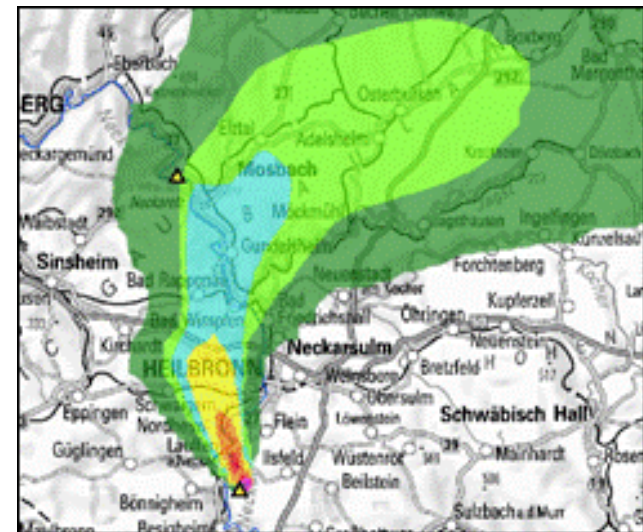
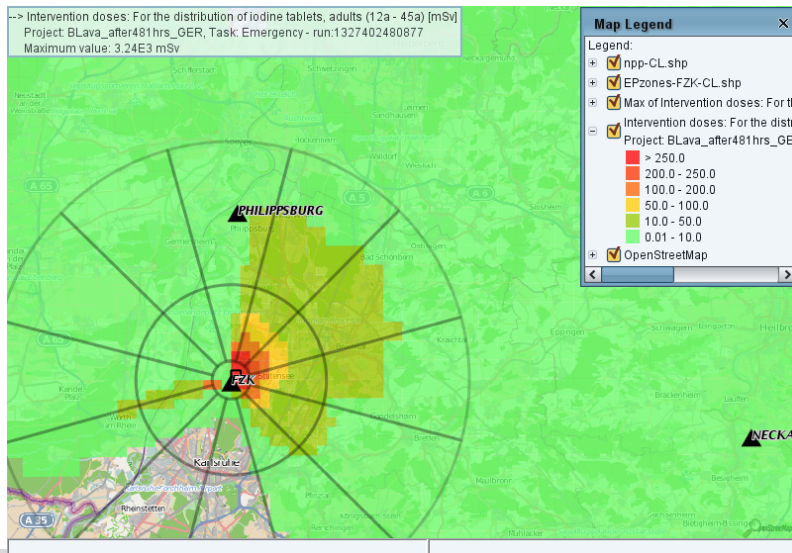


# JRODOS : Real-time online decision support system for nuclear emergency management

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- Karlsruhe Institute of Technology (KIT)

Institute of Nuclear and Energy Technologies



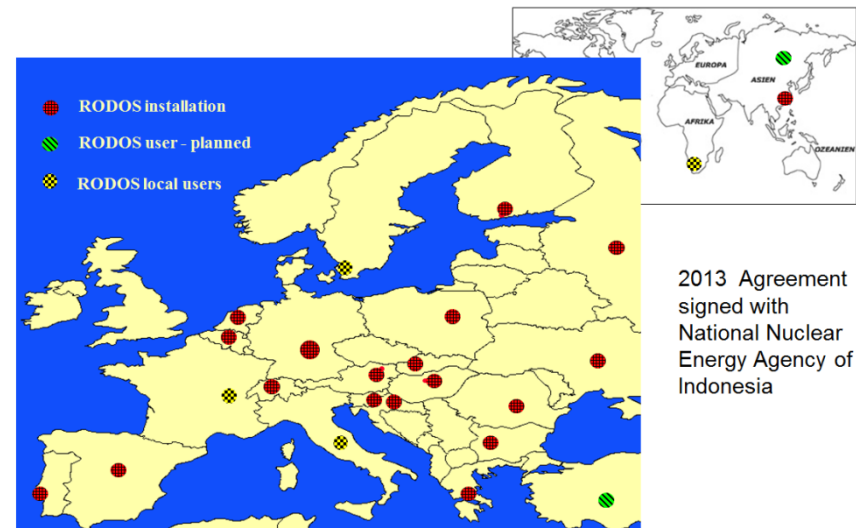
# Key features of JRODOS

## Real-time On-line Decision Support system

- Multi-user operation in national/regional emergency centres for off-site nuclear emergency management

- Provision of information for decision-making

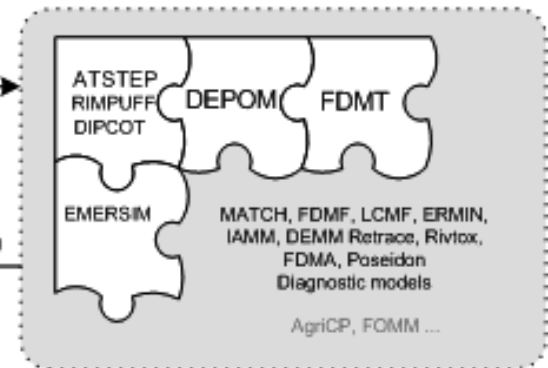
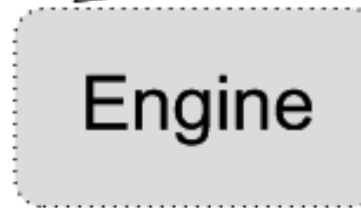
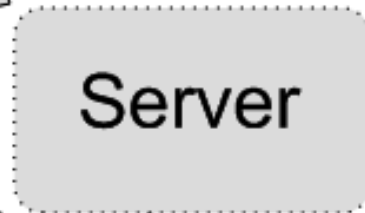
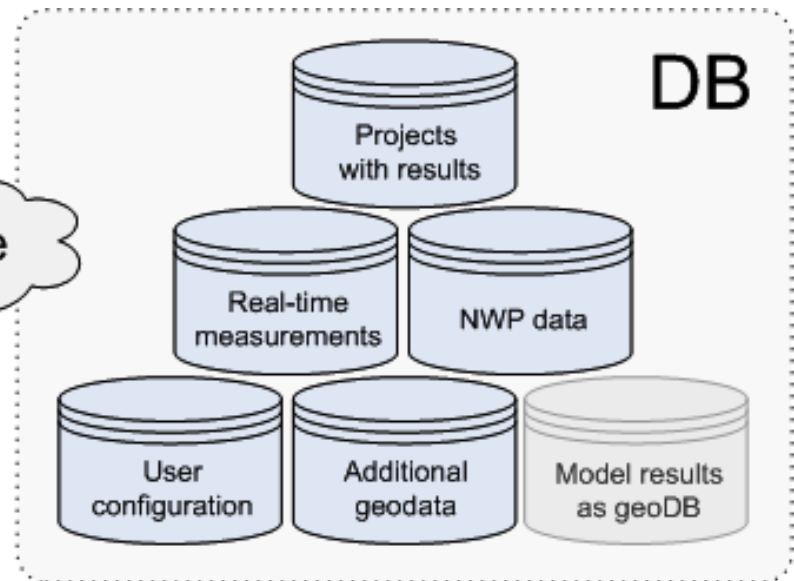
- on local / national / regional / European scales,
- in the early and later phases,
- for all relevant emergency actions and countermeasures.



- Wide IT applicability - HP-UX and Linux (RODOS), Microsoft Windows, Linux and Mac OS (JRodos)

# JRodos software structure

## Web Interface



# General JRodos ingredients and results

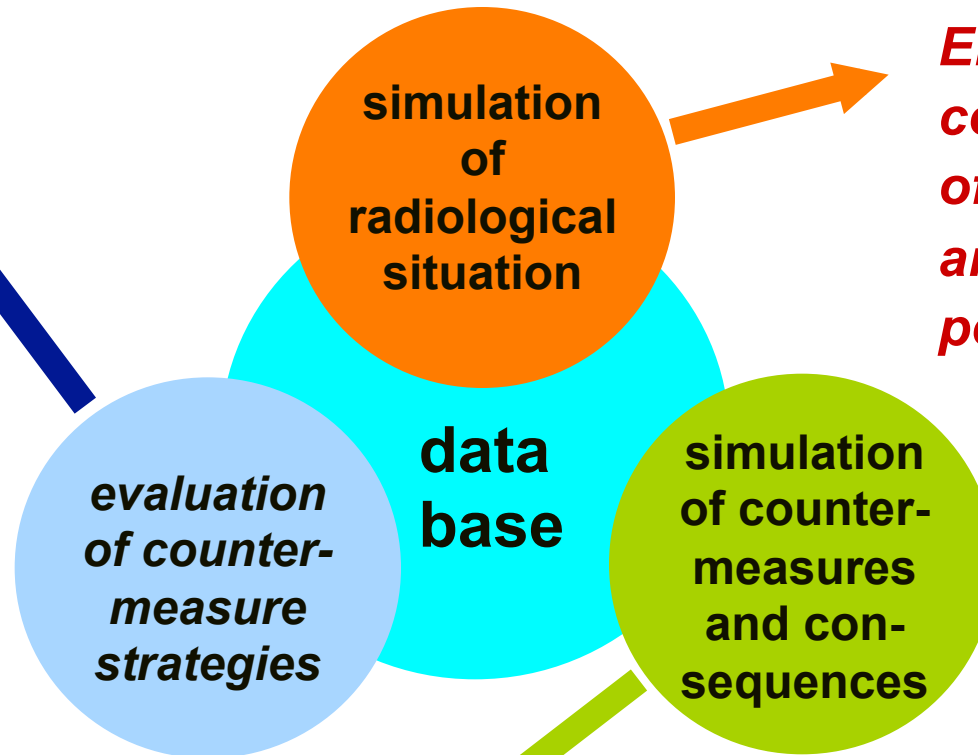
*(measurements)*

***Radiological monitoring data***

*(measurements, forecasts)*

***Meteorological data, release data***

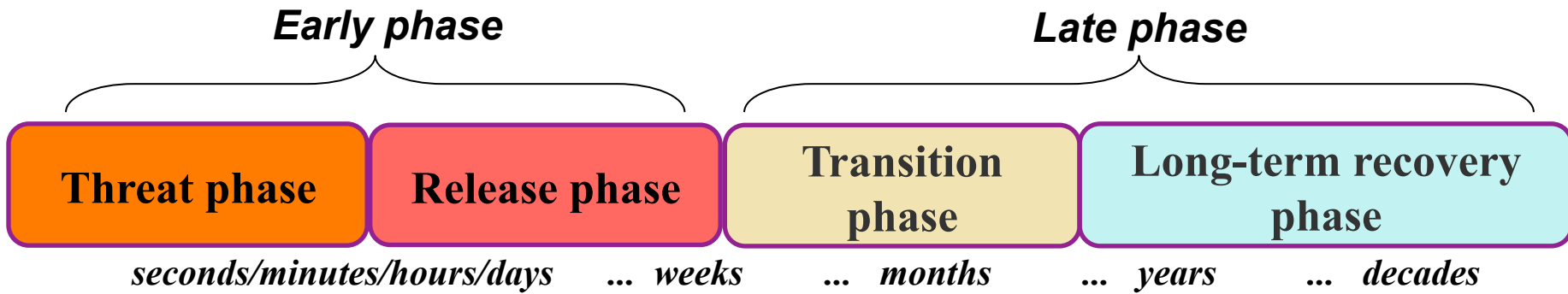
***Feasible strategies for longer term actions***



***Environmental contamination of air, ground, and food, potential doses***

***Areas and people affected, doses, health effects, effort, costs***

# JRodos products relevant for early and late phases Karlsruhe Institute of Technology



**Radiological situation; early countermeasures;  
reduction of contamination**

**JRodos "Emergency" chain models**

(atmospheric dispersion, early actions, food chain)

**AgriCP**  
**Countermeasures in agricultural areas**

**ERMIN**  
**European model for inhabited areas  
(decontamination, relocation)**

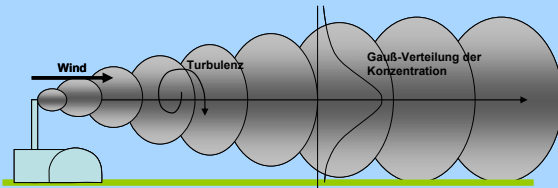
# JRodos EMERGENCY chain models - Overview

Released activity  
(Measurement / User)

Meteorological data  
(Measured / Prognostic / User)

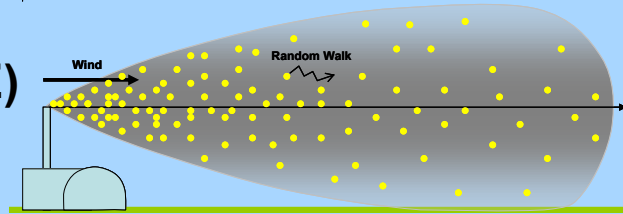
Further data  
(from JRodos Data bases)

**LSMC: Atmospheric dispersion and deposition, local scale (up to several 100 km)**



**Rimpuff (DEN)  
Atstep (IKET)**

**Dipcot (GRE)  
Lasat (GER)**



## Calculated results

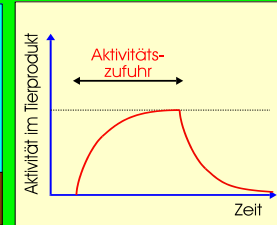
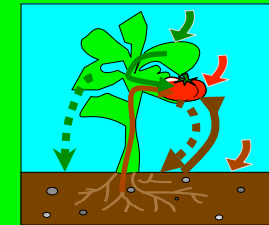
- Contamination of air, ground, vegetation; food- and feedstuffs
- Doses without countermeasures
- Potential countermeasure areas
- Organ doses with/without actions, health effects, effort, effectiveness

**Current dose rate and dose calculation**

**Early countermeasure simulation**

**Health effects and costs**

**Food chain and dose model, terrestrial  
FDMT (GER)**





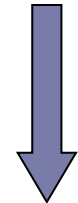
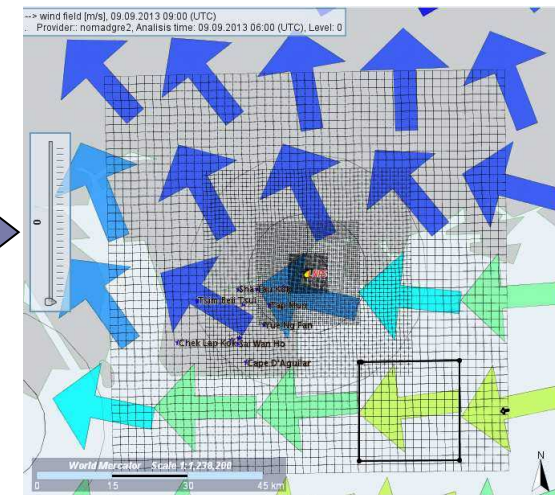
# LSMC: Role of Meteorological Pre-Processor

**Input:** Wind field, temperature, precipitation, geo-potential height, for different heights, in given time intervals, on regular grid (as delivered)

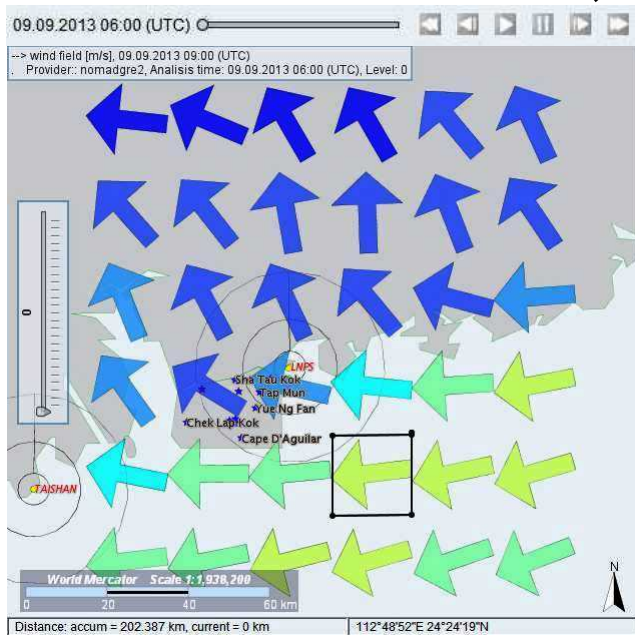
**MPP:**  
Meteorological  
Pre-Processor

Account of  
topography,  
land use,  
physics etc.

Interpolation to  
JRodos  
calculation grid,  
ADM time  
steps, ADM  
level heights,  
etc.



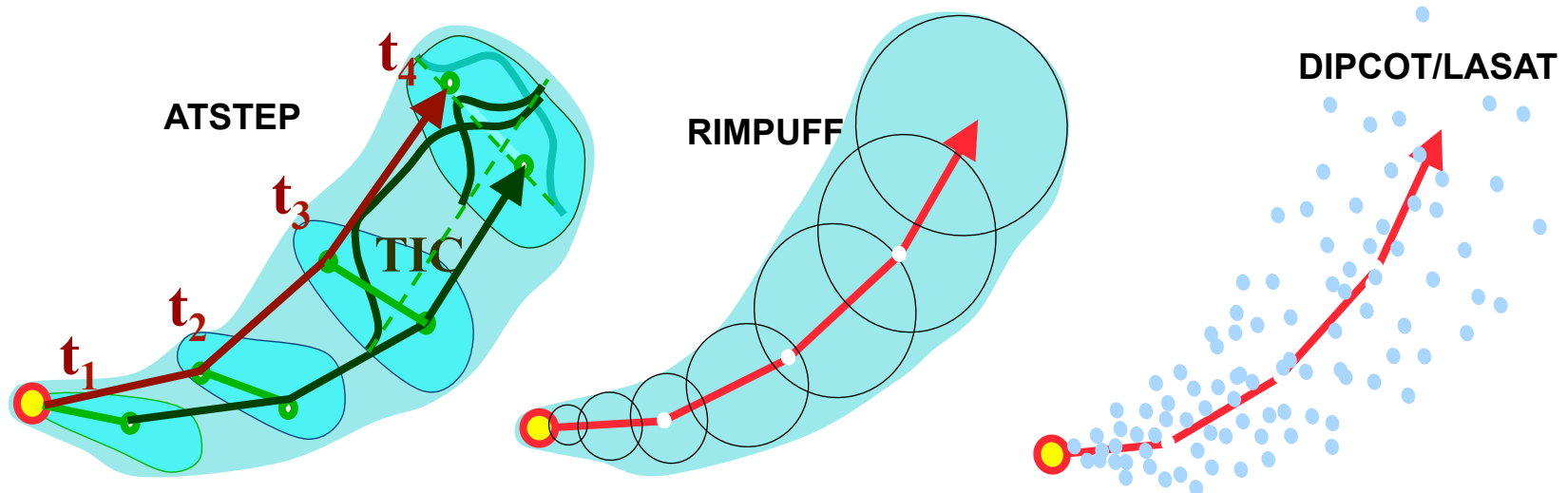
**MPP output:**  
Meteorological **input fields**  
for the atmospheric  
dispersion and deposition  
models (ADM), local scale



Example: NOMADS re-analysis data in GRIB2 format (pixel size 0.5 degree)

# Near-range ADM models

- Several models for atmospheric dispersion and deposition in the near range (historical):
  - Gauß-"puff"-models **ATSTEP** (KIT, Karlsruhe, not longer fully supported) and **RIMPUFF** (DTU, Roskilde)
  - For complex terrain: Particle model **DIPCOT** (Demokritos, Athens)
  - For powerful servers: Lagrange Particle Model **LASAT** (with licence)



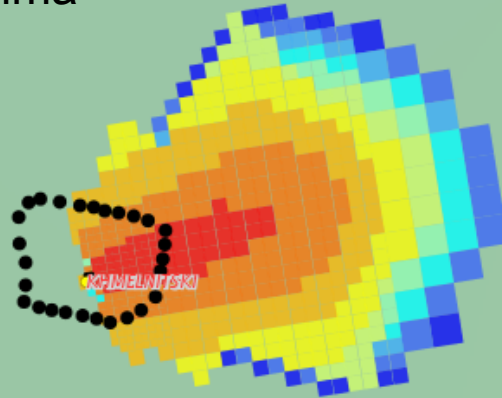


# Source term estimation

- Source term: quantities of released radionuclides to the atmosphere
- Difficult to estimate and very important for the prognoses
- Computational tools: **combination** – in an optimal way – of **measurements with modelling results** – “inverse” modelling
- Simple and fast method
  - Dose rate measurements “**at the NPP fence**”, sensitivity curves at monitoring positions – considering several parameters and their uncertainties, total release quantities of radionuclides
- More advanced method
  - Variational principles, **cost function minimization**, dose rate or concentration **measurements at all distances**, source-receptor functions calculated by Lagrangian dispersion model, time varying releases, multi-nuclide releases

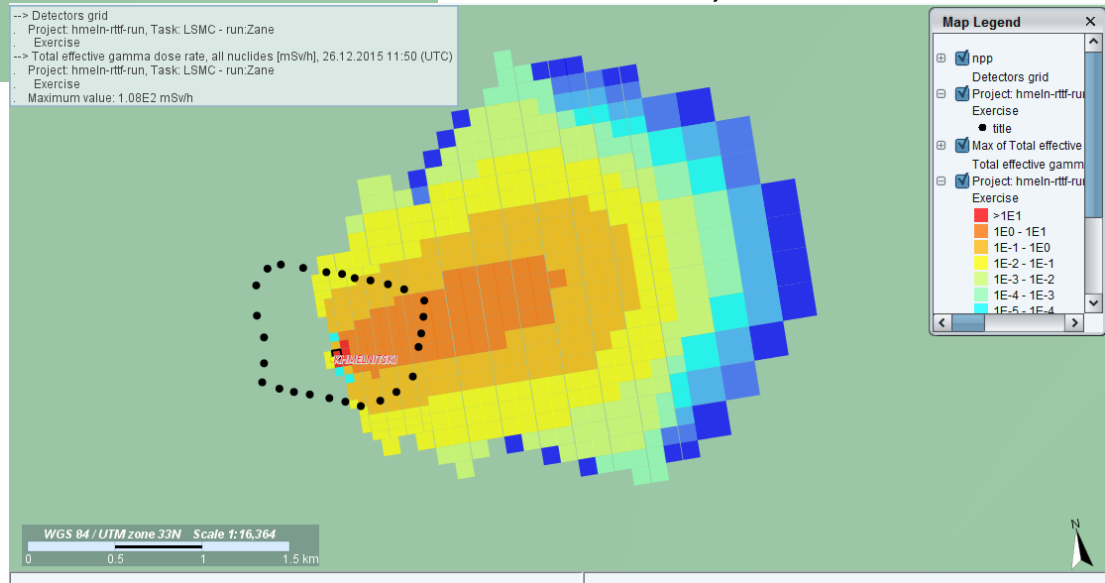
# Calculated gamma dose rate in detector points was used as measurements

Calculated field of gamma dose rate with 'true' source term



Calculated gamma dose rate field with adjusted source term (underestimated by some few times)

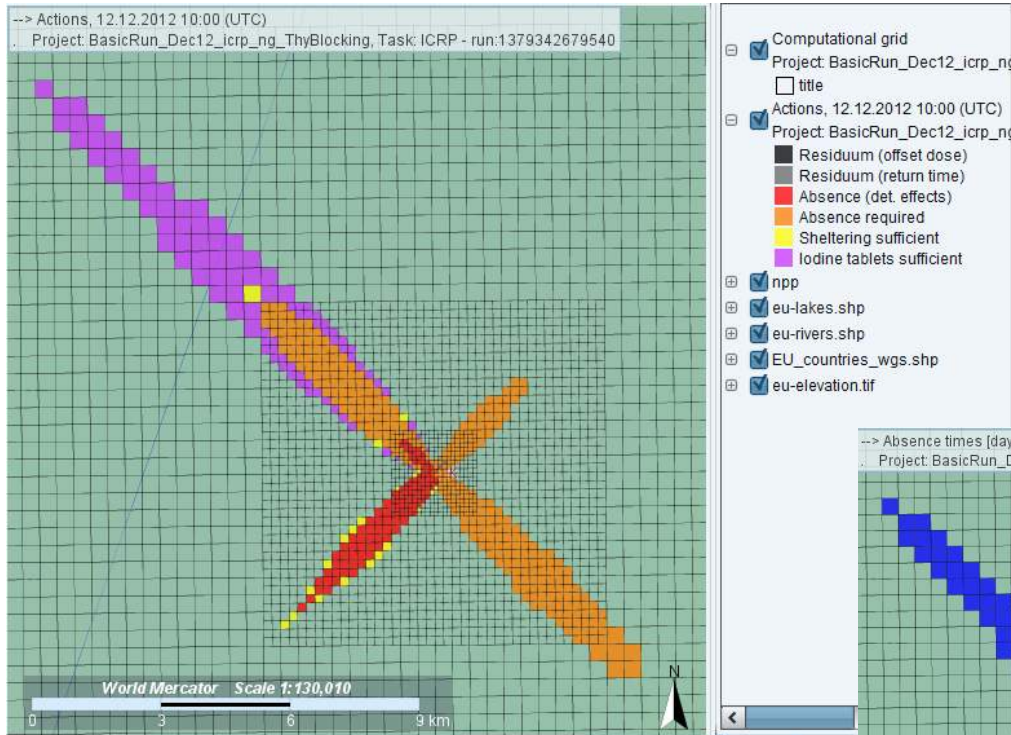
--> Detectors grid  
Project: hmeln-rtf-run, Task: LSMC - run:Zane  
Exercise  
--> Total effective gamma dose rate, all nuclides [mSv/h], 26.12.2015 11:50 (UTC)  
Project: hmeln-rtf-run, Task: LSMC - run:Zane  
Exercise  
Maximum value: 1.08E2 mSv/h



# ICRP Screening tool of JRodos

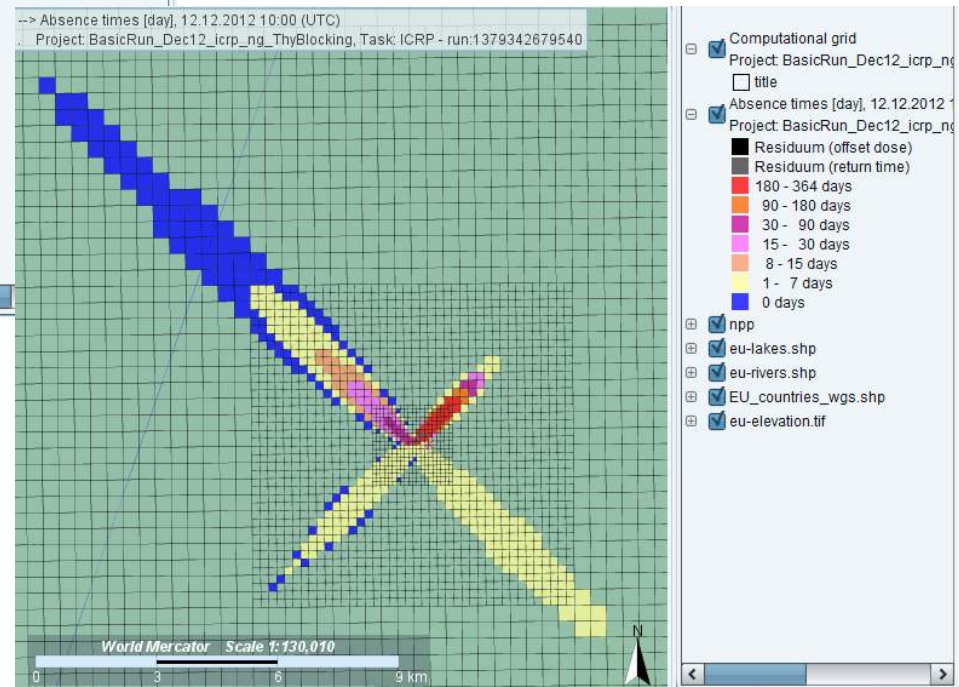
- **Objective:** consider the ICRP-103 recommendations for the planning of **early phase** countermeasures
- Realisation as “ICRP Screening” module in JRodos
- The ICRP Screening Tool fulfils **three main requirements:**
  - Takes into account **all terrestrial exposure pathways**, including **ingestion** in one assessment
  - Considers **sheltering, evacuation, relocation, food restrictions**, and the use of **iodine tablets** for thyroid blocking, for reducing or avoiding doses
  - Identifies an action set for limiting the total effective equivalent dose received from **all pathways** over a given time period **below a given reference level** (residual dose)
- The residual dose can be selected by the user, same with the contribution of the ingestion pathways

# Main results of S-E-R+I screening analysis



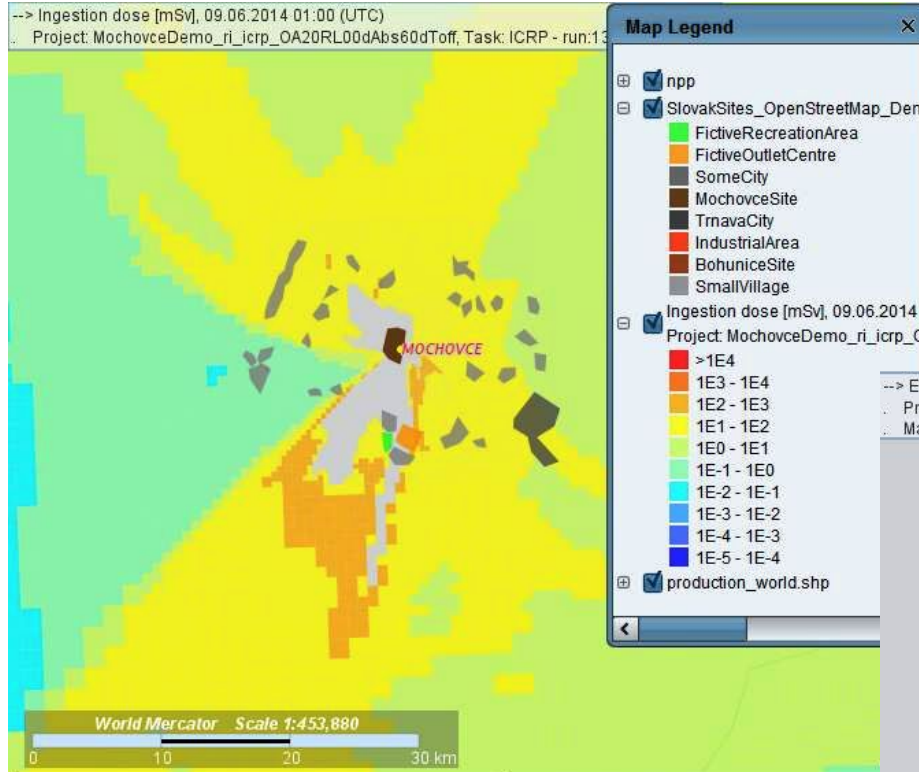
Left: The set of actions needed to stay below the residual dose

Right: Absence times from area associated with above action set

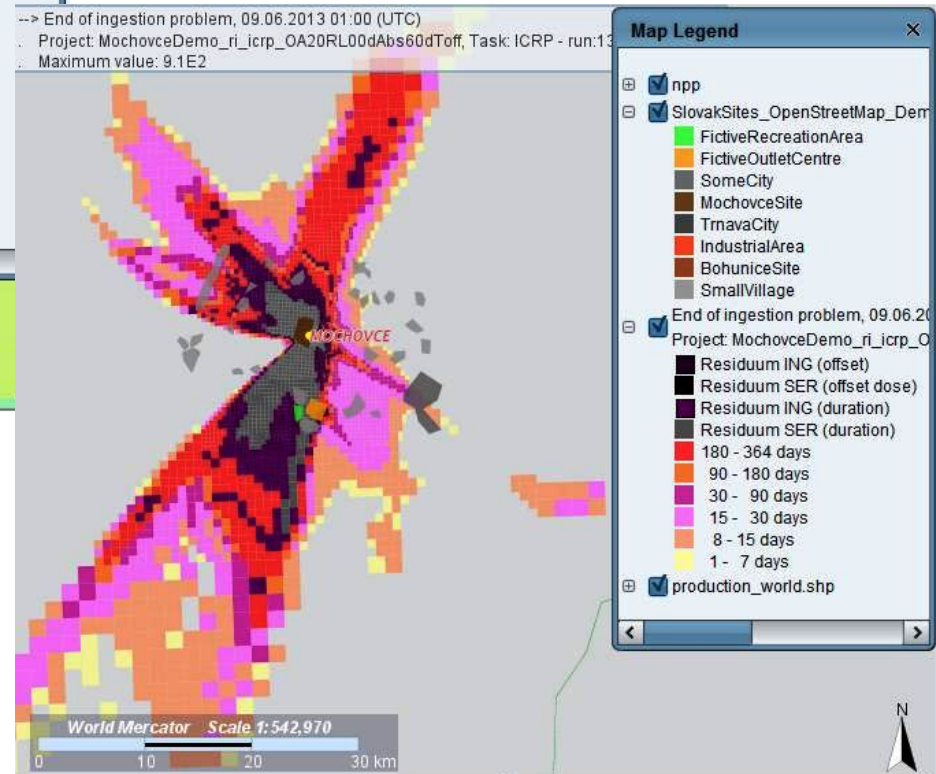




# Main results of ingestion screening analysis



**Left:** Ingestion dose, food basket, case CFILs = no, to be compared with CDR (CD remainder) => "Ingestion Criterion Dose"



**Right:** Result of check if uncontaminated food replacement would bring the ingestion dose below CDR. If yes, day is recorded when there is no longer an ingestion problem for the grid cell under consideration until the end of the first year.

# Risk study type applications

- Combine categorized **source terms** with a **large number of weather sequences** and require a large number of runs
- Carrying out was the domain of probabilistic risk assessment codes like COSYMA (Europe; KfK and NRPB, 1991) and MACCS (USA, Chanin et al., 1990)
  - These codes generate the complete result spectrum and perform the probabilistic analysis within one run
- Can nowadays also be tackled with modern decision support systems due the developments in information technology
- JRodos approach: Separate the **result generation** (with **JRodos**) from the **statistical analysis** (with **external tool**)



# The JRodos Statistic Output tool (1)

- The tool was introduced in 2014 on behalf of users with interest to generate with JRodos statistically distributed results by utilizing different weather sequences for risk study like applications
- Using the tool requires the presence of **numerical weather forecast data** covering the time period for the study, usually several years
- Once kicked, JRodos will **automatically** start **one calculation** for **each day** in the **time period**
  - Each day, a pre-defined scenario with **fixed release location** and **source term** is applied, but the **starting time** in the respective day is **selected randomly**
  - This produces a statistical distribution from the variation of the weather conditions

## Use Case: Statistic Output Generation tool application, carried out by a customer

- **Given task: Investigate the long- and short term consequences of a severe accident for each reactor in the country**
- The customer adapted JRodos for the country (NWP data, radiological regions with parameters for FDMT, ...)
- One accident per day from a **12 month period** in 2013/14
- Postprocessing of data with **MATLAB**.
- For each release time, the **maximum dose** at a **certain distance** (from 1 km up to 800 km) was extracted.
- Average maximum dose and 95th percentiles were calculated for each distance

# Conclusions

- JRODOS is applicable in **all phases of an emergency**
- It contains models for the **atmospheric** and **aquatic** pathways
- **Customisation** is possible to **national conditions** applying national criteria for evacuation, sheltering and iodine distribution
- The ICRP Screening module allows to prepare countermeasure strategies consistent with ICRP-103
- The **Statistical output** mode allows a “**probabilistic**” approach for preparing of countermeasure strategies
- As a result of the **PREPARE** project, **source term** estimations based on monitoring and dispersion modelling are possible to reduce uncertainty
- In the new European project **CONFIDENCE** deals with **uncertainty** handling and reduction in **decision making** for nuclear emergencies and prototypes will be implemented into JRodos

**Thank you very much for  
your attention**

**Questions?**

**<https://resy5.iket.kit.edu/>**