Estonian Environmental Research Centre

Measurement and modelling of PM2.5 from wood combustion in Estonia

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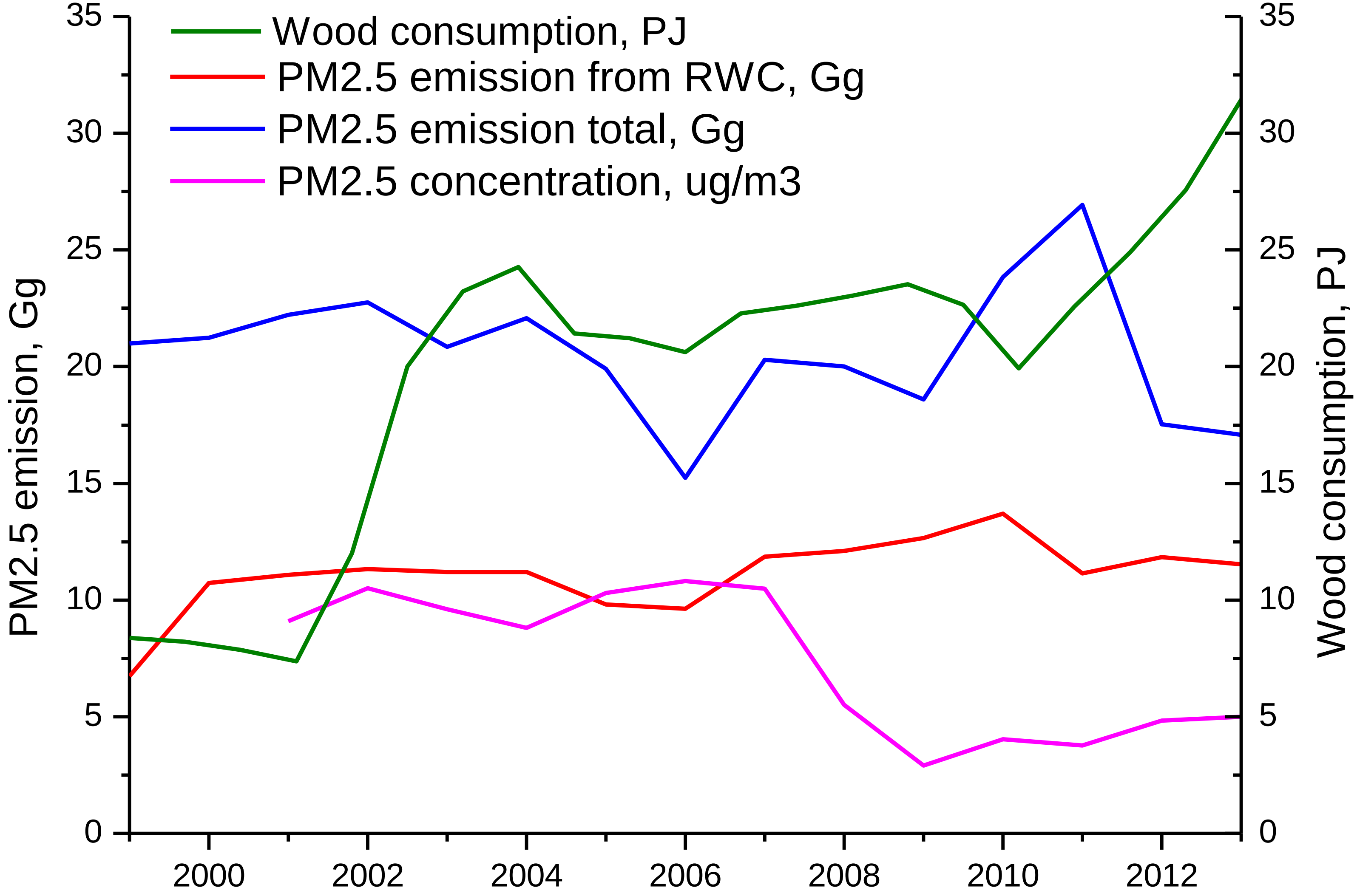
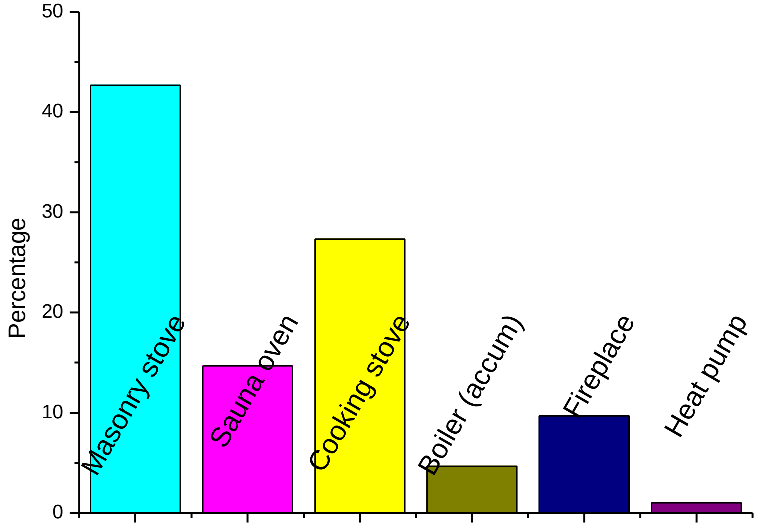
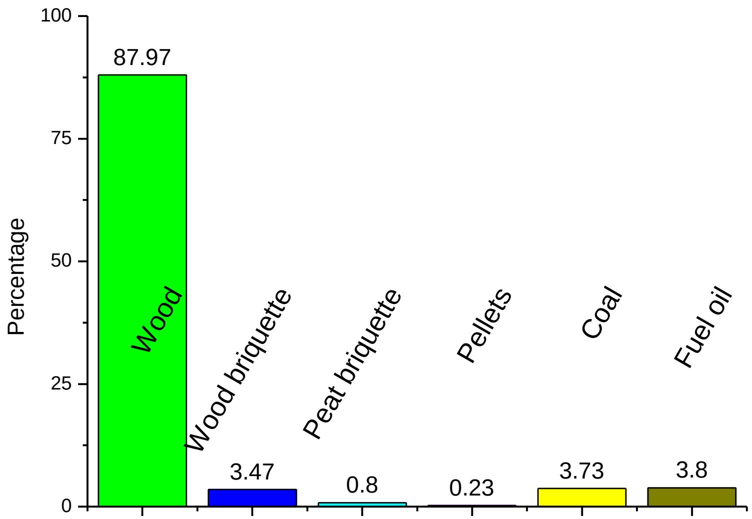
Introduction

- Estonian national emission inventory indicates slight increase of PM2.5 emissions in the future.
- About 50% of total PM2.5 emission is attributed to residential wood combustion (RWC).
- To reduce GHG emissions the use of biomass in energy production has been favoured
- Use of wood in residential combustion is increasing, which is affecting directly emission and ambient levels of PM2.5


Wood consumption, PJ
PM2.5 emission from RWC, Gg
PM2.5 emission total, Gg
PM2.5 concentration, ug/m3
PM2.5 emission, Gg
Wood consumption, PJ
0
5
10
15
20
25
30
35
2000
2002
2004
2006
2008
2010
2012





- Wood is dominant fuel used in residential areas in small cities
- In Estonia wood and wood chips account >90% of the fuel used for residential heating
- Typical masonry stoves are used in >50% of residential households in Estonia
- In majority of houses old type batch fueled masonry stoves are still used
- Typical energy consumption for residential houses is 200-300 kWh/m^2

Loosaar et al. *2008*

Current situation

- Presently official PMx emissions are calculated on the basis of the EMEP/EEA Air Pollutant Emission Inventory Guidebook
- According to the Guidebook the EF-s are not dependent from the type of combustion equipment
- Only few control measures are proposed
- More specific EF-s are needed for the official emission inventories

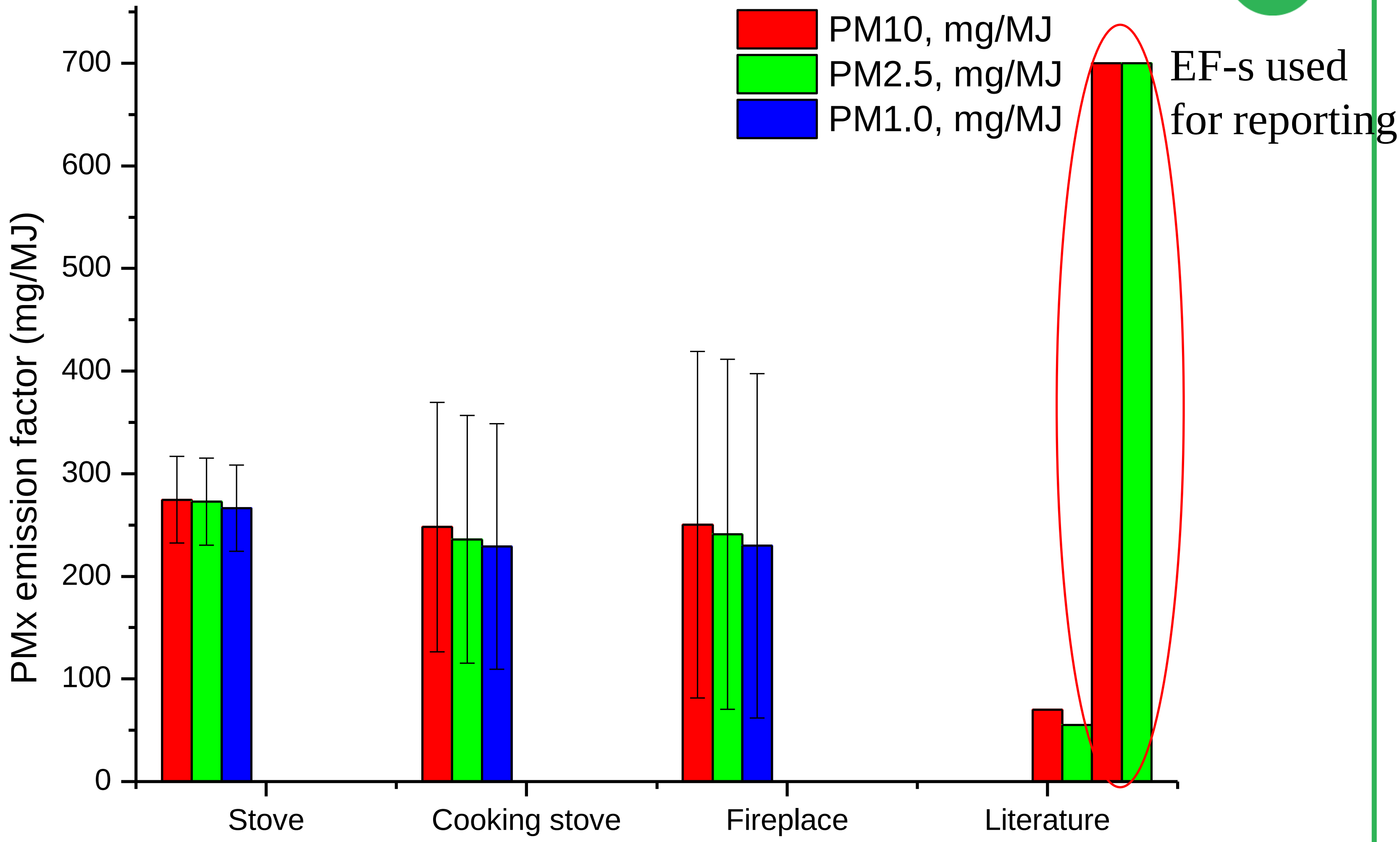
RWC EF-s in Estonia

- Emission measurements at small scale combustion devices were carried out
- Three typical stove types common in Estonia have been measured:
  - Masonry stove
  - Cooking stove
  - Fireplace
- Hardwood and conifer wood with different RH were used

Emissions from RWC

- Measurements from hot flue gas (up to 200ºC) with different wood type and humidity
- PMx samples were collected with Dekati PM10 impactor and ELPI, ELPI+ (64 x dilution), flue gases (SO_2, NOx, CO, CO_2, NMVOC) and other relevant parameters were measured
- From PM10, PM2.5, PM1.0 and PM<1.0 filters ions, levoglucosane, EC/OC, PAH-s, HM were analyzed
- Additionally from TSP fraction PCDD/F, HCB and PAH-s were analyzed

Emission factors



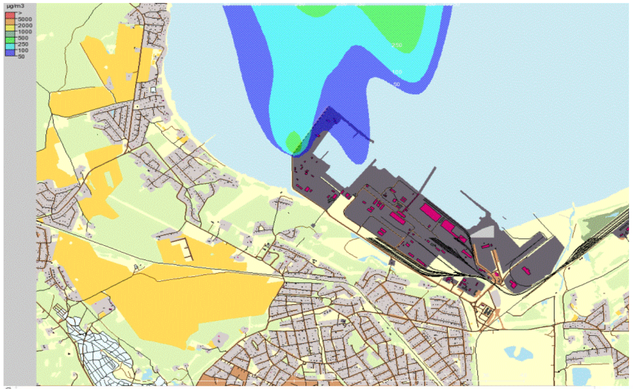
Using EF-s in dispersion calculations

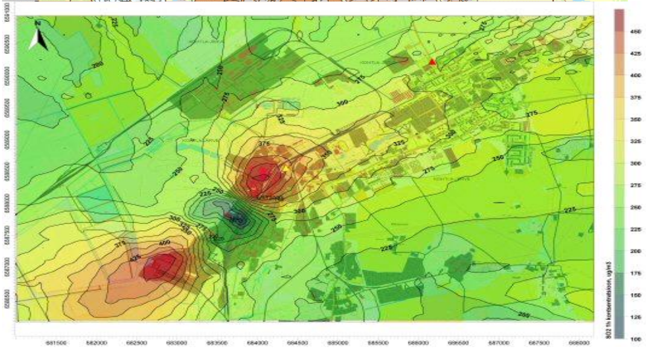
- The household stove emission database was created
  - Data from construction (heated area in m^2 and heating system) and cadastral (cadastral coordinates) registry was used
  - According to Loosaar et al. (2008) in average 242.38 kWh energy per m^2 is used to heat households in Tallinn area
  - PM10, PM2.5, PM1.0 emissions (g/s) were calculated for each household
- Dispersion calculation results were validated against the ambient air measurements

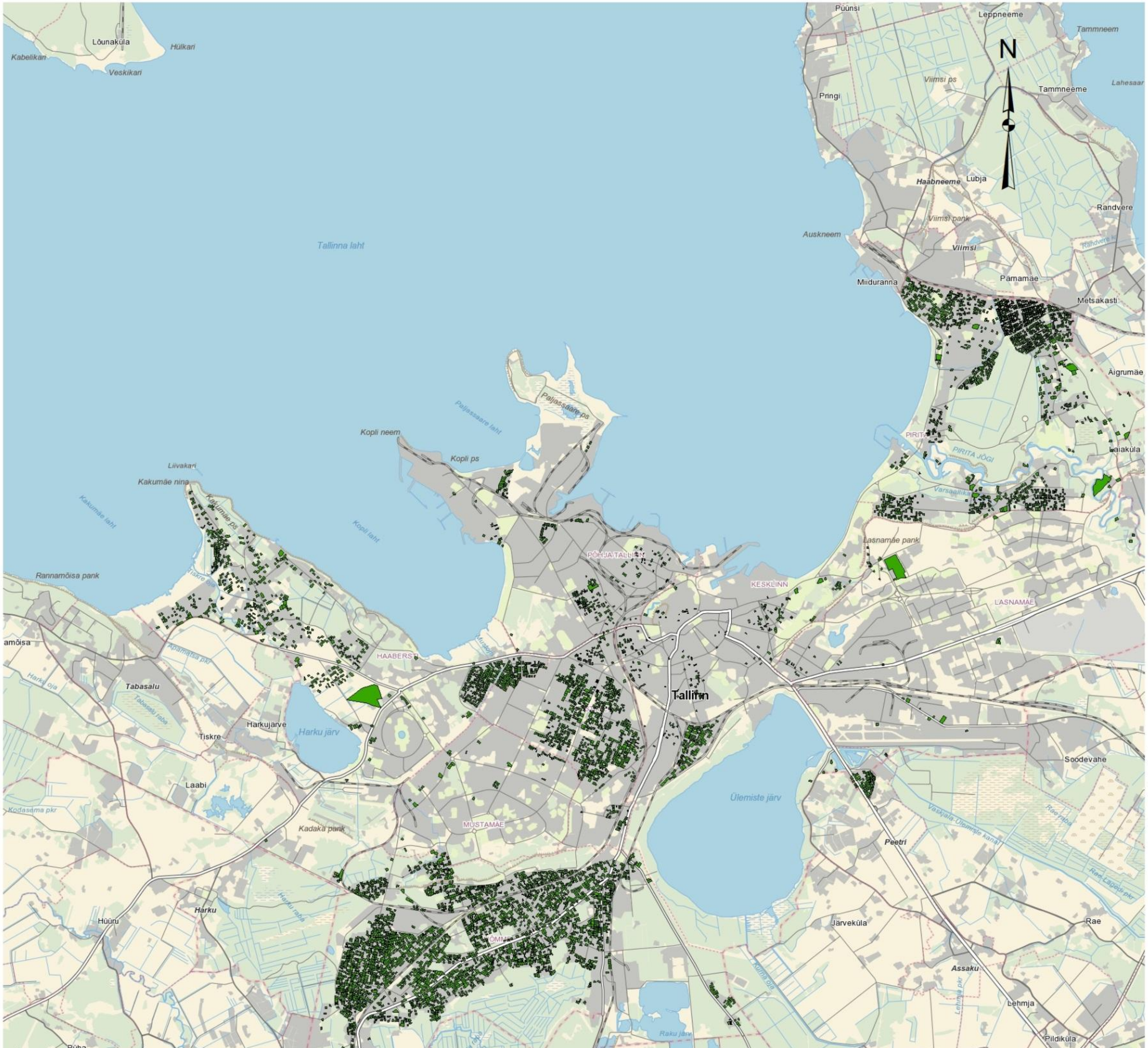
Air quality modelling

- Air quality modelling is based on AirViro software.
- Currently our system includes 10 dispersion models:
  - SMHI Gauss
  - SMHI Eulerian
  - Aermod
  - CALPUFF
  - MATCH
  - Heavy gas
  - Street canyon
  - Receptor
  - Austal2000G
  - OSPM

Ensemble (SMHI Gauss, SMHI Eulerian, Aermod, CALPUFF)







EDB for Tallinn

Cadastral units

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Kasutatud Maa-ameti aluskaarti
(WMS teenus)

1:50 000

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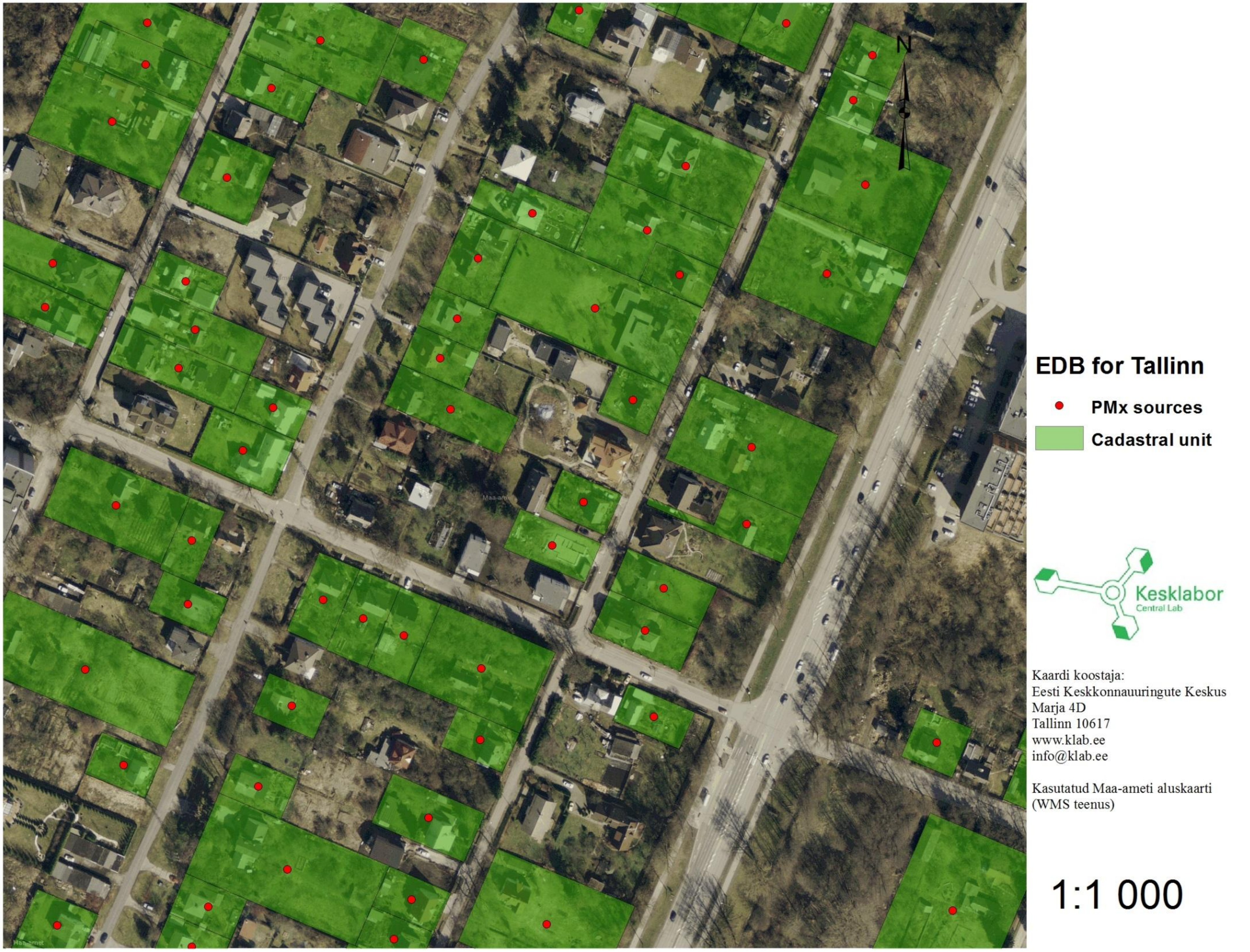
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EDB for Tallinn
PMx sources
Cadastral unit
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EDB for Tallinn

RWC PM2.5 emission

PM2.5, g/s

- 0.0001 - 0.0007
- 0.0008 - 0.0013
- 0.0014 - 0.0025
- 0.0026 - 0.0084
- 0.0085 - 0.0809

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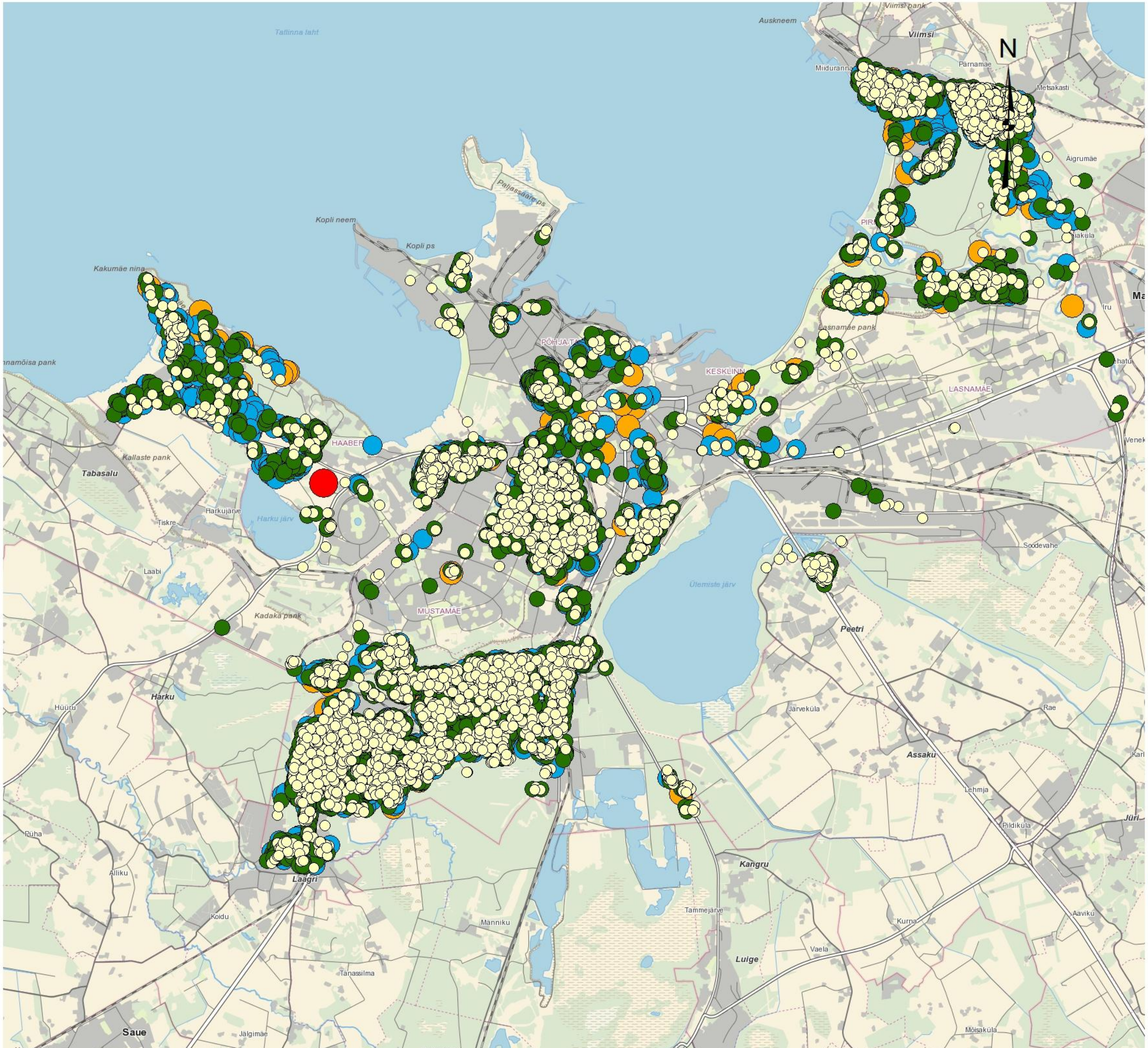

EDB for Tallinn

RWC PM2.5 emission

PM2.5, g/s

- **0.0001 - 0.0007**
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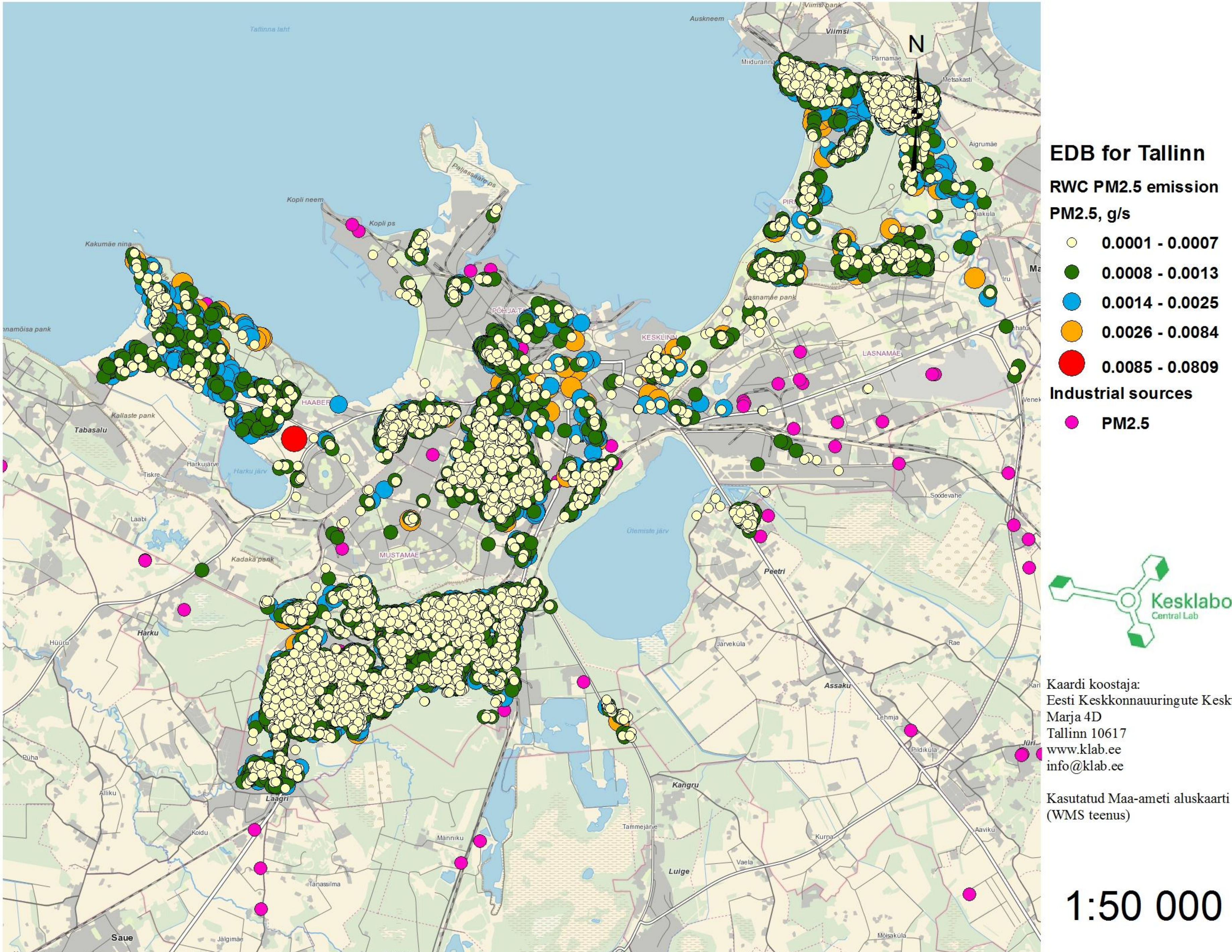

EDB for Tallinn
RWC PM2.5 emission
PM2.5, g/s
0.0001 - 0.0007
0.0008 - 0.0013
0.0014 - 0.0025
0.0026 - 0.0084
0.0085 - 0.0809
Industrial sources
PM2.5
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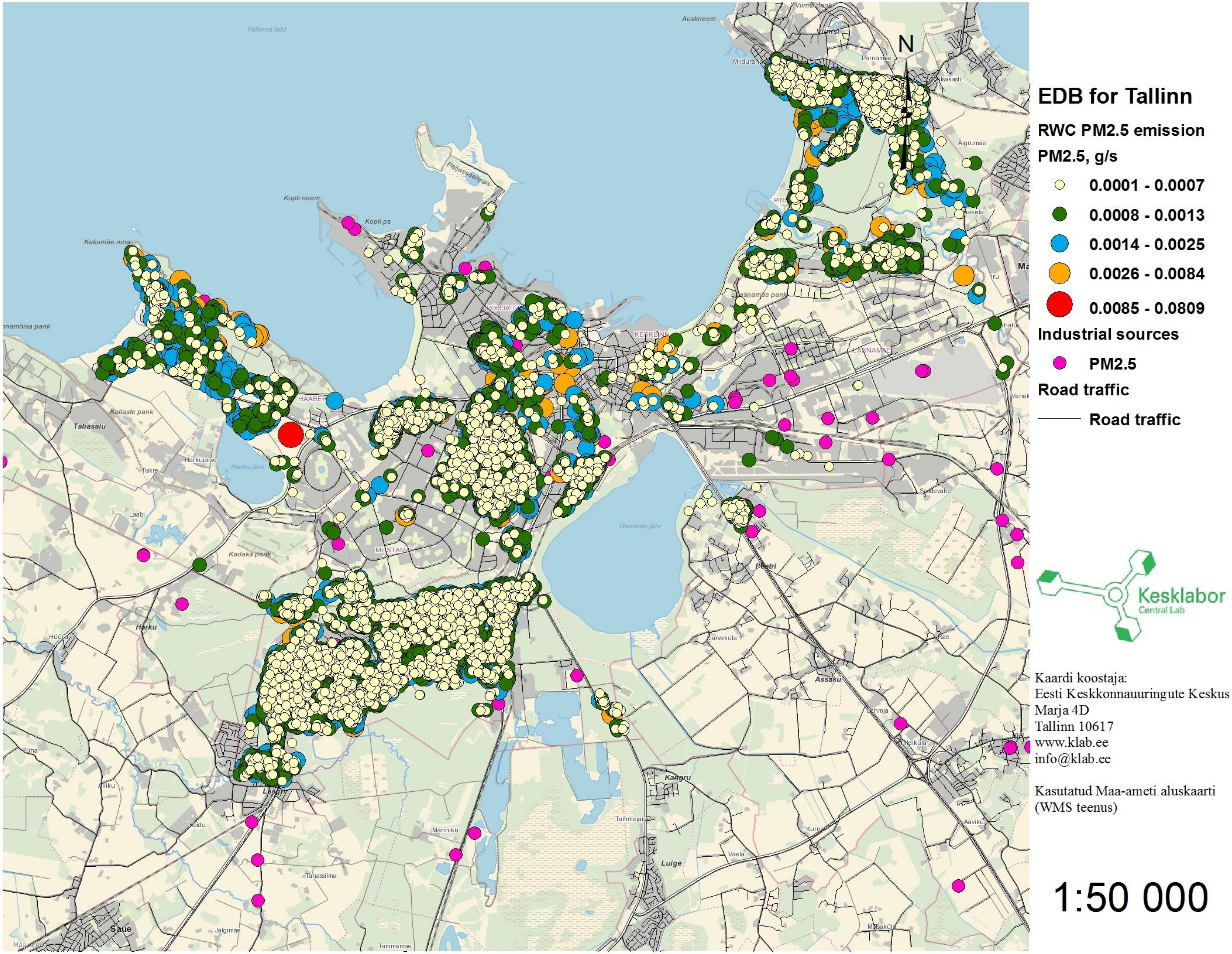
Kasutatud Maa-ameti aluskaarti
(WMS teenus)
1:50 000
N
Tallinna laht
Auskneem
Viimsi
Miiduranna
Pärnamäe
Metsakasti
Aigrumäe
Paljassaare ps
Kopli neem
Kopli ps
Kakumäe nina
KESKLINN
LASNAMÄE
Lasnamäe pank
Iru
Tabasalu
Kallaste pank
Harkujärve
Harku järv
Tiskre
Laabi
Kadaka pank
MUSTAMÄE
Ülemiste järv
Peetri
Soodevahe
Järveküla
Rae
Assaku
Harku
Hüüru
Püha
Alliku
Laagri
Koidu
Lehmja
Pildiküla
Jüri
Kangru
Tammejärve
Manniku
Kurna
Aaviku
Luige
Vaela
Tanassilma
Saue
Jälgimäe
Tammemäe
Mõisaküla


N
EDB for Tallinn
RWC PM2.5 emission
PM2.5, g/s
0.0001 - 0.0007
0.0008 - 0.0013
0.0014 - 0.0025
0.0026 - 0.0084
0.0085 - 0.0809
Industrial sources
PM2.5
Road traffic
Road traffic
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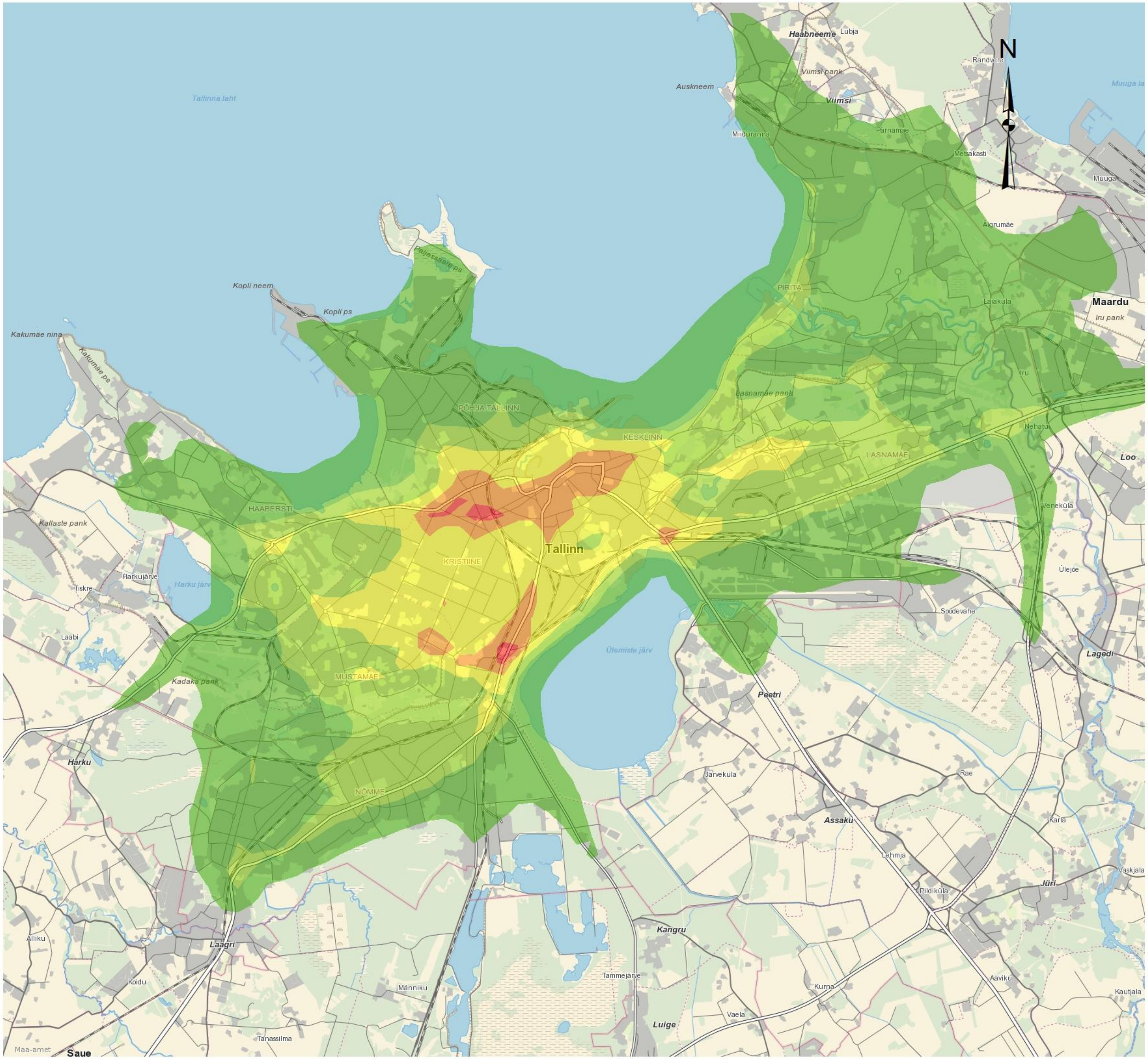
1:50 000



EDB for Tallinn

PM2.5, ug/m3

- 3.00 - 6.00
- 6.01 - 12.00
- 12.01 - 18.00
- 18.01 - 24.00
- 24.01 - 30.00

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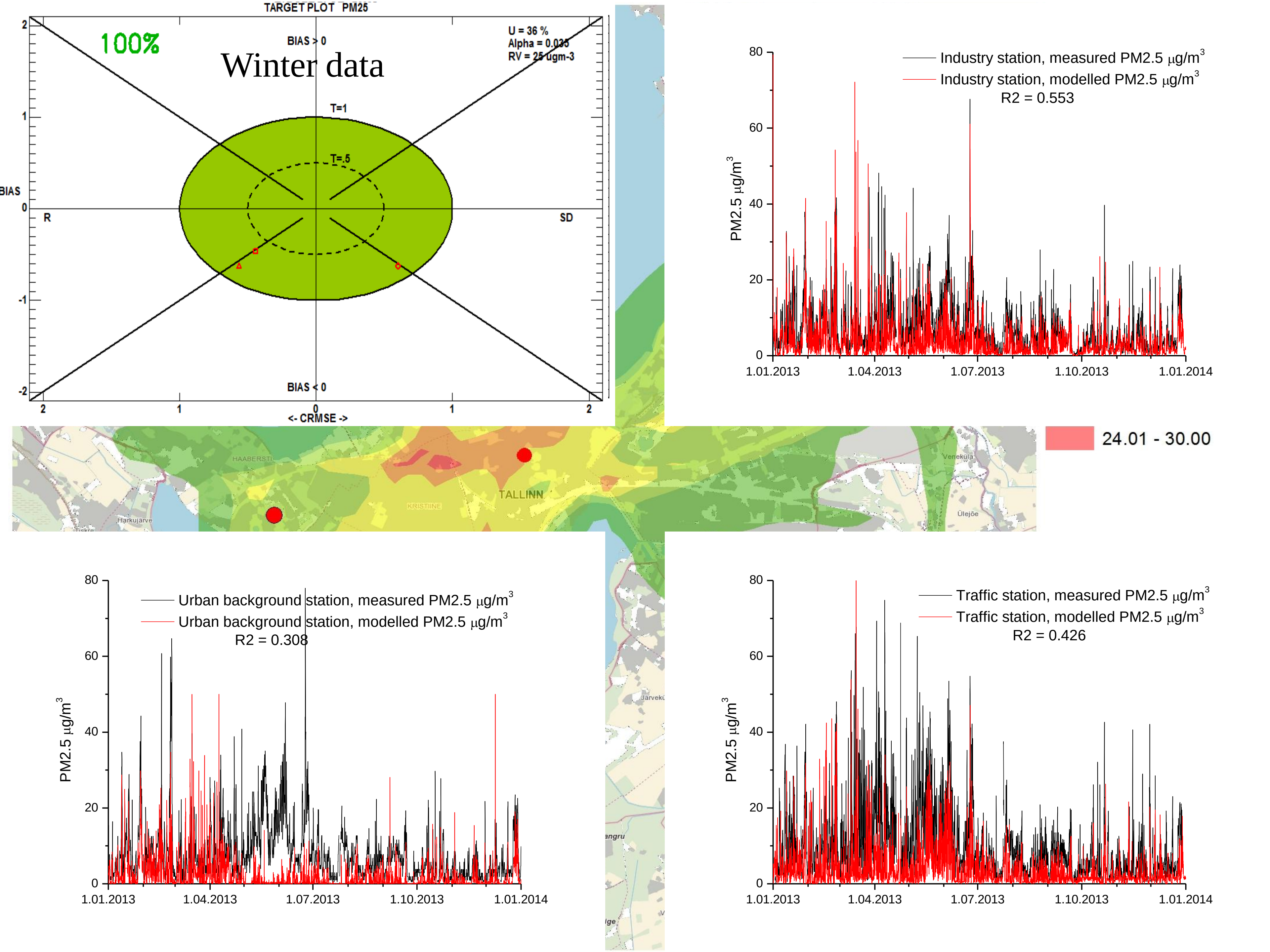
1:50 000


TARGET PLOT PM25
100%
Winter data
BIAS > 0
U = 36 %
Alpha = 0.035
RV = 25 ugm-3
T=1
T=.5
BIAS
R
SD
BIAS < 0
<- CRMSE ->
Industry station, measured PM2.5 μg/m3
Industry station, modelled PM2.5 μg/m3
R2 = 0.553
PM2.5 μg/m3
1.01.2013
1.04.2013
1.07.2013
1.10.2013
1.01.2014
24.01 - 30.00
HAABERSTI
TALLINN
KRISTIINE
Harkujärve
Venekula
Ülejõe
Urban background station, measured PM2.5 μg/m3
Urban background station, modelled PM2.5 μg/m3
R2 = 0.308
Traffic station, measured PM2.5 μg/m3
Traffic station, modelled PM2.5 μg/m3
R2 = 0.426

Conclusions

- Measured PMx EF-s are lower than in Guidebook
- Measured and modelled values showed in general good agreement, but the temporal dynamics of emission sources should be revised + resuspension and emission estimation during the spring dust event
- Secondary PMx should be taken into account
- Revision of the share of different stove types using latest census data

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Thank You for your attention!

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