WORLD METEOROLOGICAL ORGANIZATION

COMMISSION FOR BASIC SYSTEMS
EMERGENCY RESPONSE ACTIVITIES
CO-ORDINATION GROUP

WASHINGTON, D.C, USA, 10-14 SEPTEMBER 2001

CBS ERA/COG/Doc. 6

(3.IX.2001)

ITEM: 6

ENGLISH ONLY

PROCEDURES TO ACTIVATE ADDITIONAL OBSERVATIONS IN THE EVENT OF NUCLEAR ACCIDENT

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Summary and purpose of document

The document presents some results obtained by the RSMC Obninsk to improve reliability of model products concerning atmospheric transport of radioactivity based on using on-line data of monitoring network.

Action proposed

The meeting is invited to explore the use of on-line data of radiological monitoring data.

Data Exchange with Radiation Monitoring Network in the Operations of RSMC Obninsk

1. Formulation of the problem

The primary goal of the WMO Regional Specialized Meteorological Canter (RSMC) of emergency response is to prepare results of modelling the dispersion of contaminants in the environment in case of an accident. The specificity of emergency response consists in lack of information for selecting adequate countermeasures in the first phase of an accident when application of such measures can be most effective [1].

The fidelity of predictions can be increased by extending capabilities of the center with respect to receiving data from specialized monitoring systems. These data can be used as input for models as is the case with source term data or can be used for adjusting calculations. The second approach is known to specialists as the data assimilation method.

The document presents some results obtained by the RSMC Obninsk to improve reliability of model products concerning atmospheric transport of radioactivity based on using on-line data of monitoring network.

2. Network for gathering on-line data in the RSMC Obninsk

The data collection network of the RSMC Obninsk is designed for collection of on-line information on the radiation situation. Currently the network includes three main components (*Fig 1*.) for gathering:

- on-line information on the radiation situation in the territory of Russian Federation (RF) supplied by Roshydromet monitoring network (component 1),
- data from local systems of monitoring the radiation situation around nuclear facilities in the territory of RF (components 2),
- data from the national radiation monitoring system of the republic of Belarus.

Moreover, an international exchange of radiation data on is arranged with several European countries within the EURDEP project and the agreement of the Baltic countries.

All supplied information is processed and loaded into the operational database. The available software make possible both local and remote access to data.

1) Roshydromet network

The data on the radiation situation in the territory of RF from the Roshydromet network are transmitted to the RSMC Obninsk by dedicated communication channel connected with the Main Radiometeorological center (Moscow). Given normal situation, data on radiation dose rates are received from Roshydromet network points located within 100 km zone around nuclear facilities in the territory of RF. There are 187 points of this type. Measurements in these points are made once every 3 hours at synoptic observational times. In case of normal radiation situation information is passed once a day at 6 o'clock GMT in the national code RHOB which is used for transmission of data on the radiological and chemical situation.

As telegrams are received, they are automatically deciphered, verified and loaded to the operational DB.

2) Radiation monitoring systems around nuclear facilities

Access to on-line information from local automatic monitoring systems (ASCRO) around nuclear facilities (NF) is provided based on the agreement on data exchange between Roshydromet and Minatom of RF.

Schematically, access to data is organized as follows. The RSMC Obninsk possesses dedicated communication channels connected with the Crisis Center of Rosenergoatom and specialized crisis center of Minatom. The RSMC Obninsk receives information from the ASCRO systems of nuclear power plants by the channel with the Crisis Center of Rosenergoatom and from other nuclear facilities located in the territory of RF by the channel with Minatom crisis center. In both cases data transmission is based on the server-server interaction, i.e. the servers exchange data directly.

As soon as information is received by Rosenergoatom crisis center and Minatom crisis center, it goes to the server of the RSMC Obninsk. The frequency of measurements and transmission of data on radiation dose rate from local systems ASCRO is normally 1 hour.

3) National radiation monitoring network of the republic of Belarus

Receipt of data from the radiation monitoring network of Belarus is arranged through the dedicated channel between Goscomhydromet of Belarus and the national radiation monitoring center. Data are exchanged throough interaction of the server of the operational DB of the RSMC Obninsk and a similar server in Center of environmental and radiation monitoring of Belarus (Minsk). By the procedure used in Belarus in case of normal radiation situation data are transferred in as SYNOP code once a day at 6 o'clock GMT from 33 monitoring points. As soon as information is received in the radiation monitoring center of Belarus. it is transmitted to the server in the RSMC Obninsk.

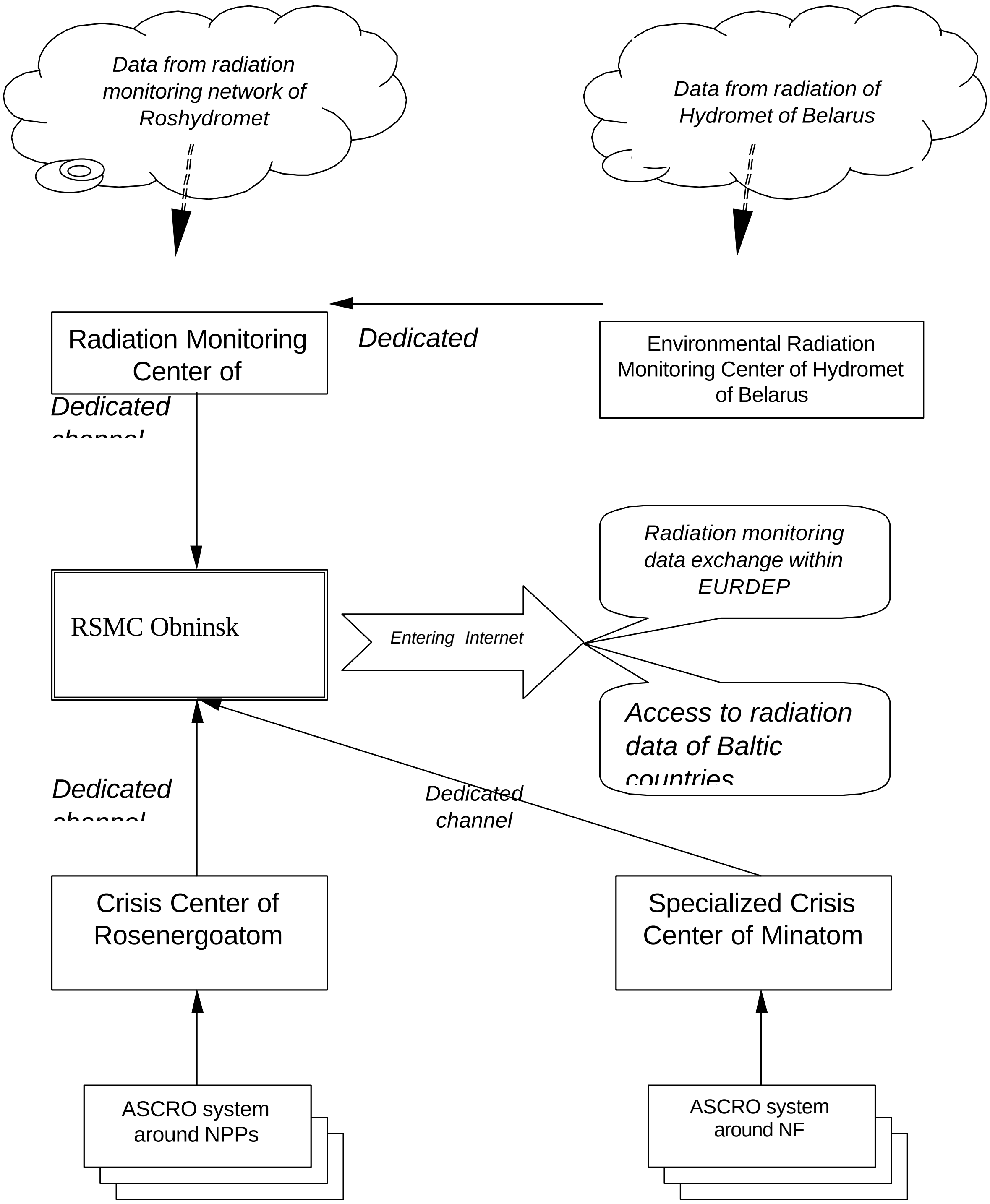
Data from radiation monitoring network of Roshydromet
Data from radiation of Hydromet of Belarus
Radiation Monitoring Center of
Dedicated
Environmental Radiation Monitoring Center of Hydromet of Belarus
Dedicated channel
RSMC Obninsk
Entering Internet
Radiation monitoring data exchange within EURDEP
Access to radiation data of Baltic countries
Dedicated channel
Dedicated channel
Crisis Center of Rosenergoatom
Specialized Crisis Center of Minatom
ASCRO system around NPPs
ASCRO system around NF

Fig. 1

4) Data exchange within the EURDEP project

Since the beginning 1999 the RSMC Obninsk is involved in the EURDEP project on exchange of data on the radiation situation between European countries. The project is coordinated by JRC Ispra. Transmission of data is based on using Internet. By the project rules, information is passed once a day to the ftp-server located in JRC Ispra. Data are transmitted in the special format EURDEP. Data are downloaded from the operational database of the RSMC Obninsk and transmitted to ftp-server of JRC Ispra automatically. In turn, generalized data on the radiation situation in the territory of Europe are transmitted by e-mail from the JRC Ispra server.

5) Exchange of data within the agreement of the Baltic countries

In the framework of this agreement concluded in July 2000 a procedure was established for access to information on the radiation situation in the territory of the Baltic countries . By this procedure each participating country appoints an authorized organization which holds a ftp-server receiving periodically information on the radiation situation in the territory of the country based on the national monitoring network. The authorized organizations of other countries-members have an access to ftp-server and, if necessary, can download data from this server. Access to ftp-server is done using Internet. In the RSMC Obninsk information on the radiation situation in the territory of the European part of RF is saved on the ftp-server daily.

3. Subsystem of radiation data assimilation

The radiation monitoring data assimilation subsystem is designed for adjustment of the initial prediction of atmospheric dispersion of a radioactive cloud formed as a result of an accident at nuclear facility. The initial prediction is a prediction based on input meteorological information and apriori data about source term. The input information can be minimal and include standard measurements at meteorological site (wind velocity and direction at vane, surface temperature, cloudness score) and can also include data of measurement at meteorological mast (profiles of wind speed and temperature etc.) and data of specialized measurements (wind speed variance).

Data of radiation measurements can be diverse in nature. These can be either measurements of radiation dose rates in different points of the region, data on radionuclides deposition, measurements of source strength etc. The assimilation subsystem can work with different types of radiation measurements, but from the standpoint of prediction adjustment the most informative are measurements of dose rate as part of radiation monitoring.

The principal features of measurements of radiation dose rate are: poor spatial resolution: measurements are made in monitoring points which are few and randomly located and good temporal resolution: measurements are performed continuously.

The main calculation characteristic of the atmospheric transport of radioactive materials is the function of radionuclide concentration in the atmospheric boundary layer which is used to estimate other important characteristics such as deposition field on the underlying surface, distribution of radiation dose rate etc.

- In modeling the atmospheric dispersion the following scheme is normally used:

    1) *It is assumed that the material occurs in the atmosphere as a result of consecutive releases of a series of clouds over the time of action of the source term.*

    2) *For each cloud, transport, deposition and decay of radioactive material is modeled.*

    3) *Instantaneous concentration of radionuclides in the atmospheric boundary layer is a sum of contributions from each cloud.*

    4) *Modeling of transport and dispersion of radionuclides for a separate cloud is based on solution of the semi-empirical equation of turbulent diffusion. Characteristics of the environment are specified by parameterization of the surface and atmospheric boundary layer.*

The common approach to data assimilation in prediction of radionuclide dispersion in the atmosphere is reduction of the problem to filtration, i.e. statistical estimation of the distribution field based on radiation measurements. One of the estimation algorithms applied (filters) is the Kalman filter. However, attempts to use the Kalman filter for solving applied tasks usually lead to loss of stability of the estimation procedure due to inconsistency of actual and theoretical (i.e. used filters) models of the process under consideration.

There are several methods for developing estimation procedures, which make it possible to overcome the indicated inconsistency. Among them are: use of numerical procedures ensuring stability of calculations, empirical selection of parameters of estimation in specific situations, Bayesian procedures allowing for the difference of aposterior distribution from the Gaussian one and minimax estimation for ensuring against maximum possible estimation errors by solving the minimax problem corresponding to the selected quality criterion.

The most general approaches to developing universal algorithms of filtration are the Bayesian and minimax ones. The Bayesian procedures are oriented at solution of problems using only stochastic models of uncontrolled factors (errors) and the minimax filtration algorithms are adapted for allowance for undefined uncontrolled factors.

In development of the assimilation subsystem a mixed approach was used which makes it possible to take into account both random and uncontrolled factors due to errors of the mathematical model of radionuclide transport and uncontrolled errors arising in measurements.

- Below are the main principles of this approach for the case of a one-time instantaneous release.

1. Statement of the estimation task

The problem of estimation of radionuclide concentration distribution is formulated as follows. The evolution of the concentration distribution function for one-time instantaneous release in the finite-difference form is described by recurrent ratios of the form:

$$\vec{C}_{i+1} = \tilde{A}_i \vec{C}_i + \vec{\imath}_i \qquad (1)$$

where index i accounts for discrete time moments with a constant step, the vector $\vec{C}_i$ is a discrete presentation of the radionuclide concentration distribution function at time moment with number i, $\vec{\imath}_i$ is the vector of independent random disturbances which accounts for fluctuations in the concentration distribution in the cloud.

$\vec{A}_i$ is the operator of transfer from concentration distribution at time moment i to distribution at time moment i +1. Data of radiation measurements are modeled by the relation:

$$\vec{D}_i = \tilde{H}_i \vec{C}_i + \vec{\varsigma}_i \qquad (2)$$

where $\vec{D}_i$ is the measurement vector;

$\tilde{H}_i$ is the measurement operator specifying the connection between $\vec{D}_i$ and $\vec{C}_i$

$\vec{\varsigma}_i$ is the vector of independent random measurement errors.

With respect to operators $\tilde{A}_i$ and $\tilde{H}_i$ it is assumed that their precise form is unknown and only their analogues A_i and H_i are available. The operator A_i is the finite-difference approximation of the operator of the semi-empirical equation of turbulent diffusion and, in turn, H_i is the operator specifying the theoretical (within the adopted model) linkage between the radionuclide concentration function and measured values. The differences of operators

$$\Delta A_i = \tilde{A}_i - A_i \qquad (3)$$

$$\Delta H_i = \tilde{H}_i - H_i$$

have the meaning of errors of the used theoretical models of transport and measurements. It is assumed with respect to these errors that their values occur within the known limits. Besides, the statistical characteristics $\vec{\imath}_i$ and $\vec{\varsigma}_i$ are considered to be known as well as the statistical characteristics of the release $\vec{C}_0$.

2. Main principles of filter building

The procedure of estimation is carried out in the class of linear filters.

As the criterion of filter optimum the condition of reaching of the maximum of aposterior density is taken.

$$p\left(\vec{C}_i / \vec{D}_1,...,\vec{D}_i\right)$$

The statistical characteristics related to errors of the accepted theoretical models are selected from the assumption of the worst effect of these characteristics on the estimation procedure (analogues of the conservative error).

Implementation of the formulated approach to the filtration problem makes it possible to build a family of estimation algorithms (data assimilation) among which the Kalman filter occurs. The Kalman filter is made possible by zero errors of the theoretical models of transport and estimation.

- **References**

1. *Shershakov V.M. The Federal Environment Emergency Response Centre: decision support for off-site emergency management in Russia. International IDNDR -Conference on Early Warning Systems for the Reduction of Natural Disasters EWC '98. Potsdam, Federal Republic of Germany. September 7-11, 1998. Programme and Abstracts, pp. 102-103*