Urban air quality modelling of Dublin

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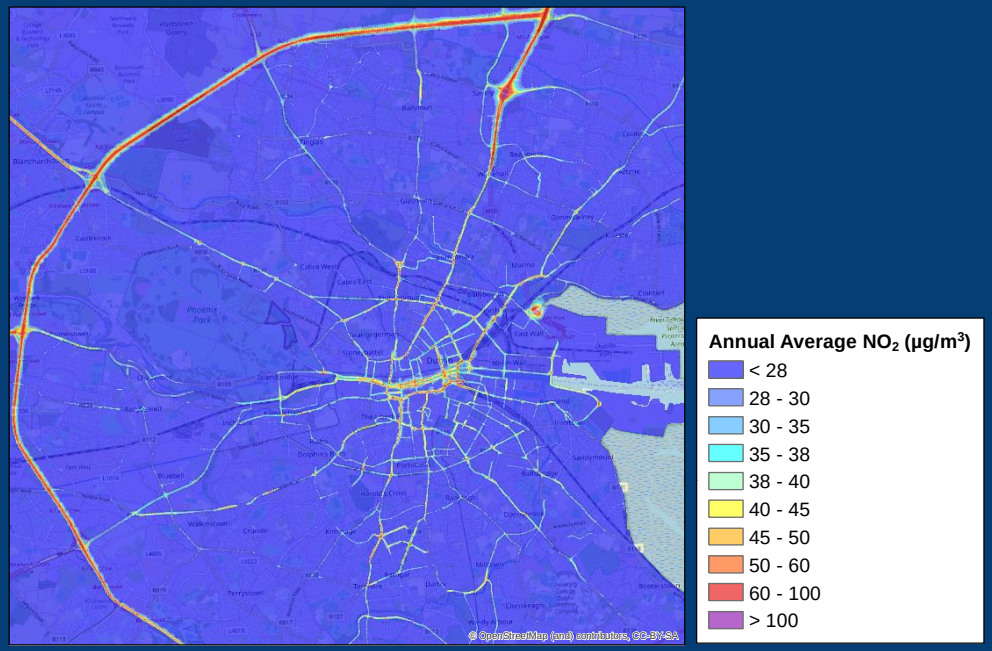
Kevin Delaney (EPA Ireland)

ADMS-Urban & ADMS-Roads User Group Meeting

14 November 2019

Oxford



CERC

Cambridge Environmental Research Consultants
Environmental Software and Services

Outline

- Introduction to air quality in Dublin
- Monitoring sites
- Input data
  - Emissions data
  - Meteorological data
  - Background data
  - Additional Model Options
- Model Results
  - Verification
  - Contour plots
- The future of air quality in Dublin
  - Urban Environmental Indicators Report

Overview

- A National Ambient Air Quality Monitoring Programme established under Section 65 of the EPA Act – placing air quality monitoring on a statutory footing, funded by Government

Why?

- Provide comprehensive air quality data. Inform environmental management policy. Improve health outcomes. Engage the public. Links to the National Clean Air Strategy (NCAS).

What was proposed?

- A five year programme consisting of three main pillars
  - A greatly expanded national monitoring network in three tiers
  - Modelling and forecasting capability
  - Citizen science and citizen engagement initiatives

What will the new programme deliver?

Modelling and forecasting capability:

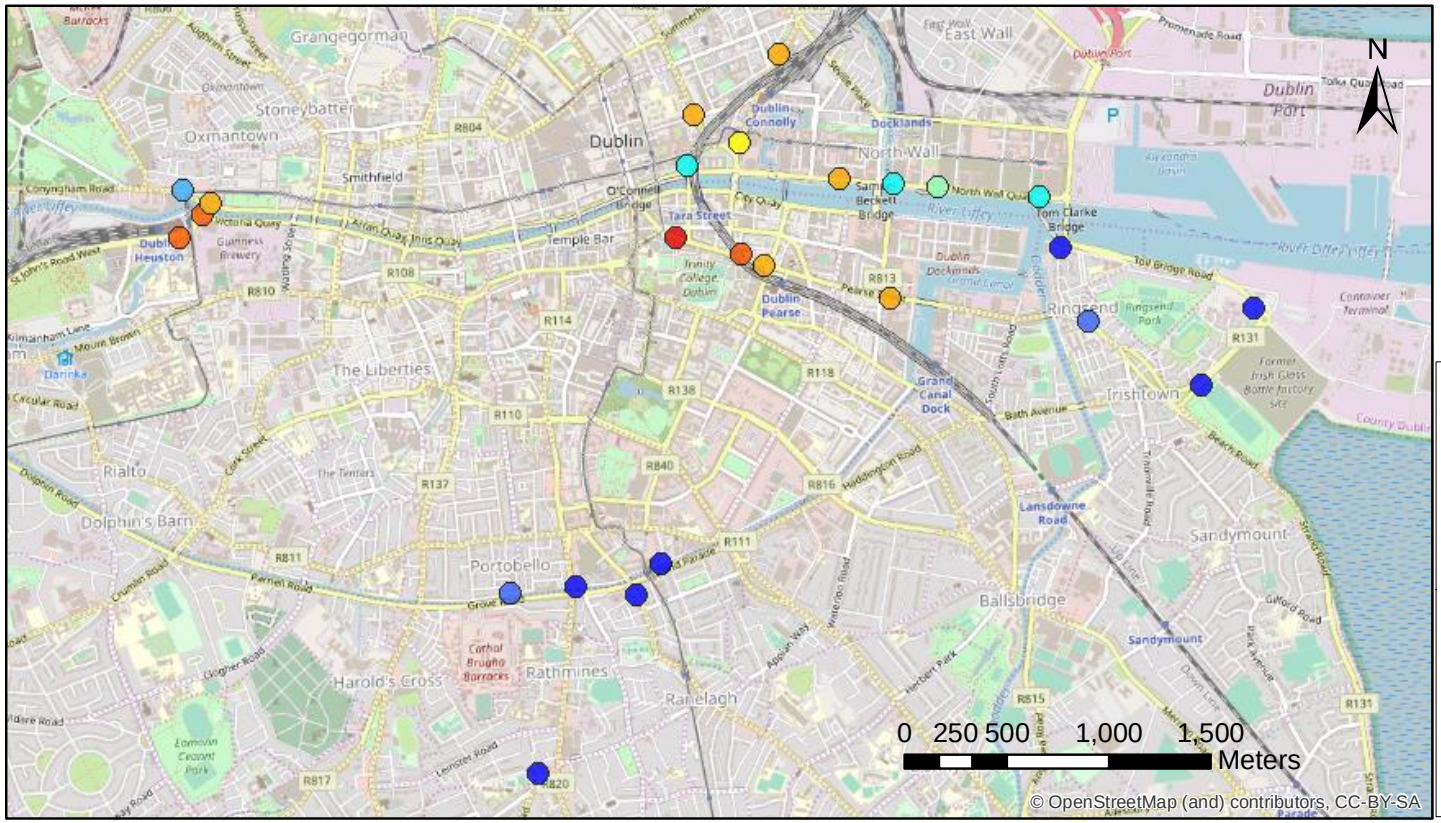
- An air quality forecast for Ireland to enable citizens to make choices about their activities over the next 48 hours
- Develop further ambient air quality modelling capacity and capability

Citizen science and citizen engagement (CS/CE) initiatives:

- Capacity to further air quality citizen science and citizen engagement activities including utilisation of low cost sensors
- Provide added value to EPA data including review of local air quality data
- Provide support to other EPA CS/CE activities

Monitoring Sites

Diffusion Tube Sites

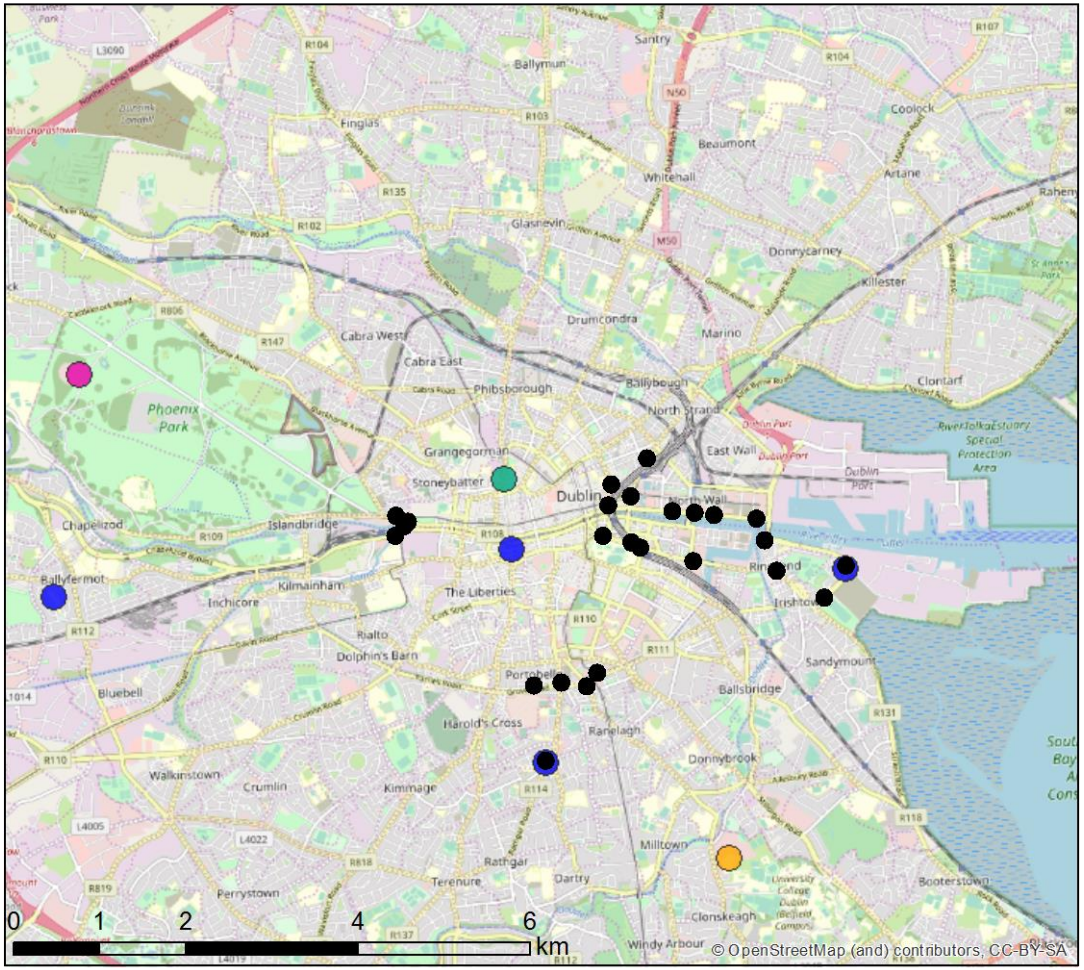


EPA Data

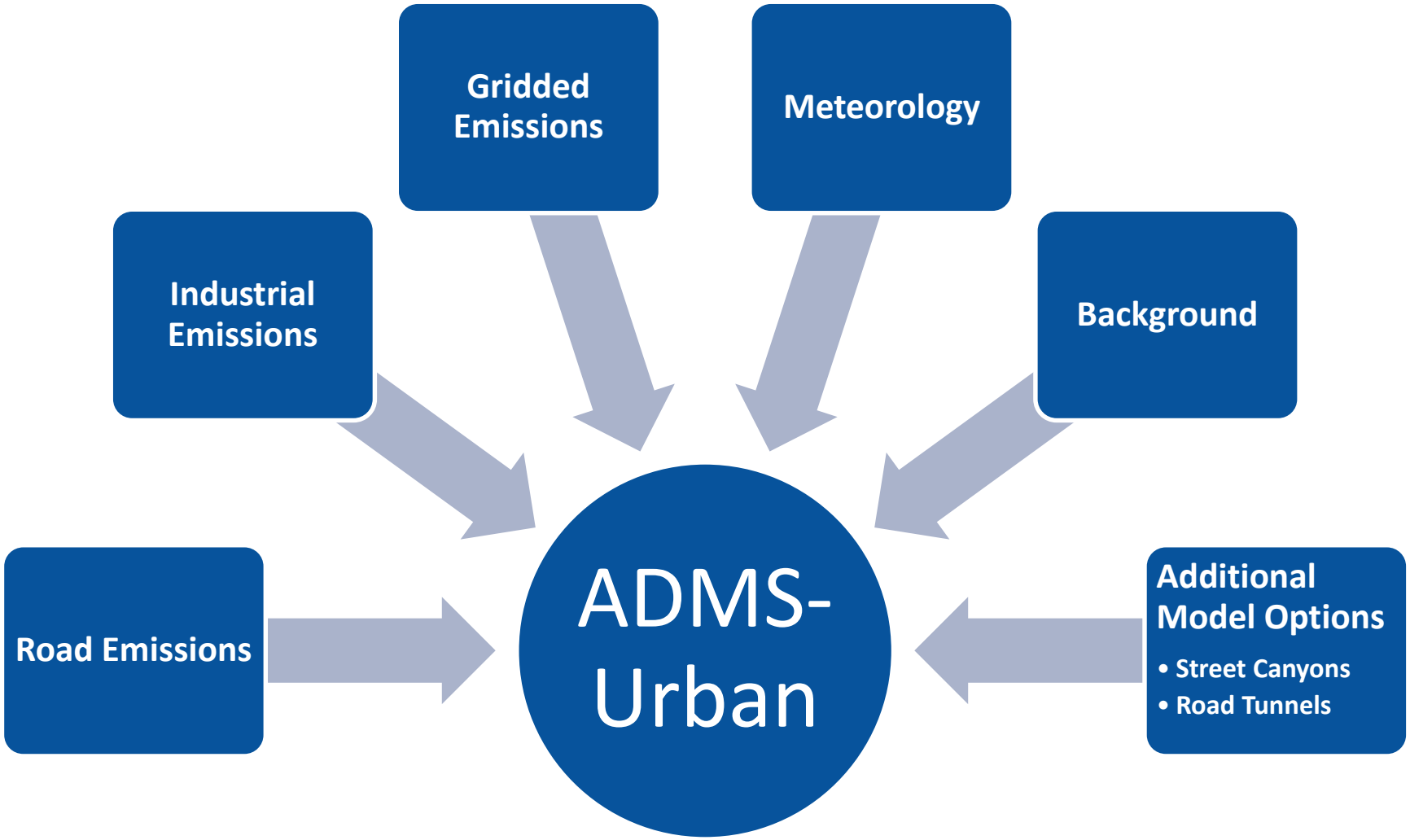
Monitoring Sites

- 11 continuous monitors
  - 3 roadside, 1 suburban, 3 urban background
  - No measured exceedences of EU standards
  - Data capture mostly hourly, some daily PM
  - Data obtained from the National Air Quality Network

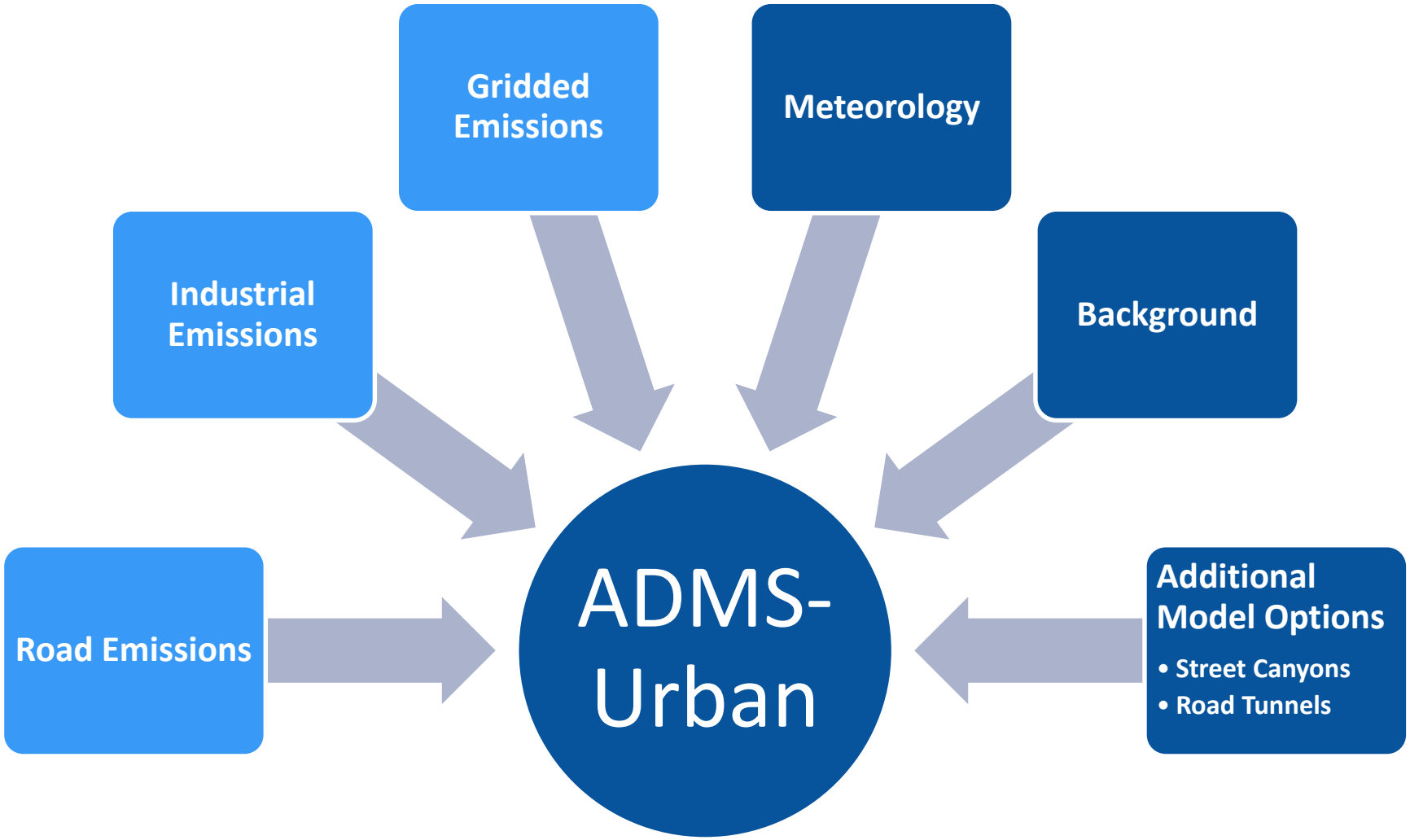
Continuous Monitors and Diffusion Tubes in Dublin



Input data


Gridded Emissions
Meteorology
Industrial Emissions
Background
Road Emissions
ADMS-Urban
Additional Model Options
• Street Canyons
• Road Tunnels

Input data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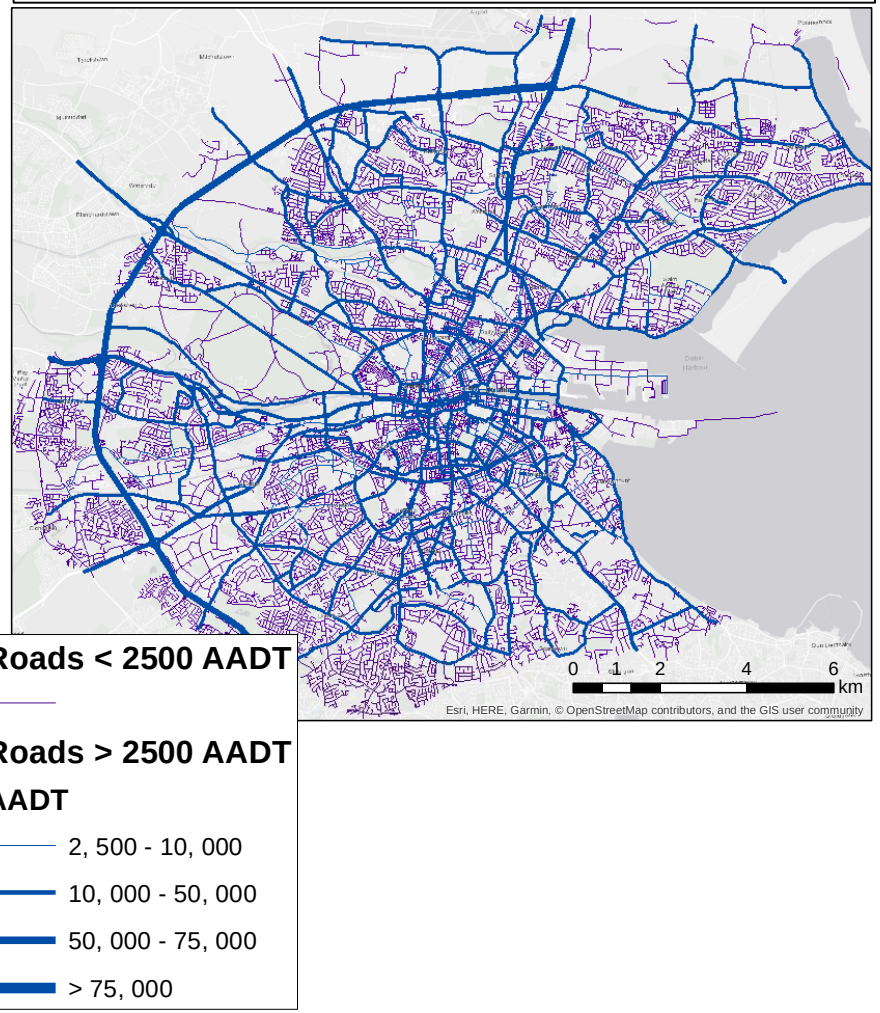
Input Data – Road Emissions

- Road traffic
  - Traffic data provided by Dublin City Council and was supplemented by Transport Infrastructure Ireland (TII) data
  - Anomalies in traffic data identified during data processing
  - Roads with an AADT under 2500 were included as gridded emissions
  - Roads with an AADT over 2500 were included explicitly
- Speeds
  - As no detailed speed data was available, vehicle speed was taken to be half the speed limit

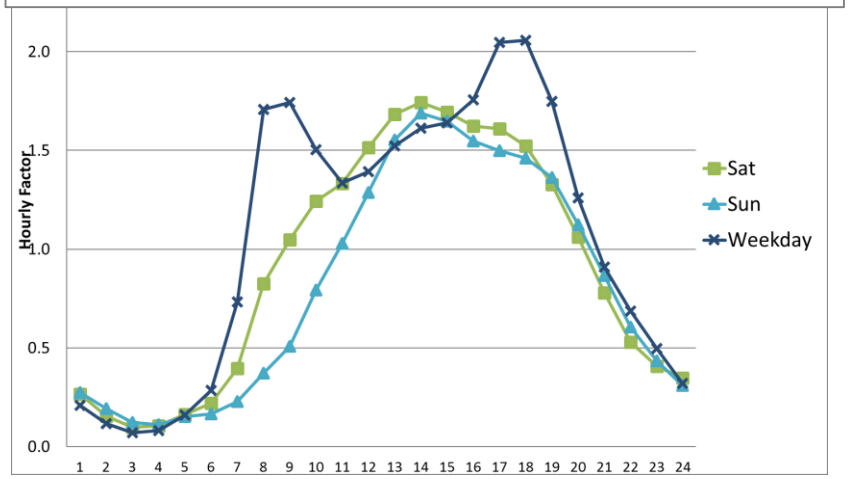
Modelled Traffic AADTs
(Annual Average Daily Totals)



Input Data – Road Emissions

- Emissions rates
  - Calculated in EMIT* using EFT v8.0
  - Emissions adjusted to account for real-world traffic behaviour
- Fleet Composition
  - Vehicle population and distance data was provided by the EPA for different vehicle types
  - The data was used to calculate percentages of each vehicle type
  - 11 vehicle categories using EMIT
- Diurnal Variation
  - Hourly profiles from TII, only available for major outer city centre roads

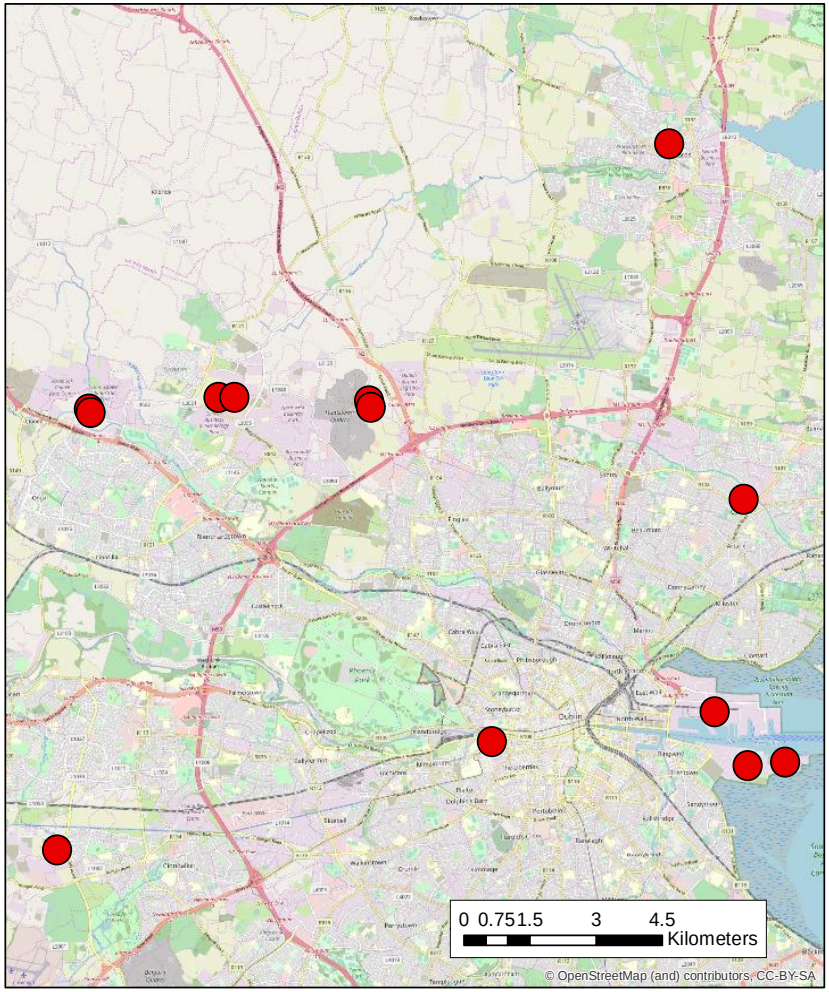
Diurnal profiles for road traffic emissions



Input Data – Industrial Emissions

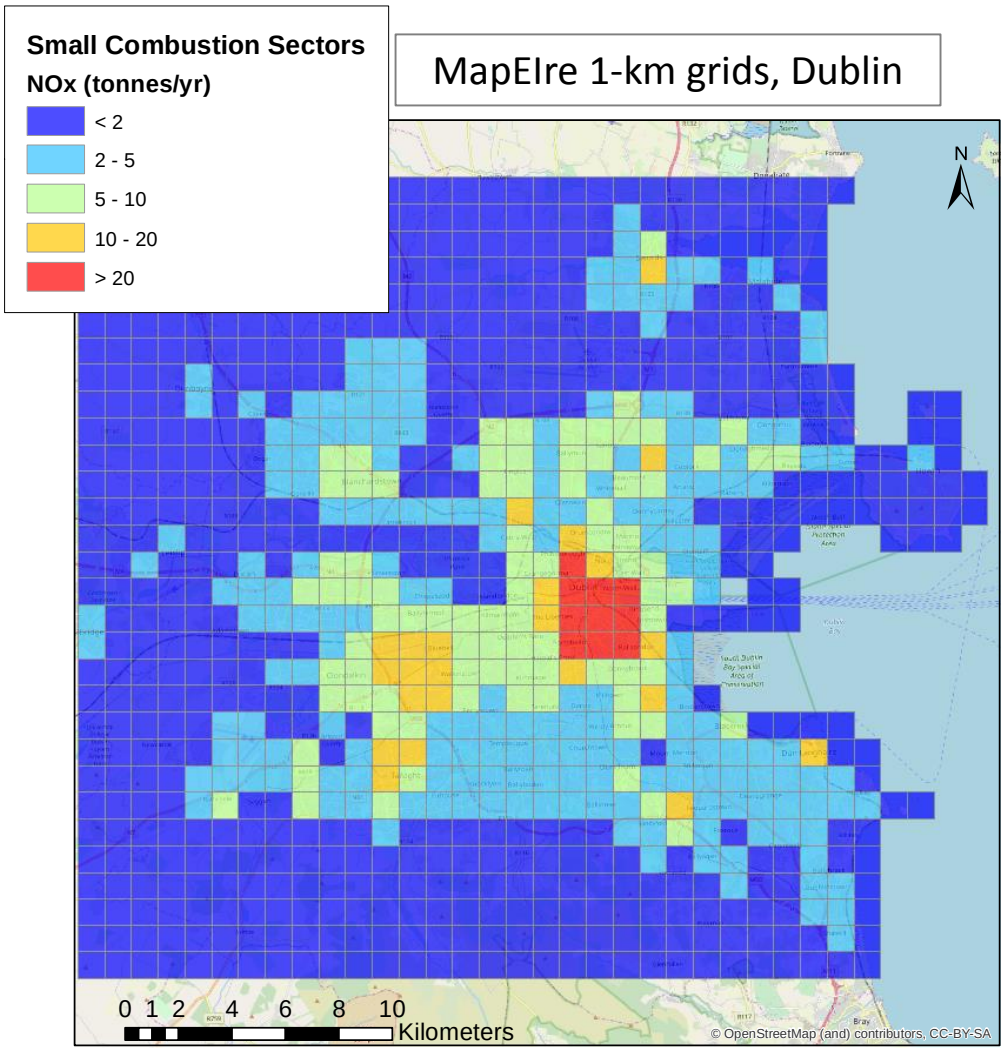
- Large industrial sources explicitly modelled
  - Data included emission rates and stack heights
  - Default values used for diameter, exit velocity and temperature
- Emissions from smaller industrial sources included as gridded emissions
- Constant emission rates assumed

Explicitly modelled industrial sources



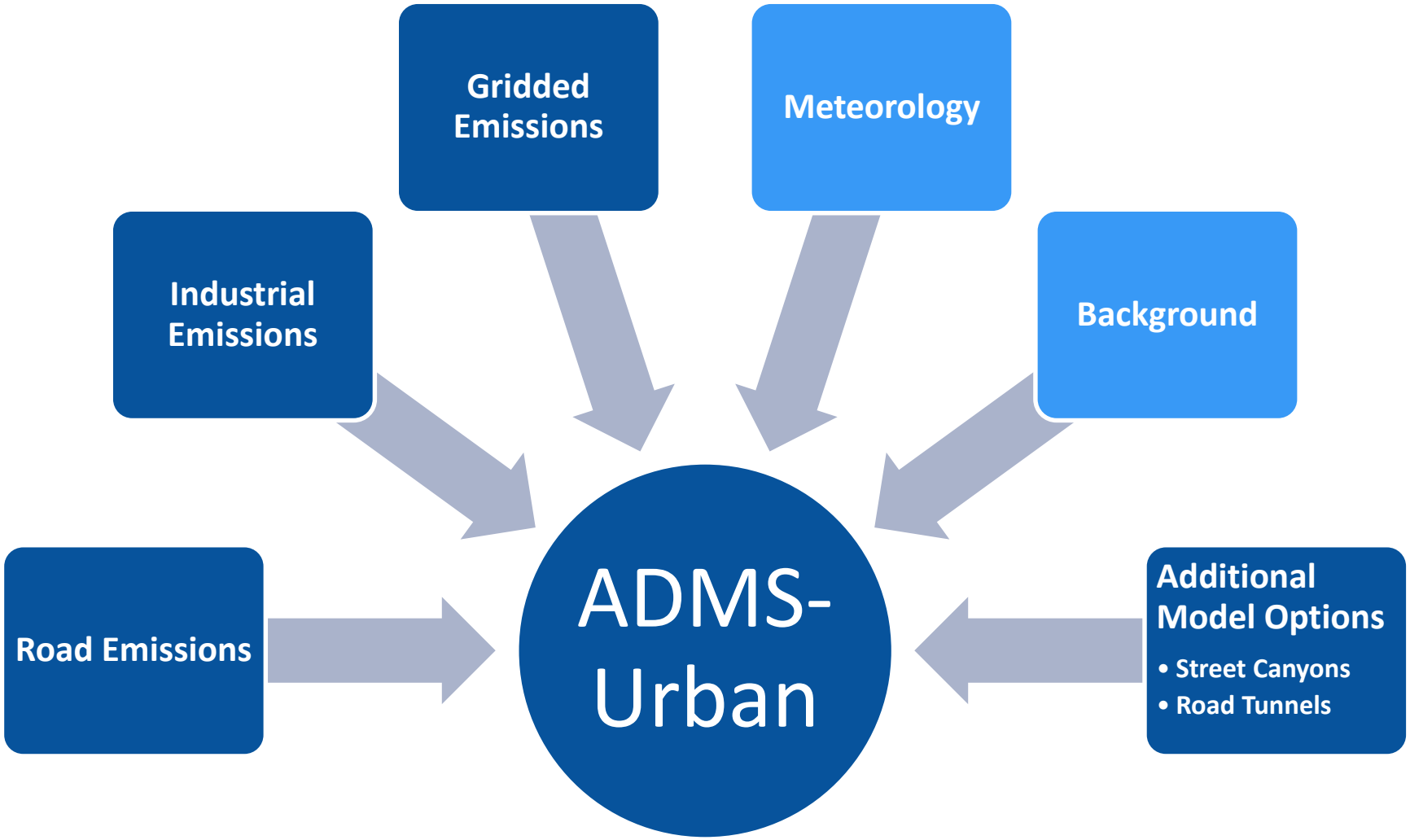
Input Data – Gridded Emissions

- National Emissions mapping model
  - **1 km data for all sectors** (power, industry, other stationary combustion, solvents, road transport, off-road transport, fugitive emissions, waste, aviation, shipping, livestock, other agriculture, land use)
  - Emissions for 2015
  - Provided in .shp format



Aarhus University - MapEIre:
https://projects.au.dk/mapeire/

Input data


Gridded Emissions
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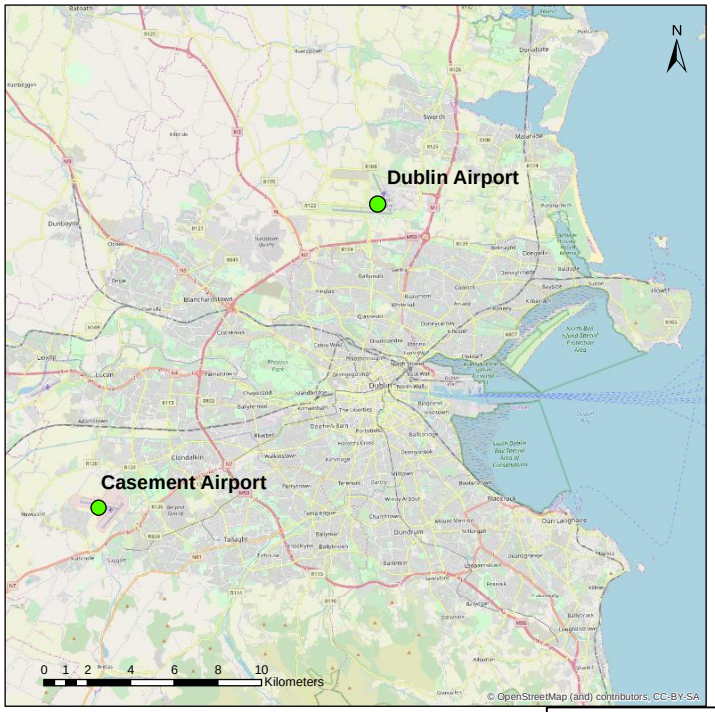
Input Data – Meteorological

- Two meteorological sites
- Surface Roughness
  - 0.1 m for meteorological sites
  - 0.5 m for Dublin

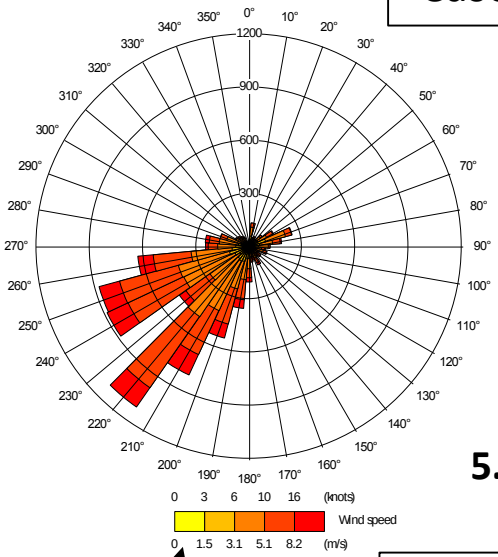
Meteorological Sites



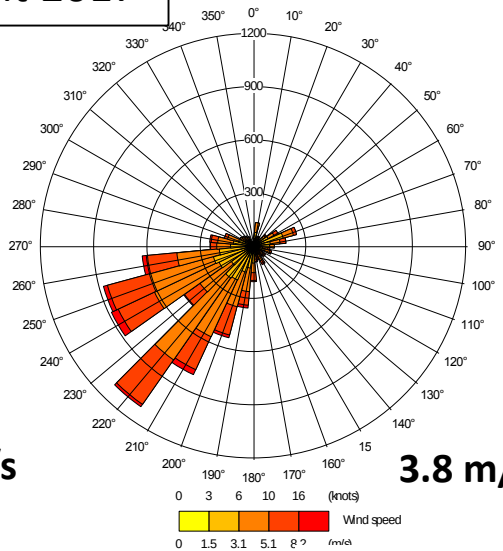
Met Site

CERC

Casement 2017



5.8 m/s

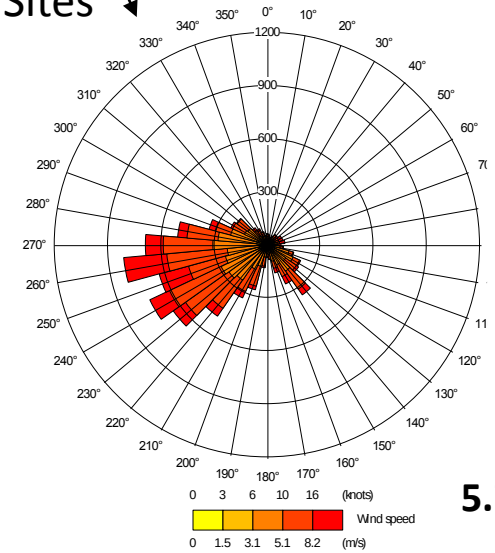


3.8 m/s

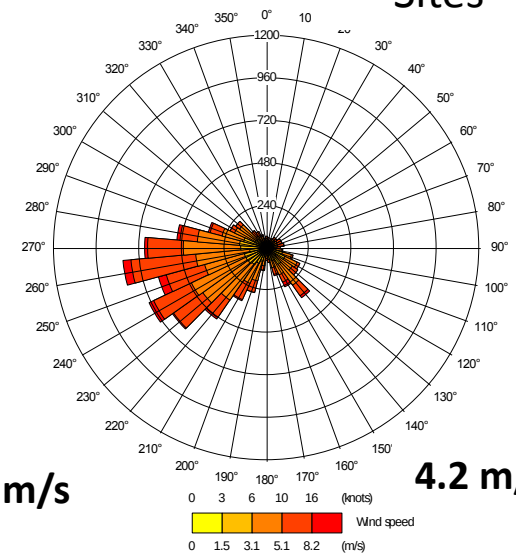
Met Sites

Dublin 2017

Dispersion Sites



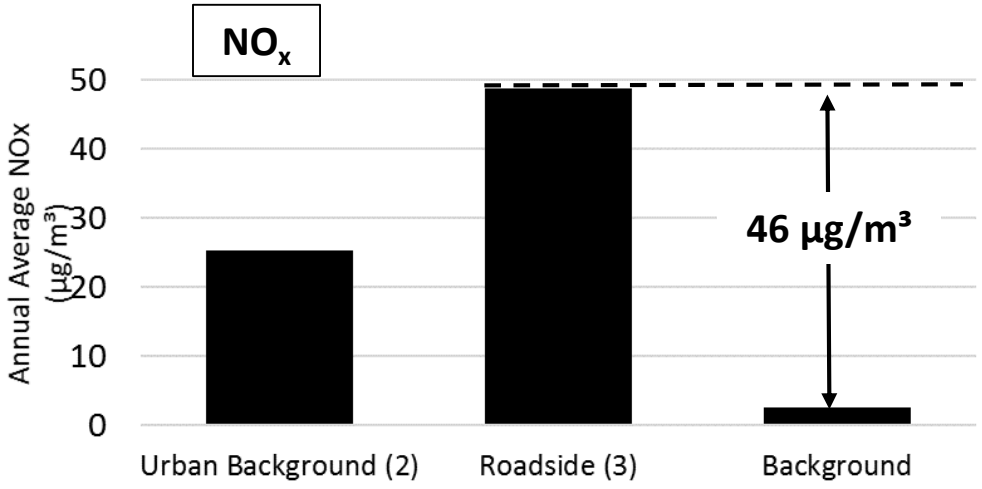
5.7 m/s

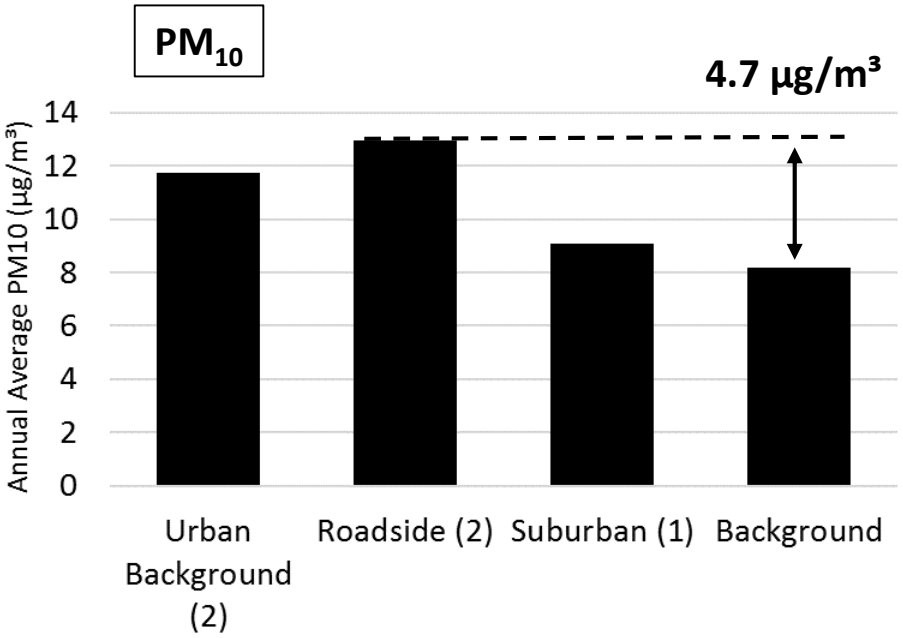


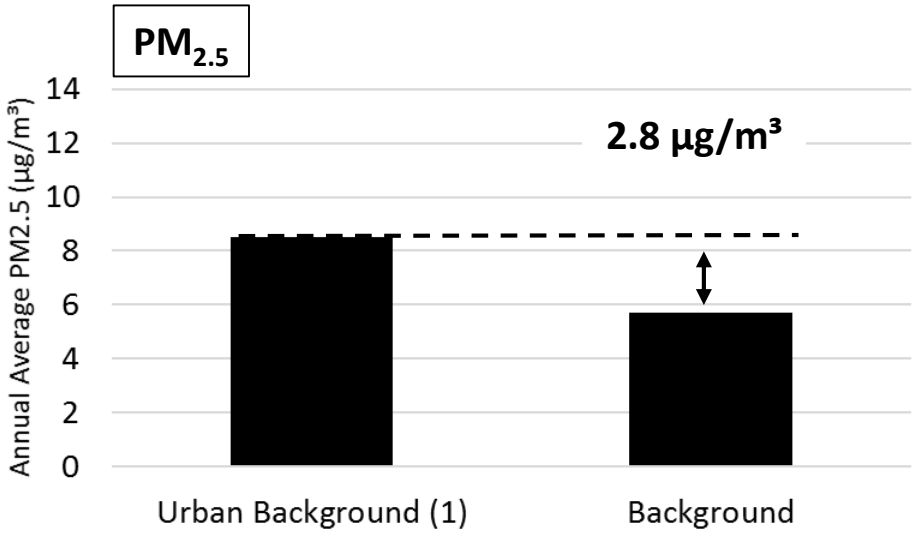
4.2 m/s

Input Data - Background

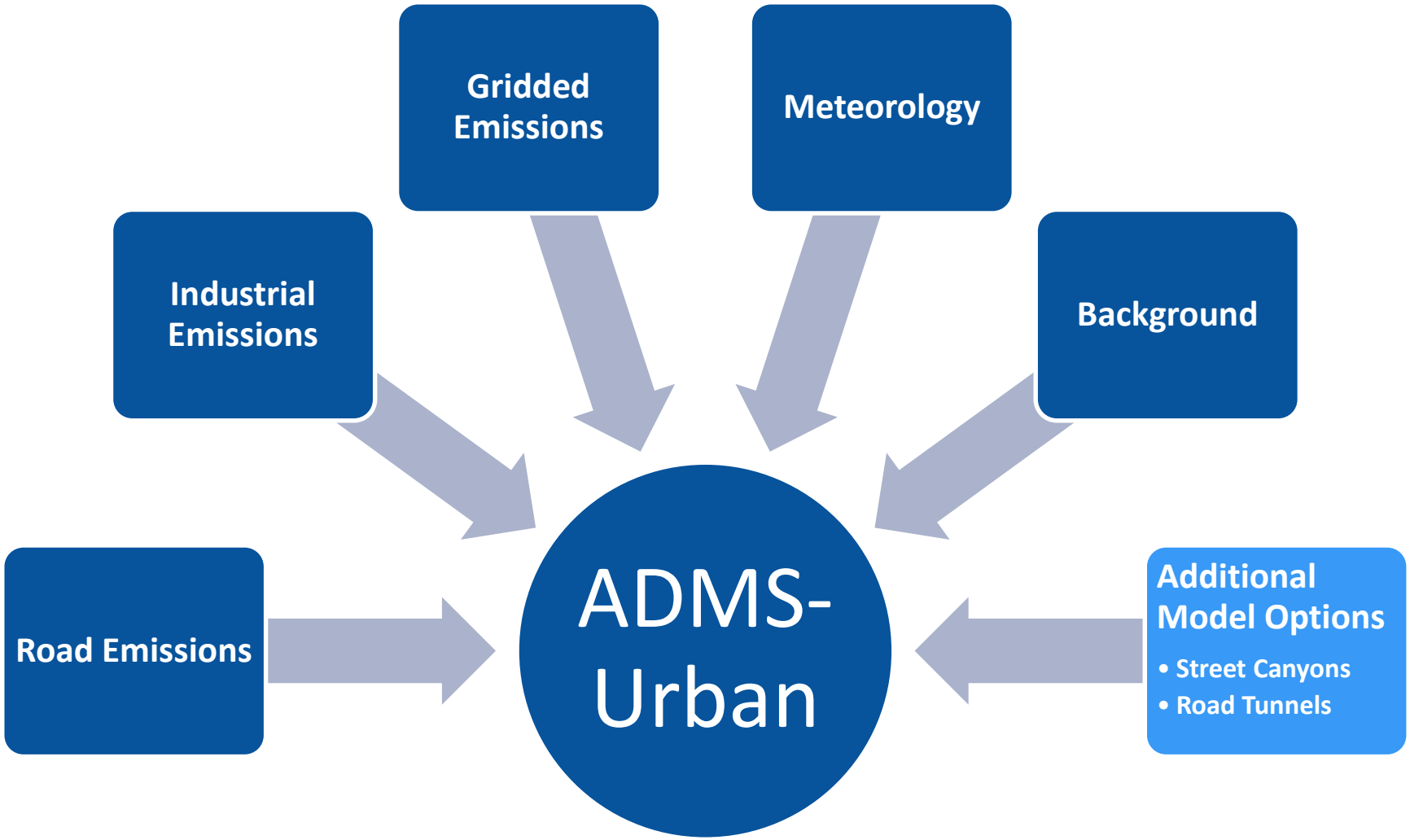
- Background data was obtained from rural monitoring sites
  - The background concentrations represent the long-range transport of pollutants
  - The difference in concentrations between the rural site and the city is demonstrated by the urban increment







Input Data – Additional Model Options



Additional Model Options - Advanced Canyons

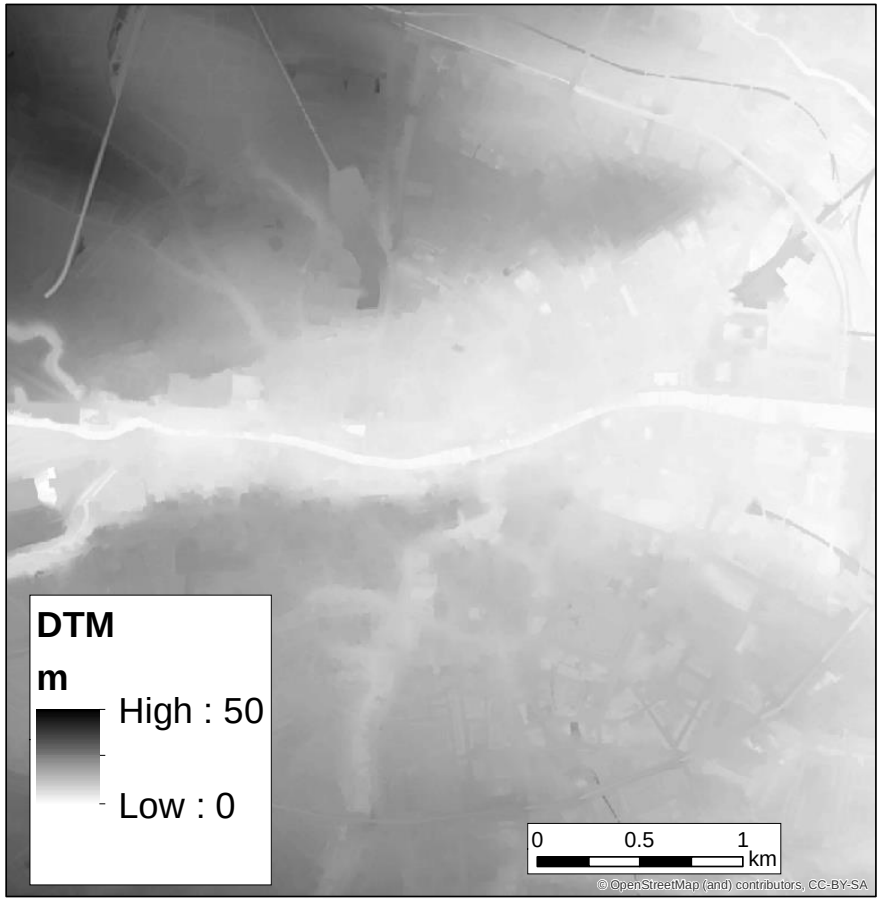
- Created advanced canyon *.csv* using the ArcGIS tool
- Requires
  - .shp of roads
  - .shp of building polygons with associated heights
- Data
  - EPA provided .shp of roads and building polygons
  - Building heights were extracted using LiDAR Data
- 2016 UGM talk provides more details on Advanced Street Canyon Option

Additional Model Options - Advanced Canyons

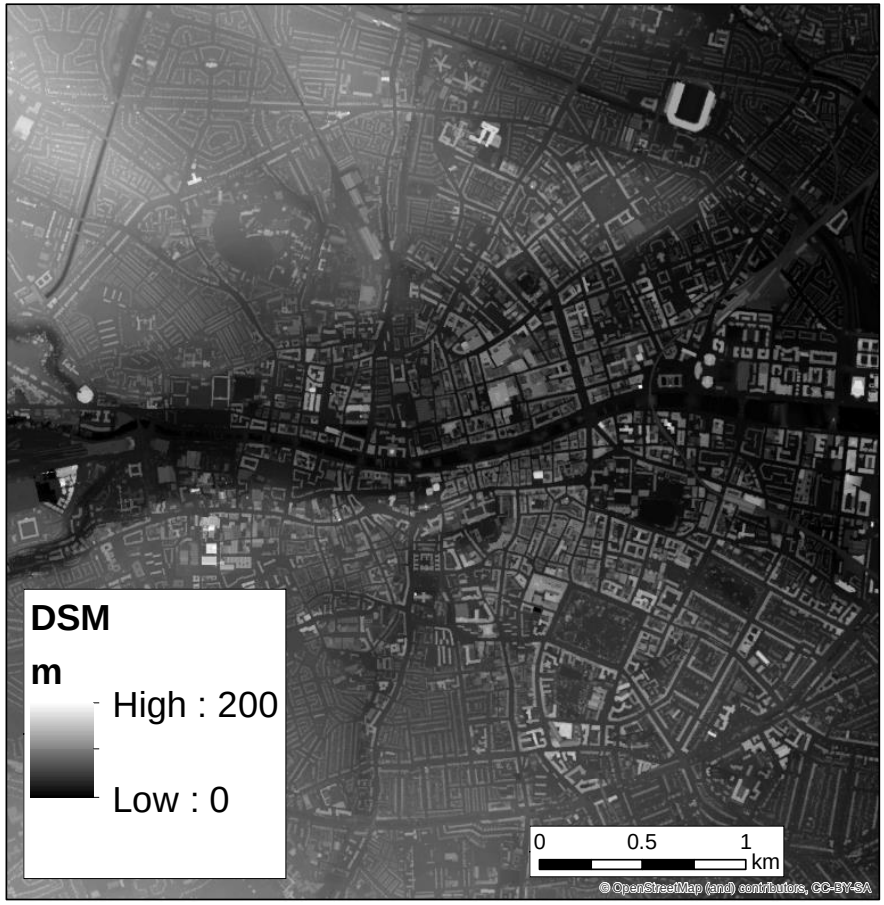
- LiDAR (Light Detection and Ranging)
  - Uses laser to measure distance between aircraft and ground
- Two datasets:
  - DSM: Digital Surface Model
    - Includes heights of objects, such as vehicles, buildings and vegetation, as well as the terrain surface
  - DTM: Digital Terrain Model
    - A ‘bare earth’ model with surface objects filtered out of the DSM
- 2 m resolution
- Provided in raster format in 1 km squares
  - 301 tiles
  - Use GIS to combine tiles

Additional Model Options - Advanced Canyons

Digital Terrain Model (DTM)

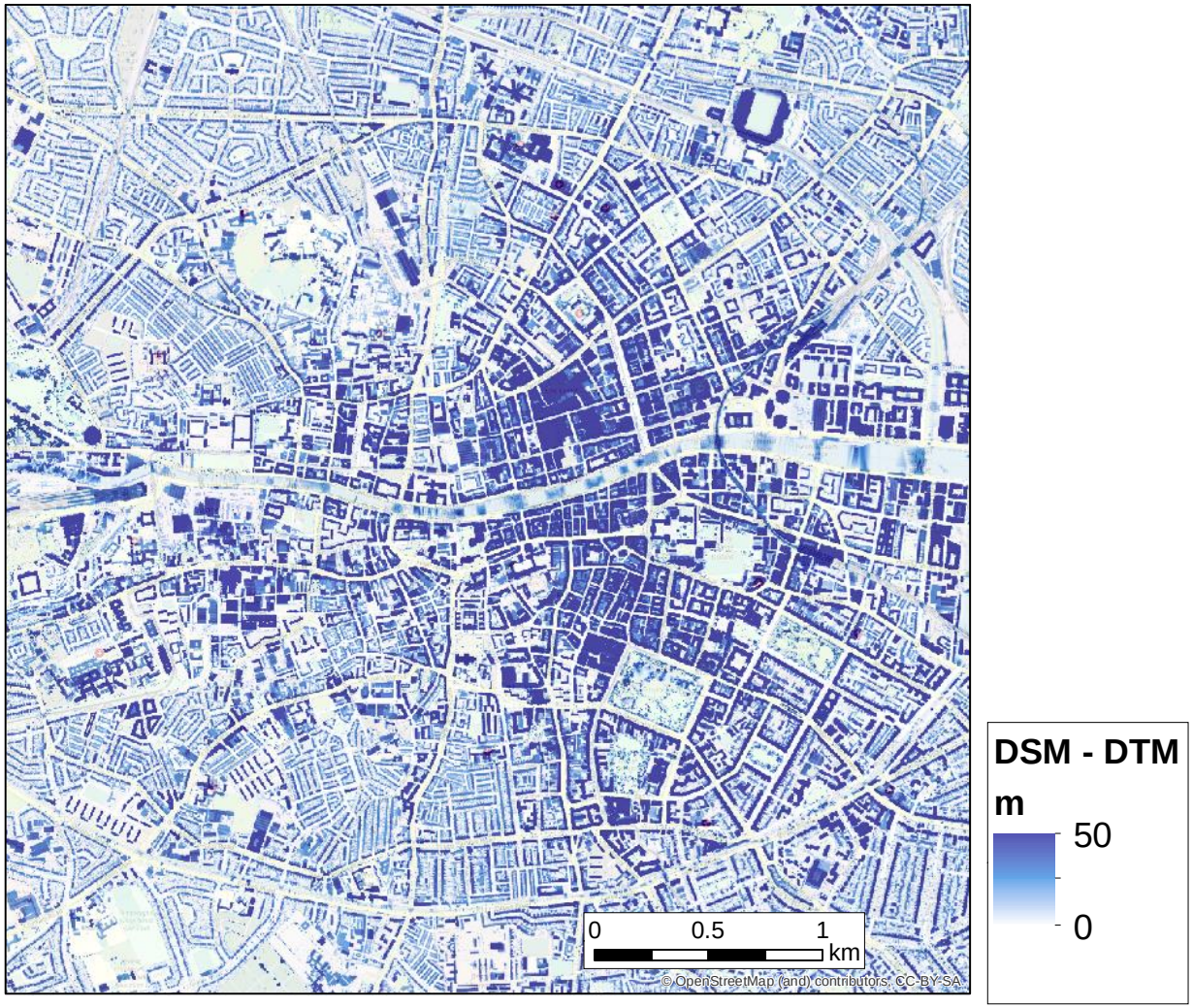


Digital Surface Model (DSM)



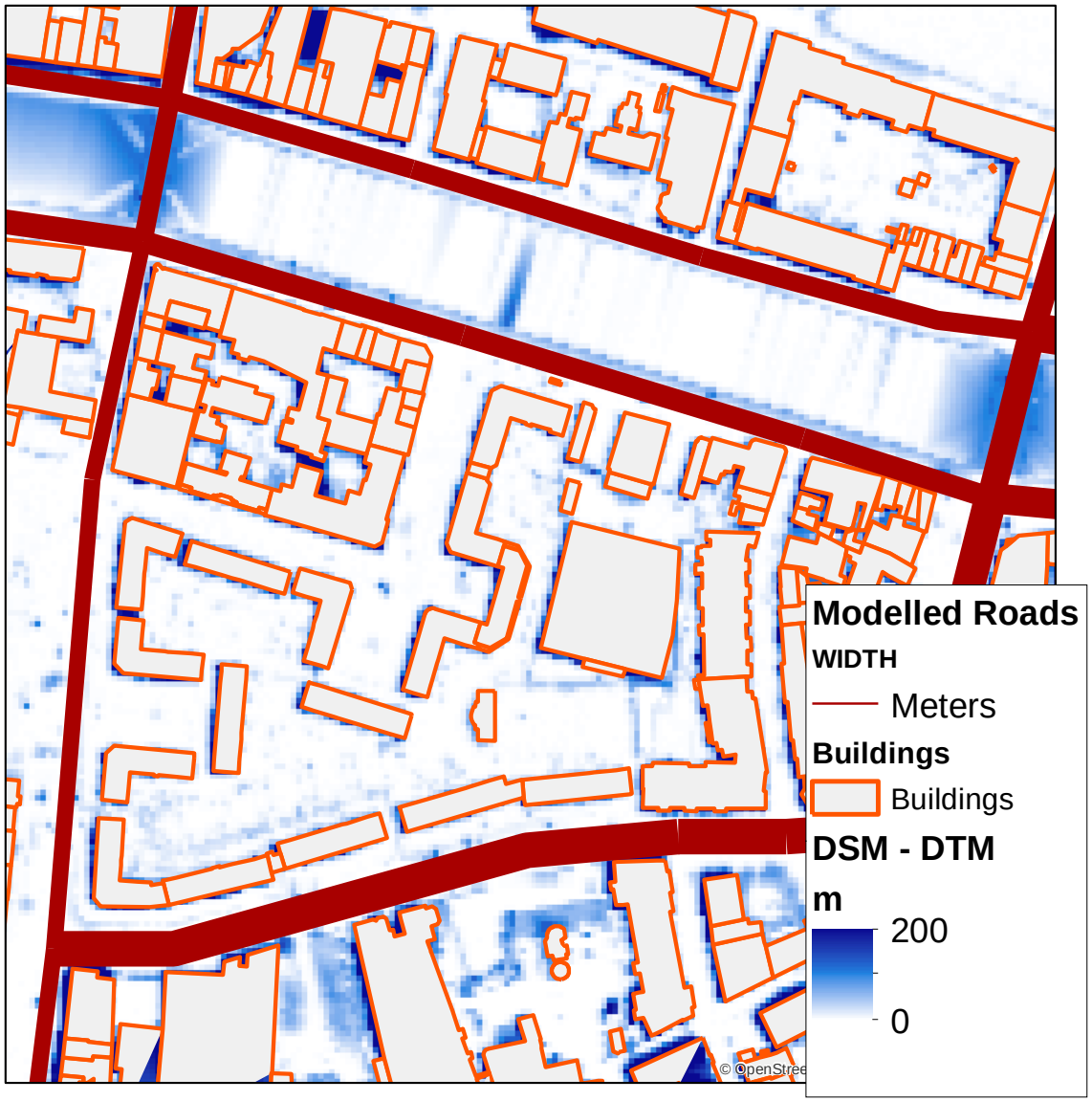
Additional Model Options - Advanced Canyons

- Subtract DTM from DSM to get building heights

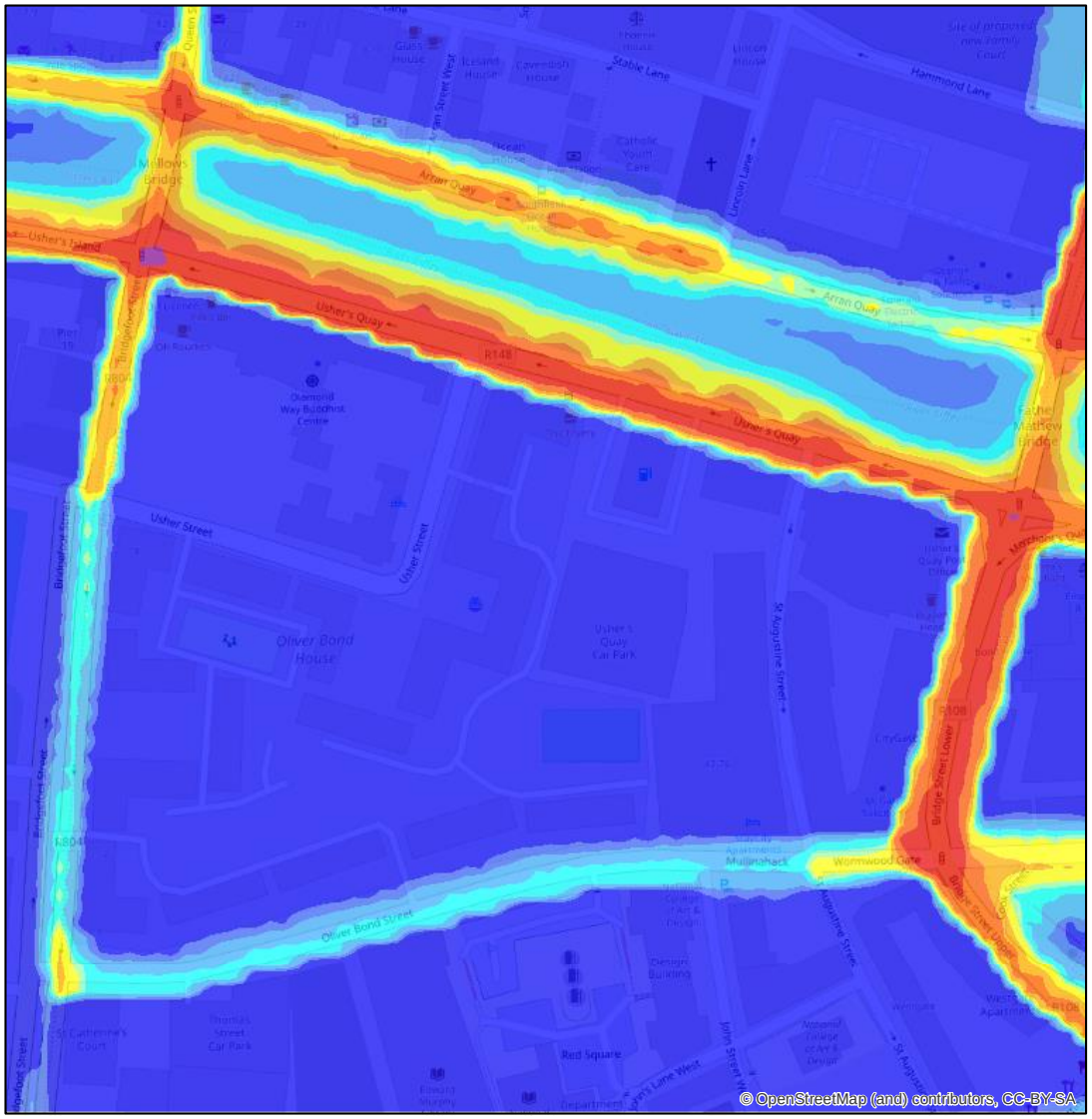


Additional Model Options - Advanced Canyons

- Overlay buildings .shp
  - Consistent coordinate systems
  - Alignment of buildings and roads
- Extract a building height for each polygon



Additional Model Options - Advanced Canyons

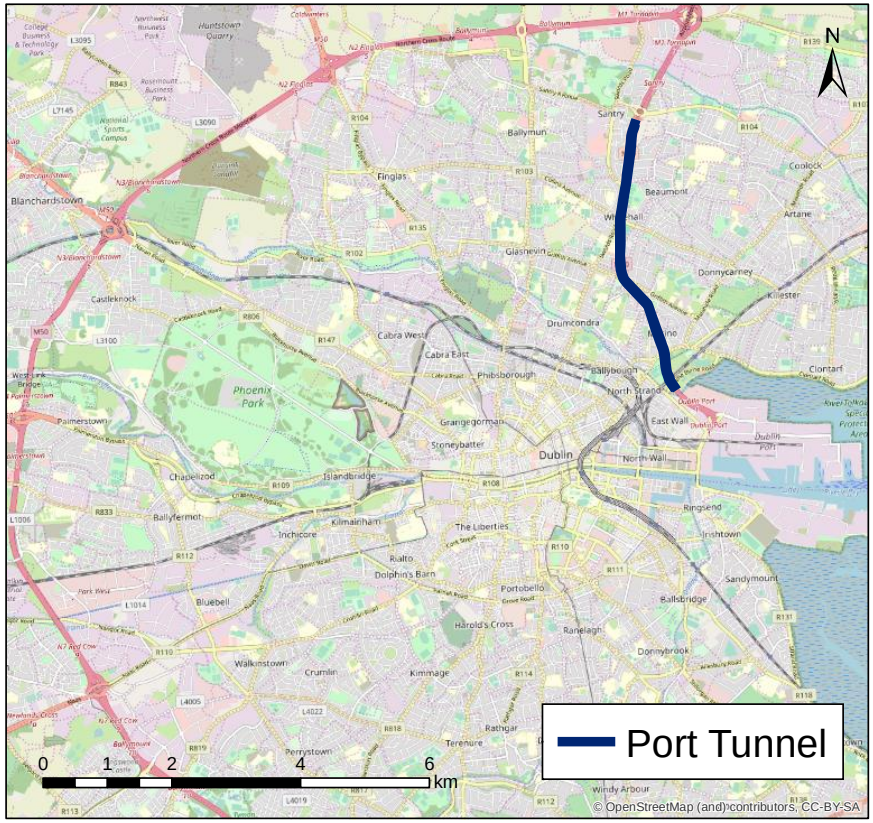


Annual Average NO_2 (µg/m³)

- < 28
- 28 - 30
- 30 - 35
- 35 - 38
- 38 - 40
- 40 - 45
- 45 - 50
- 50 - 60
- 60 - 100
- > 100

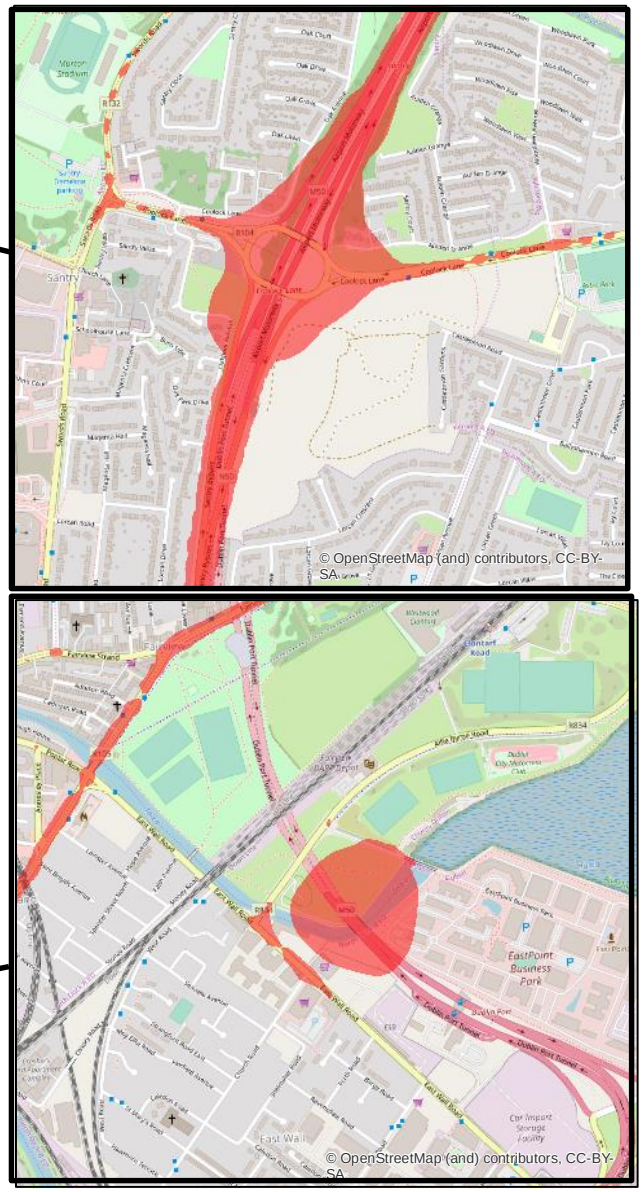
Additional Model Options - Road Tunnels

- Dublin Port Tunnel
  - Two bores
  - Two-lane dual carriageway
  - 4.5 km
  - Vents not modelled - ‘Longitudinal Ventilation’
  - Predominately HGVs



- Road Tunnel input file (.csv)
  - Include each tunnel as a road source
  - One row per tunnel

Additional Model Options - Road Tunnels



Annual Average NO_2 (µg/m^3)

< 40

> 40

Model Results - Verification

Annual Average NO_2 (µg/m³)

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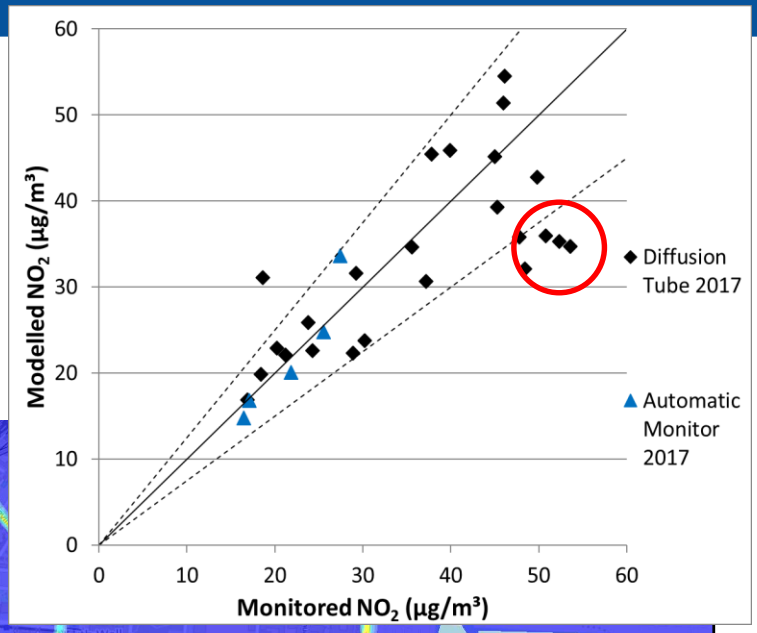
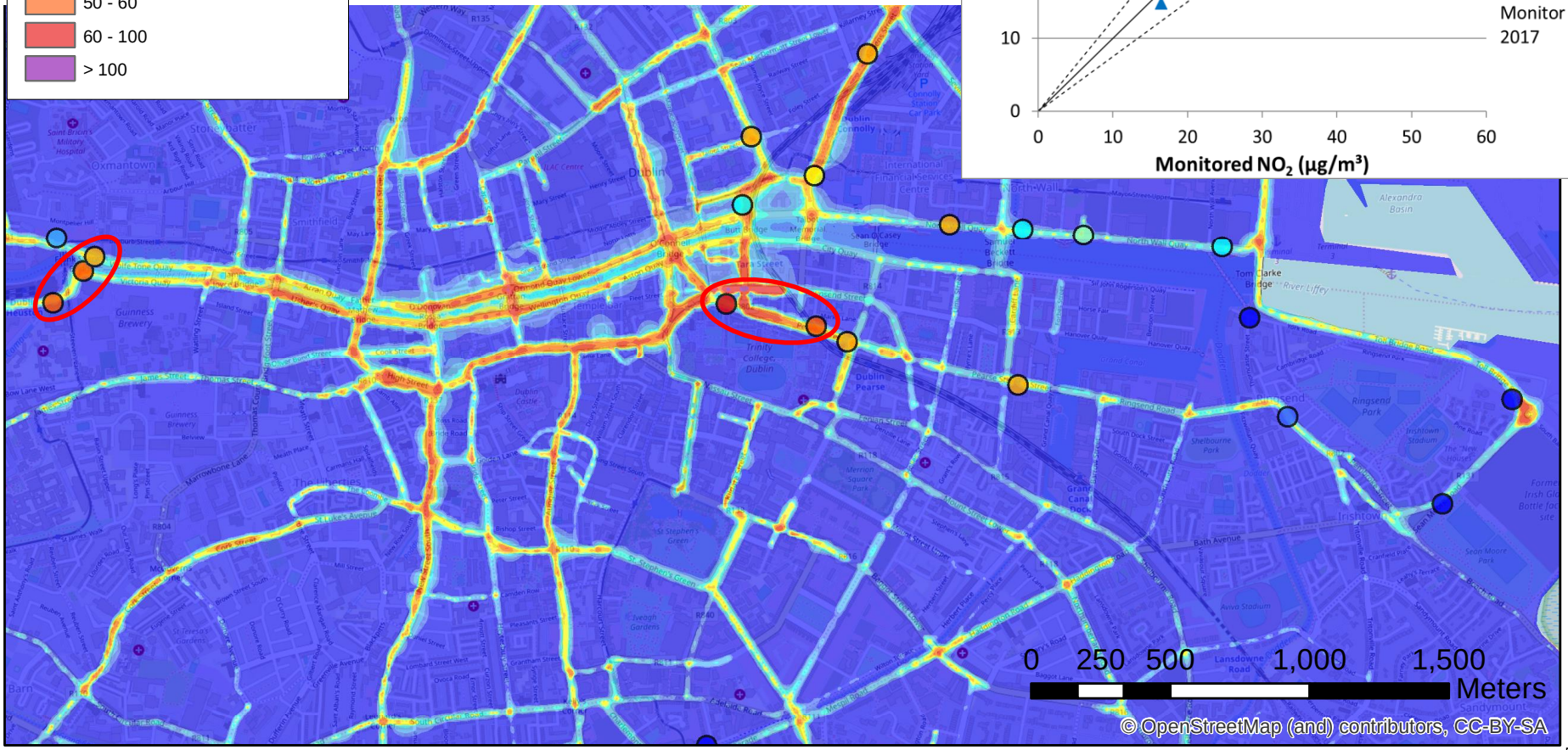
2017 NO_2: model and diffusion tubes





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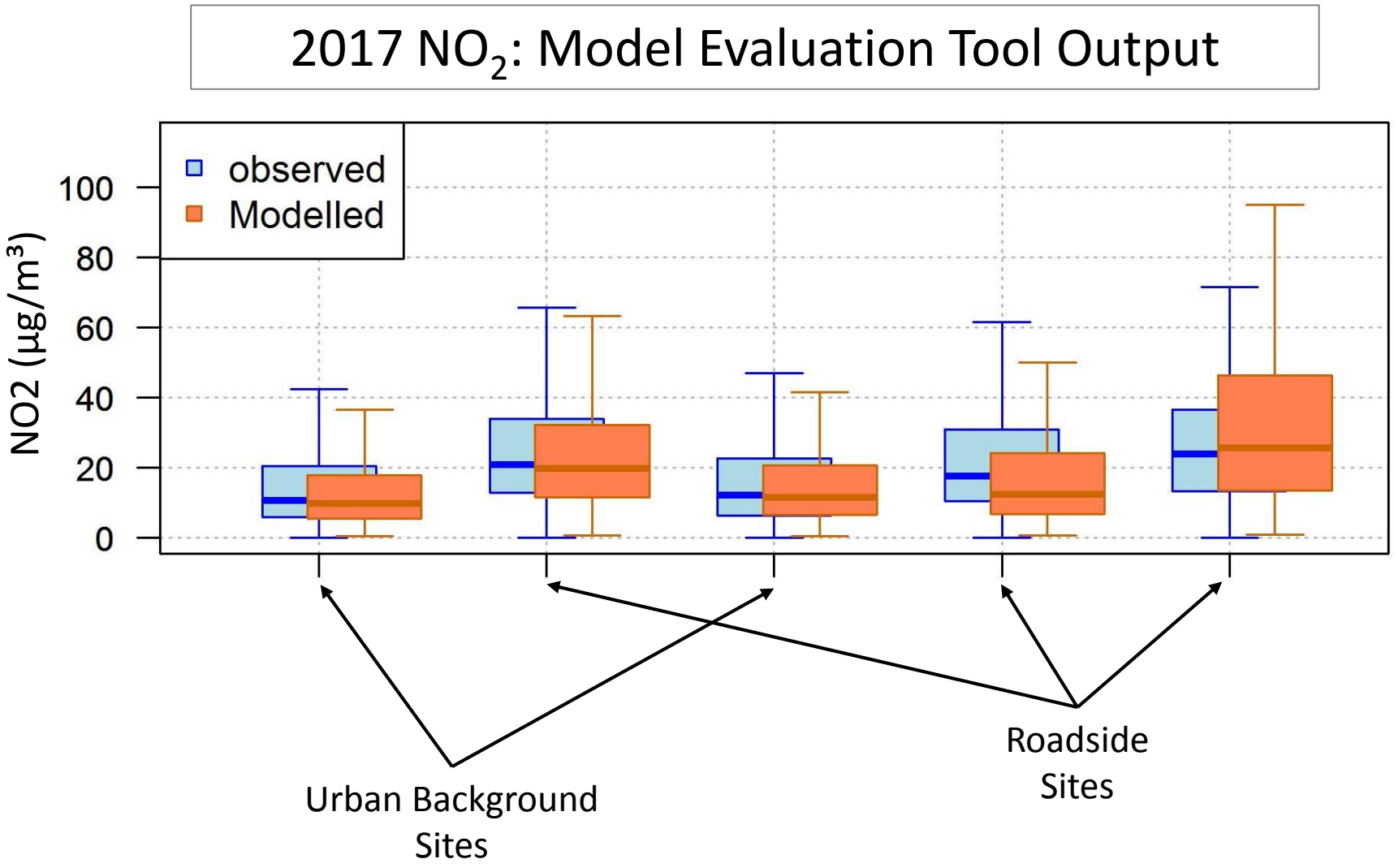
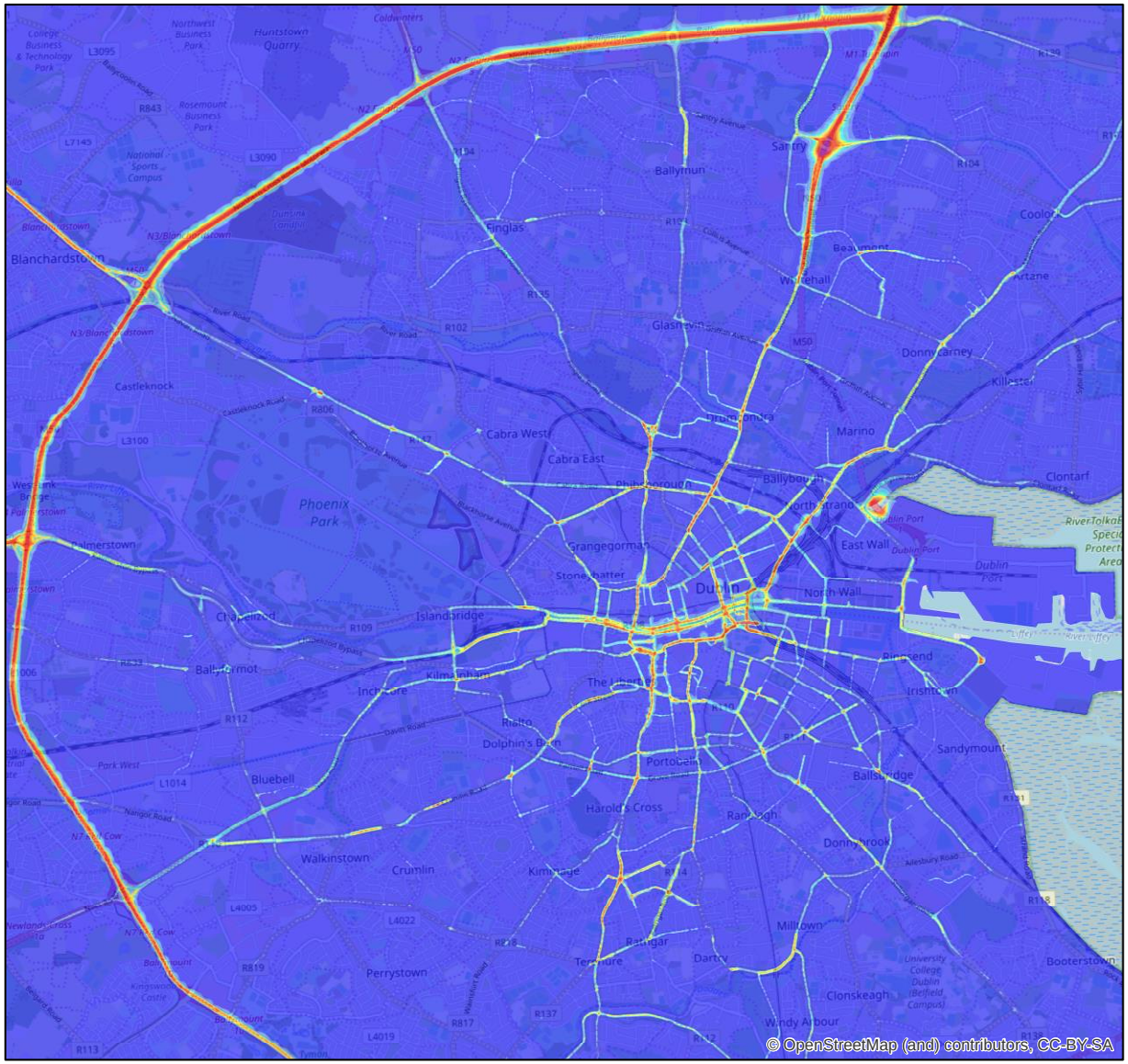


Model Results – Contour plots



2017 NO_2

Annual Average NO_2 (µg/m^3)

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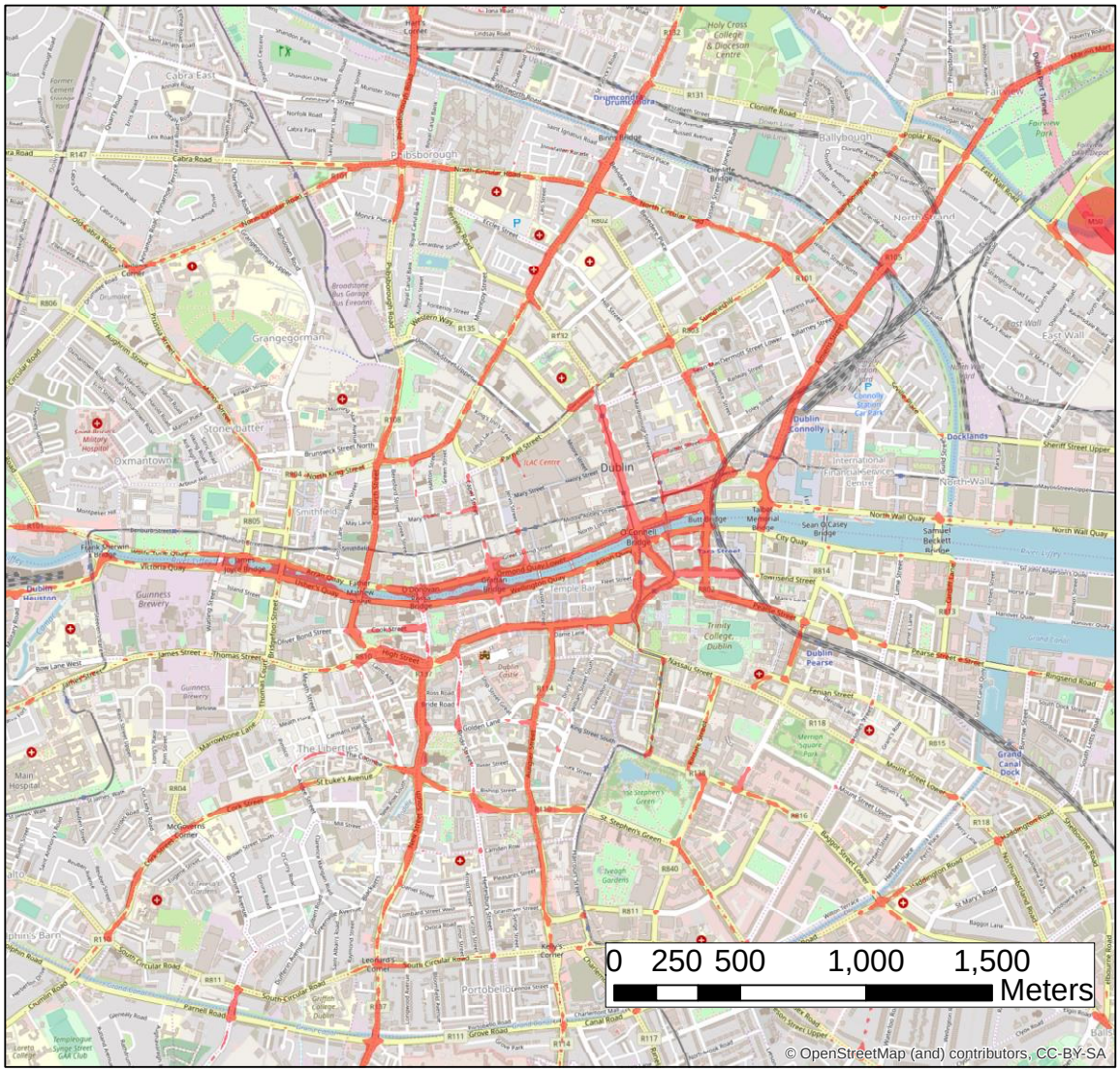
Model Results – Contour plots



2017 NO_2: modelled areas of exceedence

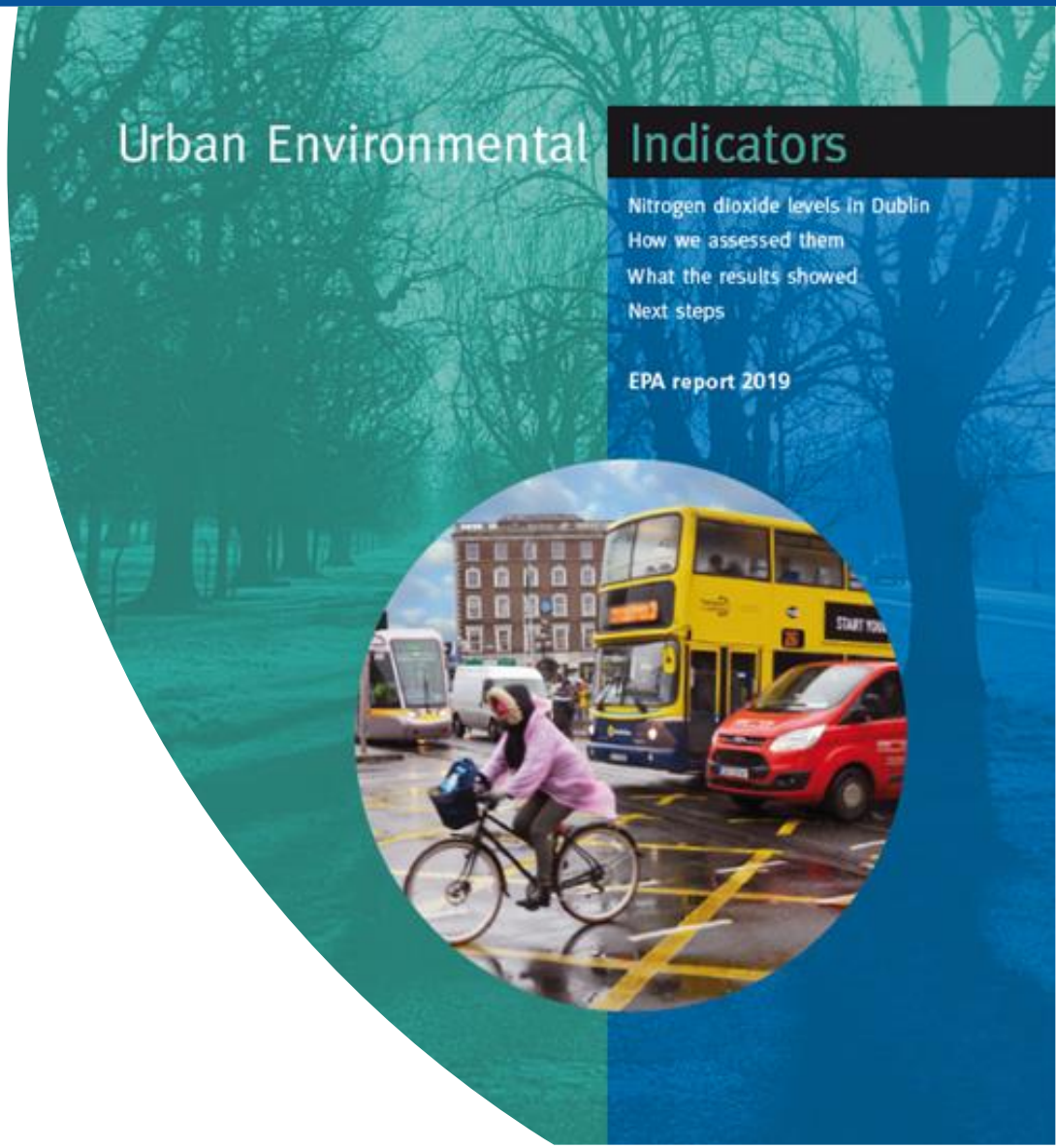
Annual Average NO_2 ($\mu g/m^3$)

< 40

> 40

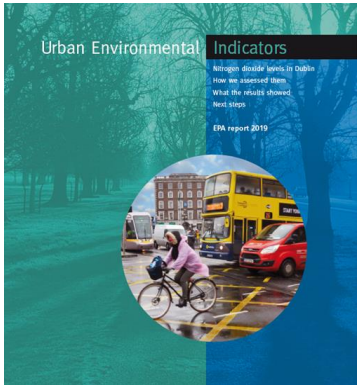
Urban Environmental Indicators Report

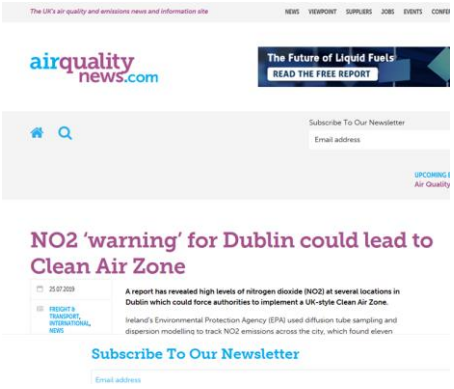
- Released 9th July 2019
- Combines both monitoring and modelling information
- Target audience: General public – input on tone / language / structure of report sought from National Adult Literacy Agency (NALA)
- Detailed technical reports on modelling and monitoring campaigns released at the same time
- Information has been used to site new traffic monitoring sites in Dublin
- Numerous requests for modelled maps – merge with other GIS data sets
- Used in EU project on composite mapping and verification



Urban Environmental Indicators Report

Media Reaction





Any Questions?

https://www.epa.ie/pubs/reports/air/quality/technicalreport2-modellingassessment.html