The energy and water exchange and its effect on the weather and climate over the Tibetan Plateau and surrounding regions

Yaoming Ma& LAIC group

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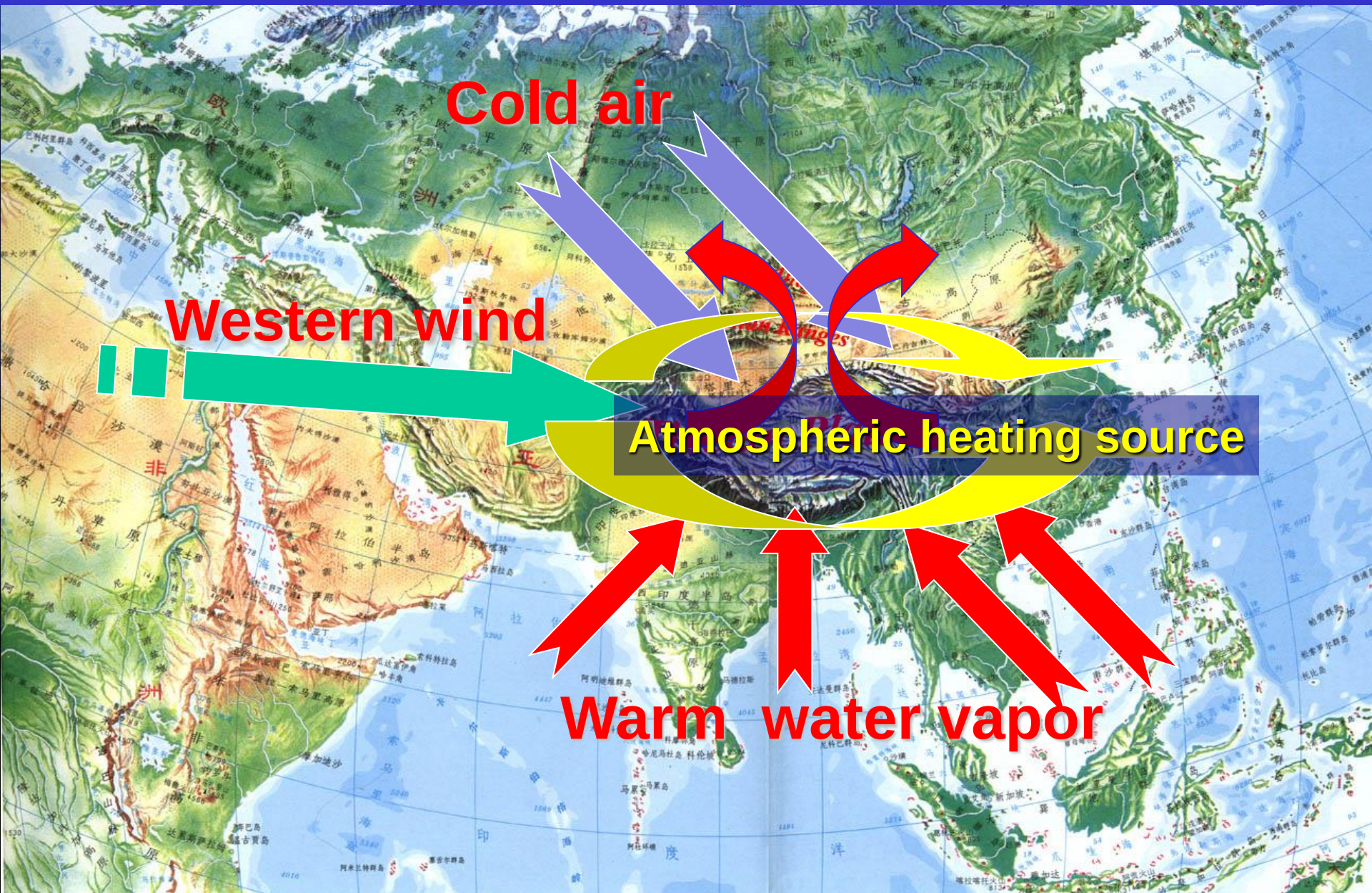
(October 14-18，2024，INACH 2024, Lanzhou（Zhangye）, China）

Outline

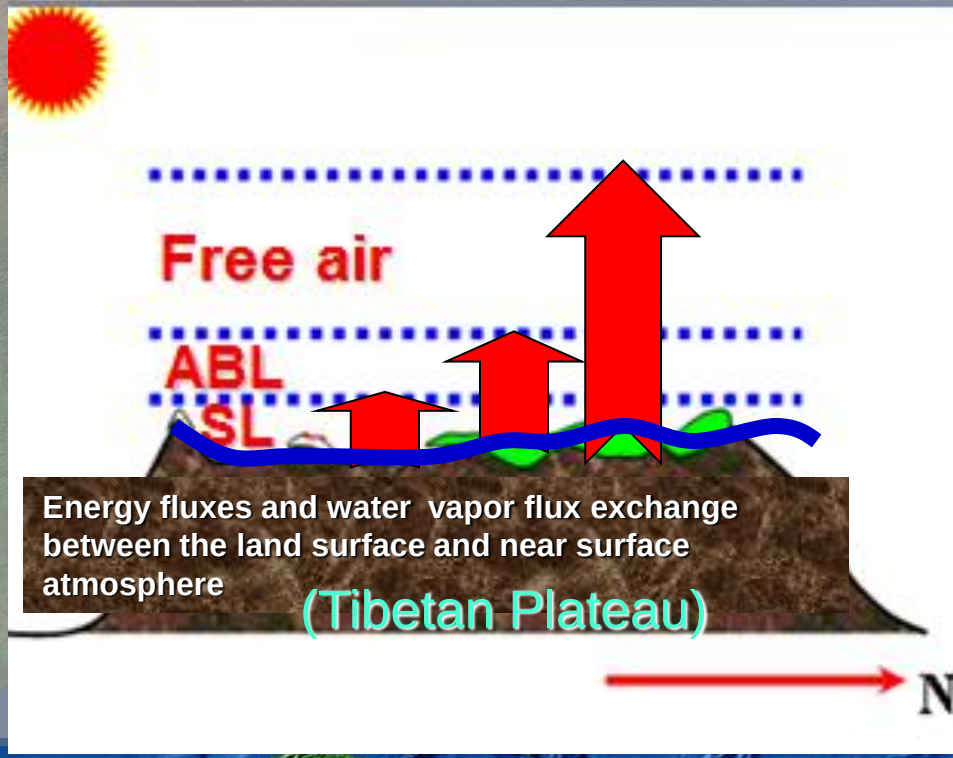
1. Why do we have this kind of study?（Background）
2. How can we carry out the research?
3. The land-atmospheric interaction observations over the Third Pole region
4. Determination of surface heat fluxes and evapotranspiration (*ET*) over heterogeneous landscape by using satellite data
5. Future work

1.Why do we have this kind of study?(Background)



Tibetan Plateau

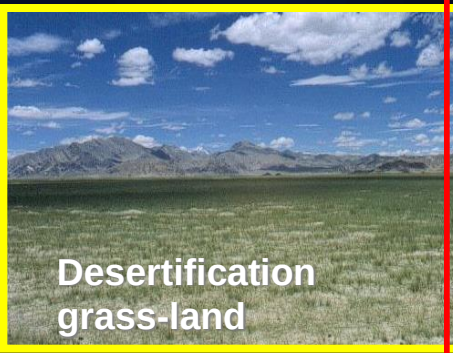
Heating to the atmosphere

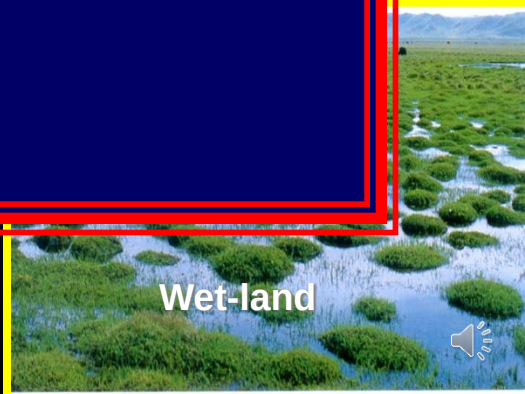


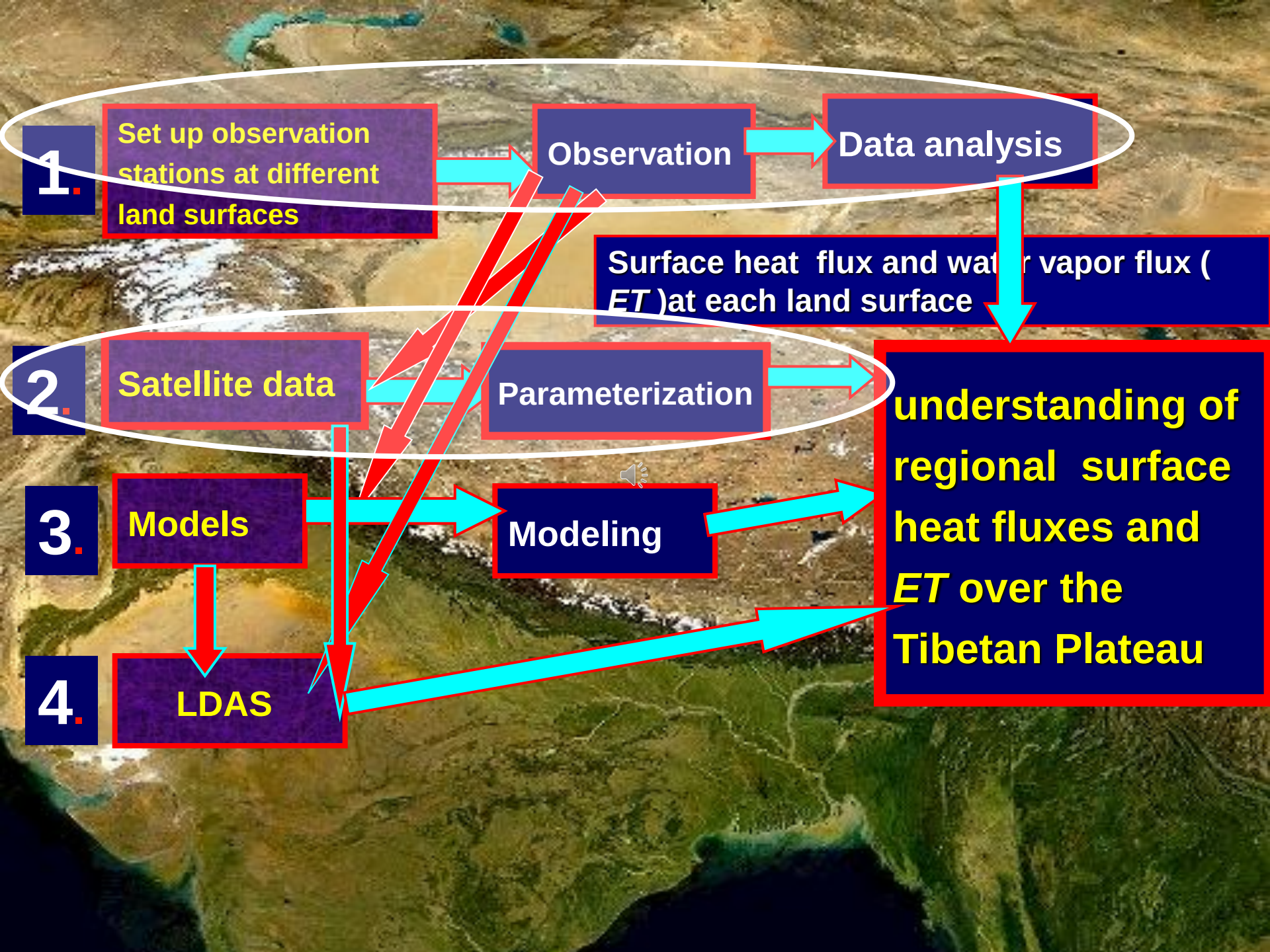
2. How can we carry out the research?

How to get the regional surface heat fluxes and water vapor （*ET*）over the Tibetan Plateau

??????????



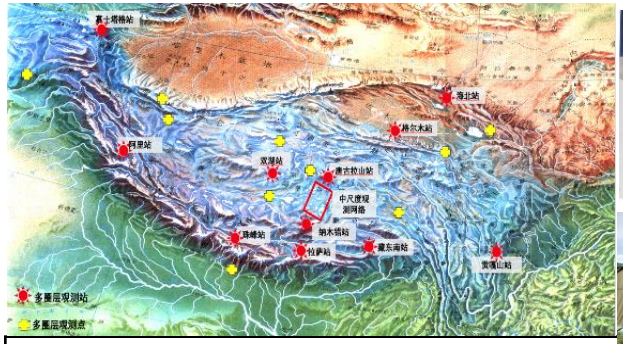



1.
Set up observation stations at different land surfaces
Observation
Data analysis
Surface heat flux and wat r vapor flux (ET)at each land surface
2.
Satellite data
Parameterization
understanding of regional surface heat fluxes and ET over the Tibetan Plateau
3.
Models
Modeling
4.
LDAS

3. The observations of radiation fluxes and land surface heat fluxes and water exchange over the Tibetan Plateau

Four Steps（1989~）

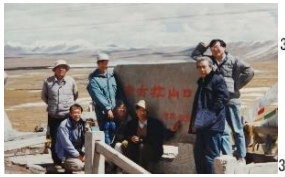
"95" National project

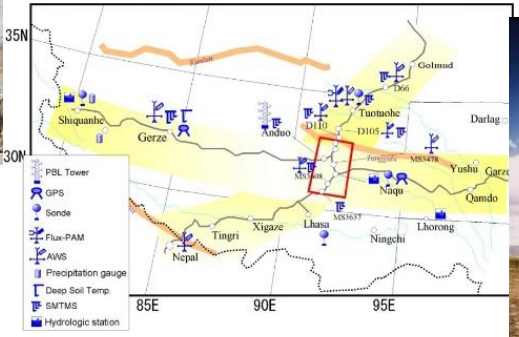


TORP+National project (Ma et al., 2008,BAMS; Ma et al., 2017 SR)

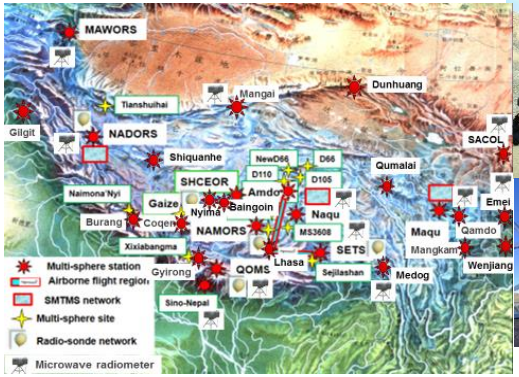
1989 ~1996 2004-2015 2018~

GAME/Tibet（1996-2000） and CAMP/Tibet（2001-2005）(Ma et al., 2003,JMSJ)

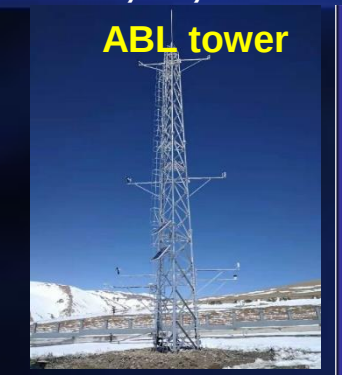


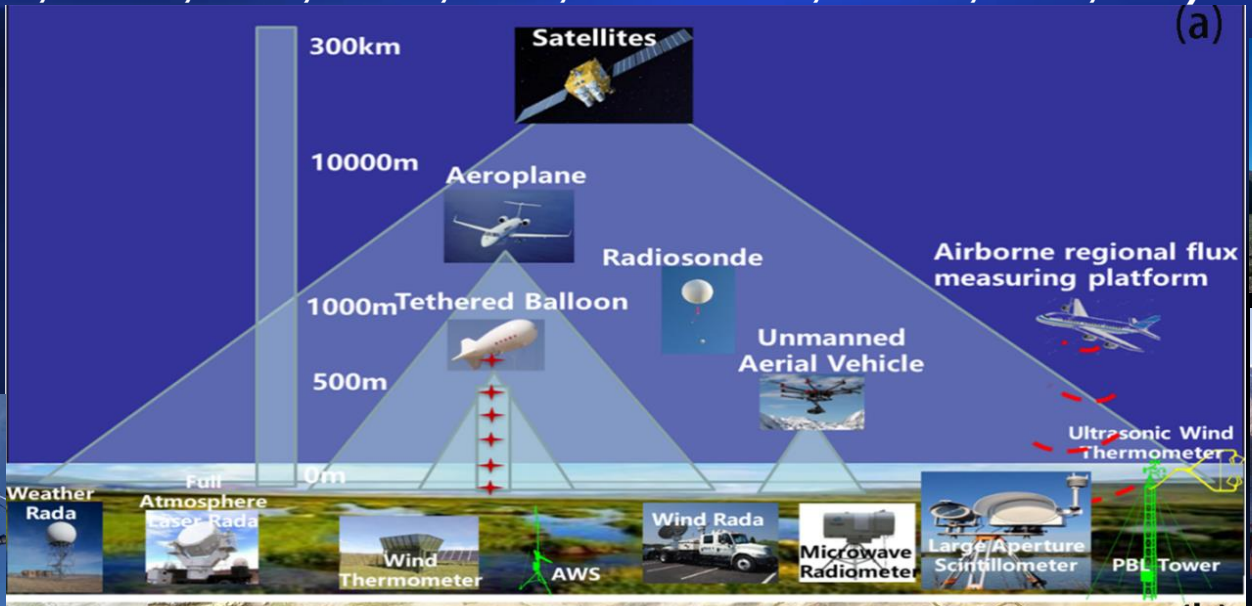


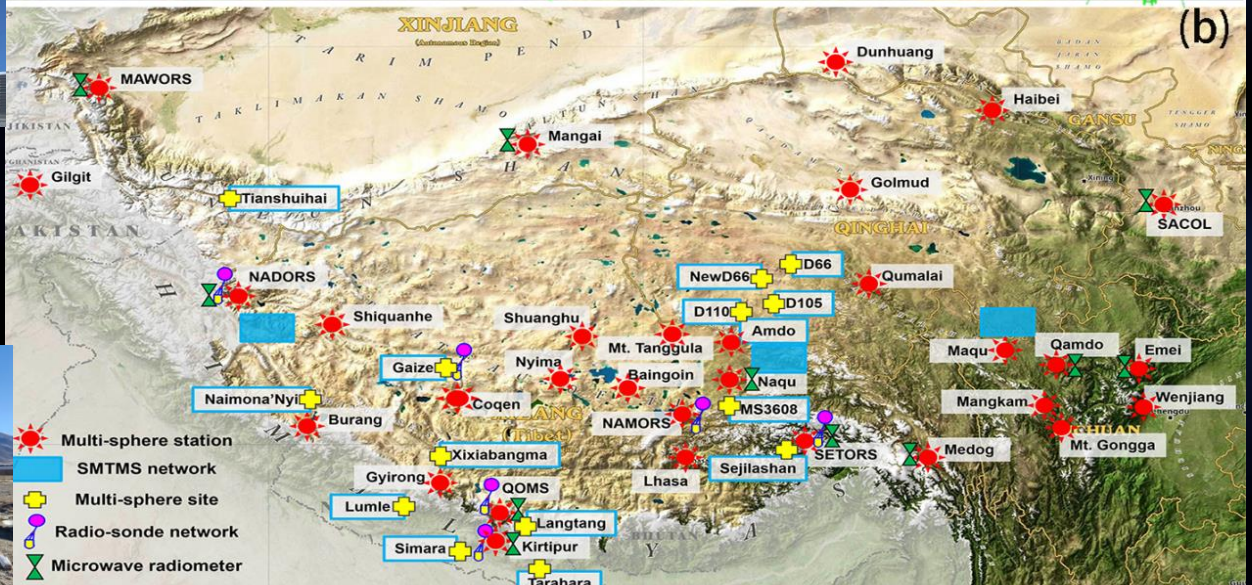
STEP(Ma et al., 2023,ESR;Ma et al., 2023,BAMS)



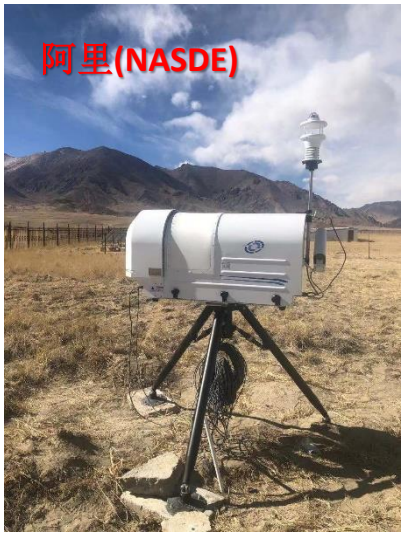
A new comprehensive observation system network for the multi-process land-atmosphere interaction in the Third Pole (TPEITORP) （27 ABL towers、37 EC system、10 microwave radimeters、8 Wind-profiler，6 radio-sonde system ， 14 AWSs and 3 SMSTEM etc.）was constructed in the end of 2022.(Ma,Y.,et al., 2023,ESR;Ma,Y., et al.,2023,BAMS；Chen,Xu,and Ma*,Y.et al., 2024,BAMS;Chen,Liu and Ma*,Y. et al., 2024,AAS)

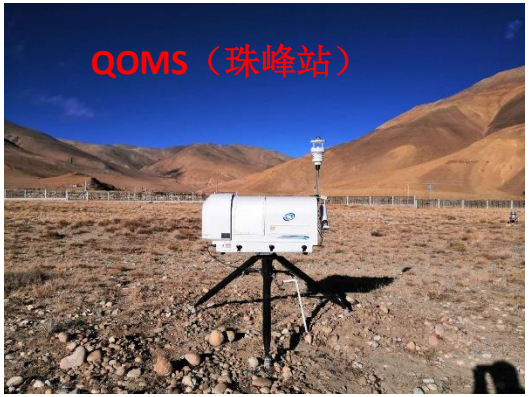


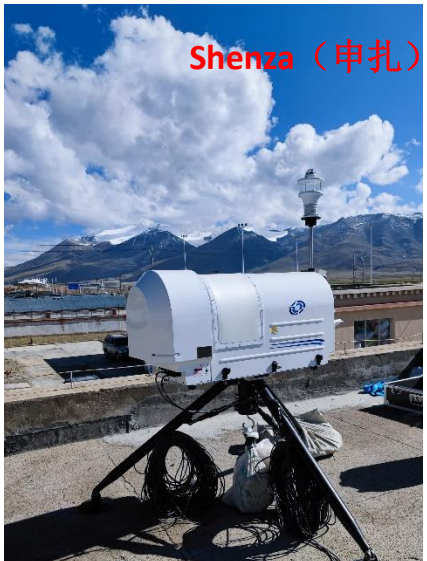




New microwave radiometer network(10) was constructed during STEP.

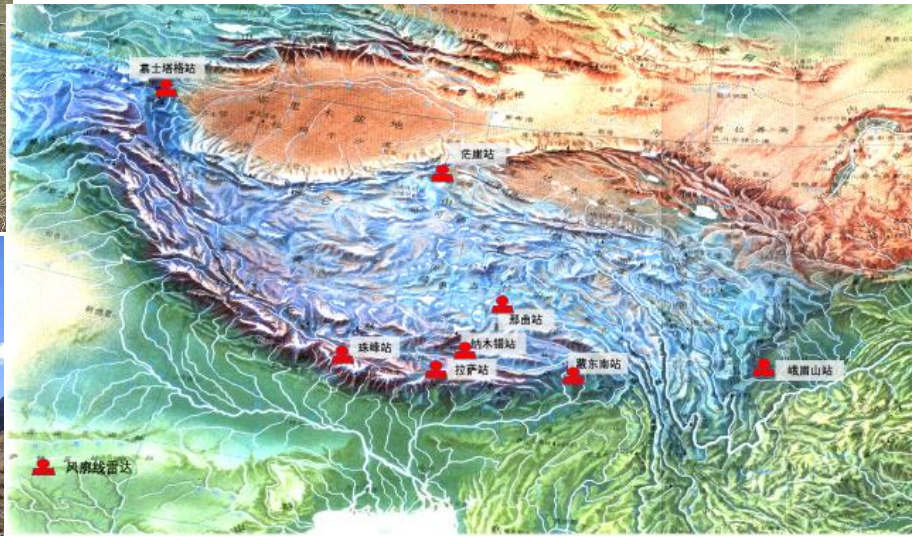




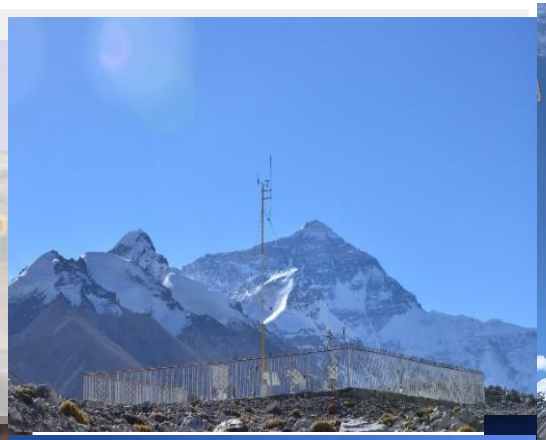


(Chen,Liu* and Ma*,Y. et al., 2024,AAS)

New Wind-profiler network(9) was constructed.



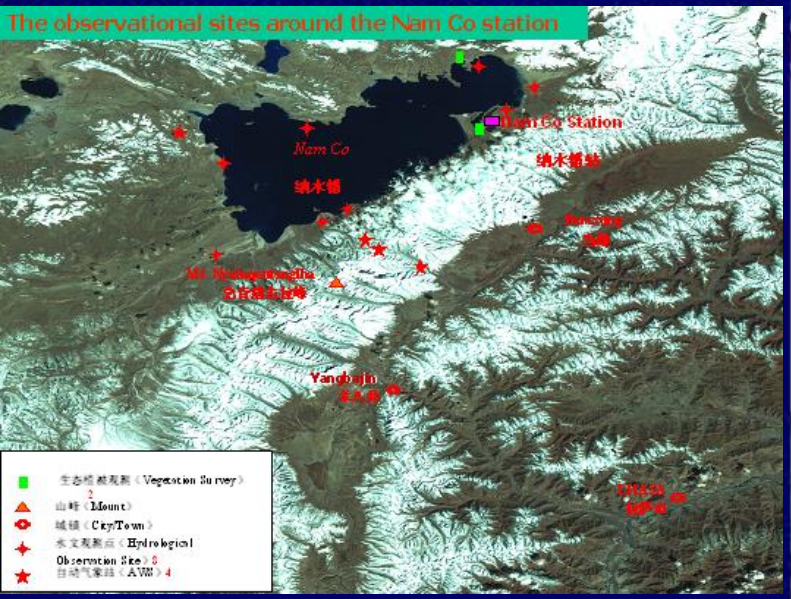
(1)National Observation and Research Station for Qomolongma Special Atmospheric Processes and Environmental Changes，Tibet，China (QOMS，2004-present)

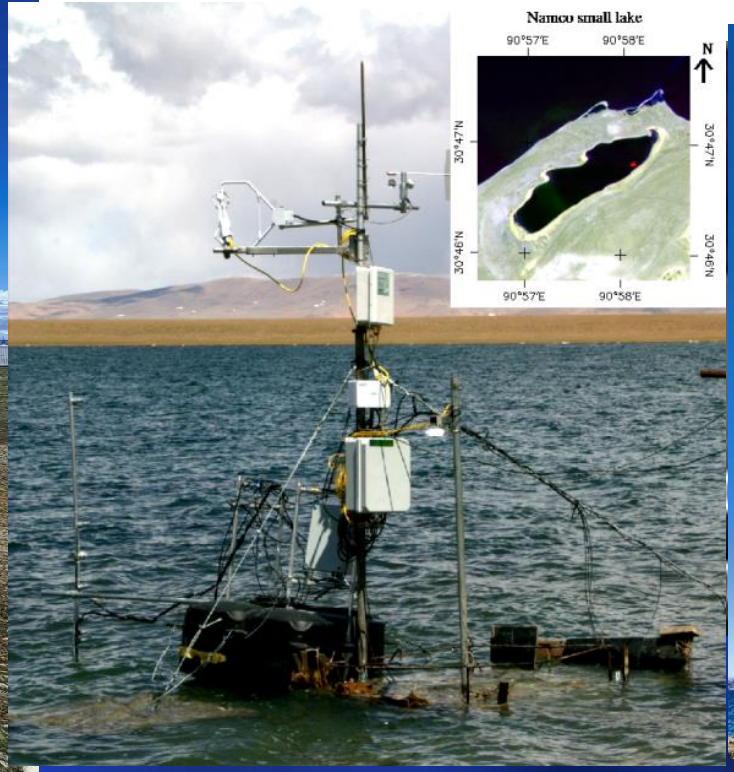


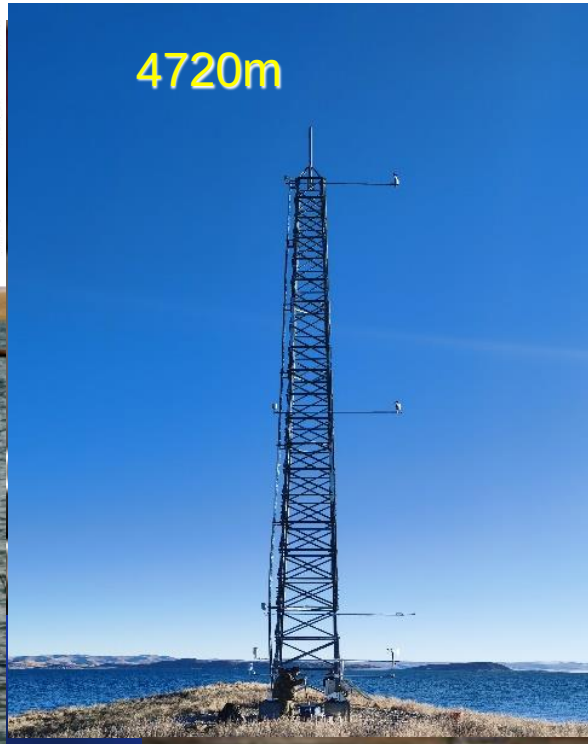

2). Nam Co Station for Multisphere Observation and Research (NAMOR), Chinese Academy of Sciences
Nam Co Station
Constructed date:
End of September, 2005

Nam Co St.

The observational sites around the Nam Co station




Namco small lake
90°57'E
90°58'E
N
30°47'N
30°46'N


4720m


Radiation system


PBL tower
iation system
SMTMS)


Turbulent system,CO2/H2O flux
and radiation system

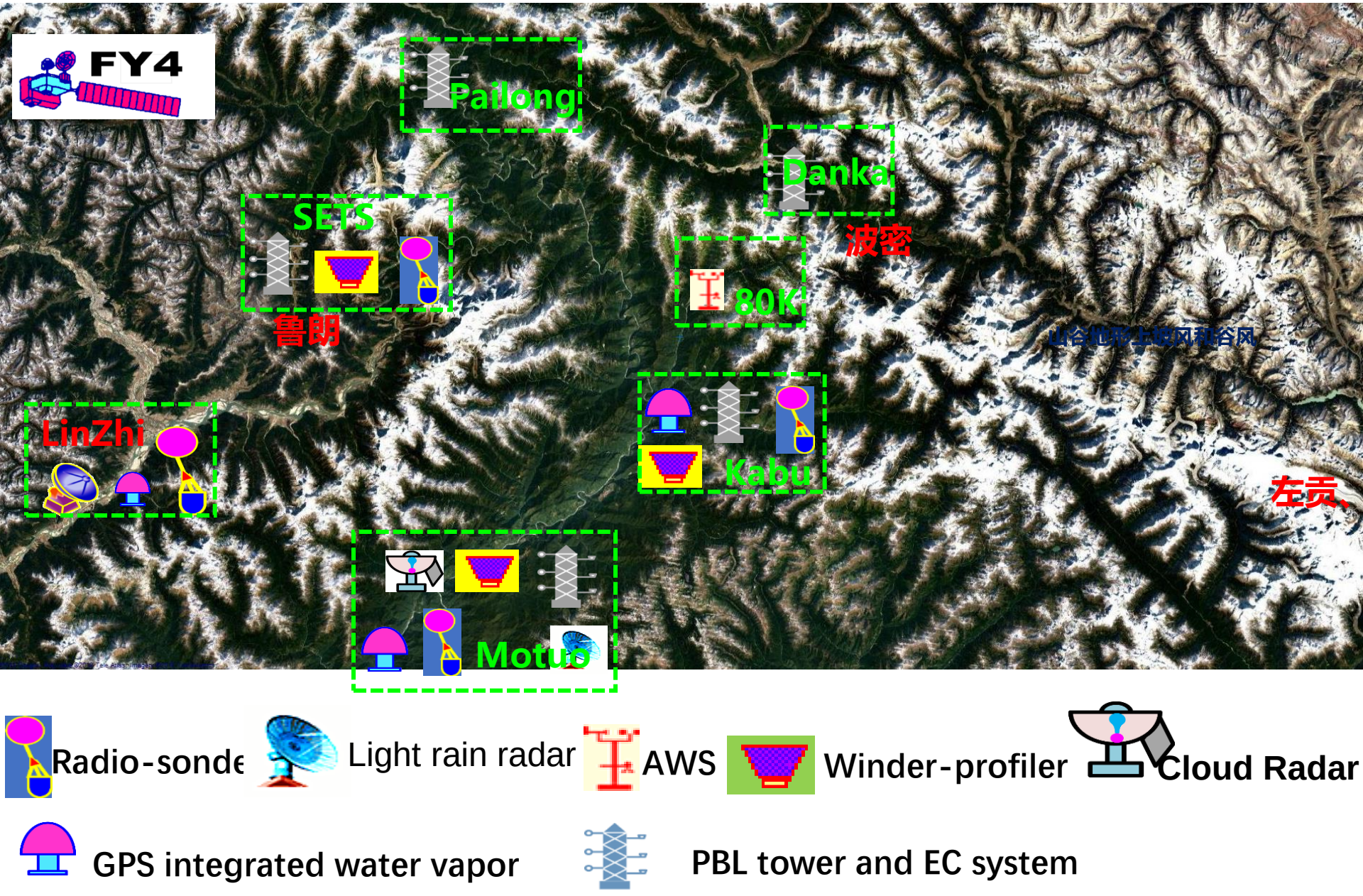

Evaporation Observatio

3). Southeast Tibet Station for Alpine Environment Observation and Research (SETS), CAS （Linzhi Station）

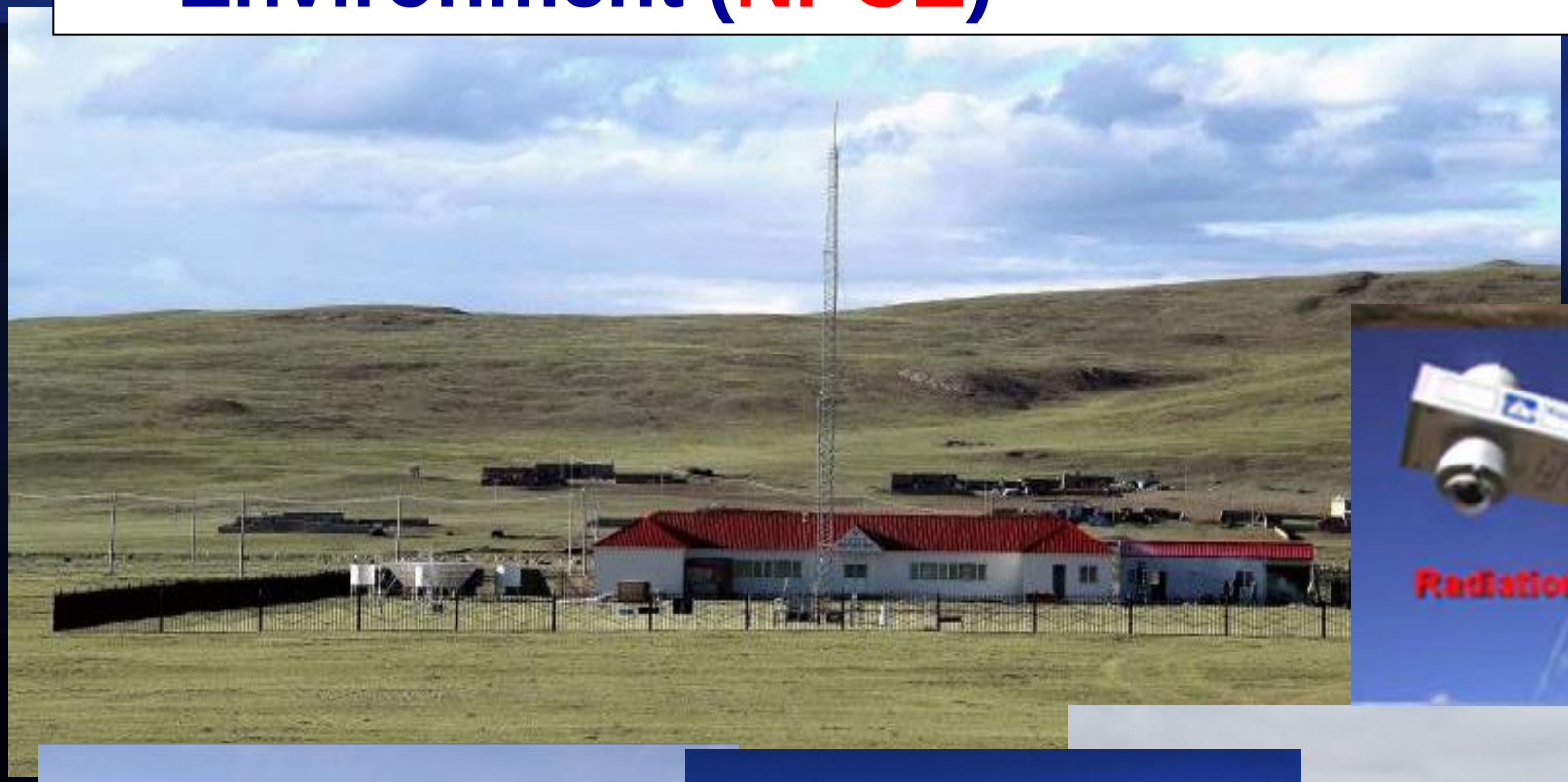
Constructed date: Beginning of November, 2006

森林生态、大气过程、湖泊-冰川相互作用

SETS intensifies observation efforts during Second Tibetan Plateau Scientific Expedition and Research (STEP) (Chen*,Xu,Ma* et al.,2024,BAMS)

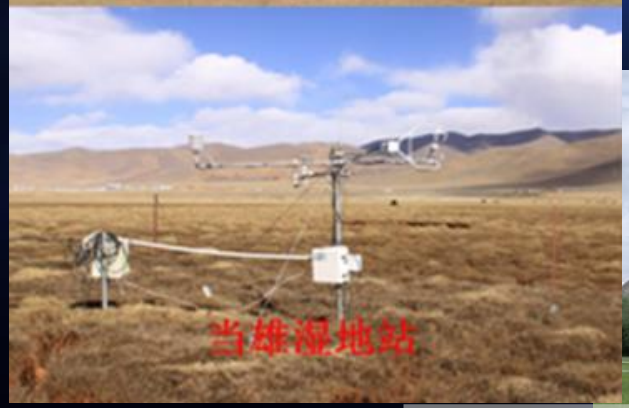


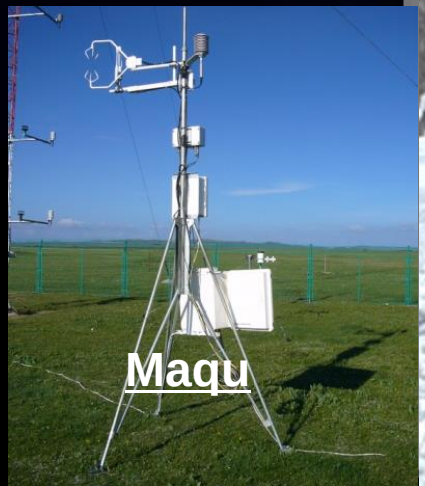
4).Nagqu Station of Plateau Climate and Environment (NPCE)

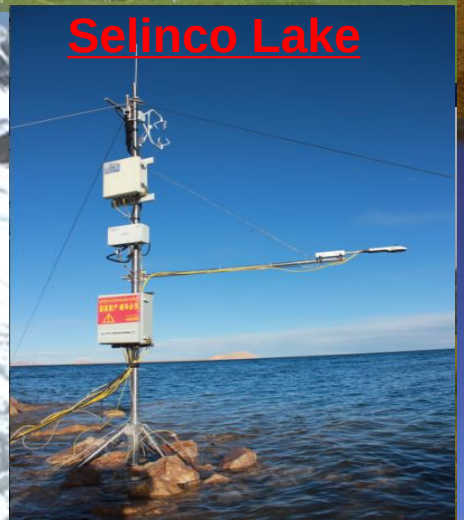


5）拉昂错湖泊（Laang Lake）站

Flux stations over the different land surface



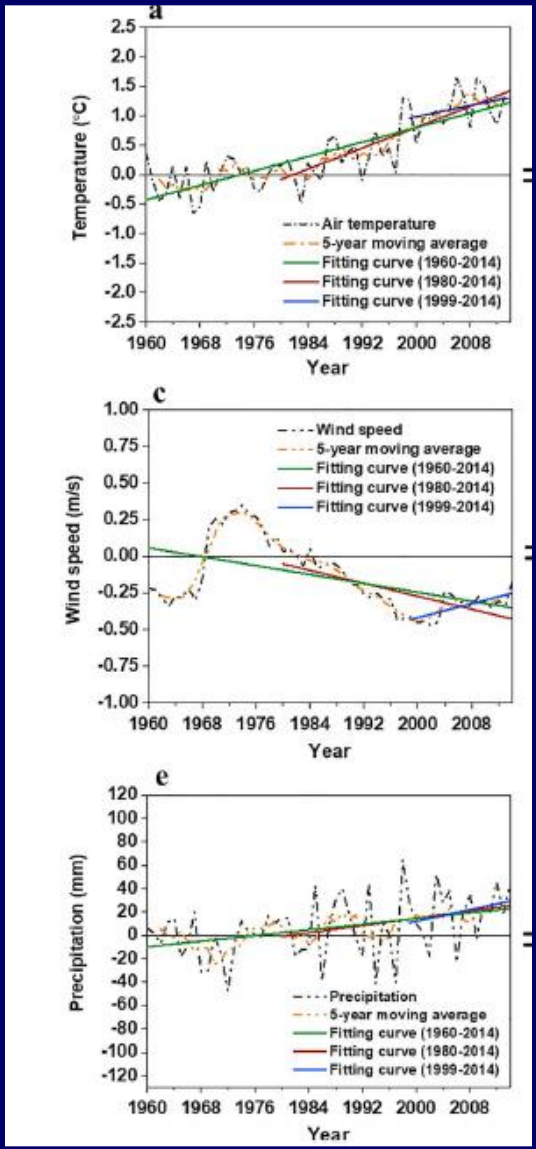




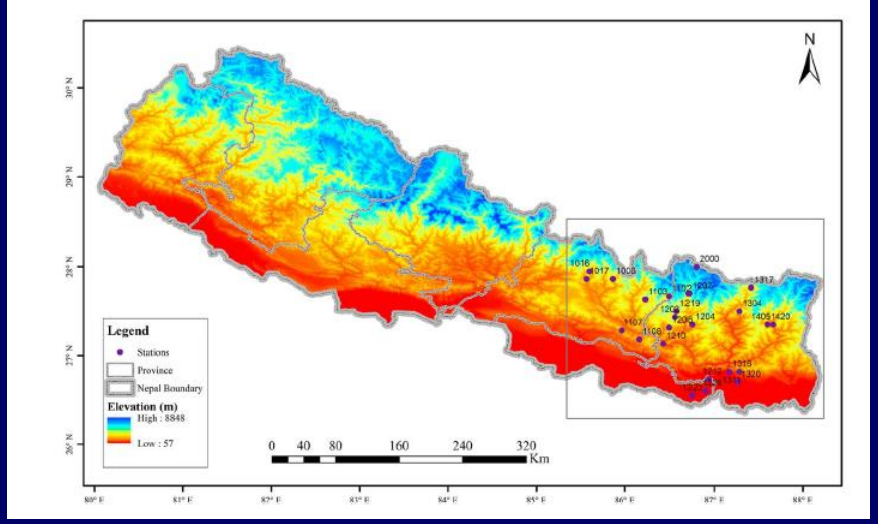
The TP database was constructed(open for the research and application, welcome!!)

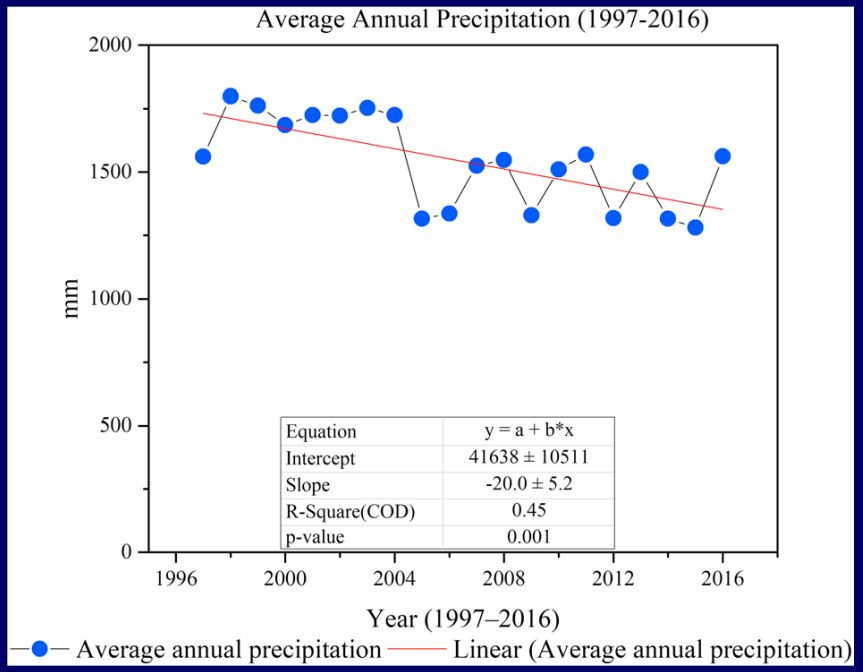
(Ma,Y. et al., 2020, *ESSD*； Wang and Ma*,Y.,2020,SA;Nieberding, ……Ma*,Y. et al., 2020, *ESSD*；Han and Ma*,Y. et al., 2021,*ESSD*; Chen et al., 2021,*JGR*；*Ma, Y. et al., 2022,AOSL;* .(Ma,Y.,et al., 2023,ESR;Ma,Y., et al.,2023,BAMS； Chen et al., 2024,AAS； Ma,Y. et al., 2024,ESSD)

Data	variables	Period	resolution
Satellite https://data.tpdc.ac.cn/allData?searchContent=%E8%A2%81%E4%BB%A4	Surface temperature, surface albedo,net radiation, soil heat flux,sensible heat flux, latent heat flux, evapotranspiration	2001-2023	1kmX1km https://data.tpdc.ac.cn/zh-hans/data/a80882c3-c764-495b-bea9-40e7b57d01f5
In-situ https://data.tpdc.ac.cn/zh-hans/data/b9ab35b2-81fb-4330-925f-4d9860ac47c3	Air temperature, wind speed, Surface temperature、radiative humility、four components radiation fluxes、soil heat flux, sensible heat flux, latent heat flux, CO_2/H_2O flux	2005-2023	NAMORS、QOMS、SETS、Naqu（1997-2018）、NASDE、MASWE、Yadong, Shuanghu（2012-2018）、Four stations in Nepal（2012-2018） https://data.tpdc.ac.cn/zh-hans/data/6442c3ca-190f-4106-a1dc-63344cd4f8e5
microwave radiometer	The profile of humidity and temperature	2021-2023	QOMS、SETS、Naqu、NASDE、MASWE、Mangai、Emei http://data.tpdc.ac.cn/zh-hans/data/56277ad2-c83e-4453-8ae2-70cc877a4581/.

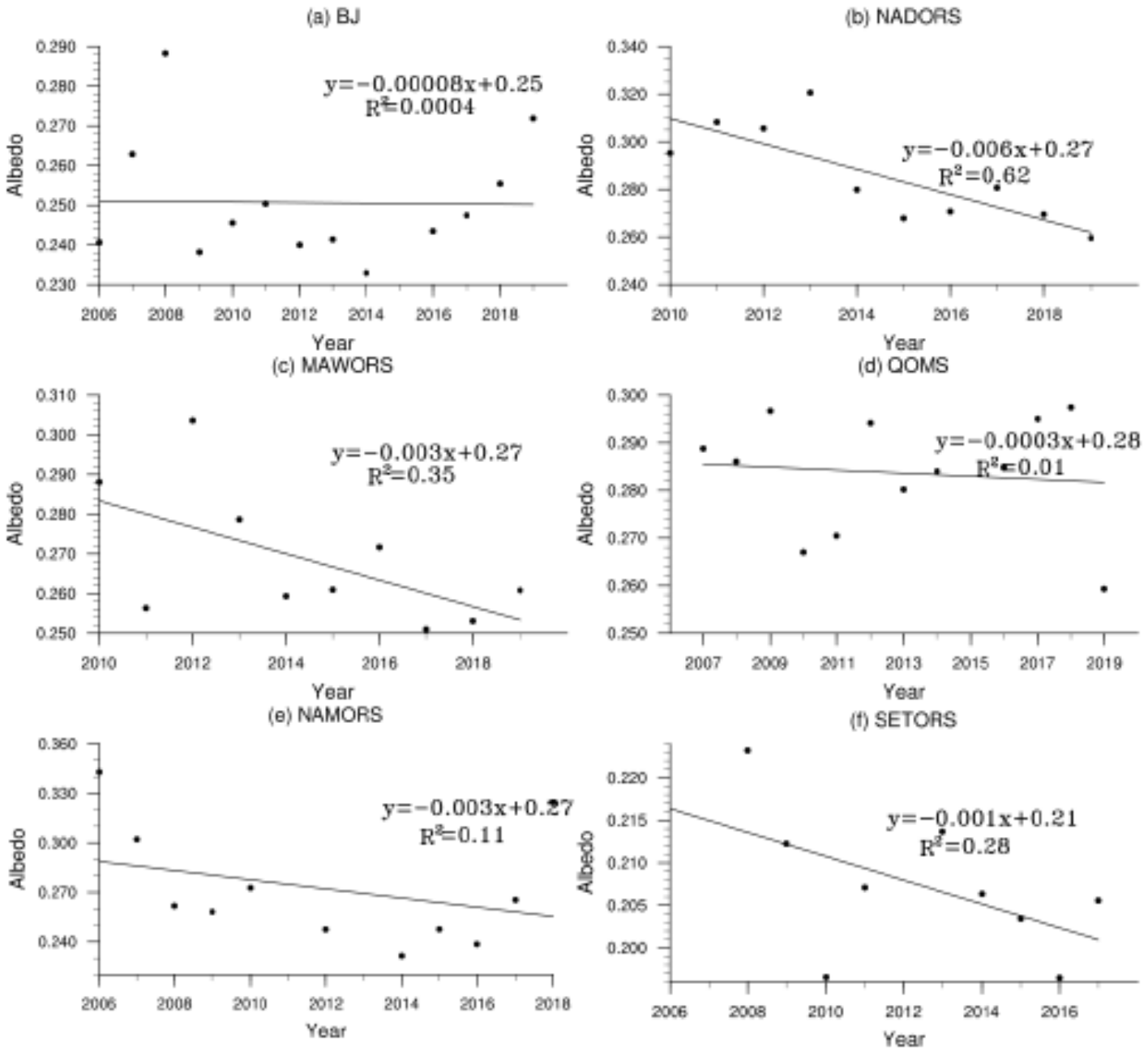


(Zhong and Ma* ,Y.et al., 2019 , *JGR-Atmospheres)*



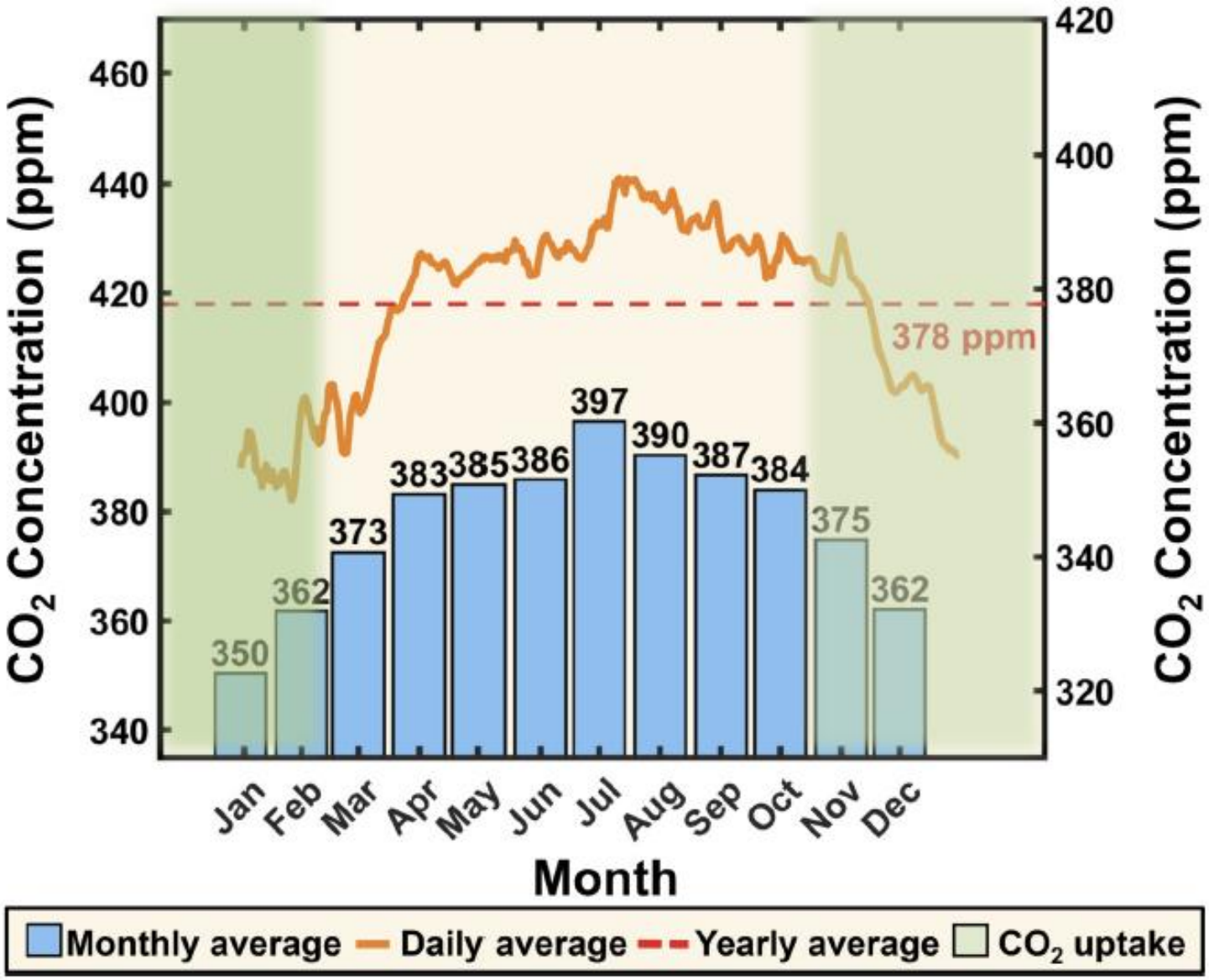


Subba and Ma*,Y. et al., 2019 , *JGR-Atmospheres*

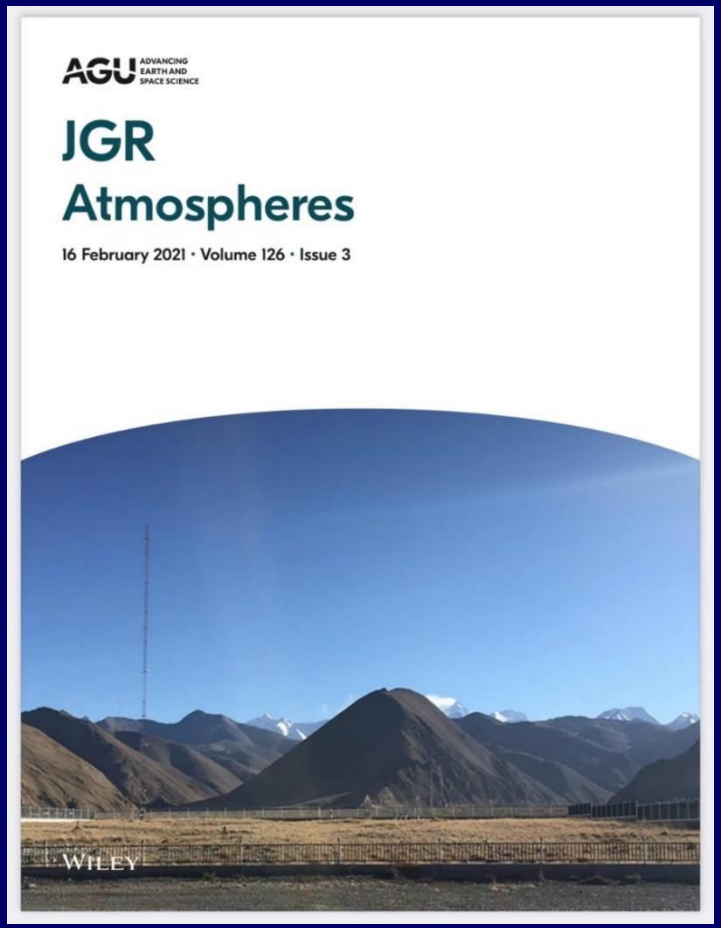


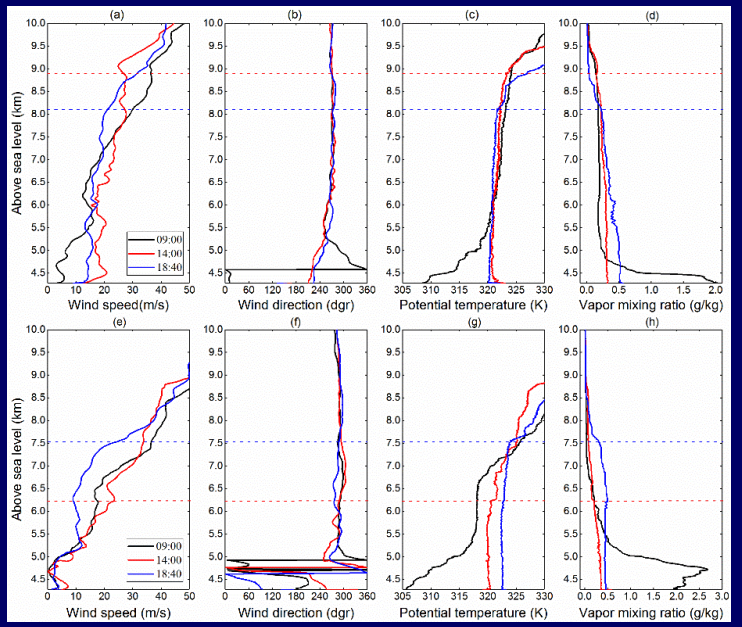
it means that TP becoming warming and wetting, ecological conditions will be better improved

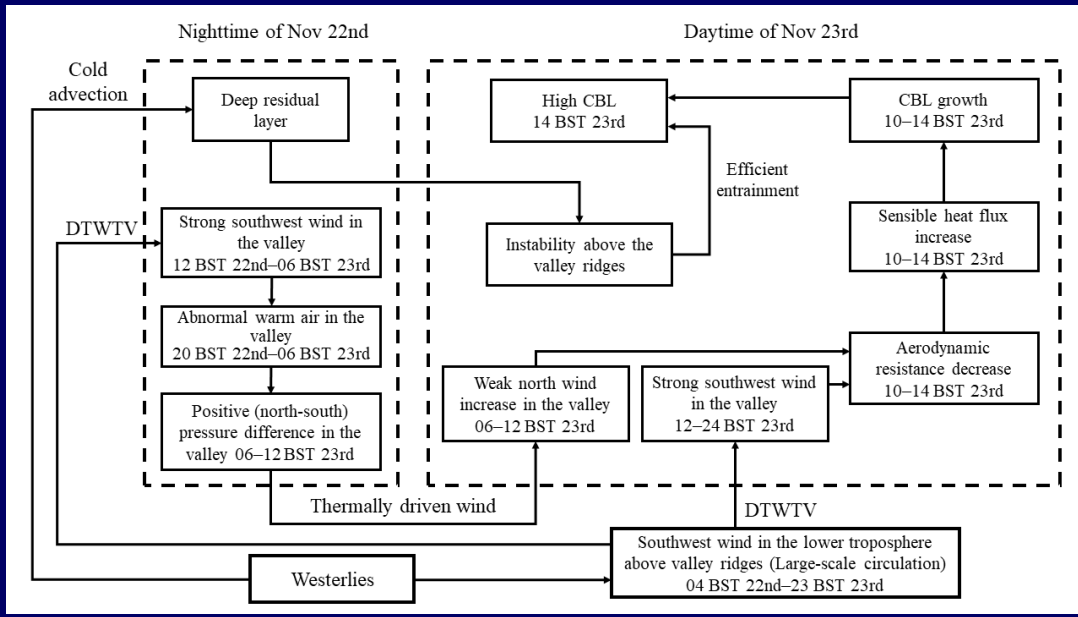
Wang and Ma*,Y. et al., 2021 , *Water*



(Li,Wang*, Ma* ,Y. et al., 2024,*STE*))







- The valley winds and PBL growth were strongly influenced by the variations of the westerlies
- The significant difference in the PBL depths demonstrates the important role played by the interaction between the local topography and large-scale synoptic winds in the formation of the PBL.

(Lai, Chen*,Ma*Y. et al., 2021,*JGR-Atmospheres*)

4. Determination of surface heat fluxes and evapotranspiration(*ET*) over the heterogeneous landscape by using satellite data

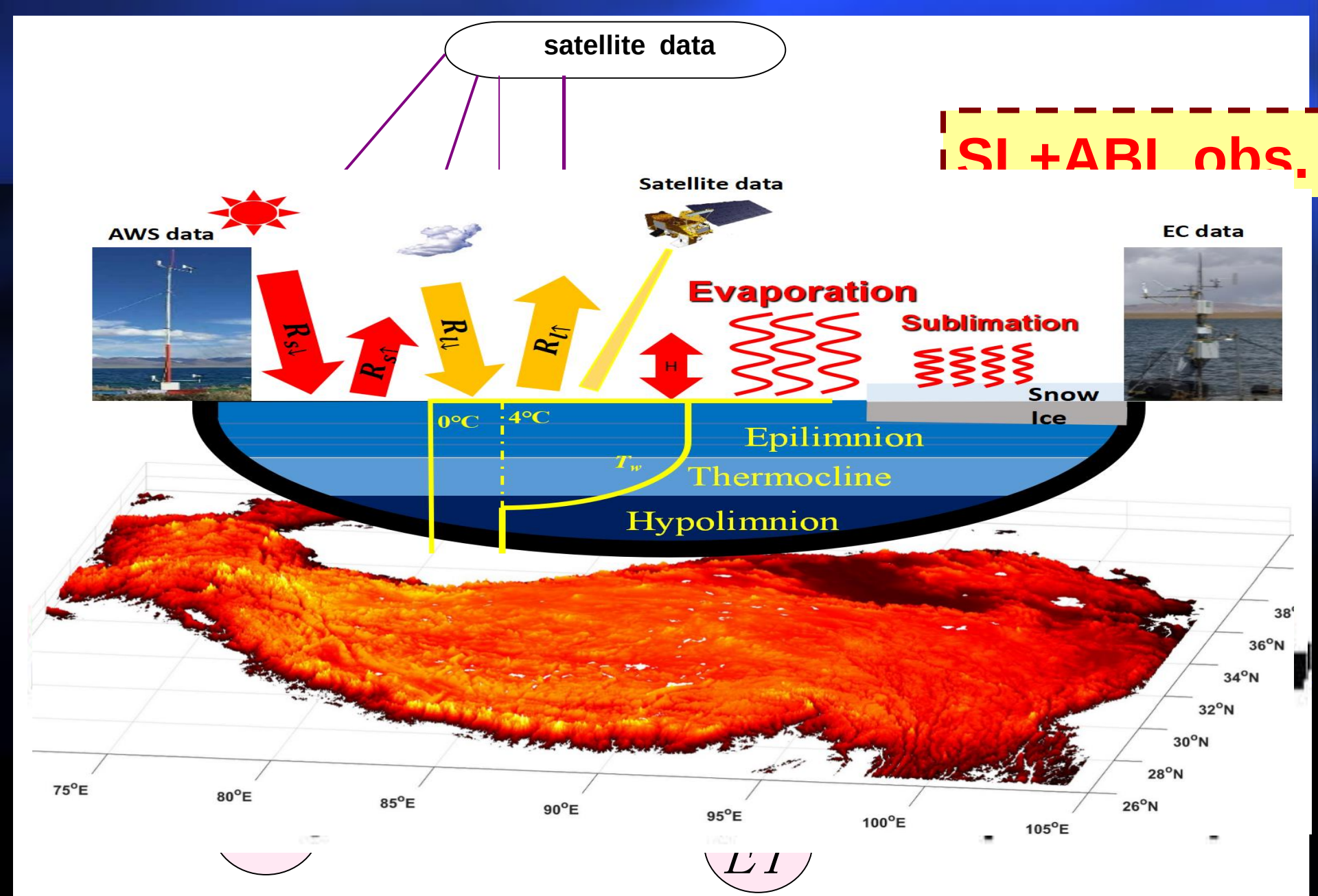
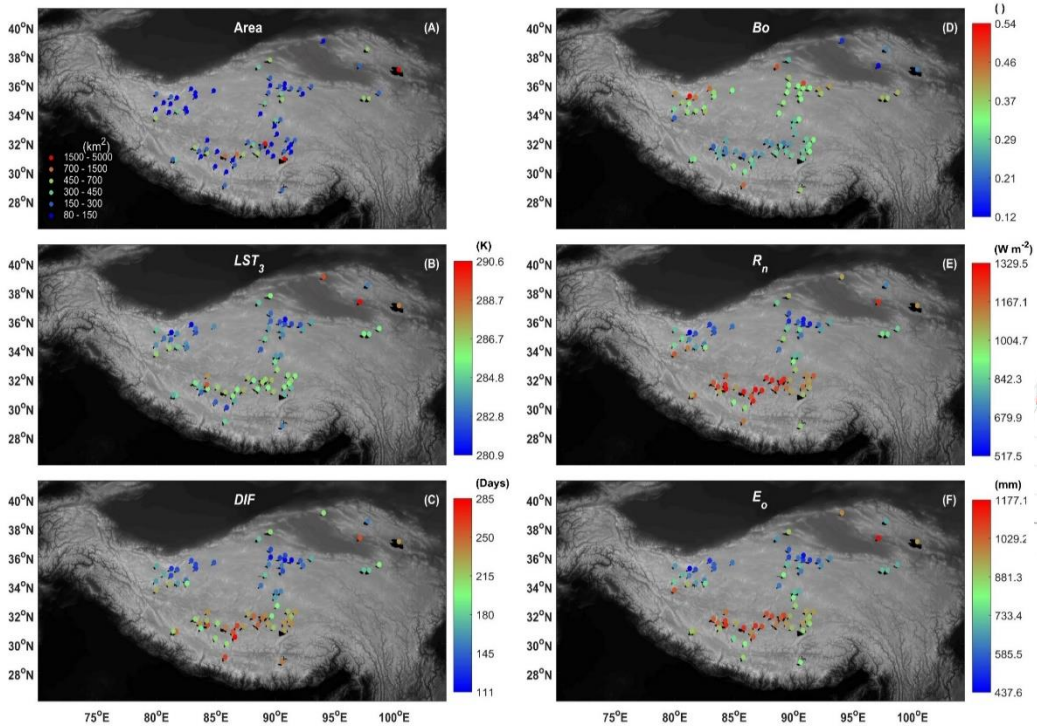
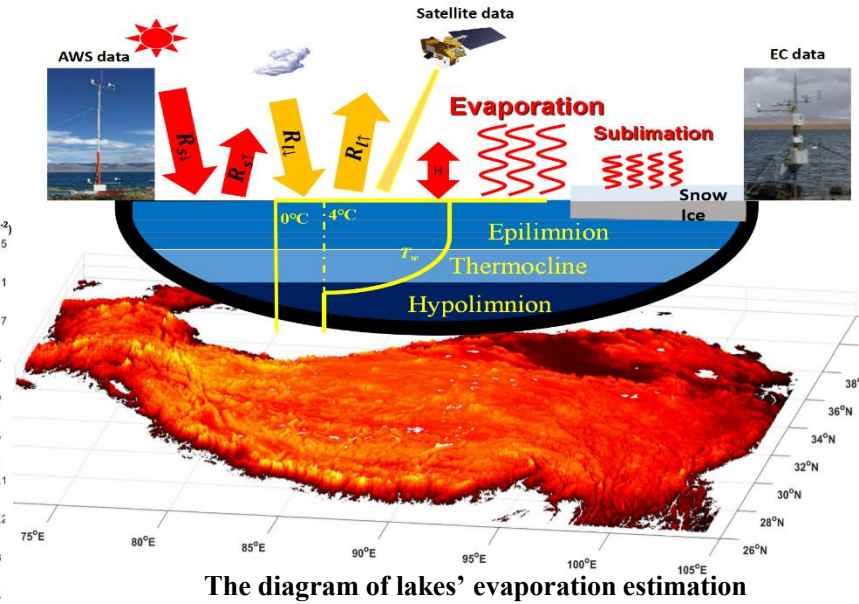


Diagram of parameterization procedure by MODIS data with field observations（Ma,Y. et al., 2014, ACP; Ma,Y. et al., 2018,IJES; Ma,Y. et al., 2021,PM,Ma et al., 2023,ESR)

We proposed an innovative method for regional lake evaporation estimation using satellite data and *in-situ* data.



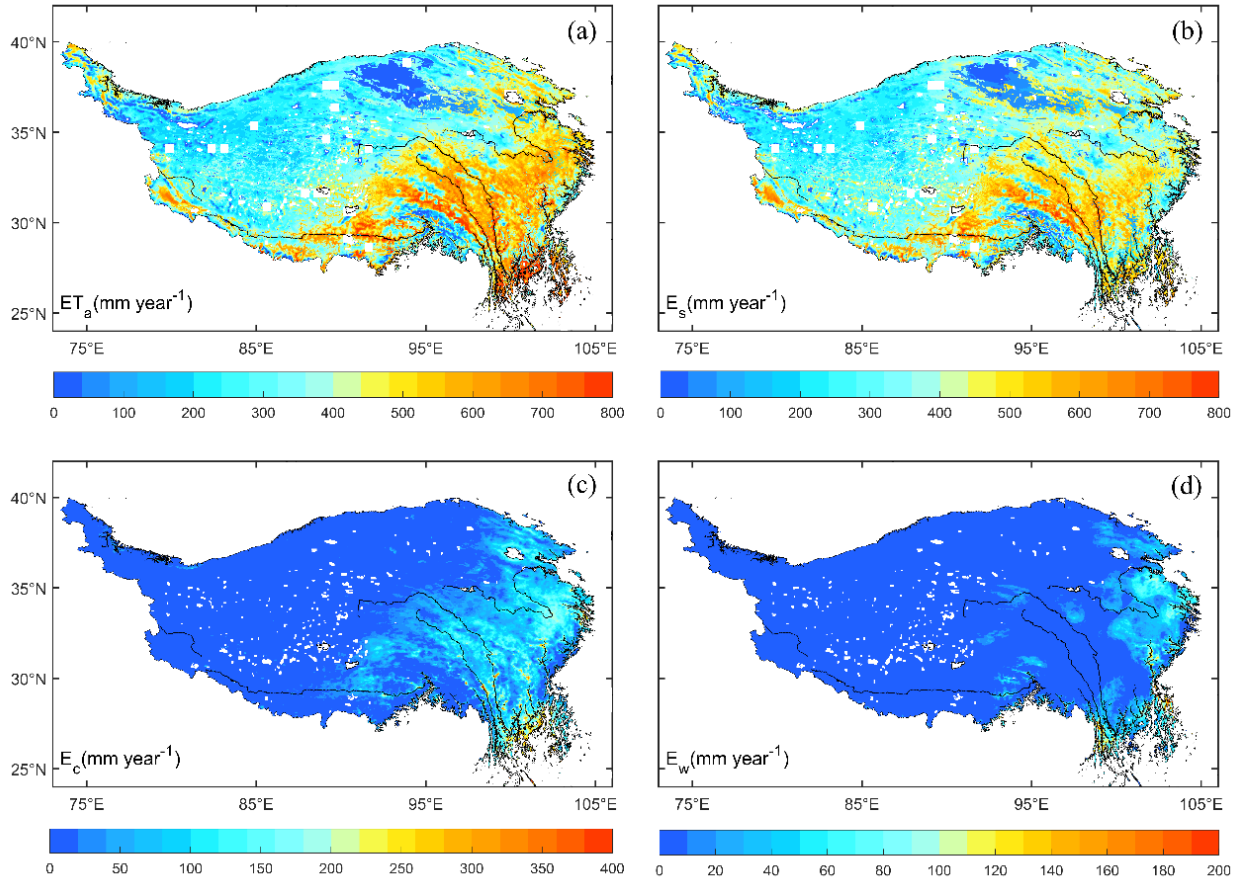


The diagram of lakes' evaporation estimation

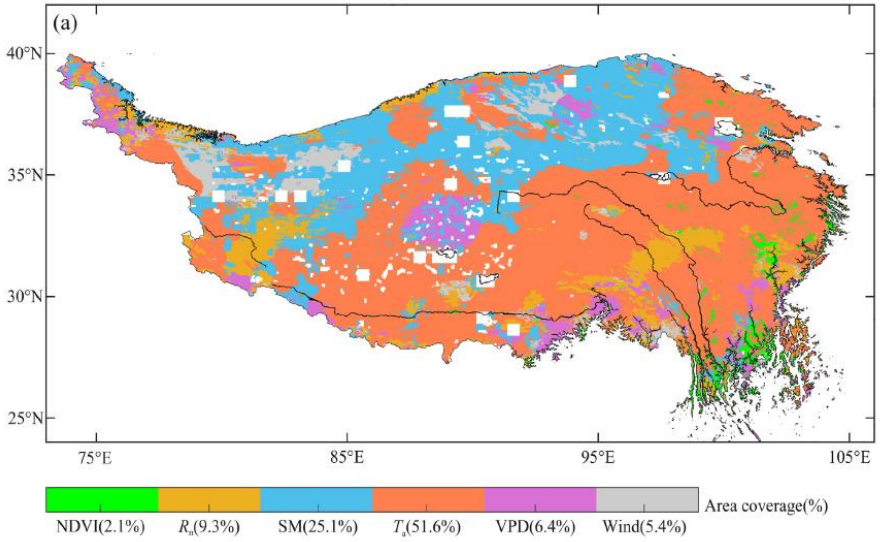
- The evaporation amounts show large variability in spatial distribution, with a pattern of higher values in the south.
- The total evaporated water amounts have values of approximately 29.4 ± 1.2 km^3 $year^{-1}$ for the 75 studied lakes and 51.7 ± 2.1 km^3 $year^{-1}$ for all plateau lakes included.

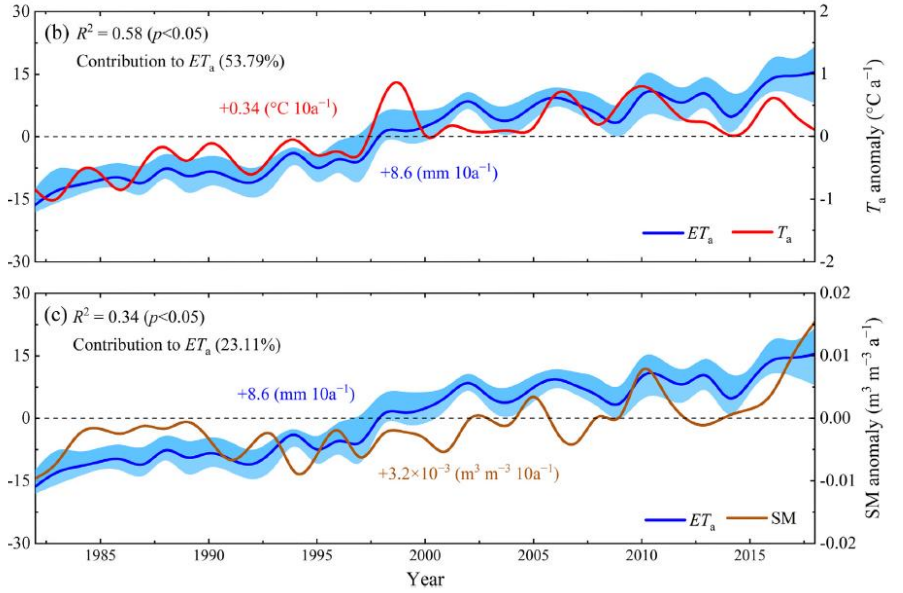
Wang et al., 2020, *Science Advances*

(Yuan, Chen*,and Ma* et al., 2024, ESSD)



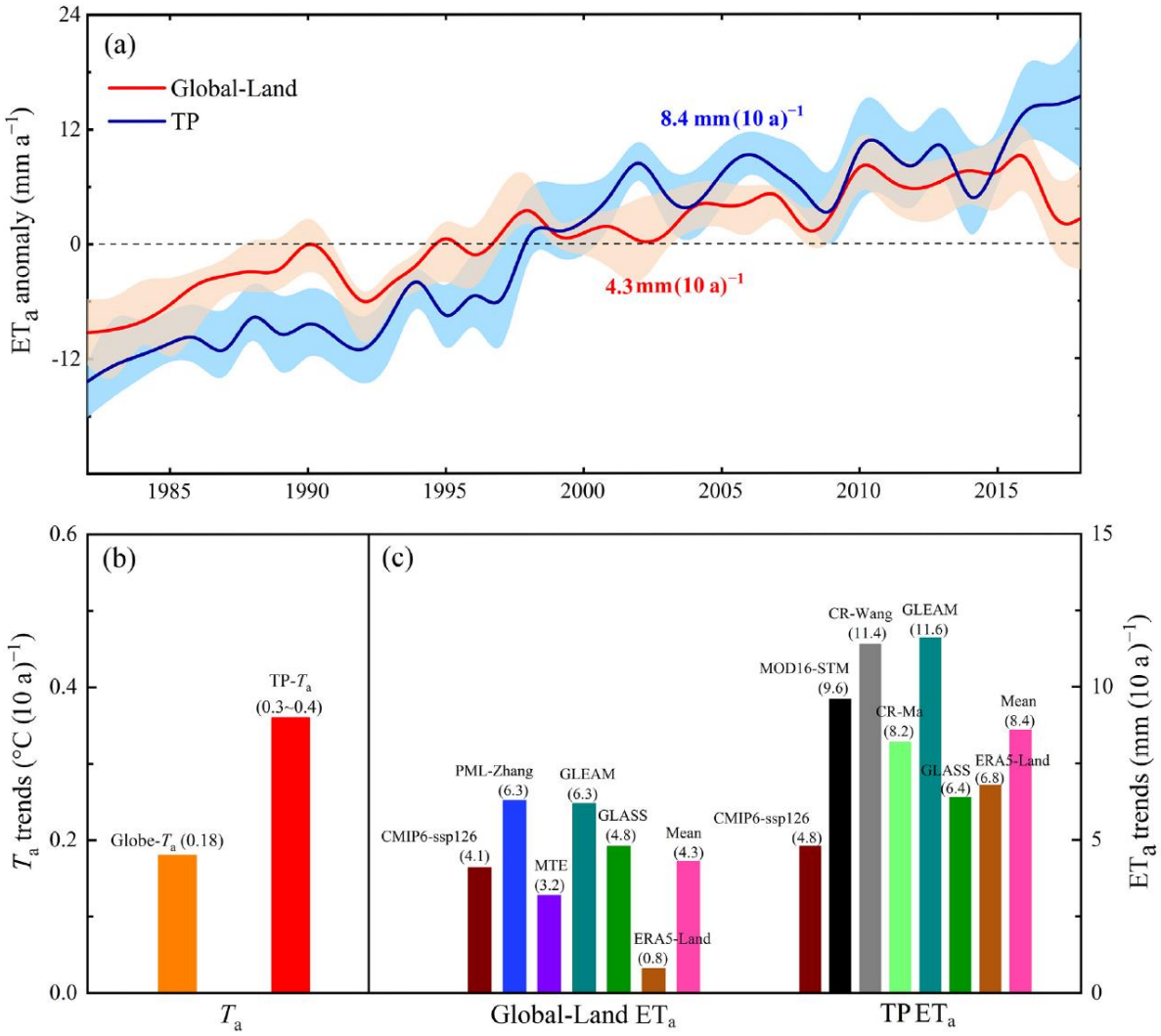
The mean annual ET_a the whole TP was 346.5 mm. Thus, the total evapotranspiration from the terrestrial surface of the TP was 930 ± 37 Gt yr^{-1}





Numerical attribution analysis revealed that a 53.8% TP area with the increased ETa was caused by increased temperature and 23.1% part was due to soil moisture rising, because of the warming, melting cryosphere, and increased precipitation.

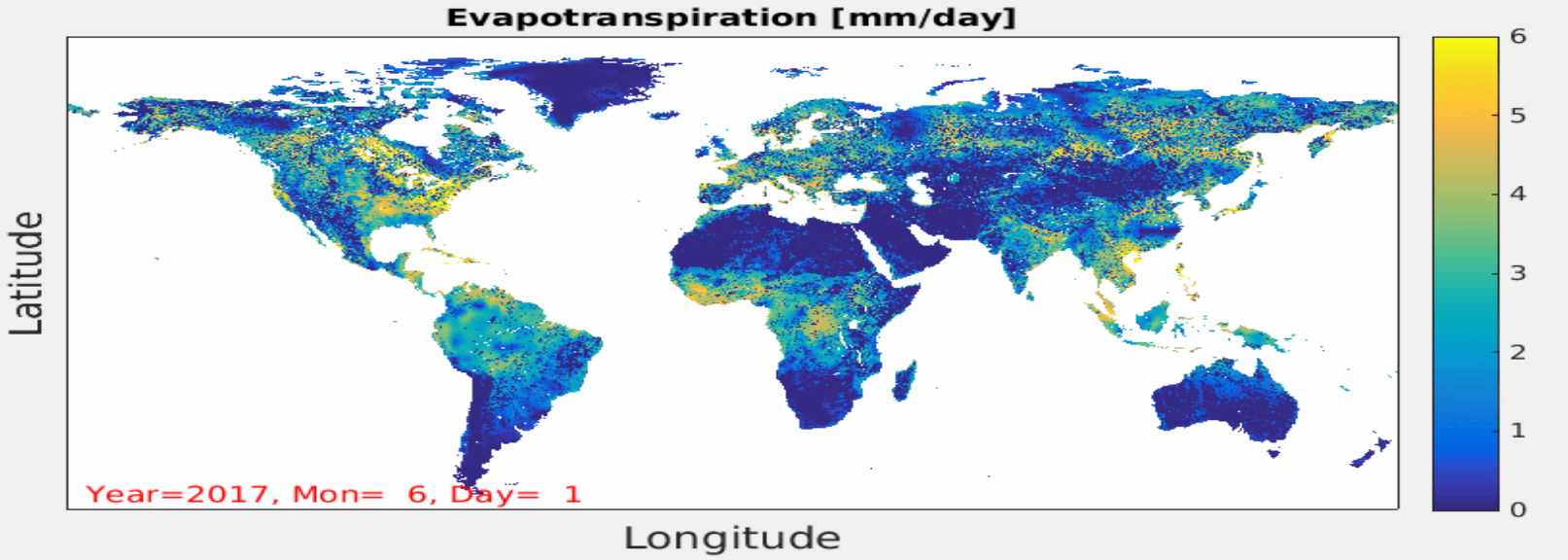
(Chen*, Yuan, Ma*,Y. et al., 2024, Science Bulletin)

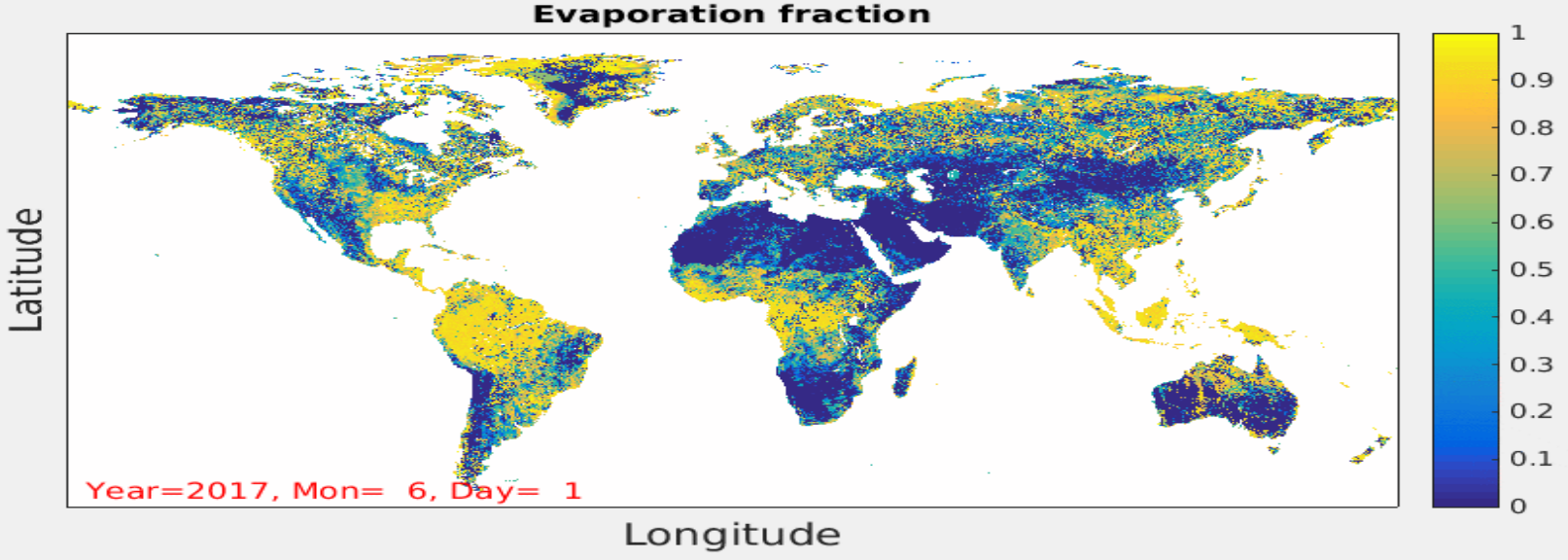


- **ET on the TP experienced a significant increasing trend of around 8.4 ± 2.2 mm/ 10y during 1982–2018, approximately twice the rate of the global land *ETa* (4.3 ± 2.1 mm/ 10y)**

(Chen*, Yuan, Ma*,Y. et al., 2024, Science Bulletin)

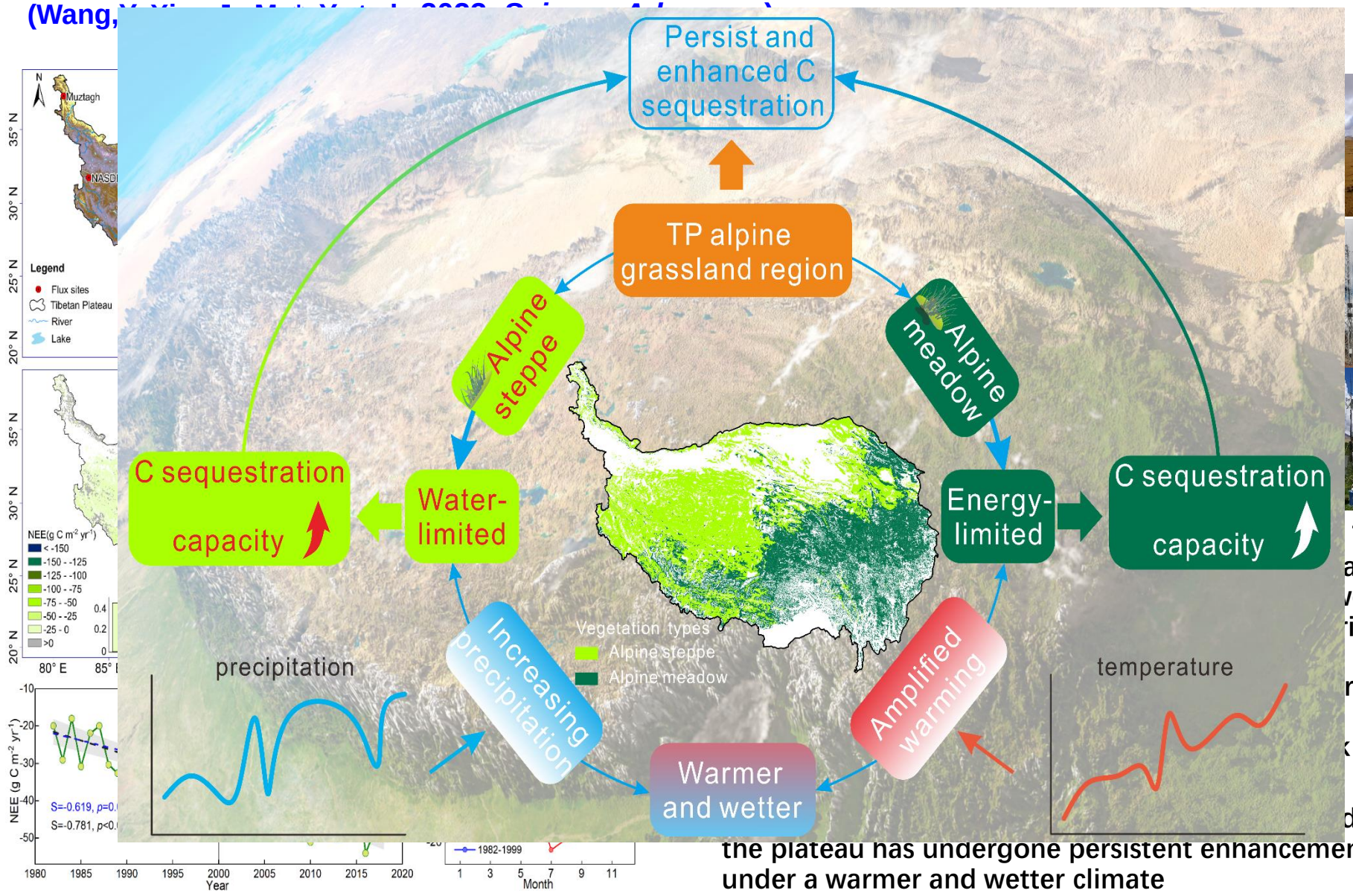
（Chen, Su and Ma et al., 2021, JGR:Atmosphere）





By using the observations, satellite data and machine leaning, we found that: Carbon sequestration capacity of alpine grasslands on the TP has undergone persistent enhancement!

(Wang,



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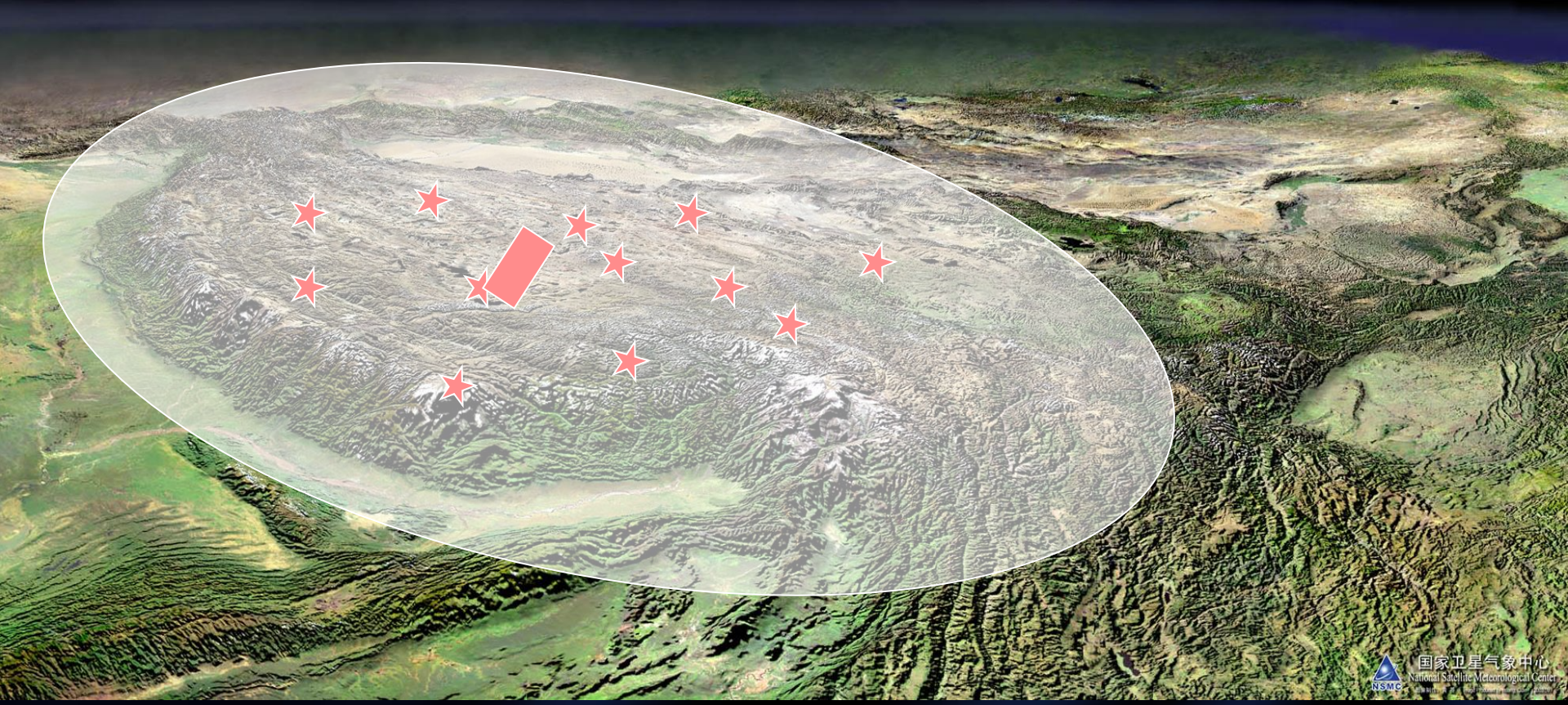
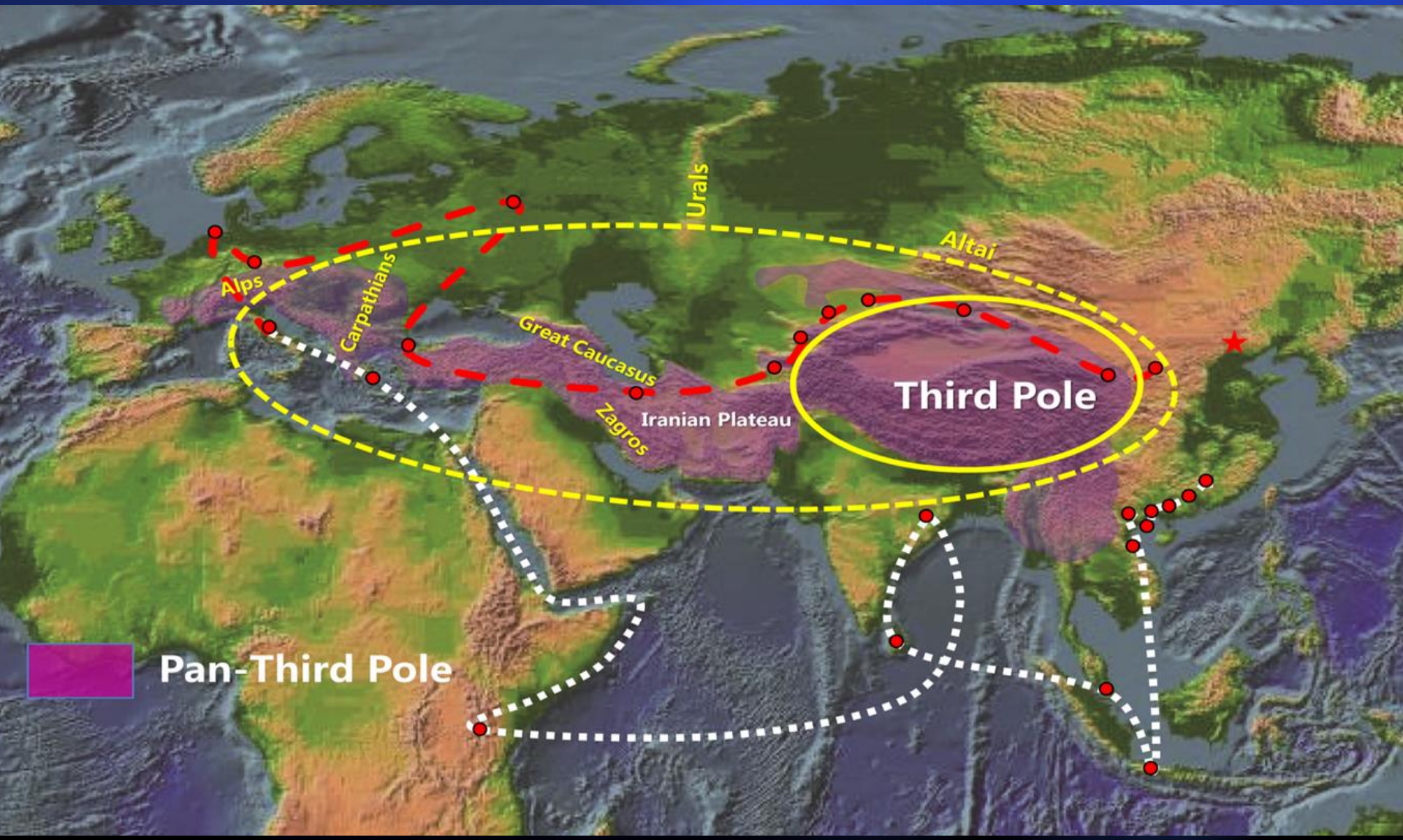
the plateau has undergone persistent enhancement under a warmer and wetter climate



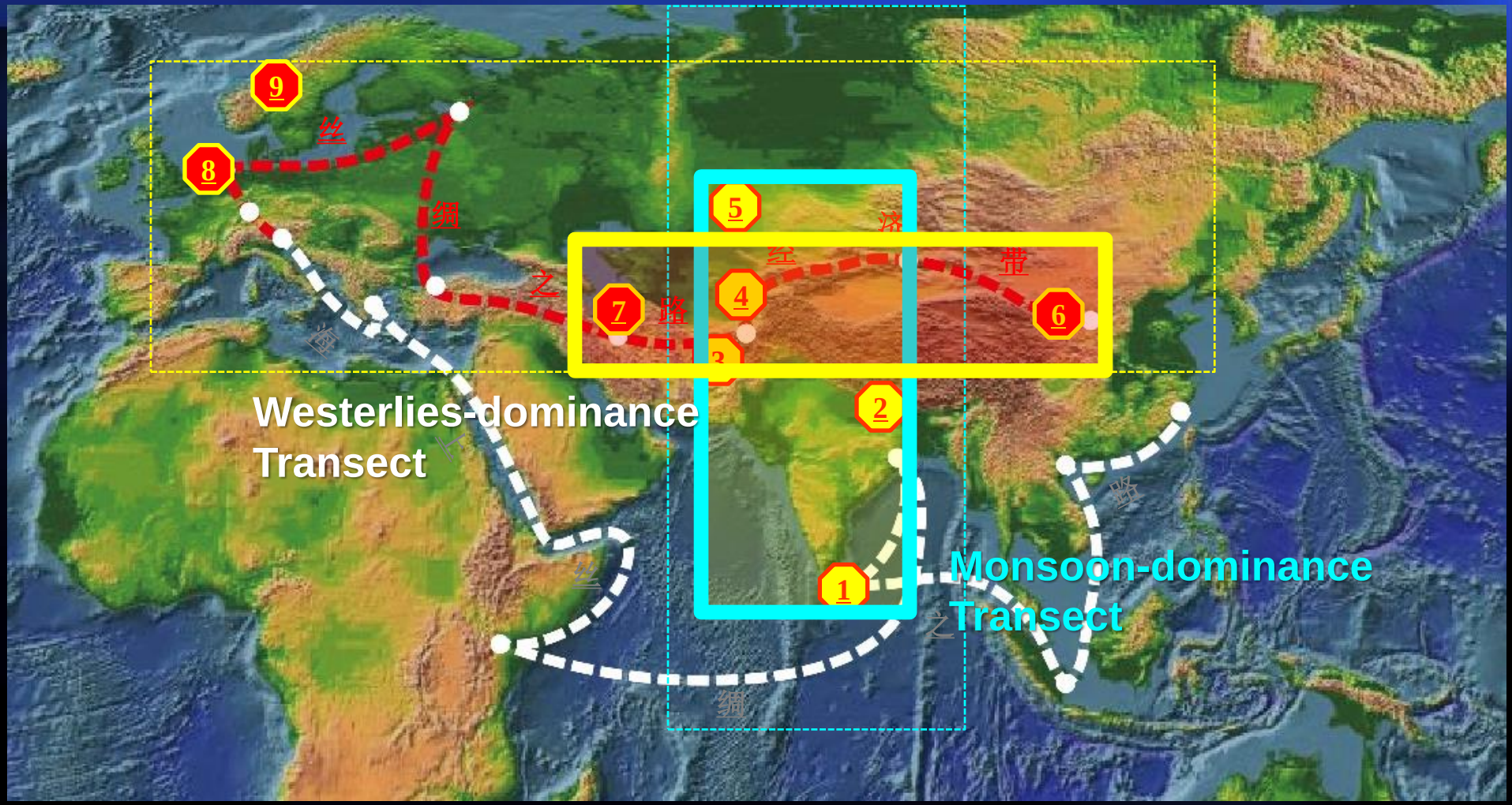
5.Future work :

How can we go to entire Third Pole region (Tibetan plateau and nearby surrounding region) and Pan-third pole region …??

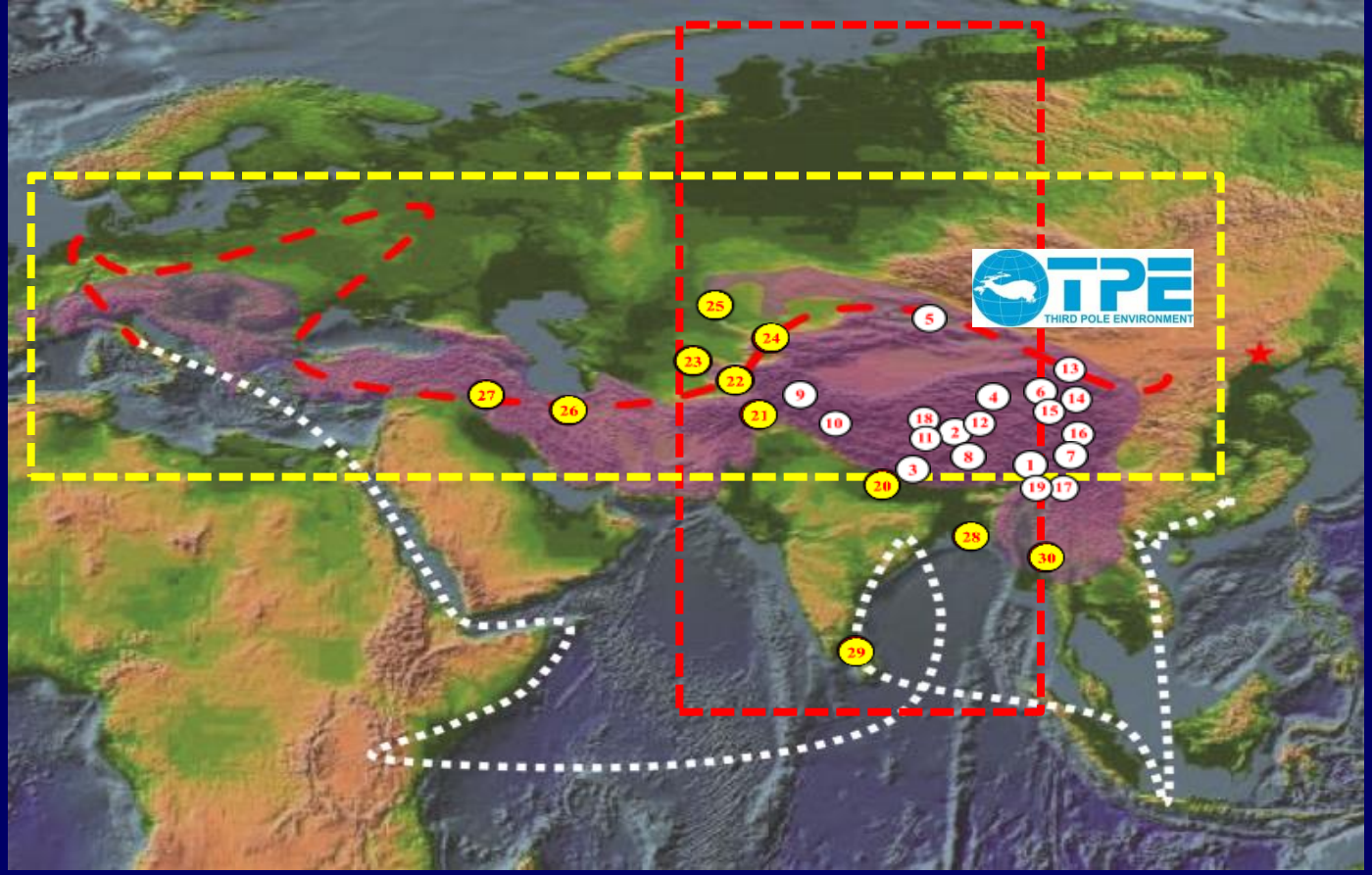


（Yao et al., 2017,BCAS）

Pan-TPE: Regional longitudinal and latitudinal transects

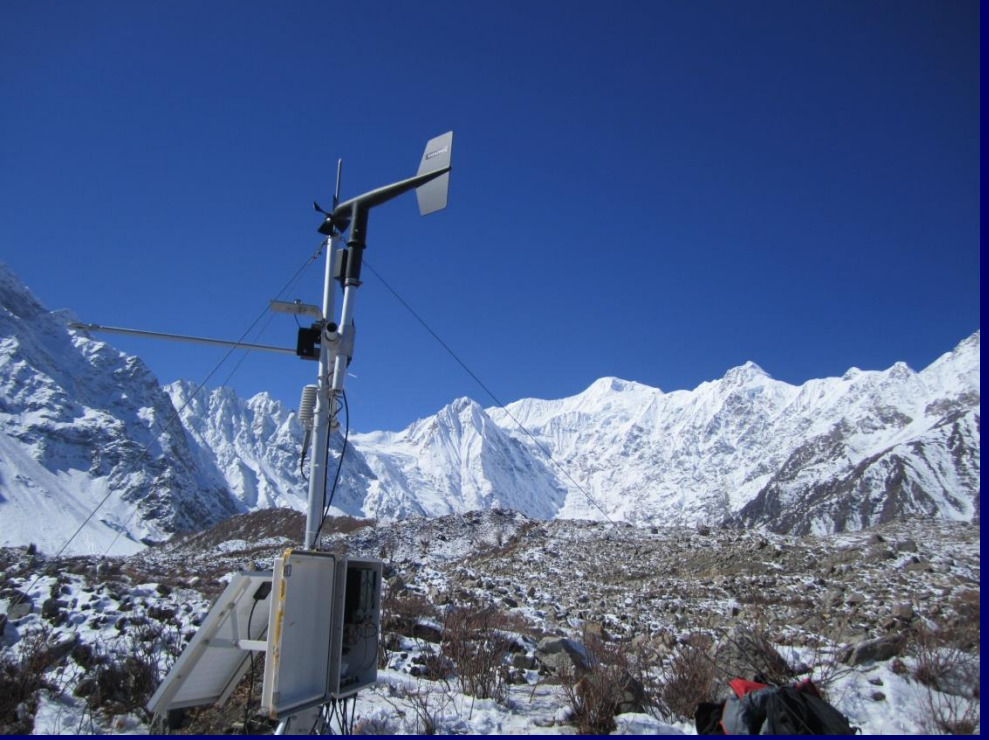


1 Sri lanka
2 Kathmandu
3 Pakistan
4 Tajikistan
5 Kazakhstan
6 Lanzhou
7 Iran
8 Germany
9 Sweden



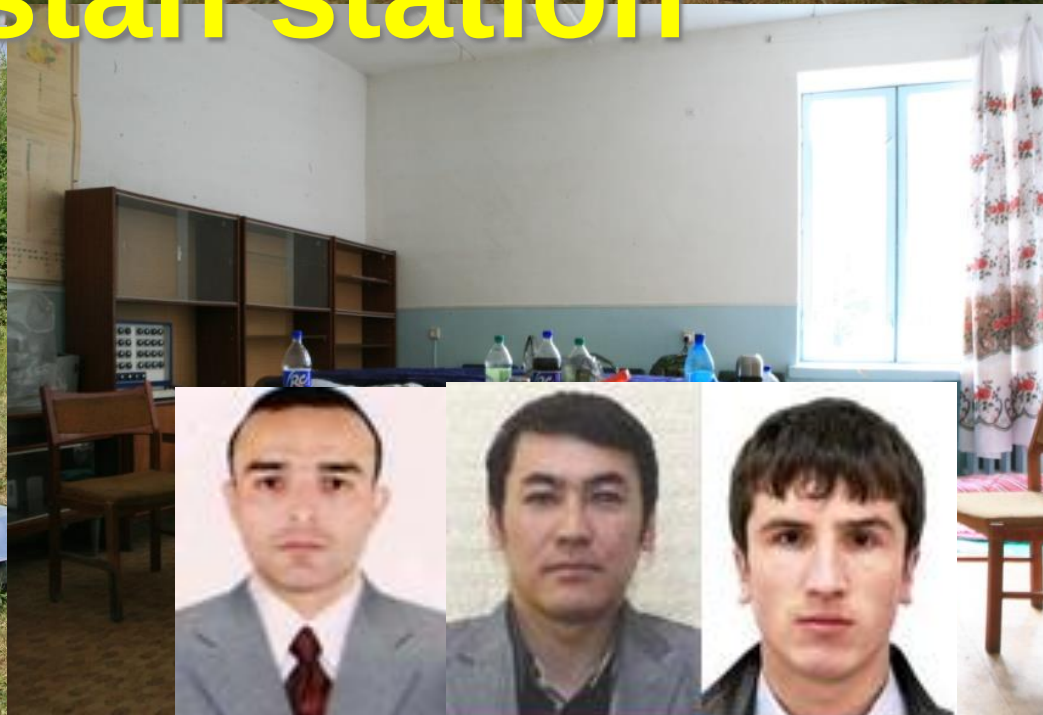
1. Southeastern TP station
2. Namco station
3. Qomolangma station
4. Golmud station
5. Tienshan station
6. Haibei station
7. Gongga station
8. Lahsa station
9. Muztagh Ata station
10. Ngari station
11. Shenzha station
12. Nagqu station
13. Qilianshan station
14. Qinghai lake station
15. Three rivers sources station
16. NoMt. Yulong station
17. Srgay station
18. huanghu station
19. Motuo station
20. Katmandu(Nepal)
21. Gilgit(Pakistan)
22. Tajikistan (3)
23. Uzbekistan (3)
24. Kyrghyzstan (3)
25. Kazakhstan(6)
26. Iran-1
27. Iran-2
28. Dacca
29. Sri Lanka
30. Myanmar

Lumle
尼泊尔
Langtang
Katmandu
Simara
南亚季风



Pakistan

Tajikistan station



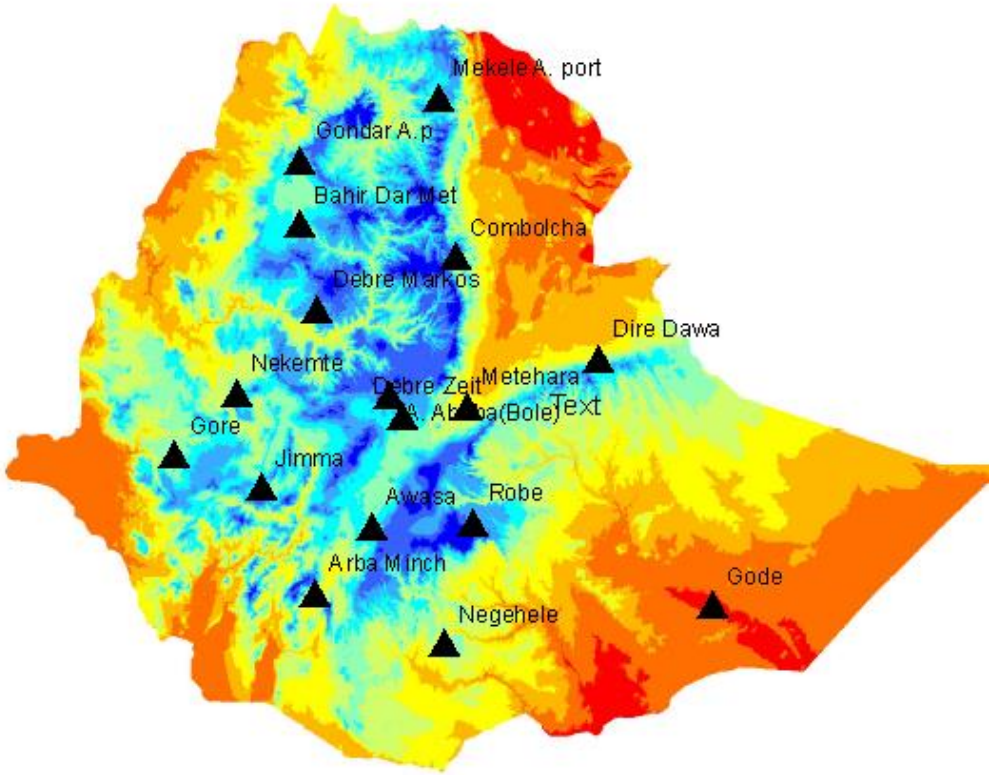


Station	Country	Lon(E)/Lat(N)	Elevation (m)	Ecosystem Type	Start year
Kalabalik	Kazakhstan	62° 06’07/53° 50’52	195	grassland	2012
Shchuchinsk	Kazakhstan	70° 13'10/52° 56‘52	400	forest	2012
Atyrau	Kazakhstan	51° 56'52/47° 9'54	20	desert	2012
Kyzylorda	Kazakhstan	60° 59'7/46° 1‘54	55	wetland	2012
Almaty	Kazakhstan	76° 13‘6/44° 38‘25	500	oasis	2012
Kyzyl-Suu	Kyrgyzstan	78° 12'00/42° 11‘29	2540	mountain ecosystem	2012
Kondara	Kyrgyzstan	68° 49′51/38° 53′37″	1411	mountain ecosystem	2013
Danghara	Tajikistan	69° 19'/38° 05′	600	cropland	2014
Zangiota	Uzbekistan	69° 07.74’/41° 10.61’	370	oasis cropland	2012

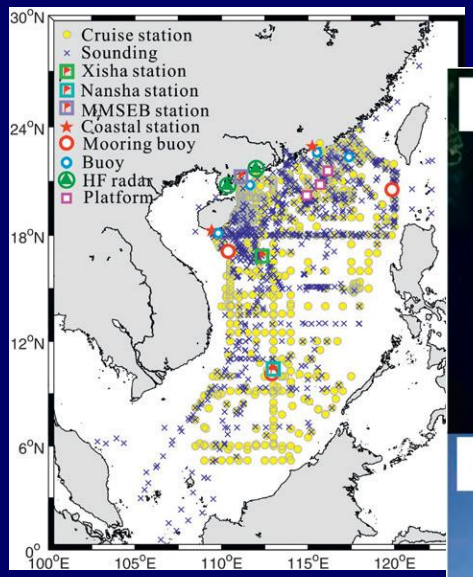

塔吉克斯坦热罗德高原山地生态系统观测站

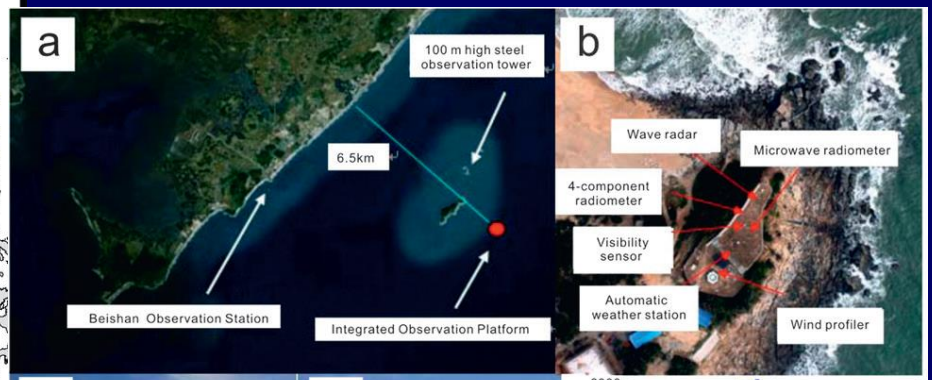
哈萨克斯坦休钦斯克森林生态系统观测站

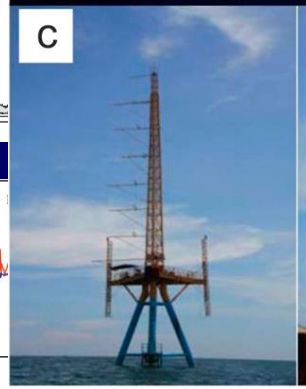
乌兹别克斯坦赞格奥塔农业生态系统观测站

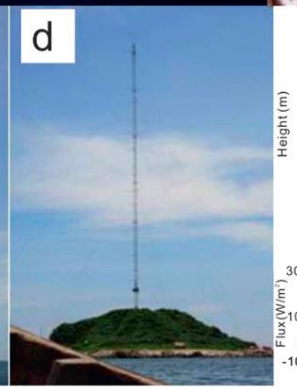

Mekele A. port
Gondar A.p
Bahir Dar Met
Combolcha
Debre Markos
Dire Dawa
Nekemte
Debre Zeit
Metehara
Text
Gore
Jimma
Awasa
Robe
Arba Minch
Gode
Negehele

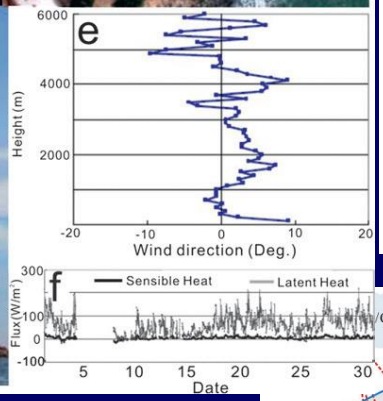
A MESOSCALE HYDROLOGICAL AND MARINE METEOROLOGICAL OBSERVATION NETWORK IN THE SCS

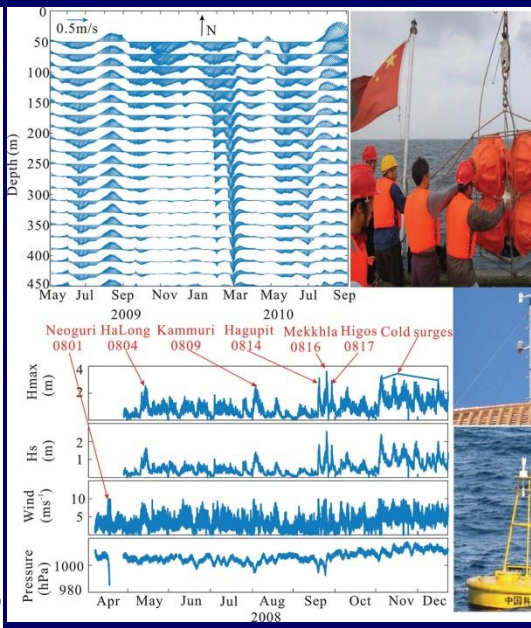


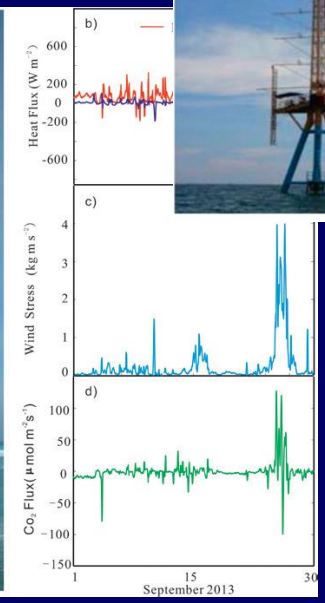


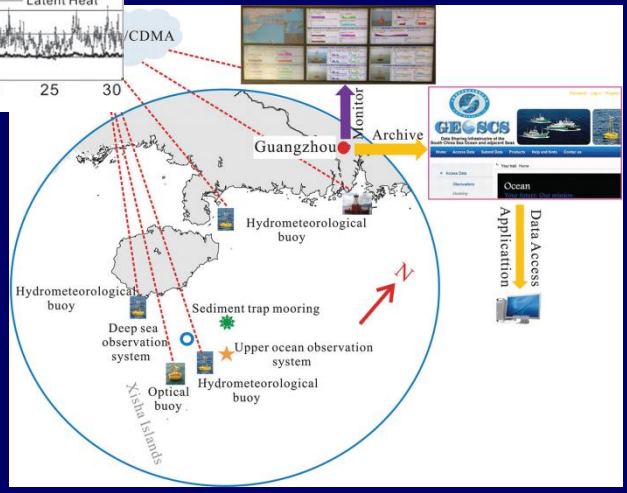




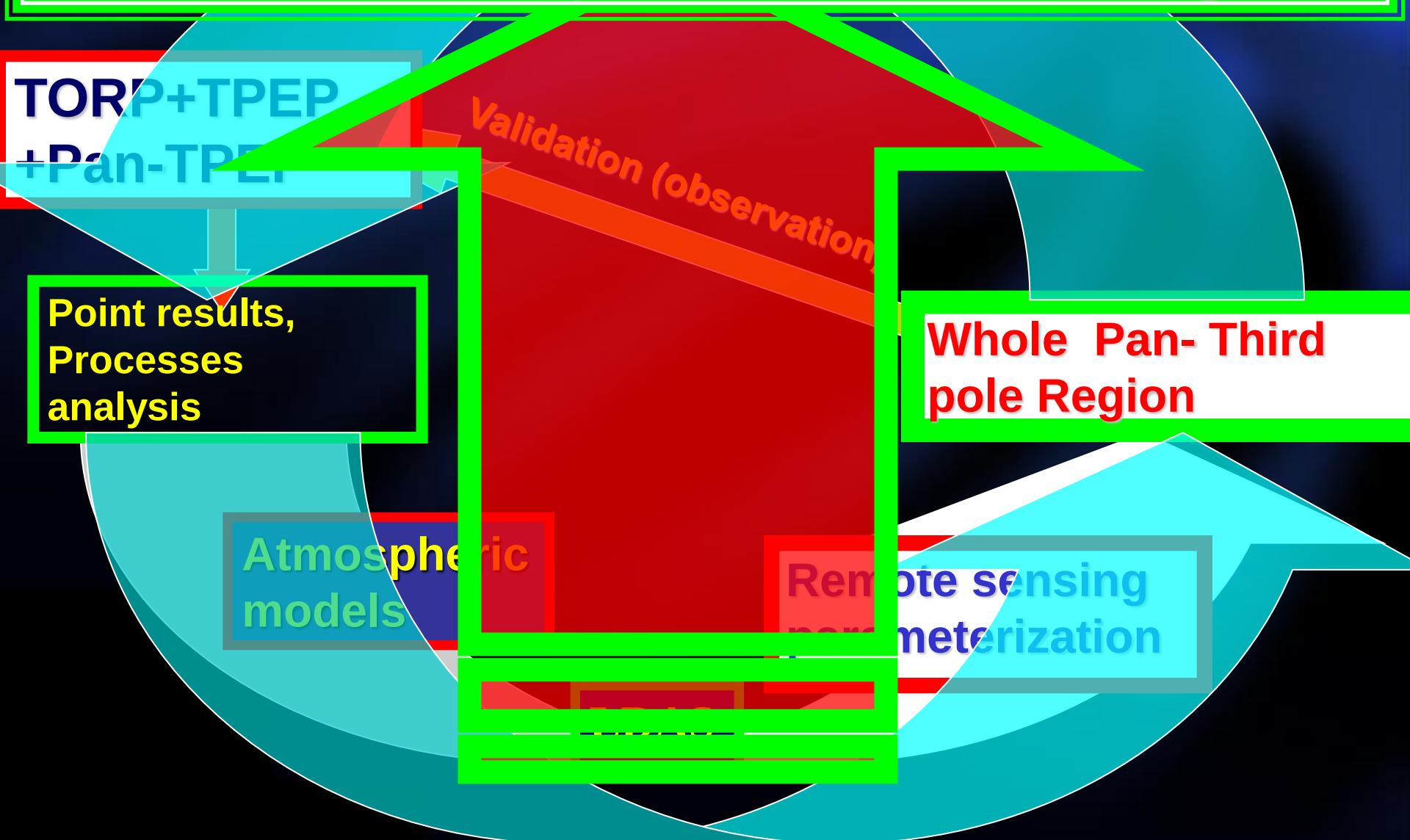








Regional distribution of land surface heat fluxes and *ET* over the Pan-Third pole region and its relationship to the climate change




Thank you!
ymma@itpcas.ac.cn