



IRTEMS project closure workshop

The use of road transport emissions at microscale on CFD modelling

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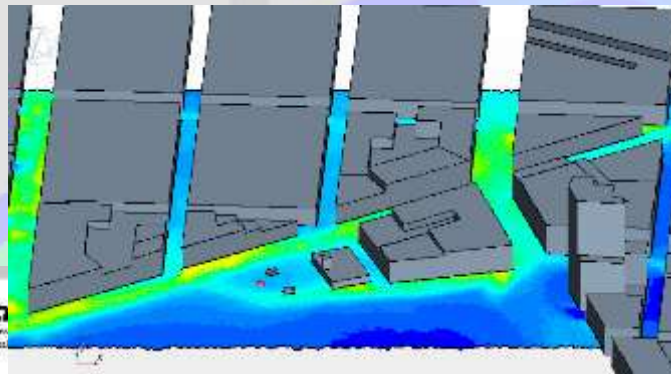
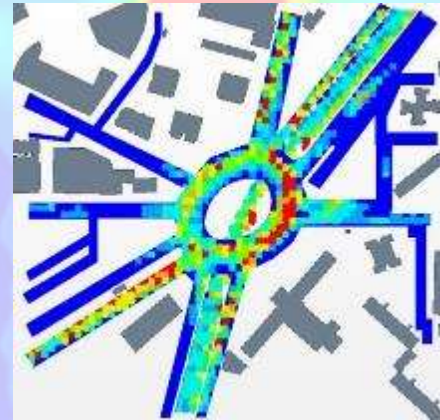
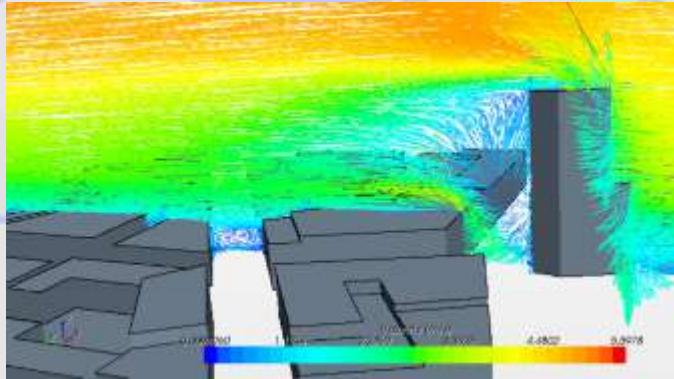
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Introduction

- ❑ Atmosphere – Urban Surfaces Interactions →
Complex flow circulation in city
- ❑ Reduced Ventilation in Streets
- ❑ Traffic Emission heterogeneities

High pollutant concentration and strong gradient of concentration (spatial and temporal)

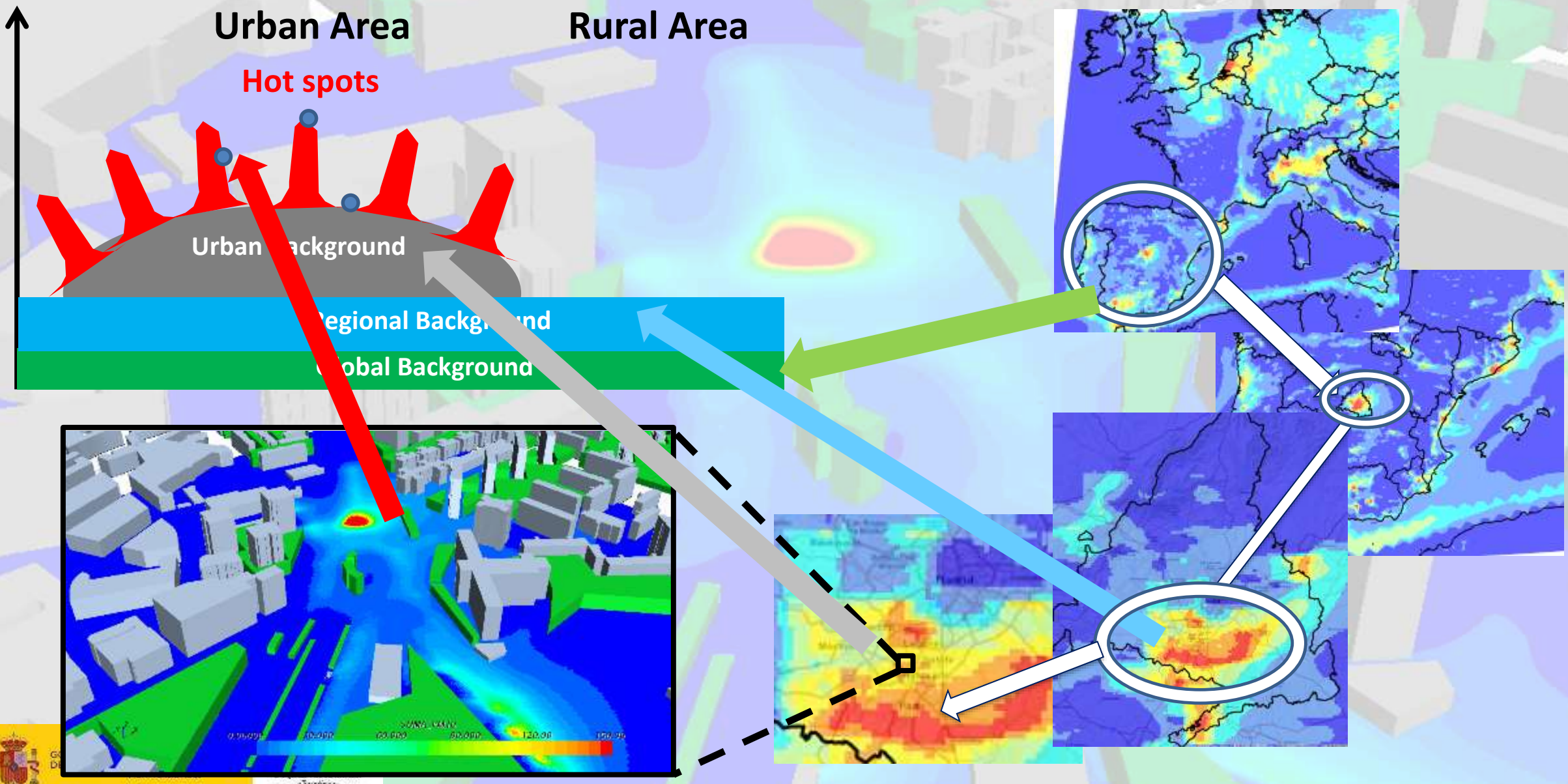


Street Scale



High Spatial Resolution Needed

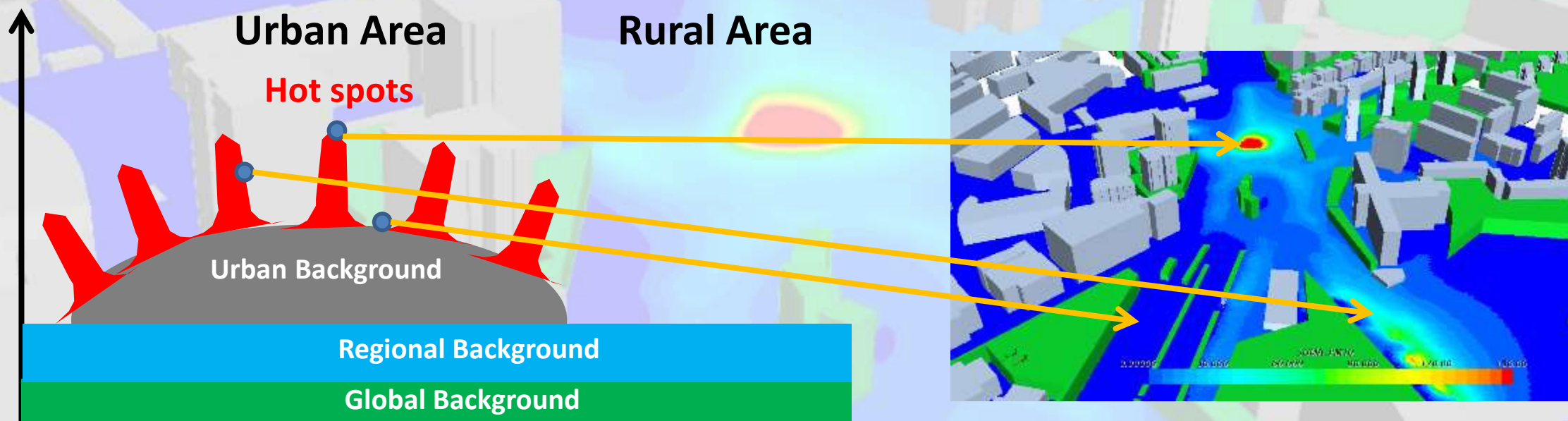
Introduction



Introduction

Processes at different scales

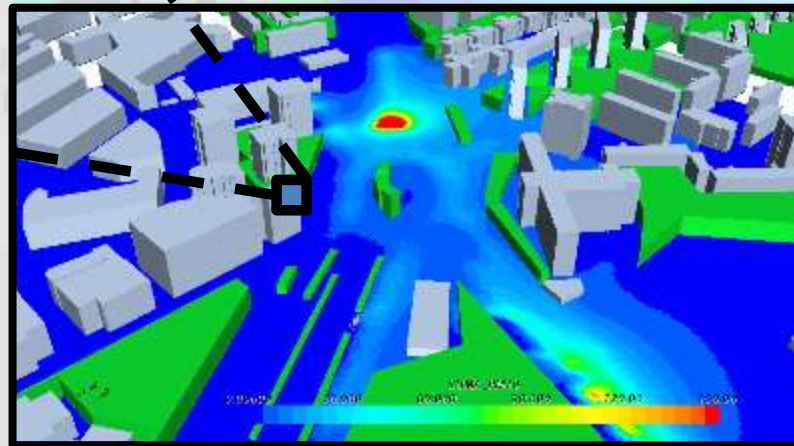
- Concentrations at Street levels → Processes and contributions at different scale



Multiscale Modelling is needed

Introduction

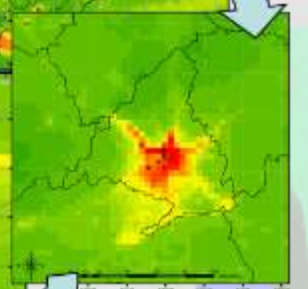
CFD MODELLING



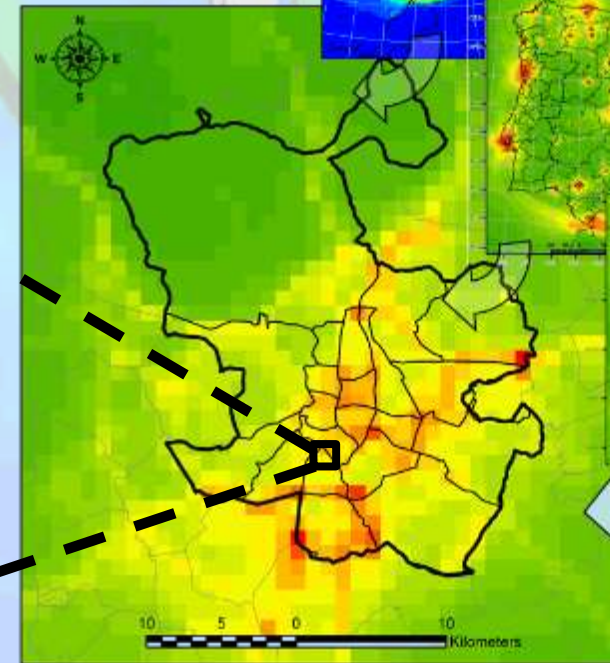
D1



D2



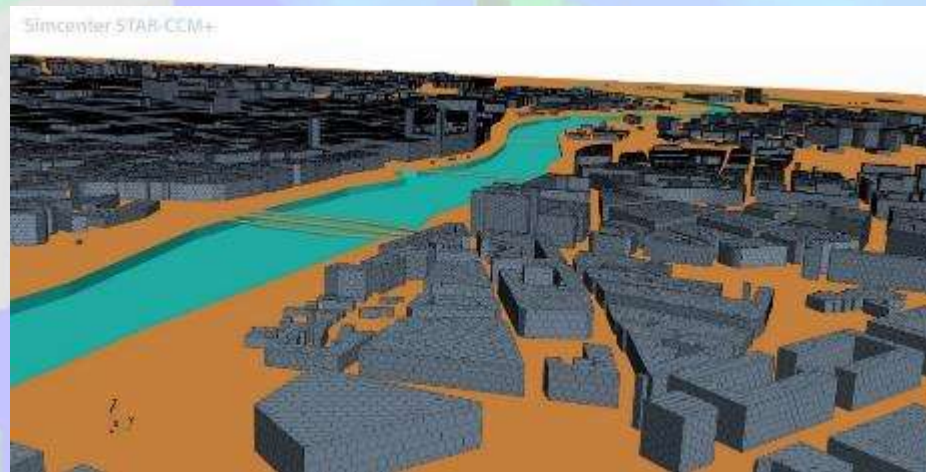
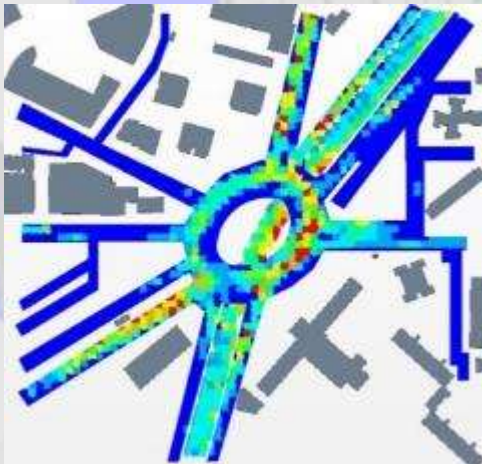
D3



D4

CFD Modelling

- ❑ Solves flow and turbulence equations considering explicitly urban obstacles (buildings and vegetation).
- ❑ Numerical domain is discretized with an irregular mesh (spatial resolution ~ 1 m)
- ❑ Reynolds-Averaged Navier-Stokes (RANS) with a Realizable $k-\varepsilon$ (model STAR-CCM+, Siemens).
- ❑ Pollutant dispersion: Transport equations
- ❑ Traffic emissions

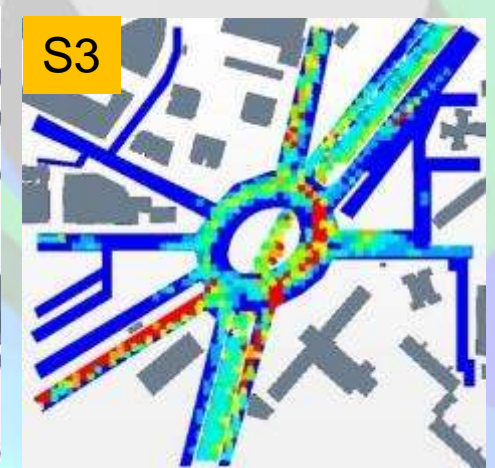
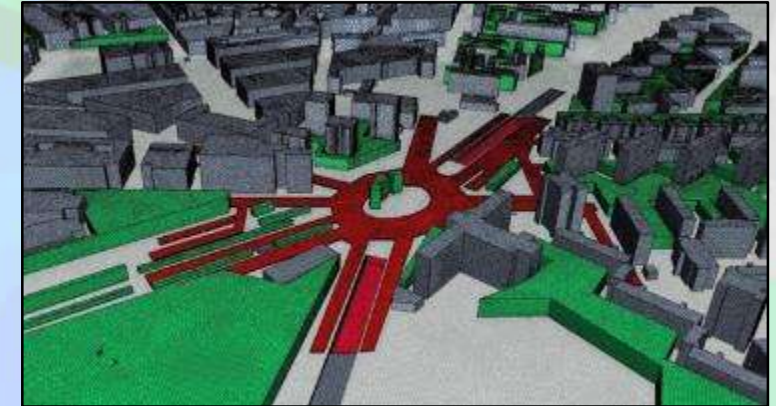


Applications: TECNAIRE-CM project

Modelling NO_x concentrations

- ❑ **CFD mesh:** $8.5 \cdot 10^6$ polyhedral cells.
Resolution: 2 m in the studied zone with prism layer of 1m close to the surfaces
- ❑ 16 wind directions with neutral inlet profiles of wind speed and TKE.
- ❑ **Traffic emissions:**
 - ❑ 300 m x 300 m
 - ❑ 14 hourly emission scenarios to reproduce hourly emissions of 1 week.
 - ❑ Spatial distribution at high resolution (5 m x 5 m).
- ❑ Background concentration from Background AQMS.
- ❑ Meteorology from meteo station

Sanchez et al., 2017. <https://doi.org/10.1016/j.atmosenv.2017.05.022>

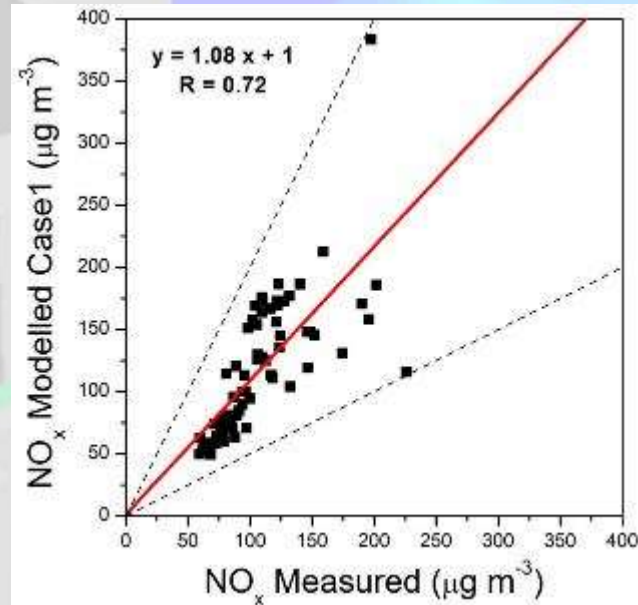
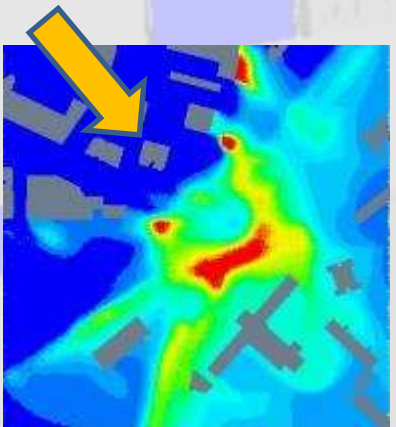
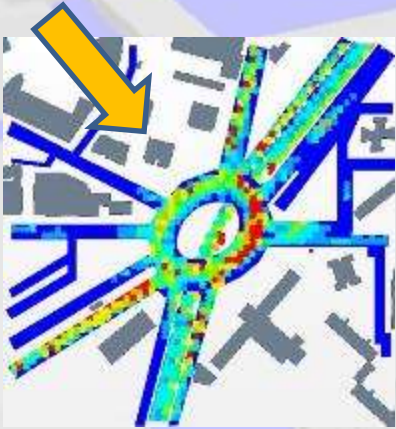


Applications: TECNAIRE-CM project

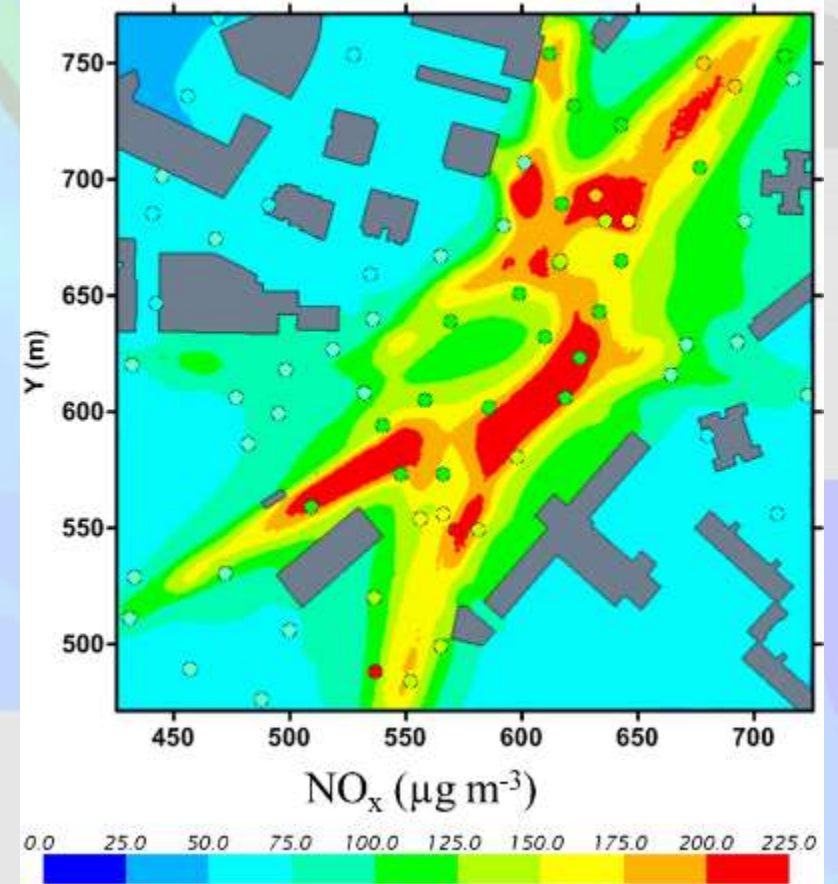
Modelling NOx concentrations

Peak Traffic scenario (8h)

Sanchez et al., 2017. <https://doi.org/10.1016/j.atmosenv.2017.05.022>



NOx average concentration at 3m



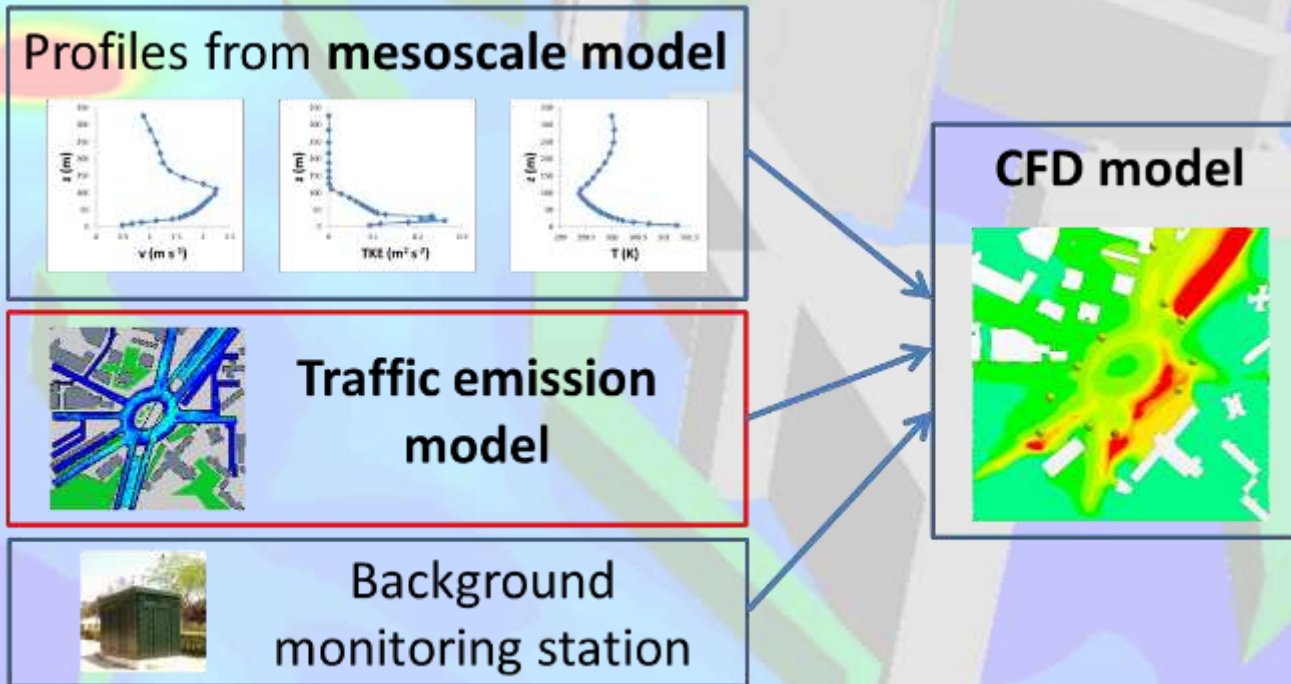
| | $C_{mod}[u_*]$ | Acceptance Criteria (Goricsan et al., 2011 and Chang et al., 2005) | |
|------|----------------|--|------|
| NMSE | 0.11 | <1.5 | Good |
| FB | -0.09 | -0.3 <0 <0.3 | Good |
| R | 0.72 | 0.5 <R <0.8 | Fair |

Applications: TECNAIRE-CM project

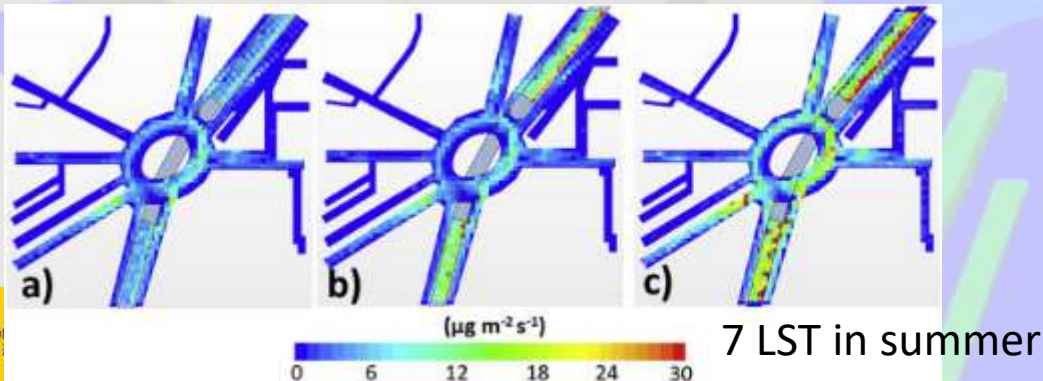
Modelling PM₁₀ concentrations

- Hourly concentration maps of PM10
- Hourly emissions (300 m x 300 m) with a resolution of 5 m x 5 m are computed using a combination of traffic and emissions micro-simulation.
- PM2.5 and PM10 emissions from vehicle exhaust, particle resuspension, pavement abrasion and brake and tire wear are considered.

Santiago et al., 2020. <https://doi.org/10.1016/j.apr.2019.10.001>

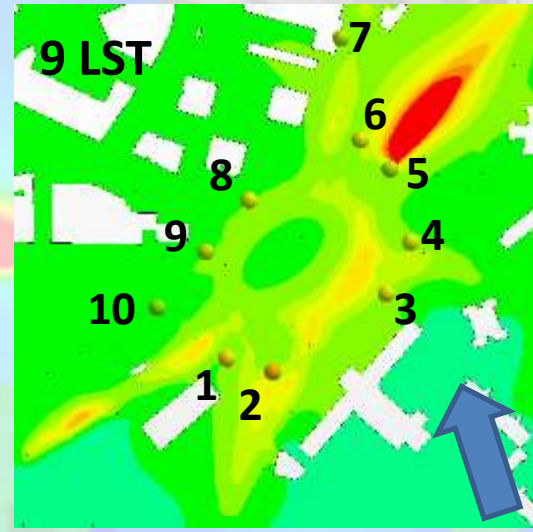
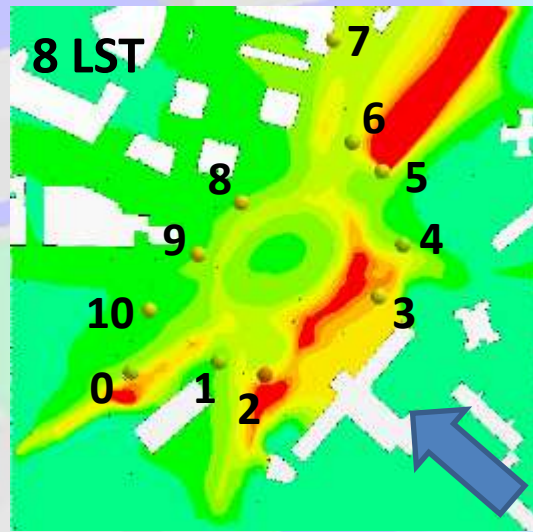
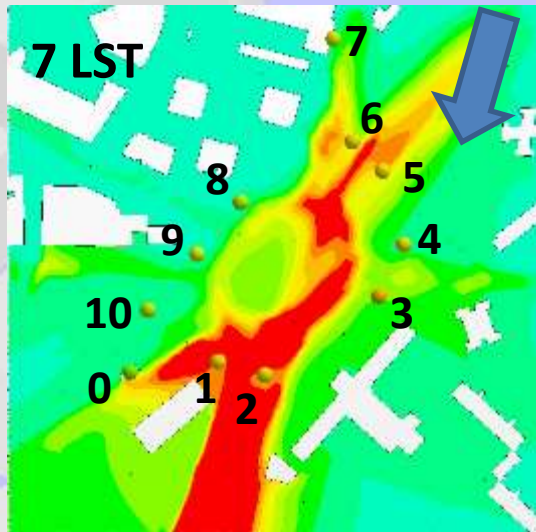


Exhaust emission Non-exhaust emission Total emission

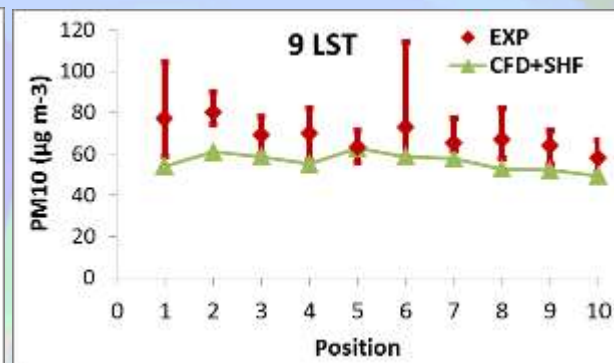
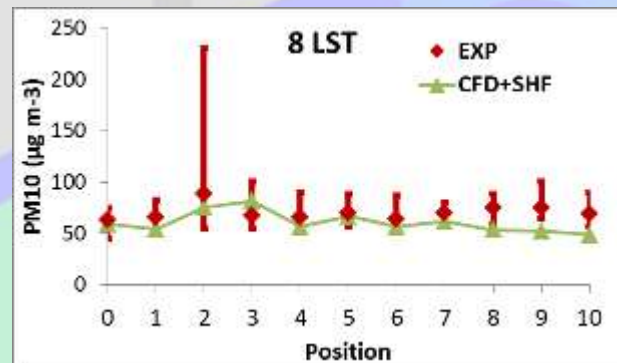
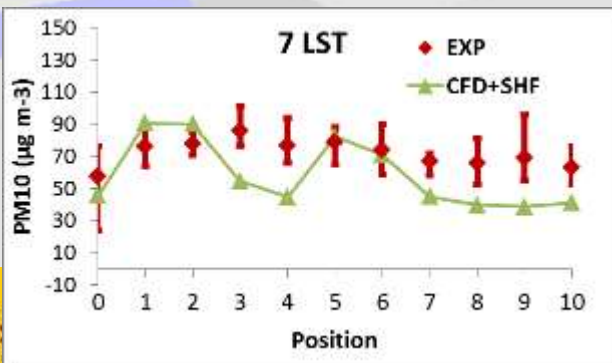
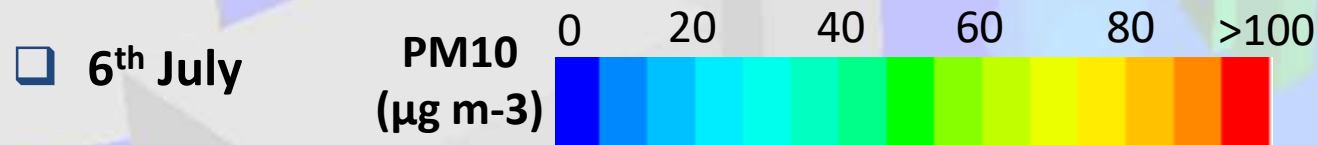


Applications: TECNAIRE-CM project

Modelling PM₁₀ concentrations

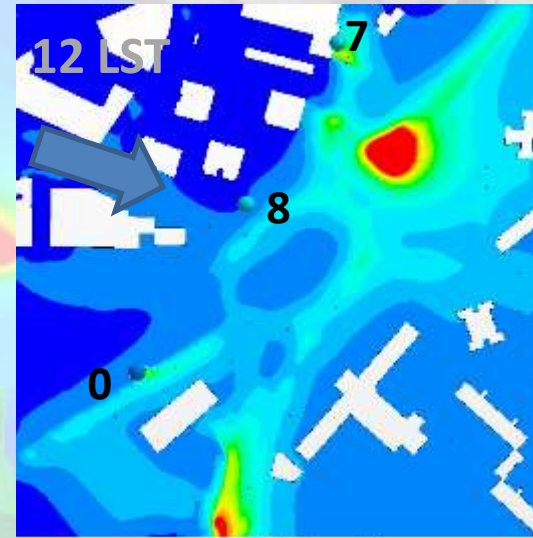
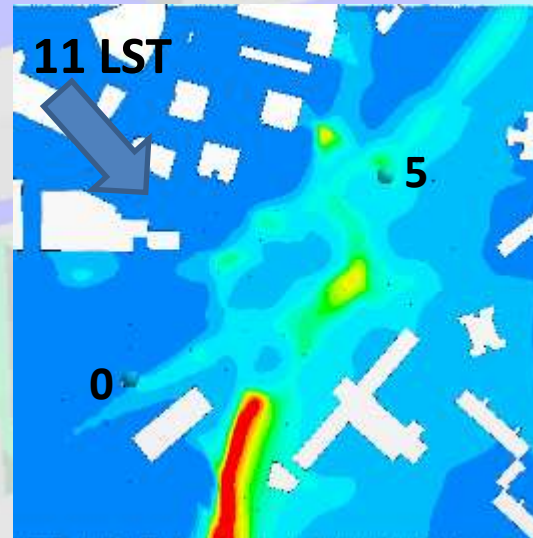
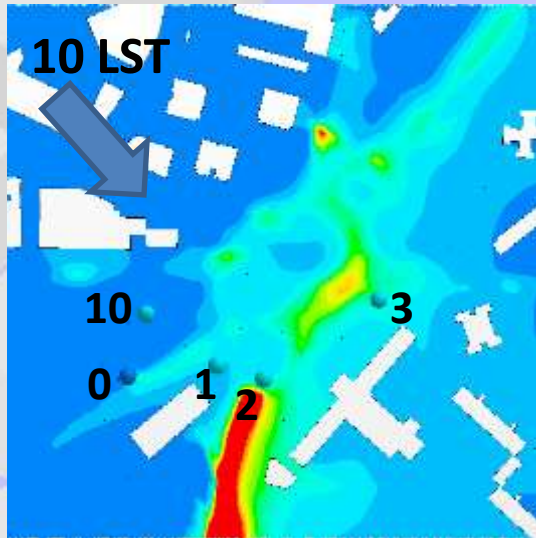


Santiago et al., 2020.
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Applications: TECNAIRE-CM project

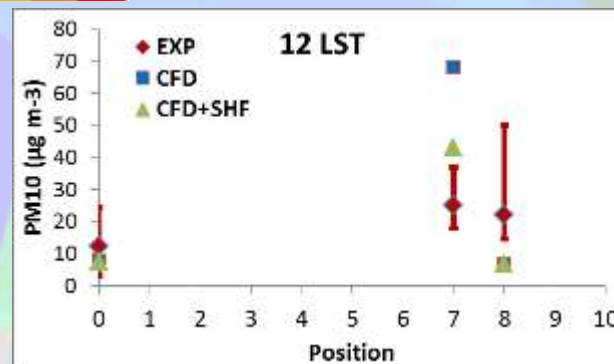
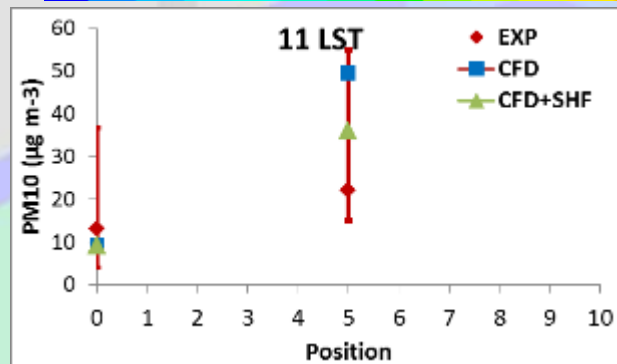
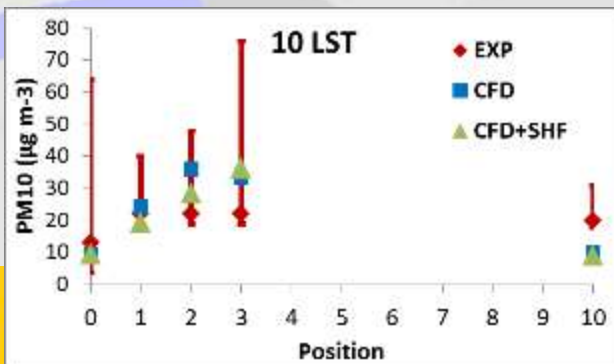
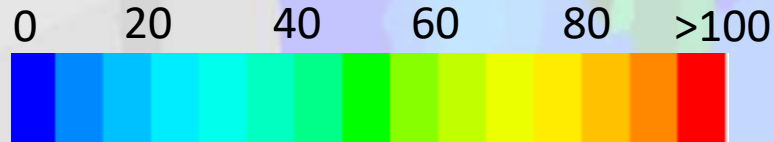
Modelling PM₁₀ concentrations



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25th February

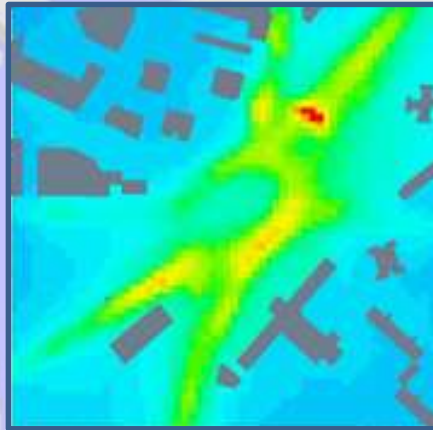
PM₁₀
($\mu\text{g m}^{-3}$)



Applications: TECNAIRE-CM project

Pedestrian Exposure

1. High resolution concentration maps → CFD modelling



($\mu\text{g m}^{-3}$)

Hourly maps during an average day

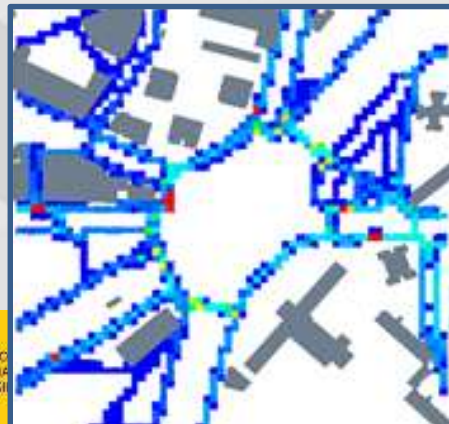
Santiago et al., 2021.

<https://doi.org/10.1016/j.scitotenv.2020.142475>

Total Exposure
($\text{person}\cdot\text{s } \mu\text{g m}^{-3}$)



2. Pedestrian data → Pedestrian flow microsimulations



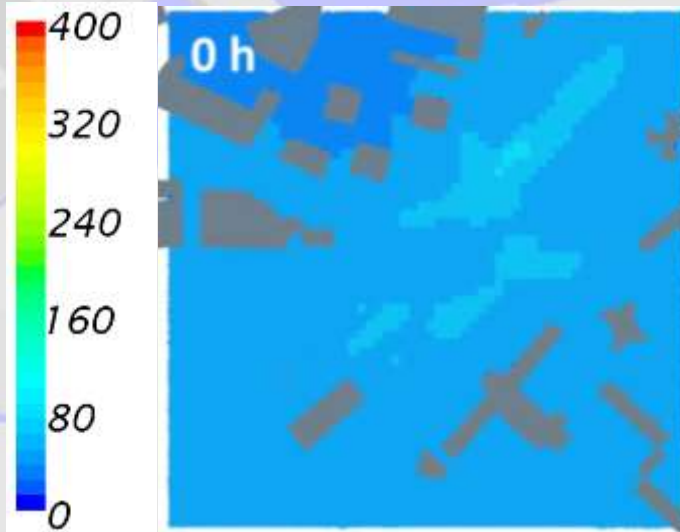
($\text{person}\cdot\text{s}$)

Pedestrian flows throughout the study area for different hourly scenarios

Applications: TECNAIRE-CM project

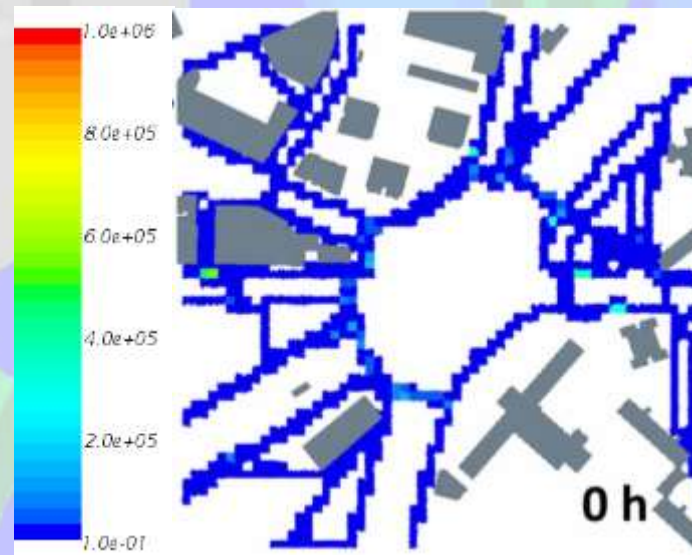
Pedestrian Exposure

Hourly NOx ($\mu\text{g m}^{-3}$)

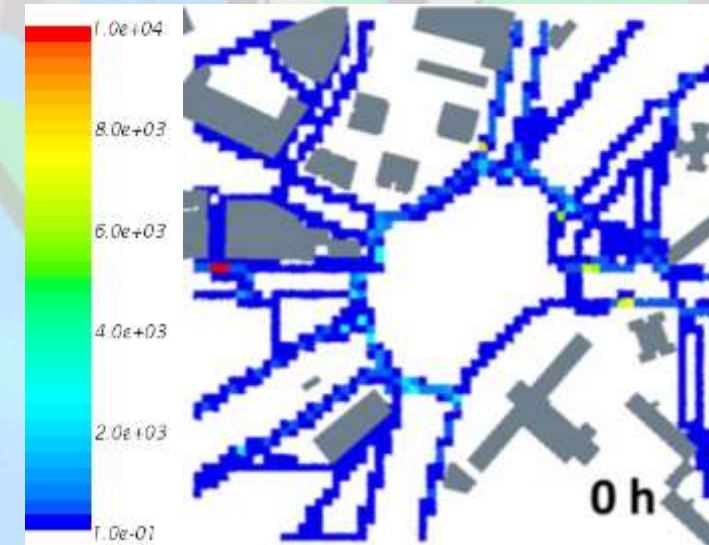


Hourly Exposure during
a Representative
Average Day

Total Hourly Exposure
($\text{person}\cdot\text{s } \mu\text{g m}^{-3}$)



Pedestrians (person·s)



- Pedestrian position (bus stops) have an important influence on total daily exposure

Santiago et al., 2021.
<https://doi.org/10.1016/j.scitotenv.2020.142475>

Other applications

- ❑ Planning:
 - ❑ Impacts of mitigation strategies (Low emission zones).
 - ❑ Future scenarios
- ❑ Unsteady simulations using emissions with high temporal resolution:
 - ❑ Pedestrian exposure



IRTEMS project closure workshop

Thank you for your attention
Questions?

