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The Krakow Integrated Project: Particulate matter: From toxic emissions to health effects

Calculation of ambient air concentrations and personal exposure using the integrated air quality management system AirQUIS

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1 Introduction

One of the objectives with the Krakow integrated project has been to investigate the relations between emissions, air quality and health impact. NILU Polska and NILU have been asked to perform dispersion and exposure model calculations for the city of Krakow using the integrated Air Quality Management System (AQMS), AirQUIS. Calculations have been performed during the heating season in 2005 for the same period as a comprehensive measurement campaign of indoor and outdoor concentrations was carried out in Krakow. This paper illustrates the utilisation of an AQM system and some preliminary dispersion and personal exposure calculations performed for Krakow.

The Air Quality management system AirQUIS and the Urban exposure tool
The air quality management system applied to simulate outdoor concentrations in this study is the AirQUIS modelling system, developed at NILU (AirQUIS, 2006). AirQUIS is a GIS based integrated management system that includes a user interface, comprehensive measurement and emission inventory databases, dispersion and exposure models.

AirQUIS is composed of suite of models, the diagnostic wind field model MATHEW (Sherman, 1978; Foster et al., 1995) and the EPISODE dispersion model (Slørdal et al., 2003). This dispersion model contains a Eulerian model with embedded sub-grid line source and point source models for calculating ambient concentrations.

Exposure model calculation for Krakow will be performed using a comprehensive computer tool for calculation of personal exposure to particulate matter in indoor and outdoor environments. This tool was developed during the EU-funded project "Integrated exposure management tool characterizing air pollution-relevant human exposure in urban environment", (Urban Exposure) (Fløisand, 2006, Laupsa and Fløisand, 2005) and was implemented within the AirQUIS system. Therefore, air concentrations of particulate matter and corresponding respiratory deposition in both indoors and outdoors environments can be generated for individuals moving along predefined daily routes using daily activity patterns. The ambient air concentrations are calculated using the AirQUIS dispersion model, the indoor concentration using an indoor model and the respiratory deposition using an inhalation model (Fløisand, 2006).

Calculation for Krakow:
The grid applied in the Krakow region is a 35 x 25 km grid, grid size 1 km, with 10 vertical levels ranging up to 2800 m. For the city of Krakow, MATHEW is used to generate winds fields and meteorological data, which are the necessary input to the dispersion model EPISODE in order to calculates ambient air concentration for Krakow. In the wind field modelling meteorological data from Krakow Czyzyny station is used as input. The emission inventory is obtained by the WP2 of the Krakow Integrated Project - from toxic emission to exposure and health effects for the Malopolska and Silesia region for the year 2002 (Fudala et, al., 2005). Background concentrations for the dispersion model are not available and are therefore not taken into account. Point sources outside the model area, however, have been included in the calculations to take into account contribution from point sources outside the model area. Calculations are carried out for a limited period during the heating season in 2005. The results are compared to concentration measurements made in Krakow city. The personal exposure calculations using the Urban Exposure tool are carried out for a limited number of persons participated in the measurement campaign carried out in 2005.

Preliminary results for ambient concentration distribution for PM and case studies of personal exposure calculation will be presented.

2 References

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3 Acknowledgements

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Werner Holländer at the Fraunhofer-Gesellschaft, Toxicology and Experimental Medicine for giving their permission using the Urban exposure tool.

Appendix A

Powerpoint presentation

Dispersion and exposure calculation using the Air Quality Management System AirQUIS

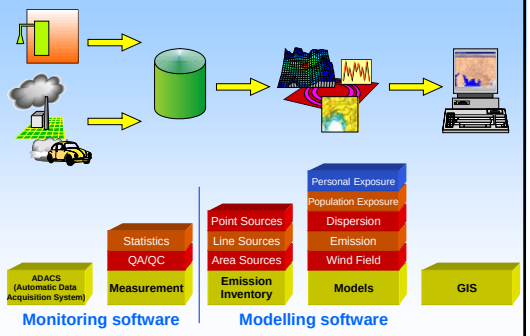
Case study for Krakow city

Herdis Laupsa, Robert Piatek,
Anna Glodek and Agnes Dudek

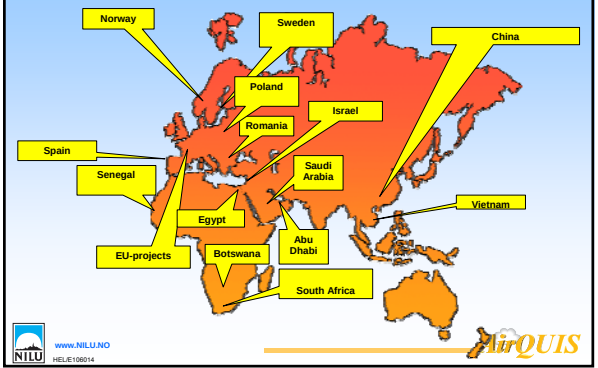
Outline

- The Air Quality Management System, AirQUIS
- Dispersion and personal exposure calculation for Krakow
- Presentation of results

The Air Quality Management System



AirQUIS Applications



What has been performed for Krakow

- Prepared an AirQUIS measurement and emission inventory database for Krakow
- Performed dispersion calculations for Krakow city for **PM_{10}**, **$PM_{2.5}$** and SO_2
- Performed personal exposure calculation for one individual
- Evaluation of the dispersion and exposure calculations

The dispersion calculations for Krakow

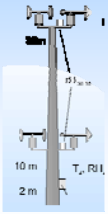
- The model calculation area is 35 km* 25 km, 1 km resolution and covers the city of Krakow.
- The vertical depth is 2800m.
- The dispersion results are evaluated against 4 stations:
  - Skawina,
  - Nowa Huta,
  - Krowodrza,
  - Aleja Krasinskiego

Emission calculations for Krakow

- Emission inventory for 2002
  - A complete emission inventory inside the grid
    - farming
    - other small residential
    - open burning of agriculture waste
    - off road
    - road transport
  - The point sources for the Malopolska region

Wind field modelling for Krakow

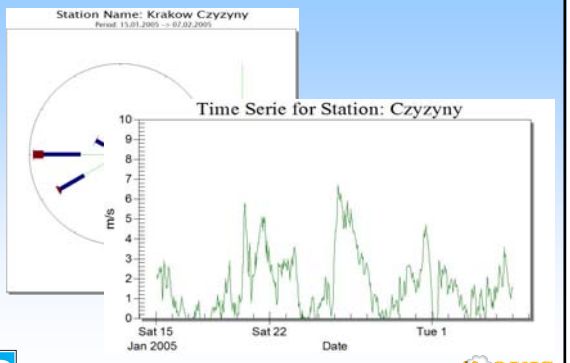
- Diagnostic mass consistent wind field model – Mathew
  - Metrological input data from Krakow Czyzyny
  - Meteorological parameters:
    - Wind speed and direction
    - Temperature
    - Stability (Pasquill)
  - Topography



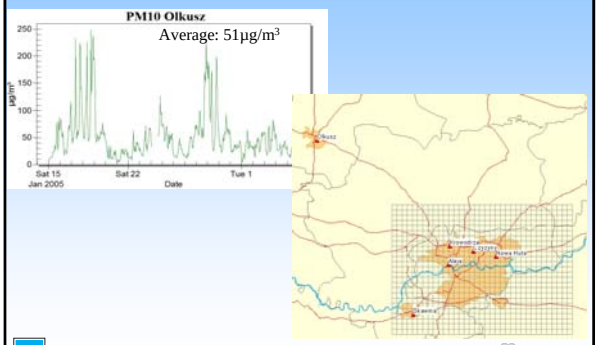
Dispersion modelling for Krakow

- Urban scale Eulerian grid model
  - sub-grid point source
  - sub-grid line sources
- Meteorological hourly gridded input data:
  - Wind field (u, v, w)
  - Temperature at ground level
  - Vertical temperature gradient (stability)
  - Mixing height
  - Turbulence (σ_v and σ_w)

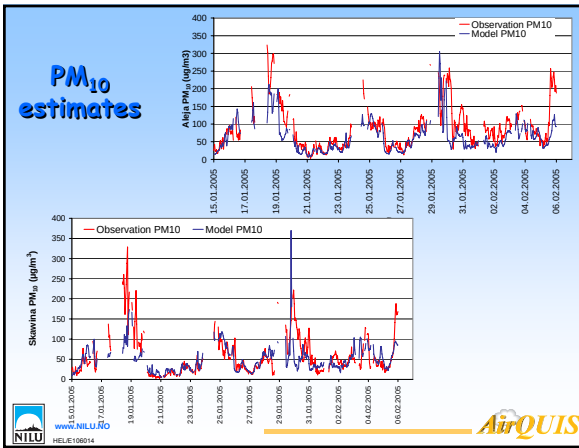
The meteorological conditions



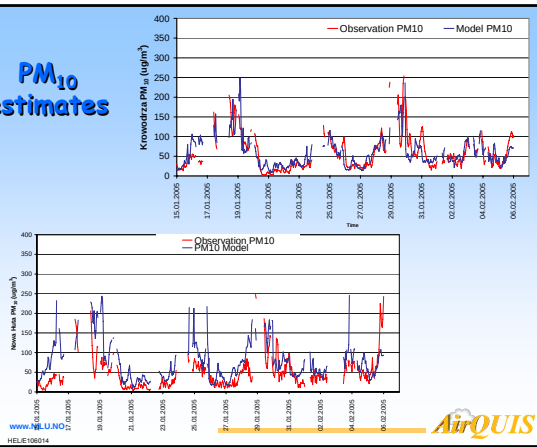
Boundary conditions



PM_{10} estimates



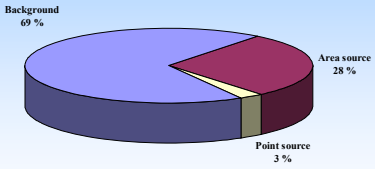
PM_{10} estimates



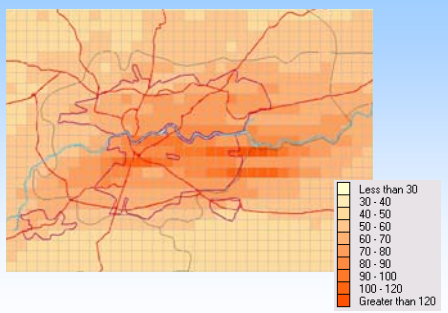
Statistics of the model results

	Aleja		Nowa Huta		Skawina		Krowodrza	
	Obs.	Model	Obs.	Model	Obs.	Model	Obs.	Model
Max	324.50	305.5	275.0	245.9	328.5	369.4	262.5	248.6
Average	88.84	63.1	49.0	76.2	58.0	49.3	57.5	58.4
Std.dev	63.65	43.7	42.8	48.9	51.7	33.1	46.1	38.3
Corr		0.68		0.59		0.61		0.73

Source contribution to the PM_{10} concentration in the dispersion calculations



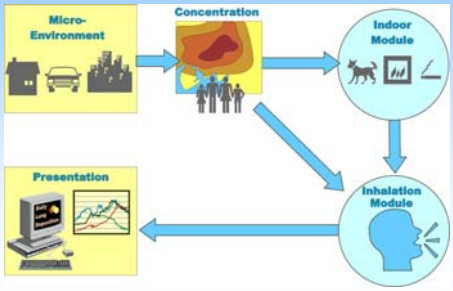
Average PM_{10} concentration field



Exposure estimates

- Population Exposure (Static)
  - static population distribution
  - home address
  - no daily activity pattern
  - outdoor concentrations
  - exposure according to guidelines
- Personal exposure (Dynamic)
  - Individual exposure calculations
  - daily activity pattern (Home, work, travel, leisure)
  - Indoor/outdoor concentrations

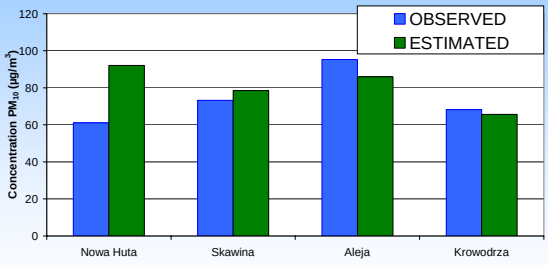
Personal exposure to particulate matter



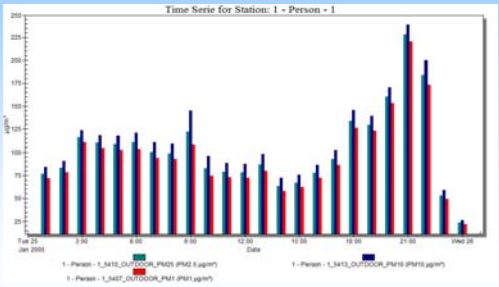
Personal exposure calculation in Krakow- living at house 7

HOUR	MICROENVIROMENT	ACTIVITY LEVEL
1	home	sleeping
2	home	sleeping
3	home	sleeping
4	home	sleeping
5	home	sleeping
6	home	sleeping
7	home	sleeping
8	home	Light Exercise
9	travel to	bus/walk
10	work	sitting
11	work	sitting
12	work	sitting
13	work	sitting
14	work	sitting
15	work	sitting
16	work	sitting
17	work	sitting
18	travel from	bus/walk
19	home	sitting
20	leisure	Light Exercise
21	leisure	Light Exercise
22	home	Light Exercise
23	home	sitting
24	home	Light Exercise

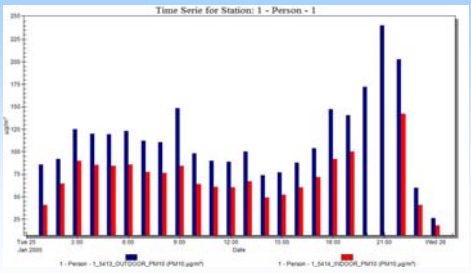
Daily values 25.01.2005



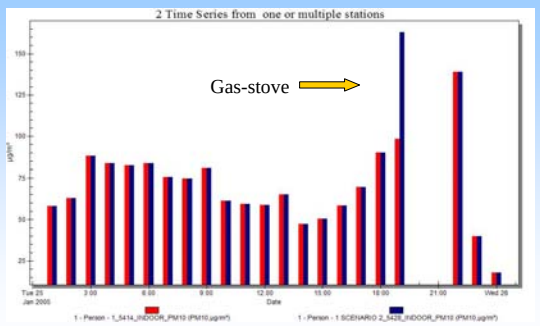
Outdoor concentrations
25.01.2005



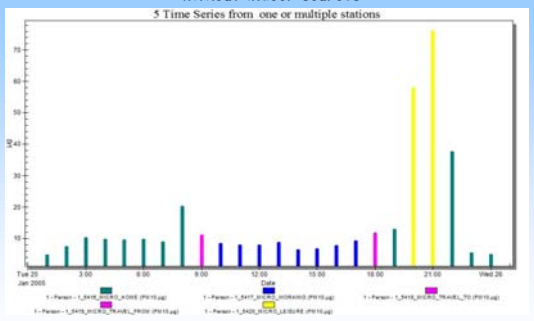
Indoor and outdoor concentrations
25.01.2005



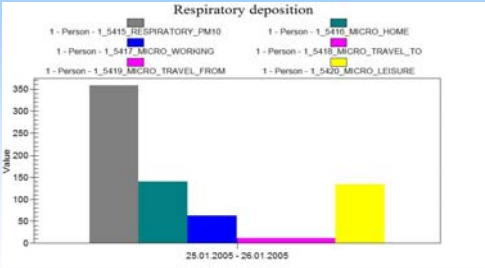
Indoor source



Respiratory deposition
without indoor sources

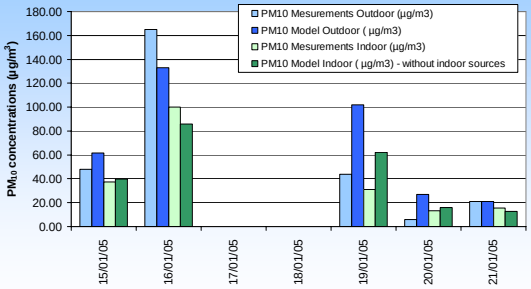


Aggregated deposition



Dose in micro environments

Measured and estimated indoor and outdoor PM_{10} concentrations-House 7



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