2.11 SUPPLEMENTARY METHODS USED FOR AIR QUALITY ASSESSMENT IN THE SLOVAK REPUBLIC.

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INTRODUCTION

The new air pollution Act 478/2002 Coll. in the Slovak Republic (transposition of the EC air pollution legislation) allows for the application of models and interpolation techniques as supplementary tools for air quality assessment. For this purpose the CEMOD dispersion model was developed. The CEMOD (*Szabo,G.*,2003) model for countrywide air quality assessment in the Slovak Republic is based on the methodologies recommended by the United States EPA - ISC and CALINE. It includes modifications for complex terrain and urban environment. That approach allows continuous transition within various surroundings and scales as well as integration of contributions from various source categories and types, including background data. Emission and meteorological input data are required in sequential form. The Slovak national maps of all indicators (as required by EC directives) for oxides of nitrogen, nitrogen dioxide, carbon monoxide and sulphur dioxide are available at present. The complex chemistry module is not included. In Slovakia for pollutants with a longer atmospheric residence time and an absence of emission data in a required non-aggregated and sequential form (PM_{10}, $PM_{2.5}$, lead, benzene, etc.) the spatial interpolation is assumed. Interpolation schemes based on an inverse weighting distance between monitoring stations and grid points were proposed. The power parameters and smoothing parameters were determined by means of assigned attributes for measuring spaces. The transformation between levels was applied too. This approach has been found to give better results to the classical. The aim of this paper is to present tools developed on the SHMÚ for air quality assessment in the Slovak Republic. These tools were developed on account of orography peculiarity and availability of required data for air pollution modeling in Slovakia. These applications indicate the uncertainty of calculated data in the framework of limits given by Act 478/2002 Coll. and EC directives in all Slovak zones and agglomerations for all required indicators.

METHODOLOGY

The CEMOD includes modifications for complex terrain and urban environment (surface roughness parameter is implemented to describe dispersion in the urban canopy layer). The Gaussian models are used on local and local-to-regional scales (up to 30 km). For greater distances the sector average approach is applied. The sector angle is increases with distance from the source. Procedures for complex terrain corrections are included. The correction factors are derived from data from the Slovak background air pollution stations located at different altitudes (EMEP). A surface roughness parameter is implemented to describe dispersion in the urban canopy layer (*Szabo,G.*, 2001). The surface roughness parameter is estimated in the particular locality (part of the town) for the well-known built-up effect aspect according to recommendation by Lettau (1970). Each source of pollution was assigned by data from representative meteorological stations in a given locality. Combination of meteorological data from a national network and outputs from the Slovak meteorological limited area model are used. The street canyons are not computed. Chemistry module is not included in the model. For computing the NO/NO_2 ratio the TA - Luft 2002 procedure for stationary sources and some adjusted procedure (respecting the surface roughness) for mobile sources are introduced. The linear chemistry for sulphur dioxide is assumed. Carbon monoxide is calculated as an inert gas.

Spatial interpolation is frequently applied in estimating air pollutant concentrations. Interpolation schemes based on an inverse weighting distance between monitoring stations and grid points were proposed. This article presents the approach to spatial countrywide interpolation. The spatial distribution of estimated concentrations is expressed in two ways. In the first place implicitly through the applied the anisotropy parameter to estimating of the weight function. In the second case through the transformation of values from EMEP stations on the nodal point level for the interpolation. The anisotropy ratio for the location of the EMEP stations is equal to 1. Changing of concentration by altitude is represented by an empirical function (exponential). It was derived for complex terrain correction from the background air pollution measuring (EMEP stations). The background air pollution stations are located at different altitudes.

Anisotropy during gridding implies a preferred direction, or direction of higher or lower continuity between data points. We chose as the basis for determination of the anisotropy ratio the representative wind rose of the scatter points' locality (e.g. the locality of monitoring stations). The anisotropy ratio is a ratio of the prevailing wind direction count from the ± 45° sectors at the direct and opposite side and the count from remaining sectors. This approach has been suggested to give superior results to the classical. The anisotropy ratio in the broad sense of the word means the complex terrain influence on diffusion. In the view of simplification the wind rose doesn't have not the original meaning in this case. Unless there is a good reason to use an anisotropy ratio, you should accept the default value of 1.0.

The power parameters were given in accordance with experience and computing results. The power parameter is equal to 3 for spots with predominant sources of pollutant. The power equal to 2 represents spots without sources of pollutant or spots with light quantity of emissions, and power equal to 1 represents spots at background.

One of the characteristics of Inverse Distance to a Power is the generation of "bull's-eyes" surrounding the position of observations within the gridded area. We can use the smoothing parameter to reduce the effect by smoothing the interpolated grid. We chose for the smoothing parameter the radius of the built-up area around the scatter point. The smoothing parameter is a mechanism for buffering this behavior.

Data input for stationary sources are from the National Emission Inventory System (NEIS). Input data in required sequential form was derived from type of operating mode for stationary sources or derived from average month temperatures for each locality. For mobile sources were applied the daily variation of hourly traffic flow on workdays and weekend days. Air pollution data were taken from Slovak local Air Pollution Monitory System (AMS) and regional network EMEP. Required meteorological data are wind speed and direction, temperature, cloudiness (cover, height) in hourly sequential form. All averaging times, percentiles are computed in exact for selected grid or in approximate form for all grids (exact form is very time-consuming).

The results of processing for reference alternatively nodal items are insured also in the form of tabular output as possible inlet tabular editor. As tabular format it is possible to choose EXCEL, or output in binary, alternatively ASCII code. Mapping processing isoline computation characteristic possible besides intrinsic graphic editor model also at the system GIS.

RESULTS

CEMOD is beta version of model and it is not a commercial article - for internal application on the SHMU. The accuracy of the model is assessed by comparison indicators acquired from measured and computed values. The model validation is in progress by Validation Kit (we are expected no worse as ISC3).

By means of model CEMOD were computed sequential concentration for all choices reference, or nodal points. For reference points were chosen localization monitoring station pollutants in networks SHMU. Pollutant concentration full-area on territory of eight zones was computed in 49200 grid points from digital map with distance 1000 m. The spatial resolution is arbitrary as for Gaussian models and the selection of its quantity strongly depends on speed of computer. The user can choose between two computation mode: zone or agglomeration. The running time is about 30 seconds for one grid point on PC Pentium IV. The program was made so that in case of large quantity of grid points is able to use simultaneously more PC.

A brief list of monitored and calculated values is shown in the following tables. The monitoring stations mostly are localized in the centre of towns in area strongly influenced by traffic.

Table 1. Monitored and calculated concentrations ($\mu g.m^{-3}$) – aglomerations Bratislava (the first 3) and Kosice

Station	Maximum of 8hr moving average value CO		Annual average NO_2		99.8^{th} percentile of 1hr average NO_2	
	CEMOD	AMS	CEMOD	AMS	CEMOD	AMS
Petržalka	2481		26.9	29.5	117	115
Trnavské mýto	5647	5374	44.8	48.8	203	279
Staré mesto	1834		32.4	28.9	111	134
Štúrova	2307	3430	28.6	36.3	100	131
Strojárenská	1976		23.9	25.3	67	-
Veľká Ida	1046	4756	21.1	29.9	77	89

The accuracy of calculated concentrations of NO_2 and CO strongly depends on completeness of input data at the urban localities. Inputs data regarding of traffic flow and the network of streets (roads) are available only for cities Bratislava and Kosice (these represent agglomerations in Slovak Republic too). The complexity of input parameters for mobile sources is adequate for countrywide (for zones) assessment (approximately 3000 sections). Information concerned about the network of streets (roads) will be completed. Input parameters of stationary sources are most comprehensive both for SO_2 and NO_2. However, the emission inventory system does not contain data about fugitive emissions and events. An example of this actuality is the concentration of CO measured on the station Velka Ida. This station is near the East Slovak iron works (US Steel).

The model result give overestimated concentration of pollutant compared to measured for limit percentile at the vicinity of predominant sources and computed values are underestimated for long-term average. The uncertainty of data on projections, regional background, and local sources and hot spots is not sufficiently known and it is taken out from database of SHMU or from another sources.

Table 2. Monitored and calculated concentrations ($\mu g.m^{-3}$) – aglomerations (the first 6) and zones

Stations	Annual average SO_2		99,2-percentile of 24 hr average SO_2		99,7-percentile of 1hr average SO_2	
	CEMOD	AMS	CEMOD	AMS	CEMOD	AMS
Petržalka	15.1	14.1	54	64	116	95
Trnavské mýto	13.0	12.5	46	41	79	58
Staré mesto	13.9	15.1	49	56	94	93
Štúrova	19.6	26.9	65	60	116	96
Strojárenská	15.0	17.1	48	37	79	65
Veľká Ida	23.3	31.4	62	-	124	-
Banská Bystrica	10.3	14.4	34	43	55	62
Ružomberok R.	17.3	20.7	62	74	132	101
Žiar n/H	9.2	10.0	27	38	40	57
Prievidza	16.2	19.2	56	65	113	140
Handlová	16.3	21.9	56	68	131	115
Bystričany	13.0	13.6	33	46	64	115
Žilina V.Okrná.	13.2	17.0	45	59	81	98
Žilina Vlčince	10.6	13.4	35	61	51	93
Martin	13.2	14.2	46	73	84	87
Jelšava	7.8	7.8	24	29	29	47
Hnúšťa	7.5	9.1	25	38	37	47
Solivar	25.5	29.3	69	65	151	128
Krompachy	11.6	15.0	41	56	84	78
Vranov	12.8	13.6	43	37	62	71
Humenné	14.7	16.1	50	37	80	70

An example of a pollutant contour map calculated by CEMOD is shown in Figure 1. This shows winter half-year average SO_2 concentrations for 2000. The Figure 2 shows annual average Pb concentrations for 2000 calculated by above-mentioned improved interpolation method. The air pollution by lead does not represent a serious problem. The highest annual average concentration 132 $ng.m^{-3}$ (Velka Ida – on the right bottom of the map) is smaller then the lower assessment threshold (250 $ng.m^{-3}$).

CONCLUSIONS

Concerned EC directives for listed pollutant substances request accuracy estimation for annual mean 30%, daily average 50% and for hourly average 50 to 60%. Preliminarily were completed comparisons of model calculations and derived parameters with measured values from air pollution automatic monitoring stations for SO_2, NO_2, and CO for the year 2000. Results satisfy requirements setting on modelling estimations.

Models if correctly apply, can be effective tools for account existing and potential task and afford opportunity to simulate alternative solution. Our aim is to build up these models for full-area assessment also by other pollutants than sulphur dioxide and nitrous dioxide. From preliminary computing result in comparison with valid air qualities measurement be evident, that this model is able to provide required data for air quality assessment of zone and agglomeration asking for Act 478/2002 Coll. on air protection (directives EC), to allow full-area air pollution assessment in Slovakia. The model is possible to use for air quality plans and programme.

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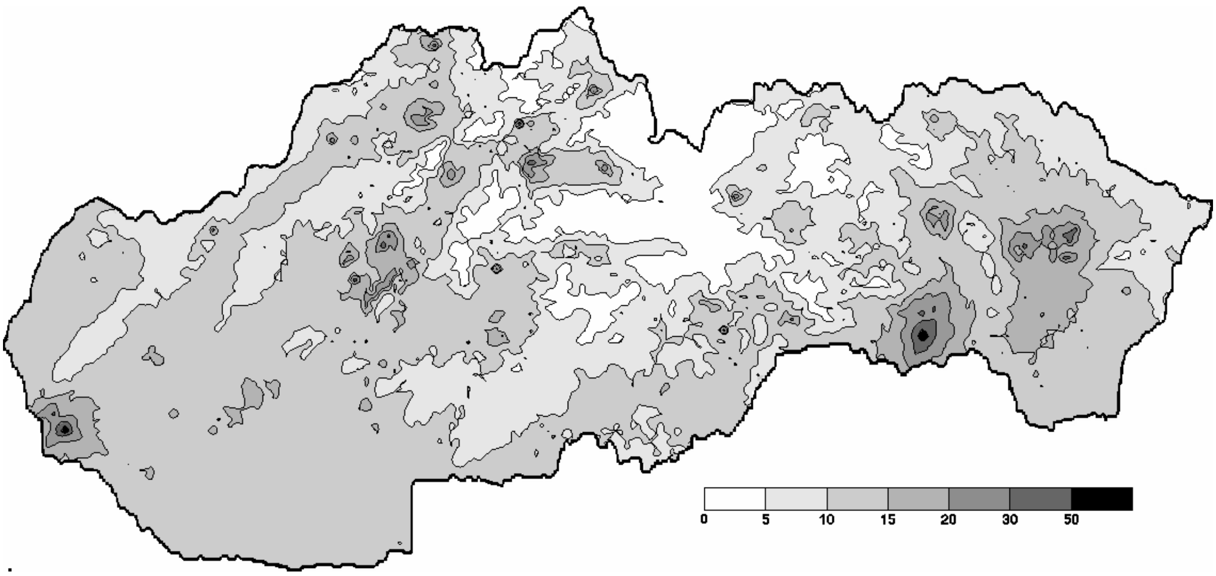

Figure 1. Winter half-year average SO_2 concentrations for 2000 in the Slovak Republic - calculated using CEMOD ($\mu g.m^{-3}$)

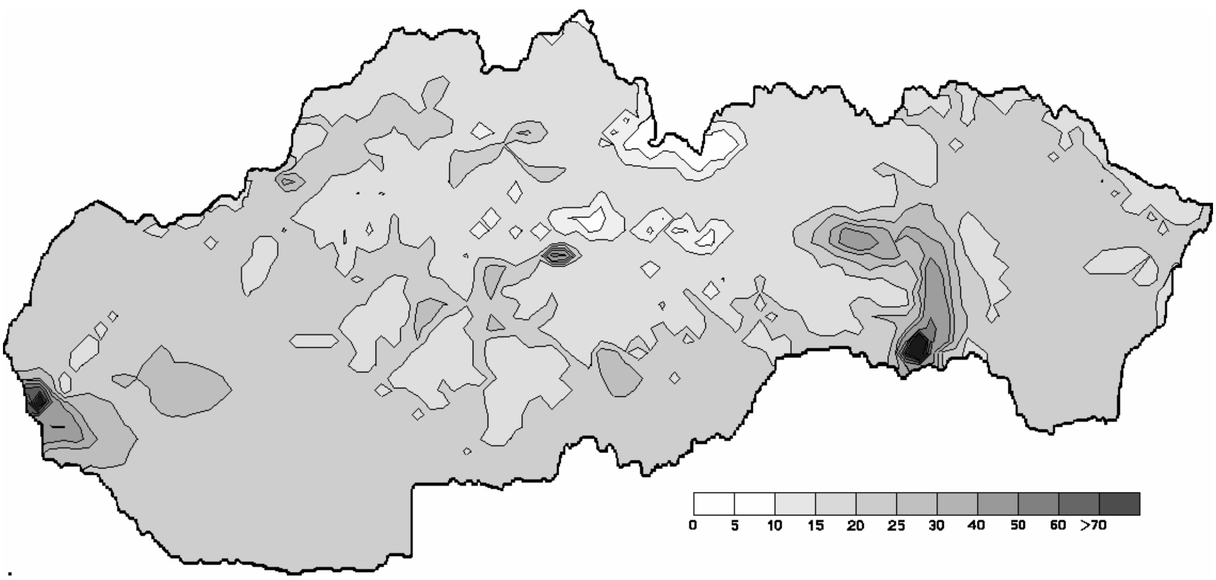

Figure 2. Annual average Pb concentrations for 2000 in the Slovak Republic - calculated using interpolation method. ($ng.m^{-3}$)