Introducing the concept of the isodose for optimization of decontamination activities based on typical Northern European houses

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Outline

- Introduction to the concept of the isodose

- Influences of
  - building materials
  - resident behaviour
  - vertical migration
  - variability in contamination

- Comparison to normal decontamination

Definition of the isodose

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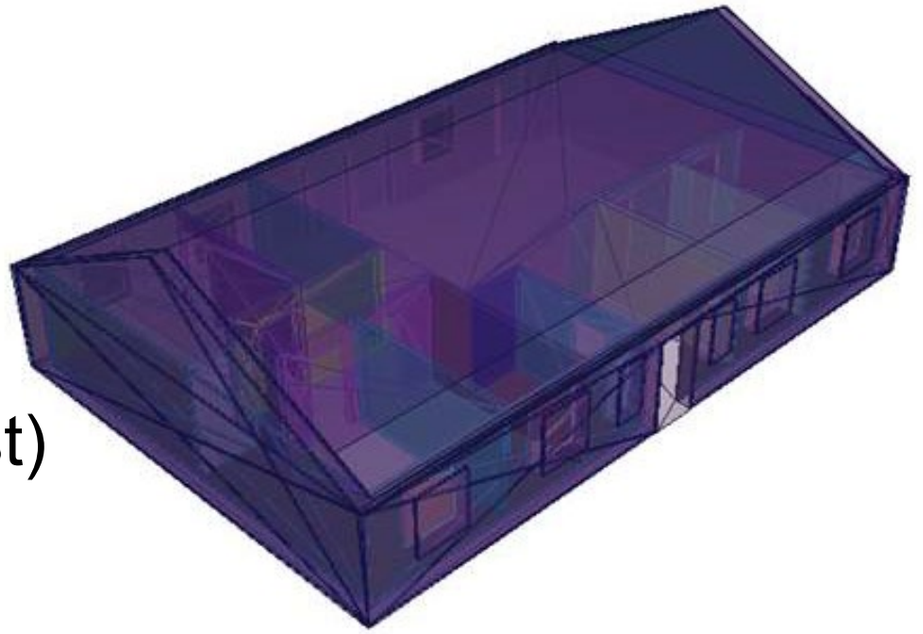
The isodose $ID_{i,k}$ is defined by the outer boundary of one or more zones in space that contribute for the most part to a given fraction k to the dose at the observation point i. For $\rho_{D,i}(\vec{r})$ being a continuous function with the maximum $\rho_{D,i,max} < \infty$ the isodose $ID_{i,k}$ can be chosen from the range $0 < ID_{i,k} < \rho_{D,i,max}$ and the fraction of dose contribution *ki* caused by the zones that were determined by the isodose is described by

$$k_i = \int f(\rho_{D,i}(\vec{r}))dV/D_{i,\infty} \text{ FOR } f(\rho_{D,i}(\vec{r})) = \begin{cases} \rho_{D,i}(\vec{r}), & \rho_{D,i}(\vec{r}) \geq ID_{i,k} \\ 0, & \rho_{D,i}(\vec{r}) < ID_{i,k} \end{cases}$$

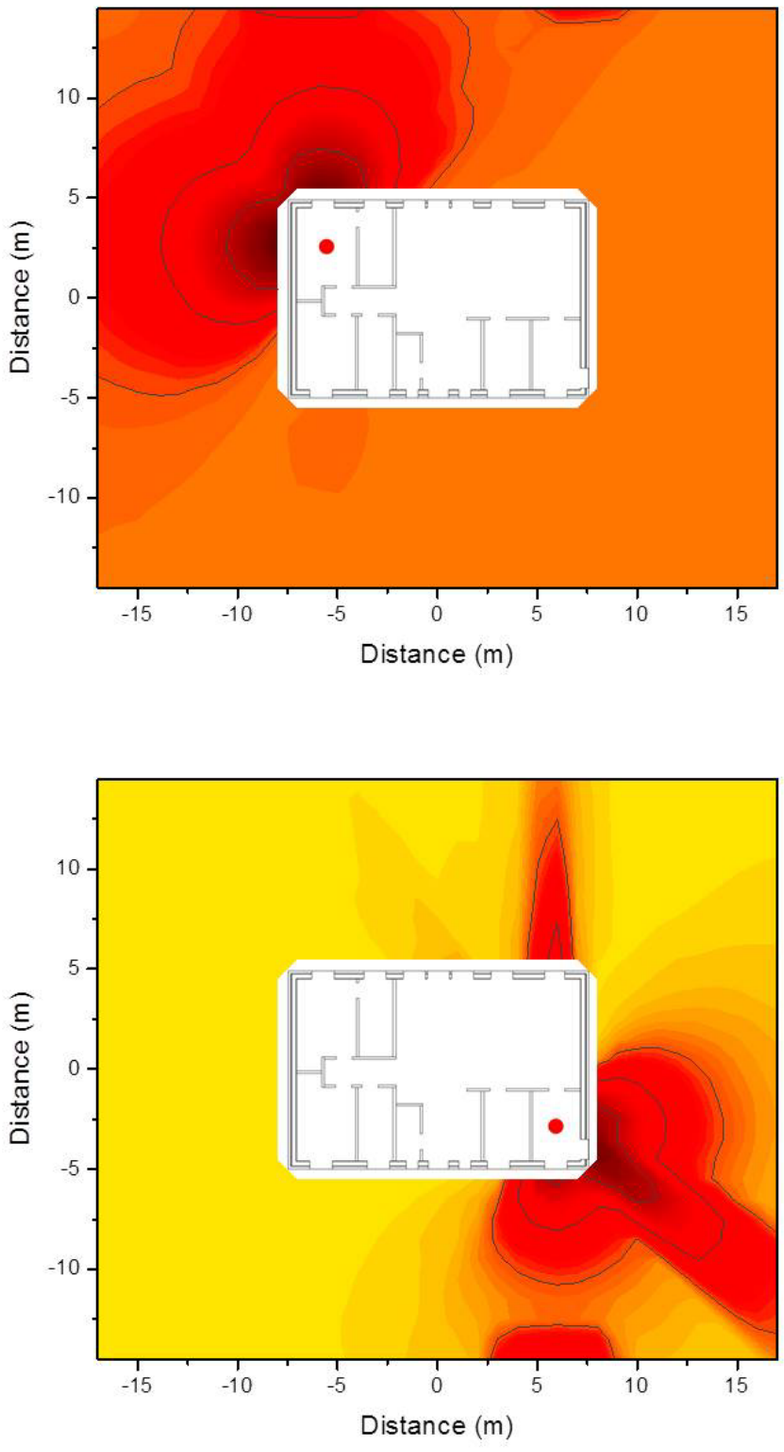
Authentic Swedish house models

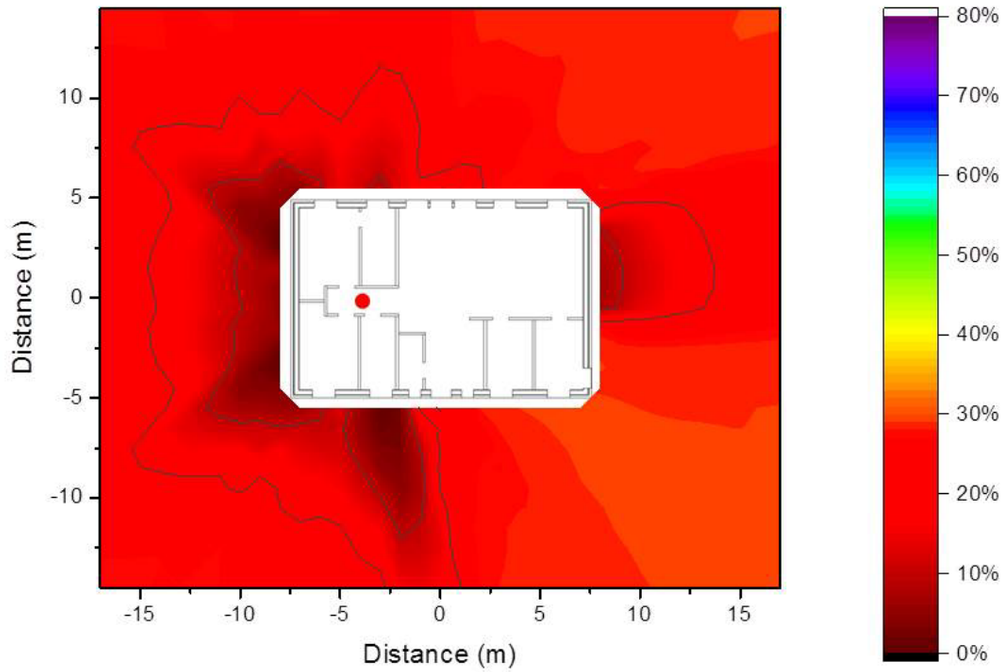
- Wooden house and brick house
- Eleven observation points:
  - #1 bedroom
  - #2 bathroom
  - #3 second bedroom (e.g. child, guest)
  - #4 dressing room
  - #5 corridor
  - #6 restroom
  - #7 hall
  - #8 workroom
  - #9 kitchen
  - #10 living room
  - #11 dining room



- Contamination on the ground as well as 2.5 cm and 5cm beneath it

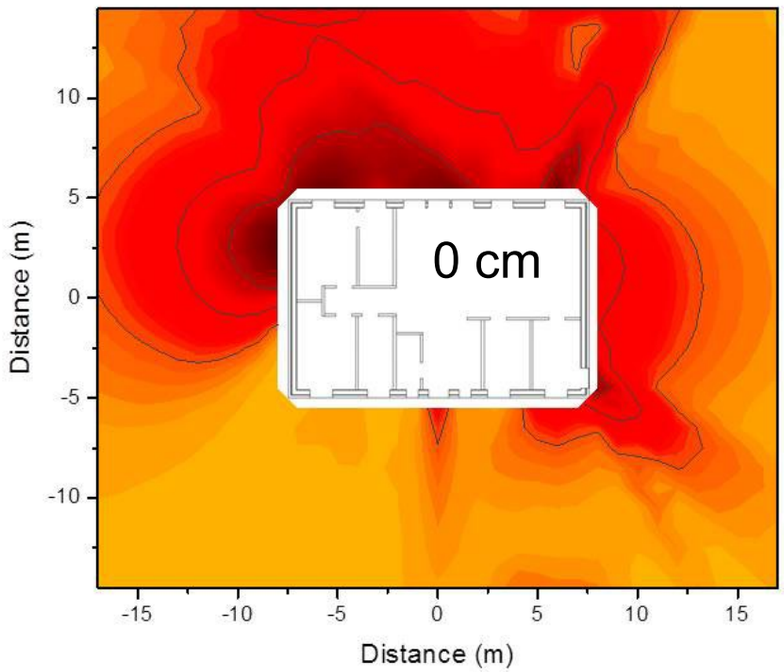
Brick house – ground contamination

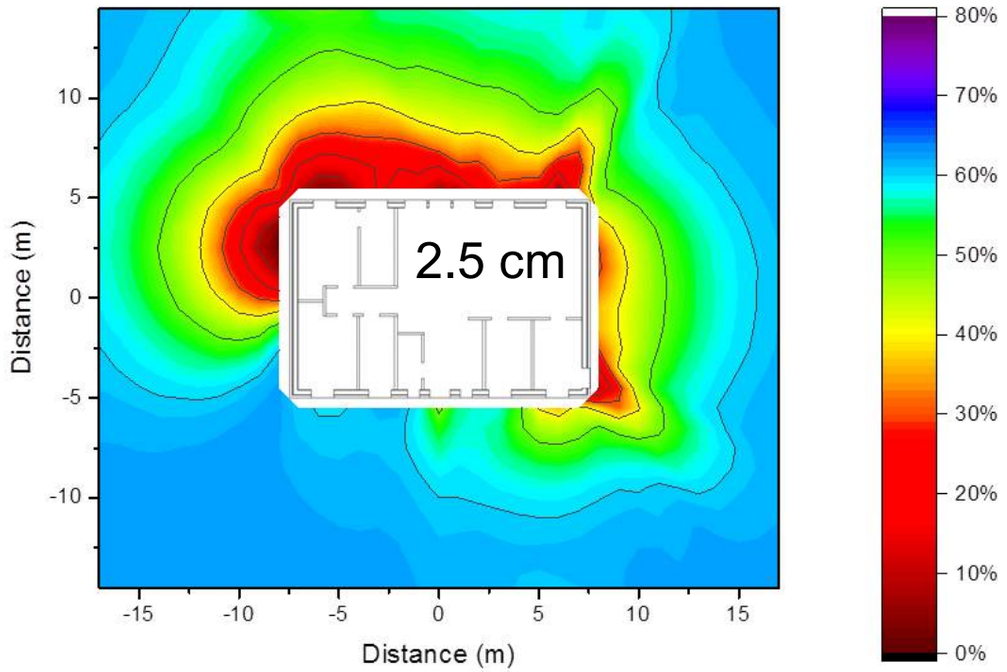


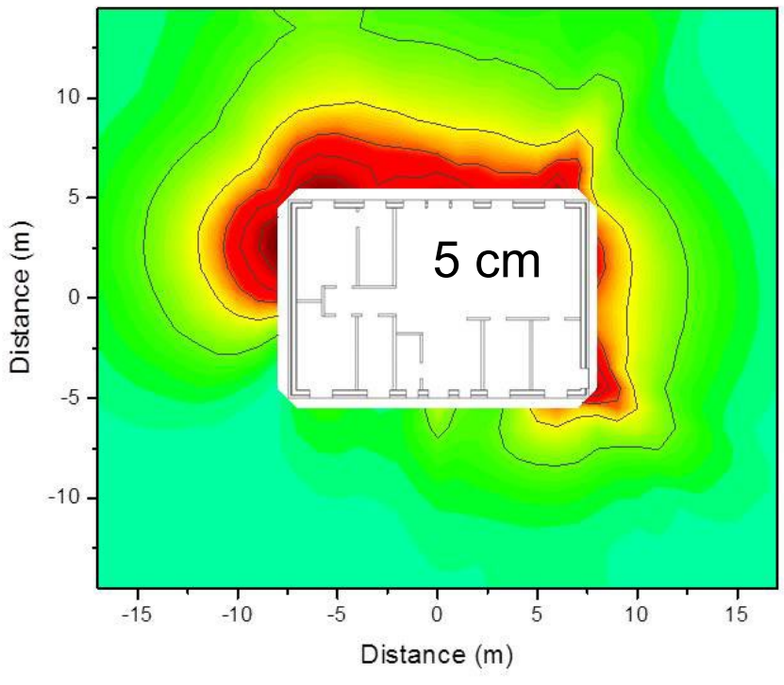


- Positions of doors and windows are reflected in the shape of the isodose lines

Brick house – residential behaviour

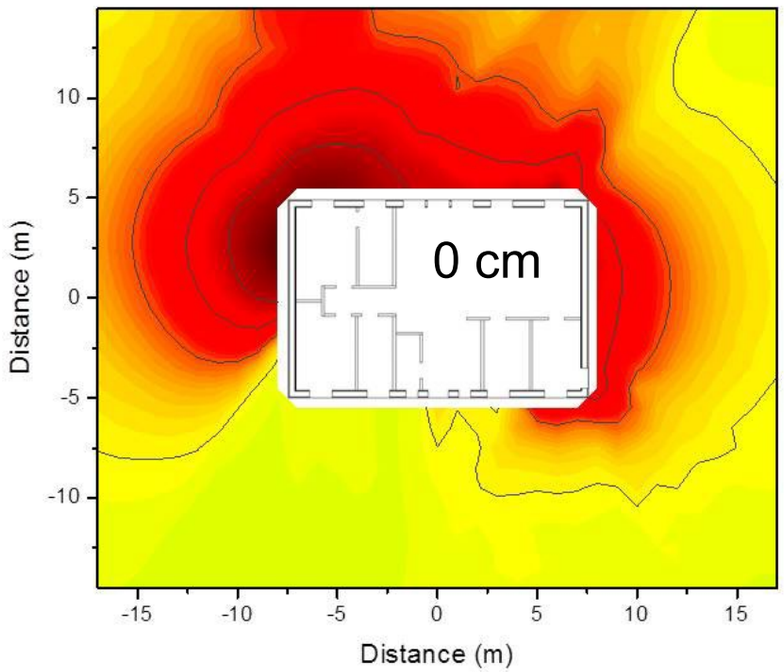


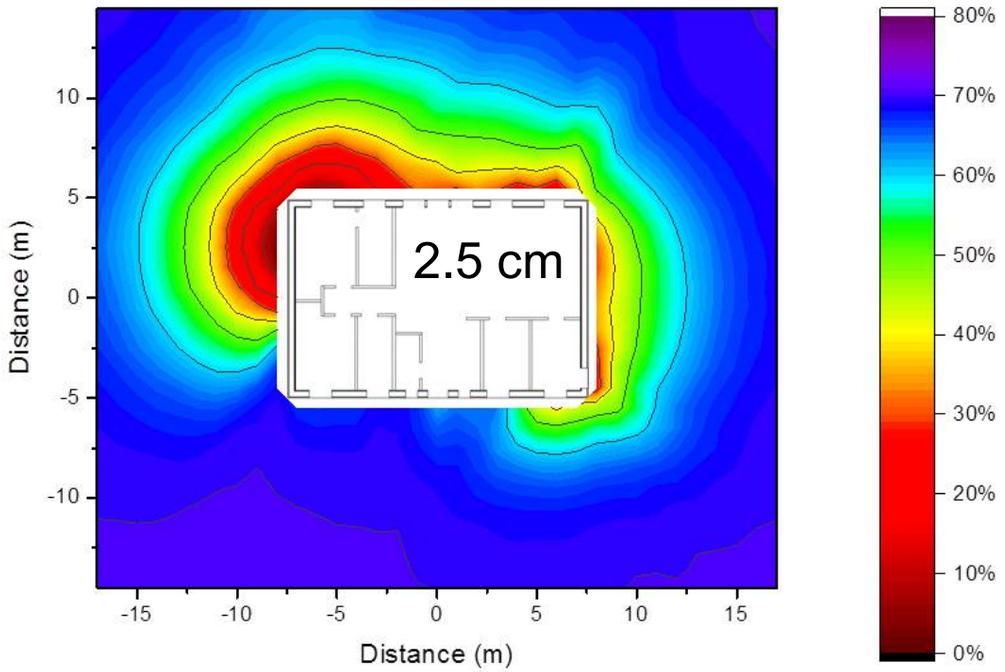


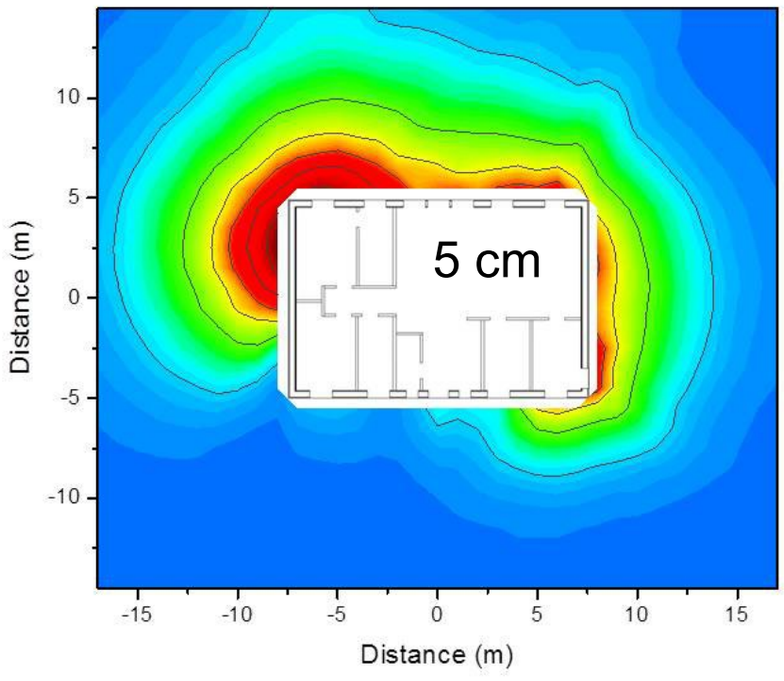


- Zones decrease with entering the soil
- Zones slightly increase for deeper soil depth

Wooden house – residential behaviour

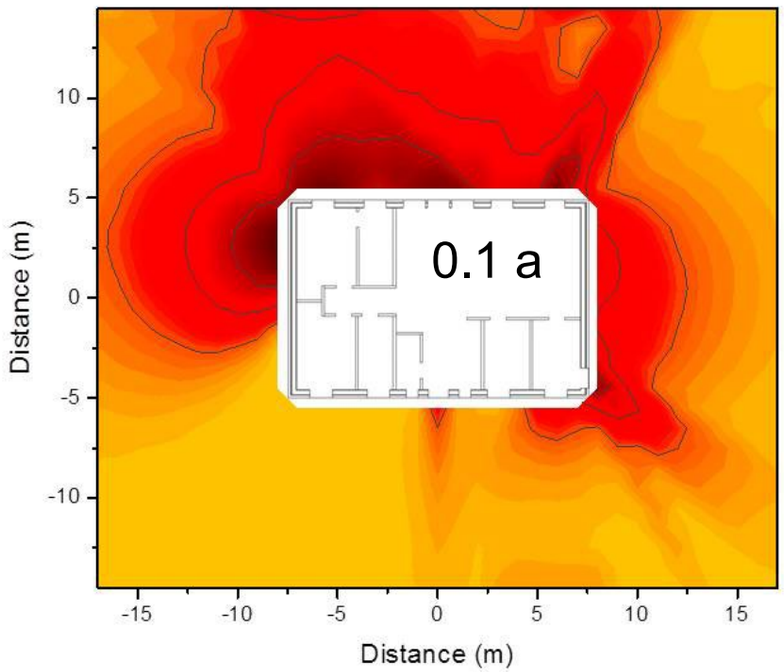


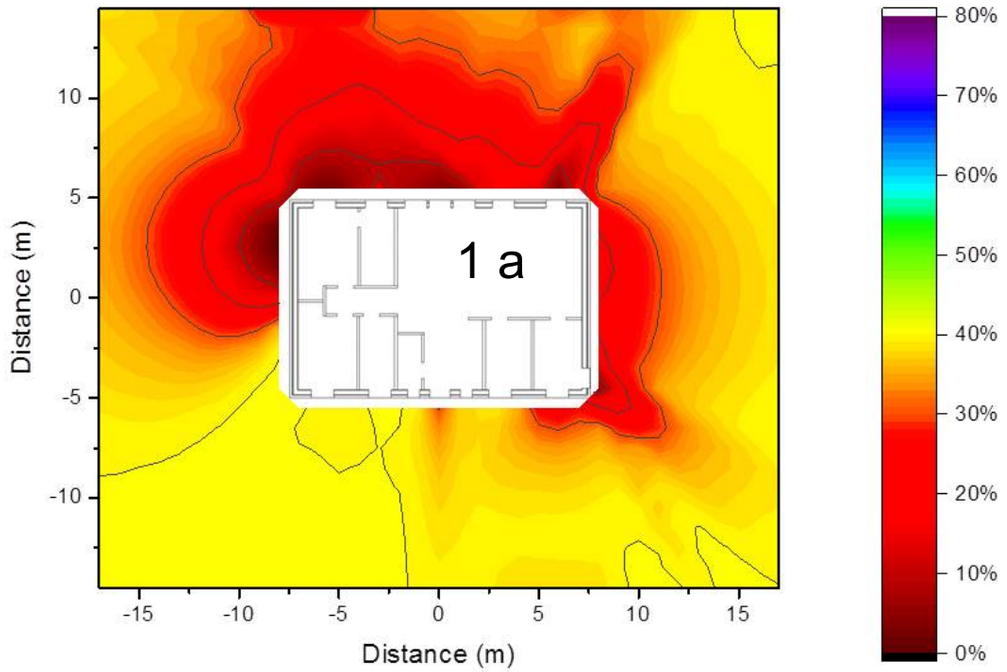


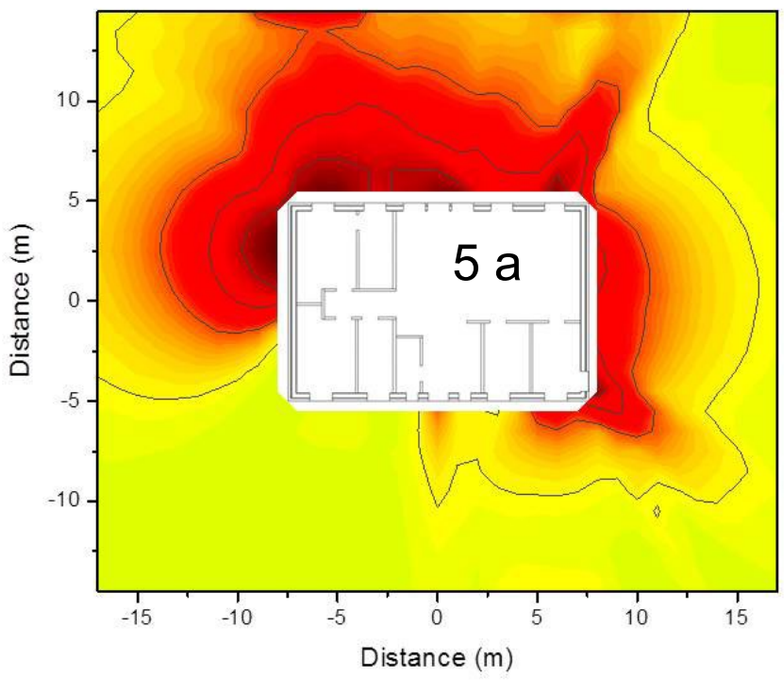


- Zones are smaller compared to the brick house
- Isodose lines are gentler compared to the brick house

Brick house – vertical migration



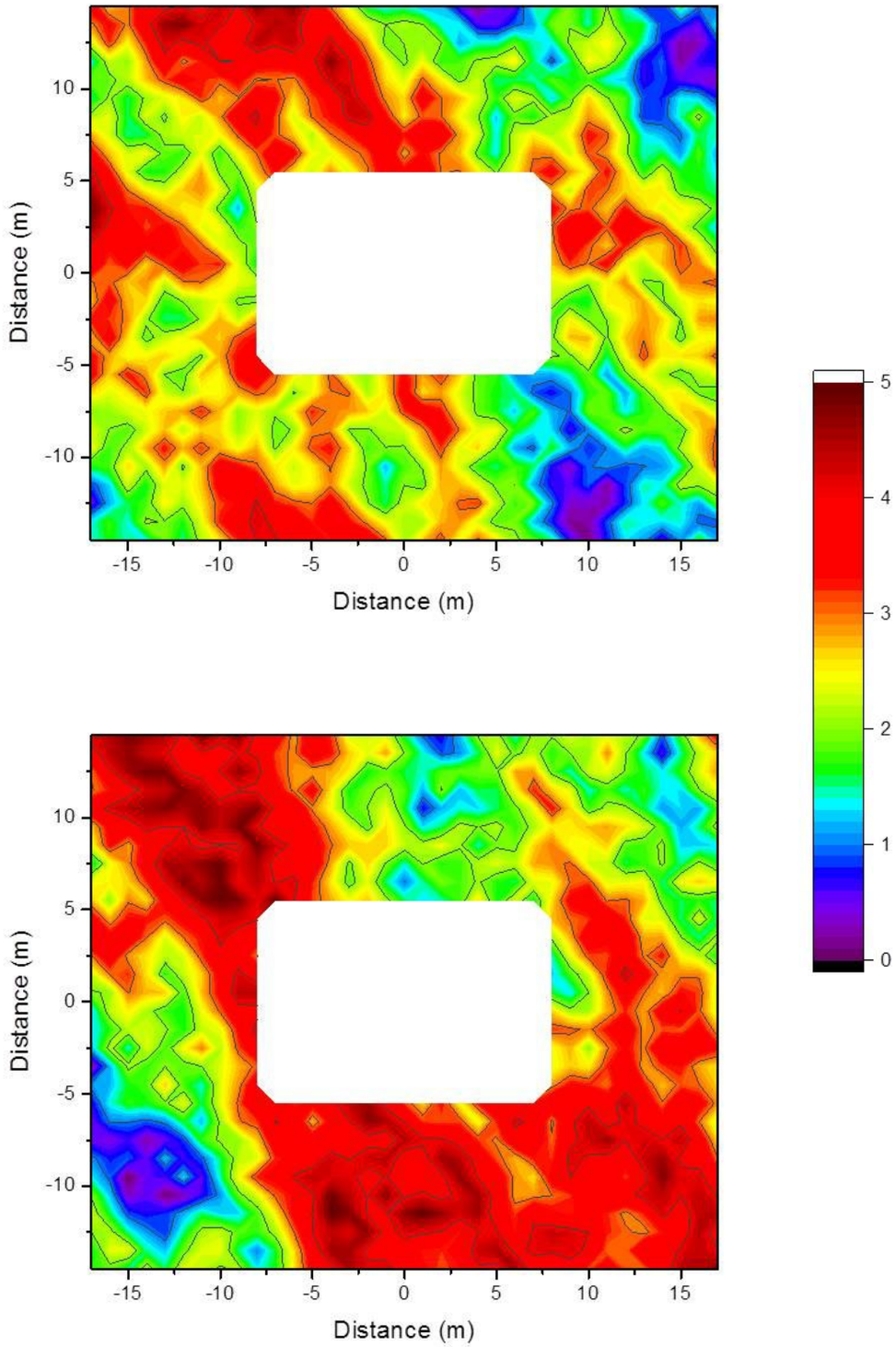


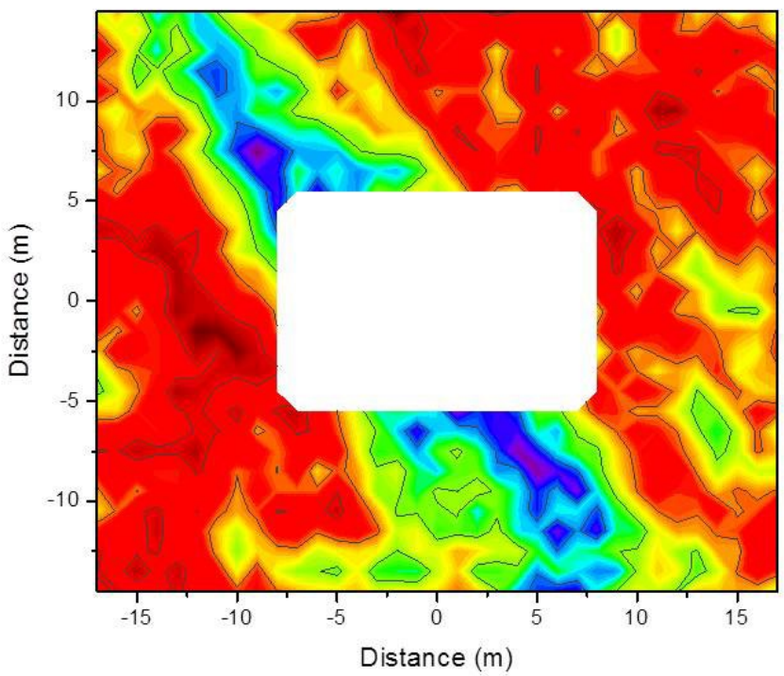


- Dominance of the top soil layer
- Zones slightly become smaller as the contaminants migrate into deeper soil levels

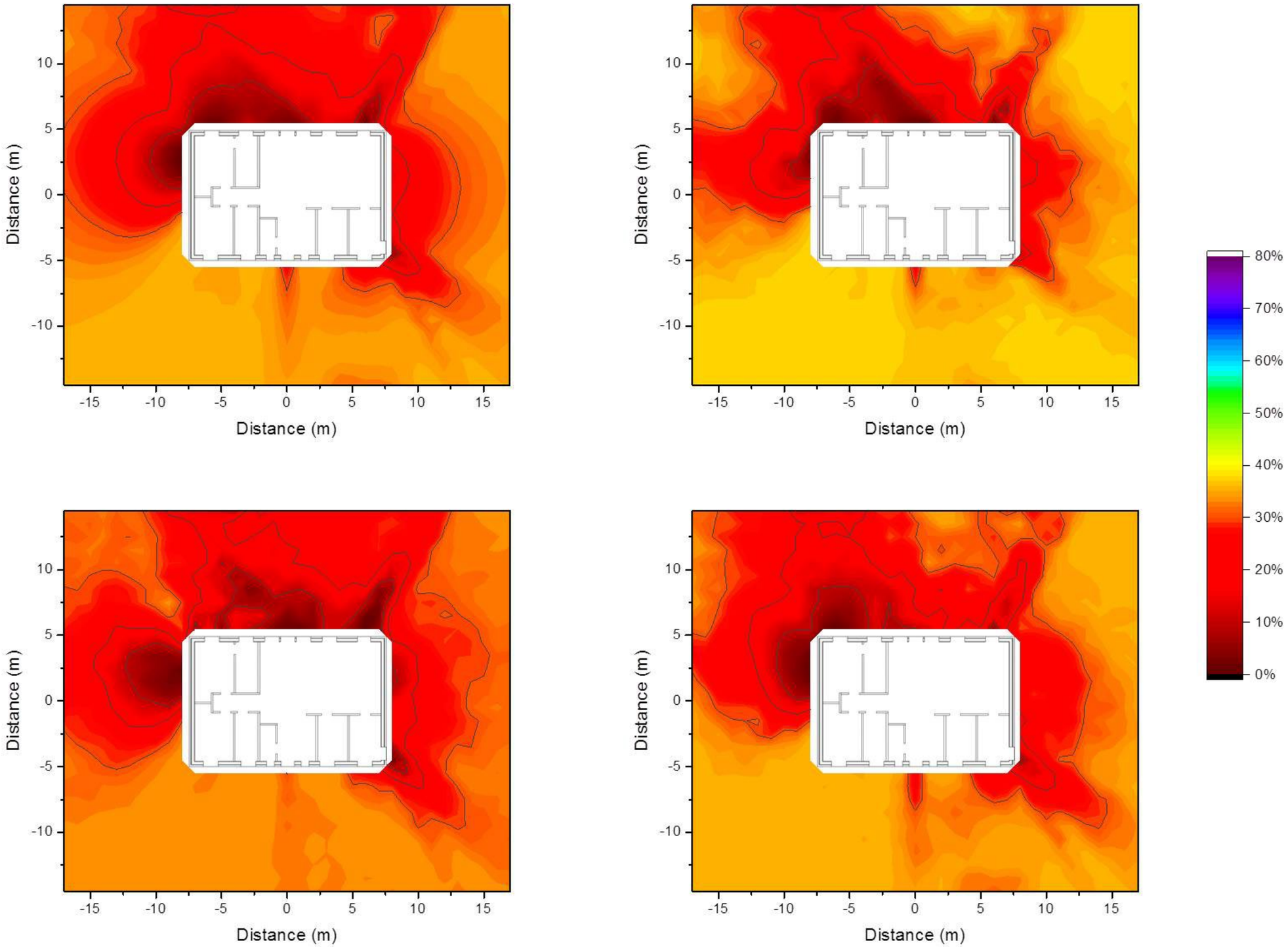
Contamination variability

- Comparison of the homogeneous contamination scenario with three different contamination variability scenarios

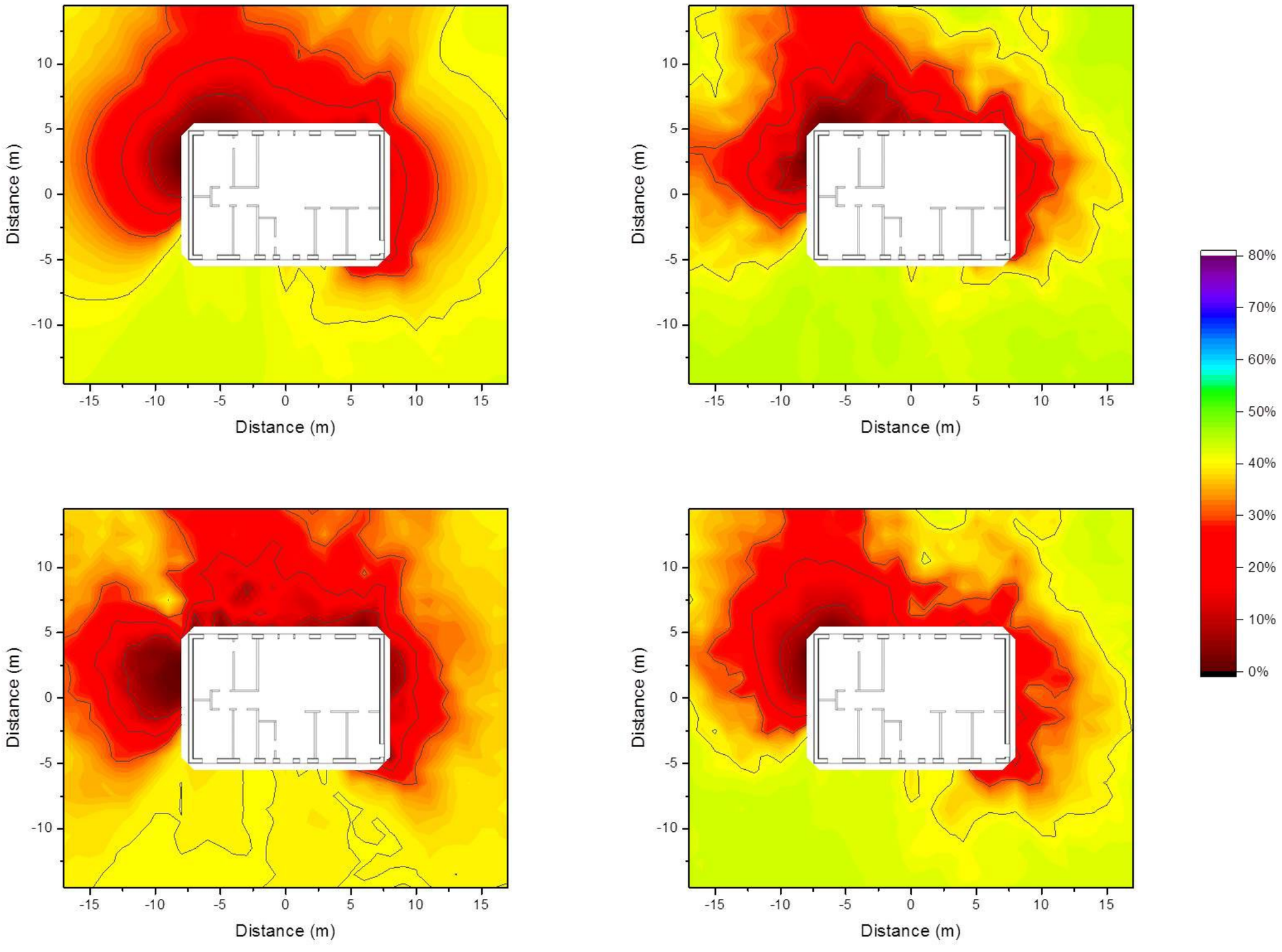




Brick house – contamination variability



Wooden house – contamination variability



Comparison of decontaminating 116 m^2

Ground contamination of 500 kBq/m^2 ^{137}Cs	Primary dose (mGy/a)	After normal decontamination		After optimized decontamination		Comparison of relative dose reductions
		Dose (mGy/a)	Relative dose reduction	Dose (mGy/a)	Relative dose reduction	
Brick house:						
Homogeneous scenario	1.37	1.21	12.3%	1.13	18.4%	1.47
Variability scenario 1	1.42	1.25	12.5%	1.14	20.3%	1.62
Variability scenario 2	1.34	1.21	9.6%	1.14	15.2%	1.55
Variability scenario 3	1.38	1.21	12.1%	1.13	18.4%	1.50
Wooden house:						
Homogeneous scenario	2.80	2.37	15.5%	2.21	21.2%	1.37
Variability scenario 1	2.91	2.47	15.3%	2.24	23.0%	1.50
Variability scenario 2	2.71	2.39	12.1%	2.25	17.1%	1.42
Variability scenario 3	2.86	2.39	16.3%	2.21	22.8%	1.39

Conclusions

- Introduction to the concept of the isodose

- Influences of
  - building materials
  - resident behaviour
  - vertical migration
  - variability in contamination

- Comparison to normal decontamination

Further details

- Hinrichsen, Y., Finck, R., Rääf, C., Andersson, K. G., 2018. Introducing the concept of the isodose for optimisation of decontamination activities in a radioactive fallout scenario. J. Radiol. Prot. 38, 1293–1310.

- Hinrichsen, Y., Finck, R., Martinsson, J., Rääf, C., Andersson, K. G., 2019. Influence of the migration of radioactive contaminants in soil, resident occupancy, and variability in contamination on isodose lines for typical Northern European houses. Sci. Rep. 9, 7876.

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