DEPARTMENT OF ENVIRONMENTAL SCIENCE
AARHUS UNIVERSITY

The spatial model

Stakeholder workshop

Marlene Plejdrup, Ole-Kenneth Nielsen, Henrik Bruun, Jesper Christensen & Steen Gyldenkærne

November 28, 2018

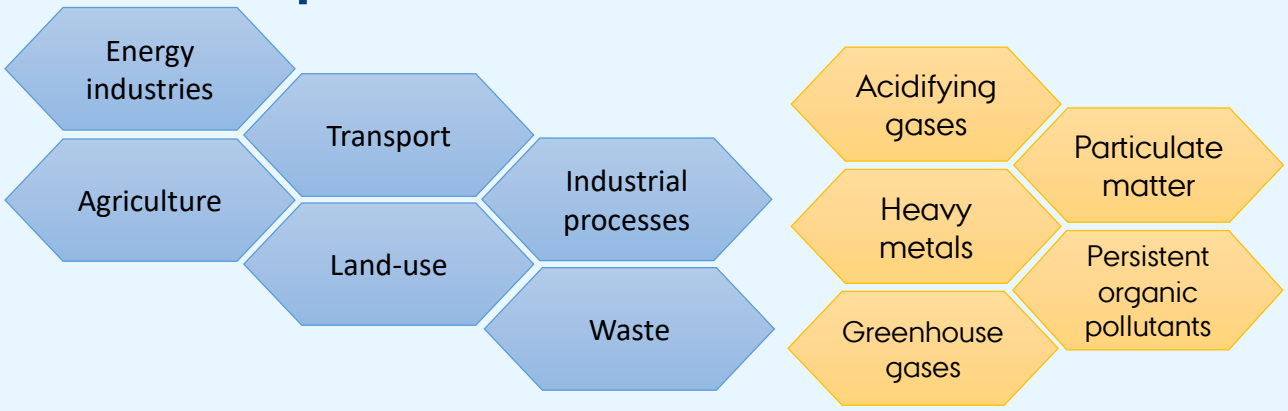
Dublin

Outline

- Model description
  - Spatial distribution keys (GeoKeys)
  - Data integration
- Results from the national model
  - Selected results
- Case study for Dublin
  - Improvements
  - Recalculated GeoKeys
  - Road transport

The spatial emission model

- Complete spatial emission mapping on 1 km x 1 km resolution for the Irish Exclusive Economic Zone
- State-of-the-art integrated database system focusing on performance optimisation
- Includes all sectors and all pollutants in the Irish emission inventory
  - 177 sectors
  - 32 pollutants



- Integrates official statistics and spatial information

Data used in the model

- National statistics, e.g. National census, Census of Agriculture
- Facility level data, e.g. PRTR reporting, ETS reporting
- Digital spatial data
  - Point themes
    - Buildings
    - Airports
  - Line themes
    - Road network
    - Aviation cruise
  - Polygon theme
    - Mines and quarries
    - LPIS
    - Land-use maps
    - Administrative units

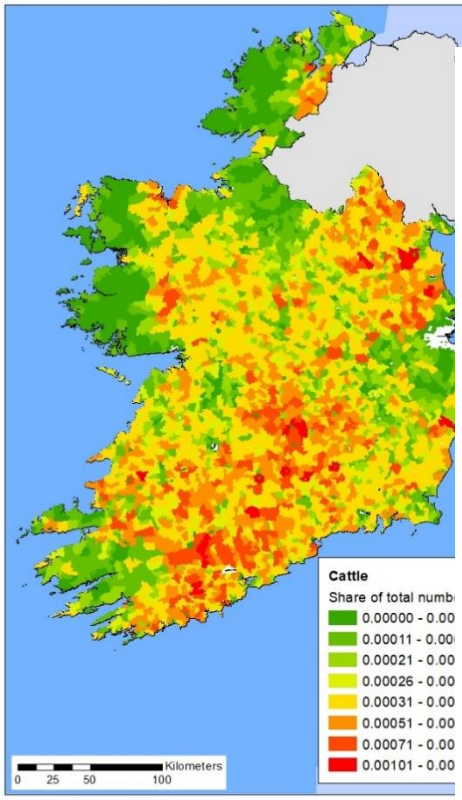
Spatial distribution keys – GeoKeys

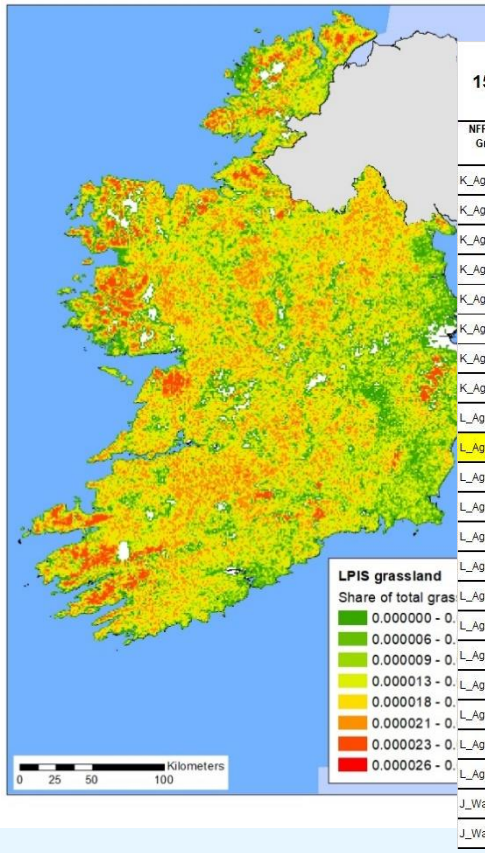
- A GeoKey is a normalized table holding shares of a national sectoral emission, which should be allocated to the individual cells in a grid
- Σ(shares) = 1
- Separate GeoKeys are prepared for each NFR/CRF sector
- Some GeoKeys are applied for more sectors

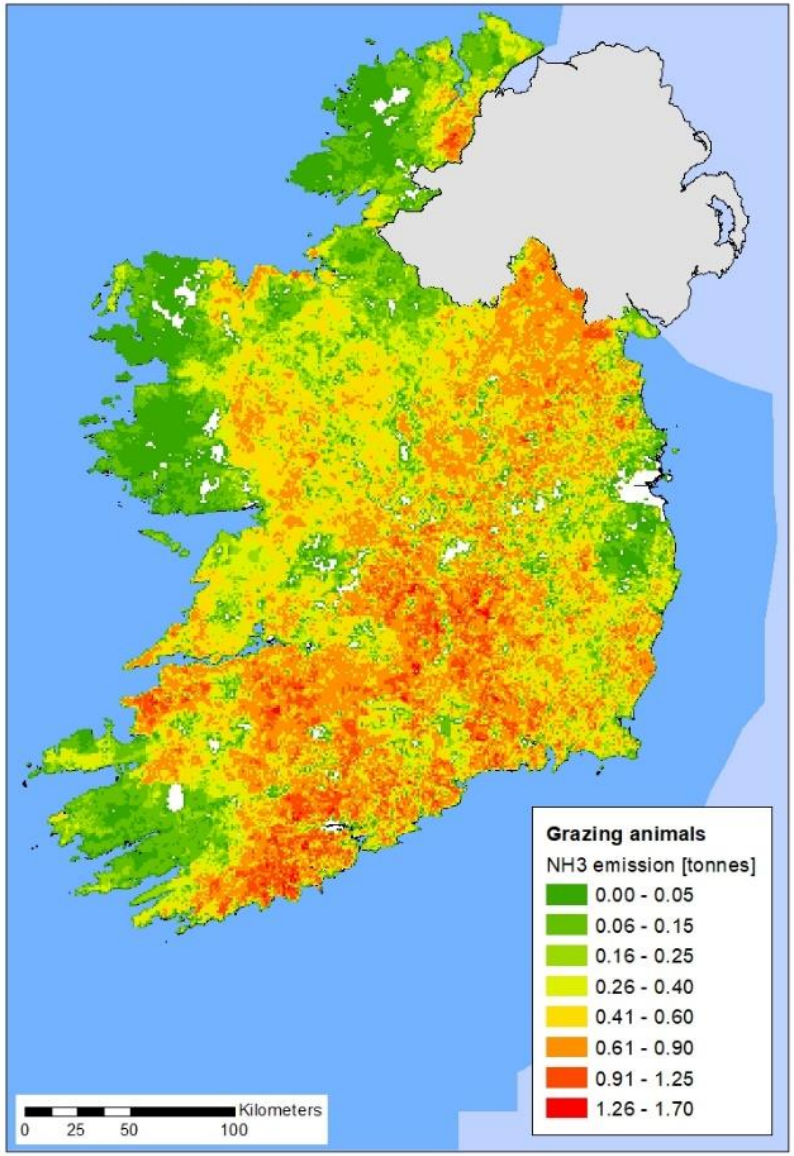
Spatial distribution keys – GeoKeys

- Depending on the spatial data available the sectoral GeoKeys
  - apply to all years and all pollutants
  - are year specific
  - are pollutant specific (for selected pollutants or groups of pollutants)
  - are year and pollutant specific
- Some GeoKeys are created as a combination of two or more sub-sector keys
  - e.g. when a NFR sector covers both point sources and area sources

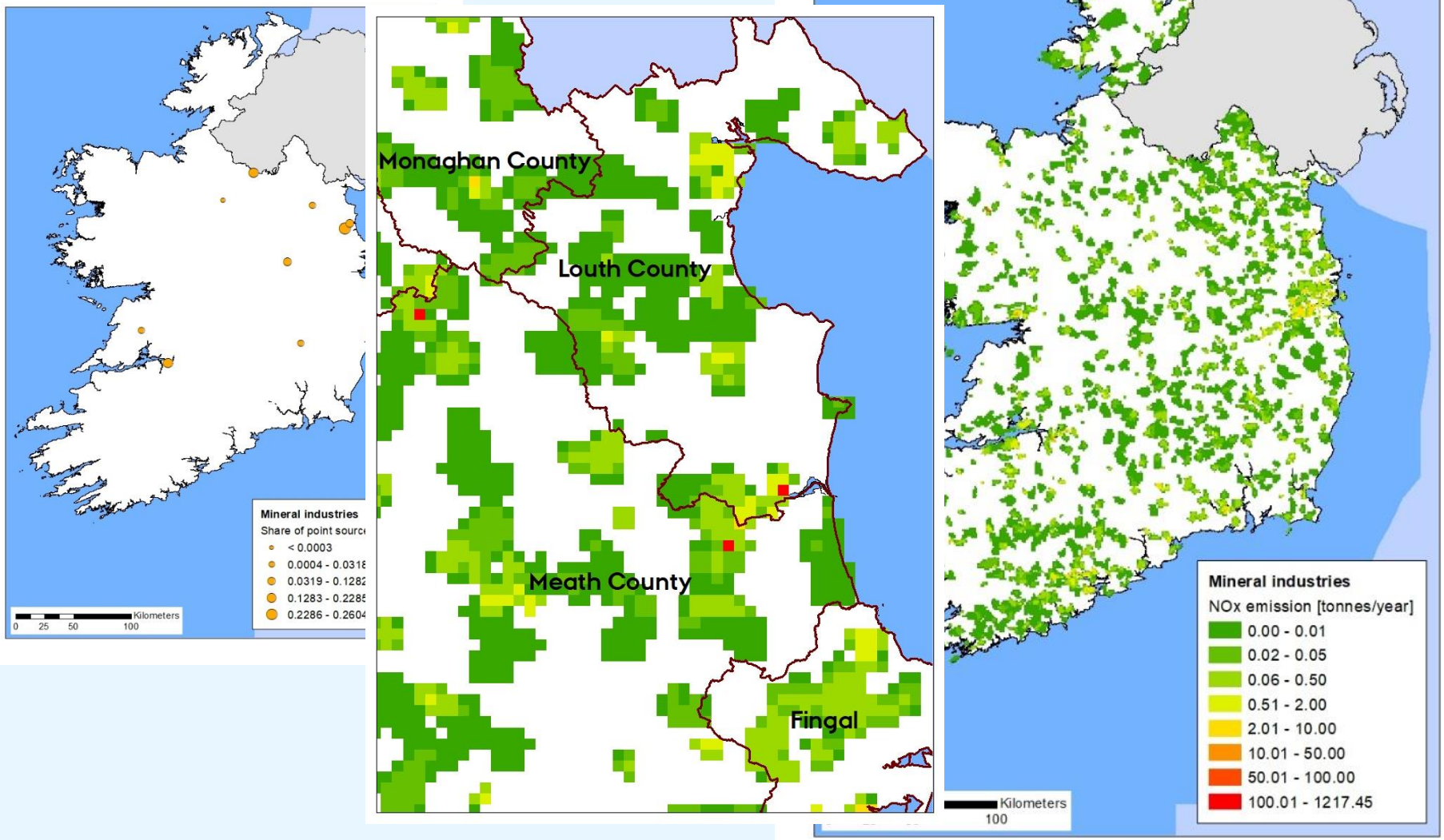
Data integration





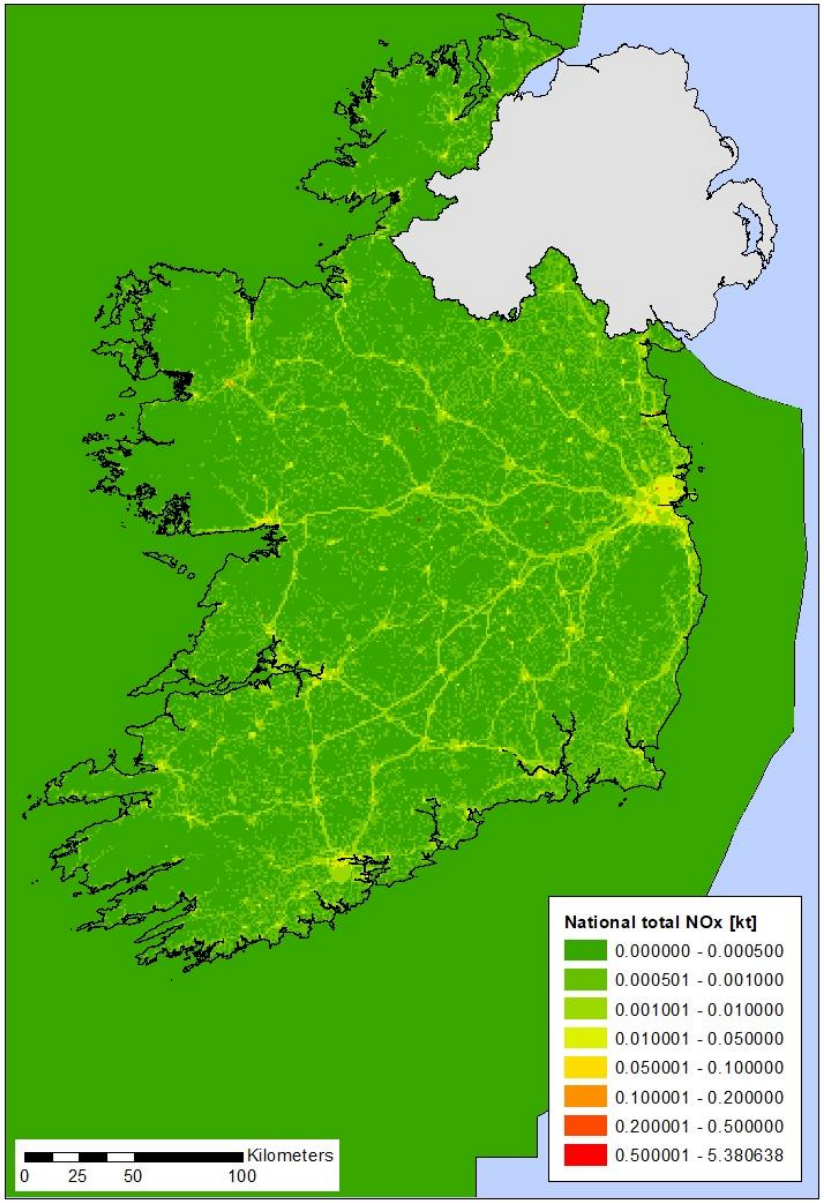


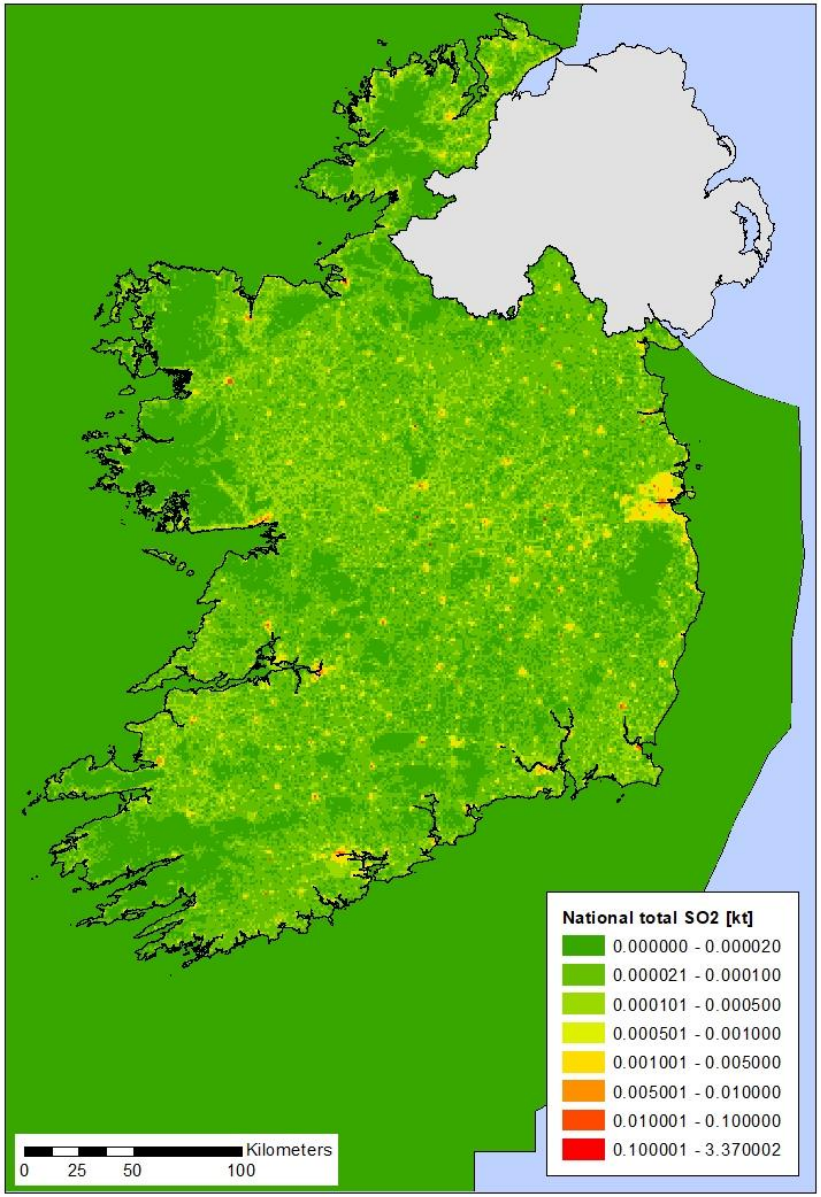
Data integration

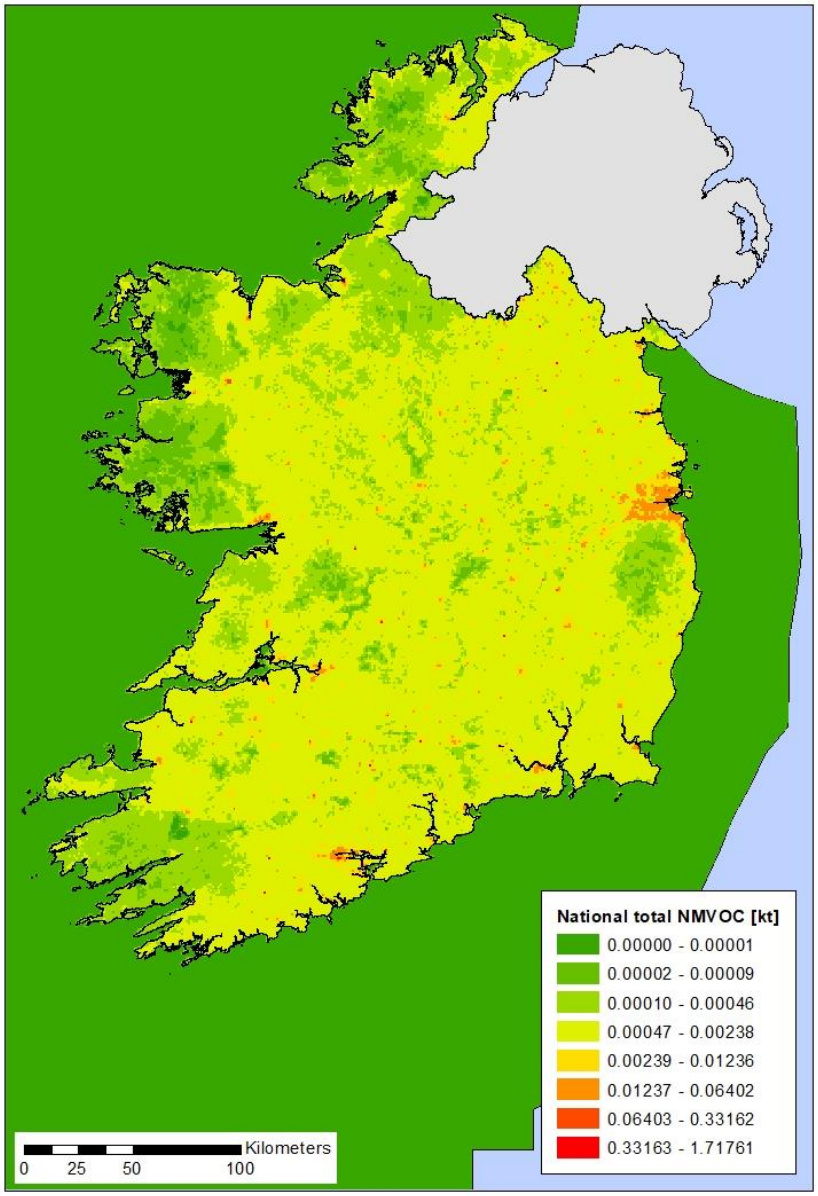


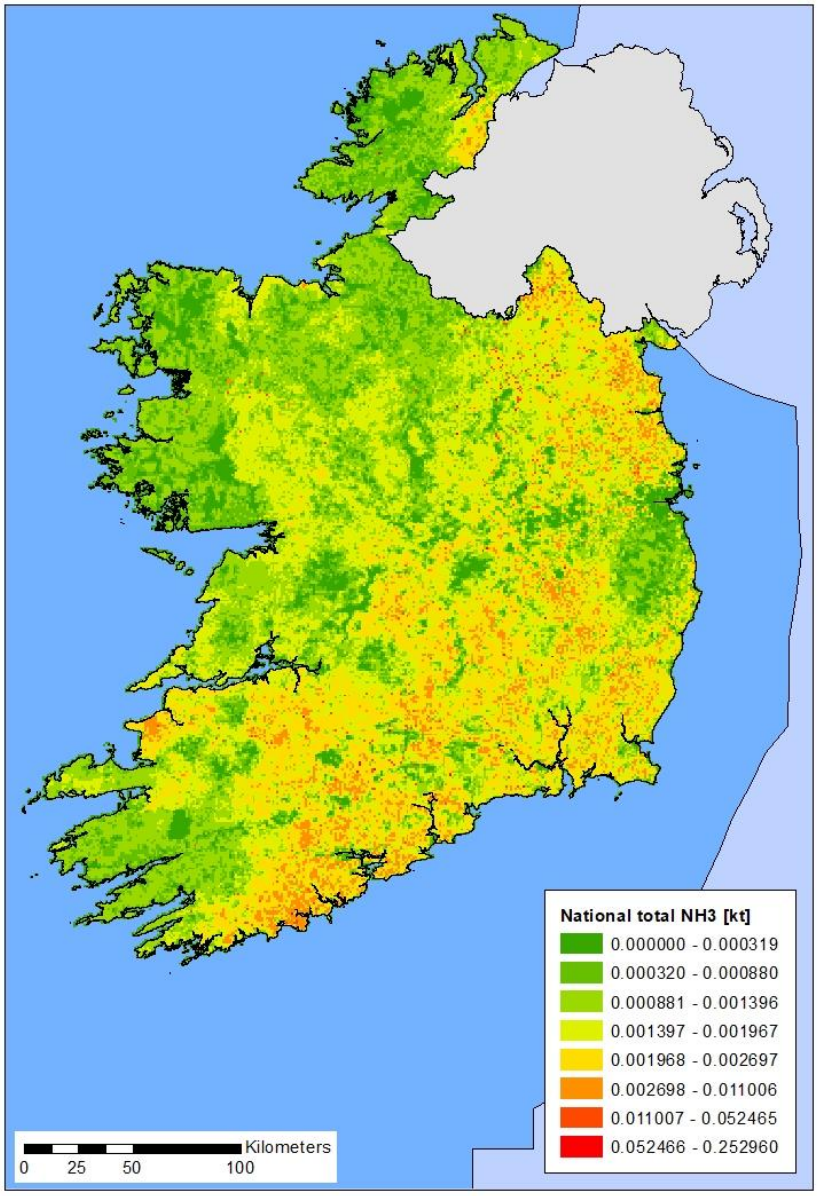
Results from the model

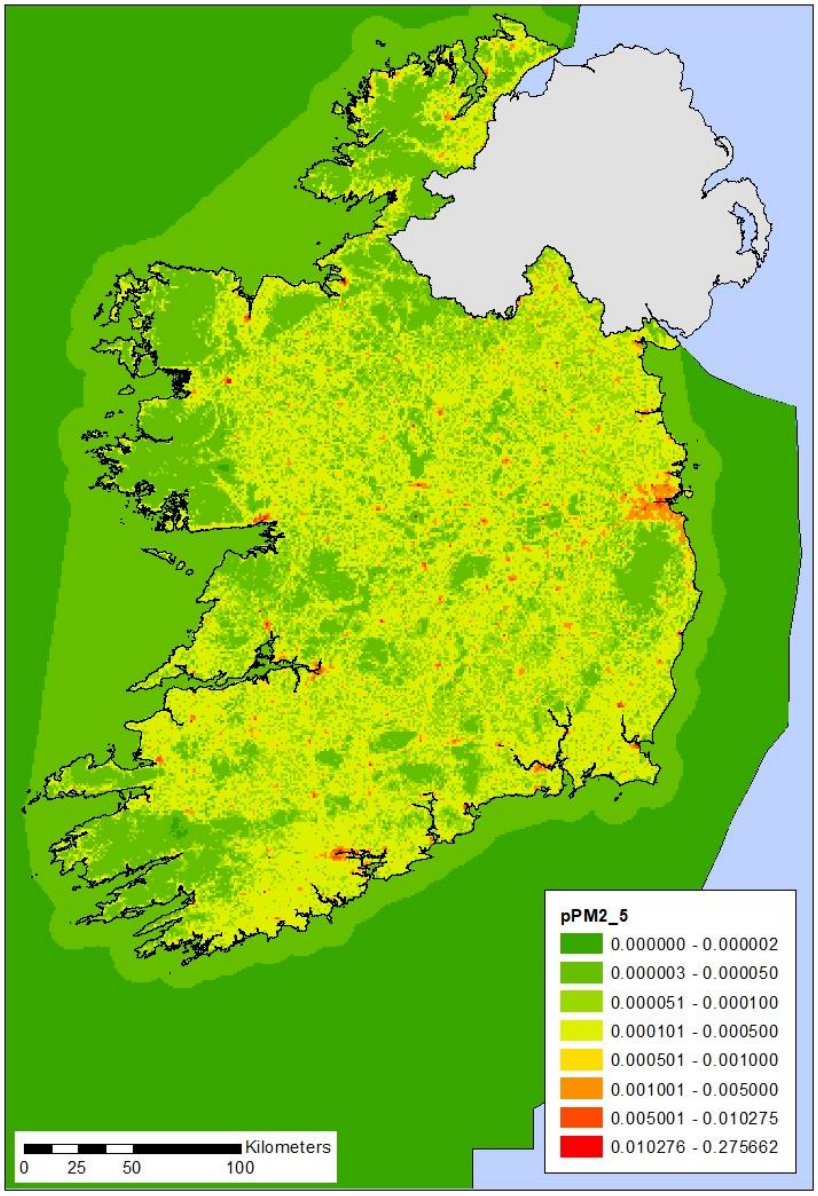
- The output from the model is aggregated to the national total emissions as well as to main sectoral emissions following the EMEP classification
- Output is available on the project website both as images and as data files for further processing in GIS
- Maps typically illustrate the spatial pattern of the dominant sector(s)

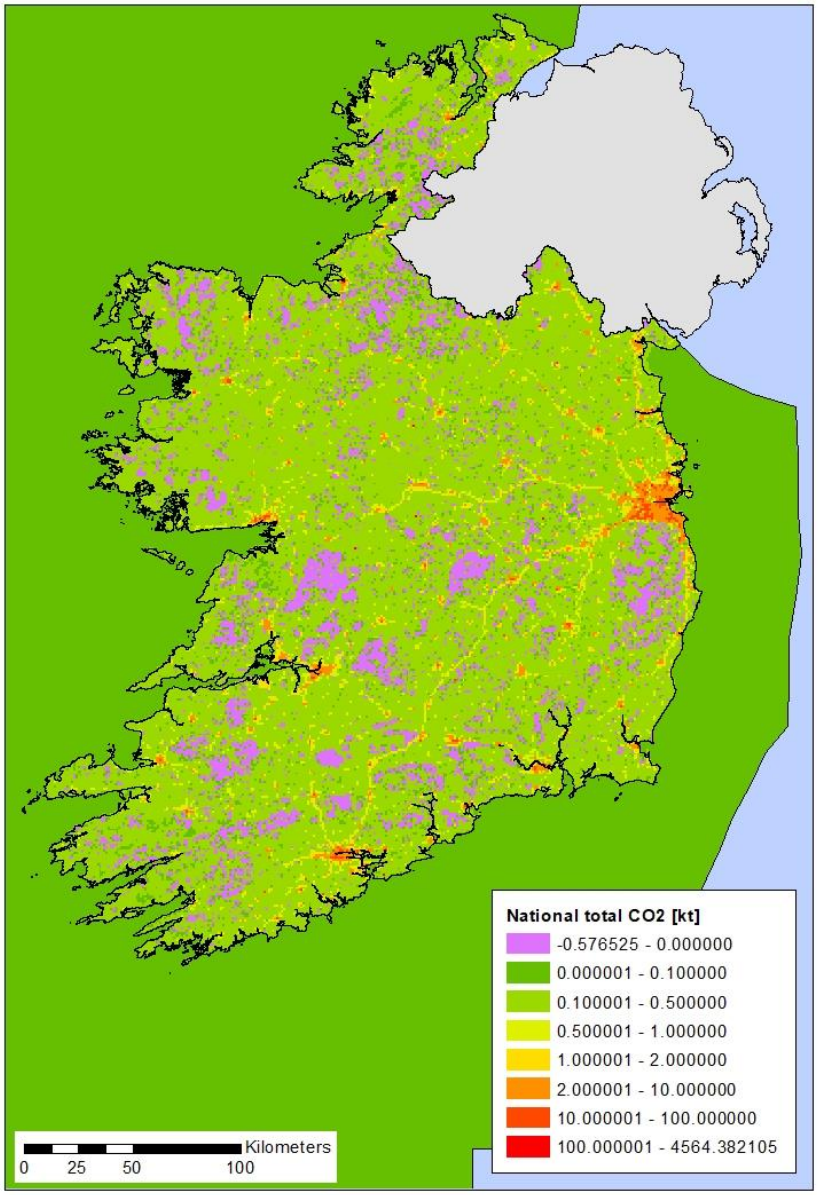

National total NOx [kt]
0.000000 - 0.000500
0.000501 - 0.001000
0.001001 - 0.010000
0.010001 - 0.050000
0.050001 - 0.100000
0.100001 - 0.200000
0.200001 - 0.500000
0.500001 - 5.380638
Kilometers
0 25 50 100

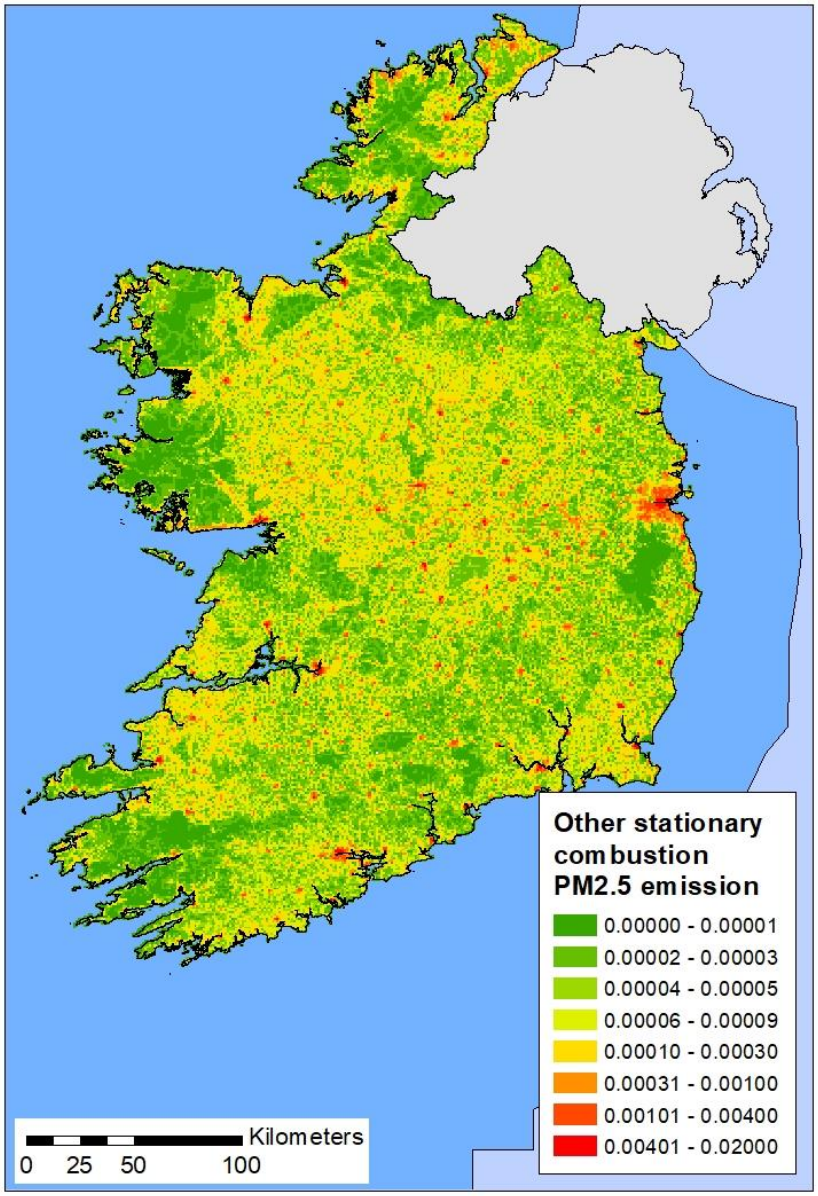

National total SO2 [kt]
0.000000 - 0.000020
0.000021 - 0.000100
0.000101 - 0.000500
0.000501 - 0.001000
0.001001 - 0.005000
0.005001 - 0.010000
0.010001 - 0.100000
0.100001 - 3.370002
Kilometers
0 25 50 100

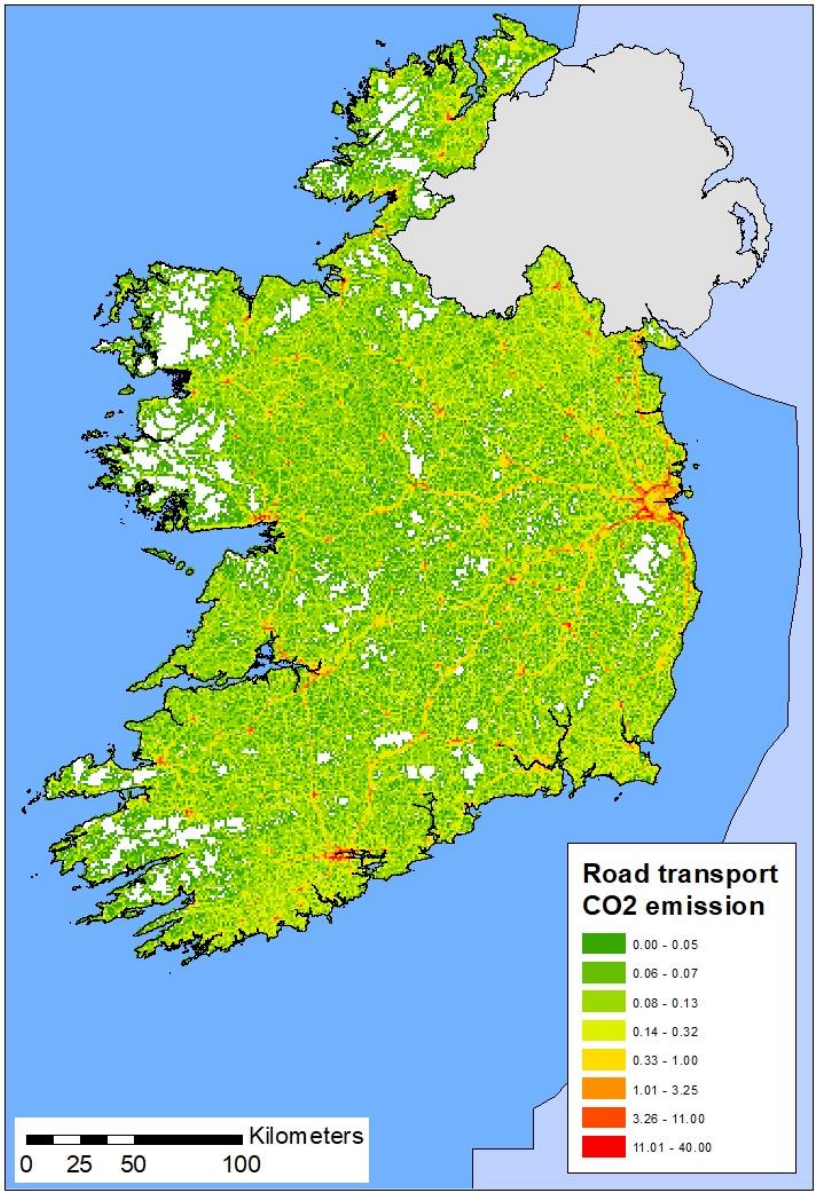

National total NMVOC [kt]
0.00000 - 0.00001
0.00002 - 0.00009
0.00010 - 0.00046
0.00047 - 0.00238
0.00239 - 0.01236
0.01237 - 0.06402
0.06403 - 0.33162
0.33163 - 1.71761
Kilometers
0 25 50 100

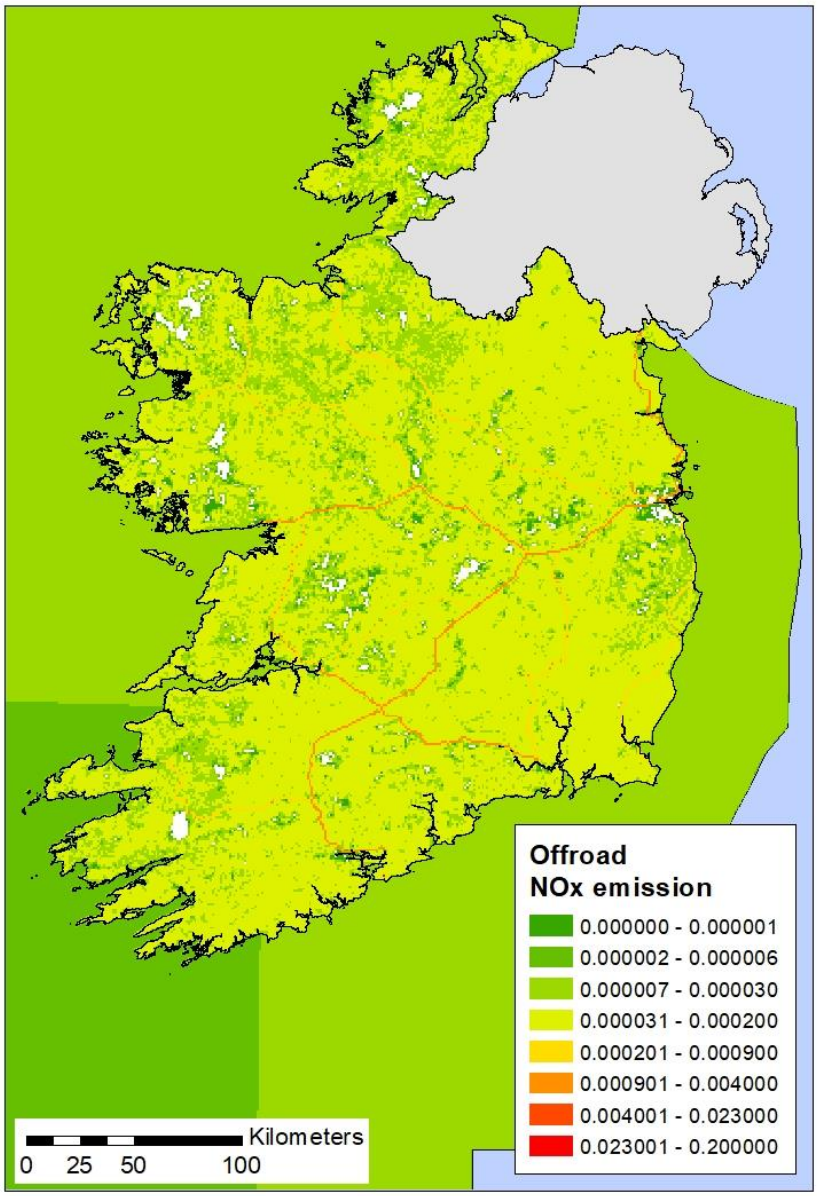

National total NH3 [kt]
0.000000 - 0.000319
0.000320 - 0.000880
0.000881 - 0.001396
0.001397 - 0.001967
0.001968 - 0.002697
0.002698 - 0.011006
0.011007 - 0.052465
0.052466 - 0.252960
Kilometers
0 25 50 100

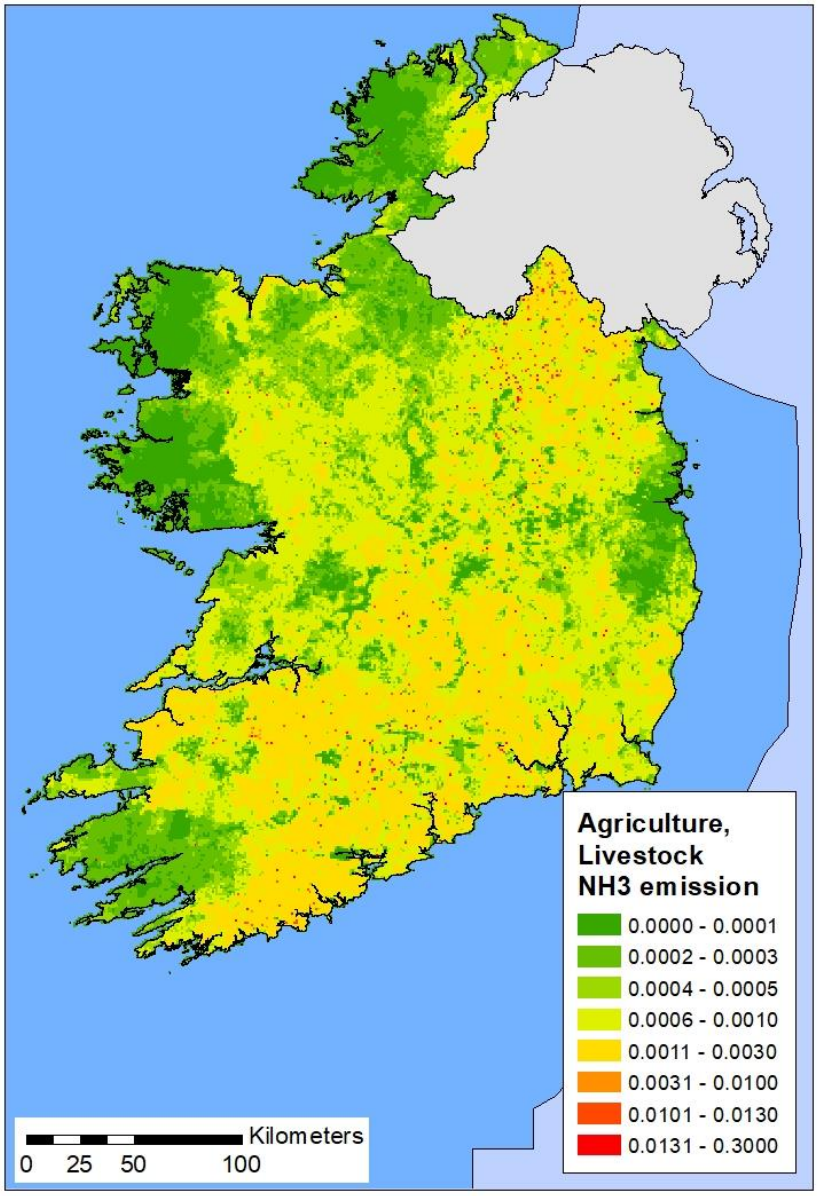

pPM2_5
0.000000 - 0.000002
0.000003 - 0.000050
0.000051 - 0.000100
0.000101 - 0.000500
0.000501 - 0.001000
0.001001 - 0.005000
0.005001 - 0.010275
0.010276 - 0.275662
Kilometers
0 25 50 100


National total CO2 [kt]
-0.576525 - 0.000000
0.000001 - 0.100000
0.100001 - 0.500000
0.500001 - 1.000000
1.000001 - 2.000000
2.000001 - 10.000000
10.000001 - 100.000000
100.000001 - 4564.382105
Kilometers
0 25 50 100


Other stationary combustion PM2.5 emission
0.00000 - 0.00001
0.00002 - 0.00003
0.00004 - 0.00005
0.00006 - 0.00009
0.00010 - 0.00030
0.00031 - 0.00100
0.00101 - 0.00400
0.00401 - 0.02000
Kilometers
0 25 50 100


Road transport
CO2 emission
0.00 - 0.05
0.06 - 0.07
0.08 - 0.13
0.14 - 0.32
0.33 - 1.00
1.01 - 3.25
3.26 - 11.00
11.01 - 40.00
Kilometers
0 25 50 100


Offroad
NOx emission
0.000000 - 0.000001
0.000002 - 0.000006
0.000007 - 0.000030
0.000031 - 0.000200
0.000201 - 0.000900
0.000901 - 0.004000
0.004001 - 0.023000
0.023001 - 0.200000
Kilometers
0 25 50 100


Agriculture,
Livestock
NH3 emission
0.0000 - 0.0001
0.0002 - 0.0003
0.0004 - 0.0005
0.0006 - 0.0010
0.0011 - 0.0030
0.0031 - 0.0100
0.0101 - 0.0130
0.0131 - 0.3000
Kilometers
0 25 50 100

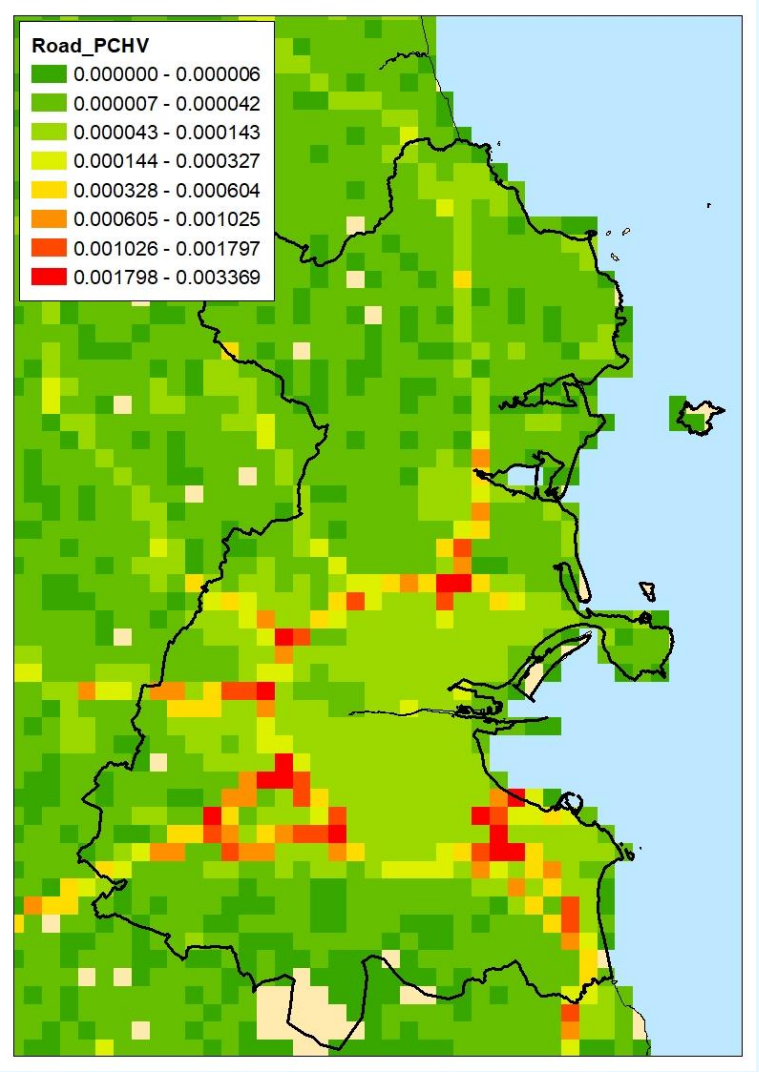
Dublin case study

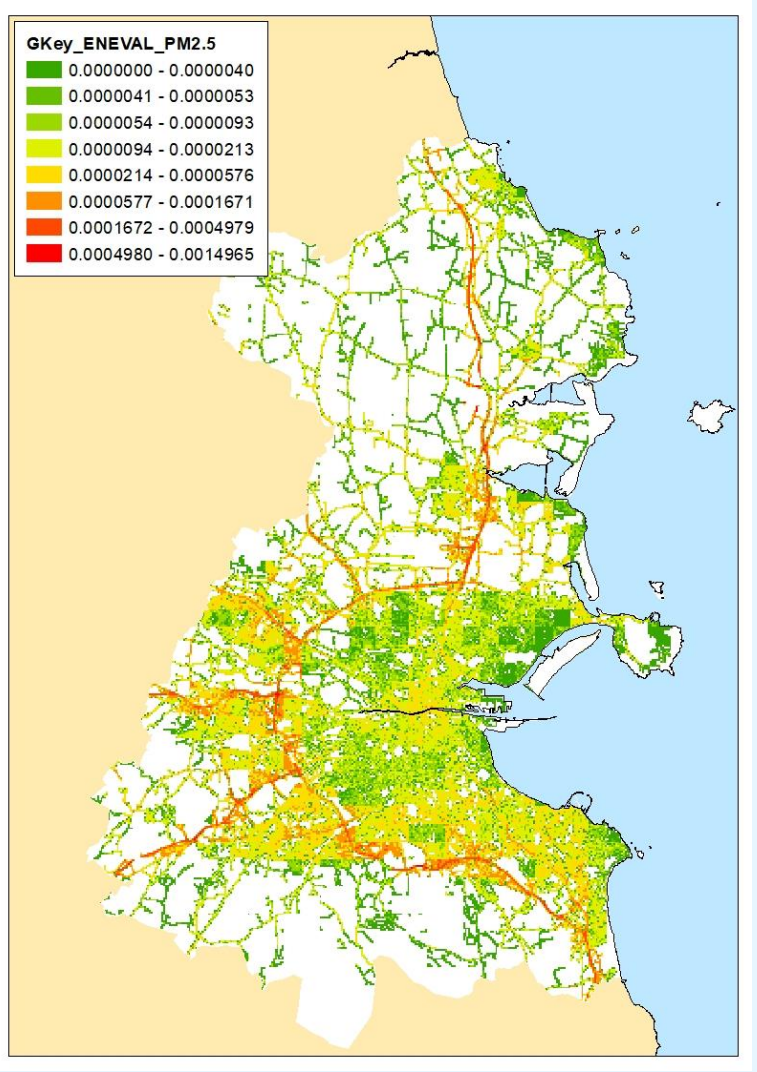
- Increased spatial resolution to 100 m x 100 m
- Improved basis for air quality modelling
- City scale gives better opportunity for comparison with measurements
- Include land based emissions from all NFR/CRF sectors
- Focus on NO_x, SO_2, NMVOC and $PM_{2.5}$
- The model setup allows for gridding of all pollutants in the Irish emission inventories
- The model is designed in a similar format as the national model

Dublin GeoKeys

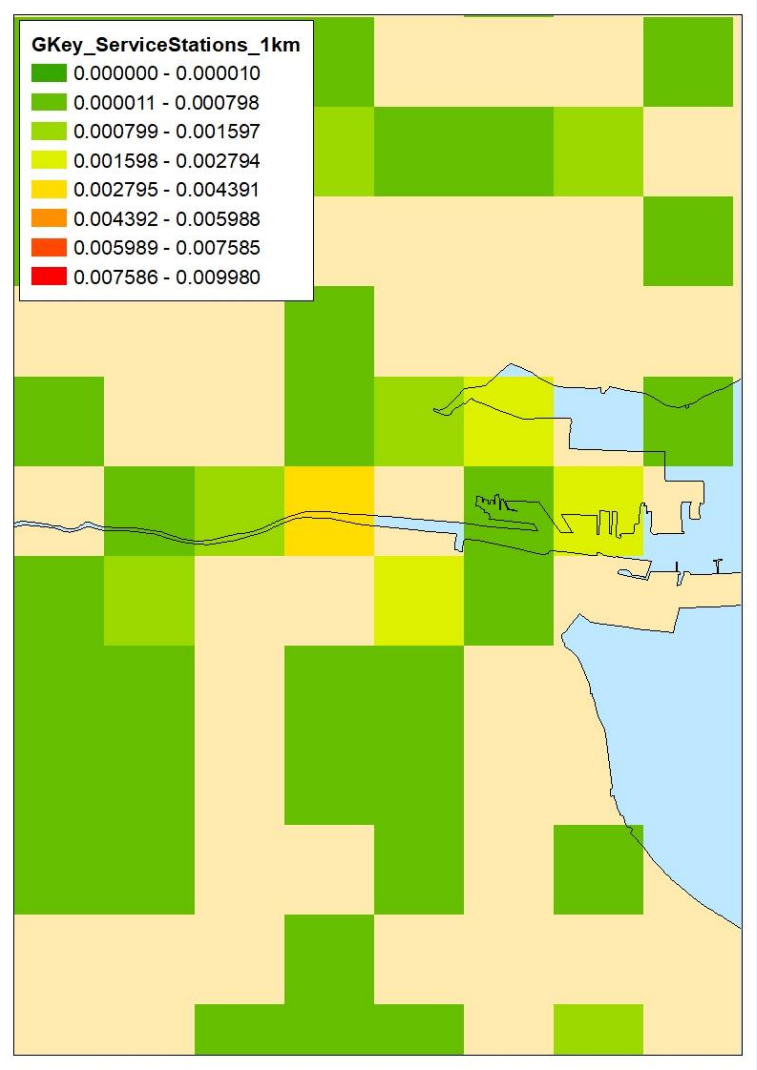
- Recalculation of all GeoKeys based on the original spatial data sets used in the national model
- Detailed point source data already included in the national model, e.g. large point sources
- Emissions from the ENEVAL model is included for road transport

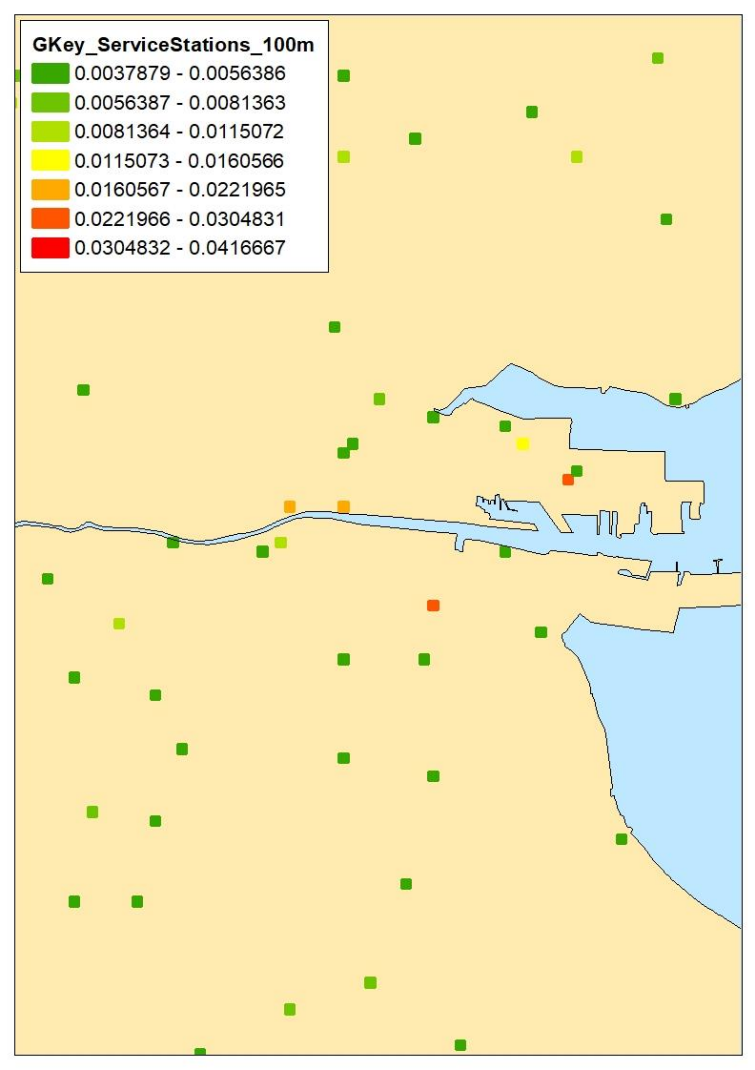
GeoKey for road transport



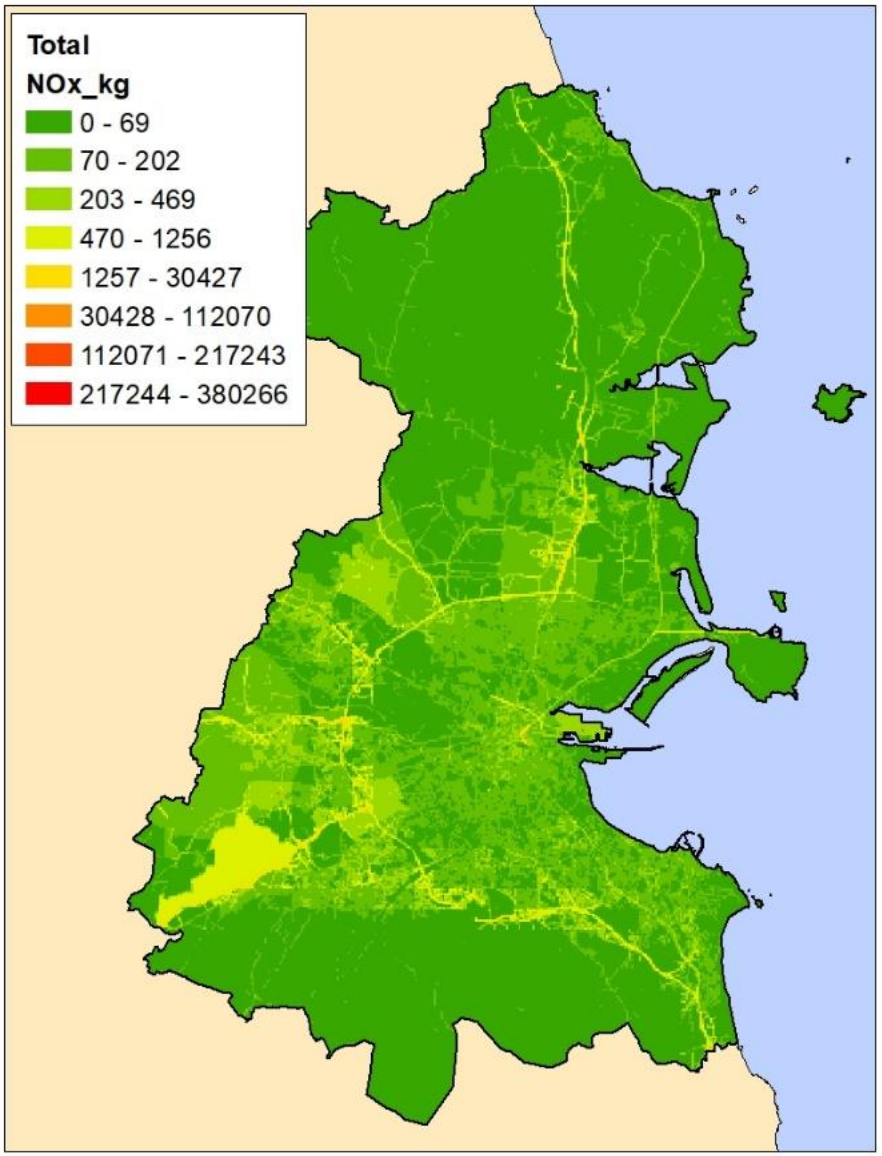


GeoKey for point sources (service stations)

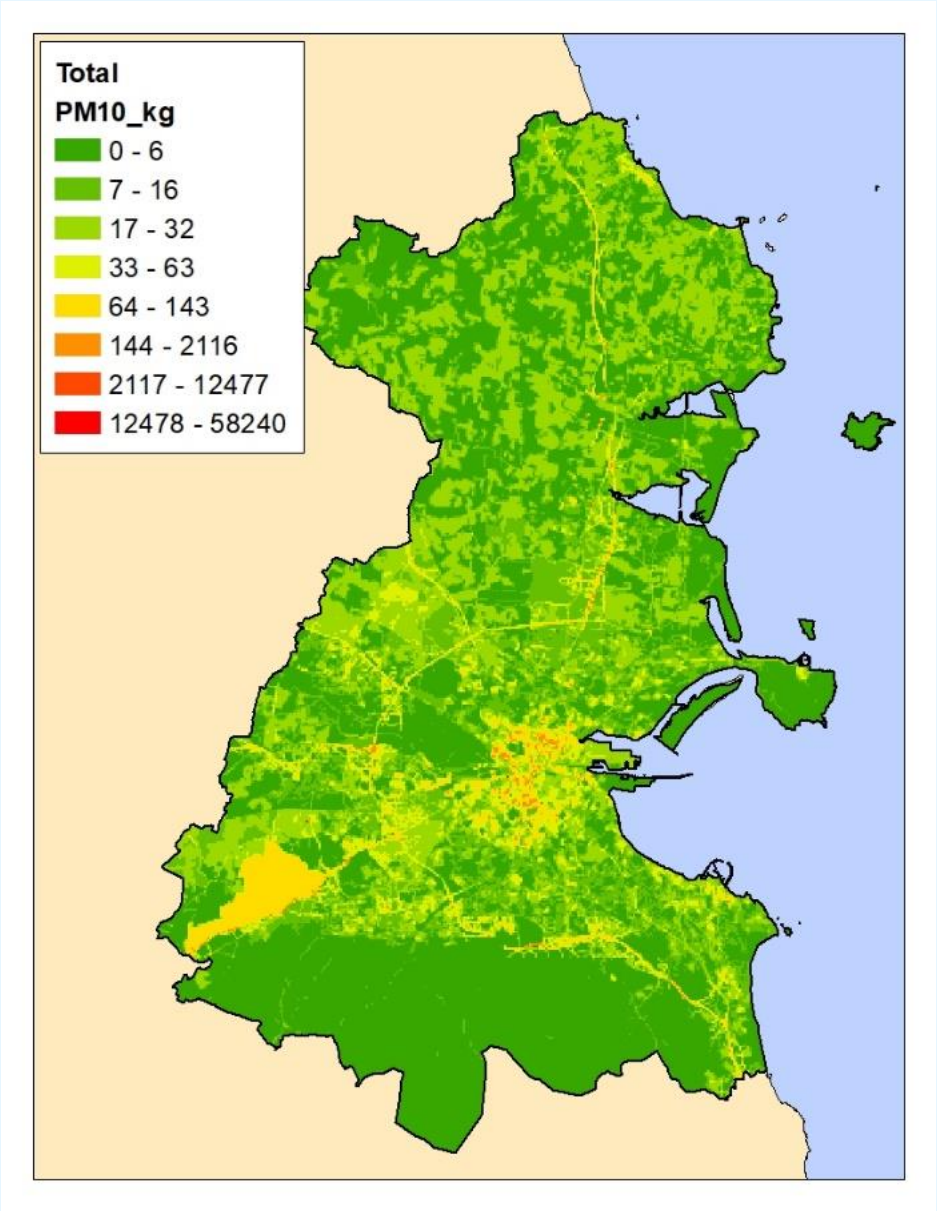




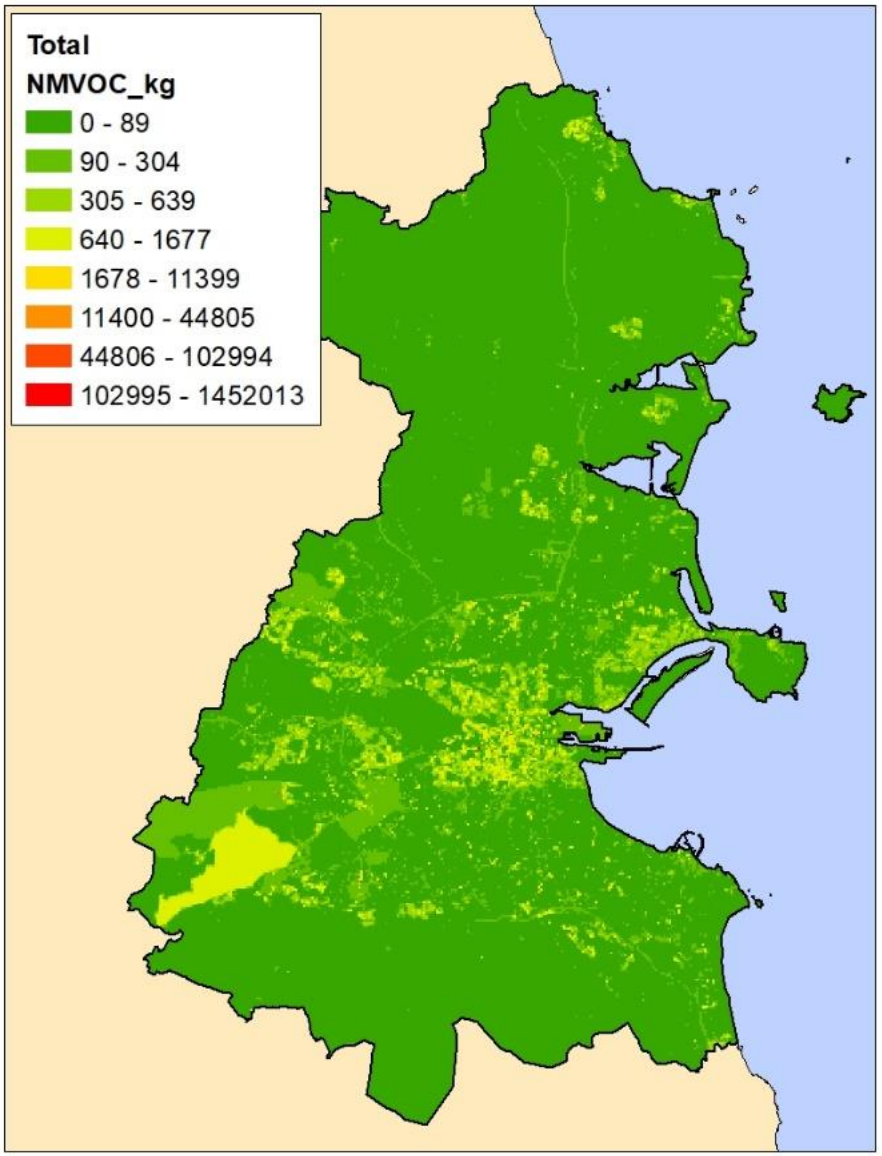
NO_x


Total
NOx_kg
0 - 69
70 - 202
203 - 469
470 - 1256
1257 - 30427
30428 - 112070
112071 - 217243
217244 - 380266

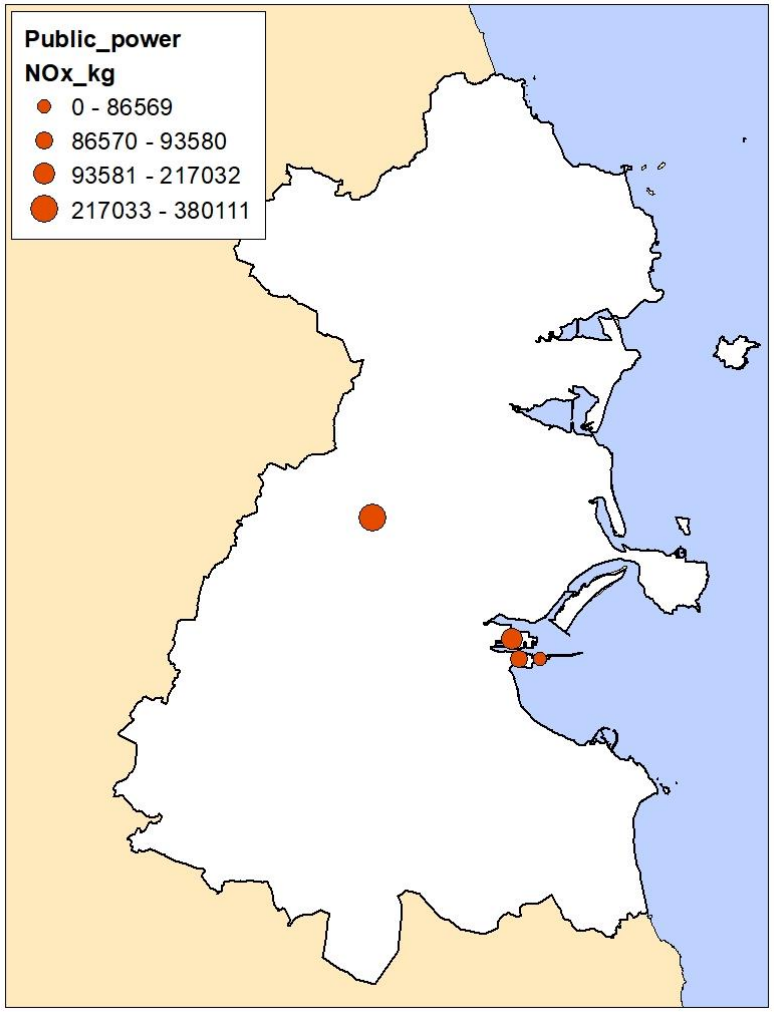
PM_{10}

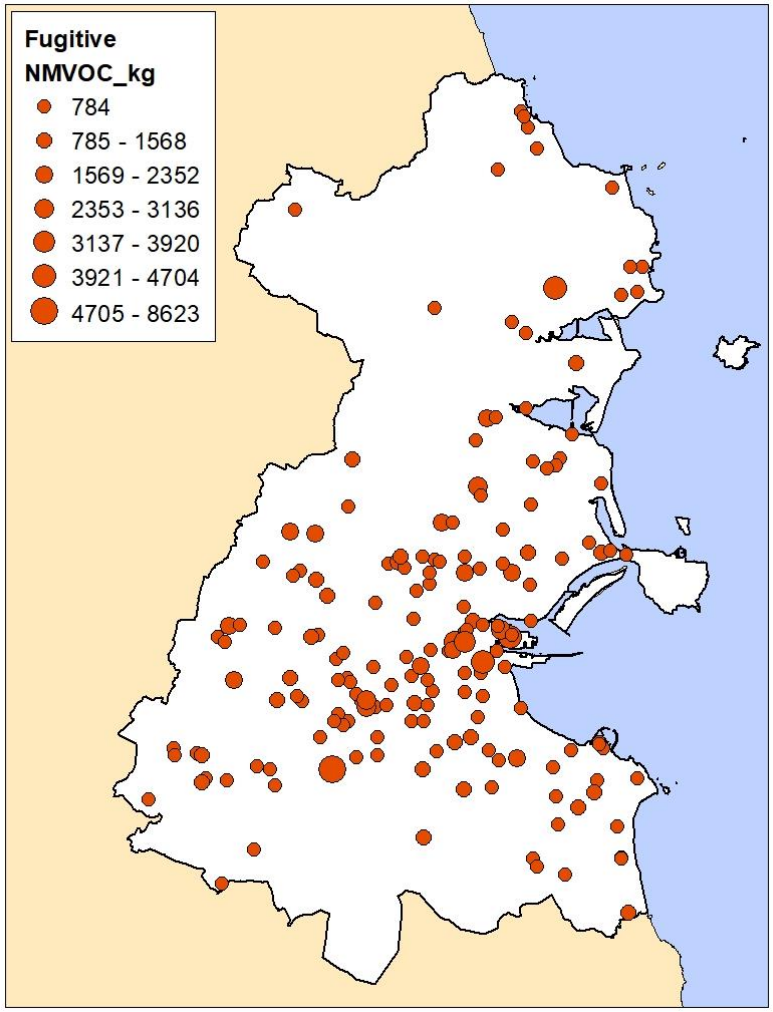

Total
PM10_kg
0 - 6
7 - 16
17 - 32
33 - 63
64 - 143
144 - 2116
2117 - 12477
12478 - 58240

NMVOC

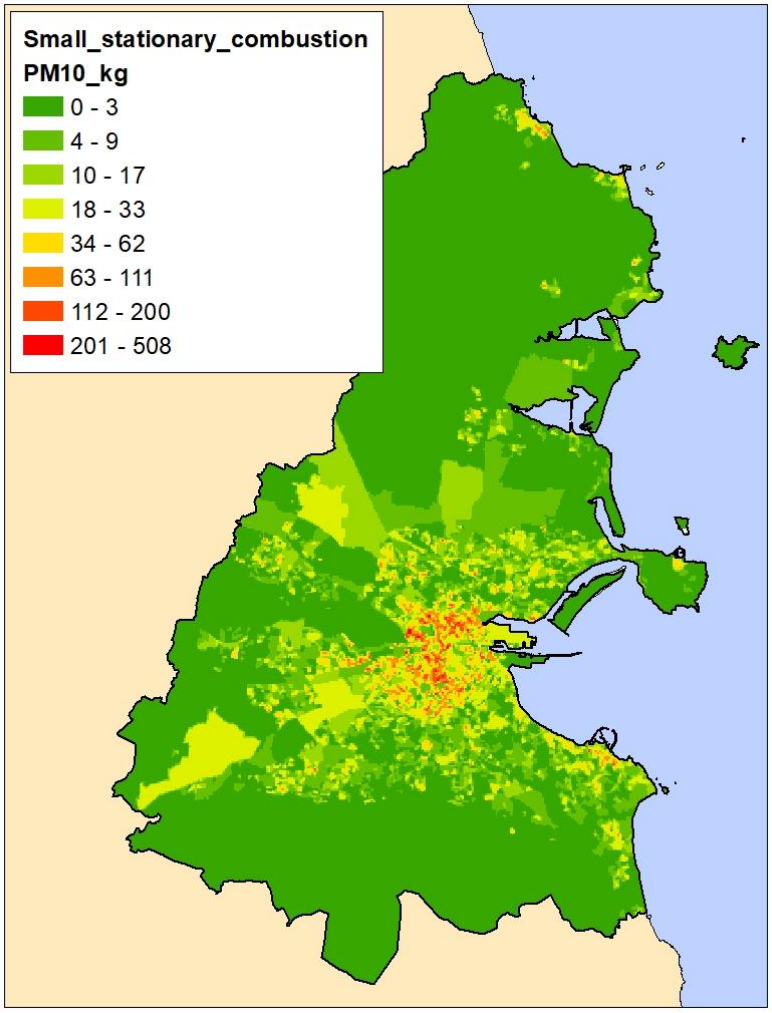

Total
NMVOC_kg
0 - 89
90 - 304
305 - 639
640 - 1677
1678 - 11399
11400 - 44805
44806 - 102994
102995 - 1452013

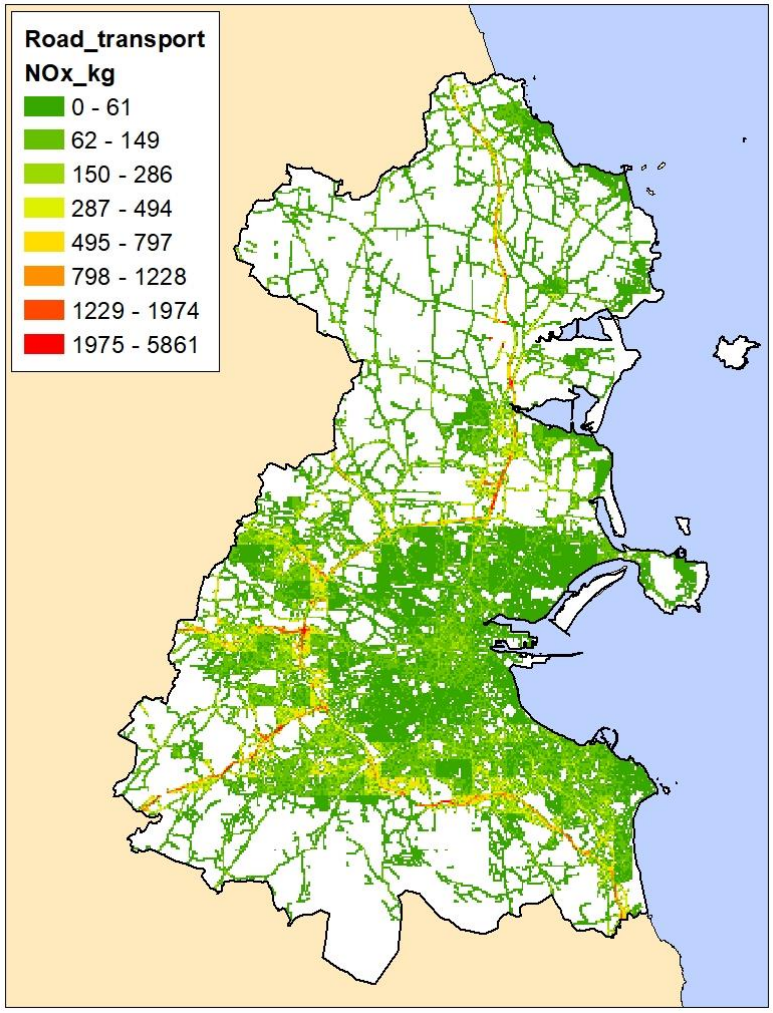
Public power and Service stations



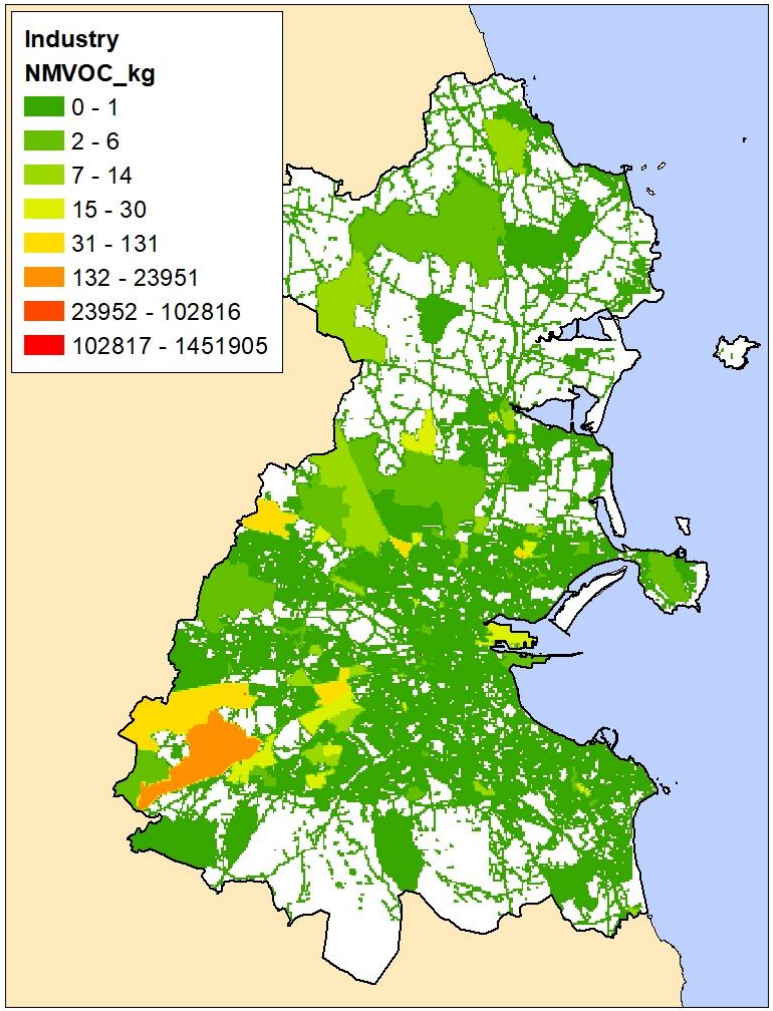


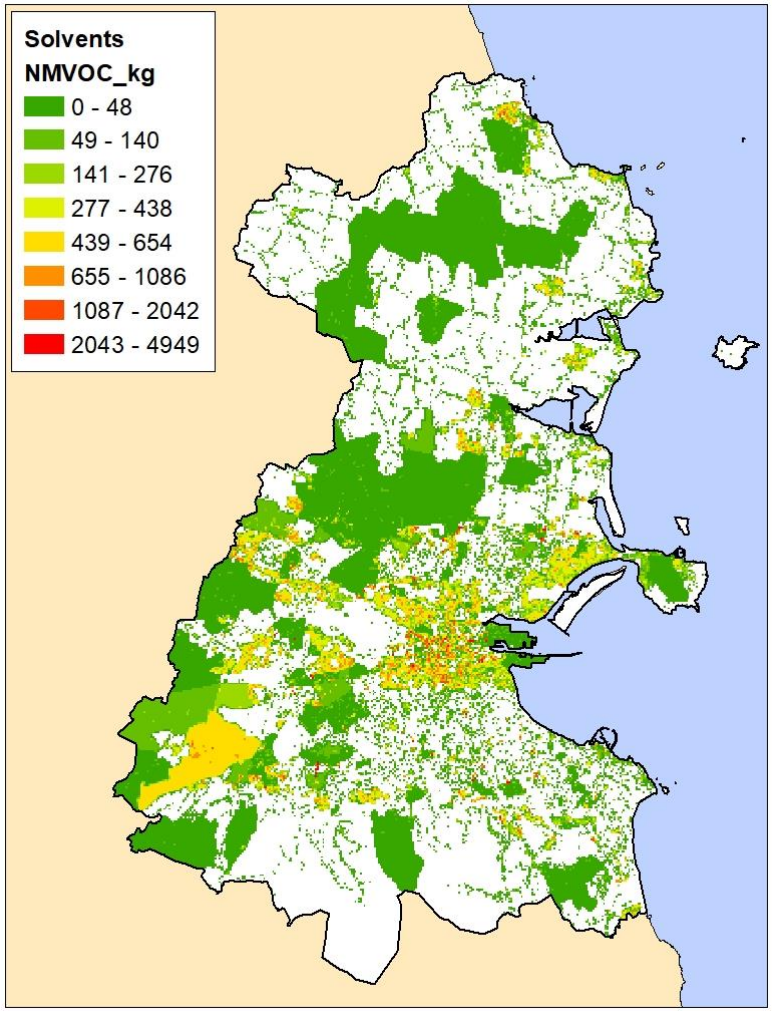
Residential combustion and road transport

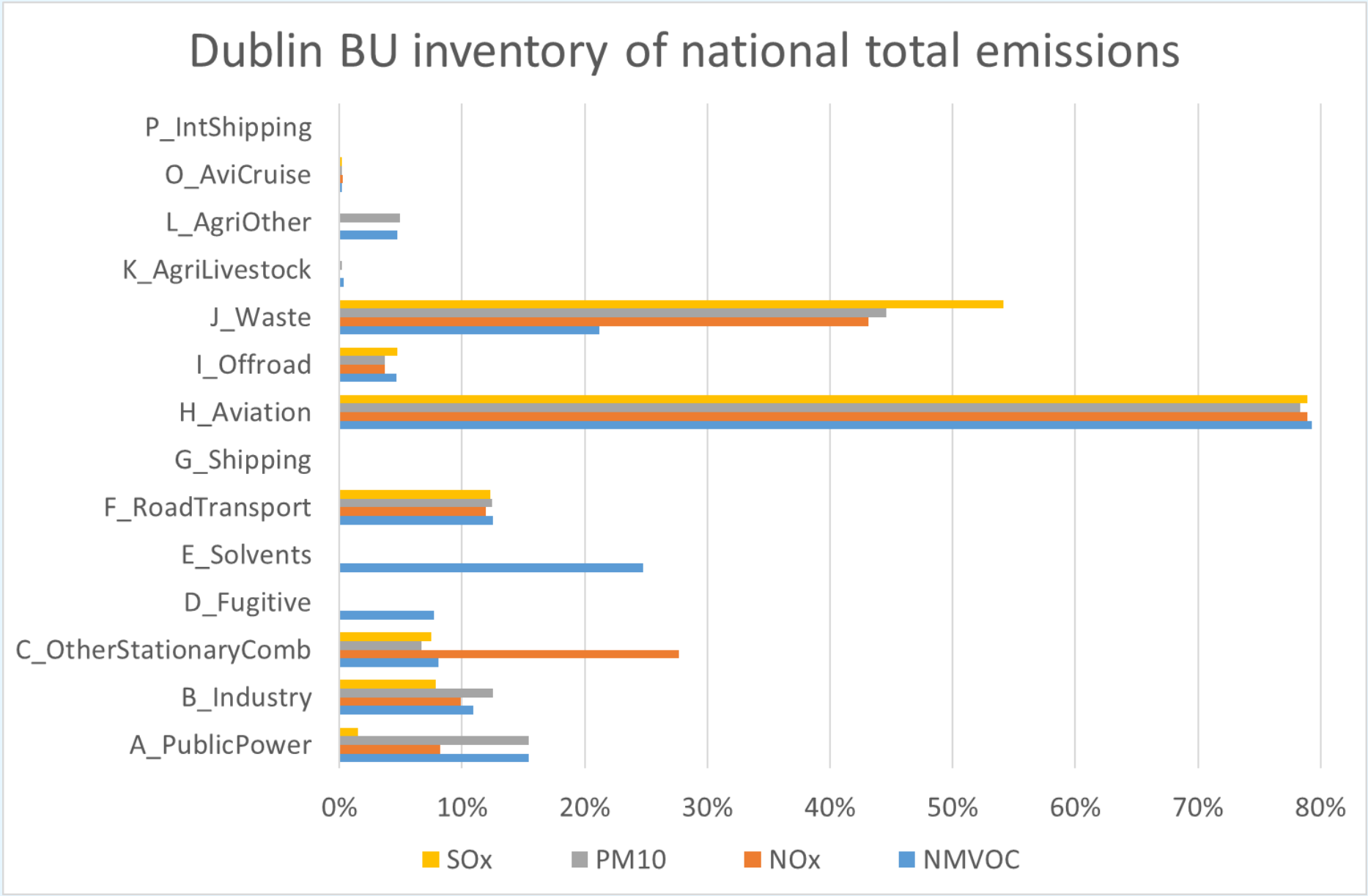


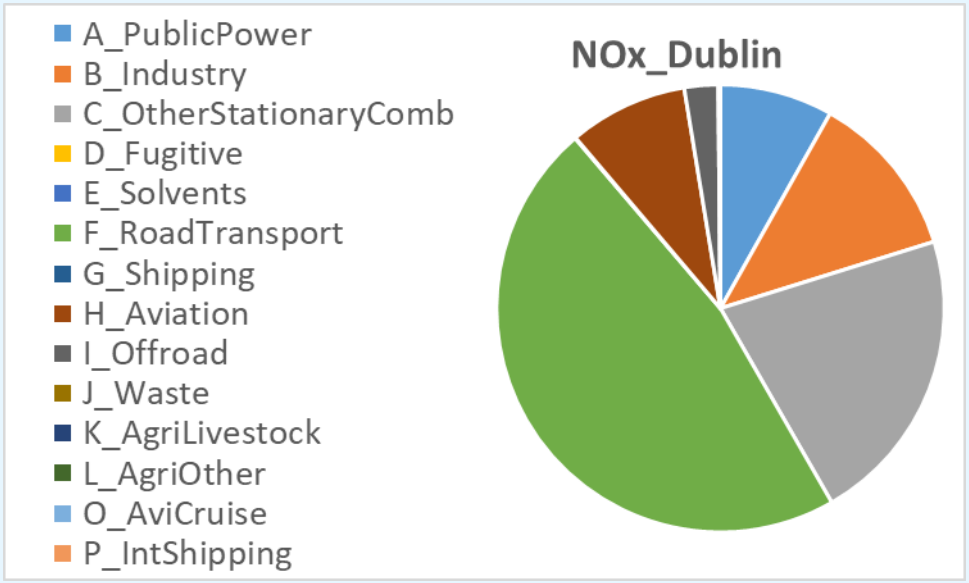


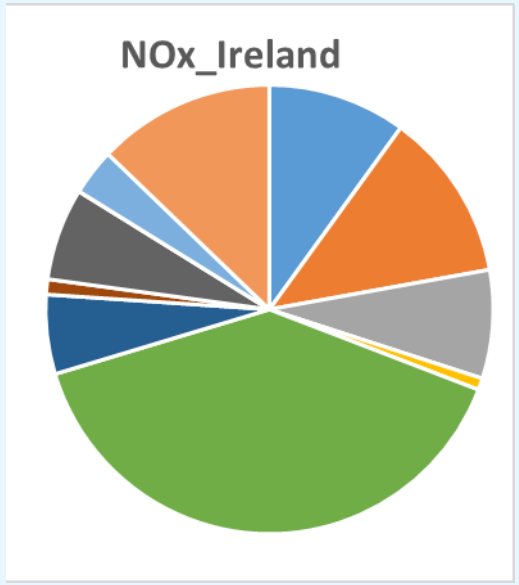
Industry and solvents

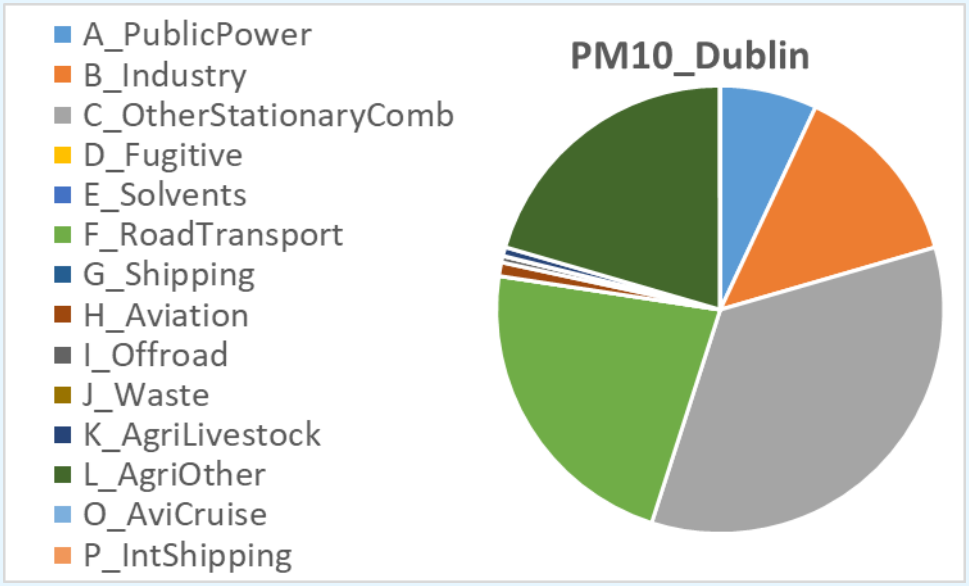


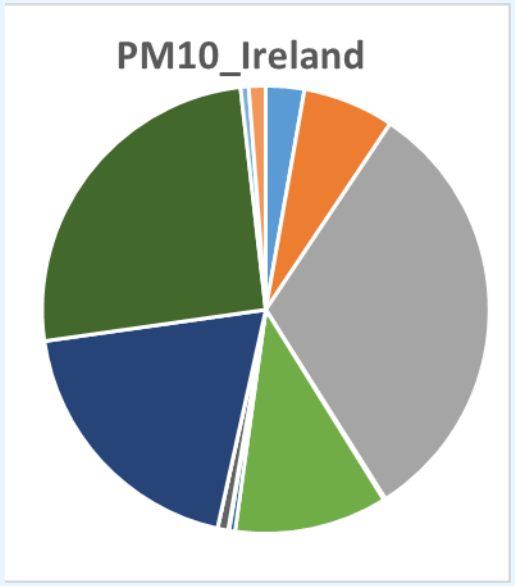


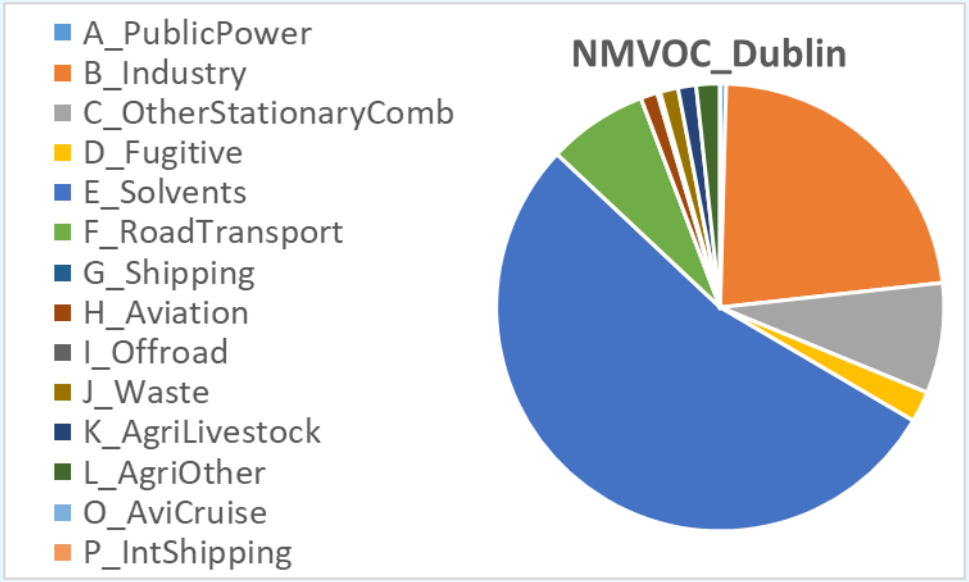

Dublin BU inventory of national total emissions
P_IntShipping
O_AviCruise
L_AgriOther
K_AgriLivestock
J_Waste
I_Offroad
H_Aviation
G_Shipping
F_RoadTransport
E_Solvents
D_Fugitive
C_OtherStationaryComb
B_Industry
A_PublicPower
0%
10%
20%
30%
40%
50%
60%
70%
80%
SOx
PM10
NOx
NMVOC

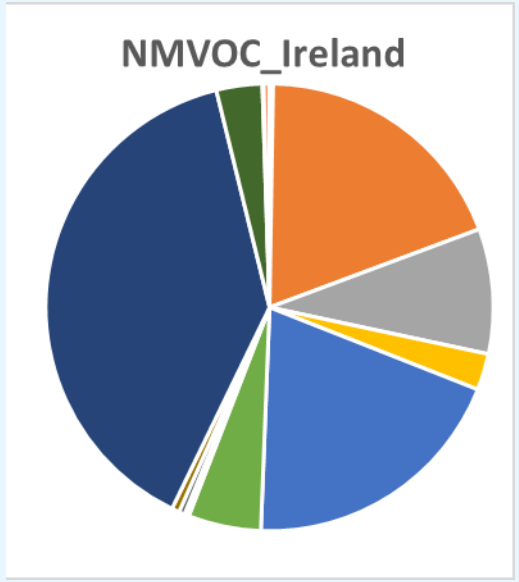

A_PublicPower
B_Industry
C_OtherStationaryComb
D_Fugitive
E_Solvents
F_RoadTransport
G_Shipping
H_Aviation
I_Offroad
J_Waste
K_AgriLivestock
L_AgriOther
O_AviCruise
P_IntShipping
NOx_Dublin

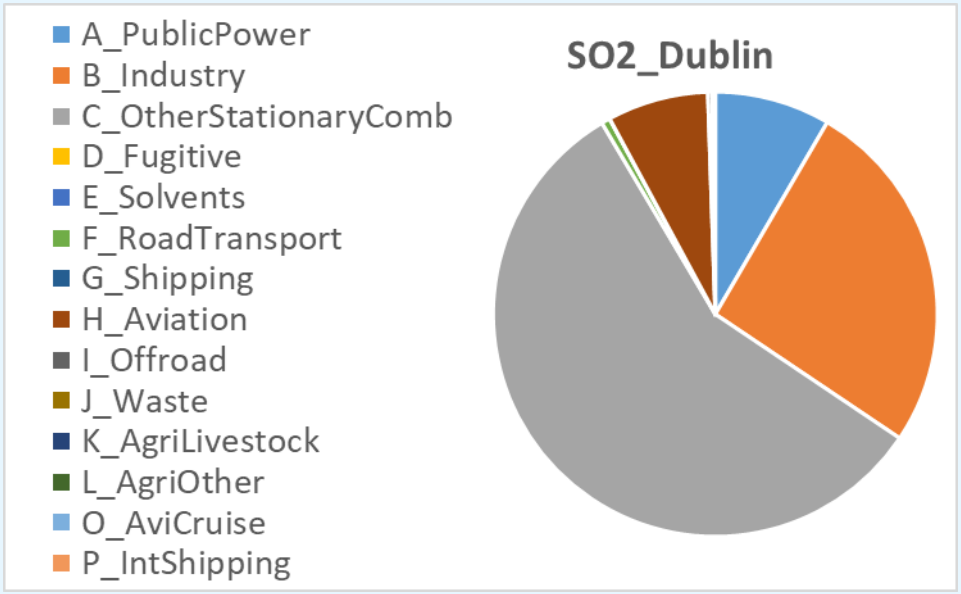

NOx_Ireland

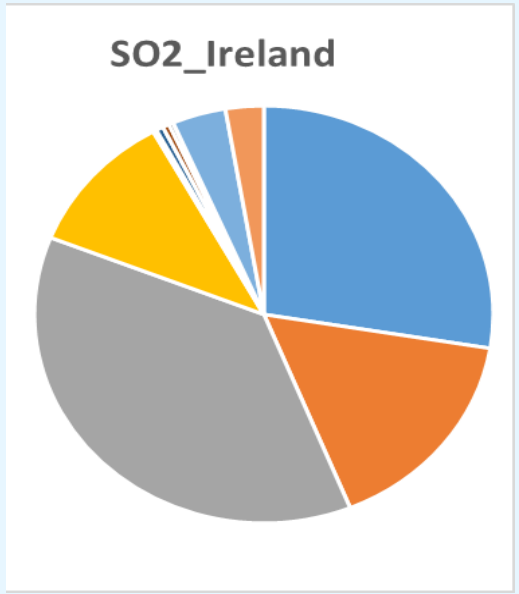

A_PublicPower
B_Industry
C_OtherStationaryComb
D_Fugitive
E_Solvents
F_RoadTransport
G_Shipping
H_Aviation
I_Offroad
J_Waste
K_AgriLivestock
L_AgriOther
O_AviCruise
P_IntShipping
PM10_Dublin


PM10_Ireland


A_PublicPower
B_Industry
C_OtherStationaryComb
D_Fugitive
E_Solvents
F_RoadTransport
G_Shipping
H_Aviation
I_Offroad
J_Waste
K_AgriLivestock
L_AgriOther
O_AviCruise
P_IntShipping
NMVOC_Dublin


NMVOC_Ireland


A_PublicPower
B_Industry
C_OtherStationaryComb
D_Fugitive
E_Solvents
F_RoadTransport
G_Shipping
H_Aviation
I_Offroad
J_Waste
K_AgriLivestock
L_AgriOther
O_AviCruise
P_IntShipping
SO2_Dublin


SO2_Ireland

Dublin BU inventory shares of national total emissions

GNFR_Code	NMVOC	NOx	PM10	SOx
A_PublicPower	15%	8%	15%	1%
B_Industry	11%	10%	13%	8%
C_OtherStationaryComb	8%	28%	7%	8%
D_Fugitive	8%			
E_Solvents	25%			
F_RoadTransport	13%	12%	12%	12%
H_Aviation	79%	79%	78%	79%
I_Offroad	5%	4%	4%	5%
J_Waste	21%	43%	45%	54%
K_AgriLivestock	<0.5%		<0.5%	
L_AgriOther	5%		5%	
O_AviCruise	<0.5%	<0.5%	<0.5%	<0.5%

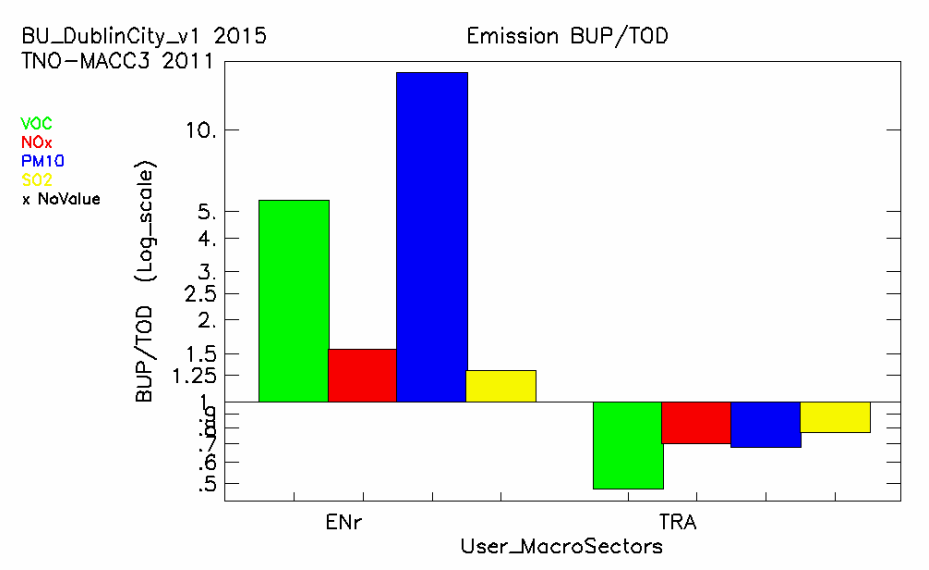
Verification of the model

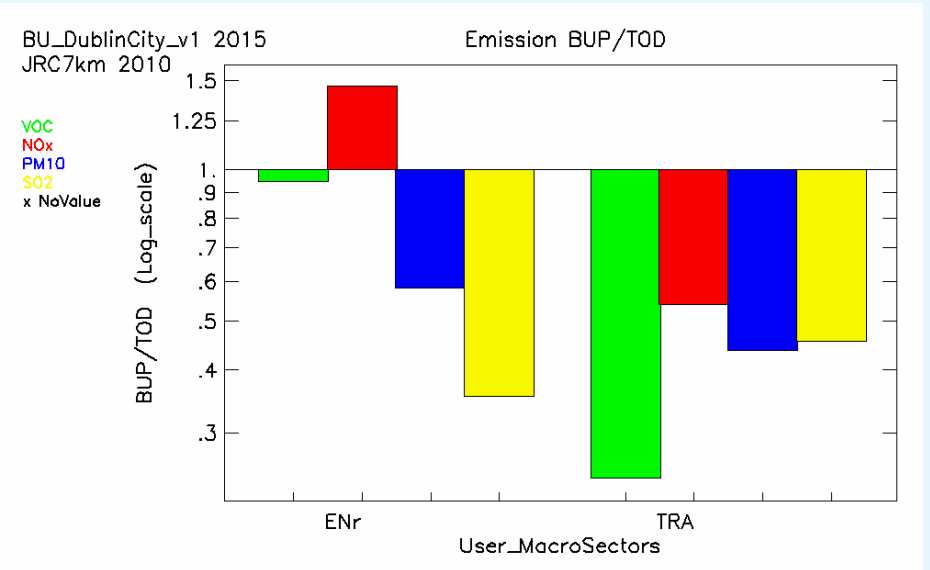
- In the European FAIRMODE project, the Delta tool has been developed to compare bottom-up city inventories with top-down inventories
- The top-down inventories can both be the Irish top-down inventory and European or global scale inventories
- The comparisons can be used to identify
  - difference between inventories, and
  - possibility of improvement of both the city and national model

Delta tool

- Comparison of emissions based on different models, e.g. local bottom-up vs. European top-down
- Output including various statistical indicators and diagrams
- Focus on under- and overestimation on sector/pollutant level
- Differences are expected due to comparison of different years,
  - e.g. Road transport show large increase in Dublin during the later years

Comparison with European models





Dublin 1 km, 2015 emissions vs. TNO-MACC3 1/8 x 1/16 degree, 2011 emissions

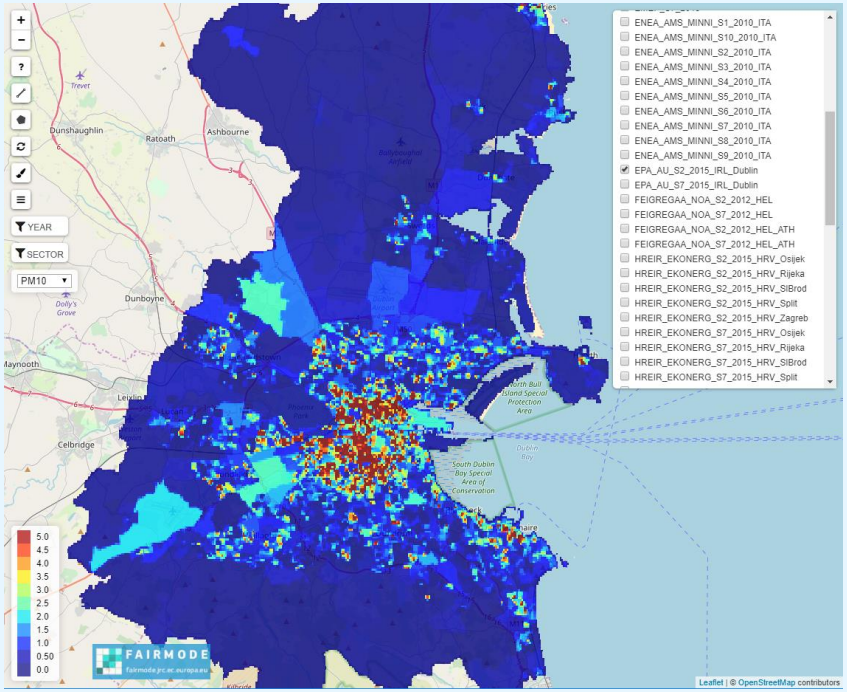
Dublin 1 km, 2015 emissions vs. JRC 7 km, 2010 emissions

- **Largest differences occur for residential combustion (ENr), especially for PM_{10} and NMVOC**
  - **Top-down model overestimate compared to the Dublin model**

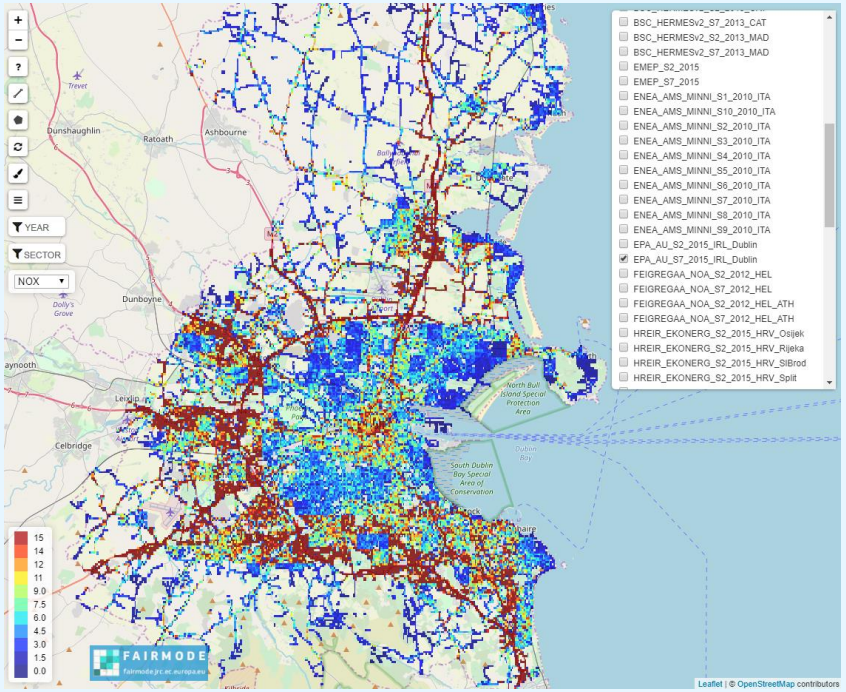
EU Composite Mapping

- A digital map collecting the best available national, regional or local estimates for different EU areas
- Aims at creating a EU-wide bottom-up composite map with emissions and air quality over Europe
- National/regional agencies or modelling teams are encouraged to provide their best available data for their particular region
- Registered users can upload data using the ECMap Database
- Allows for comparison of emission and concentration

EU Composite Mapping viewer



› PM_{10} from residential plants



› NO_x from road transport

Thank you for your attention!