

JRODOS

Real-time On-line Decision Support system

Seminarium Zakładu Energetyki Jądrowej i Analiz Środowiska (UZ3)
Departament Badań Układów Złożonych (DUZ)

Henryk Wojciechowicz

JRODOS

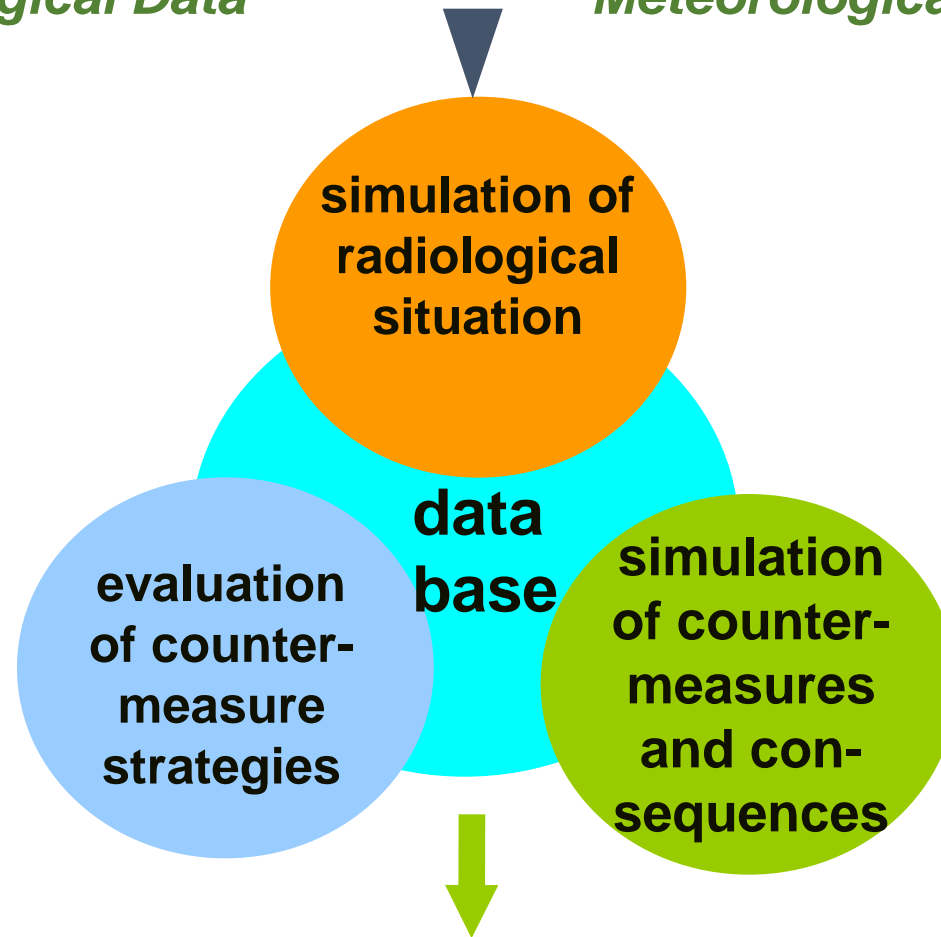
Real-time On-line Decision Support system

1. JRodos is system for emergency management following releases of radioactive material into the environment
2. Contains detailed simulation models for predicting and analysing the resulting contamination
3. JRodos is a non-commercial system with an active user community that aims to extend and development of the system
4. Multi-user operation system can be used in national or regional emergency centres
5. Provide consistent and comprehensive information
 - on local, national, regional and European scales,
 - It can be used for all stages of an accident (i. e., before, during and after release),
 - it can be used for all emergency actions and countermeasures (i.e., sheltering, relocation, evacuation, distribution of iodine tablets, food restrictions),
 - The current version of the system has been installed in national emergency centers of several countries, such as Germany, Finland, Spain, Portugal, Austria, the Netherlands, Poland, Hungary, Slovakia, Ukraine, Slovenia, Czech Republic, Switzerland, Russia, Hong Kong and China
6. Applicability - Microsoft Windows, Linux and Mac
7. Mainly developed by Karlsruhe Institute of Technology (KIT)

JRODOS: Tasks, input data, output

Radiological Data

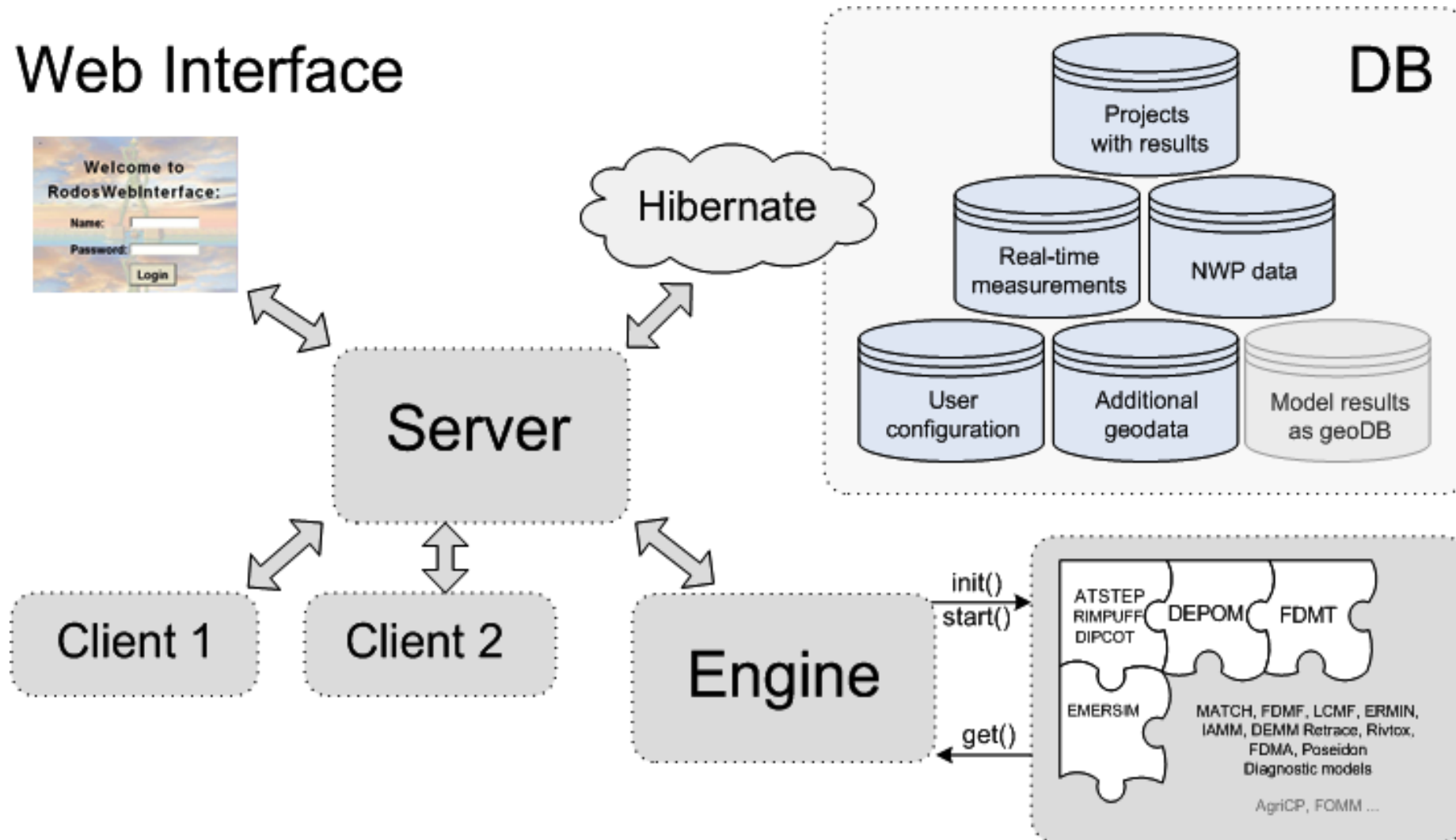
Meteorological Data



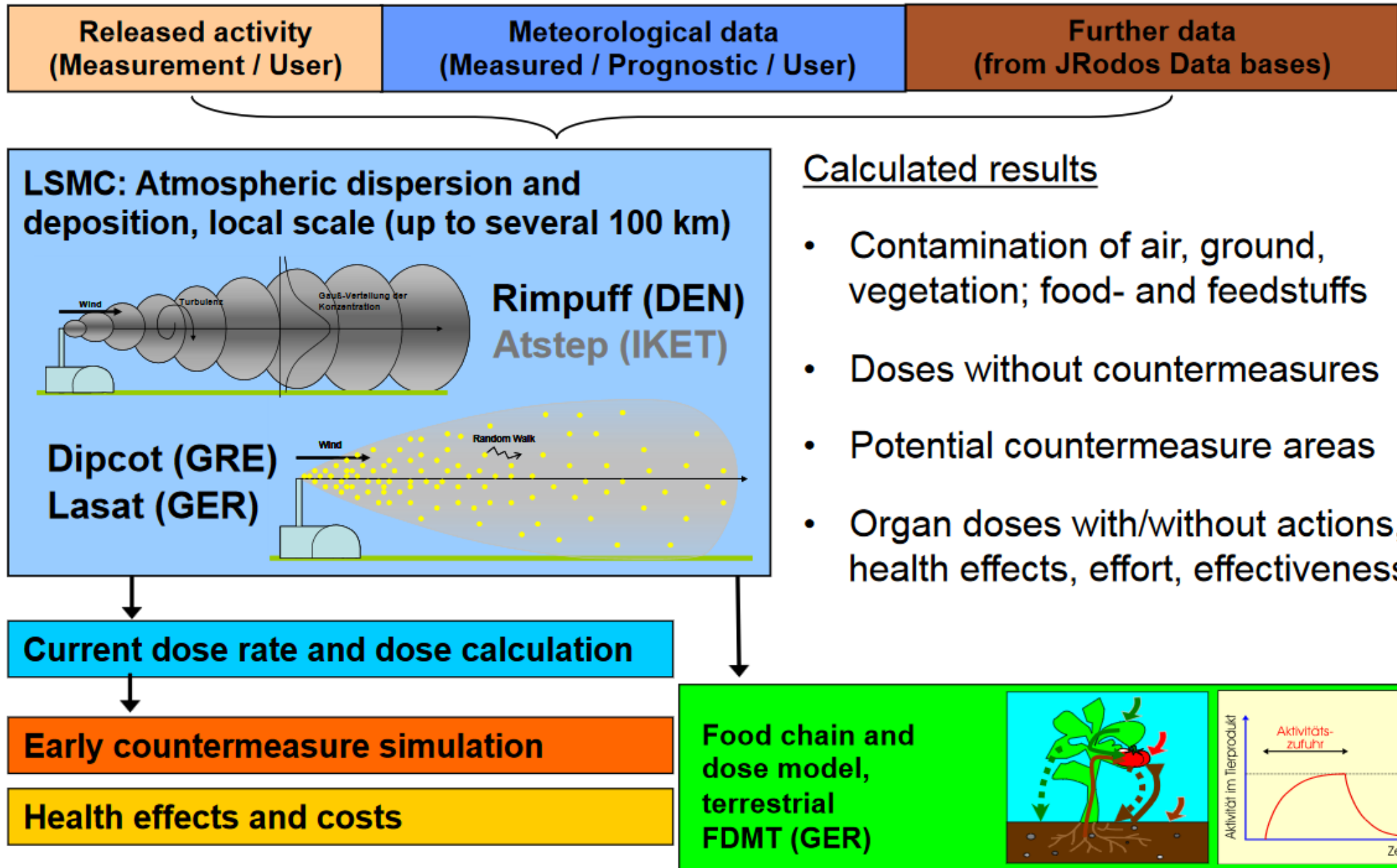
Environmental Contamination of Air, Ground, Food, Potential Doses

JRODOS software structure

Web Interface



System architecture - EMERGENCY chain models



Assessment of radiological situation (diagnostic and prognostic)

Input data

- Numerical weather measurements and prognostic data
- radiological measurements and prognostic data

Near-range model chain

- Meteorological pre-processor
- Several models for atmospheric dispersion and deposition in the near range
(*LSMC + EMERSIM + DEPOM + FDMT*)

Far-range model chain

- Meteorological pre-processor
- LASAT model
- MATCH model

Near-range atmospheric dispersion models in JRODOS

LSMC - Local Scale Model Chain

- RIMPUFF: Gaussian Puff Model; (Risø, Roskilde, Denmark)
- DIPCOT: Lagrangian Particle Models; (Demokritos, Athen, Greece)
- LASAT: Lagrangian Particle Models; (official reference German model)

Early countermeasure model

EMERSIM - consists of a combination of the three single actions sheltering, evacuation and the distribution of stable iodine tablets. In addition, EmerSim allows assessing relocation areas

Deposition Module

DEPOM - assessment of deposition of radionuclides onto soil and all kinds of agricultural crops.
Deposition calculations for FDMT

Food Chain and Dose Module

FDMT - Food Chain and Dose Module

Near-range atmospheric dispersion models in JRODOS - FDMT

The task of the food and dose module FDMT in the JRODOS system is to give an assessment of the present and future radiological situation

FDMT - Food Chain and Dose Module **INPUT**

Results from atmospheric dispersion models - LSMC

- concentration of radionuclides in the near ground atmosphere
- activity deposited on various crops and on soil
- effective dose rates for adults from radionuclides in the atmosphere
- time of the year when deposition occurs

geographical data base:

- radioecological regions (for each location)
- number of inhabitants (for each location)
- amount of foodstuff production (for each location)
- soil type category (for each location)

Model parameters describing the food chain transfer for each radioecological region:

- growing and harvesting times for different agricultural crops
- animal feeding diets
- food consumption rates

Near-range atmospheric dispersion models in JRODOS

FDMT - Longer term doses, results

Exposure pathways

- cloud , ground, inhalation, resuspension
- ingestion, skin exposure, and the sum over all
- pathways except ingestion and including ingestion

Age groups

- adults
- children of 1, 5, 10 and 15 years

Organs

- lungs, red bone marrow, thyroid, uterus
- effective, skin, bone surface, breast, colon
- stomach, liver, pancreas

Integration times

- 7 days, 14 days, 30 days, 3 months, 6 months
- 1 year, 2 years, 5 years, 50 years, lifetime

Near-range atmospheric dispersion models in JRODOS

FDMT - Longer term doses, results

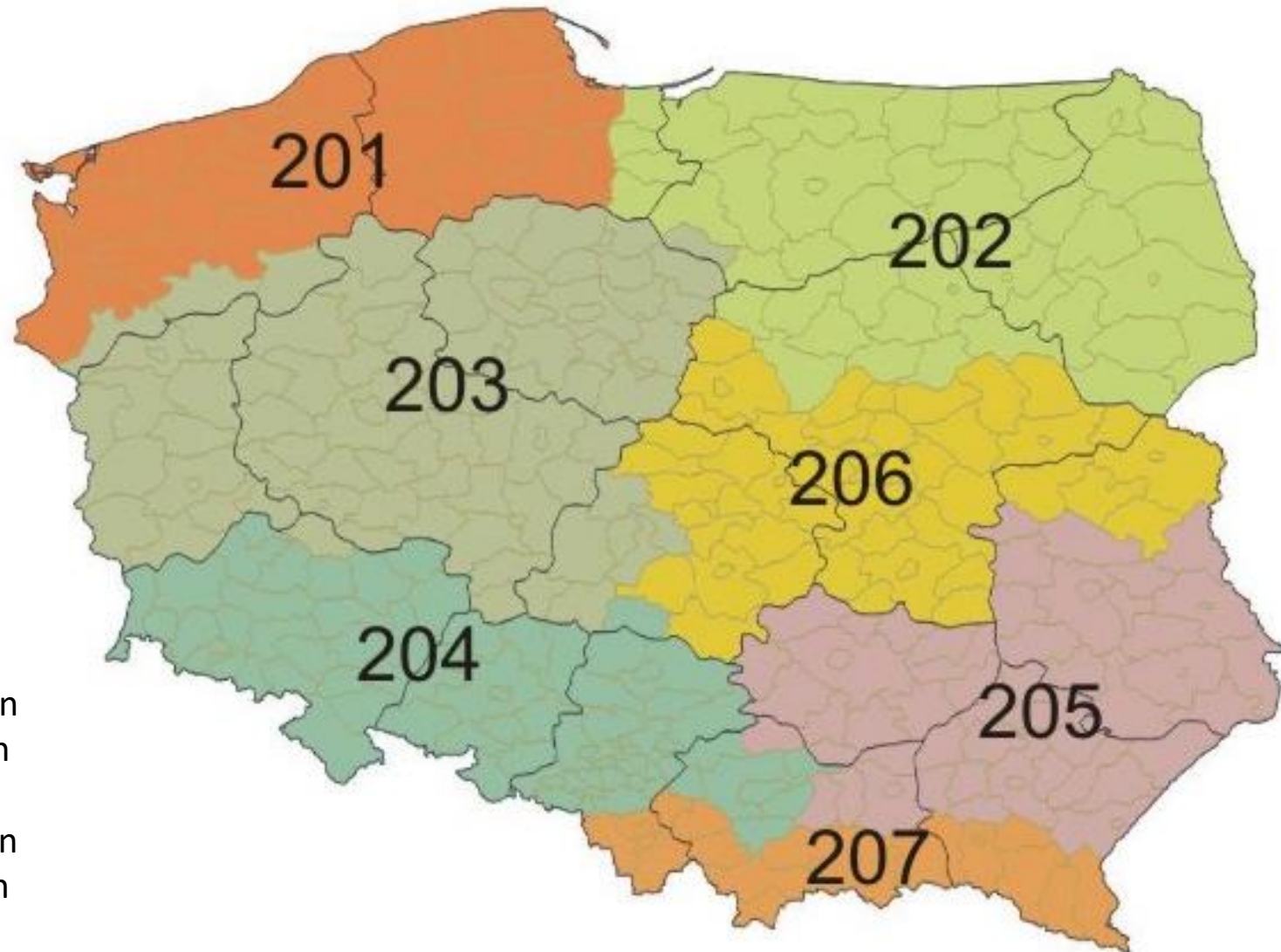
| | |
|---|---|
| ⊖ | Longer term doses |
| ⊖ | Ingestion dose |
| ⊖ | Maps [mSv] |
| | effective dose, processed, all products (sum), all nuclides (sum), adults, 1 year [mSv] |
| | effective dose, processed, all products (sum), all nuclides (sum), adults, 30 days [mSv] |
| | effective dose, processed, all products (sum), all nuclides (sum), adults, 7 days [mSv] |
| | effective dose, processed, all products (sum), all nuclides (sum), adults, lifetime [mSv] |
| | effective dose, processed, all products (sum), all nuclides (sum), age 1y, 1 year [mSv] |
| | effective dose, processed, all products (sum), all nuclides (sum), age 1y, 30 days [mSv] |
| | effective dose, processed, all products (sum), all nuclides (sum), age 1y, 7 days [mSv] |
| | effective dose, processed, all products (sum), all nuclides (sum), age 1y, lifetime [mSv] |
| | lungs, processed, all products (sum), all nuclides (sum), adults, 1 year [mSv] |
| | lungs, processed, all products (sum), all nuclides (sum), adults, 30 days [mSv] |
| | lungs, processed, all products (sum), all nuclides (sum), adults, 7 days [mSv] |
| | lungs, processed, all products (sum), all nuclides (sum), adults, lifetime [mSv] |
| | lungs, processed, all products (sum), all nuclides (sum), age 1y, 1 year [mSv] |
| | lungs, processed, all products (sum), all nuclides (sum), age 1y, 30 days [mSv] |
| | lungs, processed, all products (sum), all nuclides (sum), age 1y, 7 days [mSv] |
| | lungs, processed, all products (sum), all nuclides (sum), age 1y, lifetime [mSv] |
| | thyroid, processed, all products (sum), all nuclides (sum), adults, 1 year [mSv] |
| | thyroid, processed, all products (sum), all nuclides (sum), adults, 30 days [mSv] |
| | thyroid, processed, all products (sum), all nuclides (sum), adults, 7 days [mSv] |
| | thyroid, processed, all products (sum), all nuclides (sum), adults, lifetime [mSv] |
| | thyroid, processed, all products (sum), all nuclides (sum), age 1y, 1 year [mSv] |
| | thyroid, processed, all products (sum), all nuclides (sum), age 1y, 30 days [mSv] |
| | thyroid, processed, all products (sum), all nuclides (sum), age 1y, 7 days [mSv] |
| | thyroid, processed, all products (sum), all nuclides (sum), age 1y, lifetime [mSv] |

Far-range model chain

MATCH

- **MATCH** (**M**ulti-scale **A**tmospheric **T**ransport and **C**hemistry model) is the long-range transport model in the JRODOS system.
- A necessary requirement is access to numerical weather prediction HIRLAM or ALADIN (not free).
- New version JRodos contains a command line tool for converting LSMC suitable GRIB1 or GRIB2 NWP (Numerical Weather Prediction) data for use in MATCH
Free downloading of GRIB2 Files from the NCEP NOMAD Server
- MATCH is an Lagrangian grid model.

Implementation of radioecological regions in Poland



- Region 201 - Poland North-western
- Region 202 - Poland North-eastern
- Region 203 - Poland Western
- Region 204 - Poland South-western
- Region 205 - Poland South-eastern
- Region 206 - Poland Eastern
- Region 207 - Poland South (mountains)


Implementation of radioecological regions in Poland

1. The basic parameters defining regions:
 - vegetable products,
 - animal products,
 - food products,
 - feed products,
 - mean annual precipitation,
 - mean annual temperature
2. The parameters for the Food Chain and Dose Module (FDMT):
 - soil bonitation index,
 - soil type and vegetation data,
 - the growth rate of plants,
 - human diet,
 - feeding farm animals,
 - type of human settlements and housing.
3. Data for macroregions were obtained from:
 - Central Statistical Office (GUS), SGGW, CLOR,
 - Institute of Soil Science and Plant Cultivation (IUNG) - Puławy,
 - Production data have been entered for all counties.

Characteristics of radioecological regions in Poland

| Parameter | Macroregion | | | | | | |
|--|-------------|------|------|------|------|------|------|
| | 201 | 202 | 203 | 204 | 205 | 206 | 207 |
| Mean soil bonitation index (soil quality) | 0.8 | 0.68 | 0.84 | 0.83 | 0.91 | 0.67 | 0.88 |
| Mean annual precipitation [mm] | 540 | 572 | 500 | 566 | 550 | 512 | 600 |
| Mean annual temperature [°C] | 9.5 | 7.9 | 9.5 | 9.0 | 8.5 | 9.0 | 8.6 |
| Mean annual length of vegetation period [days] | 298 | 271 | 293 | 291 | 275 | 286 | 276 |

Characteristics of radioecological regions in Poland

 **Parameters for Region Poland Eastern** ✕

Yield/LAI/Growth Dilution Rate Feedstuff Foodstuff Nuclide Data Nuclide Plant Data

Region Animal Product Plant/Surface

Region name Region index

Mean breathing rates at moderate low activity [m^3/h]

| 1 year | 5 years | 10 years | 15 years | Adults |
|-----------------------------------|-----------------------------------|----------------------------------|----------------------------------|----------------------------------|
| <input type="text" value="0.18"/> | <input type="text" value="0.42"/> | <input type="text" value="0.6"/> | <input type="text" value="0.9"/> | <input type="text" value="1.2"/> |

Rates of exponential decrease of ground exposure [d]

Coefficients for exponential decrease of ground exposure

Resuspension factors [$1/\text{m}$]

Rate of decrease of resuspended activity in air [$1/\text{d}$]

Deposition velocity to skin and clothes [m/s]

Fraction of wet deposition on skin/clothes

Fraction of skin covered by clothes

Residence time of nuclides on skin [d]


Area of skin [m^2]

Weathering rate [$1/\text{d}$]

Characteristics of radioecological regions in Poland

| | | | | |
|--|------------------------------------|------------------------------------|------------------------------------|----------------------------------|
| Soil mass per area [kg/m²] | Arable land | Pasture intensive | Pasture extensive | |
| | <input type="text" value="350.0"/> | <input type="text" value="140.0"/> | <input type="text" value="140.0"/> | |
| Limits of the population density for deriving housetype [man/m²] | Low/Medium shielding | Medium/High shielding | | |
| | <input type="text" value="100.0"/> | <input type="text" value="250.0"/> | | |
| Occupancy factor (average rate of time spent indoors) | <input type="text" value="0.8"/> | | | |
| Location factors | Low shielding | Medium shielding | High shielding | Outdoors |
| Groundshine long term | <input type="text" value="0.5"/> | <input type="text" value="0.1"/> | <input type="text" value="0.01"/> | <input type="text" value="1.0"/> |
| Groundshine short term | <input type="text" value="0.5"/> | <input type="text" value="0.1"/> | <input type="text" value="0.01"/> | <input type="text" value="1.0"/> |
| Cloudshine | <input type="text" value="0.8"/> | <input type="text" value="0.5"/> | <input type="text" value="0.2"/> | <input type="text" value="1.0"/> |
| Inhalation | <input type="text" value="0.5"/> | <input type="text" value="0.5"/> | <input type="text" value="0.5"/> | <input type="text" value="1.0"/> |
| Resuspension | <input type="text" value="0.5"/> | <input type="text" value="0.5"/> | <input type="text" value="0.5"/> | <input type="text" value="1.0"/> |

Characteristics of radioecological regions in Poland

 **Parameters for Region Poland Eastern**

Yield/LAI/Growth Dilution Rate

Feedstuff

Foodstuff

Nuclide Data

Nuclide Plant Data

Region

Animal Product

Plant/Surface

| Plant Name | Plant Atom |
|-------------|------------|
| Grass I | fgri |
| Hay I | fhyi |
| Grass E | fgre |
| Hay E | fhye |
| Maize | fmai |
| Maize bulbs | fmab |
| Potatoes | fpot |
| Beet | fbet |
| Beet leaves | fbel |
| Wi-barley | fwba |
| Sp-barley | fsba |
| Wi-wheat | fwwh |
| Sp-wheat | fswh |
| Rye | frye |
| Oats | foat |
| Leafy vogs. | fel |
| Root vogs. | fer |
| Fruit vogs. | fvef |
| Fruits | ffru |
| Berries | fber |
| (Plant 21) | f... |
| (Plant 22) | f... |

Data for plant Potatoes

Model

5

Soil category

arable land

Begin growth of plants [Julian days]

147

Begin of harvest [Julian days]

234

End of harvest [Julian days]

274

End of first harvesting period [Julian days]

274

Weighting factor for first harvesting period

0.0

Resuspension transfer factor
[kg soil/kg fresh plant]

0.001

Soil eating factor [kg soil/kg fresh plant]

0.0

Maximum leaf area index

0.0

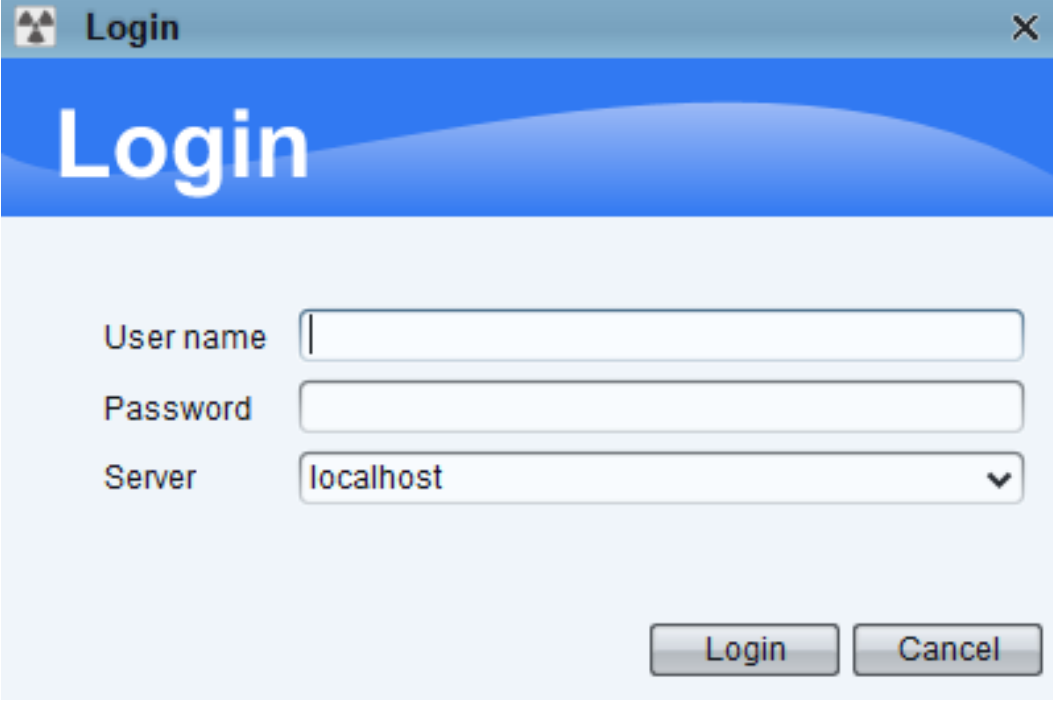
Yield of plants [kg/m^2]

1.7

Characteristics of radioecological regions in Poland

| Yield/LAI/Growth | Dilution Rate | Feedstuff | Foodstuff | Nuclide Data | Nuclide Plant Data |
|------------------|----------------|-----------|---|--------------|--------------------|
| Region | Animal | Product | Plant/Surface | | |
| Foodstuff Na... | Foodstuff Atom | Category | Data for foodstuff Milk | | |
| Wi-wheat wh. | fwww | | <div> Plant Name or Animal Product <div>Cow's milk</div> </div> <div> Food group <div>milk</div> </div> <div> Minimum time for storage and processing of foodstuff [Days] <div>1</div> </div> <div> Kg of processed food obtained per kg of raw food <div>1.0</div> </div> <div> Part of each raw food going into each process [%] <div>47.0</div> </div> | | |

Example of operation in the JRODOS system



The image shows a 'Login' dialog box from the JRODOS system. The window has a title bar with a radiation symbol icon, the text 'Login', and a close button. Below the title bar is a blue header with the word 'Login' in white. The main area is light blue and contains three input fields: 'User name' (a text box), 'Password' (a text box), and 'Server' (a dropdown menu currently showing 'localhost'). At the bottom right are two buttons: 'Login' and 'Cancel'.

Login

User name

Password

Server

Login Cancel

Example of operation in the JRODOS system

Map RODOS-Lite::test_1::Emergency-run:Pansy x

File Options Tools Help

Country | Site | Unit: Poland | ZARNOWIEC | ZARNOWIEC-1 Earliest start of release [UTC] 15.02.2019 08:47

Countermeasures for country: Poland Latest end of release [UTC] 15.02.2019 12:47

Run:

Model chain: LSMC+EMERSIM+FDMT

Site Source term Weather Countermeasures Food chain Run Summary

Site selection

Scenario

Nuclear power plant accident

☒ Country Poland

☐ Close to border

☐ Unspecified NPP

Other accident

☐ Explosion of rad. dispersal device

☐ Radiological accident with fire

☐ Wildfire

☐ Tornado

Location

Site / Unit: ZARNOWIEC / ZARNOWIEC-1

Geo

Latitude: 54.741 [°]

Longitude: 18.091 [°]

Information about the Site

Mashup

Search the web

Google Maps Wikipedia IAEA PP-World

No additional information...

...on this site available. Please enable internet access or provide additionally information on this site in an separate HTML file. Refer to the administrator guide how to achieve this.

Help Confirm

Example of operation in the JRODOS system

Map RODOS-Lite: test_1::Emergency-run:Pansy x

File Options Tools Help

Country | Site | Unit: Poland | ZARNOWIEC | ZARNOWIEC-1 Earliest start of release [UTC] 15.02.2019 08:47

Countermeasures for country: Poland Latest end of release [UTC] 16.02.2019 14:04

Run:

Model chain: LSMC+EMERSIM+FDMT

Site Source term Weather Countermeasures Food chain Run Summary

Source term - F6.SWR-FKKAZ1

ST1

Type of release data input Released activity for individual nuclides without inventory reference

Delay before start of release [h] 3.633 End of chain reaction [UTC] 15.02.2019 05:09

►► Noble gases ►► Iodines ►► Aerosols

| | Interval 1 | Interval 2 | Interval 3 | Interval 4 | Interval 5 | Interval 6 |
|----------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Begin [UTC] | 15.02.2019 08:47 | 15.02.2019 09:00 | 15.02.2019 10:20 | 15.02.2019 11:11 | 15.02.2019 11:55 | 15.02.2019 12:35 |
| End [UTC] | 15.02.2019 09:00 | 15.02.2019 10:20 | 15.02.2019 11:11 | 15.02.2019 11:55 | 15.02.2019 12:35 | 15.02.2019 13:21 |
| ►► I-131 [Bq] | 3.91E15 | 2.26E16 | 3.00E15 | 1.56E15 | 5.25E14 | 2.44E14 |
| ►► I-132 [Bq] | 5.62E15 | 3.23E16 | 4.26E15 | 2.21E15 | 7.40E14 | 3.43E14 |
| ►► I-133 [Bq] | 7.43E15 | 4.19E16 | 5.39E15 | 2.74E15 | 9.02E14 | 4.11E14 |
| ►► I-134 [Bq] | 1.32E15 | 4.51E15 | 2.76E14 | 8.03E13 | 1.55E13 | 4.34E12 |
| ►► I-135 [Bq] | 5.26E15 | 2.81E16 | 3.33E15 | 1.60E15 | 5.01E14 | 2.17E14 |
| ►► Kr-87 [Bq] | 7.53E14 | 8.23E15 | 1.96E15 | 1.57E15 | 9.27E14 | 8.22E14 |
| ►► Kr-88 [Bq] | 3.05E15 | 4.19E16 | 1.39E16 | 1.42E16 | 1.05E16 | 1.14E16 |
| ►► La-140 [Bq] | 1.86E11 | 2.37E12 | 3.20E11 | 1.53E11 | 3.79E10 | 6.30E9 |
| ►► Mo-99 [Bq] | 1.83E14 | 2.10E15 | 2.86E14 | 1.47E14 | 3.87E13 | 6.01E12 |
| ►► Pu-238 [Bq] | 9.78E5 | 1.10E8 | 1.01E7 | 6.54E6 | 5.94E6 | 1.16E8 |

Selection of calculation nuclides (25 of 140)

Example of operation in the JRODOS system

File Options Tools Help

Country | Site | Unit: Poland | ZARNOWIEC | ZARNOWIEC-1
Earliest start of release [UTC] 15.02.2019 08:47

Countermeasures for country: Poland

Run: Exercise
Latest end of release [UTC] 16.02.2019 14:04

Model chain: LSMC+EMERSIM+FDMT

☒ Site
☒ Source term
☒ Weather
☒ Countermeasures
☒ Food chain
Run Summary

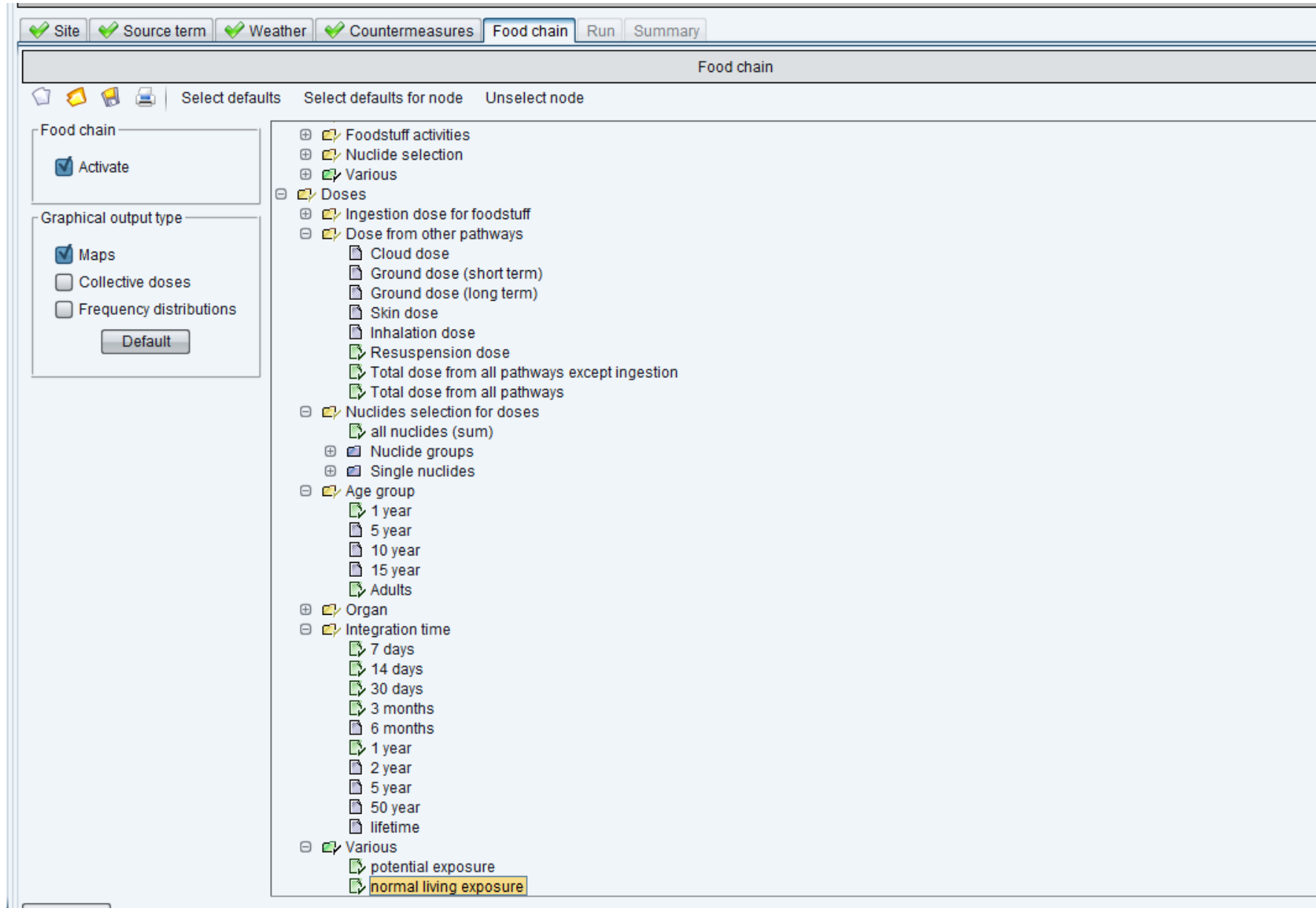
Weather user input

Measurement height [m] 10

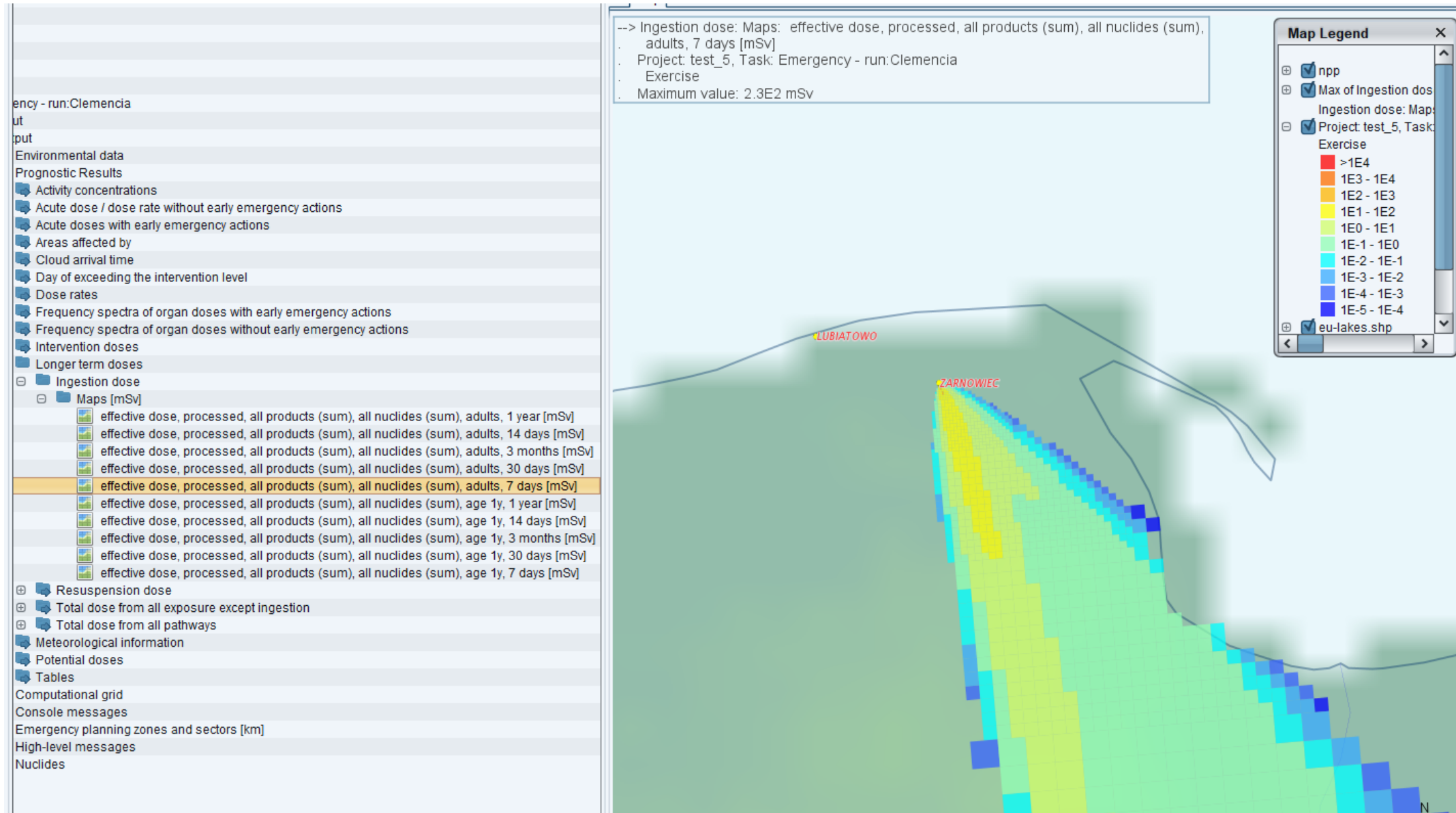
Meteorological data from user

| | Interval 1 | Interval 2 | Interval 3 | Interval 4 | Interval 5 | Interval 6 |
|-----------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Begin interval [UTC] | 15.02.2019 08:47 | 15.02.2019 09:47 | 15.02.2019 11:47 | 15.02.2019 14:47 | 15.02.2019 20:47 | 16.02.2019 02:47 |
| End interval [UTC] | 15.02.2019 09:47 | 15.02.2019 11:47 | 15.02.2019 14:47 | 15.02.2019 20:47 | 16.02.2019 02:47 | 16.02.2019 08:47 |
| Duration [h] | 1 | 2 | 3 | 6 | 6 | 6 |
| Wind direction [°] | 340 | 350 | 320 | 325 | 345 | 330 |
| Wind velocity [m/s] | 2 | 3 | 1.5 | 4 | 1 | 2 |
| Rain intensity [mm/h] | 0 | 2 | 0 | 4 | 0 | 0 |
| Diff category | D | D | C | D | E | D |
| Validation check | valid | valid | valid | valid | valid | valid |

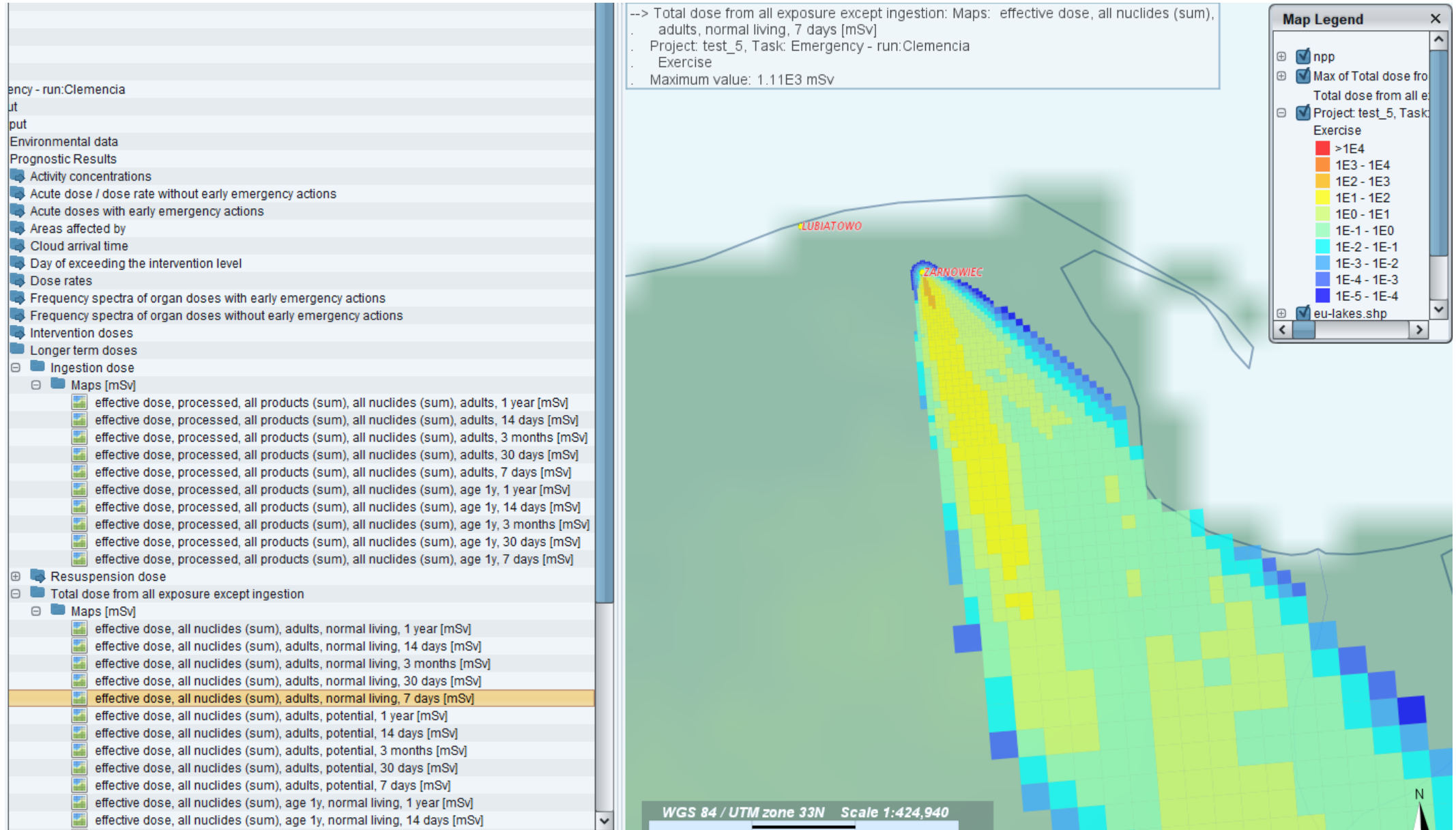
Example of operation in the JRODOS system



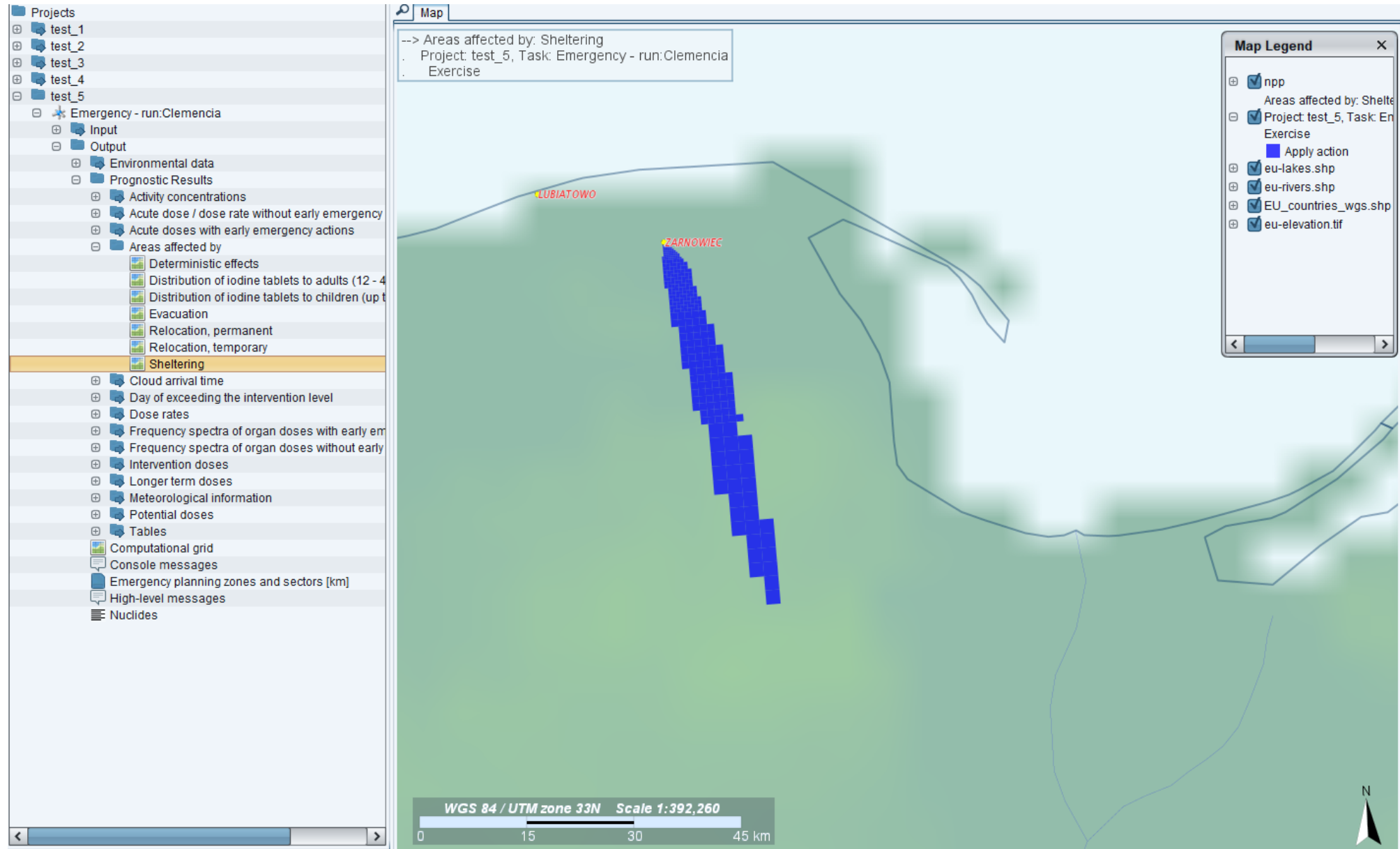
Example of operation in the JRODOS system



Example of operation in the JRODOS system



Example of operation in the JRODOS system



Performing simulations of the dispersal of radioactive contamination in atmosphere using the JRODOS system for five technologies of nuclear reactors

1. The calculations were made for two locations in Pomerania: Lubiatowo-Kopalino and Żarnowiec.
2. Five technologies are taken into the process calculation (EC6-Candu, AP1000, EPR, APR1400, ABWR).
3. Criteria for calculations were provided by the PGE EJ1 customer.
4. The following meteorological sequences data was used for the calculations:
 - data from the whole year 2010 (it gave the largest exposition and deposition)
 - data from 2005 (the most common occurrence of inversion)
 - data from 2012 (the most frequent strong winds)
 - In total, 115 weather sequences were selected for calculations
5. For this purpose, the JRODOS decision support system has been applied as the main tool for calculating possible human doses for different meteorological conditions.
6. The calculations were carried out for the following criteria:
 - determine of a restricted use area,
 - determine of emergency planning zones
7. The simulation results were presented in the form of a report submitted to PGE EJ1

Calculation criteria

CRITERIA FOR RESTRICTED USE AREA

OOU1: Annual effective dose received from all exposure pathways in normal operation period
zone limiting value: 0.3 mSv/year

OOU2: Annual effective dose received from all exposure pathways in case of accident without core melt
zone limiting value: 10 mSv

OOU3: In case of design basis accident: 2-days effective dose received from all pathways except of ingestion
zone limiting value: 10 mSv

OOU4: In case of design basis accident with extended conditions: 7-days effective dose from all pathways except of ingestion
zone limiting value: 100 mSv

OOU5: In case of design basis accident with extended conditions:

OOU5a: lifetime dose (50 adults, 70 children) effective dose received from all pathways except of ingestion
zone limiting value: 1 Sv, or

OOU5b: if 30-days effective dose received due to from all pathways except of ingestion
does not decrease below 10 mSv during first 2 years from the occurrence of radiation accident

Calculation criteria

CRITERIA FOR EMERGENCY PLANNING ZONES

Internal zone: for external exposure

SPA1. Absorbed radiation dose in internal human organ (bone marrow, lung, intestine, gonads and thyroid) and eye lens: $D_{\text{red marrow}} = 1 \text{ Gy}$ in 10 hours.

SPA2. Absorber radiation dose for fetus: $D_{\text{fetus}} = 0,1 \text{ Gy}$ in 10 hours.

External zone:

SPA3. Effective dose: $E = 100 \text{ mSv}$ – received, during 7 consecutive days from the beginning of exposure.

SPA4. Equivalent dose for fetus: $H_{\text{fetus}} = 100 \text{ mSv}$ – received, during 7 consecutive days from the beginning of exposure.

Calculation process

1. Creating databases for different meteorological sequences
2. Preparation and configuration of computers to carry out simulation
 - 2 computers running Linux – CENTOS
 - 1 computer with Windows 10
 - installation of the JRODOS system
3. Development and writing of software in Python language that generates calculation files in the "xml" format for the JRODOS system
4. Preparation of "xml" files for calculations in batch processing
5. Performing calculations for each technology (time of calculations without breaks - 7 months)
6. The use of MATLAB software for the presentation of results

Run JRODOS in batch mode

- Prepare „xml” input files
- Run JRODOS server
- Put xml files to Automatic directory (batch processing)
- The use of MATLAB software for the presentation of results

JRODOS „xml” input file

```
<?xml version="1.0" encoding="UTF-8"?>
<ritelInterface created_with_RODOS-Lite_version="6.0.1 build(7260)" created_at="2019-02-15T10:20:55.073Z">
.....
  <programGroupName>EMERSIM/RL</programGroupName>
  <programGroupName>FDMT/RL</programGroupName>
  <programGroupName>RLSMCprogn</programGroupName>
</programSequenz>
.....

  <siteInfo active="true">
    <siteName>ZARNOWIEC</siteName>
    <blockName>ZARNOWIEC-1</blockName>
    <siteLongitude>18.090578079223633</siteLongitude>
    <siteLatitude>54.741214752197266</siteLatitude>
    <thermalPower>3000.0</thermalPower>
    <operationTime>999</operationTime>
    <inventory>INVE.PWR_3000MWth_POLAND</inventory>
    <stackHeight>100.0</stackHeight>
    <timeZone>UTC</timeZone>
    <countryOfSite>POL</countryOfSite>
    <siteLocationType>Country</siteLocationType>
  </siteInfo>
.....
    <releaseTimeInterval start="0.0" end="0.22">
      <releaseAttribute height="10.0" thermalEnergy="3.0" volumeFlux="0.0" ventArea="2.0" />
      <relativeIodineFraction elemIod="0.00848696" orgBolod="3.18261E-4" aerosollod="99.9912" />
      <nuclide name="Ba-140" value="1.93E13" />
      <nuclide name="Ce-144" value="4.11E8" />
      <nuclide name="Cm-242" value="5.11E9" />
      <nuclide name="Cm-244" value="1.94E8" />
      <nuclide name="Cs-134" value="8.67E14" />
      <nuclide name="Cs-137" value="6.05E14" />
      <nuclide name="I -131" value="3.91E15" />
      <nuclide name="I -132" value="5.62E15" />

    <measurementHeight>10.0</measurementHeight>
    <weatherData timeInterval="1.0" windDi="340" windSp="2.0" rainIn="0.0" diffusionCategory="D" autoDiffCat="false" cloudCover="1" diffCat="3" />
    <weatherData timeInterval="3.0" windDi="350" windSp="3.0" rainIn="2.0" diffusionCategory="D" autoDiffCat="false" cloudCover="1" diffCat="3" />
    <weatherData timeInterval="6.0" windDi="320" windSp="1.5" rainIn="0.0" diffusionCategory="C" autoDiffCat="false" cloudCover="1" diffCat="2" />
    <weatherData timeInterval="12.0" windDi="325" windSp="4.0" rainIn="4.0" diffusionCategory="D" autoDiffCat="false" cloudCover="1" diffCat="3" />
    <weatherData timeInterval="18.0" windDi="345" windSp="1.0" rainIn="0.0" diffusionCategory="E" autoDiffCat="false" cloudCover="1" diffCat="4" />
    <weatherData timeInterval="24.0" windDi="330" windSp="2.0" rainIn="0.0" diffusionCategory="D" autoDiffCat="false" cloudCover="1" diffCat="3" />
    <timeStepOfPrognosis>3600</timeStepOfPrognosis>
    <duration10minSteps>360</duration10minSteps>
    <duration30minSteps>720</duration30minSteps>
  </weatherInfo>
.....
```

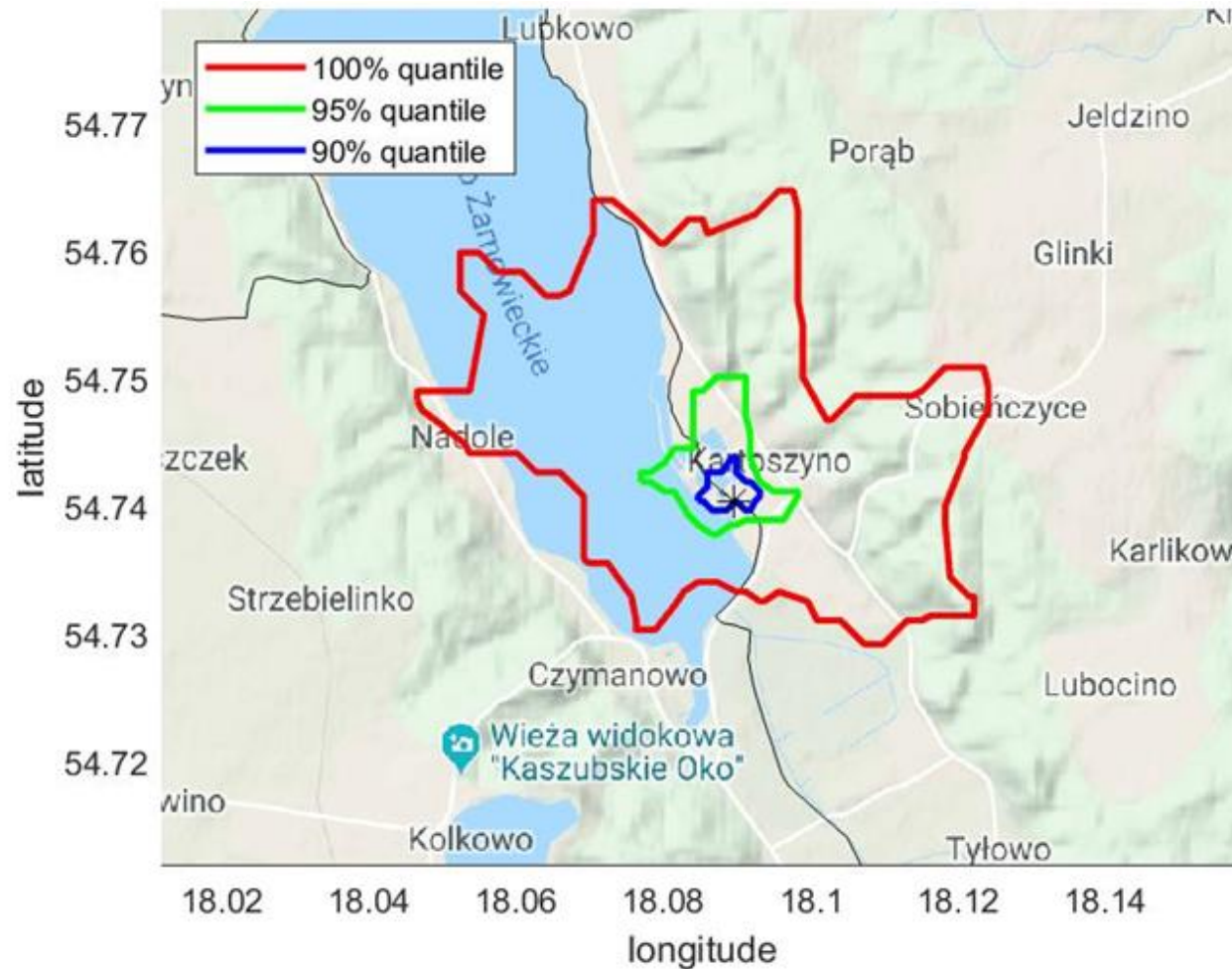

JRODOS output text file

| Cell | x | y | Area | cinggmapiintt03mepotnsumlallaa... |
|------|-----------|-----------|--------|-----------------------------------|
| 0 | 310344.44 | 6067503.5 | 6.25E4 | 0E0 |
| 1 | 310594.44 | 6067503.5 | 6.25E4 | 0E0 |
| 2 | 310844.44 | 6067503.5 | 6.25E4 | 0E0 |
| 3 | 311094.44 | 6067503.5 | 6.25E4 | 0E0 |
| 4 | 311344.44 | 6067503.5 | 6.25E4 | 0E0 |
| 5 | 311594.44 | 6067503.5 | 6.25E4 | 0E0 |
| 6 | 311844.44 | 6067503.5 | 6.25E4 | 9.3E-2 |
| 7 | 312094.44 | 6067503.5 | 6.25E4 | 2.04E0 |
| 8 | 312344.44 | 6067503.5 | 6.25E4 | 1.24E1 |
| 9 | 312594.44 | 6067503.5 | 6.25E4 | 5.03E1 |
| 10 | 312844.44 | 6067503.5 | 6.25E4 | 1.25E2 |
| 11 | 313094.44 | 6067503.5 | 6.25E4 | 1.98E2 |
| 12 | 313344.44 | 6067503.5 | 6.25E4 | 2.12E2 |
| 13 | 313594.44 | 6067503.5 | 6.25E4 | 1.7E2 |
| 14 | 313844.44 | 6067503.5 | 6.25E4 | 1.08E2 |
| 15 | 314094.44 | 6067503.5 | 6.25E4 | 5.75E1 |
| 16 | 314344.44 | 6067503.5 | 6.25E4 | 2.96E1 |
| 17 | 314594.44 | 6067503.5 | 6.25E4 | 1.63E1 |
| 18 | 314844.44 | 6067503.5 | 6.25E4 | 1.01E1 |
| 19 | 315094.44 | 6067503.5 | 6.25E4 | 6.37E0 |
| 20 | 310344.44 | 6067753.5 | 6.25E4 | 0E0 |
| 21 | 310594.44 | 6067753.5 | 6.25E4 | 0E0 |
| 22 | 310844.44 | 6067753.5 | 6.25E4 | 0E0 |
| 23 | 311094.44 | 6067753.5 | 6.25E4 | 0E0 |
| 24 | 311344.44 | 6067753.5 | 6.25E4 | 0E0 |
| 25 | 311594.44 | 6067753.5 | 6.25E4 | 0E0 |
| 26 | 311844.44 | 6067753.5 | 6.25E4 | 0E0 |
| 27 | 312094.44 | 6067753.5 | 6.25E4 | 1.53E0 |
| 28 | 312344.44 | 6067753.5 | 6.25E4 | 1.16E1 |
| 29 | 312594.44 | 6067753.5 | 6.25E4 | 5.45E1 |
| 30 | 312844.44 | 6067753.5 | 6.25E4 | 1.43E2 |
| 31 | 313094.44 | 6067753.5 | 6.25E4 | 2.21E2 |
| 32 | 313344.44 | 6067753.5 | 6.25E4 | 2.18E2 |
| 33 | 313594.44 | 6067753.5 | 6.25E4 | 1.53E2 |
| 34 | 313844.44 | 6067753.5 | 6.25E4 | 8.51E1 |
| 35 | 314094.44 | 6067753.5 | 6.25E4 | 4.13E1 |
| 36 | 314344.44 | 6067753.5 | 6.25E4 | 2.12E1 |

Calculation process

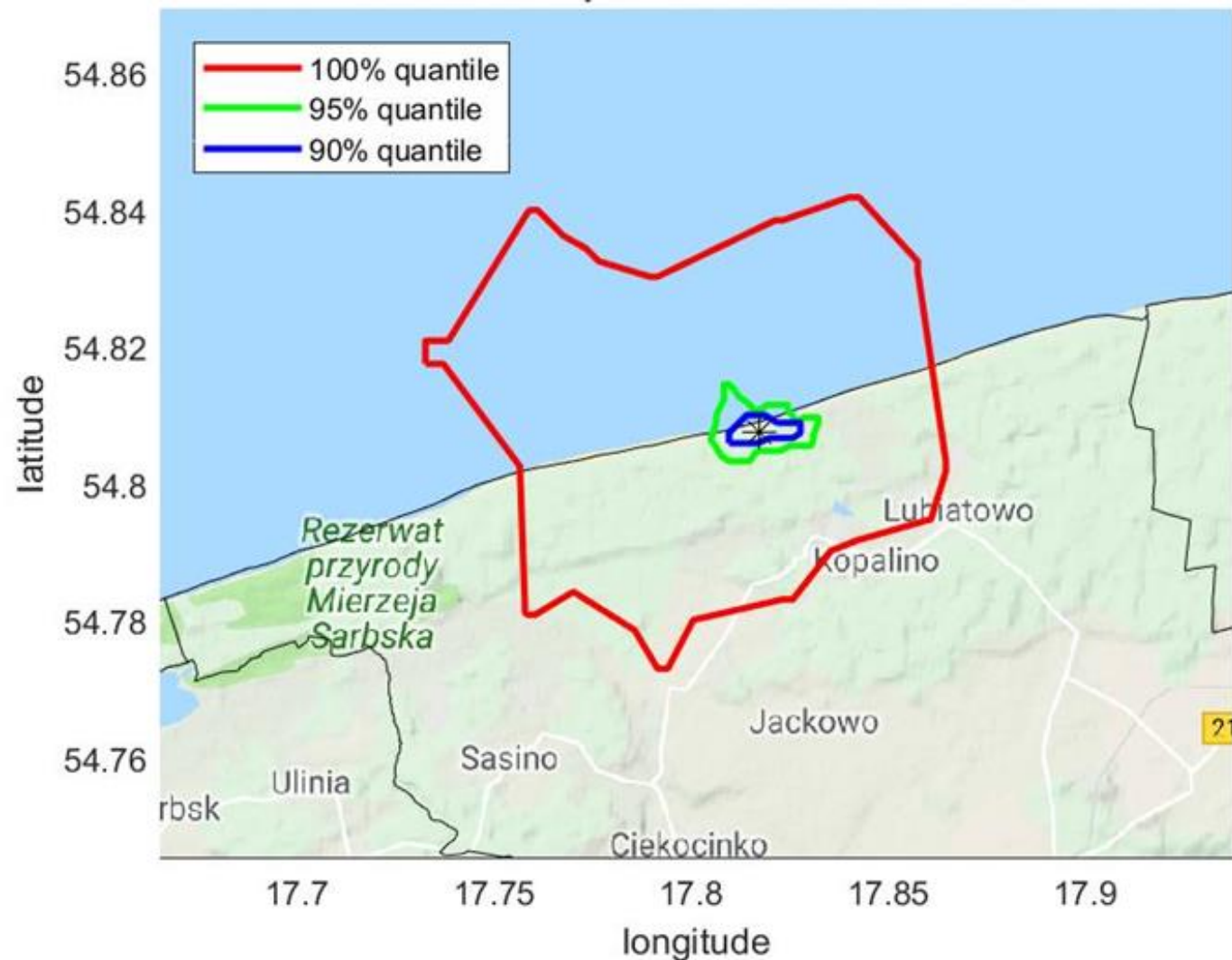
| | | Lubiatowo | | | Żarnowiec |
|-----------|-------|--------------|--|-------|--------------|
| | XML | Output files | | XML | Output files |
| EC1-candu | 628 | 18 788 | | 681 | 19 880 |
| AP1000 | 628 | 16 475 | | 628 | 16 460 |
| EPR | 1 203 | 31 786 | | 1 203 | 31 783 |
| APR1400 | 1 363 | 54 308 | | 1 362 | 54 307 |
| ABWR | 860 | 30 952 | | 858 | 30 952 |
| | 4 682 | 152 309 | | 4 732 | 153 382 |

Example calculation



Limits of the restricted use zone obtained for the criterion for limit failure in the category of sequences submitted under extended design conditions in the case of release at 10m high (dose from all routes of exposure). Location Żarnowiec. Zone limit: 10 mSv /a.

Example calculation



The boundaries of the restricted use zone in case of a severe failure included in the extended design conditions in the Lubiatowo-Kopalino location. 7-day effective dose. Zone limit - 100 mSv

Thank you
for your attention