WP6 "Wind Energy and Atmospheric Quality Studies in Bulgaria using extensive multi-scale simulations"

1. Major Activities and Results

Task 6.1: Modelling System for Emergency Response to the Release of Harmful Substances in the Atmosphere. An approach, which includes joint use of resistance law (RL-method) – PBL – and none-Gaussian PlumeMM diffusion model, coordinated with the statistical moments method, is developed in the present work. The influence of a wide range of turbulent regimes, parameterized in similarity format, on the basic diffusion parameters has been studied. Cases over rural, as well as over urban areas have been considered. A modified RL-method version, applying the effective characteristics (roughness length, etc.) concept has been used for urban cases.

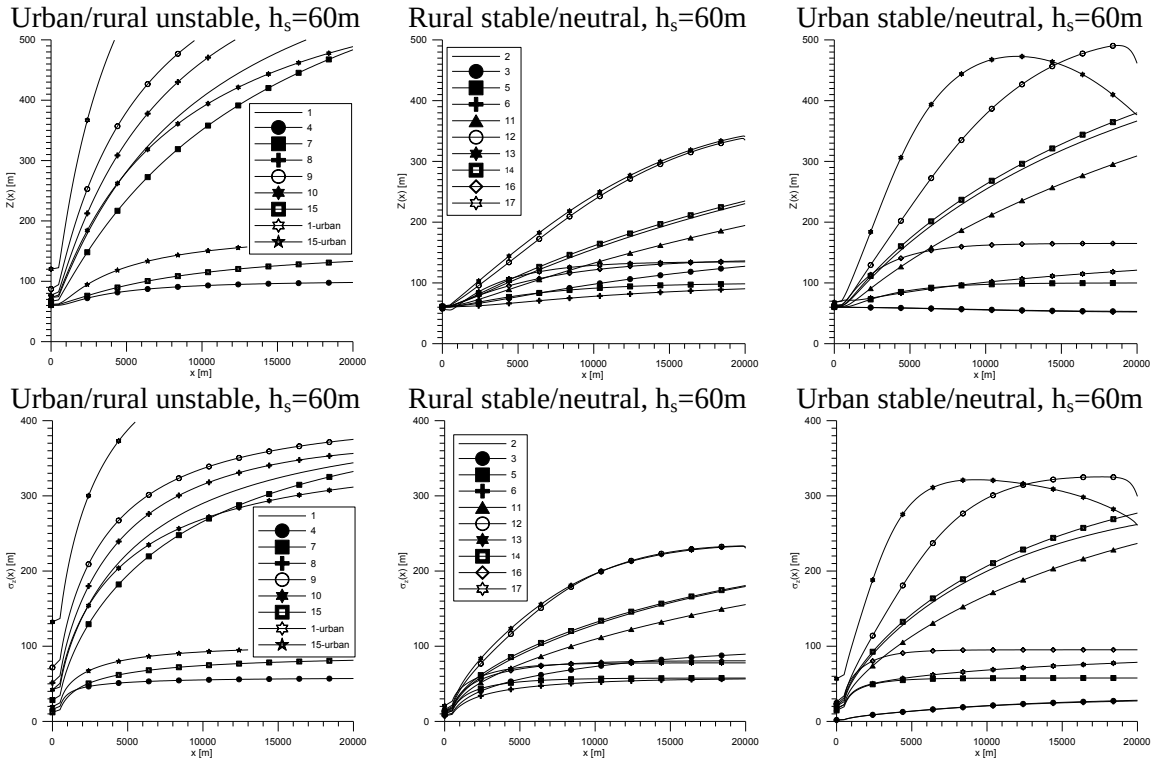

Fig. 1. Comparison of $\sigma_z(x)$ and Z(x) for urban and rural conditions at different turbulent regimes.

The basic goal of the study is to carry out comparative analysis of the following diffusion characteristics: trajectories, vertical and horizontal dispersion, as well as higher order statistical moments like skewness and kurtosis, over rural and urban areas. Special attention is paid to the last two characteristics. From general statistical-probabilistic considerations Kendal and Stuart show that there is quadratic relation between them, which is confirmed for some conditions in the atmosphere. This problem is in particular studied for widely extended range of the turbulent regimes at stable-neutral-unstable conditions in PBL.

It has been qualitatively studied to what extend such a quadratic relation is valid, as well as the skewness and kurtosis behavior for these conditions.

The bulk Richardson number method (Rb-method) is extended and modified for the purpose of parameterization over urban areas. The urban roughness sub-layer height is chosen as reference height, above which the influence of urban heterogeneities is negligible and the MO-similarity theory is valid. At that the displacement height concept is applied and effective aerodynamic and temperature roughness parameters and other surface parameters are introduced (by using simple weighted averaging procedure). In that way effective integral Richardson number in urban roughness sub-layer is defined and the Rb-method is modified.

Two problems are treated on this basis:

a) determining of the dependence of urban roughness layer drag and heat transfer coefficients and modified Obukhovs length on stratification for different heights of the urban elements,

b) study of the sensitivity of the above parameters with respect to the significant difference between roughness parameters for momentum and temperature, typical for urban areas.

The considered effects are significant, compared to the rural area. This is a reason why the presented approach could be recommended for parameterization of dynamic and diffusion processes over urban area.

The suggested methodology makes possible the detailed study of the influence of wind sheer and rotation, roughness, stratification, inversions, baroclinicity, terrain slope, etc., in a similarity format, on the basic pollution characteristics – trajectories, dispersions, concentration and concentration field shape – skewness, kurtosis, etc. The approach can be used for applied tasks including estimation of extreme and critical pollution parameters, regulatory procedures and optimization, sub-grid parameterization procedures, etc., which would be necessary in order to downscale the risk analysis and fast decision modes of the system to finer resolution at urban scales.

The team working on this task includes A. Brandiyska, K. Ganev, and G. Gadjhev. Some of the obtained results are published in [SG_13a, SG_13b]

***Task 6.2*: Multi-scale atmospheric composition modelling.** The aim of this task is to use the Grid environment to produce an integrated, multi-scale Balkan region oriented modelling system, able to interface the scales of the problem from emissions on the urban scale to their transport and transformation on the local and regional scales. The major activities, carried out at this stage of the task development are the following:

a) participation in the AQ model Inter-comparison exercise AQMEII-p2: AQMEII (***Air Quality Modelling Evaluation International Initiative***) aims at promoting research on regional air quality model evaluation across the European and North American atmospheric modelling communities. It is coordinated by two chairs, one for North America and the other for Europe. It is supported by the Joint Research Centre/IES, Environment Canada and US-EPA that act as regional focal points. The objectives of AQMEII are:

- exchanging expert knowledge in regional air quality modelling
- identifying knowledge gaps in air quality science,
- developing methodologies to evaluate uncertainties,
- building a common strategy on model development and future research priorities,
- establishing methodologies for model evaluation to increase knowledge on processes and to support the use of models for policy development,
- preparing coordinated research projects and inter-comparison exercises.

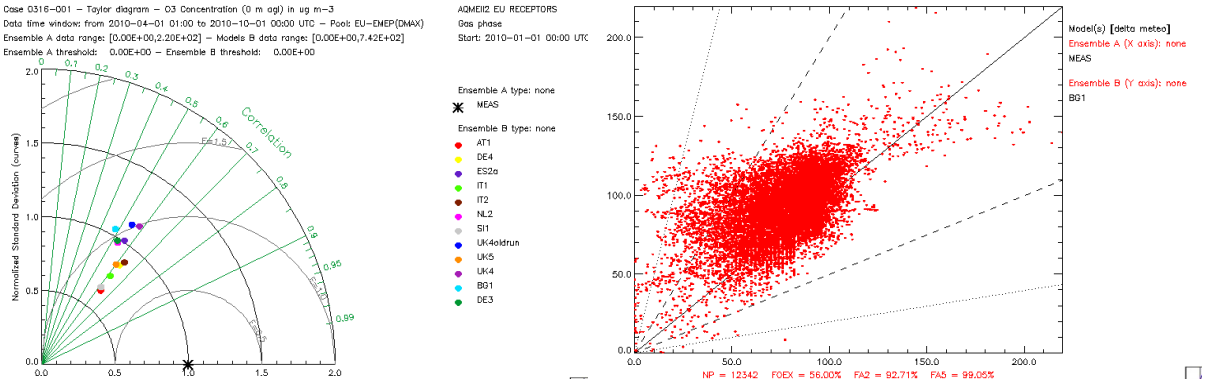

Fig. 2. Comparison of ozone daily maxima with measurements

As to make all model results available to all groups, it is decided to use the ENSEMBLE system for data archival and consultation. The system is a web-based platform for model intercomparison and multi-model ensemble analysis with many built-in on-line statistics and graphical tools. The ENSEMBLE system accepts data in a customized format. Participating groups convert their data in the required format and deliver it to JRC via FTP. Technical Specification Documents (TDSs) are distributed with detailed instructions.

An example of some results of the Bulgarian group are given in Fig. 2.

b) calculation of different air quality indices: The already constructed ensemble of computer simulated surface ozone concentrations is used for calculating indices, which evaluate the ozone pollution impact on human health and ecosystems:

AOT40C/F - Accumulated over threshold of 40 ppb in the day-time hours during the period from May 1 to July 31 concentrations, which are damaging ***crops*** when they exceed 3000 ppb.hours and for ***forests*** (during the period from April 1 to September 30) , which are damaging ***crops*** when they exceed 10000 ppb.hours.

NOD60 - Number of days in which the running 8-hour average over ozone concentration exceeds at least once the critical value of 60 ppb. If the limit of 60 ppb is exceeded in at least one 8-hour period during a given day, then the day must be classified as "bad". People with asthmatic diseases have difficulties in "bad" days.

Examples of these indices are given in Fig. 3.

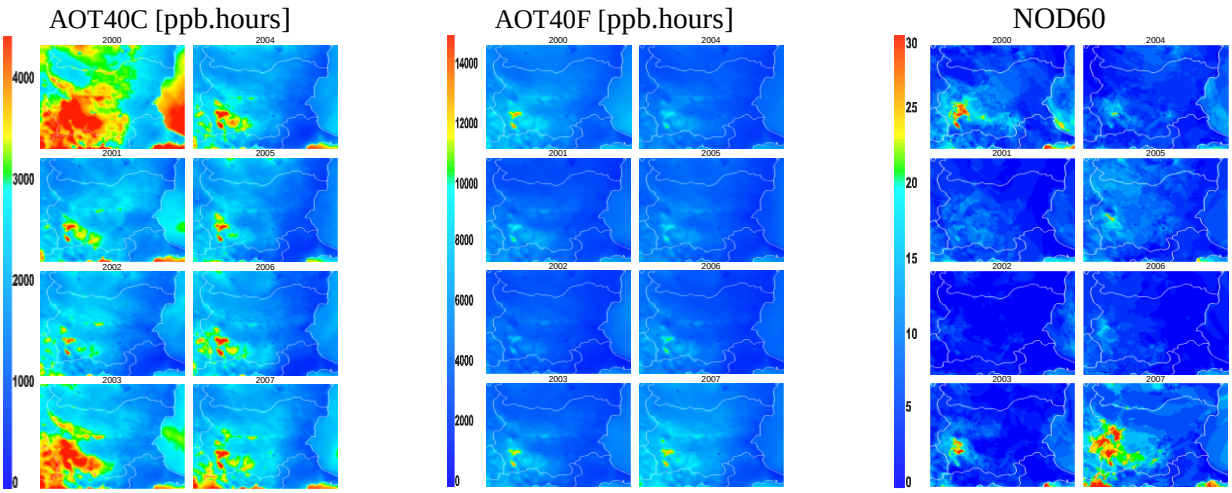

Fig. 3. Plots of AOT40C, AOT40F and NOD60 for years 2000-2007

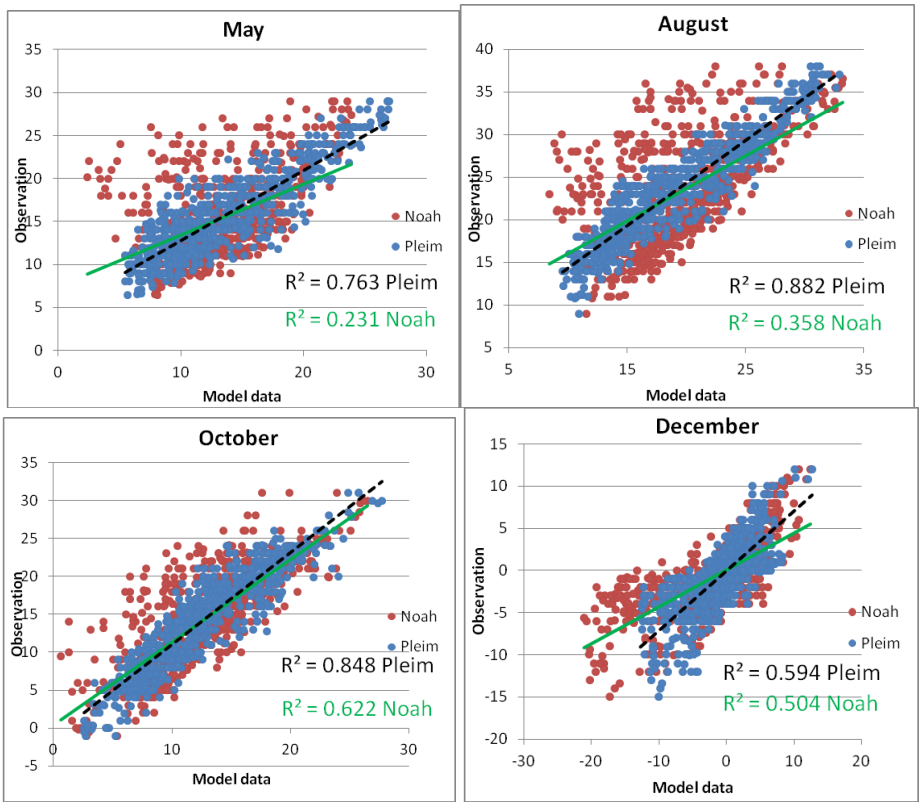

Fig. 4. Scatter diagrams of simulated vs measured surface temperature for Noah-MP, Pleim Xiu models

c) model set-up and numerical experiments for urban scales: The WRF model was configured for carrying out computer simulations for the region of Sofia with 1 1km horizontal resolution. Numerical simulations were carried out for comparison of two land surface models - Noah-MP, Pleim Xiu. Noah-MP is the more complex of the models which includes additional options for surface description: several options for vegetation, snow cover, MODIS lakes, frozen soil scheme, separate vegetation canopy, evaporation in different parts of plants , etc. In comparison, Plame is quite simple model, which also includes enough options: surface flow soil moisture , temperature, delay and more.

The comparison of the model results (Fig. 4) shows, however that in this case the model Pleim performs definitely better.

The team working on this task includes G. Gadzhev, D. Syrakov, K. Ganev, I. Ivanova and V. Ivanov. Some of the obtained results are published in [GGMSP_13a - GGMSP_13e, GGPSM_13].

***Task 6.3*: Study of the renewable energy sources potential in Bulgaria.** 8 year simulations for the territory of Bulgaria with a more coarse resolution (3 km) are already completed.This data will show the average wind speed on different heights above the ground, also the calculated wind energy taking into account the pressure, temperature and moisture. Auxiliary software was created, which can be used for retrieving the necessary information from the data set. This information could be presented on maps, or wind distribution plots (see Fig. 5) and it will be easy to interpret for the needs of development and choosing a proper site for wind turbines installment. The group working on this task includes G. J. Georgiev, K. Ganev, G. Gadzhev and V. Ivanov. Some of the obtained results are published in [JGGMSP_12, JGGMSP_13]

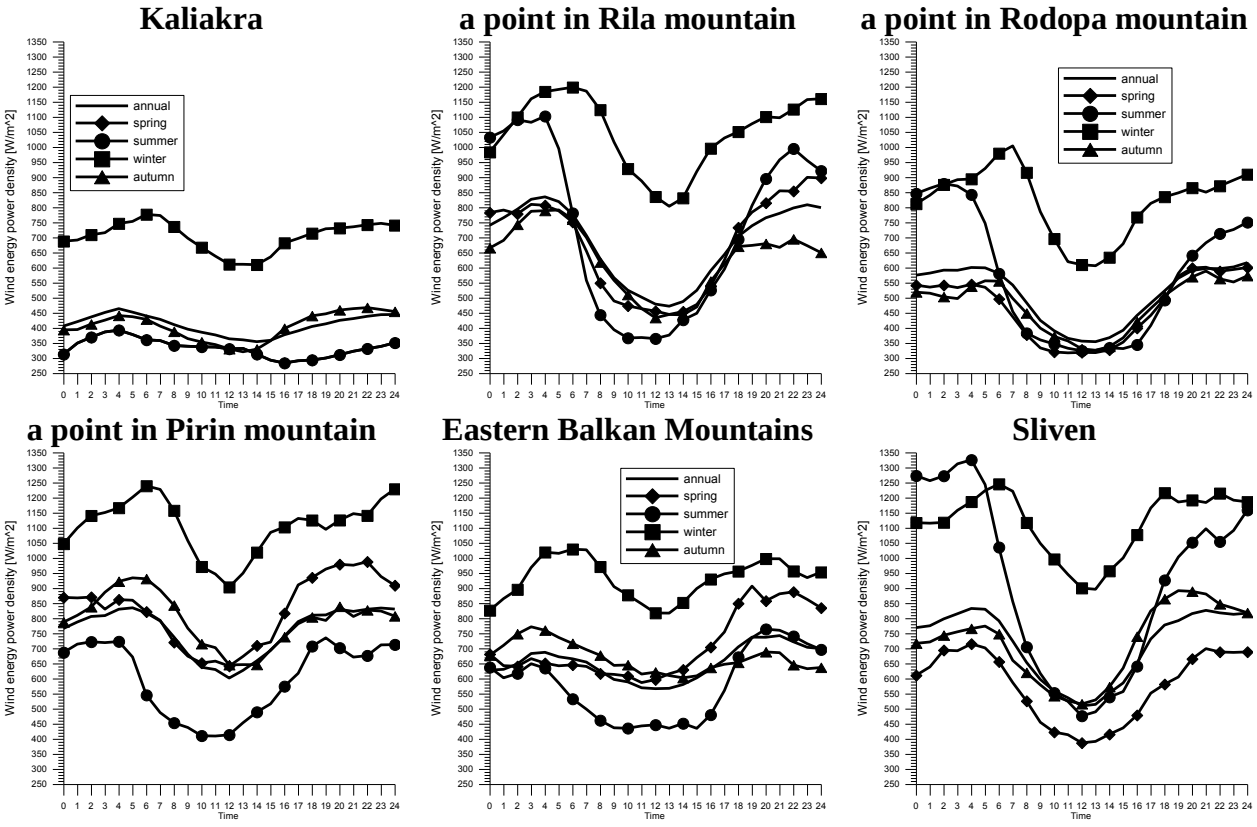

Fig. 5. Diurnal course of the wind power density [W/m^2] for several points in Bulgaria, averaged annually and for the four seasons

2. Publications with acknowledgements to the project ДЦВП-02/1/29.12.2009

a) published:

[JGGMSP_12] G. Jordanov, G. Gadzhev, K. Ganev, N. Miloshev, D. Syrakov, M. Prodanova, (2012) Numerical study of the wind energy potential in Bulgaria – some preliminary results, AIP Conf. Proc. 1487, 71; doi: 10.1063/1.4758943, 71-78

[GGMSP_13a] G. Gadzhev, K. Ganev, N. Miloshev, D. Syrakov, M. Prodanova (2013) Numerical study of the atmospheric composition in Bulgaria, Computers and Mathematics with Applications 65, doi:10.1016/j.camwa.2012.07.002, 402–422

[GGPSM_13] G. Gadzhev, K. Ganev, M. Prodanova, D. Syrakov, N. Miloshev (2013) Some statistical evaluations of numerically obtained atmospheric composition fields in Bulgaria, Proceedings of the 15th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, ISBN 978-84-695-7353-5, 373-377

[SG_13a] E. Syrakov, K.Ganev (2013) Extension and modification of the bulk Rrichardson number method for parameterization of exchange and interaction processes over urban areas, Proceedings of the 15th International Conference on Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes, ISBN 978-84-695-7353-5, 539-542

[GGMSP_13b]G. Gadzhev, K. Ganev, N. Miloshev, D. Syrakov, M. Prodanova (2013) Numerical study of the atmospheric composition climate in Bulgaria, Ecology & Safety, Volume 7, ISSN 1313-2563, 63-82

б) accepted:

[GGMSP_13c] G. Gadzhev, K. Ganev, N. Miloshev, D. Syrakov, M. Prodanova (2013) Analysis of the Processes which Form the Air Pollution Pattern Over Bulgaria, Proceedings of the 9th International Conference on "Large-Scale Scientific Computations", June 3 - 7, 2013, Sozopol, BULGARIA

[GGMSP_13d] G. Gadzhev, K. Ganev, N. Miloshev, D. Syrakov, M. Prodanova (2013) Some Basic Facts About the Atmospheric Composition in Bulgaria –Grid Computing Simulations, Proceedings of the 9th International Conference on "Large-Scale Scientific Computations", June 3 - 7, 2013, Sozopol, BULGARIA

[GGMSP_13e] G. Gadzhev, K. Ganev, N. Miloshev, D. Syrakov, M. Prodanova (2013) Numerical study of the atmospheric composition climate of Bulgaria, II Conferense in physical sciences, Sofia, Bulgaria

[JGGMSP_13] G. Jordanov, G. Gadzhev, K. Ganev, N. Miloshev, D. Syrakov, M. Prodanova (2013) Numerical study of the wind energy potential in Bulgaria, II Conferense in physical sciences, Sofia, Bulgaria

в) submitted:

[SG_13b] E. Syrakov, K.Ganev (2013)Extension and modification of the bulk Richardson number method for parameterization of exchange and interaction processes over urban areas (submitted to International Journal of Environment and pollution, ISSN: 0957-4352)

г) in preparation:

PhD thesis of G. Gadzhev

3. Presentations and talks

4. Others