AirGIS system description

Version April 2011

Location-based estimation of human exposure

AirGIS has been developed by the National Environmental Research Institute. It is a human exposure modelling system for traffic air pollution developed for application in Danish air pollution epidemiological studies (http://www.airpolife.dk/English/, Hansen et al. 2006), human exposure studies, as well as urban air quality assessment and management (Jensen et al. 2005).

One of the unique features of AirGIS is that it is able to generate street configuration and traffic data for the OSPM model based on digital maps and national databases. This enables estimation of air quality levels at a large number of addresses in an automatic and effective way.

The modelling system is currently being applied in a number of Danish epidemiological studies that involve exposure calculations at more than 200,000 addresses in Denmark or about one tenth of all addresses in Denmark. The model system allows for exposure estimates at a high spatial resolution (address level) and a high time resolution (hour). The system integrates air pollution dispersion models, digital maps, national and local administrative databases, concentrations of air pollutants at regional, urban background and street level, meteorological data, and a Geographic Information System (GIS) (Jensen 1999; Jensen et al. 2001).

The system uses on the Danish Operational Street Pollution Model (OSPM) (Berkowicz 2000a; ospm.dmu.dk), digital maps on roads with traffic data, buildings with building height data and geocoded addresses of study subjects, and it applies ArcView 3.x. A conceptual outline of the system is shown in Figure 1. The OSPM model requires input data on traffic for the individual street in question, street configuration data, emission factors, urban background concentration data and meteorological data. The OSPM has an internal vehicle emission module.

The Urban Background Model (UBM) (Berkowicz 2000b) is typically applied to generate an urban background concentration field in e.g. a resolution of 1km x 1km based on emission data, and regional concentration data and meteorological data. Alternatively for very large data sets the urban background concentration can be calculated from a simplified area source dispersion formula (SUB method) that takes into account urban vehicle emission density, city dimensions (transport distance) and building height (initial dispersion height) (Berkowicz et al. 2008).

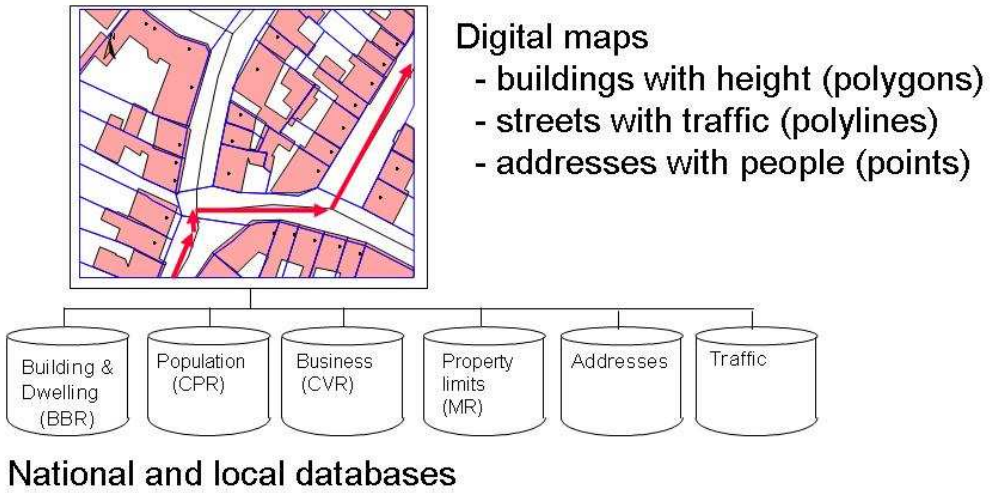

Figure 1 The AirGIS system makes use of digital maps, national and local administrative databases, and a Geographic Information System (GIS).

In epidemiological studies the ambient air quality level at the residential address is in most cases used as exposure indicator and can be supplemented by e.g. the work place address if information is available about the time spent at the various addresses. The calculation point represents a location

close to the facade of the building in question. The receptor height (e.g. to represent 2nd floor conditions) can be specified as the OSPM model takes into account the decrease of concentrations by height. In urban air quality assessment and management studies, one receptor location in each street segment at a height of 2.5 m is usually used to represent the air quality conditions of the street.

2½ dimensional Urban Landscape Model

One of the unique features of the AirGIS system is that it is possible to automatically generate street configuration and traffic data for the OSPM model. A GIS model in ArcView 3.x has been developed named the 2½ dimensional Urban Landscape Model. This enables estimation of air quality levels and human exposures at a large number of addresses in an automatic and effective way provided required input data is available. A building theme with building heights and a road theme with traffic data have to be available. Generated street configuration data includes street orientation, street width, building heights in wind sectors etc., see Figure 2.

Automatic generation of street configuration data from digital maps and databases for OSPM:

1. General building height
2. Building height in wind sectors
3. Width of street
4. Street orientation
5. Distances to street intersections
6. Traffic data

Avenue program (ArcView 3x) more than 10.000 lines

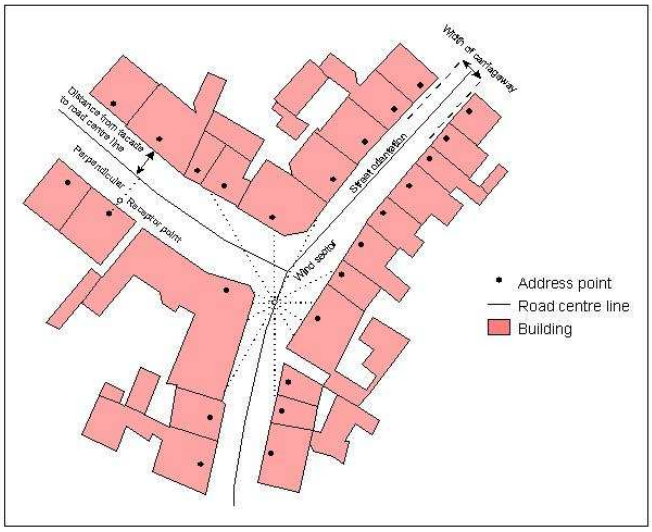

Figure 2 The 2½ dimensional Urban Landscape Model of the AirGIS system automatically generates required street configuration and traffic input data for the Operational Street Pollution Model (OSPM)

Estimation of Personal Exposure by Tracking People in Transit

Apart from modelling exposure at address level the system has been further developed into a model system for estimation of exposure under transport along a route provided tracking data is available. In this way it is possible to estimate personal exposure taking into account the exposure at fixed locations like home and work place but also exposures under transport. To support collection of tracking information, a system has been developed for tracking people using Global Positioning System (GPS). This system is mainly applicable for smaller field studies (Hertel et al. 2008). A commercial available cell phone that has a built-in GPS is used for providing tracking data. SMS text messages (Short Messages Service) sent from the cell phone transfer positions of a study subject to a computer e.g. every 20s. A tracking program has been developed for collection of GPS data and remote-control of phone settings. The movement of a study subject in field studies can be tracked on digital maps in real-time for on-line monitoring.

The opportunity of remote-control of the settings of the phone was used to develop a dynamic area-tracking functionality that ensures that SMSs are only sent when the subject is moving out of a defined area (defined by a centre coordinate and a radius). The dynamic area tracking functionality was developed to minimize the number of SMSs sent and the associated costs as positions can not be stored in the cell phone for subsequent submission in batches. The daily time a study subject spends in transport will typically be about one hour. If the telephone sends a pre-defined number of equal positions the application sends a SMS with an Area Tracking message (TRG), holding a position and an area radius, to the modem/telephone. The phone now enters area tracking mode where no positions

are sent as long as the phone stays in the area. When the phone leaves the area it automatically starts tracking. The GPS tracking system is visualised in Figure 3.

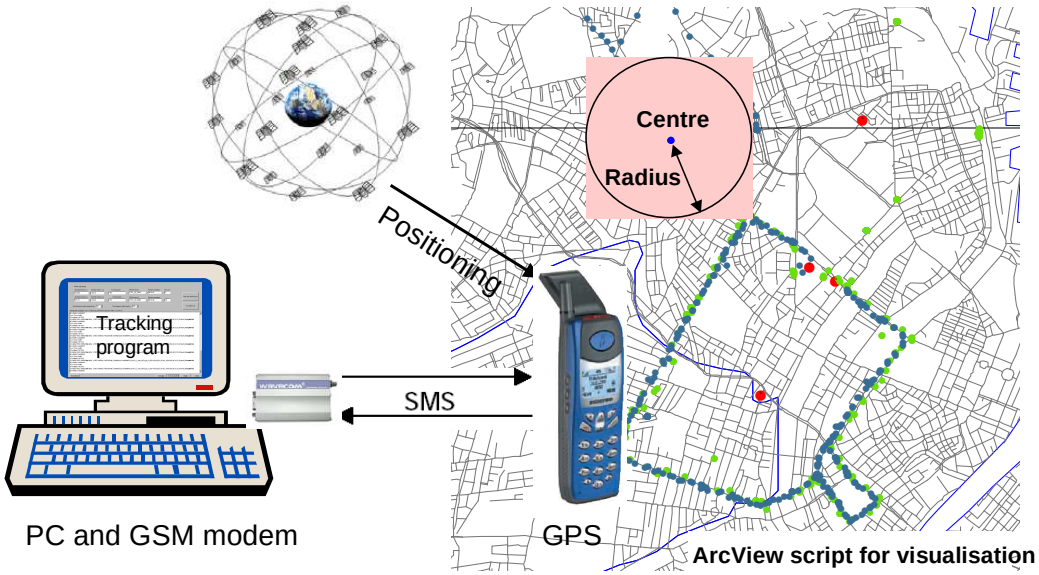

Figure 3 System for tracking people using Global Positioning System (GPS). The GPS is integrated into a cell phone and SMSs are used for transferring positions of a study subject to a computer. A tracking program collects the GPS data. A dynamic area-tracking feature ensures that SMSs are only sent when the subject is moving. The movement of a study subject can be tracked on digital maps in real-time.

Selected References

There is an extended reference list available at the AirGIS web page: http://AirGIS.dmu.dk/

Descriptions of the AirGIS System
Jensen, S.S., Berkowicz, R., Hansen, H. Sten., Hertel, O. (2001) A Danish decision-support GIS tool for management of urban air quality and human exposures. Transportation Research Part D: Transport and Environment, Volume **6**, Issue 4, 2001, pp. 229-241.

Jensen, S.S. (1999): A Geographic Approach to Modelling Human Exposure to Traffic Air Pollution Using GIS. PhD Thesis. National Environmental Research Institute, Roskilde, Denmark, 165 p. - www.dmu.dk/1_viden/2_Publikationer/3_Ovrige/rapporter/SSJphd.pdf

AirGIS system – tracking based
Hertel, O., Jensen, S.S., Hvidberg, M., Ketzel, M., Berkowicz, R., Palmgren, F., Wåhlin, P., Glasius, M., Loft, S., Vinzents, P., Raaschou-Nielsen, O., Sørensen, M., Bak, H. 2008, 'Assessing the Impact of Traffic Air Pollution on Human Exposures and Linking Exposures to Health', in *Road Pricing the Economy and the Environment*, Springer, Berlin Heidelberg, pp. 277-299.

Description of Air Quality Models in the AirGIS System
Berkowicz, R. (2000a): OSPM - A parameterised street pollution model. Environmental Monitoring and Assessment, Vol. **65**, Issue 1/2, pp. 323-331.

Berkowicz, R., (2000b): A Simple Model for Urban Background Pollution. Environmental Monitoring and Assessment Vol. **65**, Issue 1/2, pp. 259-267.

Berkowicz, R., Ketzel, M., Jensen, S.S., Hvidberg, M., Raaschou-Nielsen, O. (2008): Evaluation and application of OSPM for traffic pollution assessment for a large number of street locations. *Environmental Modelling & Software*, vol. **23** no. 3, pp. 296-303.

Application of OSPM/AirGIS in Epidemiological Studies
Raaschou-Nielsen, O., Andersen, Z. J., Hvidberg, M., Jensen, S. S., Ketzel, M., Sørensen, M., Loft, S., Overvad, K. and Tjønneland, A. (2011): Lung Cancer Incidence and Long-Term Exposure to Air Pollution from Traffic. Environmental Health Perspectives.

Andersen, Z. J., Hvidberg, M., Jensen, S. S., Ketzel, M., Loft, S., Sørensen, M., Tjønneland, A., Overvad, K. and Raaschou-Nielsen, O. (2010): Chronic Obstructive Pulmonary Disease and Long-Term Exposure to Traffic-Related Air Pollution: A Cohort Study. American Journal of Respiratory and Critical Care Medicine **183**, 455-461

Jensen SS, Larson T, Deepti KC, Kaufman J. (2009): Modeling traffic air pollution in street canyons in New York City for intra-urban exposure assessment in the US Multi-Ethnic Study of atherosclerosis and air pollution. Atmospheric Environment **43**: 4544-56.

Application of AirGIS in Air Quality Assessment and Management
Jensen, S.S., Ketzel, M., Berkowicz, R., Hvidberg, M., Høj, J. 2009: Cleaner transport technology most efficient to ensure compliance with 2010 NO_2 limit values in Copenhagen, Denmark, *International Journal of Environment and Waste Management*, vol. **4** no. 1/2, pp. 179-196.

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