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Environmental information systems in Slovenia—the present and future state

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Summary. — Industrial air pollution is still one of the biggest environmental problems in Slovenia. To monitor air pollution, automated environmental information systems were built. These are complex computerized networks that couple automated measuring techniques and information technology. A typical environmental information system is described. Guidelines are given for the strategy of air pollution monitoring in complex terrain, attempting to find a balance between costs, the available funds and system performances desired. In the paper a strategy for achieving desired system performances is described. The most important parameters are measuring accuracy, reliability and maintenance simplicity. In complex terrain an environmental information system cannot cover the whole domain. Appropriate dispersion models should be added to the system to reconstruct the whole movement of the pollutant plume and to estimate its harmful effects in regions without measurements.

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1. – Introduction

Slovenia is a small country lying between the Adriatic Sea and the Alps. Its terrain varies from the very complex mountainous and semimountainous (with many basins and valleys), to the partially flat type (fig. 1). Industry and coal-fired thermal power plants are situated in valleys and basins near coal mines (fig. 2). The meteorological situations in most of these places are characterized by very low wind speeds during the whole year and often thermal inversions during winter. Most of the industrial and thermal power plants do not have desulphurisation plants installed. Therefore SO_2 air pollution is one of the biggest environmental problems. Polluted areas can be divided into two groups. The first are larger cities with a variety of pollutants from ozone to nitrogen oxides and particulates. The second are areas around major thermal power plants and some other

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Fig. 1. – Slovenia —large cities and power plant locations.

large industrial sources of pollution which are spread around the country, mostly far from large cities. SO_2, particulate and nitrogen oxides pollution prevail there.

To monitor air pollution, some modern environmental systems were built. They are located around the largest thermal power plants and around the nuclear power plant at Krško.

Environmental information systems are distributed measuring systems. They can be focused on air pollution [1], radiology [2], meteorology or water pollution or any combination of these. Their common features are off-site measuring equipment jointed in automated measuring stations, communication links to a central unit that processed the

Fig. 2. – The Trbovlje Thermal Power Plant with a 360 m stack.

Fig. 3. – Typical ambiental automated measuring station.

measured data and local or remote-user presentation programmes for exploring measurement data bases.

2. – Description of environmental information systems

The environmental information system (EIS) consists of automated measuring stations, a central unit and data users [3]. It is a distributed system where data are processed on all levels. It is designed for measuring and distributing data, for controlling data quality, forming a database, presenting data and processing data with different models.

An automated measuring station (AMS) is the basic element of the EIS (fig. 3). It can vary from a small (mounted in a sealed box) to large measuring system in an air-conditioned container. Its primary functions are

- data collection from sensors and monitors,
- data collection of measuring conditions (monitor status, measuring references, power supplies, ambient temperature),
- quality control of basic measurements,
- statistical data processing,
- formation of a database,
- local data presentation,
- communication with the central unit.

Usually AMSs are located at exposed locations to satisfy measuring criteria to provide representative data. These exposed locations are characterized by unstable line power with frequent power breaks. The communication lines are very sensitive to atmospheric discharges. Therefore it is very difficult to achieve a very long mean time between failures (MTBF), and a mean time to repair (MTTR) as short as possible.

The central unit (CU) is usually located in the power plant or accredited agency. It consists of one or more PCs. Their tasks are:

– communication with AMSs,

– data quality control,

– formation of a database,

– generation of numerical and graphical presentations and printer reports,

– special data processing,

– distributing data to remote users.

The most critical task of the CU is communication with the AMS. System reliability depends on the proper choice of communication media, hardware interfaces and communication protocols according to the funds available for system operation.

EISs are built to monitor environmental pollution from continuous releases (emission sources) or from accidental releases. In past years an EIS was built only to monitor environmental data. Emission data measurements should be added to the EIS to upgrade it with a decision support system. Due to restrictive regulations with a tendency to reduce environmental concentrations of pollutants, a decision support system should be added. A decision support system forming part of the EIS will become a primary task of the EIS in the near future.

3. – Examples of EISs

The environmental information system around the Šoštanj Thermal Power Plant (700 MW, emissions reduced from 100000 tons of SO_2 (1995) to 18000 tons (2001) per year) [1, 4] consists of one mobile and eight fixed stations around the power plant that measure ambient concentrations of SO_2, NO, NO_2, O_3, dust (PM10) and meteorological parameters like wind velocity and direction at 10 m height, relative humidity, air temperature, global solar radiation, air pressure and precipitation. Three emission stations measure concentration of pollutants in the stack gasses and some operational parameters of the power plant. The hydrological station measures the quality of the river Paka from which water is used for cooling. All the data are collected at half hour intervals in the central unit, which is located in the power plant. The collected data are sent automatically to authorized remote users, *i.e.* local authorities and the Environmental Agency of the Republic of Slovenia (ARSO).

The EIS of the Trbovlje Thermal Power Plant (fig. 2) is very similar to the Šoštanj one above described. It consists of 6 fixed ambient stations around the thermal power plant, an emission station and a hydrological station.

Another similar EIS is located around the Krško Nuclear Power Plant [5].

All these environmental information systems are owned by the power plants. In addition, Slovenian Environmental Agency has an air quality measuring network (8 stations around Slovenia) and automated meteorological, hydrological and climatological stations (more than twenty).

4. – EIS around the Krško Nuclear Power Plant

The Krško Nuclear Power Plant is a potential pollutant. In the case of an accident in can emit very dangerous radioactive material. The environmental information system was built to monitor radioactive pollution and meteorological parameters. It consists of four

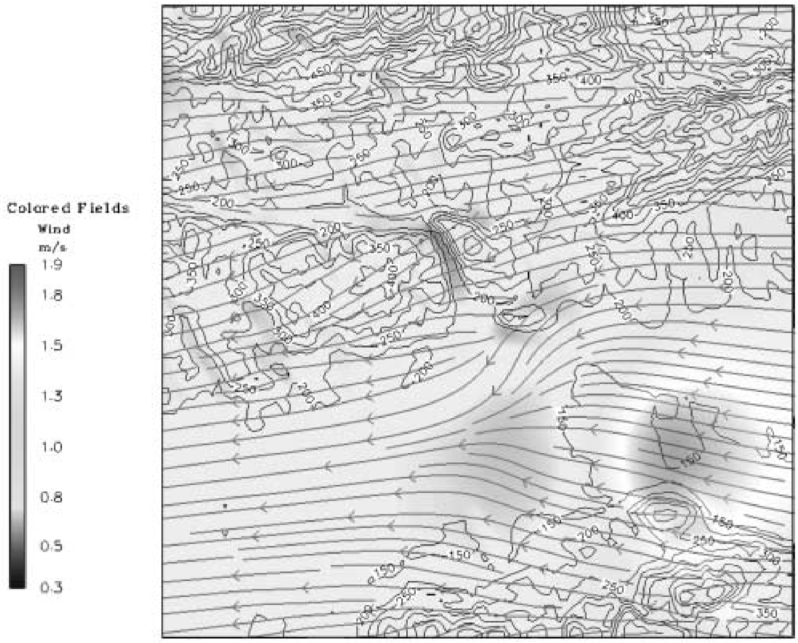

Fig. 4. – 2D presentation of ground level part of wind field reconstruction (in vector form).

fixed AMS for meteorological and dose-rates measurements. 3 AMS in the surroundings of the NPP measure basic meteorological parameters (wind speed and direction at 10 m, air temperature, precipitation and relative humidity). One station, located near the power plant, has a 70 m high meteorological mast with measurements at four levels (2 m, 10 m, 40 m and 70 m). It also measures global solar radiation and air pressure. The SODAR station near the tower station measures wind speed and direction at several levels up to 300 m or 500 m. All data are collected instantly and at half hour intervals.

The emission station measures dose-rates inside the power plant. The hydrological station measures the temperature and flow of the river Sava that is used for cooling. All these stations are connected to the central unit inside the power plant. Fixed telephone lines or current loops are used for communication. Some distant ambient stations use leased telephone lines.

In a circle around the Krško Nuclear Power Plant more than ten dose-rate–measuring monitors are placed to ensure quick detection of radiological pollution. They have a separate central unit. Radio stations are used for on-line communication. The data collected are automatically sent to the central unit inside the nuclear power plant.

The data collected at the central unit inside the nuclear power plant are primarily distributed to users in the power plant through a local area network. They are also accessible by the Process Information System of the power plant.

A decision support system at Krško NPP has been developed during recent years to upgrade the EIS [6]. Its main feature is dose projection in the case of an accidental release for people living in the NPP surroundings. The system is based on real-time calculations of reactor core activity and determination of the quantity released and advanced modelling of atmospheric dispersion.

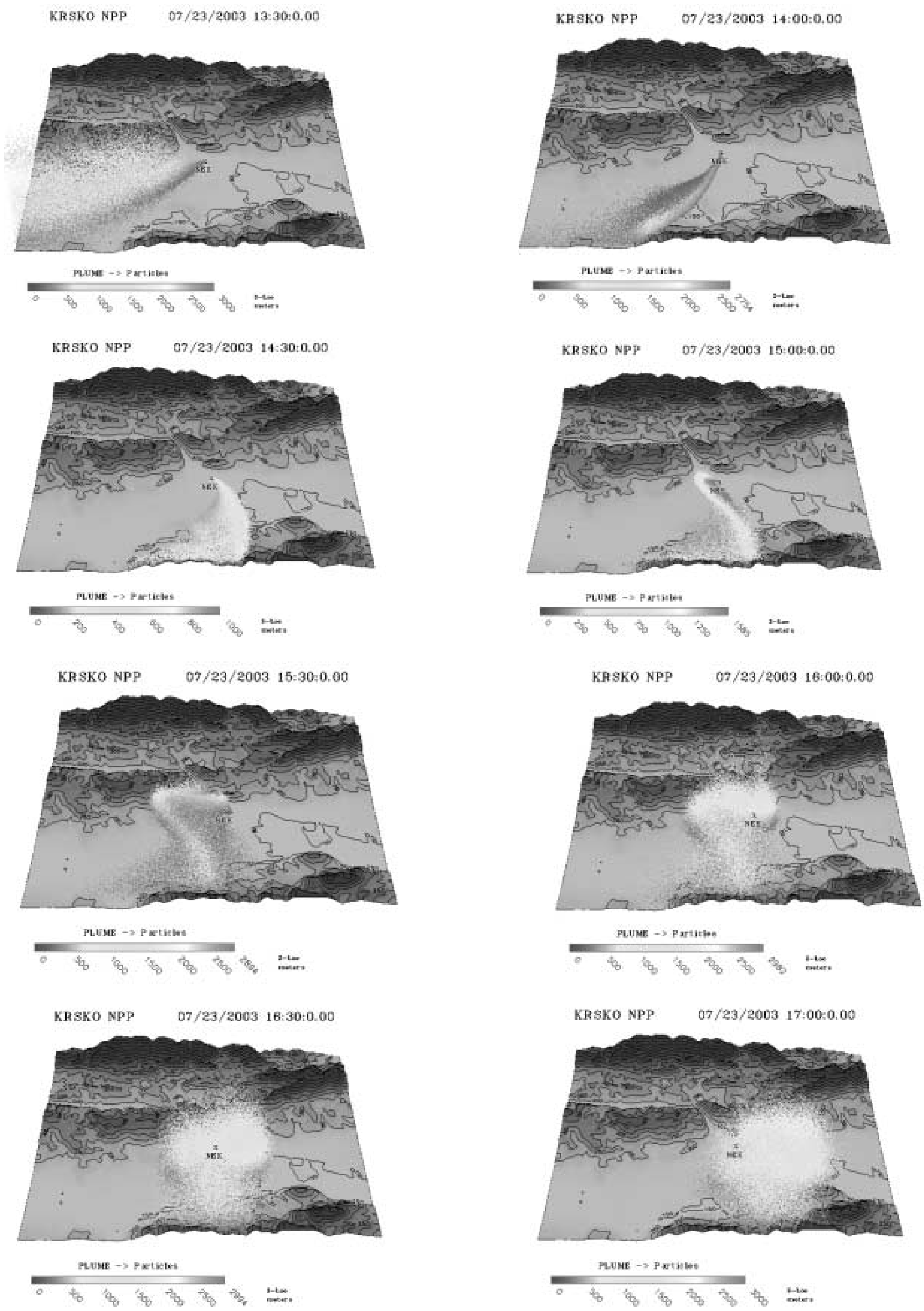

Fig. 5. – Sequence of 4 hours simulation (dilution coefficients).

User-friendly decision support system software presents information to the operator about an actual release, or provides him with the possibility of modelling a potential release. Protective action decision making is derived from the plant status emergency classification, supported by radiological measurements. Recommendations to the authorities in case of an emergency situation can be prepared immediately using radiological emergency assessment procedures.

The basic platform for the decision support system is an atmospheric dispersion modelling system, capable of accurate calculations in complex orography [7]. There are two options available. The old software option uses a simple Gaussian air pollution dispersion model. The new version is based on a numerical Lagrangian particle model called "Spray", with three-dimensional wind and turbulence field reconstructions [8-10]. It was installed in the year 2003.

Measured meteorological data are automatically fed into the meteorological preprocessor module. This represents a platform for a three-dimensional mass consistent wind field reconstruction and numerical Lagrangian particle model simulation of atmospheric dispersion that is used to determine dilution coefficients. These dilution coefficients are later used for dose calculation. The system is installed on a 25 km $\times$ 25 km domain at 250 m resolution (terrain, land use). The data acquisition and modelling calculations are made completely automatically every half hour.

The MINERVE6 diagnostic model [11] is used to reconstruct a 3D mass-consistent wind field over the complex terrain of the Krško region (see fig. 4). It uses all the available on-line meteorological data from EIS. The modelling system uses terrain-following coordinates. The SURFPRO module calculates the turbulence field and the results of the above modules are used by the SPRAY3 model —a stochastic Lagrangian particle dispersion model. It is capable of simulating complex conditions determined by the terrain and meteorological inhomogenities. The results of the atmospheric dispersion modelling system are used in the decision support system as an important part of dose projection procedures (see fig. 5).

Presently the whole system runs in a diagnostic way using on-line measured meteorological data. In this way it enables an accurate reconstruction of an accidental air pollution event. If reliable enough, prognostic meteorological data are available for the Krško region, it is also possible to run the whole system in a prognostic way to evaluate the consequences of any nuclear emergency situation in advance.

5. – Future strategy

The above-described environmental information systems for thermal and nuclear power plants are constructed similarly. They use personal computer-based automated meteorological stations. The hardware and software are adapted to the needs of a different selection of meteorological sensors and pollutant measuring monitors. An important task of the personal computer is also data storage for longer periods.

The central unit is doubled up for redundancy. It consists of two personal computers, which collect and distribute data, form a data base, perform statistical analyses, present data to the users and perform data quality control. The elaborated data are automatically available on the local area computer network in the power plants.

6. – Conclusions

Over Slovenian territory there is a dense network of automated meteorological stations and air pollution stations. The average percentage of good data collected is over 90%. Such exellent results are due to the very good maintenance of the systems performed by the local staff.

When designing new systems in complex terrain, special attention should be given to station placement. Station locations should take into account air pollution patterns dependent on complex orography. Locations should give the best possible meteorological and air pollution overview of the observed region.

Remote-sensing equipment, like SODAR-s, enable the use of sophisticated numerical dispersion models which give good results in the case of complex orography. Dispersion models are a necessary superstructure of the measuring network. These models can show the whole movement of the pollutant gas plume in the atmosphere and not just the part which is detected by the ground level monitoring stations. In this way the harmful effect of air pollutants can be better estimated and as a consequence a better abatement strategy can be adopted.

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