Karlsruhe Institute of Technology

How to use decision support systems in a nuclear emergency?

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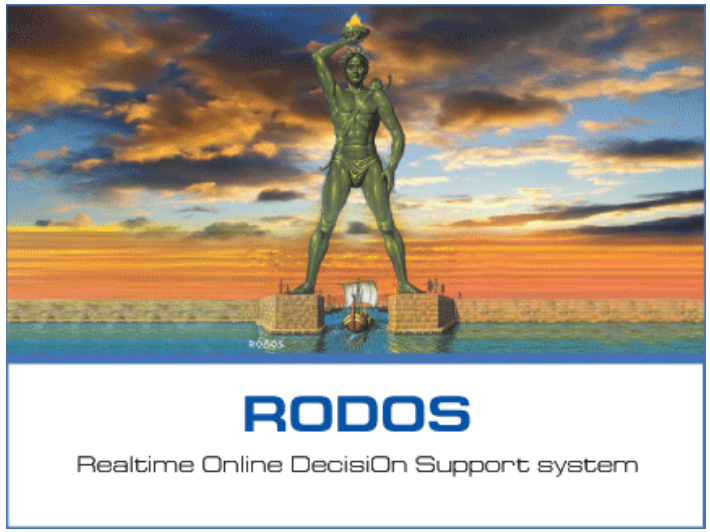
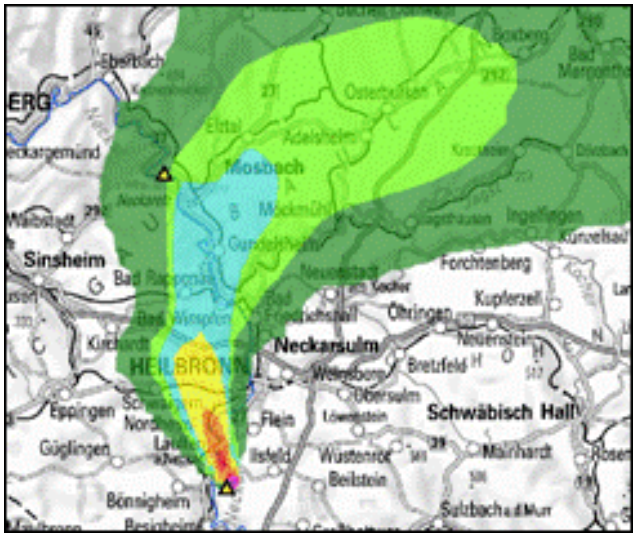




Outline

- Phases of a nuclear accident, from the emergency management's point of view
- What a decision support system can deliver to decision making teams in case of a severe nuclear accident
- Discussion

History

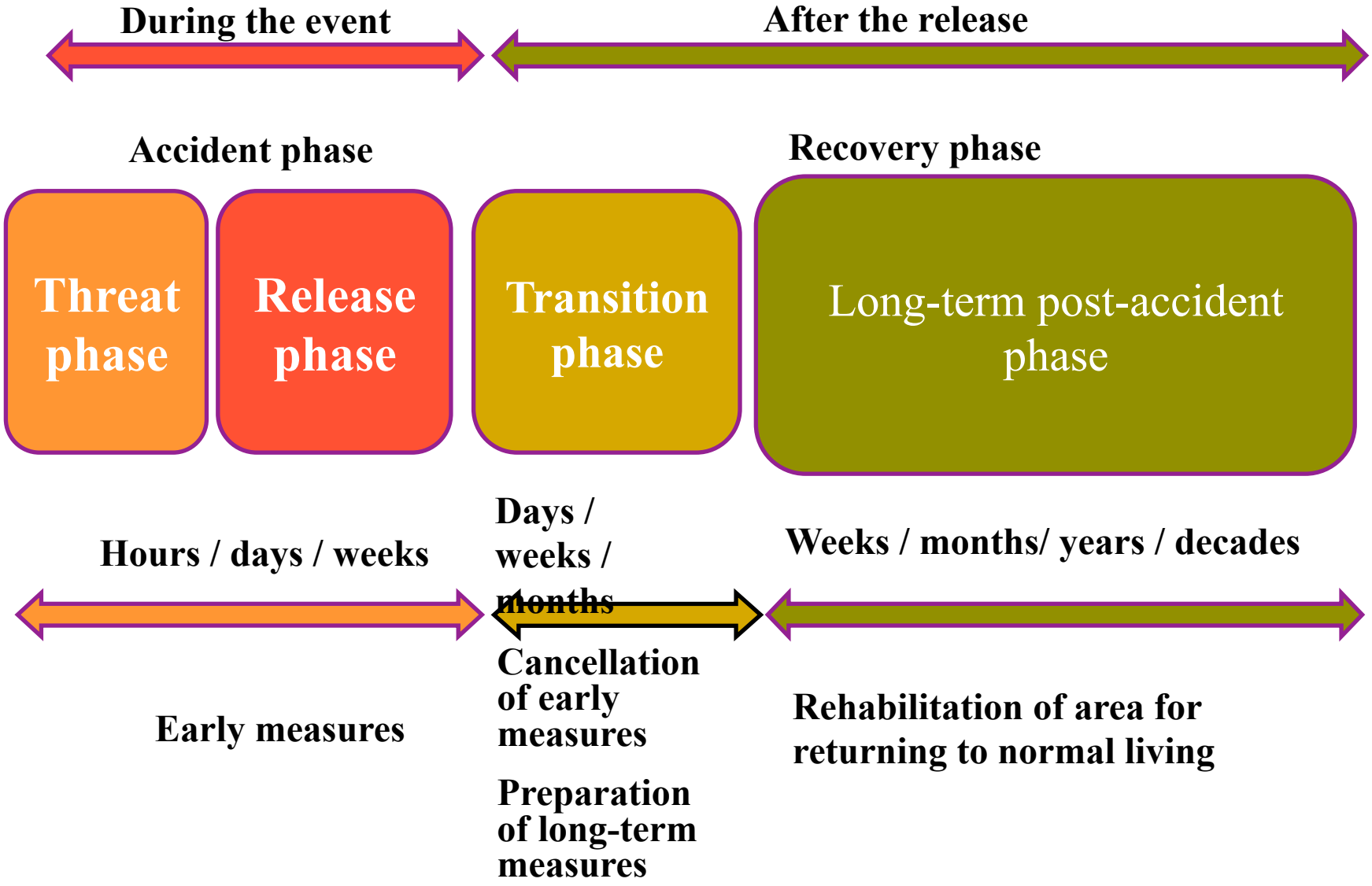
EC Project EURANOS (2004 – 2009)
Improvement of the coherence and effectiveness of nuclear and radiological emergency management including the rehabilitation of contaminated areas

NERIS-Platform
- Keep the momentum from EURANOS
- Improve the effectiveness of current European, national and local approaches
- Promoting more coherent approaches through the establishment of networking activities
- Maintaining and improving know-how and technical expertise among all interested stakeholders
- Identifying needs for further developments and addressing new and emerging challenges

EC Project NERIS-TP (2011-2014)
- Close gaps from EURANOS
- Promote the NERIS Platform

EC Project PREPARE (2013-2016)
- Close gaps based on Fukushima experience

Phases of a severe NPP accident



Threat phase: source term estimation

- Using in plant data
- FP5 project has resulted in two simulation tools,
  - one using a Bayesian net and pre-calculated source terms from PSA studies (STERPS)
  - One calculating the source term directly with a fast approximation of the complex processes (ASTRID)
- Both have been further developed and this development will continue in the EC project FASTNET
- STERPS was refined and is available as QPRO from GRS
  - Tested in German NPPs and with a direct link to RODOS
  - PSA level 2 source terms are needed and in plant data are used to define the probability of a pre-defined source term

Threat phase: source term estimation II

- Source term estimation based on atmospheric dispersion calculations and gamma dose rate monitors (examples of many different approaches and projects)
  - Optimisation of atmospheric dispersion model inputs using inverse modelling of instantaneous or time-integrated gamma dose rate measurements (part of the project PREPARE, realised with DIPCOT)
  - Development of a software tool for simple and fast estimation of source term using gamma dose rate measurements at the fence (part of the project PREPARE, stand alone tool)
  - Use of Bayesian approaches to correct the content and extension of individual puffs from a dispersion plume (part of EURANOS, tested with RIMPUFF)

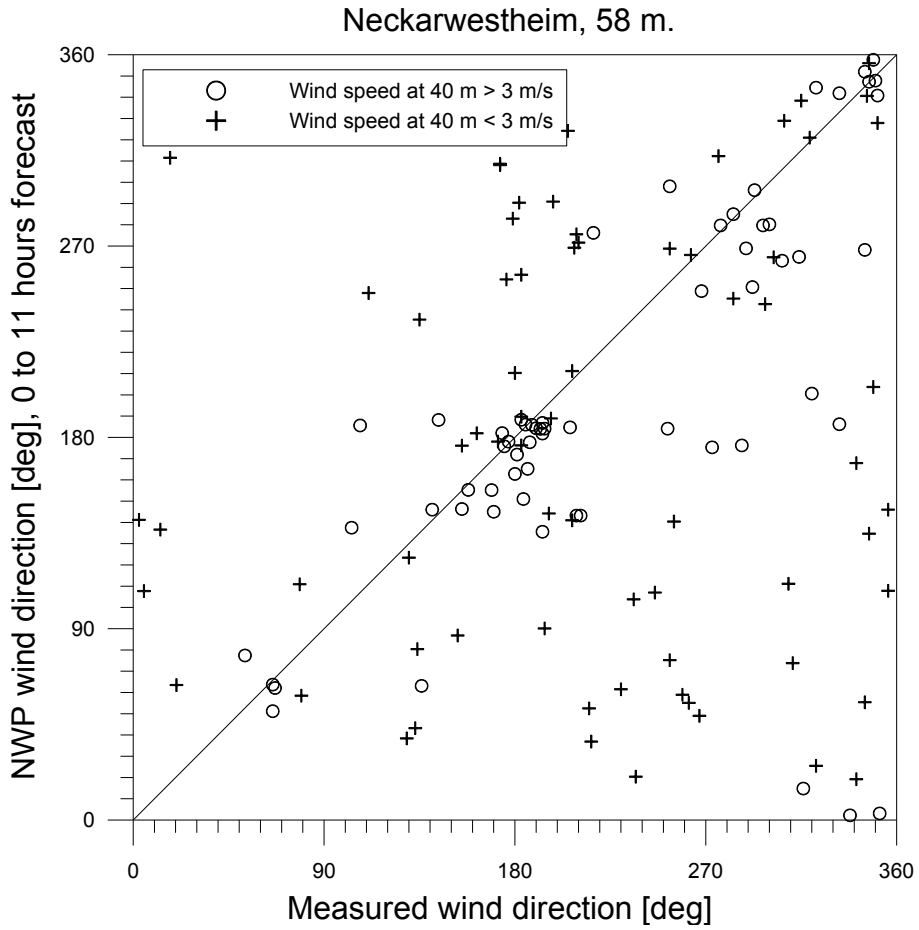
Source term estimation III

- Is there a third possibility in combining both approaches?
- Step 1: estimation based on in-plant data
- Step 2: estimation by data assimilation from dispersion models and monitoring stations
- Step 3: refinement of the source term for the in-plant models
- Looping .....????

Uncertainty

- What are main causes of uncertainty in results?
- How to deal with uncertainty in the models?
- How to communicate uncertainty to decision makers?

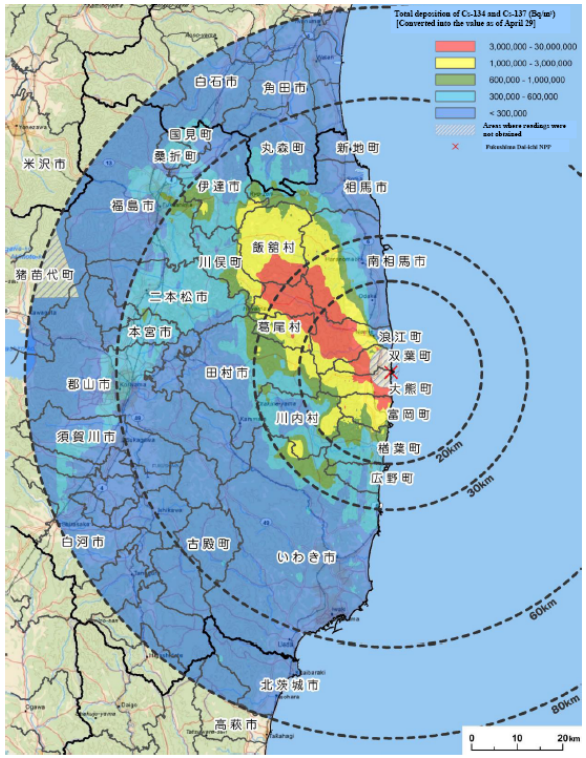
On-site and prognostic weather data - Example 1



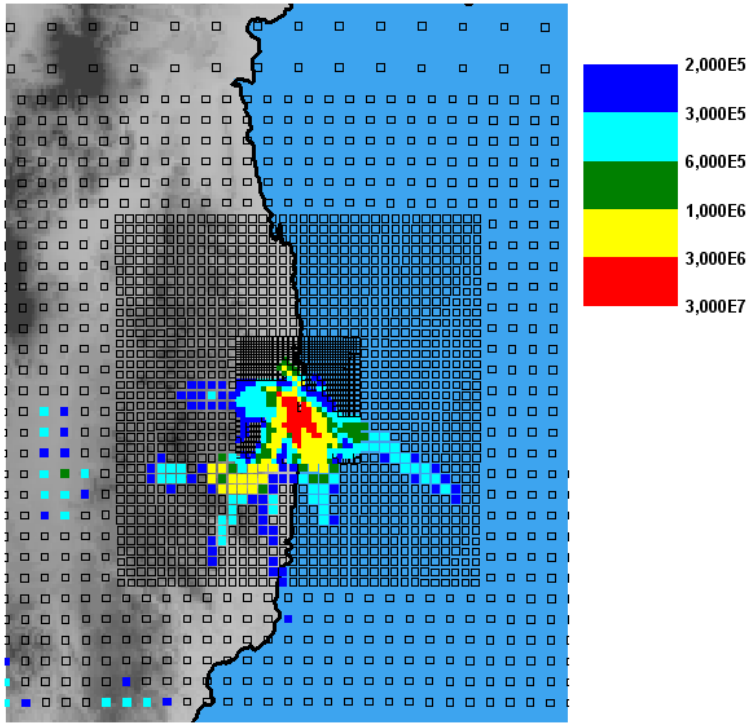
- Results for a NPP in hilly terrain in Germany
- Statistics of differences between numerical weather forecast and Neckarwestheim data for the first 11 hours of a 48 hour prognosis
- Statistical analysis period less than 3 months

Comparison of station data with NWP data

- Standard source term, but weather data only from station near Fukushima (RODOS mit ATSTEP)

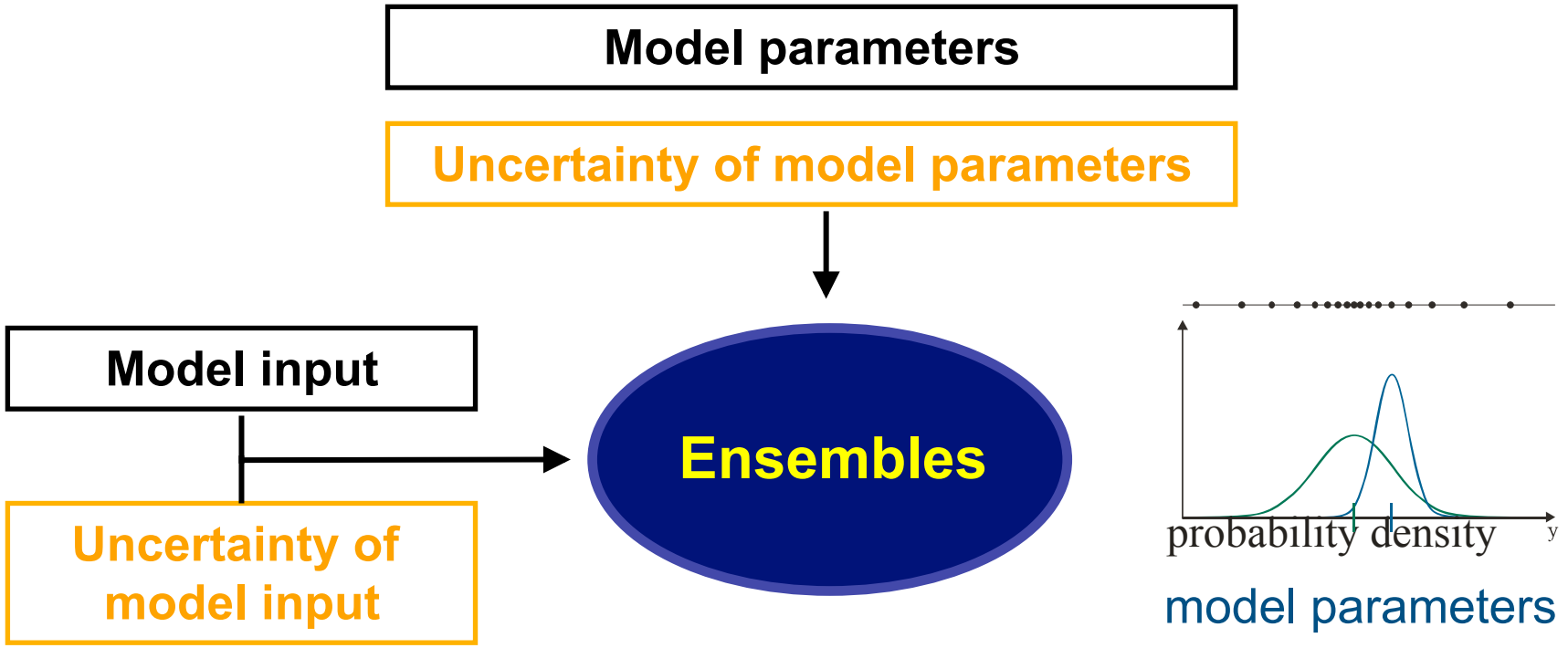


Monitoring total Cs



Calculations total Cs

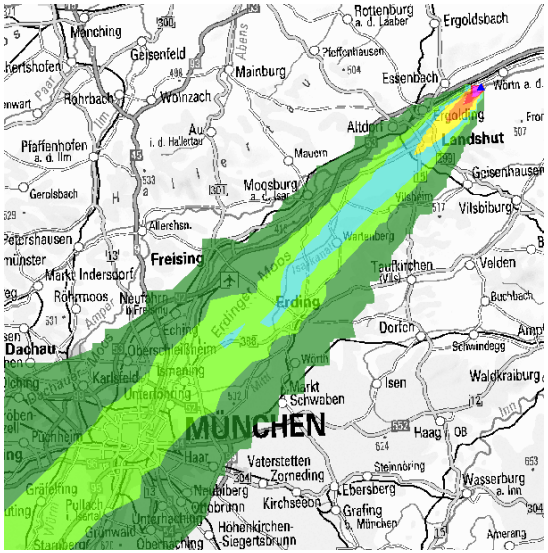
Uncertainty modelling

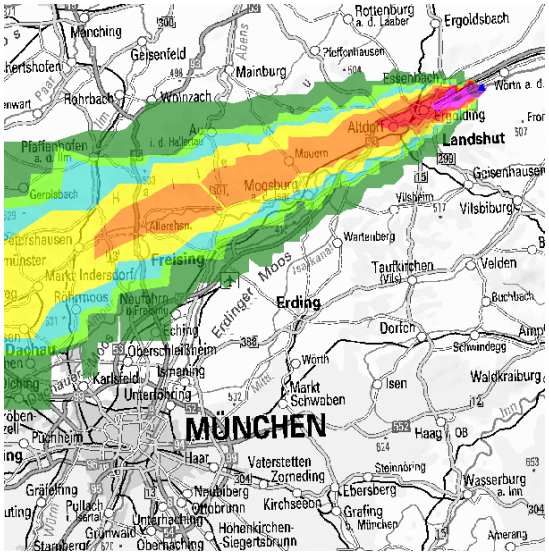


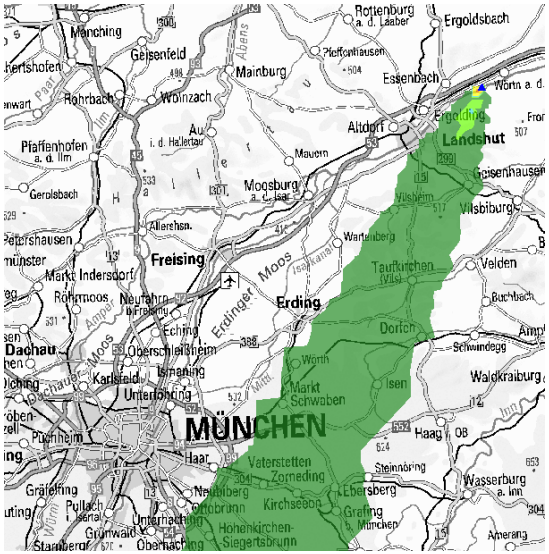
- Ensemble-Kalman filter used to generate 100 Ensembles
- Distribution of uncertain model parameters is derived a priori

Ensemble calculations

- Main source of uncertainty for atmospheric dispersion modelling is the input data (two key variables):
  - Source term: log-normal distribution is assigned to the source term since a deviation of an order of magnitude is considered to be equiprobable in both directions
  - Wind direction: normal distribution is assigned to the mean wind direction with a standard deviation of 30°

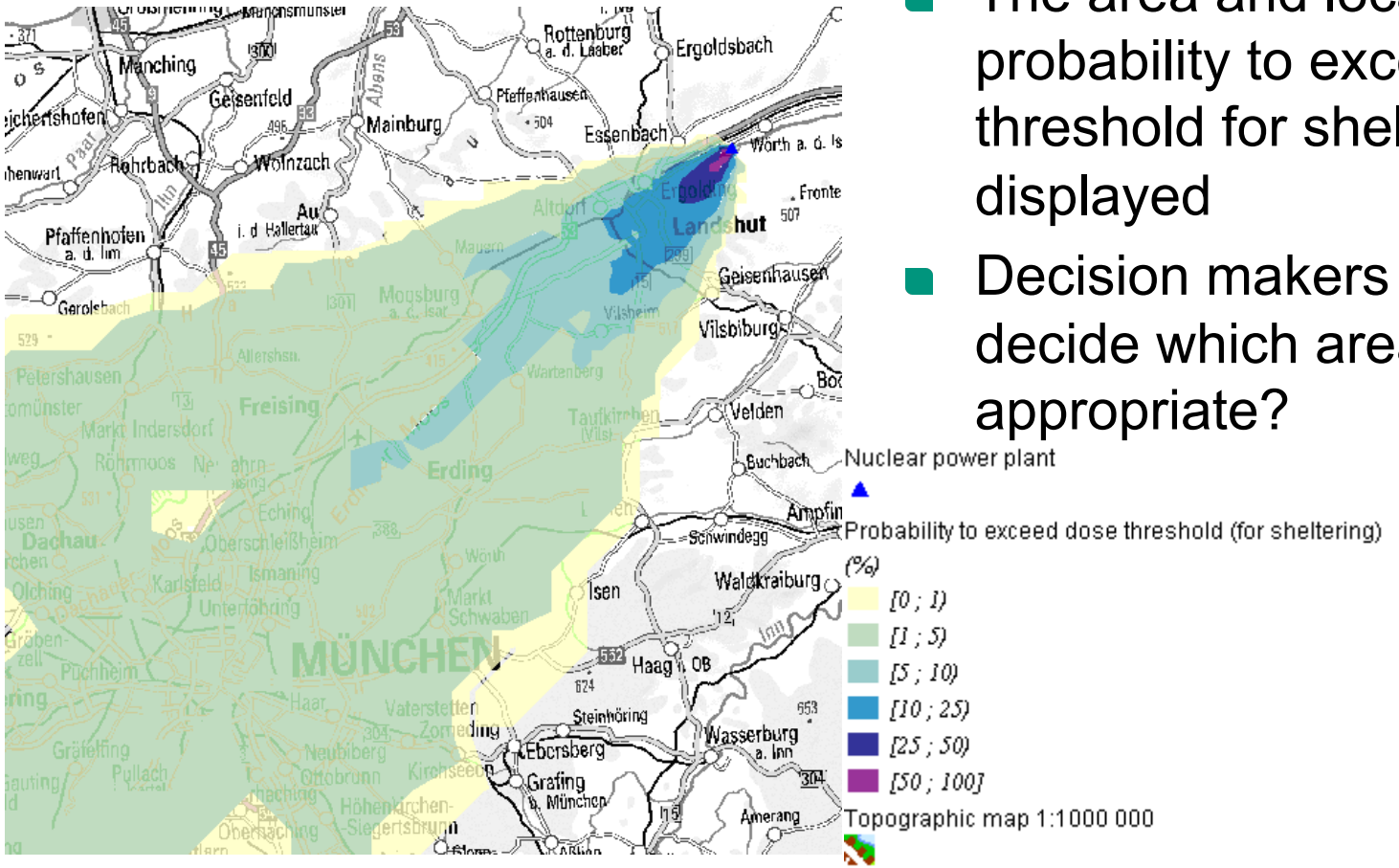






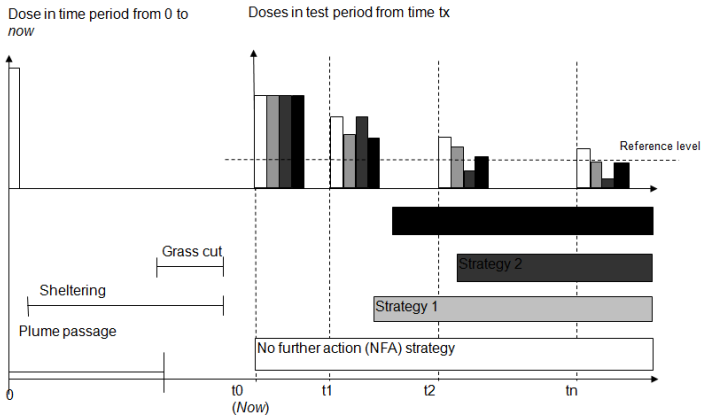
Proposed visualisation

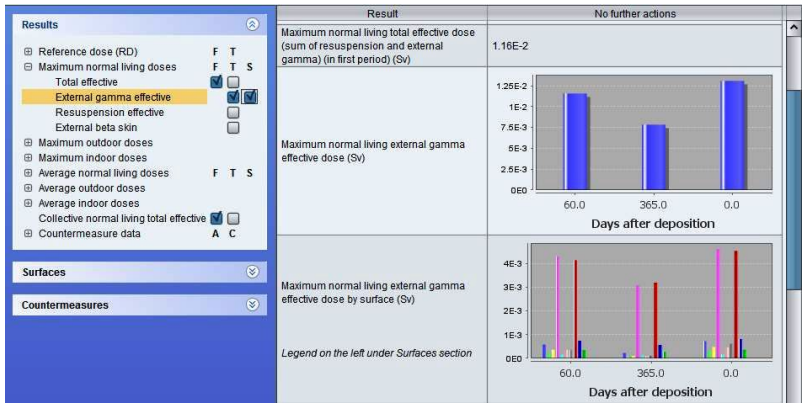
- Proposed visualisation of the impact of data uncertainties
- The area and location of the probability to exceed the dose threshold for sheltering is displayed
- Decision makers have to decide which area is appropriate?



Late phase: Inhabited area modelling

- Improvement of ERMIN
  - Development of a wizard that facilitates the development of decontamination strategies
- As result, ERMIN-2 was developed
  - The wizard exists, which guides the user through the selection of measures based on the contributing surfaces
  - How to further develop the tool by integrating objectives such as costs or others in the strategy selection – beyond NERIS-TP





Use of a DSS in the preparedness phase

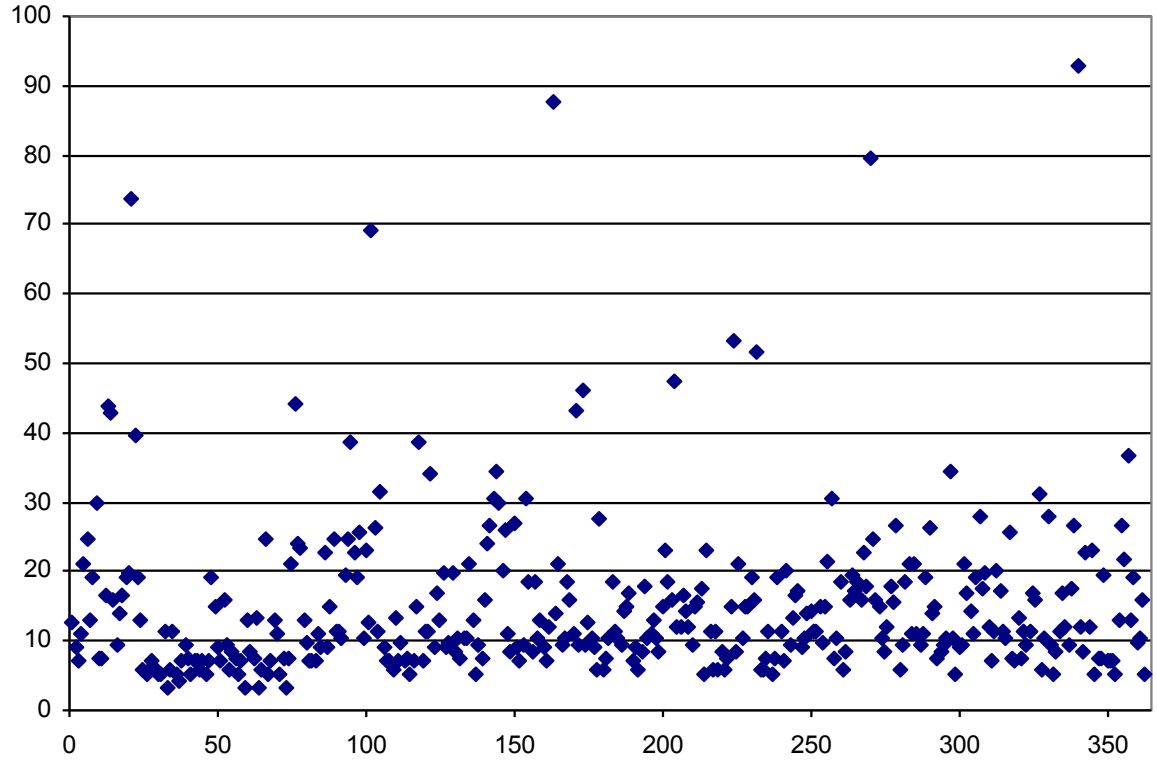
- Possible areas for application
  - Strategy development with respect to ICRP 103
  - Planning of areas for countermeasures
  - Scenario preparation
  - Training
  - Others ….

New ICRP recommendations

- Expand the simulation models for the new “residual dose” approach of ICRP-103
  - So far existing models treat countermeasures individually
  - The new recommendations requested that all exposure pathways should be taken into account in the countermeasure simulations
  - Strategies of individual measures should be possible
- As result, the ICRP model has been developed
  - Screening for individual measures or combinations including food
  - There is still the need to further develop such a model for operational use and in developing countermeasures strategies in a national regulatory framework

Use of historic data for response

- Use historic or scenario data to perform decisions under uncertainty (use of knowledge data bases and CBR)

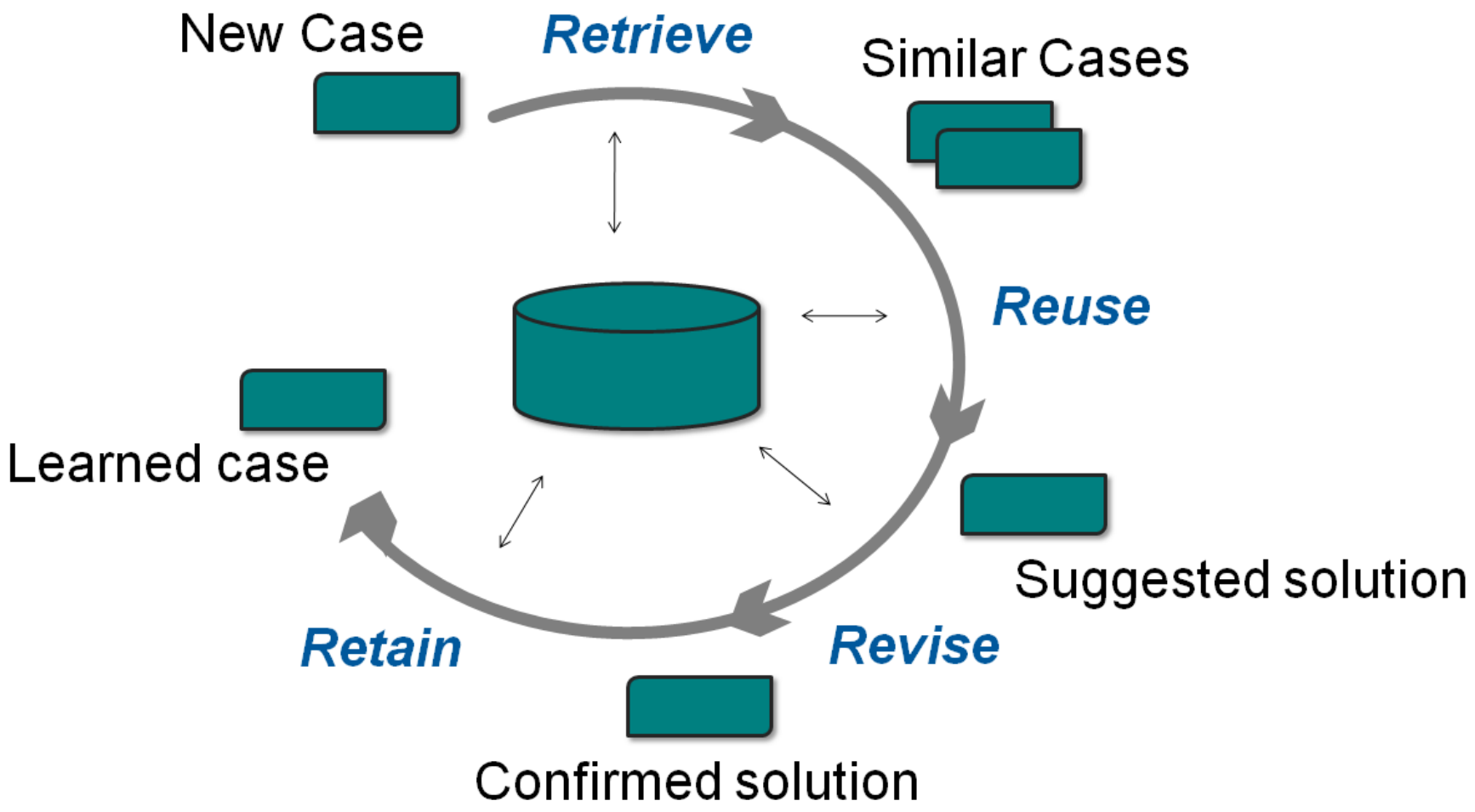


Maximum distance in which dose reference level for evacuation was exceeded for INES 7 source term and NPP Unterweser (Gering 2014, personal communication)

Case-based reasoning (CBR)

- CBR is a methodology to **solve new problems** by utilising knowledge of **previously experienced** problem situations
- CBR is a **cycle process** starting problem solving with identifying, assessing, and describing the current problem situation (case)
- Afterwards, **similar historic cases from a case base** should be determined to **reuse their solutions** and to adapt them to the current problem situation, if necessary
- The knowledge in the case base is updated by storing the **new case** with its possibly corrected or **improved and confirmed solution**
- Besides the previous cases, a CBR system **includes similarity measures**, and **adaptation knowledge**

CBR II


New Case
Retrieve
Similar Cases
Reuse
Learned case
Suggested solution
Retain
Revise
Confirmed solution

Knowledge database

- Requirement: Providing a **structured storage facility** for **historic events and fictitious scenarios**, their **propagation with time** and their applied (or applicable) **emergency measures**
- Objective: Supporting a **fast assessment of a current event**
- Means:
  - Defining **attributes** and **attribute ranges** to provide a **unique representation**
  - Taking into account **decision-making factors** and **resulting effects**
  - Taking into account **accident phases** and hence the status of the release, type and urgency of countermeasures, type and availability of resources, and relevance of exposure pathways

Knowledge database II

- The knowledge database will contain historic cases and generic scenarios
- Scenarios will consider types of
  - Source terms (low to high)
  - Weather (with and without rain)
  - Environments (urban, rural)
  - Population density
- These scenarios will allow to define generic countermeasure scenarios which can be ranked according to preferences of the decision makers
- Ranking based on multi-criteria approaches

Complexity of a DSS

- Each year, new features/ functionalities are added to the RODOS system
  - Simulation models
  - Reporting e.g. GIS results/compatibility
  - User interfaces
- Operability under all conditions is of highest interest by end user
- According to Bugzilla, mainly bug reports are listed for the emergency chain
- Question: is there a need to separate emergency models from late phase and complex simulation models?

Conclusions

- DSSs are an important instrument for supporting the decision making team in all phases of an emergency – should be come more important in the preparedness phase
- Source term estimation is still a weak point in the chain and innovative ideas might be necessary
- Uncertainty handling is so far not an integral part of a DSS and work should be also directed towards the implementation but also the communication of uncertainties
- Use of the DSS to prepare strategies in advance is a valid option and with the new Analytical Platform tools will be provided to further evaluate results (Training/demonstration in October 2015 in Trnava)

Thank you very much for your attention

Questions?

PREPARE: Training on the Analytical Platform in October 2015 in Trnava