Journal of Environmental Protection and Ecology 2, No 2, 356–362 (2001)

Air pollution

IMPORTANCE OF THE LOCAL MONITORING NETWORK FOR MORE ACCURATE PREDICTION OF TRANSBOUNDARY POLLUTION

Z. GRSIC[a*], P. MILUTINOVIC[b], M. POPOVIC[b]

[a] *Institute of Nuclear Science "Vinca", Belgrade, Yugoslavia*
[b] *Institute of Physics, Belgrade, Yugoslavia*

Abstract. One of the conclusions of most of the reports about environmental pollution (especially air pollution) after NATO bombing different targets in FRY, is that there was not enough relevant data about emissions, local meteorology and environmental monitoring. Government and environmental experts in FRY mainly are not satisfied with the information in those reports that relate to the degree of environmental pollution after bombing, but there is a small number of them who seriously analyse why results could not be different. There is not an understanding that nobody could not write different report of that reported, because practically there were no useful data of local monitoring recently after these accidents. Reports from the other Balkans countries show that the situation in environmental protection is not significantly different, and that FRY and big part of the Balkans are generally one big "black spot" where is not possible to get relevant ecology information about emissions and local environmental conditions. Without establishing local monitoring networks at the locations of "ecological black spots" and transboundary monitoring networks in Balkans countries, it is hardly to talk about successfully solution of transboundary pollution problems at these spaces. Data collected at the automated meteorology station in the Nuclear Institute "Vinca" during the huge bombing of the industrial zone Pancevo, give opportunity of air pollution reconstruction after targets in Pancevo industrial zone were hit. Local scale modelling of air pollution distribution during that episode, is seen as an additional data set for more accurate prediction presented in the paper of Zerefos et all.[1]

Keywords: local monitoring, automated meteorological station, local conditions, transboundary pollution.

AIMS AND BACKGROUND

In transboundary air pollution, we intuitively feel that meteorological phenomena of meso- and synoptic scale play the main role. After Chernobyl accident and recent events in Yugoslavia, after NATO bombing, it is clear that only synoptic set of meteorological data is not enough if there are not relevant local informations about air pollution source, i.e. about quantity and type of air pollutants, thermodynamical conditions at the source and local meteorological conditions. Effective source height, initial air pollution concentrations and local meteorology so are

* For correspondence.

conditio sine qua non for any serious analysis of transboundary air pollution transport.

In the nuclear institute "Vinca", local meteorological program was developed before about forty years. This program was started especially due to one of the first accident with fatal consequences at the nuclear reactors in the world. The basis of meteorological program in the institute "Vinca" are meteorological tower 40 m tall, automated meteorological station and software for air pollution distribution as a constitutive part of the automated meteorological station.

Main task of this program is getting picture of the air pollution plume in practically real time and due to that, automation of meteorological measurements and their connection with atmospheric diffusion code have to be done. This was important task, especially with the aspect of fast assessment in the accidental situations.

Automated meteorological station is in use in the Institute of Nuclear Science "Vinca" since April 1997. All measured quantities are continuously displayed on the PC monitor in a digital and graphical form, they are averaging every 10 min and sending to the atmospheric diffusion code.

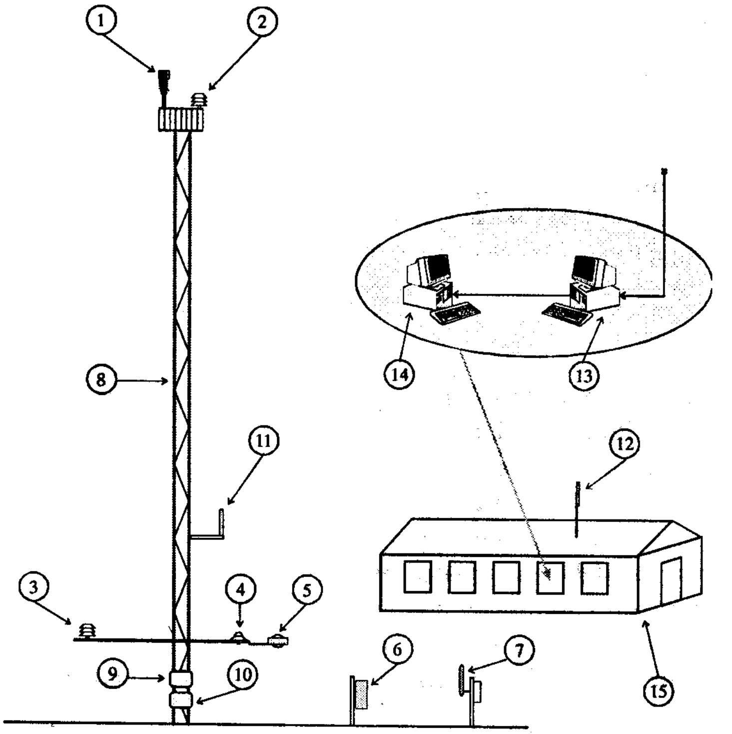

Fig.1. Scheme of the automated meteorological station in the Institute "Vinca"
1 – wind direction and speed; 2 – air temperature at 40 m height; 3 – air temperature at 2m height and relative humidity; 4 – global Sun radiation; 5 – radiation balance; 6 – precipitation; 7 – Geiger counter; 8 – meteorological tower; 9 – acquisition system; 10 – power supplies; 11 – radio emitter; 12 – radio receiver; 13 – PC for AMS; 14 – central PC; 15 – meteo-house

357

Results of these calculations are used for solving basic and some special atmospheric dispersion problems in the Institute like pollution distribution assessment in practically real time, zoning surrounding of the reactor stack and risk estimation in accordance with accidental releases.

EXPERIMENTAL

At the top of the meteorological tower 40 m tall (that is the height of the four ventilation stacks in the Institute) are placed sensors for the wind direction and speed, at 40 and 2 m – air temperature sensors, at 2 m – relative humidity, short and long wave radiation sensors, and at 1 m above surface – precipitation sensor and Geiger counter (Fig. 1). The automatic acquisition system is capable of receiving simultaneously 16 analogue signals with 13-bit resolution. The acquisition system is, in turn, controlled by a microcontroller, which a packs the received signals into a 42 bytes long message. This message is sent via RS232 interface to a radio emitter working at 432 MHz. Receiver is located on a laboratory roof, which is at a distance of 300 m from the emitter. The signals that are received are sent via RS232 interface to a PC. The operating system used by the PC is a real time and multipurpose one. Custom designed software has been designed using C language, as a set of four programs-four separate tasks, which communicate via message passing. User interface is based on graphical Window system.

A constitutive part of the automated meteorological station is the Gaussian algorithm of the atmospheric diffusion. This algorithm is translated in the f77 Fortran code. For the dispersion prediction it needs as the input meteorological variables all of them listed above. As it was mentioned, type of the model is Gaussian and takes into account the multi-source case. Input source parameters are: time of integration, coordinates and height of the sources, its diameters, source strength, temperature of pollutants and level above ground for concentration calculation, effective source height and its physical dimension. It can operate in the prognostic mode or in the diagnostic mode. Further, plume rise and effective stack height, are calculated using the Briggs model and wind power low, respectively. Model takes into consideration topography.

An operational Gaussian puff diffusion software has been developed in Radiation and Environmental Protection Laboratory of the Institute of Nuclear Sciences – Vinca, for routine and some special analysis of the atmospheric pollution[2]. As was mentioned, this software is a constitutive part of the presented automated meteorological station produced in the Institute of Physics from Belgrade. This formula "dispersion model + automated meteorological station" provides an estimate of the current concentration or dosage distribution, practically in real time. Obviously, this system gives opportunity of reconstruction concentration distribution in any past time covered with appropriate meteorological and source data.

A continuous point source release is modelled using a series of Gaussian puffs. Each puff is considered as a cloud with Gaussian distribution of material of the form:

$$C(x,y,z,t)=\frac{q}{\sqrt{(2\pi)^3}\sigma_x\sigma_y\sigma_z}\exp\left\{-\left[\frac{(x-ut)^2}{2\sigma_x^2}+\frac{y^2}{2\sigma_y^2}\right]\right\}\left\{\exp\left[-\frac{(z-H)^2}{2\sigma_z^2}\right]+\exp\left[\frac{(z+H)^2}{2\sigma_z^2}\right]\right\}$$

where ut is the downwind travel distance covered by the cloud through the time t; the standard deviations σ_i – functions of ut; and H – the effective point source height, or height of the cloud center. Other variables in the formula have usual meanings.

The plume is transported with wind which is measured at the automated meteorological station situated on the representative location for the source, so the puff model is able to predict time and space concentration distribution in actual changing wind conditions, at the short distances to the air pollution source.

From wind speed data, solar radiation-day and net radiation-night, every 10 min atmospheric stability is derived, which lead to the standard deviations of concentration distribution in accordance with some empirical set of σ curves. Then the horizontal concentration distribution in the puff is only dependent on the distance to the location of the puff center, which is mainly determined in dependence of the wind speed and direction, and on the atmospheric stability. Locations of the puff centers are calculated every 10 min, giving puff trajectories. Results of the dispersion calculations in the xy plane at some level z, and in the xz planes for every direction of the wind rose are presented in tabular and graphical form.

RESULTS AND DISCUSSION

Events from 18th April 1999, the Pancevo incidents. Pancevo is a large industrial center of oil, chemical and petrochemical industry. It is only 20 km away from the center of Belgrade, the capital of FR Yugoslavia. In the industrial zone of Pancevo, only 3.5 km away from the center of the city, about 7000 workers are employed.

On April 18th, 1999 at 01:10 p.m. (CET), Pancevo industrial zone was hardly bombed. That was not the first bombing of the industrial area of Pancevo, but it was the most severe air strike. That night factories in Pancevo industrial zone were hit by 6 missiles, which destroyed the Oil Refinery (petrol and diesel), the Petrochemical Complex (chlorine, vinyl-chloride-monomer, ethylene) and HIP Azotara Fertilizer Co. (ammonia, NPK, fertilizer tanks). The bombing caused explosions and fires as well as a release of huge quantities of hazardous substances in the surrounding area and emissions of toxic gases in the air. The toxic clouds created by the bombing were consisted of mixture of toxic gases and particles that were produced in combustion and in the uncontrolled chemical and photochemical reactions in the atmosphere.

359

Even now, more than one year after those events, nobody knows exactly what really has happened above our heads. Environmental monitoring in industrial zone Pancevo, like in the all industrial zones in FRY signed as "black spots", does not exist, so during bombing there was not elementary information about concentrations of pollutants and about their movement, neither from Pancevo industrial zone, nor from any industrial bombed zone. There were some attempts of air pollution distribution reconstruction after the mentioned events, but a joint estate of those attempts is that there were not relevant ecological measurements.

That is characteristic not only for FRY but for the most Balkans countries. An illustrative situation is that experts from Greece have made some assessments, relayed to the measurements of the City Institute for Health Protection of Belgrade and to the weather maps produced on the NOAA Air Sources Laboratory, but it was not a good support for Belgrades institute data because they improvised measurements with wrong meteorological information, and NOAAs meteorological information which may be good for weather forecast, but surely are not correct for air pollution assessment in the local area and for the mesoscale area because the effective source heights were not known.

"Vinca" meteorological data probably are not quite exactly representative, but those data are from the smallest distance from the Pancevo accidents (about 9 km away from the Pancevo industrial zone, on the other bank of river Danube). That what we have seen by our eyes and some results of the heavy metal soil analysis in the vicinity of Pancevo (Deliblatska pescara), which will be published in the Journal Environment Protection and Ecology (No 2, 2001) in the article "Speciation of Fe, Ni, Pb and Cd in Soil and Sediment Samples from Pancevo and

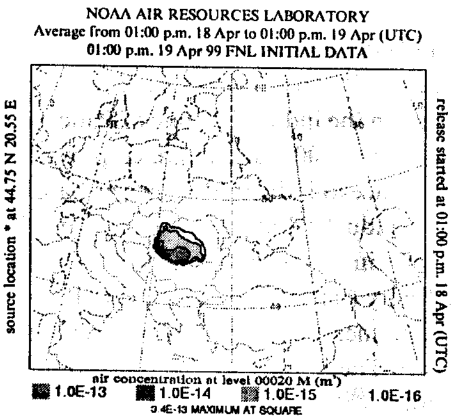

Fig. 2. Air concentration calculated with HYSPLIT_4 modelling system. A line source is assumed which stretches from 100 to 500 m AGL. The concentrations are given in relative units, corresponding to an emission rate of 1 unit of pollutant per hour[1]

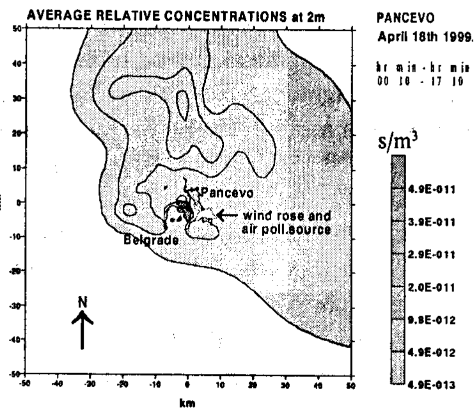

Fig. 3. Similar as on the previous figure, but with meteorological data collected at every 10 min at automated meteorological station, about 9 km from the air pollution source. Effective height of the source is 1100 m (see Fig.4)

Deliblatska pescara (National Park in Danube Area, Northern Serbia)", correspond to that what we have calculated with our atmospheric models.

The results of our model, based on Vinca meteorological data, are graphically presented together with similar results of Zerefos et al.[1]

Only from the rough analysis of these two figures (Figs 2, 3) originates that maximum relative concentrations are different for the two orders of the size, but HYSPLIT_4 analysis corresponds to the 24 h averaging, while "Vinca" analysis corresponds to the 17 h averaging. On the contrary, HYSPLIT_4 concentrations are at 20 m height, while "Vinca" concentrations are at 2 m height. Main reason for differences in maximum concentrations is probably the fact that grid domain in "Vinca" model is significantly smaller. Without going into more details, it is also obvious that "Vincas" calculations are related to the 1200 m effective source height, while HYSPLIT_4 calculations are related to the 500 m height (Fig. 4).

Fig. 4. An amateur photo, made at 7:10 a.m. illustrates events at the sky above hardly destroyed oil refinery "Pancevo" on April 18, 1999. Height of the tallest stack is 150 m (author of the photo Mr. Aleksandar Ristic)

In Fig. 4 the highest stack, in the destroyed oil refinery Pancevo, is 150 m tall. From that picture is obvious that the height of the air pollution plume was more than 1000 m, while HYSPLIT_4 calculations were made with maximum 500 m.

Detailed meteorological situation, recorded with automated meteorological station in the institute "Vinca", shows that, from the point of view of air pollution transport, situation was very complicated in the first 30 min after industrial zone Pancevo was bombed on April 18, since every 10 min the wind direction three times was dramatically changed. In the moment of attack, wind direction was WNW, after 10 min WSW and then NE. May be it seems for the first moment that it is not important for transboundary pollution, but for local conditions it was of the utmost importance, especially because only few minutes after bombing fire companies and engines and the other persons were in the middle of the tremen-

361

dous air pollution plumes. After all it seems that it was very important and for the modelling of transboundary transport of air pollution too, because input parameters which relate to the source characteristics are strongly determined with local meteorological conditions.

CONCLUSIONS

From these some roughly quitted facts it is obvious that it is not possible to make good concept about transboundary air pollution without including local environment monitoring. Local meteorology together with local scale diffusion model must prepare input for mesoscale (tansboundary) air pollution models. So source characteristics, measured concentrations and meteorology parameters are of the most importance in those assessments.

REFERENCES

1. C. ZEREFOS, D. MELAS, S. RAPSOMANKIS, A. ALEXANDROPOULOU: A Provisional Assesment of Environmental Consequences in the Balkans of the Operation Allied Force. 1999. Available at http://www.bpu.auth.gr/berdi.htm.
2. Z. GRSIC, P. MILUTINOVIC: Automated Meteorological Station and Appropriate Software for Air Pollution Distribution Assessment. Air Pollution Modelling and Its Application XIII (Eds S.-E. Gryning, E. Batchvarova). Kluwer Academic/Plenum Publishers, 2000,781-782.

Received 24 November 2000
Revised 28 April 2001