7.17 STATISTICAL PERFORMANCE OF TWO DISPERSION MODELS(OML AND ADMS) FOR MEASUREMENTS OBTAINED IN A LIFE PILOT STUDY-ASSESEMENT SYSTEM FOR URBAN ENVIRONMENT(ASSURE)

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INTRODUCTION

In the first section of this paper a new technical method of evaluation of the environmental impact caused by urban land-use planning is presented. The methodology regards impacts in the air quality as well as impacts on surface and underground water.
The ASURE Project, financed by the European Commission, have had the following main objectives:
- to implement a demonstrative numerical system for integrated assessment of probable pollution in urban environment, pollution caused by implementation of urbanistic development;
- to demonstrate the capabilities for modelling of the environmental parameters in air, surface and underground water for the local authorities;
- the first attempt to develop an integrated Open-GIS-on-line allowing remote operation of the system, in the benefit of the local authorities;
- daily forecast of air pollution, pollution caused by the main metallurgical industries in the area of Baia Mare.

The Life ASSURE Project relies on the Open-GIS system and on dispersion models for estimation of pollution levels in all three domains: air, surface water and underground water. In successfully implementing the Project, top IT technologies have been used: Geographical Information Systems (GIS), Open Geographical Information Systems (Open -GIS), Compute Aided Design (CAD), Global Positioning Systems (GPS), Object Oriented Programming (O-O Programming), CAD Programming, WEB-GIS-programming in vector and raster GIS environments.
In the first section of the paper, the Open-GIS-on-line system which is implementing an Internet computing environment is described. The system contains and is able to use deterministic models: digital terrain model, surface water pollution model, underground vulnerability model and air pollution dispersion and transport models as well as pollutant direct/backward trajectory models. The whole system incorporates three main modules (or sub-systems) for pollution assessment: atmosphere, surface water and underground water all interacting through the Open GIS-on-line (operable in the Internet) integrator system. Starting from it the user is be able to use special environmental functions as to:- visualize, optionally separate, model results; - optionally dispose of any post-processed diagnostic index, mean /daily pollutant trajectories; - dispose of the integrated system of cumulated impacts as tool for an optimal decision choice for a given event of land-use design; - is able to include designed data into an Expert system for an objective decision indicator.

In the second section of this paper the daily mean air concentrations of SO_2 calculated with OML and ADMS dispersion models are compared with measurement made in a point from Baia Mare city for a three months interval. The statistical performance of the mentioned dispersion models and the conclusions concerning the way in which the integrated system developed in this project can be used by the local authorities are presented.

Part1: Description of technical/methodological solution; Role of OpenGIS technologies in the implementation

One of the main achievements of the ASSURE Project consists in developing and implementing an **integrated computerized environmental protective system**, a tool able to assess for urbanistic planned land-use triggered environmental impacts concerning: atmosphere, surface water and underground water pollution.

At the final phase of the Project, the system has been developed in all of it's components, such as: Knowledge Database; Digital georeferenced GIS-based databases; User input interface in GIS environment; Environmental protection models development; Models interface with GIS (air, surface water and underground water); System functioning automation; Output georeferenced for user analysis; Open-GIS on-line available to users with impact assessment on air pollutant, surface water pollutant, underground water pollution.

The proposed system aims at concurrent description of the environmental parameters on air and water at the town scale and beyond, in it's peri-urban areas. The project is designed as a pilot system on behalf of Baia Mare City Council, a town which has one of the largest and broadest industrial display of activities, with emphasize on overlapping of environmental impacts. For that reason, the most suitable tool for the assessment, is the Open-GIS technology, as the cutting edge of the GIS methodologies for environmental impact assessment.

The methodology for system integration: Open-GIS - as an integration tool for the system.

The Open-GIS environment ensures the easy access to a various types of formats used by the land-use designers operating at the urbanistic bureaus . Thus, in the case of the Baia Mare City Hall urbanistic bureau, Autodesk is the deployment tool for the land-use planning. Using an Open-GIS tool (such as Intergraph's GeoMedia Open-GIS) offers the open architecture environment in order to allow georeferenced input from the urbanistic bureaus, to the environmental modeling.

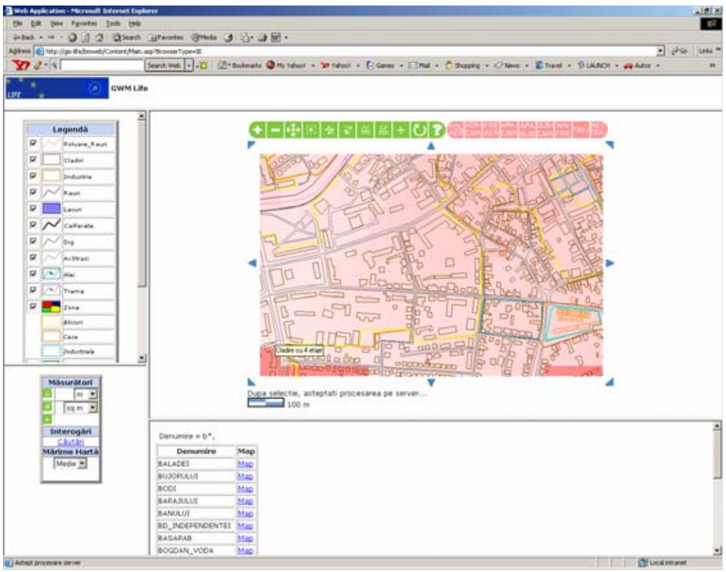

Figure 1.- Example of web-GIS computing of air pollution distribution over Baia Mare town

The system functions due to the integration of each model into the OpenGIS. The input of pollution emissions is constructed by the users in Baia Mare in the urbanistic GIS that they have at their disposal In Baia Mare's case, they are using the AutoCAD. The input is developed automatically by using a special interface operating into AutoCAD environment, the interface being developed by NIMH for the project. The input is sent by the user via FTP protocol in the internet, towards the OpenGIS data server at NIMH. An automation software triggers the models respectively to the type of input which has been sent by the user. The models run automatically and their input is integrated in the same automatic way into the OpenGIS-on-line server. The user in Baia Mare then open an Internet Explorer (or a NetScape) window and views the results in an GIS environment. The same window has a set of buttons constructed by NIMH, that allows the loading of special analysis functions such that allows the display of each type of pollution, the interrogation of the punctual pollution over an GIS element or the pollution simulated over entire areas over the city of Baia Mare. The buttons are specific for: 1) punctual and distribution of air pollution; 2) punctual and distribution of frequency of pollution surpassing the sanitary levels 3) punctual and distribution of air pollution climatologically pathways; 4) punctual and distribution of retro trajectory of air pollution pathways; 5) areas where pollution exceeds the sanitary level; 6) surface water pollution, reaches where the surface water exceeds defined levels; 7) level of aquifer; 8) areas where the pollution of the aquifer exceeds the sanitary levels; 9) punctual and distribution of levels of aquifer pollution (Ionescu et al., 2002).

Part 2 - The statistical measures of model performances

The performance of the dispersion model can be described by means of the relevant statistical measures. In this paper the statistical performance of the two dispersion model (OML and ADMS) has been highlighted by making use of the statistical evaluation models BOOT (Hanna et al., 1991).

The following statistical parameters were chosen to quantify dispersion model skill:

(i) The mean of calculated and measured values of concentrations (*mean*);

(ii) The bias, which is the mean value of the differences between the observations and predictions*(bias)*:

$$bias = \overline{C_O} - \overline{C_P}$$

In a perfect model the bias is equal to zero. Positive (negative) value of bias indicate that, on the average, the model is under predicting (over predicting) the observations.

(iii) Standard deviation of the observations and of the predictions *(sigma)*:

$$\sigma_o = \sqrt{\overline{(C_o - \overline{C_o})^2}}\ ;\quad \sigma_p = \sqrt{\overline{(C_p - \overline{C_p})^2}}$$

Ideally σ_p would equal the corresponding statistic for the observations.

(iv) Normalized mean square error (*nmse*):

$$nmse = \frac{\overline{(C_o - C_p)^2}}{\overline{C_o} \bullet \overline{C_p}}$$

The *nmse* is a fundamental statistical performance parameter, since it gives information on the actual value of the error produced by the model. The normalization assures that in most application the *nmse* will not bias toward models that over predict or under predict.

(v) Correlation coefficient (*cor*):

$$cor = \frac{\overline{(C_0 - \overline{C_o}) \bullet (C_p - \overline{C_p})}}{\sigma_{C0} \bullet \sigma_{Cp}}$$

The correlation coefficient can describe proportional change with regard to the means of the two quantities in question, but cannot distinguish the type or magnitude of possible covariance.

(vi) normalized bias used by EPA (*fb*).

$$fb = \frac{\overline{C_o} - \overline{C_p}}{0.5\,(\overline{C_o} + \overline{C_P})}$$

(vii) Fraction of prediction within a factor two of observation (*fa2*):

$$fa2 : 0.5 \le C_p / C_o \le 2$$

RESULTS AND DISCUSSION

Using the OML and ADMS dispersion models, the daily mean concentrations at the ground-level have been estimated in the same point in which the measurements were carried out for a three month interval. The meteorological input data for dispersion models were obtained at the meteorological station from Baia Mare city.

The statistical performances of the two dispersion model are presented in Table 1-3 and where C_{obs} stands for observed concentration and C_{mod1}, C_{mod2} stand for the simulated concentration using the OML and the ADMS dispersion models.

Table 1. Statistical analysis for daily mean concentration (μg/m³) – January

Model	mean	Sigma	bias	nmse	cor	Fa2	fb
Cobs	209.03	132.28	0.00	0.00	1.000	1.000	0.000
Cmod1	240.71	92.73	-31.68	0.53	0.318	0.613	-0.141
Cmod2	80.97	56.53	128.06	2.42	0.256	0.419	0.883

Table 2. Statistical analysis for daily mean concentration (μg/m³) – February

Model	mean	Sigma	bias	nmse	cor	Fa2	fb
Cobs	145.71	134.81	0.00	0.00	1.000	1.000	0.000
Cmod1	236.14	95.88	-90.43	0.75	0.378	0.564	-0.474
Cmod2	94.75	53.90	50.96	2.01	0.285	0.536	0.424

Table 3. Statistical analysis for daily mean concentration (μg/m³) – March

Model	mean	sigma	bias	nmse	cor	Fa2	fb
Cobs	166.13	86.42	0.00	0.00	1.000	1.000	0.000
Cmod1	224.35	69.71	-58.23	0.26	0.494	0.710	-0.298
Cmod2	122.90	69.04	43.23	0.59	0.180	0.613	0.299

With regard to the global statistics the results indicate a positive bias between measured and modelled concentrations of approximately 61%, 35%, 26% (against the mean value) for the ADMS model in January, February and March respectively. The OML model perform with a negative bias of 15%, 62%, 35% for January, February and March. The normalized mean square error *(nmse)* is the best for the OML dispersion model (0.53, 0.75, 0.26). The best value of *fa2* (0.613, 0.564, 0.710) is also provided by the OML dispersion model for all statistics. In figure 2-3 an example of the predicted concentration values for the two dispersion models are presented.

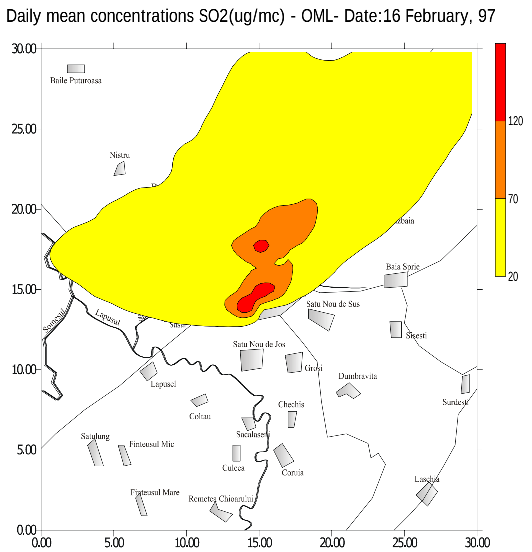

Figure 2 Daily mean concentration OML. Date: 16 February

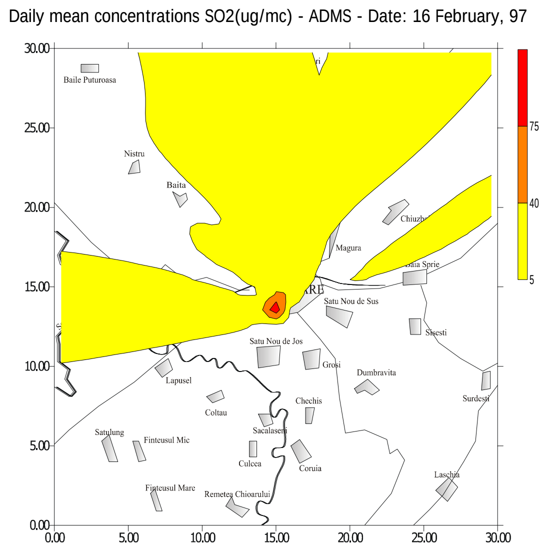

Figure 3 Daily mean concentration ADMS Date: 16 February

In conclusion, the OML dispersion model over predicts the measured values for all statistics and the ADMS dispersion model under predict the analysed measured values. Both dispersion models produce poor correlation coefficients.

As a concluding remark, we note that the level of agreement between predicted and observed values found in this paper show the fact that the performance statistics reflect the limitations of the Gaussian model related to the real atmospheric physical processes, especially when a Gaussian model assumptions (the flat terrain) is not deeply fulfilled.

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