Uncertainties in the early phase influencing the transition phase issues

Irene Korsakissok*, Wolfgang Raskob

*IRSN, France; Karlsruhe Institute of Technology (KIT)

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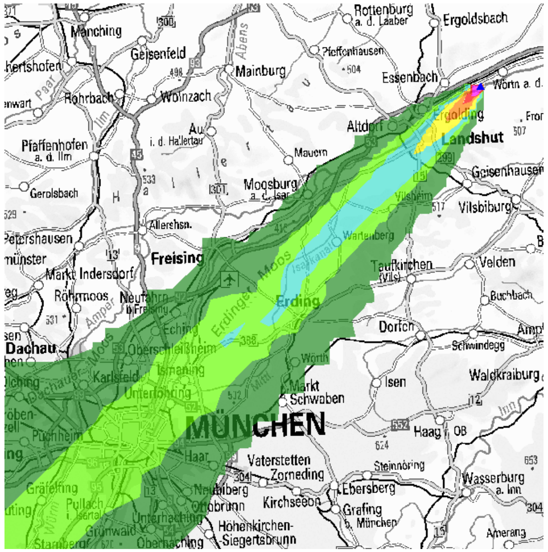

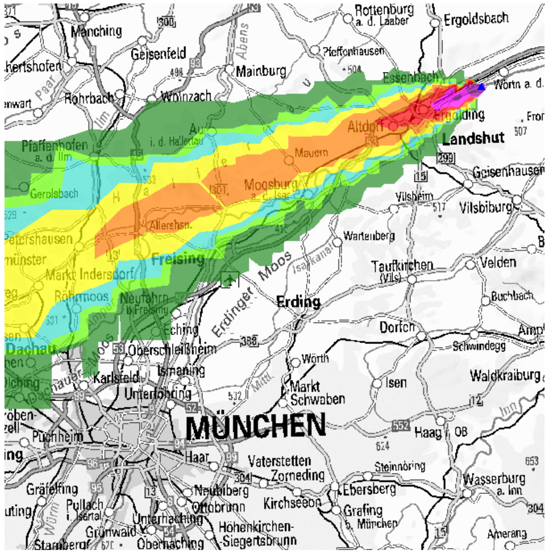

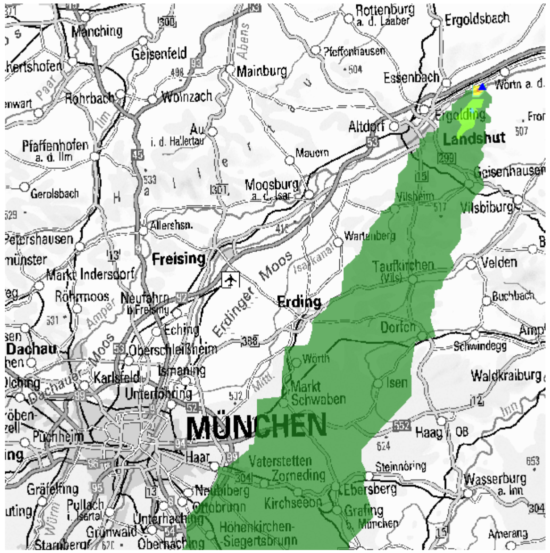

This project has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 662287

Context

In case of an accidental release of radionuclides

- Atmospheric dispersion models are used to *forecast* the health and environmental impact
- A tool for decision making: countermeasures (evacuation, sheltering, stable iodine intake)
- A tool to reconstruct the contamination events combining simulation and measurements

Key uncertainties affecting the early phase

1. Meteorological uncertainties
2. Uncertainties related to source terms
3. Uncertainties related to models
4. Using meteorological measurements to reduce uncertainties

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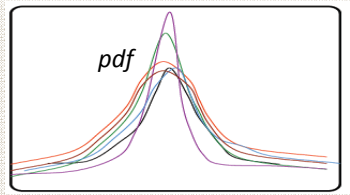
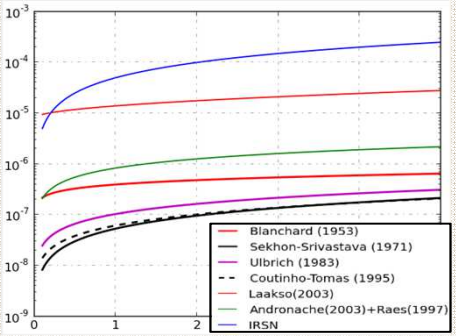
How to quantify the uncertainty of data?

Model parameters



↗ Experts' judgment, literature review



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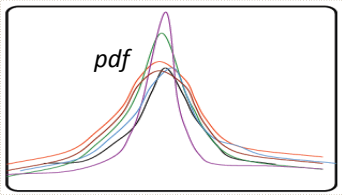
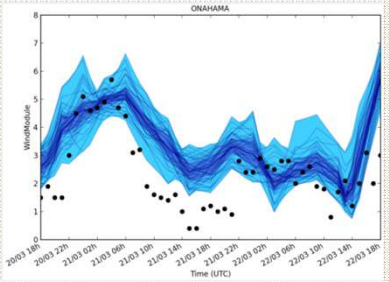
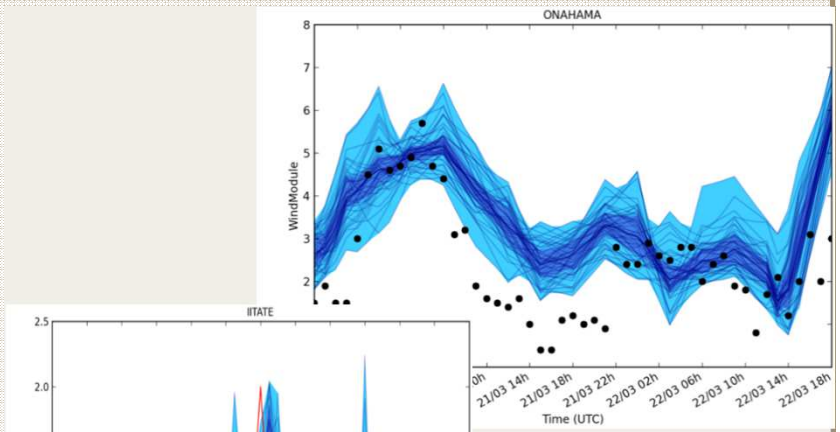
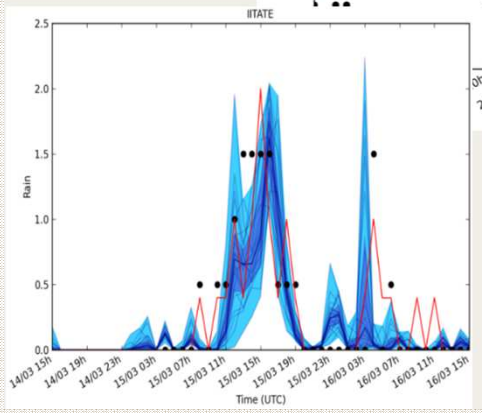


Input : meteo



↗ Using meteorological forecast ensembles





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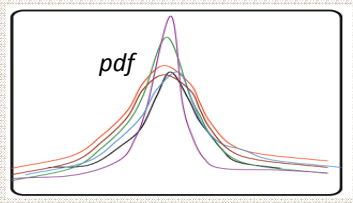
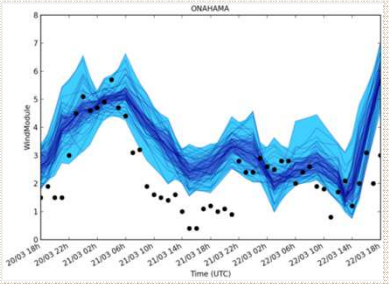
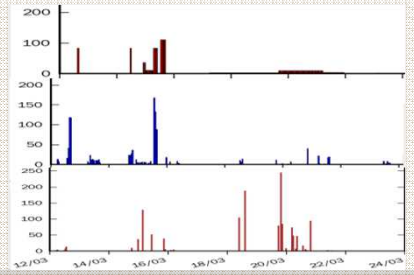


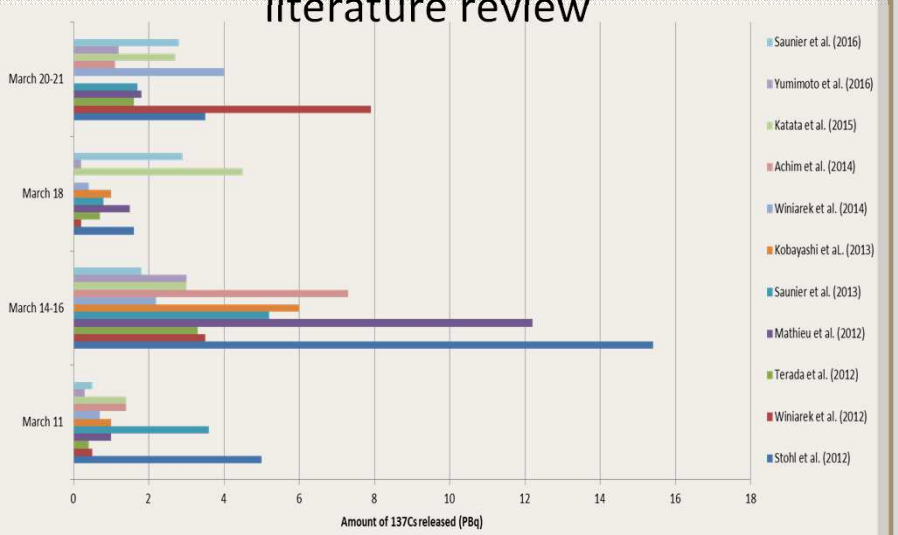
Input : meteo



Input: source term

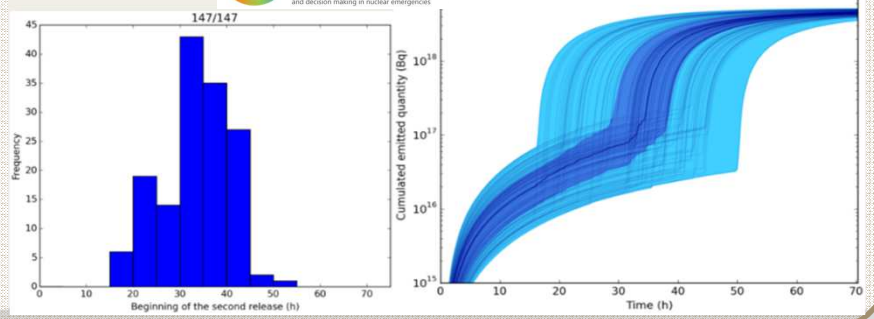


↗ Past-accident analysis (Fukushima) literature review



↗ Emergency : May rely on experts' judgment / ensemble of ST

European projects



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Further on input uncertainties…

http://www.concert-h2020.eu/en/Publications

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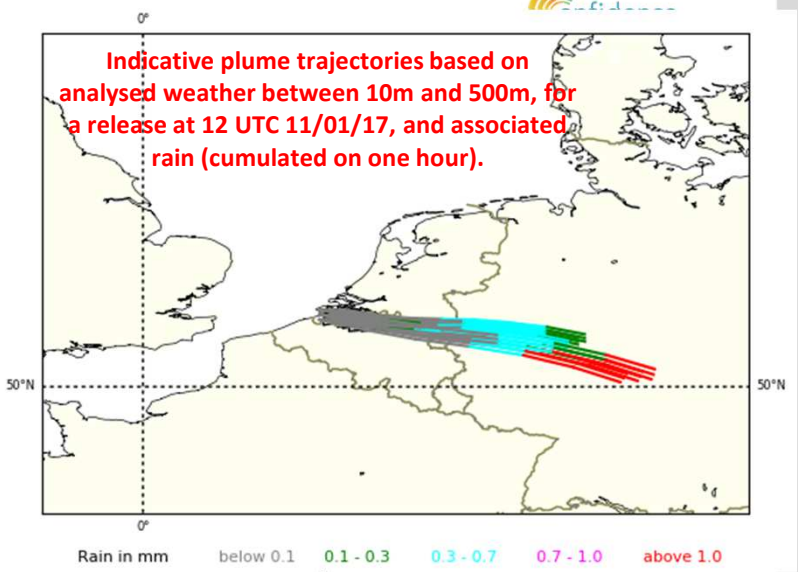
Case study: Borssele

Meteorological scenario

- Ensemble (KNMI), 10 members, 2,5 km resolution
- 72-hours forecast, 1-hour time step
- 11-13 January 2017: “Easy case” (established wind direction), rain

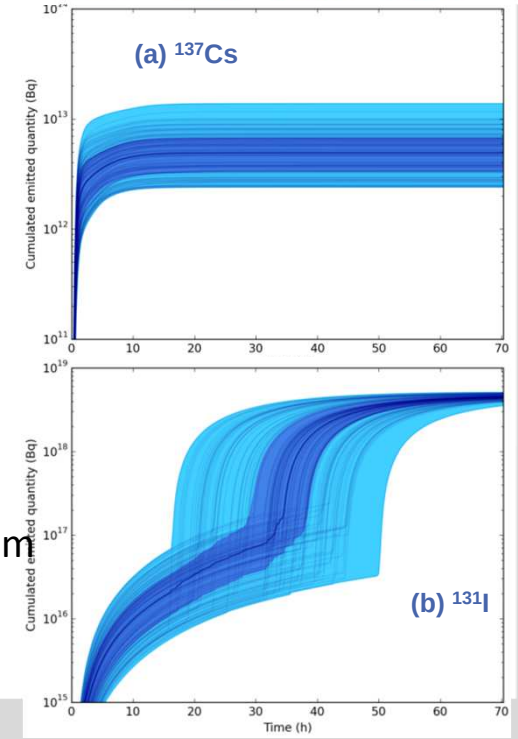


Short release scenario

- Duration 4 hours - Release time 11 January at 12 UTC
- 8 radionuclides, no kinetics
- Representative of uncertainties in the pre-release phase

Long release scenario: ensemble (FASTNET)

- Duration 72 hours
- Extracted from a database built with ASTEC severe accident code
- Release time 11 January at 06 UTC **without uncertainties**
- Second major release = opening of the venting containment system
- Aerosols are filtered for the second release
- Representative of model uncertainties (release phase)



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Short release scenario

- Release time 11 January at 12 UTC +/- 6 hours
- Release height 50m +/- 50m
- Released quantity X [1/3, 3]

Radionuclide	Xe-133	I-131	I-132	Te-132	Cs-134	Cs-136	Cs-137	Ba-137m
Activity(Bq)	3.51E18	2.25E16	2.84E16	1.37E16	2.69E15	6.37E14	2.06E15	2.78E14

Participant	Number of simulations	Source perturbations		
		Release height	Release time	Released quantity
IRSN	100 (Monte Carlo)	[0, 100m] uniform	[-6h, 6h] uniform	[1/3, 3] uniform
BfS	150	[0m, 50m, 100m]	T0 + [-6h, -3h, 0h, +3h, +6h]	
MetOffice/ PHE	90	[50m]	T0 + [-6h, 0h, +6h]	[x1/3, x1, x3]
EEAE	50	[50m]	T0 + [-6h, -3h, 0h, +3h, +6h]	
MTA EK	150	[0m, 50m, 100m]	T0 + [-6h, -3h, 0h, +3h, +6h]	
RIVM	650	[0m, 25m, 50m, 75m, 100m]	[-6h, +6h] with a time step of 1 hour (13 steps)	
DTU	10	-	-	-

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Short release scenario

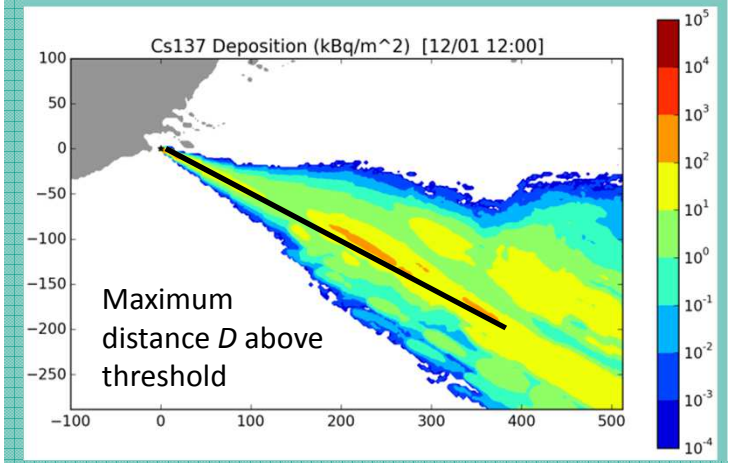
Endpoints: consequences computed at T0+24h

- Ground deposition of ^{137}Cs and ^{131}I
  - Post-Chernobyl reference level: 37 kBq/m^2 for ^{137}Cs
  - Other levels: 10 kBq/m^2 for ^{137}Cs, ^{131}I
- Effective dose and inhalation thyroid dose for 1-year old child – 10, 50, 100 mSv

How to use ensemble results?

Deterministic: *one* simulation

^{137}Cs deposition, threshold 37 kBq/m^2

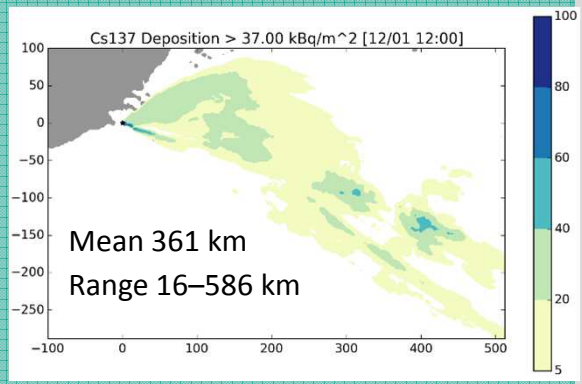


Probabilistic: ^{137}Cs ground deposition for *N* simulations

- ✓ *N* maps of deposition: "postage stamp"
- ✓ Median (or 25th, 75th percentile…) of the *N* deposition maps

For a given threshold *t*

- ✓ *N* maximum distances D_i above *t*
- ✓ Map of probability of exceeding *t*



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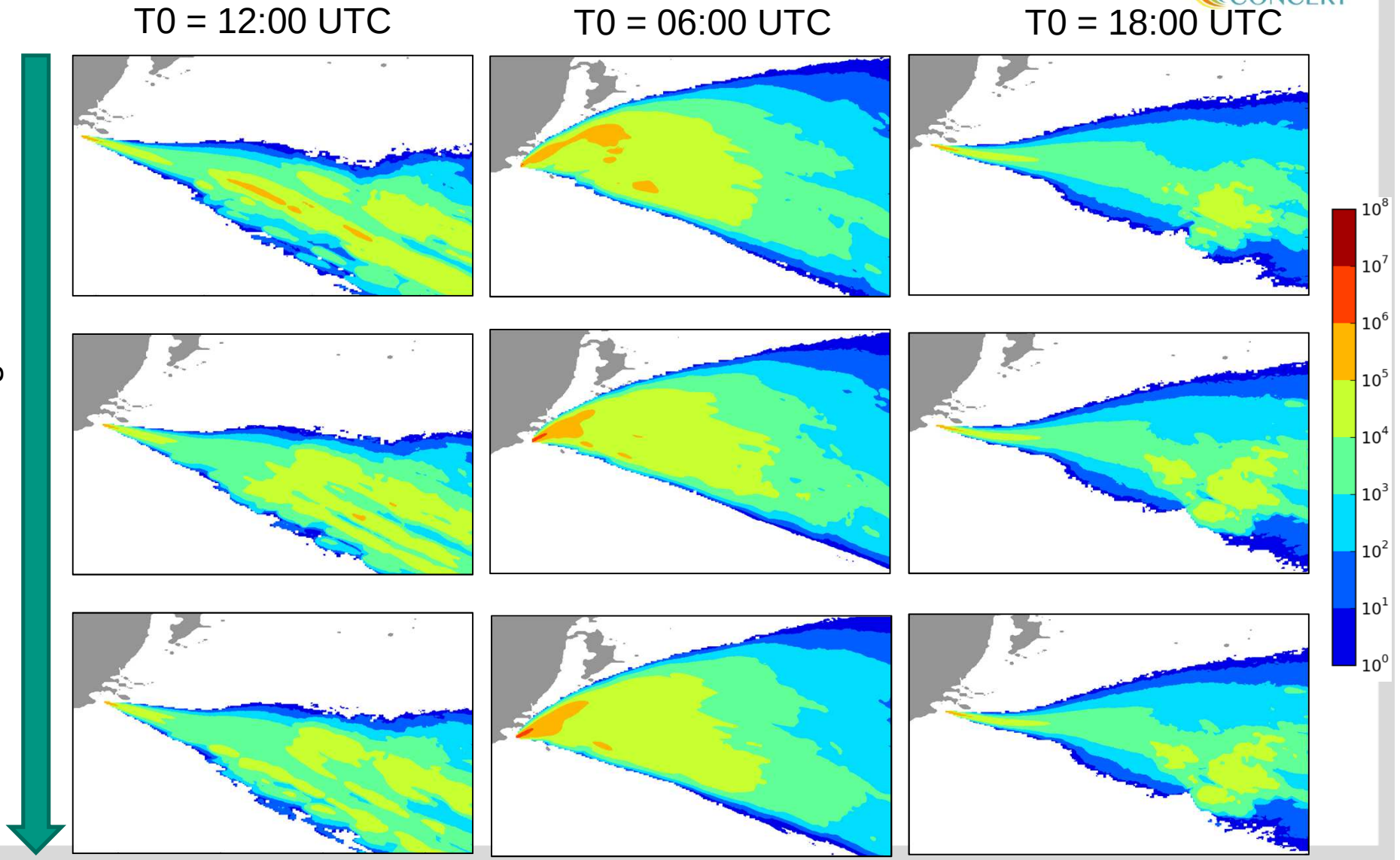
Short release: “postage stamp”

^{137}Cs deposition (kBq/m^2)
at T0+24h - UK MetOffice



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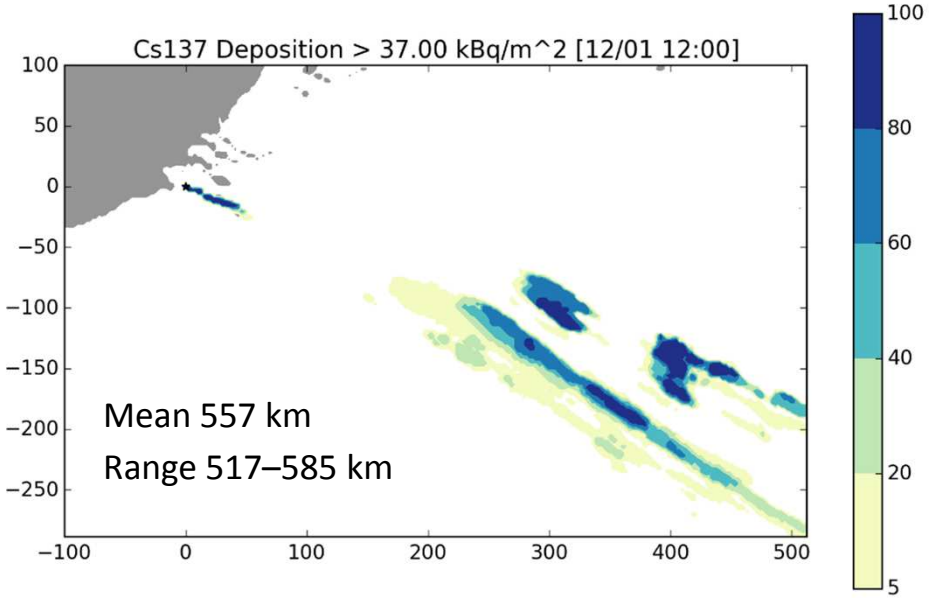
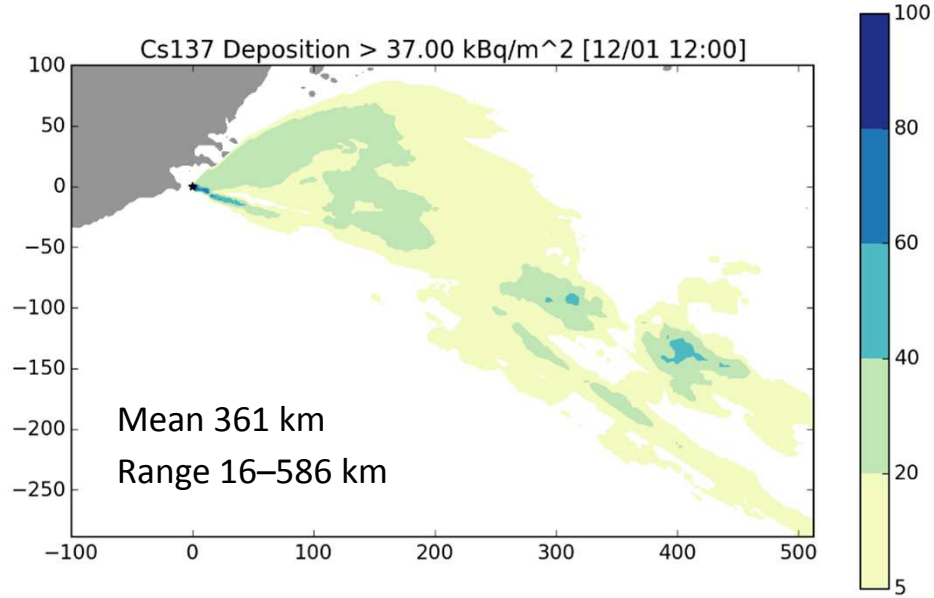
Short release: probability maps

- Maps of probability of threshold exceedance
- For a threshold of 37 kBq/m² for the ^{137}Cs deposition
- Example of UK MetOffice (NAME model)



10 simulations (meteorology only)



90 simulations (meteorology + source term)

With source perturbations

- ↗ **Maximum distance of threshold exceedance is lower**
- ↗ **Surface covered by low probabilities is larger**

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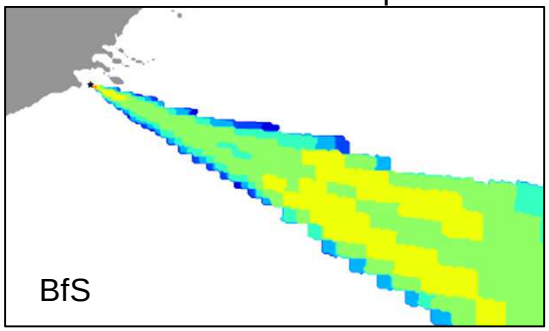
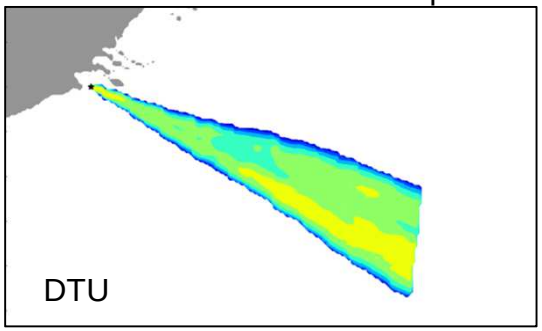
Short release: median of ^{137}Cs deposition (kBq/m^2)

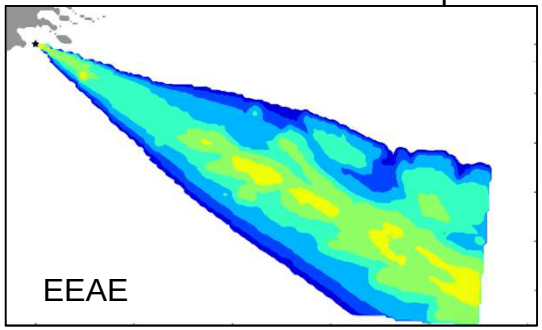
RIMPUFF – Gaussian puff

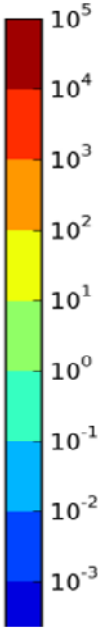


RIMPUFF – Gaussian puff

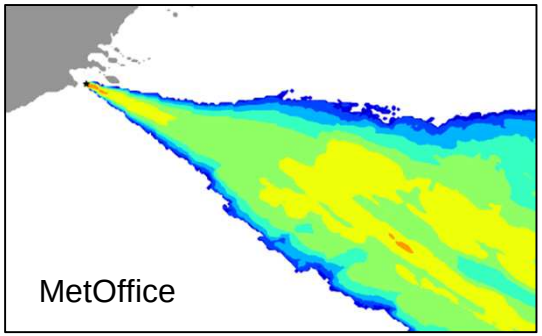


DIPCOT– Gaussian puff

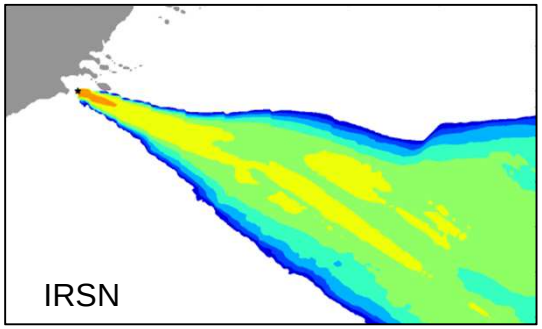




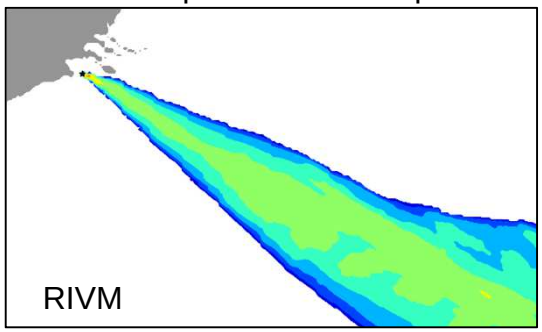
NAME – Lagrangian



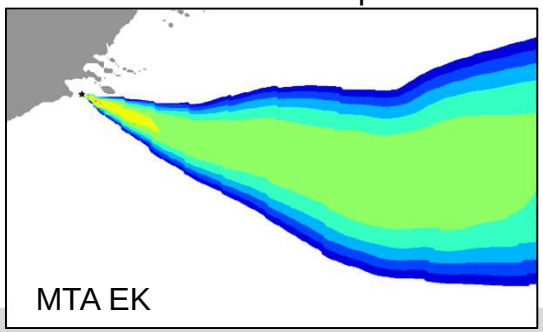
LdX– Eulerian



NPK-puff – Gaussian puff



SINAC – Gaussian puff



10 simulations (meteorology only)

Differences may come from:

- ✓ Type of models (Gaussian, Eulerian, Lagrangian)
- ✓ Different wet deposition schemes
- ✓ Diffusion coefficients
- ✓ Modelling domain, interpolation…

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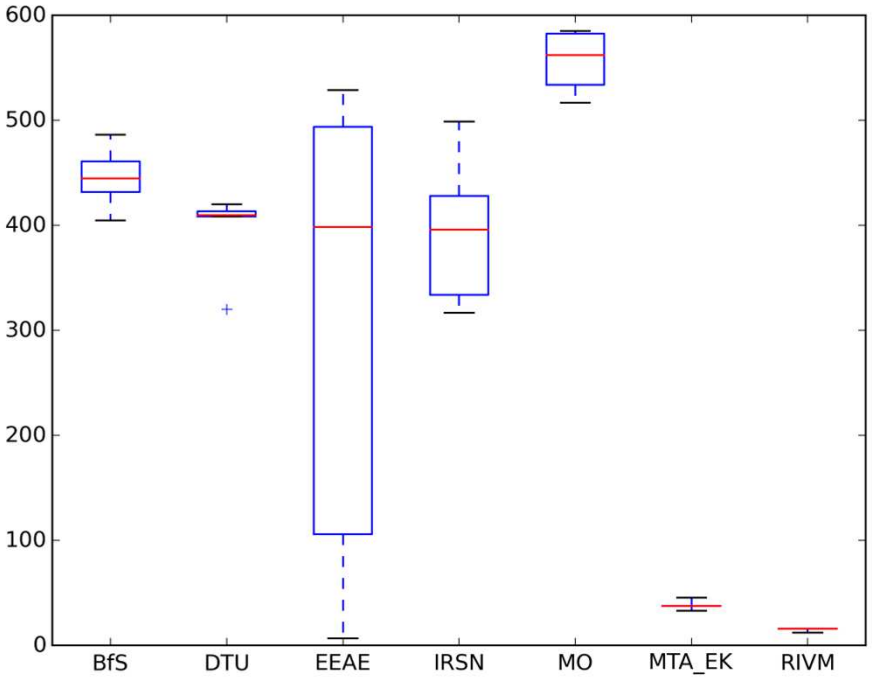
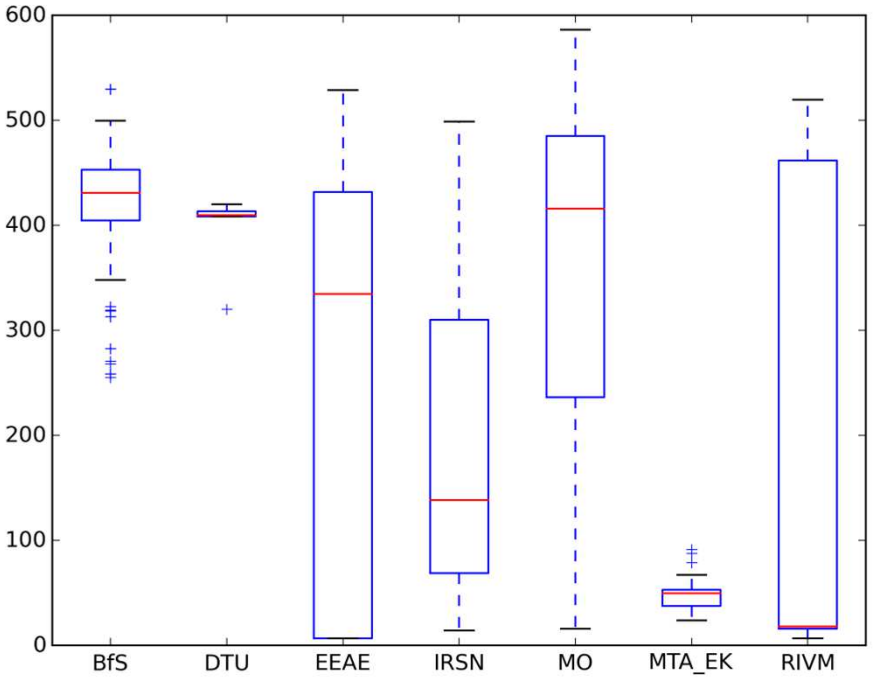
Short release: box plots

- Maximum distance from the source (km)
- For a threshold of 37 kBq/m² for the ^{137}Cs deposition



10 simulations (meteorology only)



10-650 simulations (meteorology + source term)

- ↗ **Larger variability (boxes' size) with ST perturbations**
- ↗ **Inter-model variability not totally encompassed by the range of variation**

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Conclusions

Influence of source perturbations

- Importance of taking into account source perturbations
- Larger ensembles' spread
- **More perturbations induce lower distance above a given threshold**

Inter-model variability

- Less important when overall uncertainties are larger
- Some models or configurations may be more appropriate to the case
- Part of this variability may be taken into account
- **An uncertainty assessment with only one model will always be partial**

Uncertainty assessment

- Lower threshold induces higher distances / probability
- Surface above threshold (instead of distance) limits the effect of outliers
- **Importance of choosing correctly the threshold and percentile**

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Uncertainties in an emergency context

- Our knowledge of uncertainties will always be partial…
  - Deep uncertainties, lack of information
  - Have to tackle the main sources of uncertainties!
  - Avoid false confidence in probabilistic results…

- Ensemble results will be used by other modules
  - Reducing the number of members: clustering techniques, adaptive sampling
  - Model reduction: emulators, model assumptions
  - Adaptation to the endpoint: domain size and resolution…

↗ **How to include uncertainties in output products for decision makers?**

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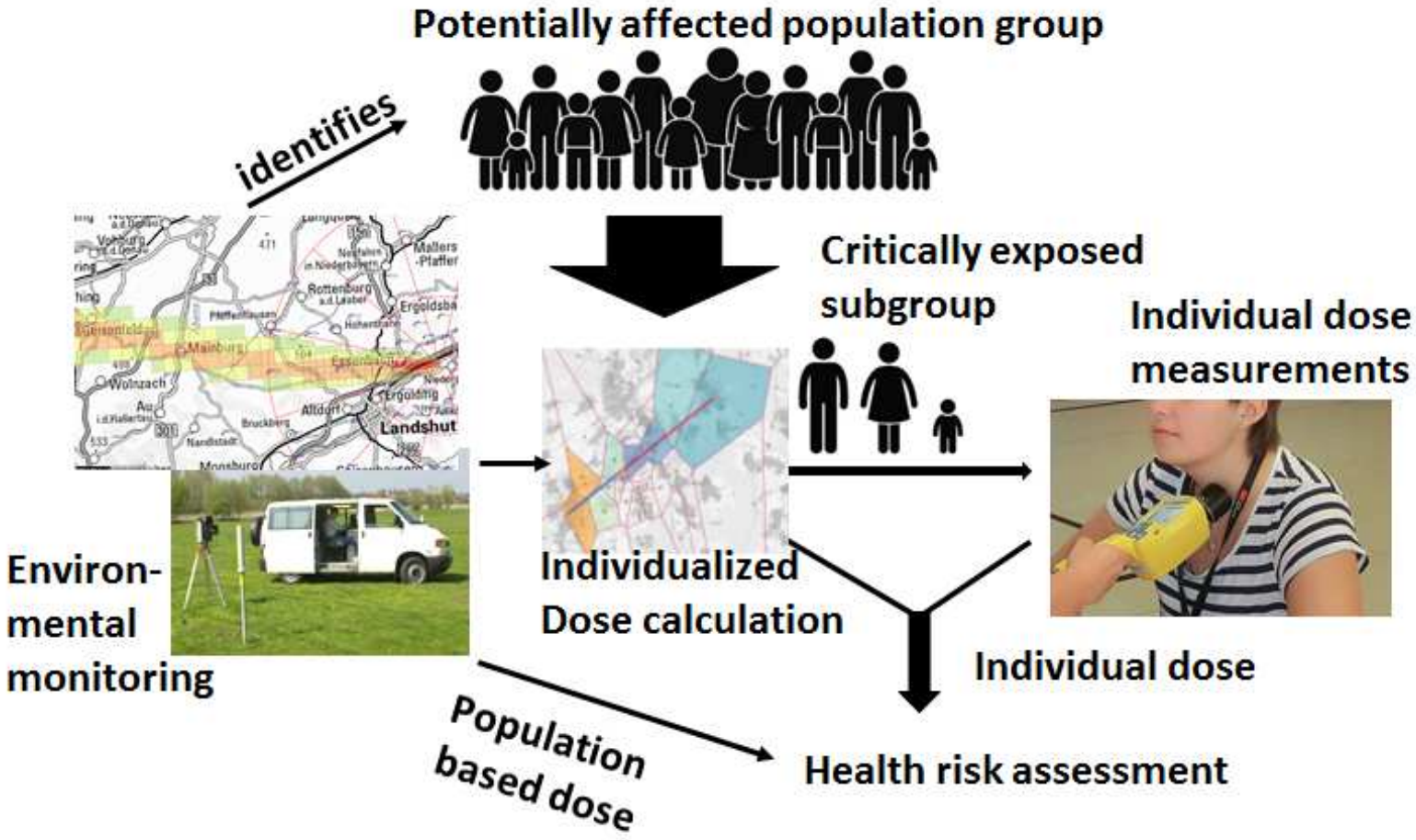
In the transition phase

Combine modelling and monitoring to obtain a “realistic” radiological picture



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Thank you very much for your attention

Questions?

https://portal.iket.kit.edu/CONFIDENCE/

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