Using satellite data to monitor the quality of urban air

By Daniel Spitzer, Gray O'Byrne, Natty Urquizo and Bojan Bojkov

Air quality in major Canadian cities continues to improve, but the negative health impacts of air pollution remain a serious issue. Urban development and transportation planners, as well as municipal health officers, realize that more is needed than just monitoring air pollutant concentration levels at a few critical sites. For a full assessment of the health impacts, detailed information is required about the levels of the air pollution over populated areas and public facilities such as parks, schoolyards and sports fields.

Installation, maintenance and operational costs of extended air quality monitoring networks are considerable. Fortunately, space technologies can offer innovative yet practical and cost-effective solutions. In the past decade, new earth observation satellites were designed and launched to provide daily maps of global and local distributions of major air pollutants. New methodologies are being developed to exploit this rich source of environmental information.

In North America, A-MAPS Environmental Inc., based in Ottawa, has specialised in applications of environmental satellite remote sensing. The company has developed a new approach to provide municipal planning and health offices with essential information on urban air pollution issues. Years of scientific research, in co-operation with several universities and other innovative Canadian enterprises, preceded the development and launch of this product.

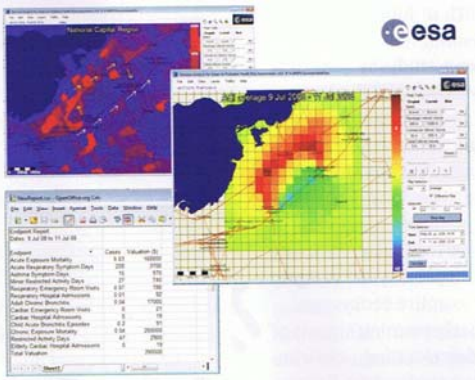

Figure 1. The upper display shows rerouting traffic from Hwy 417 (white arrows) through a densely populated residential area in the western part of Ottawa (yellow arrows) with several school, sport, and medical facilities. Displayed on the central map is the average change in Air Quality Index (AQI) for a three-day period in July 2008 in the area surrounding the affected roads. Pollutant concentration levels decreased (blue-green colours) in the vicinity of the closed highway section, but increased (yellow–red colours) along the roads where the traffic was rerouted. The AQI scaling, original and modified traffic parameters and dates are indicated in the legend on the right hand side. In the lower panel, a report displays health impacts on the local population. The health benefits in the areas along the closed highway section are overshadowed by the adverse impacts on population health in the densely populated residential area, where the pollutant levels have significantly increased.

Air quality mapping

Data collected by earth observation satellites are distributed by national and international space agencies such as the Canadian Space Agency, NASA and the

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European Space Agency. Processing the atmospheric remote sensing data requires detailed understanding of atmospheric physics and chemistry.

Using the satellite observation data does not mean that traditional air quality monitoring networks will become obsolete. On the contrary, creating reliable air pollutant distribution maps requires adjustment of the satellite data by using the results of air pollutant concentration measurements at several ground level sites. Subsequent interpretation of the data is based on complex geospatial and emission dispersion models.

These efforts result in detailed, hourly distribution of digital maps of harmful air pollutants such as nitrogen dioxide, ozone and small particulates. The air quality mapping products in GIS formats are presented through interactive graphical user interfaces or web applications. Development of such web applications for the National Capital Region (Canada) was funded by GeoConnections/Natural Resources Canada.

To disclose the vast amount of information concealed in the air pollution databases, geospatial analysis of the data is needed, so the company developed a graphical user interface called MAGIQA (Map Analysis Graphical Interface for Quality of Air) that enables analyses and easy presentations of air pollution data. The software includes conversion of any environmental records into GIS mapping formats. Specific time periods and areas can be selected on screen within the mapped region for processing and analysis. Moreover, series of imagery can be viewed as an animation.

The analyses include standard statistical and custom-designed functions such as averaging, maximum, minimum, standard deviation, percentiles, and critical pollutant level exceedancies. This information is presented in mapping and other graphical formats, which can be displayed, printed and saved.

Assessing air pollution health impacts

One of the key concerns of municipal planners is evaluating the consequences of different city development and land use scenarios. Particularly important is considering the implications for public health. Another product developed by A-MAPS Environmental, in co-operation with Risk Sciences International, is a customized interactive graphical interface that enables direct assessments of the impacts of urban road traffic emissions on population health.

Different traffic control scenarios can be tested by modifying traffic volumes and speeds on selected roads or in entire neighbourhoods. The consequences of such changes in terms of air pollution and health impacts can then be reviewed and evaluated in mapping and tabular formats.

Development of the new population health assessment tool was funded by the European Space Agency's Data User Element program (www.esa.int/due). An example of an application of the interface, showing the consequences of traffic rerouting from a busy highway section to a residential area in Ottawa, is shown in Figure 1.

Since 2007, the City of Ottawa has introduced a regional air quality mapping system based on satellite remote sensing, ground-level air quality measurements and geospatial modelling. This unique system comprises an interactive air quality mapping website and interfaces for data analysis and health impacts assessments. Concentration levels of NO_2, NO, O_3, $PM_{2.5}$ and CO are measured hourly at several locations by monitoring instruments, and then recorded and processed for further mapping of the air pollutant concentration distributions over the entire National Capital Region.

Along with local measurements, the mapping process is supported by data from the National Air Pollution Surveillance system and from the Aura/OMI atmospheric satellite sensor. All collected and processed data are then used as inputs into a geospatial model, allowing air pollutant distribution maps to be generated and presented hourly in GIS formats.

To expand the air quality information system, the City's Community Sustainability department will include a new specific module that will provide detailed information about air pollution on busy streets.

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