Applications of GIS and Remote Sensing for Analysis of Urban Heat Island

Since the last century, the global mean surface temperature has increased six centigrade. Then, more and more studies have pay attention to the global warming. With the rapid growth of world population, more and more fields are urbanizing or have been urbanization. More than half of the current world’s population lives in urban areas. Urbanization and urbanizing are the important components of global warming, and hence resulting in remarkable urban heat island (UHI). UHI means urban air temperatures over temperatures in surrounding rural areas. The differences of temperature are always greater at night than during the day, and the maximum difference always occurred after sunset. For seasonal, the maximum average urban heat island effect in winter is stronger than in summer. UHI effect will influence the regional climate and environment. Heat stress, caused by urban heat island, exceed the threshold of human comfort will create physical and mental illness.

UHI effect is associated with many factors, including changes in land use, urban surface geometry, seasonal variation, and climatic and meteorological condition. Therefore, studies are focused on relationship between land use and land cover (LULC) types and urban heat island effect. Land use and land cover is a scale to inspect the impacts of human activities. Land cover classification is necessary for detection of LULC. Herein, the covers formed of urban or built-up area, farmland, forest, shrub, water, and the bare land. Built-up area is the most important area during the analysis of urban heat island effect. It is caused by deforestation and the replacement of the land surface by non-evaporating and non-porous materials such as asphalt and concrete. The result is reduced evapotranspiration and more rapid runoff of rainwater. Not only the properties of urban construction materials, but also the planning of buildings and pavements within an urban landscape can affect the urban heat island effect. The city layout has a crucial impact on the development of urban heat islands. Therefore, urban planning can be applied to avoid or remit the effect of urban heat islands. Vegetated (farmland, forest, and shrub) area, which can cool the surrounding area, is an also important indicator in land use and land cover analysis. Various vegetation indices obtained from remote sensing images can be used in the assessment of vegetation cover qualitatively and quantitatively, such as Ratio Vegetation Index (RVI), Normalized Difference Vegetation Index (NDVI), Difference Vegetation Index (DVI) and Perpendicular Vegetation Index (PVI).

Land use and land cover change (LUCC) is a significant element of global warming and urban
heat island effect. LUCC includes the processes of urban extend, degradation of vegetation, sea reclamation, and etc. LUCC studies will be difficult without of GIS and remote sensing (RS) global imaging capacity. They are good technologies to analyze the relationship between land use and land cover change and land surface temperature (LST) such as NOAA AVHRR data, Landsat Thermatic Mapper (TM) and Enhanced Thermatic Mapper Plus (ETM+) thermal infrared (TIR) data. Remote sensors measure top of the atmosphere (TOA) radiances, and using Plank’s law to calculate brightness temperatures. The TOA radiances are the mixing result of three fractions of energy: (1) emitted radiance from the Earth’s surface, (2) up welling radiance from the atmosphere, and (3) down welling radiance from the sky. Before the computation of LST, brightness temperatures should be corrected by consideration of the roughness properties of the land surface, the amount and nature of vegetation cover, and the thermal properties and moisture content of the soil. For images, noise reduction is necessary, especially for the thermal infrared band. The noise may affect the retrieval of brightness temperature or LST. There is periodic noise (stripes in the TM/band6) and aperiodic noise (speckles).

Although GIS and remote sensing images were ideal for analyzing UHI effect, it is difficult to detailed surface roughness. Due to the limited GIS and remote sensing data, it is difficult to explain all the influences of these factors on UHI effect. Images are unable to depict micro-climatic features within cities, such as the temperatures of city blocks and street canyons. Images are also difficult to select images with similar conditions areas; uniform atmosphere condition is more difficult. Therefore, further improvements are required: reducing the influence of inhomogeneous atmosphere condition by improving the method of temperature recording; much deeper research of the impact of different land use and cover types in the urbanized area on UHI is necessary; more accurately estimated the errors caused by different land use and land cover conditions; and making better urban planning to increase vegetation area and reduce built-up area.

Annotated Bibliography


Pearl River Delta (PRD), in Guangdong Province of China, is one of the rapid urbanization regions in the world. Then it leads the urban heat island phenomenon happened in the cities of this area, and influences the regional climate, environment, and socio-economic development. In this study, remote sensing images, Landsat TM and ETM+ images from 1990 to 2000 in the PRD, were used to analysis the relationship between the temperature and LULC changes. There are four indifferent indices were use to support thr study: Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), Normalized Difference Bareness
Index (NDBaI) and Normalized Difference Build-up Index (NDBI). It was found that negative relationship between NDVI, NDWI, NDBaI and temperature, and positive relationship between NDBI and temperature.


This study is base on the remote sensing data acquired in 1997 and 2004. There are several important finding by the successful coupling of these data. Well-vegetated or developed for fishery had the important cooling effect on the bare lands. Due to the impervious materials of the construction, urbanized and unbanning landscapes has heating effect of surfaces. Furthermore, the change of land use and land cover of the satellite towns aggravated the urban heat island effect of the Shanghai. For example, removing the residences to the satellite towns. The increasing green space can partly help to stop then extent and magnitude of urban heat island. Such like reestablish the water and green area in the inner part of the central urban area. However, annual vegetated area increasing is much less than the increasing area of urbanization area. Then, the cooling effect of the vegetation is very limited.


This paper introduces how the detail of highly complex urban land cover types can be matched clearly by the high-resolution thermal infrared image and GIS approach. Thermal channel number 13 data with the best noise-equivalent temperature change (NEDT) and Normalized Difference Vegetation Index (NDVI) were selected for use in this analysis. By this research, the finding is that the roles of different land cover types in the city are not same in the day and night. Commercial, industrial, and services uses show the highest daytime temperature. Residential uses are on a floating position because of their varying green cover degree, and they always higher in the night. Water has a very small different between day and night. Agricultural, and vegetation land cover types can lower their surface temperatures by their association with biomass. Then water, agriculture, and vegetation uses have the lowest temperature reflection.


This article provides a comparison of urban heat island effect during the daytime and nighttime. The effect is visible as elevated surface temperatures on images of both day and night, in especial during the day. Thermal images are also using to analysis the difference of temperature of Urban Boundary Layer (UBL) and Urban Canopy Layer (UCL). Daytime images shows that step temperature gradients exist between different land cover types area. The urban vegetated areas
have the similar temperature as rural green areas. The increasing temperature between urban area and rural area is not as much as on nighttime images. On the nighttime images, the difference of temperature between urban and rural area is six centigrade.


By the year 2015, 16 of the world's mega cities are located in Asia. In the rapid urbanization processes of these cities, the expansions of urban construction land use not only increase the amount of resource use, but also damage the ecological environment and climate of cities. Due to the limitation of technology of remote sensing, the past studies on urban heat island are focus on one specific city. However, the research of climate effects of urbanization of different cities can be attempted with high-resolution data. Components of urban surface energy balance can be recorded from MODIS data. These data can be input into climatic modeling in order to understand the impacts of urbanization on local climate in Asia, and also to have insights into the genesis of the surface UHIs.


Through this research Weng introduces the knowledge of impervious surfaces. The magnitude, location, geometry, spatial pattern of impervious surfaces and the perviousness–imperviousness ratio are significant factors in the analysis of environmental problems. Then, impervious surface data is important for urban heat island analyzing. There are three types: (1) various sub-pixel algorithms applied to estimate and mapping impervious surfaces as a type of surface material; (2) per-pixel algorithms applied to classify impervious surfaces as a type of land cover or land use; (3) feature extraction methods applied to extract roads and buildings, implicitly suggesting impervious surface as a special type of land use/cover. Feature extraction methods are more popular in Europe North America, and less in Asia.


Thermal infrared (TIR) remote sensing techniques have been applied in urban climate and environmental studies. It could use for analyzing the relationship between land surface temperatures with surface characteristics, and for assessing urban heat island effect with the surface energy fluxes. This paper reveals the current methods, applications, and trends for the TIR techniques. The most important issue of urban environmental research is the definition of urban surface. For better define urban surface, well measurement is required. There are four
significant factors should be determined: surface albedo, surface roughness, soil thermal inertia, and soil moisture. Modeling scale is as same important as measurement. A better understanding of the differences between modeled and measured fluxes is also indispensable.