Observed Surface Warming Induced by Urbanization in East China

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Abstract: Monthly mean temperature data from 463 meteorological stations in a range of urban and rural settings between 1981 and 2007 were analyzed. Using both raw and NCEP/NCAR reanalyzed (NMR) data, we found that urbanization is responsible for roughly 24 percent of the warming in eastern China in recent decades, thanks to the urban heat island (UHI) effect. In metropolitan areas, UHI contributed up to 44 percent (nearly 0.4°C decade−1) of the temperature increase. The largest increase in the UHI effect came after 2000, coinciding with a period of rapid industrialization in China.

Introduction: China’s rapid urbanization in the past three decades led to a quick transition of stations from rural into urban in a very short period. Note, however, that almost all of the previous studies did not consider this factor in their UMR (urban minus rural) analysis. The type of station remained fixed throughout an entire analysis period once it was identified as rural or urban. Thus, disregarding the effect of the conversion of stations from rural to urban on temperature records may give rise to a considerable underestimation of the UHI effect.

Results and Discussion

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Data and methods:
- Monthly mean surface air temperature data during 1981-2007 from 463 weather and climate stations at elevations below 500 m (Fig. 1).
- NMR 2m air temperature data for the same period.
- DMSP/OLS V4 stable nighttime light products (1992-2007) with 1 km spatial resolution downloaded from NGDC.
- Statistical data of the administrative unit-based urban land area.

DMSP/OLS nighttime light data from 1992 to 2007 were employed to dynamically categorize urban and rural stations. Then urban stations were grouped into four types using non-agricultural population data:
- Large city
- Medium city
- Small city
- Suburban

The temperature anomalies were averaged over six station categories to create a six-time series according to the dynamic classification for 1992-2007.

Observation minus reanalysis (OMR)

Urban minus rural (UMR)

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Table 1 Temperature trends from station observations and NMR, and the differences between the observations and NMR (i.e., OMR) [unit: °C decade−1] for different station groups in east China during 1981–2007.

Table 2 Urban minus rural (UMR) results for station observations [unit: °C decade−1] for different station groups in east China during 1981–2007.

Table 3. Urban minus rural (UMR) results for station observations [unit: °C decade−1] for different station groups in east China during 1981–2007.

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Conclusions:

- The objective and dynamic station classification, the observed reanalyzed temperature changes over rural areas show good agreement, indicating that the reanalysis can effectively capture regional rural temperature trends.
- The trends of 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 most substantial UHI effect occurred after the early 2000s, implying a significant effect of rapid urbanization on surface air temperature change during this period.

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