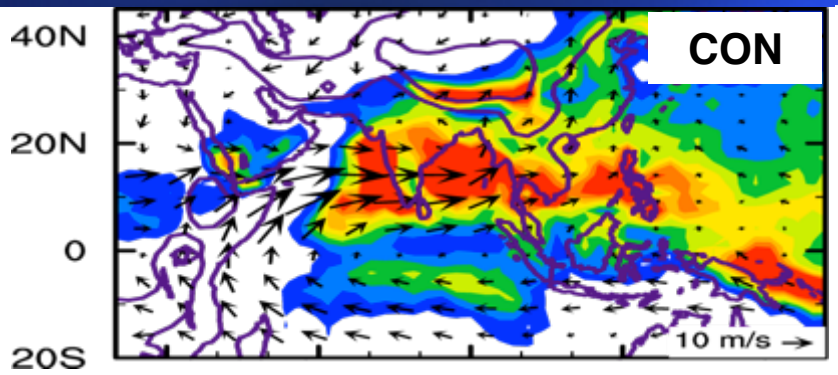
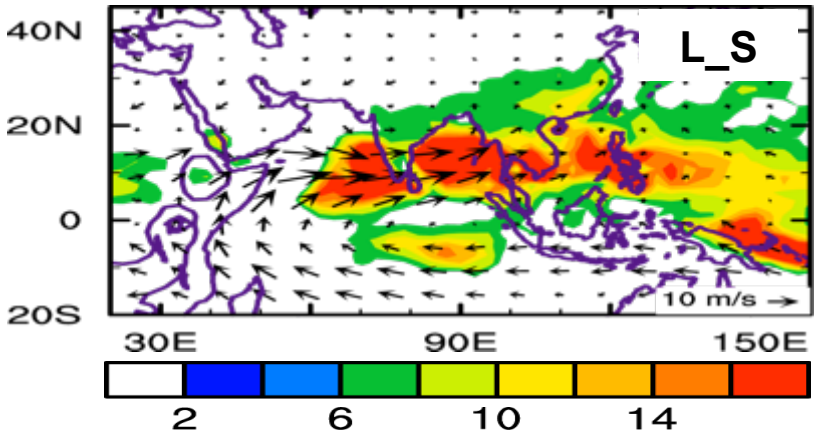
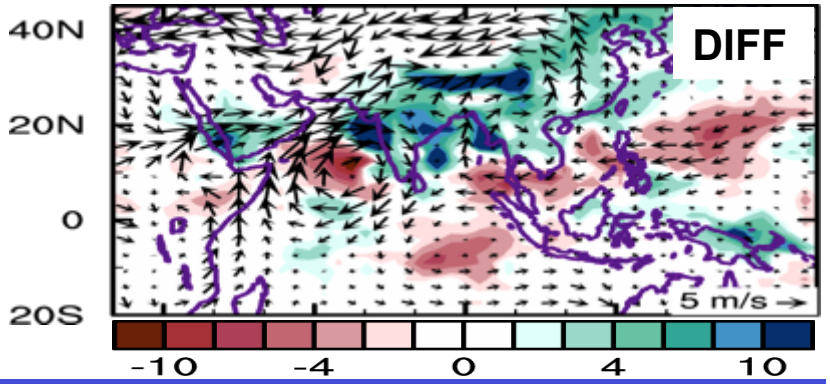
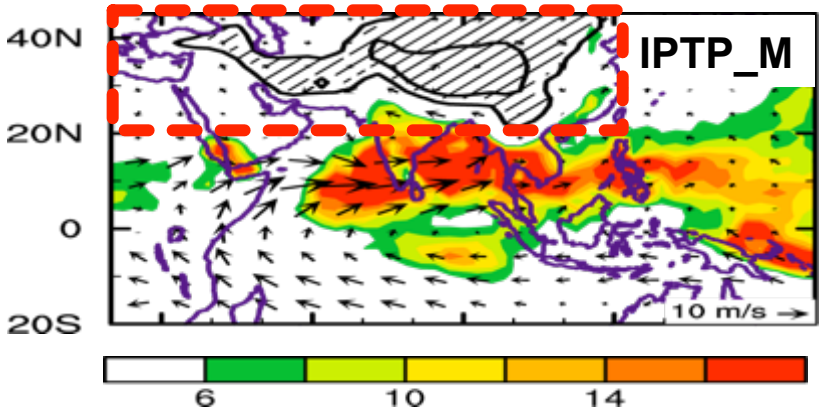
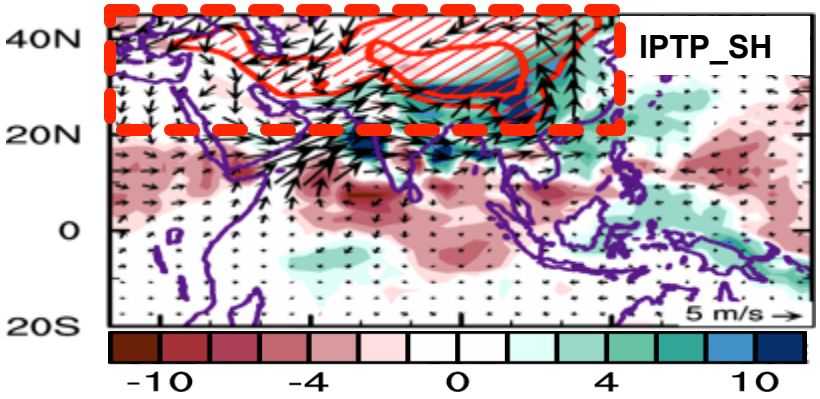
Impacts of mountain mechanical ~thermal forcing







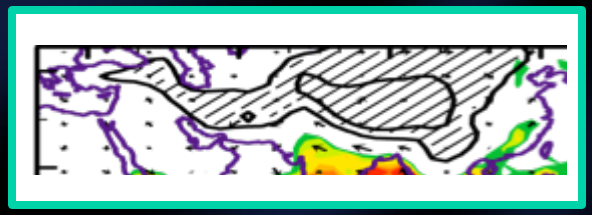




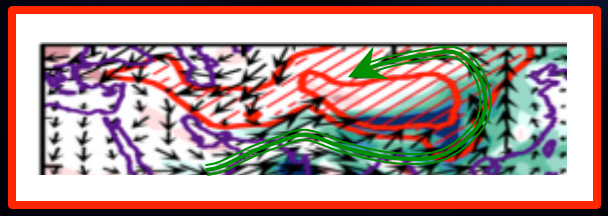
Required Circul. and Precip. to make up the Asian summer monsoon

PV-Q perspective of the TIP impact on the Asian summer monsoon

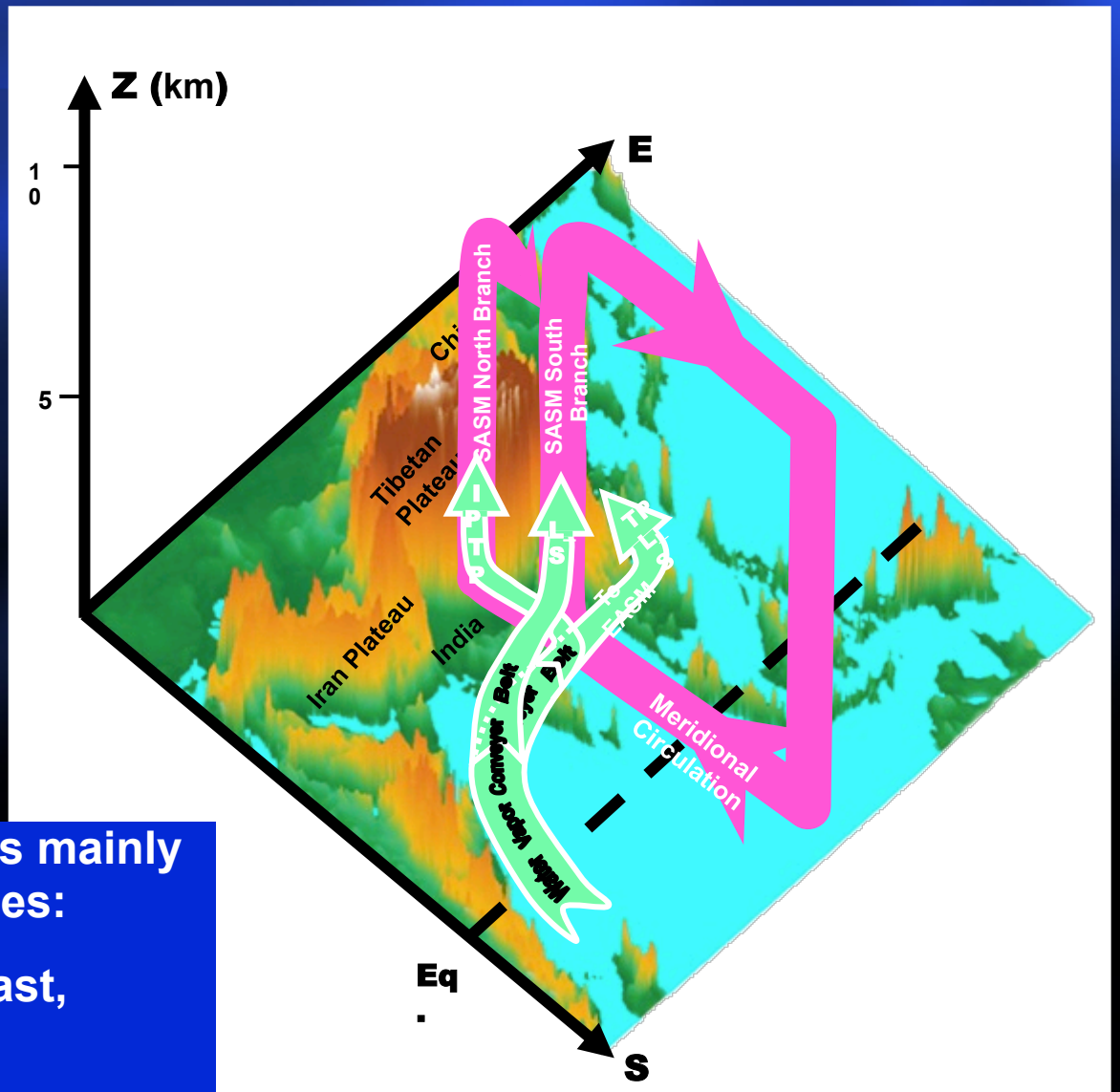
IPTP_M



IPTP_SH



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.

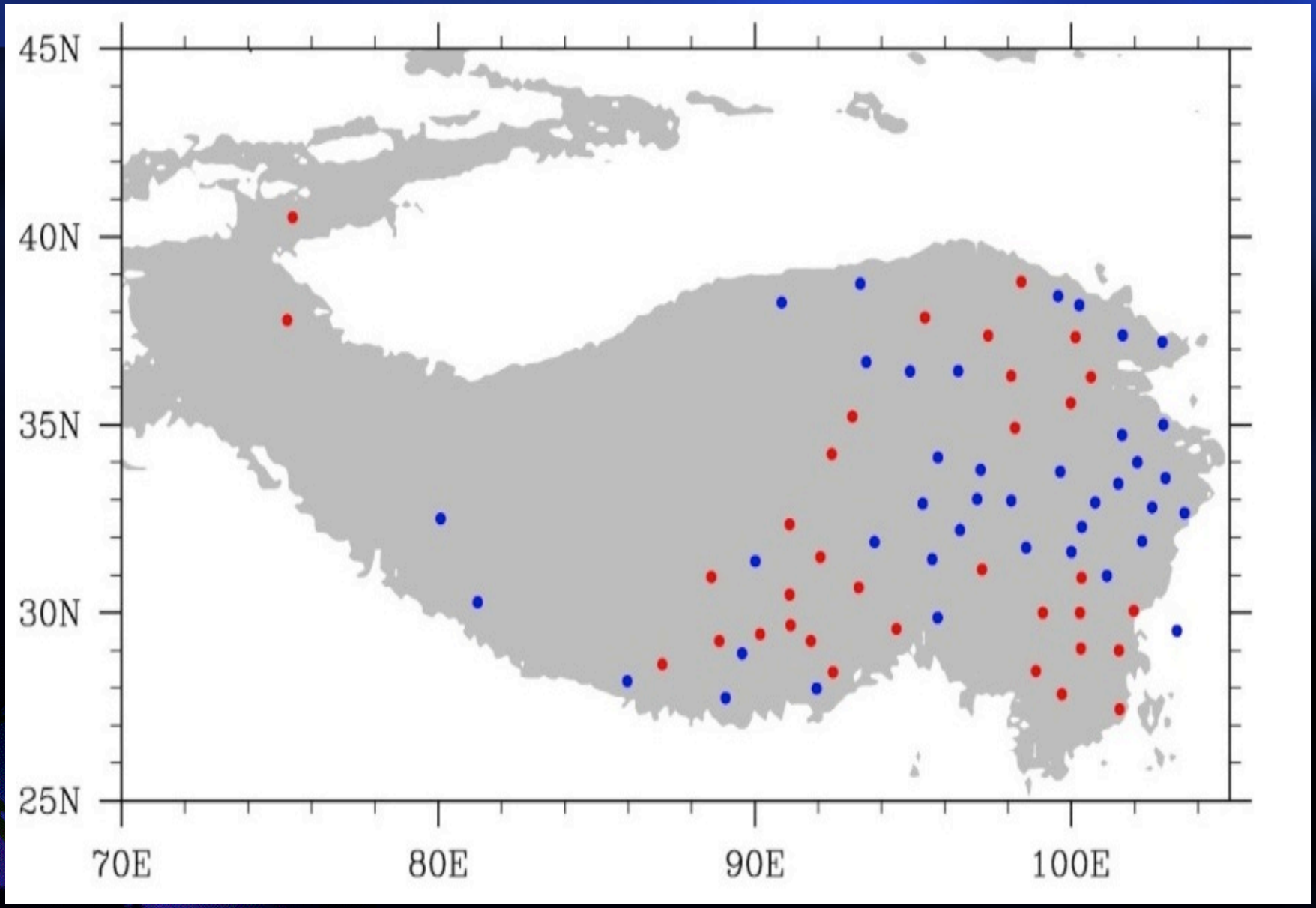
Outline

1. Introduction- 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

OUTLINE

1. Significance
2. Problems
3. Target and Content
4. Implementation Plan

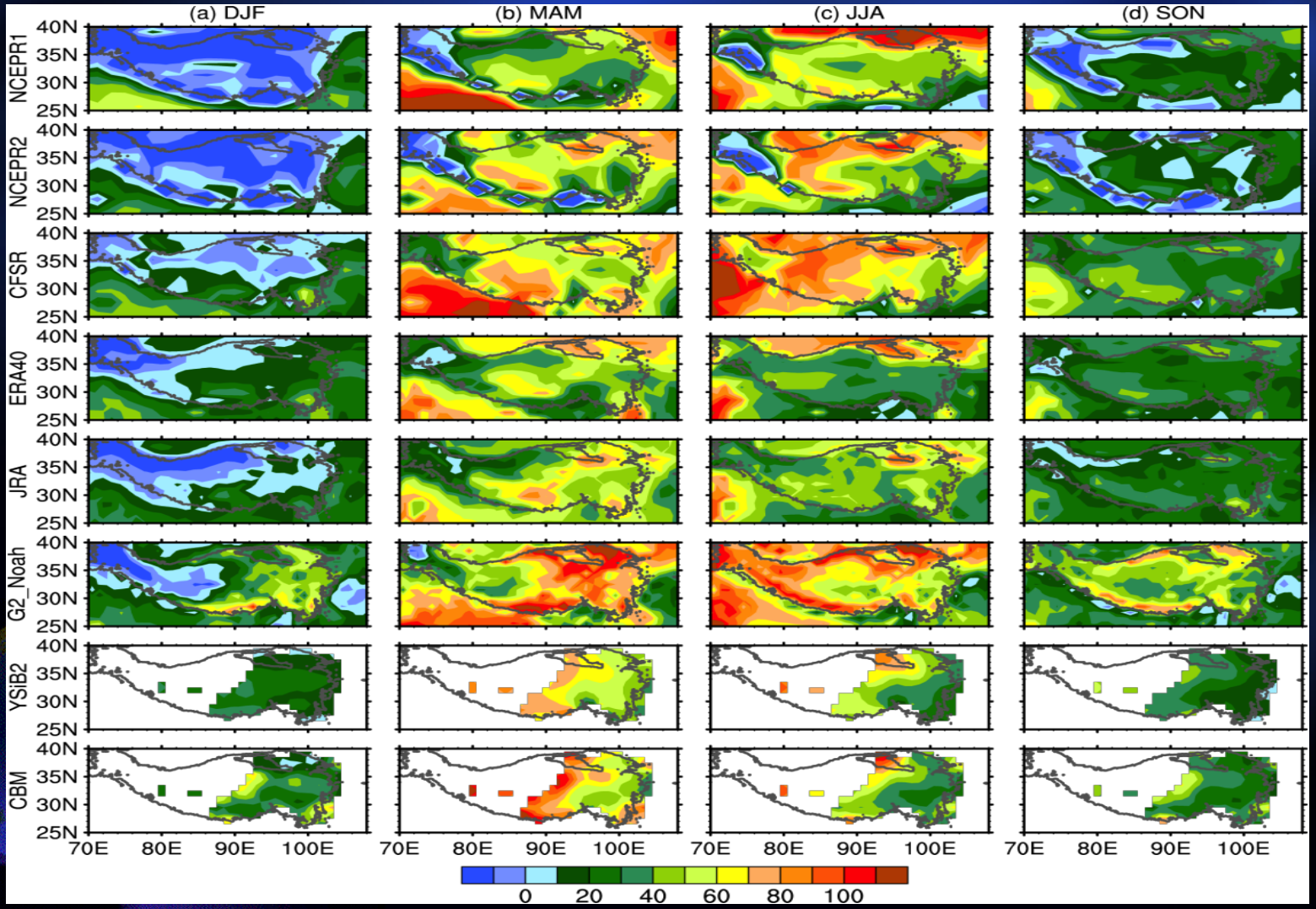
Scarceness of observations over the TP



Reanalysis has larger bias over the TP

Surface sensible heating in different reanalysis

winter spring summer autumn



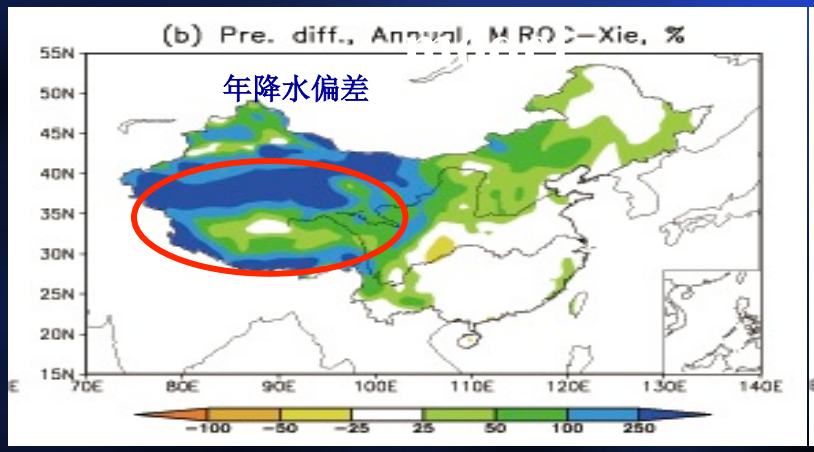
竺夏英等，2012 SCI China

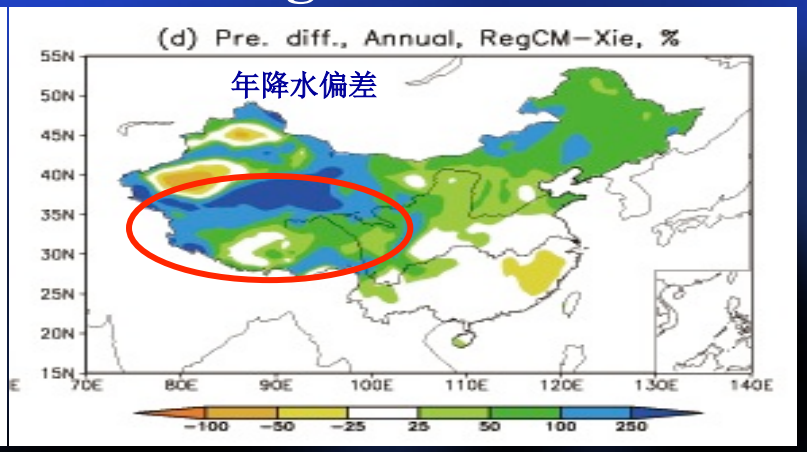
Global/regional models have largest bias over the TP

Global

Regional model

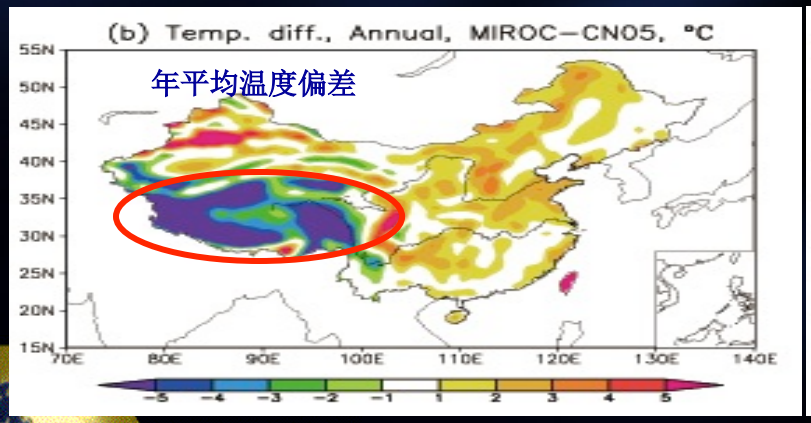
Prec.

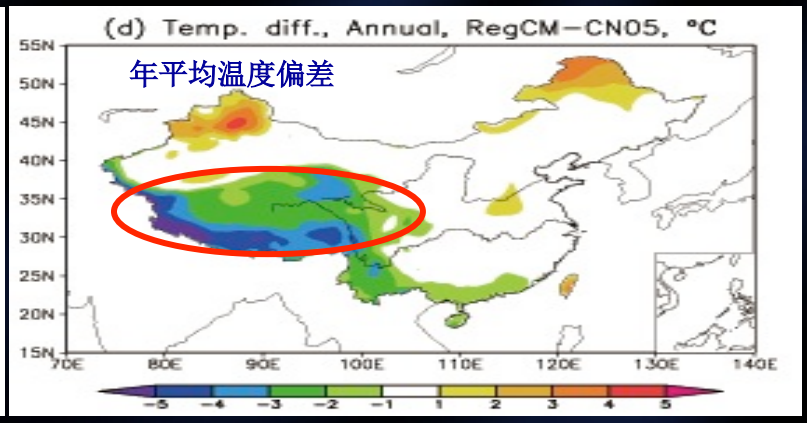




Tem

a•





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

高原区域降水量、地面温度模拟误差都很大！

China Meteorological Administration (CMA)

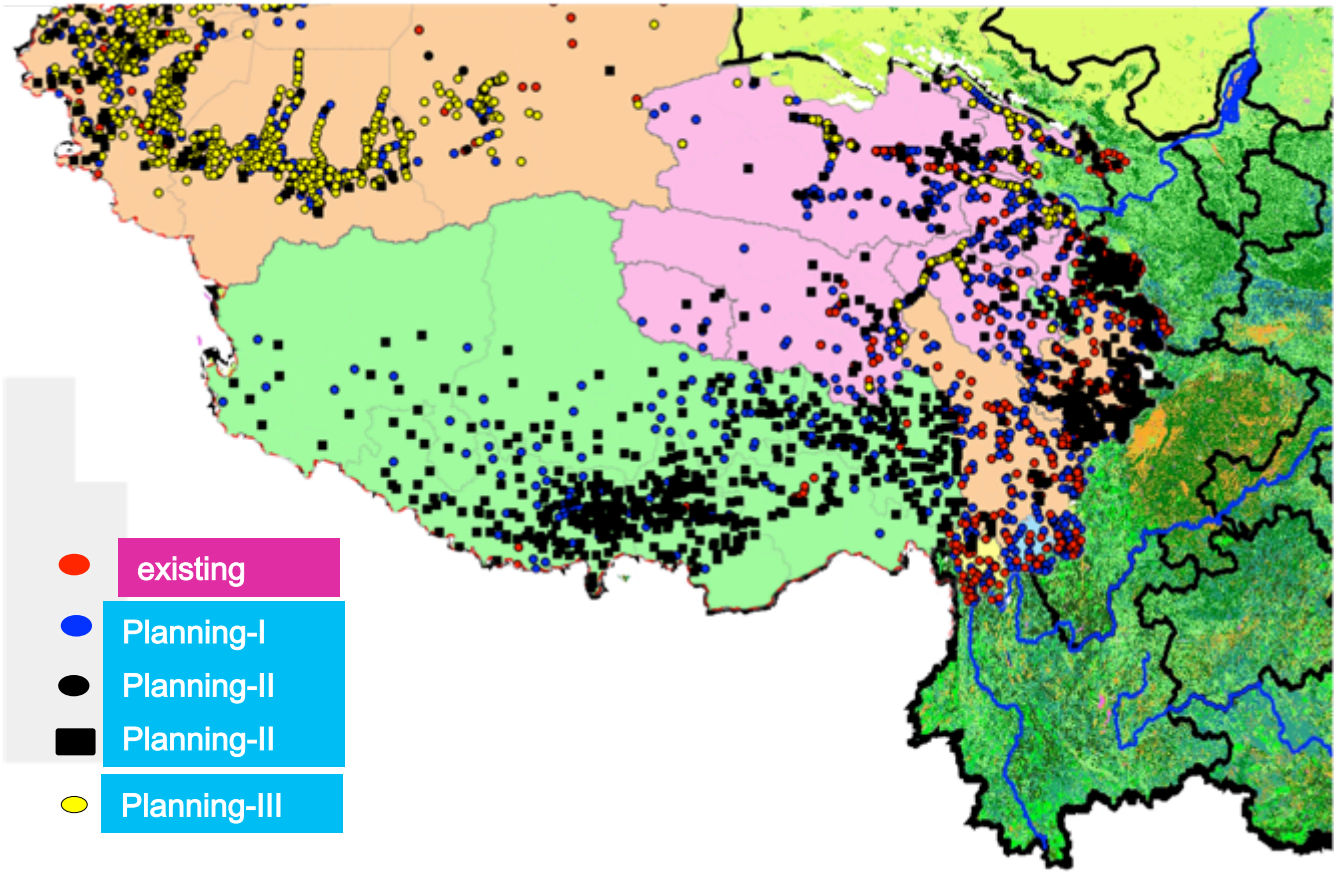
Observation Development Plan for the Tibetan Plateau area (2014-2023)

CMA national surface observation stations

西藏		四川		云南		甘肃		青海	
已建	增加	已建	增加	已建	增加	已建	增加	已建	增加
39	0	156	0	125	0	81	0	52	0

AWS（6754个）

Xizhang		Sichuan		Yunnan		Gansu		Qinghai	
已建	拟建	已建	拟建	已建	拟建	已建	拟建	已建	拟建
17	580	2110	581	1627	23	900	135	101	680



Elements:

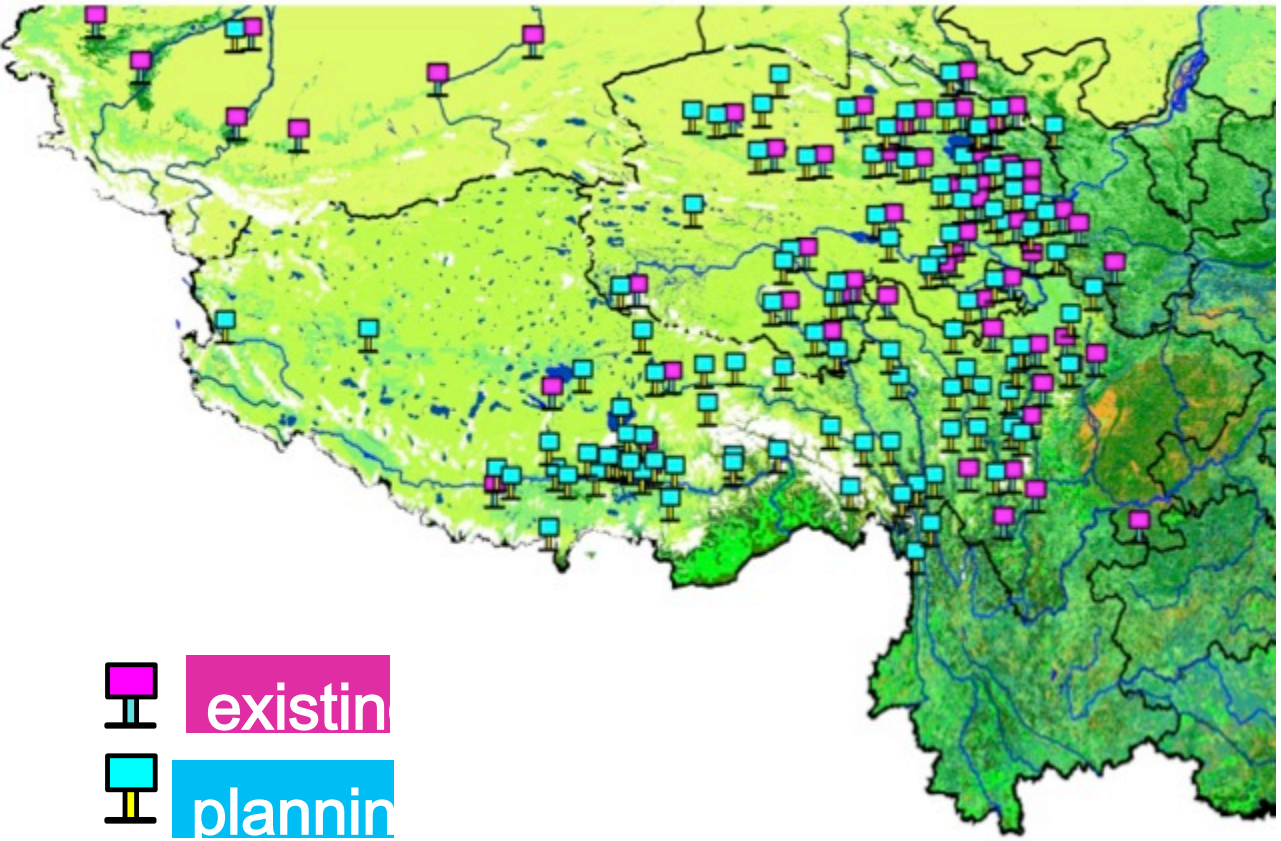
Pre., T_a,

Wind,

q, p

Soil moisture observation stations

西藏		四川		云南		甘肃		青海	
已建	拟建	已建	拟建	已建	拟建	已建	拟建	已建	拟建
8	41	197	20	20	3	61	5	55	50



- 土壤状况：10-100 cm
- 观测频次：1小时

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)

Funding：200 Million RMB

Period：Jan. 2014- Dec. 2023

Program Configuration

- Administration Committee:
  Chair: Chai, Yucheng (NSFC);
  Zhang, Chaoling; Liu, Yu;
- Advisory Committee:
  Chair: Zhou Xiuji (CAMS/CMA);
- Science Committee:
  Chair: Wu, Guoxiong (IAP/CAS),
  Co-Chair: Xu, Xiangde (CAMS/CMA).

OUTLINE

1. Significance
2. Problems
3. Target and Content
4. Implementation Plan

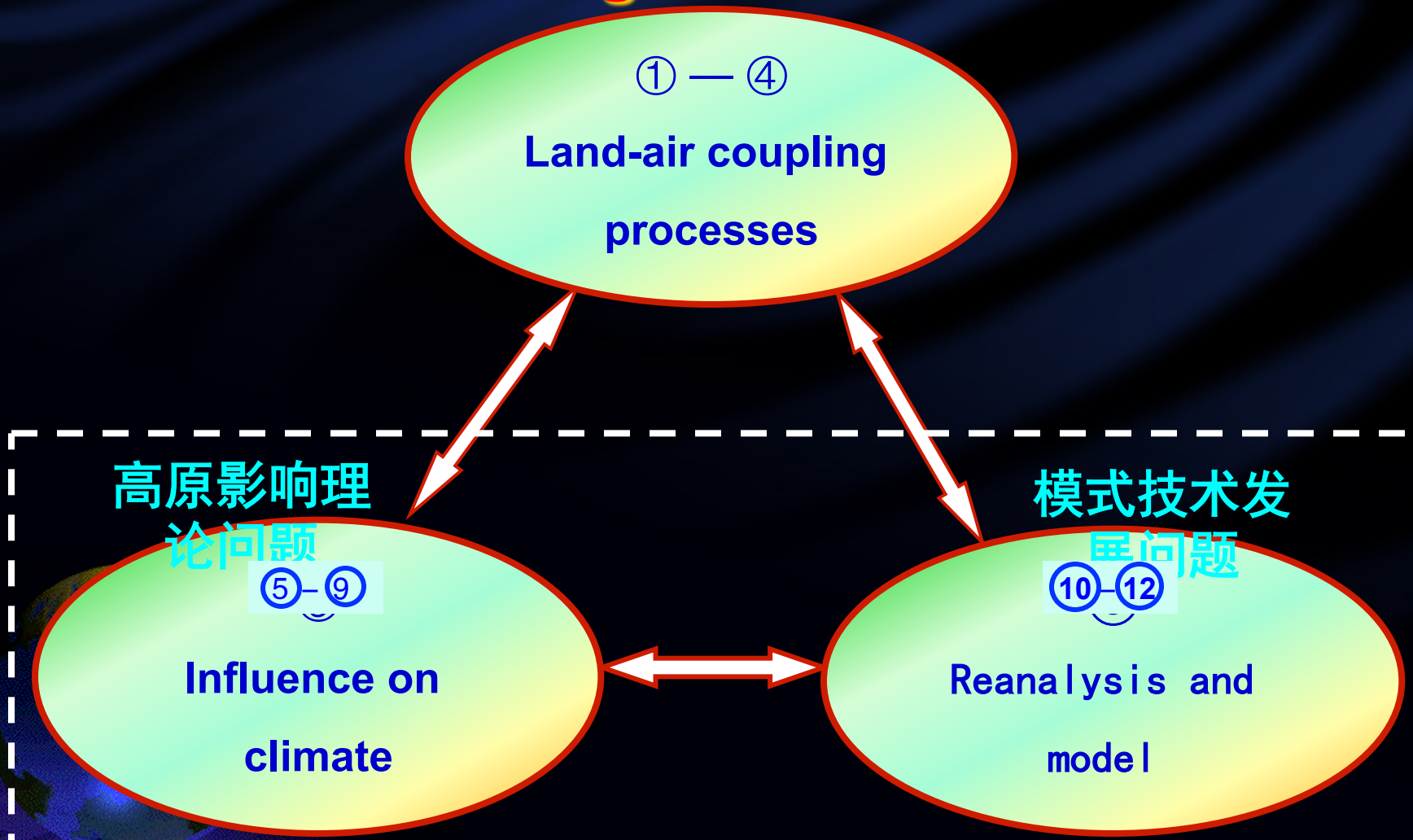
Program General Goals

- 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!**

Program Main Framework

Co- Design Co- Produce



OUTLINE

1. Significance
2. Problems
3. Target and Content
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Guideline

1. Cloud and precipitation
2. Physical processes in the land-air coupled system (gravity wave drag, boundary layer, radiation, and physical and chemical processes in the stratosphere)
3. Land-air coupled processes and their impacts on the downstream catastrophic weather
4. Complex terrain, the multi-scale variation of water cycle in the surrounding area, and their weather/climate impacts
5. Land-air coupling process and its impacts on global and regional water and energy cycle
6. Material transport crossing the tropopause and its global climate impacts
7. Local climate change in association with global climate
8. Dynamic and thermodynamic processes, their interaction with the circulation in mid- and low- latitudes, and the climate impacts.

Interaction of SH over IP and TP, and PV forcing near tropopause

SH and surface wind

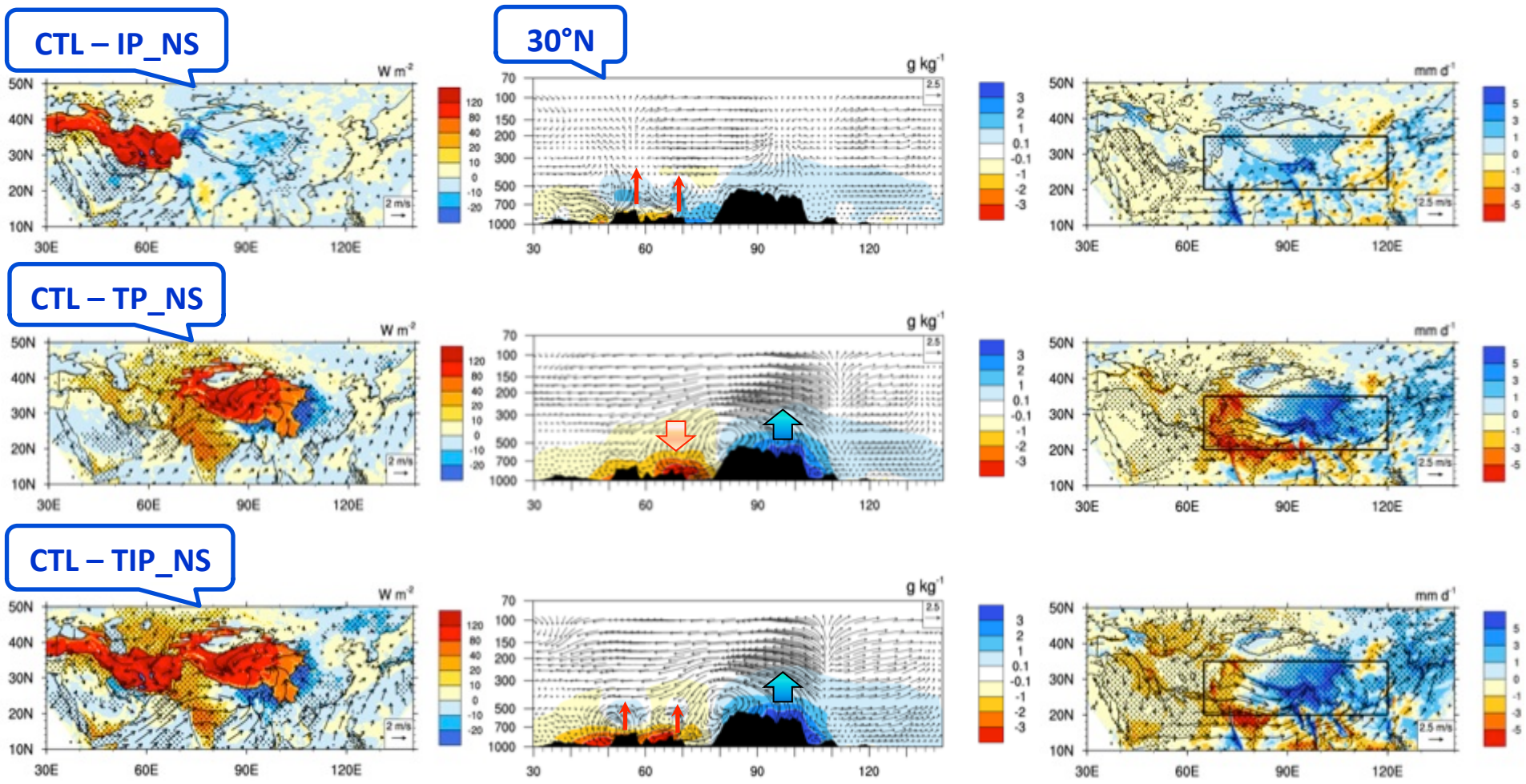
q and circulation

Prec. and wind$_{850hPa}$

CTL – IP_NS

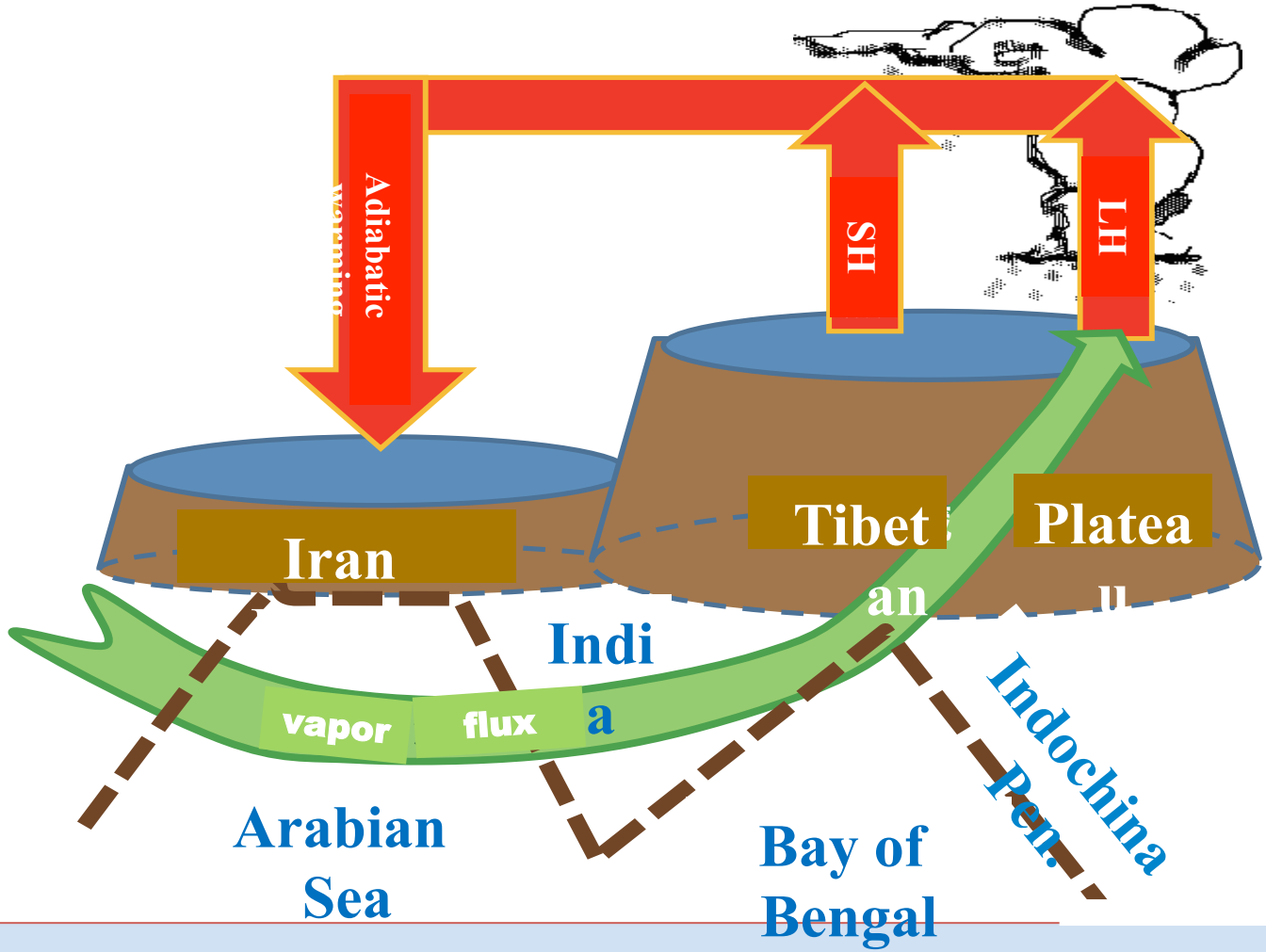
CTL – TP_NS

CTL – TIP_NS



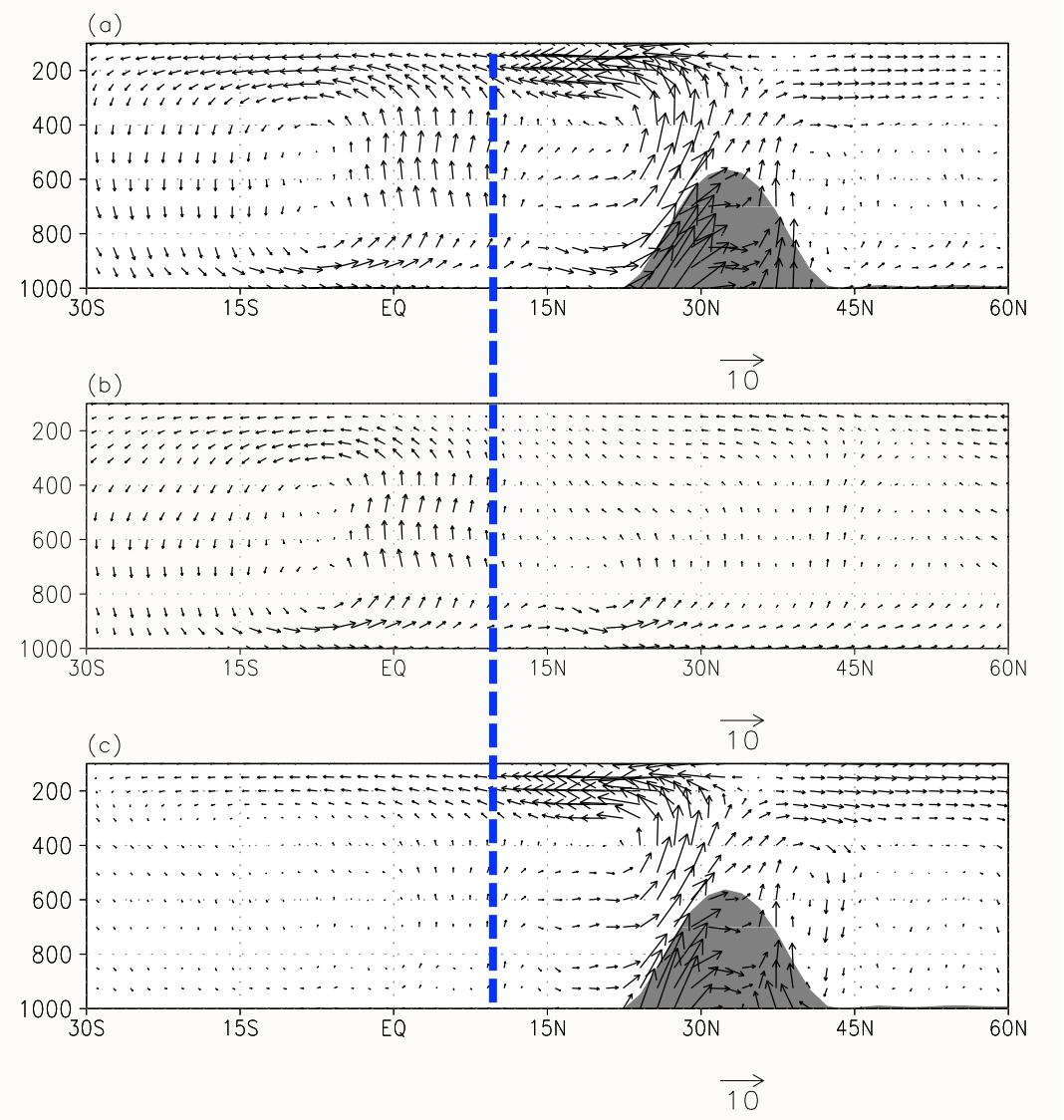
Difference distribution

Interaction of SH over IP and TP, and PV forcing near tropopause



Schematic diagram of the TIPs System

Fig. 5 Mean meridional circulation (v, -ω) averaged over (90° and 120°E) in Exps TPIR (a), TRO (b), and their difference (c). The vertical pressure velocity ω is amplified by 60 in the plotting.
(Wu, Liu, Dong…, 2012: Climate Dyn.,39(5), 1169–1181)



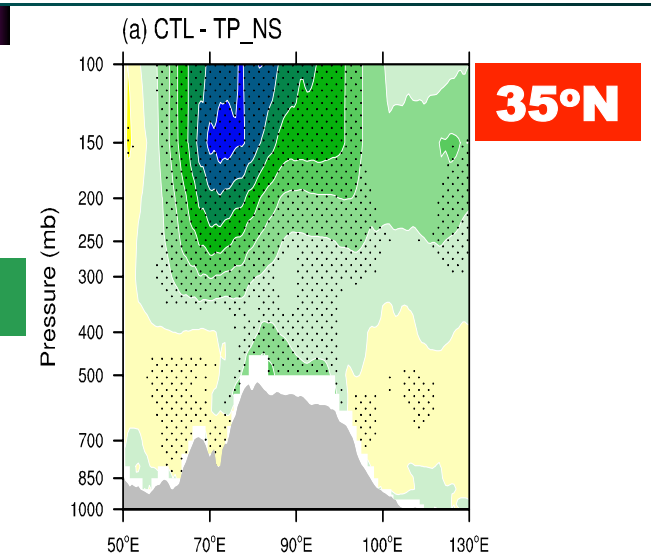
(a): TPIR

(b): TRO

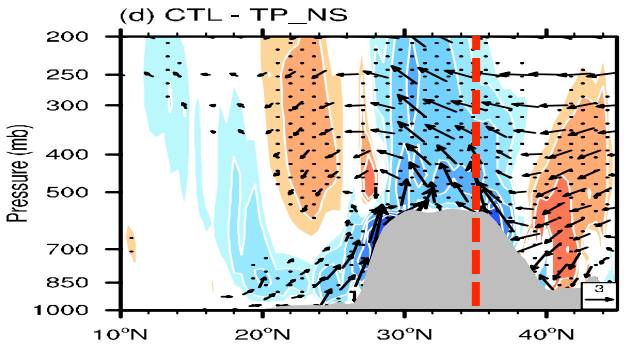
(c): (a)- (b)

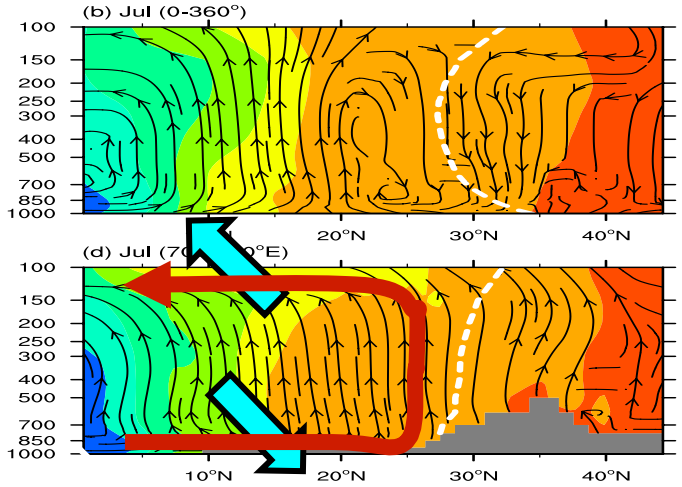
$$M_D\zeta_a = 2\Omega^2 a^2 \sin\varphi\cos^2\varphi + \frac{1}{2}\frac{gD}{T_0}\frac{1}{\cos\varphi}\frac{\partial}{\partial\varphi}\left[\frac{\cos^3\varphi}{\sin\varphi}\frac{\partial\hat{T}_e}{\partial\varphi}\right]$$

Plumb and Hou, 1992



35°N





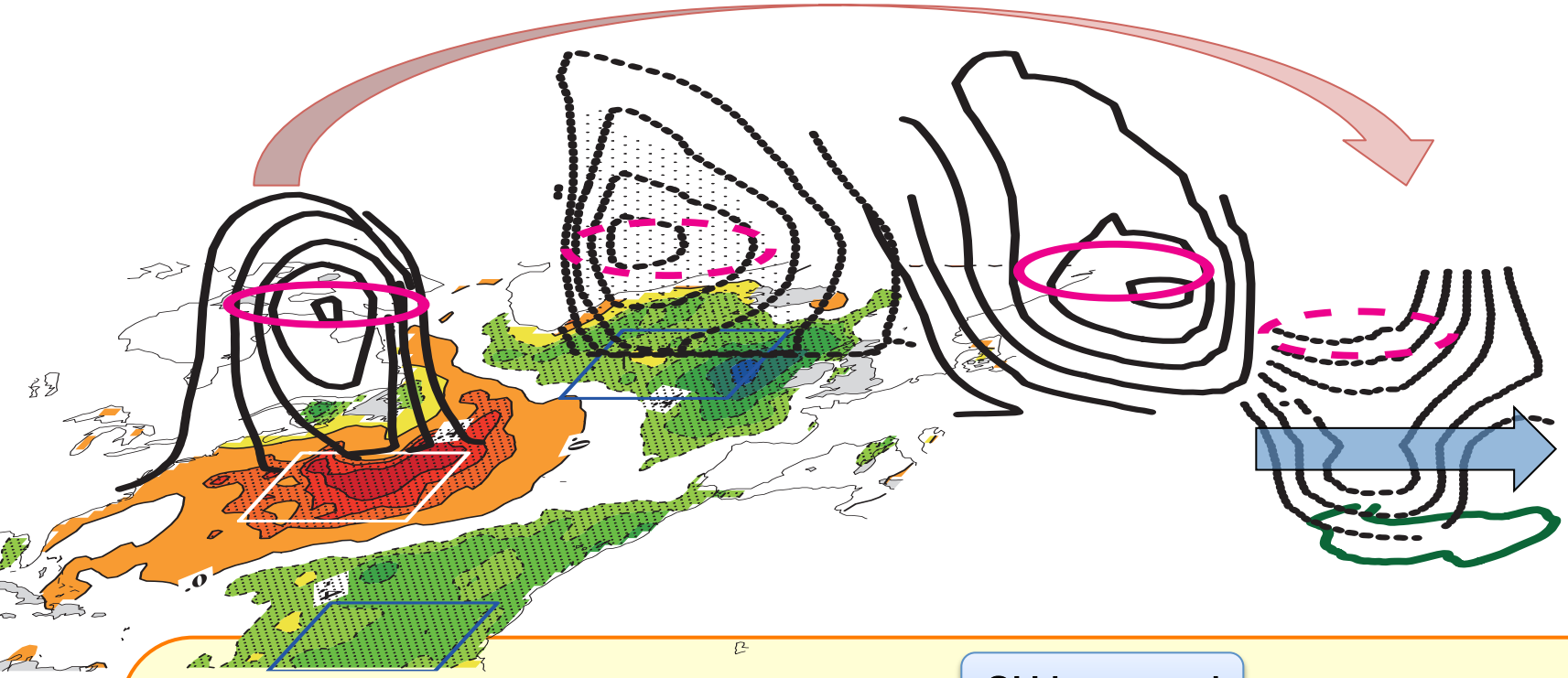
$f\,v$ Easterly Shear

Monsoon R (70-90°E)

$$W \propto \frac{\partial}{\partial z}\left[-\vec{V}\cdot\nabla(f+\zeta)\right]$$

Schematic diagram showing How the TP heating contributes to the development of monsoonal meridional circulation

How the air-sea interaction over the N Atlantic in spring can influence the sensible heating source over the TP



Winter NAO

spring

3-pole SSTA

U_/TP intensified

SH increased

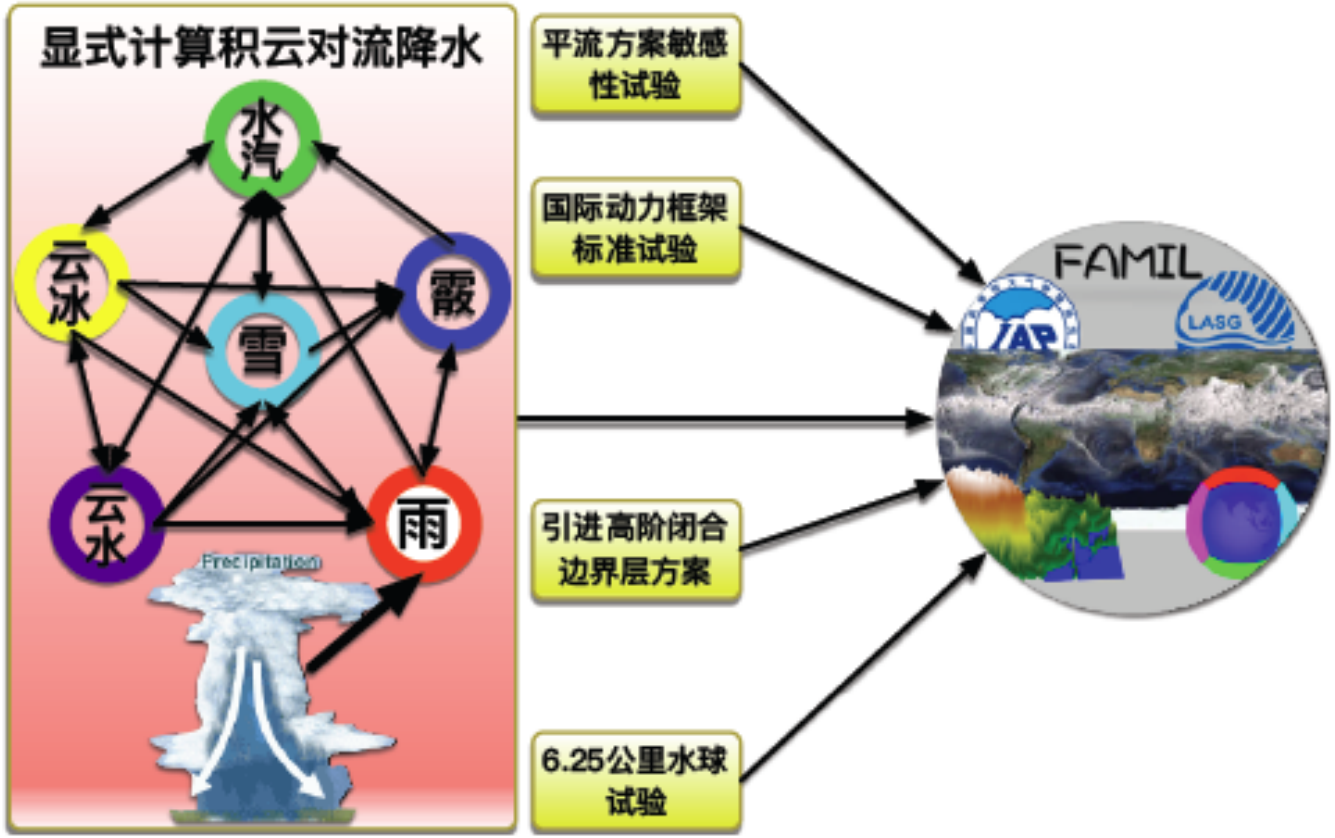
潜热 南少北多

大气净辐射 冷却加强

Atm heat source intensified

Cui, Duan (通讯作者), et al., Clim. Dyn.

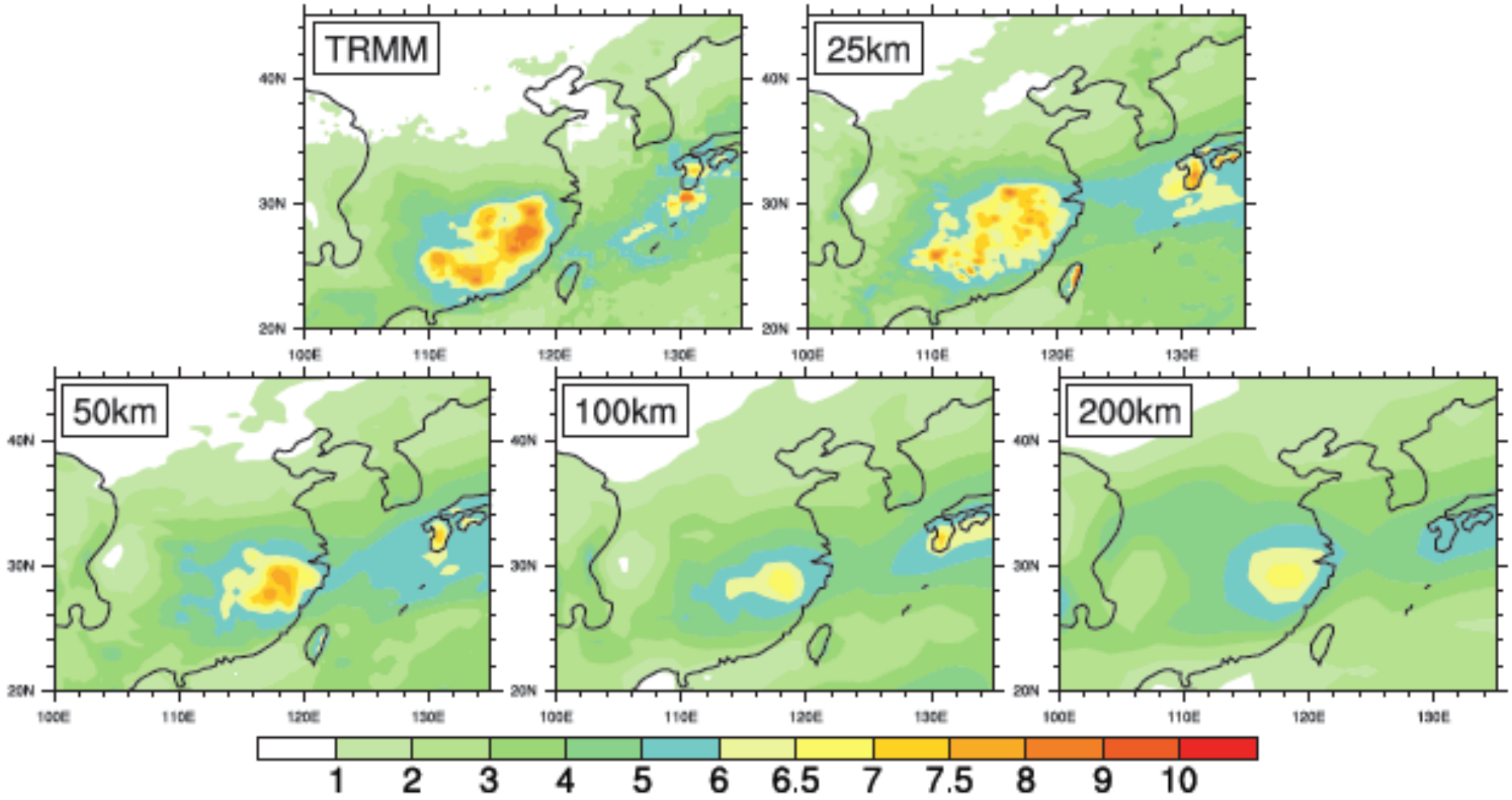
Developed global high resolution model FAMIL



Bao et al. 2014, Zhou , Bao(通讯） et al., 2014; Zhou Bao(通讯) et al., 2015,JAMES(IF 6.4)

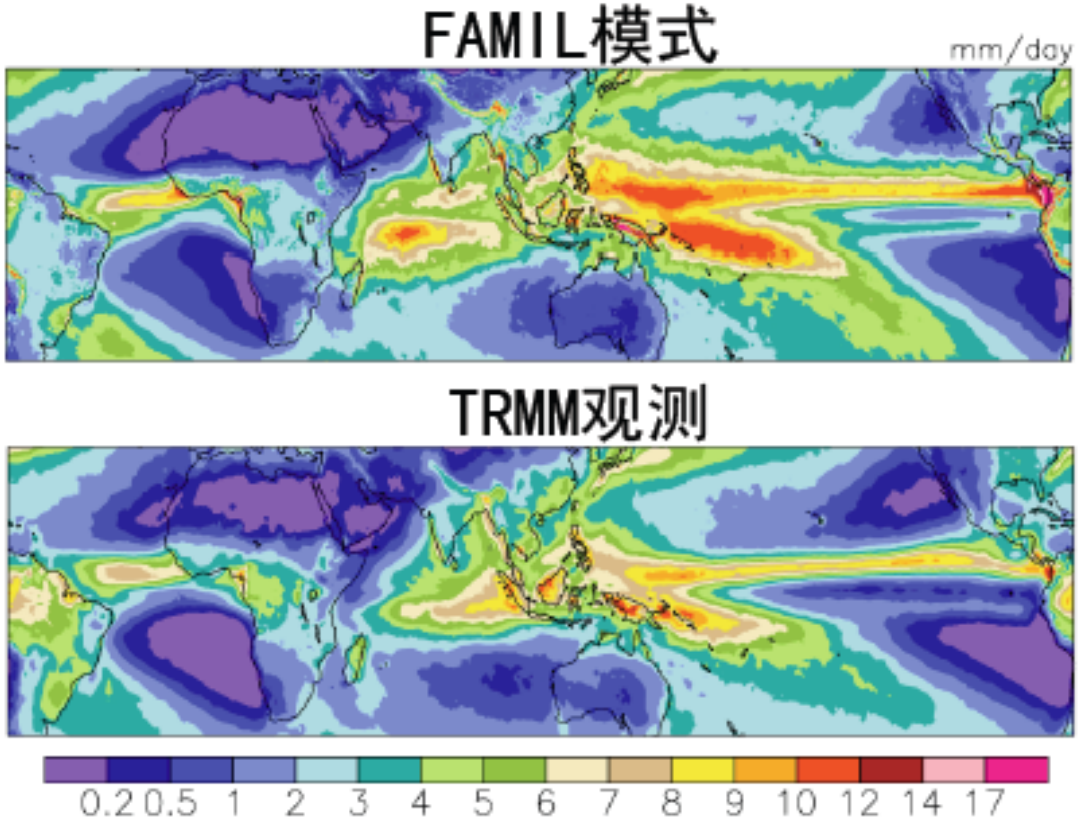
Created an explicit calculation scheme for cumulous convective precipitation

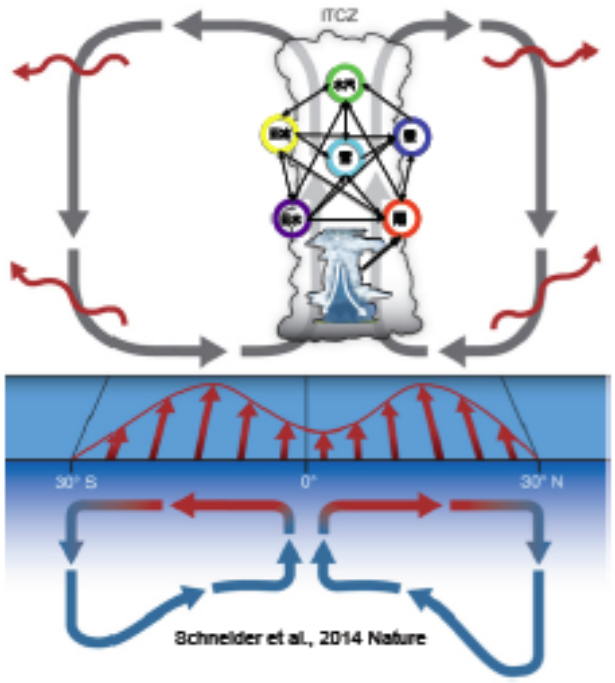
Successfully simulated the Persistent Rainfall in Early Spring (PRES) in S China



Courtesy of Bao et al. 2015

Overcome the double ITCZ in modeling

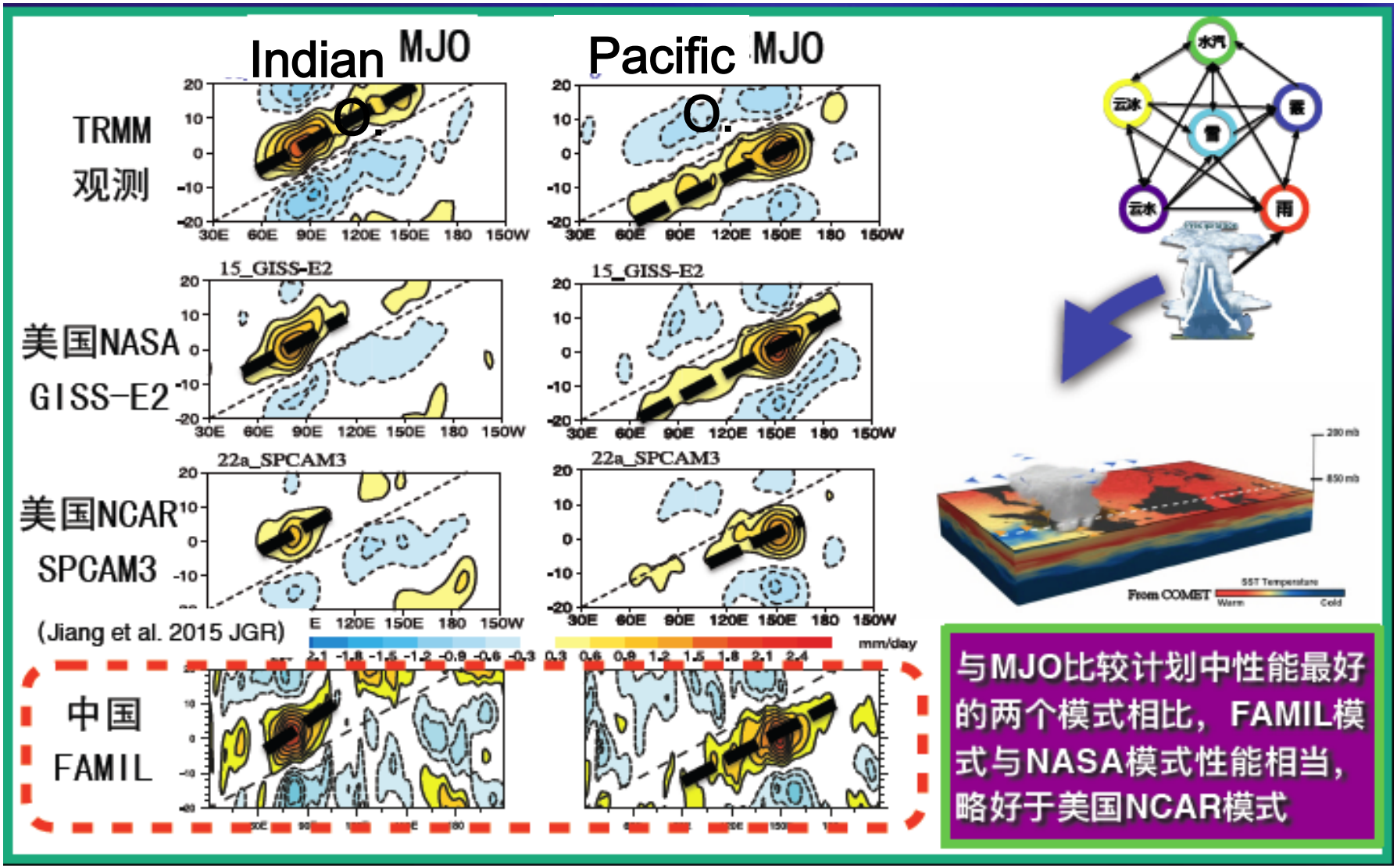




25 Km- resolution

Courtesy of Bao et al, 2015

Can well represent the MJO



Courtesy of Bao et al. 2015

Integration Study

2016 approved for 2017-2019：

- Synergic impacts on regional energy and water cycle and global climate of oceans and the land- air coupling process over the TP ；
- Development of synthetic data platform for the multi-source information over the TP.

2017 planned for 2018-2020：

- Multi-scale characteristics of the water and energy cycle in the TP Land-air coupled process and their impacts on catastrophic weather extremes;
- multi-source information coalescence, data assimilation for the TP area and global model development

Conclusion

- Summertime subtropical circulation and climate are closely linked with multi-scale forcing: LO-SE-CO-D quadruplet heating + sea breeze + mountain ranges
- Through transporting water vapor from sea to land, the thermal forcing of the Tibetan-Iranian Plateau has strong impacts on the onset, evolution and maintenance of the ASM.
- Surface boundary conditions and topography have significant impacts on weather and climate and must be an important component of GEWEX study.

Thanks for your attention!