Using outdoor radon and radon flux to predict areas with high radon risk
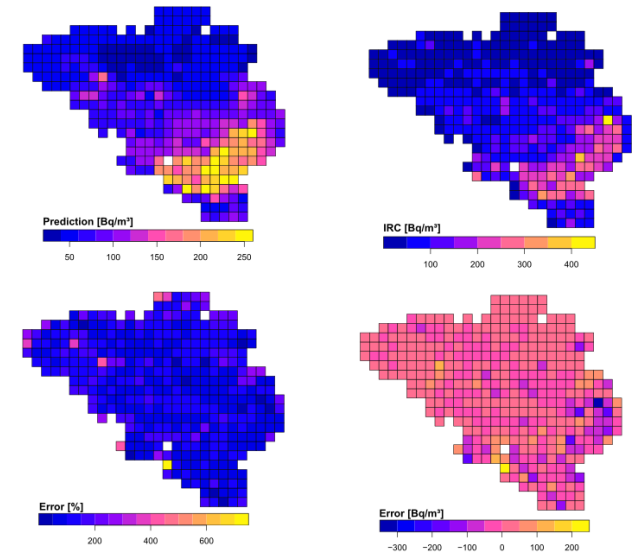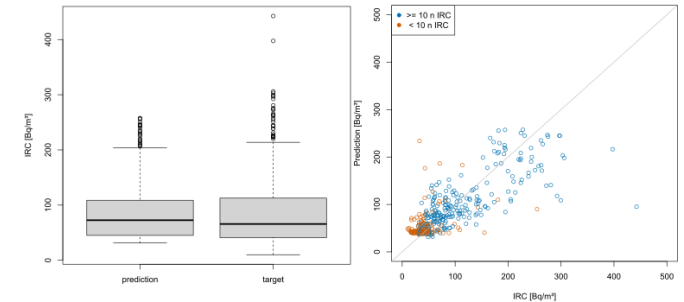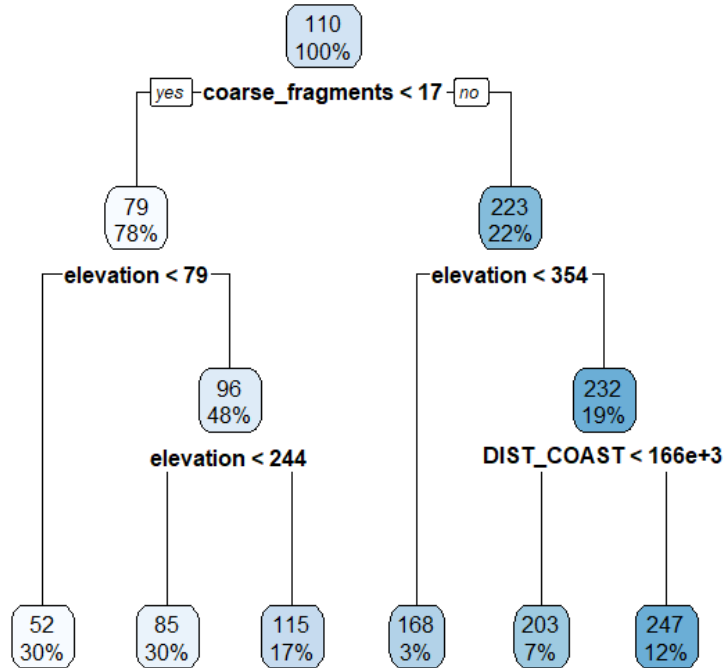
EMPIR 19ENV01 traceRadon

EGU, 28. April 2023, Vienna

Sebastian Baumann, Valeria Gruber, Eric Petermann and Giorgia Cinelli

Content

Rn outdoor / flux for radon mapping

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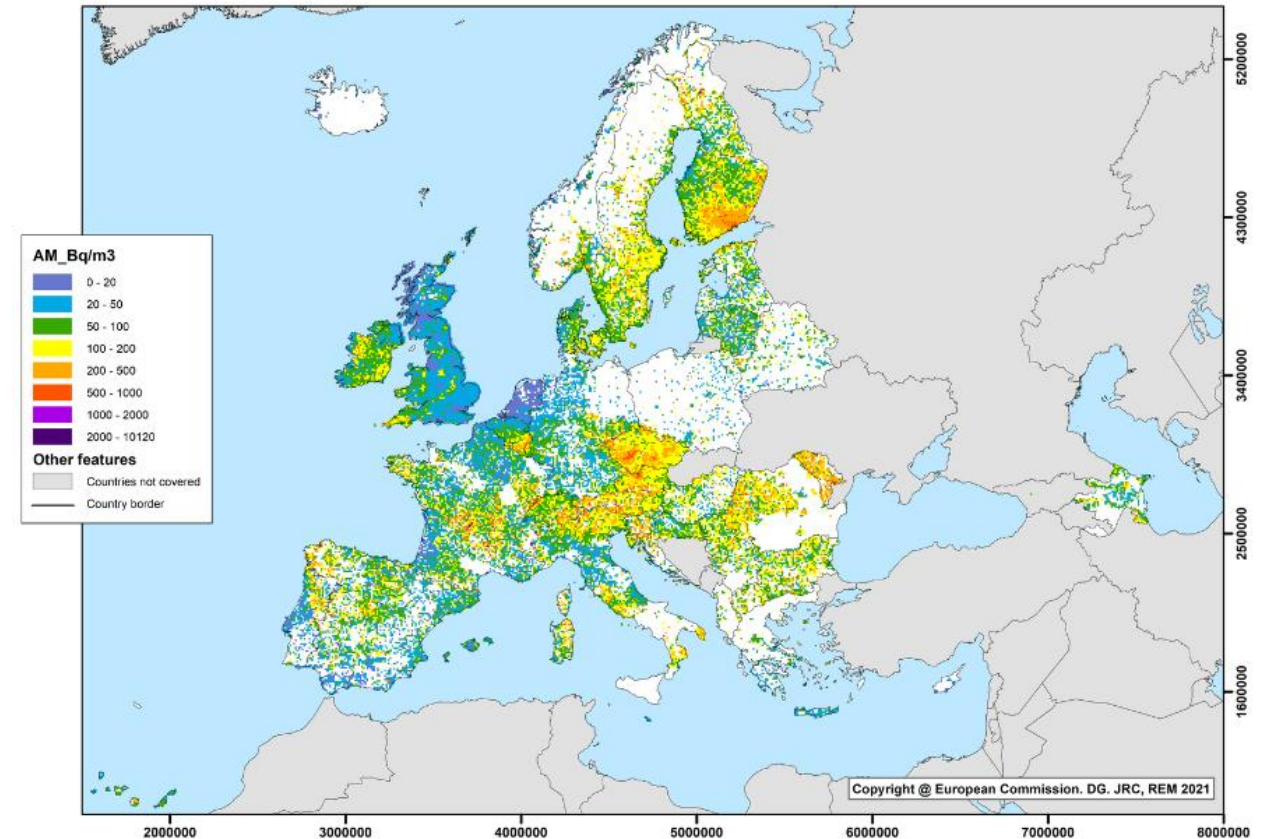- Score and results
- Press Conference

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Arena

Rn outdoor / flux for radon mapping

- Predictive Model: **random forest**
- **Target value**: gridded mean indoor radon concentrations (**IRC**) of the European Atlas of Natural Radiation.
- New players: **Outdoor radon** and **radon flux** as predictors
- Knowledge transfer from one region to another?

European Indoor Radon Map, November 2021

AM_Bq/m3
0 - 20
20 - 50
50 - 100
100 - 200
200 - 500
500 - 1000
1000 - 2000
2000 - 10120
Other features
Countries not covered
Country border

Arithmetic means over 10 km x 10 km cells of long-term radon concentration in ground-floor rooms.
(The cell mean is neither an estimate of the population exposure, nor of the risk.)

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Source:
European Commission, Joint Research Centre (JRC),
Directorate G - Nuclear Safety & Security, REM project

Contender

Rn outdoor / flux for radon mapping

- 30 predictors
  - Radon parameters
  - Soil properties
  - Categorical maps
  - Weather and climate
  - Terrain
  - Others

- **mapped on 10 x 10 km² grid**
  for Belgium and Germany

Outdoor radon [Bq/m³]

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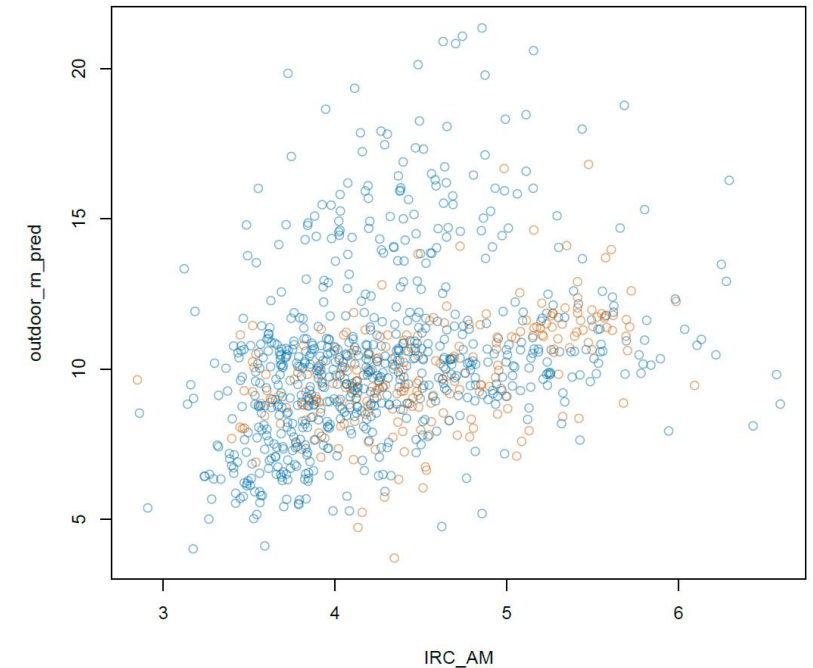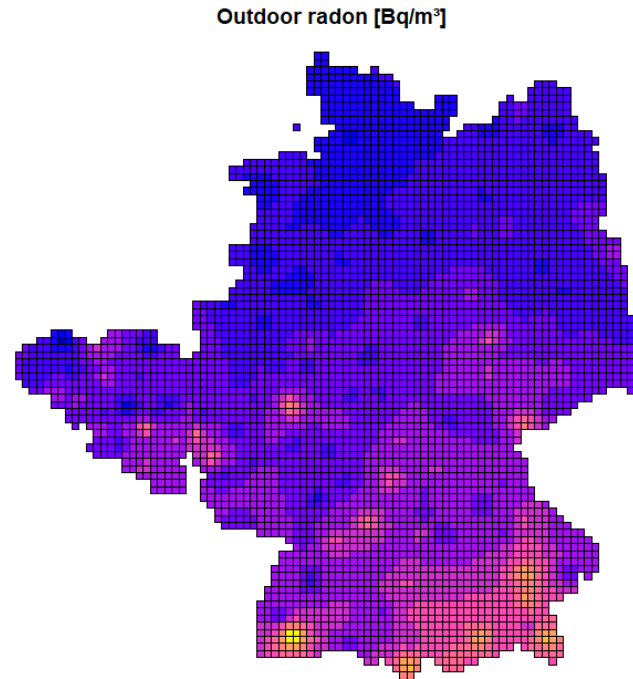
Rules

Rn outdoor / flux for radon mapping

- **German validation and Belgian test set – distance!**
- Performance metric: **mean squared error** (MSE)
- Random forest model
- Target value: **IRC**, number of measurements >= 10 per grid.
- 30 predictors mapped on 10 x 10 km grid.

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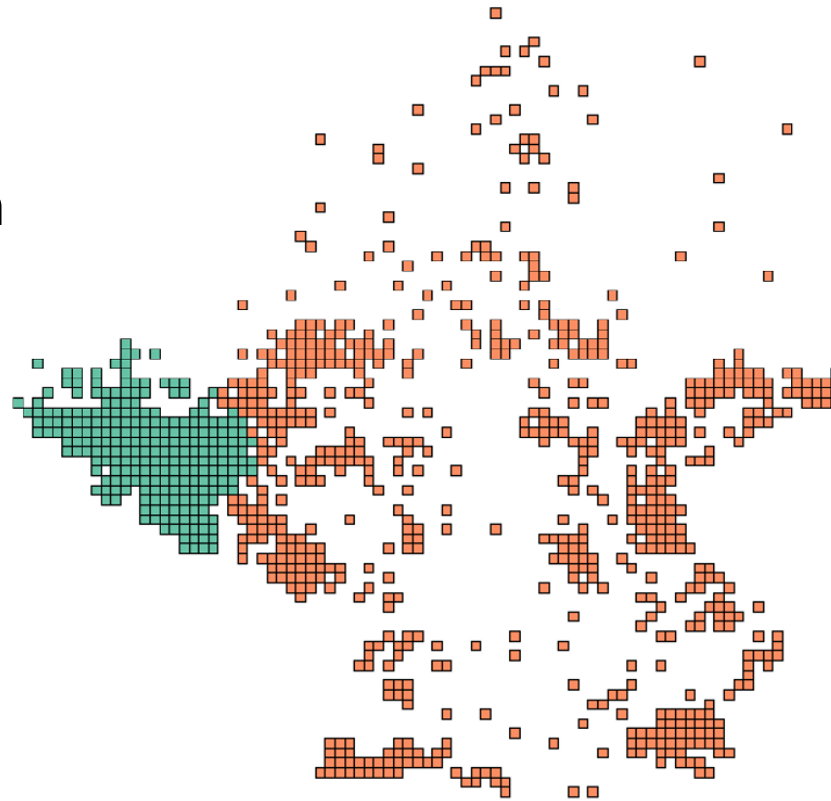
Match

Rn outdoor / flux for radon mapping

- Random forest: 500.000 model representations
- Random **feature selection** (number and variable)
- Fixed hyperparameters: number of trees: 200, mtrys = floor(sqrt(n_features))
- **Model performance evaluation (MSE)** on German validation and Belgian test set.
- Selection of best models and optimisations

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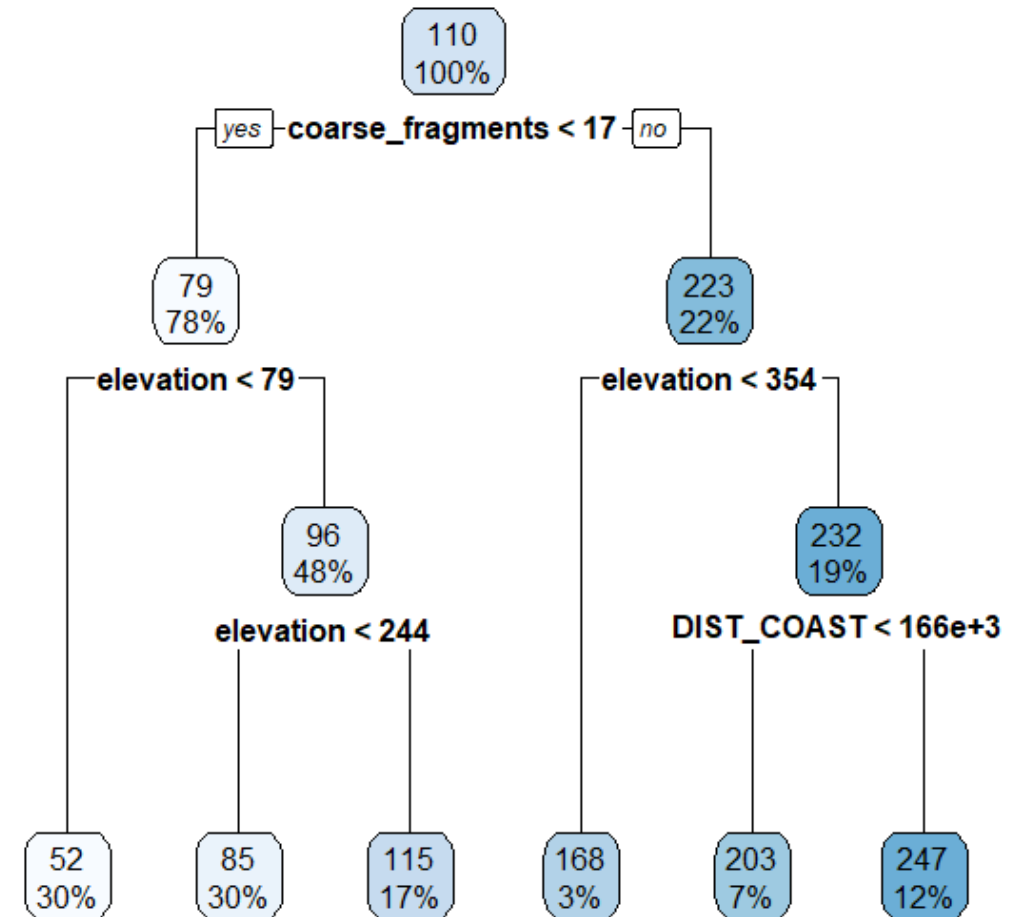
Score and results

Rn outdoor / flux for radon mapping

- The **best models** regarding the German validation and the Belgian test set **use different input features**.

- The parameter **soil moisture** occurs in both models.

- **Performance difference!**

- The feature importance of single features is considerable higher for the best Belgian than for the best German model.

| MSE Belgian test set	MSE German Validation set	Number of trees	mtrys	Number of features	Input features
2440	7446	1000	3	6	Rn flux ERA5, slope, wind, pressure, coarse fragments, soil moisture
7834	4708	1000	2	8	TGDR, hydrological units, distance to coast, temperature, precipitation, surface runoff, both soil moistures

Belgian test data
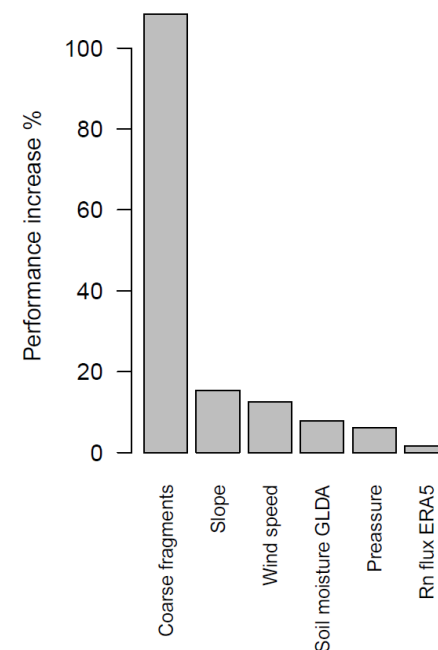
German validation data
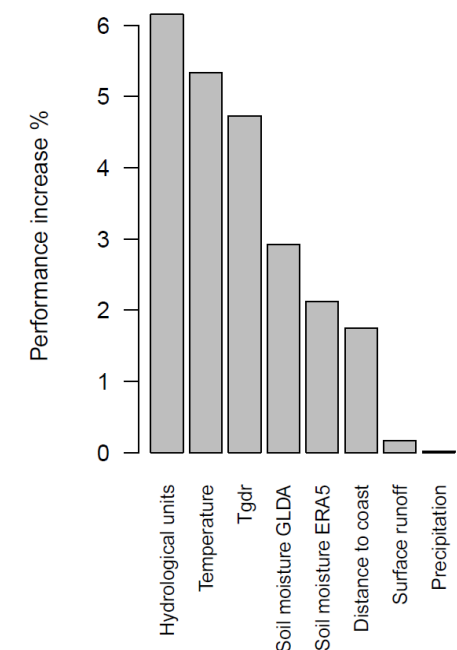
Score and results

Rn outdoor / flux for radon mapping
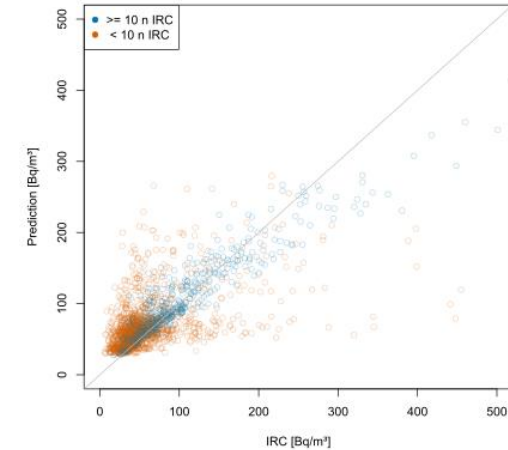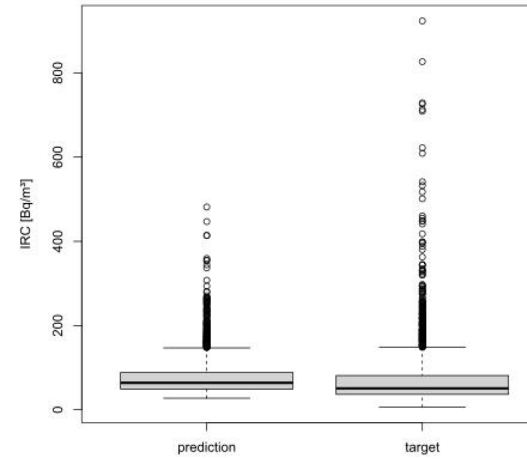
- **Best Beligian model**
- Similar distributions of predictions and IRC
- Similar spatial pattern
- Rho = 0.77 (n >= 10)
- Rho = 0.75 (all grid with IRC)
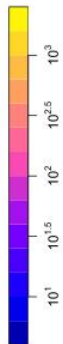

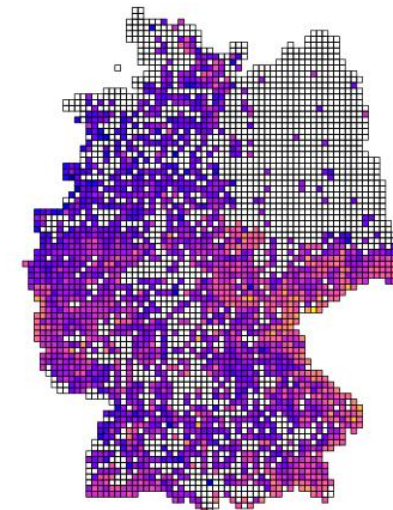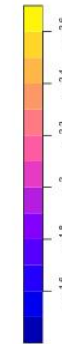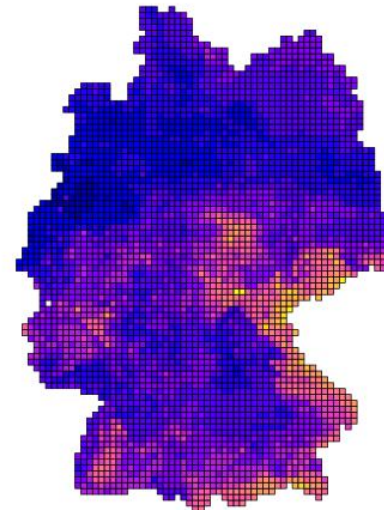
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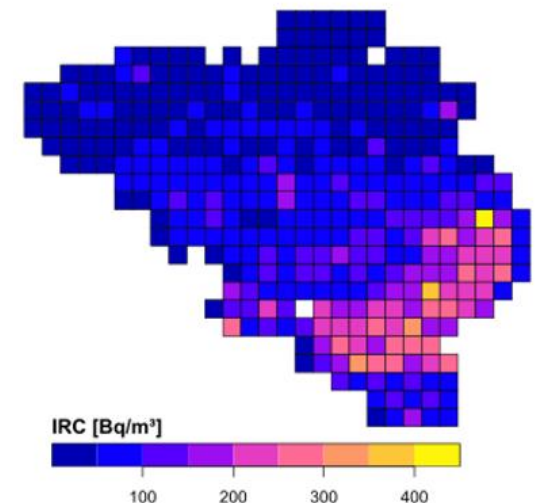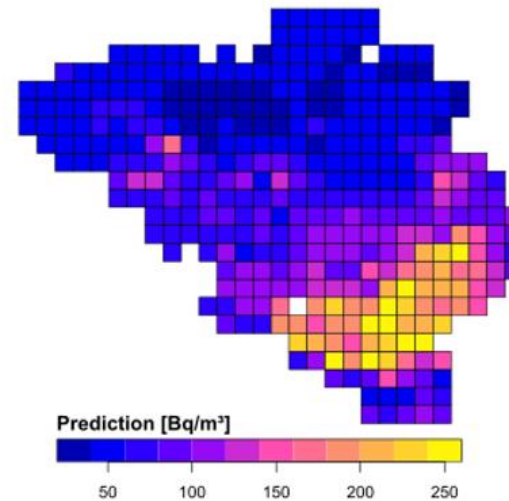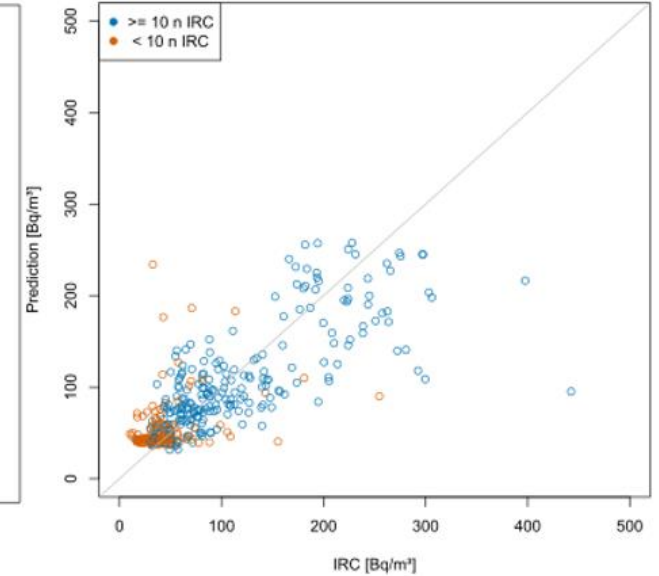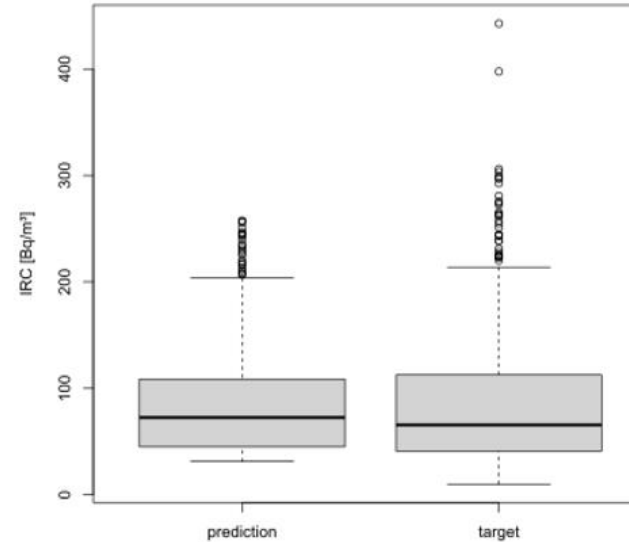
Score and results
Rn outdoor / flux for radon mapping

- **Best german model**
- Similar distributions of predictions and IRC
- Similar spatial pattern
- Rho = 0.93 (n > = 10)
- Rho = 0.66 (all grids with IRC)

Predictions log([Bq/m³])

IRC log(Bq/m³)

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Can Rn flux and outdoor radon improve radon risk prediction?

⟹ Yes, radon flux was selected as input parameter in the best Belgian model. Radon flux and outdoor radon might be valuable contenders in similar scenarios. But, other parameters are more relevant.

Implications for radon mapping

⟹ Feature importance shows regional differences and transfer of findings from one region to another can be misleading.

⟹ It is possible to build a predictive model solely on one region and accurately predict the IRC in another neighboring region. **But**, without additional information for performance evaluation this best model would not be selected but another model, possibly causing poor predictions and wrong insights.

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