Effects of radioactive contamination

flexRISK final event

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Overview

- Effects of radioactive contamination resulting from a severe nuclear accident
- Doses and pathways considered in flexRISK
- Dose levels and limits as endpoints of the flexRISK dose calculation
- Selected flexRISK dose results and discussion

Effects of radioactive contamination

- Effects for human health:
  - Health effects depend on received doses
  - Human health:
    - Deterministic effects: acute radiation syndrome
    - Stochastic effects: cancer and many other diseases, genetic effects, psychological consequences,…
  - For almost all stochastic health effects the dose-response-relationship is still in discussion between scientific communities
  - We calculated doses that are used in emergency planning and in radiation protection policy
  - We did not assess cancer risk, but it is a future option to use flexRISK for such assessments
- Not considered in flexRISK:
  - Social and economic effects
  - Effects for the environment

Doses and pathways considered

- Considered doses:
  - Thyroid dose: only organ dose we calculated (mSv)
  - Effective dose: weighted sum of all organ doses (mSv)
- Considered pathways:
  - Ground-shine
  - Cloud-shine
  - Inhalation
- Ingestion is the most important pathway for long-term doses
  - In the first year after Chernobyl, ingestion dose contributed up to 75 % to total dose in Austria (BKA 1988)
  - We did not calculate ingestion doses because of the scope of the project, therefore 1-year doses will be underestimated

Methods of dose calculation

- Dose factors:
  - Internal radiation (ICRP 1996)
  - External radiation (Eckerman and Leggett 1996, Health Canada 1999)
- Two age groups: different dose factors, breathing rates
  - Infants (0-1 a)
  - Adults (>18 a)
- Dose reduction factors for long-term doses:
  - Location and occupancy factors (Müller et al. 2003)
  - Soil shielding factors (SSK 2003, Jacob 1990)

Dose levels and limits as endpoints

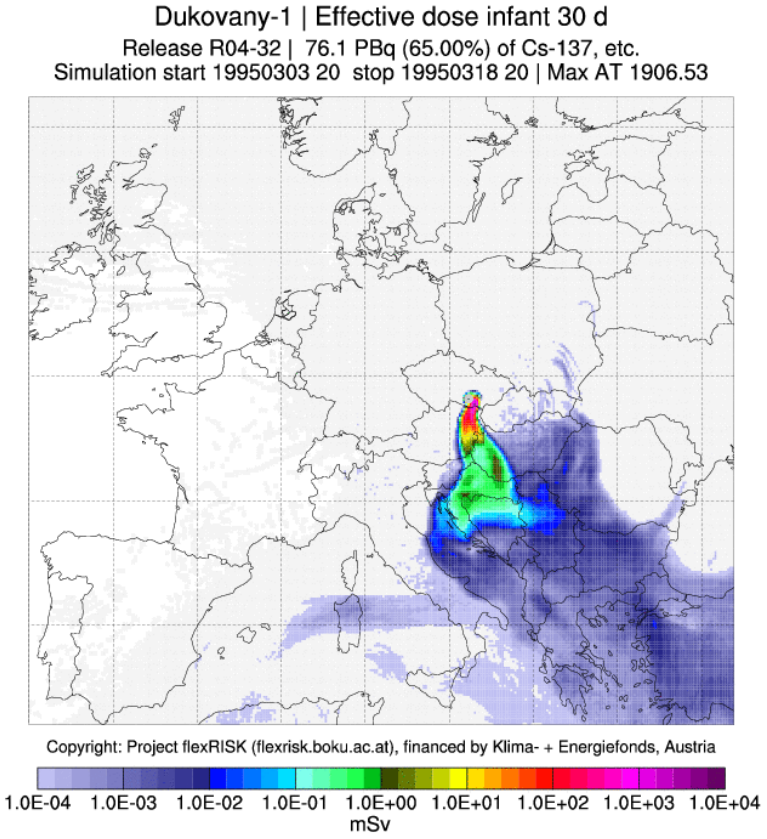
Endpoints of dose calculation	mSv adult	mSv infant	Type of dose	Nuclides	Pathways	Contam. period	Period for dose calcul.
Intervention level sheltering (Austria)	10	1	Effective	All	Inhalation, ground-shine, cloud-shine	7d	Inhal: lifetime, g+c: 7d
Intervention level iodine prophylaxis (Austria)	100	10	Thyroid	Iodines	Inhalation	7d	Lifetime
Intervention level temporary relocation (Austria)	30	30	Effective	All	ground-shine	30d	Inhal: lifetime, g+c: 30d
Dose limit for members of the public (Directive 96/29 EC)	1	1	Effective	All	Inhalation, ground-shine, cloud-shine	1y	Inhal: lifetime, g+c: 1y
Former intervention levels 2, 3 and 4 (Austria)	2.5/25/250	2.5/25/250	Effective	All	Inhalation, ground-shine, cloud-shine	1y	Inhal: lifetime, g+c: 1y

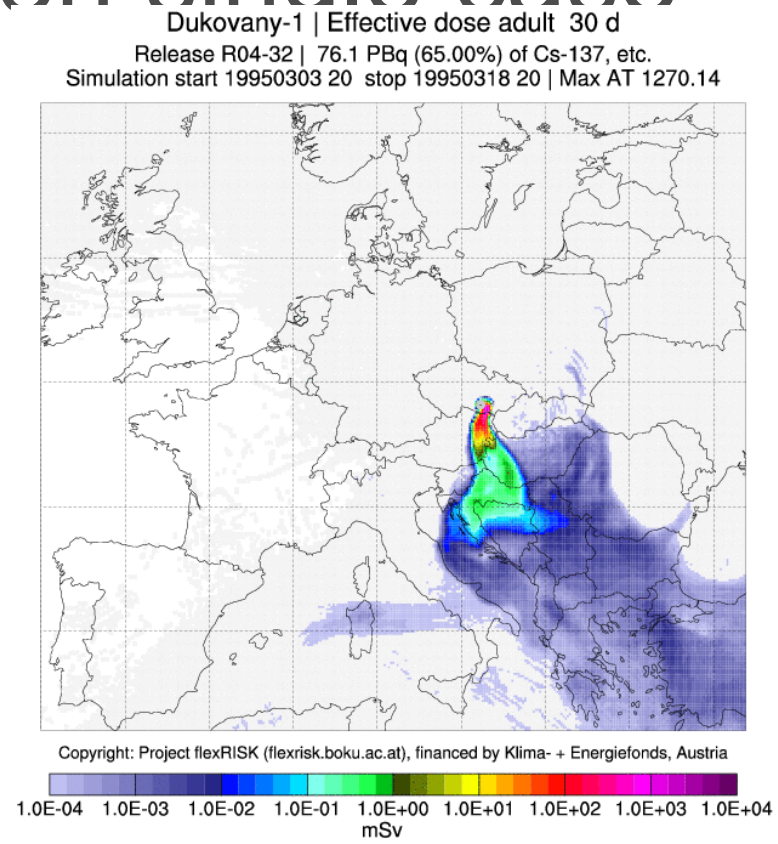
Four types of dose results/1

- Dose results for each NPP unit for 1995 for all levels and limits according to the endpoints of flexRISK
  - 7-d thyroid inhalation dose adults
  - 7-d thyroid inhalation dose infants
  - 7-d effective dose adults
  - 7-d effective dose infants
  - 30-d effective dose adults
  - 30-d effective dose infants
  - 1-y effective dose adults
  - 1-y effective dose infants
  - 50-yrs (lifetime) effective dose adults

flexRISK

Example: temporary relocation single case





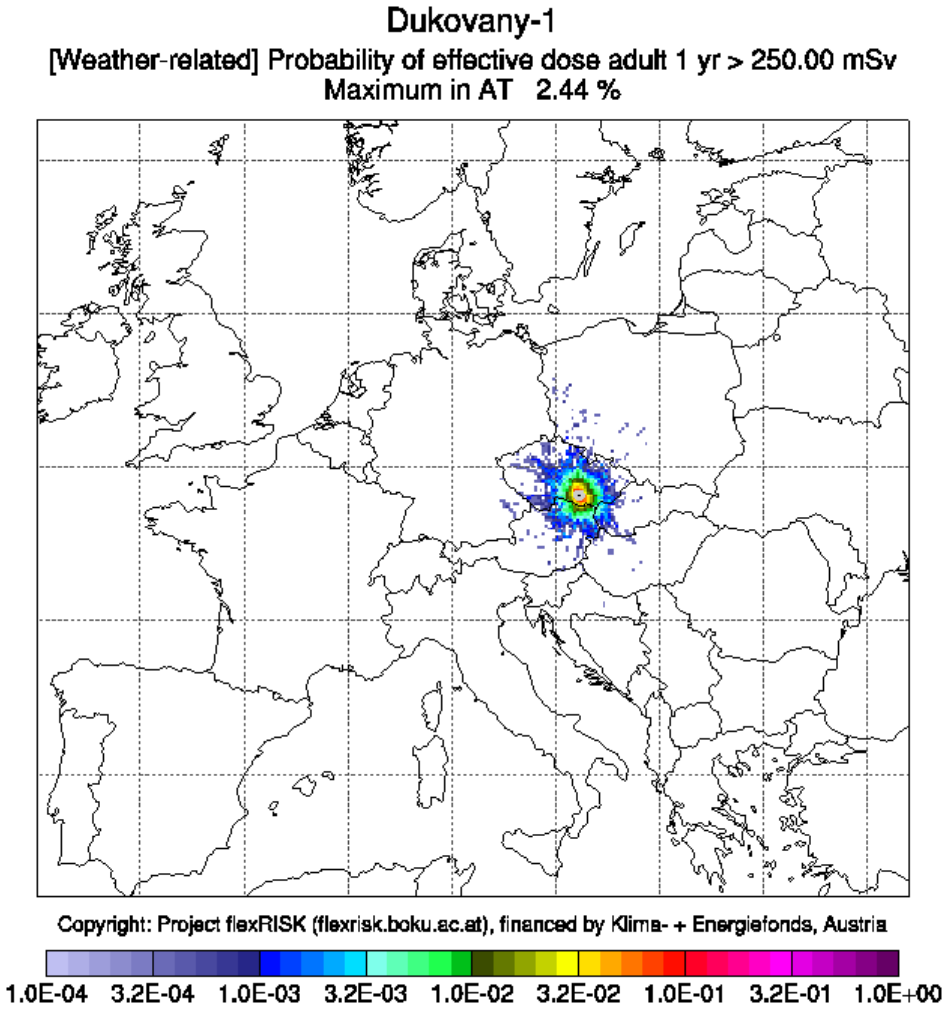
- 30 d-effective dose from ground-shine
  - For children and adults > 30 mSv
  - Example Dukovany-1, 03-03-1995

Four types of dose results/2

- Risk per NPP unit: Probability of exceedance of selected dose levels (aggregated over all cases)
  - Weather-related probability of 7-d thyroid dose for infants >10 mSv
  - Average 7-d thyroid dose for infants
  - Weather-related probability of 1-y effective dose for adults > 2.5 mSv
  - Weather-related probability of 1-y effective dose for adults > 25 mSv
  - Weather-related probability of 1-y effective dose for adults > 250 mSv
  - Average 1-y effective dose for adults

Example aggregated risk

- 1-y effective dose > 250 mSv
  - Example Dukovany-1, aggregated over all cases
  - Former Austrian intervention level 4: relocations and evacuations can be necessary
  - Maximum in Austria is a probability of 2.4 %



Four types of dose results/3+4

- Risk export of NPP countries: Probability of exceedance of selected dose levels (aggregated over all cases)
- Risk import for all countries: Probability of exceedance of selected dose levels (aggregated over all cases)

- Will be available soon

Iodine prophylaxis for children

- 7 d-thyroid dose from iodine-inhalation for children < 18a:
  - Austria: 10 mSv
  - Germany: 50 mSv (iodine tablets stored only in 100 km-zone)

- Comparison flexRISK – BfS study:
- Gering et al. (2012): Analyses of German emergency planning measures in the light of Fukushima experiences
  - NPP sites Unterweser, Philippsburg
  - Release of about 10 % of iodine over up to 30 days
  - Results for Philippsburg: in nearly all scenarios the maximal distance of 100 km was exceeded for thyroid dose intervention levels for children (50 mSv), up to 190 km distance
  - Conclusion of the authors: emergency planning is not adequate

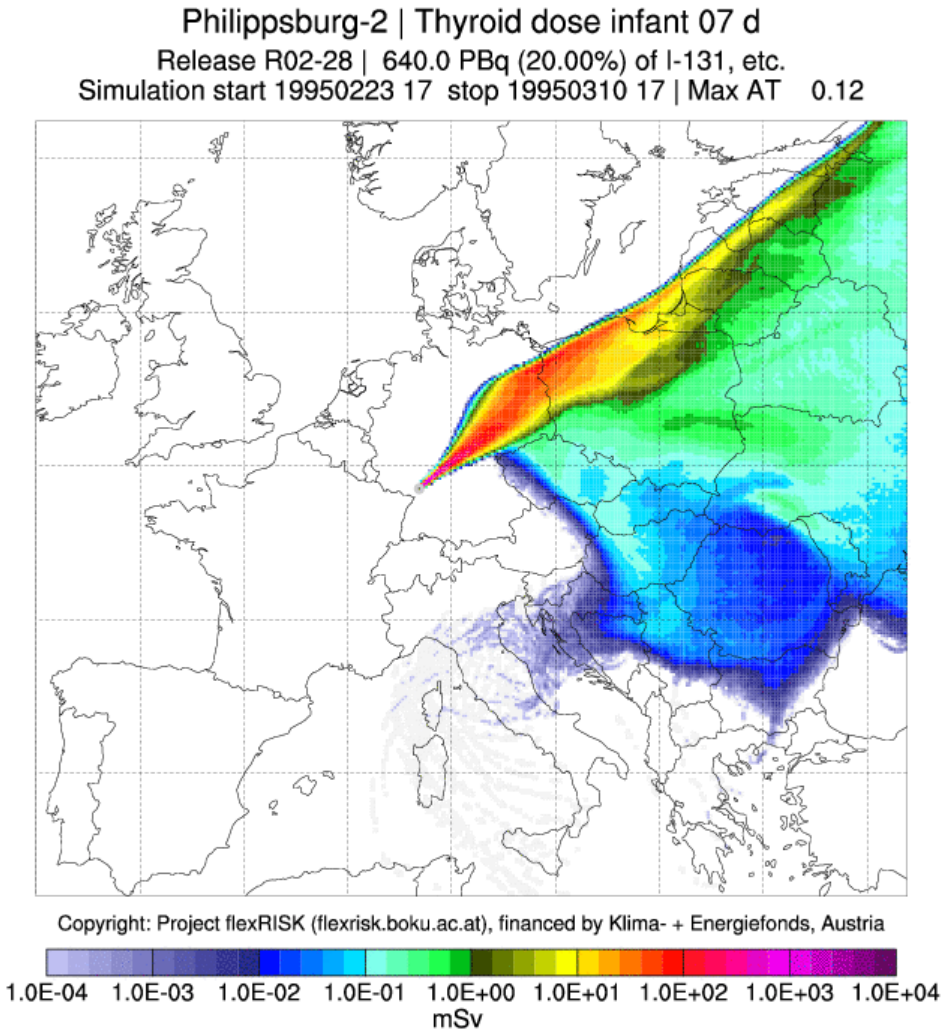
Iodine prophylaxis for children

- flexRISK results:
  Philippsburg Unit 2
  7 d-thyroid dose for infants
  02-23-1995

- 50 mSv: region in orange/red has maximal dimensions:

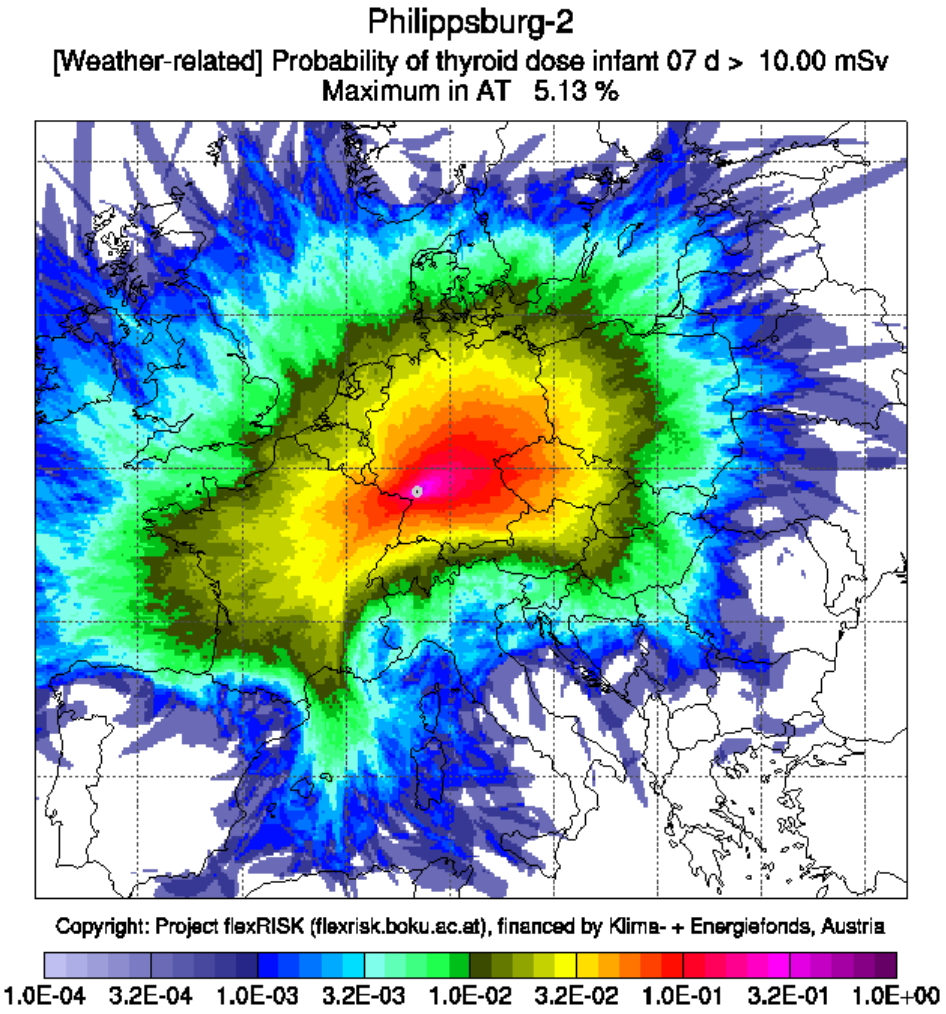
  North-south: > 700 km

  East-west: > 950 km



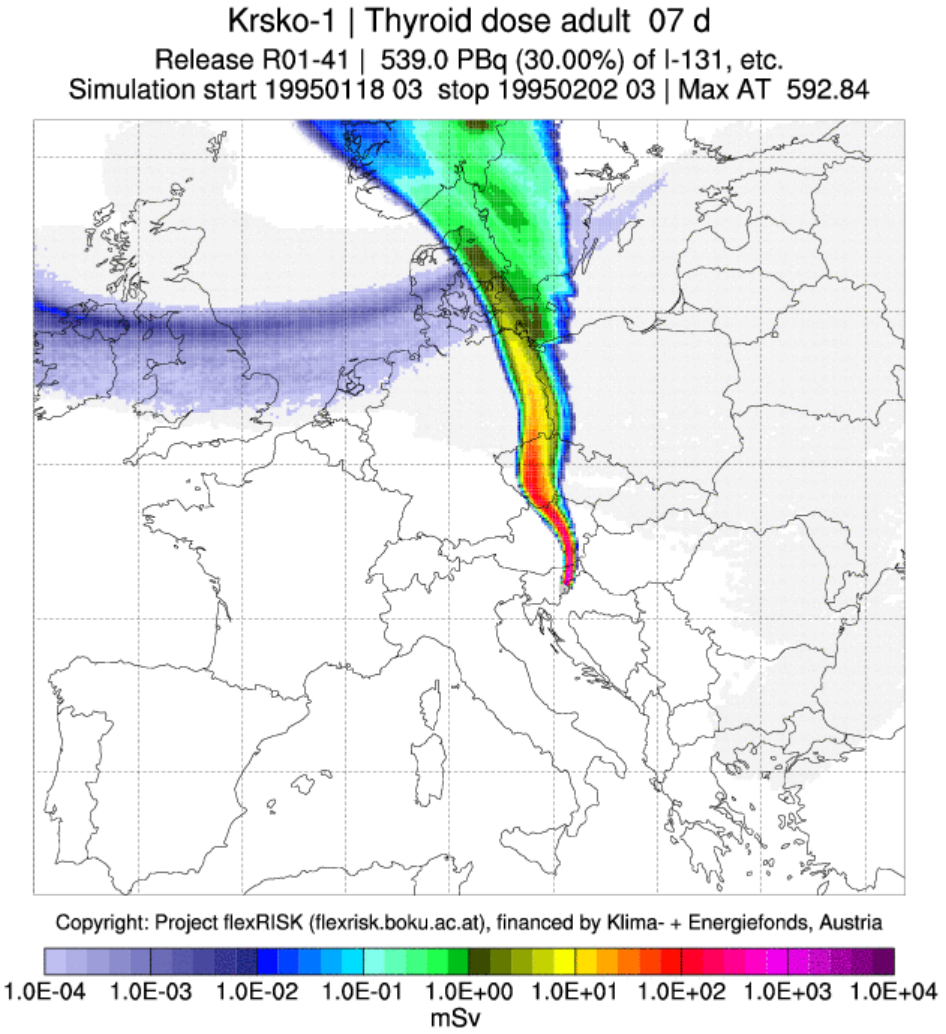
Iodine prophylaxis for children

- Intervention level in Austria:
  7 d-thyroid dose for infants
  Philippsburg Unit 2
- 10 mSv: maximum in Austria is a probability of exceedance of this intervention level in of 5.1 %



Iodine prophylaxis for adults

- Intervention levels 7 d-thyroid dose in Austria for adults:
  - 18-40 a: 100 mSv
  - > 40a: 500 mSv
- Example Krsko
  - Max. thyroid dose for adults: 593 mSv



Iodine prophylaxis

- Re-think iodine prophylaxis:
  - Emergency planning zones in NPP-countries are too small-dimensioned
  - Iodine tablets for children should be disseminated not only in emergency planning zones but in the whole population (best practice in Austria)
  - Adults (18-40 a, and older!) can also get a dose above intervention level - iodine tablets for adults should also be disseminated

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