THEME 1: Radioactive Release Assessment

Working Group 3

The Chernobyl I-131 release: model validation and assessment of the countermeasure effectiveness working group

Paweł Krajewski

(EMRAS Iodine Working Group Leader)

Central Laboratory for Radiological Protection

WARSAW, POLAND

EMRAS Iodine Working Group

Background

IWG continues some of the more traditional work of the previous international programmes that have been aimed at increasing confidence in methods and models for the assessment of radiation exposure related to the environmental releases.

the IAEA's Validation of Model Predictions (VAMP)

the IAEA's BIOMOVS

the BIOMOVS II* (Biospheric Model Validation Study)

the IAEA's BIOMASS (BIOsphere Modelling and ASSessment)

terminated in 2001

* supported by organisations from Canada, Spain and Sweden.

EMRAS Iodine Working Group

Background (cont.)

activity of the IWG

environmental modelling exercises on radioiodine

- **to test and compare models' predictions with real environmental data**
- **to intercompare modelling approaches and model predictions among several assessors**

EMRAS Iodine Working Group

Background (cont.)

major areas of emphasis:

- improvement of models predictions accuracy by identification the most important sources of bias and uncertainty
- check models applicability to countermeasure response
- implementation of new modelling procedures supported by current state of knowledge about processes and phenomena

main targets of IWG

- check models performance in dose reconstruction in a case when ^{137}Cs (^{129}I) tracer is used for estimation of ^{131}I deposition
- uncertainty ?, limitation ?, requested input data ?

EMRAS Iodine Working Group

Background (cont.)

ADDITIONAL ASPECT OF IWG ACTIVITY

numerous reports 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

the confident reconstruction of the average and personal thyroid dose in affected areas is required:

- **to confirm the special medical aid to the population and measures of social protection**
- **to provide information for the public and the authorities and ensure epidemiological investigations.**

EMRAS Iodine Working Group

Background (cont.)

- **uncertainty ?, limitation?**

  case–control studies of thyroid cancer

the quantitative relationship between radiation dose to the thyroid from Chernobyl and the risk of thyroid cancer.

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.

EMRAS Iodine Working Group

Background (cont.)

major sources of the uncertainty:

- 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 lack of milk samples in early periods of accident.
- large variety in inhabitants behaviour and agricultural practices (the time when cows had been put on a fresh pasture) have considerable impact on doses variability.

EMRAS Iodine Working Group

Background (cont.)

The ^{131}I- scenarios provide an excellent opportunity to compare a number of modelling approaches to a single assessment problem, in a dose reconstruction context

EMRAS Iodine Working Group

Background (cont.)

In the past environmental modelling exercises,

only two I-131 scenarios had been evaluated, namely:

BREMEN SCENARIO (BIOMOVS II)

HANFORD SCENARIO (BIOMASS)

HANFORD SCENARIO - release of ^{131}I from the Hanford Purex Chemical Separations Plant in the northwestern United States in September 1963

BIOMASS Theme 2, the Dose Reconstruction Working Group was concerned with the evaluation of the reliability of methods and models used for dose reconstruction for specific individuals and members of specific population subgroups.

Background (cont.)

Necessity of performing environmental modelling exercises?

Selected conclusions of HANFORD SCENARIO (BIOMASS):

Predicted thyroid doses to the two children with high milk consumption ranged from 0.006 to 2 mSv

Compensatory effects (a high prediction in one model compartment being offset by a low prediction in another compartment) were quite common in this test exercise.

Major sources of uncertainty in this exercise include:

atmospheric transport (which could contribute as much as a factor of 20-50), representativeness of available measurements, iodine speciation, treatment or neglect of terrain effects, actual consumption and metabolic rates

EMRAS Iodine Working Group

MILESTONES

- **before 1st EMRAS meeting (1-5 September 2003)**

  Questionnaire

  to identify participants of potential working group

  to identify suitable data sets and models for testing

  9 modellers 10 scenarios proposals

- **1st EMRAS meeting (1-5 September 2003)**

  developing appropriate scenarios for model validation and collecting measurement data sets
  quality checking of input and measurement data

- **end of January 2004**

  the Scenario Plavsk was evaluated and distributed among the participants together with prediction formularies (in Excel file)

  The Scenario is also available on the EMRAS WEBSITE:
  http://www-ns.iaea.org/projects/emras/emras-iodine-131-wg.htm

EMRAS Iodine Working Group

MILESTONES

SCENARIO P *(draft)*

Validation of enviromnemtal models

using data from Chernobyl fallout in the Plavsk agricultural area

Irina Zvonova
Institute of Radiation Hygiene
Mira St.8, 197101 St. Petersburg, Russia
E-mail: irvaz@iz10087.spb.edu

CONSIDERED FURTHER SCENARIO

^{131}I WARSAW SCENARIO (Chernobyl)

in preparation (description, electronically available input data)

crucial points for model validation!

- **effectiveness of thyroid blocking!**
- **inhomogeneous ^{131}I deposition**

end points considered for model testing:

- **^{131}I concentration in milk**
- **^{131}I thyroid burden for different age groups for two specified location**

countermeasures

- **administration of stable iodine solution (interviews DB),**
- **limitation of fresh milk consumption (uncertain data),**
- **restriction of cows pasturing (uncertain data)**

PLAVSK Scenario (Chernobyl)

Primery prepared by SENES, (description, electronically available input data) customised for IWG by Irina Zwonowa, Paweł Krajewski

- **model validation problem!**

  reconstruction of ^{131}I deposition using ^{137}Cs as a tracer

- **scenario advantages!**

  numerous measurements of ^{131}I thyroid contents

  adequate data set of $^{131}I/^{137}Cs$ ratio in soil (28 May 1986)

- **a new subject to be validated!**

  ^{131}I thyroid burden for new born and <3m:

process - transfer factor from mother breast to milk

^{131}I PLAVSK Scenario (Chernobyl)

end points considered for model validation:

- ^{131}I deposition (soil concentration)
- a time dependent ^{131}I concentration in milk

  in the period 27 April –30 May 1986 for 18 milk farm and Town Plavsk situated at different ^{131}I deposition density
- ^{131}I thyroid burden for different age groups:

for urban population (Plavsk town): new born, 1-2, 3-7, 8-12, 13-17, adult
for specified rural locations: new born, 1-2, 3-7, 8-12, 13-17, adult

end points considered for model intercomparison:

committed doses to thyroid from ingestion

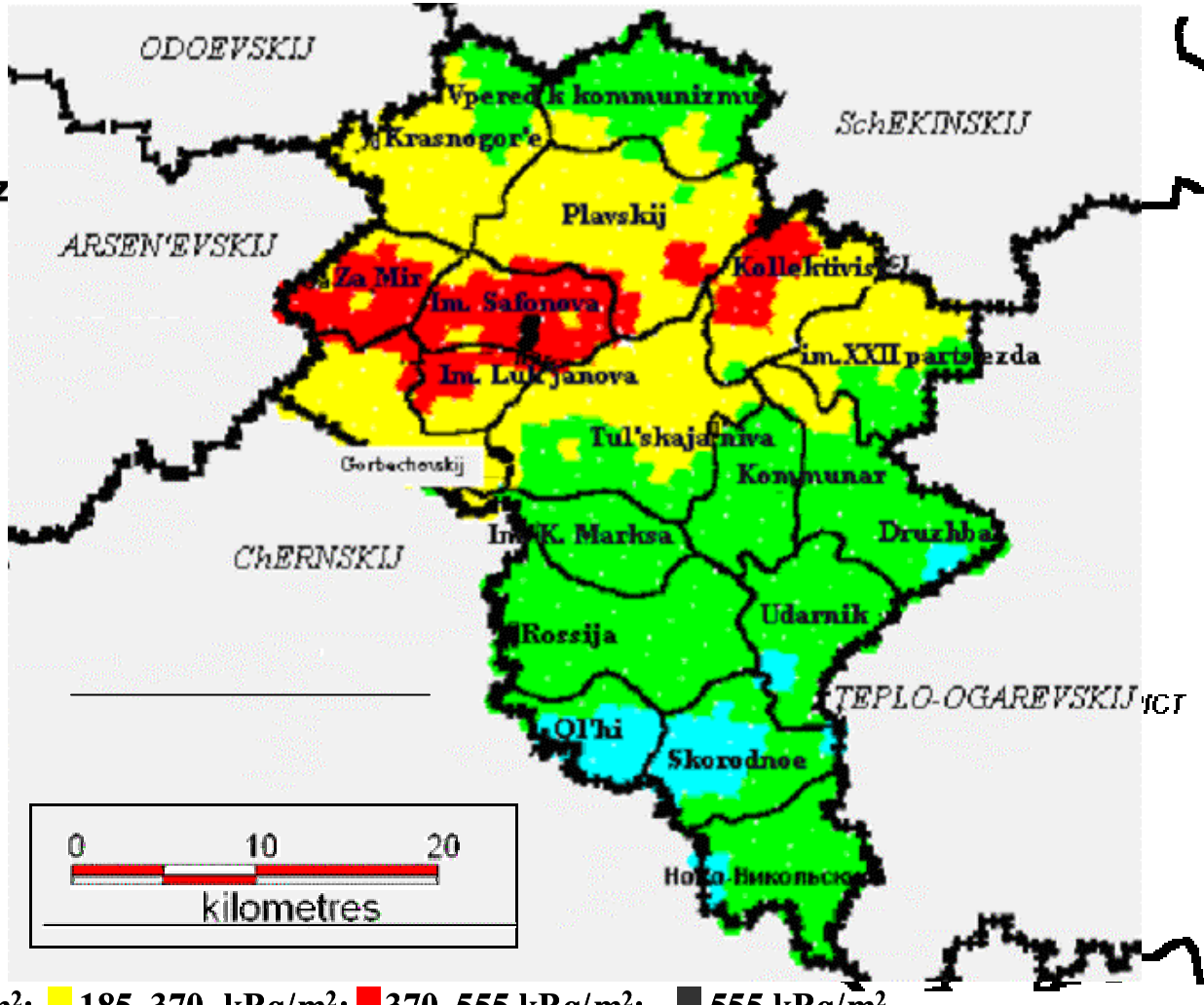
reconstruction of ^{131}I air concentration from deposition

inhalation dose contribution to the total dose

^{131}I **PLAVSK Scenario** (Chernobyl)

1 Krasnogor'e
2 Za Mir
3 Im. Safonova
4 Plavskij
5 Vpered k kommuniz
6 Im. Luk'janova
7 Gorbachevskij
8 Tul'skaja niva
9 Im. K. Marksa
10 Rossija
11 Kollektivist
12 Kommunar
13 Druzhba
14 im.XXII parts'ezda
15 Udarnik
16 Ol'hi
17 Skorodnoe
18 Novo Nikol'skij

40 km width; 60 km high



>37 kBq/m² ; 37–185 kBq/m²; 185–370 kBq/m²; 370–555 kBq/m²; 555 kBq/m²

EMRAS Iodine Working Group

MILESTONES (cont)

- from February to May 2004

blind test exercise
(when measurements results remained unknown to participants) and sent results before

- 2nd Meeting of the IAEA's EMRAS IWG
  (held at the CIEMAT, Madrid, Spain, 31 May to 2 June 2004)

9 participants sent results, together with questionnaire summarized assumptions and used parameters.

Irina Zvonowa provided the observed data for the Plavsk region.

analysing predictions versus observed data

EMRAS Iodine Working Group

MILESTONES (cont)

- **2nd Meeting of the IAEA's EMRAS IWG (held at the CIEMAT, Madrid, Spain, 31 May to 2 June 2004)**

conclusions

The measurements for use as test data were not ideally suited for model testing purposes (i.e. milk samples were not entirely representative of the test locations or the thyroid measurements were incomplete).

For these reasons, the second run of predictions was planed with results to be sent before the November 2004.

This exercise will be still representative for an actual dose reconstruction based on existing data, whatever their limitation, and conclusions still be valid for dose assessment purposes, especially if not most dose reconstruction situations, the data available are incomplete or imperfect.

EMRAS Iodine Working Group

MILESTONES (cont)

- **June – November 2004**

TESTING AND VALIDATION OF DOSIMETRY MODELS USING DATA FROM CHERNOBYL ^{131}I FALLOUT IN THE PLAVSK AGRICULTURAL AREA

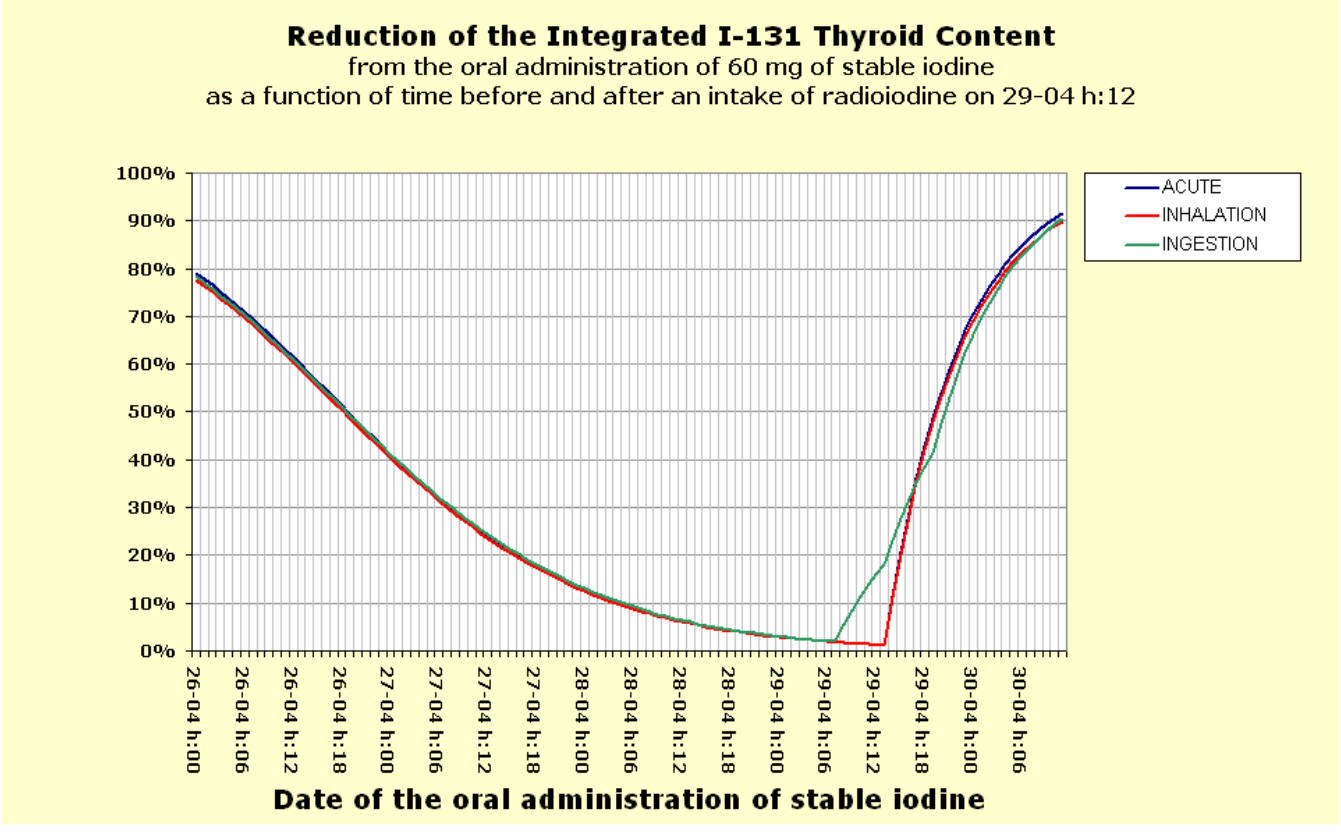
Intermediate report of ^{131}I Working Group
on the model validation
and assessment of the countermeasure effectiveness
of the Environmental Modelling for Radiation
Safety Programme (EMRAS)

EMRAS Iodine Working Group

MILESTONES (cont)

- **June – November 2004**

WORKSHEET "THYROID v2.2" (extended!)
SUPPORTED IODINE WORKING GROUP OF EMRAS PROGRAM



EMRAS Iodine Working Group

MILESTONES (cont)

The group agreed that the first model validation and intercomparison exercise will be carried in 2004 using the Plavsk Scenario. Calculations for the Warsaw scenario will be delayed until after the completion of the Group's work on the Plavsk Scenario.

- **2nd Combined Meetings of the IAEA (EMRAS) 8–11 November 2004**
  - **evaluation and discussion of results of second run predictions**
  - **preparation of draft Final Report**
  - **introduction to the Warsaw scenario**

EMRAS Iodine Working Group

MILESTONES (planned)

- **end of December 2004**
  - distribution of draft Warsaw Scenario
- **January 2005 - June 2005**
  - predictions for Warsaw Scenario
- **IWG meeting May-July 2005**
  - disclosing observed data, evaluation of predictions
- **July- October 2005**

  second run of predictions
- **3rd Combined EMRAS meeting Autumn 2005**
  - data evaluation, IWG Report

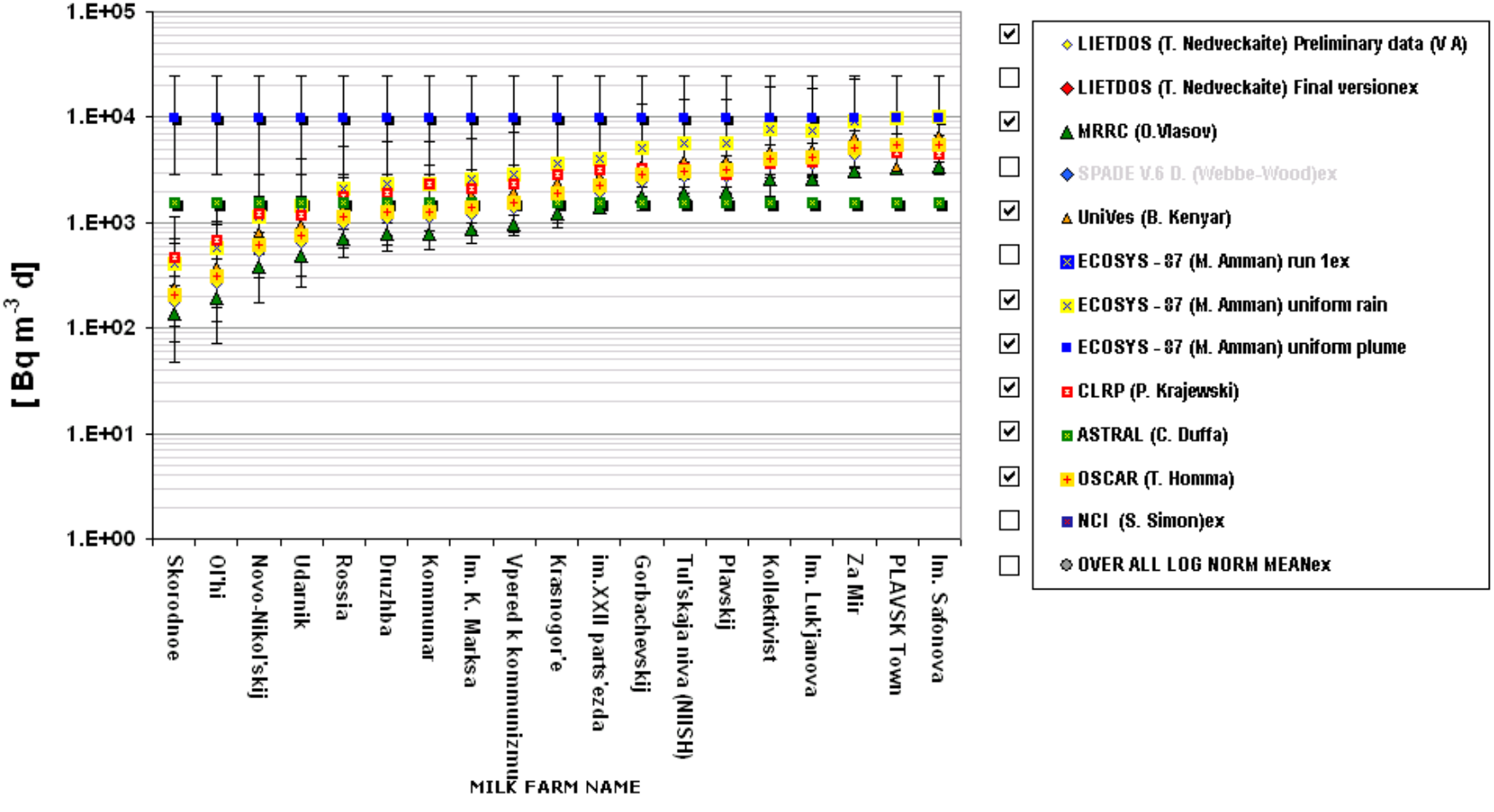
MODELS (*9 participants*)

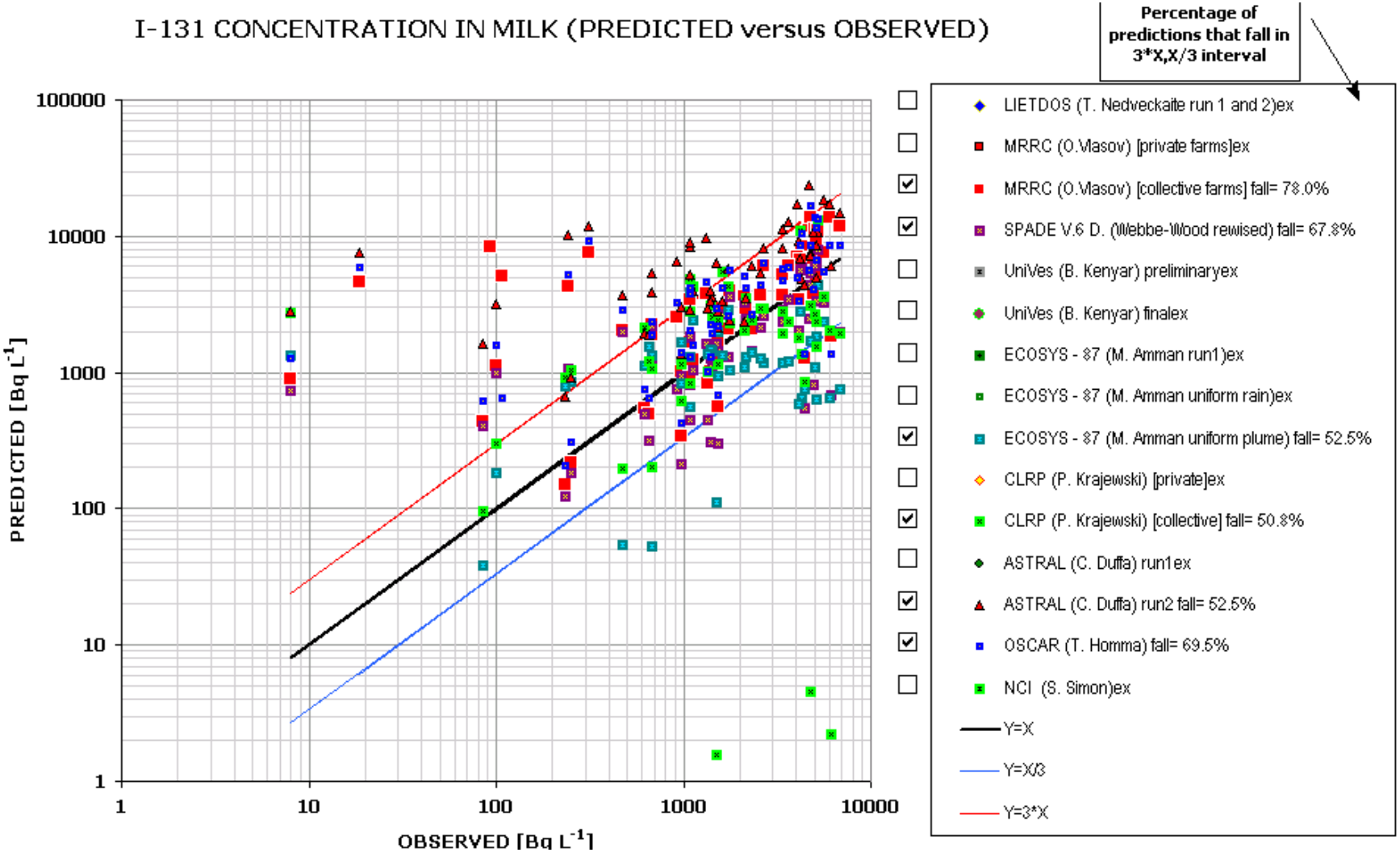
	Model	Participant Name	Country	Organization
1	LIETDOS	Ms T. Nedveckaite (BIOMASS)	Lithuania	Institute of Physics
2	OSCAAR	Mr T HOMMA (BIOMASS)	Japan	Japan Atomic Energy Research Institute
3	UniVes	Mr B.Kanyár (BIOMASS)	Hungary	University of Veszprém Department of Radiochemistry
4	CLRP	Mr P. Krajewski (BIOMASS)	Poland	Central Laboratory for Radiological Protection
5	ASTRAL	Ms C. Duffa (New)	France	Institut de Radioprotection et de Sûreté Nucléaire (IRSN)
6	Ecosys-87	Mr M. Ammann (New)	Finland	Radiation & Nuclear Safety Authority (STUK)
7	Plavsk Dose Calculator	Mr S. Simon (New)	USA	National Cancer Institute
8	SPADE V.6	Mr D. Webbe-Wood (New)	UK	Food Standard Agency
9	CLIMRAD	O. Vlasov (New)	Russian Federation	Medical Radiological Research Center

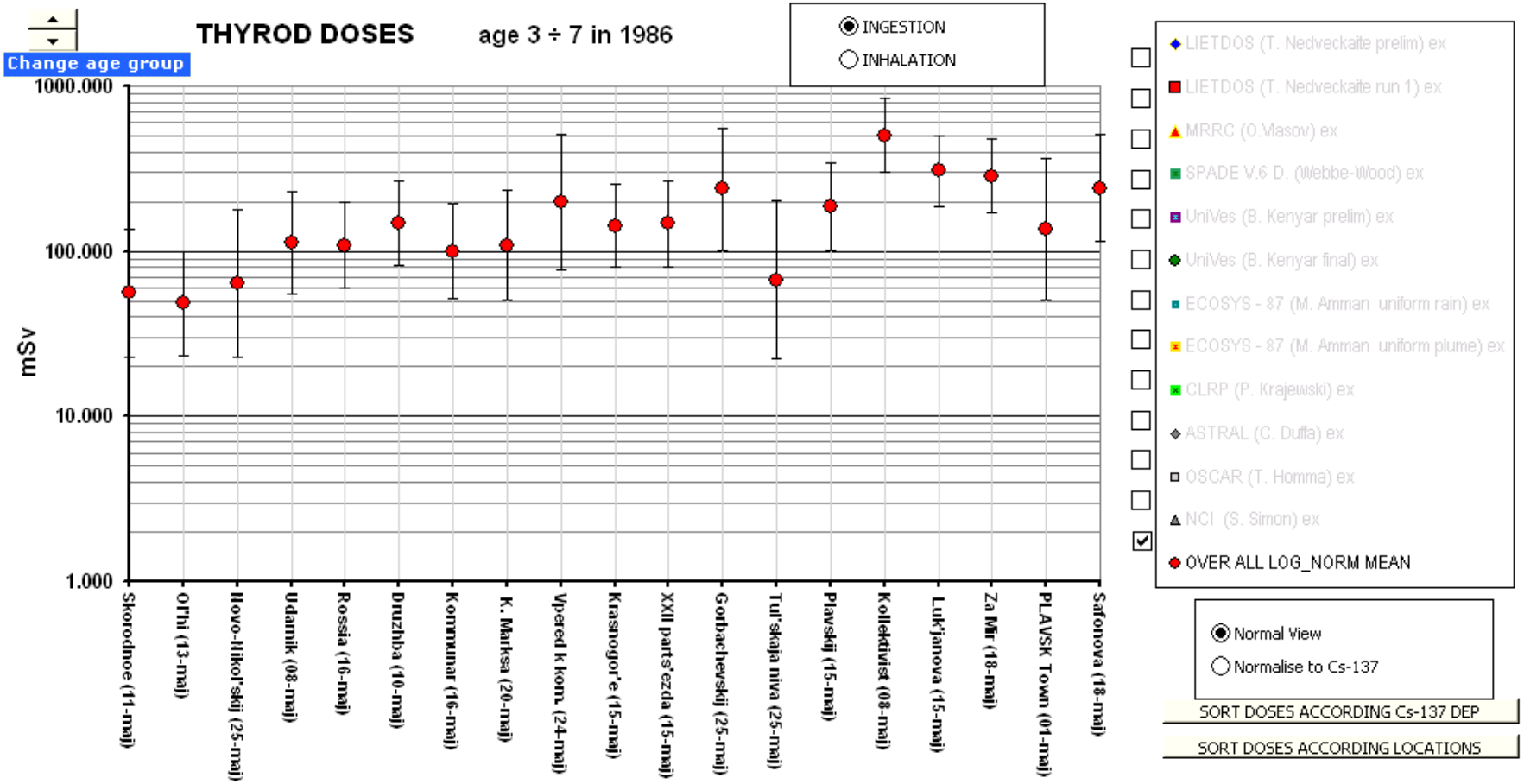
SORT ACCORDING DEPOSITION

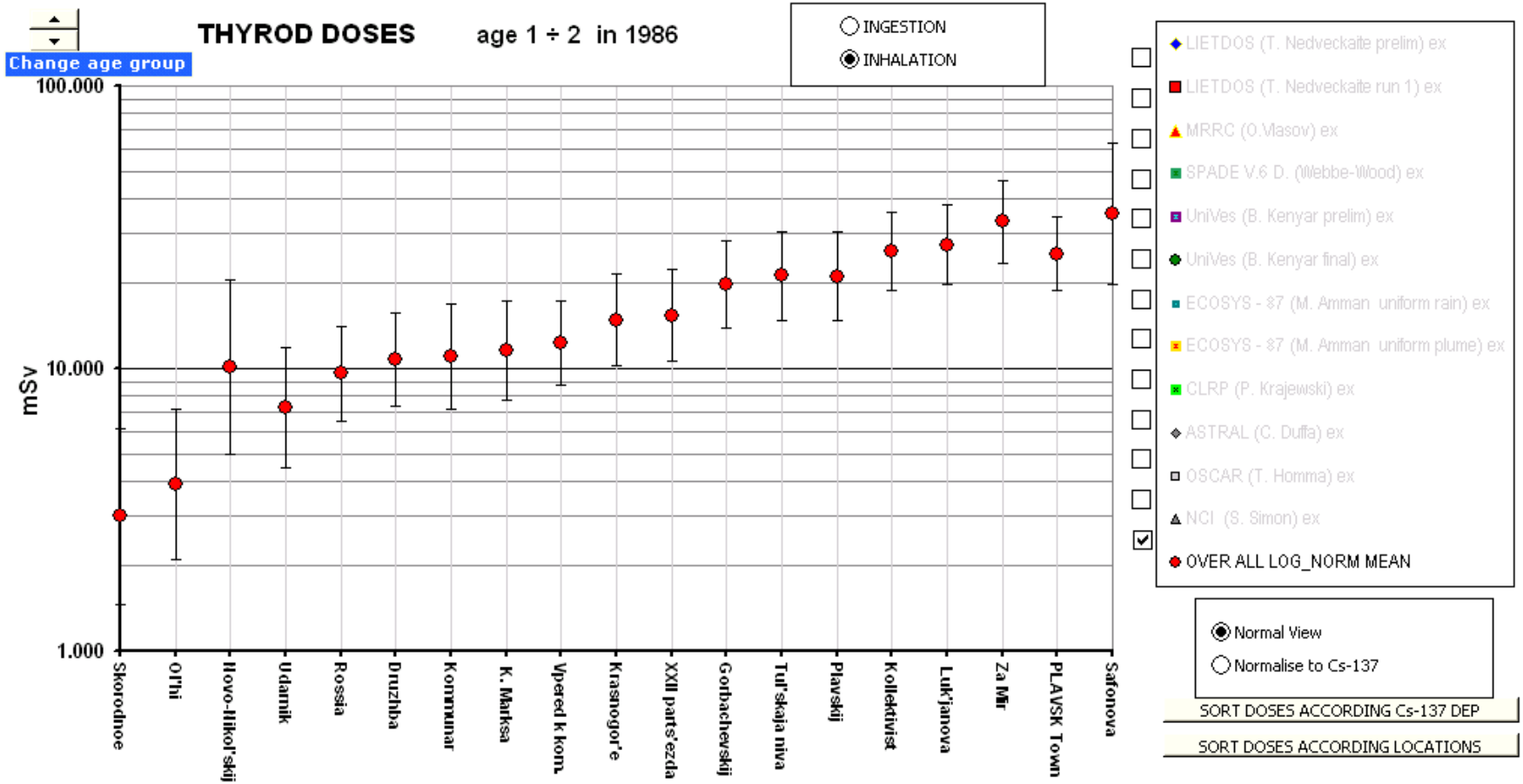
SORT ACCORDING SETELMENT

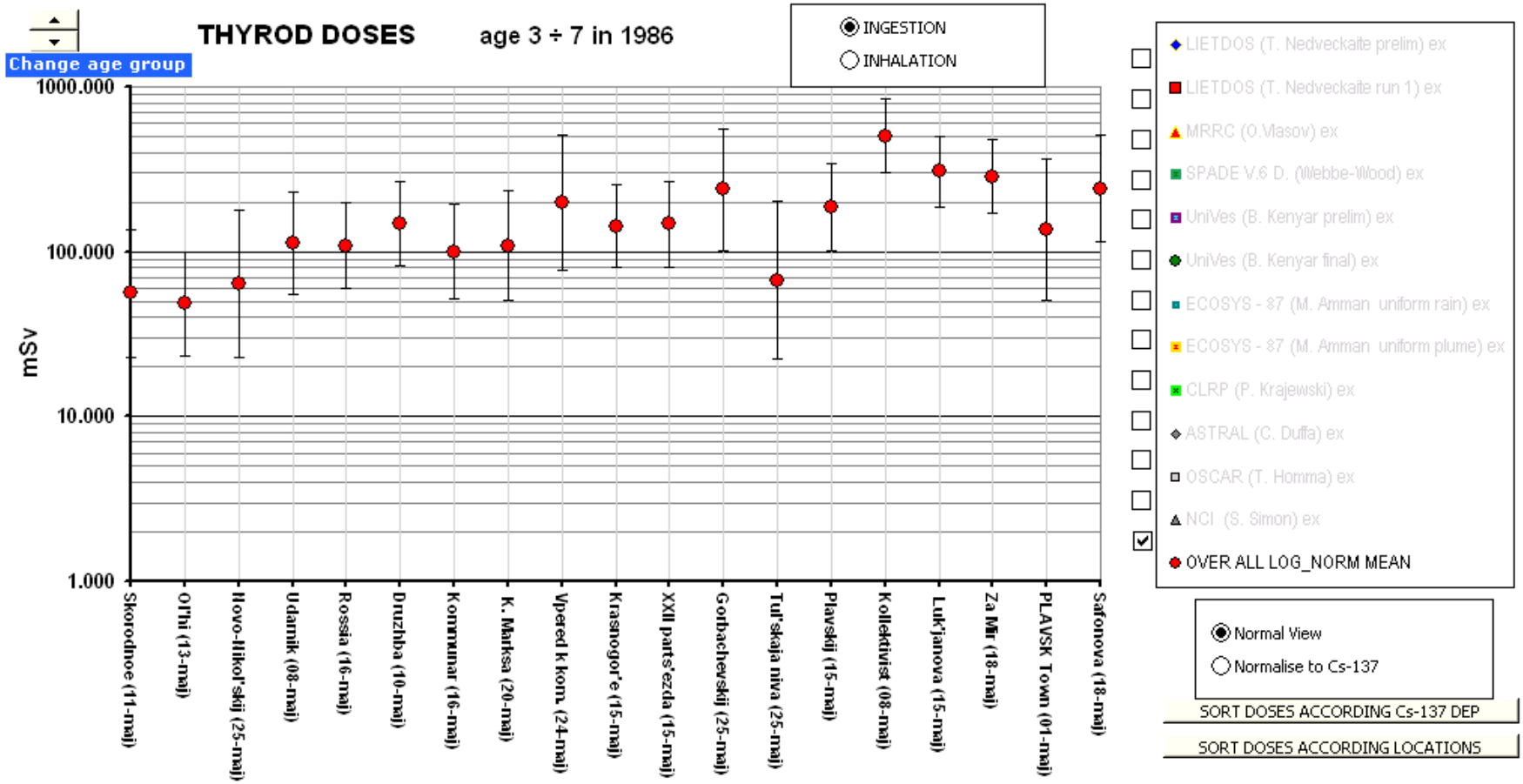
^{131}I INTEGRATED AIR CONCENTRATION IN PLAVSK DISTRICT FOR PERIOD 29-April 1 May 1986




I-131 CONCENTRATION IN MILK (PREDICTED versus OBSERVED)
Percentage of predictions that fall in 3*X,X/3 interval
PREDICTED [Bq L-1]
OBSERVED [Bq L-1]
100000
10000
1000
100
10
1
1
10
100
1000
10000
LIETDOS (T. Nedveckaite run 1 and 2)ex
MRRC (O.Vlasov) [private farms]ex
MRRC (O.Vlasov) [collective farms] fall= 78.0%
SPADE V.6 D. (Webbe-Wood rewised) fall= 67.8%
UniVes (B. Kenyar) preliminaryex
UniVes (B. Kenyar) finalex
ECOSYS - 87 (M. Amman run1)ex
ECOSYS - 87 (M. Amman uniform rain)ex
ECOSYS - 87 (M. Amman uniform plume) fall= 52.5%
CLRP (P. Krajewski) [private]ex
CLRP (P. Krajewski) [collective] fall= 50.8%
ASTRAL (C. Duffa) run1ex
ASTRAL (C. Duffa) run2 fall= 52.5%
OSCAR (T. Homma) fall= 69.5%
NCI (S. Simon)ex
Y=X
Y=X/3
Y=3*X


THYROD DOSES
age 3 ÷ 7 in 1986
Change age group
INGESTION
INHALATION
1000.000
100.000
10.000
1.000
mSv
Skorodnoe (11-maj)
Ol'hi (13-maj)
Novo-Nikol'skij (25-maj)
Udarnik (08-maj)
Rossia (16-maj)
Druzhba (10-maj)
Kommunar (16-maj)
K. Marksa (20-maj)
Vpered k kom. (24-maj)
Krasnogor'e (15-maj)
XXII parts'ezda (15-maj)
Gorbachevskij (25-maj)
Tul'skaja niva (25-maj)
Plavskij (15-maj)
Kollektivist (08-maj)
Luk'janova (15-maj)
Za Mir (18-maj)
PLAVSK Town (01-maj)
Safonova (18-maj)
LIETDOS (T. Nedveckaite prelim) ex
LIETDOS (T. Nedveckaite run 1) ex
MRRC (O.Vlasov) ex
SPADE V.6 D. (Webbe-Wood) ex
UniVes (B. Kenyar prelim) ex
UniVes (B. Kenyar final) ex
ECOSYS - 87 (M. Amman uniform rain) ex
ECOSYS - 87 (M. Amman uniform plume) ex
CLRP (P. Krajewski) ex
ASTRAL (C. Duffa) ex
OSCAR (T. Homma) ex
NCI (S. Simon) ex
OVER ALL LOG_NORM MEAN
Normal View
Normalise to Cs-137
SORT DOSES ACCORDING Cs-137 DEP
SORT DOSES ACCORDING LOCATIONS


THYROD DOSES
age 1 ÷ 2 in 1986
Change age group
INGESTION
INHALATION
100.000
10.000
1.000
mSv
Skorodnoe
Ol'hi
Novo-Belkol'skij
Udarnik
Rossia
Druzhba
Kommunar
K. Marksa
Vpered k kom.
Krasnogor'e
XXII parts'ezda
Gorbachevskij
Tul'skaja niva
Plavskij
Kollektivist
Luk'janova
Za Mir
PLAVSK Town
Safonova
LIETDOS (T. Nedveckaite prelim) ex
LIETDOS (T. Nedveckaite run 1) ex
MRRC (O.Vlasov) ex
SPADE V.6 D. (Webbe-Wood) ex
UniVes (B. Kenyar prelim) ex
UniVes (B. Kenyar final) ex
ECOSYS - 87 (M. Amman uniform rain) ex
ECOSYS - 87 (M. Amman uniform plume) ex
CLRP (P. Krajewski) ex
ASTRAL (C. Duffa) ex
OSCAR (T. Homma) ex
NCI (S. Simon) ex
OVER ALL LOG_NORM MEAN
Normal View
Normalise to Cs-137
SORT DOSES ACCORDING Cs-137 DEP
SORT DOSES ACCORDING LOCATIONS


Change age group
THYROD DOSES
age 3 ÷ 7 in 1986
INGESTION
INHALATION
1000.000
100.000
10.000
1.000
mSv
Skorodnoe (11-maj)
Ol'hi (13-maj)
Novo-Ilikol'skij (25-maj)
Udarnik (08-maj)
Rossia (16-maj)
Druzhba (10-maj)
Kommunar (16-maj)
K. Marksa (20-maj)
Vpered k kom. (24-maj)
Krasnogor'e (15-maj)
XXII parts'ezda (15-maj)
Gorbachevskij (25-maj)
Tul'skaja niva (25-maj)
Plavskij (15-maj)
Kollektivist (08-maj)
Luk'janova (15-maj)
Za Mir (18-maj)
PLAVSK Town (01-maj)
Safonova (18-maj)
LIETDOS (T. Nedveckaite prelim) ex
LIETDOS (T. Nedveckaite run 1) ex
MRRC (O.Vlasov) ex
SPADE V.6 D. (Webbe-Wood) ex
UniVes (B. Kenyar prelim) ex
UniVes (B. Kenyar final) ex
ECOSYS - 87 (M. Amman uniform rain) ex
ECOSYS - 87 (M. Amman uniform plume) ex
CLRP (P. Krajewski) ex
ASTRAL (C. Duffa) ex
OSCAR (T. Homma) ex
NCI (S. Simon) ex
OVER ALL LOG_NORM MEAN
Normal View
Normalise to Cs-137
SORT DOSES ACCORDING Cs-137 DEP
SORT DOSES ACCORDING LOCATIONS