Summary Report
Enviro-HIRLAM
Research Training
(21-25 Mar 2011)

Enviro-HIRLAM Research Training
21-25 Mar 2011, Copenhagen, Denmark

Young scientists – Adomas Mažeikis (Nature Research Center, University of Vilnius; Vilnius, Lithuania) and Iratxe González-Aparicio (Tecnalia Research and Innovation; Bilbao, Spain) – had attended practical research training on the technical support, research and development topics of the Enviro-HIRLAM (Environment - HIgh Resolution Limited Area Model) in the Research Department of the Danish Meteorological Institute (RD DMI). The item of this visit was a joint work/ research/ discussions/ consulting/ co-advising/ etc. of young researches as well as preparation of practical exercises for the upcoming YSSS-2011 (3-9 Jul 2011, Odessa, Ukraine).

On 21, 23, and 25 Mar 2011, joint round-table discussions (on preparation of the AEROSOL "*The Impact of Aerosols Effects on Meteorology*" and URBAN "*The Influence of Metropolitan Areas on Meteorology*" exercises for the YSSS-2011 School) were organized. These included the following items outlined: General information on the exercise (as a small scale 1 week duration research project); Working schedule of the exercise; Introduction into exercise (required background discussions); Analysis of meteorological situations for selected cases/ dates; Technical aspects of modelling and aerosol and urban modules implementation; Model runs for selected dates; Visualization of results; Evaluation of aerosols and urbanization impacts on meteorology; and draft outlines of teams presentation. The revised student workbooks (to be used during the School) for both exercises are placed at the MUSCATEN-wiki website.

The DMI scientists – Ashraf Zakey, Roman Nuterman, Kristian P. Nielsen, Ulrik S. Korsholm, Bent H. Sass, Alexander Baklanov, Alexander Mahura; and the University of Copenhagen – Eigil Kaas – were involved into discussions on related research themes for the Enviro-HIRLAM. The relevant topics included general discussions on progress made so far by young researches, topics of the aerosols feedbacks implementation, chemistry schemes, urbanization aspects, visualization and analysis of results; tasks of further collaboration, and others.

On 25 Mar 2011, students have presented (followed by discussions) recent progress on research they have done so far:

- Adomas Mažeikis (PhD): "*Exchange of aerosols between surface water bodies and urban territories*";
- Iratxe González-Aparicio (PhD): "*Urban surface layer analysis for a megacity and a medium size city".*

The results of students' studies have been included into the MEGAPOLI NewsLetters:

- González-Aparicio I. (2010): *"Processing of Land-Use Database for Meso-Scale Model Urbanization". NewsLetter N9, Dec 2010; MEGAPOLI-NL09-10-12, p.9; http://megapoli.dmi.dk/nlet/MEGAPOLI_NewsLet09.pdf*
- Mazeikis A. (2011): Influence of Urban Territories on Meteorological Parameters: Vilnius Case Study". *NewsLetter N10, Mar 2011; MEGAPOLI-NL10-11-03, p.9; http://megapoli.dmi.dk/nlet/MEGAPOLI_NewsLet10.pdf*

The summary report by González-Aparicio et al. "*Land-use Database Processing Approach for Meso-Scale Urban NWP Model Initialization*" has been published as the DMI Scientific Report 10-02; 32p., ISBN: 978-87-7478-593-4; www.dmi.dk/dmi/sr10-02.pdf; and the poster presentation by González-Aparicio "*Urban scale modelling for a megacity and a medium size city: evaluating urban heat island and sulphate aerosol effects*" is scheduled for the up-coming EGU-2011 General Assembly (3-8 Apr 2011, Vienna, Austria).

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MUSCATEN – *Towards Multi-Scale Modelling of the Atmospheric Environment* (http://muscaten.ut.ee);
TECNALIA - Tecnalia Research and Innovation (Bilbao, Spain) (http://www.technalia.com);
FP7 EC MEGAPOLI – *Megacities: Emissions, urban, regional and Global Atmospheric POLlution and climate effects, and Integrated tools for assessment and mitigation* (http://megapoli.info).
CEEH – *Center for Environment, Energy, and Health* (http://ceeh.dk).

Processing of Land-Use Database for Meso-Scale Model Urbanization

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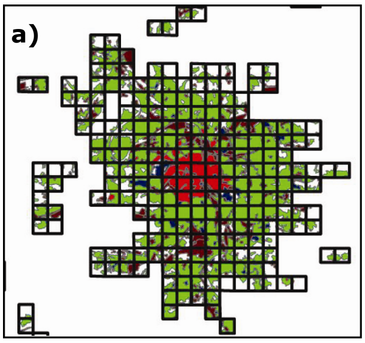
General Approach

This study is devoted to elaboration of general methodology for adjustment of original land-use dataset (CORINE Land Cover 2000; *CORINE, 2000*) for urban scale modelling in numerical weather prediction (NWP) and environmental applications. Three metropolitan areas – Paris (France), Copenhagen (Denmark), and Bilbao (Spain) – of different spatial sizes and population were considered. The CORINE and Basque Government land use (*UDALPLAN, 2009*) databases of different details and resolutions were selected. Several approaches were suggested for treatment of selected databases multilayer content using Geographical Information System (GIS) tools, depending on the data available in each case. It is applied to an operational online coupled numerical weather prediction and atmospheric chemical transport modelling system Enviro-HIRLAM (Environment-HIgh Resolution Limited Area Model; *Baklanov et al 2008; Korsholm, et al., 2009*). The interaction Soil-Biosphere-Atmosphere (ISBA) land surface scheme was modified to include urban effects using the Building Effect Parameterization (BEP, *Martilli et al., 2002*) module and Anthropogenic Heat Fluxes (AHF) extracted from LUCY model (which considers energy fluxes from traffic, metabolism and energy consumption. *Allen et al., 2010*).



The methodology is based on the extraction of the modelling domain from the Enviro-HIRLAM climate files. By processing the grid in GIS environment it was possible to convert the irregular grid points into irregular polygons. Then, they were integrated with the regional/European database and finally, performed the urban classification into different types of districts over the domain (Table 1).

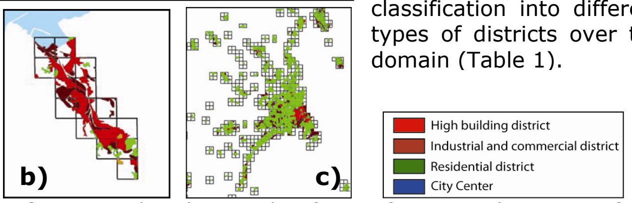


Figure 1*: Urban districts classification for metropolitan areas of: (a) Paris, (b) Bilbao, and (c) Copenhagen.*

The districts were divided according to a few specific thermo-dynamical characteristics (height of buildings, street width, wall building temperature, specific heat, etc.l *Mahura et al., 2010*). Figure 1 shows the urban classification for the three cities: high building, Industrial and commercial, residential and city centre.

Metropolitan area	Res. (km)	Total grid points	Urban grid points	Metrop. grids	Area Covered (km^2)
Bilbao	2.4x2.4	14834	68	16	92.16
Paris	2.5x2.5	10148	580	220	1267.2
Copenhagen	1.4x1.4	65022	3080	500	980

Table 1*: Information of the climate files extracted from Enviro-HIRLAM to be processed in GIS tools for the three cities studied.*

High resolution short-term runs (2.4 km) for specific dates (summer 2009 and winter 2010) with variable wind conditions were performed for the Bilbao metropolitan area, based on different urban scenarios generated by means of this approach. Several scenarios were generated with AHF= 40 W/m^2 modifying the size of the city: firstly, the area considered in CORINE 2000 (16 urban grids); then the double size city expansion (30 urban grids) and the triple size city expansion (48 urban grids). Other scenario considers an increased of AHF in double (80 W/m^2) with the original size of the city (16 urban grids). The last scenario combined the triple size city expansion (48 urban grids) plus the increased AHF in double (80 W/m^2). The goal was to evaluate the urbanized (with BEP module and AHF) Enviro-HIRLAM and to estimate the influence of the city on formation of the air temperature at 2 m and wind velocity at 10 m. Three nested domains were selected with spatial grid resolution of 15, 5 and 2.4 km which contain 154x148, 130x100, and 130x116 cells, respectively. There were performed two simulations for each urban scenario: 1) control runs, without any modifications and 2) urban runs including BEP+AHF within the corresponding modification for scenarios.

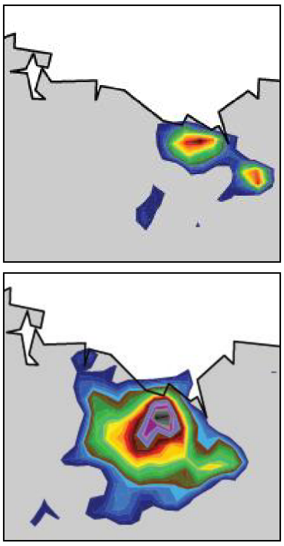
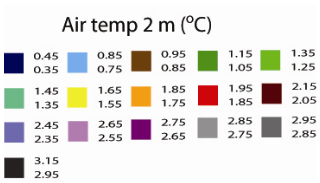


Figure 2: *Difference plots between outputs of the urbanized ENVIRO-HIRLAM (BEP module and AHF fluxes modified in the ISBA land surface scheme) and control runs for the air temperature at 2 m on 12th Aug 2009 at 6:00 am for urban area as (a) considered in CORINE (i.e. 16 urban grids) and AHF=40 W/m^2; and (b) based on triple size city expansion (48 urban grids) and double AHF=80 W/m^2).*



As it was found, for the urban area considered with 16 urban cells and AHF=40 W/m^2, on average, for air temperature at 2 m the difference was 1.3ºC between 3-6 UTC (with a maximum of 1.9ºC at 6 UTC) (Fig. 2a). For wind velocity at 10 m the difference was 1 m/s between 3-6 UTC (with a maximum of 1.5 m/s at 6 UTC). However, for the scenario combining triple size city expansion and double increased in AHF, on average, for temperature at 2 m the difference was 1.8 ºC between 3-6 UTC (with a maximum of 3.15ºC at 6 UTC) (Fig. 2b). For wind at 10 m the difference was 1.9 m/s between 3-6 UTC (with a maximum of 2.9 m/s at 6 UTC).

Acknowledgements

Thanks to Dr. M. Mendizabal for the constructive discussions related to GIS processing.

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Influence of Urban Territories on Meteorological Parameters: Vilnius Case Study

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The surface of urban areas differs from other territories in many parameters. These differences impact the boundary layer meteorological parameters which are especially important for dispersion of air pollutants. This study concentrates on main meteorological parameters (which are important for air pollution dispersion processes) sensitivity to urban areas surface parameters such as albedo, surface roughness and anthropogenic heat flux. The Vilnius agglomeration was selected because it is the largest urban area in Lithuania. The cases when air pollution dispersion conditions are good (i.e. high speed winds), poor (i.e. calm conditions), quick removal (i.e. heavy precipitation), and long stay in boundary layer (i.e. stable stratification of the atmosphere) are of importance in this study.

Methodology

The research version of numeric weather prediction (NWP) model Enviro-HIRLAM (*Korsholm et al., 2008*) was used in this study. The aerosol module was switched off to exclude the aerosols' effects on meteorological fields. Different modeling domains were selected with the Vilnius urban area in the center of domain areas): LT1 (250 x 150 grids along longitude x latitude, and 1.4 x 1.4 km resolution) and LT3 (298 x 220 grids along longitude x latitude, and 2 x 2 km resolution). The NWP urbanization included modifications (in the ISBA surface scheme; *Noilhan & Mahfouf, 1996*) of roughness, albedo and anthropogenic heat flux only for grid cells having non-zero urban fractions. Note that all modified runs had same settings for roughness (2 m) and albedo (0.15).

Results and analysis

Two fields: air temperature at 2 m (Fig. 1) and wind speed at 10 m were compared and differences between control and modified runs had been estimated. The provided graphs (Figs. 2-3; see Tab. 1) illustrate the difference in temperature and wind speed at the urban grid cell of Vilnius city (measurement station is placed in the Žvėrynas urban district) where the urban fraction was the highest. Due to anthropogenic heat flux (AHF) the air temperature can increase, due to higher roughness the wind speed can become low. Even a small change in wind speed could lead to large changes in concentrations of air pollutants, and temperature changes might led also to changes in chemistry.

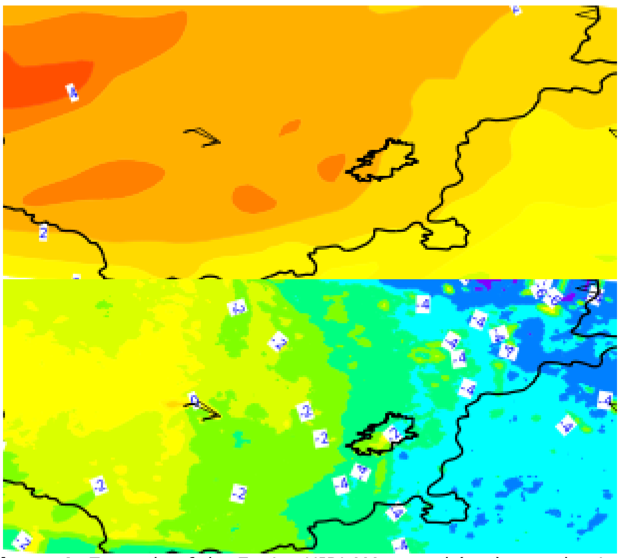

Figure 1: ***E****xample of the Enviro-HIRLAM control (top) vs. urbanized (bottom) run: air temperature at 2 m at 17 UTC on 29 Jan 2009.*

Table 1: *Definition of computed experiments.*

Case	Date	Domain	Modifications
LT1-0129C	2009 - 01.29	LT1	None
LT1-0129I			AHF 100W/m^2
LT1-0129II			AHF 200W/m^2
LT3-0314C	2009 - 03.14	LT3	None
LT3-0314I			AHF 100W/m^2
LT3-0314II			AHF 200W/m^2
LT3-0623C	2009 – 06.23		None
LT3-0623I			AHF 100W/m^2
LT3-0623II			AHF 200W/m^2

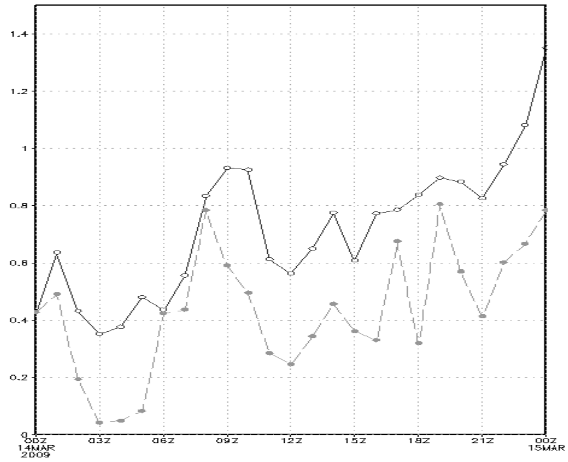

Figure 2: *Temperature at 2 m difference (vertical axis, °C) between control and modified runs /solid line – LT3-0314II run and dashed line - LT3-0314I run/.*

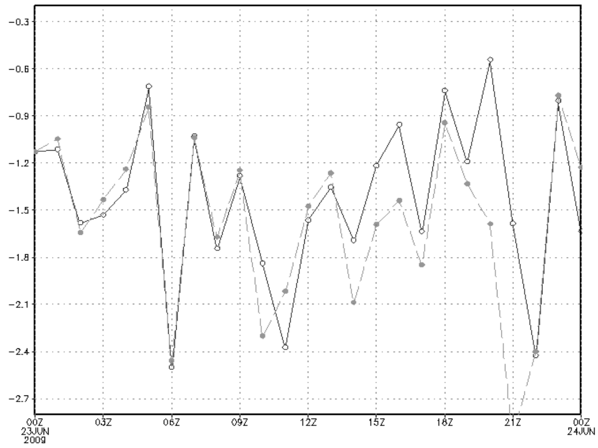

Figure 3: *Wind speed at 10 m difference (vertical axis, m/s) between control and modified runs /solid line – LT3-0623II run and dashed line - LT3-0623I run/.*

Conclusions

- The modifications of the surface parameters within the urban territories, such as the Vilnuis metropolitan area, have impact on formation of meteorological fields that affect air pollution dispersion.
- The temperature at 2 m height is typically higher in urbanized simulation runs.
- The difference in wind speed between two types of runs can be up to 2.7 m/s.
- The impact of urban territories in simulations is of more local scale, i.e. up to 2.8 km from heavily urbanized territories and up to 40 m in height.
- To study the sensitivity of meteorological fields to modifications of every single surface parameter a more detailed study should be carried out. The effect of simultaneously combined modifications can give different feedback (positive/ negative) depending on dominating influence mechanisms.

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