STUDY ON URBAN HEAT ISLAND OF BEIJING USING ASTER DATA
----A QUANTITATIVE REMOTE SENSING PERSPECTIVE

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1. INTRODUCTION

Since the rapid development of urbanization, the urban heat island (UHI) becomes a more and more serious problem. It can be studied on regional scale by remote sensing technology which is much better than traditional method based on ground observations. LST (Land Surface Temperature) is one of the most important parameters of UHI study, and it has been used to analyze UHI in many cases. ASTER (Advanced Space borne Thermal Emission and Reflection Radiometer) data has been chosen to retrieve LST because of its high resolution of spectrum and space [1], so that mixed pixel problem can be released and high resolution of LST can be gained. The aim of this paper is to analyze the UHI patterns of Beijing and its seasonal variety by means of LST retrieval using ASTER data. Beijing is a representative metropolis with rapid development of urbanization, so the results and analytical methods of this paper are also applicable to other big cities with similar level of development.

2. LST RETRIEVAL

Five ASTER images of level 1B dated on Apr.9, Jun.12, Oct.18 and Jan.27, 2004 respectively are utilized, which cover the urban and the surrounding rural areas of Beijing. LST is calculated using local split window algorithm as a linear combination of the brightness temperatures of band 13 and 14(10.25-10.95, 10.95-11.65μm)[2]. Local split window algorithm expresses the radiance received by the sensor as

\[ L_\lambda(\theta) = t_{\lambda 0}e_\lambda(\theta)L_{b\lambda}(T_s) + t_{\lambda 0}f_{\lambda}(\theta - \theta)L_{a\lambda}(\theta)\cos \theta d\Omega + L_{a\lambda}(\theta), \]

so LST is calculated as the linear combination of the brightness temperatures of the two thermal bands:

\[ T_s = \frac{T - D + D}{D - D} + \frac{T - T}{D - D} - \beta W A_{2} \frac{1 - \varepsilon}{2} - \frac{L_{a\lambda}}{2} \frac{1 - \varepsilon}{2} \]

Since split window algorithm is first introduced for AVHRR data[2], efforts should be made to adjust these experiential coefficients related to atmospheric conditions, namely \( D_1 \), \( D_2 \), \( W \), \( A_1 \) and \( A_2 \), for the use of ASTER data. These coefficients are obtained according to different seasons using Look Up Table method with the aid of MODTRAN 4.0 software package and the ASTER response functions of band 13 and 14, 393 standard atmospheric profiles located in the north hemisphere of TIGR database are chosen according to the weather of Beijing.

The emissivities are obtained from an emissivity map generated from VNIR bands (band1, band2 and band3). Firstly the images of VNIR bands are resampled to the same resolution with the two thermal bands (90m). The VNIR images are then classified to four land use types, namely water body, vegetation, bare soil and concrete. Then emissivity values are obtained from MODIS Spectral Library and assigned to different land use types and different bands to produce an emissivity map.
Lacking of in-situ measurements, a numerical simulation is used to assess the accuracy of LST retrieved. The results are showed credible. The LST distribution maps in summer and autumn are given in Graph 1.

![Graph 1 Geographic distribution of LST in summer and autumn](image)

3. ANALYSIS

The statistical data including the minimum LST, the maximum LST, the average LST, the mode of LST and the standard deviation of LST of both the urban areas and the rural areas are calculated, and the statistical test parameters are also derived to examine the difference of LST between the two regions.

Urban areas and rural areas exhibit evident difference in LST. Rural area displayed a cooler LST compared with urban area in summer and autumn, which is the reverse in spring and winter. Urban heat island effect exists in summer and autumn and is the most intensive in summer. The intensity of urban heat island in summer is around 0.6~1.5°C. It is found that the above results are better explained by differences of vegetation density between urban and rural area in the four seasons. The differences of vegetation density are larger in summer and autumn when urban heat island effect exists. In spring and winter, the differences are not evident. Vegetation density difference appears to indicate the difference between the characteristics of the two land surfaces, so it makes a better explanation to the above results. According to the analysis based on the statistical data obtained, patterns of LST distribution were found to be closely related to land use types and season. Higher LST is observed in the bare soil and the concrete and lower one in the water body and the vegetation. The differences between LST of different land use types are larger in warm seasons. But the UHI is affected by various factors, such as the wind speed and the air temperature, the seasonal variety deserves further study using more data, and this paper is just an attempt.

4. REFERENCES