Yale

耶鲁大学-南京信息工程大学大气环境中心

Yale-NUIST Center on Atmospheric Environment

Study of Regional Urban Heat Island in Yangtze River Delta

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Video conference on May 4, 2012

Outline

1. Introduction
2. Site and Data
3. Objective
4. Results
5. Discussion

1.Introduction

Definition: Urban Heat Island(UHI) is defined as the rise in temperature of any man-made area, resulting in a well-defined, distinct "warm island" among the "cool sea" represented by the lower temperature of the area's nearby natural landscape .

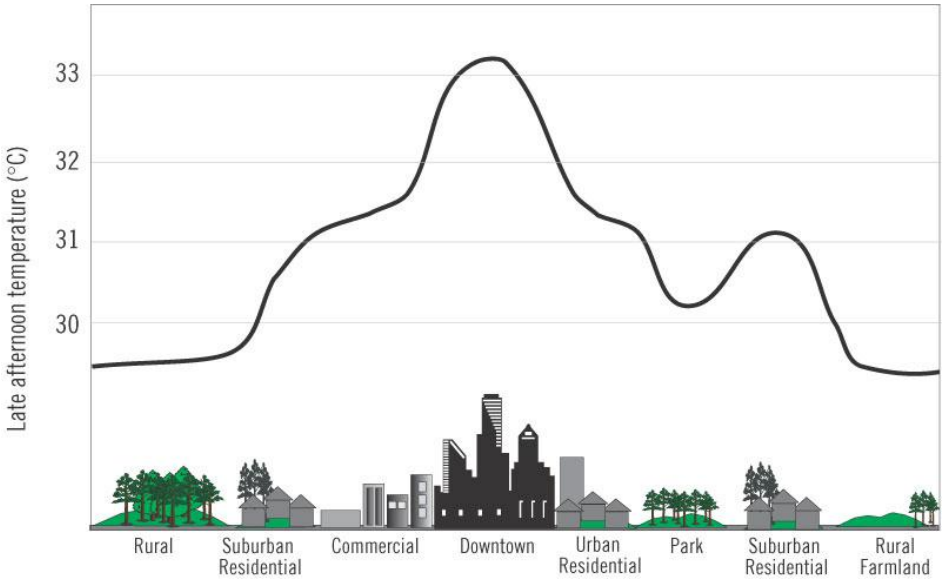

Fig. 1 Source : EPA, 2008

(Source: http://www.urbanheatislands.com)

Primary Cause: Urbanization

- Urbanization negatively impacts the environment mainly by the production of pollution, the modification of the physical and chemical properties of the atmosphere, and the covering of the soil surface. Considered to be a cumulative effect of all these impacts is the UHI. (Source: http://www.urbanheatislands.com)
- In China, two forms of urbanization have occurred: the growth of cities following urban economic development and population concentration, and rural urbanization based on the growth of smaller towns in rural areas (Cui and Ma, 1999).

(Source: http://www.urbanheatislands.com)

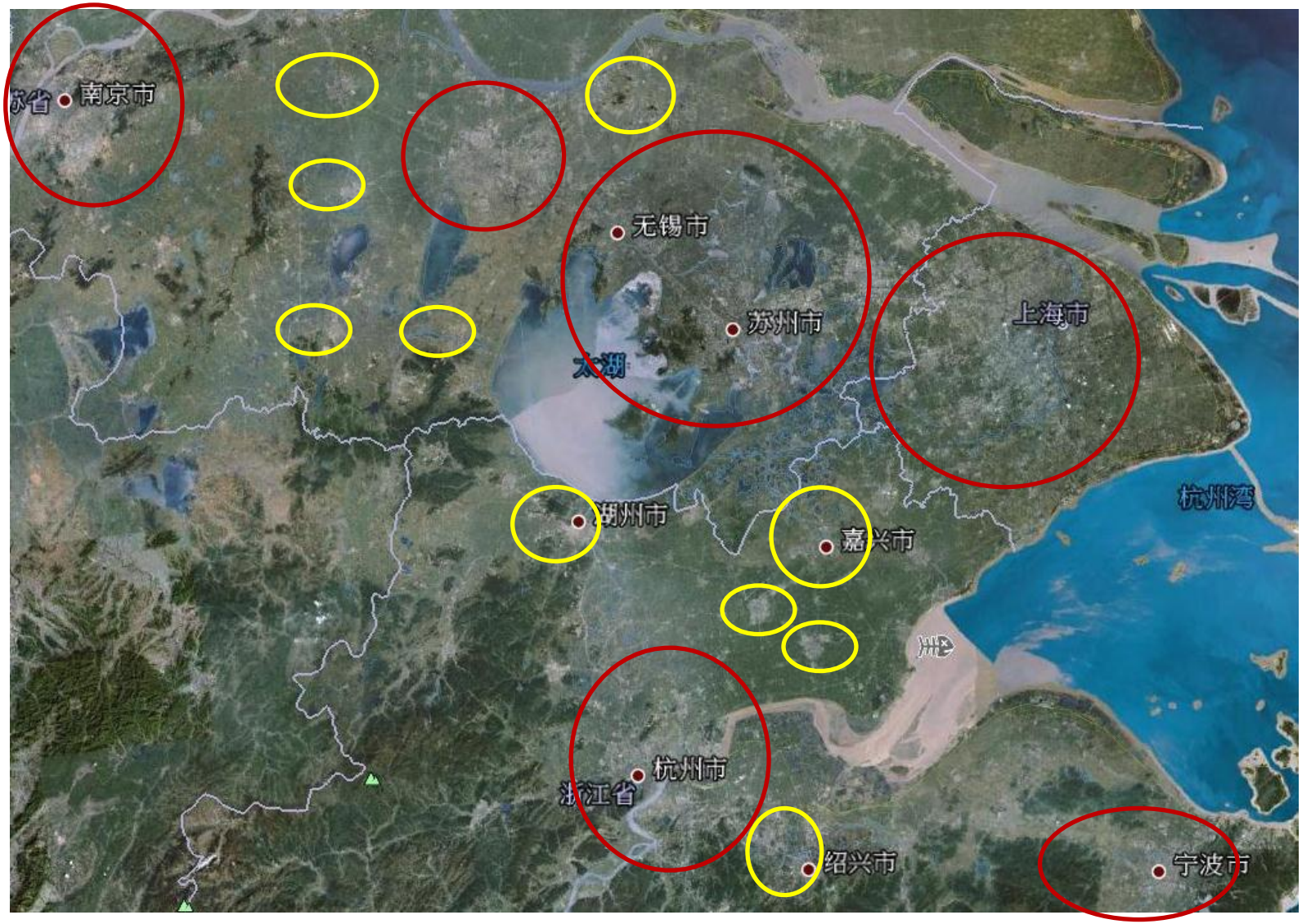

Fig. 2 Urbanization at YRD in east China

Observed surface warming induced by urbanization in east China

Xuchao Yang,[1,2] Yiling Hou,[3] and Baode Chen[1]

Received 7 December 2010; revised 7 April 2011; accepted 6 May 2011; published 28 July 2011.

[1] Monthly mean surface air temperature data from 463 meteorological stations, including those from the 1981–2007 ordinary and national basic reference surface stations in east China and from the National Centers for Environmental Prediction and National Center for Atmospheric Research (NCEP/NCAR) Reanalysis, are used to investigate the effect of rapid urbanization on temperature change. These stations are dynamically classified into six categories, namely, metropolis, large city, medium-sized city, small city, suburban, and rural, using satellite-measured nighttime light imagery and population census data. Both observation minus reanalysis (OMR) and urban minus rural (UMR) methods are utilized to detect surface air temperature change induced by urbanization. With objective and dynamic station classification, the observed and reanalyzed temperature changes over rural areas show good agreement, indicating that the reanalysis can effectively capture regional rural temperature trends. The trends of urban heat island (UHI) effects, determined using OMR and UMR approaches, are generally consistent and indicate that rapid urbanization has a significant influence on surface warming over east China. Overall, UHI effects contribute 24.2% to regional average warming trends. The strongest effect of urbanization on annual mean surface air temperature trends occurs over the metropolis and large city stations, with corresponding contributions of about 44% and 35% to total warming, respectively. The UHI trends are 0.398°C and 0.26°C decade^{-1}. The most substantial UHI effect occurred after the early 2000s, implying a significant effect of rapid urbanization on surface air temperature change during this period.

(Source:Yang,Hou and Chen,2011)

2. Site and Data

- Site: Yangtze River Delta
- Data: MODIS(AUQU) 8day LST Products
- Processing: Calculate Mean Annual LST , Mean Warm Season LST ,Mean Cold Season LST by IDL

Warm season: May to September

Cold season: November to March

3.Objective

- Seeking the new method to study Regional Urban Heat Island in YRD
- Analysing Regional Urban Heat Island in YRD

4. Results

4.1 The Temporal and Spatial Distribution of LST in YRD

4.2 The Temporal and Spatial Distribution of the Regional Urban Heat in YRD

4.1 The Temporal and Spatial Distribution of LST in YRD

- MODIS LST Annual Mean in YRD
- MODIS LST Warm Season Mean in YRD
- MODIS LST Cold Season Mean in YRD


2
1
南京市
安徽省
上海市
杭州市
宁波市
3
鄱阳湖
江西省
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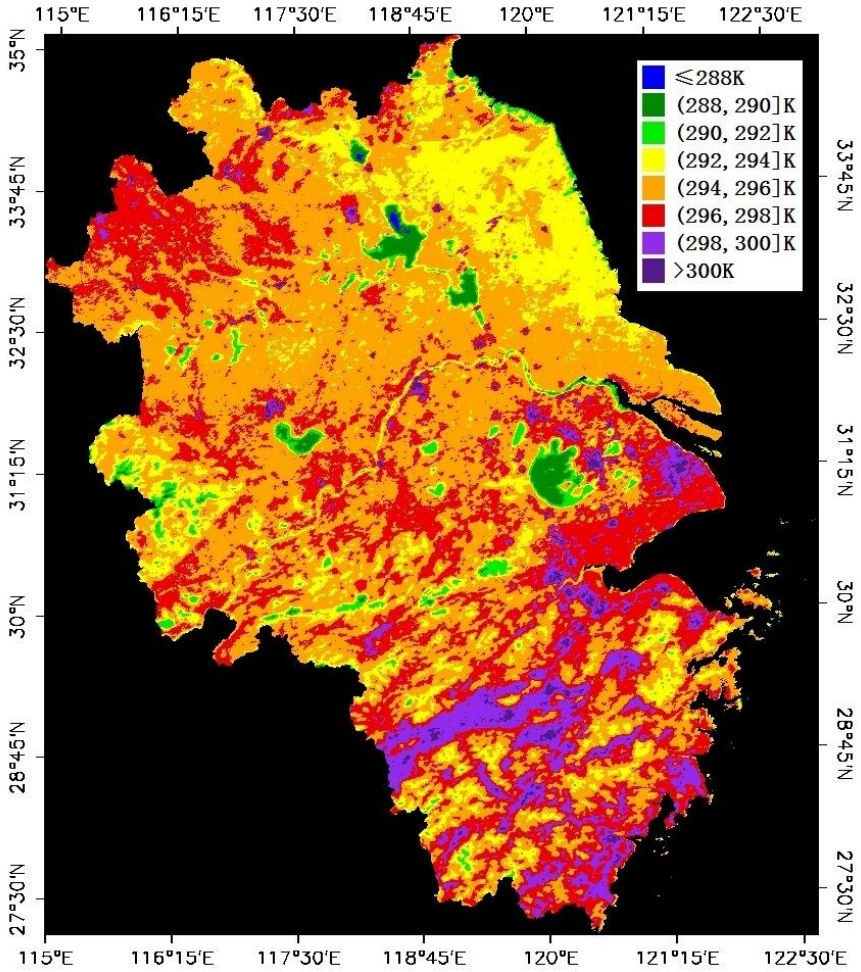
MODIS LST Annual Mean in YRD

daytime

nighttime



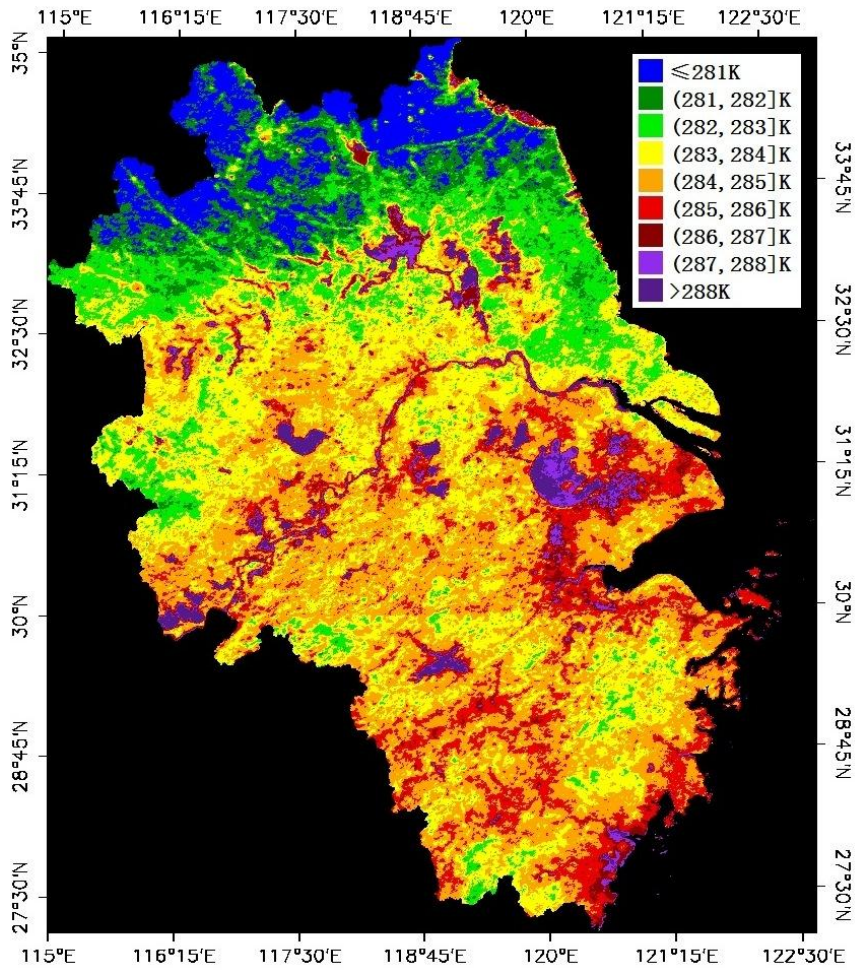


Fig. 3 MODIS LST annual mean ,2003 in YRD

daytime

nighttime

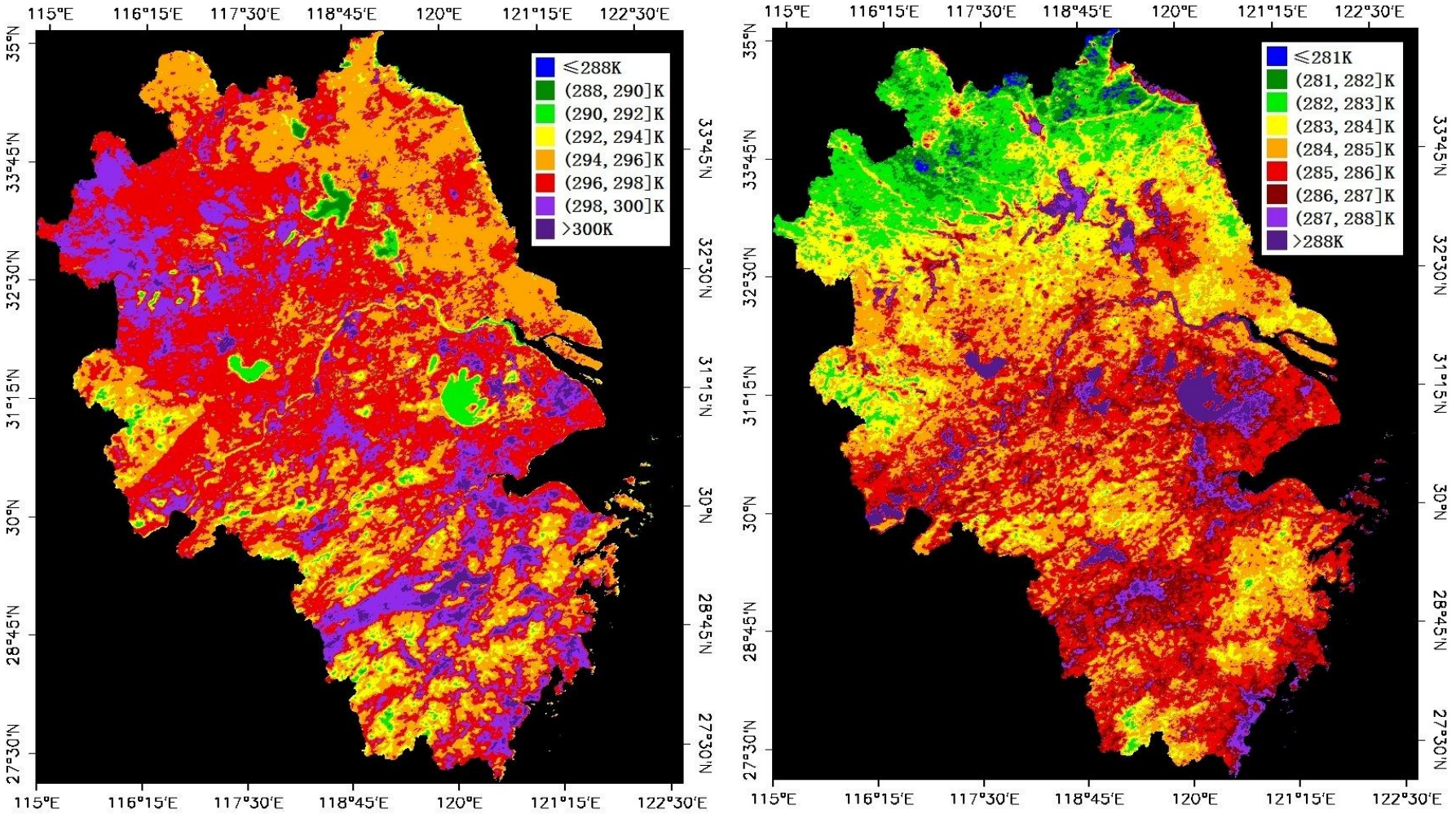


Fig .4 MODIS LST annual mean,2004 in YRD

daytime

nighttime

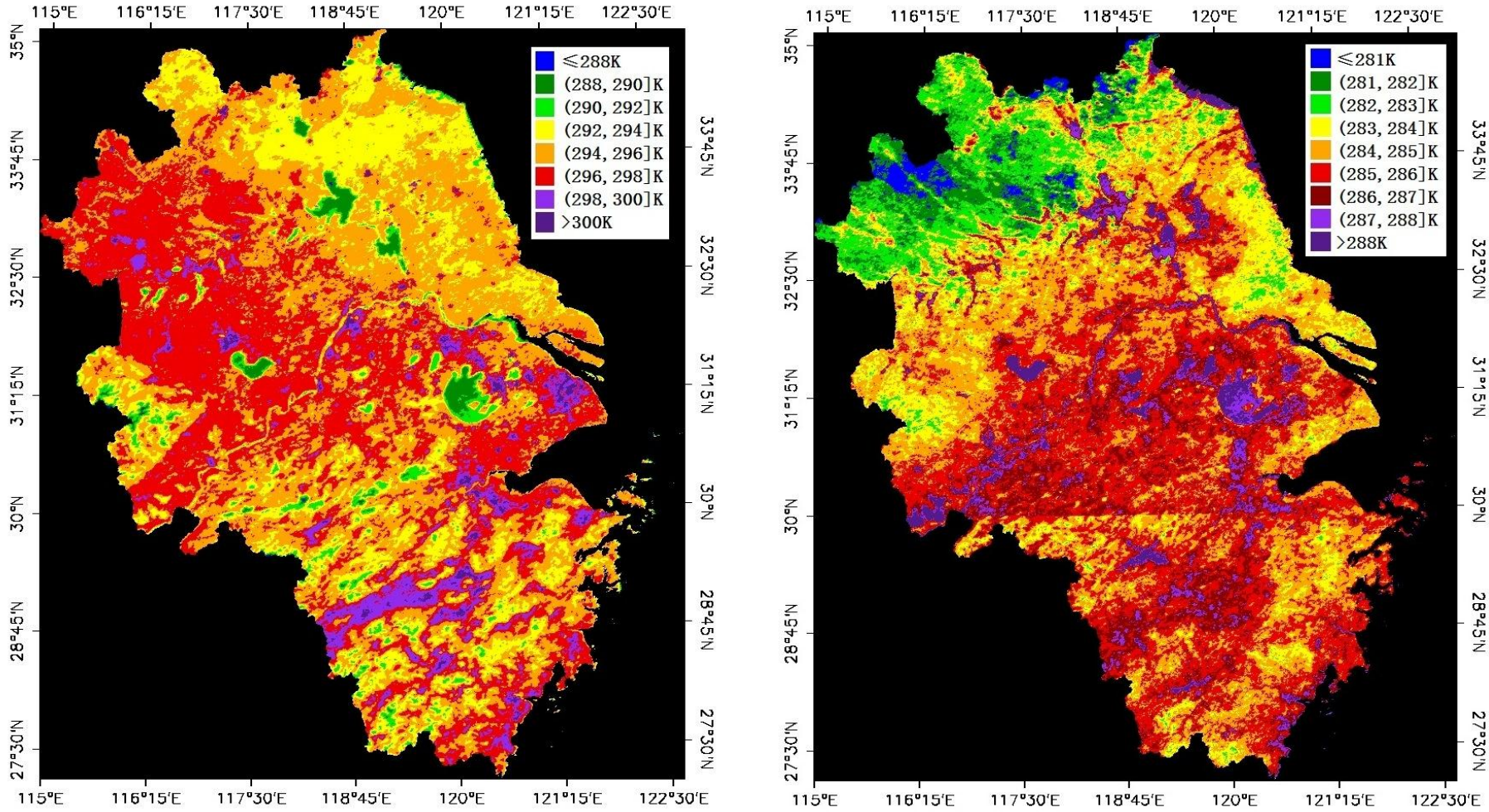
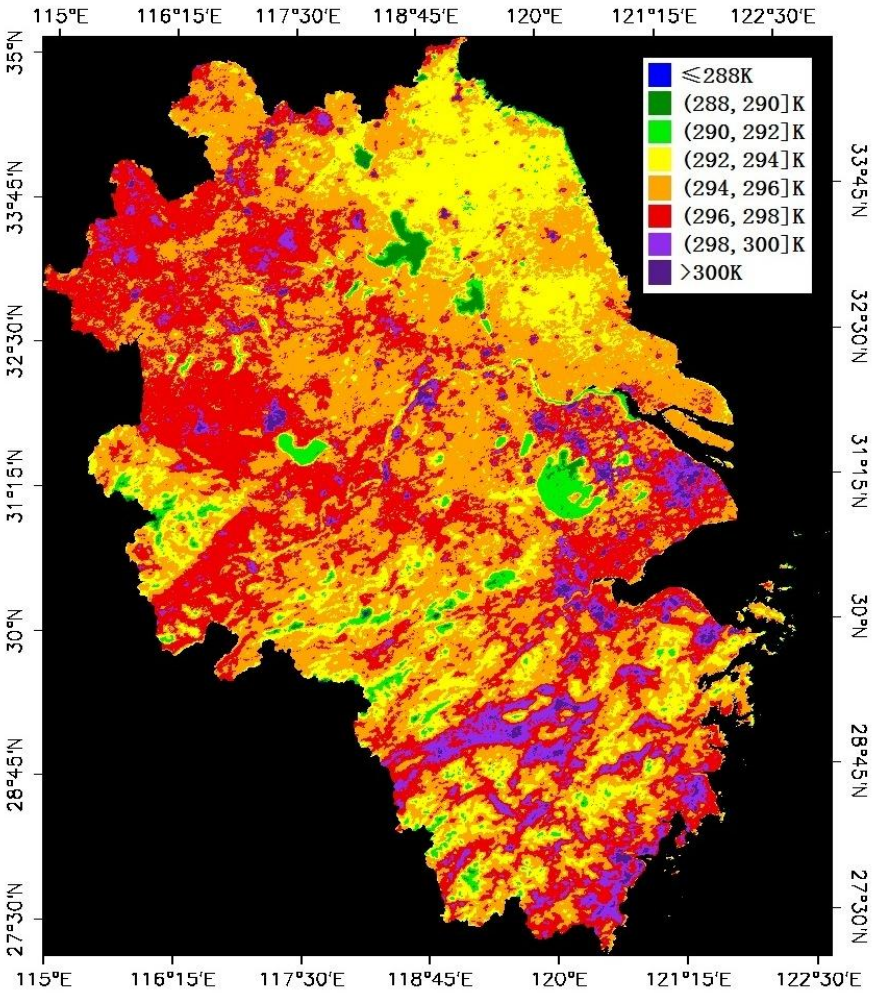


Fig. 5 MODIS LST annual mean,2005 in YRD

daytime

nighttime



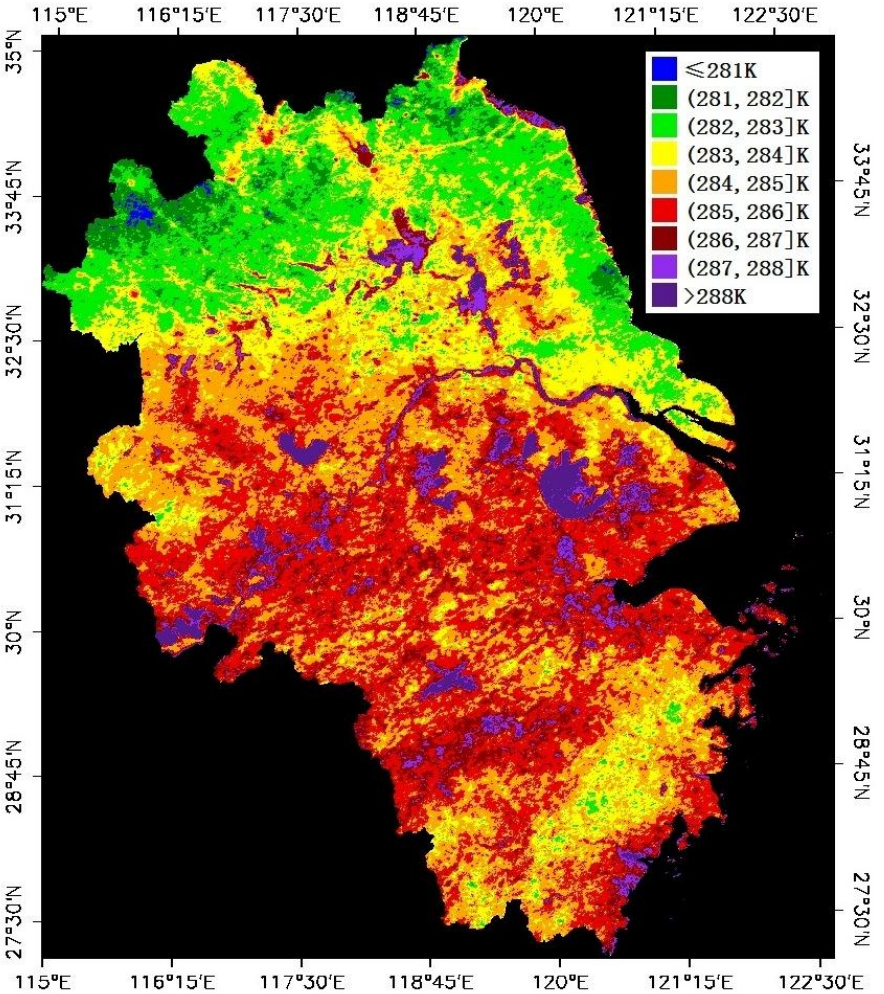
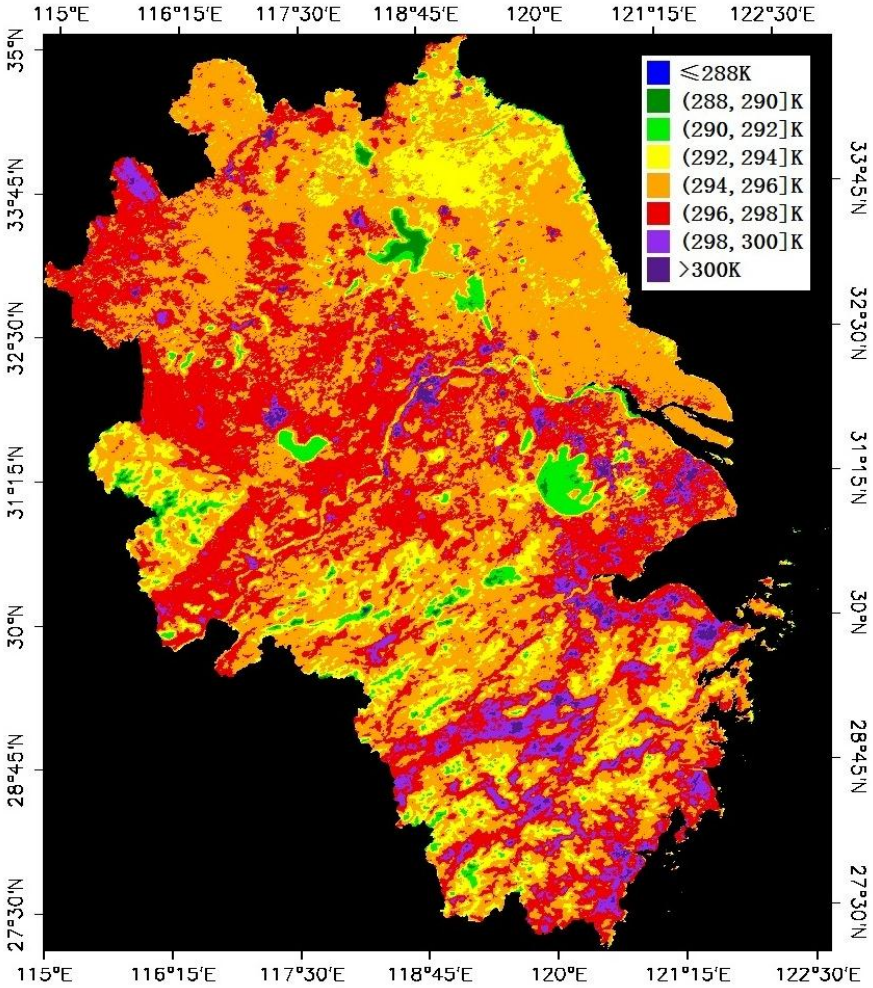


Fig .6 MODIS LST annual mean,2006 in YRD

daytime

nighttime



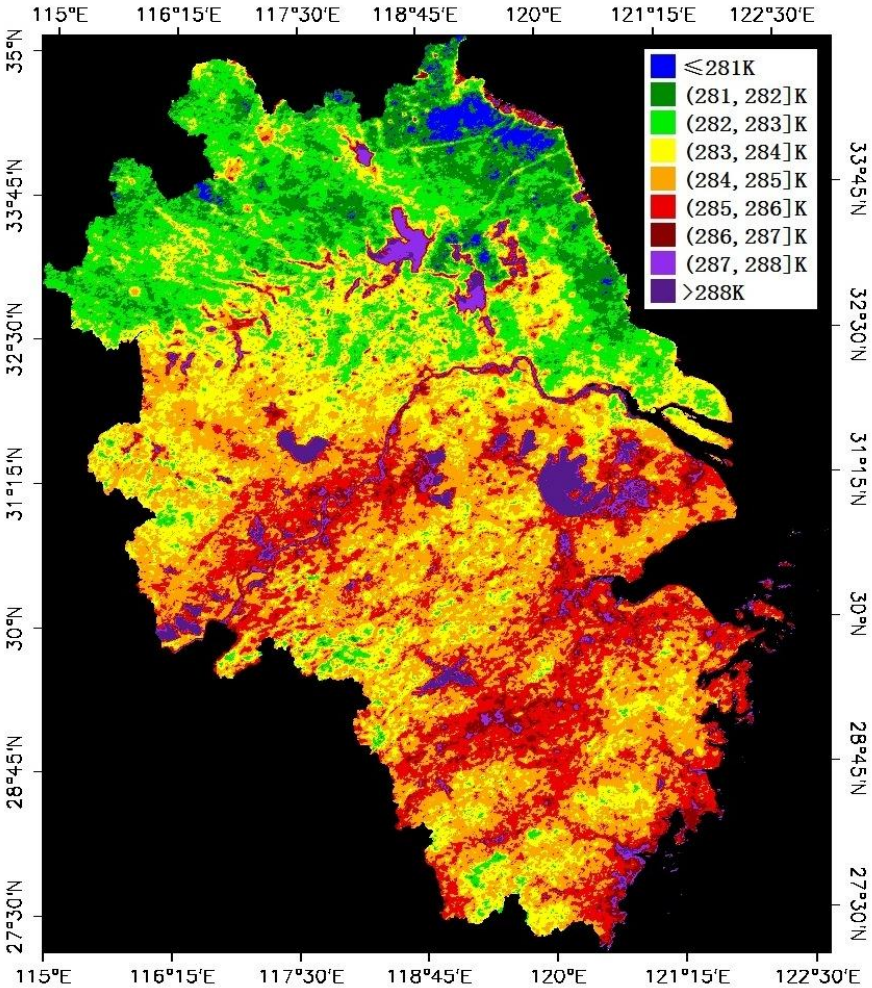
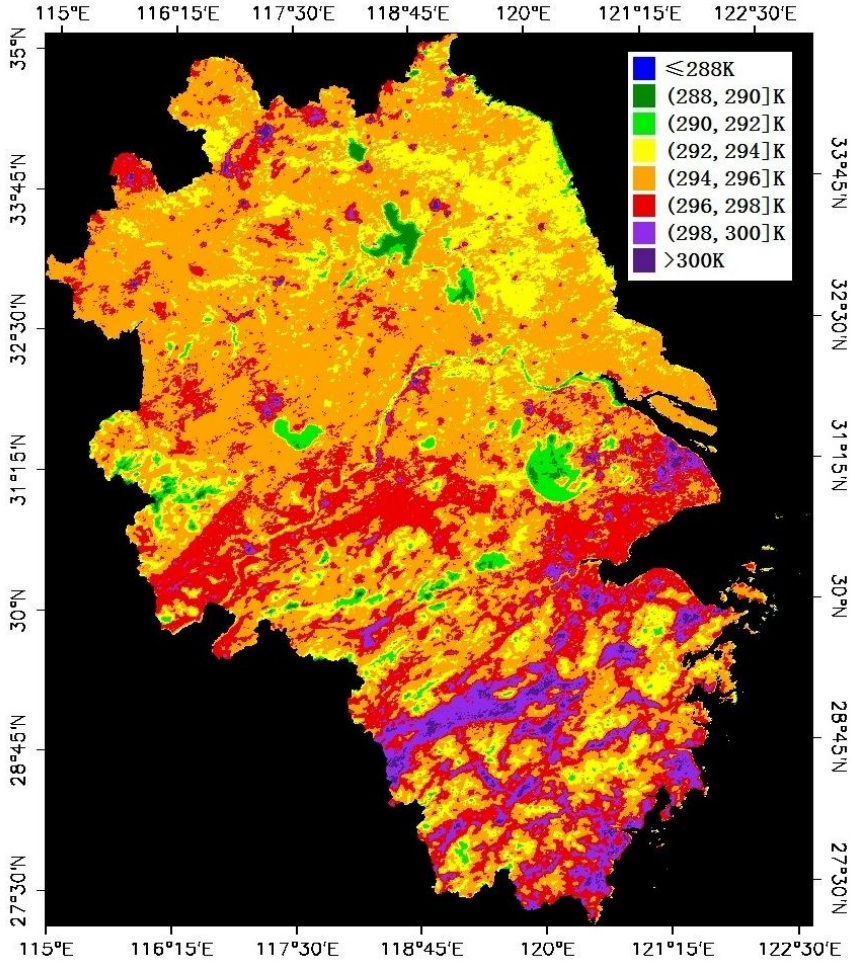


Fig .7 MODIS LST annual mean, 2007 in YRD

daytime



nighttime

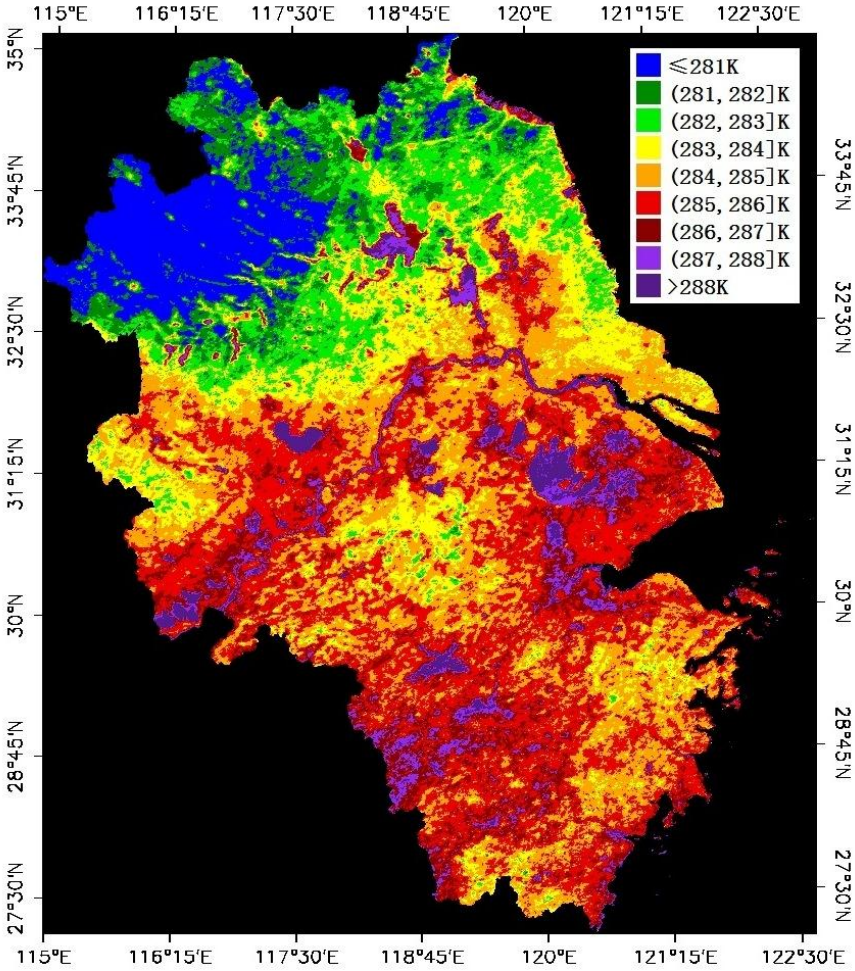
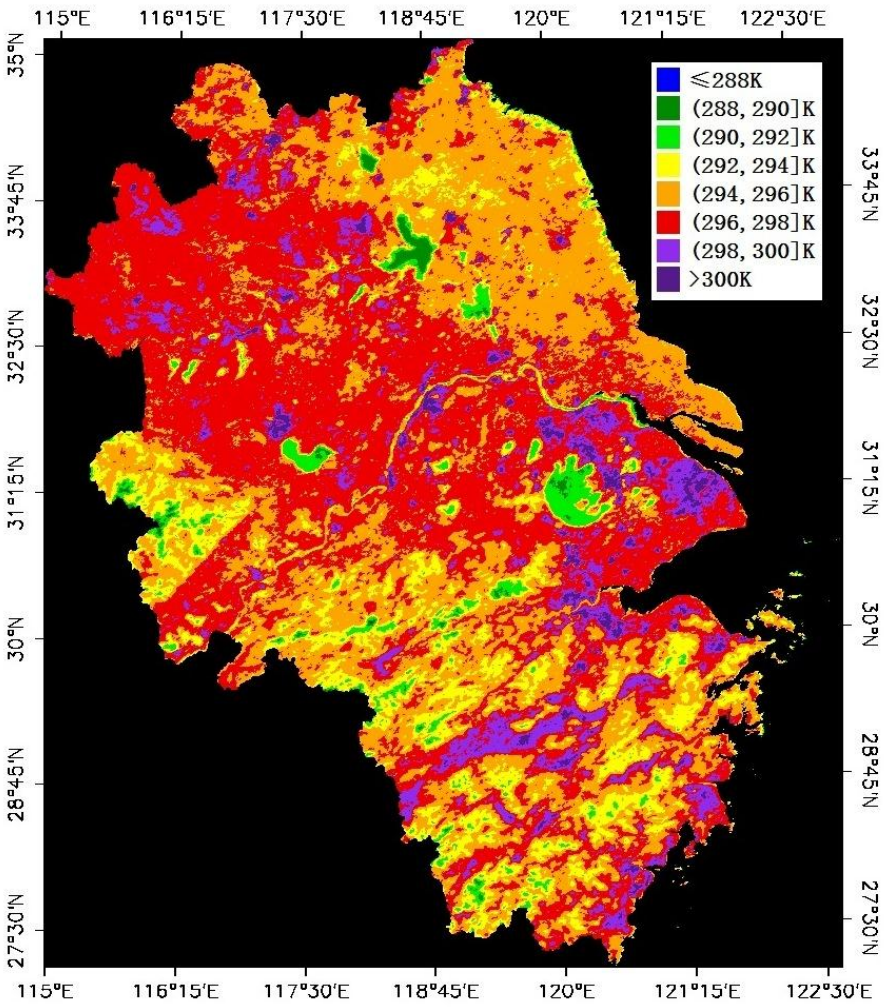


Fig .8 MODIS LST annual mean,2008 in YRD

daytime

nighttime



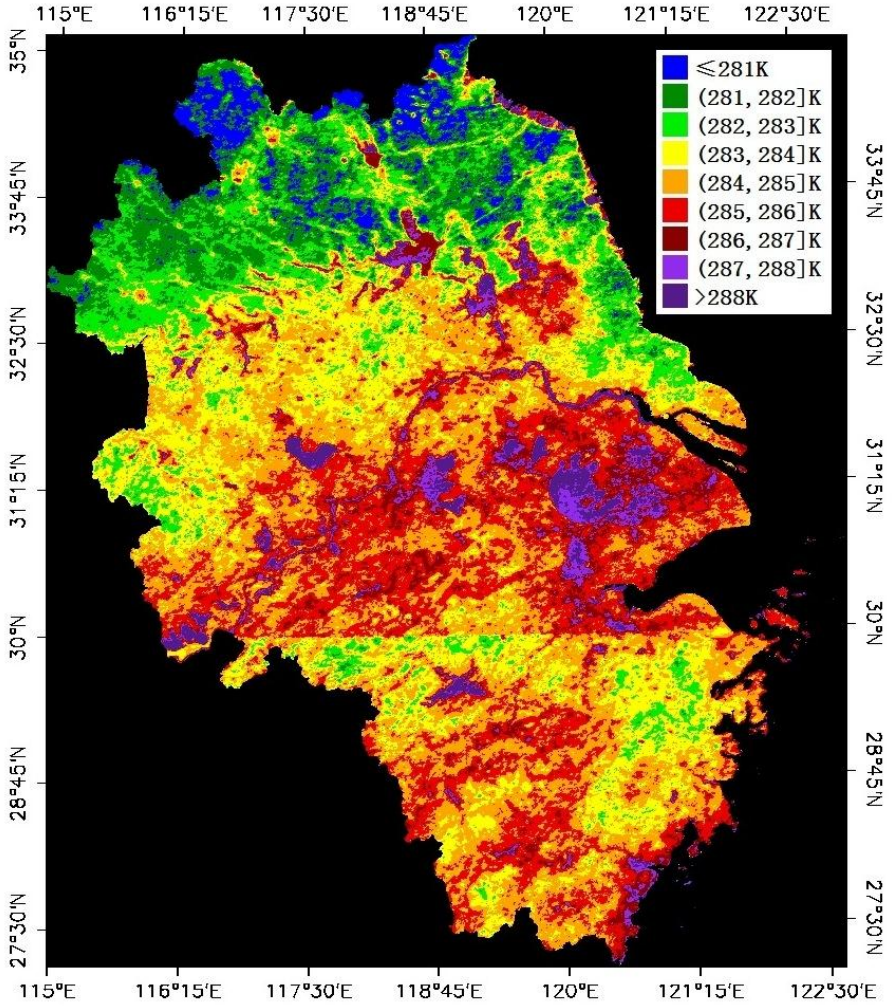
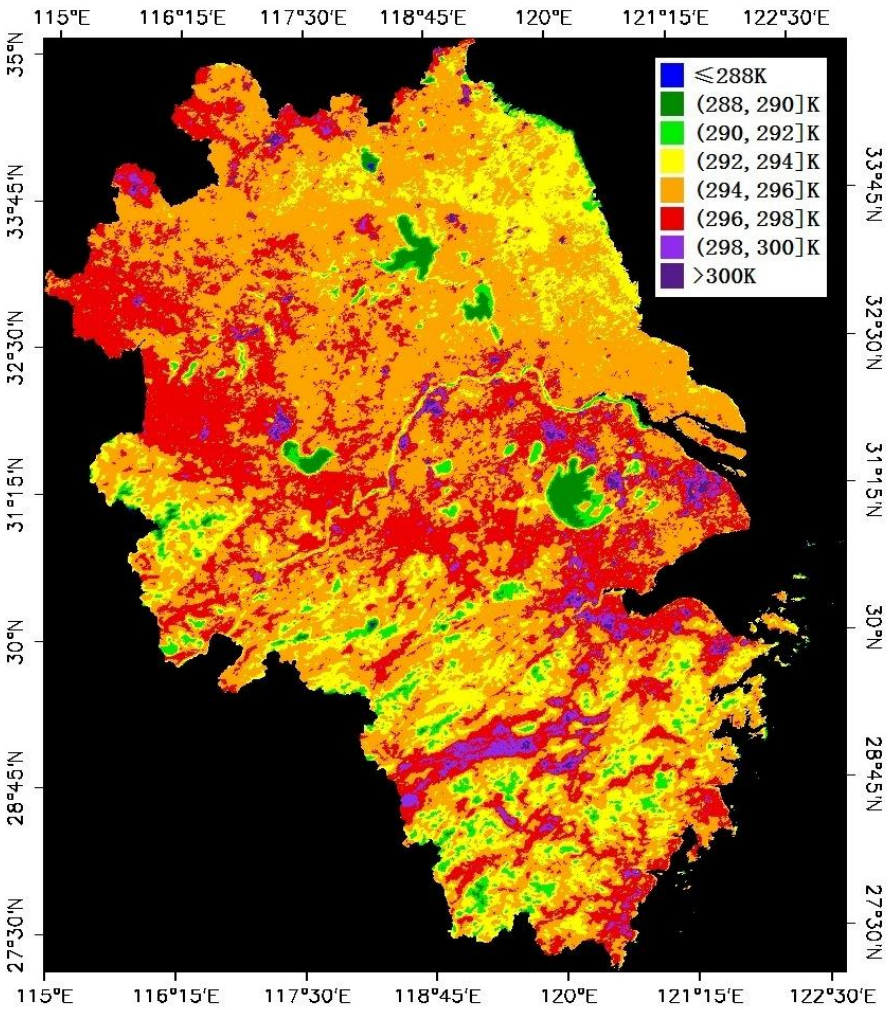


Fig. 9 MODIS LST annual mean,2009 in YRD

daytime

nighttime



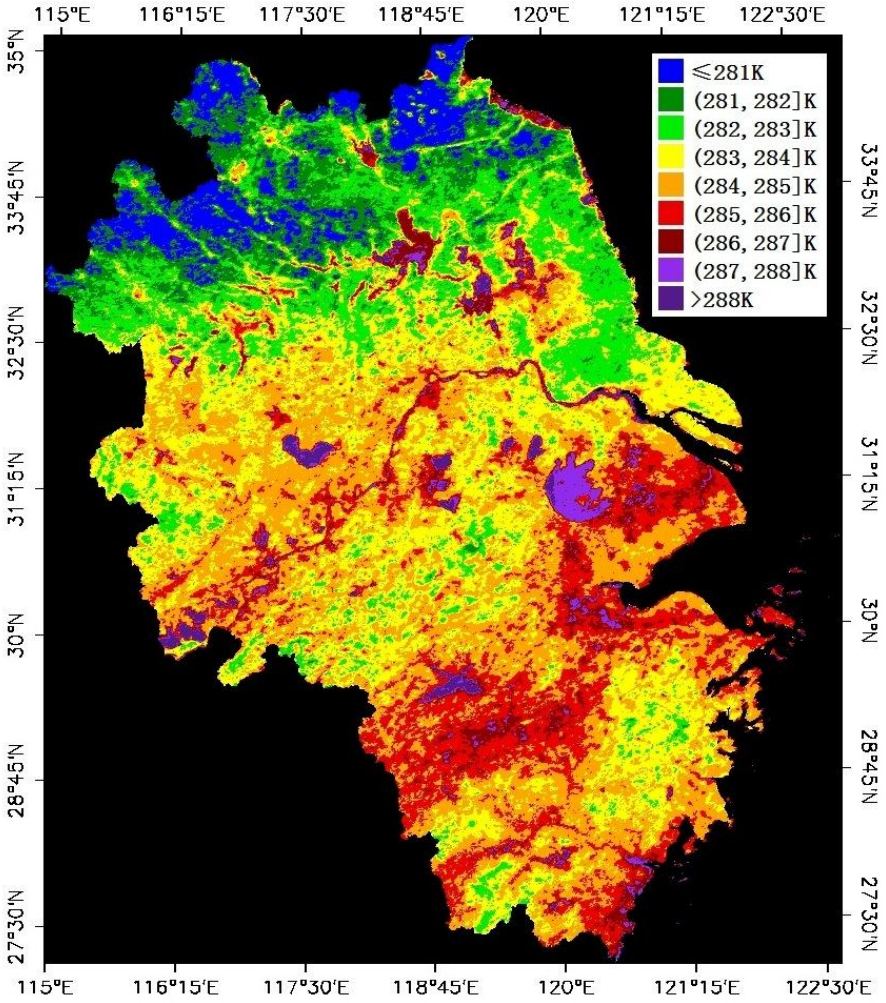


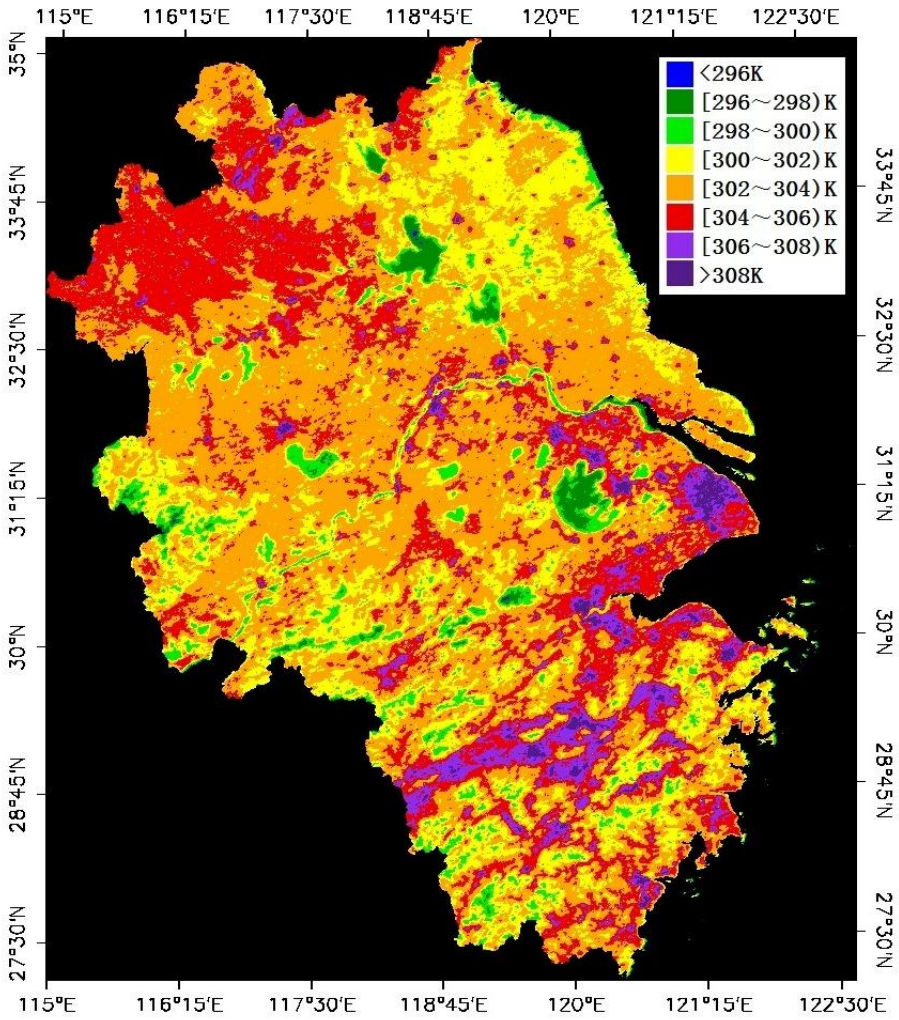
Fig. 10 MODIS LST annual mean,2010 in YRD

MODIS LSTWarm Season Mean in YRD

May to September

daytime

nighttime



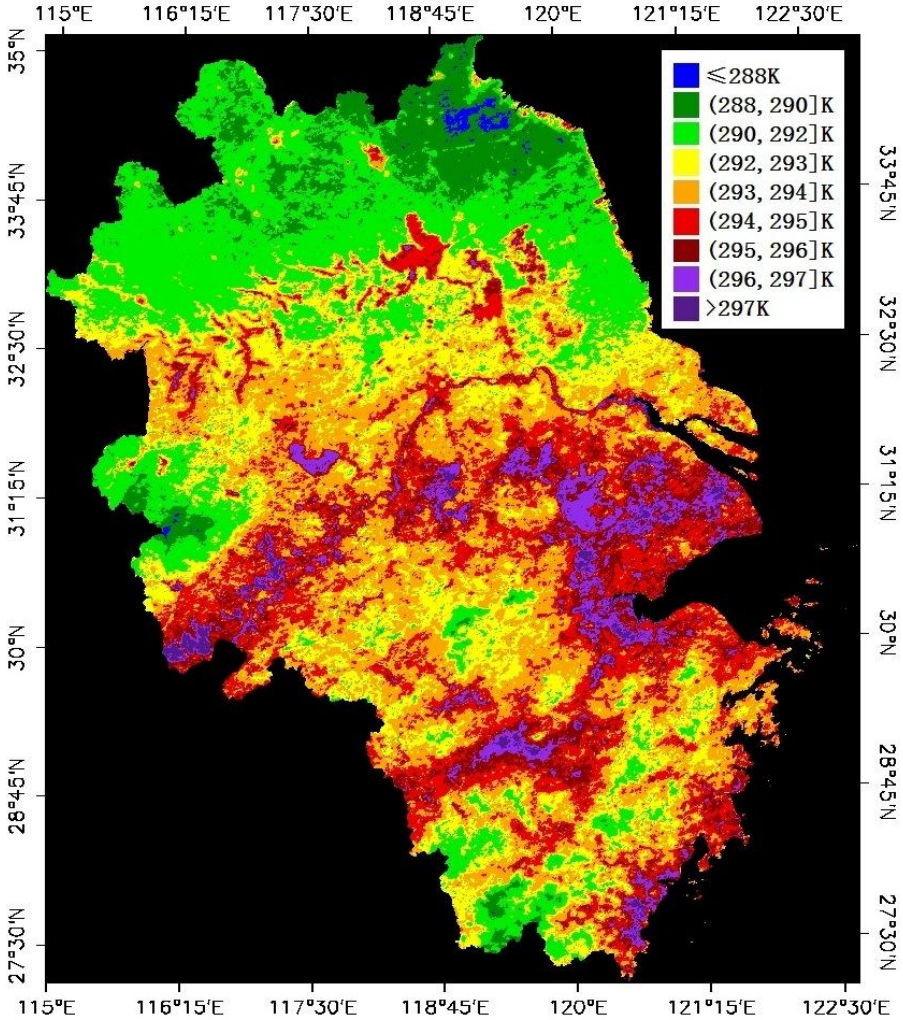
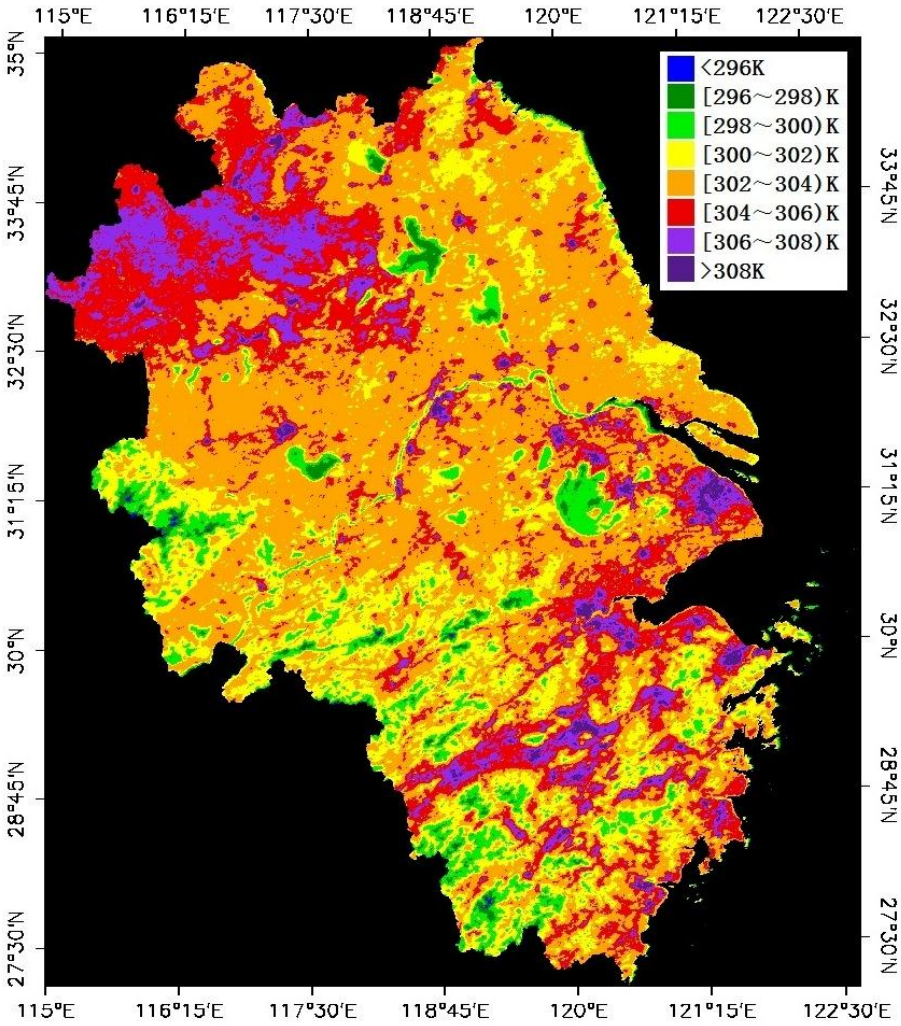


Fig. 11 MODIS LST warm season mean , May to Sep.,2003 in YRD

daytime

nighttime



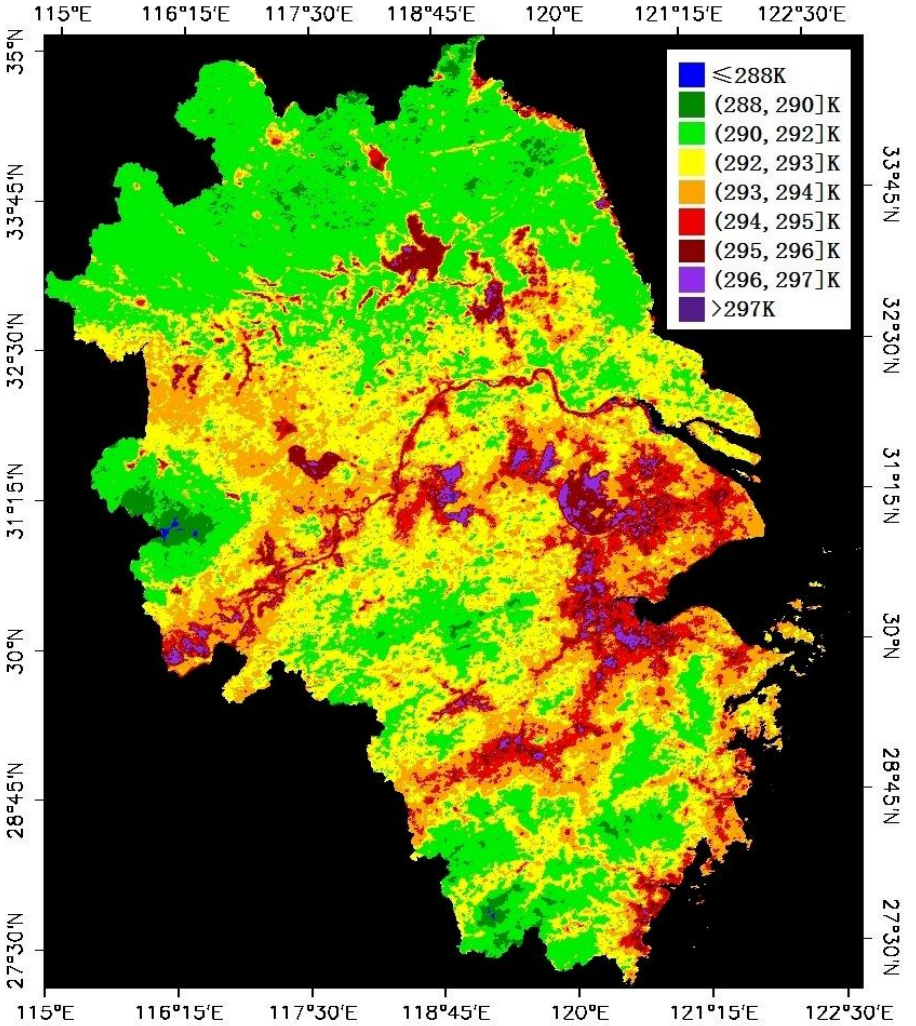
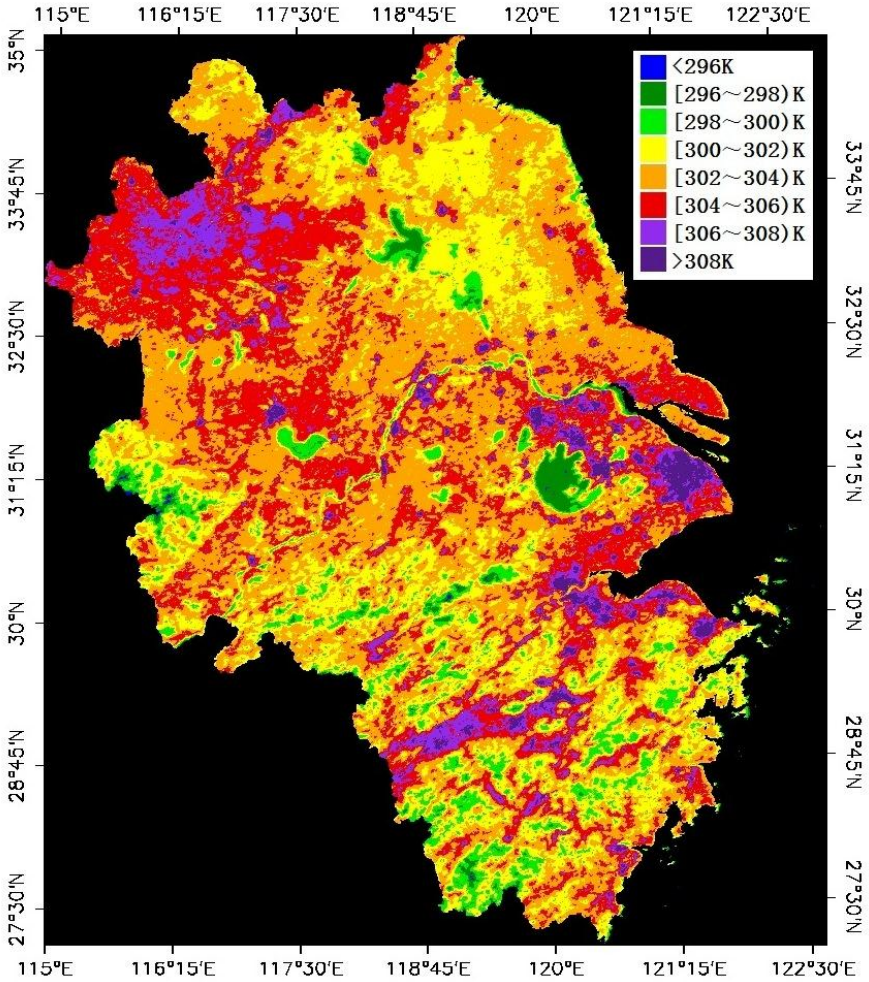


Fig .12 MODIS LST warm season mean , May to Sep., 2004 in YRD

daytime

nighttime



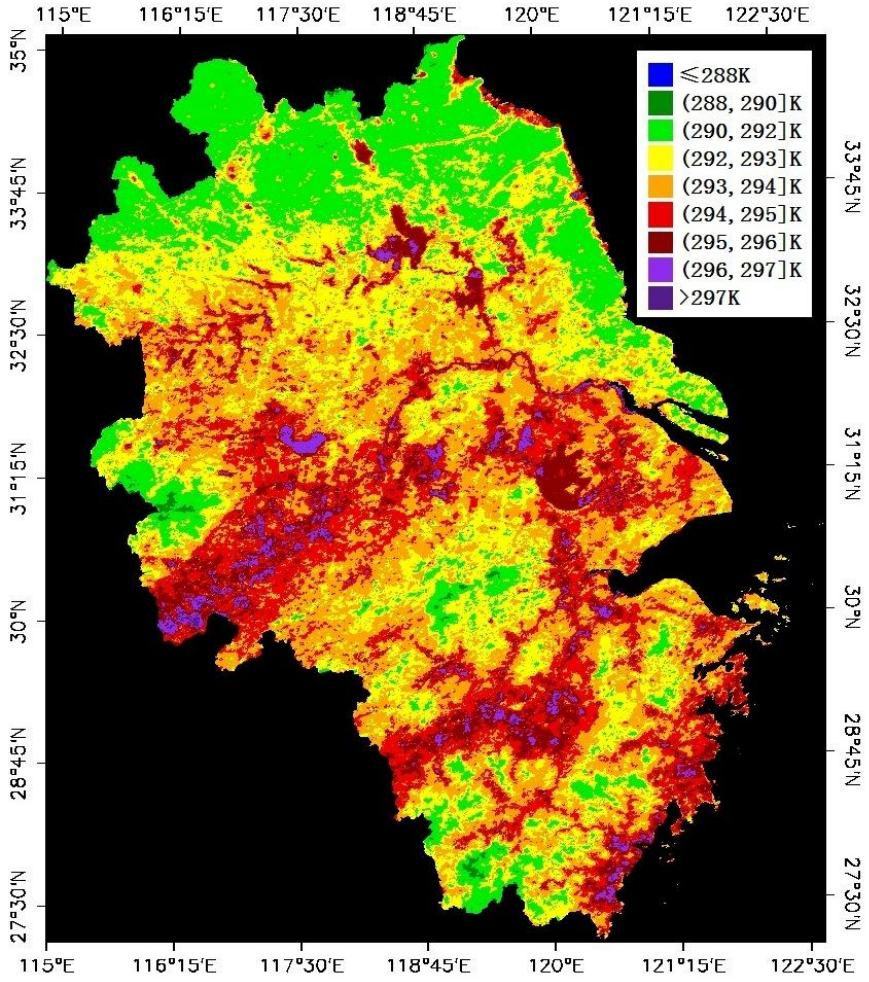
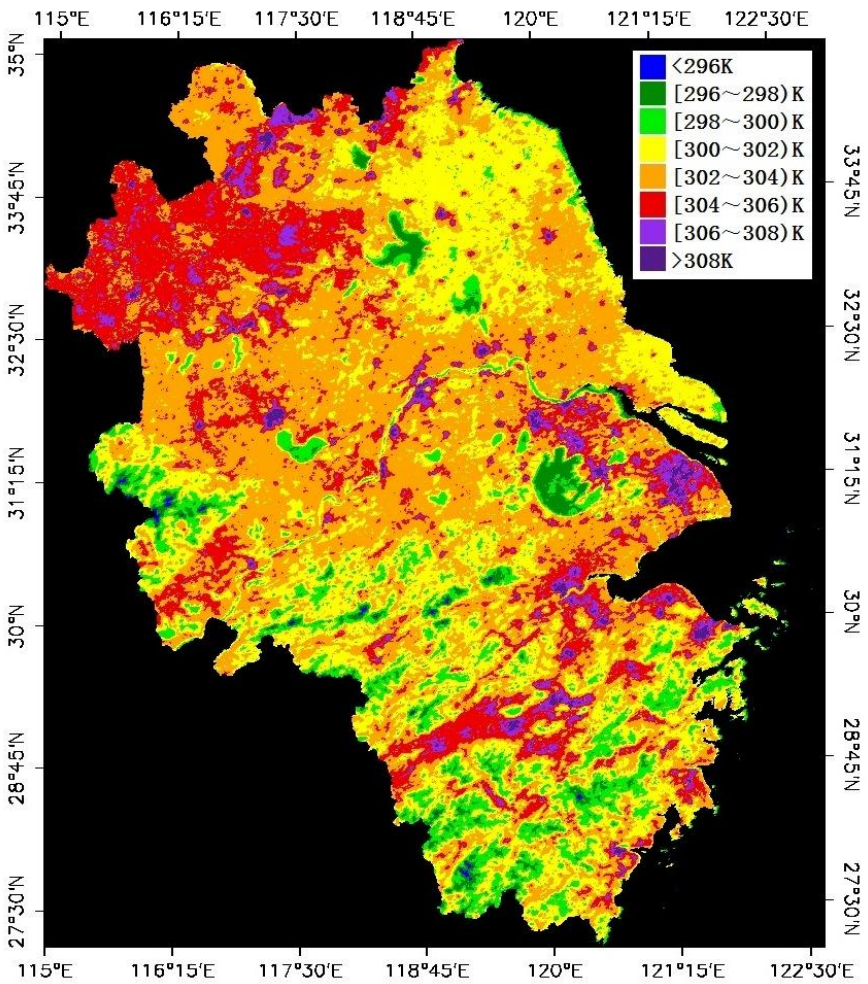


Fig .13 MODIS LST warm season mean , May to Sep.,2005 in YRD

daytime

nighttime



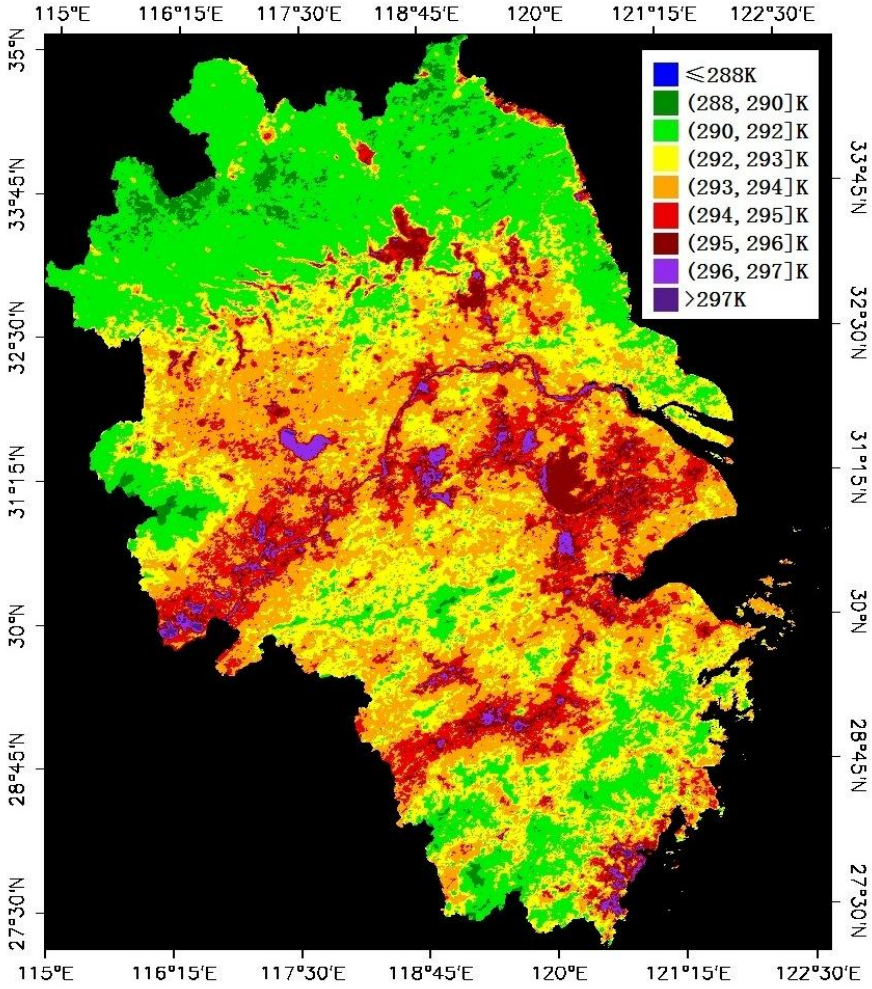


Fig. 14 MODIS LST warm season mean , May to Sep., 2006 in YRD

daytime

nighttime

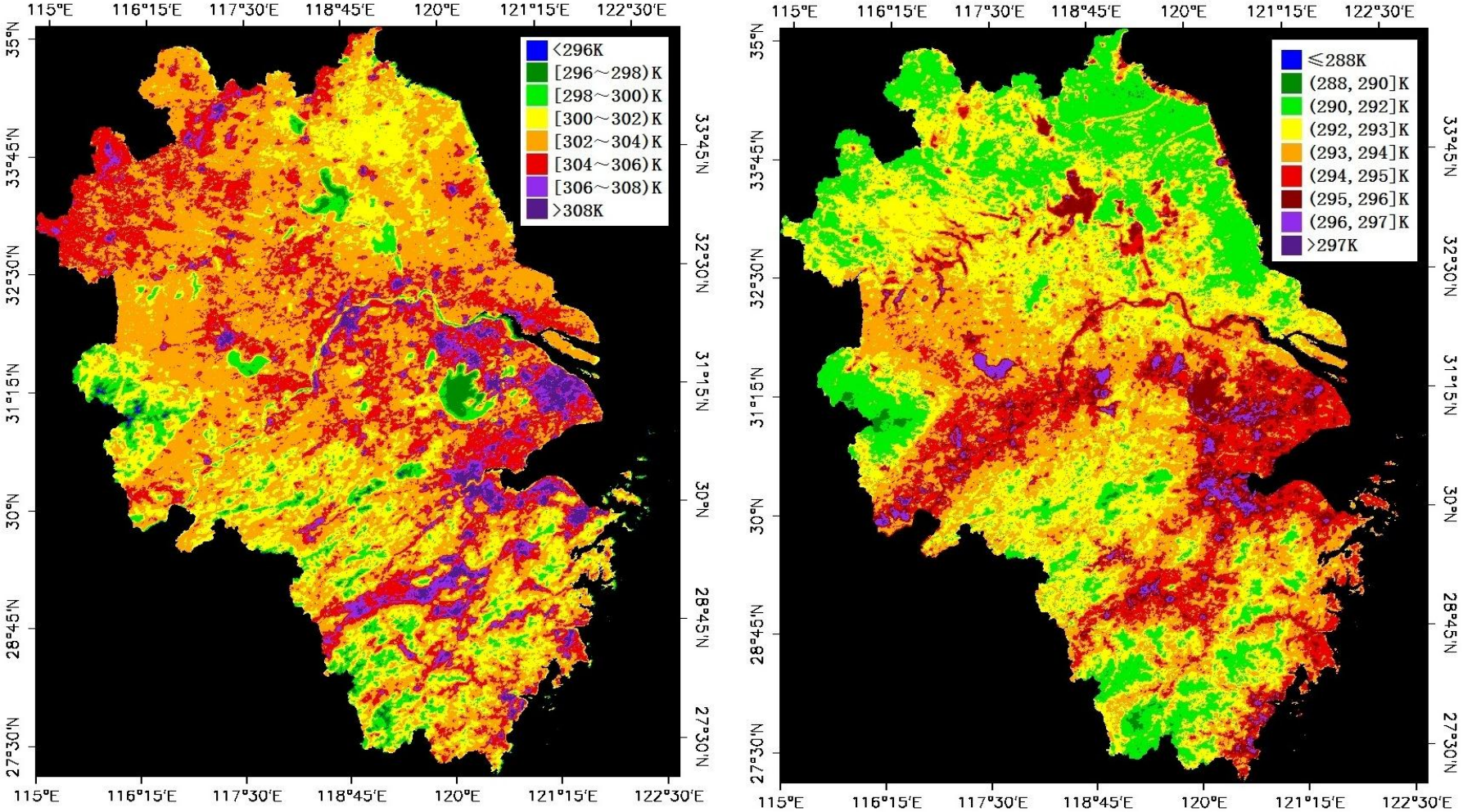
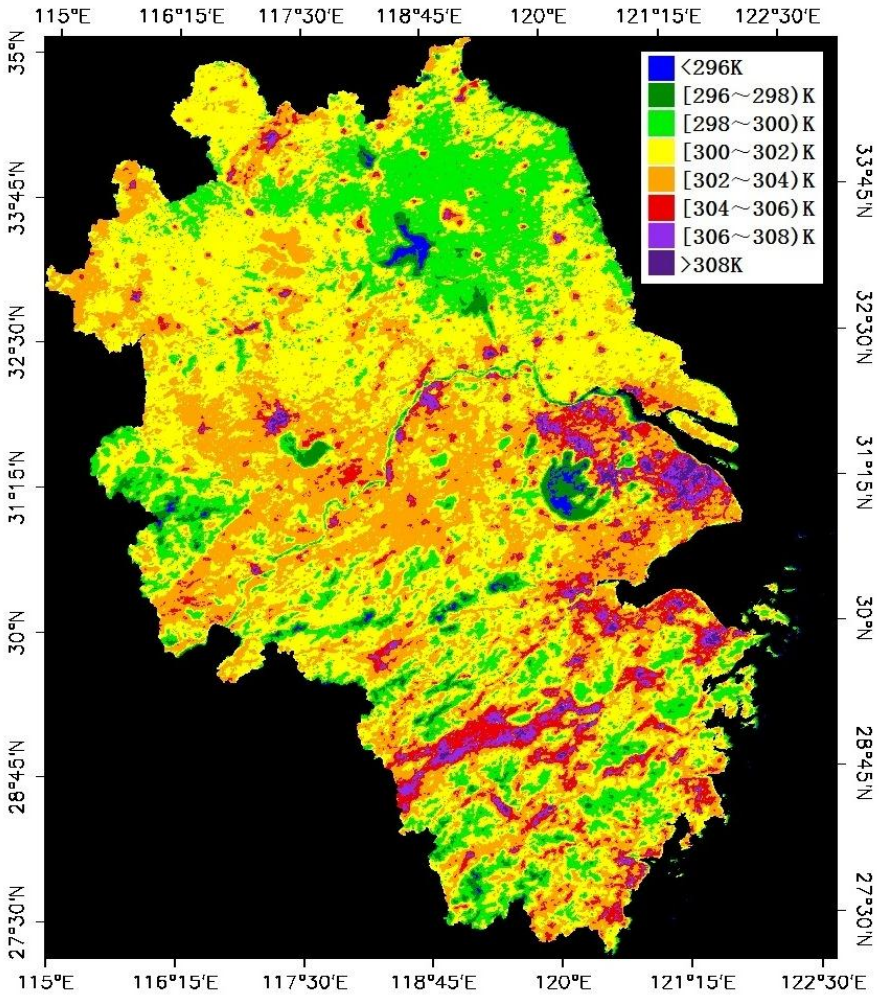


Fig. 15 MODIS LST warm season mean , May to Sep., 2007 in YRD

daytime

nighttime



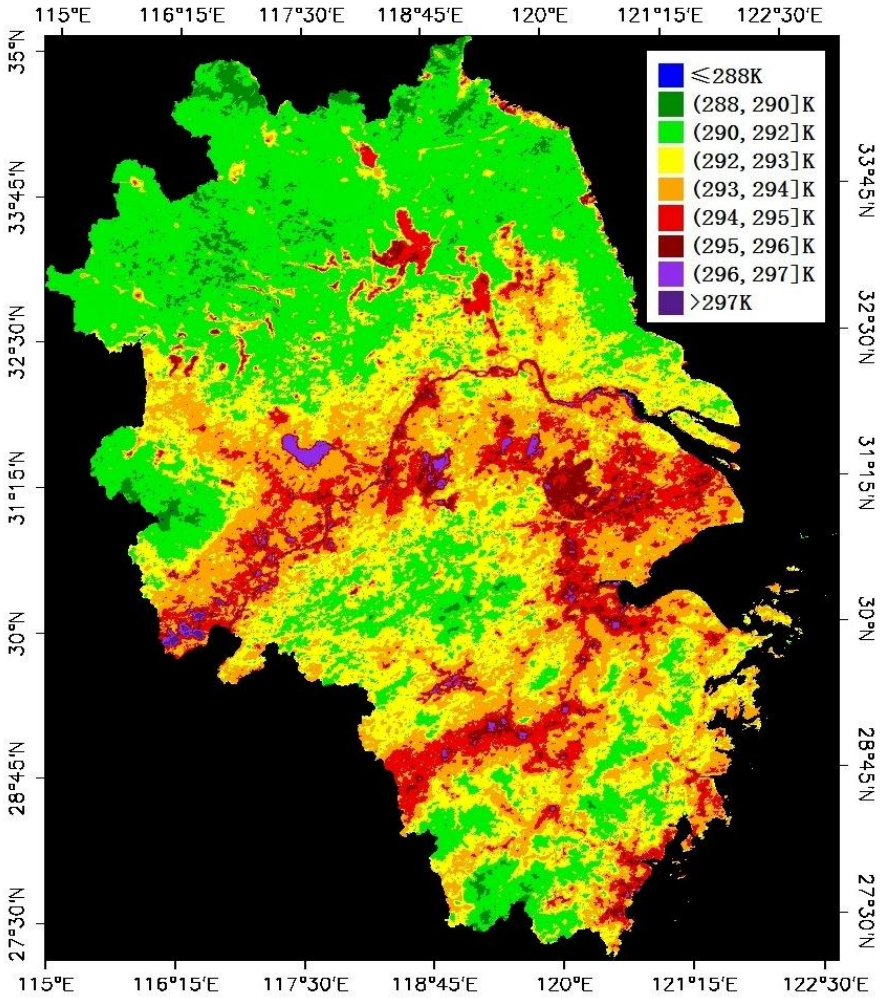
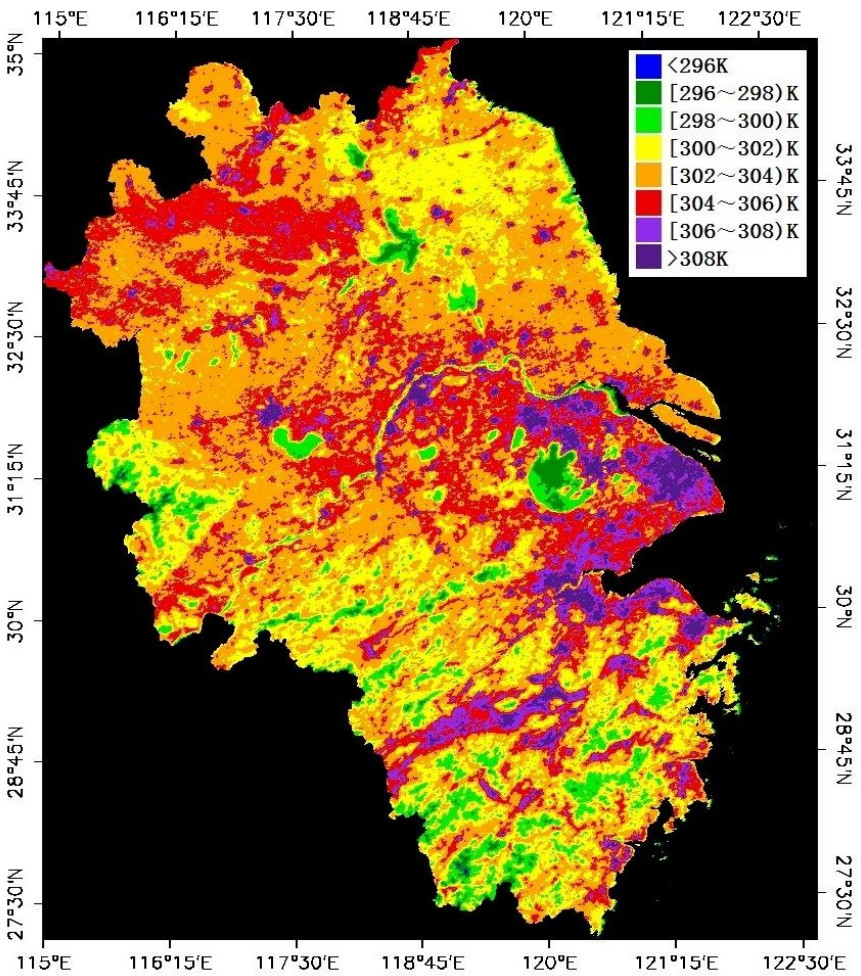


Fig. 16 MODIS LST warm season mean , May to Sep.,2008 in YRD

daytime

nighttime



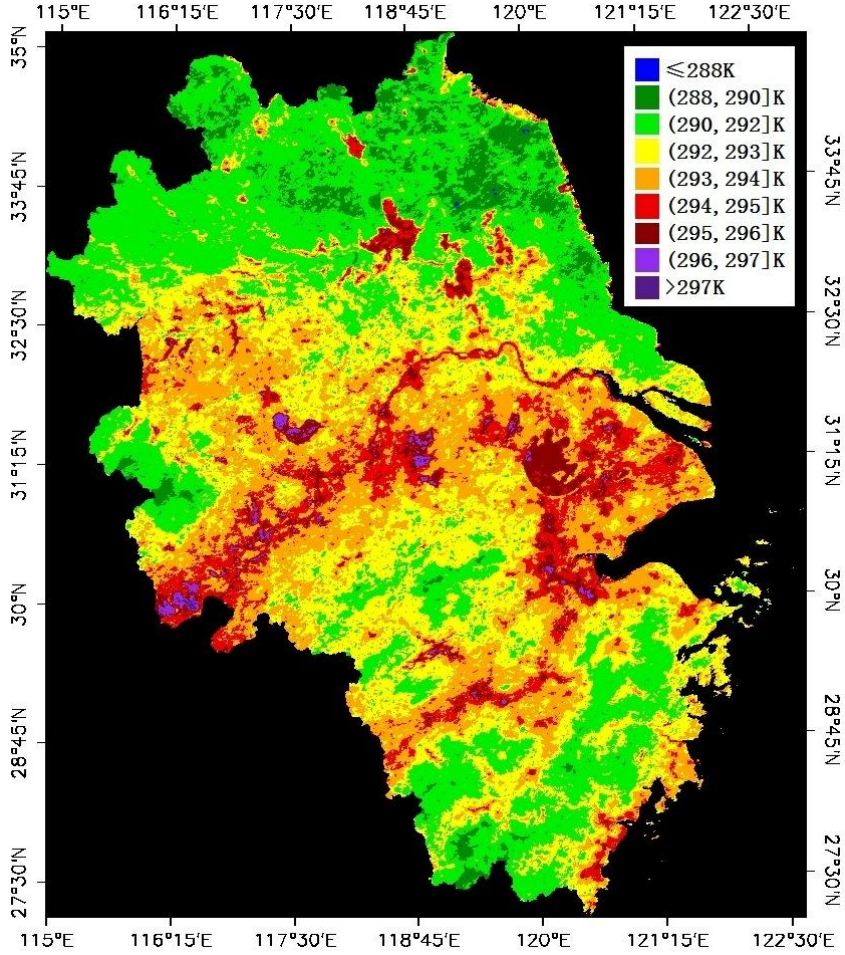


Fig. 17 MODIS LST warm season mean , May to Sep., 2009 in YRD

daytime

nighttime

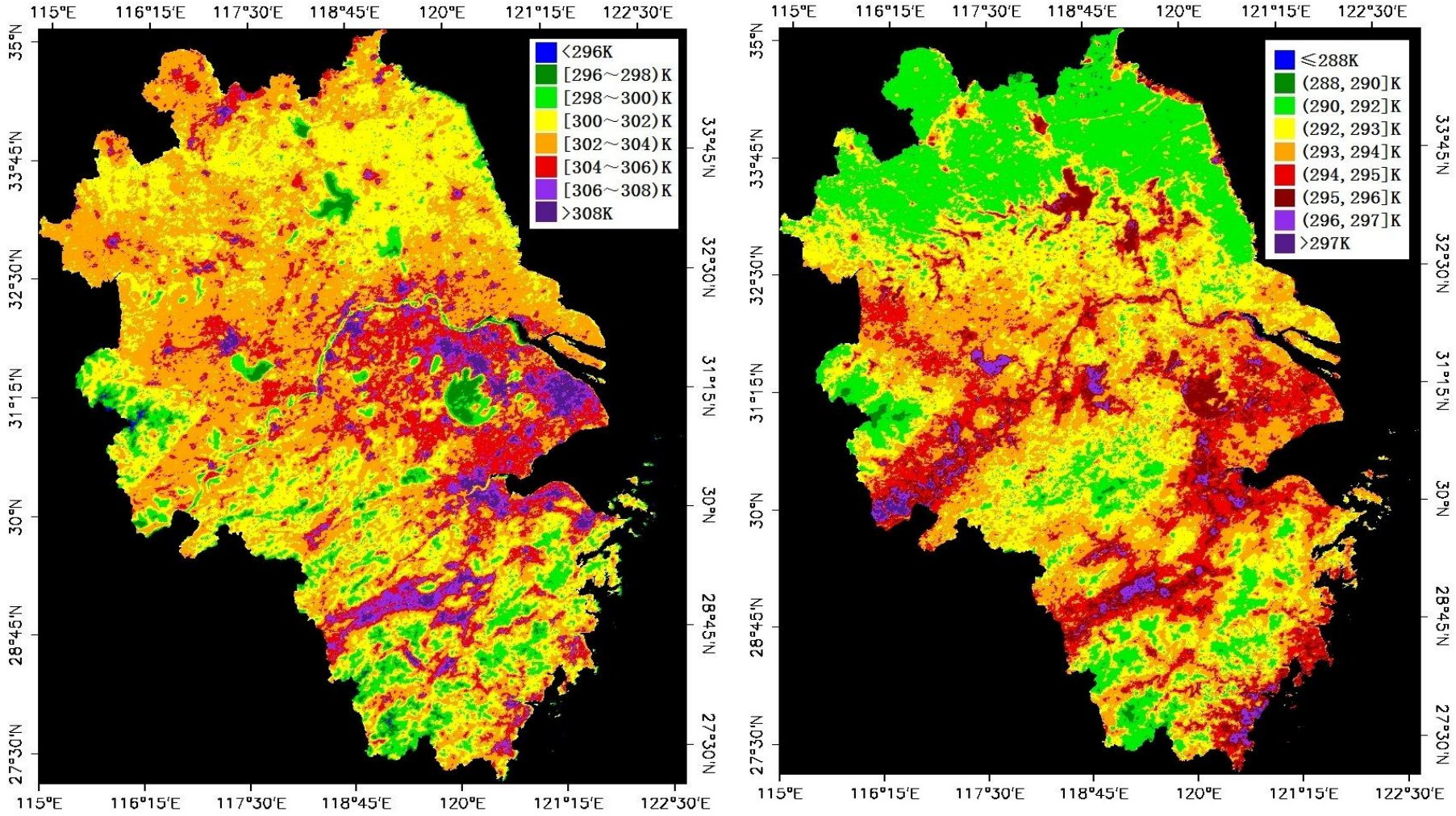


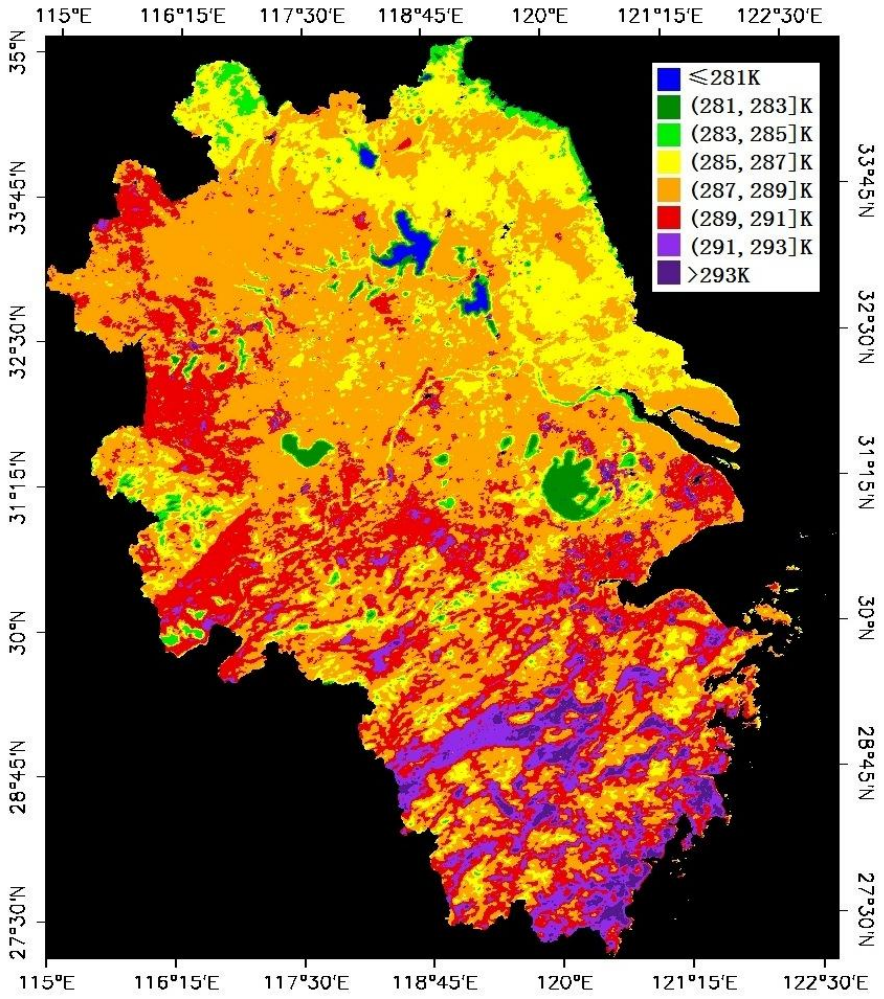
Fig. 18 MODIS LST warm season mean , May to Sep., 2010 in YRD

MODIS LST Cold Season Mean in YRD

November to March

daytime

nighttime



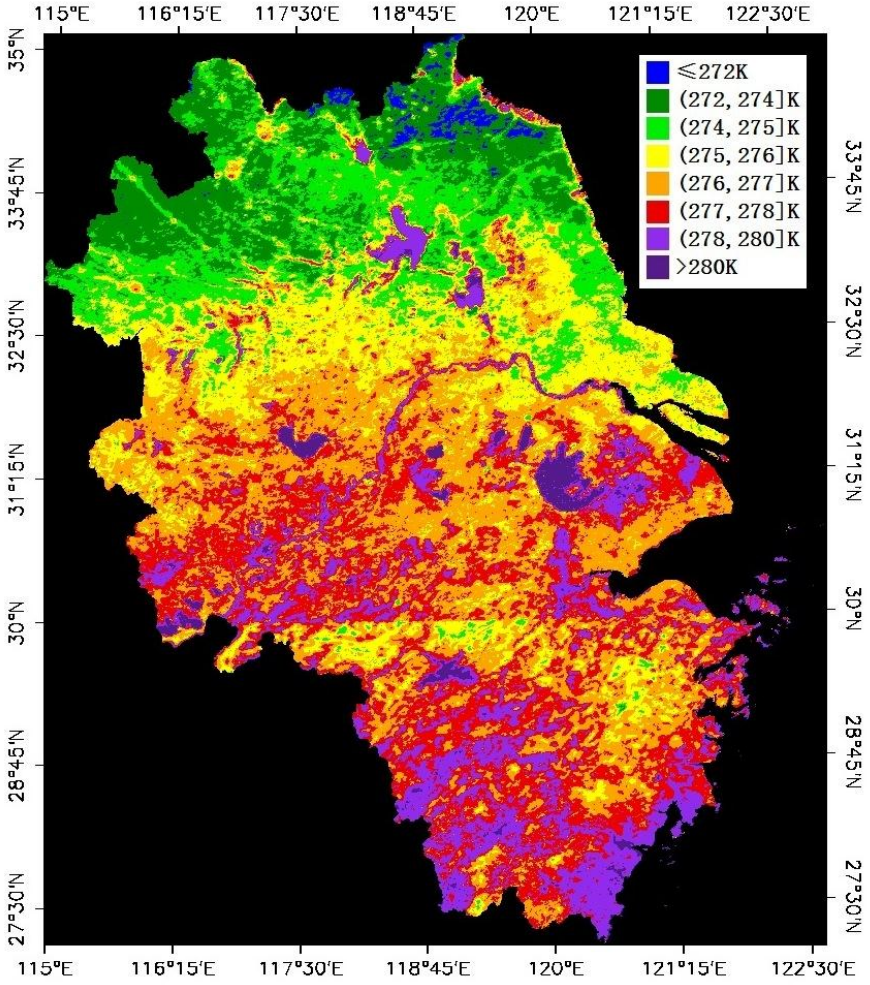
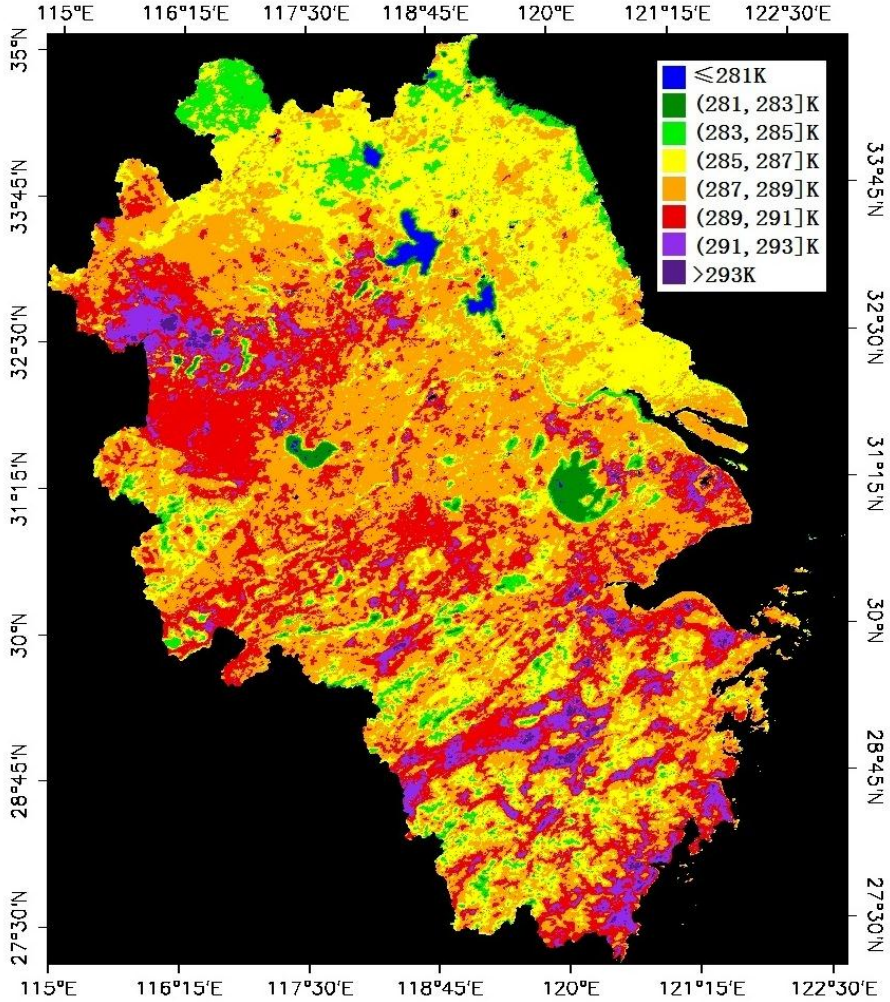


Fig. 19 MODIS LST cold season mean, Nov. to Mar. ,2003-2004 in YRD

daytime



nighttime

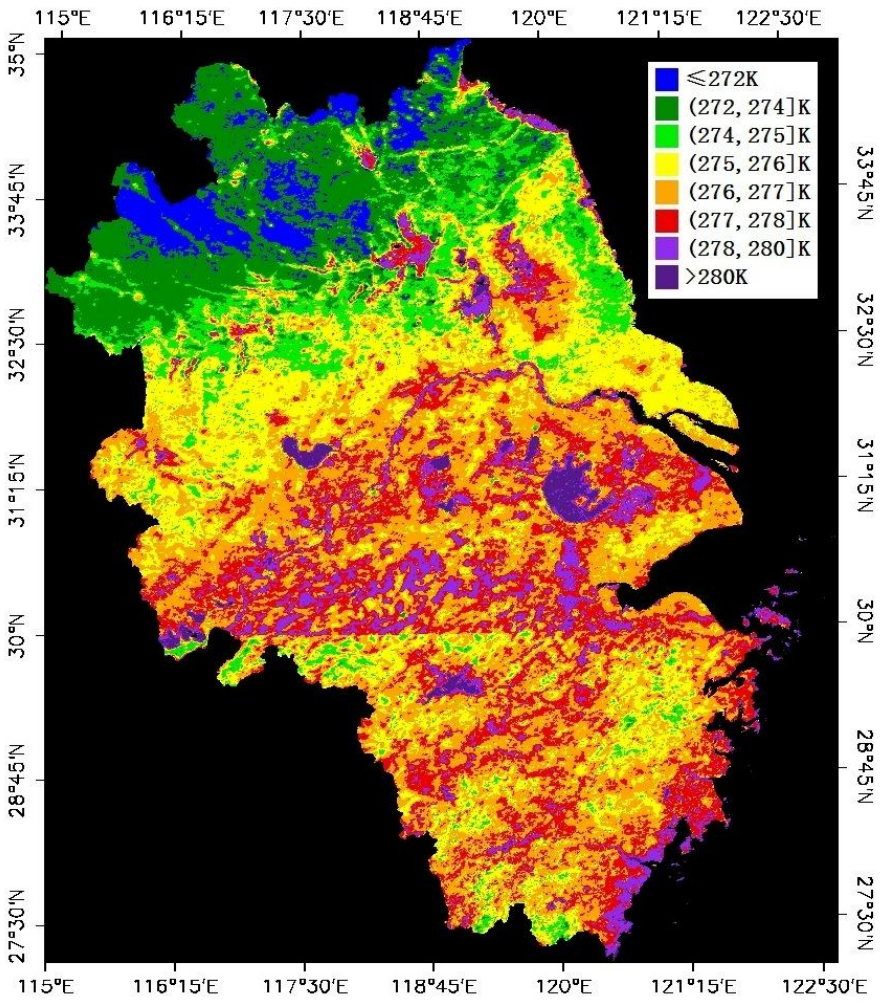
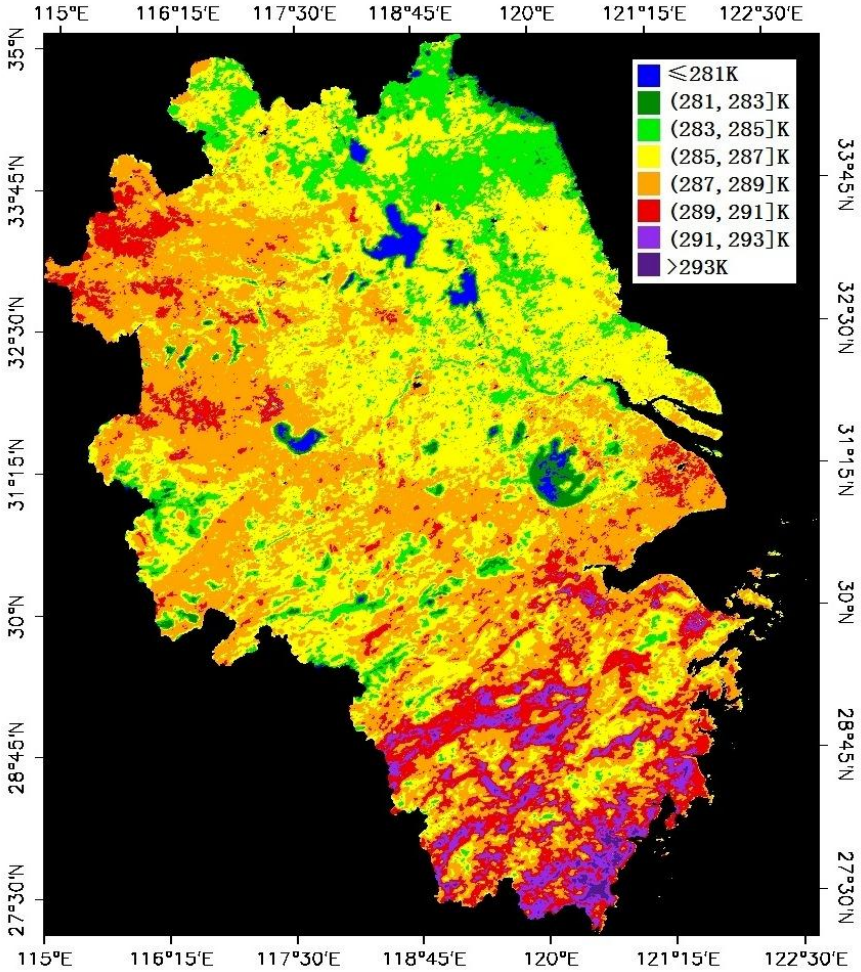


Fig. 20 MODIS LST cold season mean, Nov. to Mar. , 2004-2005 in YRD

daytime

nighttime



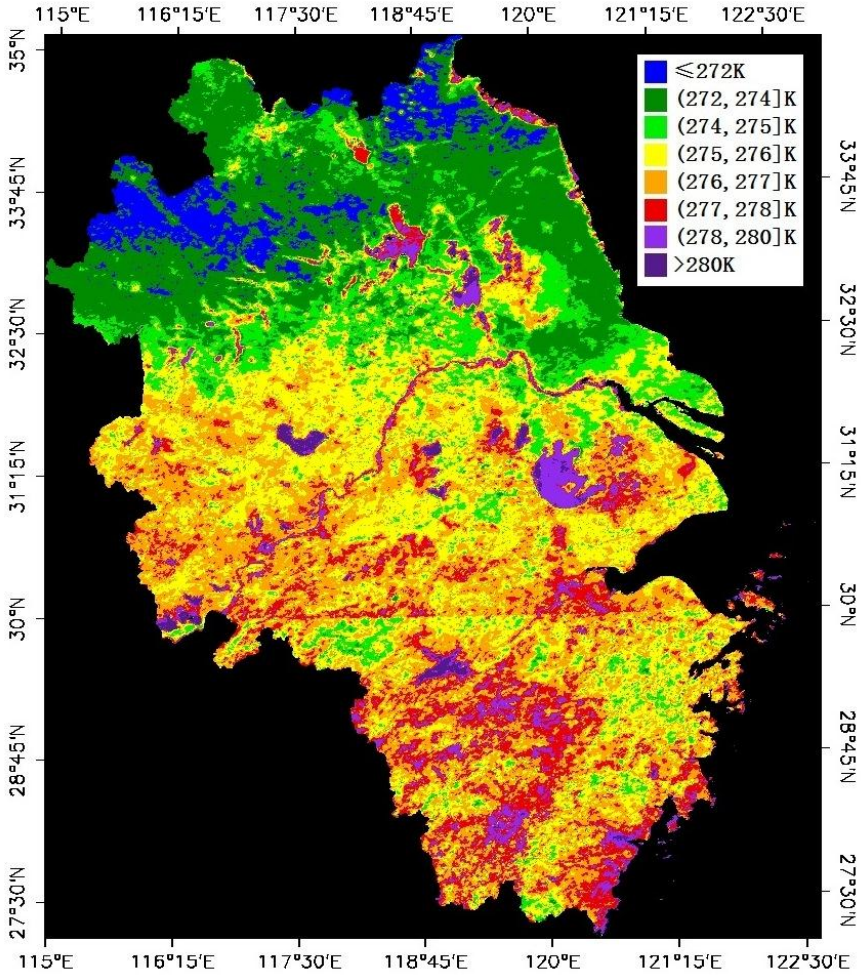
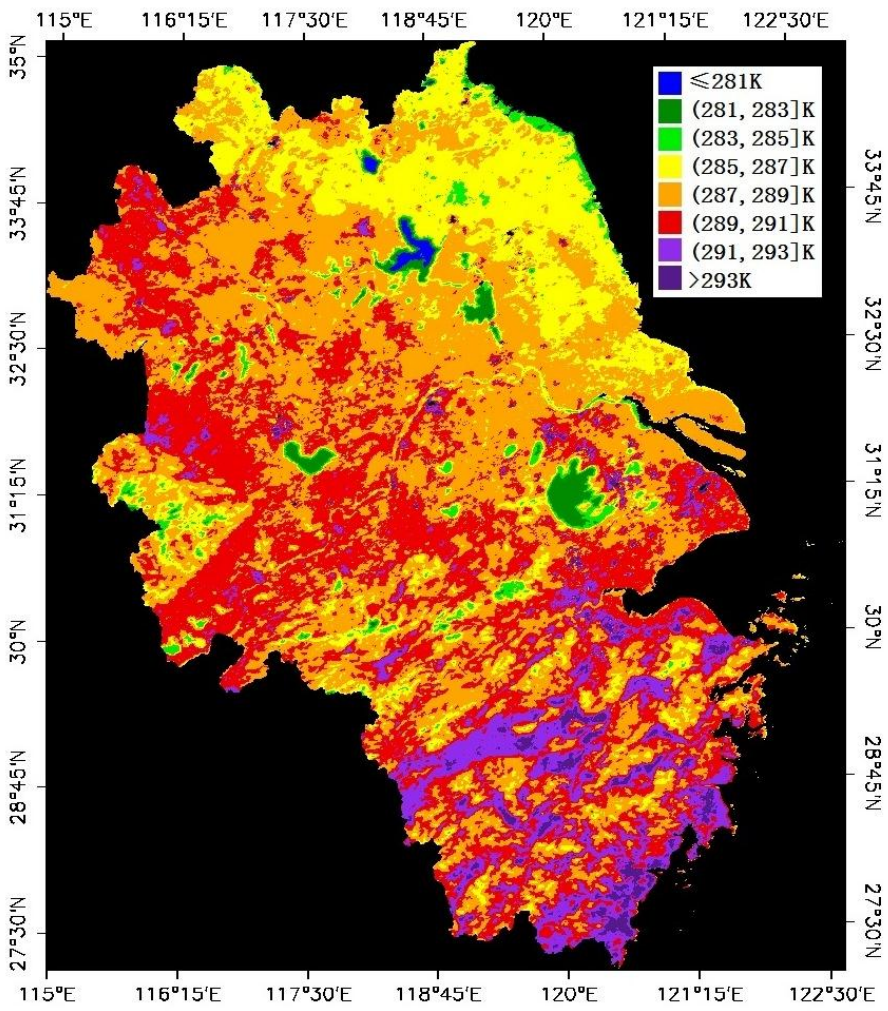


Fig. 21 MODIS LST cold season mean, Nov. to Mar. , 2005-2006 in YRD

daytime

nighttime



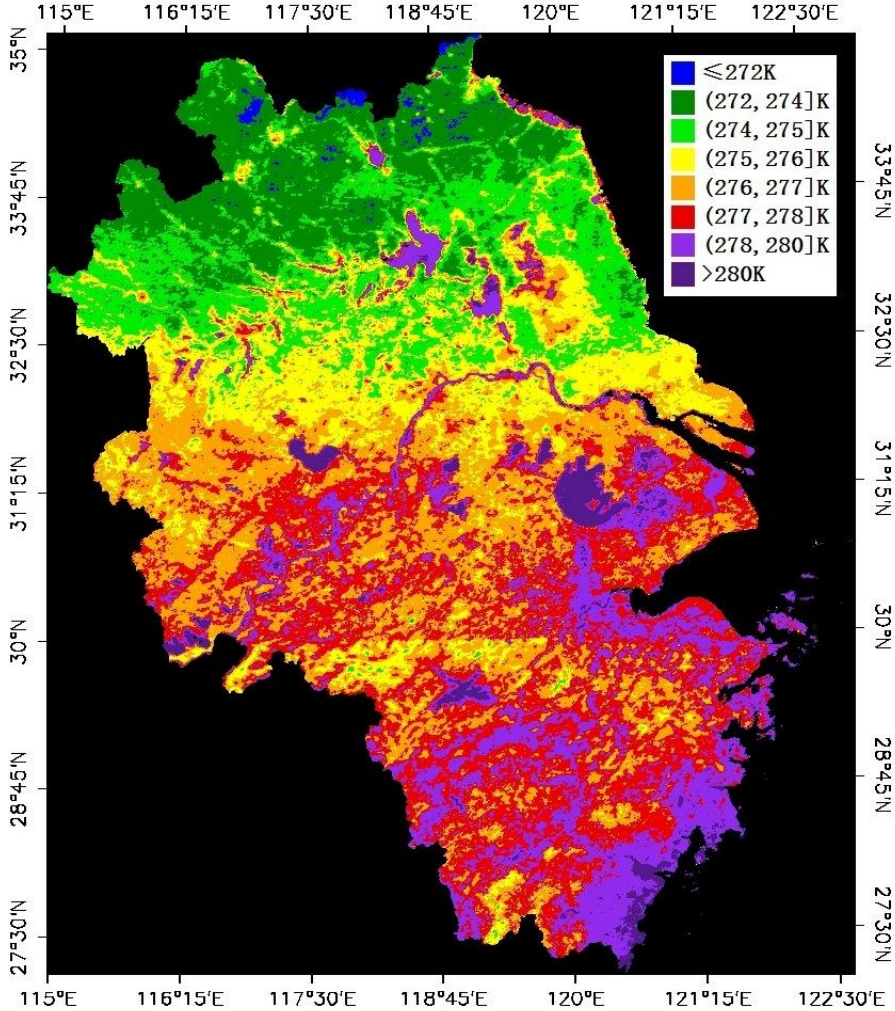
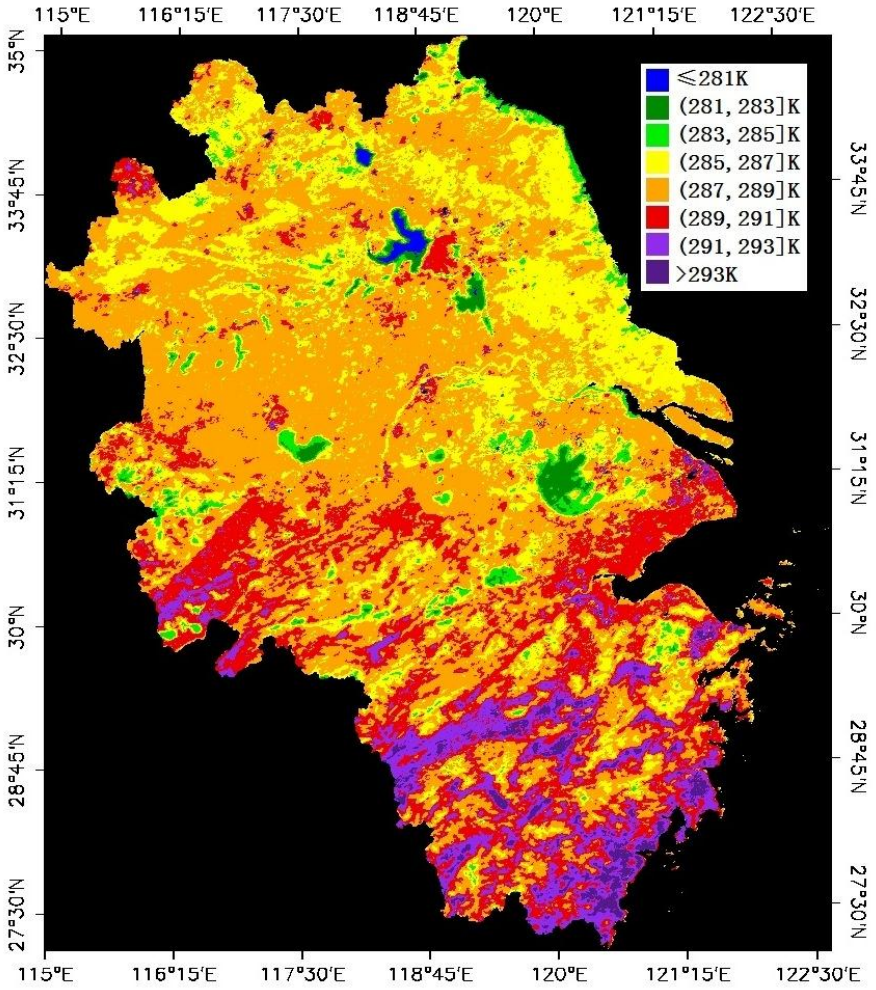


Fig. 22 MODIS LST cold season mean, Nov. to Mar. , 2006-2007 in YRD

daytime



nighttime

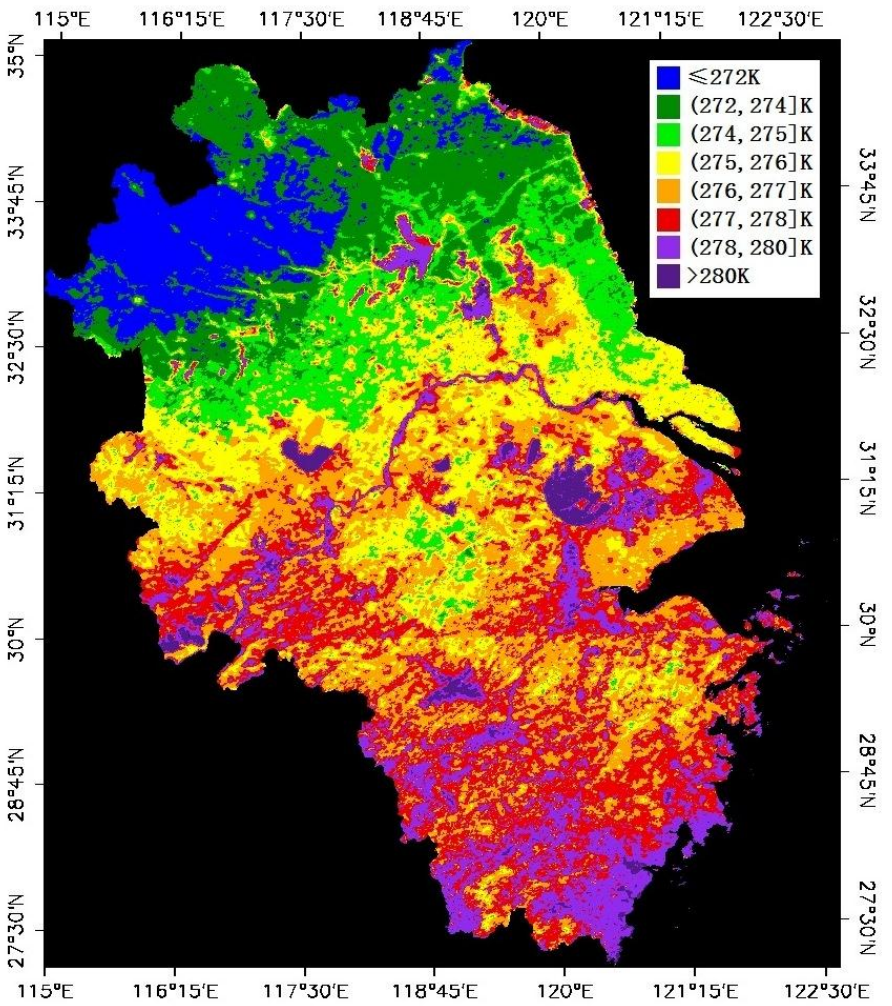
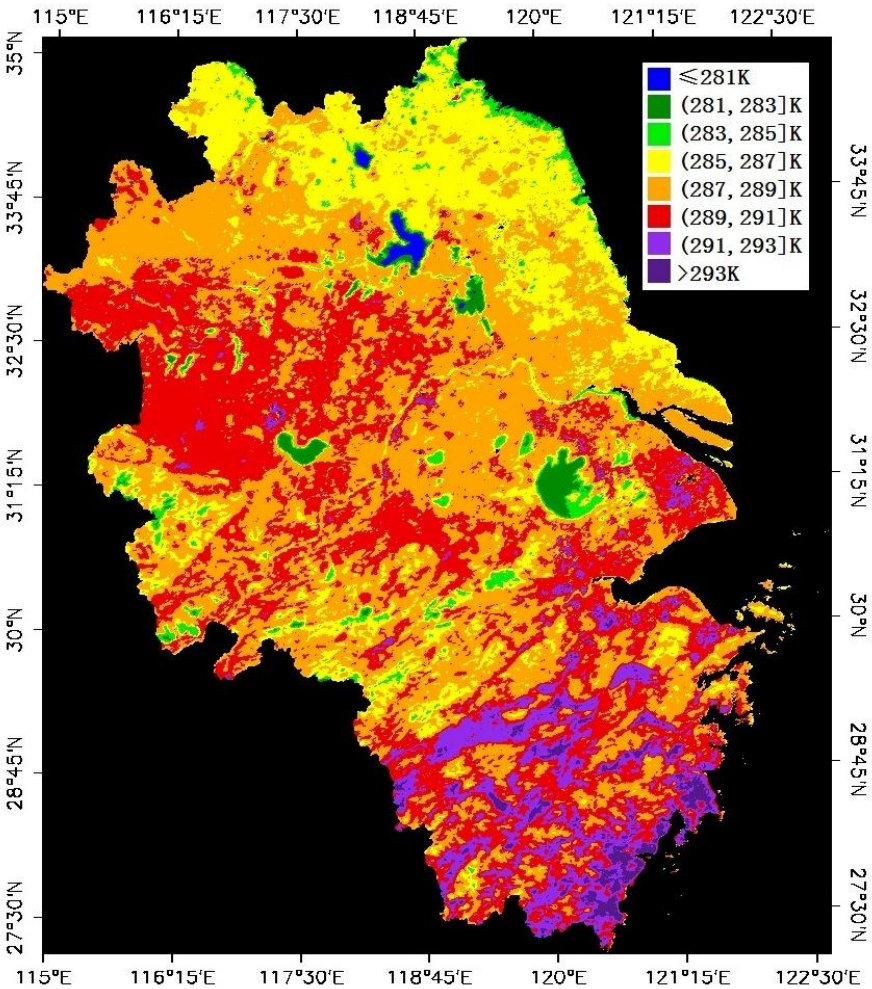


Fig. 23 MODIS LST cold season mean, Nov. to Mar. , 2007-2008 in YRD

daytime



nighttime

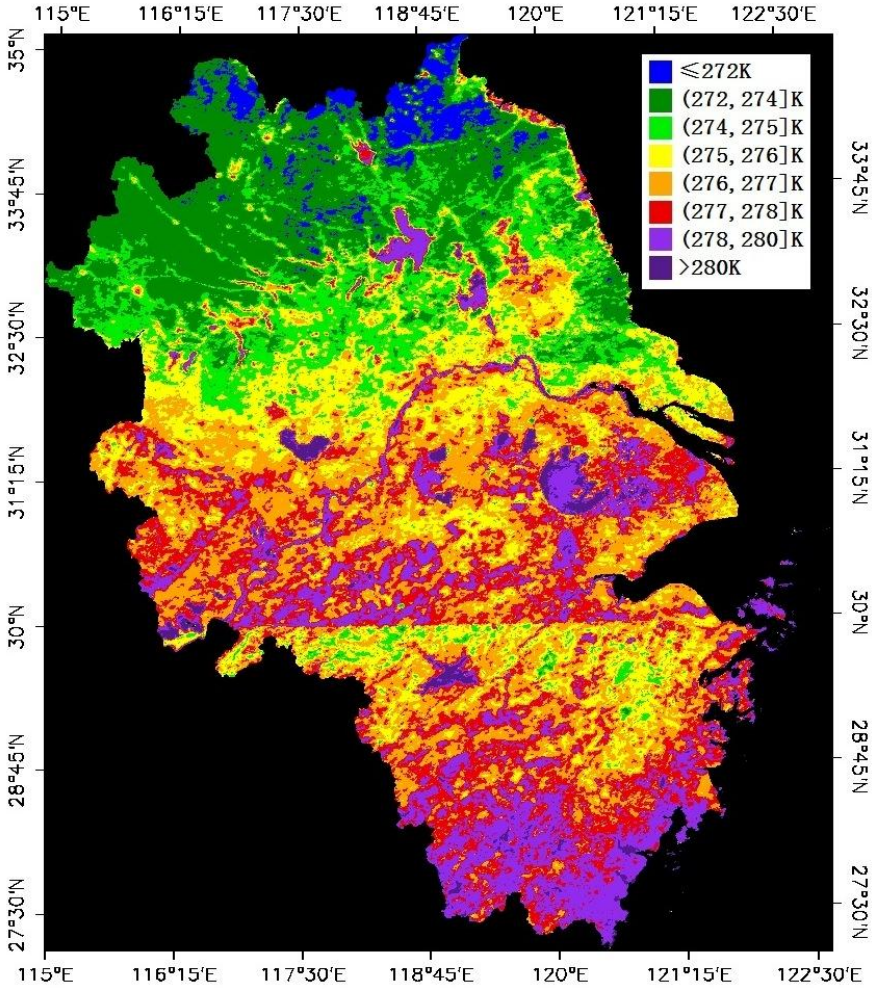
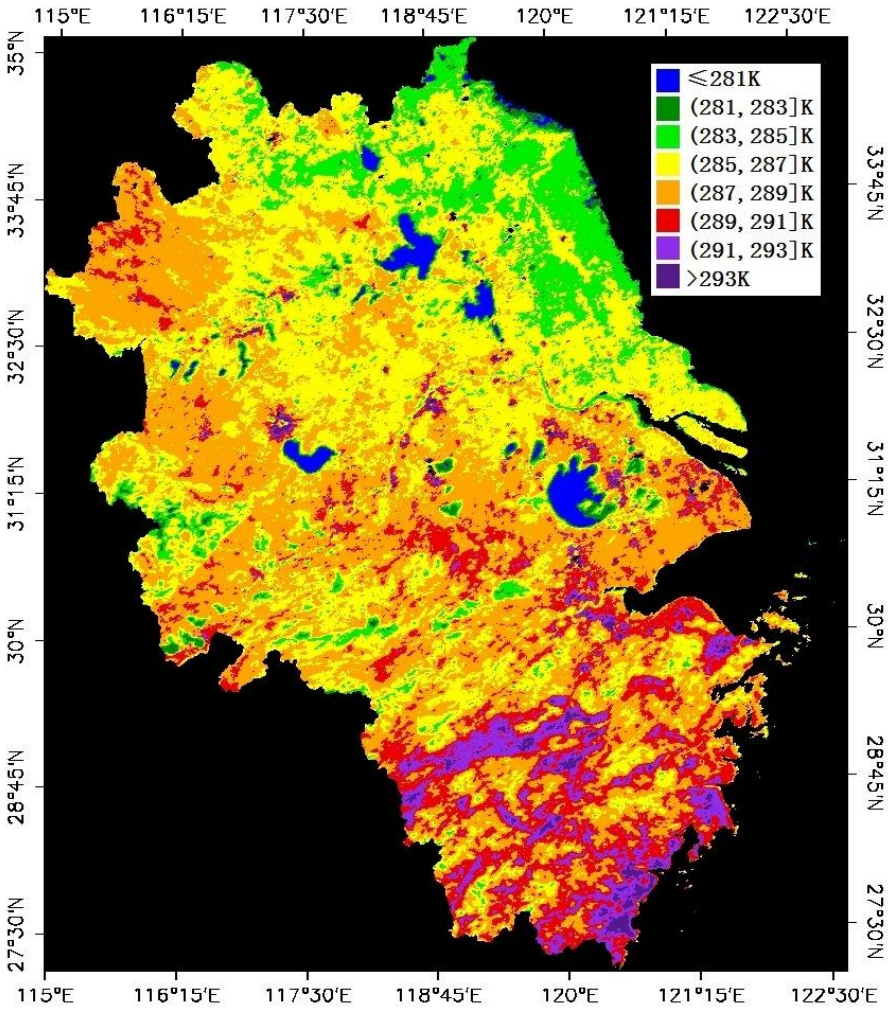


Fig. 24 MODIS LST cold season mean, Nov. to Mar. , 2008-2009 in YRD

daytime



nighttime

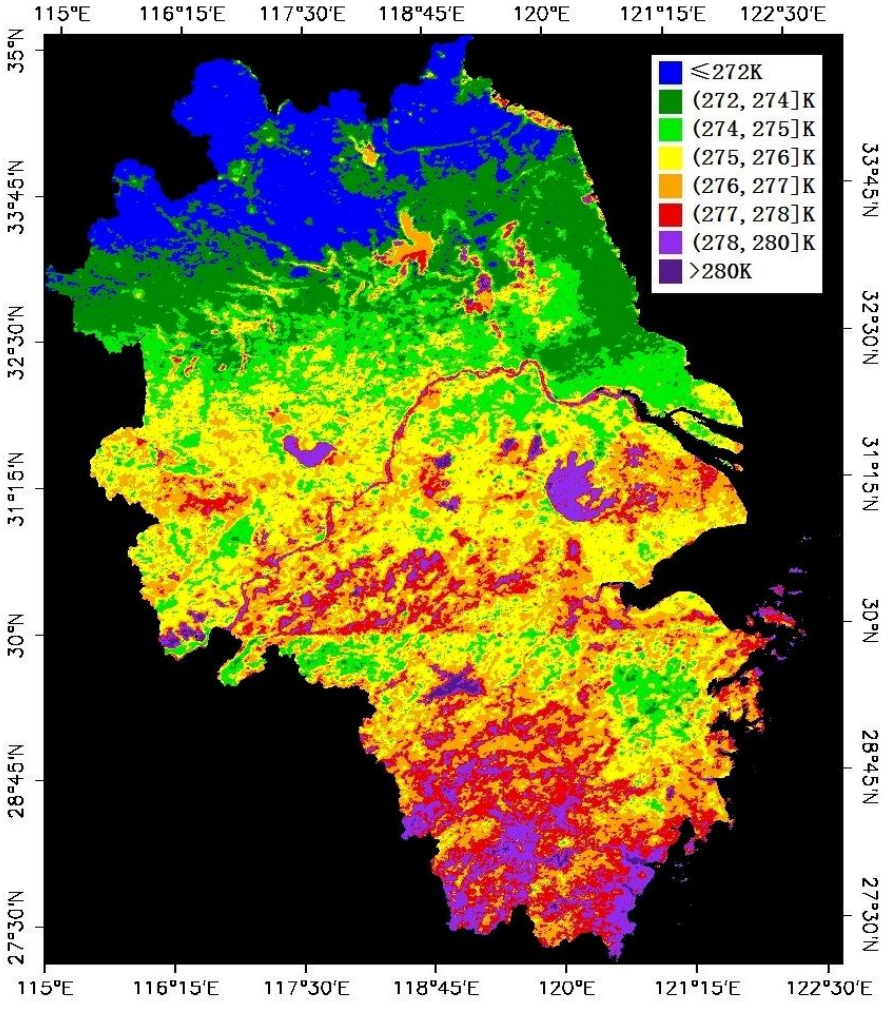
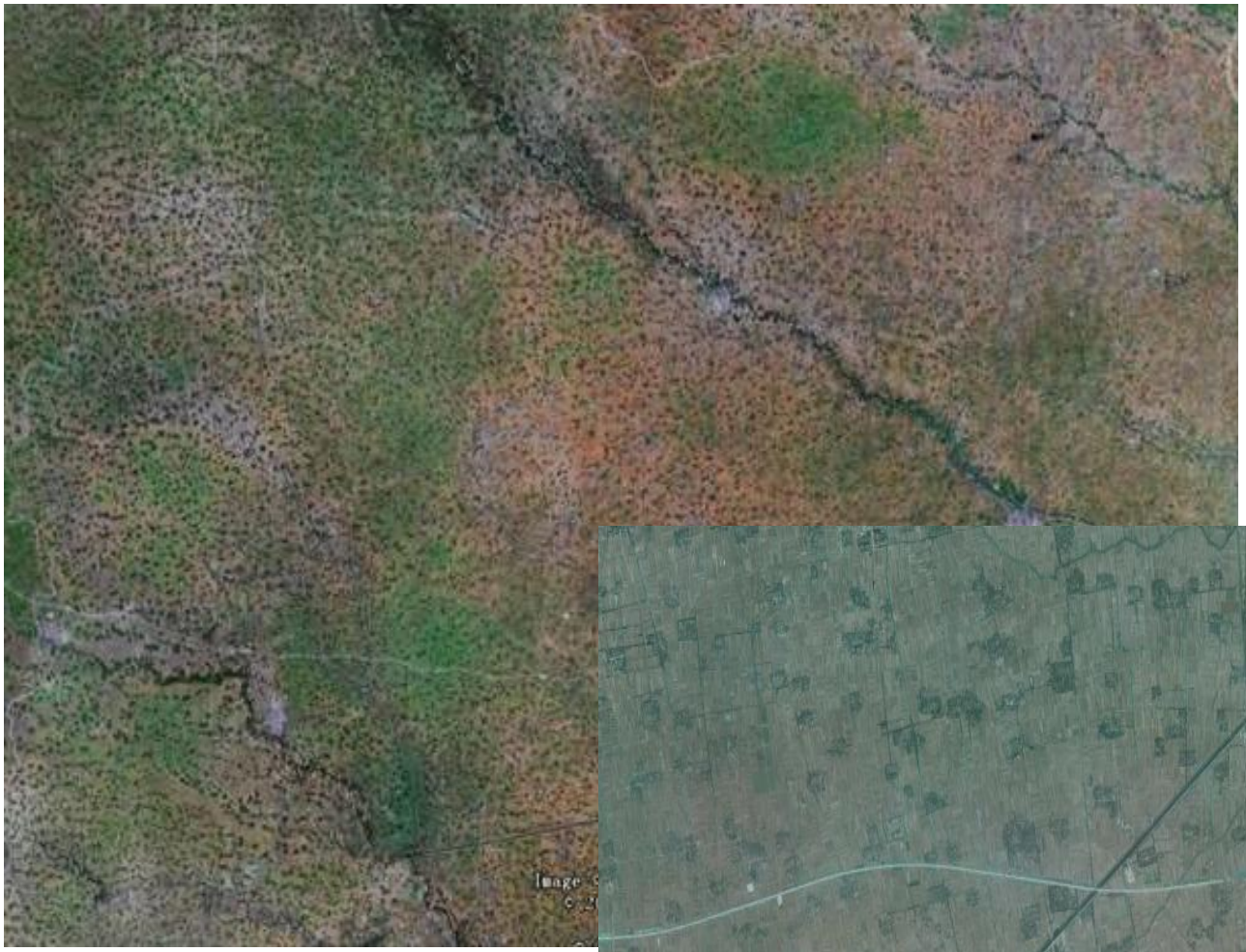


Fig. 25 MODIS LST cold season mean, Nov. to Mar. , 2009-2010 in YRD



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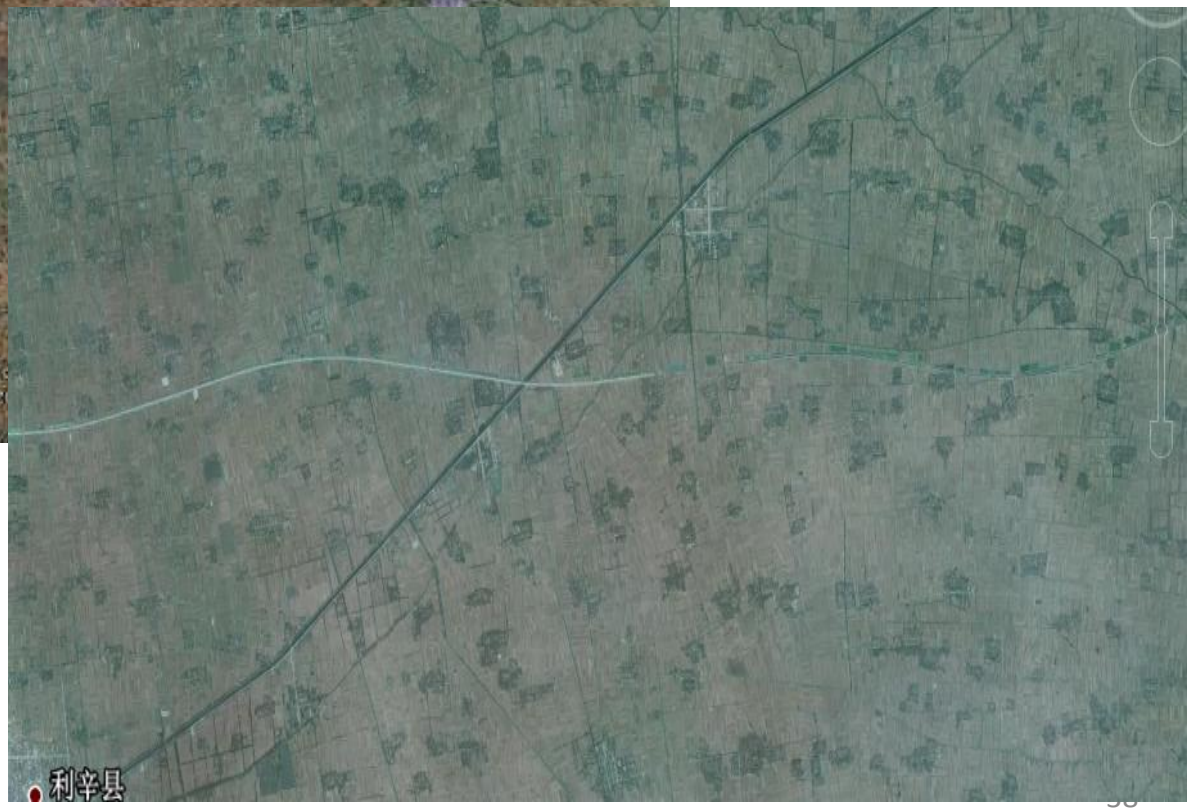

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浙江省
宁波市
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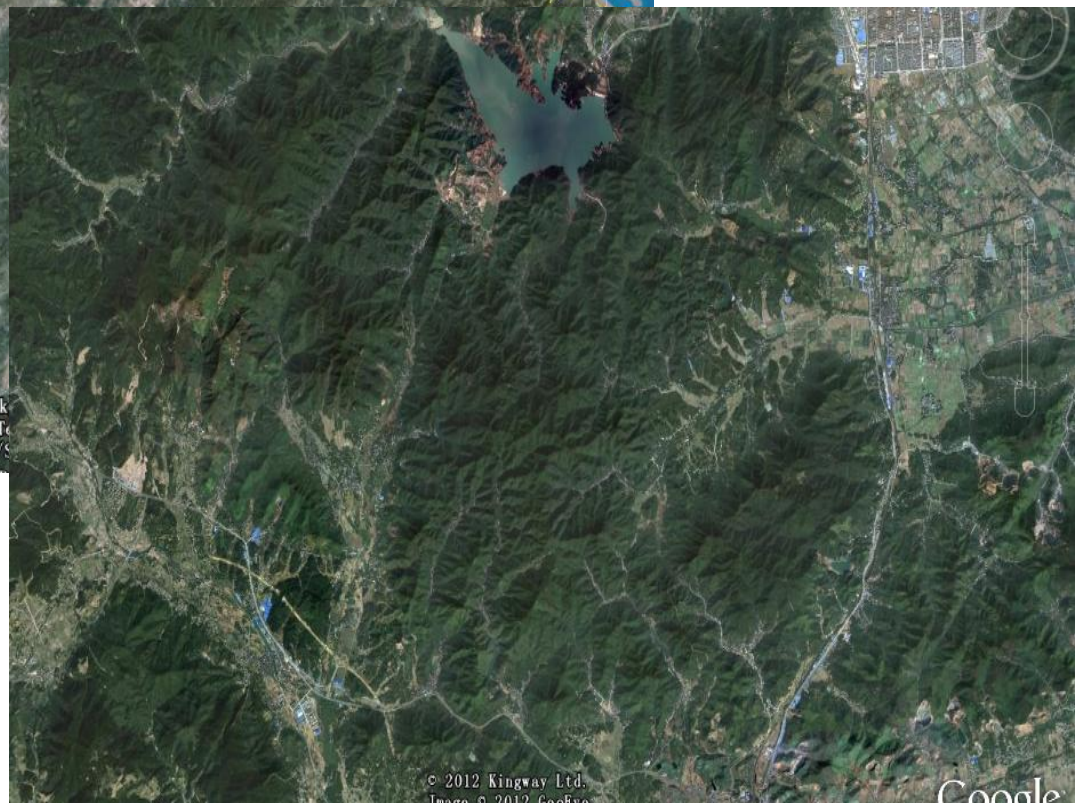
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3

LST temporal variation isn't regular!

How to study the regional Urban Heat Island in YRD?

4.2 The Temporal and Spatial Distribution of the Regional Urban Heat in YRD

4.2.1 The Temporal and Spatial Distribution of LST Difference between YRD and Taihu

4.2.2 The Temporal and Spatial Distribution of the Daily LST Range in Urban Cluster

4.2.1 The Temporal and Spatial Distribution of LST Difference between YRD and Taihu

Theory: $UHII=LST_U-LST_R$

UHII: Urban Heat Island Intensity

LST_U: Urban LST

LST_R: Rural LST

Question: Be difficult to make a clear distinction between urban and rural.

Solution:

Fig.26 Diagrammatic Study Area Drawing

MODIS LST Mean at Taihu Lake

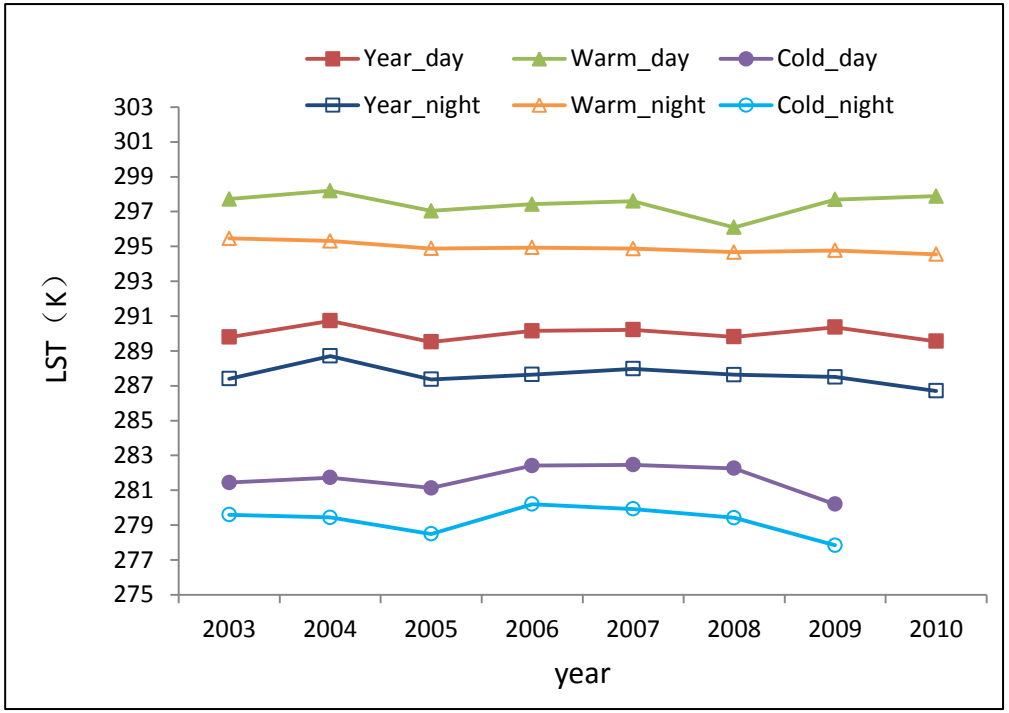


Fig. 27 MODIS mean LST , 2003-2010 at taihu lake

Tab. 1 LST daily range at taihu

	Daily LST Range		
	Year	Warm	Cold
2003	2.39	2.26	1.85
2004	2.03	2.88	2.29
2005	2.15	2.16	2.64
2006	2.51	2.49	2.21
2007	2.24	2.73	2.53
2008	2.17	1.42	2.84
2009	2.86	2.92	2.36
2010	2.85	3.34	

Tab. 2 LST annual range at taihu

	Day			Night		
	Year	Warm	Cold	Year	Warm	Cold
LST_{max}	290.73	298.20	282.46	288.7	295.46	280.20
LST_{min}	289.52	296.10	280.20	286.7	294.55	277.85
Δ LST	1.21	2.10	2.26	1.00	0.91	2.35

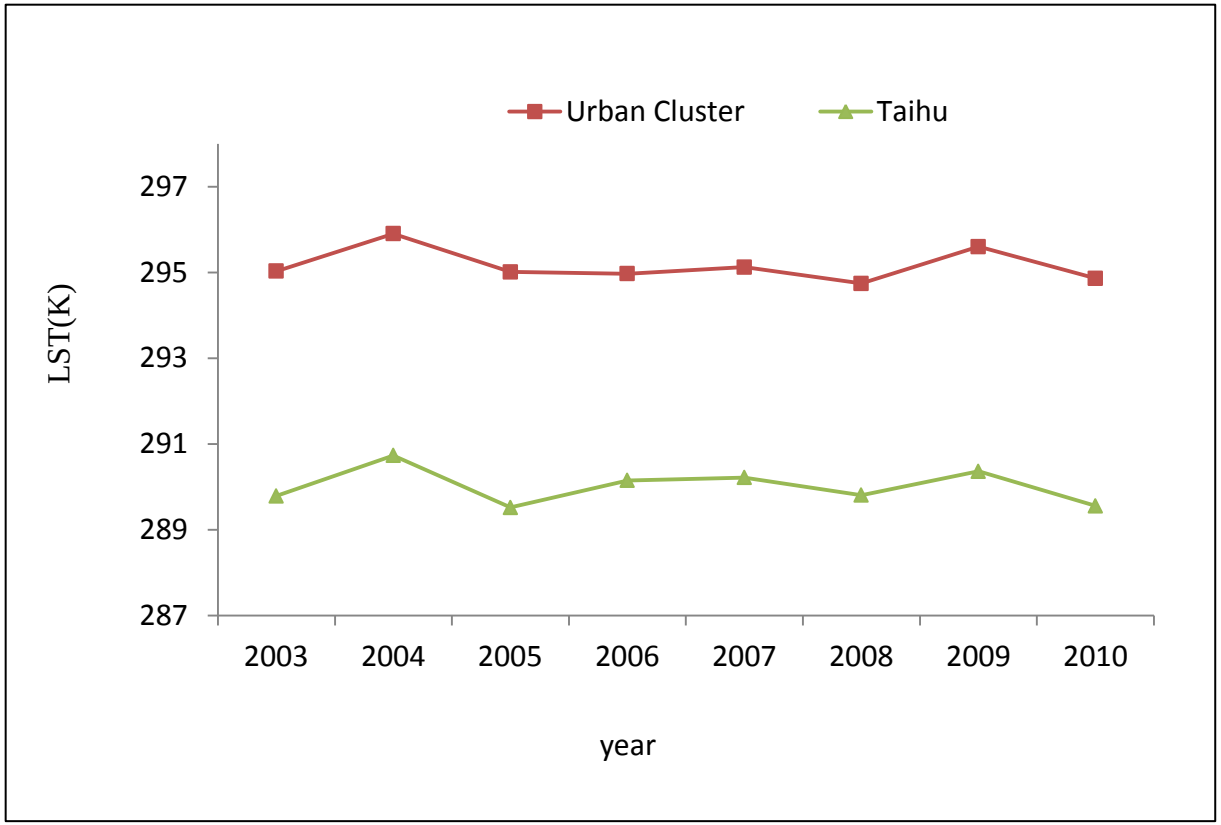


Fig. 28 MODIS LST annual mean , 2003-2010 in urban cluster and taihu

Experiment:

$$UHII=LST_U-LST_W$$

UHII: Urban Heat Island Intensity

LST_U: Urban LST

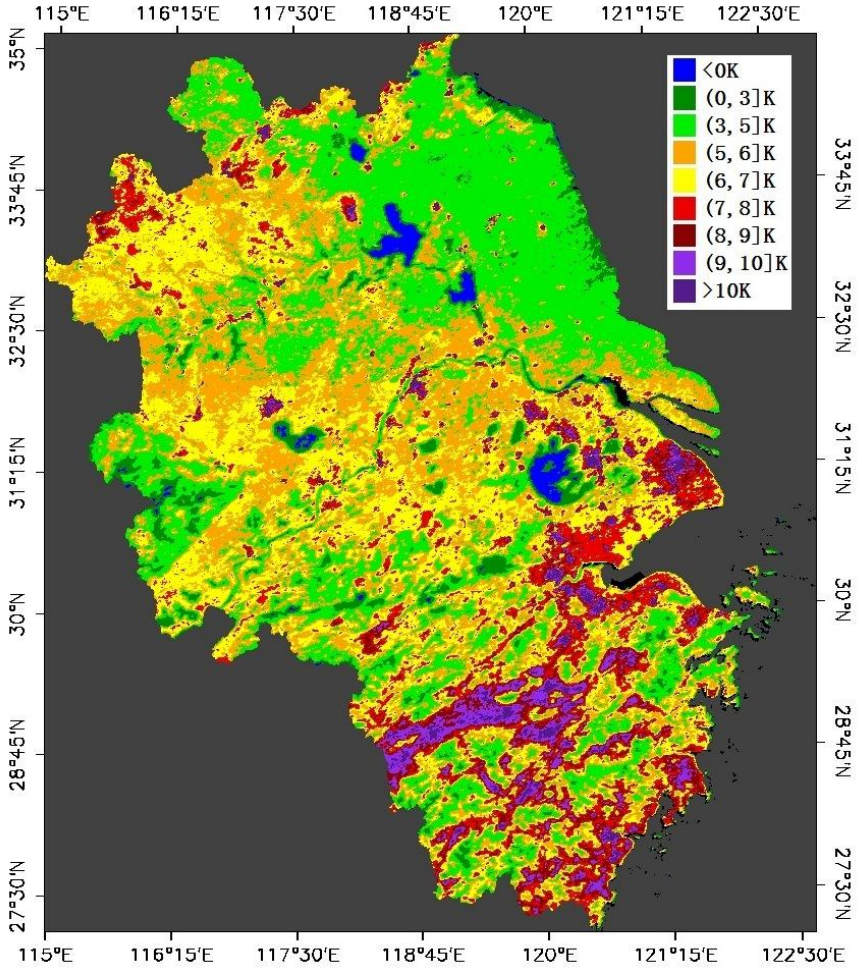
LST_W: Water Body LST

- MODIS LST Difference Annual Mean
- MODIS LST Difference Warm Season Mean
- MODIS LST Difference Cold Season Mean
- The Temporal Variation of LST Difference

MODIS LST Difference Annual Mean

between YRD and Taihu

daytime



nighttime

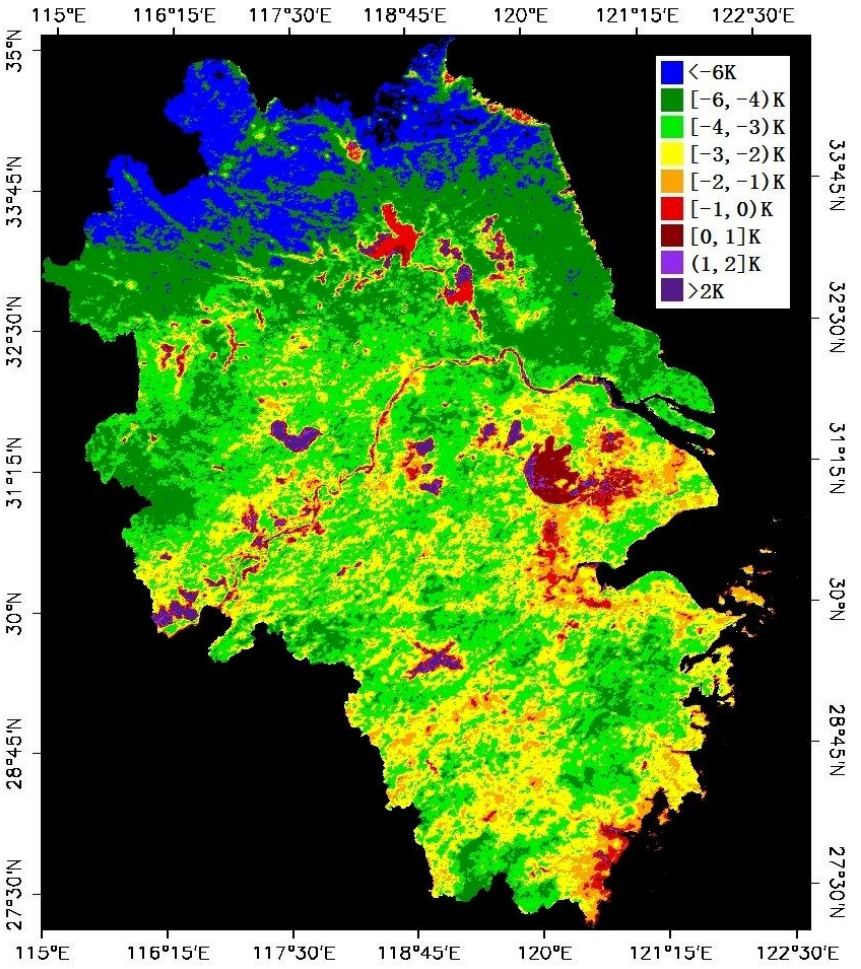


Fig.29 MODIS LST difference annual mean between YRD and taihu, 2003

daytime

nighttime

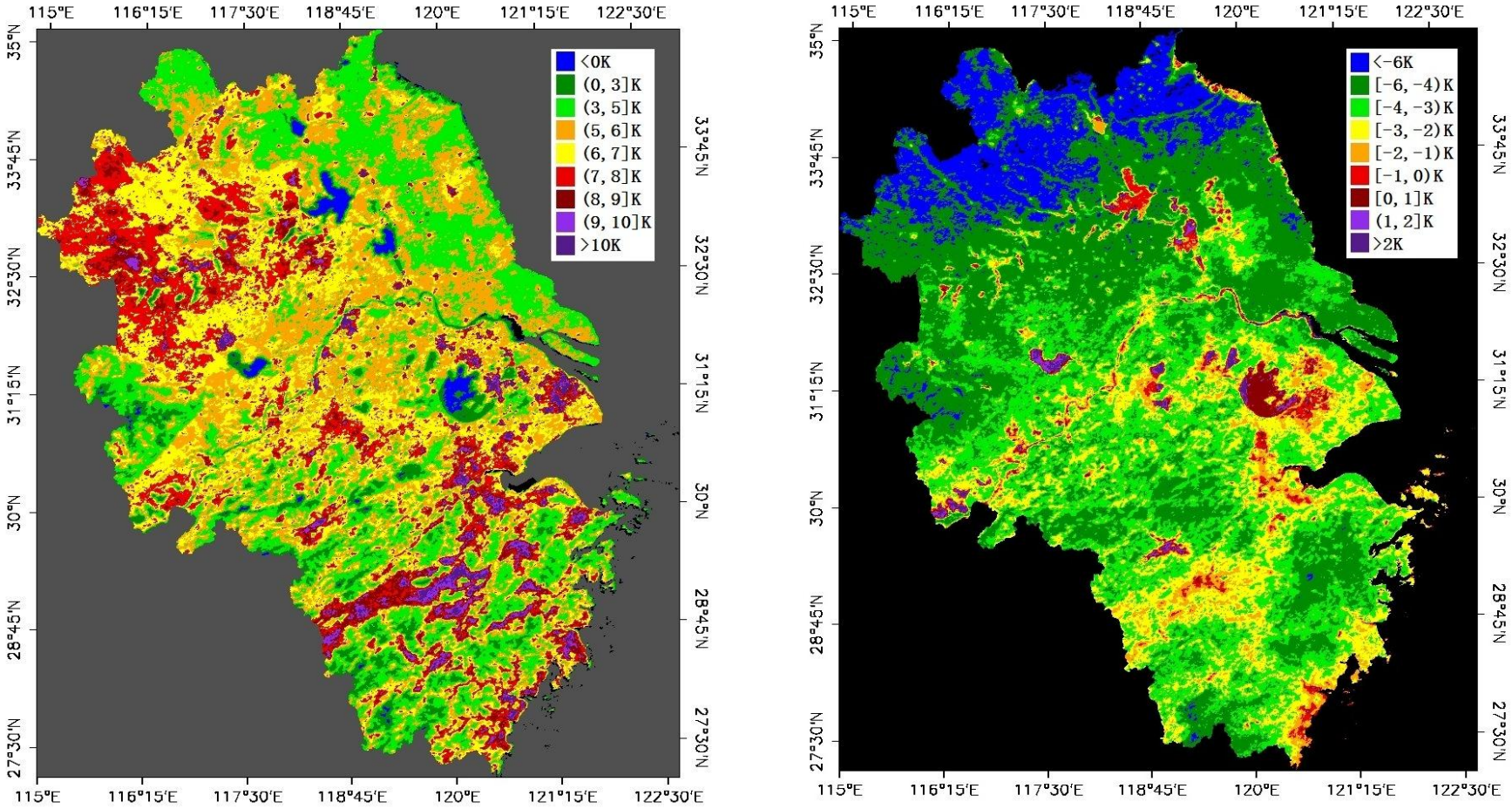
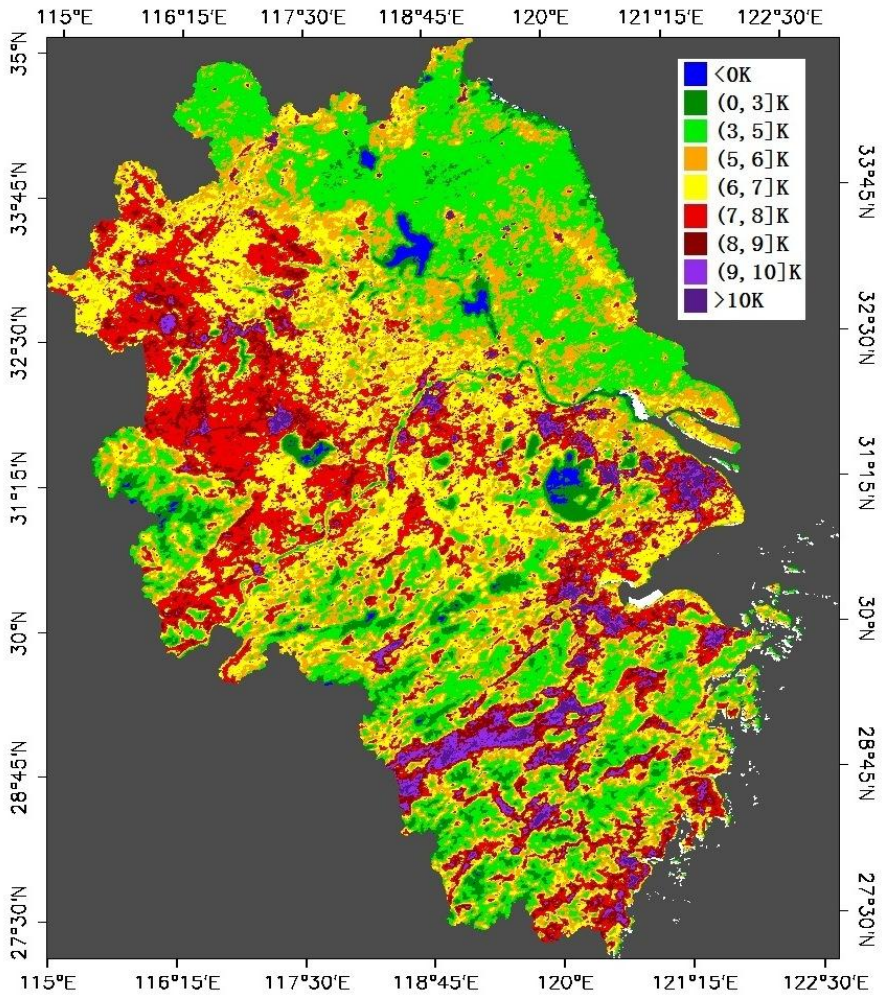


Fig.30 MODIS LST difference annual mean between YRD and taihu, 2004

daytime

nighttime



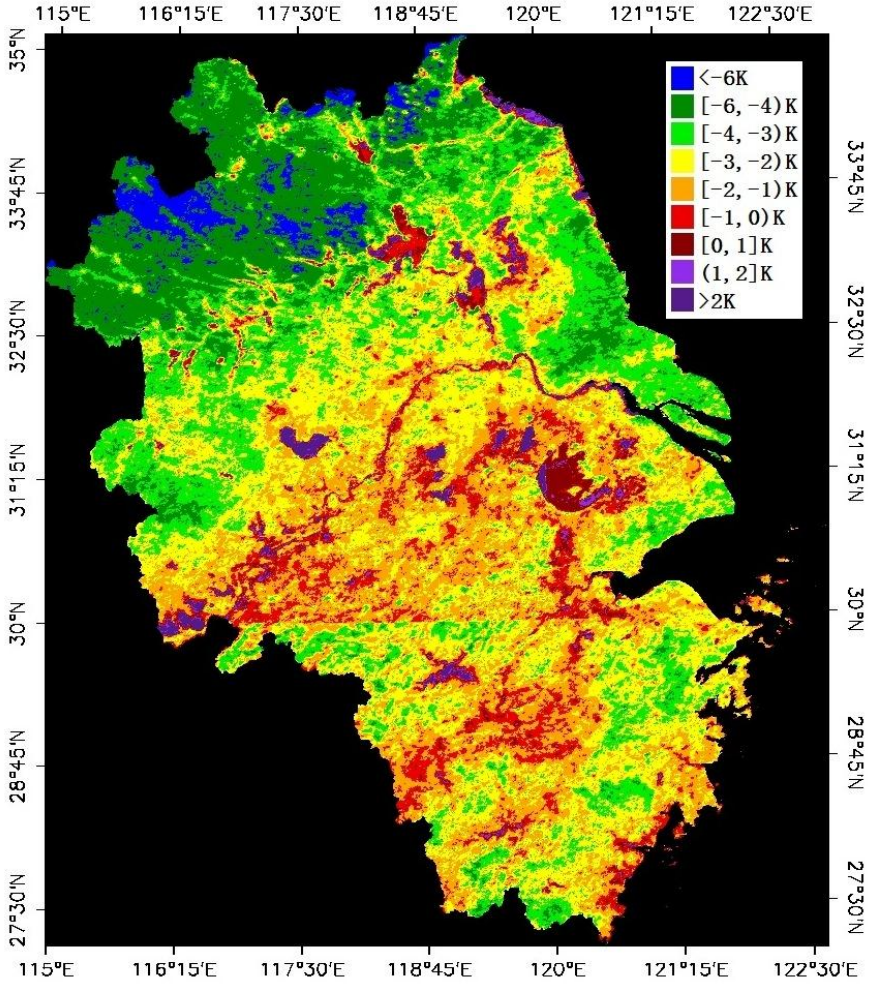


Fig.31 MODIS LST difference annual mean between YRD and taihu, 2005

daytime

nighttime

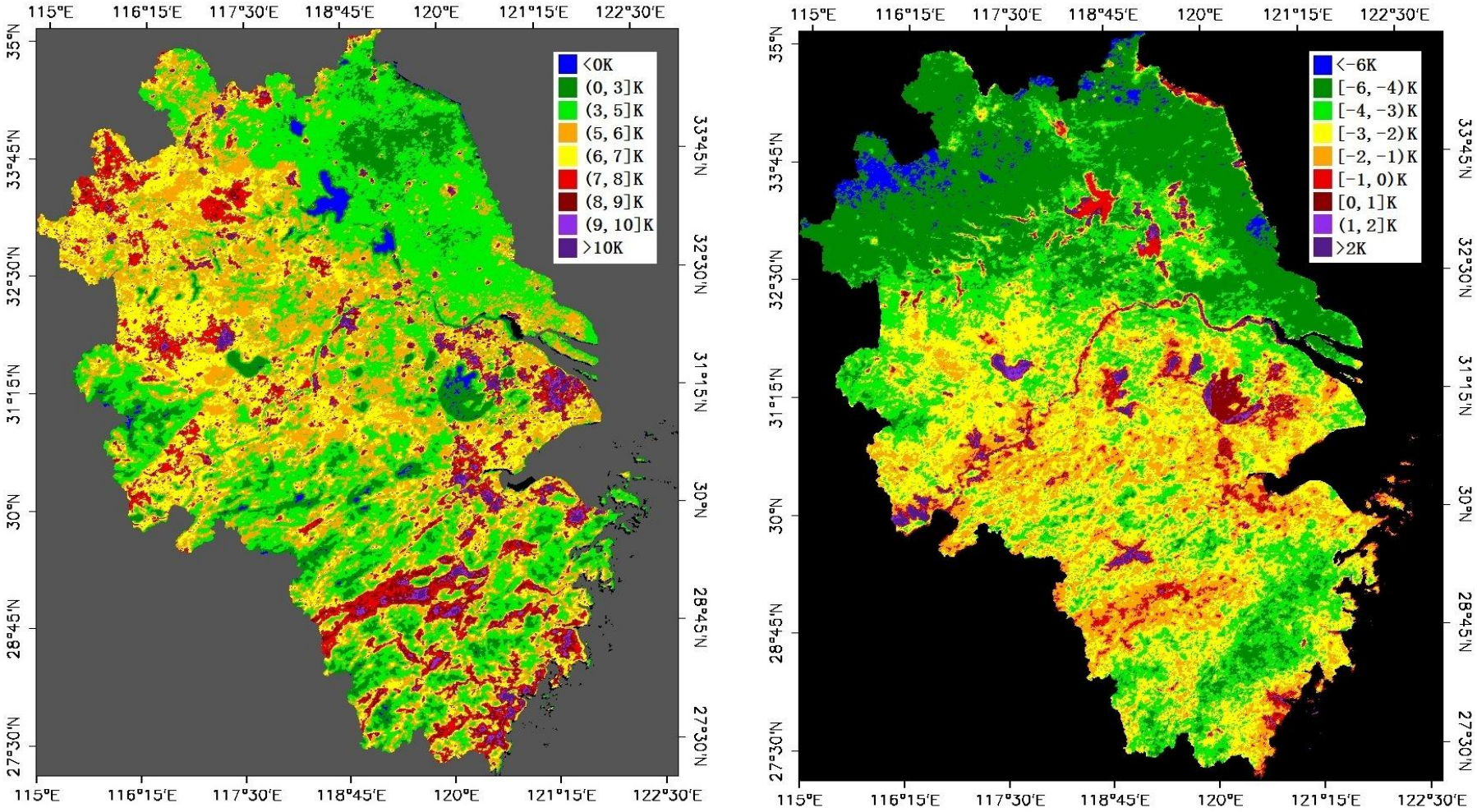
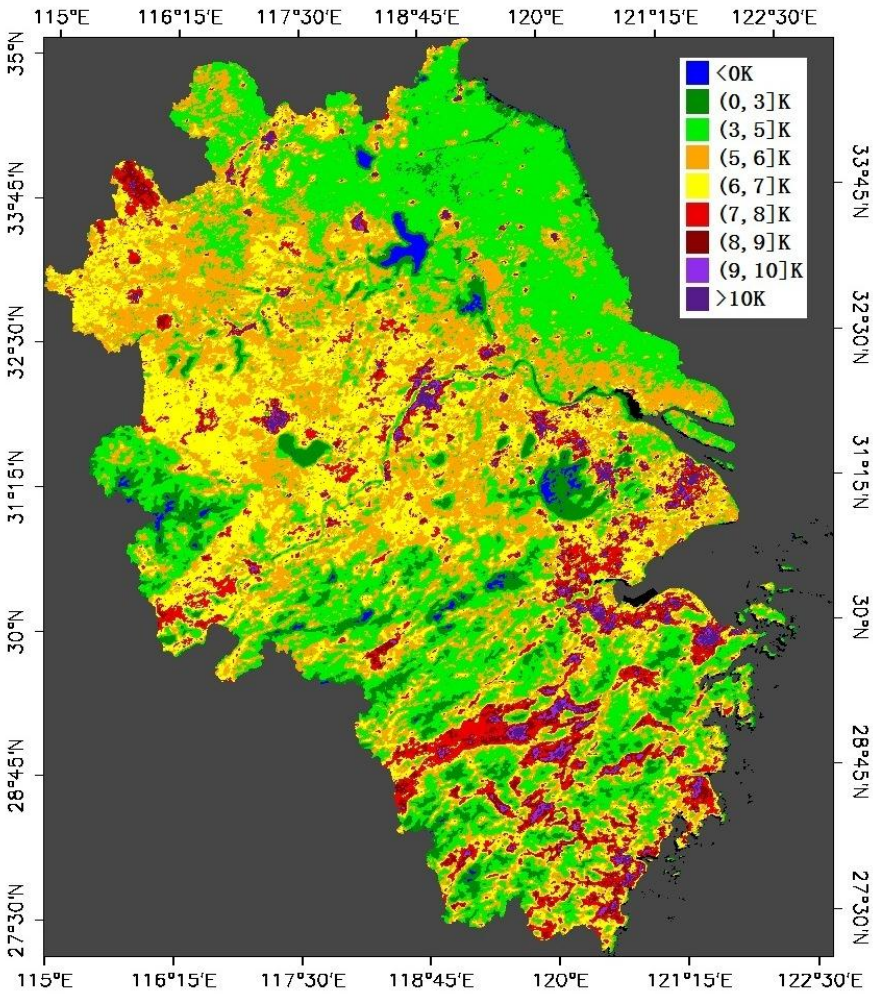


Fig.32 MODIS LST difference annual mean between YRD and taihu, 2006

daytime

nighttime



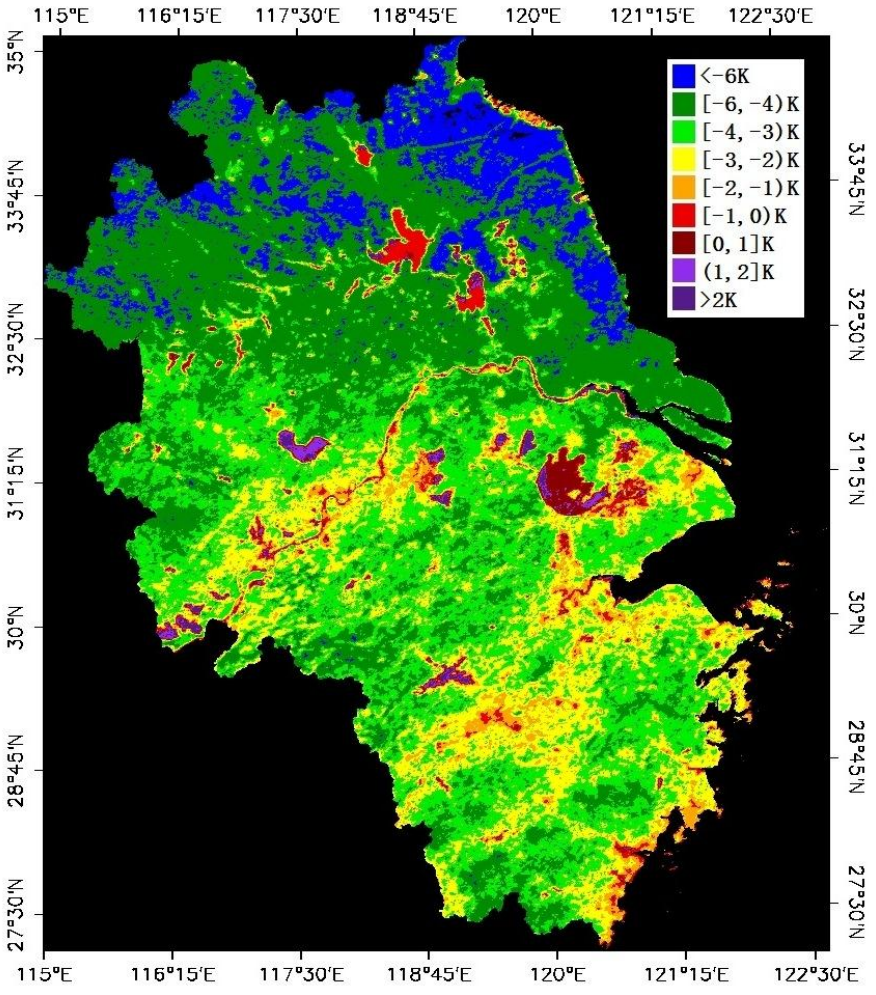


Fig.33 MODIS LST difference annual mean between YRD and taihu, 2007

daytime

nighttime

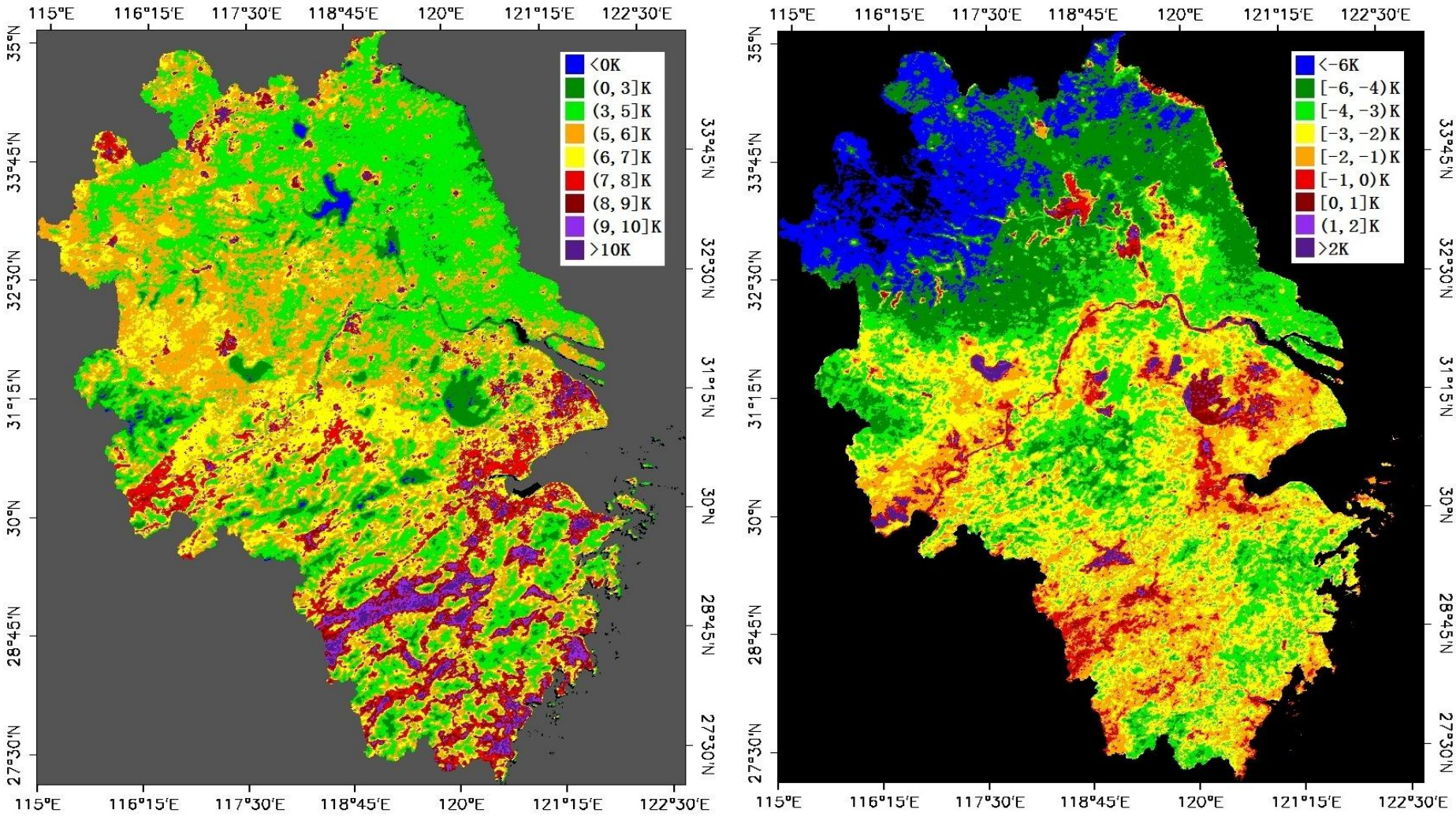
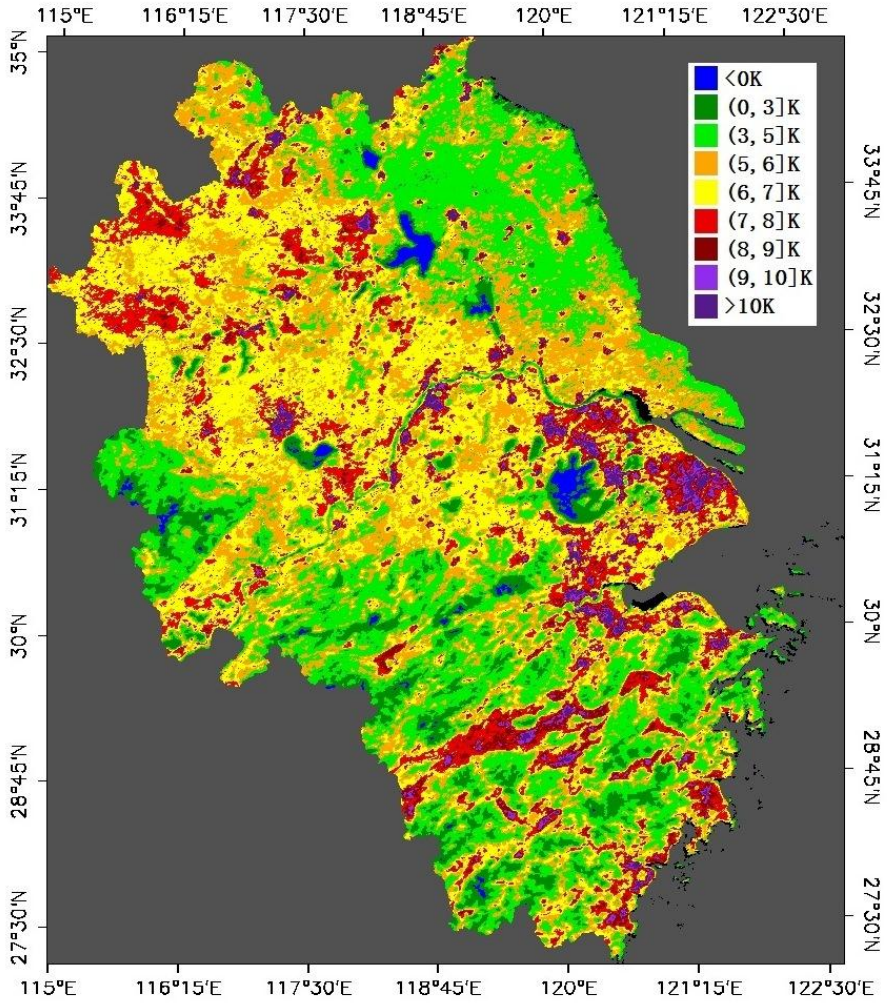


Fig.34 MODIS LST difference annual mean between YRD and taihu, 2008

daytime

nighttime



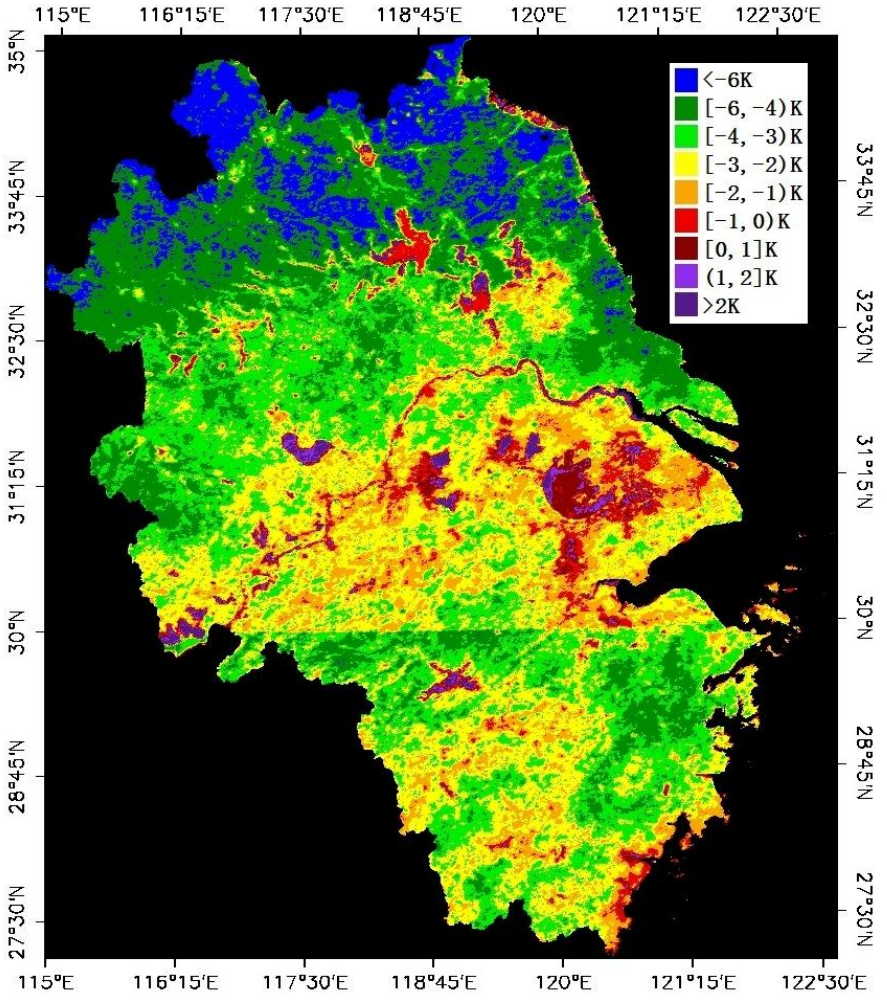


Fig.35 MODIS LST difference annual mean between YRD and taihu, 2009

daytime

nighttime

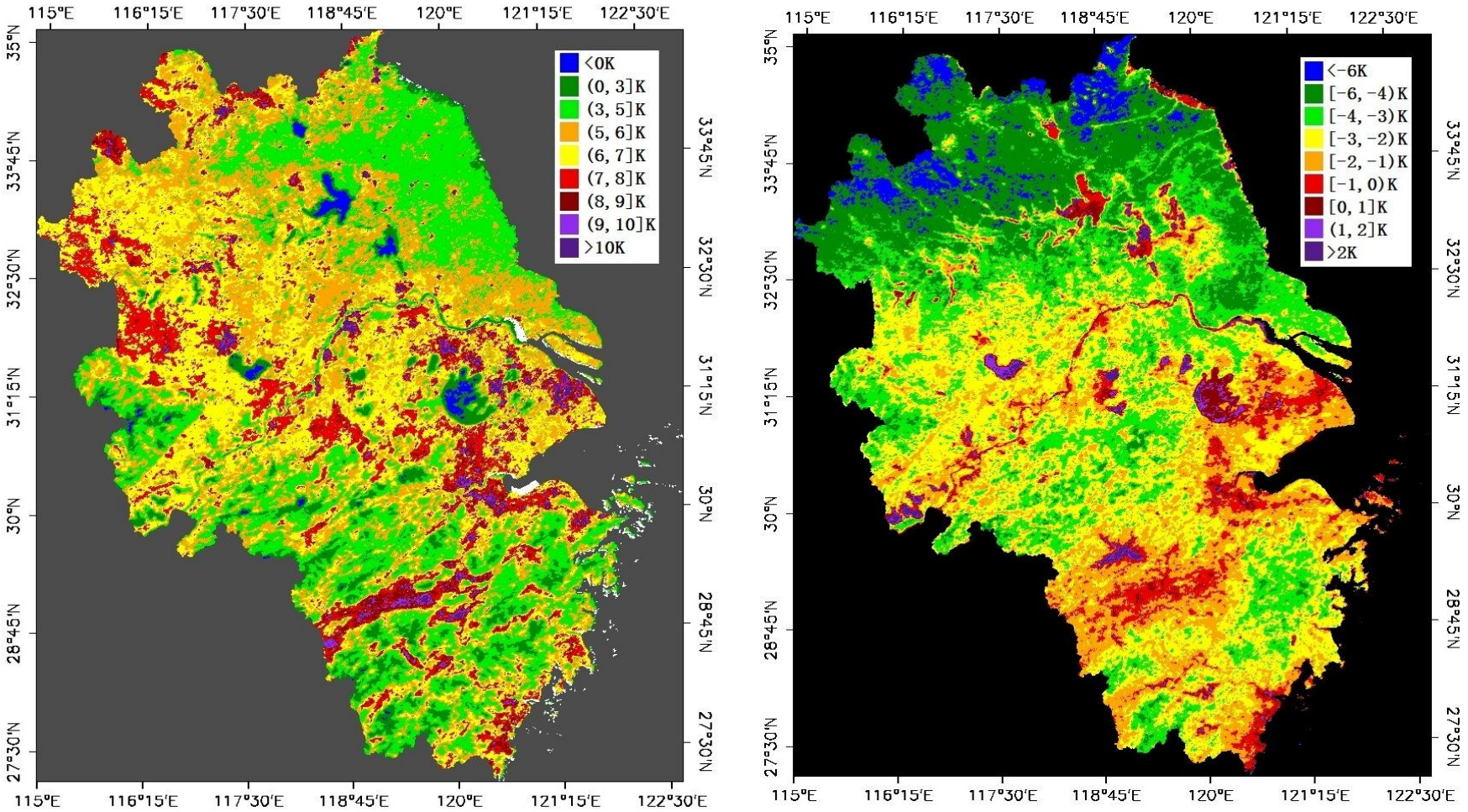


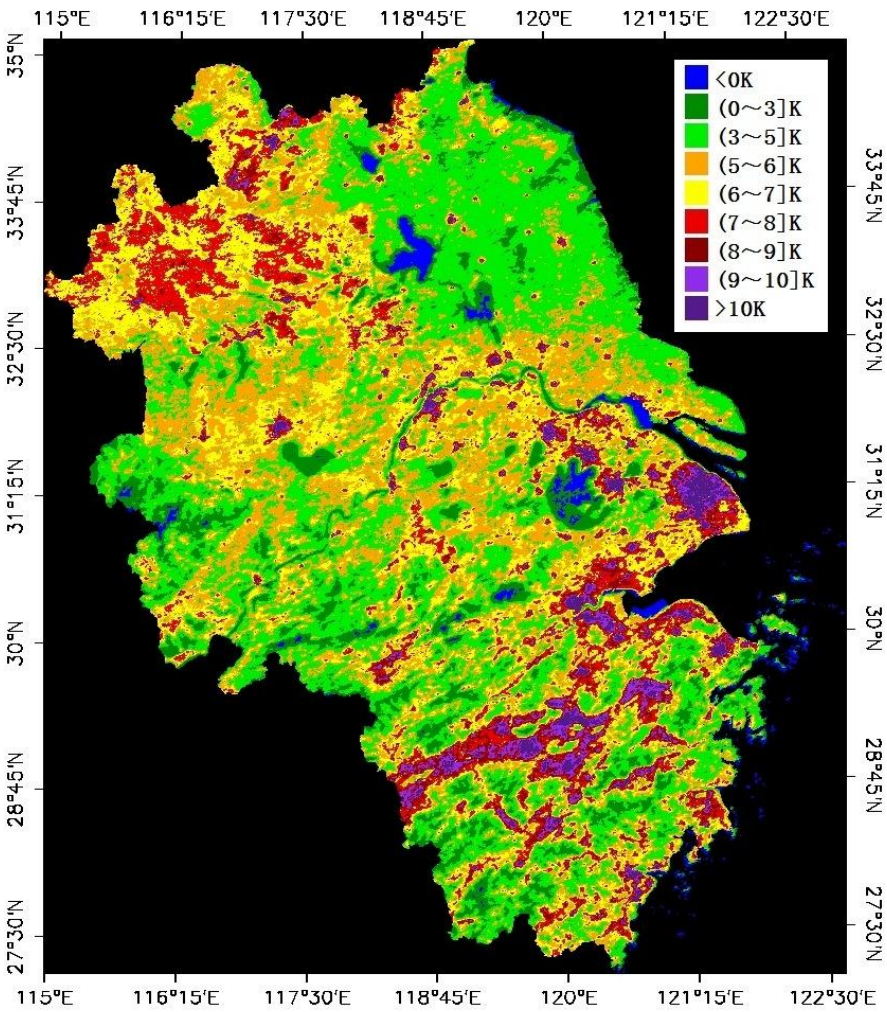
Fig.36 MODIS LST difference annual mean between YRD and taihu, 2010

MODIS LST Difference Warm Season Mean

between YRD and Taihu

daytime

nighttime



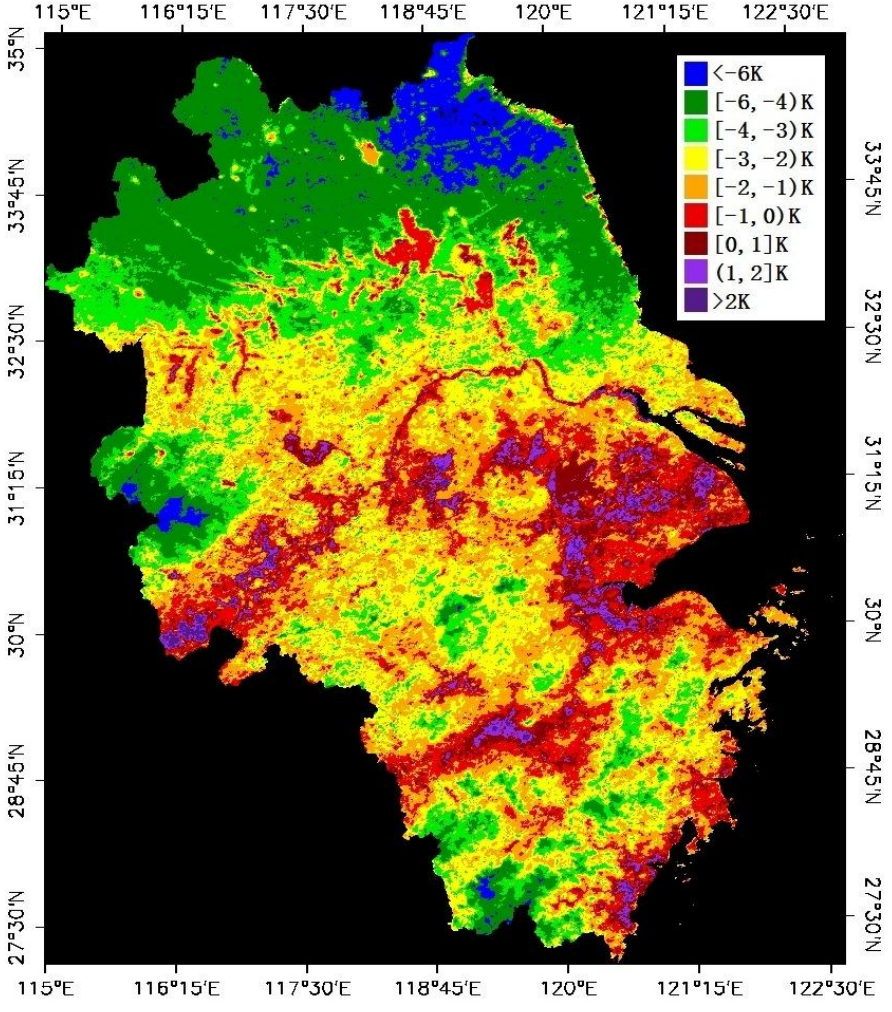


Fig.37 MODIS LST difference warm season mean between YRD and taihu, 2003

daytime

nighttime

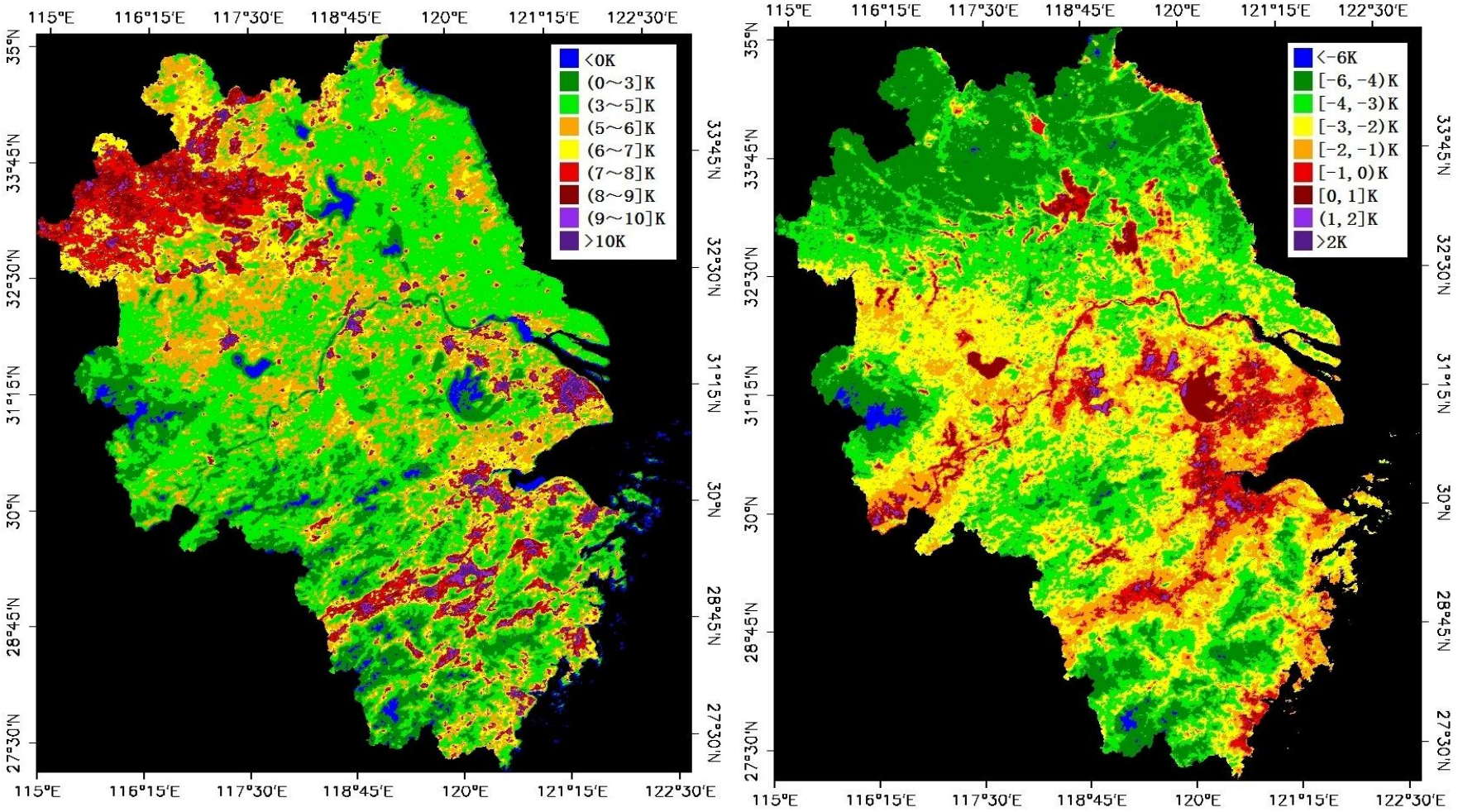


Fig.38 MODIS LST difference warm season mean between YRD and taihu, 2004

daytime

nighttime

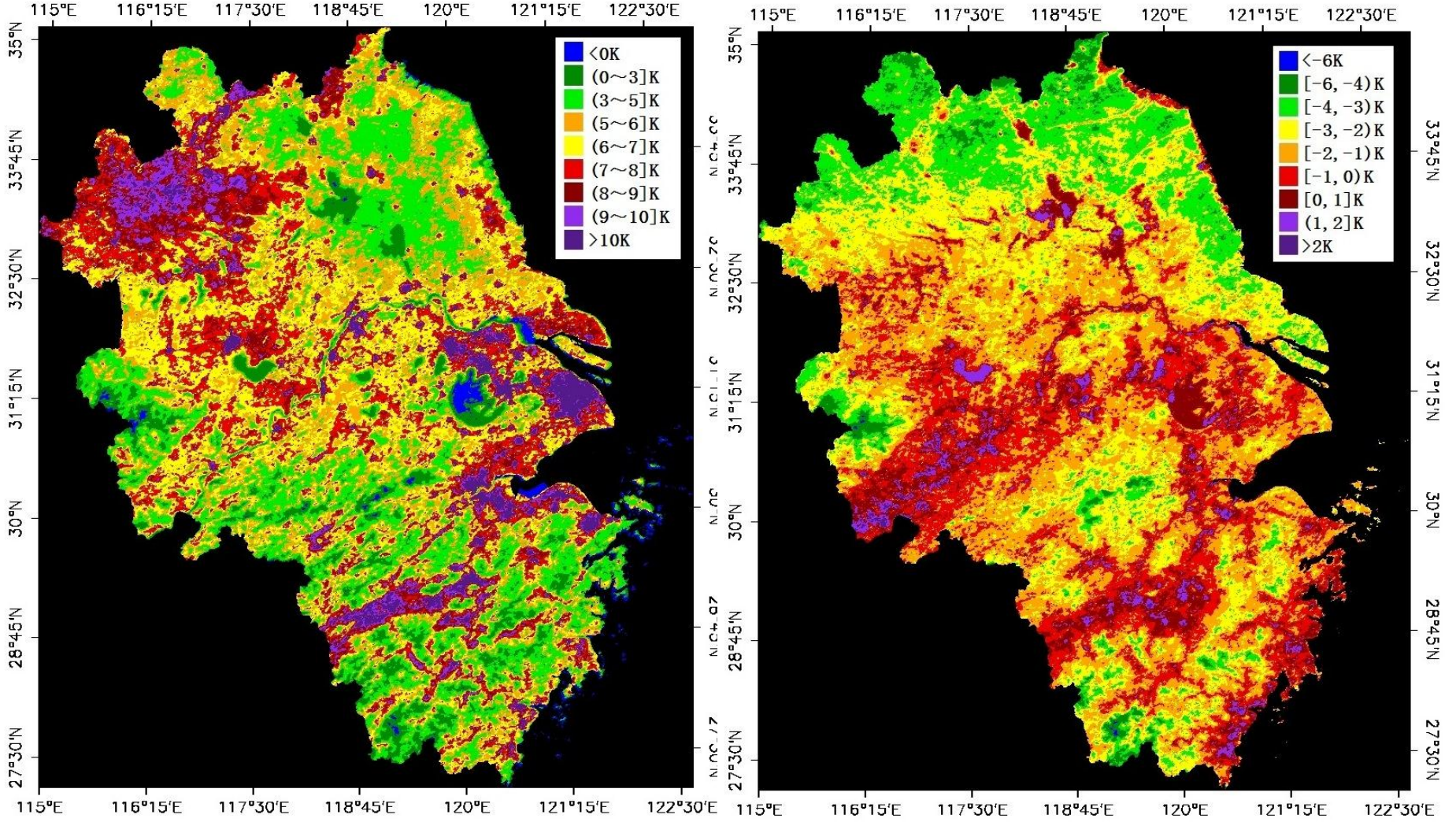
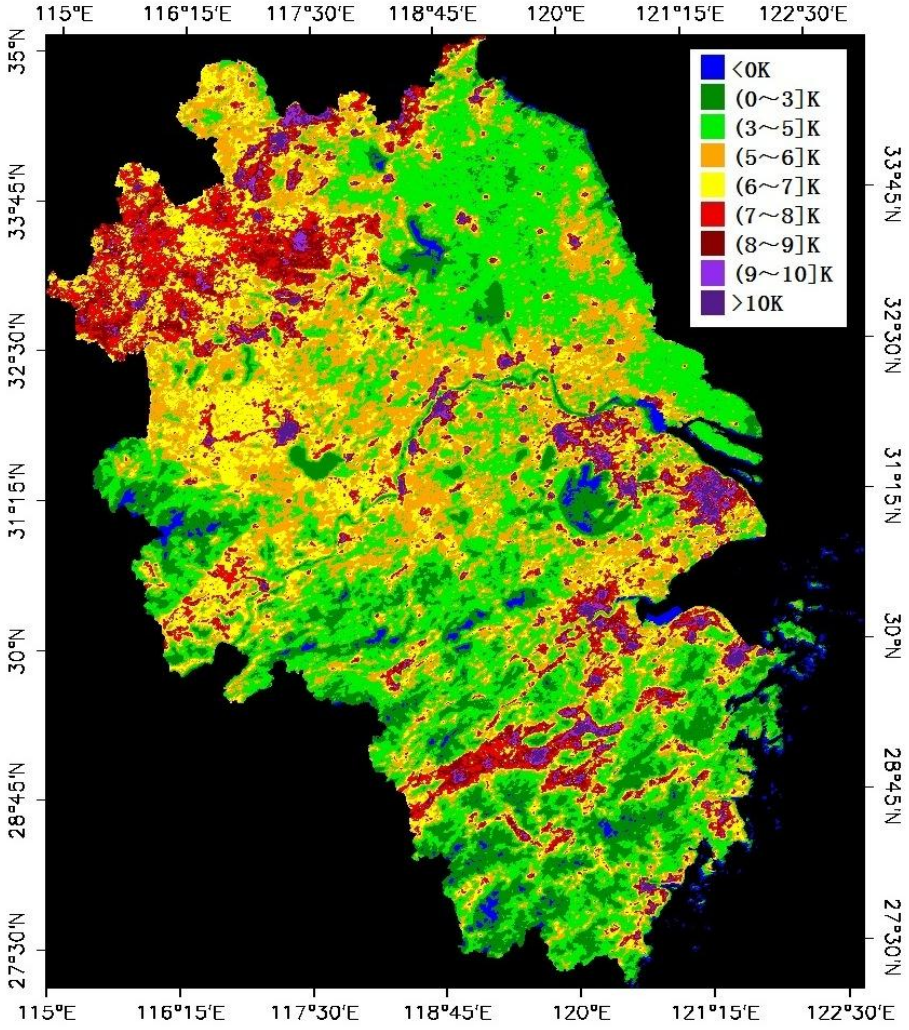


Fig.39 MODIS LST difference warm season mean between YRD and taihu, 2005

daytime

nighttime



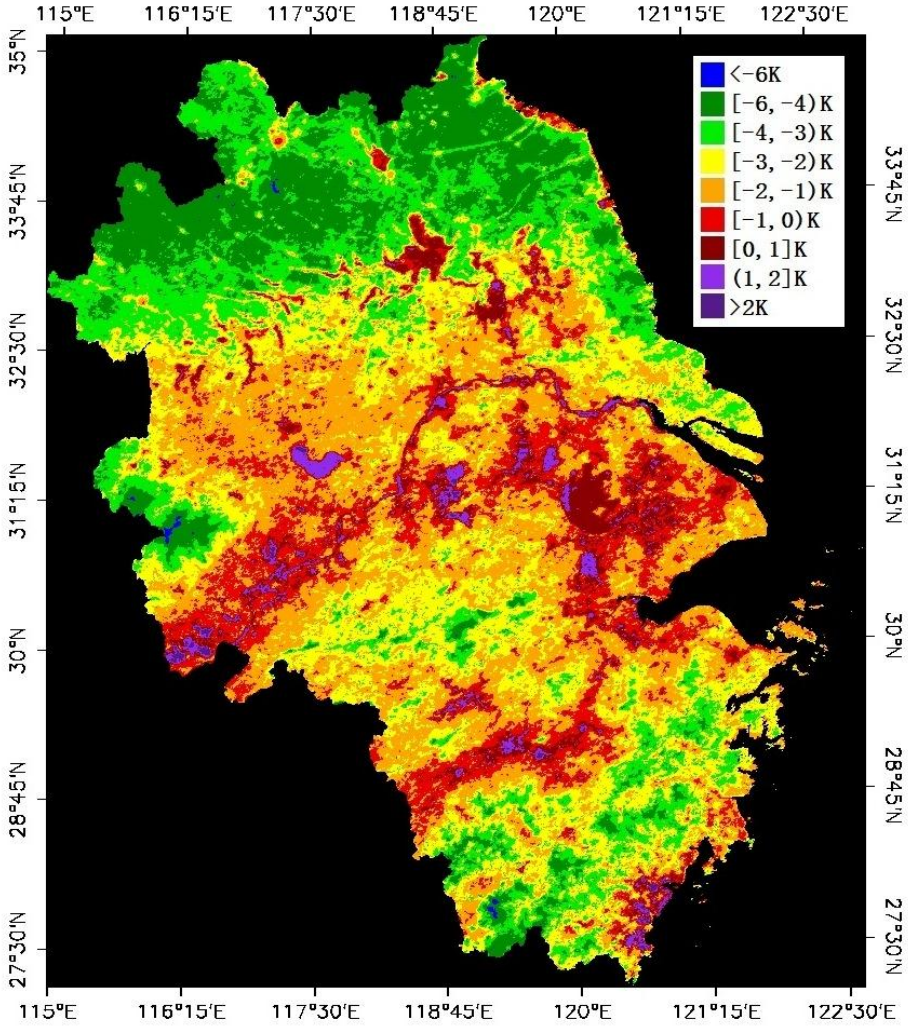
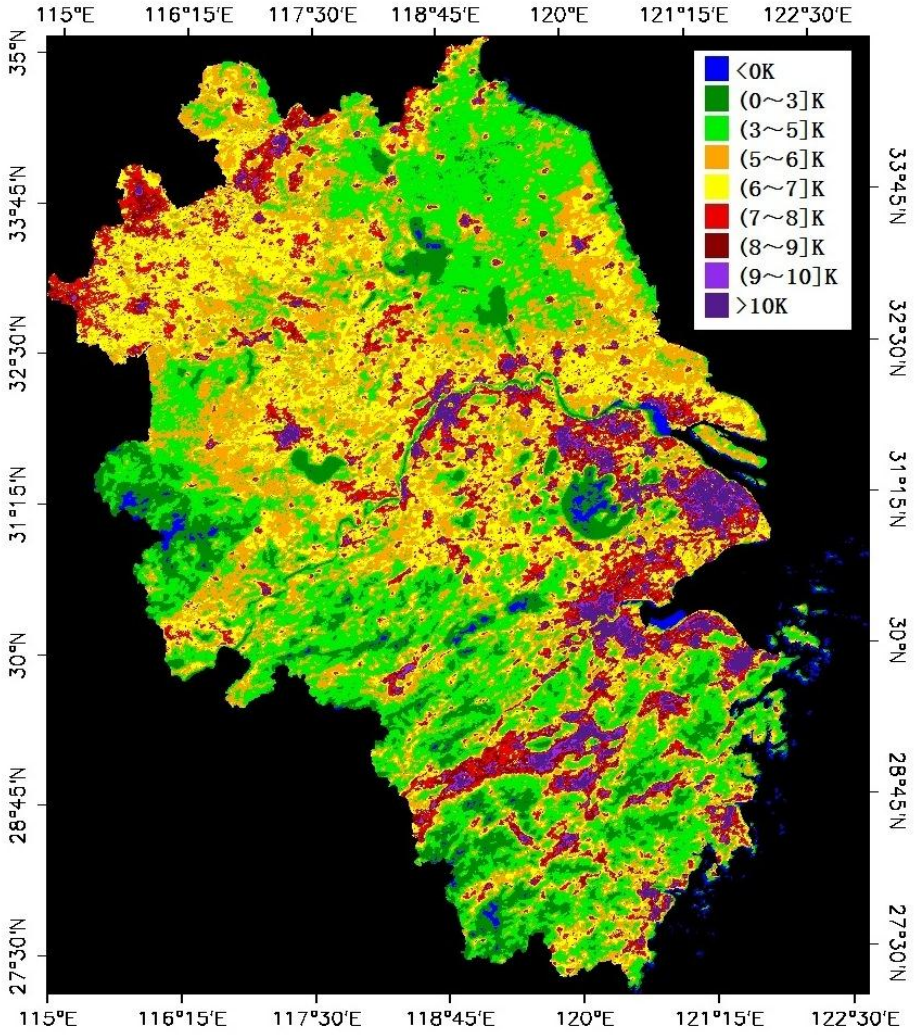


Fig.40 MODIS LST difference warm season mean between YRD and taihu, 2006

daytime

nighttime



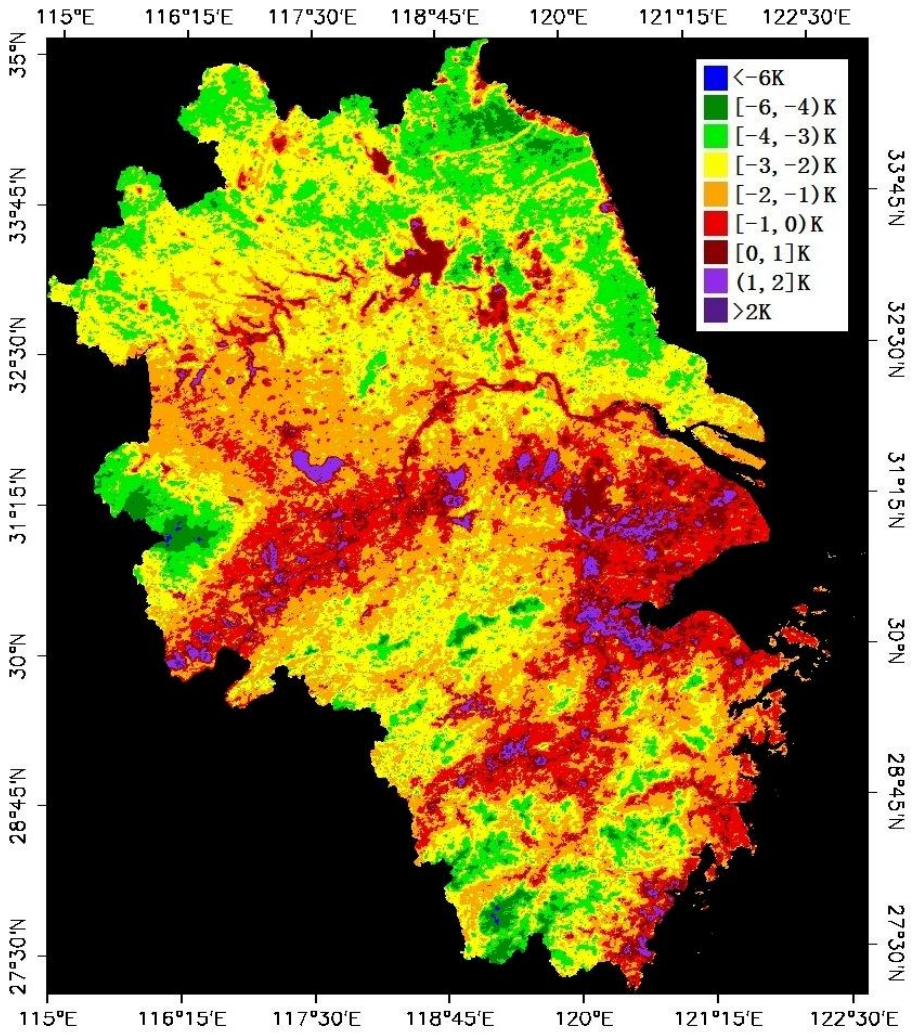


Fig.41 MODIS LST difference warm season mean between YRD and taihu, 2007

daytime

nighttime

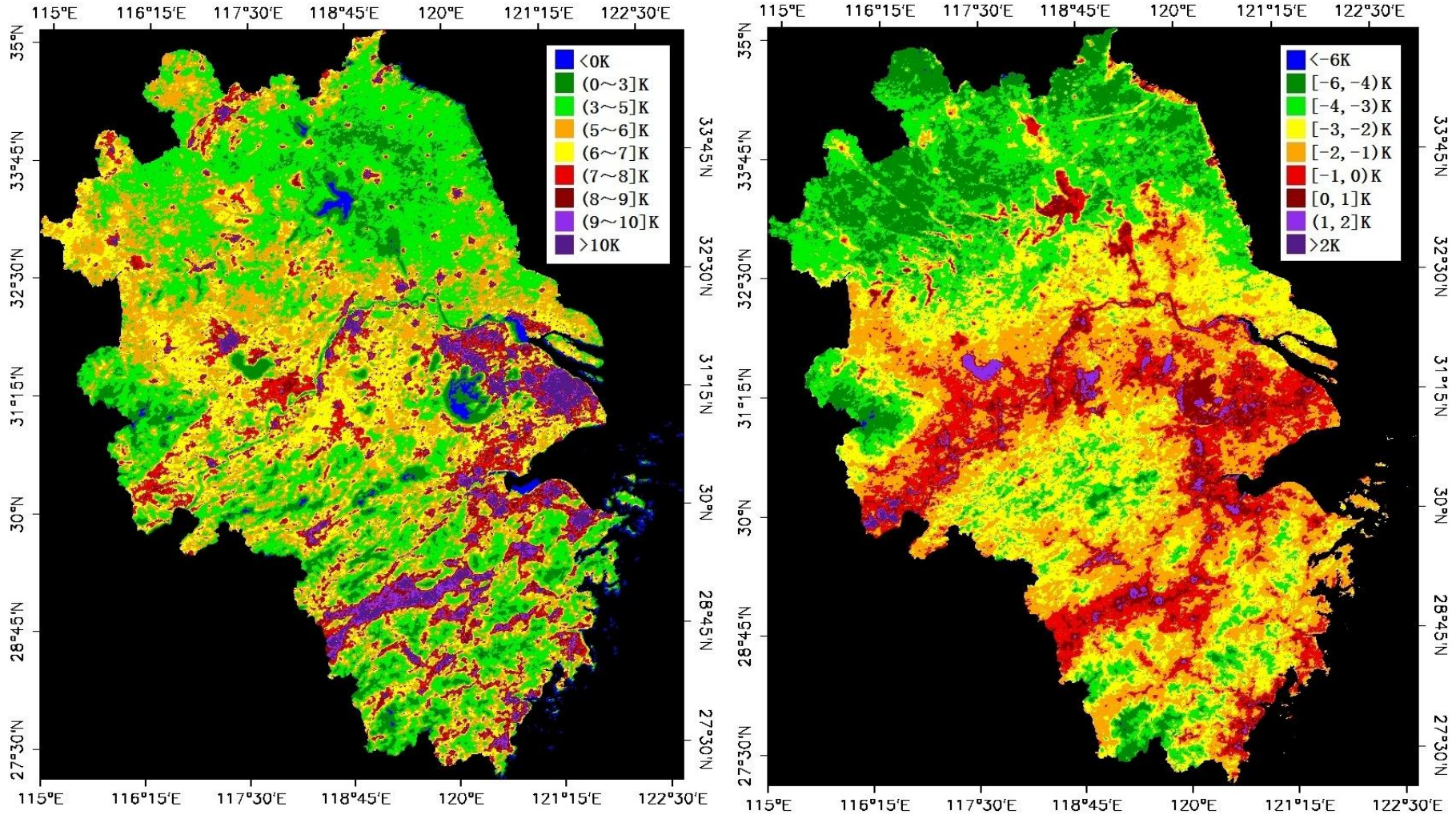
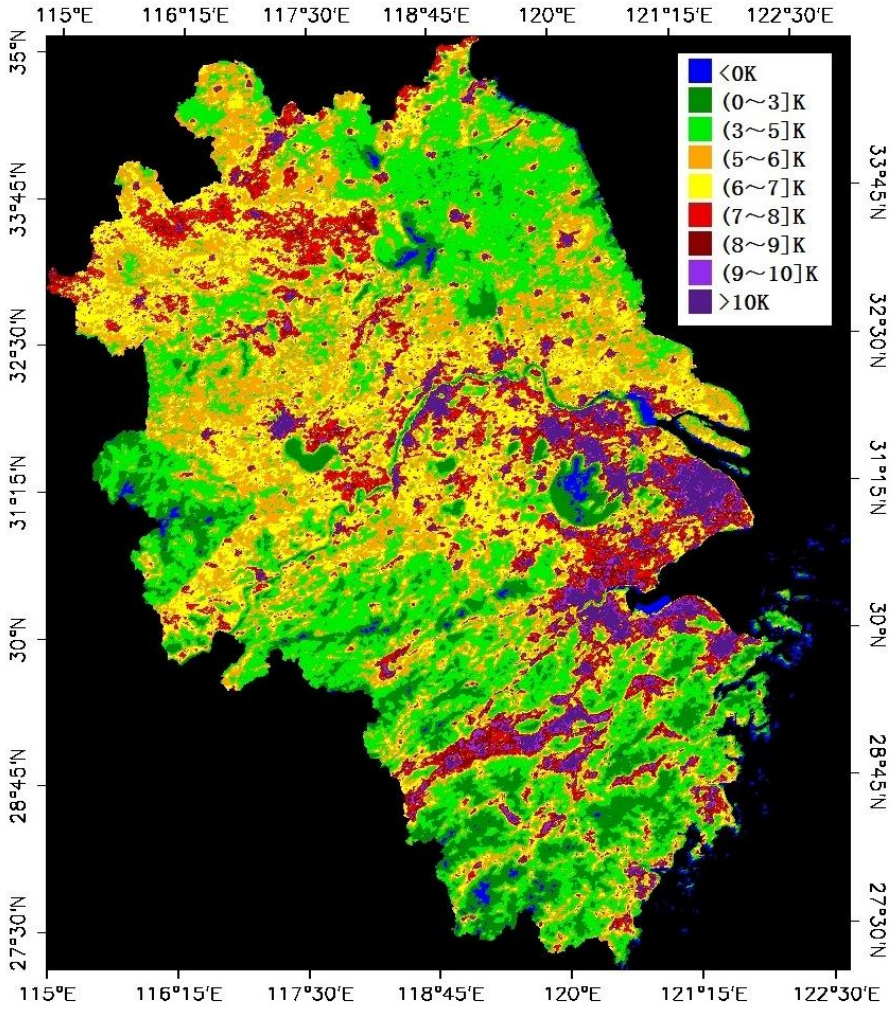


Fig.42 MODIS LST difference warm season mean between YRD and taihu, 2008

daytime

nighttime



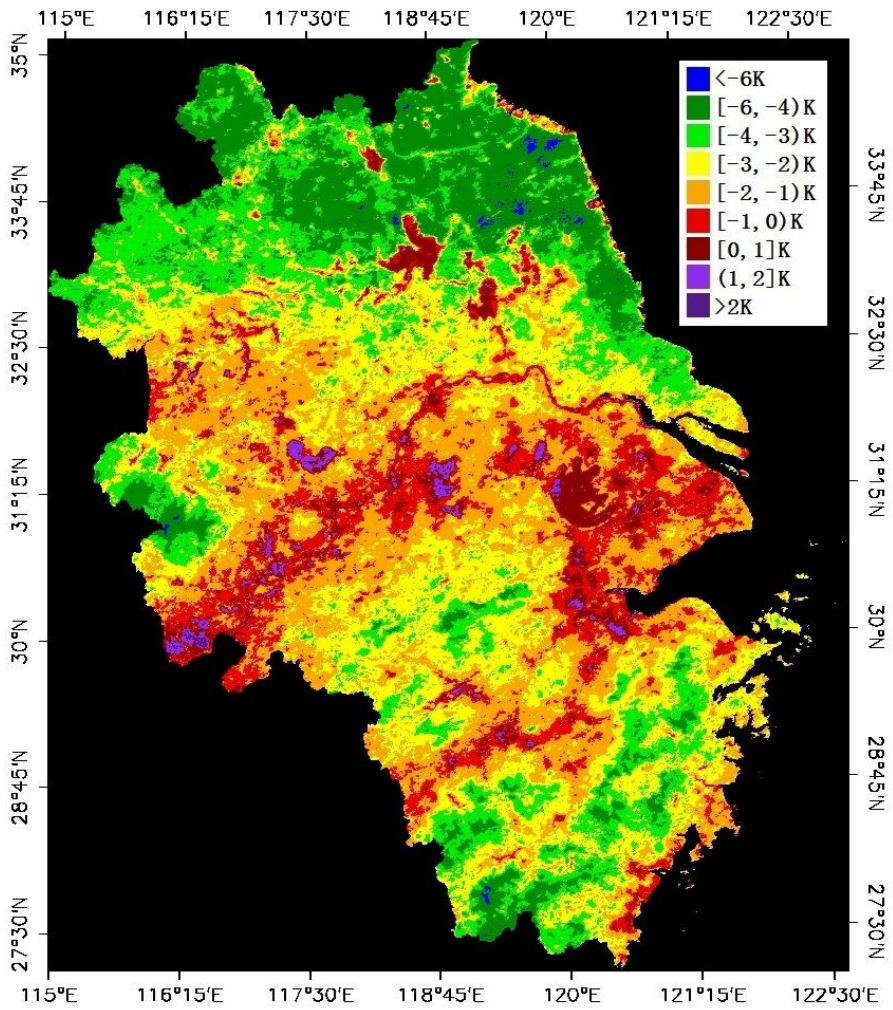
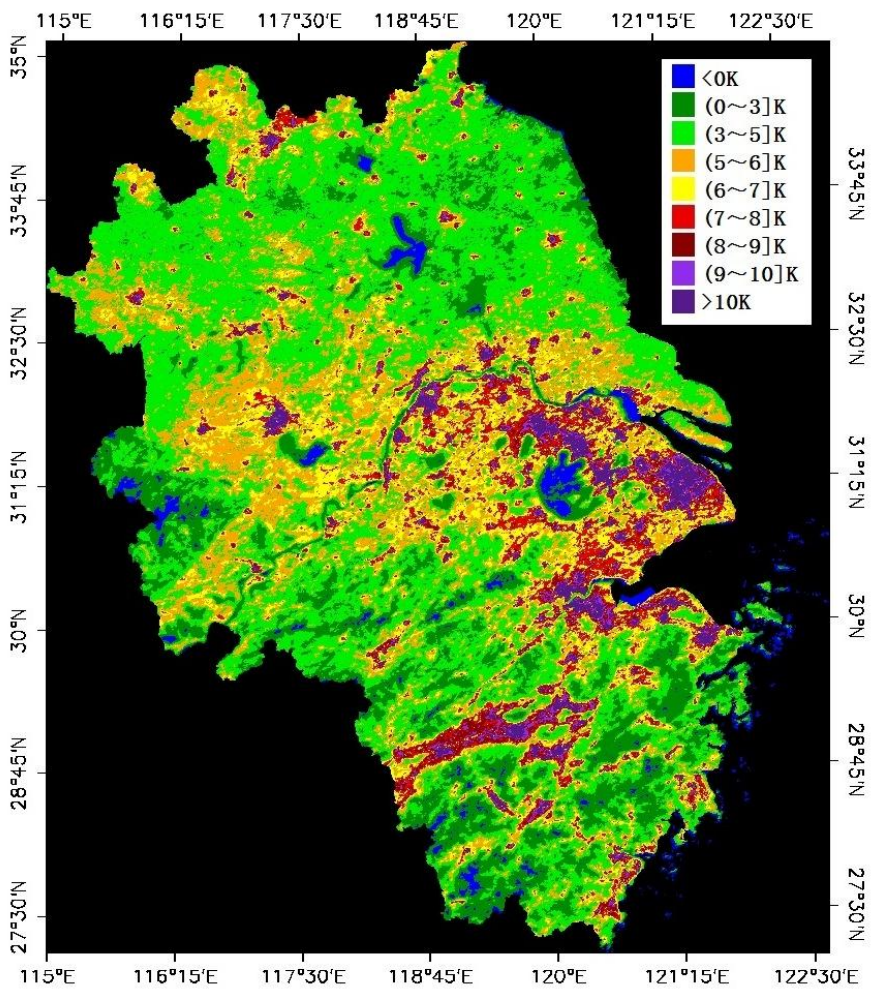


Fig.43 MODIS LST difference warm season mean between YRD and taihu, 2009

daytime

nighttime



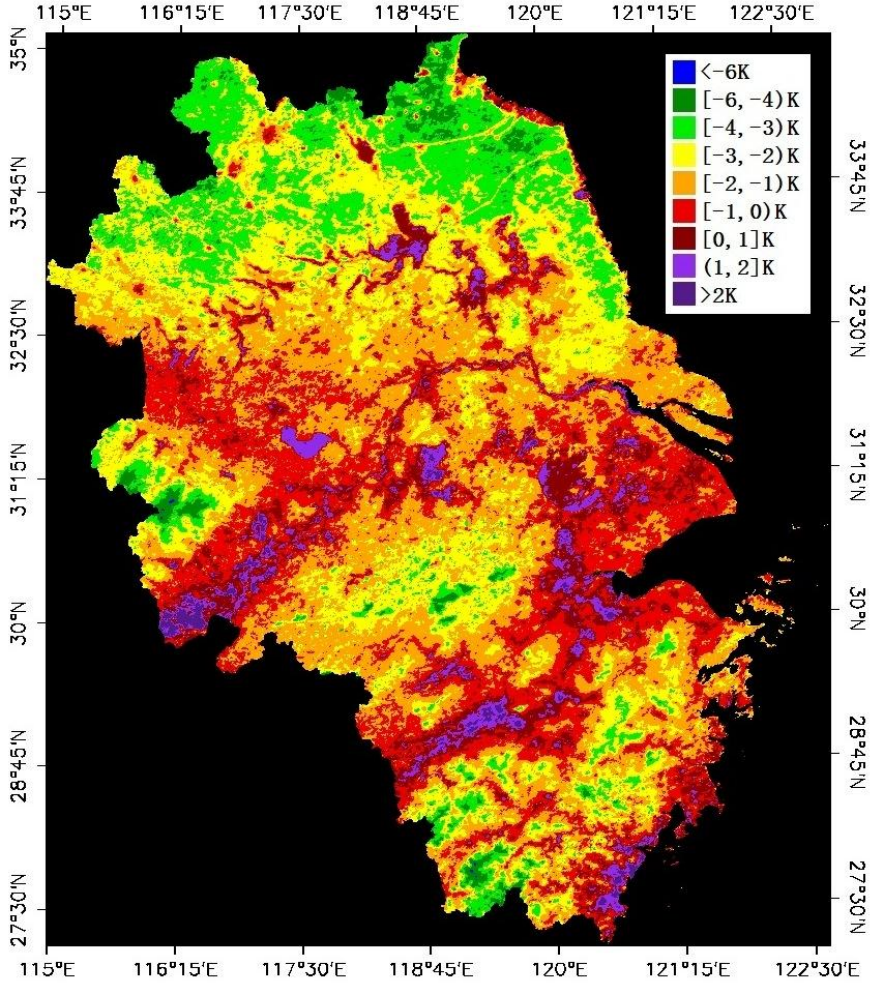


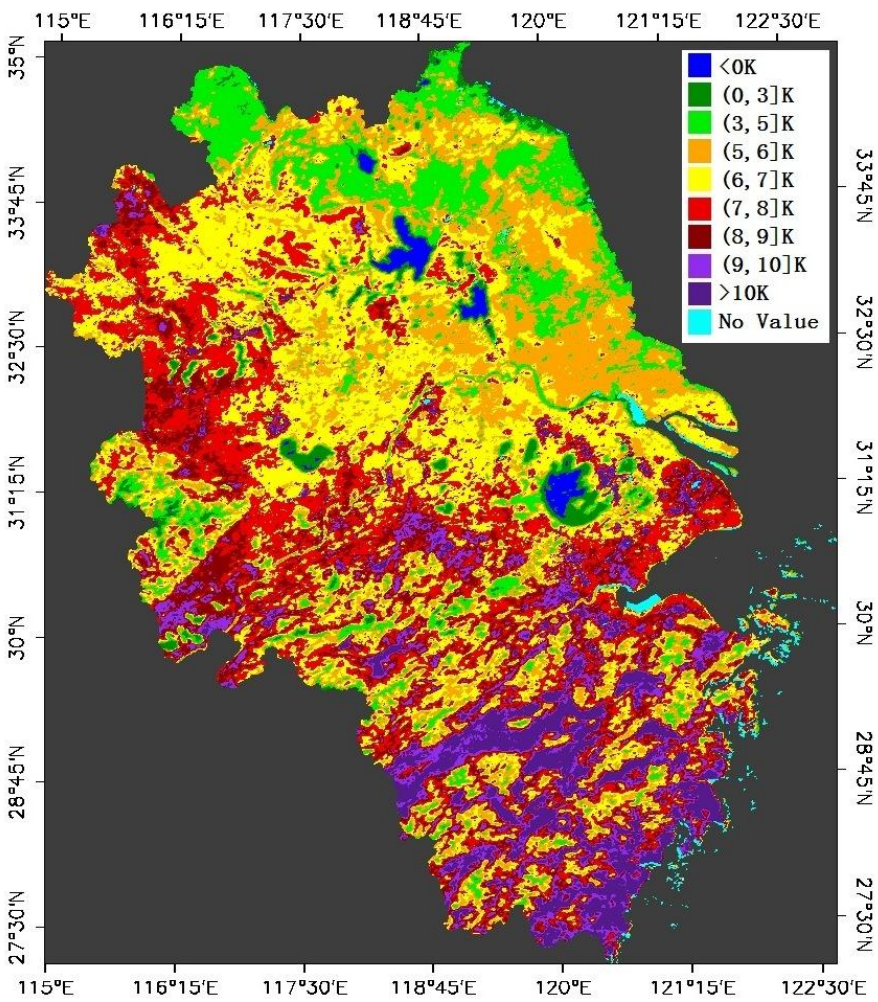
Fig.44 MODIS LST difference warm season mean between YRD and taihu, 2010

MODIS LST Difference Cold Season Mean

between YRD and Taihu

daytime

nighttime



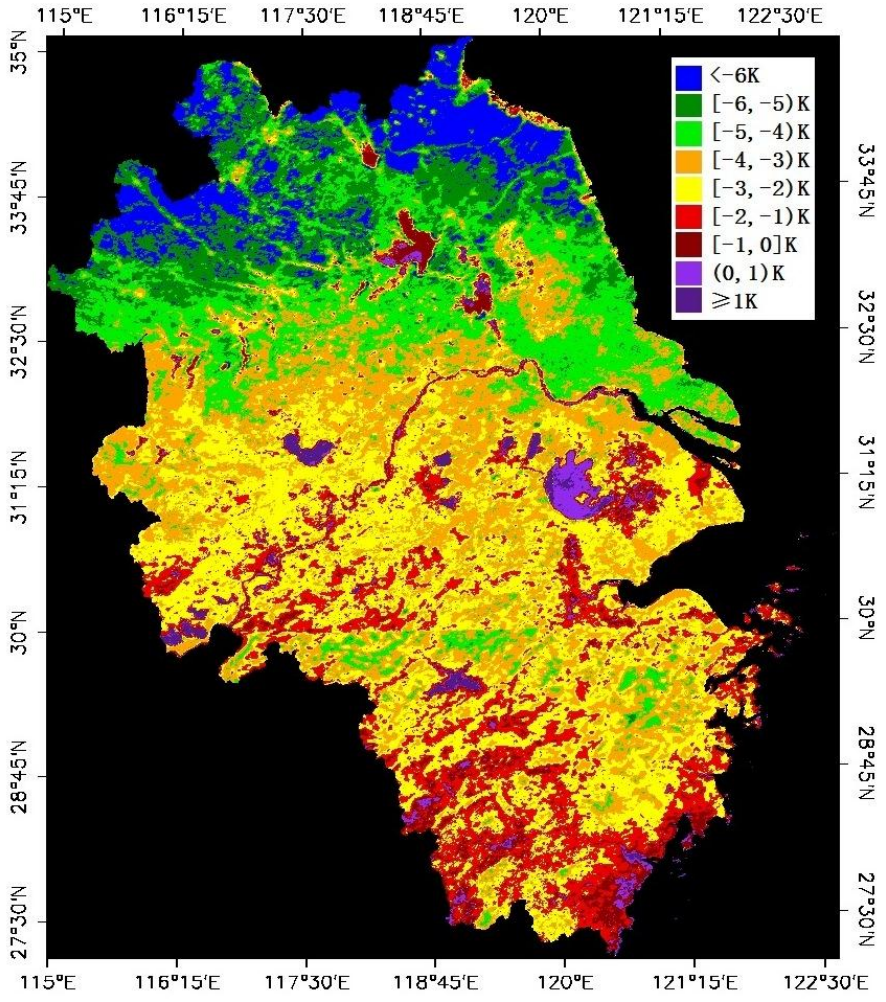
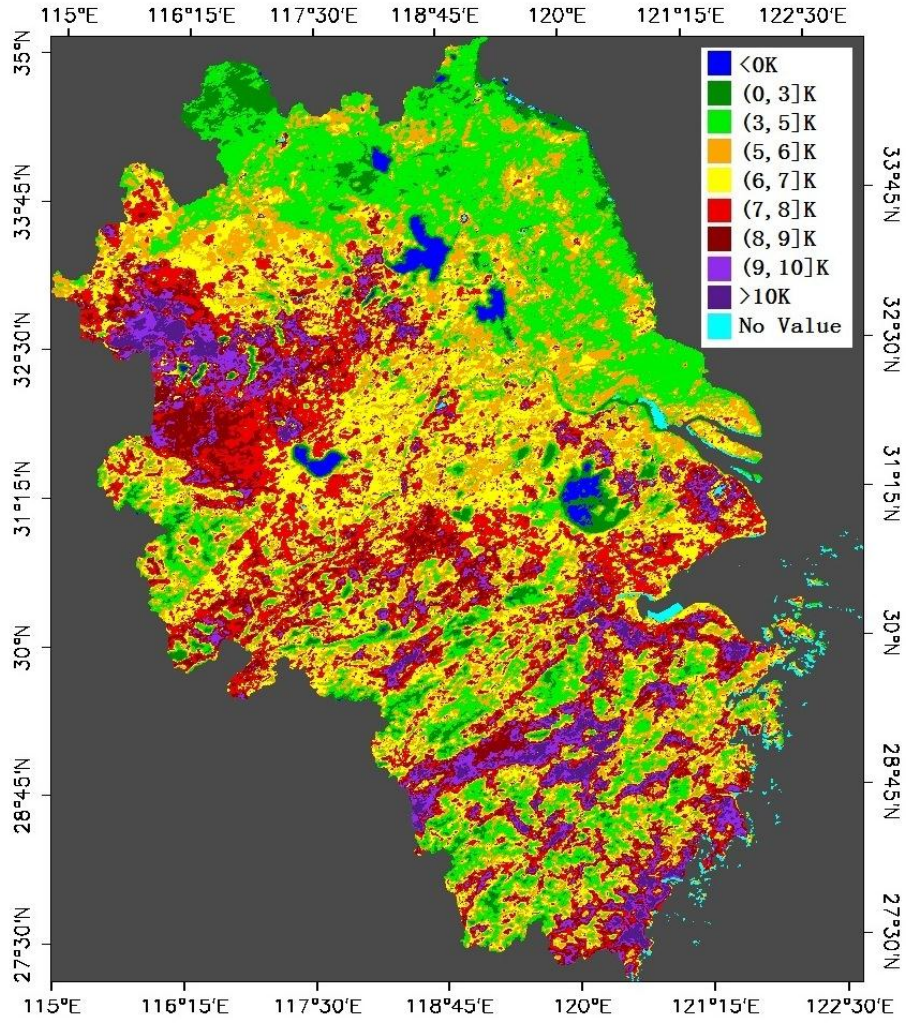


Fig.45 MODIS LST difference cold season mean between YRD and taihu, 2003-2004

daytime

nighttime



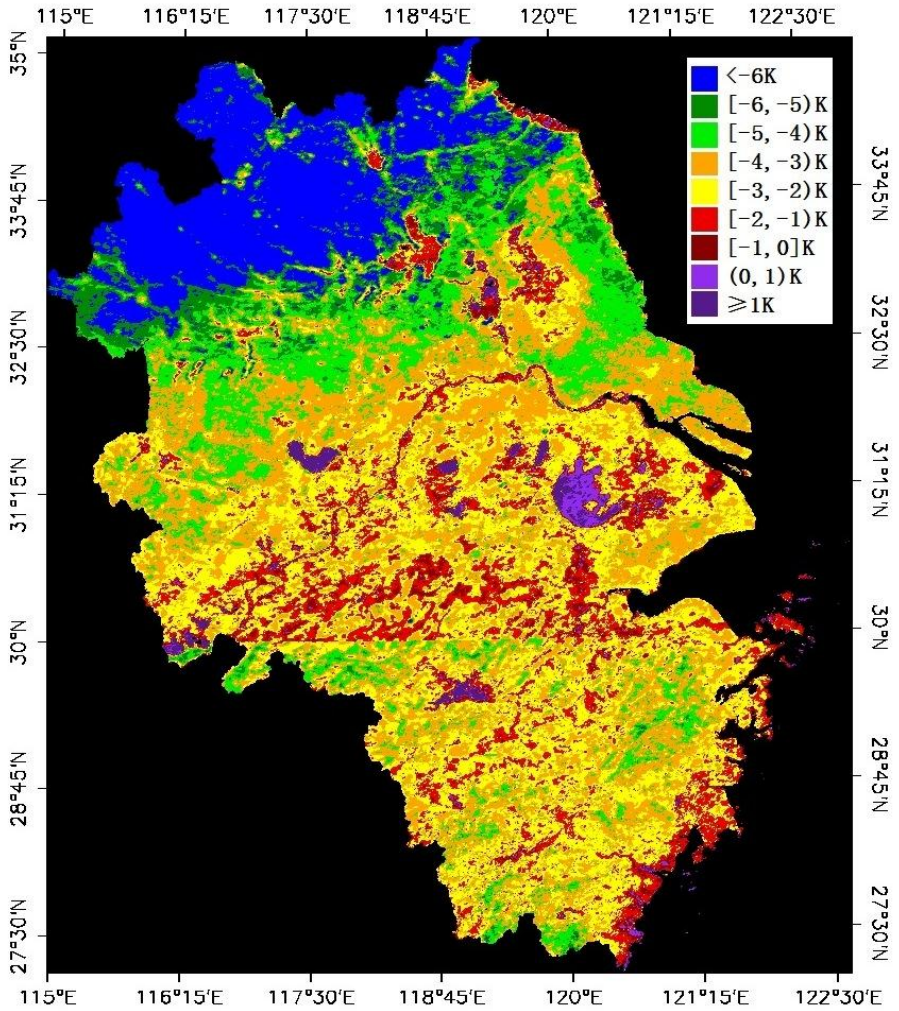


Fig.46 MODIS LST difference cold season mean between YRD and taihu, 2004-2005

daytime

nighttime

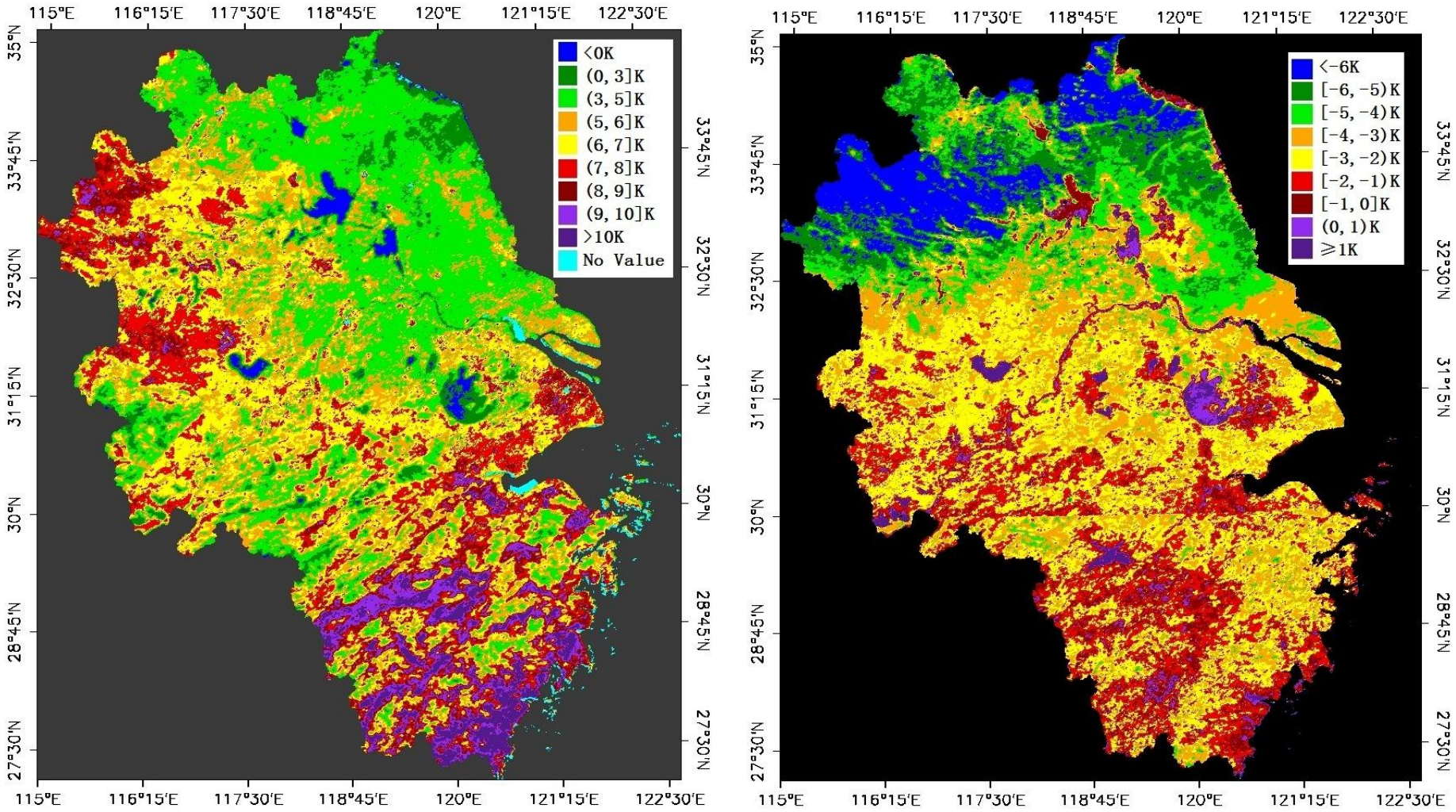


Fig.47 MODIS LST difference cold season mean between YRD and taihu, 2005-2006

daytime

nighttime

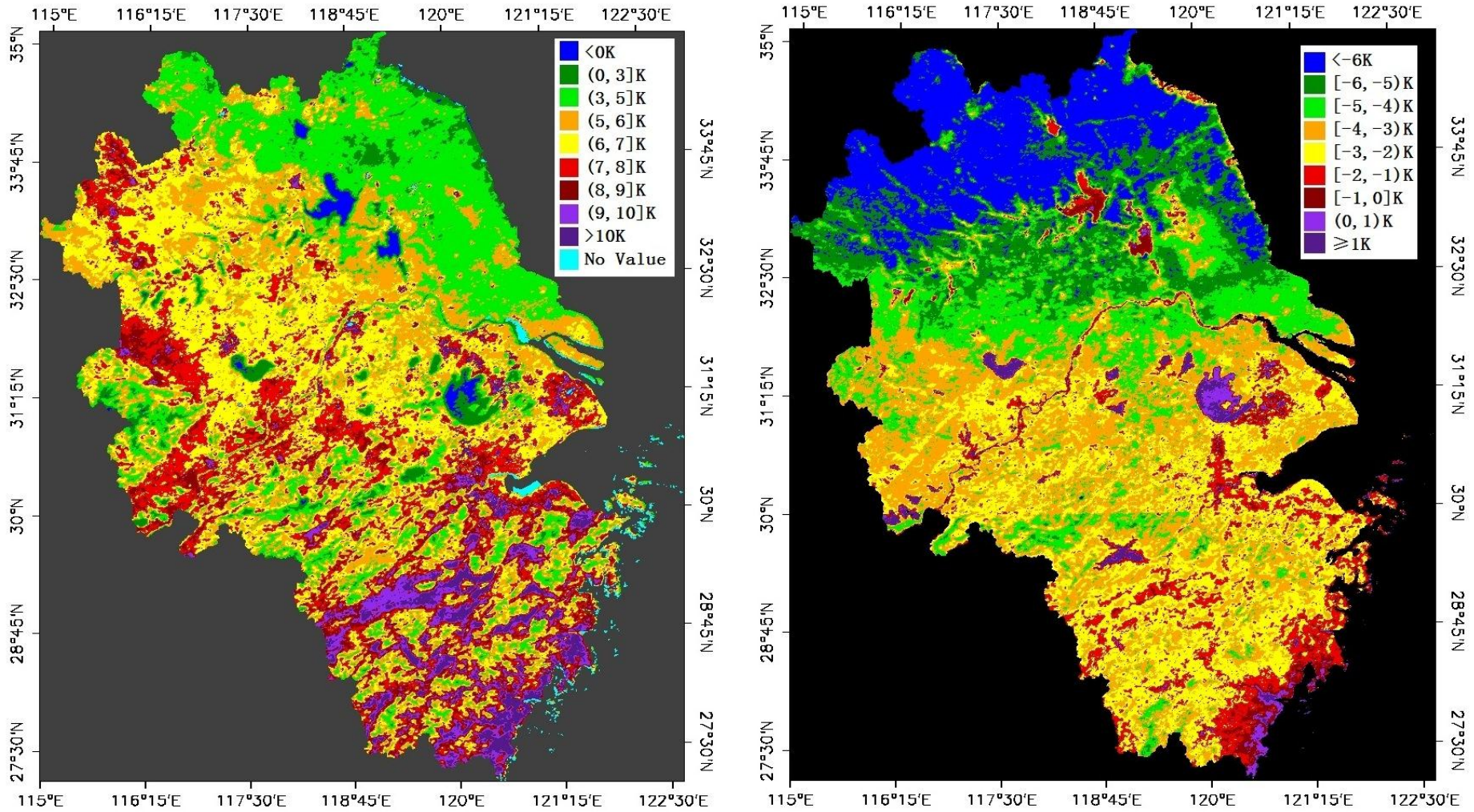
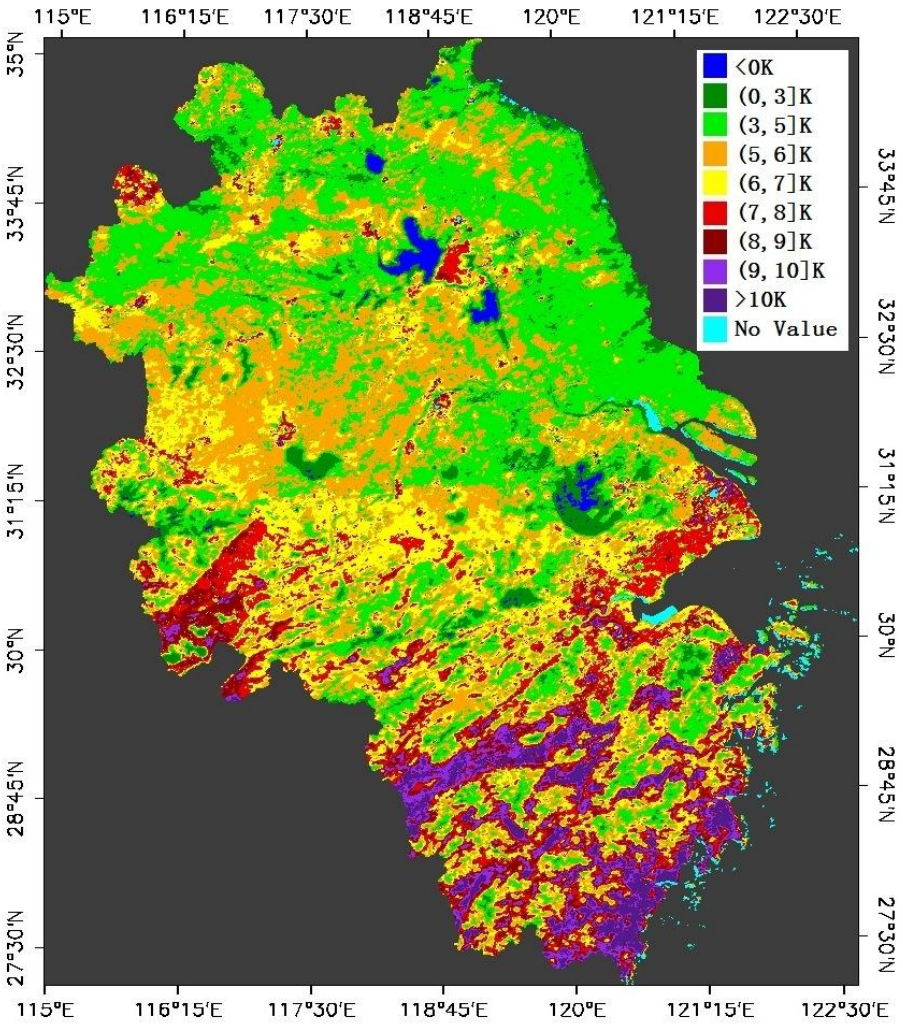


Fig.48 MODIS LST difference cold season mean between YRD and taihu, 2006-2007

daytime



nighttime

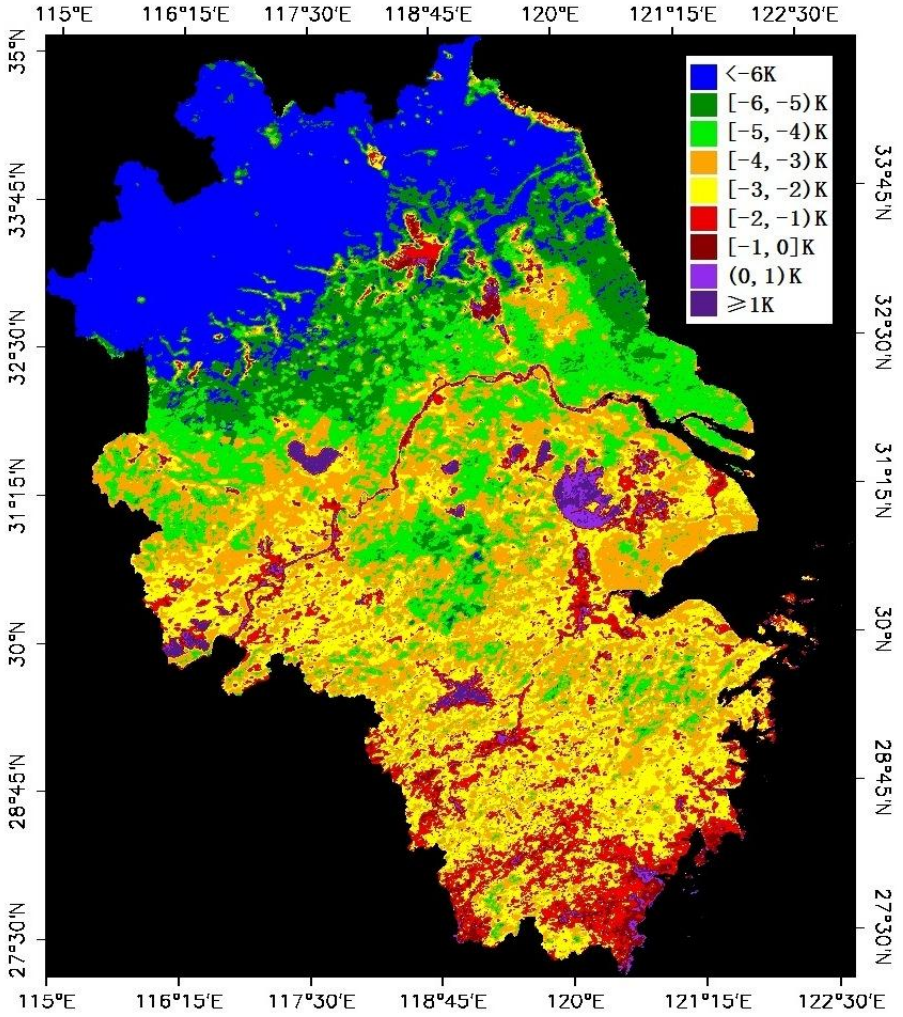
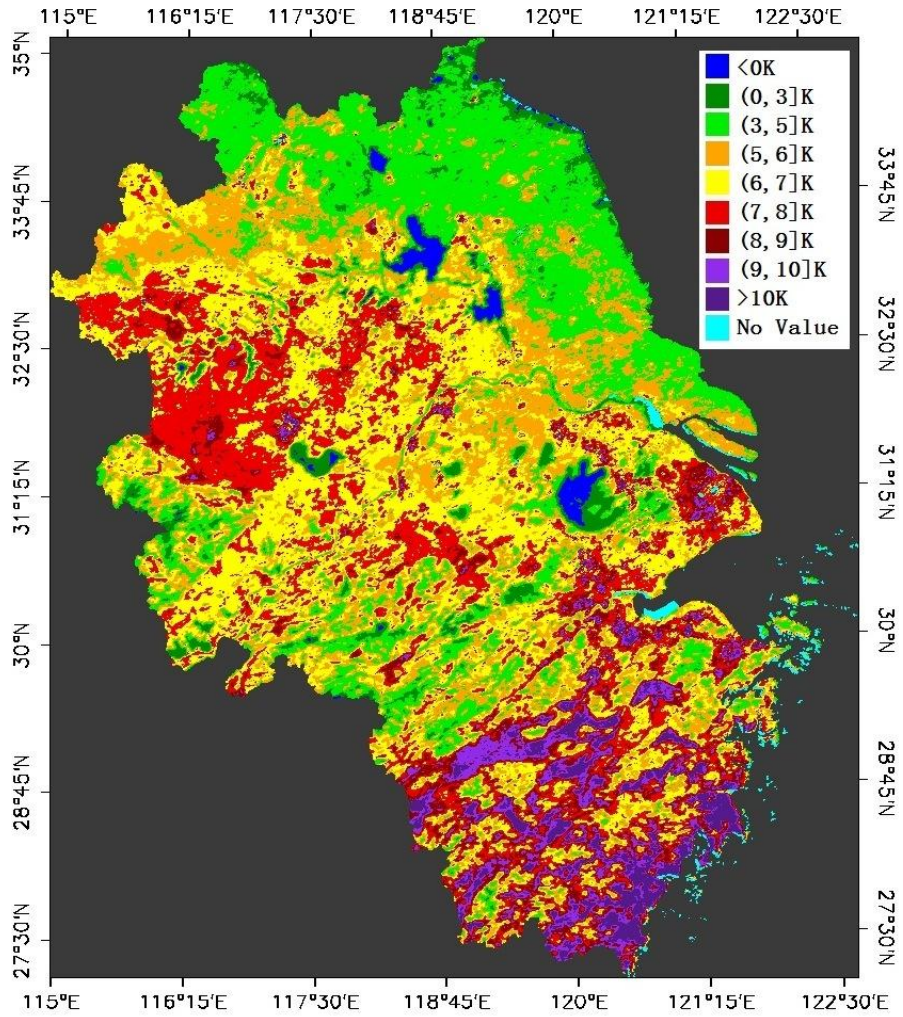


Fig.49 MODIS LST difference cold season mean between YRD and taihu, 2007-2008

daytime



nighttime

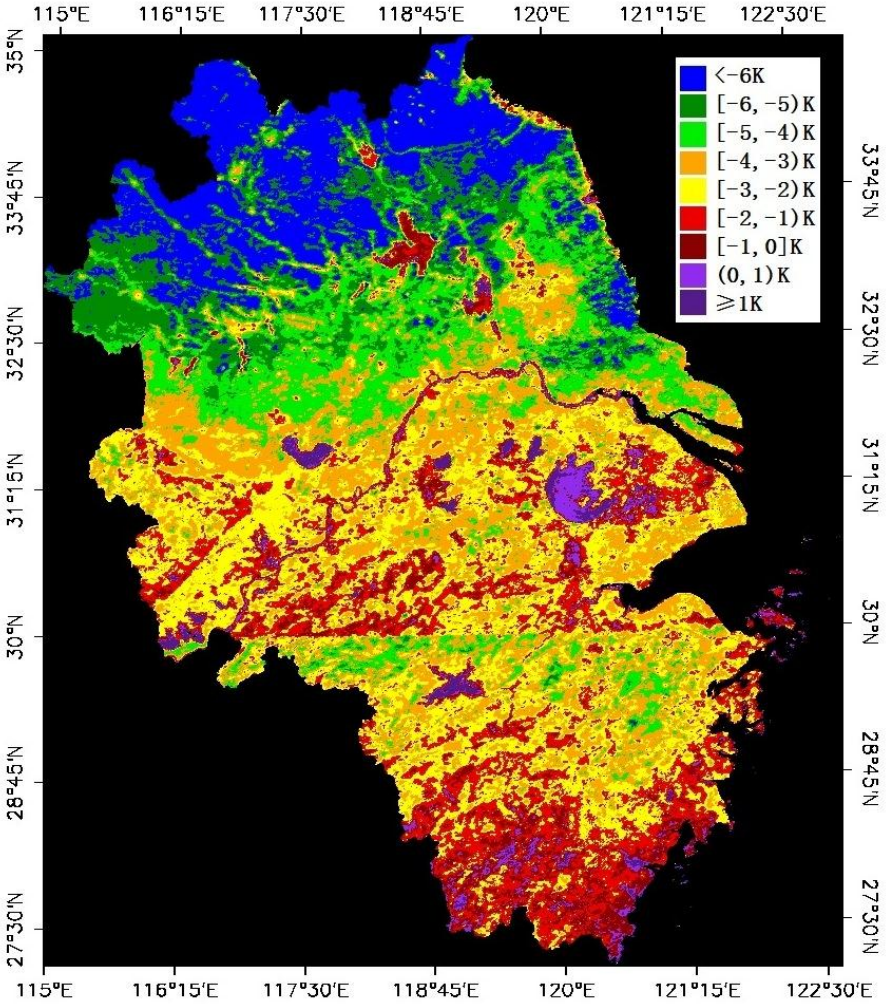
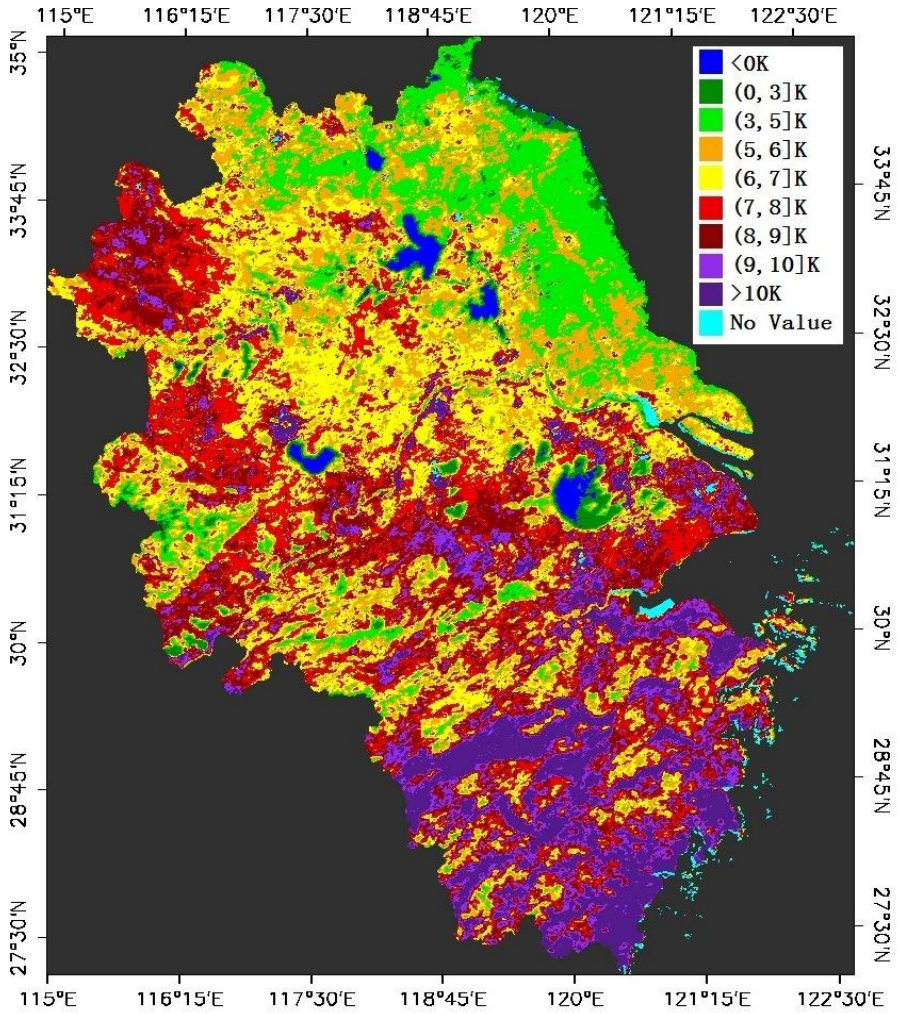


Fig.50 MODIS LST difference cold season mean between YRD and taihu, 2008-2009

daytime

nighttime



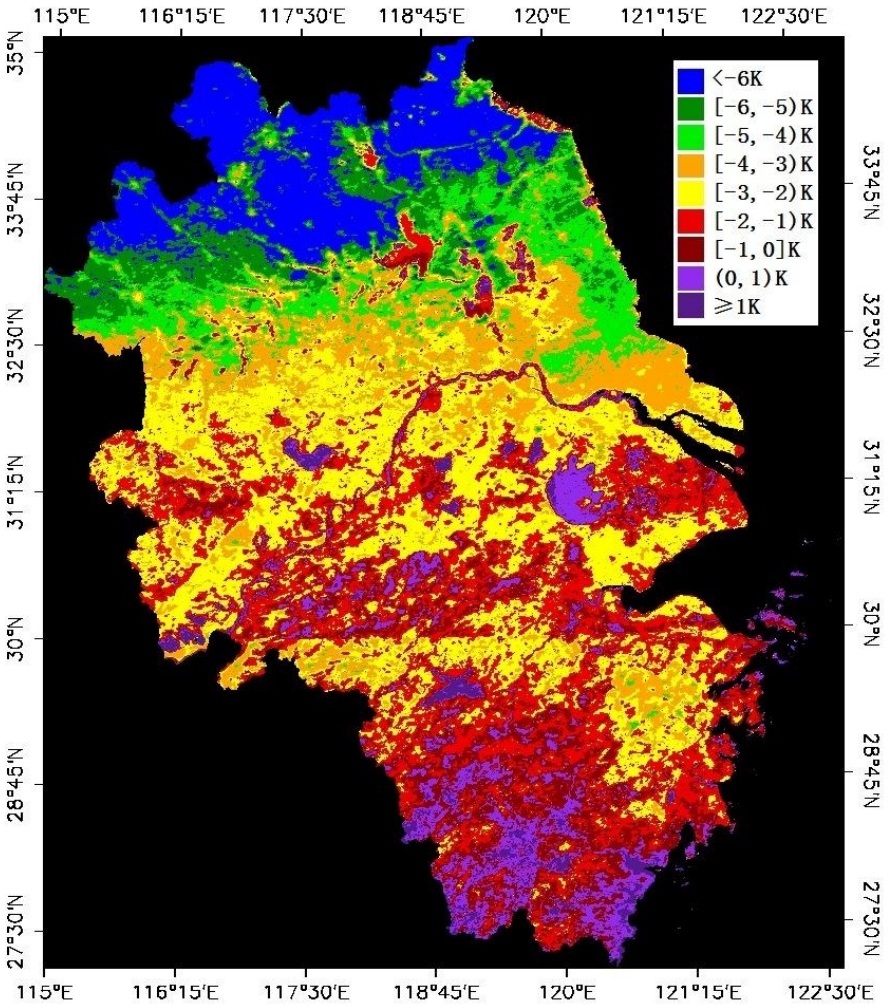


Fig.51 MODIS LST difference cold season mean between YRD and taihu, 2009-2010

The Temporal Variation of LST Difference in Urban Cluster

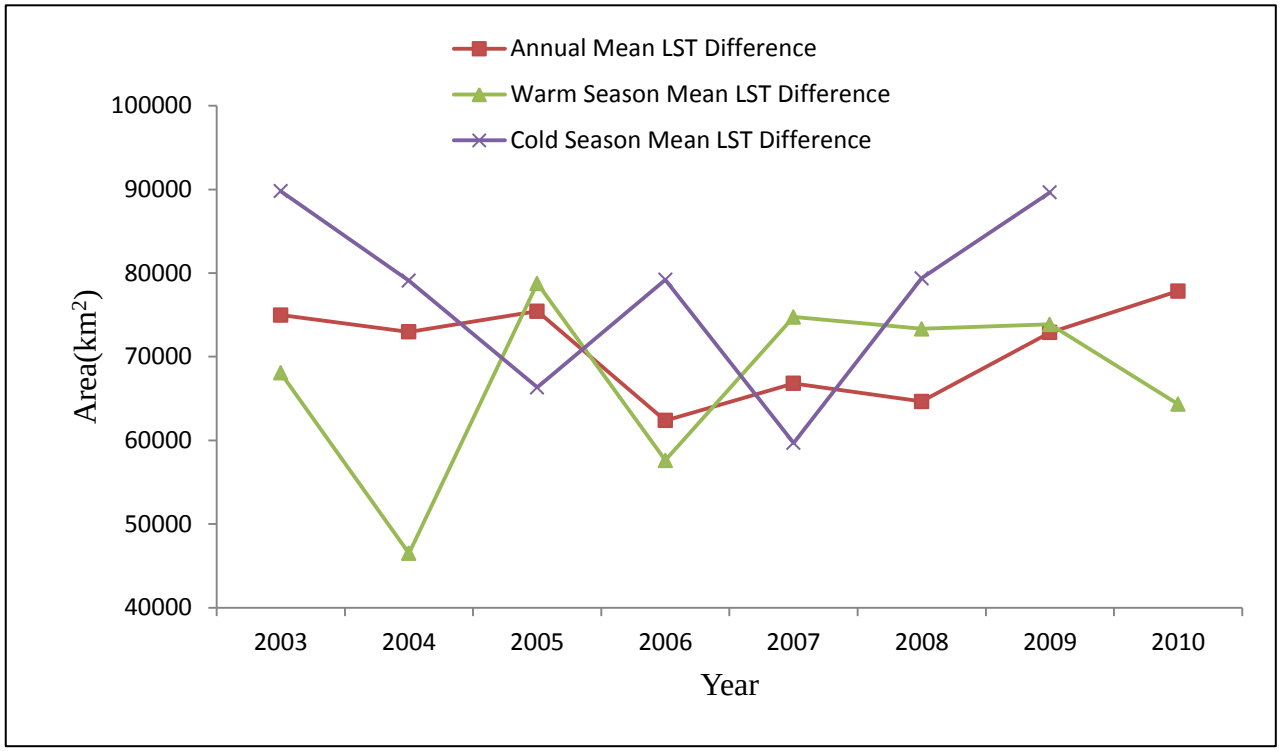


Fig.52 Area of MODIS daytime LST difference higher than 5K in urban cluster

Question: MODIS nighttime LST difference is negative ,

How to do?

4.2.2 The Temporal and Spatial Distribution of the Daily LST Range in Urban Cluster

Theory: Daily LST range is higher in urban than rural.

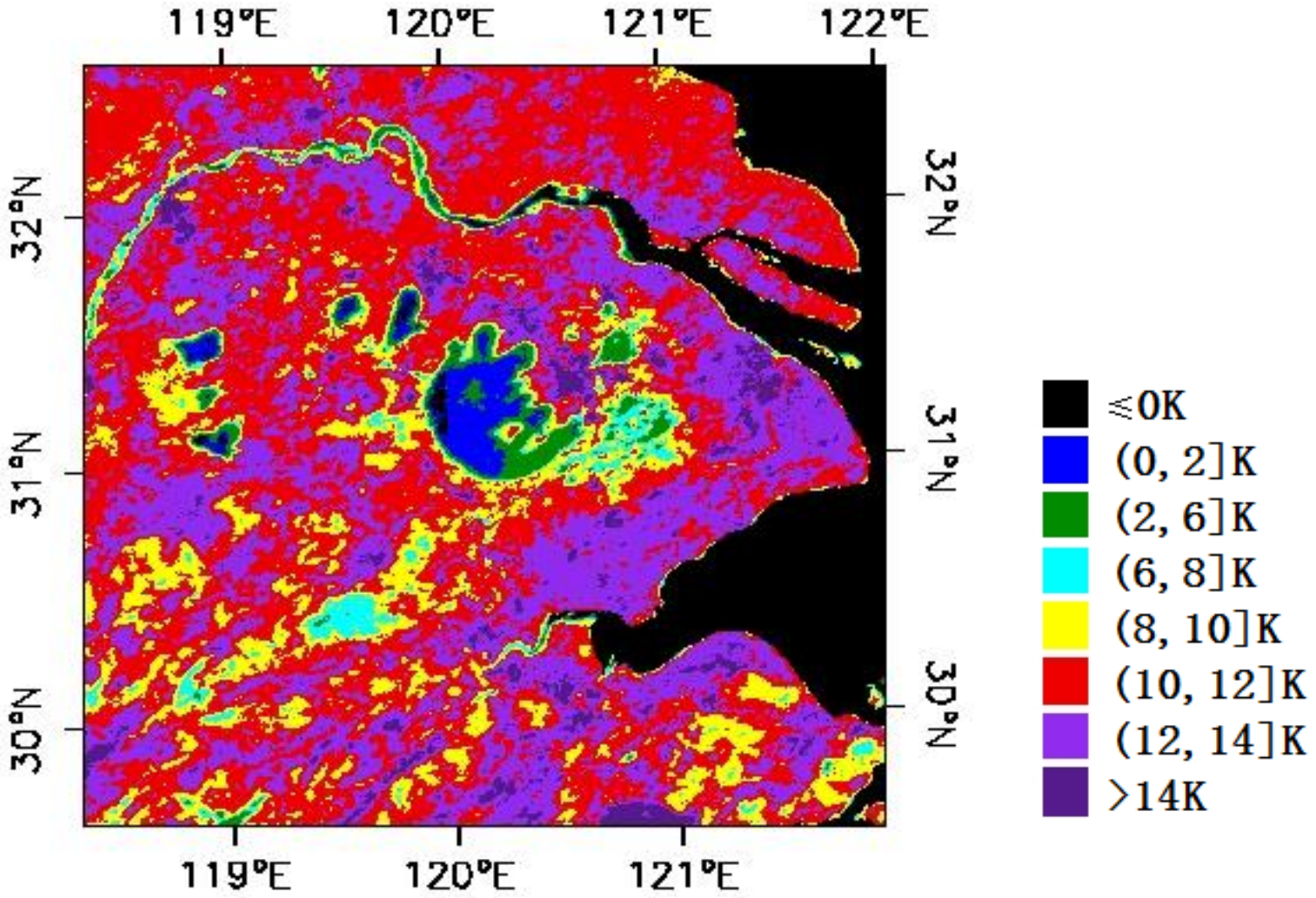


Fig.53 Annual daily LST range in urban cluster, 2003

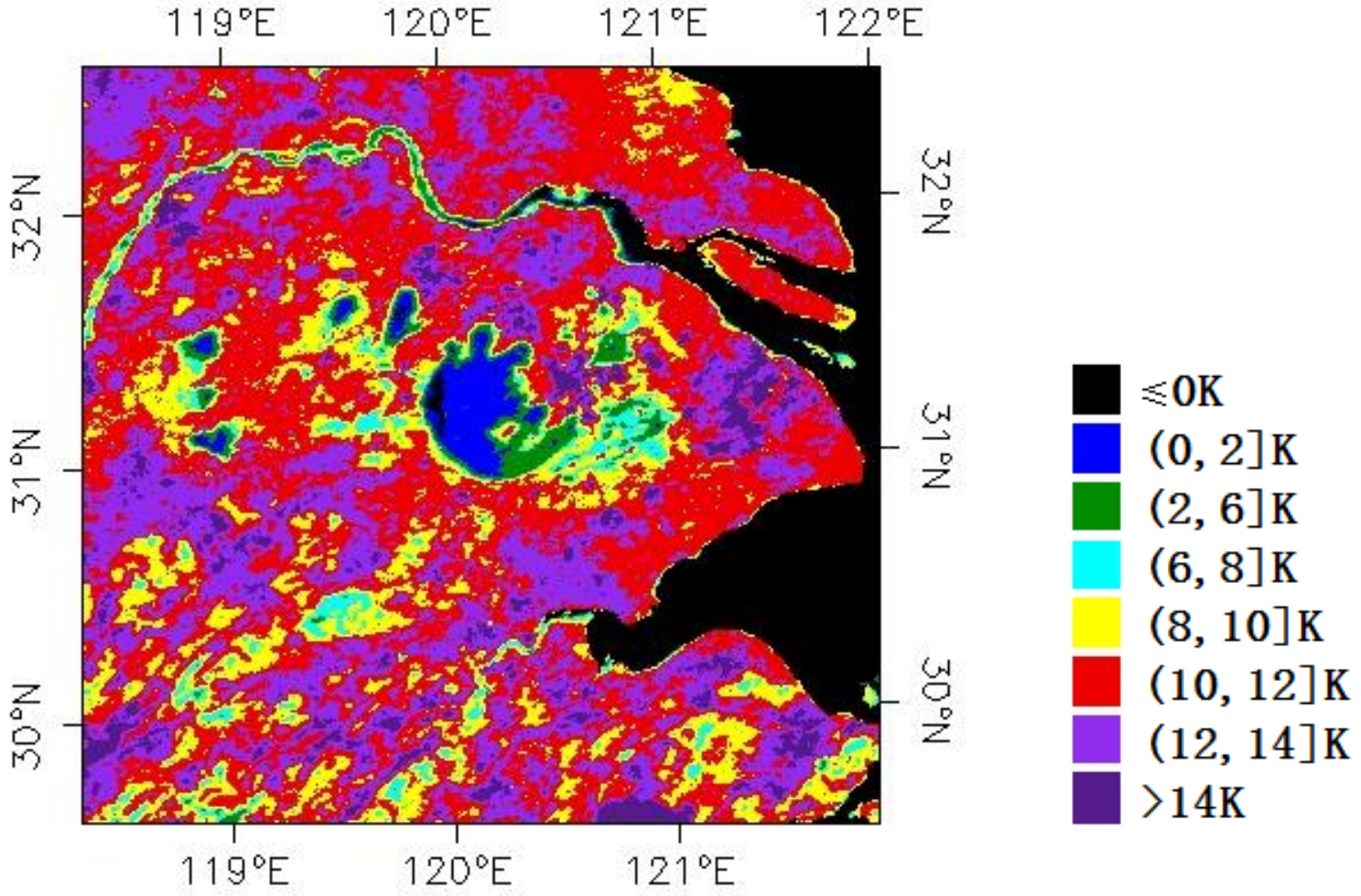


Fig. 54 Annual daily LST range in urban cluster, 2004

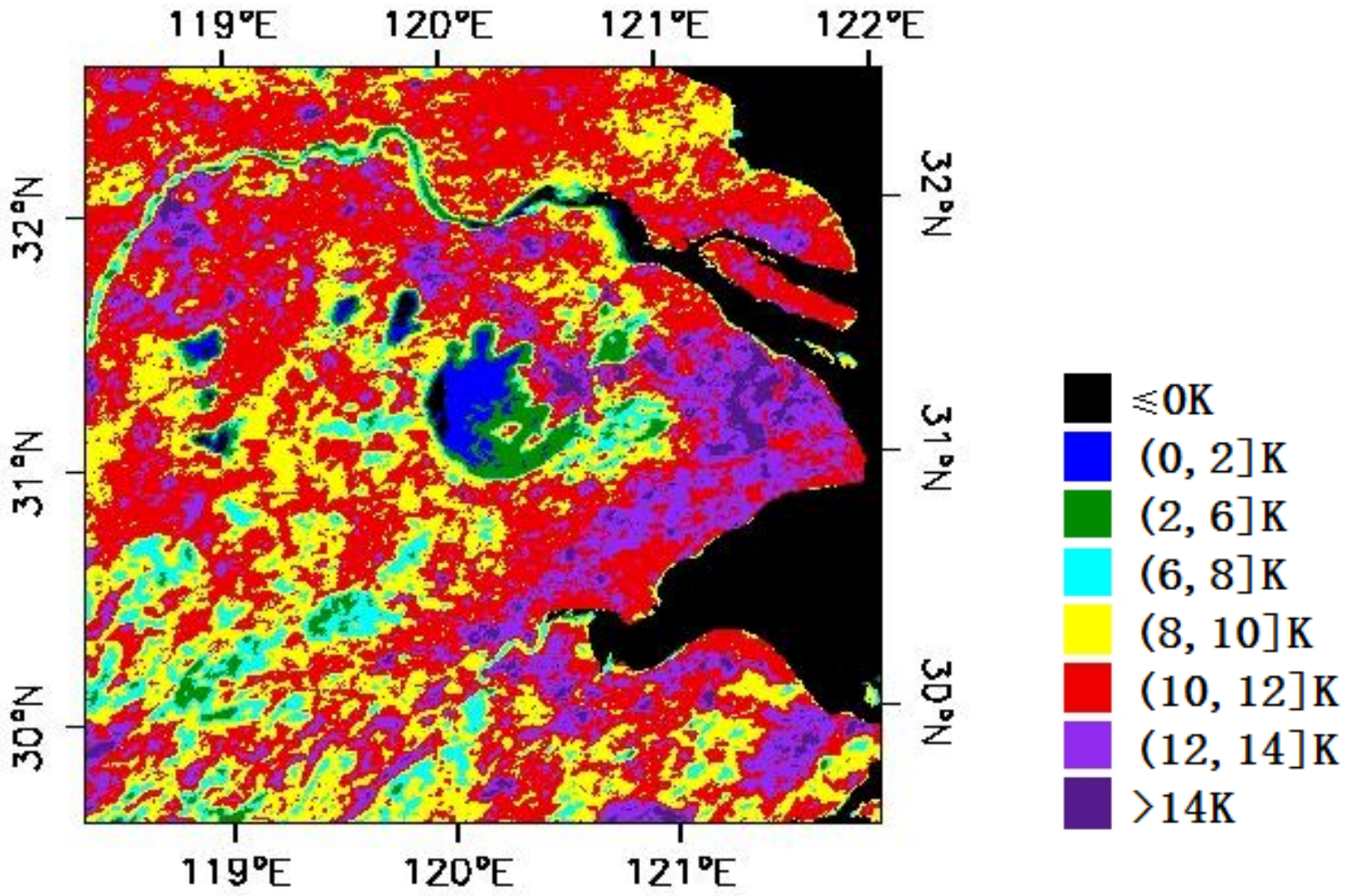


Fig. 55 Annual daily LST range in urban cluster, 2005

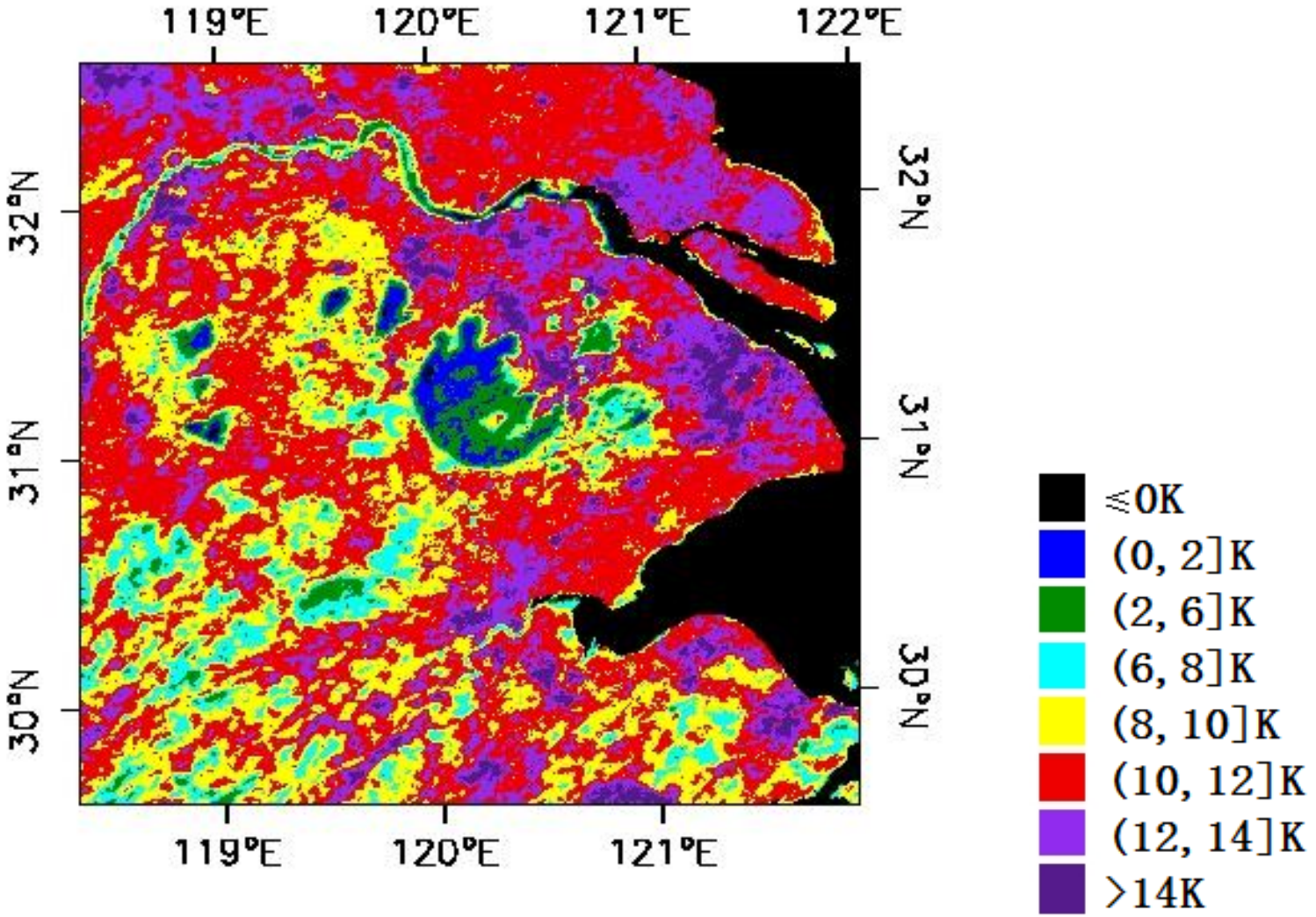


Fig. 56 Annual daily LST range in urban cluster, 2006

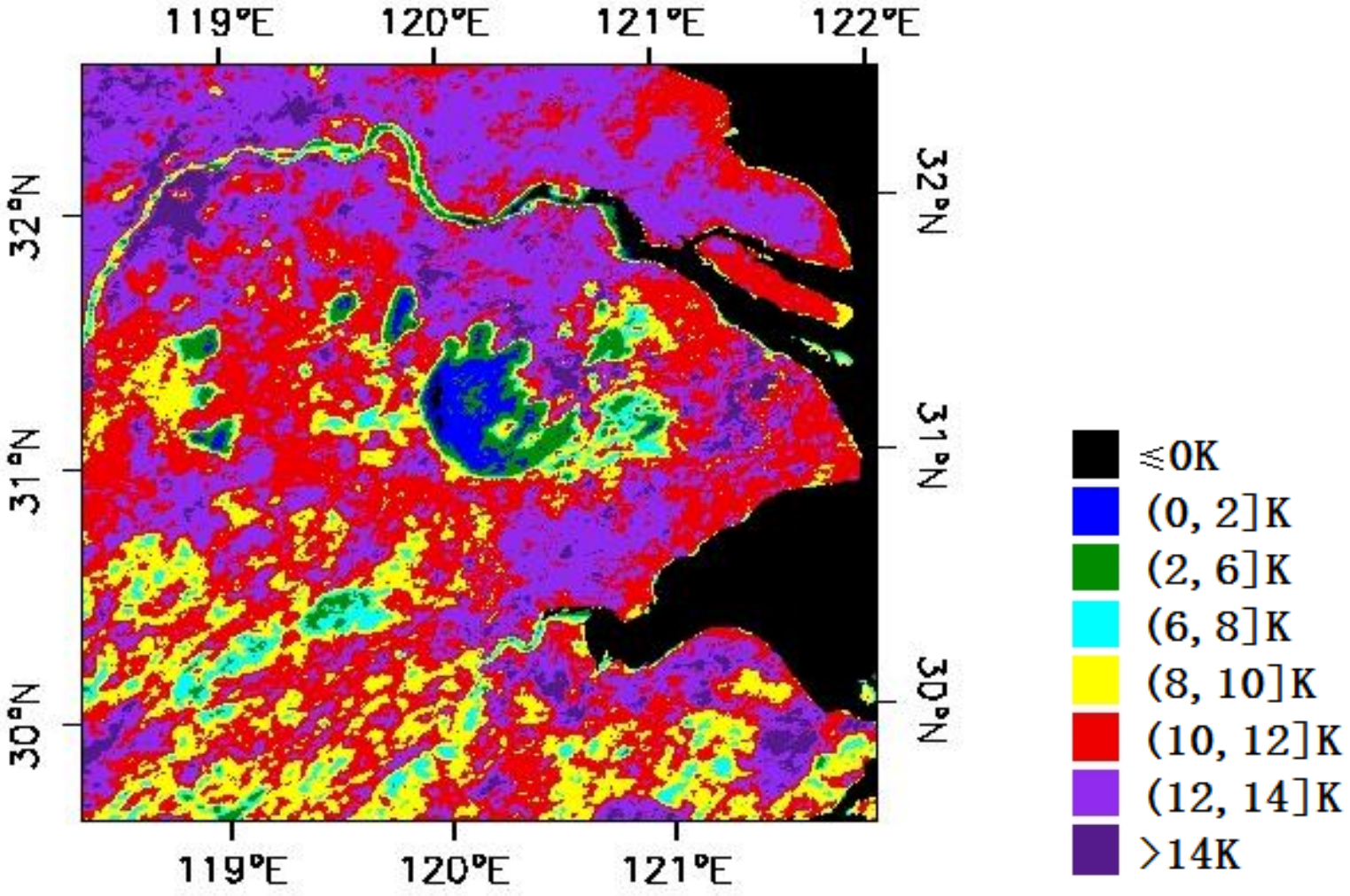


Fig.57 Annual daily LST range in urban cluster, 2007

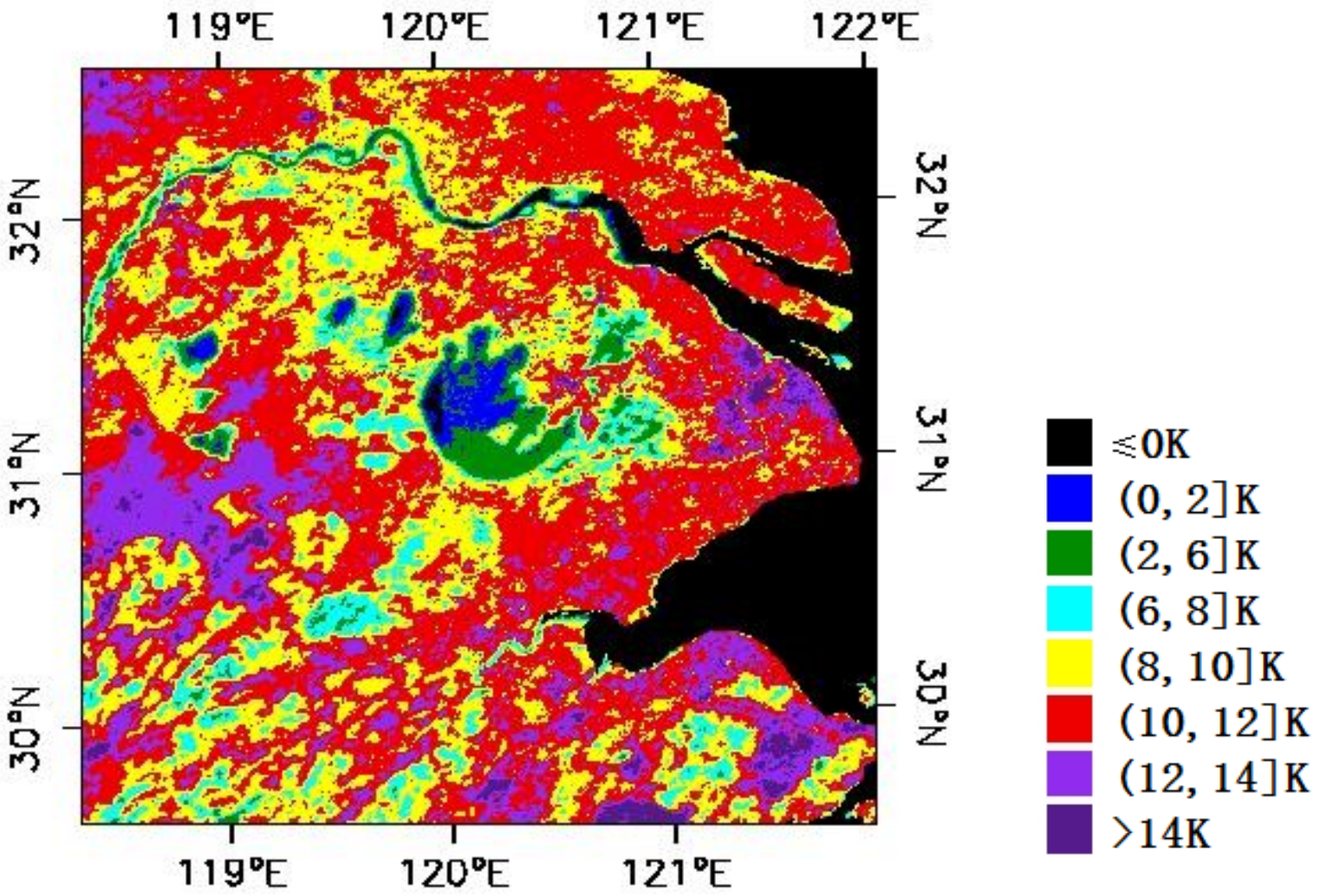


Fig.58 Annual daily LST range in urban cluster, 2008

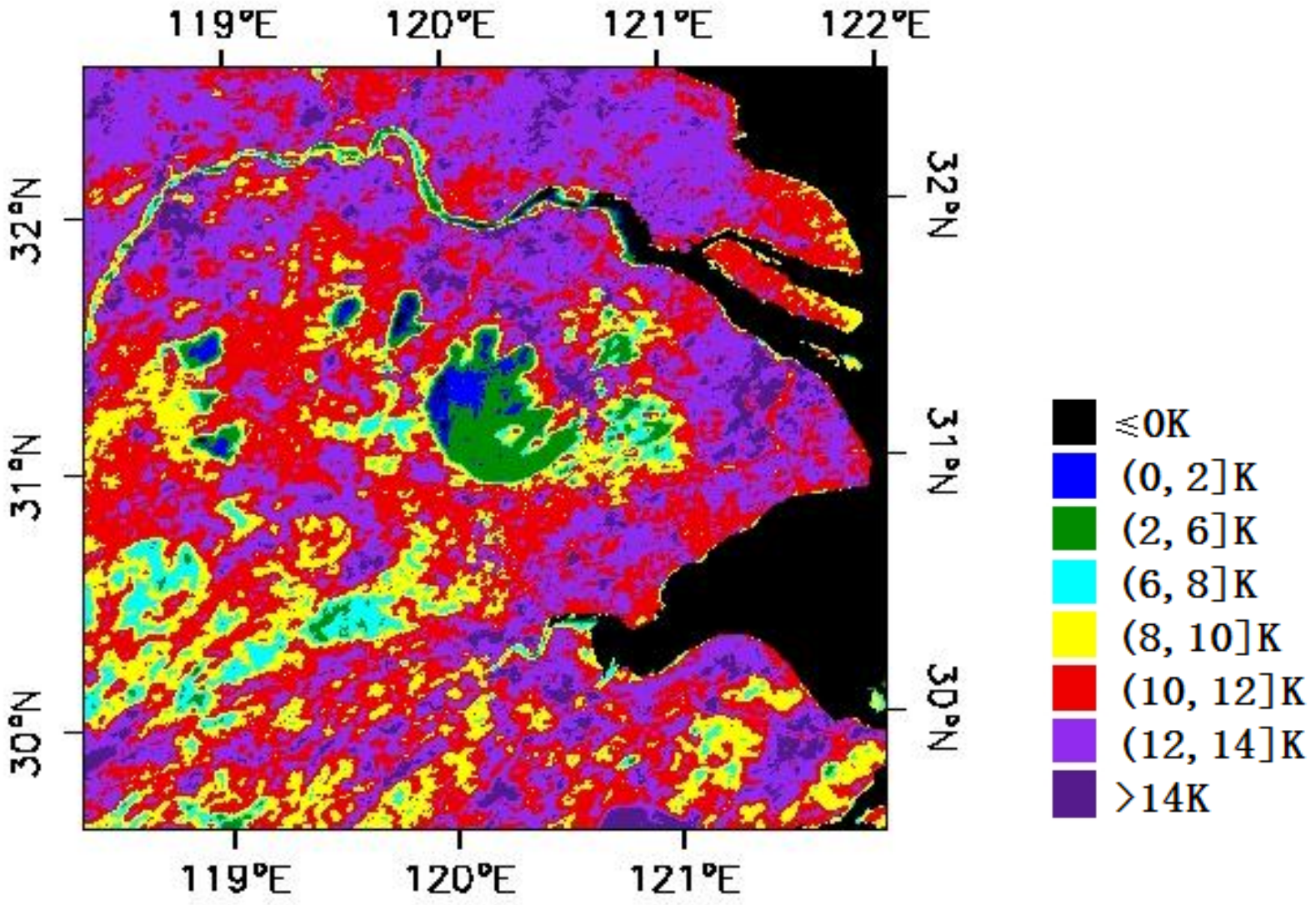


Fig. 59 Annual daily LST range in urban cluster, 2009

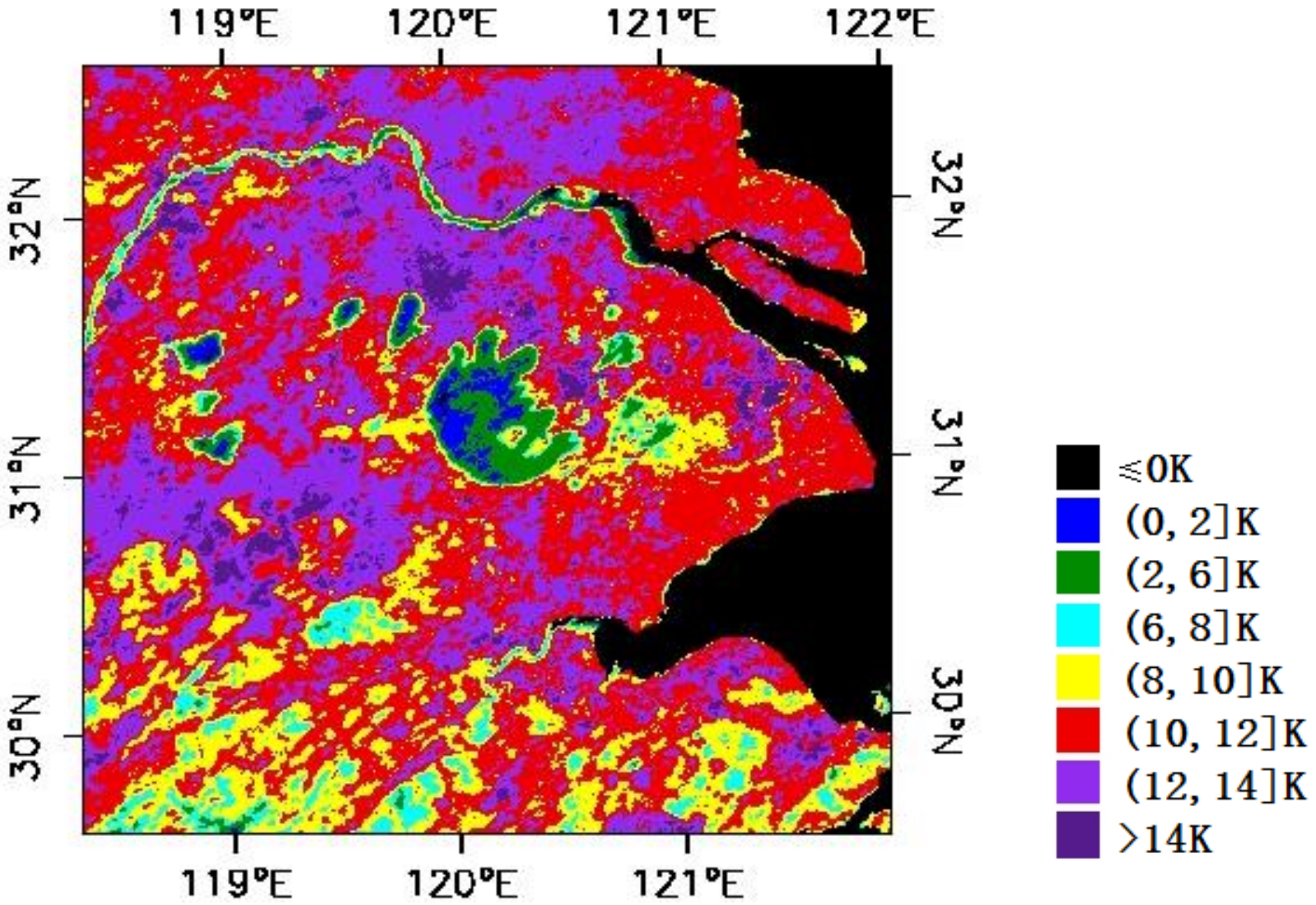


Fig.60 Annual daily LST range in urban cluster, 2010

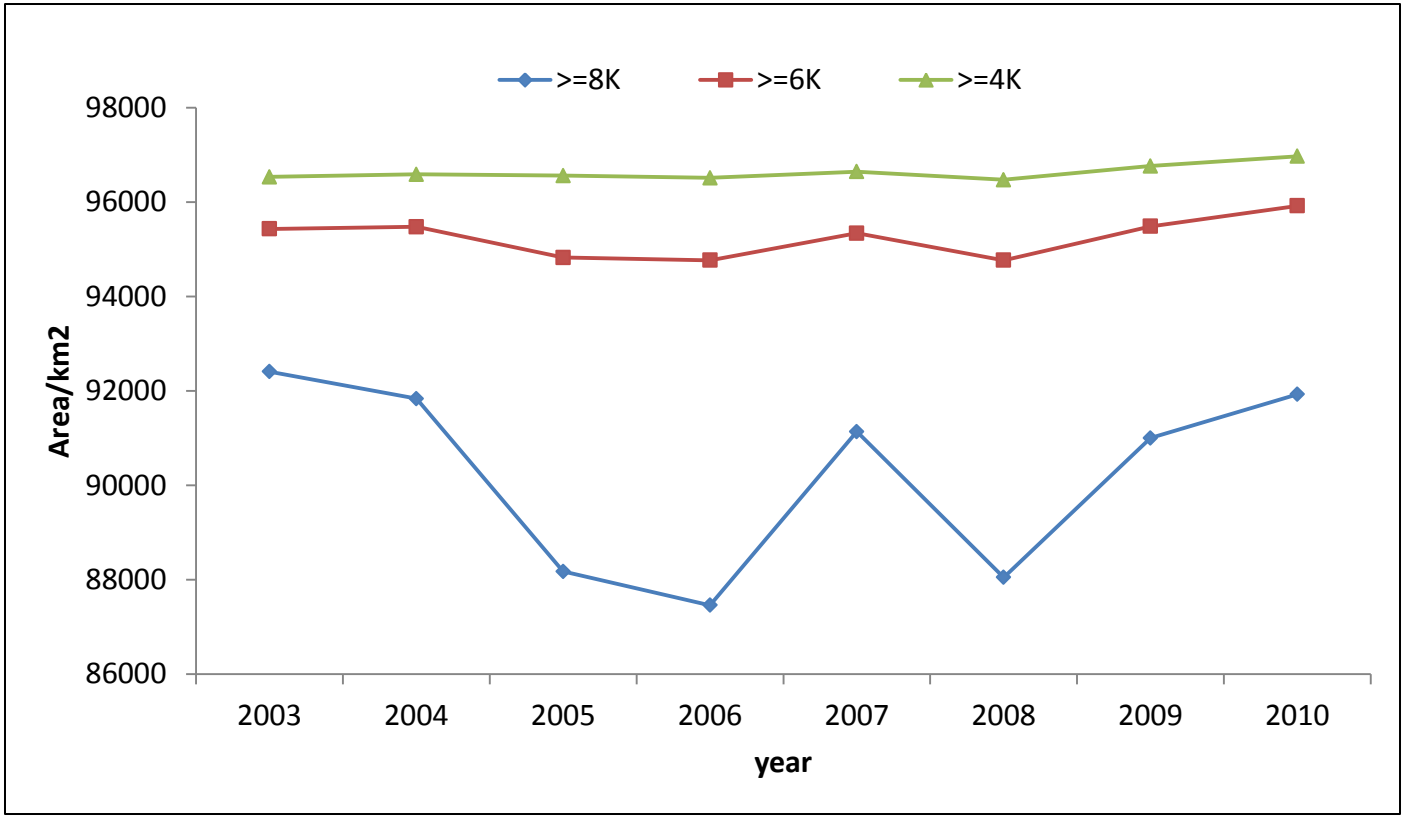
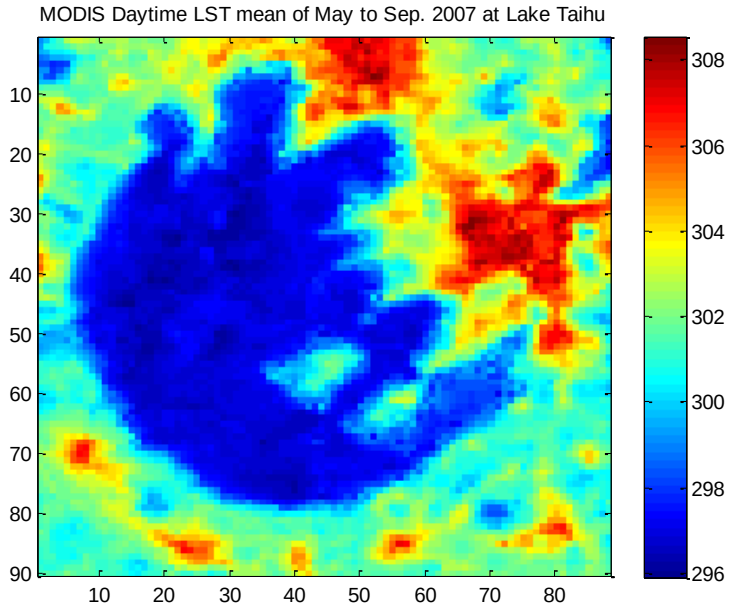
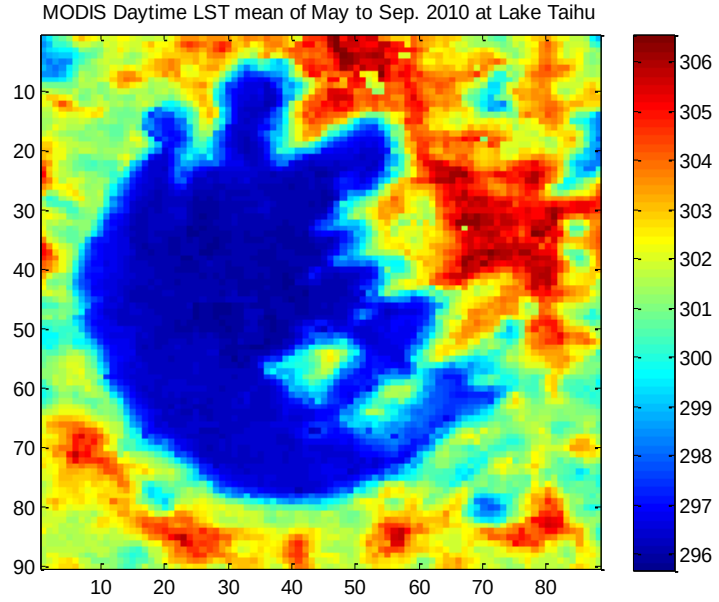


Fig.60 Area of annual daily LST range higher than 8K (6K,4K) in urban cluster, 2003-2010

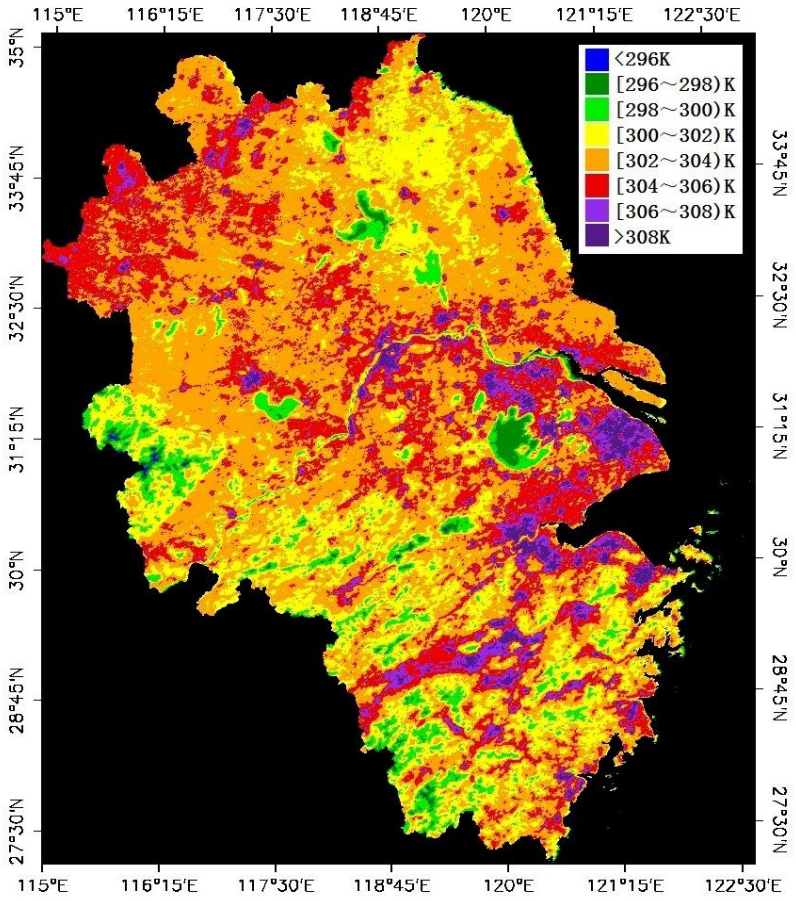
5. Discussion

- Nighttime LST is higher at taihu than surrounding region , how to express UHHI ?
- The temporal variation isn't regular, what are the reasons?
- What are the contents that I need analysis in future work?





Source: Lei Zhao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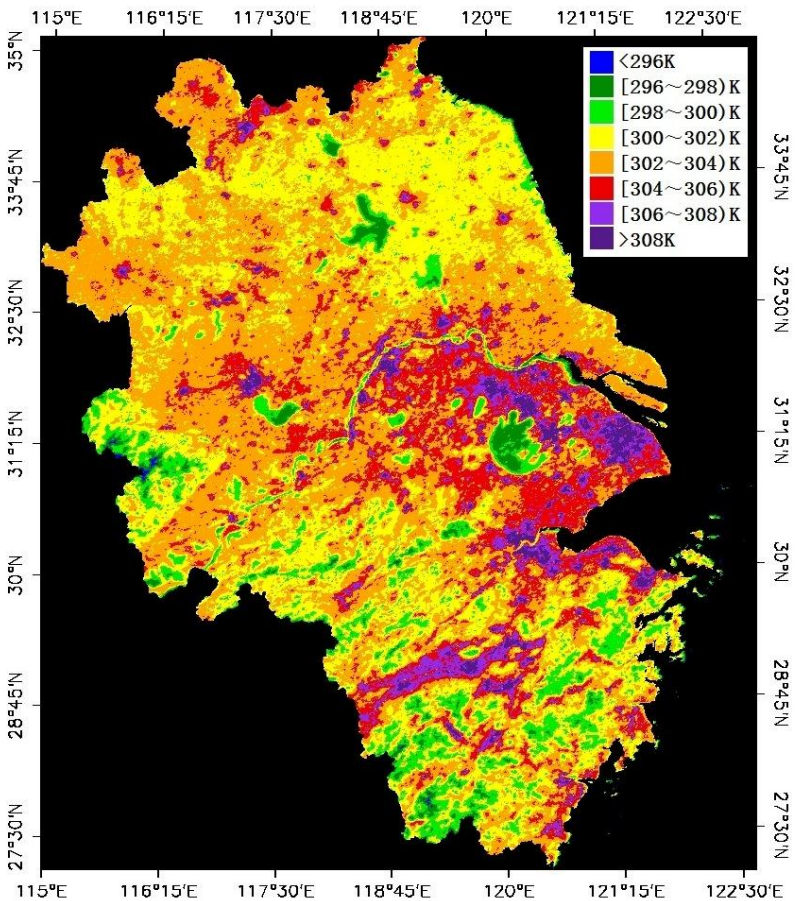
116°15′E
117°30′E
118°45′E
120°E
121°15′E
122°30′E
35°N
33°45′N
32°30′N
31°15′N
30°N
28°45′N
27°30′N
<296K
[296～298)K
[298～300)K
[300～302)K
[302～304)K
[304～306)K
[306～308)K
>308K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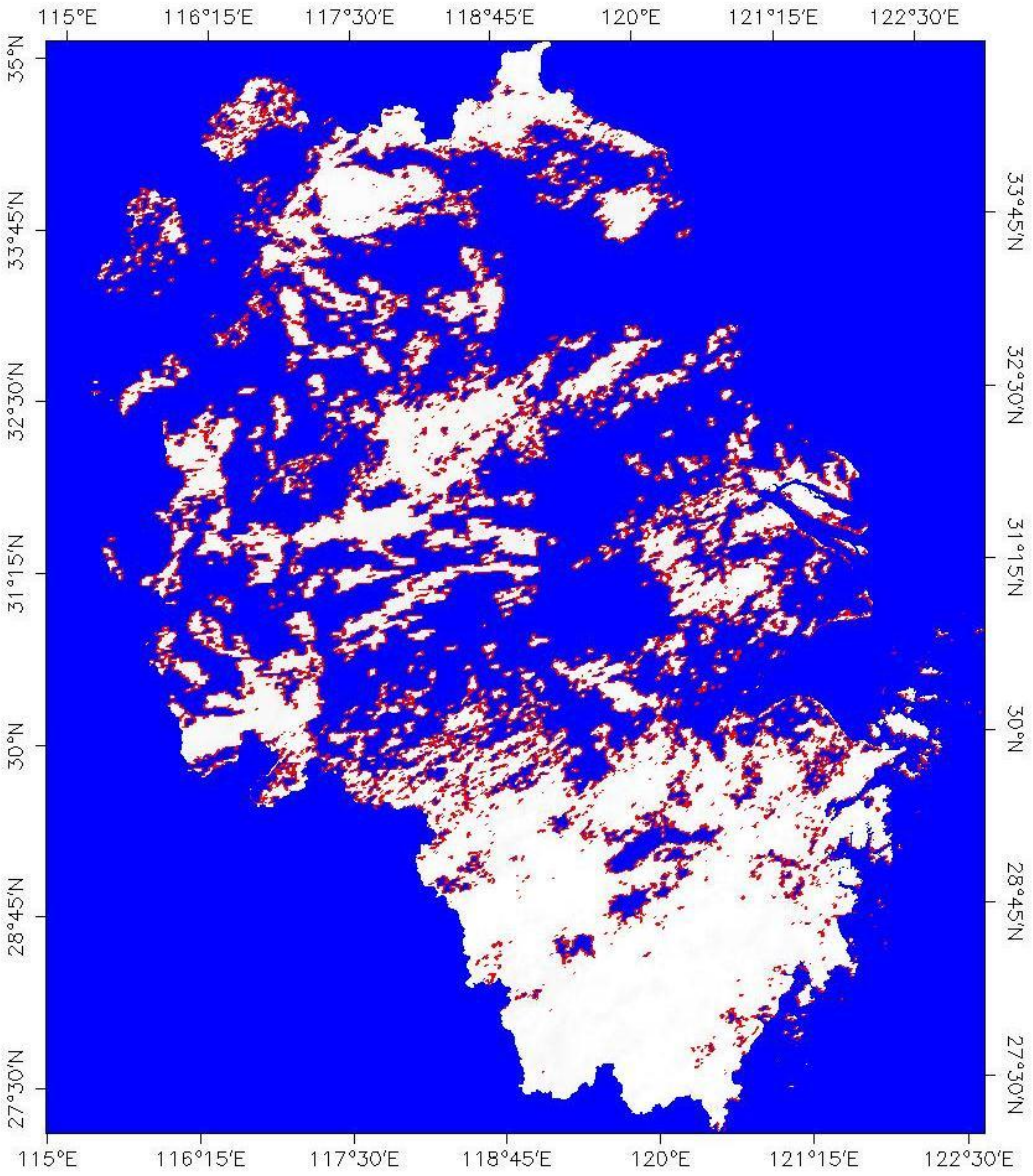
MODIS LST 8 day product's existing problems

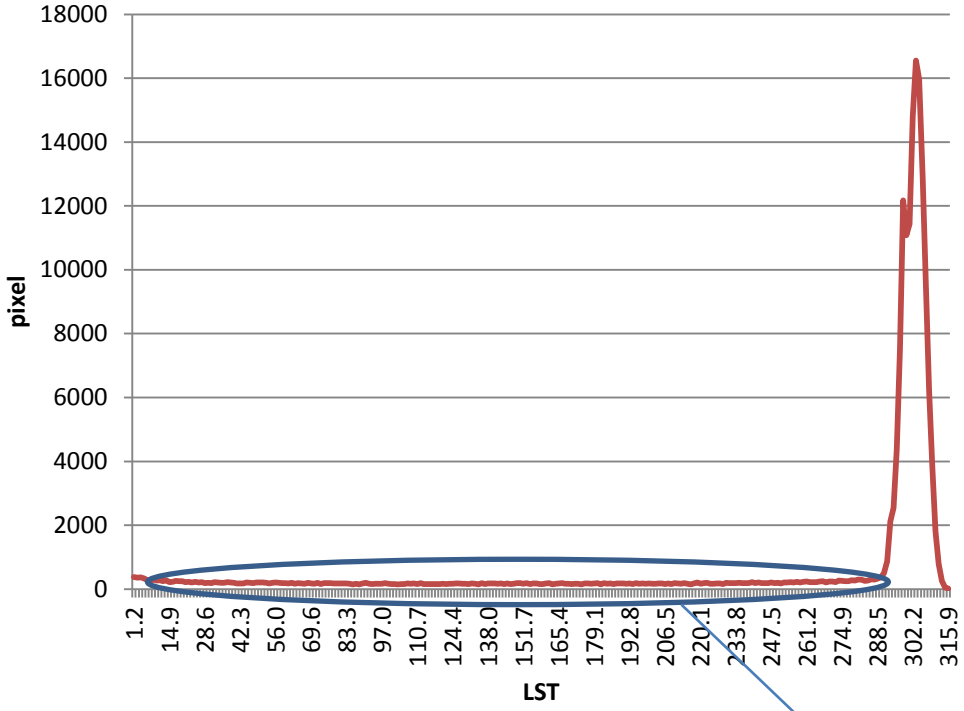


MODIS 8day product form 185-192,2003

red： LST lower than 273K；

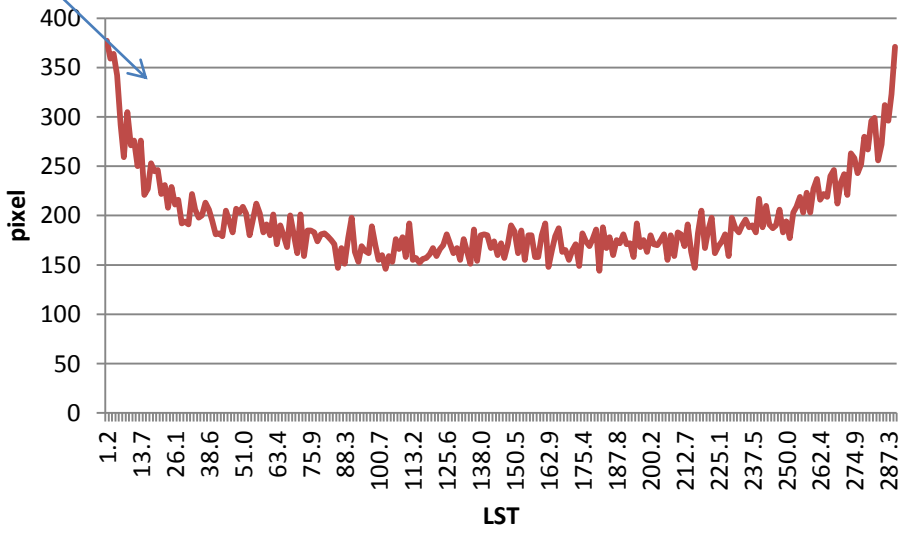
blue： No value；

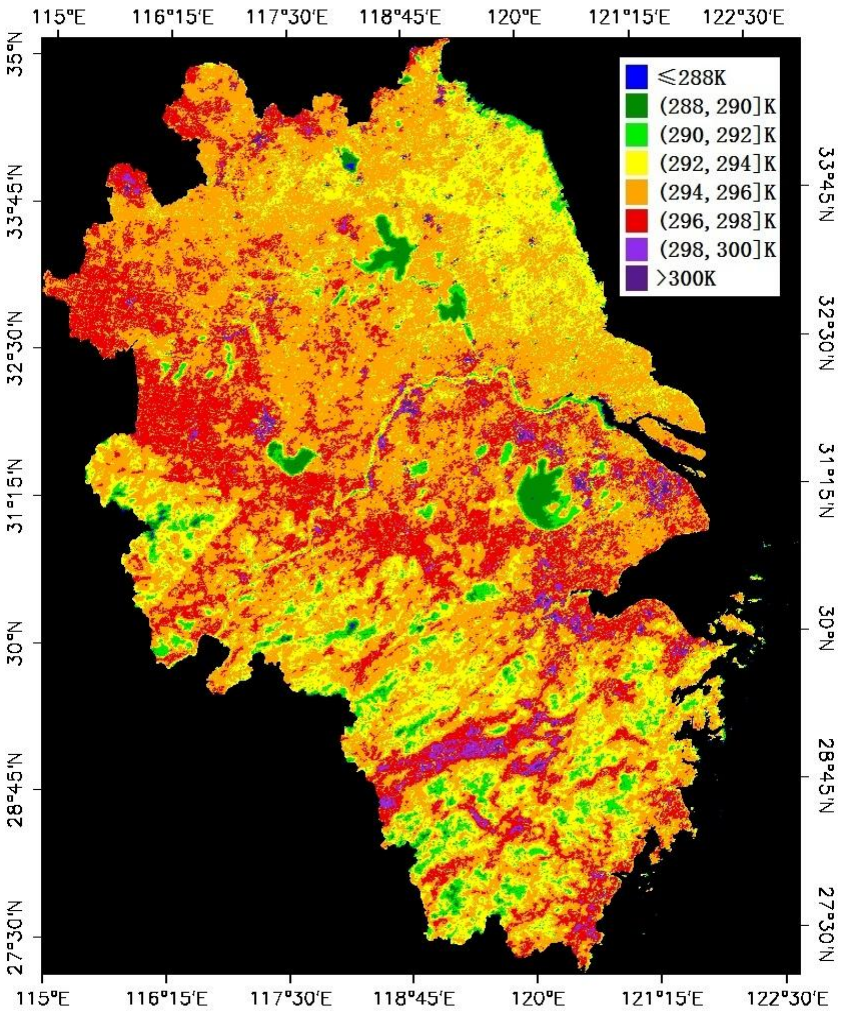
white： LST higher than 273K。



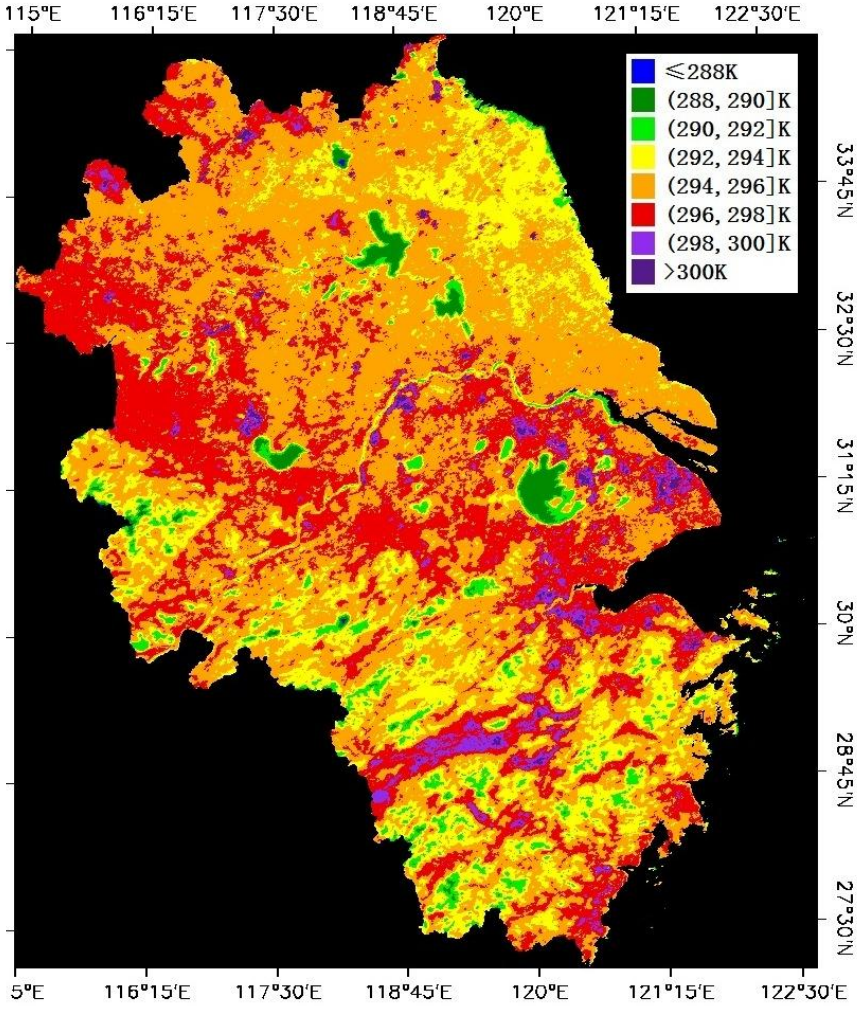
Pixels of LST variation range

Pixels of LST lower than 290K





Initial data,2010



Quality control data ,2010

Thank you!

Welcome your proposals!