DESCRIPTION AND PERFORMANCE OF BULGARIAN EMERGENCY RESPONSE SYSTEM

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INTRODUCTION

The industrial accidents causing a release of harmful (chemical or nuclear) material to the atmosphere can have consequences extending to hundreds and even thousands of kilometers. In such a case the decision-makers need information about the possible long-range transport of pollution over the country. For that purpose computer-based Emergency Response Systems (ERS) has been established in many countries simulating and predicting the distribution of the released pollution.

A PC-oriented ERS in case of nuclear accident is developed and works in the National Institute of Meteorology and Hydrology (NIMH) of Bulgaria. Its creation and development was highly stimulated by the European Tracer Experiment project (ETEX). NIMH took part in all activities of ETEX with the puff model LED (Syrakov et al., 1983), results described in Syrakov and Prodanova (1994). In the second phase of ETEX a new model EMAP (Syrakov, 1995) was tested performing better than LED (Mosca et al., 1997). The main results connected with ETEX-II are given in Syrakov and Prodanova (1998a,b).

STRUCTURE OF ERS

Currently ERS comprises of two main parts, operational and accidental ones, both of them in two variants: region "Europe" and region "Northern Hemisphere". In Fig.1 the ERS overall structure and modules are presented.

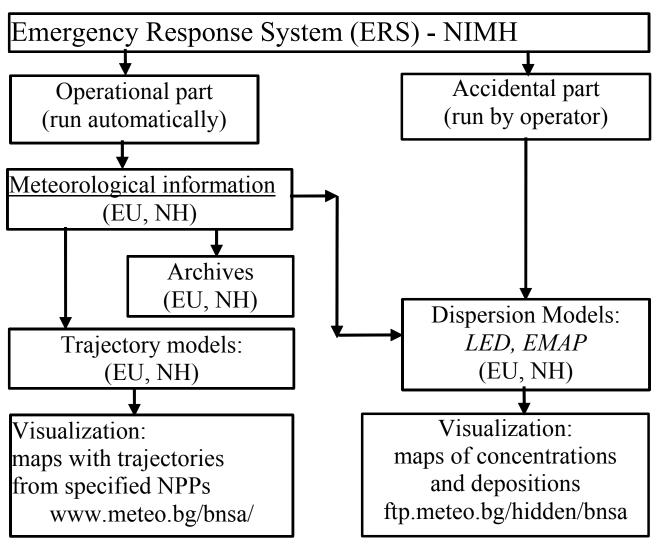
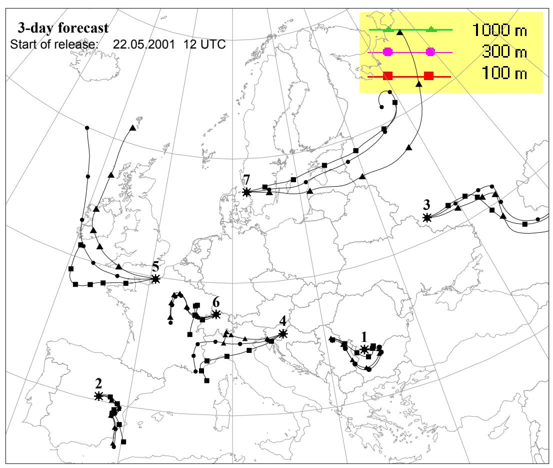


Figure 1. ERS - overall structure. **EU** *stands for version "Europe",* **NH** *– for version "Northern Hemisphere".*

The operational part runs automatically every 12 hours, after new meteorological information is received in NIMH via the Global Telecommunication System (GTS) of WMO. This part includes: asking for and downloading of the necessary meteorological information, preparing of input met-files to the both trajectory and dispersion models (operational data base); creating of archives with analyzed meteorological data (archive data base); running of trajectory models; visualization of results and uploading the maps to the specialized Web-site of NIMH.

In fact, the meteorological input to the trajectory models, LED and EMAP is an input to the built-in PBL model. In the present, the simplest barotropic version of YORDAN model (Yordanov et al., 1983) is used. It is based on the similarity theory and needs only characteristics at the upper and lower boundaries of the PBL. These characteristics are: top boundary (850 hPa level) wind components u_g and v_g, and top-bottom potential temperature difference ($\Delta\theta=\theta_{850}-\theta_{gl}$). The additional parameters are surface roughness z_0 and Coriolis parameter f. The aim of the meteorological pre-processing is to obtain these characteristics in the points of domain grids. They are calculated from the respective Deuttsher Wetterdienst (DWD) numerical products by number of calculations and interpolations.



1. Kozloduy, BG ; 2. Jose Cabrera, ES ; 3. Kursk, RU ; 4. Krsko, SL ; 5. Paluel, FR ; 6. Leibstadt, CH ; 7. Ringhals, SE

Figure 2.Forward trajectories from 7 European NPP calculated using DWD numerical products

Example of one of the trajectory maps (they are 5 for Europe and one for Northern Hemisphere) is shown on Figure 2. On the picture, trajectories from the enumerated points in the list are given. The stars are the sites of plants. Three trajectories begin from each point corresponding to three start levels - 100, 300 and 1000 m. Initial moment of all trajectories is the current synoptic term (00 UTC or 12 UTC) as indicated. Along each trajectory, the points that the emitted parcels will reach after 12, 24, 36,…..72 hours are marked.

The accidental part is activated by operator when a real radioactive release occurs or during emergency exercise. It is initiated by an authorized user who provides information about the source (coordinates, release height, start, duration and rate). The dispersion models LED and EMAP are the core of the accidental part. Three types of input information are necessary for them: permanent, operational and source information. Permanent is the land-use information: sea-land mask, the orography and the roughness fields for the model domains. Operational is the meteorological information prepared during the automated runs of ERS. The output is the ground-level concentration and accumulated deposition fields. The concentration and deposition maps are visualized automatically and then sent to specific ftp-site accessible for the interested institutions.

DISPERSION MODEL EMAP

Description and validation

EMAP (Eulerian Model for Air Pollution) is a 3-D simulation model that allows one to describe the dispersion of multiple pollutants (BC-EMEP, 1994-1998, Syrakov, 1995). Such processes as horizontal and vertical advection, horizontal and vertical diffusion, dry deposition, wet removal, gravitational settling and specific chemical transformations are accounted for in this model. Within EMAP, the semi-empirical diffusion-advection equations for scalar quantities are treated. The numerical solution is based on discretization applied on Arakawa C-type staggered grids. Conservative properties are fully preserved within the discrete model equations. The horizontal resolution depends on the task solved. Vertically, the governing equations are solved in terrain-following coordinates. Non-equidistant grid spacing (log-linear gridding) is settled in that direction. Time splitting is applied as solution technique that transforms the complex problem to a number of simple tasks. For a single time step, one-dimensional schemes are applied sequentially for every dimension for advection and diffusion and for all other processes included in the model. As to decrease the splitting error their order is reversed at the next time step. The temporal resolution depends on the Courant stability condition. All related parameters can be determined by the user.

The numerical schemes applied to describe the different processes are as follows:

Advection. Advective terms are treated with the TRAP scheme (Syrakov, 1996, Syrakov and Galperin, 1997a) which is a Bott type (i.e. flux-type) one. The version applied in the model is 1st order explicit in time and 3rd order Bessel polynomial is used for fitting the concentration distribution in the space around any grid point. While displaying the same simulation properties as the Bott scheme (explicitness, conservativeness, and positive definiteness, transport ability, limited numerical dispersion), the TRAP-scheme occurs to be several times faster. The advective boundary conditions are fixed at income flows and "open boundary" type – at outcome ones. Special version of the scheme able to perform on non-equidistant grid is applied in vertical direction.

Diffusion. Turbulent diffusion equations are digitized by means of the simplest implicit (vertical) and explicit (horizontal) schemes. The accuracy of both schemes is 1st order in time and 2nd order in space. The horizontal diffusion coefficients are constants (defined by the user). The vertical diffusion coefficient can vary in space and time depending on PBL stability. The lateral boundary conditions for diffusion are of "open boundary" type. The bottom boundary condition for the vertical diffusion equation is flux-type; the top boundary condition is optionally of "open boundary" and "hard-lid" type.

Dry deposition. The dry deposition is accounted for as bottom boundary condition in the vertical diffusion equation. The dry deposition flux is determined as roughness level concentration multiplied by the dry deposition velocity. The last parameter depends on many factors. In EMAP, it is assumed depending only on the type of the pollutant and on the character of land coverage and must be specified in advance. In the surface layer (SL), a parameterization is applied that allows one to have the first computational level at the top of the SL. It provides a good estimate for the roughness level concentration and accounts also for the action of continuous sources on the earth surface (Syrakov and Yordanov, 1997).

Wet removal. The simplest decay approach is applied, coefficient depending on pollutant properties and on rain intensity.

Chemistry. Different schemes are applied depending on the task solved. In case of dispersion of nuclear material, only the radioactive decay is accounted for.

The EMAP model is applied to study annual acid loads in the region of Southeastern Europe. It is also applied for calculating the Bulgarian impact of lead, cadmium, mercury and benzo(a)pyrene in the same region for different years (BC-EMEP, 1984-1988). The model passed validation and evaluation in some international exercises: participation in the ETEX study as mentioned above, its results rated 9th among 34 models (Syrakov and Prodanova, 1984); EMEP/MSC-E inter-calibrations of lead and cadmium models (Syrakov and Galperin, 1087a, Gussev et al., 2000).

Currently, Bulgarian ERS is taking part in the ENSEMBLE project with 5FP. A number of releases (so called "dry runs") are simulated in the frame of this project. All participants make their calculations, results gathered and compared. In the next figure, the EMAP simulation of the 6th dry run of ENSEMBLE is compared with the averaged results of a number of models.

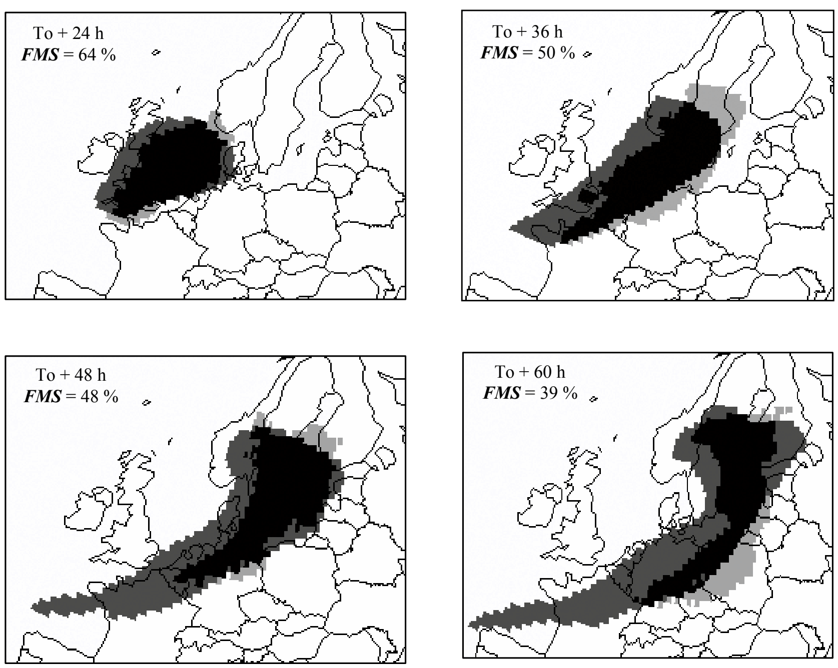


Figure 3. Comparison of EMAP simulation with ENSEMBLE average fields Dark gray – EMAP, light gray – ENSEMBLE, black –overlapping; FMS – percentage of overlapping.

CONCLUSION

The presented results prove that good emergency response can be produced on the base of personal computers using meteorological information, distributed via GTS. This can be useful for warning-system's development in the East European Countries. The EMAP model demonstrates that rather sophisticated models can be run on small platforms producing reliable forecast.

ACKNOWLEDGEMENT
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