IAEA/EMRAS – The Chernobyl I-131 release: model validation and assessment of the countermeasure effectiveness working group.

Minutes of the Working Group Combined Meeting. 8th-11th November 2004, IAEA Headquarters

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Introduction

The Working Group on Iodine which has been established in the framework of the EMRAS programme continues some of the more traditional work of previous international programmes (VAMP -Validation of Model Predictions; BIOMOVS -BIOospheric Model Validation Study, BIOMOVS II, BIOMASS -BIOsphere Modelling and ASSessment) that were aimed at increasing confidence in methods and models for the assessment of radiation exposure related to the environmental releases.

Following the explosion at the Chernobyl Power Station in Ukraine on April 26, 1986, large quantities of radionuclides were released into the atmosphere, resulting in the contamination of a large geographic area. Initially elevated exposures of populations in Ukraine, Belarus and Rusia were due to thyroid-gland irradiation by radioisotopes of iodine, primarily iodine-131 and subsequently to radiocesiums, primarily cesium-137 from both external exposure and the consumption of contaminated milk and other foods.

An increase in the incidence of thyroid cancer first was reported in Ukraine for 1990[1] and in Bielarus for the time period 1990-1992[2,3] . The questions appeared that such increases were related directly to radiation exposure from Chernobyl[4,5] due to the unexpectedly short latency period (only 4 years), uncertain background rates of thyroid cancer , the influence of widespread population screening and the rightness of the pathological diagnoses. Numerous reports6 have confirmed an increasing number of cases of thyroid cancer, particularly in the most heavily contaminated regions of Ukraine and Belarus, but also in Russia [6-7]. There is still very little information regarding the quantitative relationship between radiation dose to the thyroid from Chernobyl and the risk of thyroid cancer. Only few published population-based case–control studies of thyroid cancer indicates on a firm relationship between estimated radiation dose and thyroid cancer [8,9].

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2 V. S. Kazakov, E. P. Demidchik and L. N. Astakhova, Thyroid cancer after Chernobyl. Nature 359, 21 (1992).
3 K. Baverstock, B. Egloff, A. Pinchera, C. Ruchti and D. Williams, Thyroid cancer after Chernobyl. Nature 359, 21–22 (1992).
4 V. Beral and G. Reeves, Childhood thyroid cancer in Belarus. Nature 359, 680–681 (1992).
5 I. Shigematsu and J. W. Thiessen, Childhood thyroid cancer in Belarus. Nature 359, 681 (1992).
6 United Nations Scientific Committee on the Effects of Atomic Radiation, *Sources and Effects of Ionizing Radiation,* Vol. II, *Effects*. United Nations, New York, 2000.
7. A. F. Tsyb, E. M. Parshkov, V. V. Shakhtarin, V. F. Stepanenko, V. G. Skvortsov and I. V. Chebotareva, Thyroid cancer in children and adolescents of Bryansk and Kaluga Regions. In The Radiological Consequences of the Chernobyl Accident, Proceedings of the First International Conference (A. Karaoglou, G. Desmet, G. N. Kelly and H. G. Menzel, Eds.), pp. 691–698. EUR 16544, ECSC-EC-EAEC, Brussels, 1996.
8 . L. N. Astakhova, L. R. Anspaugh, G. W. Beebe, A. Bouville, V. V. Drozdovitch, V. Garber, Y. I. Gavrilin, V. T. Khrouch, A. Y. Kuvshinnikov and M. A. Waclawiw, Chernobyl-related thyroid cancer in children of Belarus: A case–control study. Radiat. Res. 150, 349–356 (199

However, in both studies the uncertainty combined with individual estimates of radiation dose constitutes a crucial point in establishing this relationship, since, any release of radioiodine into environment creates wide range of uncertainty for internal dose assessments. The major sources of the uncertainty include the small number and poor quality of thyroid measurements performed after Chernobyl accident, difficulties in evaluation and validation of the dynamic of the ^{131}I intakes function into a human body based on sparse (single point) individual thyroid measurements and milk samples (in early periods of accident). Also large variety in inhabitants behavior and agricultural practices (the time when cows had been put on a fresh pasture) have considerable impact on doses variability.

1. The scope of the meeting

This material has been prepared by P. Krajewski (Working Group Leader).

The following people contributed to the discussions and decisions documented in these Meeting Minutes:

Participant Name	Organization	Country
M. Ammann	Radiation & Nuclear Safety Authority (STUK)	Finland
T. Cabianka		
C. Duffa	Institut de Radioprotection et de Sureté Nucléaire (IRSN)	France
T. Cabianca	Scientific Secretariat	IAEA
T. Homma	Japan Atomic Energy Research Institute (JAERI)	Japan
B.Kanyár	University of Veszprém	Hungary
P. Krajewski	Central Laboratory for Radiological Protection	Poland
T. Nedveckaite V. Flistovic	Institute of Physics	Lithuania
S. Simon	National Cancer Institute	USA
D. Webbe-Wood, S.Conney,	Food Standard Agency	UK
O. Vlasov	Medical Radiological Research Center	Russian Federation
I. Zwonowa	Institute of Radiation Hygiene	Russian Federation

The most important areas on which the activities of the group is focused:

1) improvement of the accuracy of model predictions through the identification of the most important sources of bias and uncertainty;
2) implementation of new modeling procedures supported by current state of knowledge about processes and phenomena.

The main objectives of the exercises to be carried out by the EMRAS Working Group on Iodine are:

1) to evaluate the performance of the participating models in dose reconstruction exercises in cases when ^{137}Cs (^{129}I) tracer is used to estimate the deposition of ^{131}I;
2) to assess the applicability of the models to countermeasure response;
3) to assess the uncertainties of the participating models, their limitations, and the input data required to run the model.

The main target of the meeting was the finalisation of the I-131 PLAVSK Scenario, preparation of the final draft and the discussion on the future scenario that should encompasses several new aspect of model validation, particularly more aspects of deliberately introduced countermeasures.

During the meeting participants had opportunity to present their models most important features and discuss the influence of most curtail parameters on their models predictions.

2. General conclusions from Plavsk Scenario

Nine experts of environmental modelling participated in the Plavsk Scenario, including four who had not previously been involved in the international model testing programs.

The main targets of Plavsk Scenario have been achieved e.g.:

2.1. check models performance in dose reconstruction for specific locations in a case when ^{137}Cs tracer is used for estimation of ^{131}I deposition,
2.2. determination of thyroid dose uncertainty from inhalation and ingestion pathways,
2.3. identification of major sources of uncertainty

The participants agreed that the major sources of uncertainty in predictions results from following sources:

1.1. constant isotopic ratio ^{131}I/^{137}Cs provided by Scenario Plavsk gives an approximation of ^{131}I contamination of food-chain, however inhomogeneous ^{137}Cs deposition and relatively short time of rain during the cloud passage (6 hours) indicates that the radioactive fallout can be classified as mixed (dry&wet) and in this case more detailed information on deposition conditions for particular regions should be applied to determine more complex relationship between ^{131}I deposition and ^{137}Cs deposition,

1.2. model of grass interception in a case of mixed (dry&wet) radioiodine fallout need to be carefully revised,

1.3. so called weathering factor that used to be applied by most of the models aggregates more complex phenomena and strongly depends on rain occurrence during and after radioactive plume passage,

1.4. uncertainty associated with prediction of ^{131}I concentration in air over the region, depends on physico-chemical forms of airborne radioiodine during the passage of radioactive cloud as well as meteorological conditions,

1.5. inhomogeneous pattern of ^{131}I fallout might reflect both changeability of ^{131}I concentration in air over 40 x60 km area and effect of local rains, a plume dispersion model are envisaged to verify the likelihood of superimpose airborne contamination from various stages of release,

1.6. the assumptions about the time when cows had been put on a pasture seems to be the most important factor of uncertainty in predictions of ^{131}I concentration in milk and consequently ingestion doses. In the real emergency situation, when the pasturing ban is one of the countermeasures, the model predictions of ingestion doses will be burden by uncertainty associated with practical effectiveness of this measure.

In general, although IWG was dealing with areas of assessment modelling for which the capabilities are not yet well established; there is remarkably improvement in models performance comparing with previous radioiodine scenarios. Predictions of the various models were with in a factor of three of the observations; discrepancies between the estimates of average doses to thyroid produced by most participants not exceeded a factor of ten.

The more detailed information about results of Plavsk Scenario exercise one could find in "**Intermediate report of ^{131}I Working Group on the model validation and assessment of the countermeasure effectiveness of the Environmental Modelling for Radiation Safety Programme (EMRAS"** available on EMRAS IWG web site.

2. Requirements for the next scenario

The Working Group also discussed the next possible Scenario and its requirements that should encompass several new aspect of model validation, particularly more aspects of purpoeful introduced countermeasures and more detailed information on radioactive cloud passage. The Working Group leader will prepare draft scenario materials based on measurements conducted in Central Poland after Chernobyl accident.

The proposed WARSAW test scenario encompasses an area of MAZOVIA province (35,6× 103 km^2) with Warsaw as the province capital.
The main goal of the Scenario would be an assessment of the effectiveness of short-term protective measures that had been applied in this province to reduce the radioiodine thyroid burden of inhabitants.
A radioactive plum Chernobyl origin reached Warsaw probably on 28 April of 1986 and the highest air concentration of I-131 lasted from 29 to 30 April 1986. (See Fig 1)

2.1. Countermeasures to be considered

The countermeasures consisted of:

- distribution the prophylactic doses of stable iodine for infants; children 1-10 years old and teenagers up to 16 y old over eleven provinces of Poland. This action took place (on 29.04.86 to 4.05.1986), but for Warsaw district mainly (on 29, 30 April 1986).
  administrated amount of stable iodine:
    15 mg for infants younger than 1 year
    30 mg for children 1-10 years old
    60 mg for teenagers up to 16 y old
    stable iodine was administered in form of solution
- diet restriction (milk and milk product and leafy vegetables)
- cows pastured limitation (this was effective only for big state diary farms)

The pathways contributing to dose are primarily through the air and terrestrial environment (milk consumption)

A number of specific purposes of the Scenario have been discussed during the meeting.

The participants tentatively accepted to perform predictions for three pre-selected locations (See FIG. 2)

2.2. Model testing output

The following types of calculation for model testing will be performed:

2.2.1. average deposition of I-131 (dry, wet)
2.2.2. concentration of I-131 in milk (27 April – 30 May) (with and without countermeasures)
2.2.3. I-131 thyroid burden (27 April - 30 May) for different ages group: 5 y old, 10 y old, 15 y old, adults

One could consider evaluation of minimum and maximum thyroid burden for several variants of countermeasures combinations:

a) thyroids blocking,
b) ban of milk consumption,
c) staying at home

The following calculation could be performed for model comparison purposes:
doses to specified age group (critical 10 years old).

mean inhalation dose (with and without thyroid blocking)
mean ingestion dose (with and without thyroid blocking)

2.3. Model validation data

Concerning the models validation data, it was suggested to prepare the following data set:

2.3.1. air concentration of I-131 over Warsaw (measured in various hours intervals) by two independent monitoring stations of Central Laboratory for Radiological Protection - monitoring period (from 28.04.86 to 30.05.86),
2.3.2. meteorological data including: precipitation data, wind trajectory, temperature
2.3.3. Soil concentration of I-131 for 3 location of the area specified, measured daily for the period of 29 April 1986 - 21 may 1986.
2.3.4. Soil concentration of I-129 in several locations performed in the period (2000-2001),
2.3.5. (although the methodology for I-131 deposition reconstruction base on I-129 activity might be out of the scope of Scenario),
2.3.6. Soil concentration of Cs-137 in several locations performed in the period (1990-1992),
2.3.7. I-131 concentration in grass (one location) measured daily for the period of 29 April 1986 - 21 may 1986.
2.3.8. average I-131 concentration in specified leafy vegetables (lettuce)
2.3.9. daily I-131 concentration in milk samples in approximately 20 locations of the region specified (about 100 measurements).

2.3.10. Measurements were mostly performed by radiochemical methods, but for several locations gamma spectrometric measurements are given and Cs-137 and Cs-134 concentrations in the same sample were determined. Measurements were conducted both for cows on the pasture and cows kept in cowsheds.

2.3.11. thyroid burden of inhabitants of MAZOVIA district (about 1200 measurements performed in the period of 29 April-5 July 1986). The most numerous measurements were performed during the period 29 April – 15 May 1986. Information about the age, sex, date of thyroid blocking and diet (milk consumption) as well as physical activity was associated by interview with each of measurement.

The statistics of measurements is as follow:

- 40 measurements of 15 years old teenagers (thyroid blocked)
- 120 measurements of 10 years old children (thyroid blocked)
- 90 measurements of 5 and below 5 children (thyroid blocked)
- 900 measurements of adults (men women) 30 % of the group voluntarily took stable iodine.

3. Work plan

3.1. MILESTONES (planned in 2004)

3.1.1. end of December 2004 - distribution of draft Warsaw Scenario
3.1.2. January 2005 - June 2005 predictions for Warsaw Scenario
3.1.3. IWG meeting May-July 2005 disclosing observed data, evaluation of predictions
3.1.4. July- October 2005 - second run of predictions
3.1.5. 3rd Combined EMRAS meeting Autumn 2005 -data evaluation, IWG Report

3.2. MILESTONES (revised)

During Scenario preparation process it became evident that some additional data need to be carefully checked out in cooperation with The Institute of Meteorology and Water Management (IMGW). It caused small shift in IWG activities schedule as follow.

3.2.1. end of May 2005 - distribution of draft Warsaw Scenario
June - July - Discussion on Warsaw Scenario
3.2.2. end of July - IWG meeting (summary of preliminary run of predictions)

3.2.3. August – October second run of predictions
3.2.4. 3rd Combined EMRAS meeting Autumn 2005 - disclosing observed data, evaluation of predictions, IWG Report

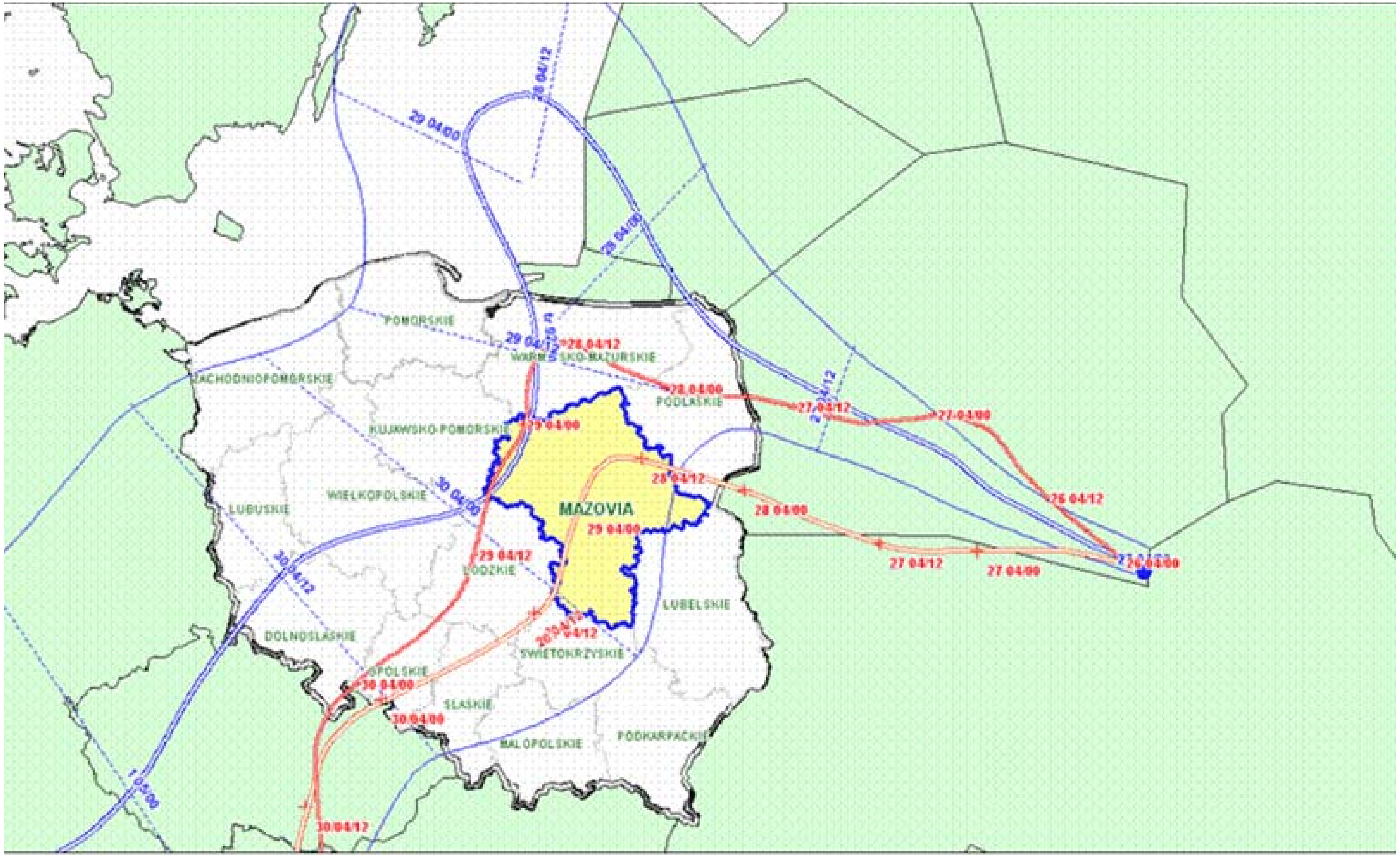

FIGURE 1. Trajectories of air mass movements (red - surface winds, blue- 925 mb (800 m) winds) over the Mazovia region. (according to The Institute of Meteorology and Water Management (IMGW))

3 locations

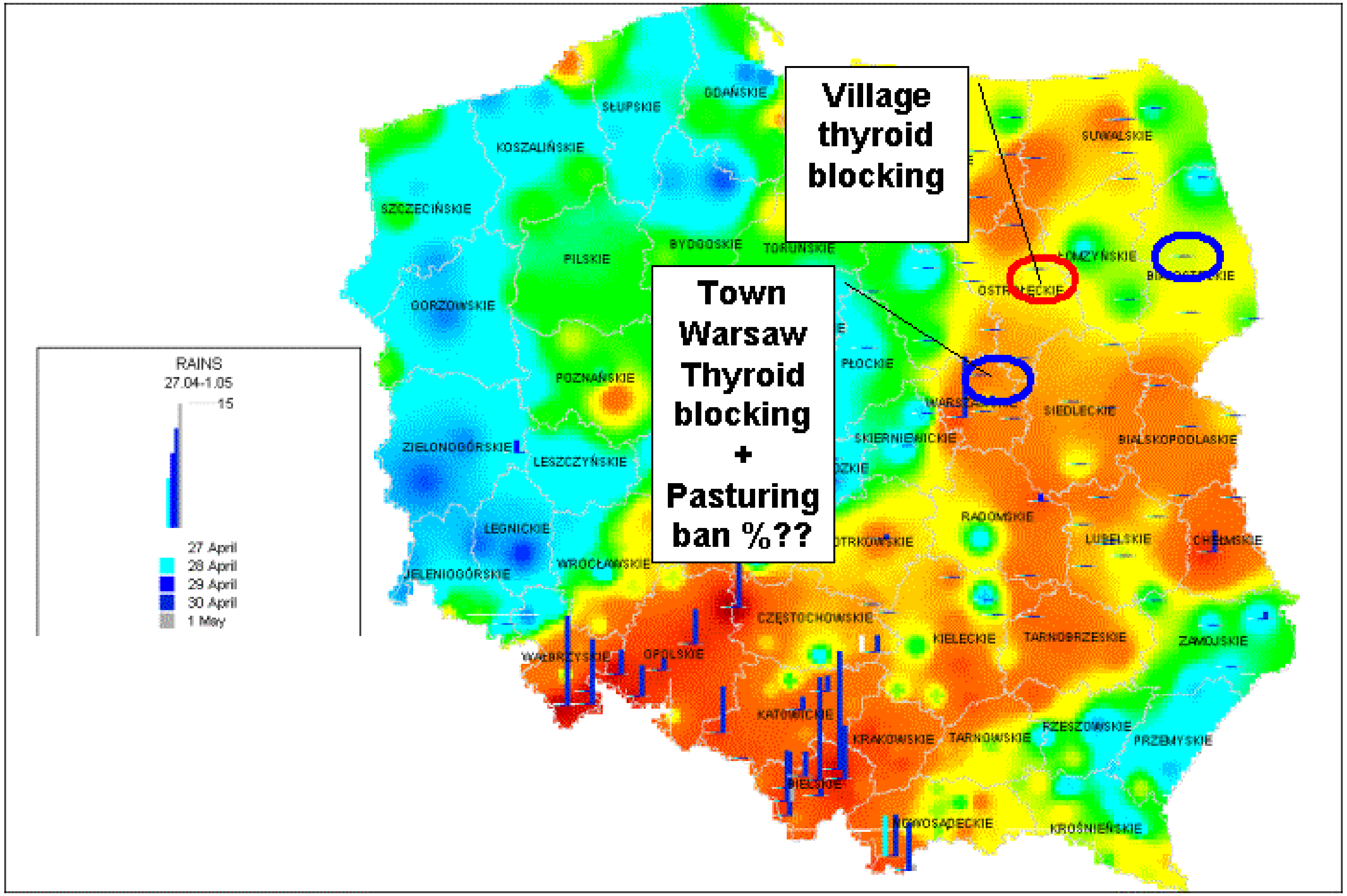

FIGURE 2. Selected 3 locations with different countermeasures applied.