Detection of Meteorological Stations' Underlying Surface Change Based on RS and Analysis of Its Influence on Air Temperature Change in China

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Abstract

Since implementation of reform and opening-up policy in China in 1970s, some meteorological observation stations 'entered' into cities passively due to urban expansion. Along with the development of economic and society, spatial expansion of urban land becomes to be the major character of land-use change now and in the future in China gradually (*Liu et al., 2003; 2005a; 2005b*).

Most of Chinese meteorological stations were built around urban land and 'entered' into cities gradually when the surroundings of the stations were changed by rapid urbanization. Natural vegetation in the cities is replaced by cement, asphalt, brick and tiles, which leads to a similar heat effect of desert together with the efficient drainage system. Canyons and cliffs formed by the high buildings along the street lead to different air temperature, atmospheric circulation, humidity, and dust particles from suburb, which is more conducive to the formation and strengthen of Urban Heat Island (*Fan, 1991; Takahashi et al., 2004; Ojima, 1990/1991; Zhou, 1999; Streutker, 2002; Tumanov et al, 1999; Zhou et al., 2003*).

Urban Heat Island Effect (UHIE) brought by land use change has direct impact on regional climate, especially on the surface air temperature. Urbanization changes the physical characteristics of underlying surface, which leads to the change of air circulation and climatic environment around and in the cities (*Li et al., 2004; Zhang et al., 2005; Kalnay and Cai, 2003*). The changes in underlying surface and building environment around the stations have had influences on the observation air temperature, leading to overestimation on the regional air temperature and disturb warming evaluation.

In the study, the surface property of more than 700 national meteorological stations in different historical periods is firstly distinguished based on the MSS images of 1970s, TM

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images fore-and-aft 1990 and ETM images fore-and-aft 2000 and 2005. We choose the images covering all the stations and composed the band 3, 2, 1 of MSS image and band 4, 3, 2 of TM/ETM image with the pseudo color composite method. The surface features around the stations such as vegetable, buildings and roads can be figured out from the composite images easily, and the stations are classified as urban and nonurban ones primarily, with the period 'entering' cities specified according to the image's obtaining time. Then the urban stations are to be verified by telephone consultation to pick up those around who the observation surroundings is apparently changed and affected by cities. The final classification result is shown in Figure 1.

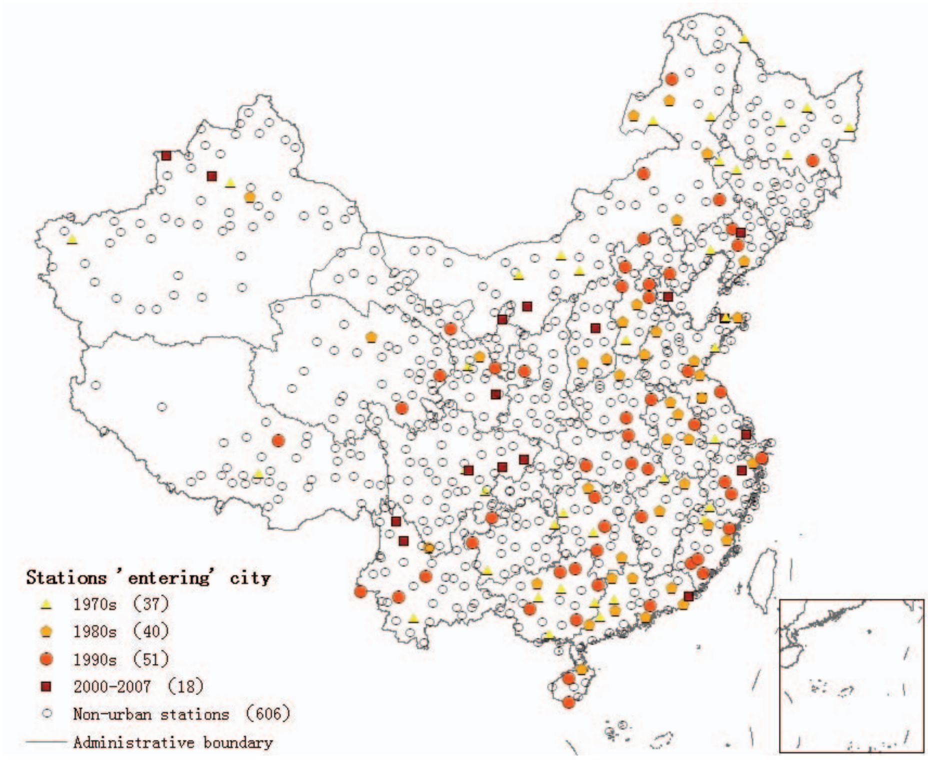

Figure 1. Spatial distribution and 'entering' city period of meteorological stations in China

In the basis of former work, annual and seasonal change characteristics of air temperature are analyzed. 608 stations with continuous observation records during 1978 to 2007 are picked out, among which there are 58 urban stations.

The linear trend of annual mean air temperature, maximum and minimum air temperature, and air temperature difference are calculated for all 608 stations firstly. Then the mean change rate is calculated respectively for all stations, urban and nonurban stations (Table 1). It can be concluded that the change rate of urban stations' annual mean air temperature is higher than the others' especially the minimum air temperature, which indicates that the observation air temperature of urban stations increase more than the other stations' because of being affected by urban circumstance. The difference in air temperature of urban stations reduces more due to the minimum air temperature's greater rise.

Table. 1 The linear trend of annual mean air temperature (Unit: ℃/10a)

	All stations	Urban stations	Nonurban stations
mean air temperature	0.449	0.544	0.439
mean maximum air temperature	0.434	0.448	0.432
mean minimum air temperature	0.507	0.660	0.491
mean air temperature difference	-0.073	-0.212	-0.058

With the similar method, the linear trend of seasonal mean air temperature is calculated. The change rate of urban and nonurban stations' mean air temperature in each season shows similar trend with the annual mean values. Among the four seasons, air temperature in winter, spring and autumn show more apparent rising trend than summer, especially the minimum temperature. As a result, the difference in air temperature in winter reduces mostly (Table 2).

Table. 2 The linear trend of seasonal mean air temperature (Unit: ℃/10a)

		All stations	Urban stations	Nonurban stations
Winter	mean air temperature	0.493	0.617	0.480
(DJF)	mean maximum air temperature	0.435	0.443	0.434
	mean minimum air temperature	0.571	0.766	0.551
	mean air temperature difference	-0.136	-0.323	-0.117
Spring	mean air temperature	0.498	0.592	0.488
(MAM)	mean maximum air temperature	0.508	0.528	0.506
	mean minimum air temperature	0.534	0.710	0.516
	mean air temperature difference	-0.027	-0.182	-0.011
Summer	mean air temperature	0.300	0.367	0.294
(JJA)	mean maximum air temperature	0.294	0.331	0.290
	mean minimum air temperature	0.362	0.441	0.353
	mean air temperature difference	-0.068	-0.111	-0.063
Autumn	mean air temperature	0.433	0.545	0.422
(SON)	mean maximum air temperature	0.442	0.450	0.441
	mean minimum air temperature	0.470	0.630	0.454
	mean air temperature difference	-0.028	-0.179	-0.013

Besides, we classify the meteorological stations according to the traditional climate division zones further. The air temperature change rate in different climate zones shows apparent difference, which indicates that air temperature change has potential relation with the geographic location.

Based on the above analysis, we can conclude that:

a) The phenomenon of meteorological stations 'entering' cities passively does occur since 1970s in China, and it is effective to distinguish urban and nonurban stations based on Remote Sensing composite images.

b) The warming trend is significant in recent 30 years in China, especially in urban districts. Air temperature in most stations shows rising trend, with urban stations higher than others. The difference in air temperature is reducing due to the minimum air temperature's greater increase than the maximum air temperature.

c) The warming trend in winter, spring and autumn is more apparent, especially the minimum air temperature. The difference in air temperature in winter reduces mostly.

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