ESA-MOST Dragon Cooperation

中国科技部-欧洲空间局“龙计划”合作

2017 DRAGON 4 SYMPOSIUM

2017年“龙计划”四期学术研讨会

Monitoring Water and Energy Cycles at Climate Scale in the Third Pole Environment (CLIMATE-TPE)

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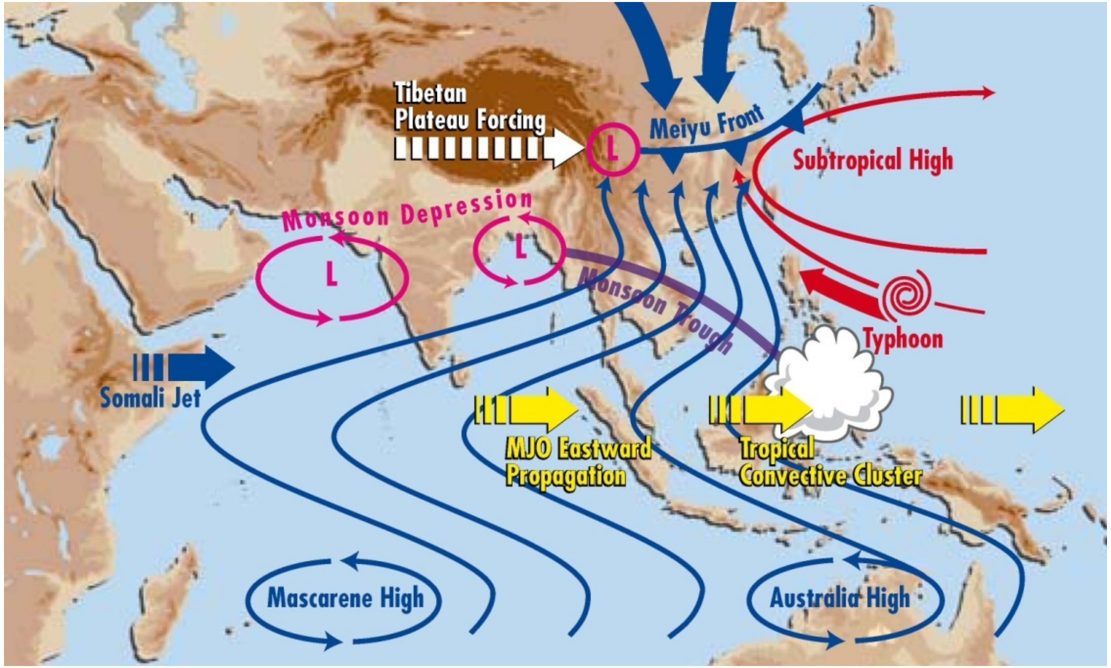
2017年6月26-30日，丹麦 哥本哈根

Background



- *Vital source of water for 1.5 billion people across 10 countries in SE Asia*
- *Significant role in global atmospheric circulation*
- *Lack of detailed observations, little known about how climate is changing*

Climate-TPE aims

- *To improve the understanding of the interactions between the Asian monsoon, the plateau surface and the Tibetan plateau atmosphere in terms of water and energy budgets*

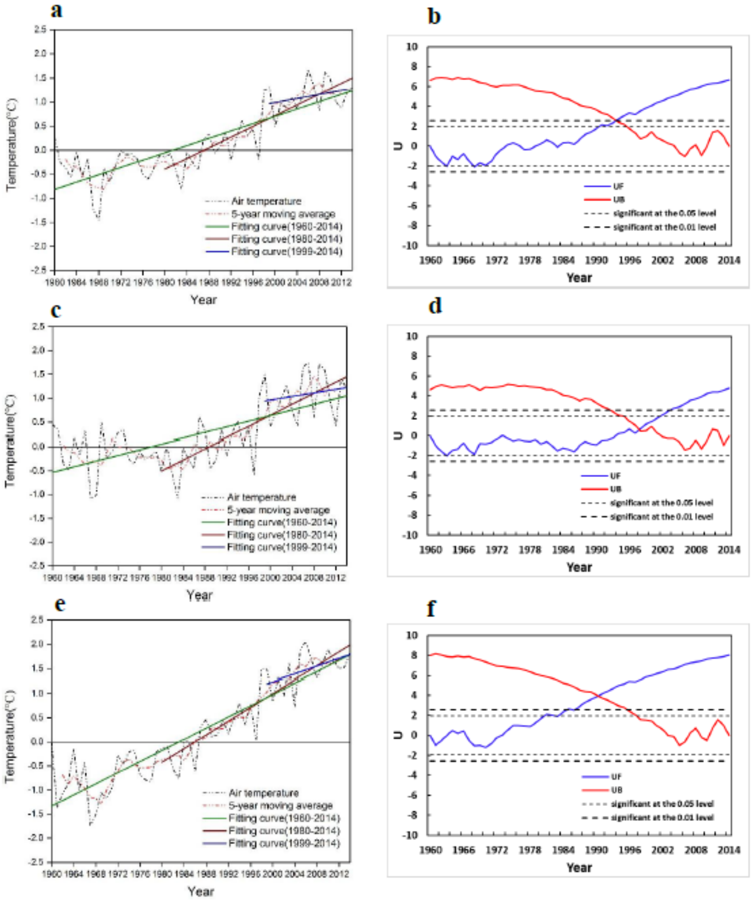
- *To predict the possible changes in water resources in the Third Pole Environment.*

Objective

Topic Nr.	PIs	Title
32070_1	*Prof.BobSu, Prof.JunWen*	***WP1: Observation and modelling of microwave scattering and emission under complex terrains and including permafrost and freeze and thawing***
32070_2	*Prof.Maria JosePolo, Prof.YaomingMa*	***WP2: Advancement of physical understanding and quantification of changes of water and energy budgets in TPE***
32070_3	*Prof.AlexanderLoew, Prof.YaomingMa*	***WP3: Advancement of quantifying changes in surface characteristics and monsoon interactions***

Achievements

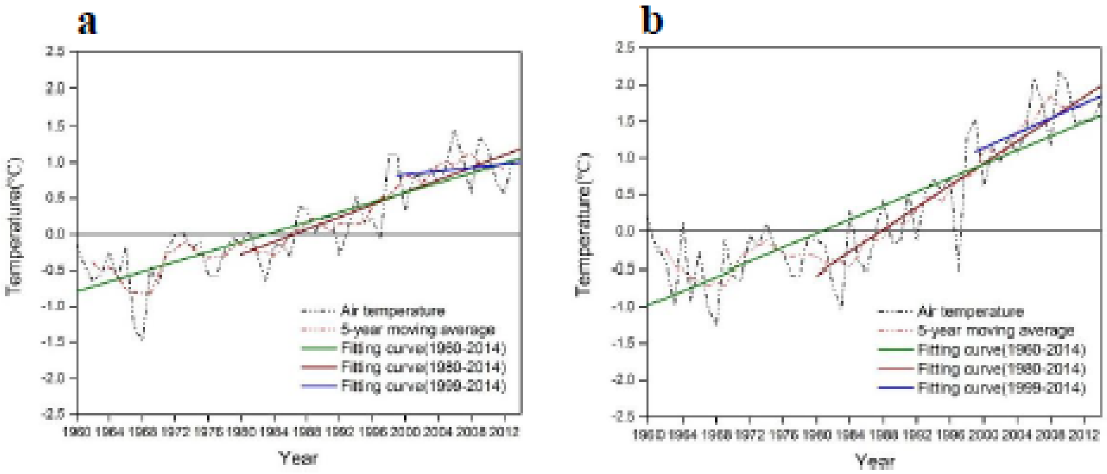
- Climate change trend and vegetation greening over the TP
- Estimation of LST from FY-2C and surface radiation components
- Trends of land surface heat fluxes over the TP and surrounding regions
- Simulation of land surface parameters by WRF model



A consistent warming trend has been identified for different time periods

Variations of annual air temperature anomalies and M-K test curves. a, **c** and **e** are anomalies for average temperature, extreme maximum temperature and extreme minimum temperature, respectively; **b, d** and **f** represent their M-K test curves, respectively.

Air temperature anomalies at different elevations. a, lower than 4000 m. b, greater than 4000 m



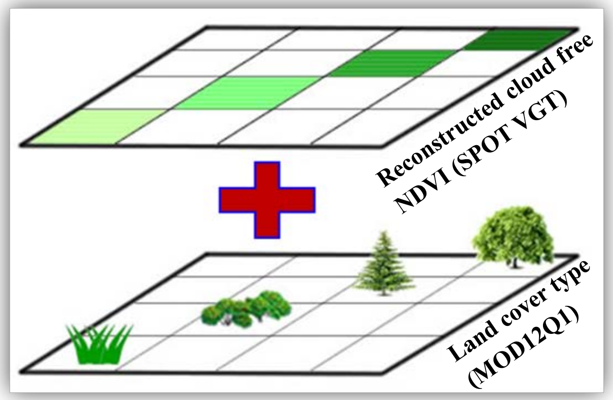
Air temperature at different altitudes has an overall increasing trend, and the increasing rate above 4000 m altitude is significantly greater than that below 4000 m which means the Asian Water Tower will face a greater potential threat

NRSCC esa

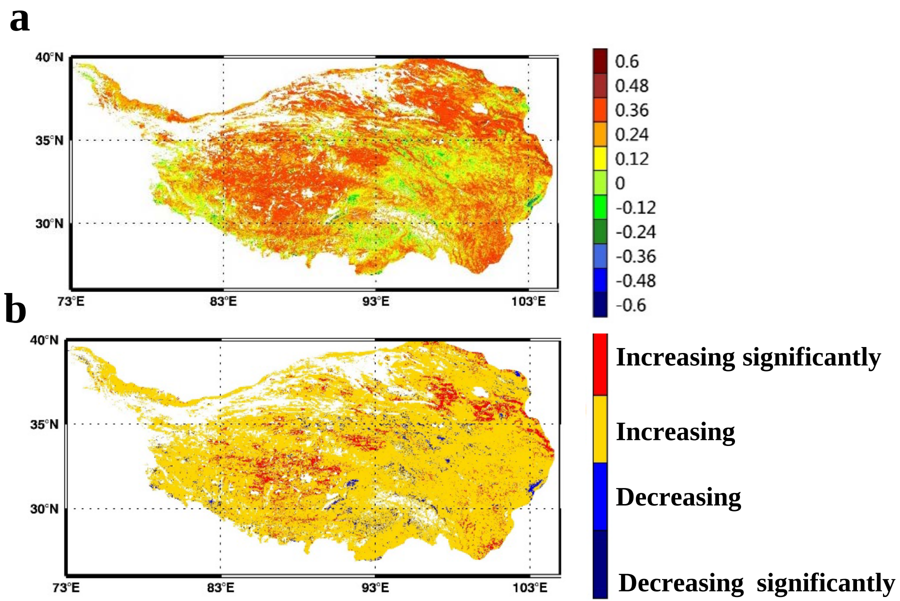
Air temperature tendency at different time scales and elevations

Air temperature	1960-2014		1980-2014		1999-2014	
	Tendency	R^2	Tendency	R^2	Tendency	R^2
Mean air temperature	0.04	0.68	0.06	0.74	0.02	0.08
Extreme maximum temperature	0.03	0.43	0.06	0.60	0.02	0.03
Extreme minimum temperature	0.06	0.82	0.07	0.80	0.04	0.19
Mean air temperature (lower than 4000 m)	0.03	0.71	0.04	0.66	0.01	0.03
Mean air temperature (higher than 4000 m)	0.05	0.70	0.08	0.77	0.05	0.28

Spatial distribution of tendency correlation coefficient over the TP(a) and its significance test result(b). The white colour represent non-vegetation regions.



Climate sensitive, vegetation changes, cloud removal



1999-2013

Seven meteorological sites and their relevant information

Station	LCT	Elevation	NDVI	Air Temperature	Precipitation	Relative Humidity	Sunshine duration	Climatic region	Mean air temperature	Precipitation
Shiquanhe	Sparsely vegetated	4278.6	0.093	1.703	70.787	31.495	3493.873	Arid	0.687	**0.511**
Purang	Grassland	4900	0.099	4.249	154.007	45.205	3158.827	Arid	0.832	**0.338**
Shandan	Grassland	1764.6	0.154	7.519	207.720	46.045	2852.400	Semi-arid	0.901	**0.928**
Tuotuohe	Grassland	4533.1	0.179	-3.007	338.067	52.583	2894.573	Semi-arid	0.831	**0.925**
Namling	Open shrublands	4000	0.117	6.297	510.353	42.545	2912.827	Semi-humid	0.546	**0.721**
Songpan	Evergreen needleleaf	2850.7	0.499	6.673	707.427	62.061	1747.427	Semi-humid	0.707	**0.555**
Bome	**Mixed forests**	**2736**	**0.698**	**9.354**	**841.480**	**69.828**	**1461.173**	**humid**	**0.675**	**0.117**

Achievements

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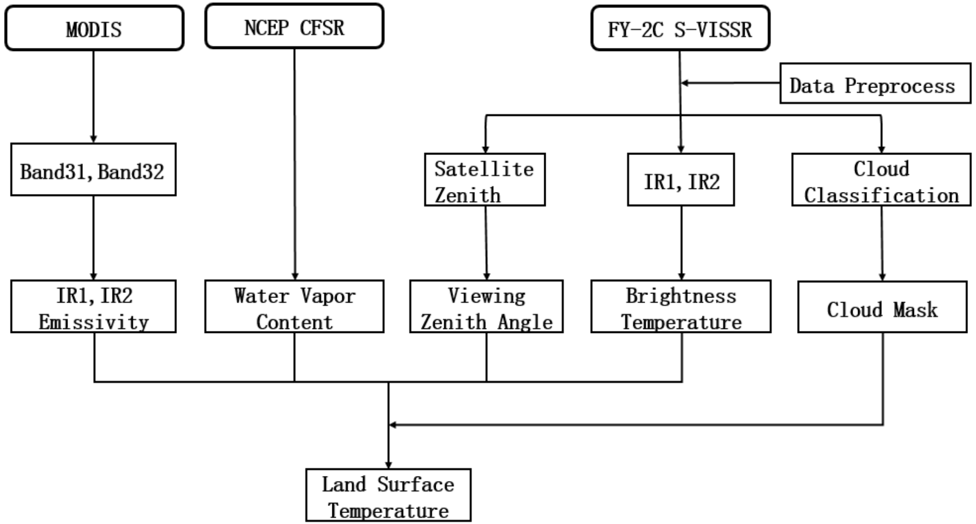
Flowchart of FY-2C LST estimation method



The motivation: little is known about the plateau scale diurnal variation of heat fluxes

$$T_s = A_0 + P\frac{T_i + T_j}{2} + M\frac{T_i - T_j}{2}$$

$$A_0 = a_0 + a_1 w$$

$$P = a_2 + (a_3 + a_4 w\cos\theta)(1-\varepsilon) - (a_5 + a_6 w)\Delta\varepsilon$$

$$M = a_7 + a_8 w + (a_9 + a_{10} w)(1-\varepsilon) - (a_{11} + a_{12} w)\Delta\varepsilon$$

$$\varepsilon_{IR1} = -0.0611 + 1.0614\varepsilon_{31}$$

$$\varepsilon_{IR2} = -0.0210 + 1.0199\varepsilon_{32}$$

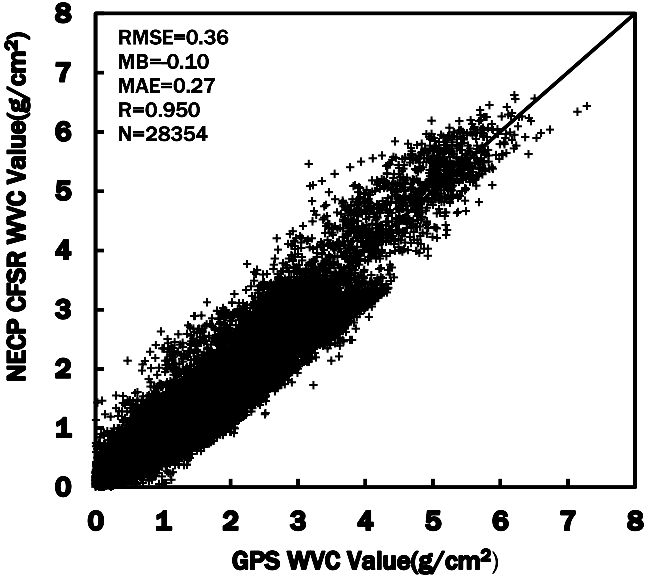
(Tang 2008)

Ground measurement sites

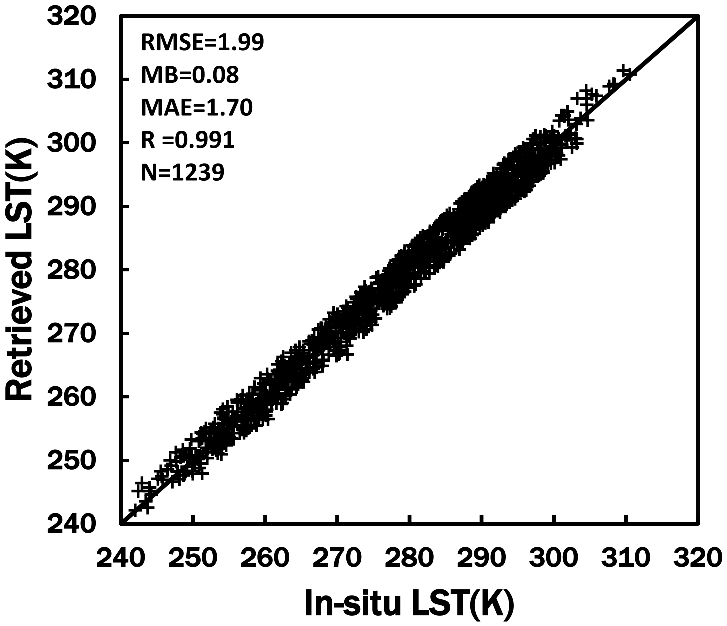
☆Meteorological stations ○GPS stations ✪Meteorological stations and GPS stations

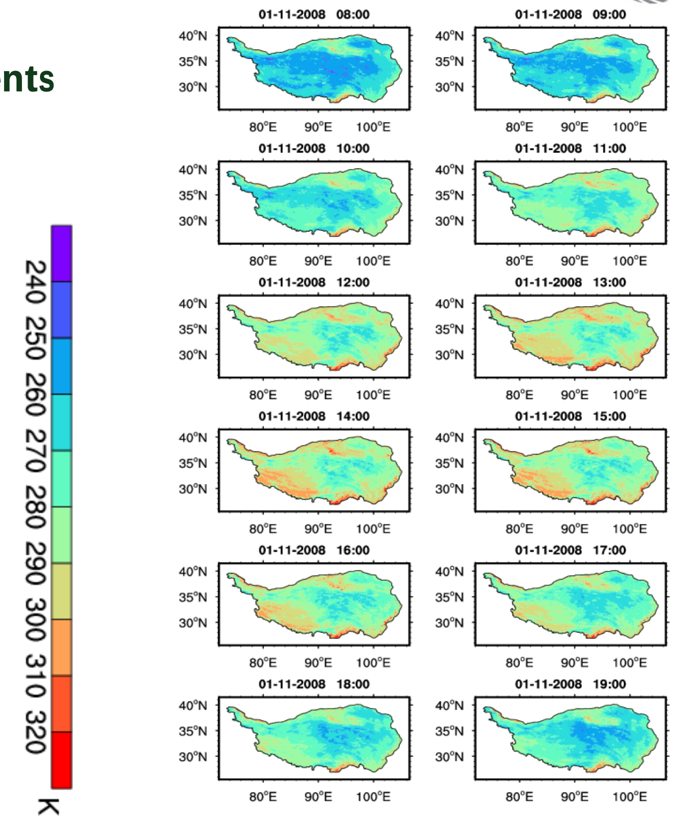
Sites	Longitude(°E)	Latitude (°N)	Altitude(m)	Land cover
☆ BJ	91.89871	31.36859	4509.0	alpine and sub-alpine meadow
☆ D66	93.78454	35.52353	4585.0	alpine and sub-alpine plain grass
☆ D105	91.94256	33.06429	5039.0	alpine and sub-alpine plain grass
✪ Linzhi	94.73840	29.76450	3326.0	needle leaved evergreen forest
☆ Nam Co	90.98850	30.77500	4730.0	alpine and sub-alpine meadow
☆ QOMS	86.94640	28.35810	4276.0	alpine and sub-alpine plain grass
☆ MS3478	91.71600	31.92600	4620.0	alpine and sub-alpine meadow
☆ MS3608	91.78328	31.22623	4588.9	alpine and sub-alpine meadow
○ GAIZ	84.06221	32.30626	4394.3	alpine and sub-alpine plain grass
○ GANZ	99.99755	31.61966	3357.8	alpine and sub-alpine meadow
○ LITA	100.27077	29.99468	3925.2	alpine and sub-alpine meadow
○ LNGZ	92.46006	28.41416	3824.4	alpine and sub-alpine meadow
○ NAQU	92.06118	31.47977	4477.8	alpine and sub-alpine plain grass
○ RUOE	102.96581	33.57598	3417.8	alpine and sub-alpine meadow
○ SHEN	88.70490	30.93161	4635.9	alpine and sub-alpine plain grass
○ DEQN	98.90737	28.48851	3295.0	needle leaved evergreen forest
○ DING	95.59356	31.41513	3843.0	alpine and sub-alpine meadow
○ DINR	87.12039	28.65461	4326.6	alpine and sub-alpine plain grass

Comparison between water vapor content from NCEP CFSR and GPS measurements

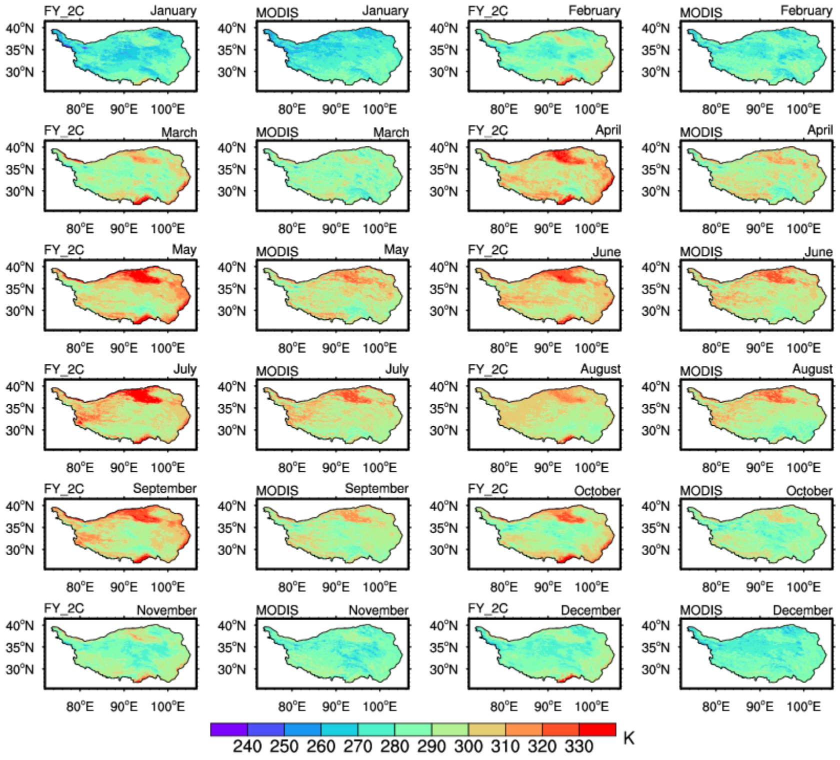


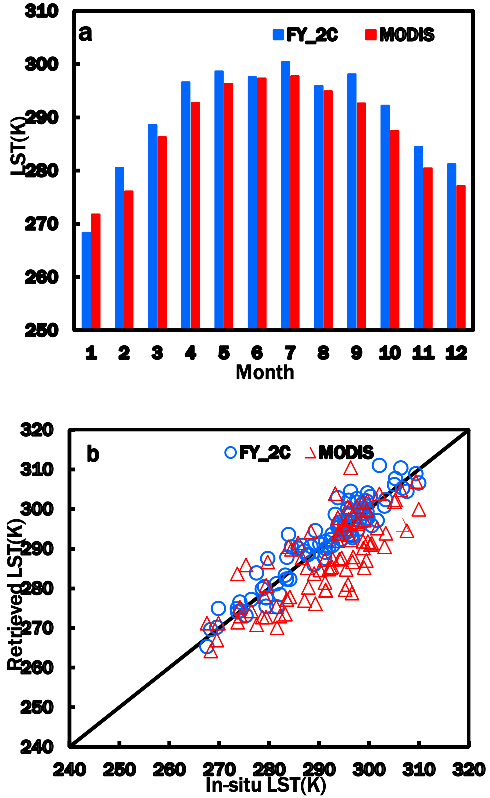
Validation of derived FY-2C LST against field measurements



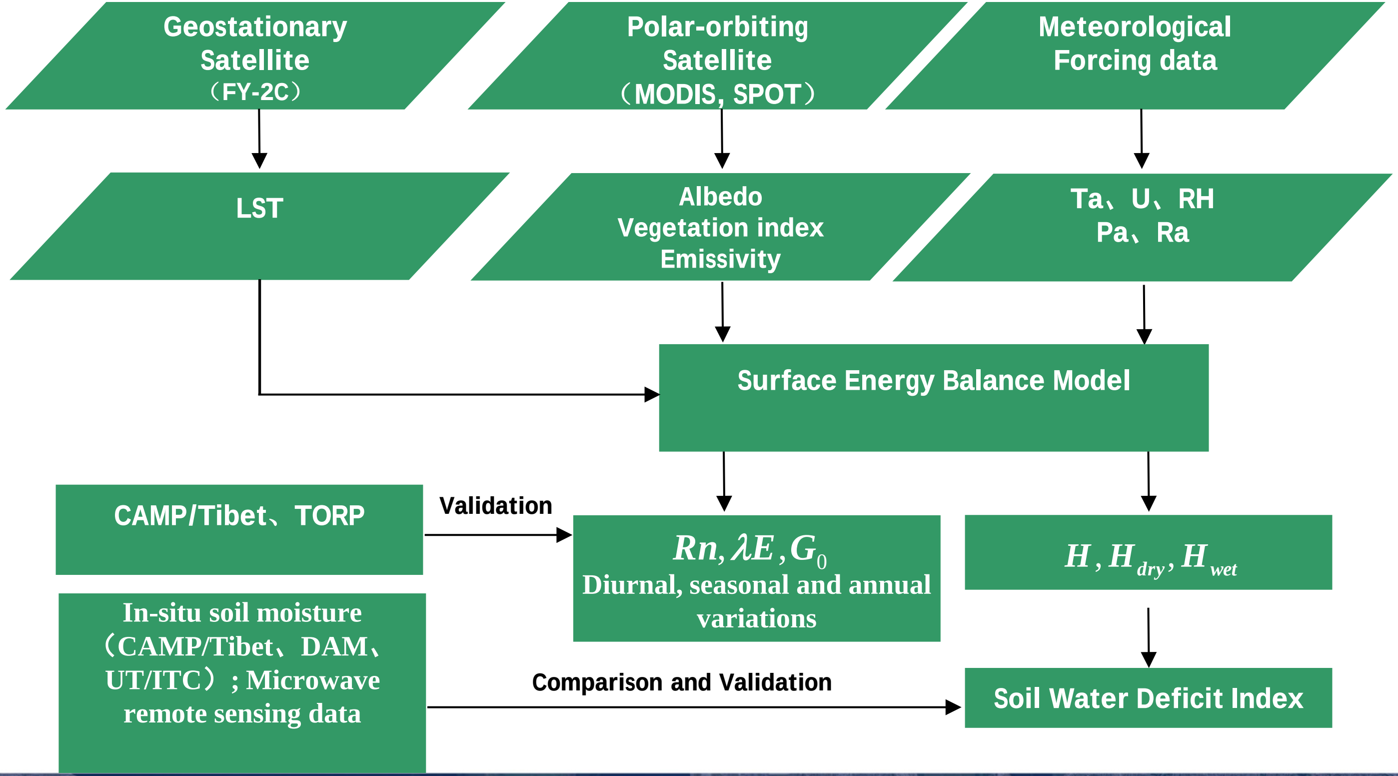


Comparison between FY-2C LST and MODIS product





On-going study

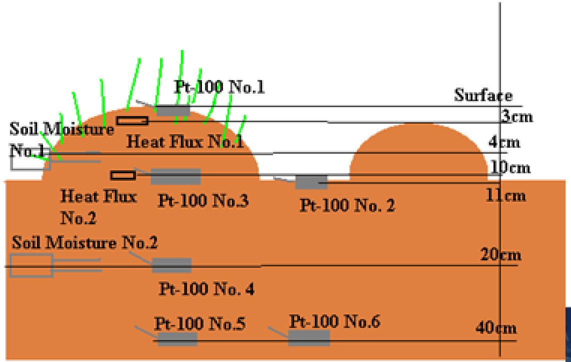


The applicability of soil water deficit index constructed from energy balance point of view

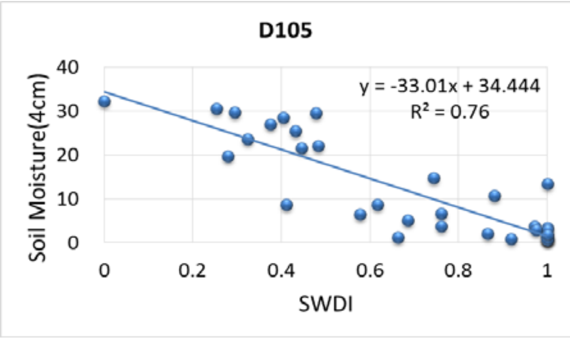
$$\lambda E_{dry} = R_n - G_0 - H_{dry} \equiv 0$$

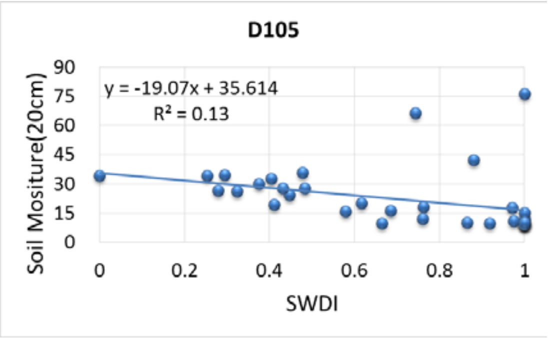
$$\lambda E_{wet} = R_n - G_0 - H_{wet}$$

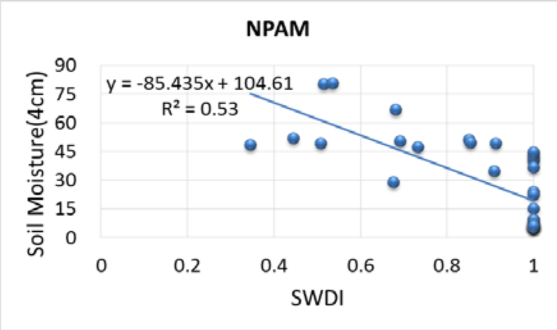
$$SWDI = 1 - \frac{\lambda E}{\lambda E_{wet}} = \frac{H - H_{wet}}{H_{dry} - H_{wet}}$$

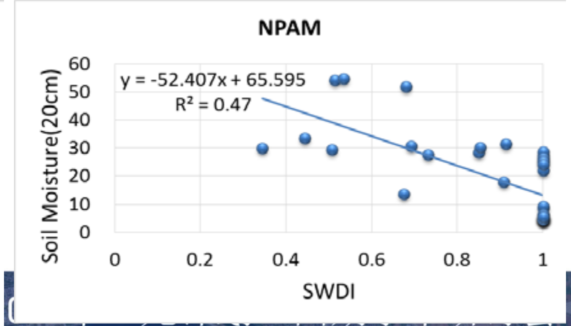


SMTM at NPAM

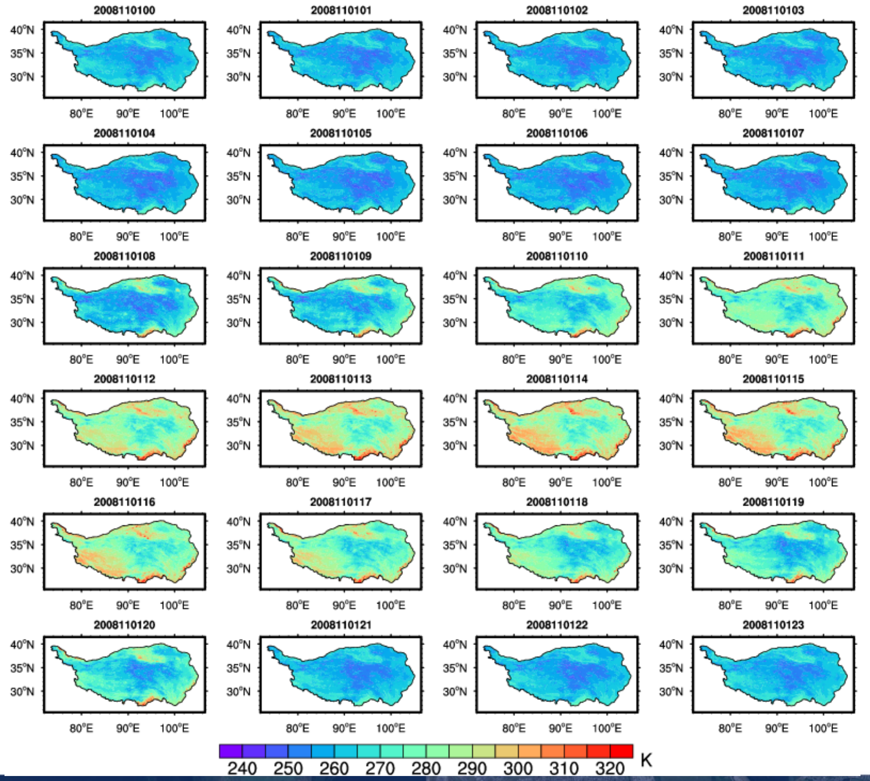




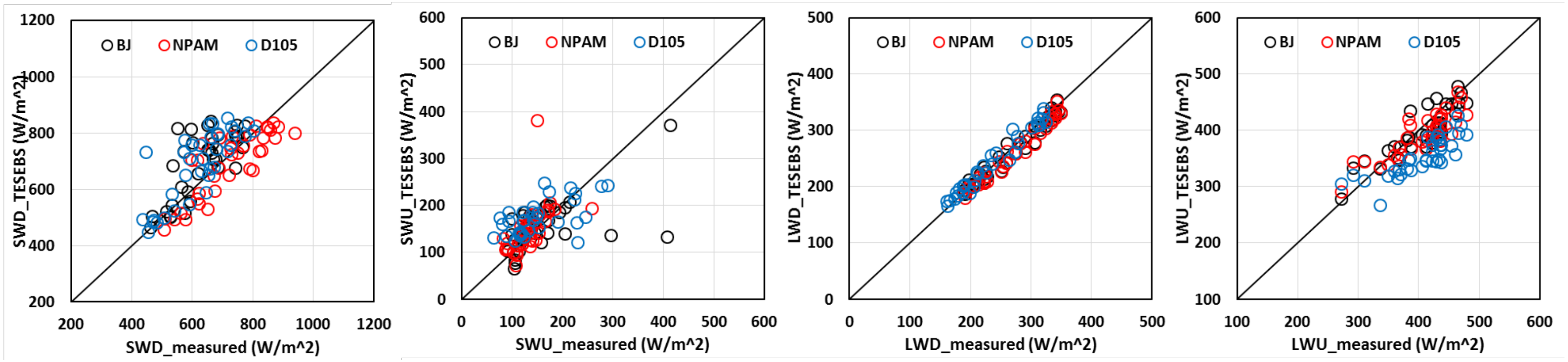




FY-2C LST diurnal cycle



Estimation of surface radiation components



	SWD	SWU	LWD	LWU
R	0.718	0.534	0.976	0.754
MB	33.845	15.260	-0.077	24.186
RMSE	91.924	60.585	30.384	40.831

D105

	SWD	SWU	LWD	LWU
R	0.79	0.59	0.98	0.82
MB	68.95	23.28	6.92	-51.30
RMSE	102.01	52.43	12.40	59.0
MPE	-11.4%	-27.4%	-3.3%	12.0%

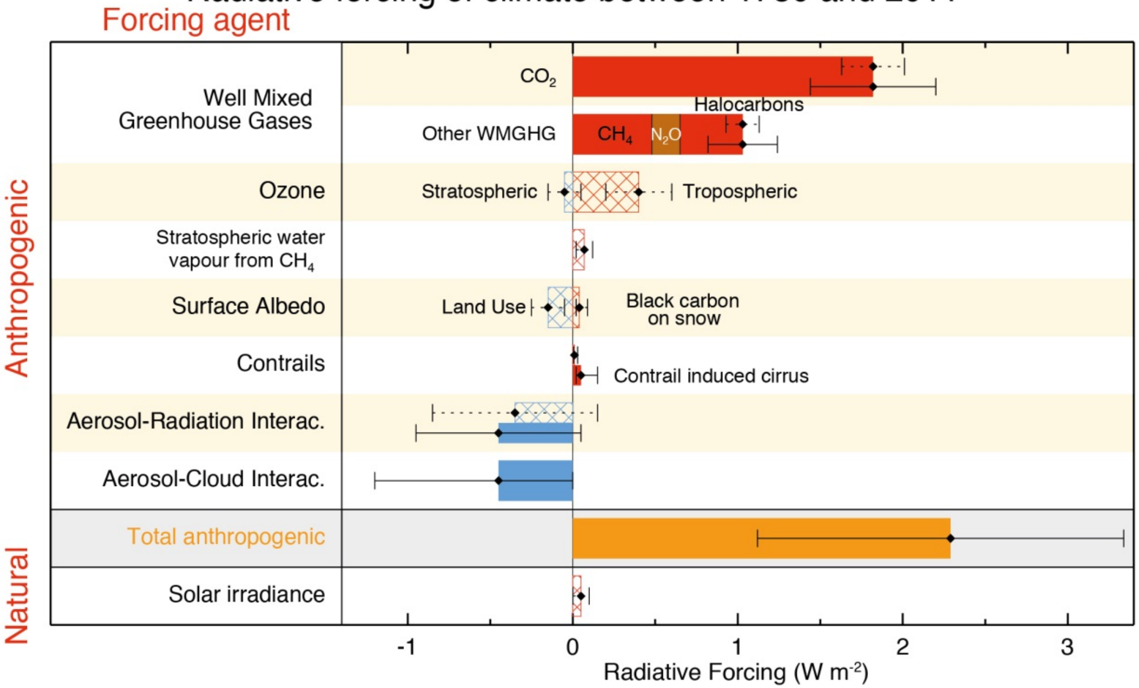
NPAM

	SWD	SWU	LWD	LWU
R	0.84	0.55	0.98	0.86
MB	-30.53	16.00	-9.85	-13.33
RMSE	70.91	46.19	13.64	29.12
MPE	4.0%	-13.1%	3.5%	2.7%

BJ

	SWD	SWU	LWD	LWU
R	0.74	0.58	0.98	0.87
MB	63.11	-4.01	-5.07	-7.93
RMSE	99.58	61.04	12.28	25.88
MPE	-10.1%	-4.6%	1.6%	1.5%

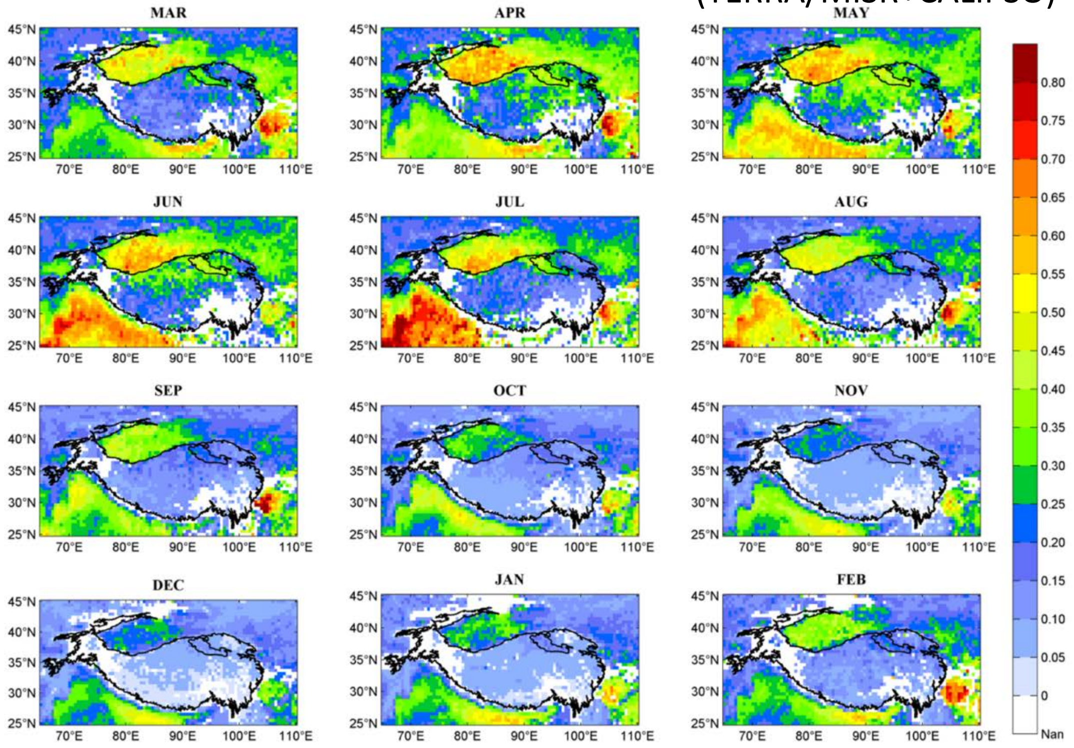
Radiative forcing of climate between 1750 and 2011

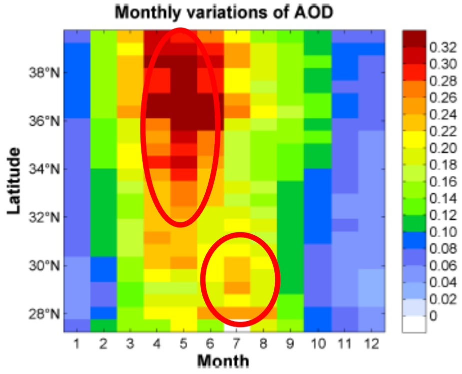


Aerosol is one of the most uncertainties in climate change study

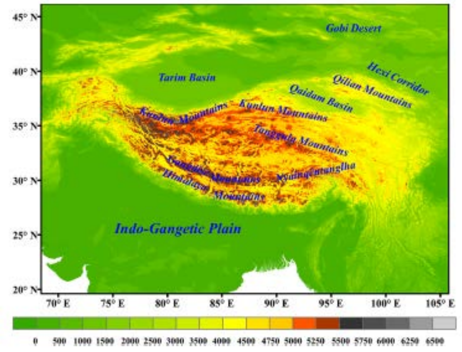
Monthly variations of AOD over the Tibetan Plateau

(TERRA/MISR+CALIPSO)





Zonal average of AOD over the Tibetan Plateau in each month. White shading indicates insufficient available data



Emission sources, topography and atmospheric circulation

Achievements

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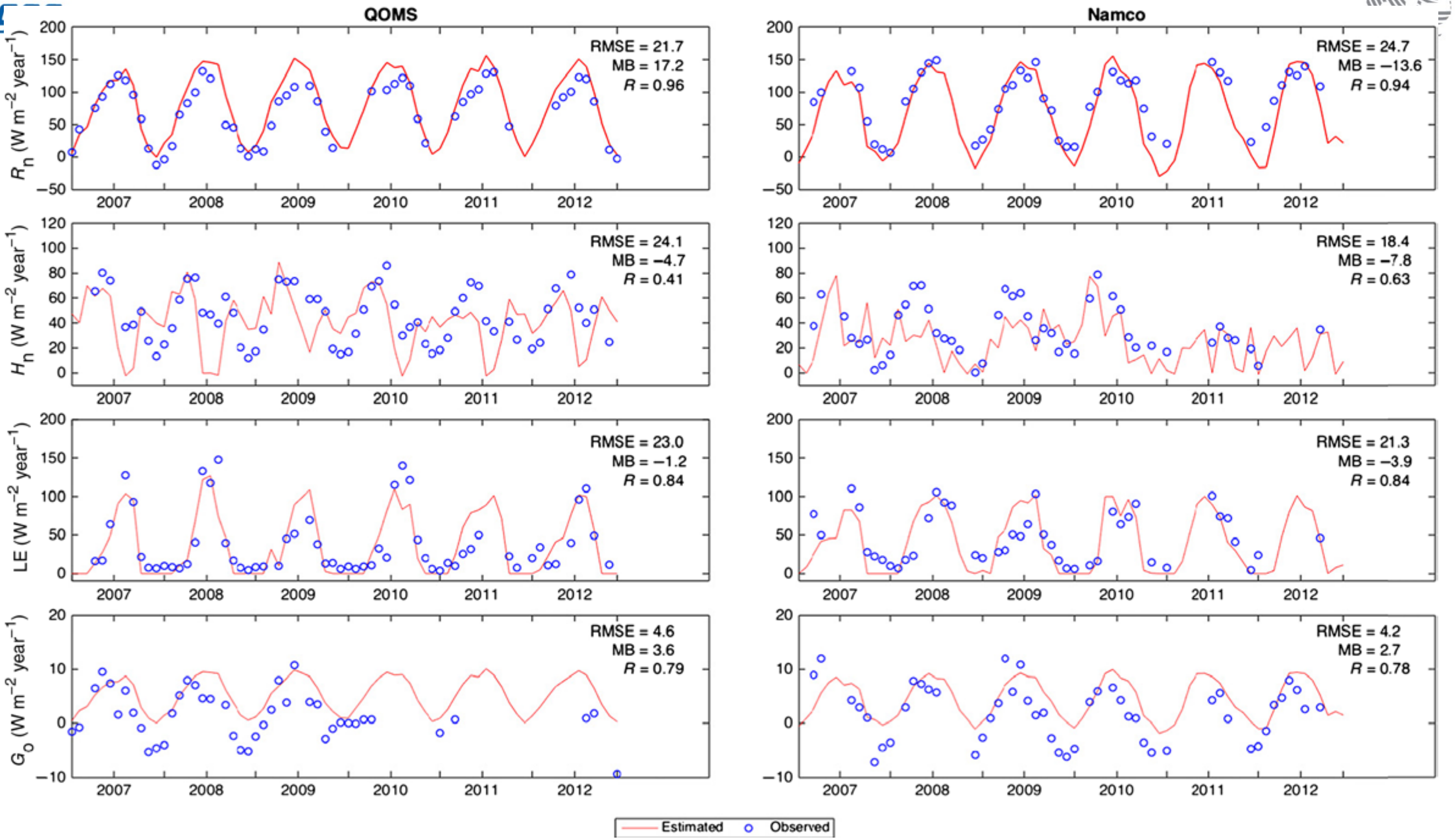
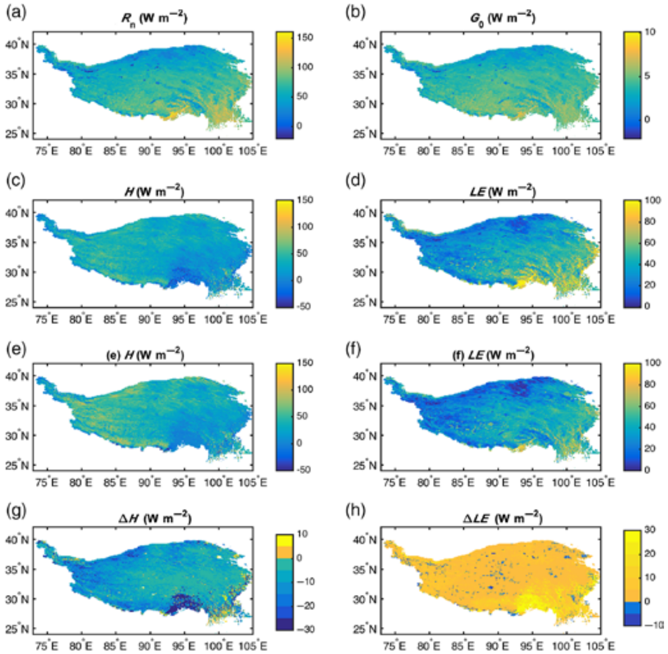
Trends of land surface heat fluxes over the TP and surrounding regions

Simulation of land surface parameters by WRF model

Comparison between observed and estimated land surface heat flux values at the QOMS and Namco stations



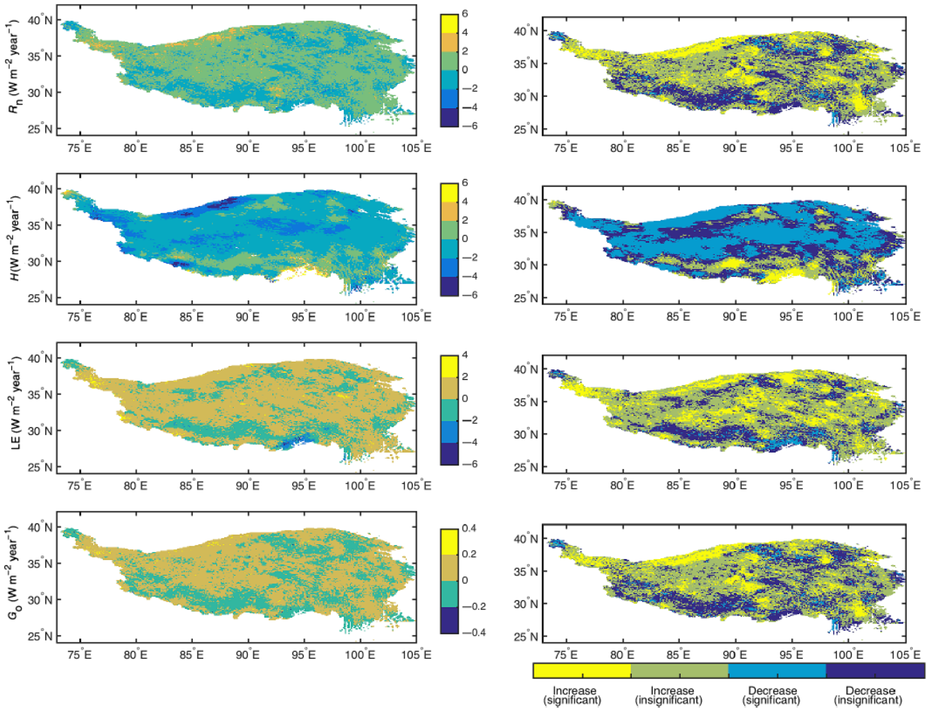
Average annual maps of land surface heat flux values on the TP from 2001 to 2012



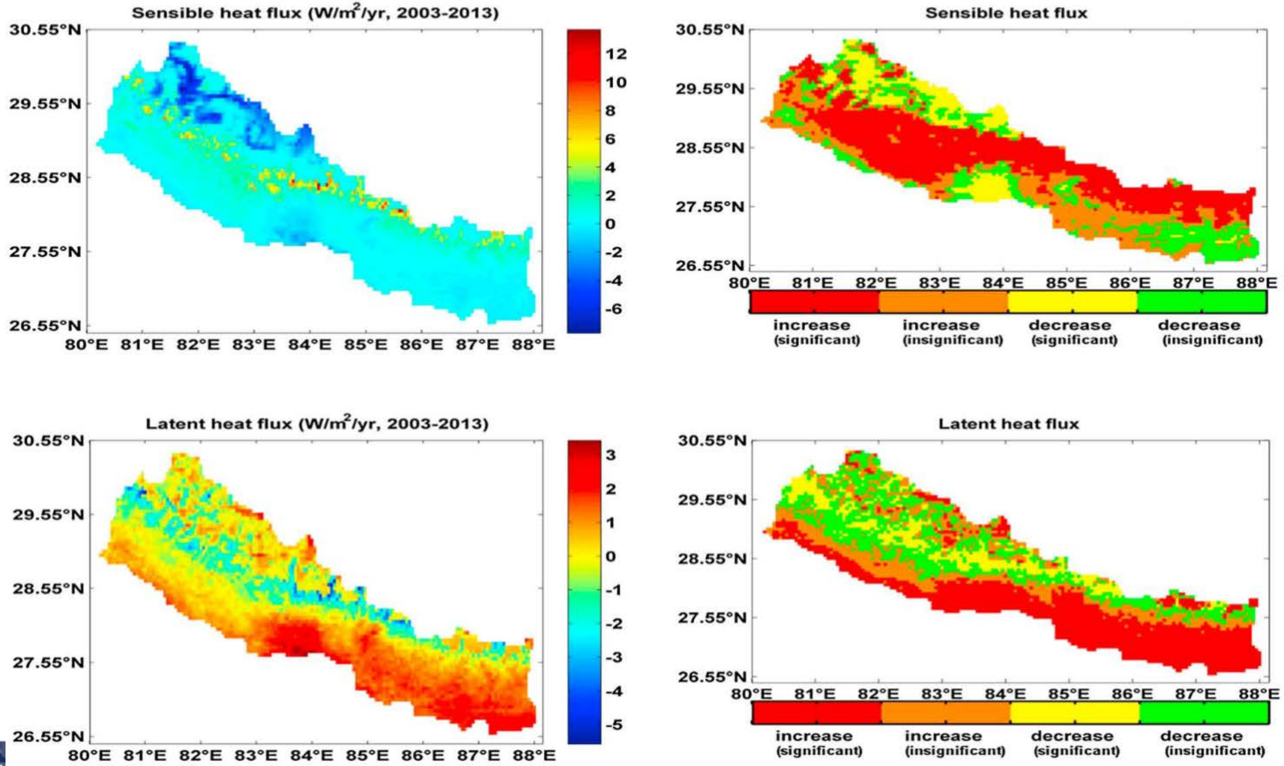
Effective roughness length

Traditional roughness length

Linear trends (left column) and significance test (right column) maps



Linear trend and significance maps of sensible and latent heat fluxes



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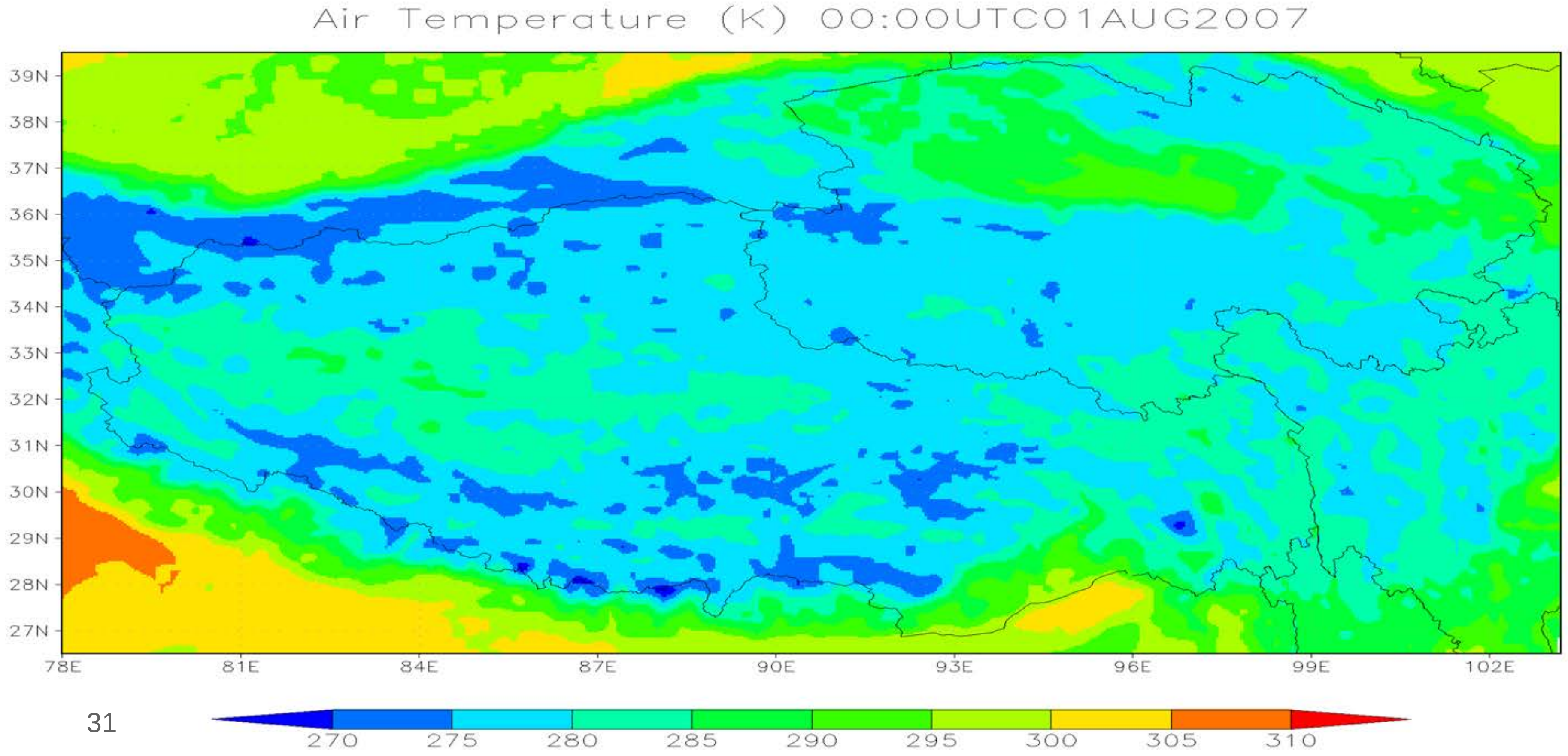
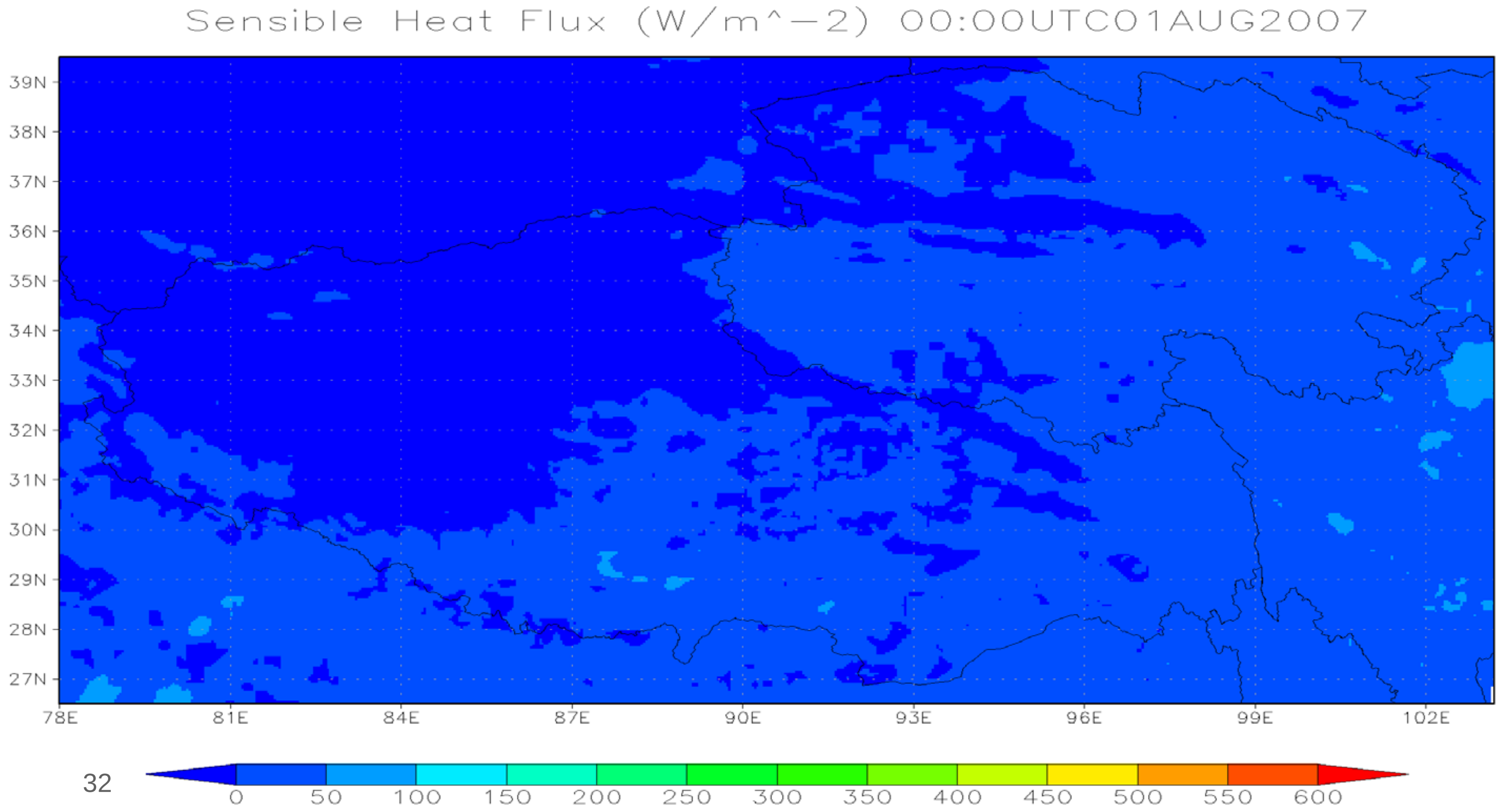
Hourly variations of air temperature



Hourly variations of sensible heat flux



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1. Wang B, Ma Y, Ma W, et al. Physical controls on half-hourly, daily, and monthly turbulent flux and energy budget over a high-altitude small lake on the Tibetan Plateau. Journal of Geophysical Research Atmospheres, 2017, 122(4).
2. Han, C., Y. Ma, X. Chen, and Z. Su Trends of land surface heat fluxes on the Tibetan Plateau from 2001 to 2012, International Journal of Climatology, 2017, doi: 10.1002/joc.5119.
3. Ma, Y., W. Ma, Z. Lei, Z. Hu, M. Li, Z. Zhu, C. Han, B. Wang, and L. Xin (2017), Monitoring and Modeling the Tibetan Plateau's climate system and its impact on East Asia, Scientific Reports, 7, 44574.
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9. Yu， W., F. Wei, Y. Ma, W. Liu, Y. Zhang, L. Luo, L. Tian, B. Xu, D. Qu. 2016, Stable isotope variations in precipitation over Deqin on the southeastern margin of the Tibetan Plateau during different seasons related to various meteorological factors and moisture sources. Atmospheric Research, 170, 123-130, doi: 10.1016/j.atmosres.2015.11.013.
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11. Meng, C., Y. Ma, C.Han, P.Gou, 2016, Effect of reducing the topographical altitude of the Tibetan Plateau on a severe winter drought in eastern China as determined using RAMS, Theoretical and Applied Climatology, DOI 10.1007/s00704-016-1817-7.
12. Madan Sigdel, Y. Ma, 2016, Variability and trends in daily precipitation extremes on the northern and southern slopes of the central Himalaya, Theoretical and Applied Climatology, doi:10.1007/s00704-016-1916-5.
13. Yasir Latif, Y.Ma, 2016,Spatial analysis of precipitation time series over Upper Indus Basin， Theoretical and Applied Climatology， DOI: 10.1007 / s00704-016-2007-3.
14. Peng, J., A. Loew, X.Chen , Y. Ma , and Z. Su,2016, Comparison of satellite-based evapotranspiration estimates over the Tibetan Plateau, Hydrology and Earth System Sciences, 20, 3167–3182.
15. Yu,W., Li.Tian, C.Risi, T.Yao, Y.Ma, H.Zhao, H.Zhu, Y.He, B.Xu, H.Zhang, D.Qu,2016，δ18O records in water vapor and an ice core from the eastern Pamir Plateau: Implications for paleo-climate reconstructions, Earth and Planetary Science Letters,456,146-156.
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Academic exchange and joint field experiments

- Five PhD students have been sent to European partner for joint training
- Lei Zhong and Xuelong Chen have got their PhD degree from University of Twente under the supervision of Prof. Yaoming Ma and Prof. Z.(Bob) Su
- Several European students from our partner also come to China regularly for joint field visiting and academic exchange

Young scientists

- Weiqiang Ma (Prof. CAS “Hundred Talent”百人计划) (land surface processes, remote sensing)
- Lei Zhong (Prof. “Outstanding youth fund”基金委优秀青年基金) (land surface processes, monsoon climate)
- Maoshan Li (Prof.) (land surface processes, land surface modeling)
- Binbin Wang (Post-D) (land surface processes, remote sensing)
- Cunbo Han(Post-D) (land-atmosphere interactions)
- Chao Xu (Post-D) (remote sensing of aerosol)
- Madan Sigdel (Post-D) (land surface processes)
- Zhangwei Ding (Post-D) (land surface process)
- Mijun Zou(PhD student) (land surface processes, monsoon climate)
- Yang Wang(PhD student) (ocean-atmosphere interaction)
- Yizhe Han, Jie Xu, Xingyue Gu, Yuanyuan Hu, Jiahe Lang, Wei Hu(Msc)

Thank you!