Remote sensing for improving understanding on Canadian urbanization

Y. Zhang, B. Guindon, K. Sun and L. Sun, Natural Resources Canada, Canada Centre for Remote Sensing

Global urbanization trends present challenges, including increased energy consumption that causes air and water pollution and ecosystem degradation and local climate modification that is caused by increased heat storage and release from built structures (i.e. the urban heat island effect). The “form” of urbanized areas, i.e. their land use and demographic geospatial patterns, has significant impacts on many energy- and environment-related processes and activities conducted in urban environments.

To improve our understanding of these impacts from regional and national perspectives, the Canada Centre for Remote Sensing (CCRS) undertook initiatives to create quantitative portrayals of urban form. As a result of these initiatives, a database called the Canadian Urban Land Use Survey (CUrLUS) was created. CUrLUS contains nationally consistent urban form information that is used for assessing Canadian urban development sustainability.

CUrLUS encompasses integrated layers including land cover and land use derived primarily from satellite imagery, national population, employment and transportation statistics from the national census and other geospatial themes such as road networks. In addition, information from historical land use maps was integrated into CUrLUS. The maps were created from satellite data for the period from 1966 to 2001. Understanding of the link between urban form and urban transportation has been improved through quantification of geospatial indicators and predictive travel modelling that are based on the CUrLUS information.

Subpixel surface information extraction

In human settlement areas, pixel-level data from moderate resolution satellites such as Landsat and SPOT are primarily a mixture of land covers. The distribution of major land covers such as built-up surfaces, open lands and urban forests in metropolitan areas are key information attributes that facilitate assessing the impact of urban form on the water and air environments.

Built-up surfaces are generally impermeable surfaces (impermeable surfaces) that prevent water infiltration and include, in the urban environment, surfaces such as rooftops, roads, driveways and parking lots and compacted soil and gravels.

Quantitative understanding of the competing effects of land cover and change on the urban environment requires comprehensive characterization of the spatial distributions and changes of urban land cover densities, especially land impervious density and forest cover density.

Methods

Methodologies have been developed for mapping land cover density at the subpixel level based on integrated information from Landsat and QuickBird data. High-resolution multispectral images from the QuickBird satellite play a key role in the subpixel mapping process (see Figure 1a).

The first step is to derive a thematic classification from these data. Next, QuickBird land cover classifications (see Figure 1b) are used to “calibrate” Landsat-derived greenness.

Applying this assimilation methodology has allowed the generation of consistent 35-year time series of maps that document the land cover change of major Canadian urbanized areas. Key variables that characterize the urban expansion process, such as urban land area, urban dwelling density, urban population density and natural land loss, have been estimated and examined. In addition, the influences of urban expansion on urban transportation and on the intensification of the effects of urban heat islands have been estimated by modelling case studies.

Urban form and urban transportation

The geospatial character of urban areas is called urban form. The spatial distributions of land use and demographics in an urban area can significantly influence its “efficiencies” in terms of energy consumption and subsequently the impact of an area on environmental and human health.

A prime example of this impact arises in transportation. North American cities are characterized by comparatively low densities and segregated land uses. These factors are reflected in high energy use per capita, which is caused by heavy reliance on using private vehicles and travelling long distances between urban areas.
The two major Canadian urban regions of Greater Toronto and Ottawa-Gatineau were studied. Comprehensive characterizations and assessments of the relationship between the urban form and the surface urban heat island effect were done by using integrated information derived from Landsat and QuickBird satellite imagery and the demographic census. The spatial information derived includes land cover fraction maps, land use and its historic changes, surface temperature from thermal sensors, and population density maps.

Three aspects of the surface urban heat island were addressed:

- the relationships between surface temperature and the three urban geospatial attributes of land use, urban land cover density and population density
- intra-city seasonal temperature variations
- the intensification of the surface urban heat island effect caused by recent urban growth

References


Acknowledgements

This work was generously supported by the Canadian Space Agency’s Government Related Initiatives Program (GRIP), City of Ottawa, Environmental Prediction in Canadian Cities (EPiCC) program, GeoBase, International Joint Commission, PCI Geomatics, Statistics Canada, DLR (German Aerospace Center).