

Role of Urban Canopy Composition and Structure in Determining Heat Islands: A Synthesis of Remote Sensing and Landscape Ecology Approach (Abstract)

The use of heat-absorbing construction materials (e.g., stone, metal, and concrete) and building of roads, driveways, sidewalks, parking lots, and rooftops in cities, and the corresponding reduction of natural vegetation and water bodies result in higher temperatures in urban areas. The increased temperature not only leads to adverse climate, but also drives up energy use for air conditioning and the pollution level. Climatologists have long been studying this phenomenon by measuring ambient air temperatures, describing it as the urban heat island effect. Over the past decade, however, remotely sensed imagery has been increasingly used to study heat islands by computing land surface temperatures from these images. The technology of remote sensing has the advantage of providing a time-synchronized dense grid of temperature data over a whole city and distinctive temperatures for individual buildings, and is thus cost-effective. A key issue in the application of remote sensing technology is how to use surface temperature measurements at the microscale to characterize, quantify, and model heat islands observed at the mesoscale. The purpose of this project is to examine the effect of urban surface composition and structure on urban surface energy budgets, in order to understand better the thermal behavior of urban landscapes and the heat island phenomena. This project will synthesize optical remote sensing of urban construction materials and the composition and structure, thermal remote sensing of land surface temperatures with the landscape ecology approach, which links remotely sensed biophysical attributes to the heat island process quantitatively. Satellite images of Advanced Spaceborne Thermal Emission and Reflection Radiometer, onboard Terra Satellite, will be applied for parameterizing urban surfaces at sub-pixel level and for measuring surface temperatures and emissivities at the pixel level. Through use of physical modeling, statistical analysis, and fractal geometry, a protocol to study the interactions among urban surface characteristics, the thermal behavior of urban landscapes and heat islands will be established. A case study will be conducted in Indianapolis, Indiana, United States. The concept and scientific procedure developed through this project will, however, provide an explicit methodology by which such type of research may be applied to other cities in the world, and be conducted using other Earth observing sensors and next generations of sensors.

The knowledge of the surface energy budget and urban heat islands is significant to a range of issues and themes in earth sciences central to urban climatology, global environmental change, and human-environment interactions, and is also important for planning and management practices. This project will expand knowledge of the thermal behavior of urban landscapes and the mechanisms of heat islands, and will improve understanding of the significance of canopy composition and structure in the interface energy exchange. More significantly, it will lead to a geographically referenced modeling and prediction of heat islands. The establishment of the relationships between urban morphology and thermal behavior of urban landscapes makes it possible for a better scientific understanding of how human and physical environment have interacted to motivate past environmental changes. Remote sensing technology will demonstrate to be capable of providing field measurements of urban canopy conditions for heat islands modeling, which is of great difficulty with the traditional energy budget approach. The microclimate information derived from remote sensing data and the data sets generated will be of great value for civic and environmental applications, and for management of the impacts of urban related activities on the natural environment. The research will provide educational opportunities for graduate and undergraduate students and a unique science education program for a group of Grade 7-12 students. Materials provided on the web and in multimedia format will help educate the public and promote heat islands related research activities worldwide.