URBAN STORAGE HEAT FLUX ESTIMATION USING ASTER REMOTE SENSING DATA

HU Deyong, Deng Lei, MENG Dan

Key Laboratory of Integrated Disaster Assessment and Risk Governance of the Ministry of Civil Affairs, Beijing 100048, China
Key Laboratory of Resources Environment and GIS of Beijing Municipal, Beijing 100048, China
College of Resource Environment and Tourism, Capital Normal University, Beijing 100048, China

1. INTRODUCTION

As one of urban eco-environmental contents, urban heat island is very significant. Nowadays, the temperature in urban is higher than the surrounding natural terrain, as the result of vegetation cover declining and impervious surface increasing, coupled with the influence of anthropogenic heat discharge. In recent years, it is possible to study the urban heat island and its formation mechanism, owing to the rapid development of quantitative remote sensing technology. The earth surface parameters can be retrieved from thermal infrared remote sensing data, supplemented by meteorological data of ground-based observations, so the formation mechanism of urban heat island can be analyzed quantitatively. Urban storage heat flux is an important parameter of heat-island formation mechanism analysis; therefore, its precise estimate is of great significance for the urban heat environment monitoring and improvement and regulation of the living environment.

2. METHODOLOGY AND PROCESSING PROCEDURE

Urban storage heat flux is the major participant of "land - air" boundary layer energy migration. It enables the urban surface energy balance equation to explain the process of urban surface.

$$\Delta Q_s = R_n + A - H - LE$$

where ΔQ_s is the storage heat flux, R_n is the net radiation, A is the anthropogenic heat discharge, H is the sensible heat flux, LE is the latent heat flux.

R_n、A、H、LE can be defined by ASTER remote sensing data and meteorological data of ground-based observations, which means ΔQ_s was estimated by urban surface energy balance equation promptly.

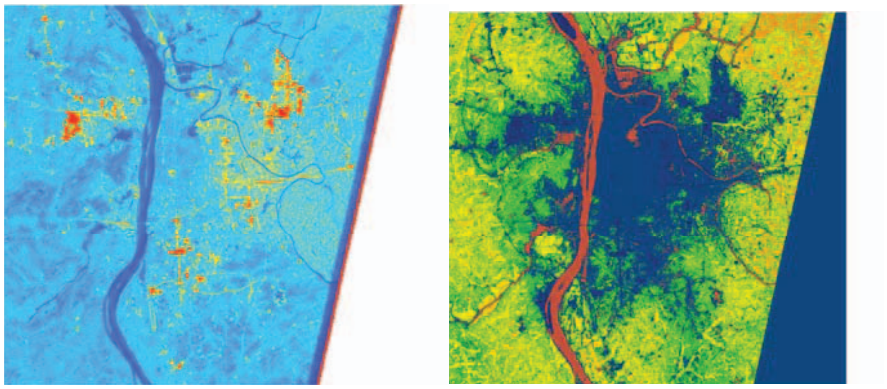
In this paper, the typical large city (Beijing, China) and the medium-sized city (Changsha, Hunan, China) were chosen as the research object, from the perspective of different urban size, different regions and different seasons to explore remote sensing estimation methods of the urban storage heat flux and to analyze the relationship between urban storage heat flux estimation, urban size, seasons and other factors.

First, ASTER remote sensing data of Beijing on August 31and January 7, 2004 and ASTER remote sensing data of Changsha on September 2, 2004 were collected. And meteorological data of ground-based observations as ancillary data which with synchronous observation time of remote sensing data were acquired. Visible band and near infrared band of ASTER remote sensing data were used to retrieve surface albedo, then thermal infrared remote sensing data were used to retrieve surface temperature.

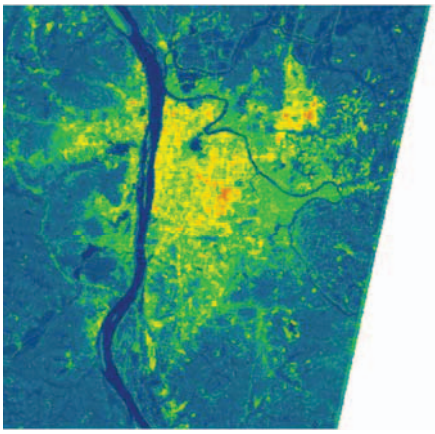
Second, based on quantitative retrieval of ASTER remote sensing data, with the combination of urban surface meteorological observation data, the net radiation, sensible heat flux, latent heat flux had been retrieved quantitatively and the changing characteristics of the energy flux in summer and winter had been analyzed comparatively.

Finally, urban surface energy balance equation was used to estimate urban storage heat flux and to acquire heat storage volume and its changes in winter and summer, then to make analysis and comparisons for urban storage heat flux with different quantity step and different geographic.

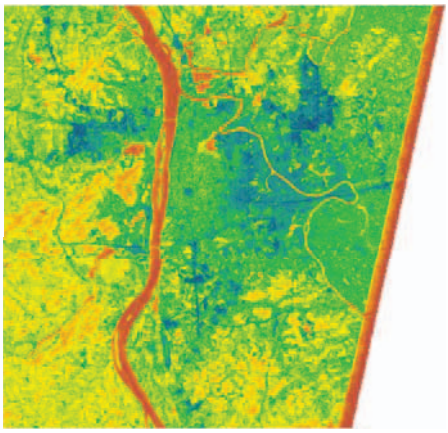
3.SCHEMATIC DIAGRAM OF PARTIAL RESULTS



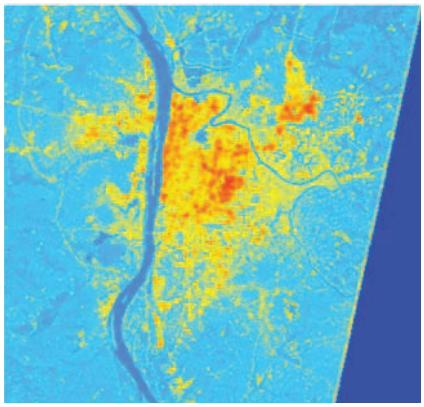
a, **Retrieval of albedo** **b, Retrieval of surface emissivity**



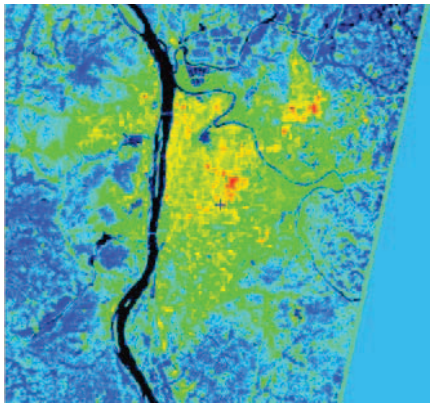
c, **Retrieval of Ts**



d, Retrieval of Rn



e, **Retrieval of H**



f, Retrieval of LE

4. CONCLUSION

The results showed that urban heat island intensity in winter is higher than that in summer, and there is seasonal variation of urban storage heat flux; furthermore, anthropogenic heat discharge, such as residents heating and cooling and factory energy consumption were the important reasons of how the urban heat island heat formatted. The urban storage heat flux and anthropogenic heat discharge of heat were of close relationship, such as anthropogenic heat discharge in northern winter was the direct cause of elevated thermal reserves. The use of remote sensing methods could estimate these parameters, so as to provide a reference for the formation of the mechanism of urban heat island.

5. REFERENCES

[1] Chrysoulakis, N. Estimation of the all-wave urban surface radiation balance by use of ASTER multispectral imagery and in situ spatial data [J]. Journal of Geophysical Research, 2003, doi: 10.1029/2003JD003396.

[2] Frey, C. M., Rigo, G., Parlow, E. Urban radiation balance of two coastal cities in a hot and dry [J]. International Journal of Remote Sensing, 2007, 1: 1- 18.

[3] Hatfield, J. L., Reginato, R. J., Idso, S. B. Evaluation of canopy temperature-evapotranspiration models over various crops [J]. Agricultural and Forest Meteorology, 1984, 32: 41- 53.

[4] Hipps, L. E., Cooper, D., Eichinger, W. Estimation of evaporation rates for riparian vegetation[C]. In Proc. American Meteorological

Society Special Symposium on Hydrology, Phoenix, Arizona, USA, Jan. 11- 16, 1998.
[5] Kato, S., Yamaguchi, Y. Analysis of urban heat-island effect using ASTER and ETM+ data: Separation of anthropogenic heat discharge and natural heat radiation from sensible heat flux [J]. Remote Sensing of Environment, 2005, 99: 44- 54.
[6] Kato, S., Yamaguchi, Y. Estimation of storage heat flux in an urban area using ASTER data [J]. Remote Sensing of Environment, 2007, 110: 1- 17.
[7] Kustas, W. P., Choudhury, B. J., Moran, M. S. et al. Determination of sensible heat flux over sparse canopy using thermal infrared data [J]. Agricultural and Forest Meteorology, 1989, 44: 197- 216.
[8] Kustas, W. P., Norman, J. M. Evaluation of soil and vegetation heat flux predictions using a simple two-source model with radiometric temperatures for partial canopy cover [J]. Agricultural and Forest Meteorology, 1999, 94: 13- 29.
[9] Norman, J. M., Kustas, W. P., Humes, K. S. A two-source approach for estimating soil and vegetation energy fluxes in observations of directional radiometric surface temperature [J]. Agricultural and Forest Meteorology, 1995, 77: 263- 293.
[10] Oke,T.R. Boundary layer climates[M]. London: Methuen and C, Itd., 1987.
[11] Rigo, G., Parlow, E. Modelling the ground heat flux of an urban area using remote sensing data[J]. Theoretical and Applied Climatology, 2007, doi: 10.1007/s00704-006-0279-8.
[12] Voogt, J. A., Oke, T. R. Thermal remote sensing of urban climates[J]. Remote Sensing of Environment, 2003, 86(3): 370- 384.
[13] Yang, L. Integration of a numerical model and remotely sensed data to study urban/rural land surface climate processes [J]. Computers & Geosciences, 2000, 26: 451- 468.
[14] Zhang, X., Aono, Y., Monji, N. Spatial variability of urban surface heat fluxes estimation from Landsat TM data under summer and winter conditions [J]. Journal of Agricultural Meteorology, 1998, 54: 1- 11.