RPP3 – Training workshop

Spatial distribution

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Outline

- Introduction

- Procedure for spatial distribution of emissions

- Input data
  - Emissions
  - Spatial data

- Examples of spatial data
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  - What we got

- Output
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  - Input to air quality modelling

Spatial distribution of emissions Introduction (1)

- To add a spatial component to the emission inventories, it is necessary to include various digitized spatial data

- Depending on the availability of spatial data, separate spatial distributions can be made for:
  - a single source
  - a group of sources with comparable properties
  - an emission sector

- Spatial emissions must be consistent with the emission inventory for the city

Spatial distribution of emissions Introduction (2)

- The spatial data have to be in a format compatible with a Geographical Information System (GIS)
  - GIS
    - ArcGIS or Quantum GIS (open source)
  - Data format
    - Shape files
    - personal geodatabase
    - file geodatabase
    - raster files
  - Datum and projection must be specified for all data sets

Spatial distribution of emissions Procedure

- Definition of city boundaries
    - City, municipality, etc.
    - Correspond to the available statistical data, if possible

- Identification of point sources within the boundaries
    - Power plants, industrial plants, refineries, etc.

- Identification of area sources within the boundaries
    - Small scale combustion, road traffic, etc.

Input data
Point sources

- The spatial model for point sources uses the coordinates for the specific plant and the calculated emissions

- Geographical coordinates can be derived from address using Google Earth
  - Longitude / Latitude (decimal degrees)
  - Datum: WGS 84

- Example of emission model input from point sources to the spatial distribution

SNAP	Long	Lat	Datum	Stack height	NO_x	SO_2	NMVOC	CO	TSP	PM_{10}	$PM_{2.5}$
03	DD.dddd	DD.dddd	WGS84	100							
03	DD.dddd	DD.dddd	WGS84	100							
01	DD.dddd	DD.dddd	WGS84	150							
03	DD.dddd	DD.dddd	WGS84	100							

Input data
Area sources (1)

- The spatial model for area sources uses the calculated emissions for the specific sources and corresponding spatial distribution keys

- Example of emission model input from area sources to the spatial distribution

SNAP	NO_x	SO_2	NMVOC CO	TSP	PM_{10}	$PM_{2.5}$
02						
03						
07						
0802						
0804						
0805						
0808						

Input data
Area sources (2)

- Area sources
  - Emissions that are spatially associated with an area (a polygon)
    - E.g. residential heating, non-road mobile sources.

- Line sources
  - Emission sources that exhibits a line type of geography
    - E.g. road, railway, pipeline or shipping lane

- Grids
  - Net of squares, in this case with a resolution of 1 km x 1 km
  - Point, line and polygon features can be combined to grids and then several different layers of information (emission sources) can be aggregated

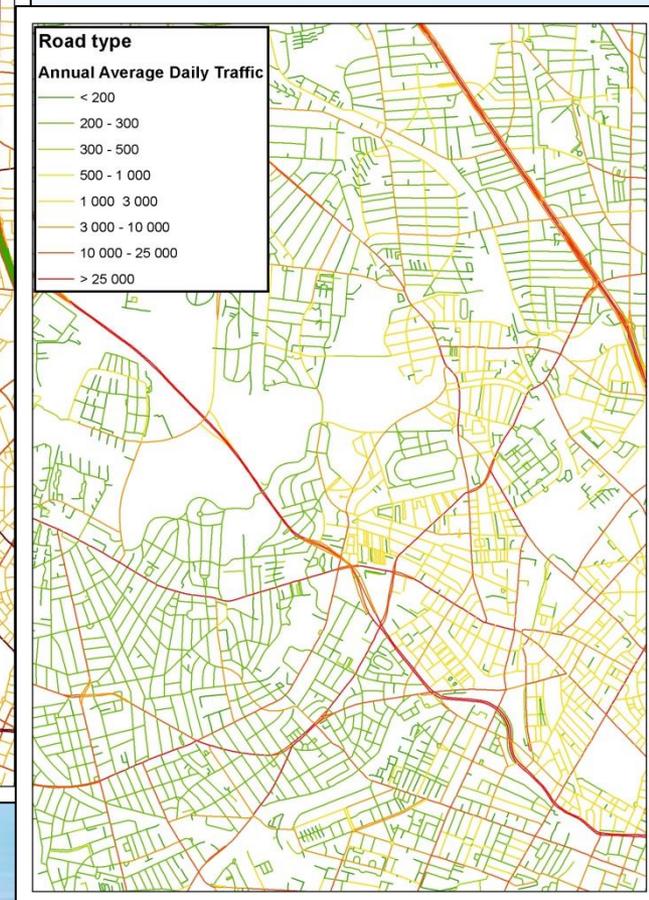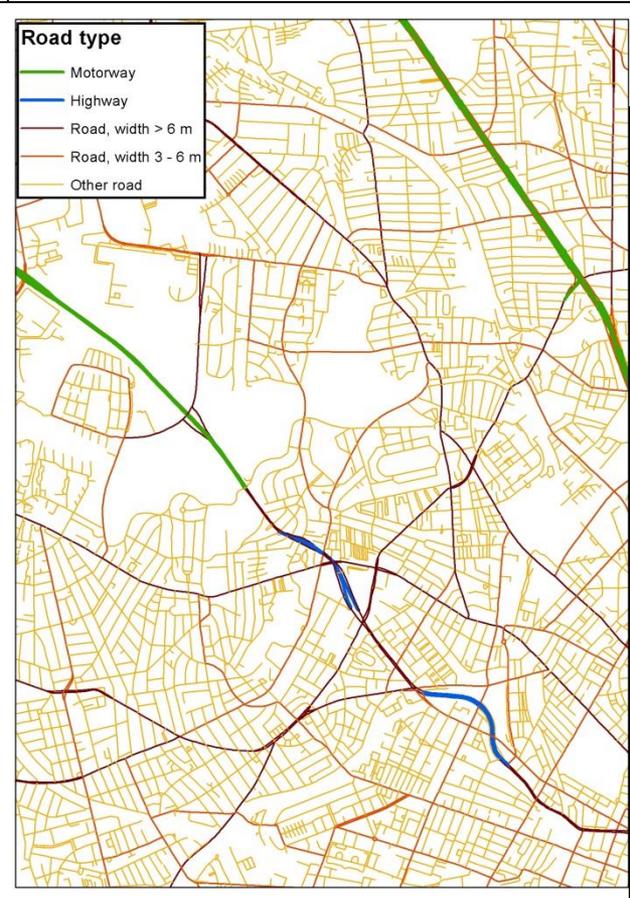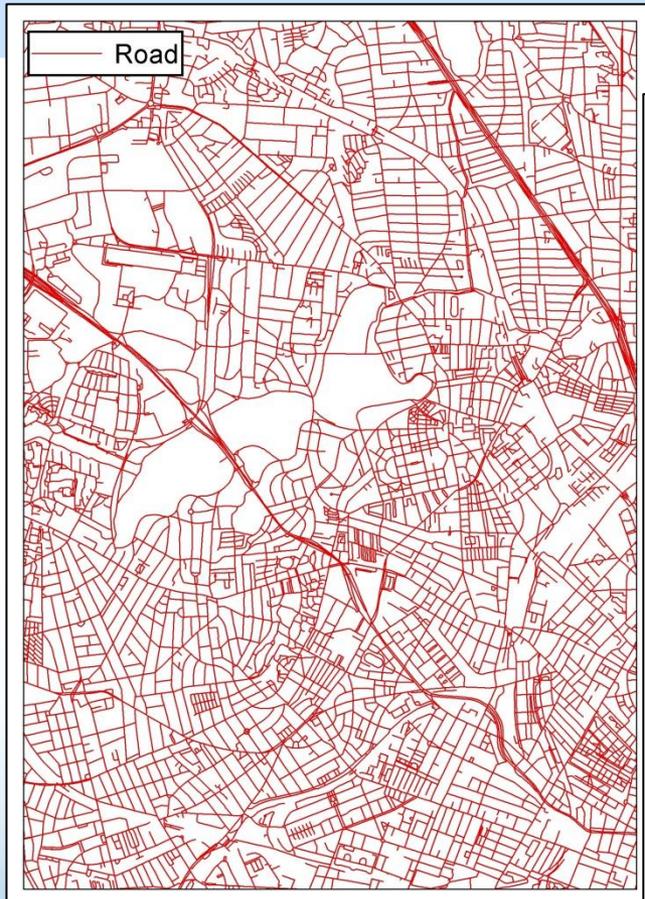# Combining different spatial features
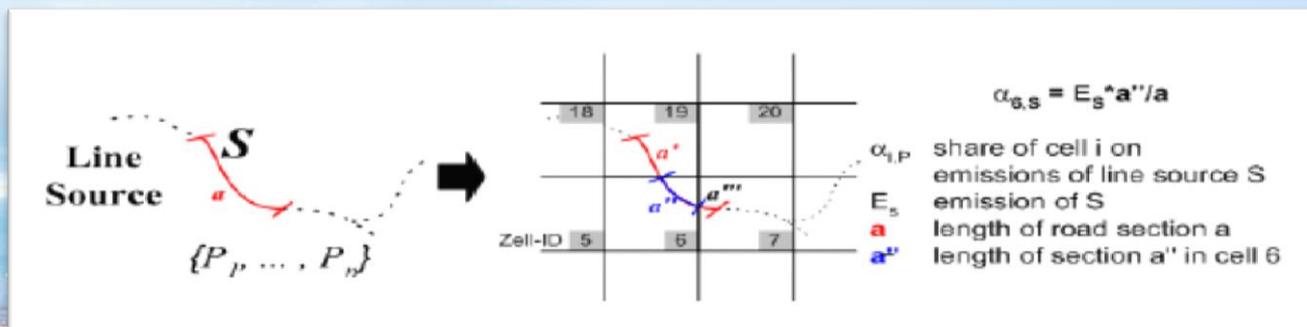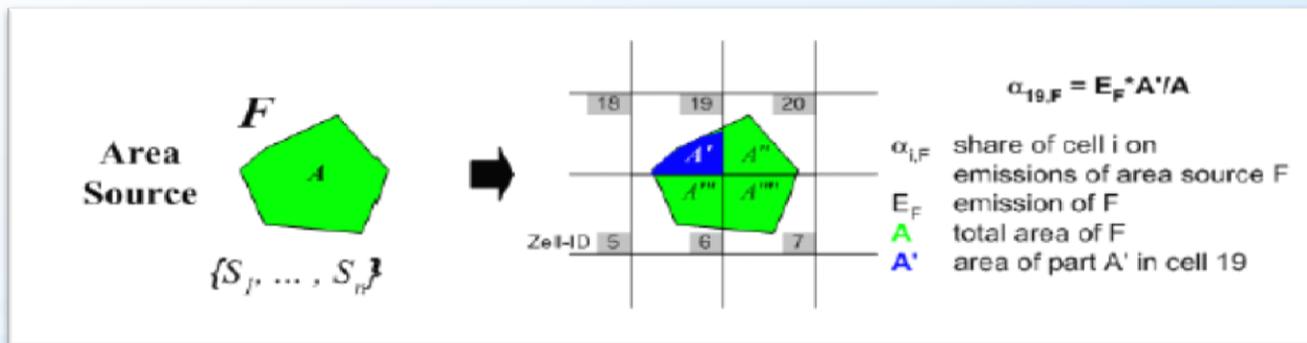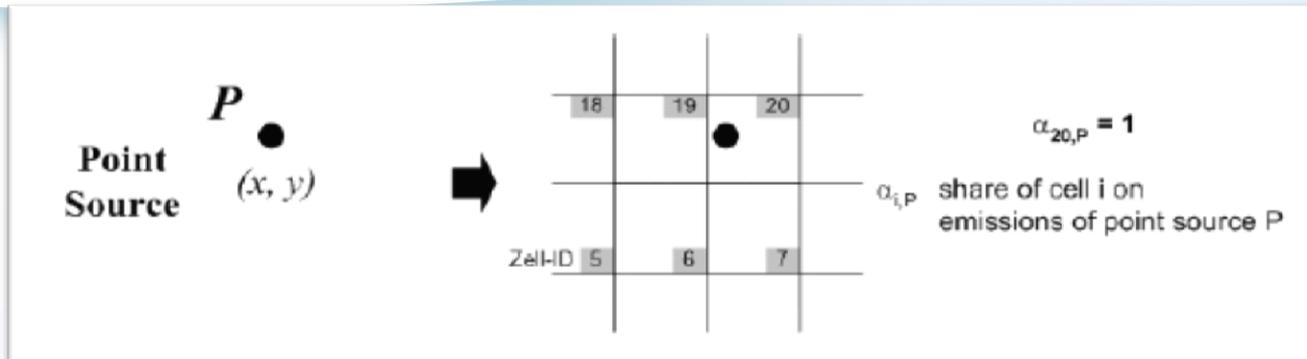
Input data
Examples of spatial data (1)

- Road traffic
  - Road network
    - Road classification
      - Motorway / urban road / rural road
      - Motorway / major road / minor road
      - Street width categories
    - Mileage
      - Annual Average Daily Traffic
        » per street segment
        » per vehicle types

Road Maps

Road

Road type
- Motorway
- Highway
- Road, width > 6 m
- Road, width 3 - 6 m
- Other road

Road type

Annual Average Daily Traffic
- < 200
- 200 - 300
- 300 - 500
- 500 - 1 000
- 1 000 3 000
- 3 000 - 10 000
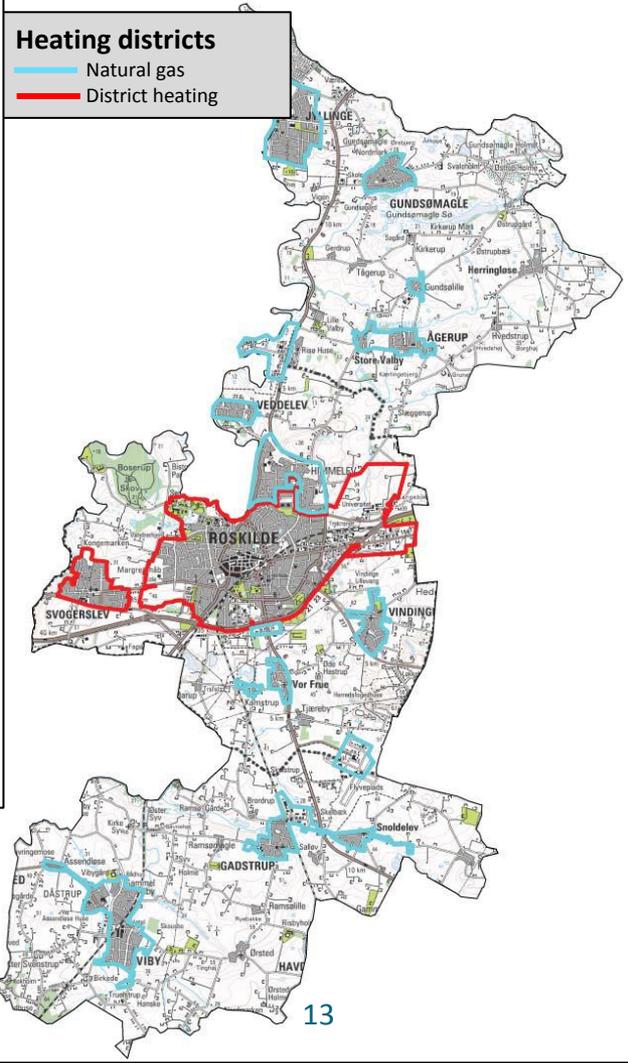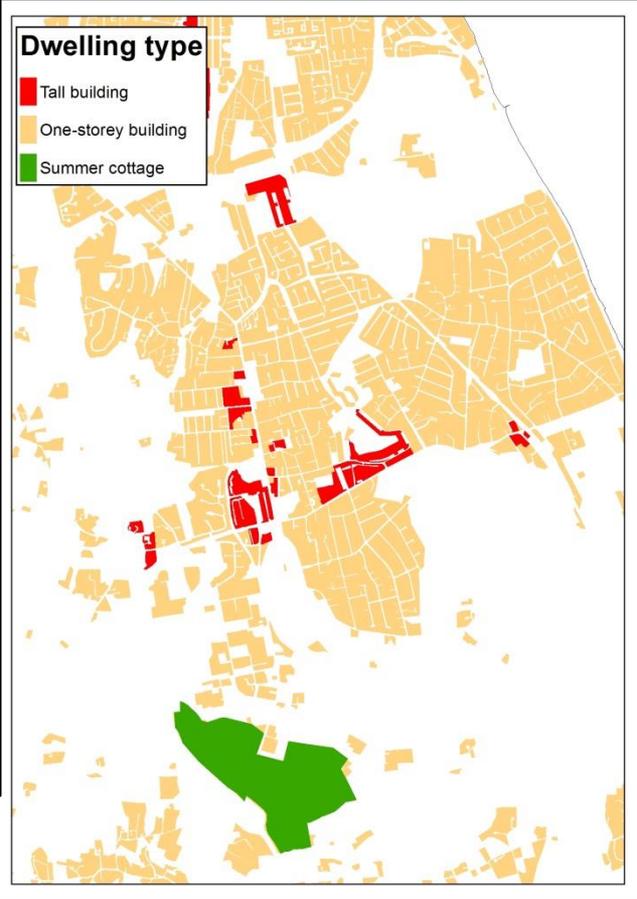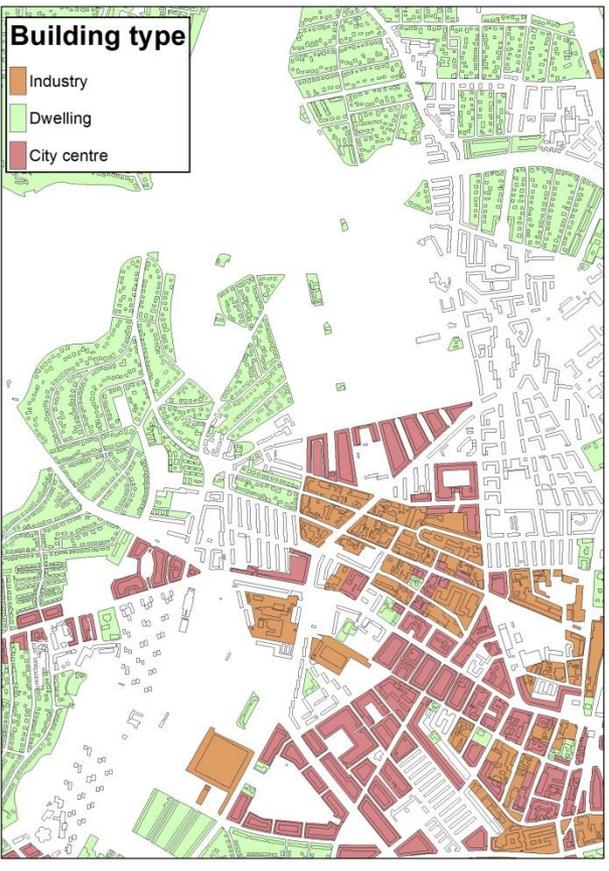- 10 000 - 25 000
- > 25 000

Input data
Examples of spatial data (2)

- Small scale combustion
  - Land use map
    - Building types
      - Residential
      - Commercial / institutional
      - Industry
  - Heating districts
    - Share of buildings connected to district heating

Land use Maps

Building type
- Industry
- Dwelling
- City centre

Dwelling type
- Tall building
- One-storey building
- Summer cottage

Heating districts
- Natural gas
- District heating

Input data
What we got from cities

- Very different spatial data available from city to city

- Some spatial data are available but could not be provided to the project for free

Feature	Number of countries	Feature	Number of countries
Demarcation of the area of the city	3	**Buildings**	2
Administrative units	1	Building types (tall / one-storage)	-
Population density	-	Urban areas	-
Road network	2	Rural areas	-
Road types (urban/rural/highway)	-	**Settlement areas**	1
Road width	-	Commercial areas	-
Annual average mileage	-	**Industrial areas**	1
Annual average mileage per vehicle type	-	Construction areas	-
Annual average number of vehicles	-	Heating districts	-
Annual average number of vehicles per vehicle type	-	Airport areas	-
Railway network	1	Port facilities	-

Input data from cities
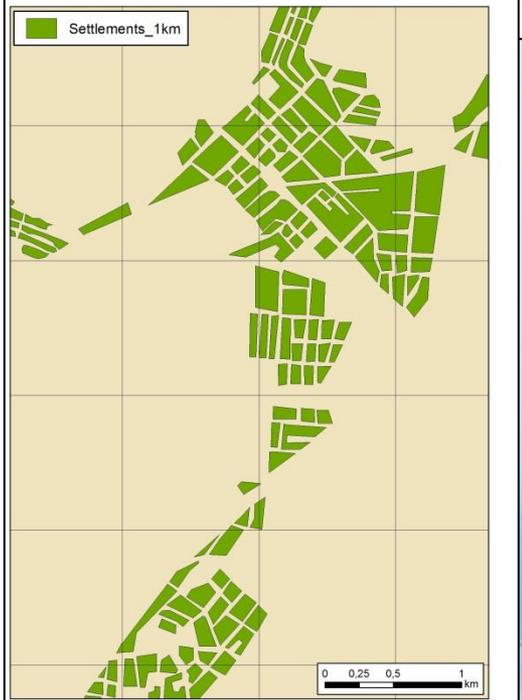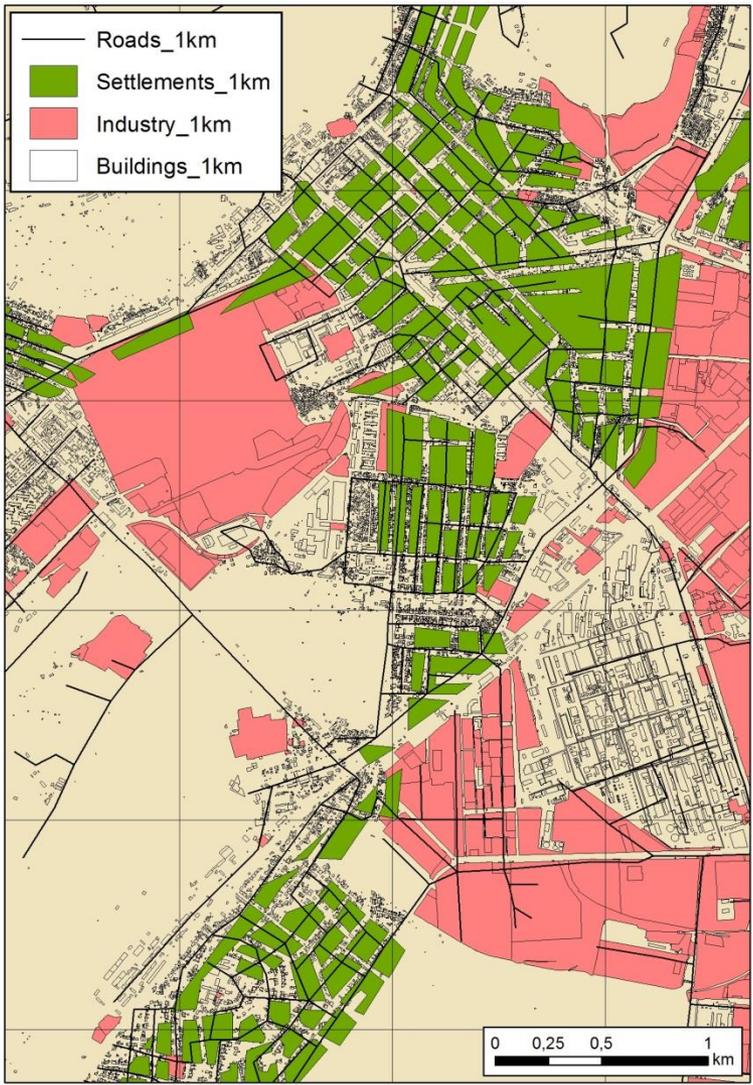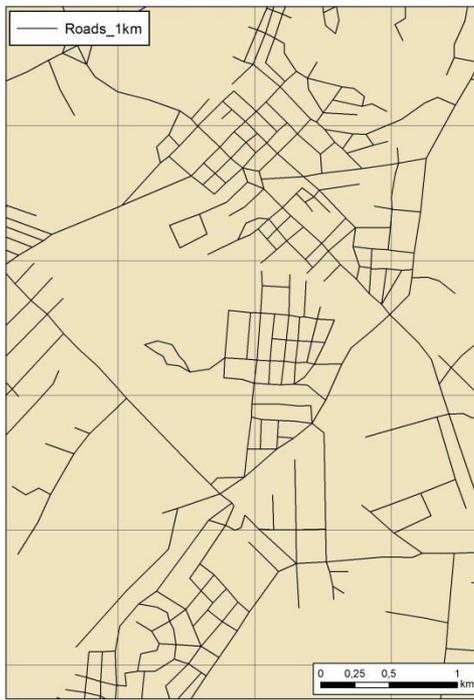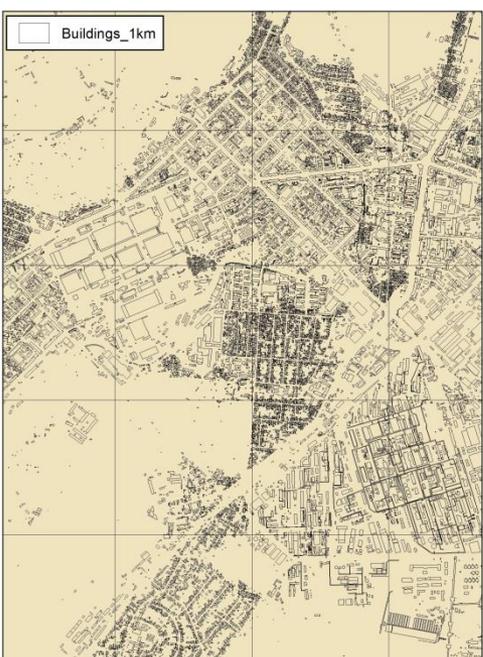
Input data
What we got elsewhere

- Due to the very limited spatial data provided for some cities, it was necessary to find alternative spatial data
  - OpenStreetMap (http://download.geofabrik.de/)
    - Road network, buildings, land use, etc.
  - Population density
    - Landscan (http://web.ornl.gov/sci/landscan/index.shtml)
    - Center for International Earth Science Information Network (CIESIN), Columbia University (http://sedac.ciesin.columbia.edu/data/collection/gpw-v3)

- These datasets were used even if the level of detail is low, to illustrate the preferred methodology, and since it in most cases provides a better result, than just distribution emissions evenly across the entire city area.

Input data
What we got elsewhere

CIESIN
Population density
[Capita]

	< 40
	41 - 60
	61 - 100
	101 - 150
	151 - 200
	201 - 300
	301 - 500
	501 - 1500
	1501 - 3000
	> 3000

0 10 20   40
km

Landscan
Population density
[Capita]

	0
	1 - 5
	6 - 25
	26 - 50
	51 - 100
	101- 500
	501 - 2.500
	2.501 - 5.000
	5.001 - 130.000

0 10 20   40
km
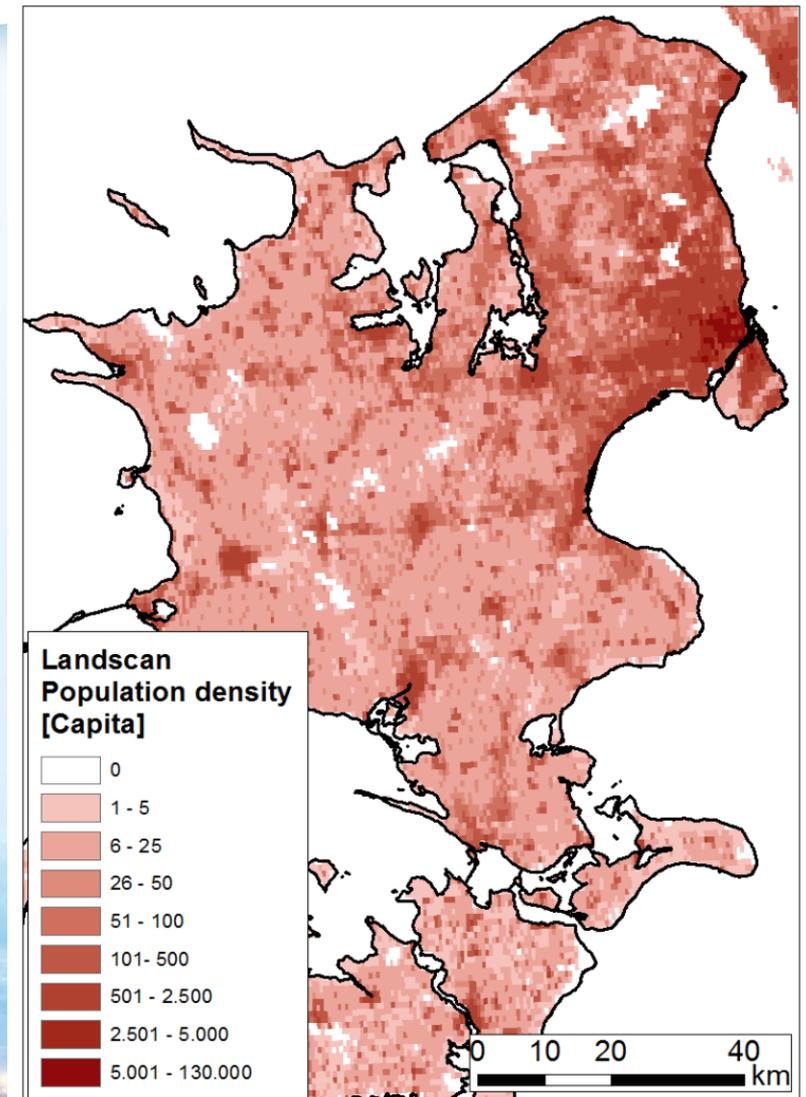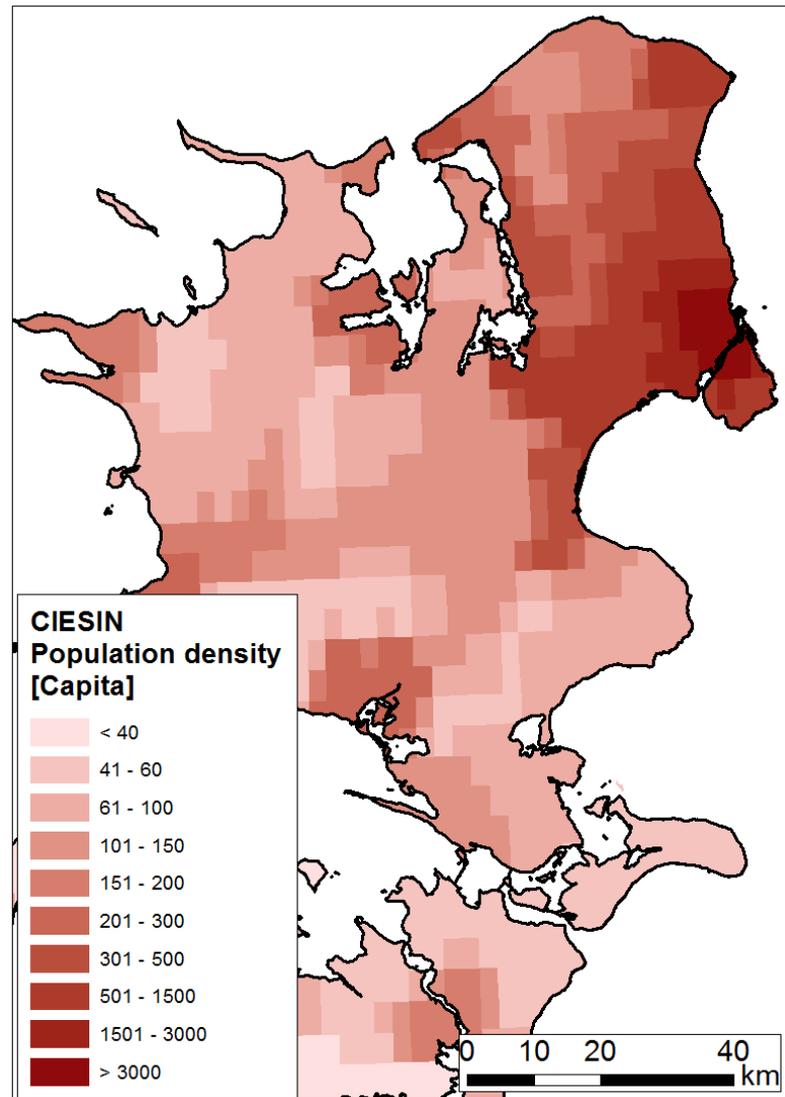
Spatial distribution key (1)

- Use GIS to:

  1. Intersect industrial area and grid

  2. Calculate area of new polygons (calculate geometry)

  3. Calculate share of total industrial area for each polygon

Industrial area

1 km x 1 km grid

Intersection of industrial area and 1 km x 1 km grid

Spatial distribution key (2)

- Example of spatial distribution keys based on road network, buildings and population density, respectively.

GridID	ShareOfLength
1km_6149_600	0,01691
1km_6150_599	0,00847
……….	…….
1km_6150_600	0,06
1km_6150_601	0,01
Grand Total	**1,000**

GridID	ShareOfBuildArea
1km_6151_598	0,00022
1km_6151_599	0,00045
……….	…….
1km_6151_607	0,028
1km_6151_608	0,034
Grand Total	**1,000**

GridID	ShareOfCapita
1km_6149_600	0,00114
1km_6149_601	0,00023
……….	……….
1km_6150_597	0,00564
1km_6150_599	0,00177
Grand Total	**1,00000**

Output data

TOTAL CITY EMISSIONS FOR AREA SOURCES				
SNAP	**NOx**	**SO2**	**CO**	**TSP**
02	1403.229	7.016	701.614	51.452

SPATIAL DISTRIBUTION KEY		GRIDDED EMISSIONS			
GridID	**ShareOfArea**	**NOx**	**SO2**	**CO**	**TSP**
		E(cell) = E(city) * ShareOfArea			
1km_3737_511	0.0081	11.3927	0.0570	5.6964	0.4177
1km_3737_512	0.0005	0.6911	0.0035	0.3455	0.0253
1km_3738_458	0.0032	4.4288	0.0221	2.2144	0.1624
1km_3738_511	00032	4.4246	0.0221	2.2123	0.1622
1km_3738_512	0.0033	4.7005	0.0235	2.3503	0.1724
.....	.....	.....	.....	.....	.....
1km_3754_513	0.0000	0.0055	0.0000	0.0027	0.0002
1km_3754_514	0.0000	0.0596	0.0003	0.0298	0.0022
SUM	**1.0000**	**1403.229**	**7.016**	**701.614**	**51.452**

Output
Emission maps

Output
Input to air quality modelling

- Output for point sources to the air quality modelling:

SNAP	X	Y	Projection	Stack height	No$_x$	SO$_2$	NMVOC	CO	TSP	PM$_{10}$	PM$_{2.5}$
03	451234,12	4321234,65	UTM38N	100							
03	452345,12	4322345,65	UTM38N	100							
01	453456,12	4323456,65	UTM38N	150							
03	454567,12	4324567,65	UTM38N	100							

- Output for area sources to the air quality modelling:

SNAP	GridID	X	Y	Projection	Z	NO$_x$	SO$_2$	NMVOC	CO	TSP	PM$_{10}$	PM$_{2.5}$
02	1km_4321_451	451234	4321234	UTM38N								
02	1km_4322_452	452345	4322345	UTM38N								
…	…	…	…	…								
07	1km_4323_453	453456	4323456	UTM38N								
07	1km_4324_454	454567	4324567	UTM38N								

Thank you for your attention