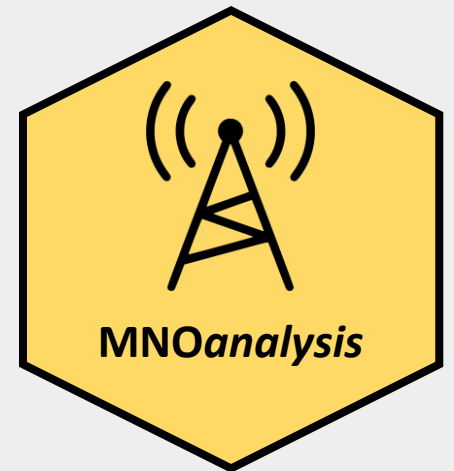


Spatial density estimation with MNO-data: A modular workflow within

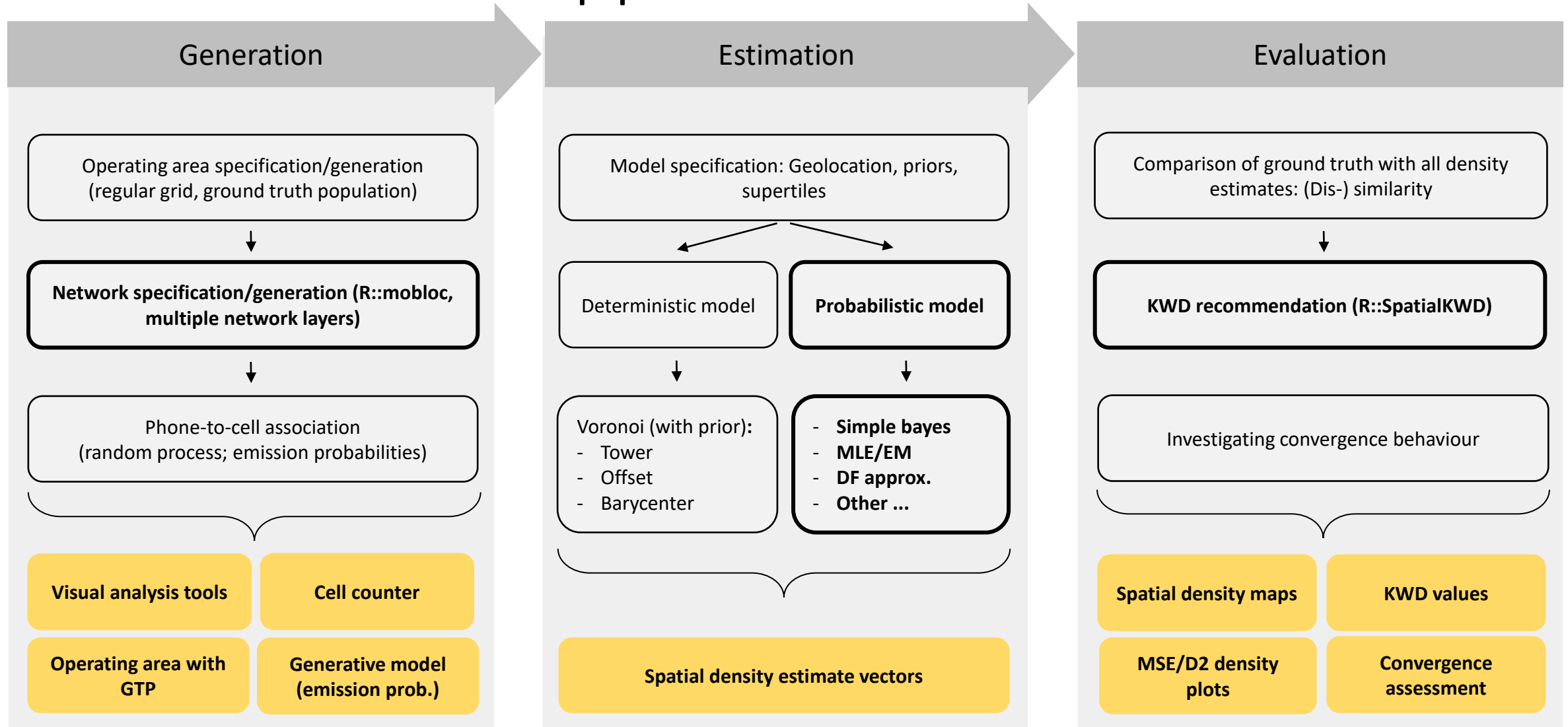
Marco Ramljak, uRos 2021 Lightning Talk

Email: marcoramljak@gmail.com

First glimpse: https://r-ramljak.github.io/MNO_mobdensity/



Modular workflow for investigating spatial density within the static approach



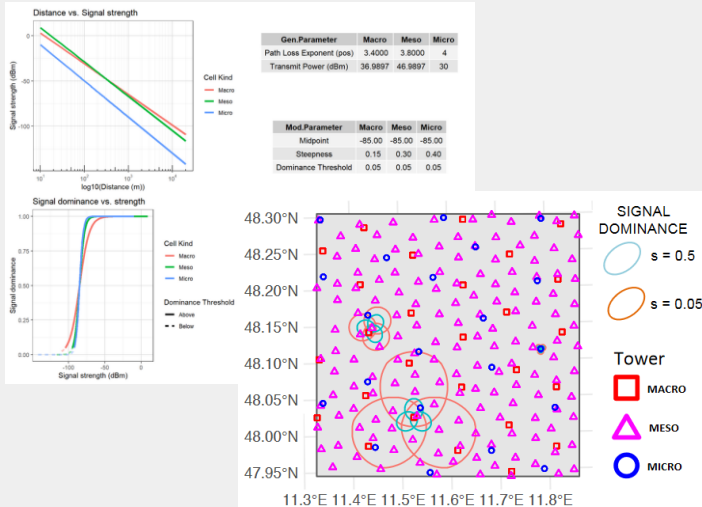
Example: Sensitivity analysis concerning model uncertainties

Generation

Population generation

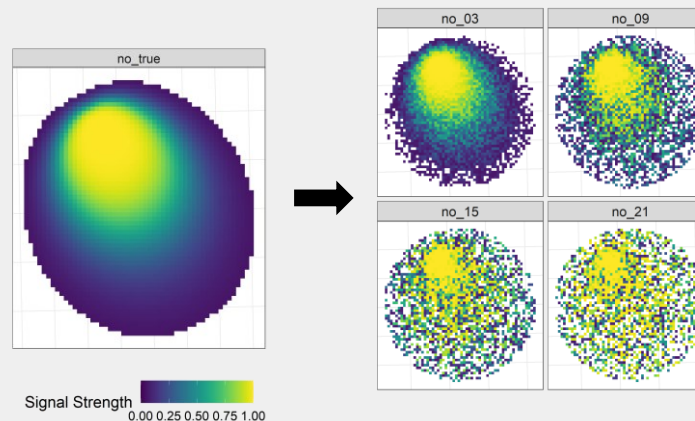
```
#real census data
pop_gen(Germany)
```

Multi Layer Network generation (R::mobloc)



Estimation

Purposefully implement model mismatch, e.g., random noise

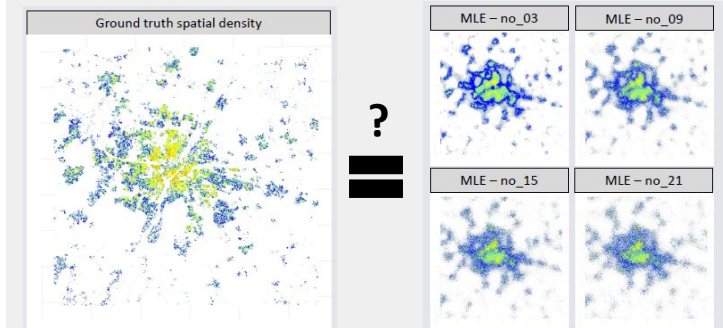


Estimators

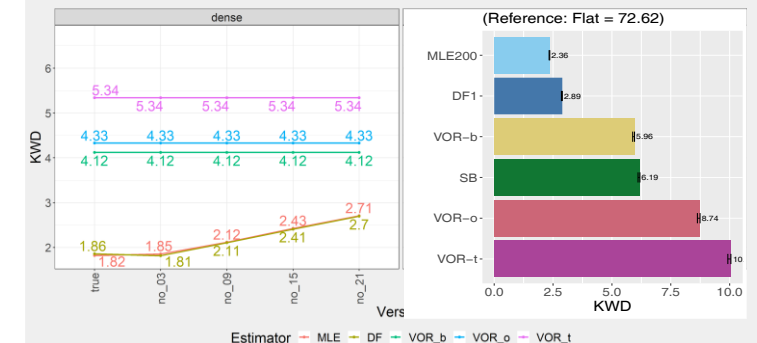
```
EM_est(prior, iter = 1,...)
EM_est(iter = 200) #thx Mátyás
DF_est(...)
VOR_est(seed = c(tower, offset,
barycenter))
```

Evaluation

Spatial density maps



KWD analysis (R::SpatialKWD)



Main R-Packages and References

```
# Data manipulation  
library(tidyverse)  
library(data.table)
```

```
# Spatial operations  
library(sf)  
library(raster)  
library(stars)
```

```
# Matrix operations  
library(Matrix)
```

```
# MNO data handling and propagation model setup  
# Credits to Prof. Martijn Tennekes  
https://github.com/mtennekes/mobloc  
library(mobloc)
```

```
# Comparison of 2d histograms (Kantorovitch Wasserstein  
distance a.k.a. Earth Movers distance)  
# Credits to Prof. Stefano Gualandi https://cran.r-project.org/web/packages/SpatialKWD/SpatialKWD.pdf  
library(SpatialKWD)
```

Ricciato, F., & Coluccia, A. (2020). On the estimation of spatial density from mobile network operator data. *arXiv preprint arXiv:2009.05410*.

Tennekes, M., & Gootzen, Y. A. (2021). A Bayesian approach to location estimation of mobile devices from mobile network operator data. *arXiv preprint arXiv:2110.00439*.

Bassetti, F., Gualandi, S., & Veneroni, M. (2020). On the Computation of Kantorovich--Wasserstein Distances Between Two-Dimensional Histograms by Uncapacitated Minimum Cost Flows. *SIAM Journal on Optimization*, 30(3), 2441-2469.