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

(Dragon 4 id. 32070)

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

European Lead PI	Chinese Lead PI
Prof. Z. Bob SU University of Twente, ITC z.su@utwente.nl (*coord. with Chinese LI, coord. European Partners, dev/val algorithms, coord. satellite data requests for all test sites and coord. field experiments, publ. & promotions of joint PhD students*)	**Prof. Yaoming MA** Institute of Tibetan Plateau Research ymma@itpcas.ac.cn (*coord. with European LI, coord. Chinese partners, dev/val algorithms (fluxes), coord. field experiments at the Tibetan sites*)

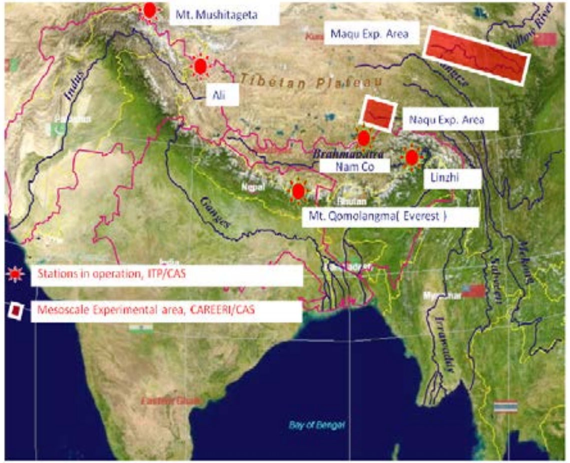
26–30 Jun

2017年

Project partners and roles

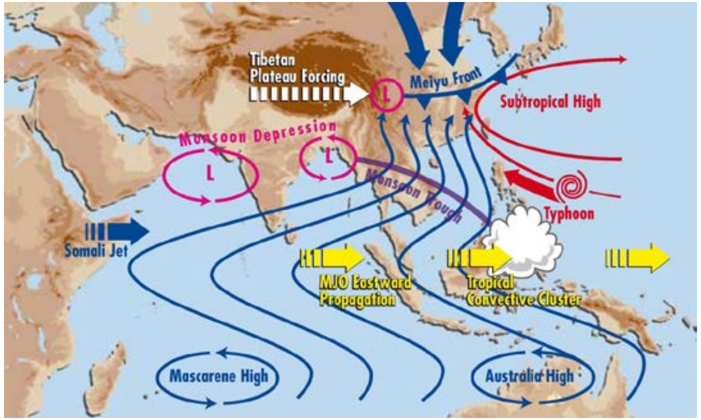
European PIs:	Chinese PIs:
Prof. Maria Jose Polo University of Córdoba, Spain, mjpolo@uco.es *(dev/val algorithms (water and energy fluxes), ass. scale effects associated to data sources, distributed modelling)*	**Prof. Jun Wen**, Chengdu University of Information Sciences, jwen@lzb.ac.cn *(soil moisture and land surface water process in SRYR, dev. retr. algorithms (MW) and coord. field exp.)*
Prof. Jose Sobrino, Universitat de Valencia, sobrino@uv.es *(dev/val TIR algorithms, joint analysis of reanalysis and satellite time series data)*	**Dr. Yanbo He**, National Meteorological Center, yanbohe@cma.gov.cn *(software dev/val satellite products, appl. algorithms, data proc., coord. data requests for routine meteor. data)*
Prof. Alexander Loew University of Munich (LMU) alexander.loew@lmu.de *(dev/val high resolution land surface products using HOLAPS/SEBS)*	**Prof. Xiaohua Dong**, China Three Gorges University, Yichang, China, xhdong@ctgu.edu.cn *(dev. RS appl. ecohydrological modelling and hydrological forecasting)*

The Third Pole Environment



- *Vital source of water for 1.5 billion people across 10 countries in SE Asia*
- *Significant role in global atmospheric circulation*
- *highly sensitive to climate change*

- *Intensive exchanges of water and energy between the Asian monsoon, the plateau land surface (lakes, glaciers, snow and permafrost) and the plateau atmosphere at various temporal and spatial scales, but lack a fundamental understanding of the details of the coupling esp. at the climate scale.*



CLIMATE-TPE **aims**

- improve the understanding of the interactions between the Asian monsoon, the plateau surface (incl. its permafrost and lakes) and the Tibetan plateau atmosphere in terms of water and energy budgets
- assess and understand the causes of changes in cryosphere and hydrosphere in relation to changes of plateau atmosphere in the Asian monsoon system
- predict the possible changes in water resources in the Third Pole Environment

WORK PACKAGES

WP1: Observation and modelling of microwave scattering and emission under complex terrains incl. permafrost and freeze and thawing

WP2: Advancement of physical understanding and quantification of changes of water and energy budgets in TPE

WP3: Advancement of quantifying changes in surface characteristics and monsoon interactions

WP1: Achievements

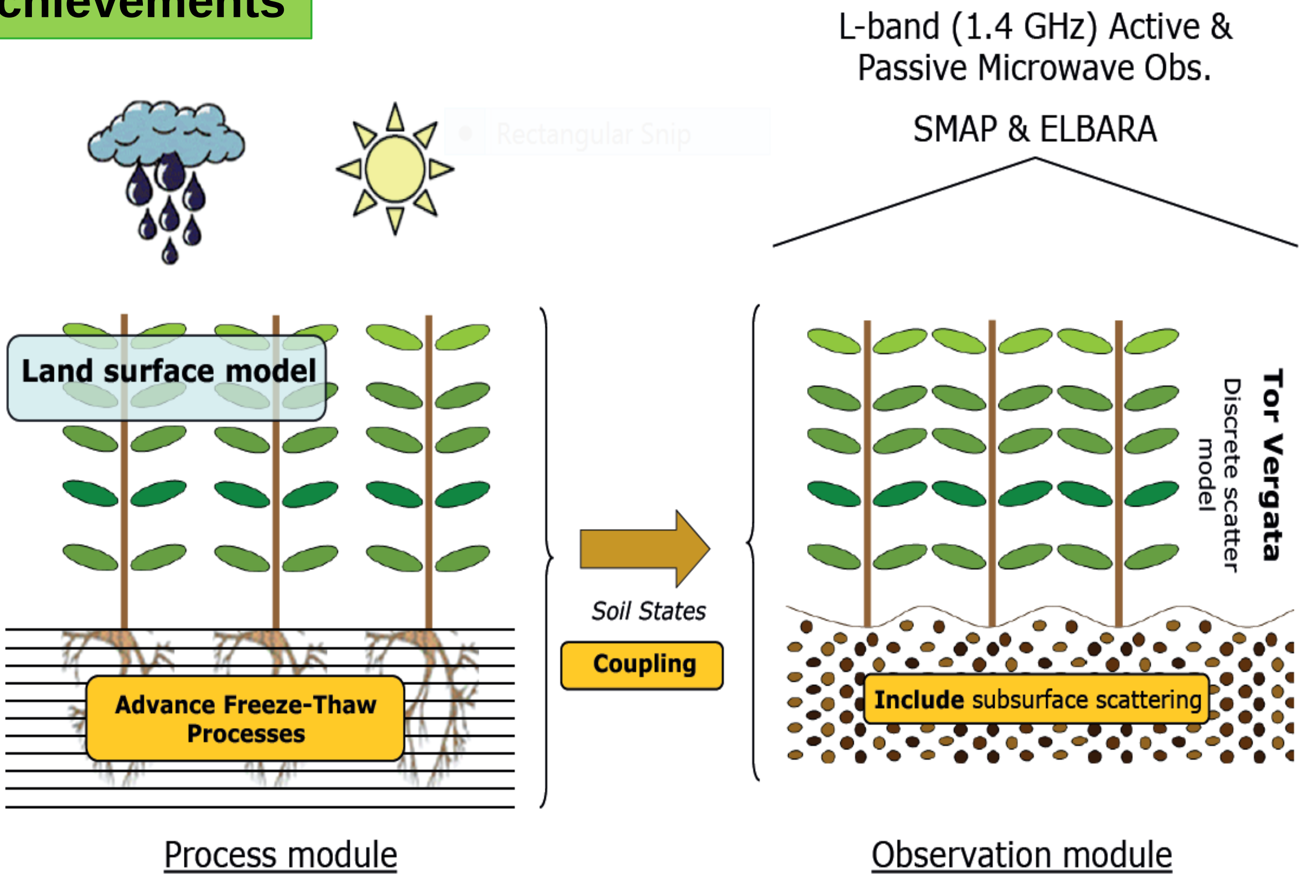
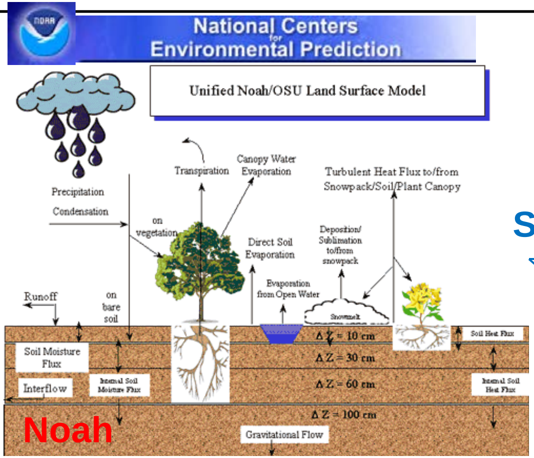


Figure 2 Coherent process modeling and radiative transfer modelling

L-Band Microwave Emission of Soil Freeze–Thaw Process in the Third Pole Environment

Donghai Zheng, Xin Wang, Rogier van der Velde, Yijian Zeng, Jun Wen, Zuoliang Wang, Mike Schwank, Paolo Ferrazzoli, *Senior Member, IEEE*, and Zhongbo Su

Noah-Tor Vergata Model



Surface SMST

SMST Profiles

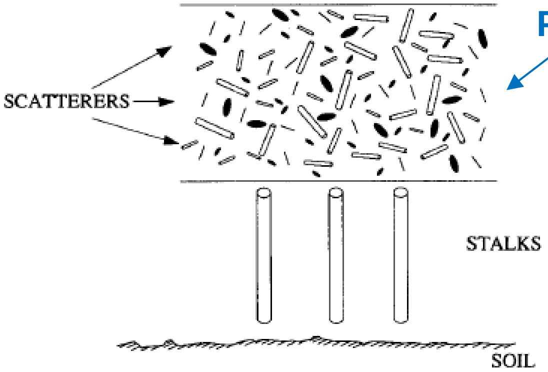
Permittivity

Four Phase Dielectric Mixing Model

$$\varepsilon^{\eta} = (\theta_s - \theta)\varepsilon_{air}^{\eta} + \theta_{liq}\varepsilon_{w}^{\eta} + (\theta - \theta_{liq})\varepsilon_{ice}^{\eta} + (1 - \theta_s)\varepsilon_{matrix}^{\eta}$$

Effective Temperature

$$T_{eff} = \int_0^{\infty} T_s(z)\alpha(z)\exp\left[-\int_0^{z}\alpha(z')dz'\right]dz$$



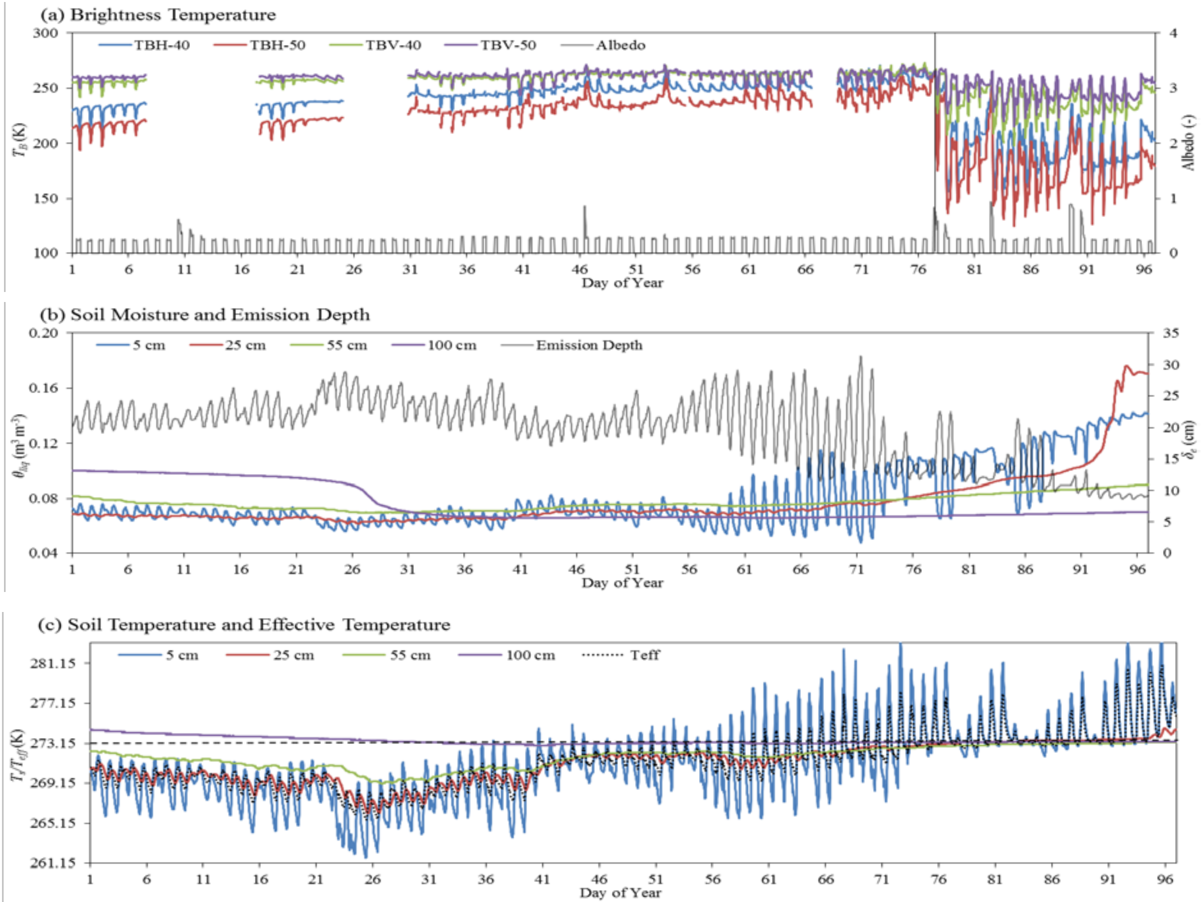
Emissivity

Brightness Temperature

U

Tor Vergata RT

Long Term Analysis



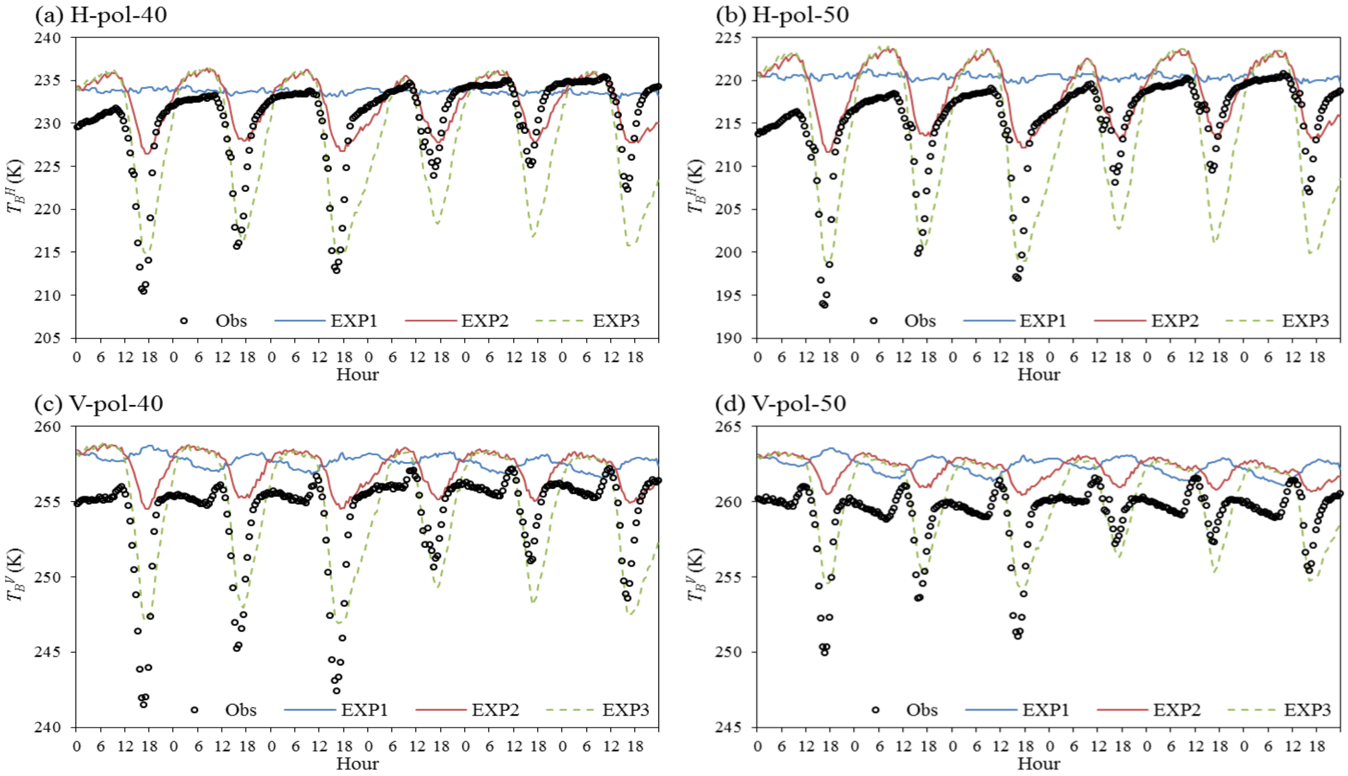
Period: Jan 1- April 5

a) Distinct periods of freezing and thawing are detected from the long-term measurements;

b) Emission depth ranges between 10 and 30 cm with the shallowest one located above 10 cm when the soil is thawed;

c) T_{eff} is comparable with the temperature at 25 cm depth when the soil liquid water is frozen, while it is closer to the one at 5 cm when the soil ice is thawing.

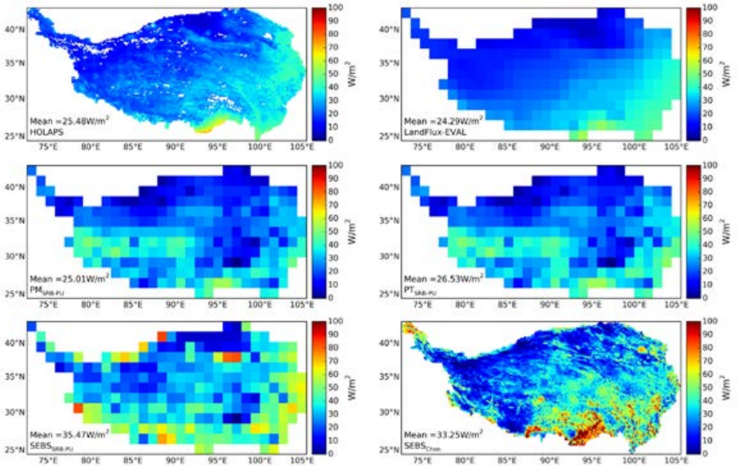
Noah-Tor Vergata Simulations

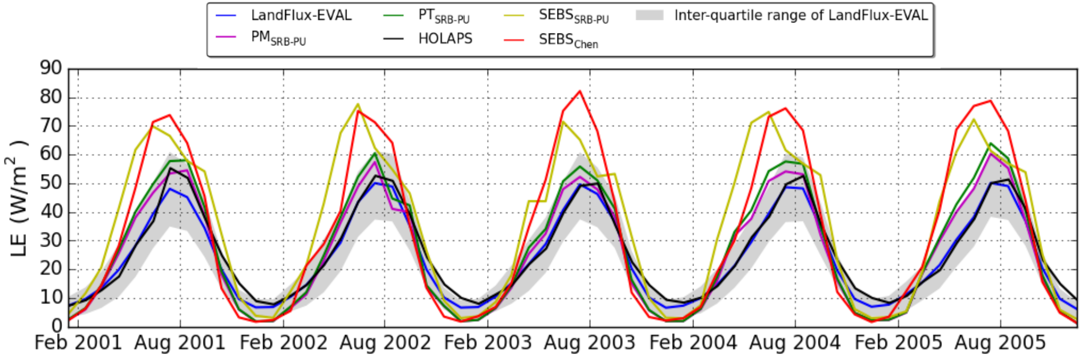


UN

TB signatures of diurnal soil freeze/thaw cycle is more sensitive to the liquid water content of soil surface layer than in situ measurements at 5 cm depth

WP2: Regional study - Tibetan Plateau - evaluation of HOLAPS





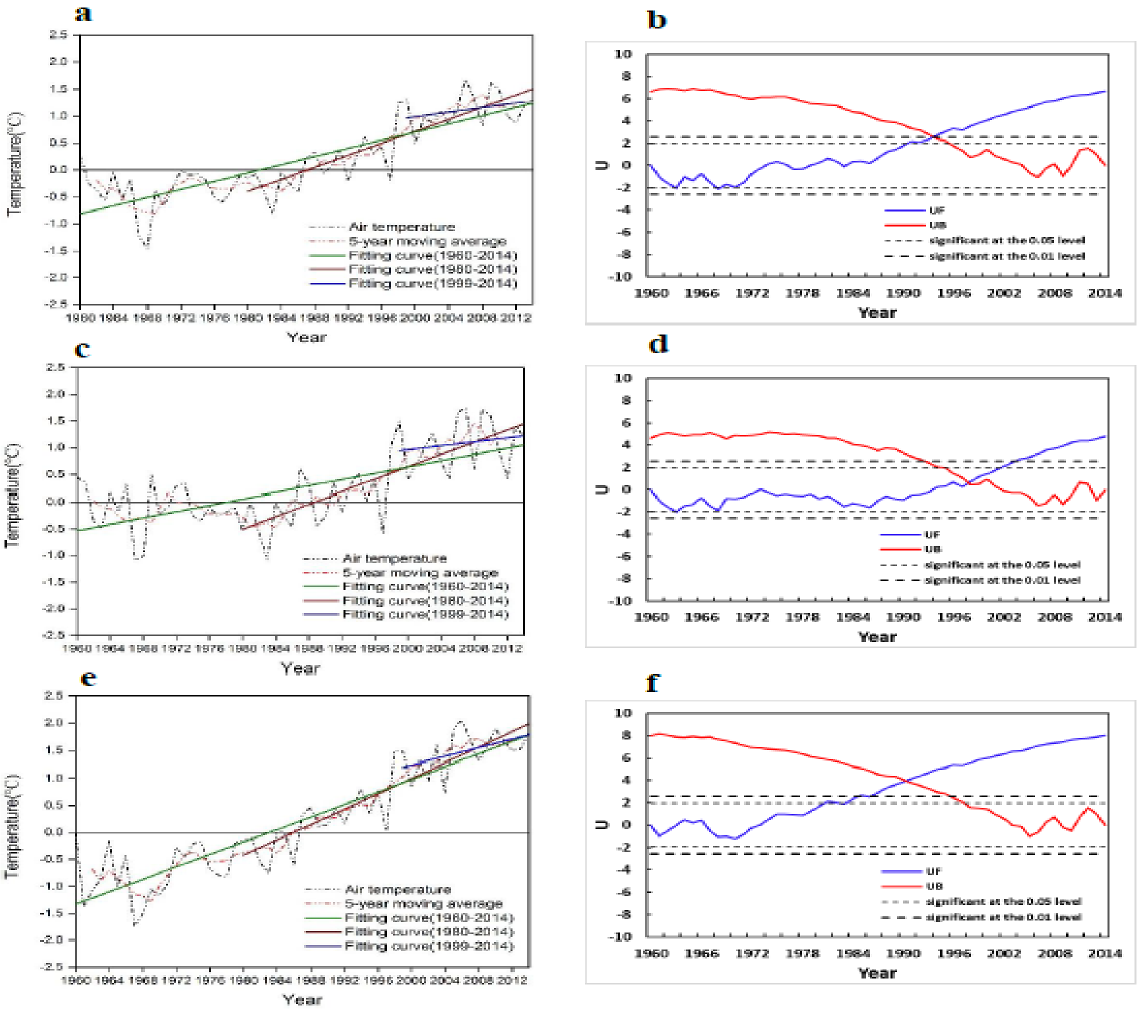
WP3: Achievements

Climate change trend and vegetation greening over the TP

LST from FY-2C and surface radiation components

Trends of land surface heat fluxes over TP and surrounding regions

Simulation of land surface parameters by WRF model



esa

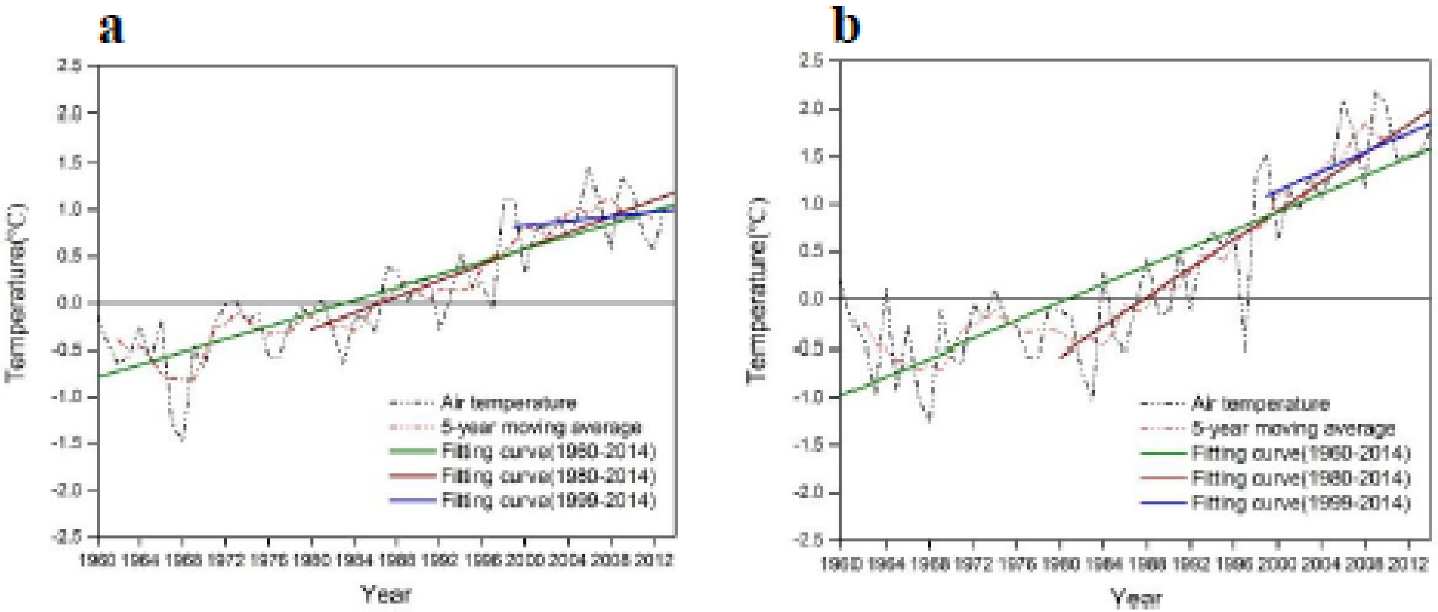
A consistent warming trend has been identified for different time periods

Variations of annual air temperature anomalies and M-K test

a, c and **e** are anomalies for Ta, Tmax, and Tmin, respectively;

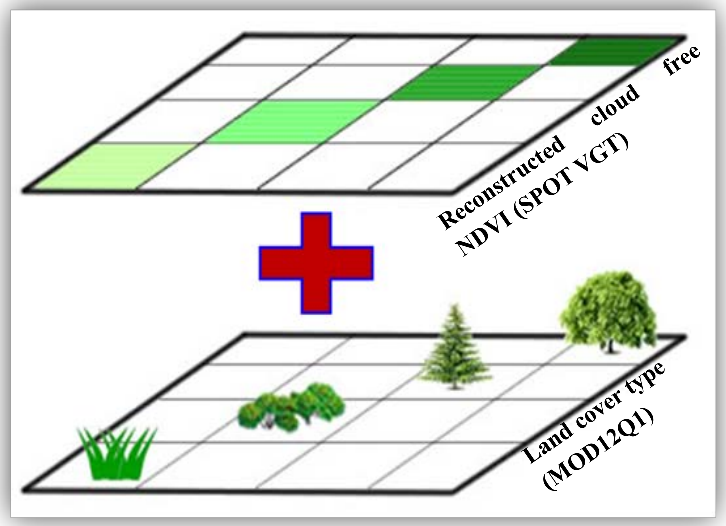
b, d and **f** represent their M-K test curves, respectively.

Air temperature anomalies at different elevations (a. lower than 4000 m; b. higher than 4000 m

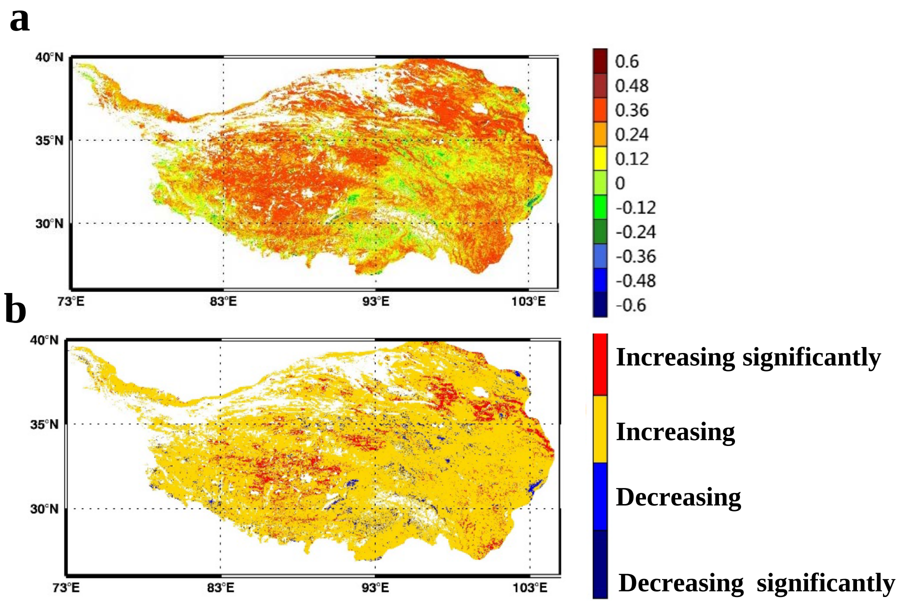


Air temperature at different altitudes has an overall increasing trend
- increasing rate abv. 4000 m significantly larger than that bel. 4000 m –
the Asian Water Tower will face a greater potential threat

Spatial distribution of tendency correlation coefficient over the TP (a) and its significance test result(b)

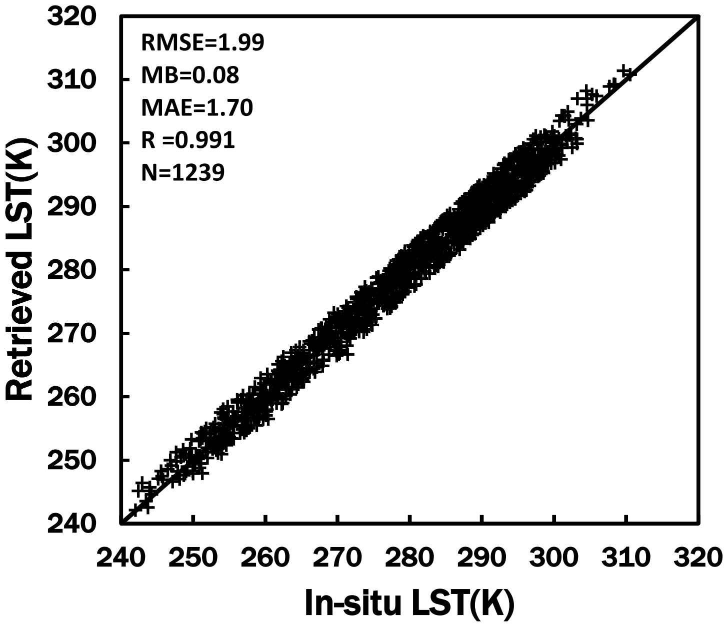


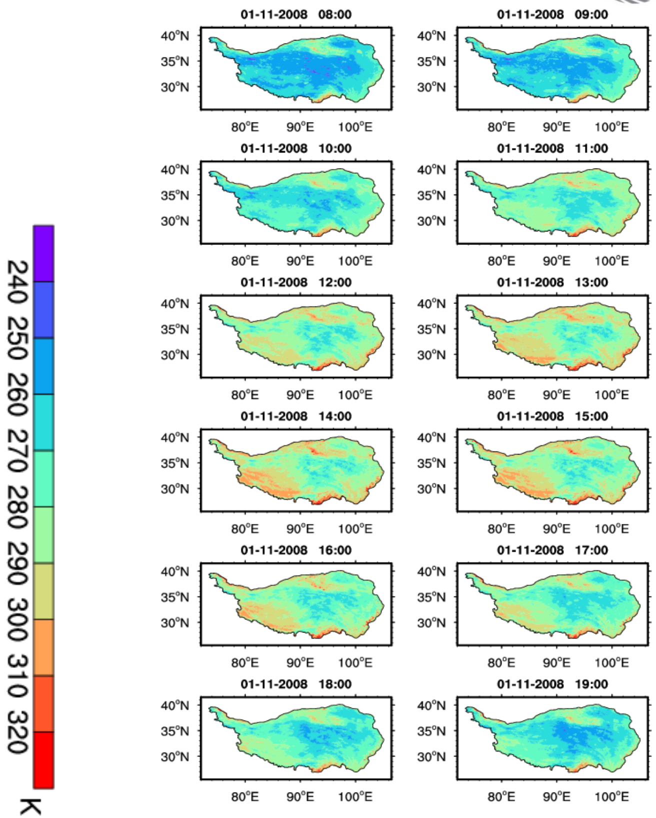
Climate sensitivity & vegetation changes



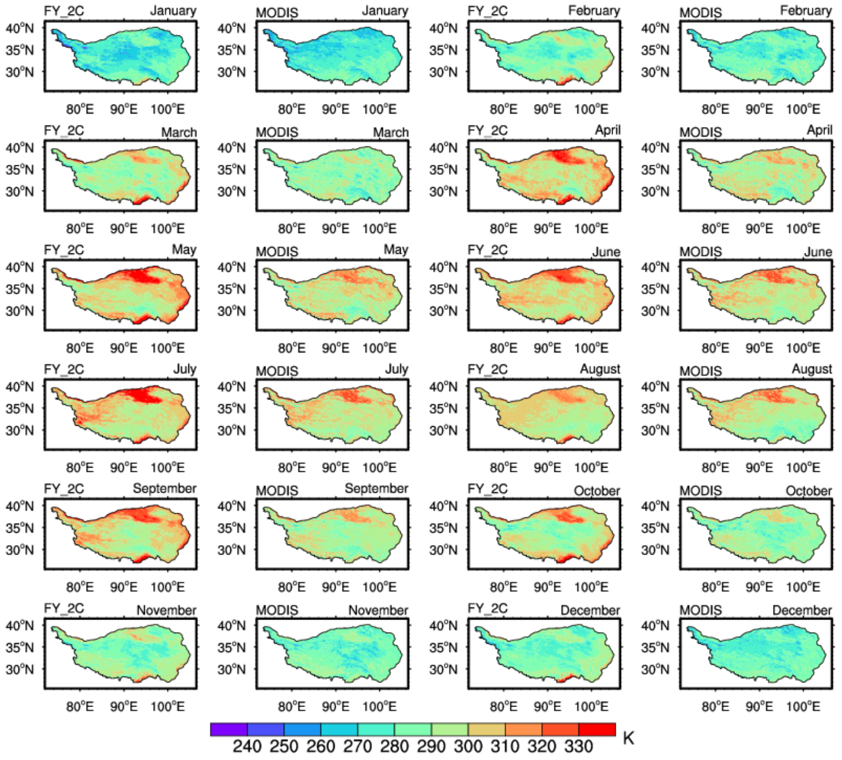
1999-2013

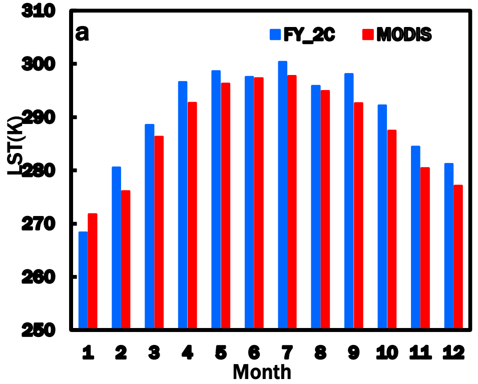
Derived FY-2C LST against field measurements

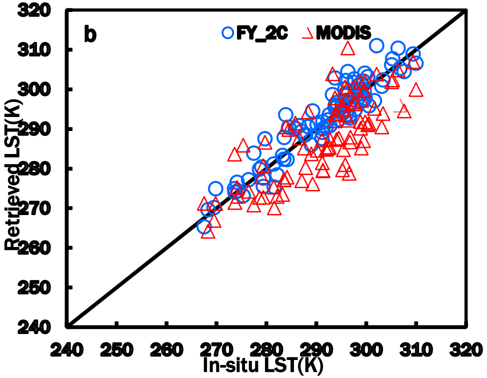




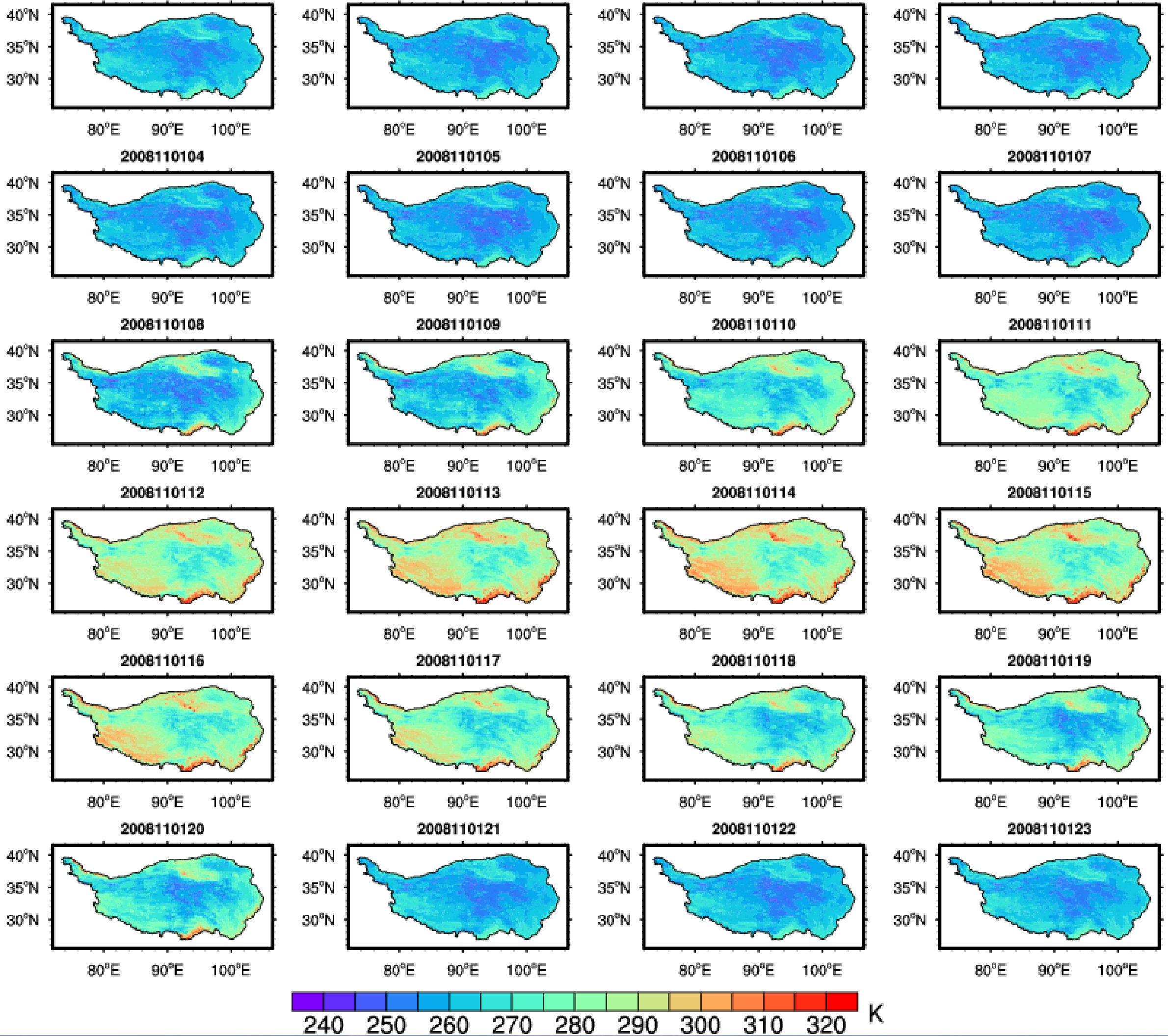
FY-2C LST vs. MODIS product





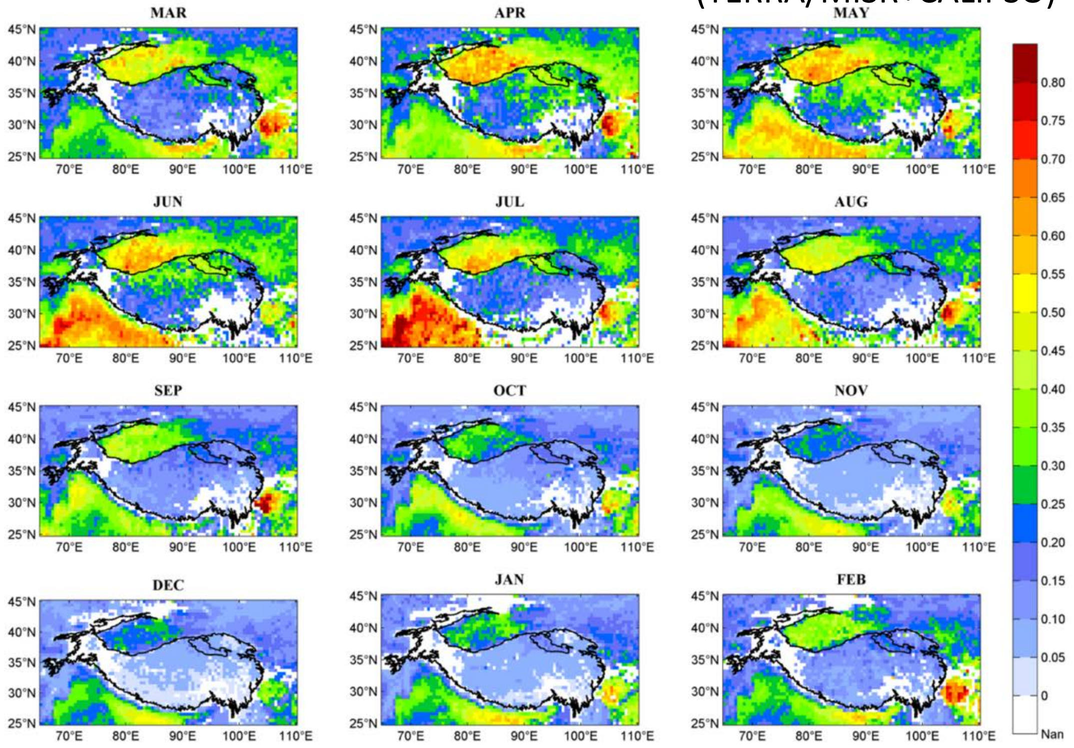


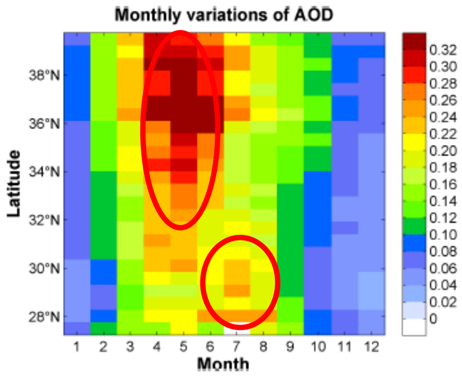
FY-2C LST diurnal cycle



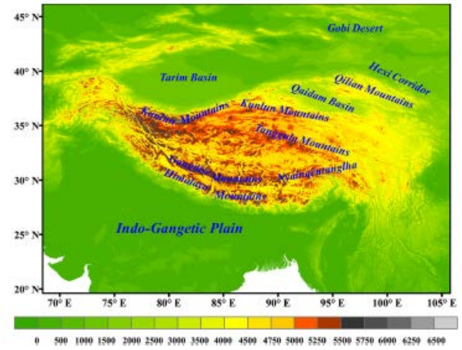
Monthly variations of AOD over TPE

(TERRA/MISR+CALIPSO)



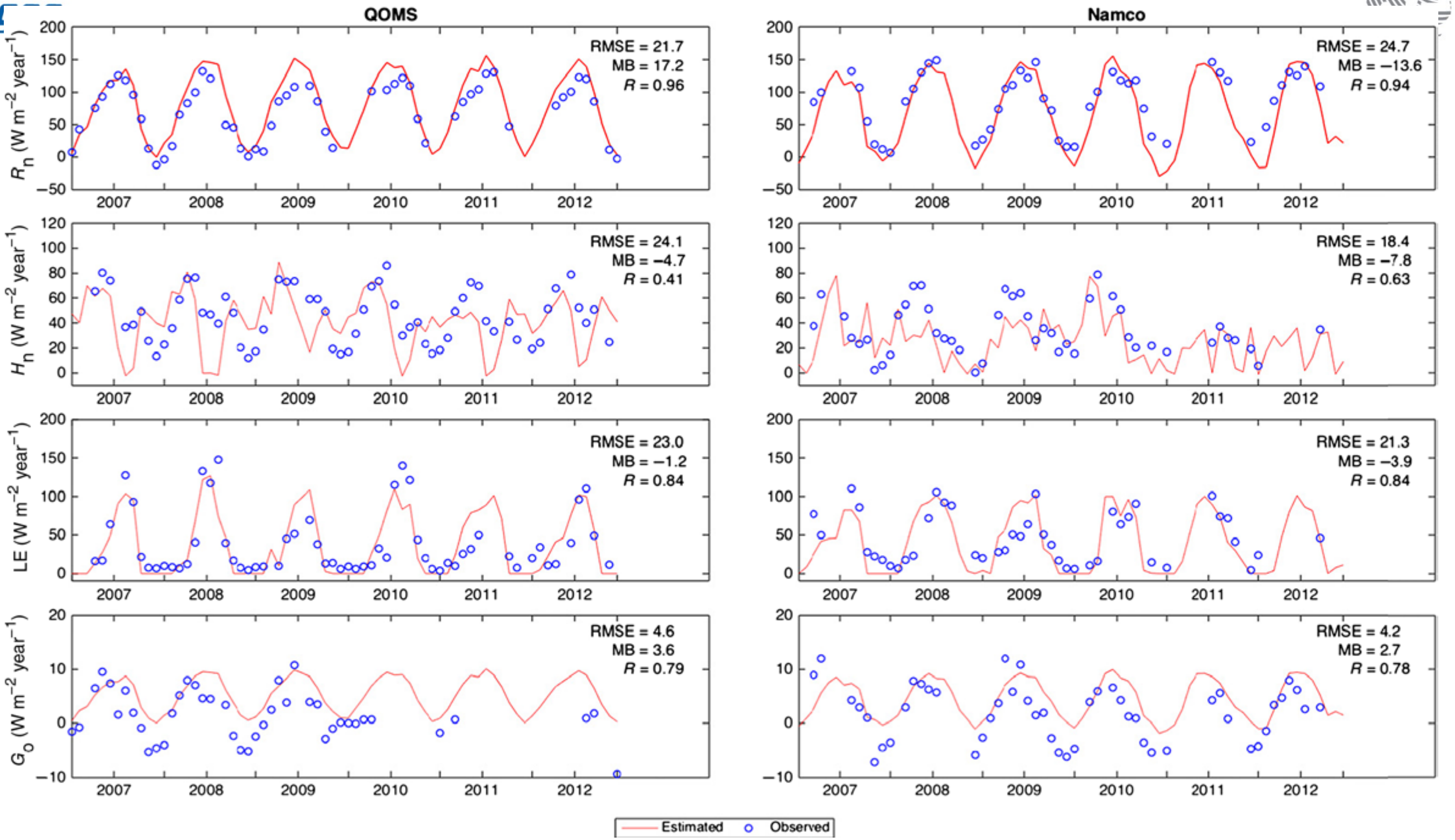


Zonal average of AOD over TPE

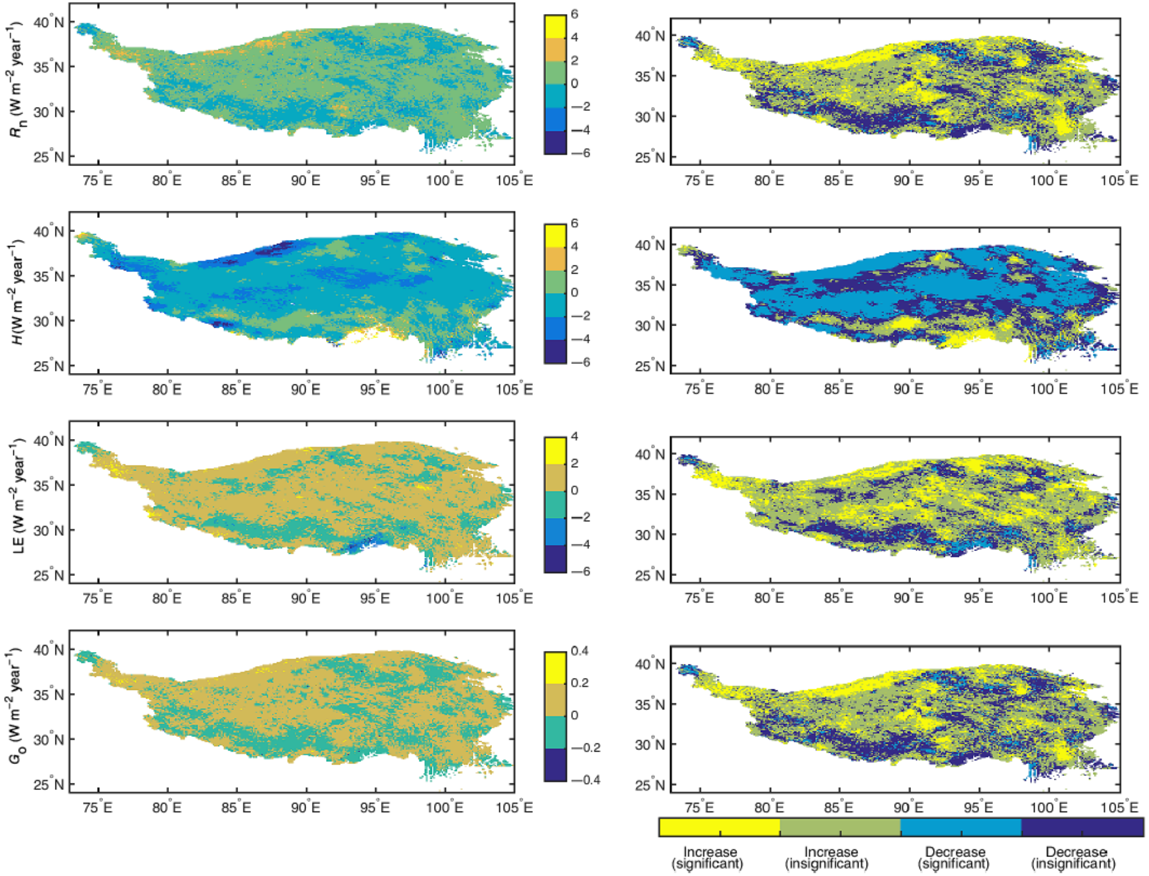


Emission sources, topography and atmospheric circulation

Land surface heat flux values at the QOMS and Namco stations



Energy budgets - linear trends (left) & significance test (right)



Contribution and training of Young Scientists

1. **Dr. Rogier van der Velde**, University of Twente, email: r.vandervelde@utwente.nl
2. **Dr. Yijian Zeng**, University of Twente, email: y.zeng@utwente.nl
3. **Dr. Xin Wang**, North-west Institute of Eco-Environmental Research, Chinese Academy of Sciences
4. **Dr. Xuelong Chen** (postdoc, UT) (land-atmosphere interactions, boundary layer processes)
5. **Dr. Donghai Zheng** (postdoc, UT) (water cycle in the upper Yellow River basin, hydrological modelling)
6. **Shaoning Lv** (PhD student, UT-CAREERI) (Microwave emission)
7. **Qiang Wang** (PhD student, UT) Soil moisture monitoring using Aquarius data
8. **Binbin Wang** (PhD student, UT-ITP) Energy balance of high plateau lakes
9. **Junping Du** (PhD student, UT-ITP) Urban hydroclimate observations10
10. **Xu Yuan** (PhD student, UT) Sea surface salinity in Indian Ocean and South Asian monsoon
11. **Hong Zhao** (PhD student, UT) Retrieval of soil thermal and hydraulic parameters from satellite observations
12. **Dongyu Jia** (PhD student, NIEER) land-atmosphere interaction study in cold region
13. **Dr. Cunbo Han** (postdoc, ITP) (land surface processes modelling)
14. **Lian Liu** (PhD student, ITP) Thermal and hydraulic parameters from satellite observations on the glaciers
15. **Dr. Cristina Aguilar,** University of Cordoba, e-mail: caguilar@uco.es
16. **Dr. Rafael Pimentel** (postdoc, UC) Data fusion and assimilation for snow and hydrological modelling
17. **Gabriel Delgado Leal** (PhD student, UC) Water and energy fluxes regime in snow mountain regions
18. **Marta Sáenz de Rodrigáñez** (PhD student, UC) Time series of snow and hydrological variables
19. **Dr. Jian Peng** (postdoc, LMU) Thermal and microwave remote sensing of surface energy and water fluxes
20. **Dr. Christiaan van der Tol**, University of Twente, Remote sensing of fluorescence
21. **Jan Hofste** (PhD student, UT), Remote sensing of land surface by scatterometry and spectroscopy
22. **Prof. Weiqiang Ma**, ITP, PBL and land-atmosphere modeling
23. **Prof. Lei Zhong**, USTC, Remote sensing of land surface processes

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)

Publications(2016-2017)

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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5. Ma, W., and Y. Ma, 2016: Modeling the influence of land surface flux on the regional climate of the Tibetan Plateau. Theoretical and Applied Climatology, 125, 45-52.
6. Zhong,, L. M. Zou, Y. Ma, Z. Su, W. Ma, Y. Hu, C. Han, B. Wang, 2016: Remote sensing of actual evapotranspiration at basin scale in the northern tibetan plateau area. Proc. 'Dragon 3 Final Results & Dragon 4 Kick-Off Symposium', Wuhan, PR China, 4–8 July 2016 (ESA SP-739, August 2016)
7. Huang, F., W. Ma, B. Wang, et al. 2017, Air Temperature Estimation with MODIS Data over the Northern Tibetan Plateau, Adv. Atmos. Sci., 10.1007/s00376-016-6152-5.
8. Ding, Z., Y. Ma, Z. Wen, W. Ma, S. Chen, 2016, A comparison between energy transfer and atmospheric turbulent exchanges over alpine meadow and banana plantation, Theoretical and Applied Climatology, DOI: 10.1007/s00704-016-1754-5.

Publications(2016-2017)

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. Sigdel, M., 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. Latif, Y,. 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.
16. Ciren Nima, BØrge Hamre,. Øyvind Frette, Svein Rune Erga,Yi-Chun Chen,Lu Zhao,Kai SØrensen, Marit Norli, Da-Ren Lu,Qian-Guo Xing,Y.Ma, Norsang Gelsor, Jakob J. Stamnes, 2016, Impact of particulate and dissolved material on light absorption properties in a High-Altitude Lake in Tibet,China, Hydrobiologia, 768:63–79,DOI 10.1007/s10750-015-2528-2.
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18. Colliander, A., et al. "Validation of SMAP surface soil moisture products with core validation sites." *Remote Sensing of Environment* 191 (2017): 215-231.

Publications(2016-2017)

19. Zheng, D., et al. "Assessment of Noah land surface model with various runoff parameterizations over a Tibetan river." *Journal of Geophysical Research: Atmospheres* 122.3 (2017): 1488-1504.

20. Zheng, D., et al. "Evaluation of Noah Frozen Soil Parameterization for Application to a Tibetan Meadow Ecosystem." *Journal of Hydrometeorology* 2017 (2017).

21. Zheng, D., et al. "L-Band Microwave Emission of Soil Freezesc-Thaw Process in the Third Pole Environment." *IEEE Transactions on Geoscience and Remote Sensing* (2017).

22. Wang, J., et al. "The on-orbit calibration of geometric parameters of the Tian-Hui 1 (TH-1) satellite." *ISPRS Journal of Photogrammetry and Remote Sensing* 124 (2017): 144-151.

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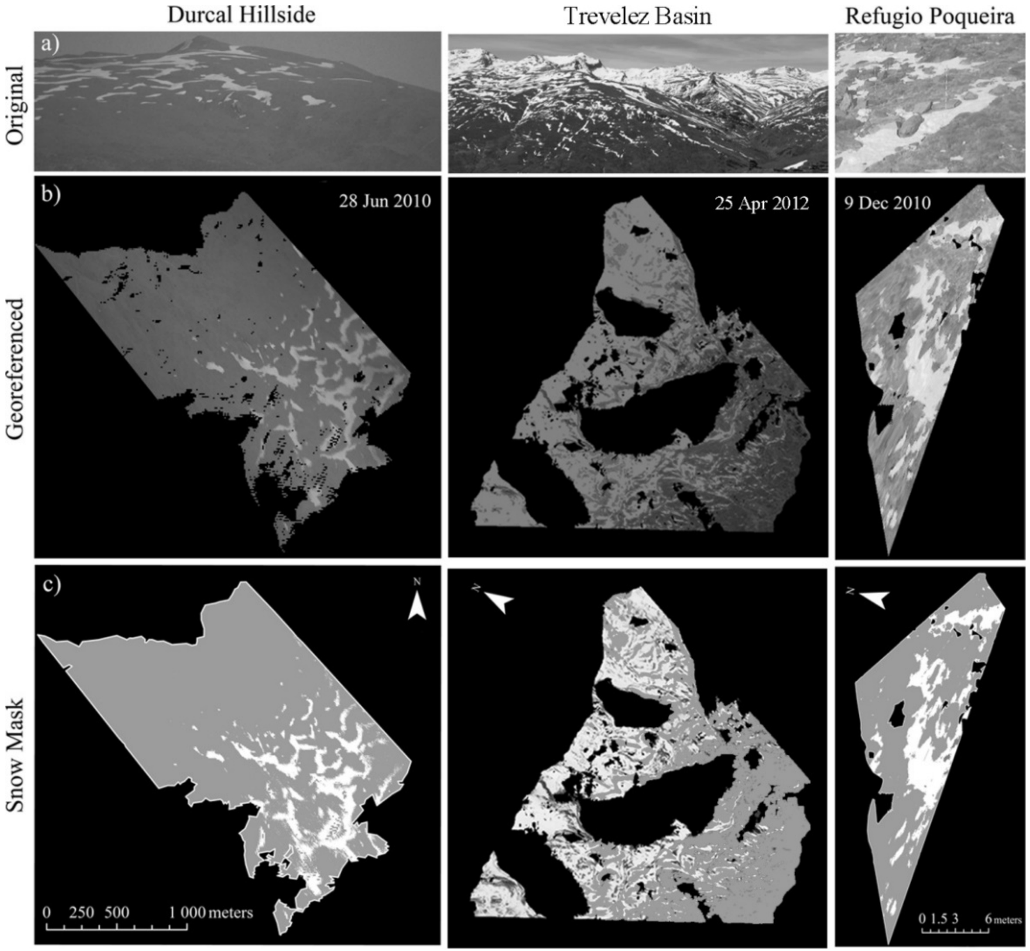
Plans for the next 2 years

WP1: Observation and modelling of microwave scattering and emission under complex terrains incl. permafrost and freeze and thawing (continue radiometry/radar observations)

WP2: Advancement of physical understanding and quantification of changes of water and energy budgets in TPE (deploy snow observations**)**

WP3: Advancement of quantifying changes in surface characteristics and monsoon interactions (continue data analysis at climate scale**)**


Durcal Hillside
Trevelez Basin
Refugio Poqueira
Original
Georeferenced
Snow Mask
a)
b)
c)
28 Jun 2010
25 Apr 2012
9 Dec 2010
N
0 250 500 1 000 meters
0 1.5 3 6 meters

Monitoring sensible heat flux over urban areas in a high-altitude city using Large Aperture Scintillometer and Eddy Covariance

Introduction

Urbanization leads to modifications of surface energy balance which governs the momentum, heat and mass transfer between urban canopy layer and the atmosphere, thus impacts dynamic processes in the urban ABL and ultimately influence the local, regional and even global climate. It is essential to obtain accurate urban ABL observations to enhance our understanding of land-atmosphere interaction process over the urban area and help to improve the prediction ability of numerical model. However, up to now, there are rarely observations in high altitude cities. This poster introduced the urban flux observation conducted in a high-altitude city, Lhasa, using eddy-covariance technique and large aperture scintillometer. As the first results, the diurnal patterns of the surface energy balance and energy partitioning in the winter of 2016 were discussed.

Methodology: Flux from LAS

A. Structure parameter of temperature (CT2)

$$C_T^2 \approx C_n^2 \times \frac{T^2}{\left(\left[-0.78\times10^{-6}\times\left(\frac{P}{T}\right)\right]\times\left(1+\frac{0.03}{\beta}\right)\right)^2}$$

B. Monin-Obukhov similarity theory (MOST)

$$T_*^2 = C_T^2 \times \left(z_{LAS}-d\right)^{\frac{2}{3}} / f_T\left(\frac{z_{LAS}-d}{L_{MO}}\right)$$

$$u_* = \frac{k_v u}{ln\left(\frac{z_u-d}{z_0}\right) - \Psi_m\left(\frac{z_u-d}{L_{OM}}\right) + \Psi_m\left(\frac{z_0}{L_{OM}}\right)}$$

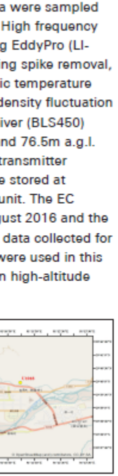
$$L_{MO} = \frac{u_*^2 T}{g k_v T_*}$$

$$H = -\rho C_p u_* T_*$$

Where Z_{LAS} is the effective height of LAS(Hartogensis, Watts et al. 2003), and Z_u is the measurement height of meteorological data. For further information, refer to (Lagouarde, Irvine et al. 2006)

Experiment Setup and Data Processing

This study took place in Lhasa, which is the administrative capital of the Tibet Autonomous Region of China. With an average altitude of 3650 m, Lhasa is one of the highest cities in the world. Over recent years it has experienced tremendous growth. From 2000 to 2015, its resident population increased from 0.47 million to 0.9 million and the number of tourists increased from 0.6 million to 20 million per year. It has a cool semi-arid climate. Flux observations are achieved by a combination of one eddy-covariance (EC) system and one Large Aperture Scintillometer (LAS). The EC system consists of a sonic anemometer (CSAT3) and an open-path infrared gas analyzer(LI-7500), which was installed on the office building of at a height of 25.1m above ground level (a.g.l.). At the same site, meteorological instruments were installed, including a four component radiometer(CNR4), a temperature/humidity probe (HMP155A), a wind monitor (Met One-034B) and a tipping bucket rain gauge(TB4MM). EC data were logged at 10Hz, and all meteorological data were sampled at 5s interval and averaged to 30 min (CR3000). High frequency EC data were processed to 30min statistics using EddyPro (LI-COR) following conventional procedures, including spike removal, time lag compensation, coordinate rotation, sonic temperature correction, frequency response correction, and density fluctuation correction (WPL). The LAS transmitter and receiver (BLS450) were mounted on two buildings at 37.1m a.g.l and 76.5m a.g.l. respectively with a path length of 2.82 km. The transmitter frequency is 5Hz and the output data (CN2) were stored at 1min-interval by the supplied signal processing unit. The EC measurements have been ongoing since 10 August 2016 and the LAS started to work on 12 November 2016. The data collected for clear sky condition from Dec 1 to Dec 28 2016 were used in this poster to analyze the sensible heat flux pattern in high-altitude urban environment.



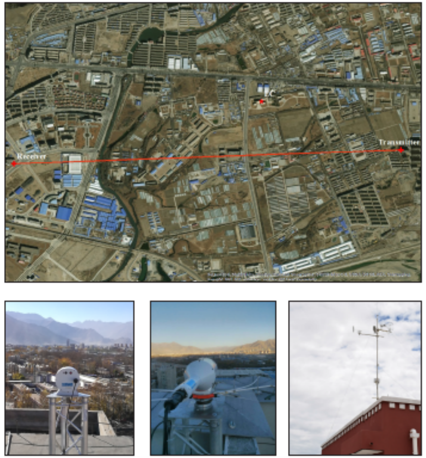
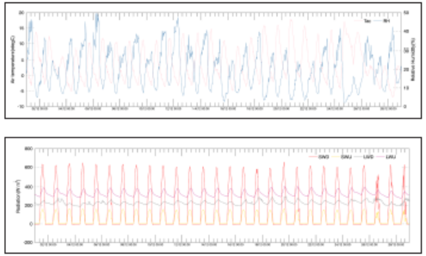


Figure 1 Locations of experimental sites

Results



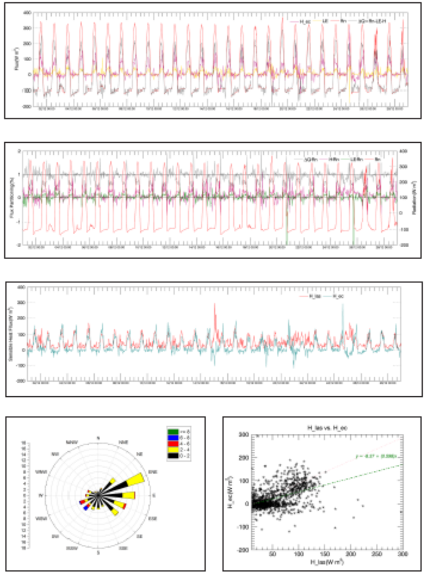


Figure 2 Diurnal variation in air temperature(Tac), relative humidity(RH), four-component radiation (SWD, SWU, LWD, LWU), surface heat fluxes (H, LE) and energy partitioning ratios during 1 -28 Dec,2016.

Conclusion

Without regard to storage heat flux, energy partitioning over urban area in winter was dominated by sensible heat flux. However, unlike natural surfaces, urban storage heat flux takes up more energy, which contributed to the large difference between Rn and (LE+H). In addition, the representativeness of Rn measurements might be another major factor.

Evaporation and energy budget observation over a high-altitude small lake on the Tibetan Plateau

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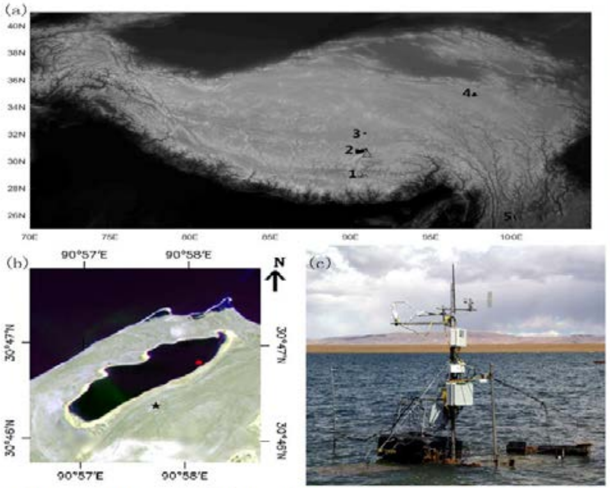

Figure 1 (a) The positions of several high-altitude lakes, with numbers 1-5 indicating the positions of Yamdrok Yum Co, Nam Co, Zige Tang Co, lake Ngoring, and Erhai, respectively; (b) an image of the small lake and the location where field observations were collected; (c) the photo of the instruments.

Wang, B., Y. Ma, W. Ma, and Z. Su, 2017: 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*.

Surface Soil Moisture Retrieval From Optical/Thermal Infrared Remote Sensing

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