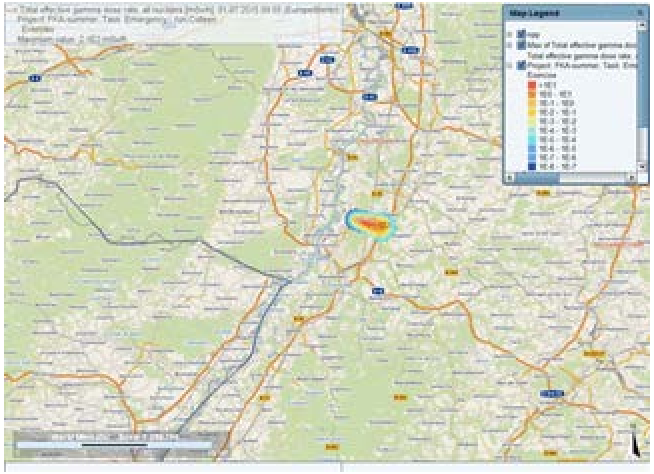
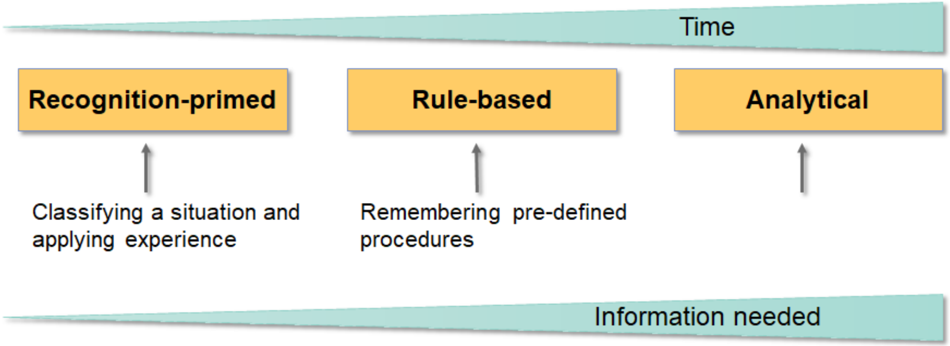
Risk assessment during an emergency

W. Raskob (retired)
Karlsruhe Institute of Technology (KIT)





Outline

- Background and introduction
  - When do we need a sound risk assessment based on monitoring and modelling in a nuclear emergency to assure proper decision making and a balanced long-term health care for the population?
- Decision-making in an emergency
  - Phases
  - Decision support system
  - Protective measures and needs
- Risk estimation bases on early assessments (CONFIDENCE project)
- Summary and conclusions

Phases of an event (adapted from NERIS SRA)

Karlsruher Institut für Technologie

PREPAREDNESS	**PRE-RELEASE PHASE / THREAT PHASE**	**EMERGENCY RESPONSE**			**LONG TERM PHASE**
	Urgent Response Phase		Early Response Phase	Transition Phase	
Nuclear and Radiological Emergency Planning **Stakeholder participation** **Education and training, Including Exercises** **R&D**	Implementation of Early countermeasures	Precautionary and urgent protective actions	Early protective actions and other response actions	Lifting of Early countermeasures Implementation of transition phase countermeasures Preparing long term remediation	Resumption of normal living conditions
Normal Exposure Situation **Planned Exposure Situation**	Emergency Exposure Situation				Existing, planned Exposure Situation Normal Exposure Situation
	Hours - days		Days - weeks	Weeks - years	

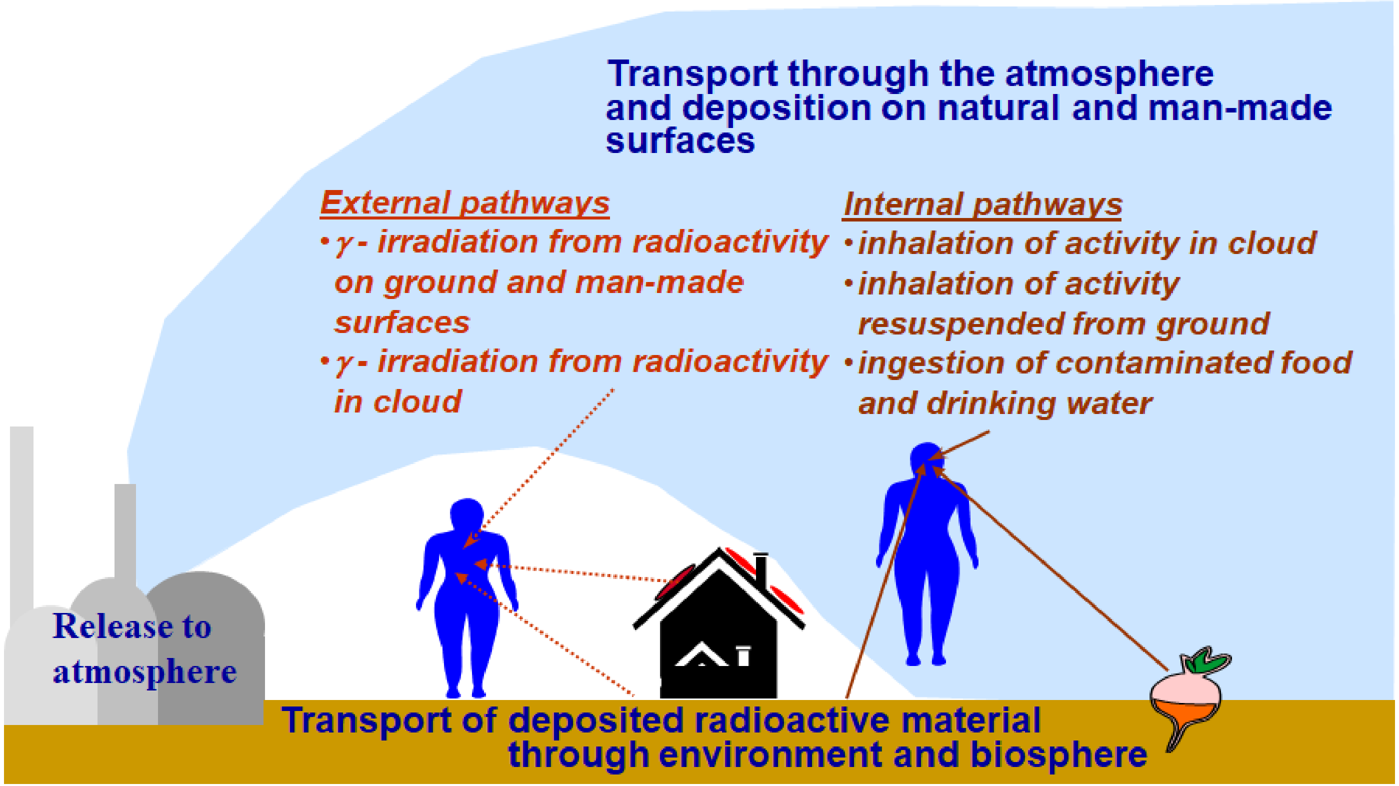
Declaration of Emergency

End of early Emergency phase

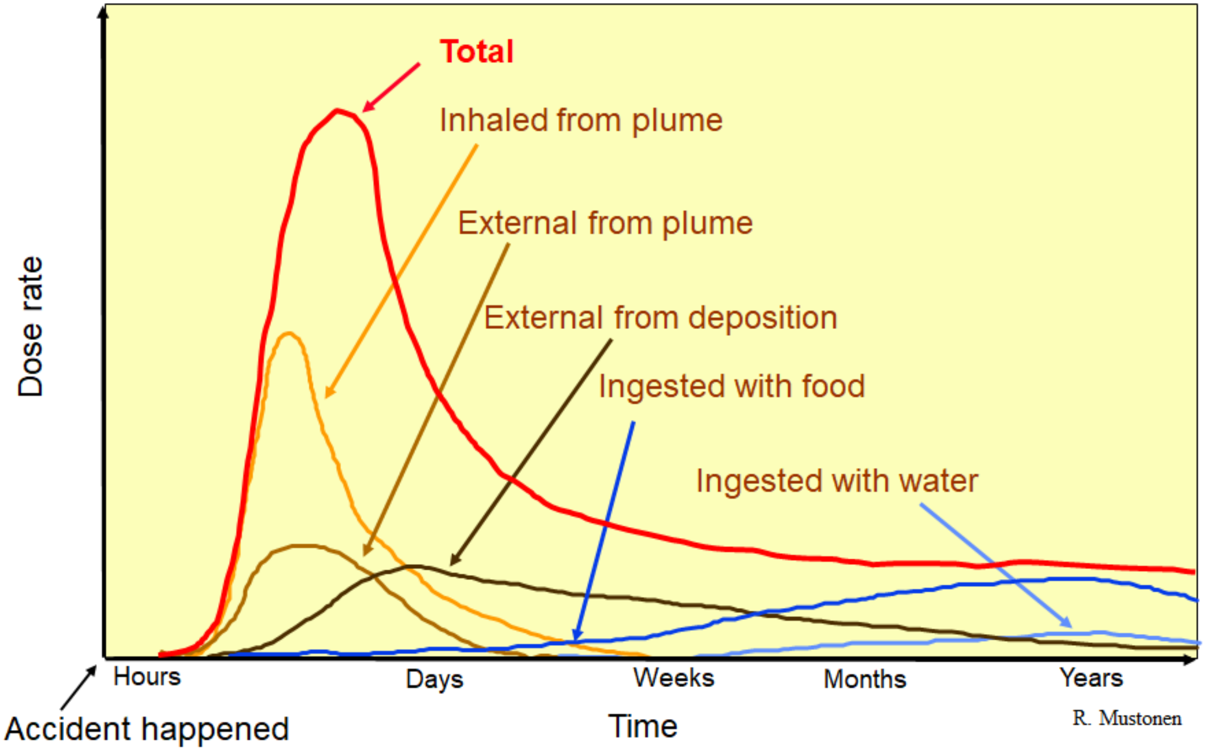
Termination of Emergency

Exposure of people, for airborne accidental releases from nuclear power plants

Karlsruher Institut für Technologie



Exposure with time



Karlsruher Institut für Technologie

Decision-making

Time

Recognition-primed — **Rule-based** — **Analytical**

- **Recognition-primed**: Classifying a situation and applying experience
- **Rule-based**: Remembering pre-defined procedures
- **Analytical**: Considering possible courses of action and selecting the best option

Information needed

Possible tasks of a decision support system for off-site nuclear emergency management

Karlsruher Institut für Technologie

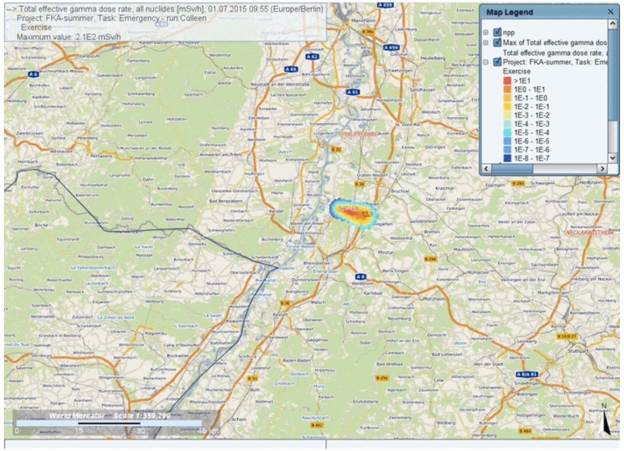
- Provide consistent and comprehensive information at local, regional and national levels, for all accident phases
  - During real event (housing and displaying of relevant information about the release, the weather, the contamination; forecast of health, agricultural and economic impacts with and without the application of countermeasure)
  - When preparing for a possible future event (creating scenarios and background material for planning, exercises and training)
- Assist decision makers in evaluating different measures against a range of quantitative and qualitative criteria
- Promote a common emergency management frame aiming to move away from national solutions

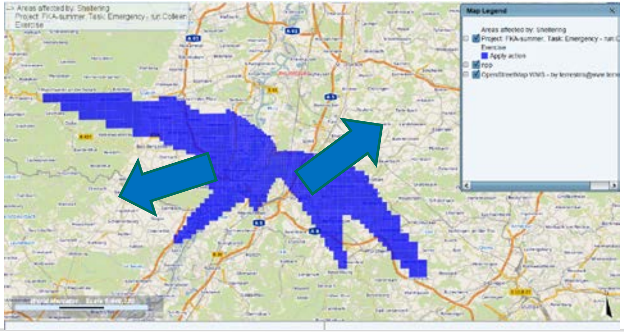
Decisions to be taken

- Early phase measures
  - Evacuation: best before the plume reaches the location
  - Distribution of iodine tablets: best before the plume reaches the location
  - Sheltering: during plume passage
- Early phase measures are taken just considering a postulated release/source term and model simulations – typically no monitoring information is available

How to use monitoring information

- As mentioned before, often decisions are taken based on prognostic information
- As soon as measurements become available, decisions taken might be adjusted
- So the area of sheltering might be checked via the Operational Intervention Limit (OIL) that fit to that protective measure
- As result, the proposed area might be adapted – or not





The CONFIDENCE Project

- The general objective was to understand and if possible reduce uncertainties in decision making during a nuclear emergency
- WP2, coordinated by Clemens Woda, aimed at: Improving awareness of the radiological situation by optimizing monitoring data, dose assessment, individual dose measurements and calculating health risk estimates
- I will present results of that work performed by the following researchers

HelmholtzZentrum münchen
German Research Center for Environmental Health
A. Mafodda, C. Kaiser, A. Ulanowski

Ciemat
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas
I. Sierra Bercedo
J.F. Navarro

IRSN
C. Challeton-de Vathaire,
D. Estelle,
D. Franck

STUK
J. Lahtinen
T. Karhunen

Bundesamt für Strahlenschutz
U. Stöhlker
U. Kulka
A. Giussani

Public Health England
J. Eakins,
J. Marsh,
D. Gregoratto

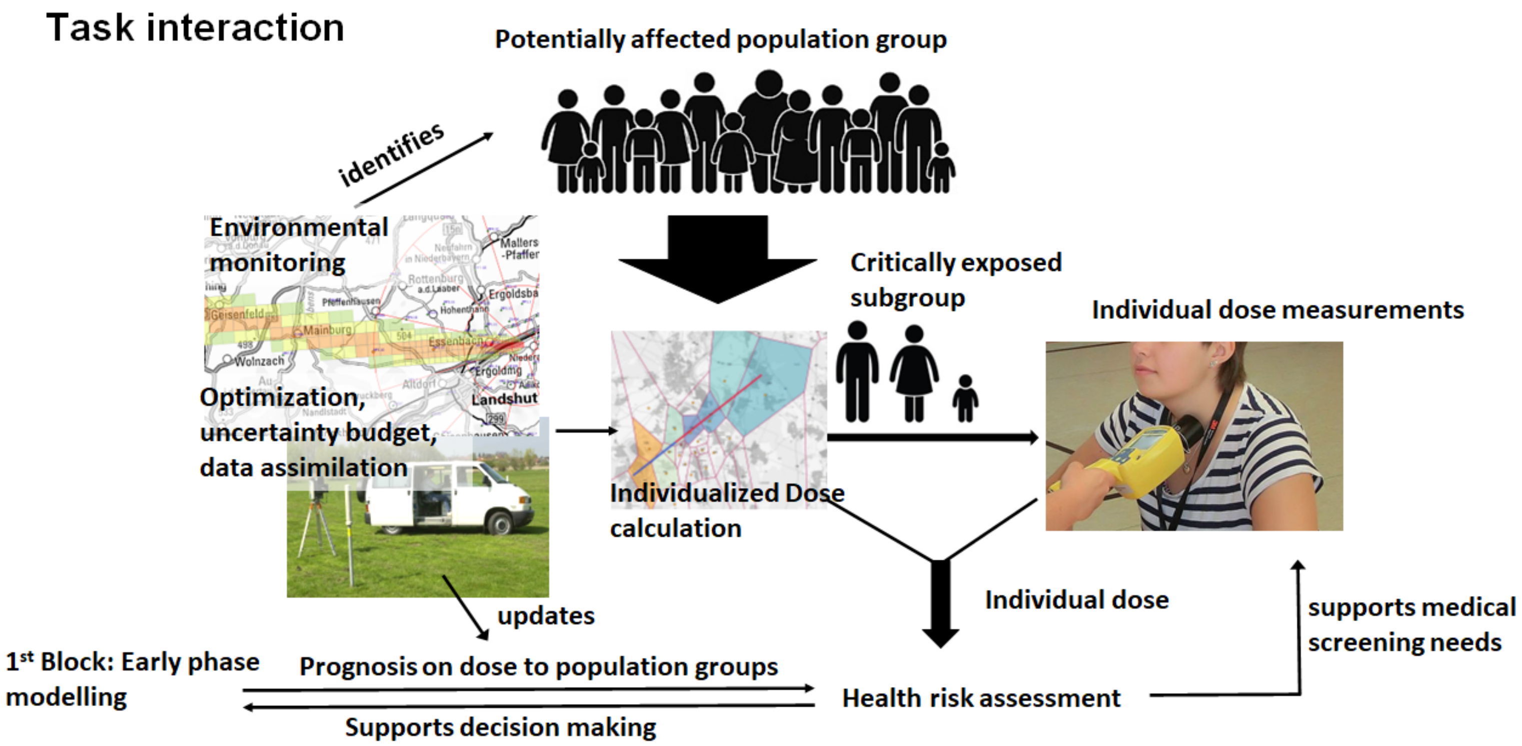
RPI Ukraine
V. Berkovskyy
Gennadii Ratia

Statens strålevern
A. Nalbandyan
A. Jaworska

KIT
B. Breustedt

Universität Zürich
L. Walsh

The various monitoring tasks



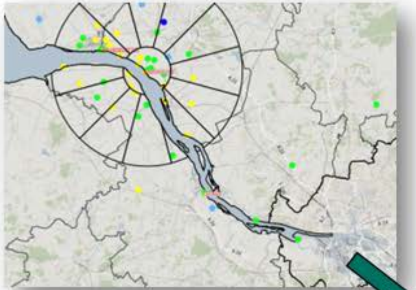
How to obtain the necessary measurements

- Stationary stations (e.g. EURDEP, gamma dose rate stations around NPPs)
- Mobile measurements with e.g. cars, helicopters or drones
- External dose-rate measurements based on smartphone CMOS sensor
- Combine measurements with occupancy information
  - Knowing the time a person stays at one location, it might be possible to get an individual dose assessment for that person

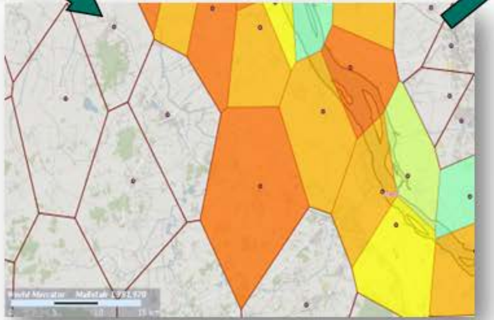
Tool that exists at BfS

Karlsruher Institut für Technologie

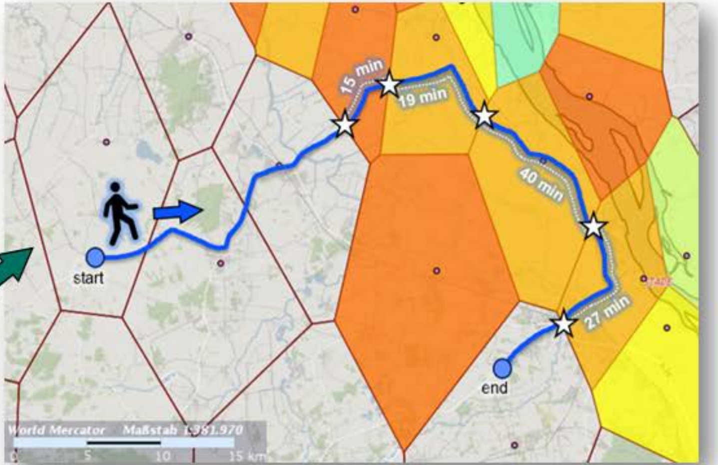
Measurement data



Dose rates and doses estimated from measurements



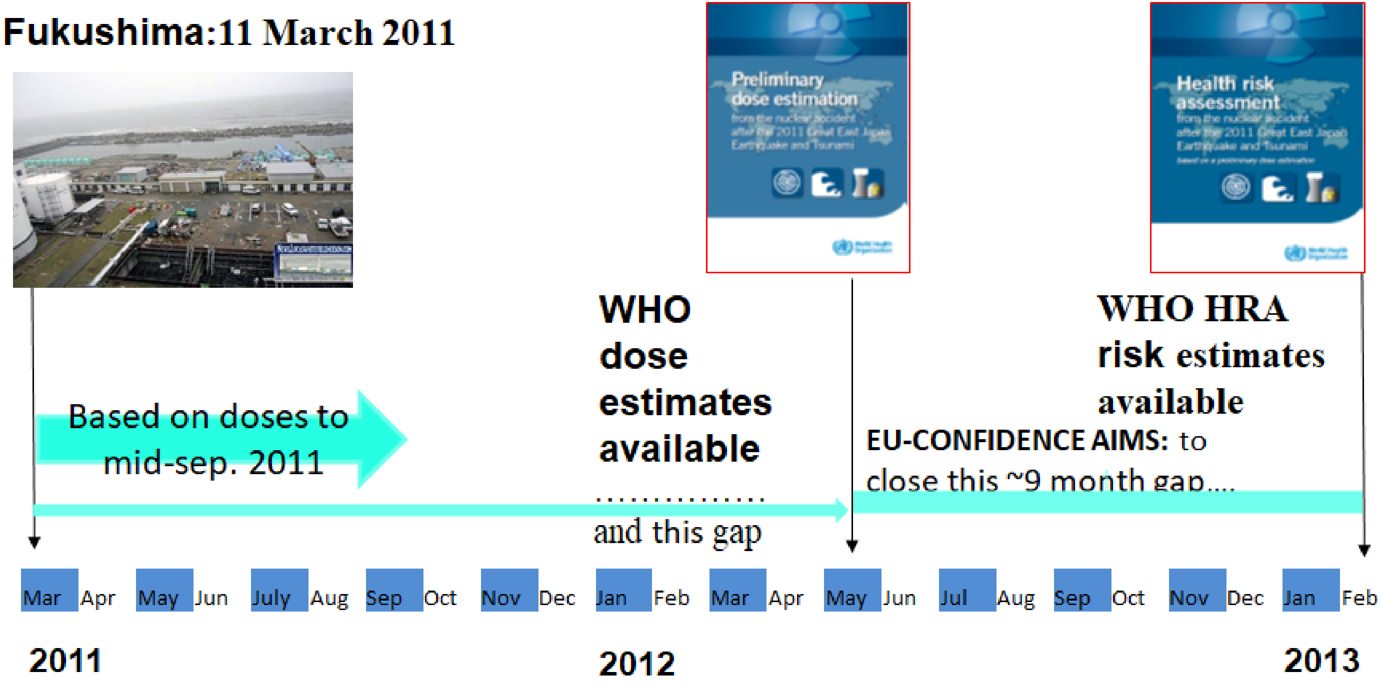
Dose calculation for an individual movement profile



Risk estimation

- In the long term recovery phase, the need for long term health care actions is obvious
- In particular, risk estimation for population groups that were either evacuated, sheltered or administered iodine tablets might be necessary as soon as possible
  - Examination of possible health effects
  - Screening activities, e.g. thyroid examination
- A sound dose estimation is important as basis for the risk estimation
- Fukushima provided an example on the processes and the time needed for the “final” risk estimation

Fukushima experience



Publication describing the CONFIDENCE approach

Karlsruher Institut für Technologie

Radiation and Environmental Biophysics
https://doi.org/10.1007/s00411-019-00809-x

ORIGINAL ARTICLE

Risk bases can complement dose bases for implementing and optimising a radiological protection strategy in urgent and transition emergency phases

Linda Walsh[1] · Alexander Ulanowski[2,3] · Jan Christian Kaiser[2] · Clemens Woda[2] · Wolfgang Raskob[4]

All solid cancer
100mSv effective dose
LAR: Lifetime Attributable risk

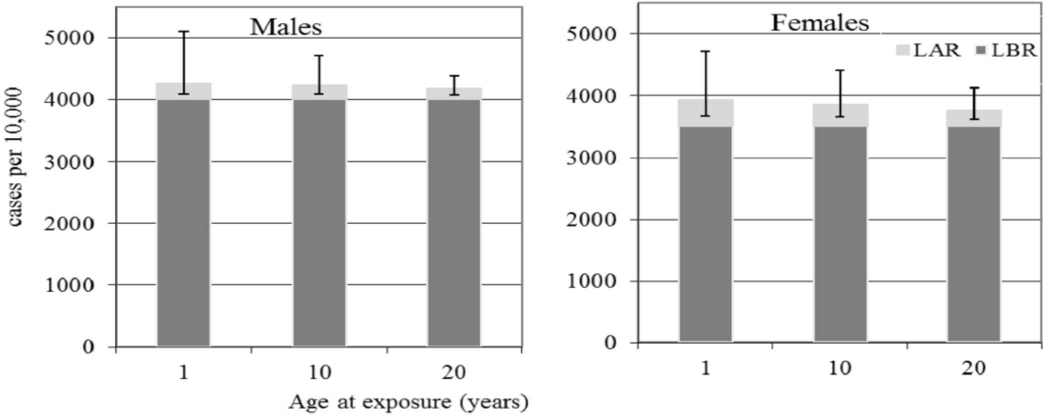


Fig. 1 Male and female all solid cancer baseline (dark grey) and radiation (light grey with error bars) risks in cases per 10,000 persons calculated from LBR and the LAR for 100 mSv effective dose. Error bars are for 95% confidence intervals

Approach

Karlsruher Institut für Technologie

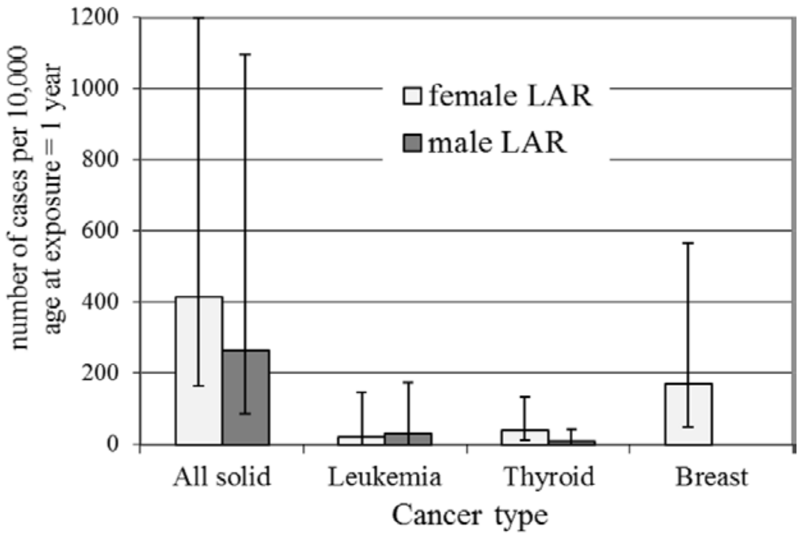
- The idea: Assessment of Lifetime risks (Lifetime Baseline Risk, Lifetime Attributable Risks, Lifetime Fractional Risks) based on one exposure
- Needs: Calculation of lifetime risks requires input from published risk to dose response models (for various ages at exposure, attained ages and sex) and population data
- Examples:
  - All solid cancers (ICD10:C00-C80) from Japanese A-bomb LSS cohort:1958-2009 (Grant et al 2017)
    - Organ dose type required: Colon
  - All leukemia (ICD10:C91-C95), excl. CLL (C91.1, C91.4) and ATL (C91.5) from LSS cohort:1958-2001 (Hsu et al 2013)
    - Organ dose type required: Red Bone Marrow

Data considered

- German cancer register (RKI) – incidence and mortality rates for the selected cancer outcomes
- Scandinavian (Sweden, Denmark, Finland and Norway) cancer statistics (NORDCAN, IARC) – incidence and mortality rates for the selected cancer outcomes
- Switzerland (WHO & *www.krebs.bfs.admin.ch*)
- General survival data from life tables for Germany (Destatis.de) and other European countries (*ec.europa.eu/Eurostat, http://ec.europa.eu/eurostat/estat-navtree-portlet-prod/BulkDownloadListing?file=data/demo_mlifetable.tsv.gz, accessed on 27.11.2017*)

How to apply

- The average population size & structure in region of interest is needed and used to calculate the absolute number of expected cases
- Population is subdivided into three age groups (female as conservative assumption)
  - Children 5 – 10 years
  - Adults 20 – 40 years
  - Seniors > 65 years
- Doses are normalised to cases per 100 mSv (mGy) as for example figure on the right side
- Uncertainties are also peovided

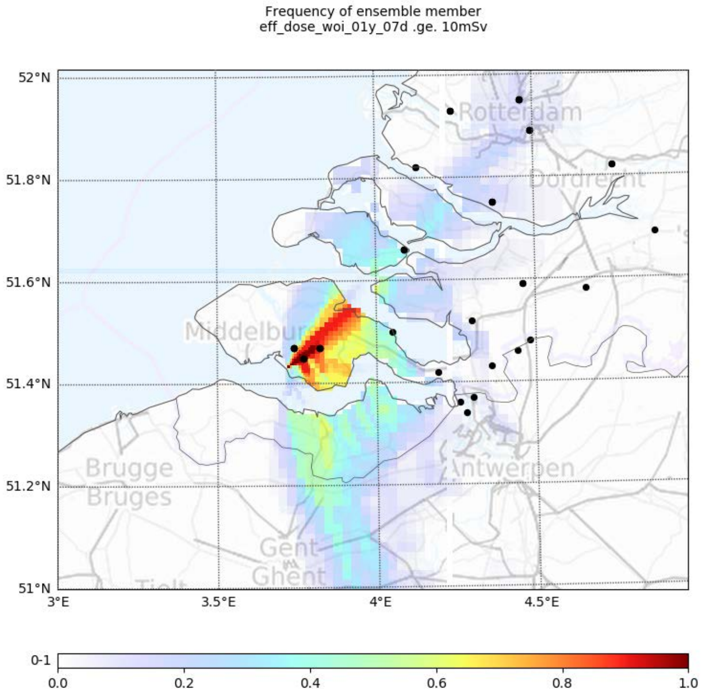


Issues to be solved

- How to get the necessary dose values for the affected population?
- How to consider internal doses obtained during plume passage – so far the method/tool is limited to external exposure?
- Number of affected population for our example case with a large source term – based on JRODOS simulations
  - About 9 Mio people living in the area considered
  - Sheltering: close to 500000 people were sheltered
  - Evacuation: about 47000 people were evacuated based on 100 mSv over 7 days
  - Iodine tablets were needed for about 330000 children and 233000 adults

Data assimilation

- Combine model results with monitoring information
- The example from the CONFIDENCE exercise shows the plume in terms of probability maps and the available monitoring stations
- Having ensemble information from the models and uncertainty from both model and monitoring networks allows using ensemble assimilation approaches
- Result is an areal dose information



Summary and Perspectives

- Decision-making in an emergency, in particular in the early and intermediate phases has to deal with large uncertainties
- First decisions are based on simulation models
- Adaptation of measures will be based on monitoring information
- A proper risk assessment can be the basis for decisions on long term health care actions
- Within the CONFIDENCE project, a methodology has been developed demonstrating such an assessment early in the emergency
- The combination of measurements, simulation results and occupancy information might be a promising method to obtain the necessary dose estimation to allow pre-planning of necessary actions in time

Thank you for your attention!

https://resy5.iket.kit.edu

Wolfgang Raskob – Consultant of KIT

JRODOS Team

Tel.: +49 721 608-22480
Wolfgang.raskob@partner.kit.edu

Karlsruhe Institute for Technology (KIT)
Institute for Thermal Energy Technology and Safety (ITES)
Hermann-von-Helmholtz Platz 1
76344 Eggenstein-Leopoldshafen, GERMANY