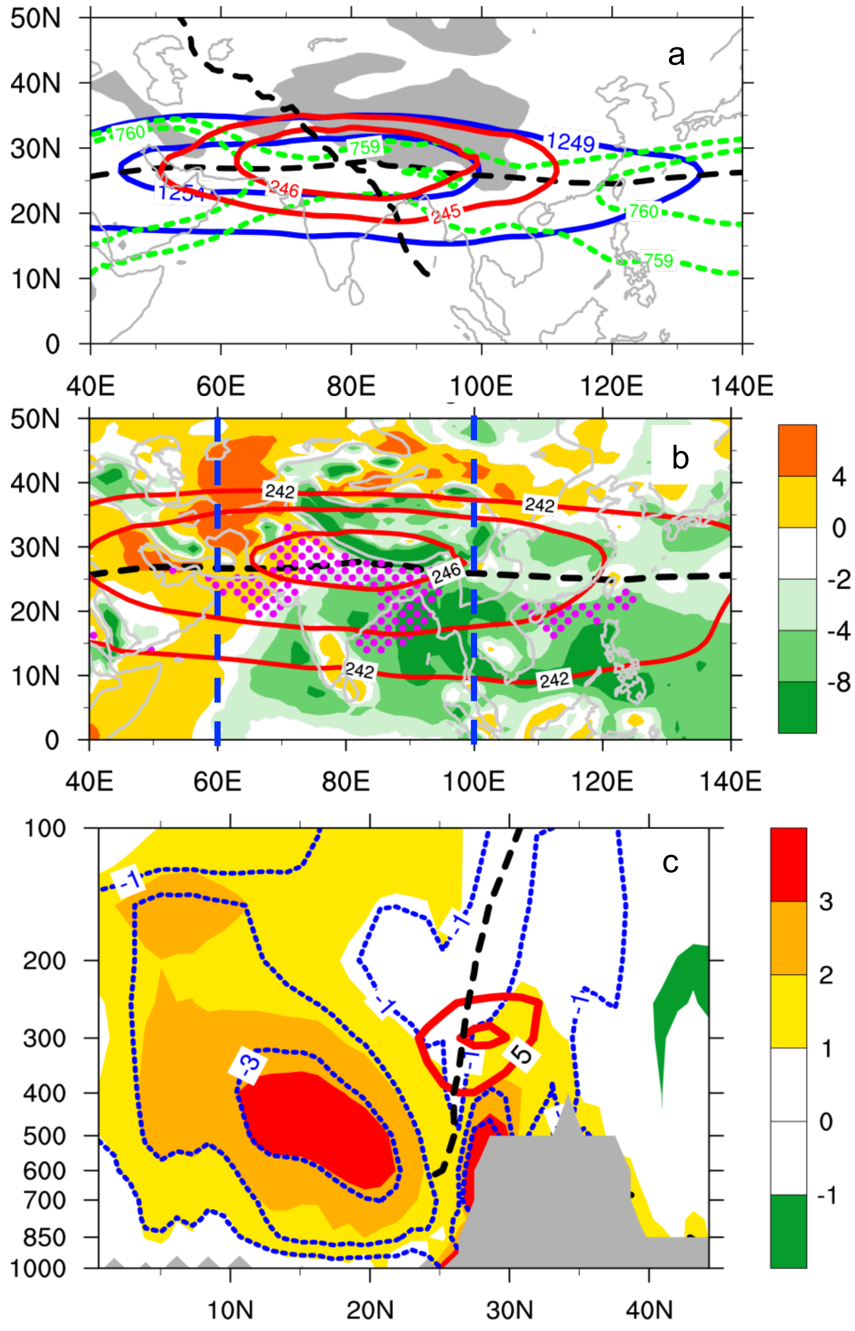
In Winter: TIP cannot block cold advection because the cold northwesterly or northeasterly can move around the TIP and intrude India!

In Summer: Shielding/blocking of the TIP is not need since there is no cold advection from higher latitudes!

Protecting TP's environment can protect its thermal status, producinging resilient ASM and world climate!

Formation of the summertime upper tropospheric temperature maximum (UTTM)

Fig. 1 The JJA mean distributions of (a) geopotential height (unit: dgpm) at 200 hPa (blue solid) and 400 hPa (green dashed), 200–400 hPa mass-weighted mean temperature (red solid, unit: K), and zero zonal and meridional wind contours at 200 hPa (black dashed); (b) 500-hPa vertical velocity (shading, unit: hPa s^{-1}), 200–400 hPa mass-weighted mean temperature (red contour, unit: K), surface entropy > 356 K (purple stippled; unit: K), and contour of u=0 at 300 hPa (black dashed); and (c) **60°–100°E mean diabatic heating Q_1/C_p (shading**, unit: K d^{-1}) and **adiabatic heating (blue** dotted contour, unit: K d^{-1}), ridgeline (black dashed line), and temperature deviation from the (40°–160°E, 0°–50°N) area mean (red contour, interval: 5°C) .



SAH/ UTTM

θe ω / UTTM

ω Q_1/ UTTM

AMC

TE

$$\frac{\partial u}{\partial \ln p} = \frac{R}{f}\left(\frac{\partial T}{\partial y}\right)$$

Monsoon AMC regime:
Vertical Easterly shear
T increases with latitude!

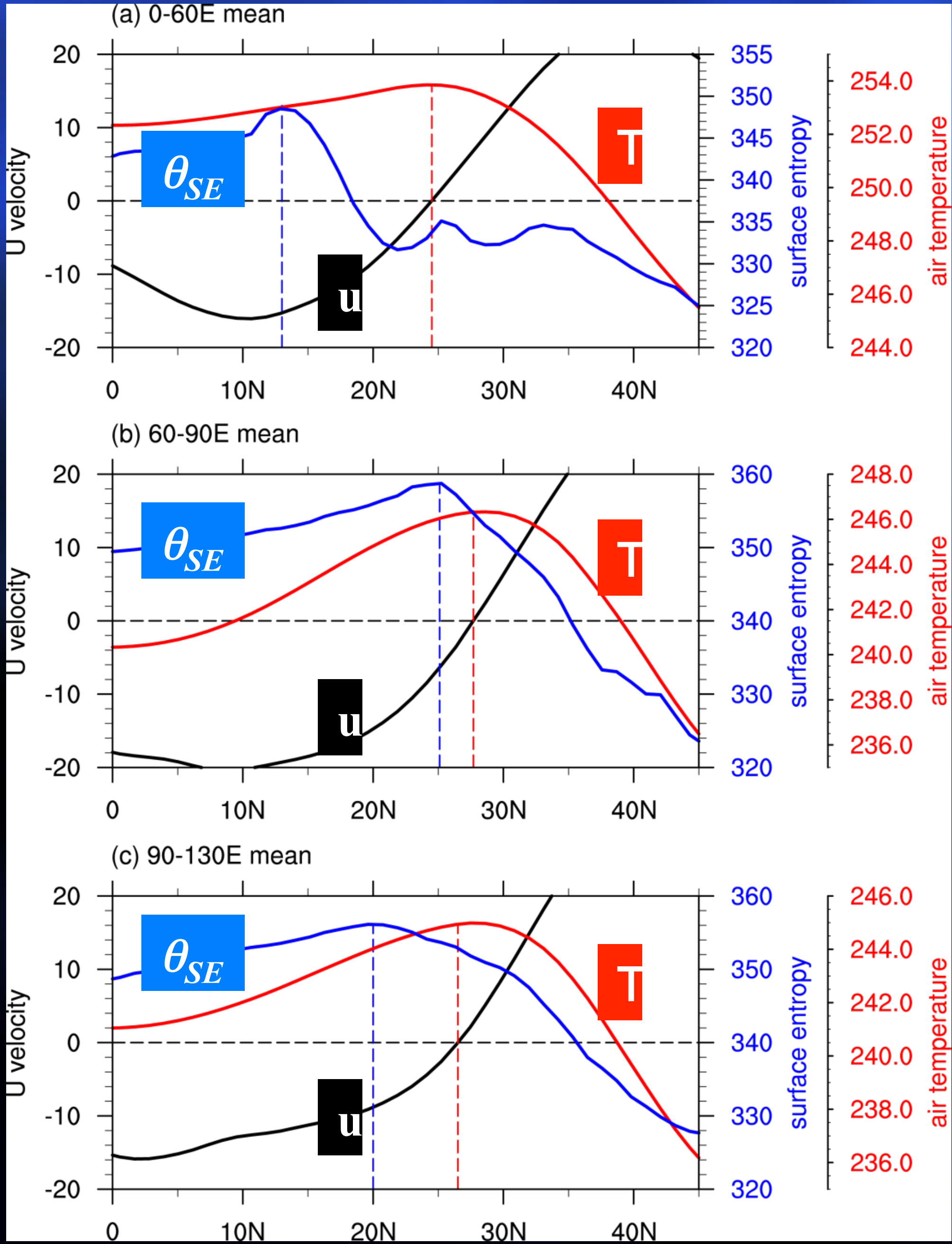


Fig. 2 ERA40 July- mean profiles of surface θ_{SE} (K, blue), 200-400hPa mass

Latitude location of the SAH and UTTM

°E mean, and (c) 90-130 °E mean. The black dashed line indicates u=0.

$$\beta v \approx (f + \zeta)\theta_z^{-1}(\partial Q / \partial z) \quad \theta_z \neq 0 \quad \vec{V}\cdot\nabla z \to 0 \quad z = -H \cdot \ln p,$$

$$\begin{cases} \dfrac{\partial^2 T}{\partial x^2} \approx \gamma \dfrac{\partial}{\partial x}\left(\dfrac{\partial^2 Q}{\partial z^2}\right) \\ \gamma = f(f+\zeta)H/(R\beta\theta_z), \quad \theta_z \neq 0 \\ Q = Q(x)\cos\left(\dfrac{\pi z}{H_Q}\right) \\ T = T(x)\cos\left(\dfrac{\pi z}{H_Q}\right) \\ T(x) = T_0\cos\left(\dfrac{\pi x}{L}\right) \end{cases}$$

Longitude location of the SAH and UTTM

$$\begin{cases} T(x) \approx \gamma L^2 H_Q^{-2}\partial Q(x)/\partial x = \lambda \partial Q(x)/\partial x, \quad \vec{V}\cdot\nabla\zeta \to 0; \\ \lambda = \gamma L^2 H_Q^{-2} \end{cases}$$

Wu et al, Climate Dynamics, 2015

$$\frac{\partial v}{\partial \ln p} = -\frac{R}{f}\left(\frac{\partial T}{\partial x}\right)$$

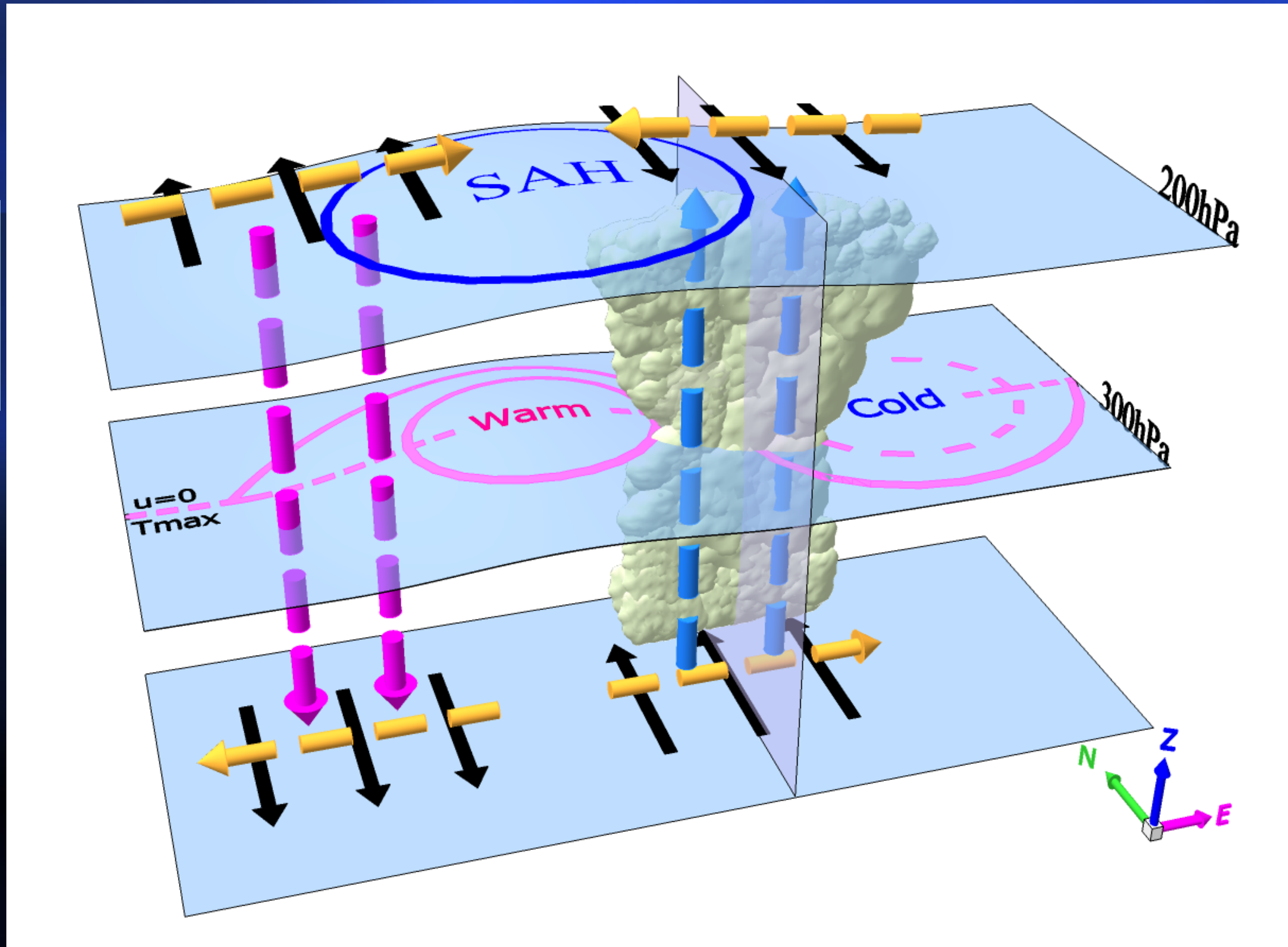


Fig. 5 Schematic diagram of the ***T-Q$_Z$*** mechanism contributing to the longitudinal location of the upper-troposphere temperature maximum (UTTM): Strong monsoon convective latent heating along the subtropics (blue upward arrow) results in the local development of a vertical northerly shear (black arrow), and induces an eastward decreasing temper ... the west of the hea ... ace sensible heating and longwave radiation cooling (red downward arrow) in the upper troposphere, contributes to the occurrence of the UTTM and SAH on the eastern end of the cooling. The induced Coriolis force (*fv*, orange arrow) is in geostrophic balance with the pressure gradient force. Refer to text for details.

Longitude location of the SAH and UTTM

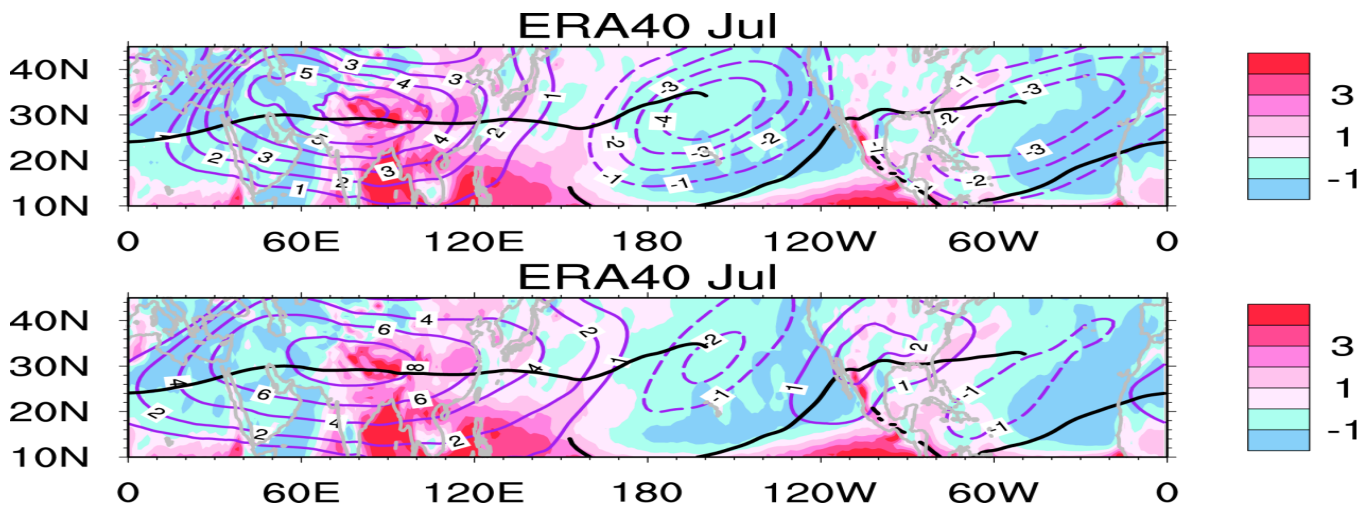


图2. 1979-1989年7月平均200-400hPa高度上的非绝热加热分布（阴影，Kd-1），以及温度对纬向平均的偏差（a）及对（180-360°）平均的偏差（b）的分布（兰线，K）。粗实线为副高轴线（Wu et al., 2015）

The UTTM location is determined by large-scale dynamics rather than local convection!

Outline

1. Introduction- TIP_ SHAP
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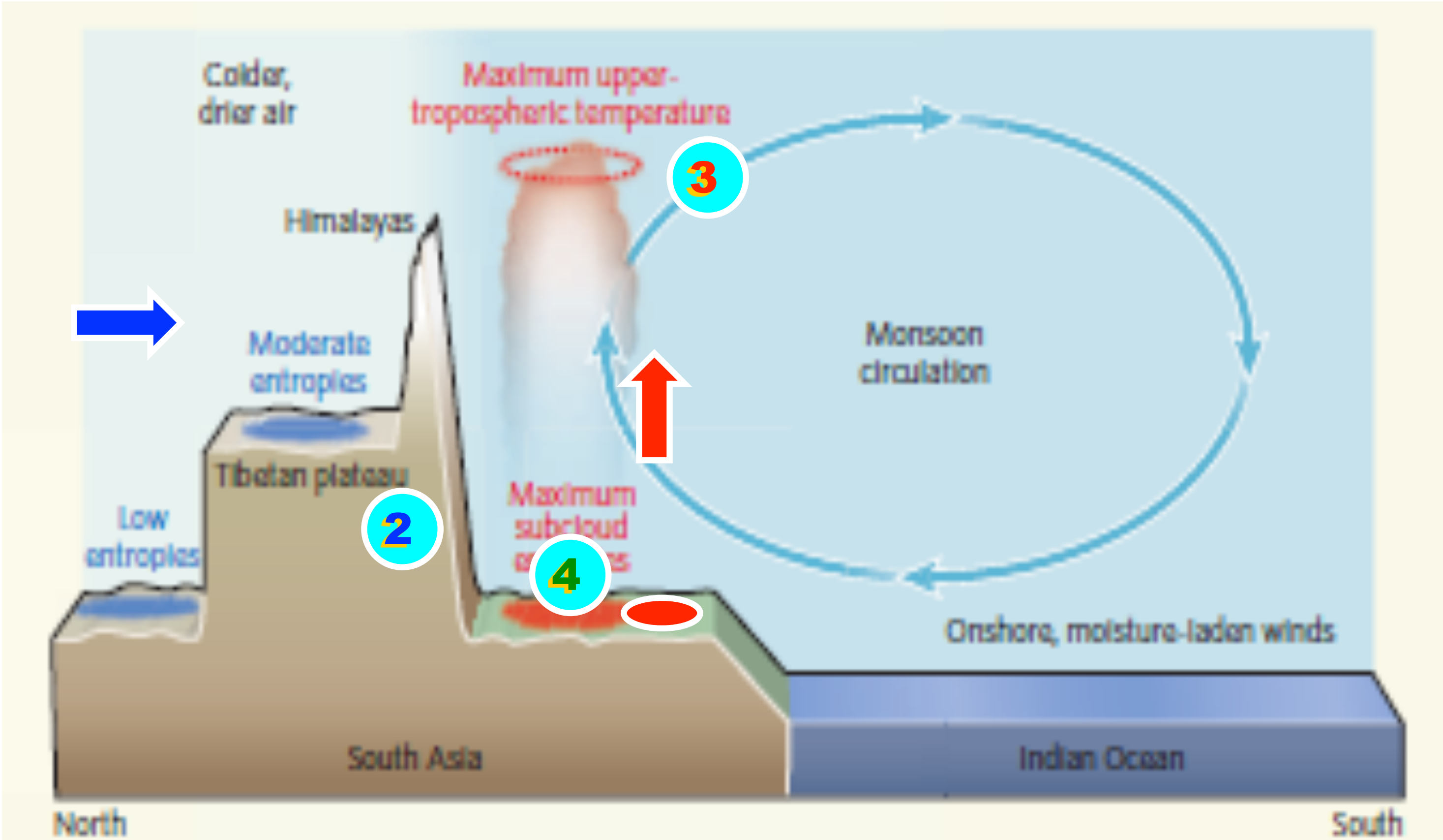
3. Maintenance of UTTM
4. Water vapor- continental monsoon
5. *PV*-θ perspective of ASM
6. Outlook

Mechanical forcing hypothesis: blocking impact of the TP :

1. Shield the India from cold and dry advection

2. High surface energy and UTTM are coupled by monsoon convection

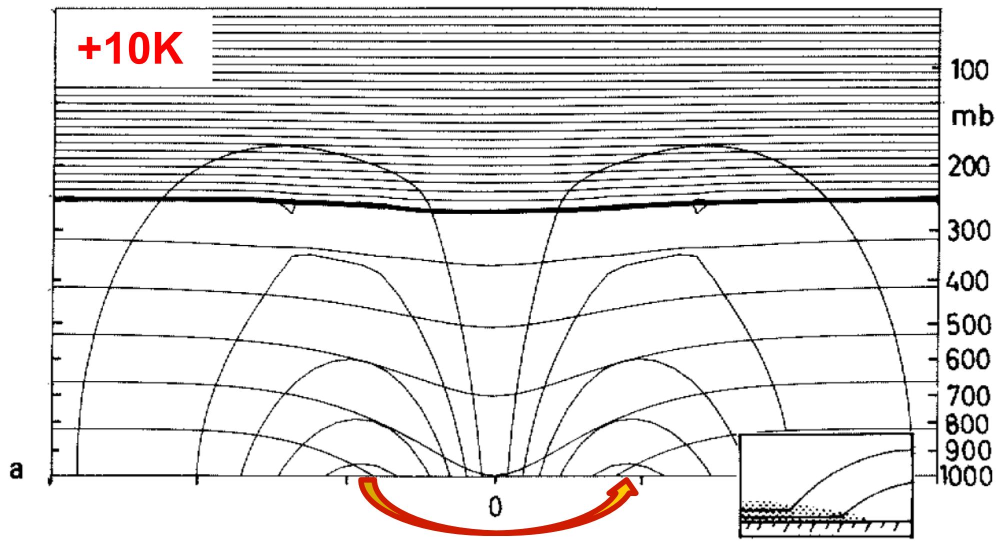


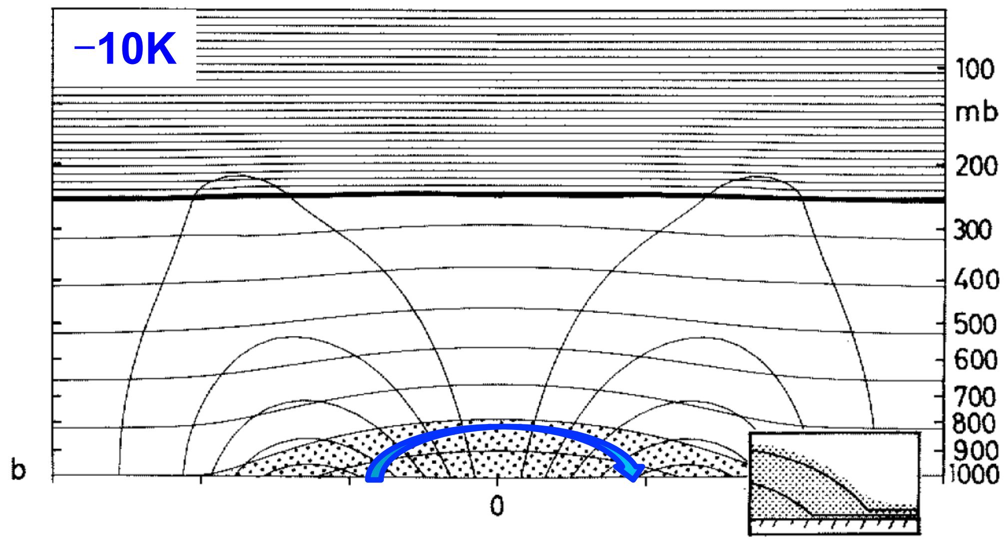
How can the high Water vapor content over land be maintained for the continental monsoon?

Outline

1. Introduction- TIP_ SHAP
2. TIP mechanical blocking effect?
3. Maintenance of UTTM
4. Water vapor- continental monsoon
5. *PV-θ* perspective of ASM
6. Outlook

Circulation symmetric flows induced by boundary temperature anomalies





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

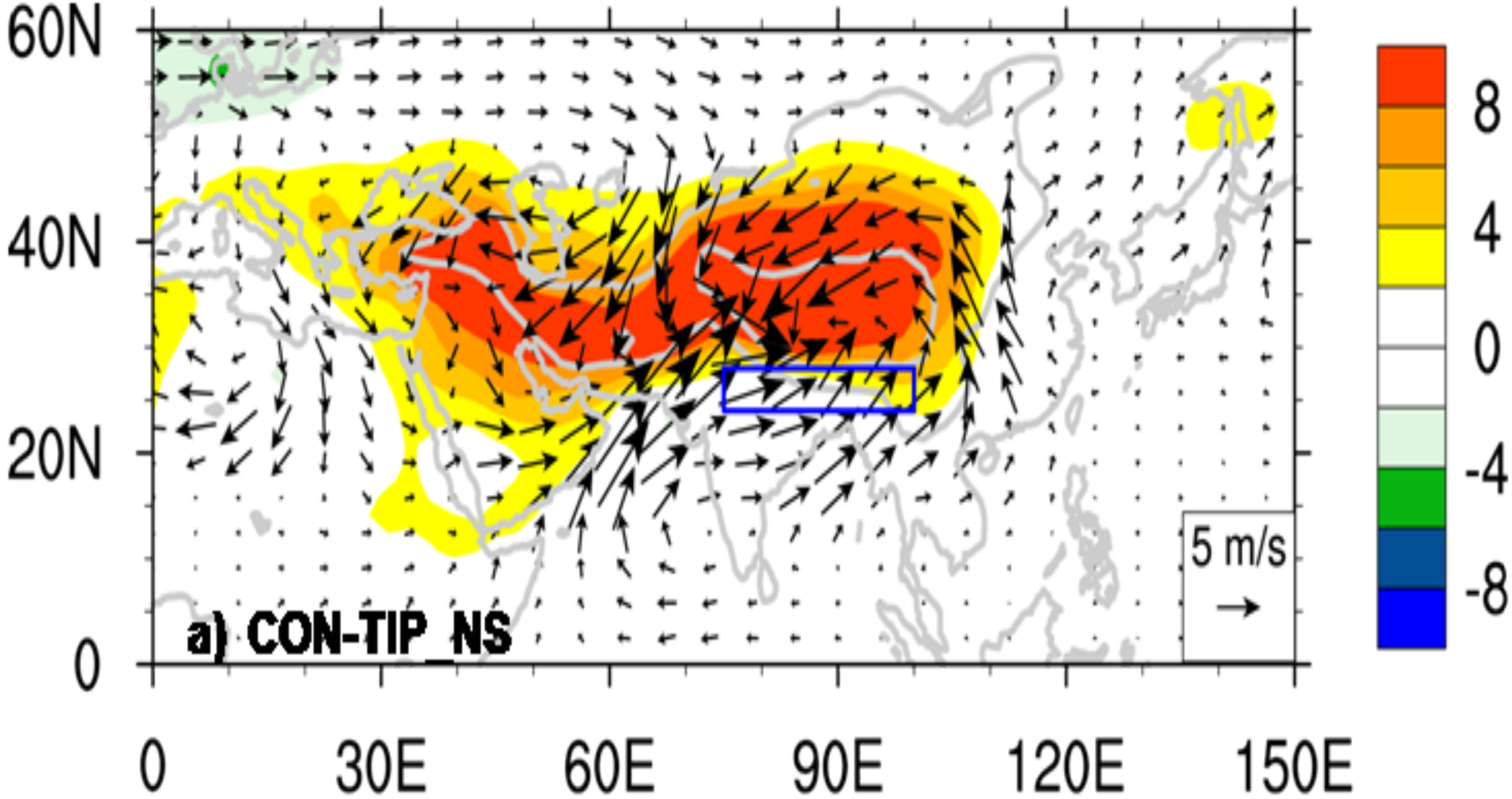
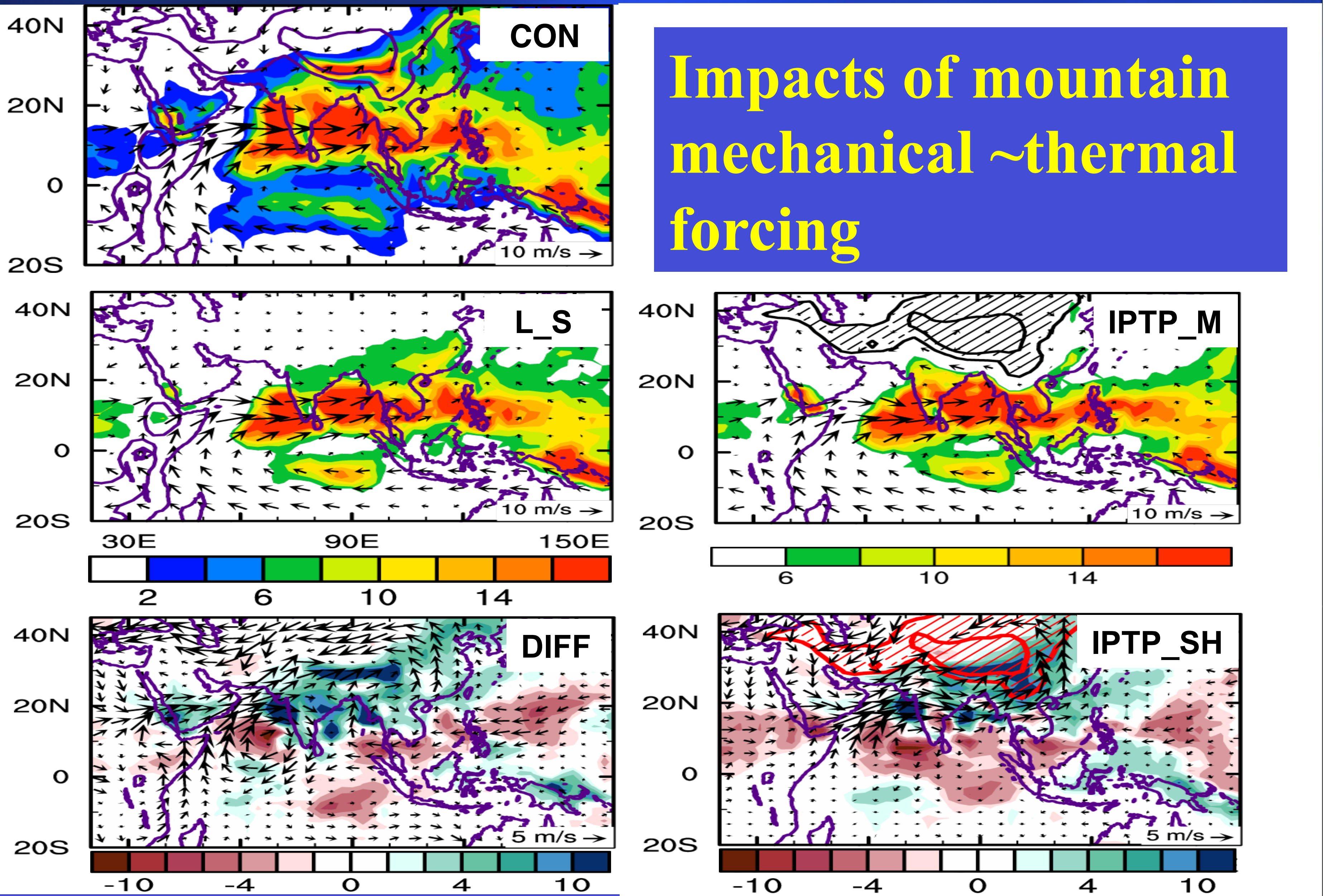


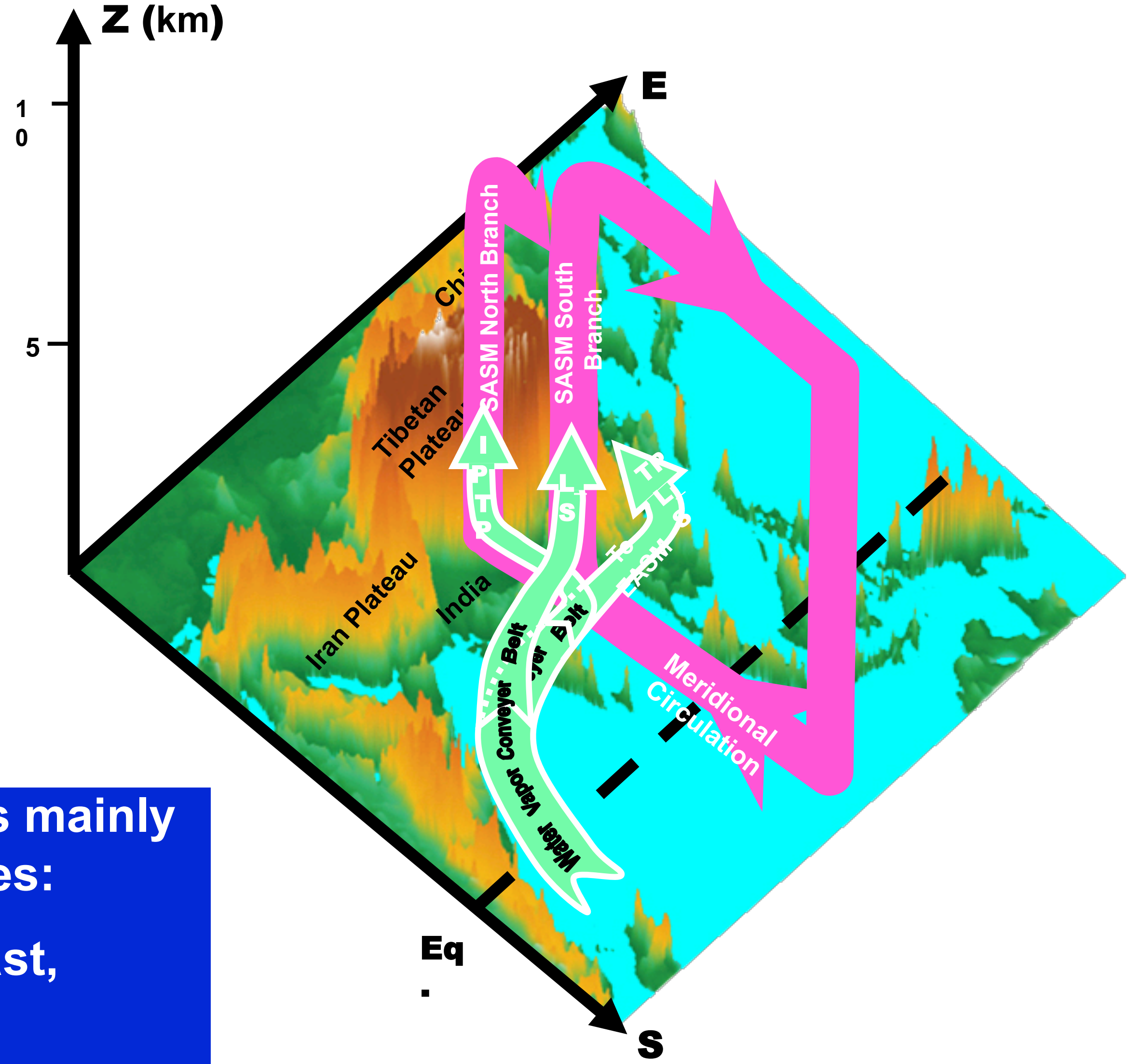
Fig. 4 JJA mean differences of near-surface (sigma=0.99) potential temperature θ (K, shading) and circulation (vectors, m s^{-1}) between (a) CON and TIP_NS

Impacts of mountain mechanical ~thermal forcing



Required Circul. and Precip. to make up the Asian summer monsoon

Highlight 7: Tibetan Plateau thermal forcing and Asian summer monsoon



The Asian summer monsoon is mainly controlled by thermal processes:

- Land_Sea thermal contrast,
- TP thermal forcing and
- Iran Plateau thermal forcing

Wu et al., 2012, NPG Sci. Rep.

Outline

1 **Introduction- TIP_ SHAP**

2 **TIP mechanical blocking effect?**

3 **Maintenance of UTTM**

4 **Water vapor- continental monsoon**

5 ***PV-θ* perspective of ASM**

6 **Outlook**

Outlook

- TP thermal status and the impact of its variation on climate anomaly
- Improvement of climate prediction and risk mitigation

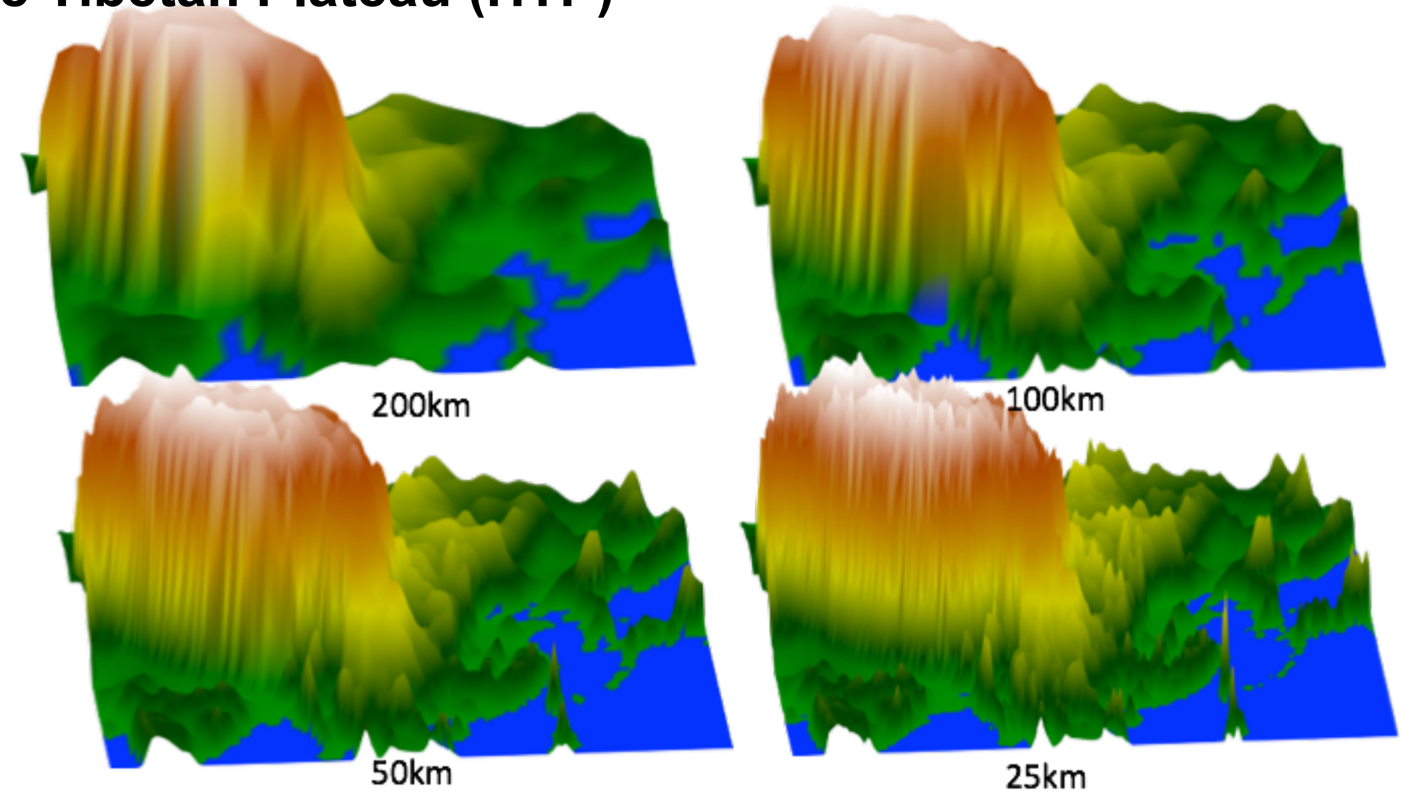
State Key Laboratory of Numerical Modelling for Atmospheric Sciences
and Geophysical Fluid Dynamics(LASG)
Institute of Atmospheric Physics Chinese Academy of Sciences

Project A2: Himalayas climate modeling:

development of a high resolution Earth System Model and Asian climate change risk assessment

Motivations

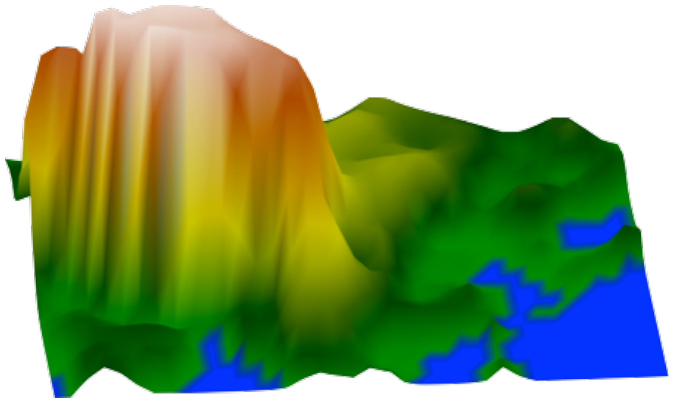
- **High resolution modeling approach is increasingly being considered as a necessary step for water cycle, climate, environment and social-economy especially in the Himalayas and the Tibetan Plateau (HTP)**

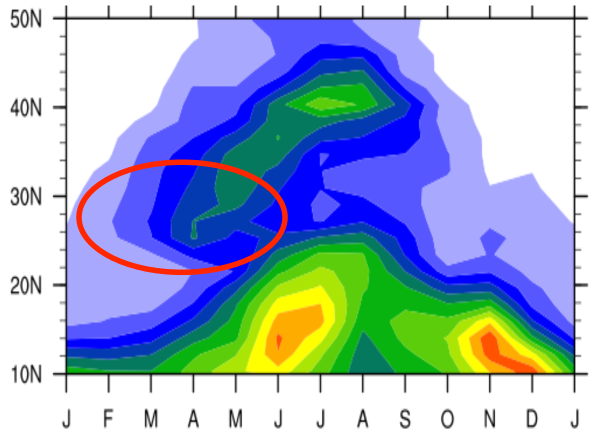


Topographic forcing of Eastern Asia with the different resolutions

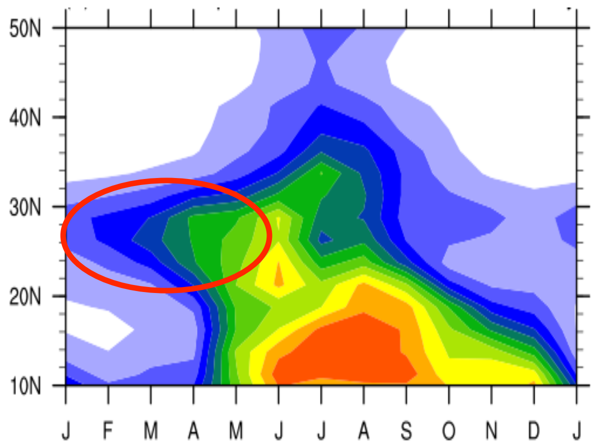
High resolution modeling of FGOALS

Low-resolution modeling

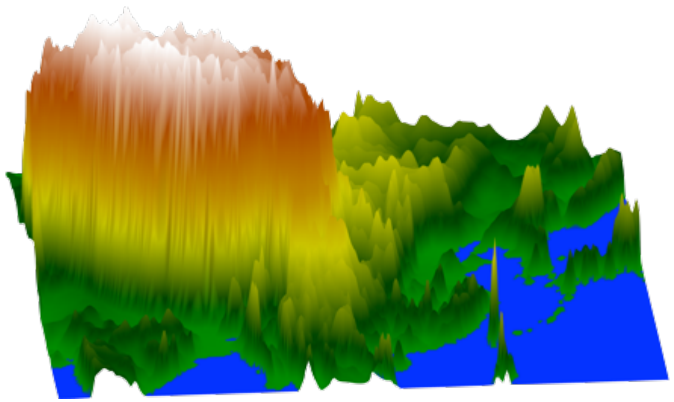


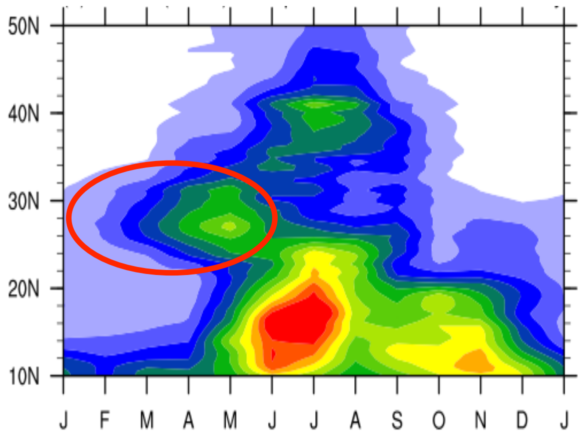


Observation



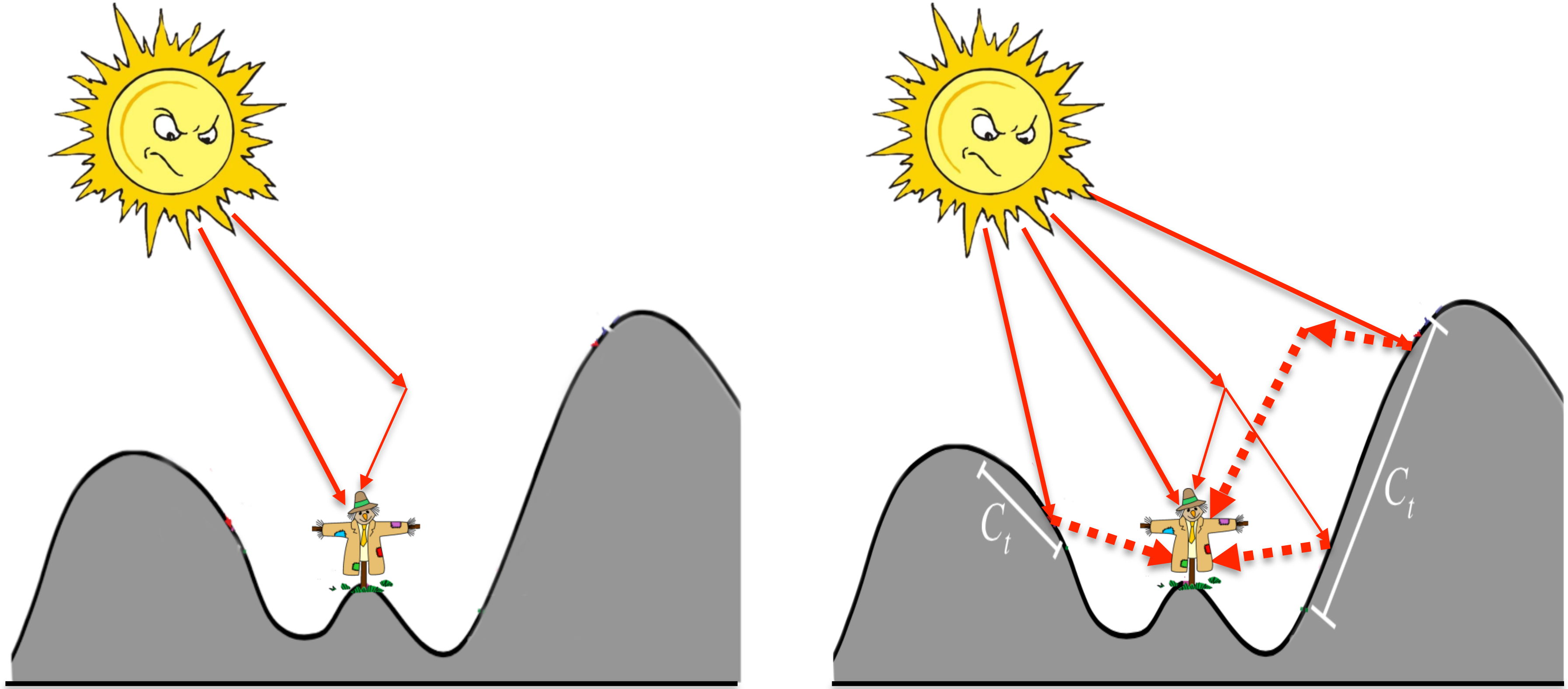
High-resolution modeling





High-resolution modeling reproduces the rainbelt of East Asia realistically

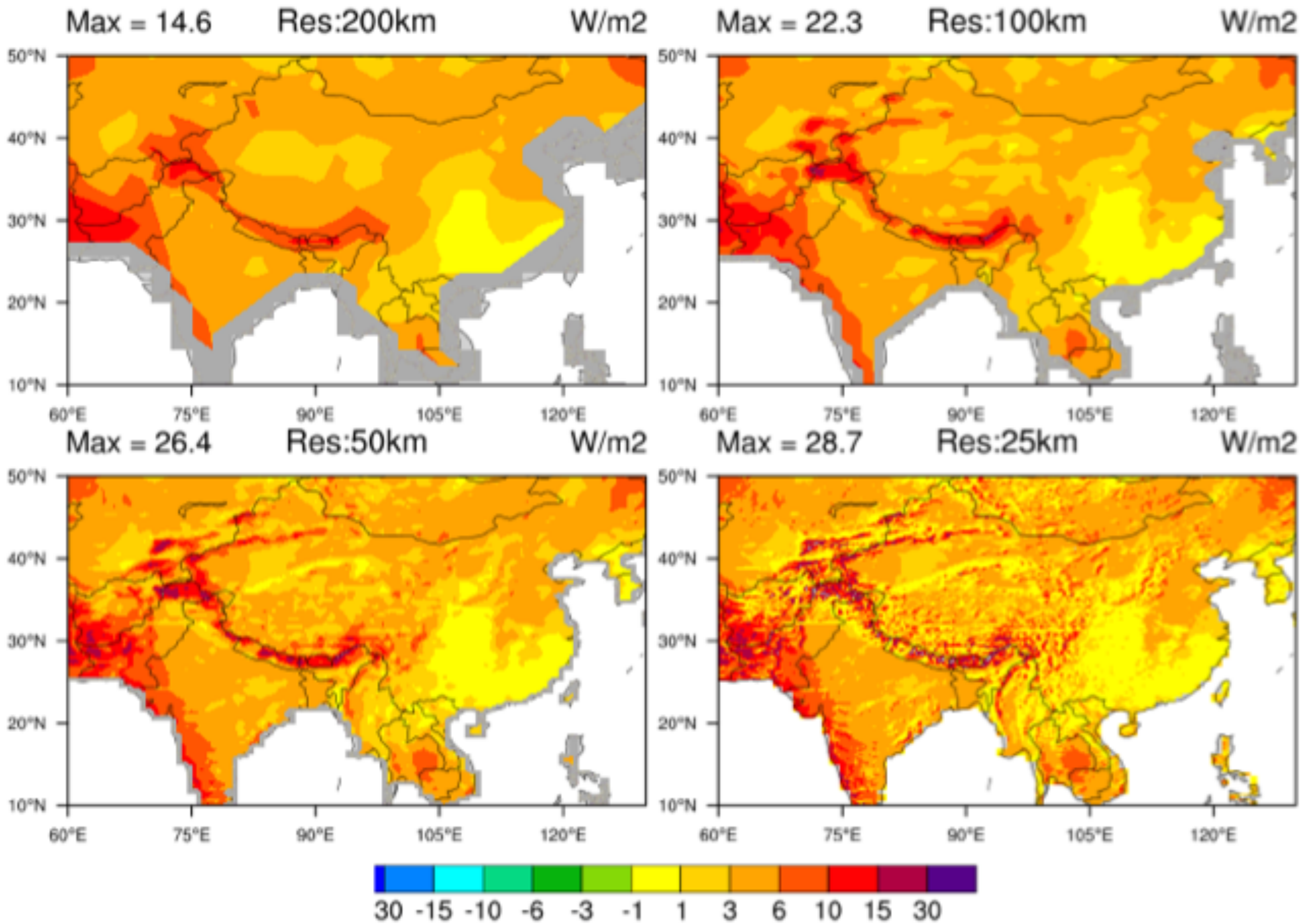
Traditional radiation in GCM   3-D Radiation in FGOALS



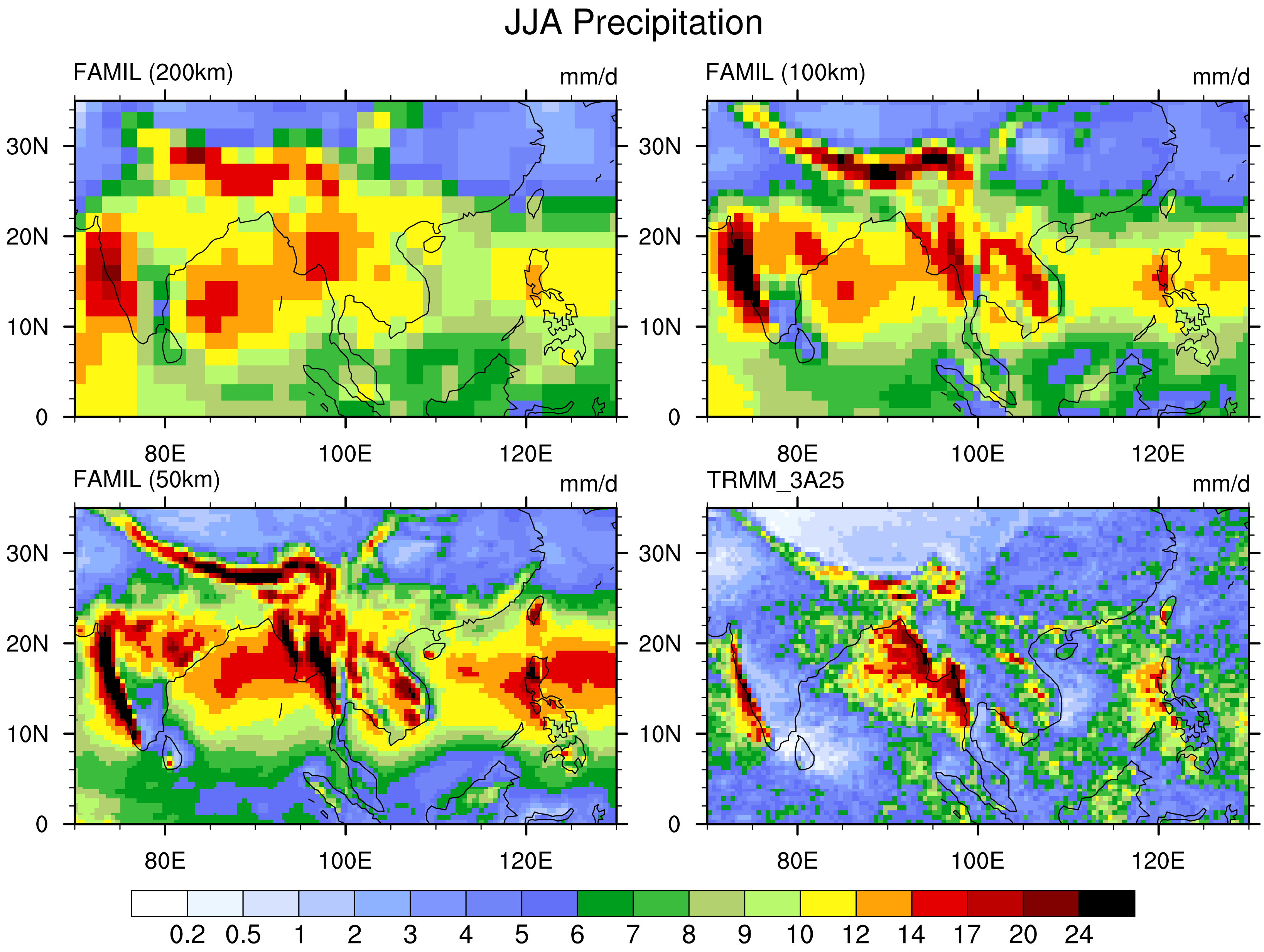
- **3-D radiation is based on the global topography datasets with 90m resolution**
- **3-D radiation effect is up to 100W•m2 with the resolution of 10~20km resolution**
- **The land-air interaction/feedback over TP (Himalayas)will further enhance the effect.**

(Lee et al, 2011)

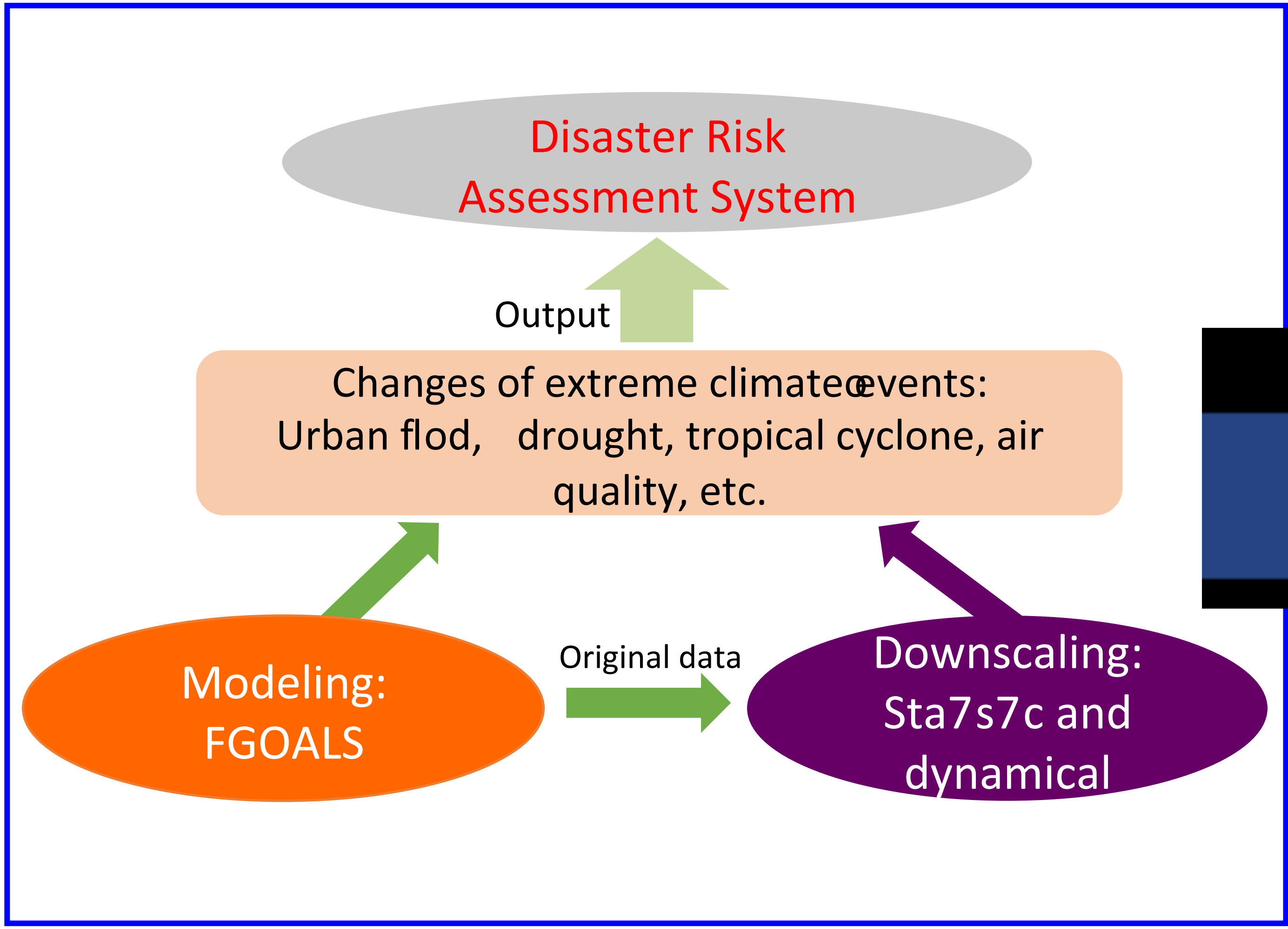
The impact of 3-D radiation can reach up to 28.7W/m2



Simulated Asian Summer Monsoon Precipitation with 200km, 100km and 50km resolutions



Himalayas climate modeling: How to do



Influences of Tibetan and Iranian Plateau (TIPs)

Coordinating influences between the TP and air-sea interactions

TP influences on the stratosphere-troposphere interactions

Himalayas climate modeling: How to do

Hindcast

- FGOALS: global **25-50km** resolution, **1950-2014**, ensembles of multi members, **hourly** output.
- CMIP HiResMIP

Future projection

- FGOALS: global **25-50km** resolution, **2015-2050**, ensembles of multi members, **hourly** output. scenarios
- CMIP HiResMIP

Downscaling

↓

Climate risk assessment

"Mountains as Sentinels of Change"

Belmont Forum Collaborative Research Action

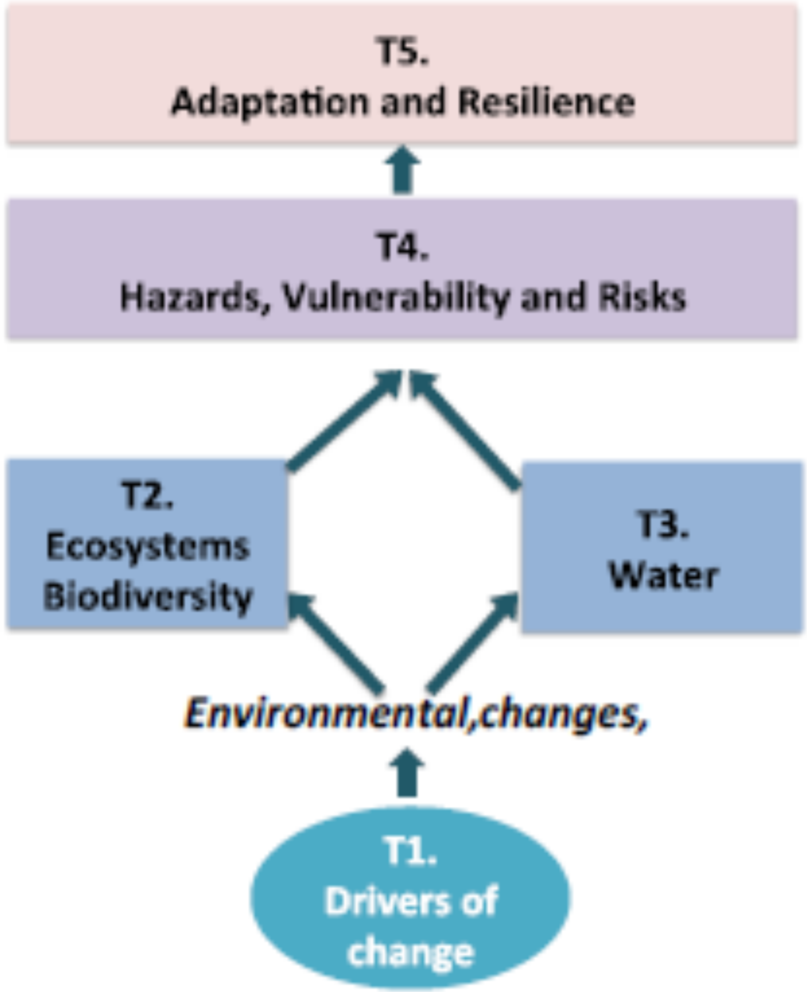


Figure 1: The Call Themes

This fits well the ACESS/ICES Initiative!

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Thanks for your attention!