Possible modification of the Enviro-HIRLAM NWP model to include urbanization effects for Saint-Petersburg

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Abstract.

A city can strongly modify the structure of Atmospheric Boundary Layer. The urban areas have significant influence on the meteorological processes and atmospheric flow, its turbulence regime, the microclimate, and, accordingly, modify the transport, dispersion, and deposition of atmospheric pollutions within these areas. The urban effects must be parameterized in a grid cell of about 1 km. Experimental studies have shown that parameterizations usually applied over smoother surfaces are not valid for urban areas. As a consequence, numerical models often experience problems in reproducing pollution concentrations in cities at ground level where people live. At the current moment the urban classes and urban scale parameterization are not well represented in the Numerical Weather Prediction (NWP) models. Due to a high resolution of modern NWP models, reaching the city scale, the improvements of existing parameterizations of urban atmospheric processes and urban physiographic data classifications became needed.

Main Aim

• The aim of study is to evaluate effects of urbanization of NWP model on simulated meteorological and pollution patterns over the urbanized areas and surroundings on example of Saint-Petersburg metropolitan area.

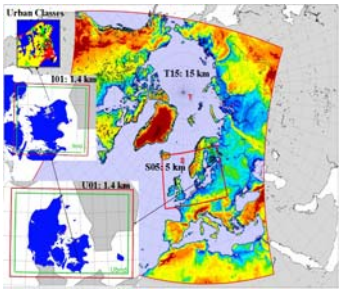
Specific Objectives

• To investigate the Enviro-HIRLAM model with different parameters.

• To evaluate the diurnal cycle variability of meteorological parameters comparing two types of runs: with anthropogenic activity influence and without it.

• To estimate the impact of the metropolitan area on meteorological fields and, thus, the weather.

NWP Model and MeteoData



NWP model consists of two nested models: DMI–HIRLAM–T15 and –S05. These two models are identical, except for horizontal resolution (15 vs. 5 km) and geographical boundaries of domains. Both versions have 40 vertical layers. The current operational forecasting model includes a digital filtering initialization, semi-Lagrangian advection scheme, and a set of physical parameterizations. A numerical weather prediction system consists of pre-processing, climate file generation, data-assimilation and analysis, initialization, post-processing and verification

References

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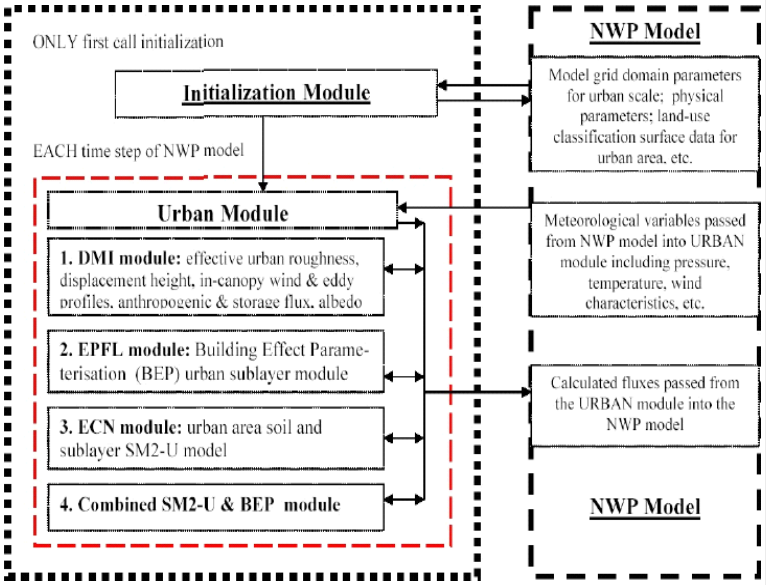
Mahura A., Petersen C., Baklanov A., B. Amstrup, U.S. Korsholm, K. Sattler, 2007: Verification of long-term DMI–HIRLAM NWP model runs using urbanization and building effect parameterization modules. Manuscript submitted to the HIRLAM Newsletters, 12p.

General scheme of the FUMAPEX urban module for NWP models



Urban Module

1. Anthropogenic Heat flux & Roughness (AHF + R)

This module includes modifications of the land surface scheme (ISBA) for anthropogenic heat flux (ranging from 10 up to 200 W/m^2) and roughness characteristics for urban areas and varying depending on the fraction of the urban class presented in grid cells of modeling remain.

2. Building Effect Parameterization (BEP)

This model includes the urban sub-layer parameterization suggested by Martilli et. al. (2002) and it is aimed at simulating the effects of buildings on a mesoscale atmospheric flow taking in to account main characteristics of the urban environment (i) the vertical and horizontal surfaces (wall, canyon floor and roofs), (ii) the shadowing and radiative trapping effects of the buildings, (iii) the anthropogenic heat fluxes through the buildings wall and roof.

3. Soil model for Sub-Meso scales Urban (SM2-U)

This model is composed with 3 soil layers and a canopy layer where: (i) 7 types of covers/surfaces are defined by their characteristics and surface density; (ii) radiation reflection and water runoff from saturated surfaces are considered; (iii) deep soil temperature and water content remain constant during a particular day; (iv) for buildings and water surfaces temperature evolution a conduction equation is used; (v) radiative trapping inside street canyon is parameterized by an effective albedo of street; (vi) surface dynamical influence is represented through roughness lengths and displacement heights; (vii) energy and water budgets are performed for each type of surface in order to deduce the heat and moisture fluxes to be set at the interface between canopy and atmosphere. A detailed description is given by Dupont et al., 2004, 2006.

4. Combined module

This includes all non-overlapping mechanisms from the SM2-U and BEP models. It was used in MM5 and applied to Paris by CORIA.

Future plans

• To choose 4 days: one per season.

• To analyze data from city station and suburb station (Saint-Petersburg and Vsevolozsk, correspondly) at selected days.

• To modify some features of Enviro-HIRLAM Urban Module , and to do numerical simulations with taking into account specific characteristics of urban areas: traffic jump, time peak, vacation and weekend time.

• To evaluate thermal effects of urban areas on meteorological parameters, namely: latent and sensible heat fluxes, temperature.

• To try to make suggestions about interaction of dynamical and thermal effects of urban areas.

• To compare simulated results from two meteorological stations between themselves and also with control runs.

• To do data statistical analysis and to estimate errors and extreme values.

Applicability of Results

• Testing and verification of numerical weather prediction and climate models performance over high resolution model domains, and especially over the urbanized areas;

• Investigation of temporal and spatial variability of various meteorological and derived variables over urbanized areas;

• Improvements in land use classification and climate generation properties;

• Distinguishing and selection of types of urban districts and their properties;

• Urbanization of climate regional and global models.