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del instrumento  
financiero LIFE  
de la Comunidad  
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# LIFE+RESPIRA

## “Reduction of exposure of cyclists to urban pollutants”

Reference: LIFE13 ENV/ES/000417

*Jesús Miguel Santamaría*

Barcelona 26-27/9/2017



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Tudela**

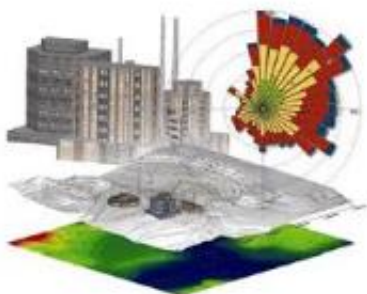


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## Project objectives

- To study Pamplona air pollution through a high-density monitoring network
- To characterize the exposure of cyclists and pedestrians to major urban air pollutants
  - ✓ NO
  - ✓ NO<sub>2</sub>
  - ✓ CO
  - ✓ O<sub>3</sub>
  - ✓ PM (Pm<sub>10</sub>, PM<sub>2.5</sub> and PM<sub>1</sub>)



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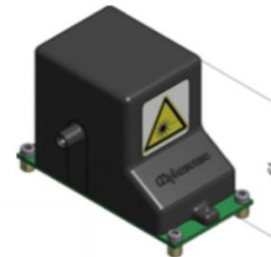
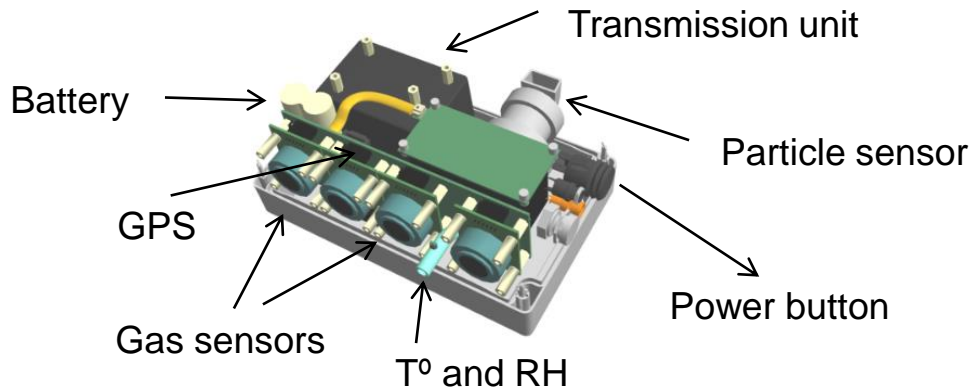


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## Characteristics of prototypes

- Electrochemical sensors for analysis of NO, NO<sub>2</sub>, CO, O<sub>3</sub> and PM
  - ✓ Sampling: every 10 s
  - ✓ Resolution: <5-10 ppb
  - ✓ Wireless communication via GPRS
  - ✓ Lifespan: 3-5 years



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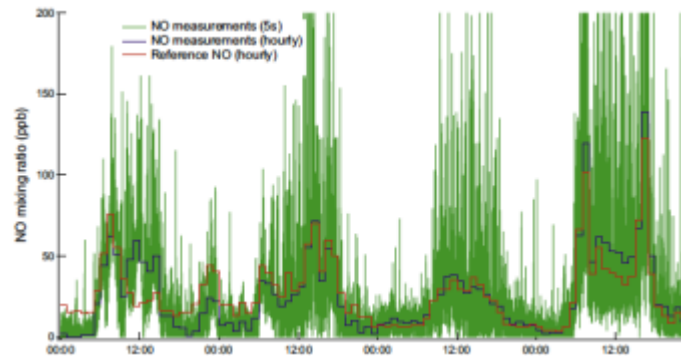


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## Sensors calibration

- Laboratory calibration
- *In situ* calibration
- Calculation of algorithms
- Data validation



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## Air pollutants monitoring

- Statistics from the beginning: May 2015 (2 years)
  - ✓ 200 volunteers (persistent: 113)
  - ✓ 20,000 trips
  - ✓ **44,000 km cycled**
  - ✓ 10,000 km driven
  - ✓ 15,000 bike-hours
  - ✓ 1500 trips with heart rate meters
  - ✓ 77,000 data-recording hours
  - ✓ **150 million measurements**
  - ✓ 817,000 total segments
  - ✓ **3 million datapoints**



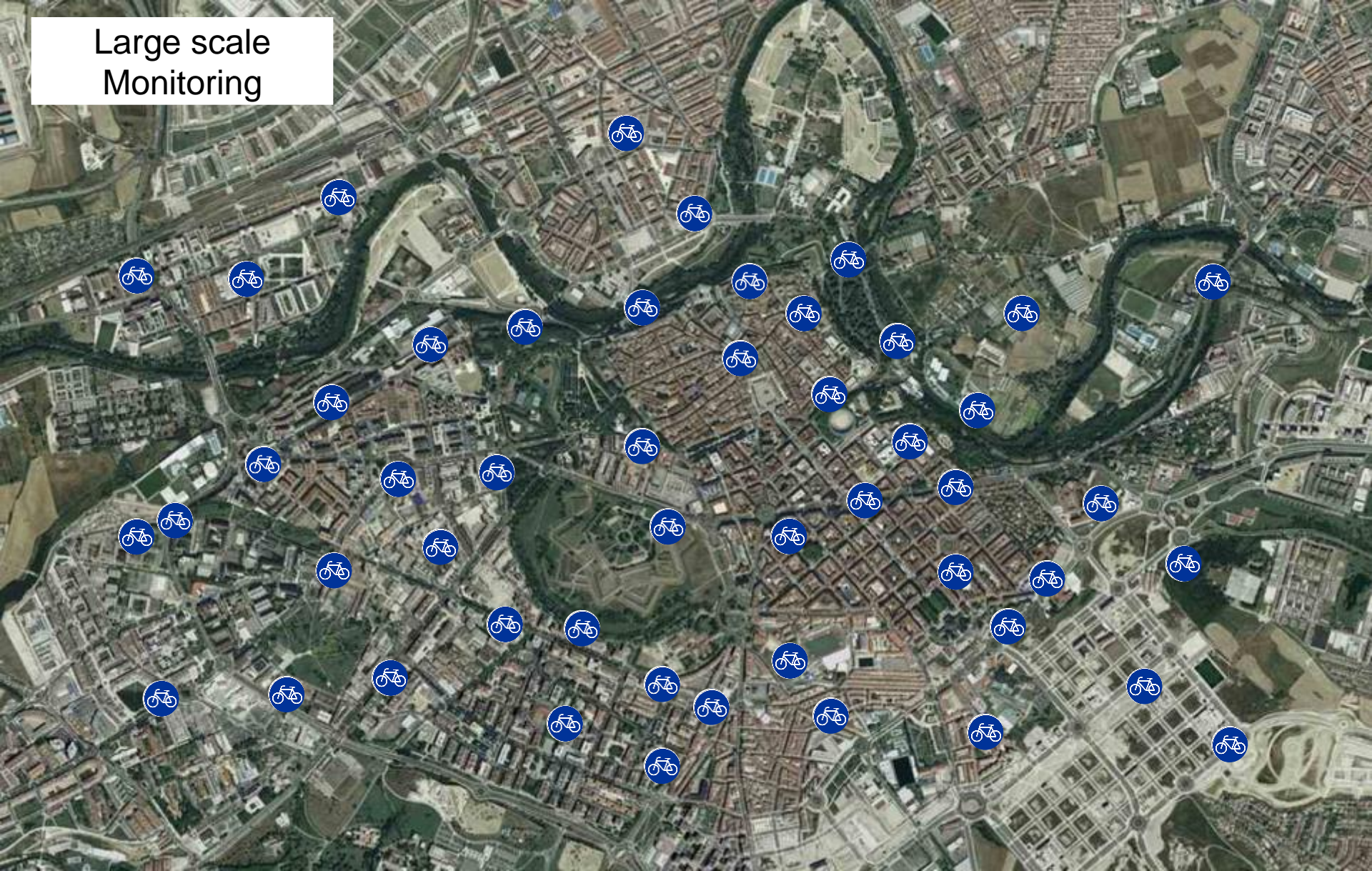
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# Large scale Monitoring



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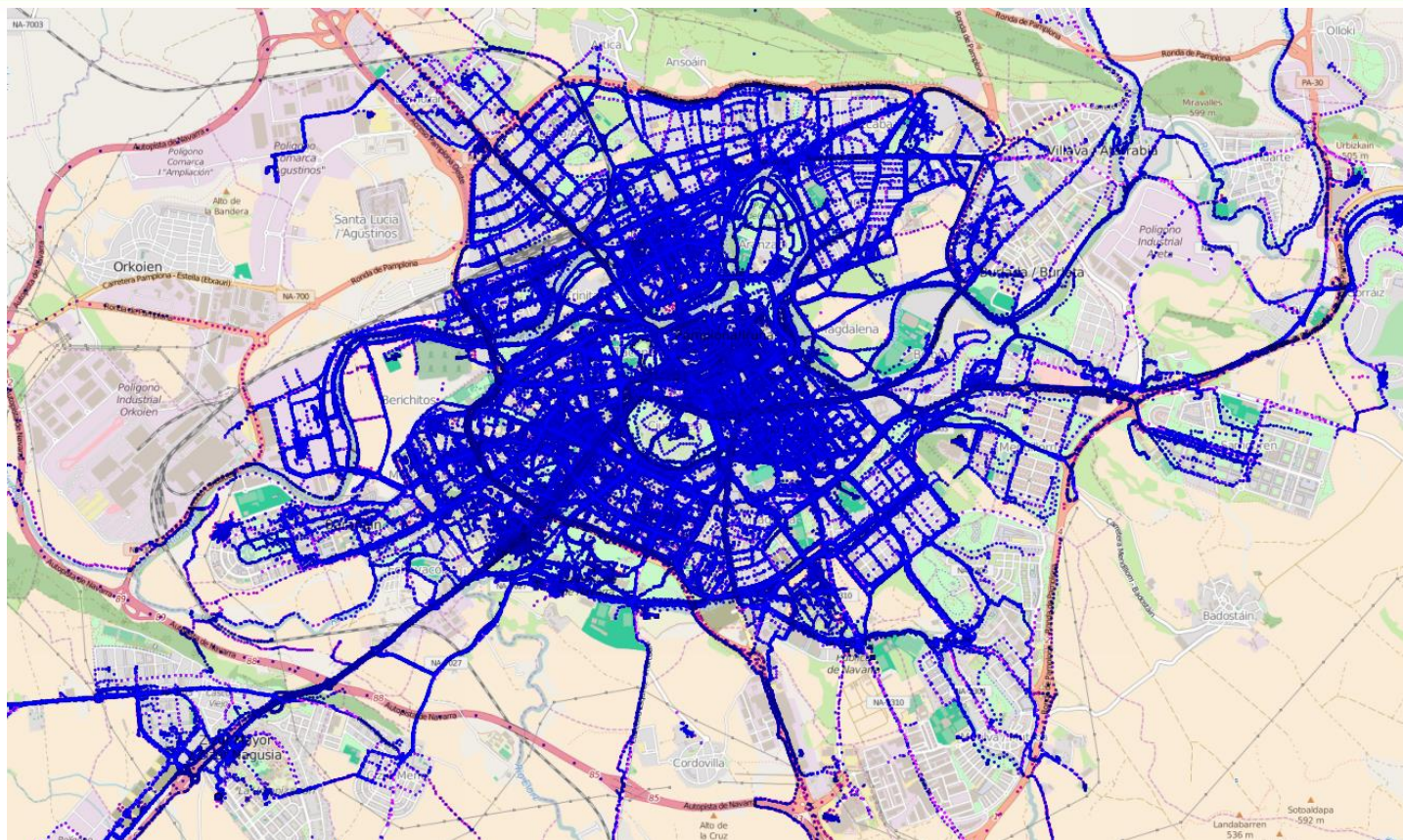


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Universidad de Navarra



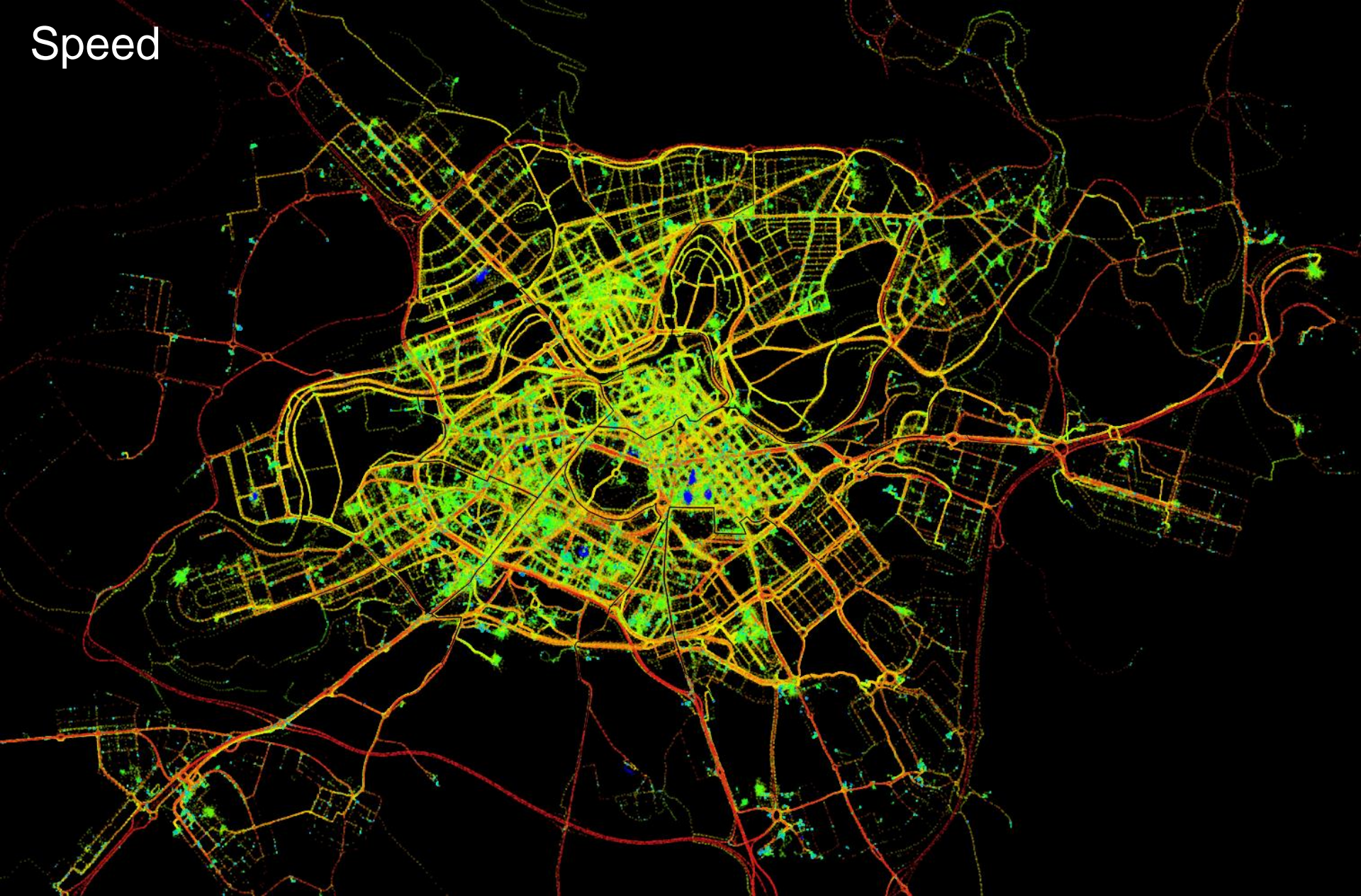
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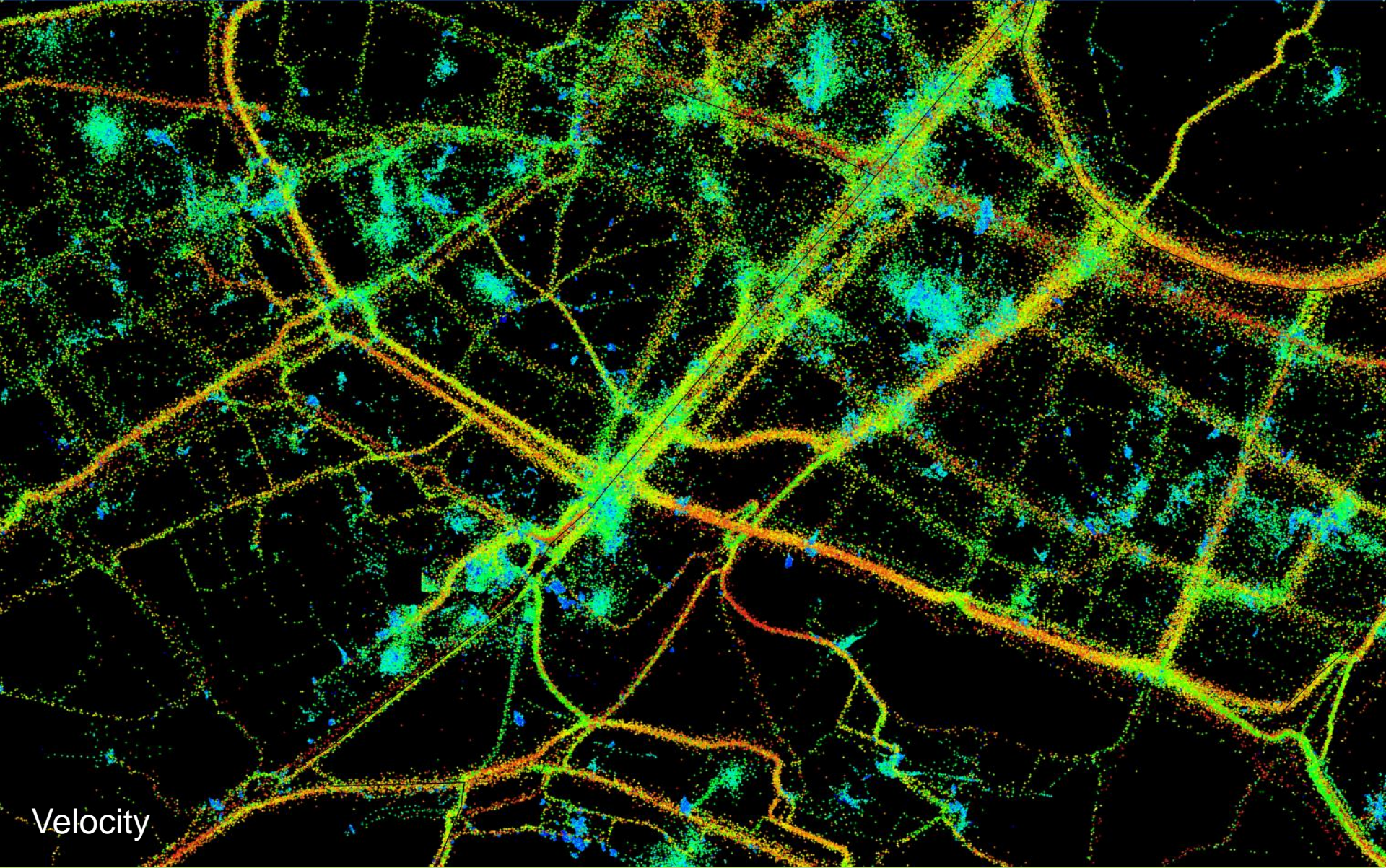
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**Pavimentos Tudela**

# Speed





Velocity

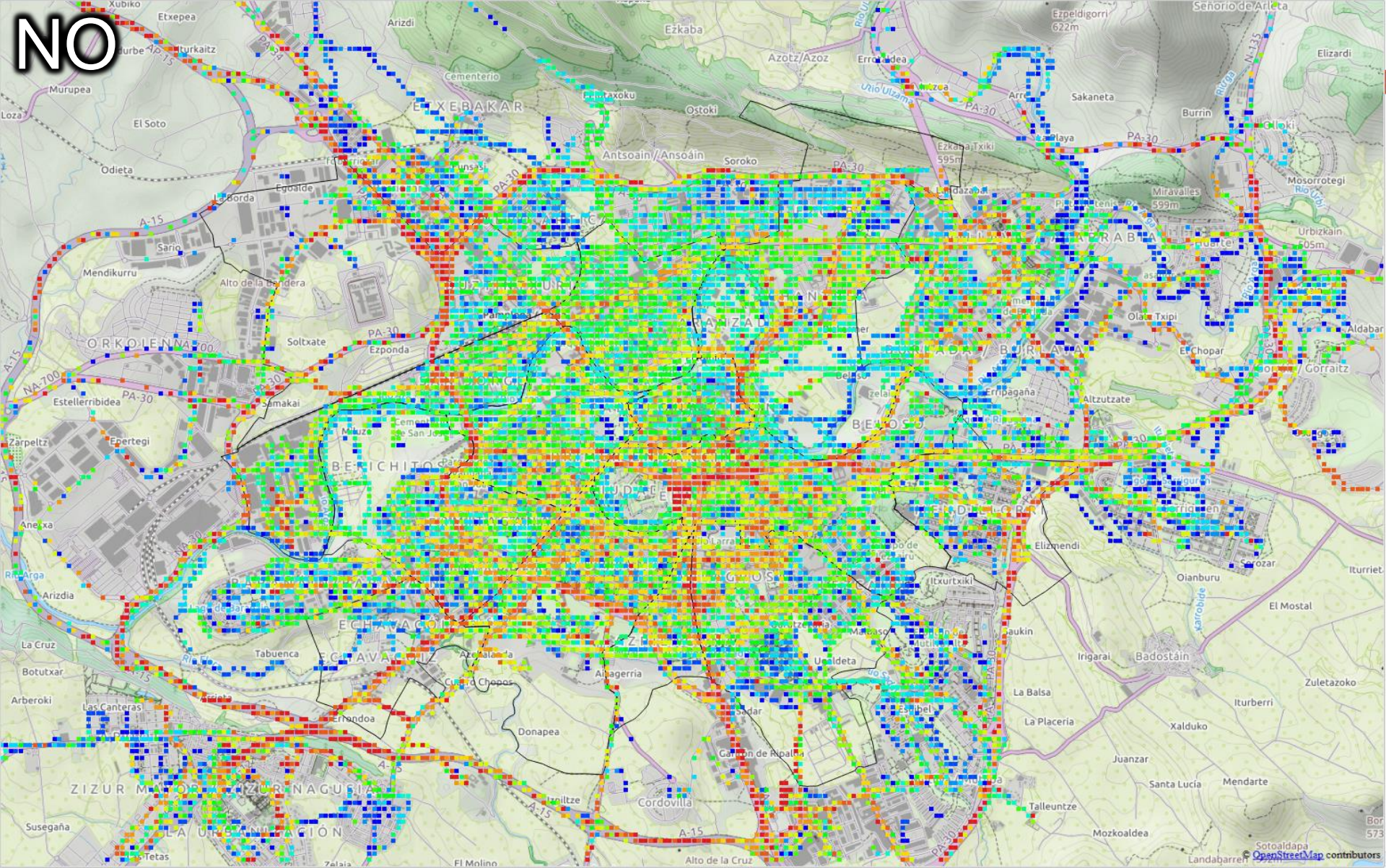
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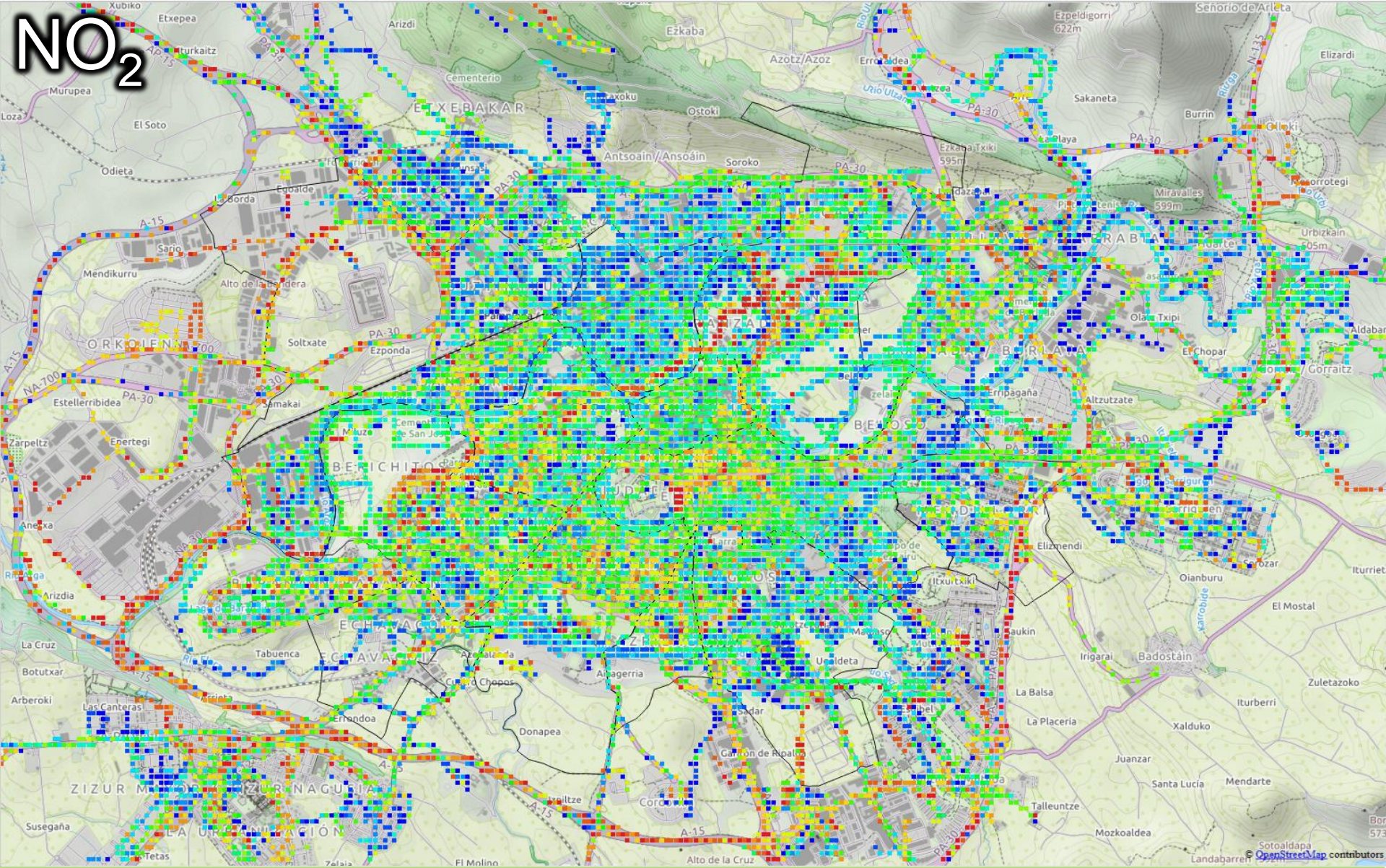
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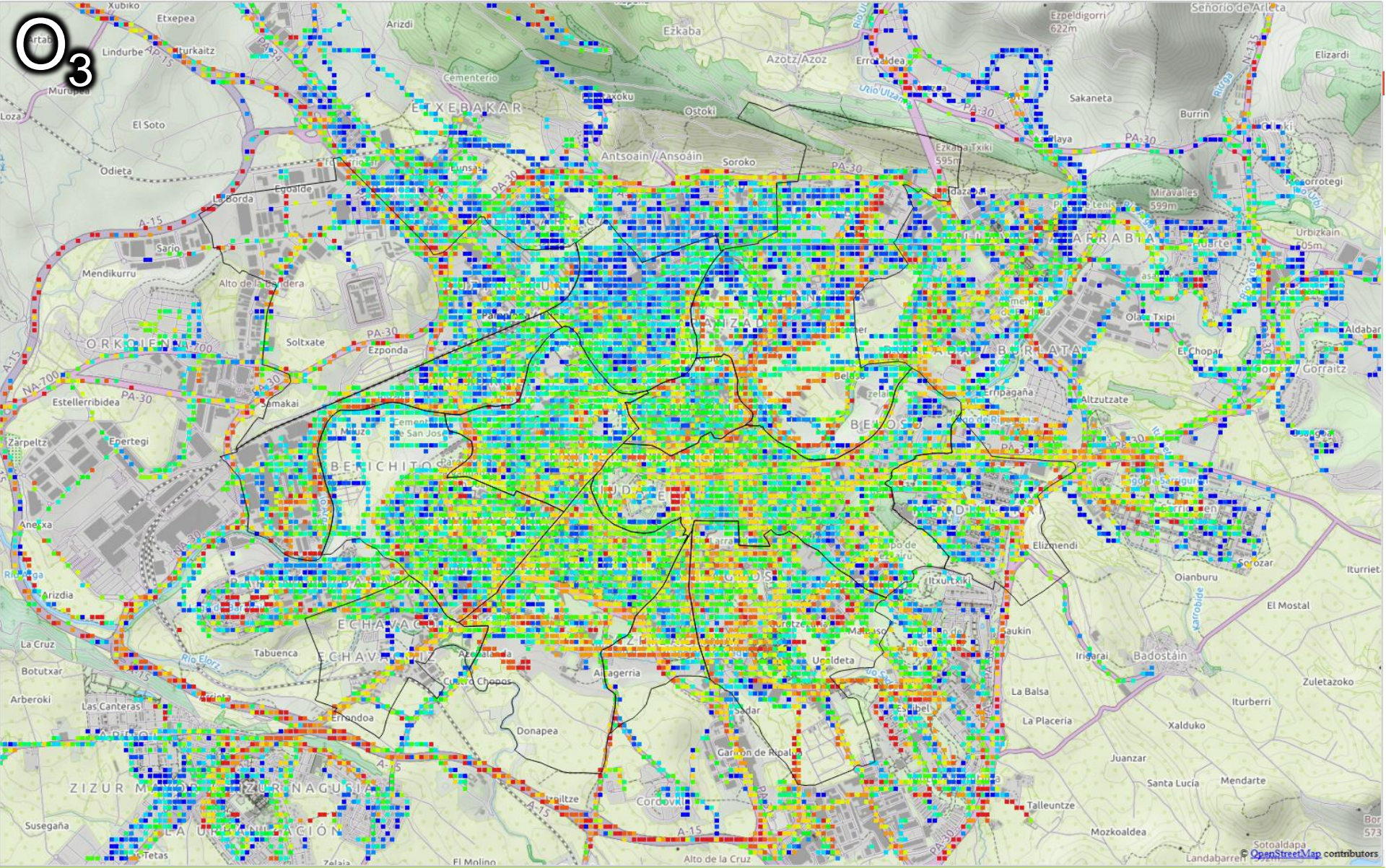


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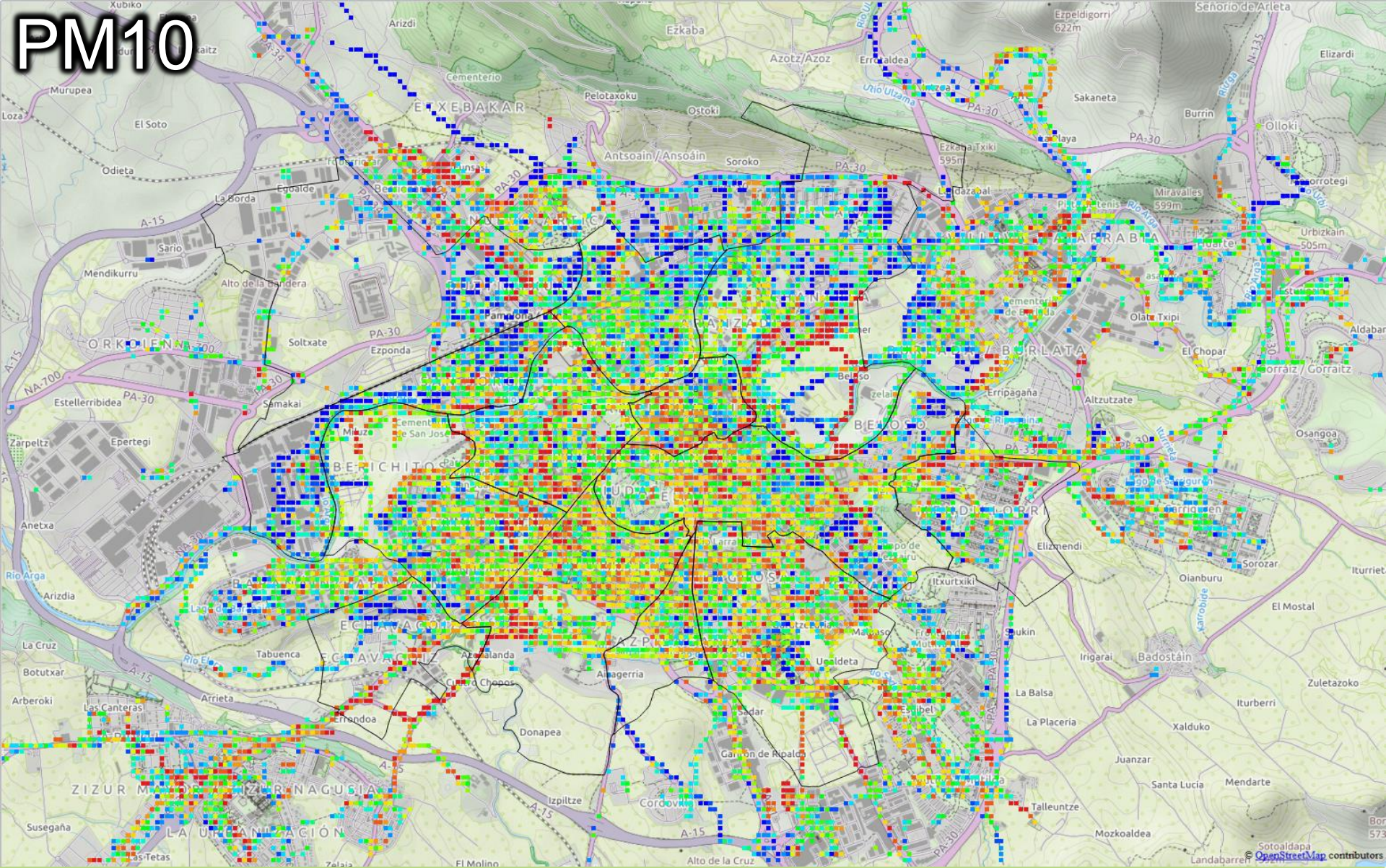


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# PM10

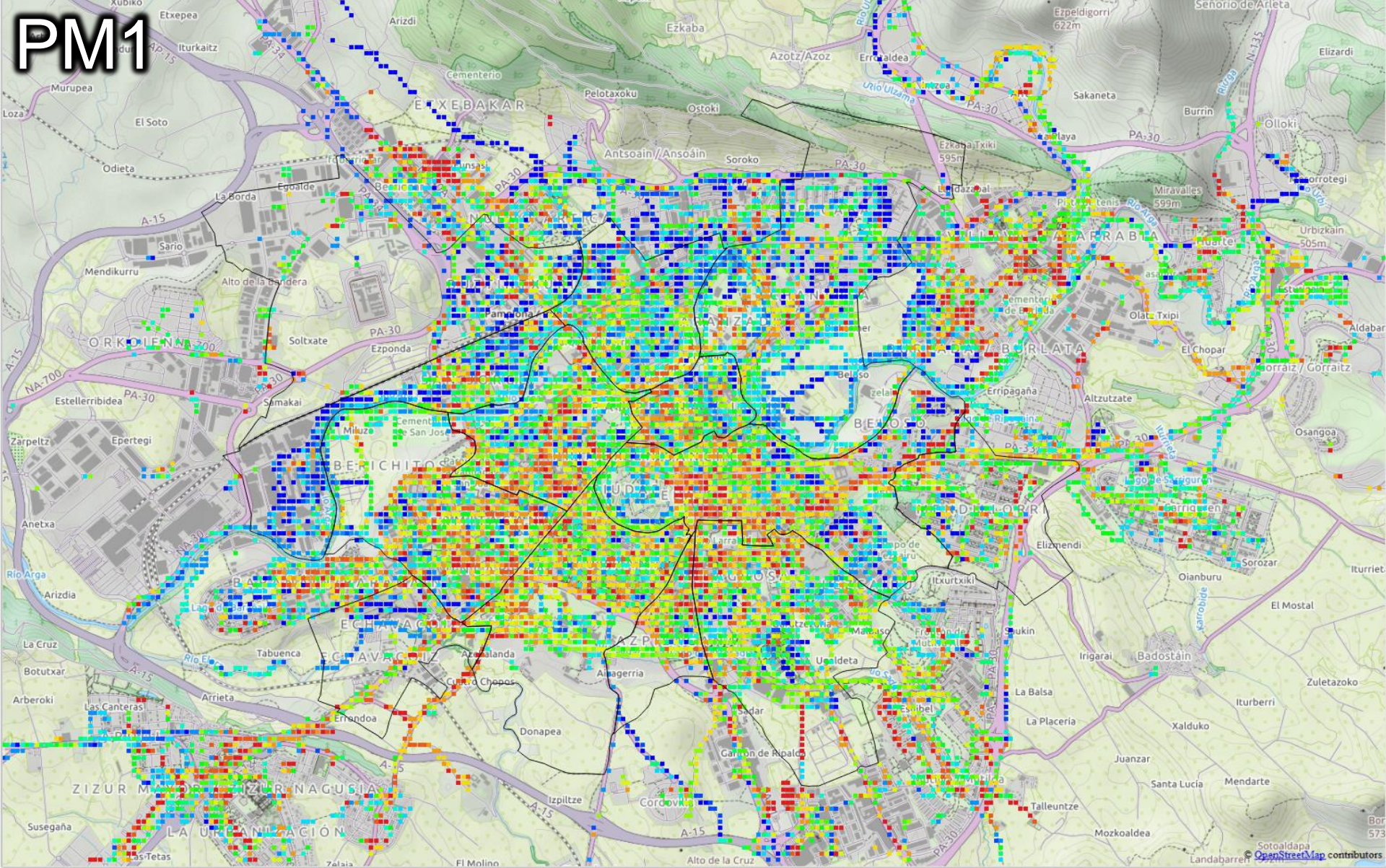


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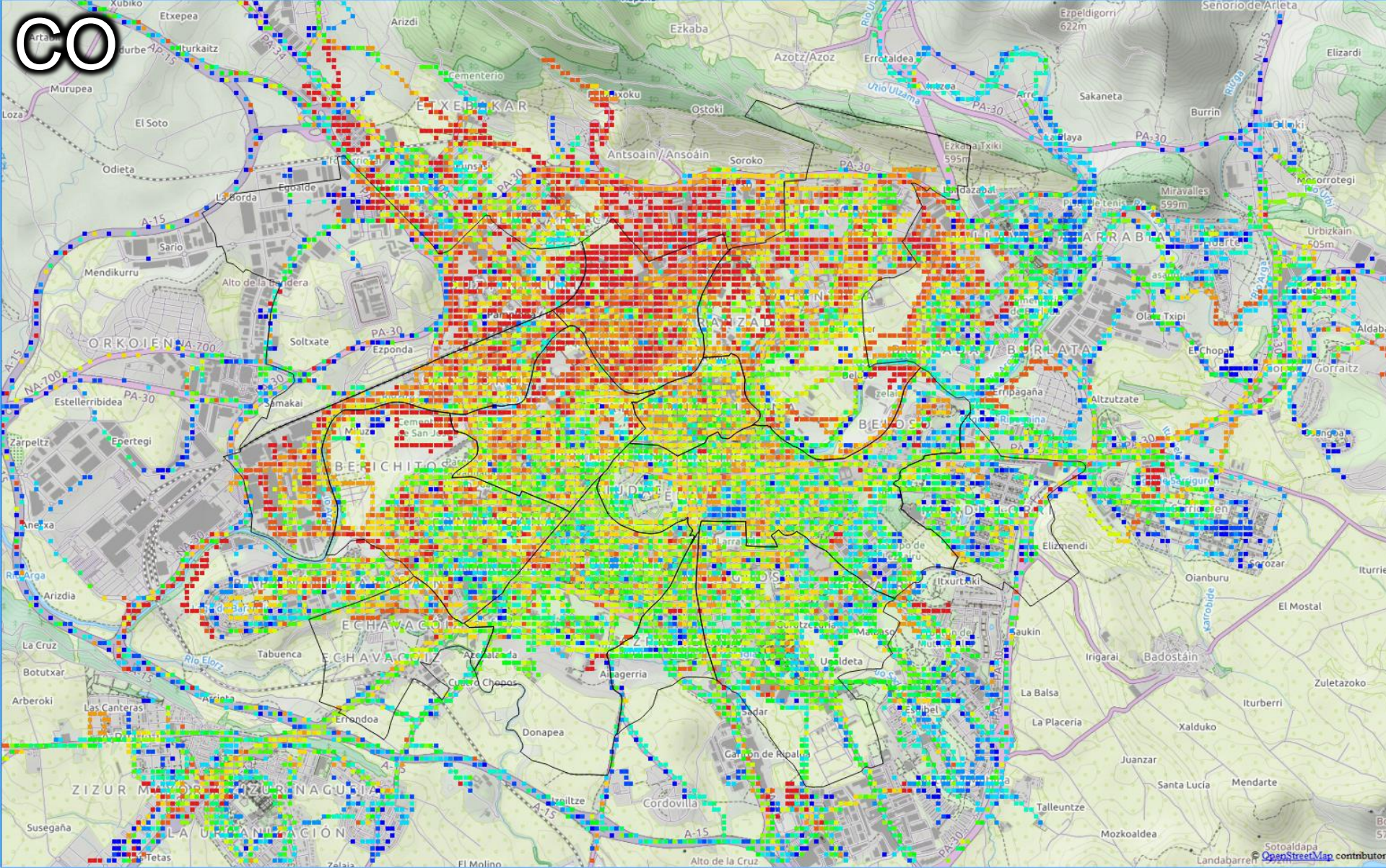
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# LIFE+RESPIRA



## Modelling

- Application of Computational Fluids Dynamics (CFD) Models
- Simulations of air quality with very high resolution (< 5m)
- Estimation of population exposure to urban pollutants
- Prediction of pollution episodes
- Simulation of pollution reduction scenarios

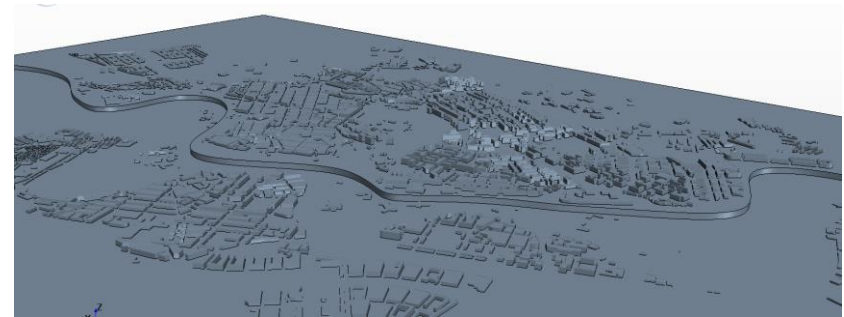
### CAD Model for Buildings



Il Ensanche neighborhood of Pamplona  
(Source: Google Maps satellite image)



Actual heights of buildings:  
CFD 3D model (\*)



(\*) CFD tool: STAR-CCM+9.04.011\*

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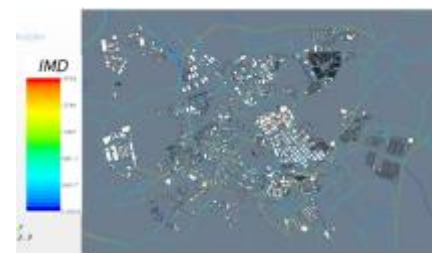
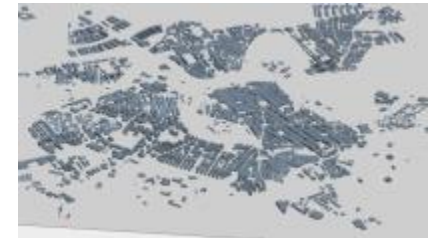
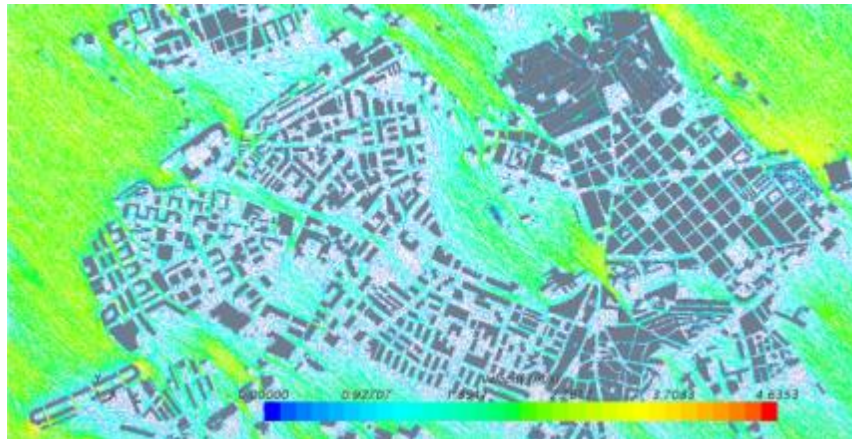
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## Modelling

- Full Geometry of Pamplona (7 km x 5 km)
- Mesh (45 million cells)
- Treatment of emissions (average daily traffic intensity)
- Simulations for 16 wind directions



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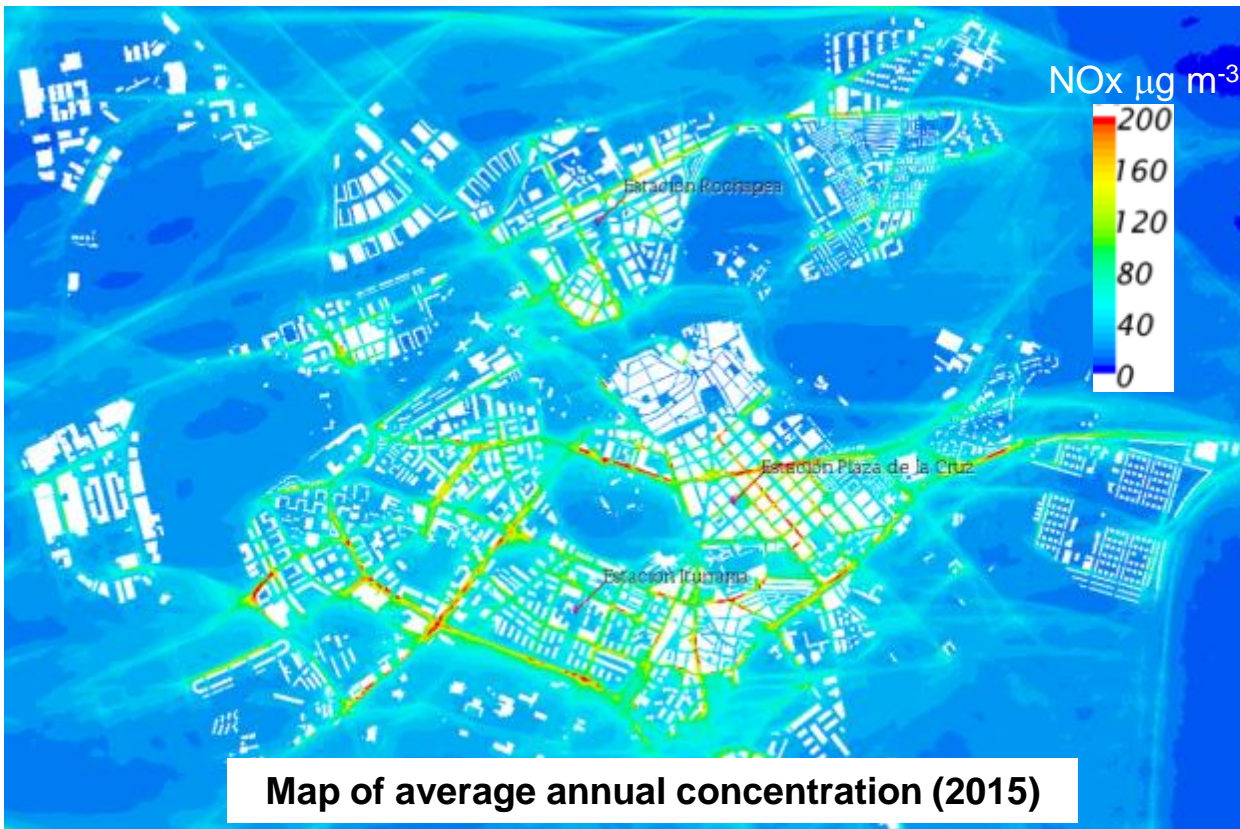
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Map of average annual concentration (2015)

## Rotxapea Air Quality Station

NOx CFD µg m <sup>-3</sup>	NOx GN µg m <sup>-3</sup>	Error %
34,1	35,2	-3,2

## Iturrama Air Quality Station

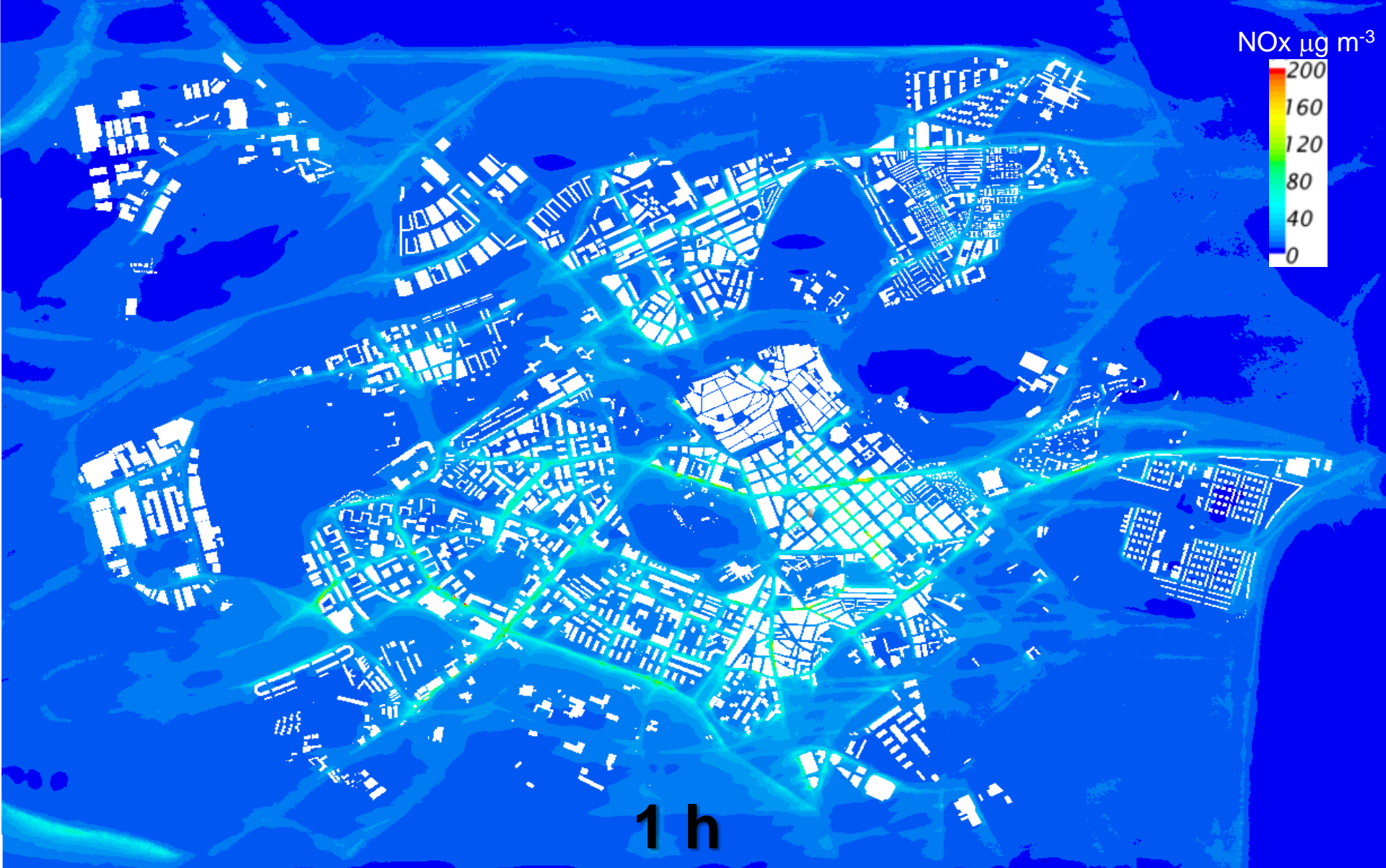
NOx CFD µg m <sup>-3</sup>	NOx GN µg m <sup>-3</sup>	Error %
39,1	38,0	2,9

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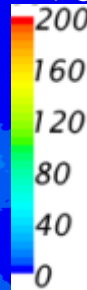


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NOx  $\mu\text{g m}^{-3}$

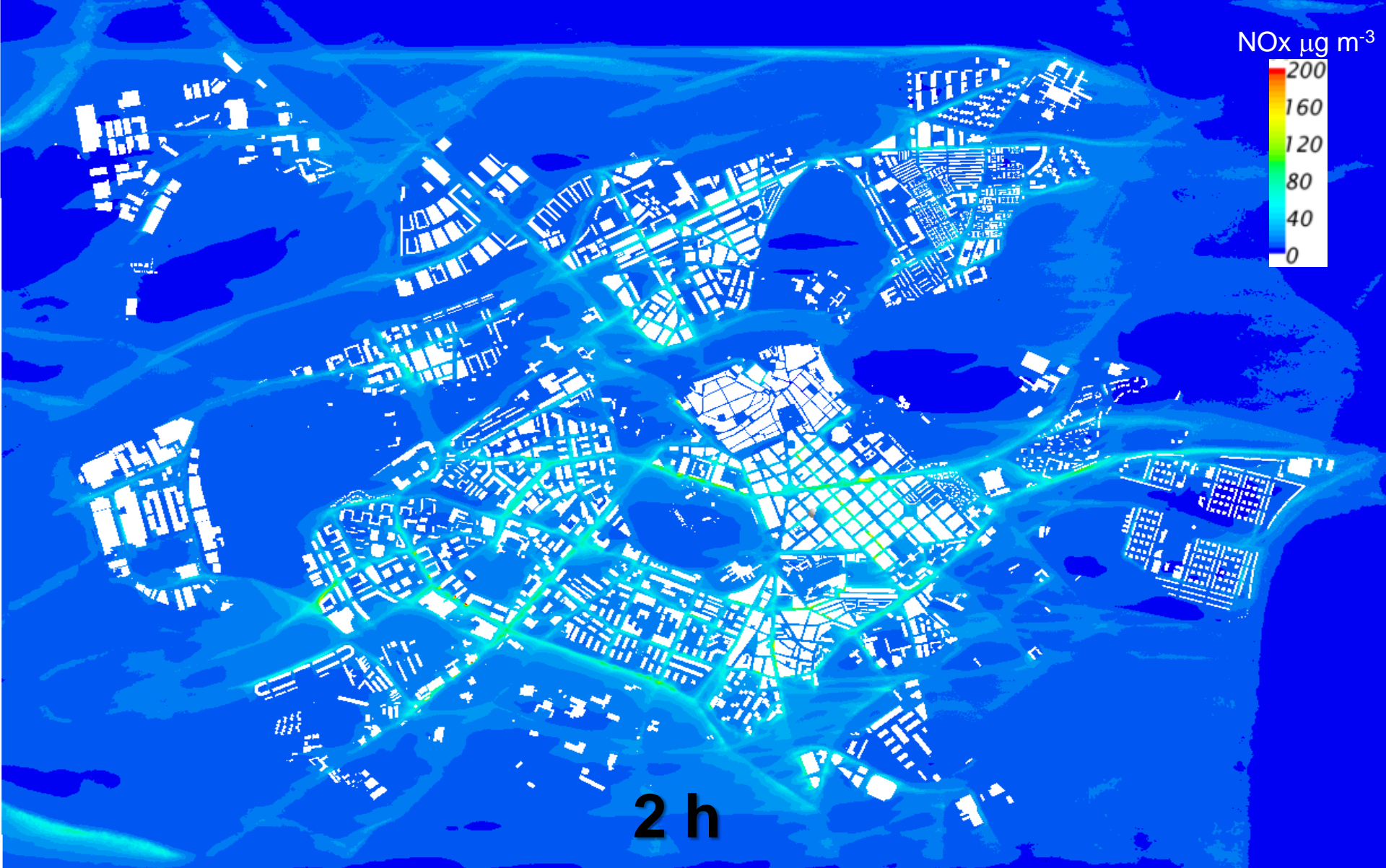


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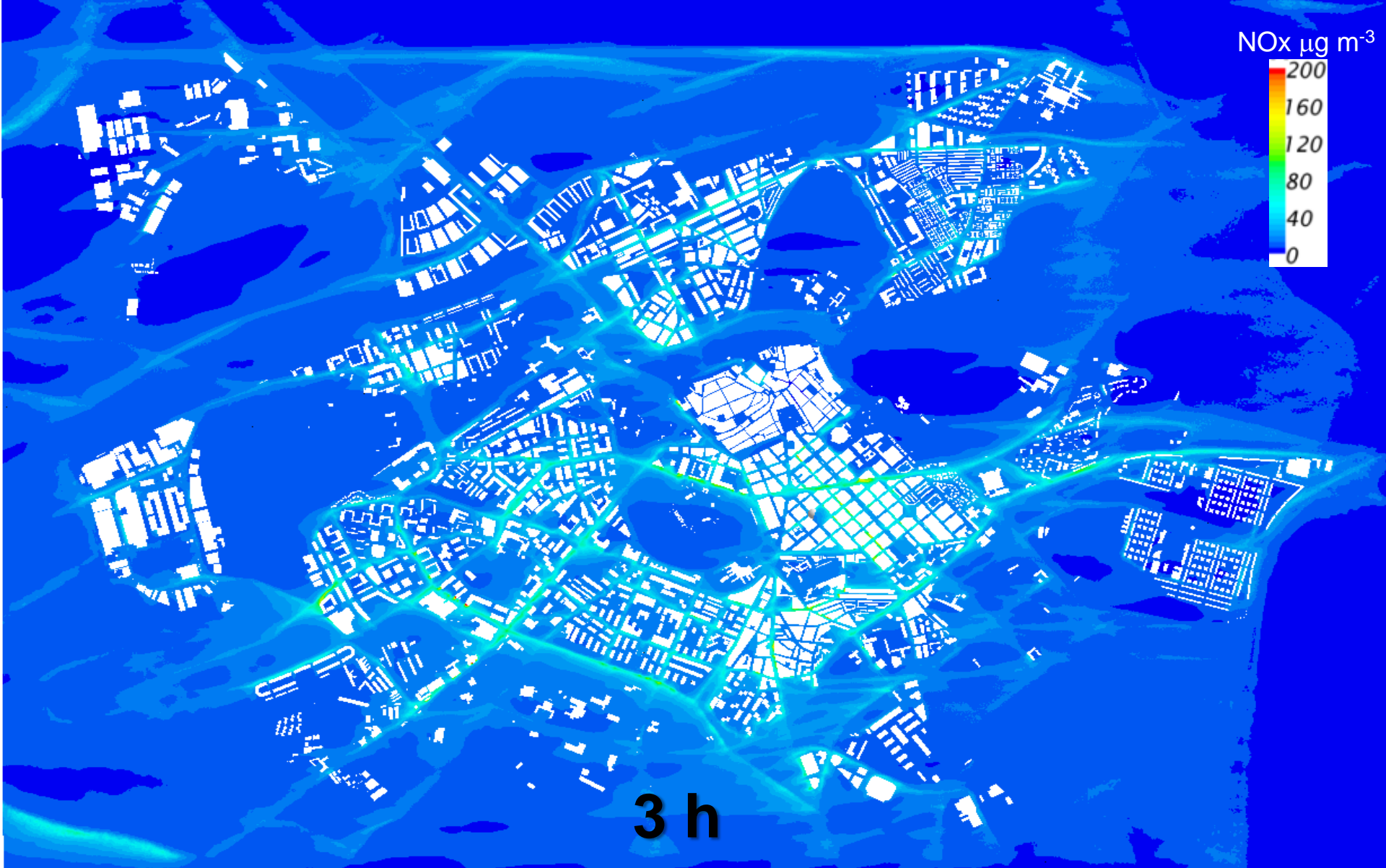
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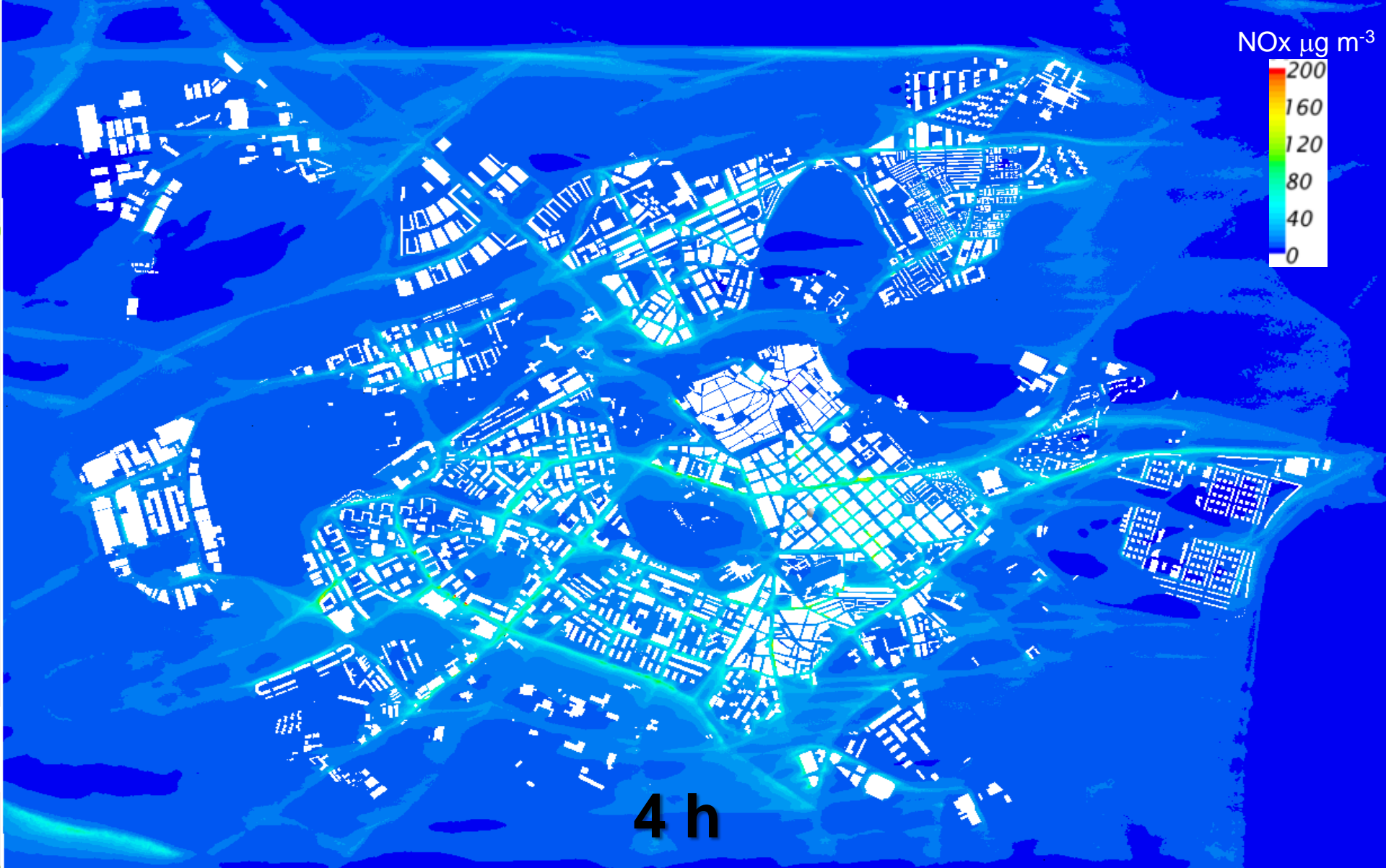
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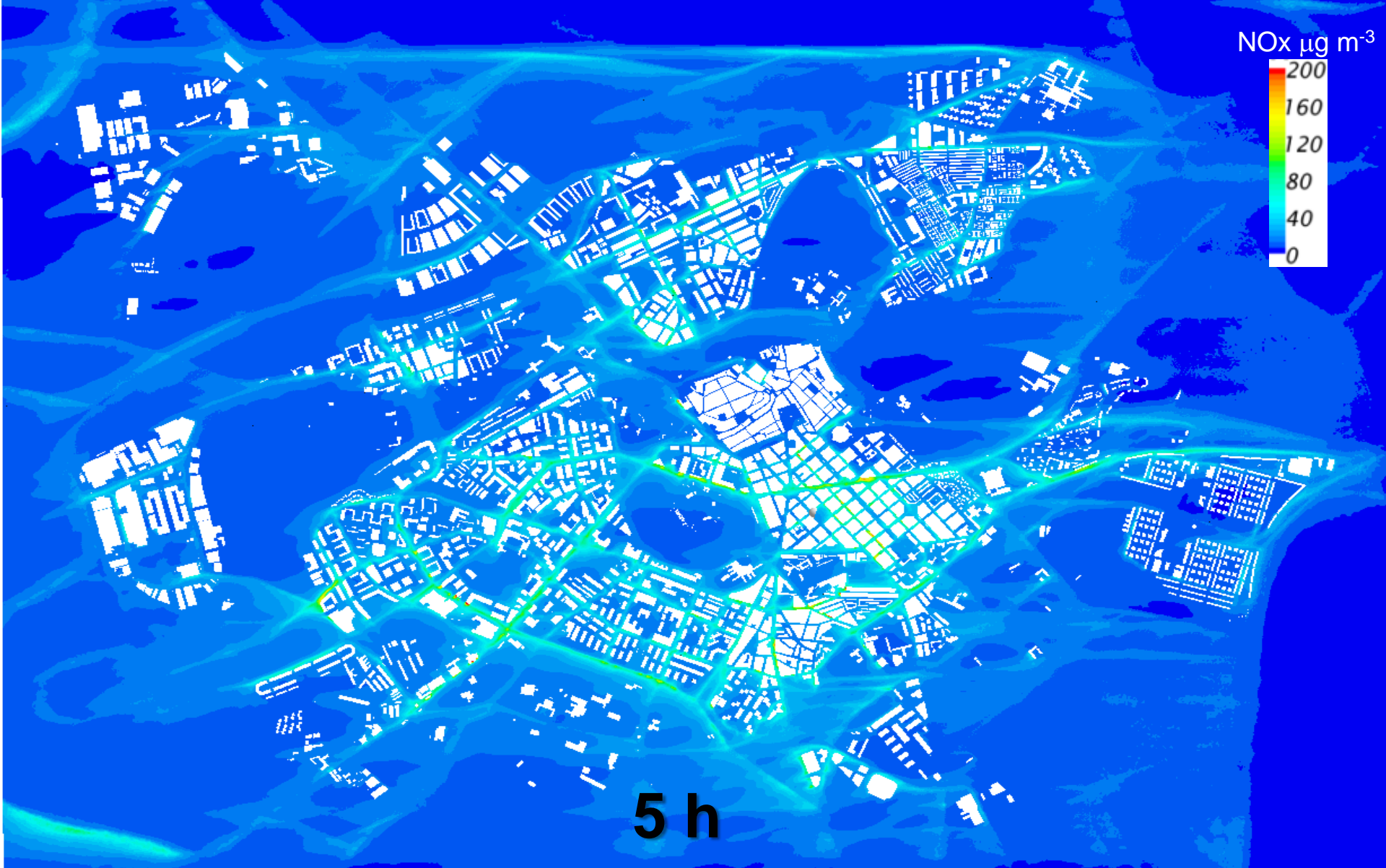
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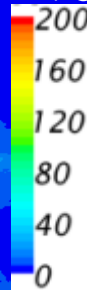
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NOx  $\mu\text{g m}^{-3}$



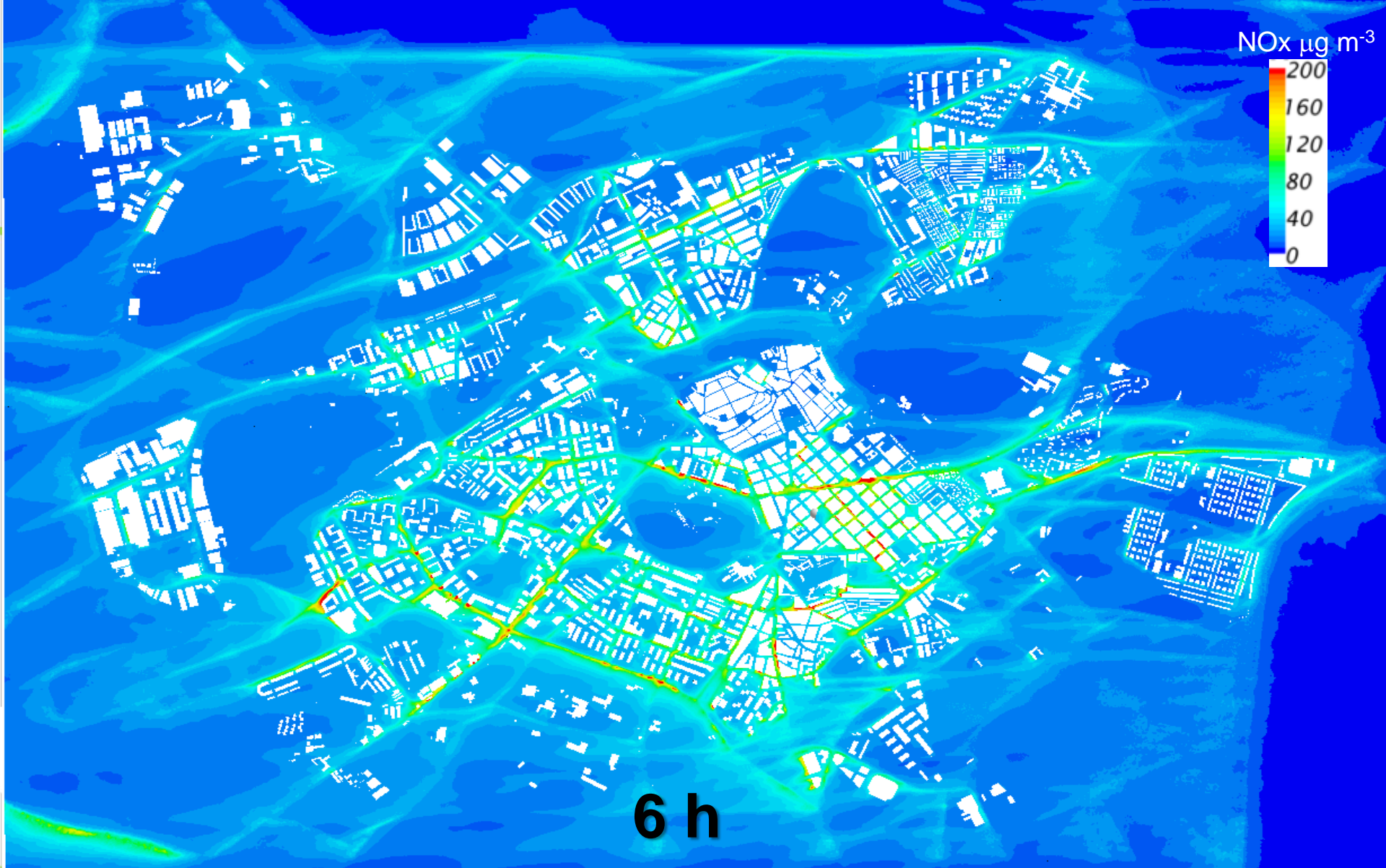
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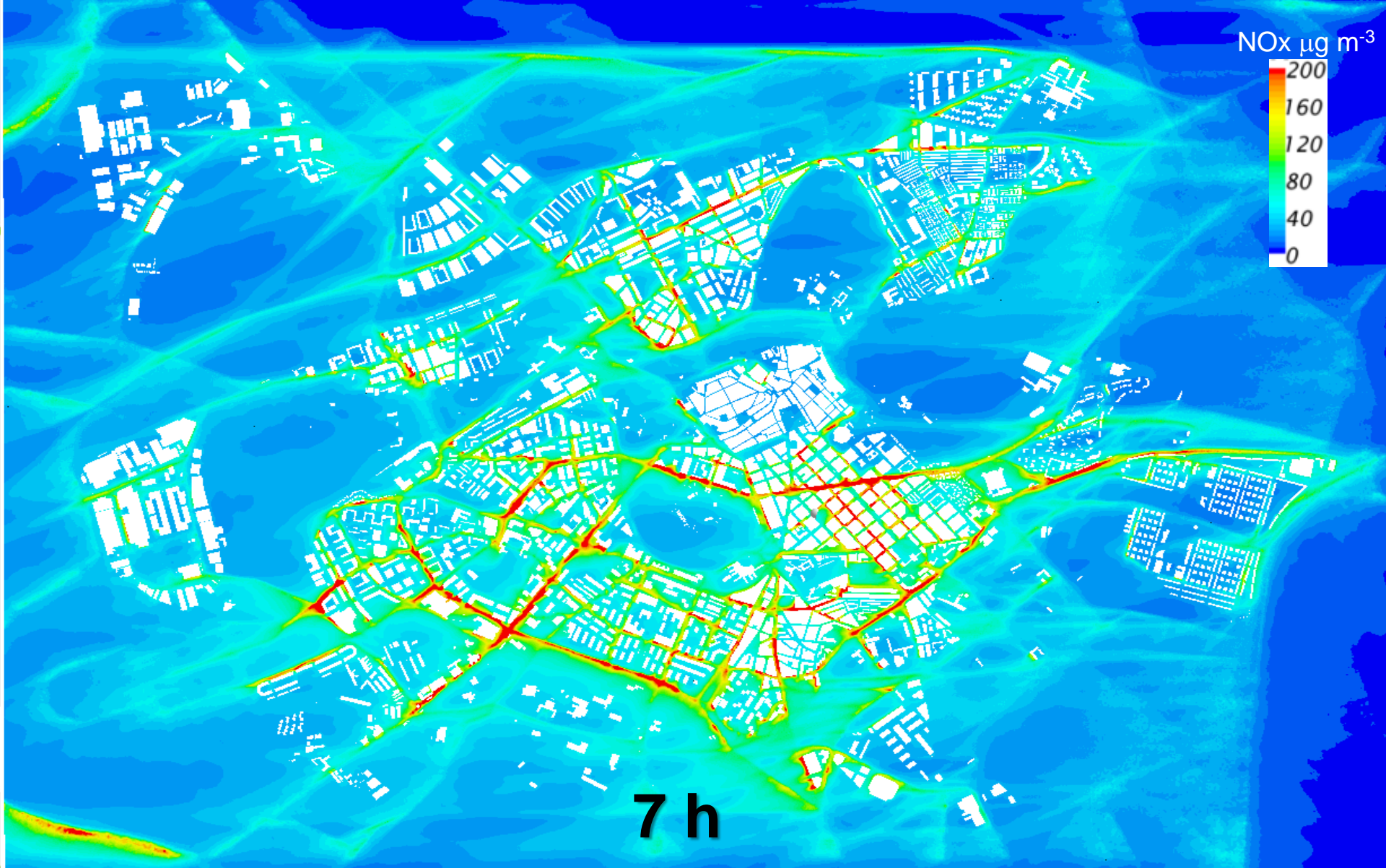
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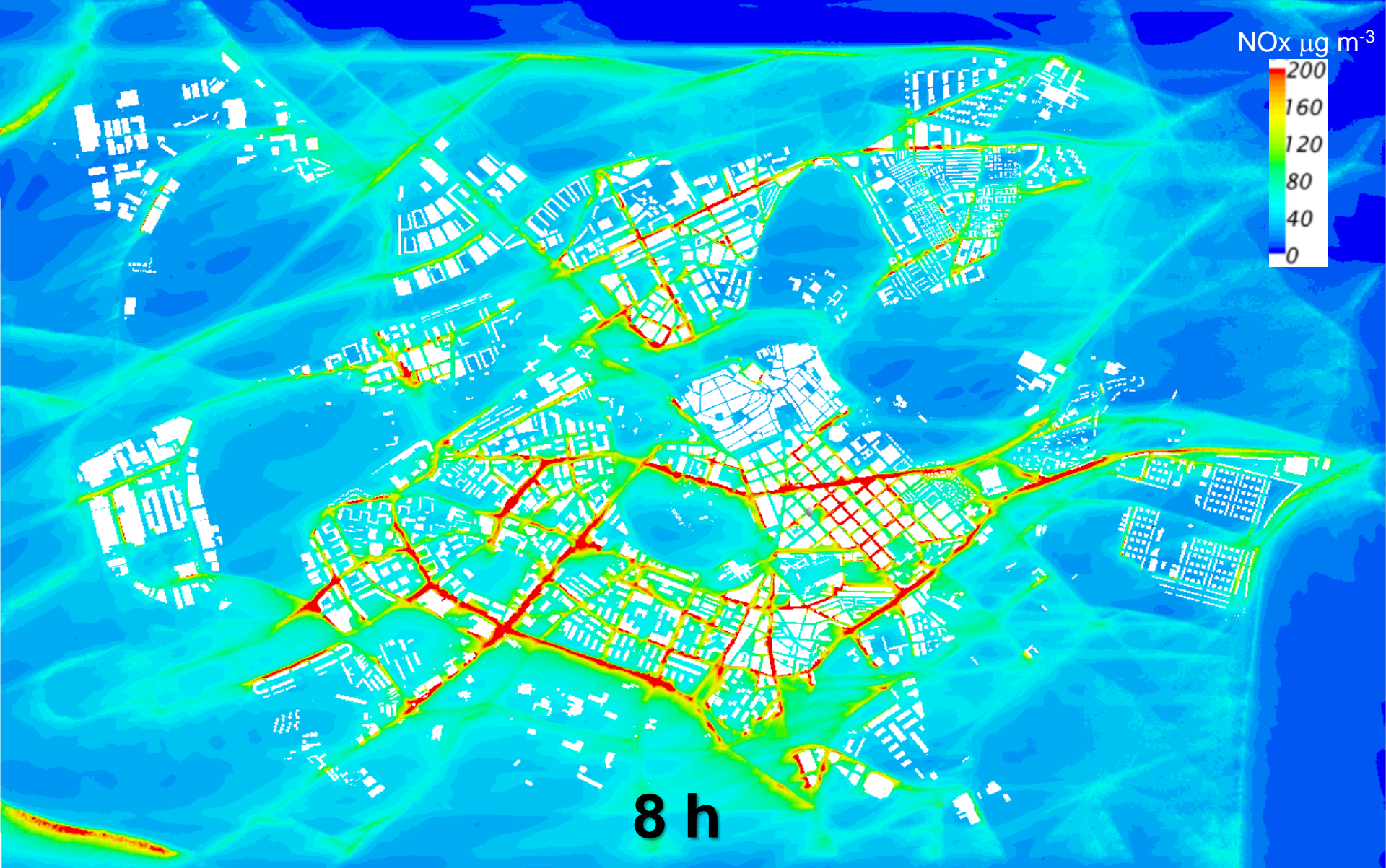
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NOx  $\mu\text{g m}^{-3}$

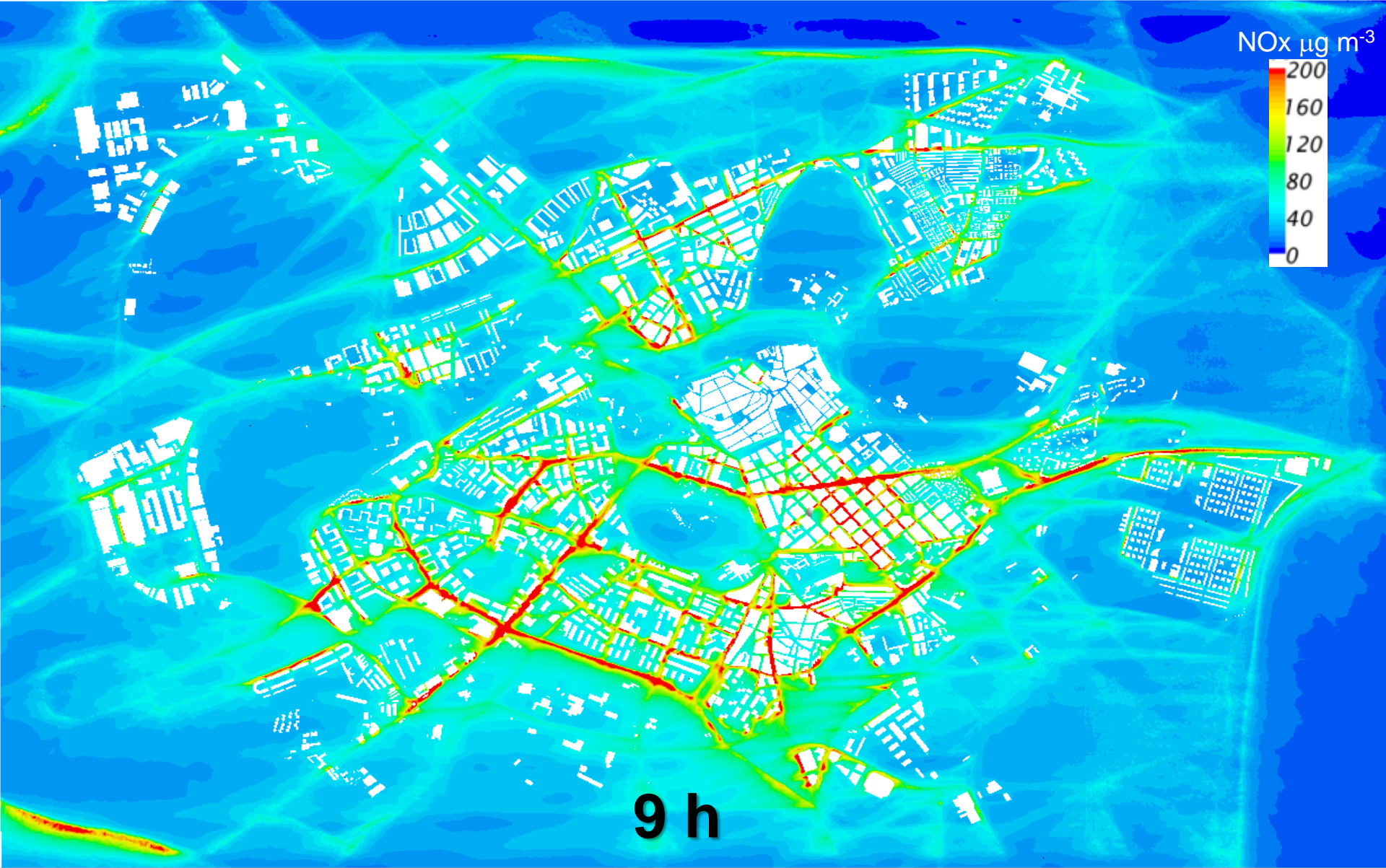


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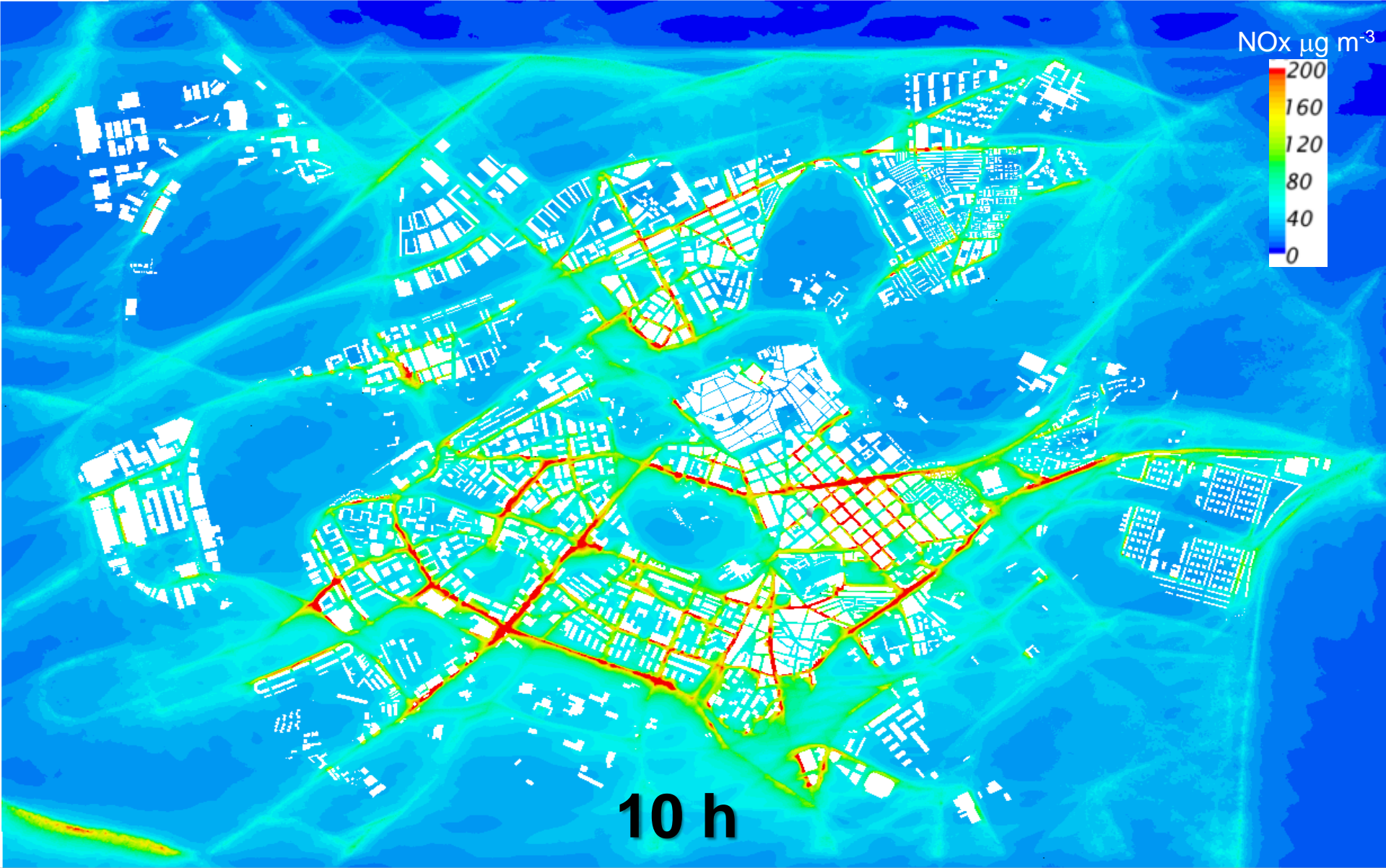
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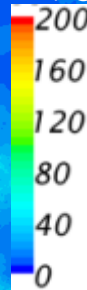
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NOx  $\mu\text{g m}^{-3}$



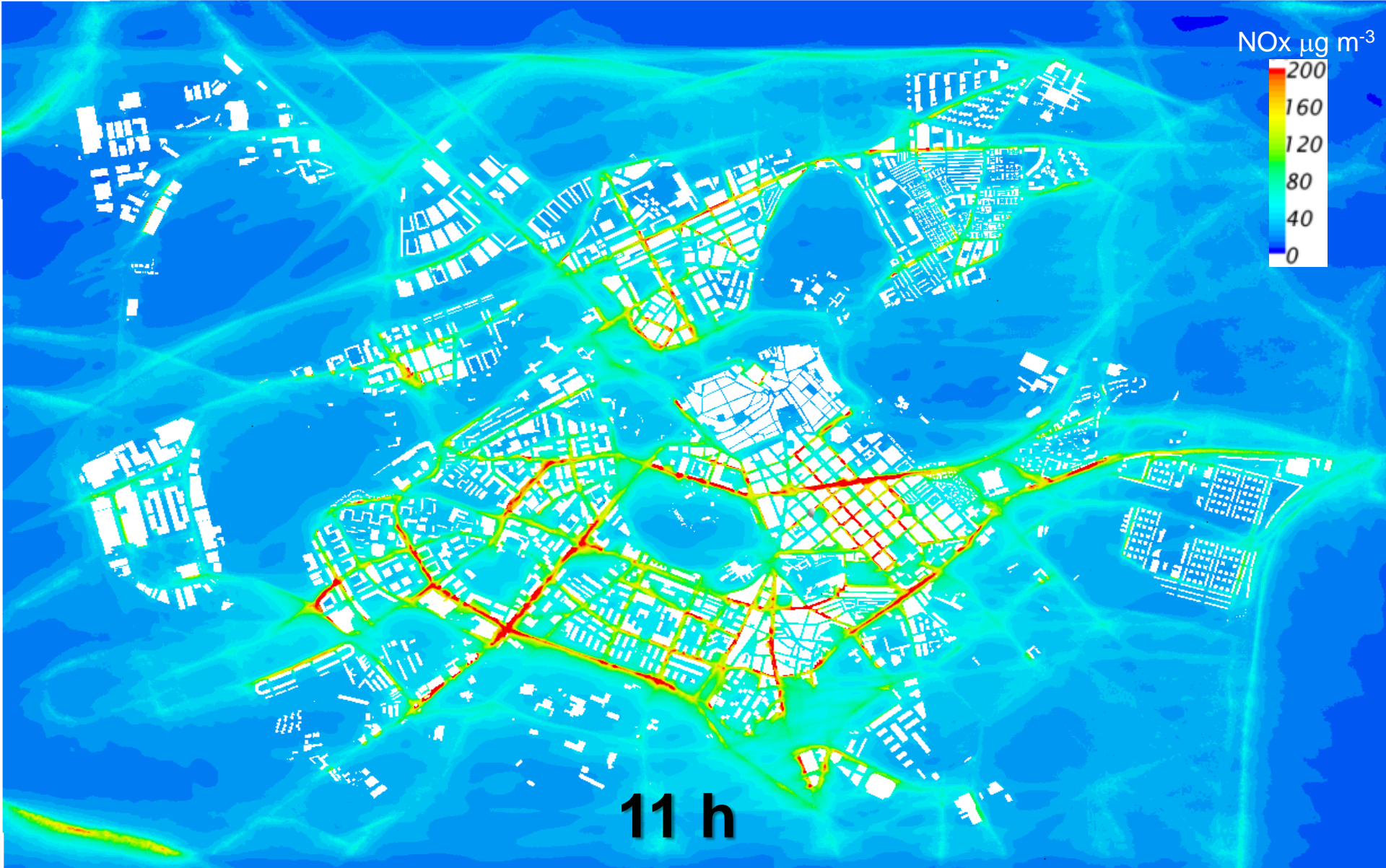
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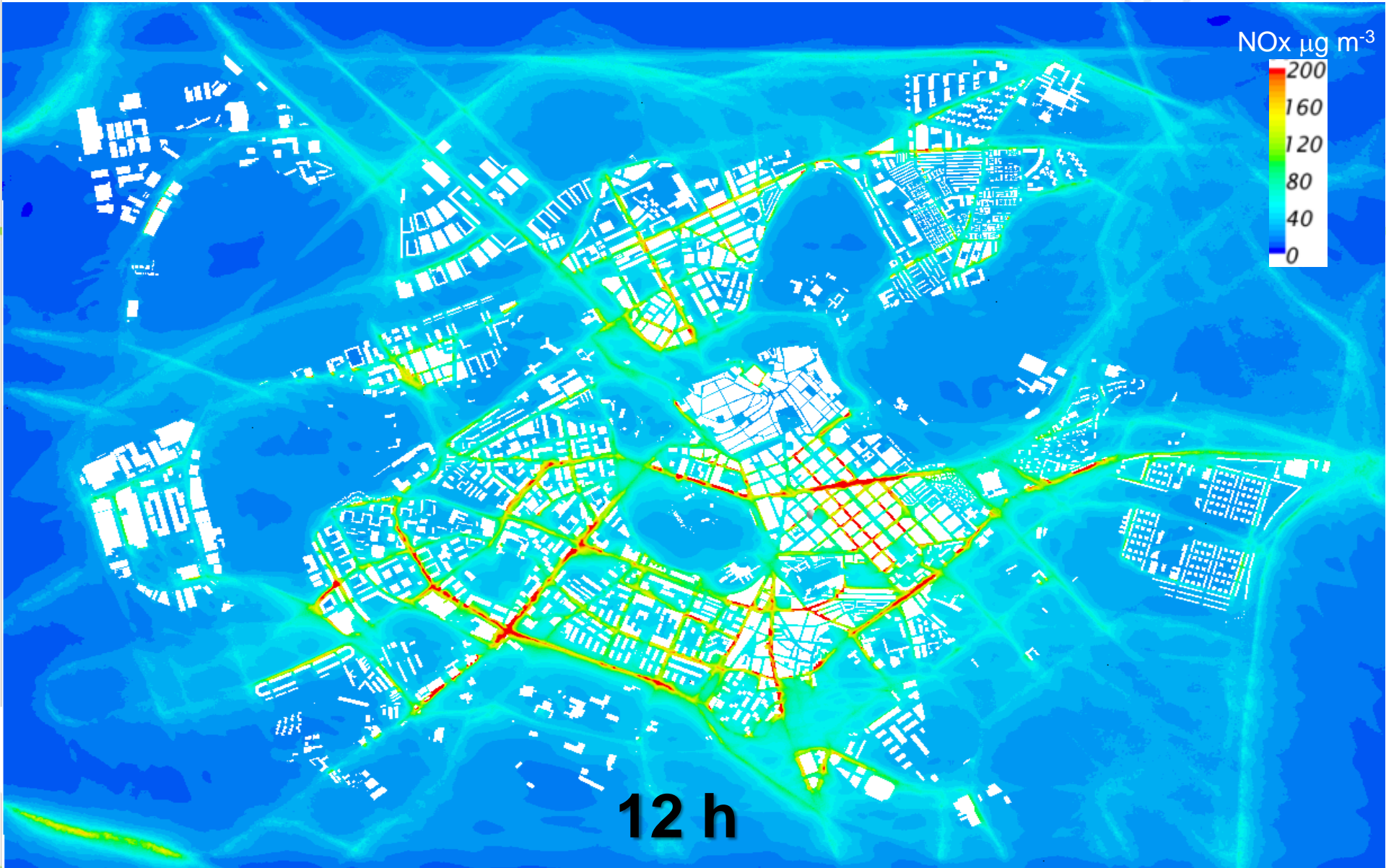
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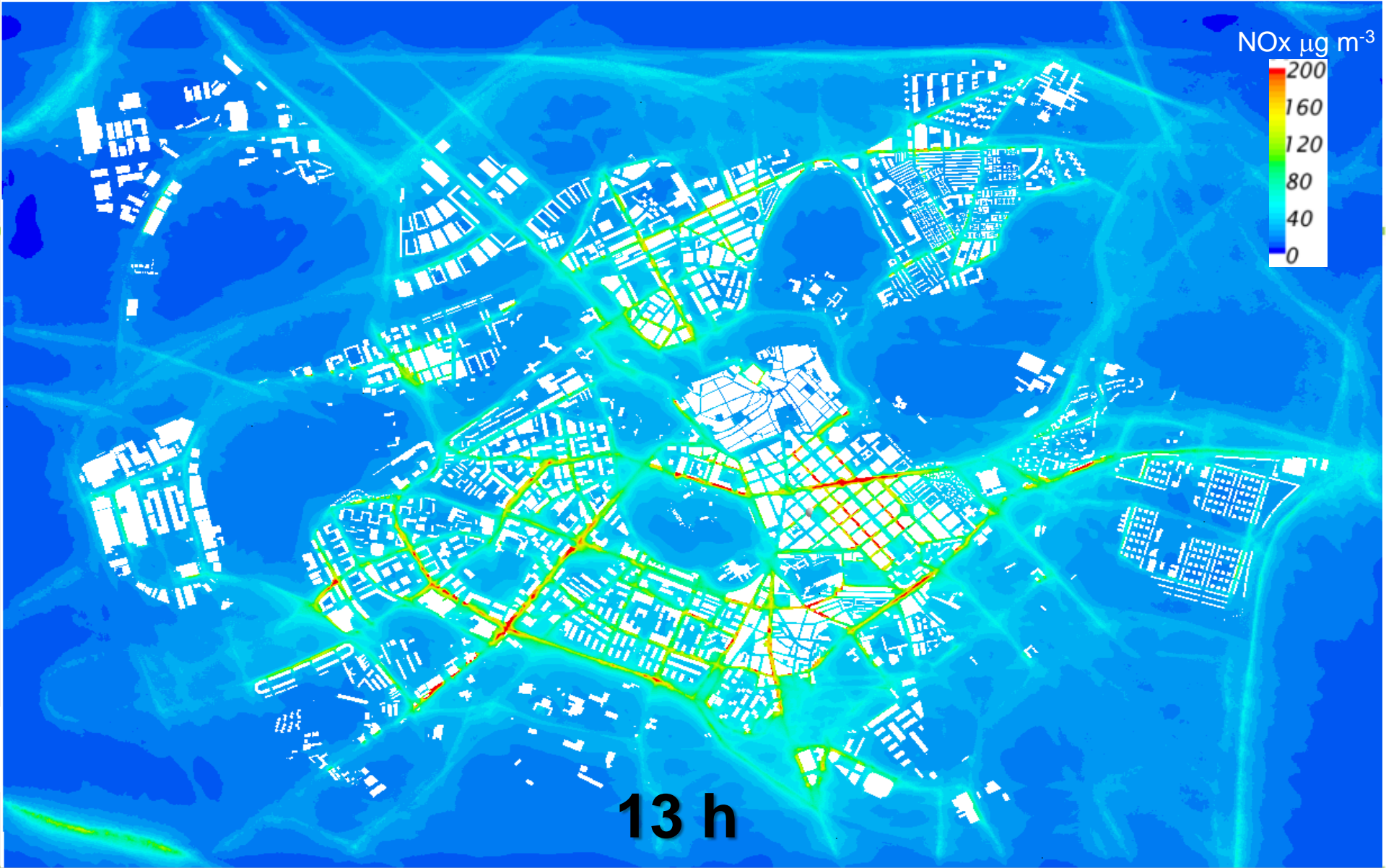
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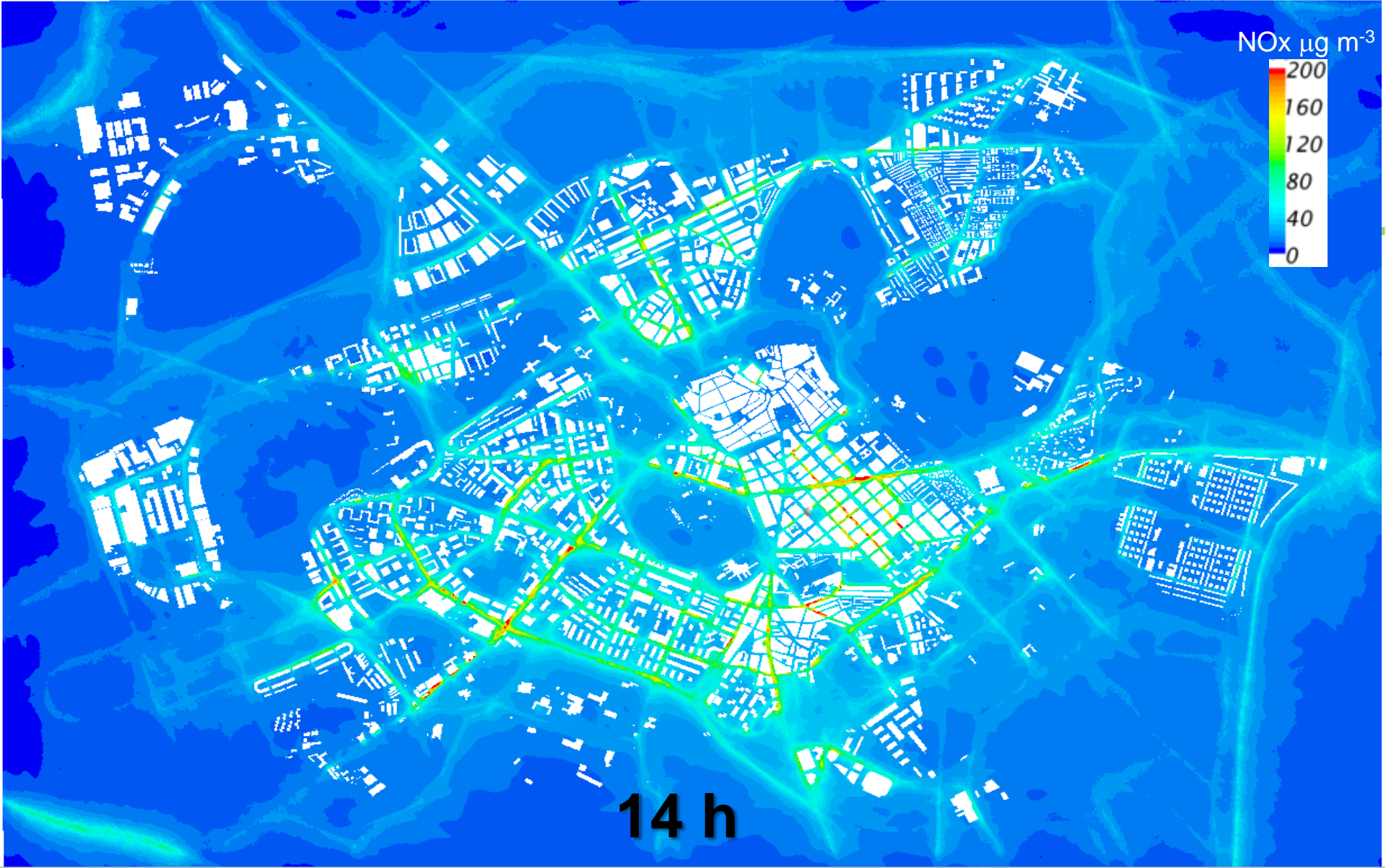
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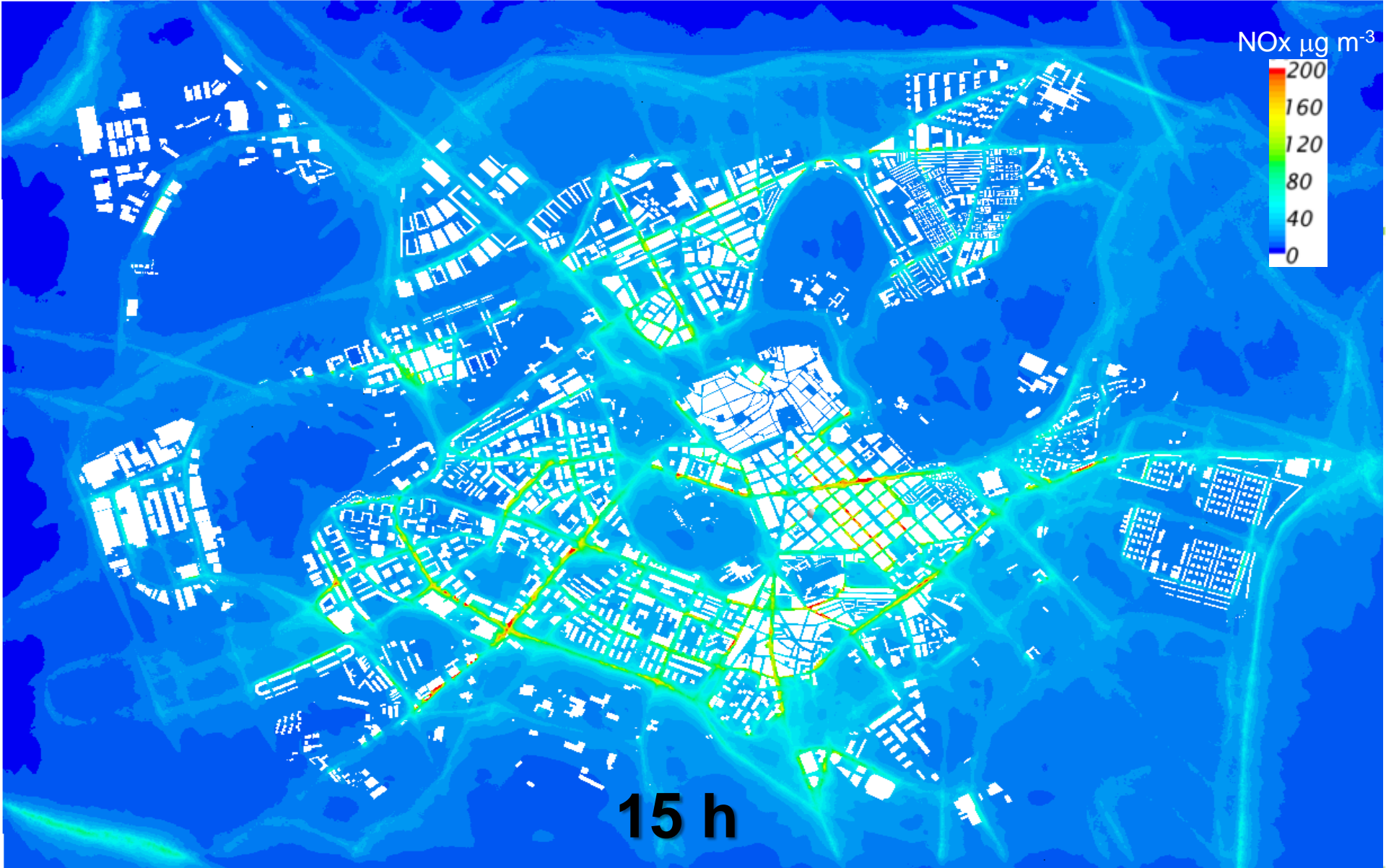
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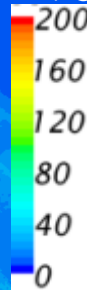
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NOx  $\mu\text{g m}^{-3}$



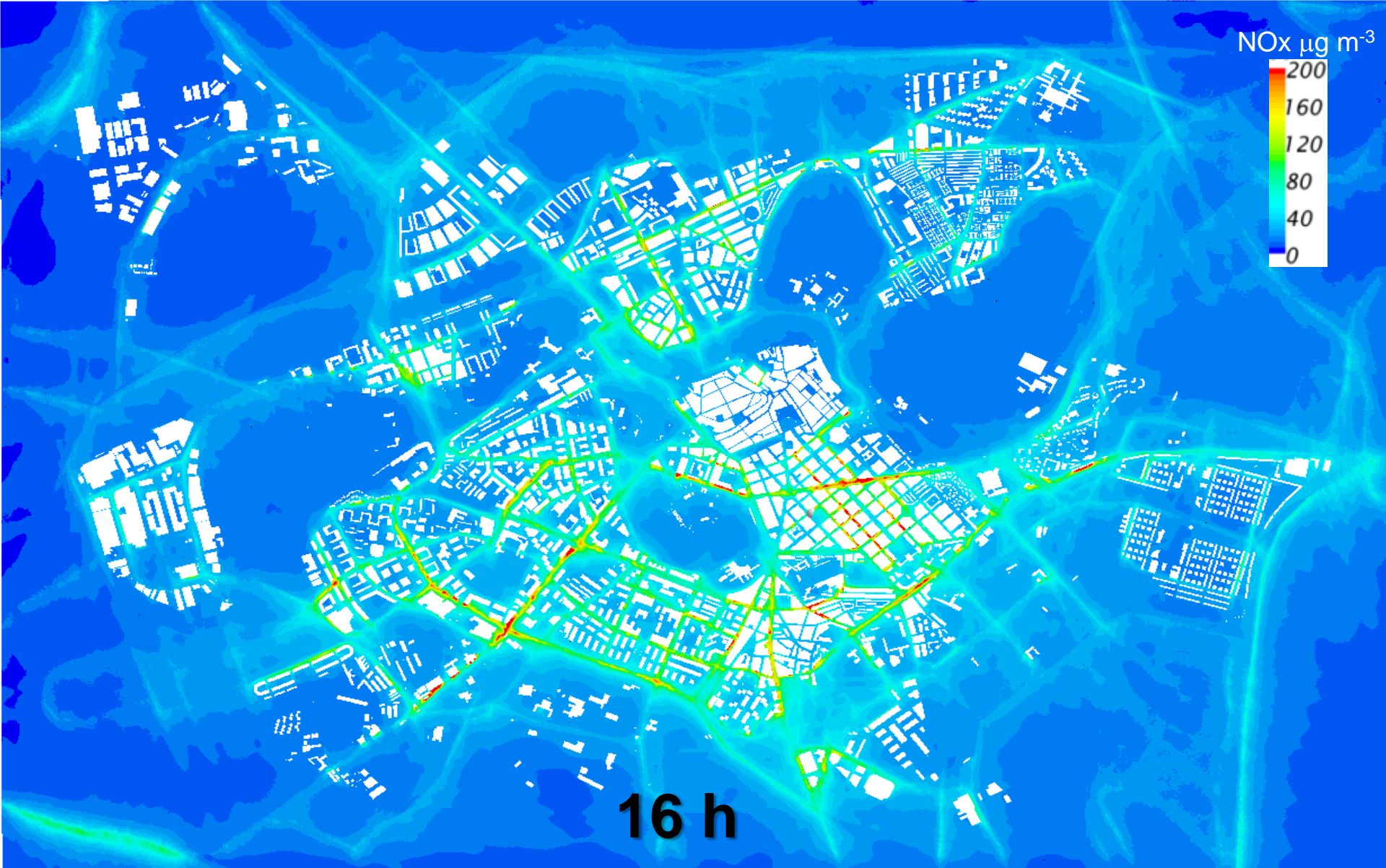
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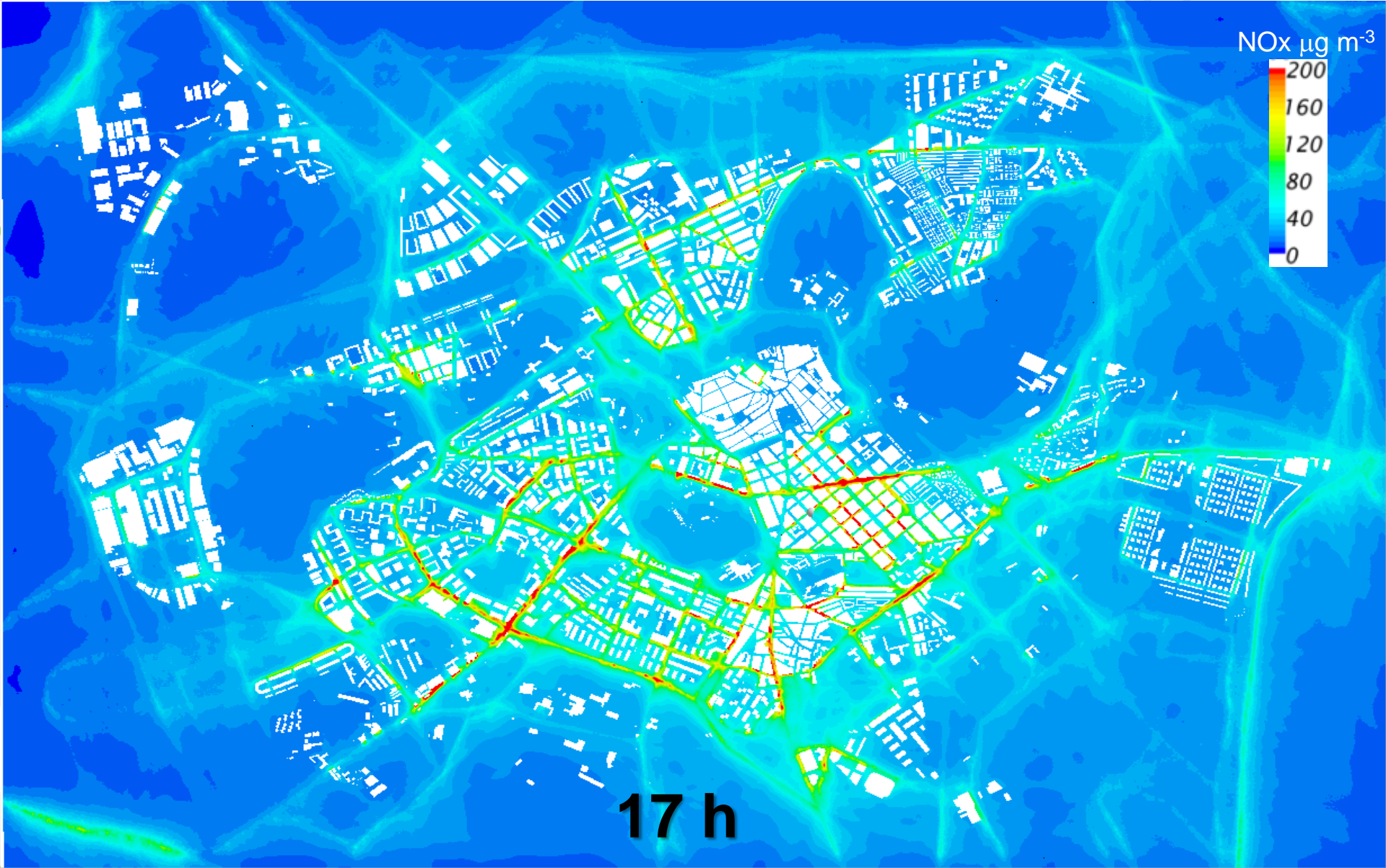
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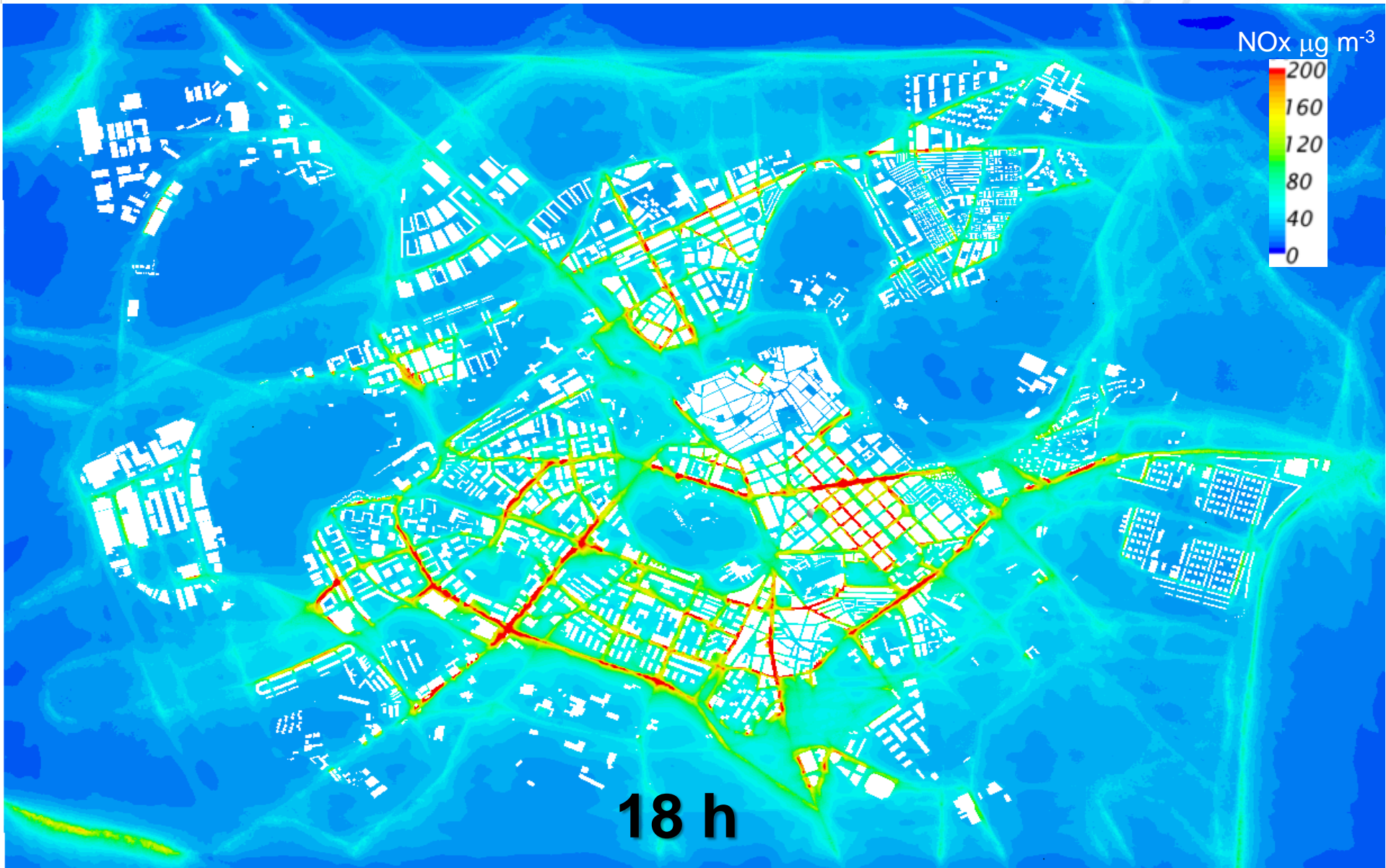
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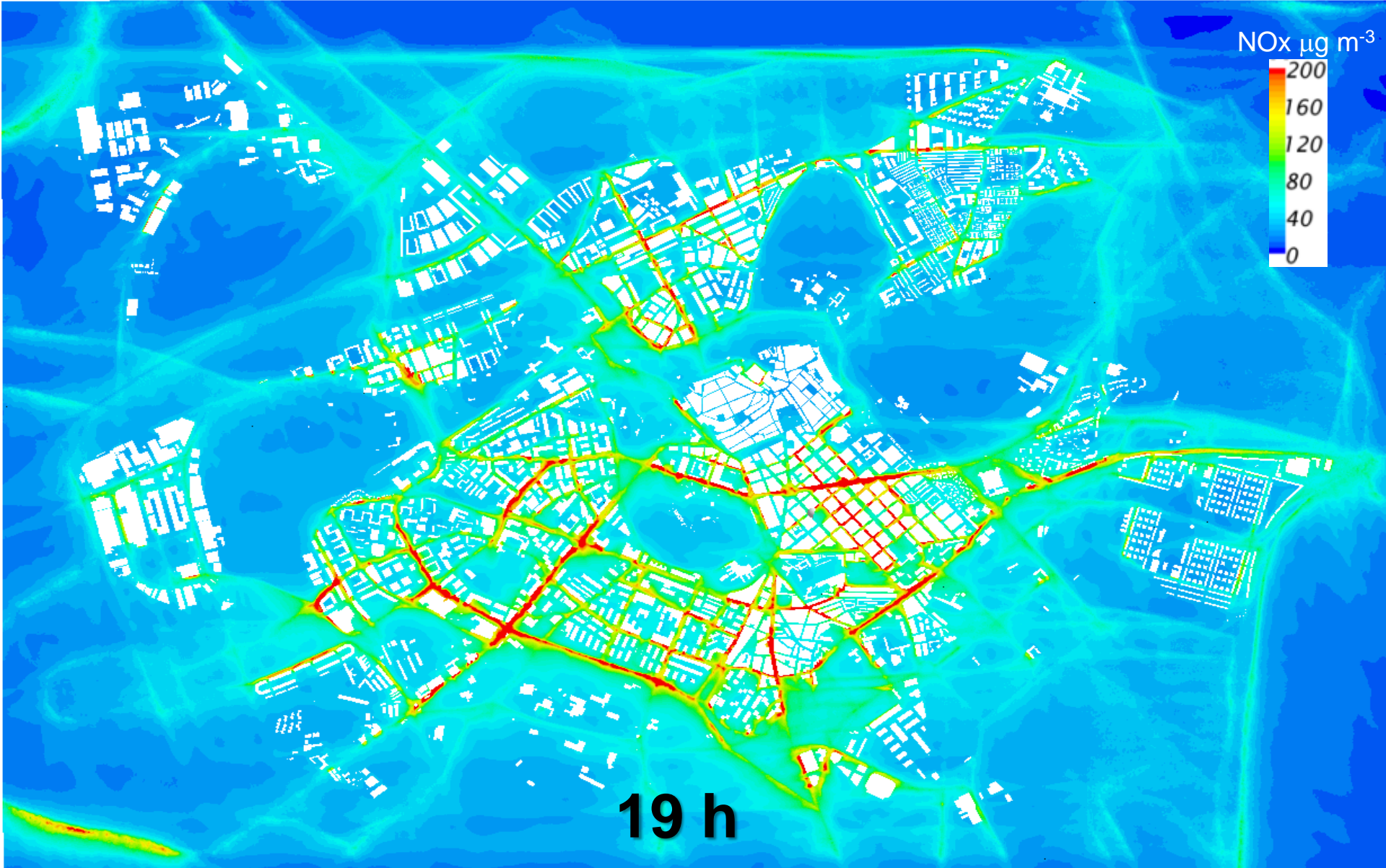
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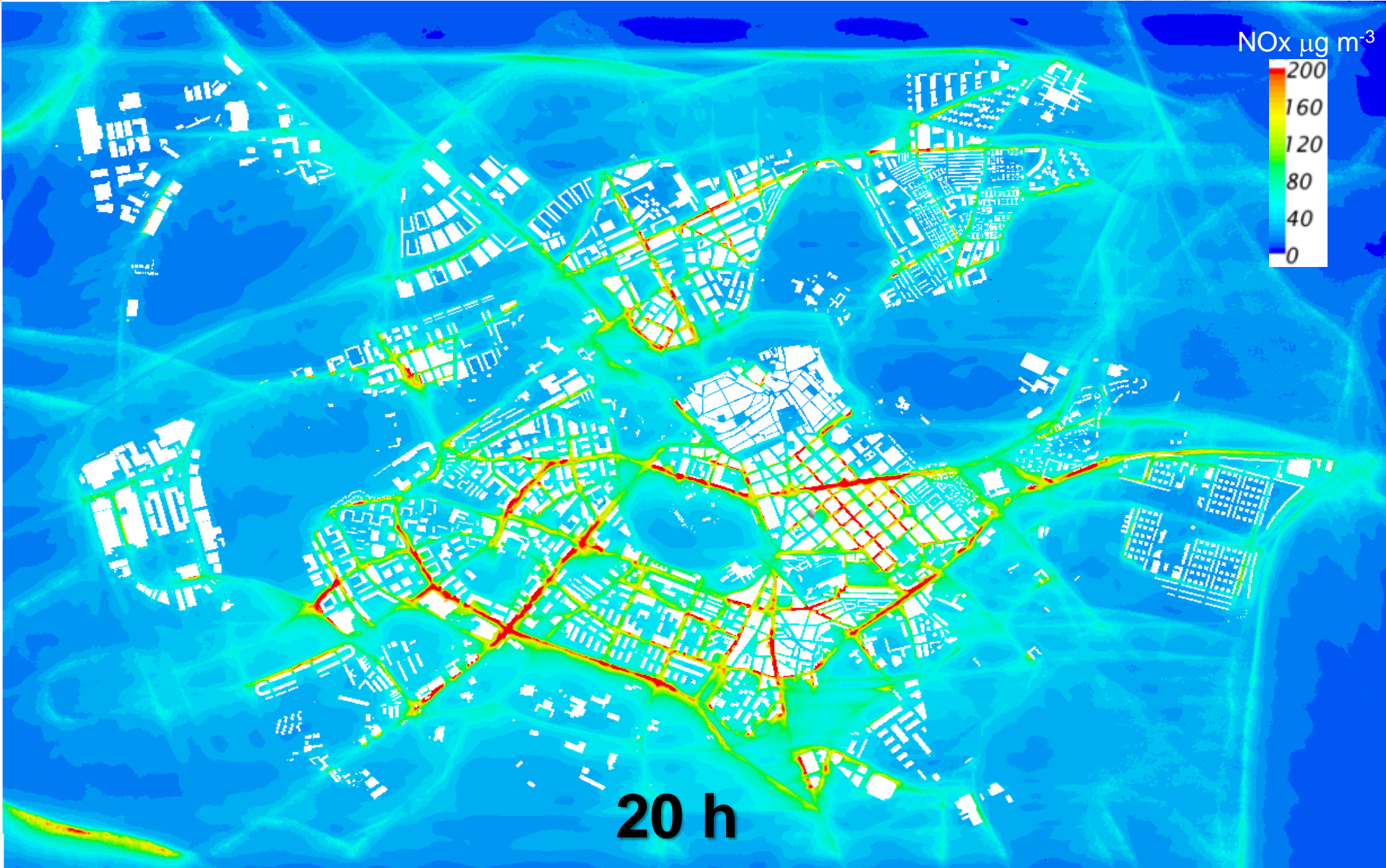
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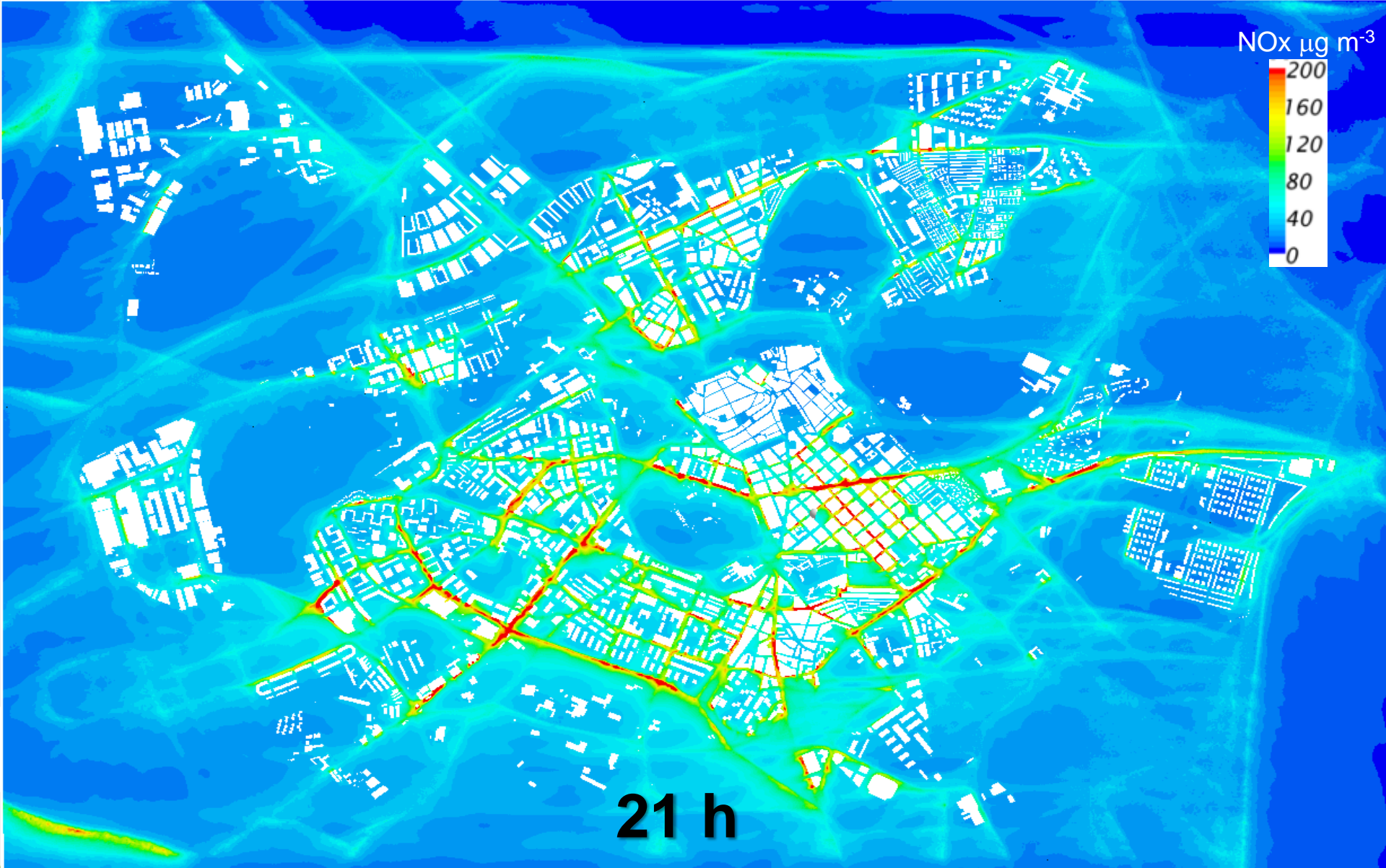
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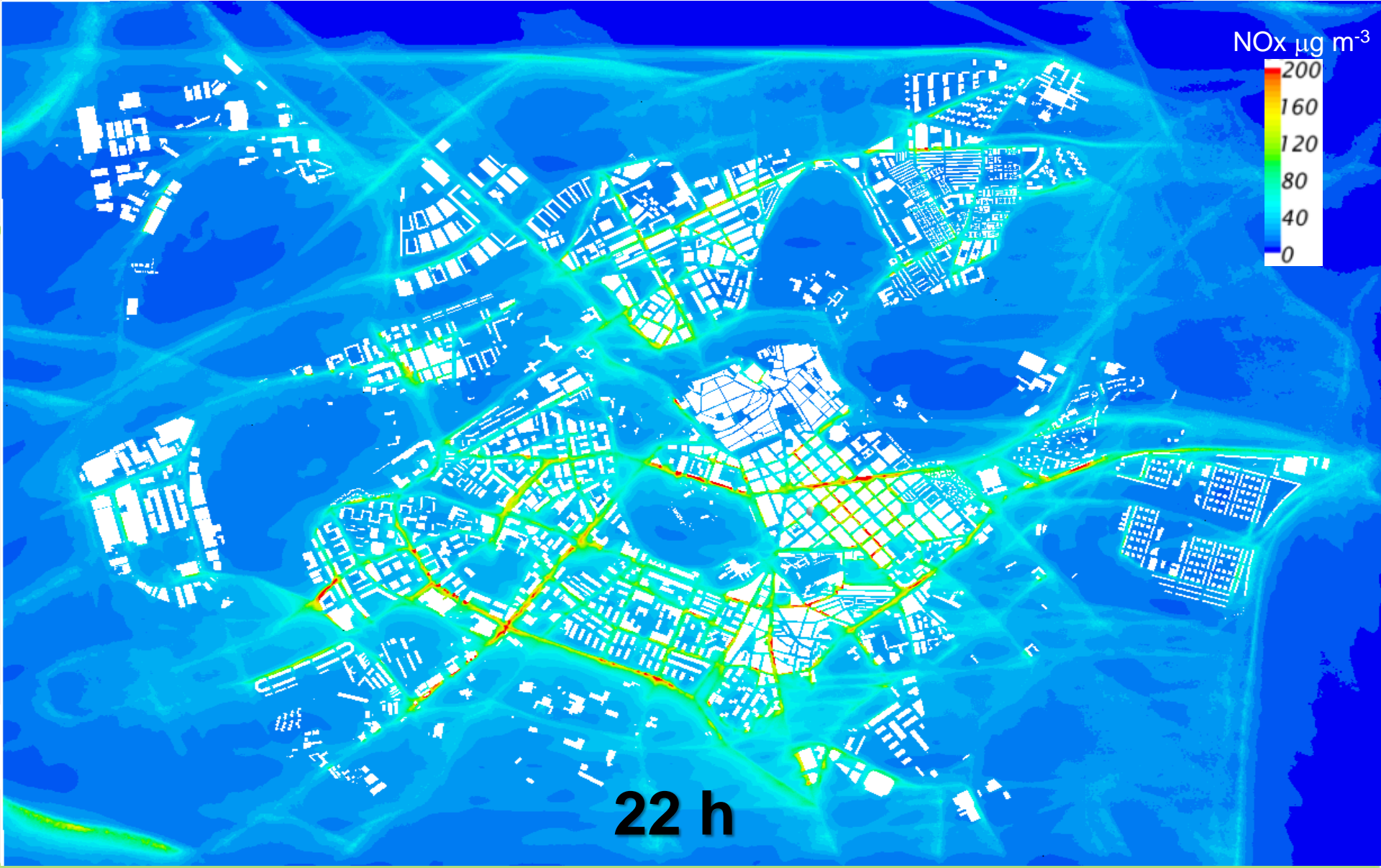
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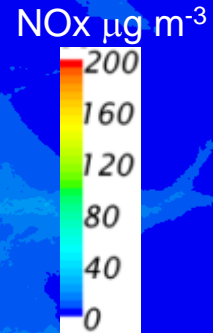
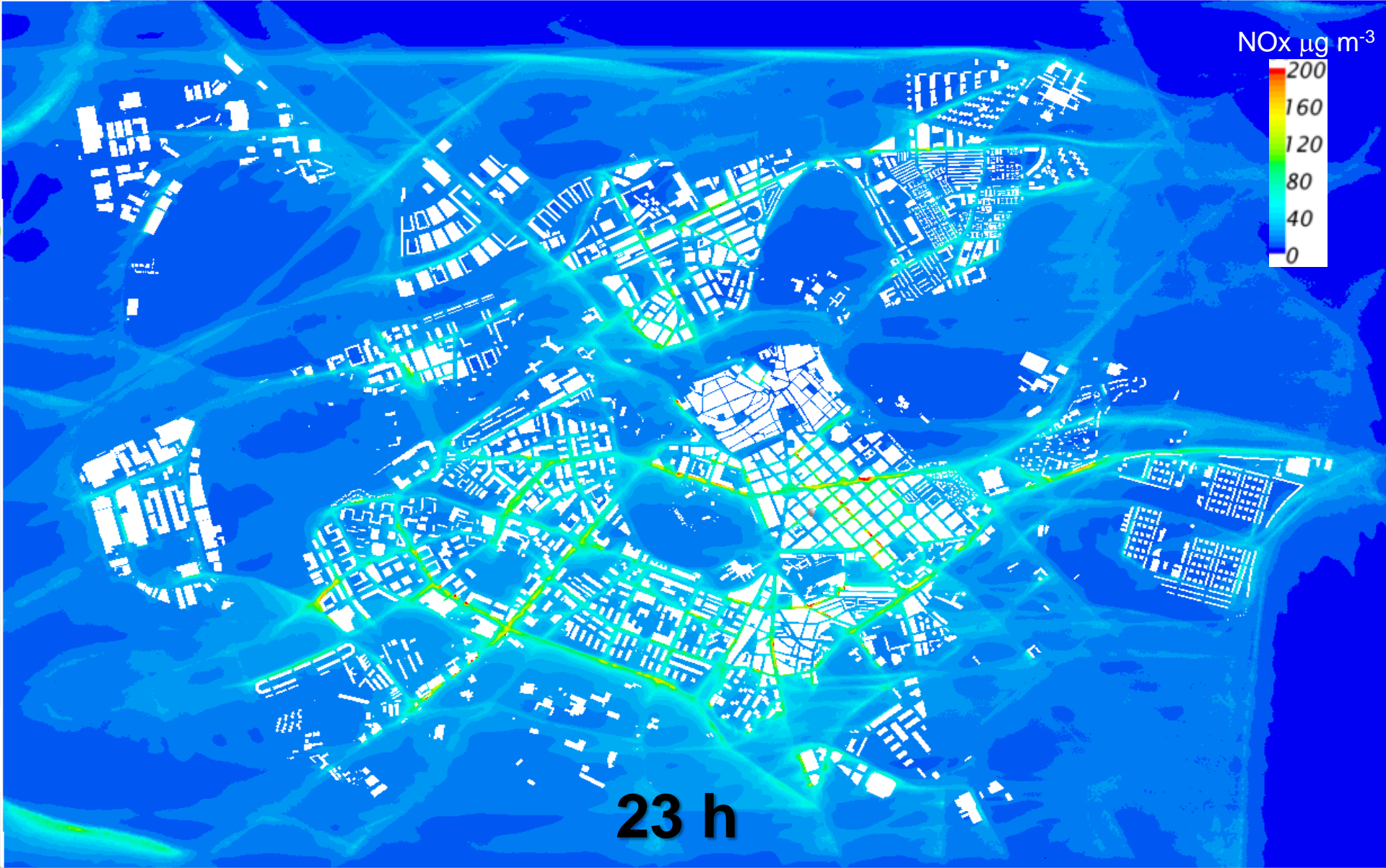
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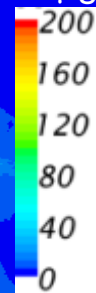


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NOx  $\mu\text{g m}^{-3}$



24 h

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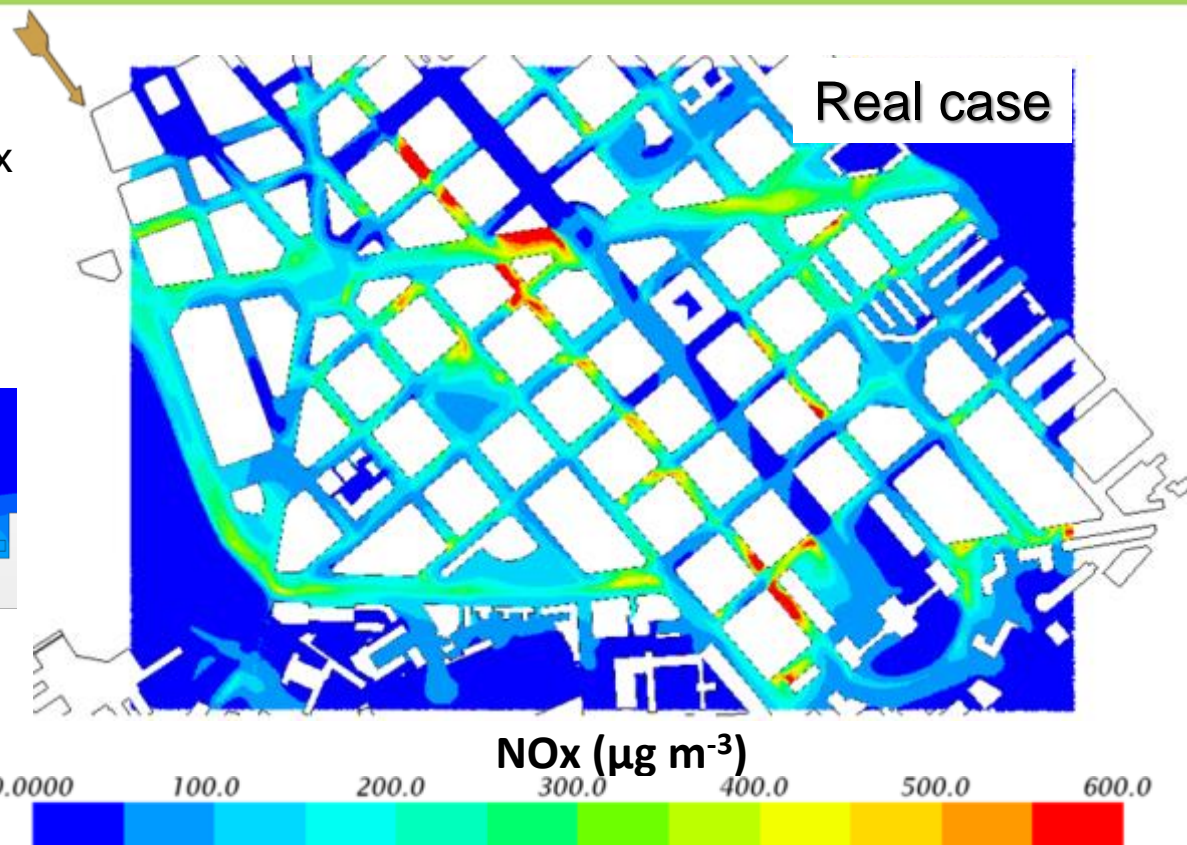
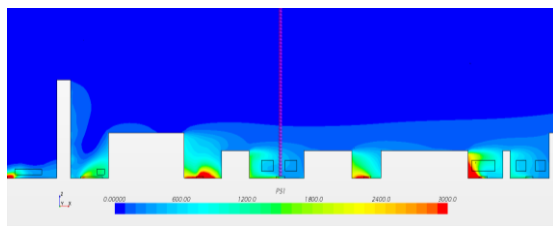


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## Urban vegetation

- Effects of vegetation on NO<sub>x</sub>
  - ✓ Wind direction: NW
  - ✓ Time: 8 A.M.



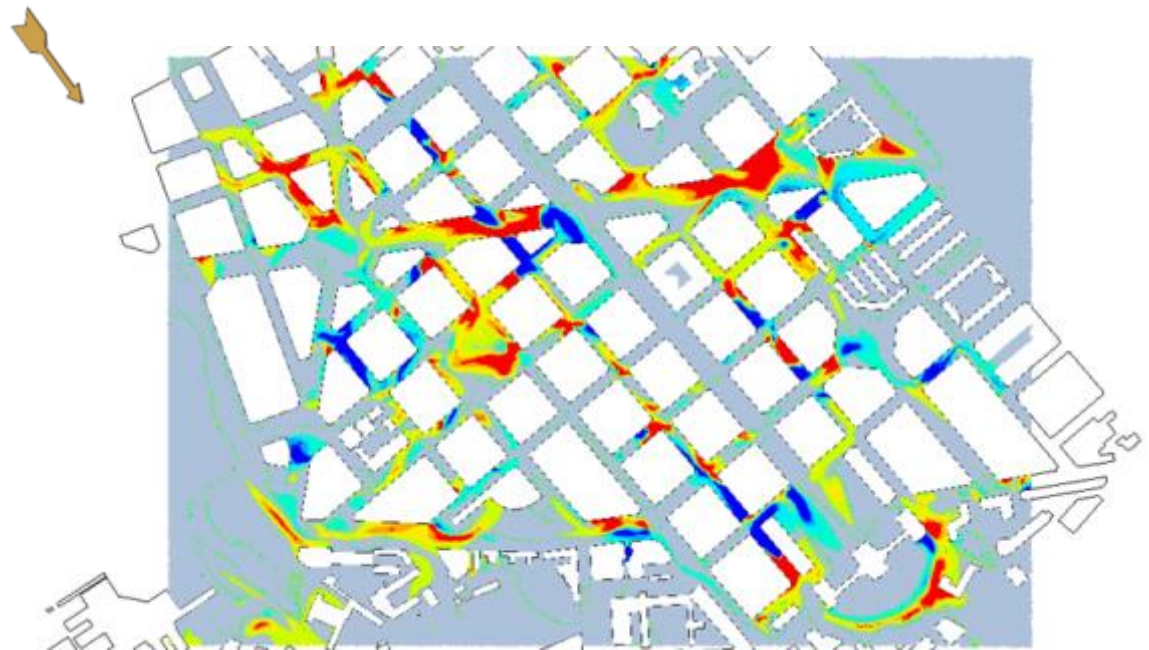
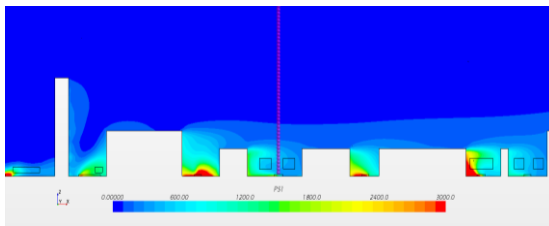
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## Urban vegetation

- Effects of vegetation on NOx
  - ✓ Wind direction: NW
  - ✓ Time: 8 A.M.



**NOx (LAD=0.5) – NOx (LAD=0.1) ( $\mu\text{g m}^{-3}$ )**



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## Urban vegetation

Tafalla Street



Real case



New vegetation scenario

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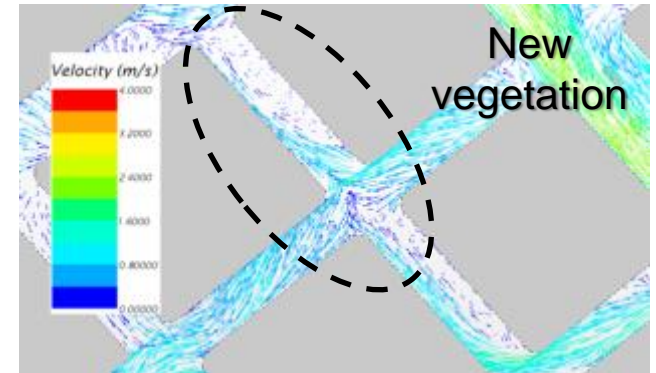
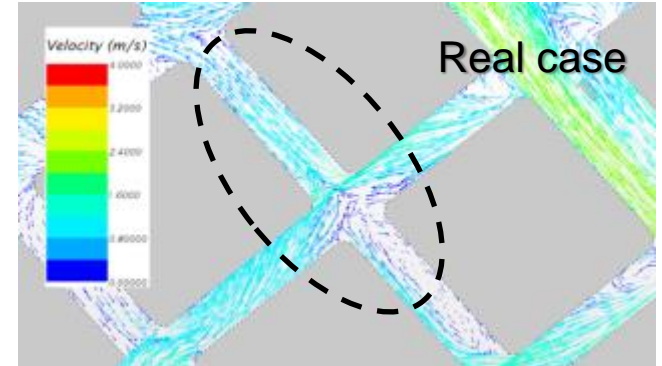
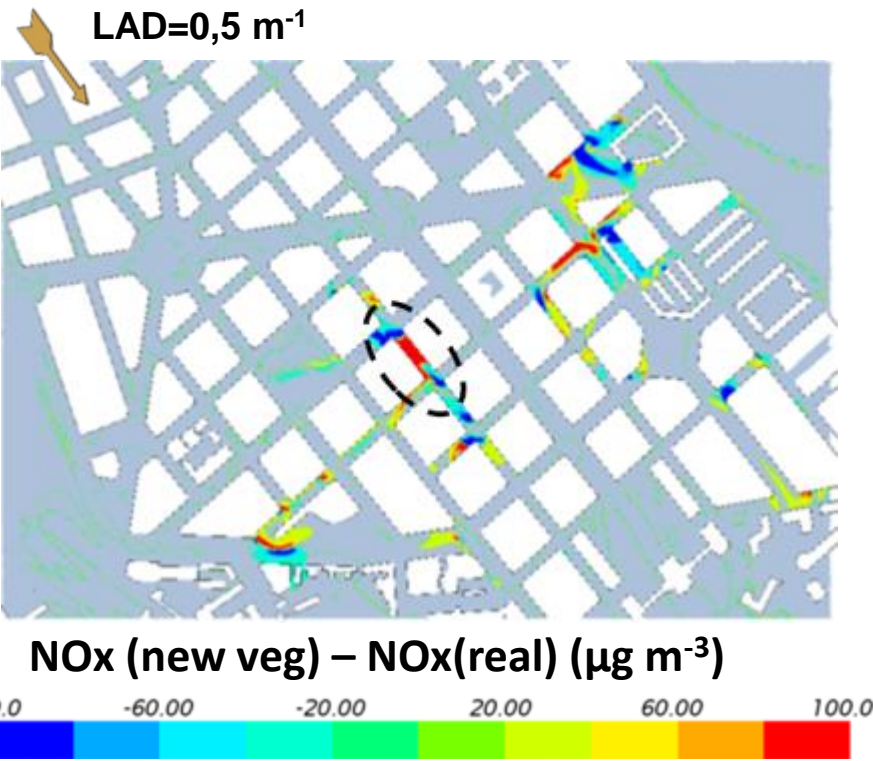


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## Field campaigns (trees and hedges)



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## Street-level sampling campaigns



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## San Fermín street (with trees)



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## Tafalla street (without trees)



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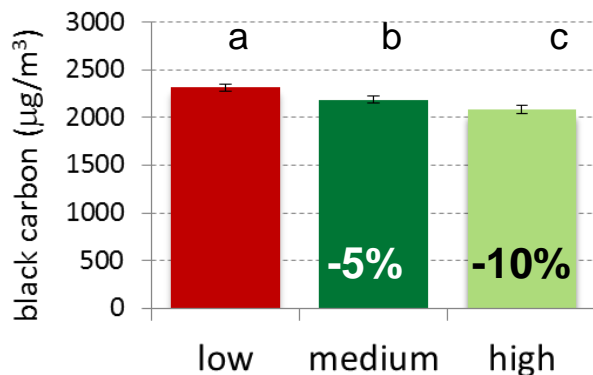
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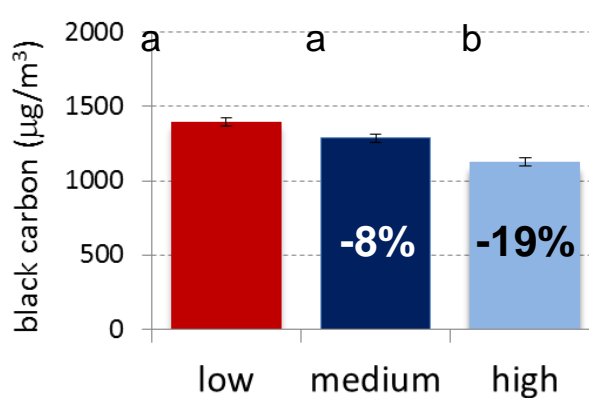
## Black carbon concentrations



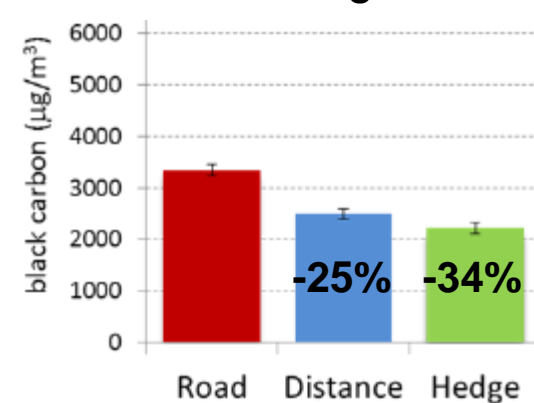
### Street with trees



### Street without trees



### Hedges



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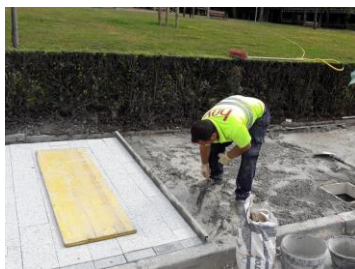
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## Photocatalytic pavement for the reduction of air pollutants

- Quantification of air quality improvement
- Removal of NOx, VOC and secondary aerosols

Pollutant	Concentration (ppb)		Total removed (ppb)	Removal (%)
	Control	ecoGranic		
<b>NO</b>	147.6	81.1	66.5	45.1
<b>NO<sub>2</sub></b>	53.0	36.5	16.5	31.2
<b>NOx</b>	200.6	117.6	83.0	41.4





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## “Healthy route” planner

- Web portal: selection of healthy routes
  - ✓ Viewing active sensors and pollution levels
  - ✓ Contamination level the user is exposed to
  - ✓ Displaying the optional routes, choosing the most convenient
  - ✓ Representation of routes and mileage made by users
- Android Application (identical functionality)
- iOS application for Apple devices (identical)



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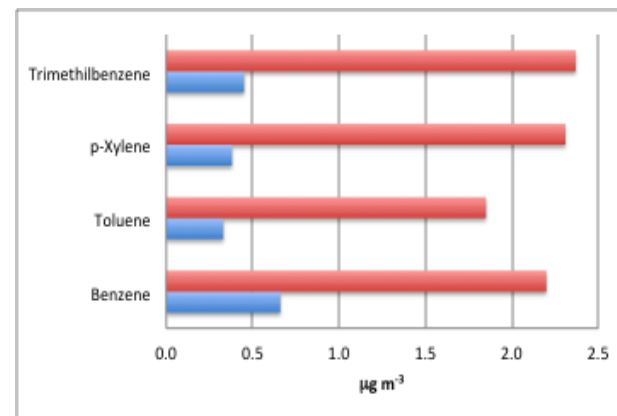
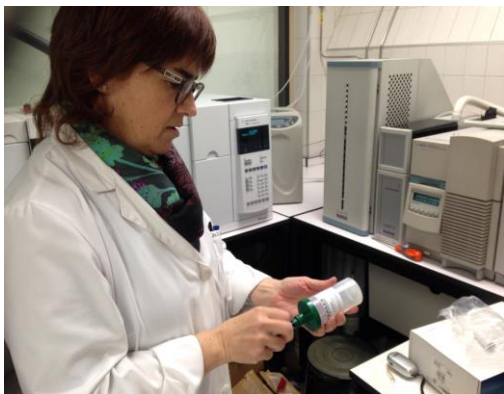
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## Effects of air pollutants on health

- Quantification of inhaling contaminants
- Analysis of exhaled VOC by volunteers
- Economic valuation of impacts caused by pollutants on health
- Calculation of the associated benefits to air pollution reduction measures



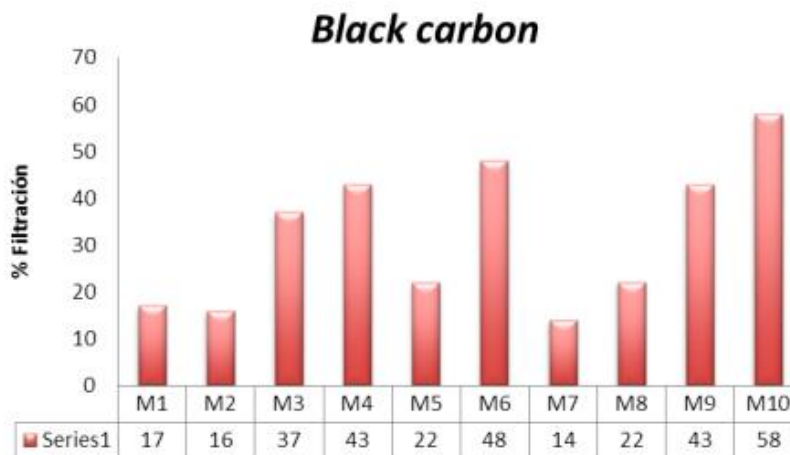


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## Effectiveness of facemasks to remove air pollutants

- Testing of masks for:
  - ✓ Black carbon
  - ✓ PM<sub>10</sub>, PM<sub>2.5</sub> and PM<sub>1</sub>
  - ✓ VOCs



Socios



Co-financiador



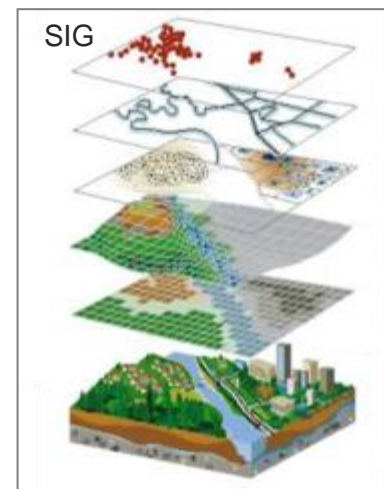
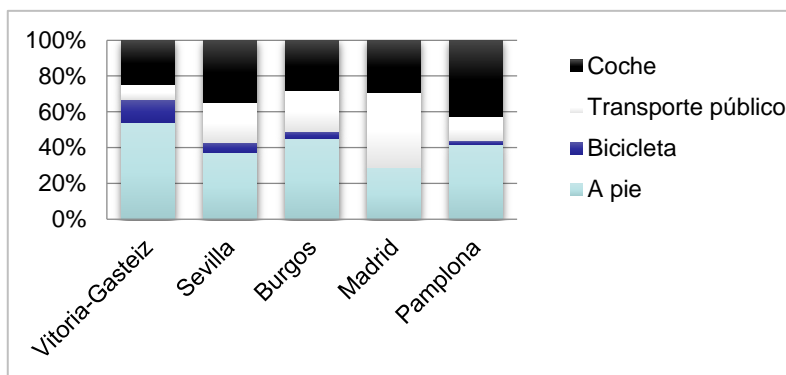
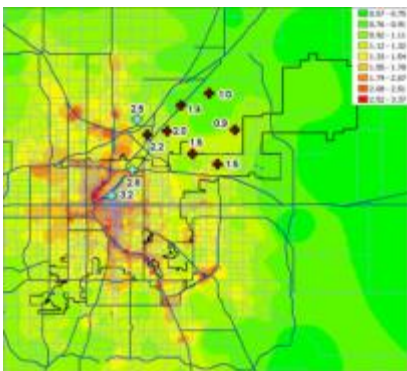


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## Mobility plan

- Study of the city cyclist profile (traffic capacity, online surveys)
- Development of mobility plans (cyclist) from the criterion of air quality
  - ✓ Data analysis through a geographic information system (GIS)
- Awareness plan aimed at changing mobility behavior
- Report on the impact of urban planning and urban design in air quality
- Contribution to sustainability: "smart cities"



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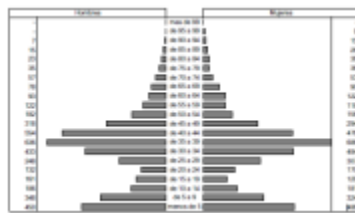
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## Economic valuation of impacts

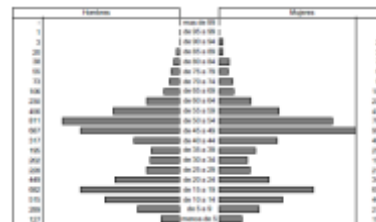
- Economic impact of pollution
  - ✓ Health and environment
- Benefits associated to the reduction of pollutants
- Creation of a tool based on Excel: application to other cities
  - ✓ Dose-response functions



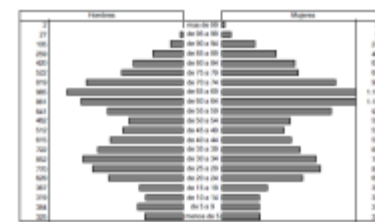
Buztintxuri



Mendiolorri



Iturrama



*Distribución de la población de Pamplona*

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**Pavimentos Tudela**



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## Social perception of urban pollution

- Assessment of the social perception of air pollution
  - ✓ Estimation of social indicators
  - ✓ Identification of behaviors related to air quality
- Conducting on-line surveys
- Holding workshops with discussion groups (on-line)
  - ✓ Detect barriers that hinder sustainable behavior
  - ✓ Deepen into the dimensions of the pollution problem



Socios

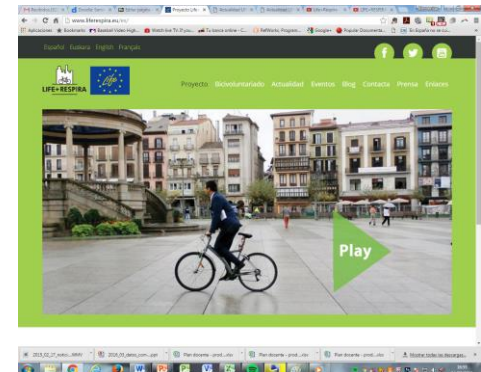
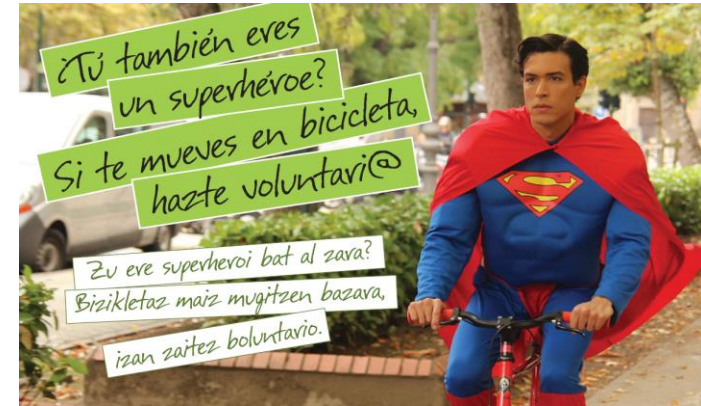


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## Communication and dissemination plan

- Web page development
- Social networks: Facebook and Twitter profiles
- Project presentation days
- Technical conferences
- Awareness of citizens on environmental quality
- Audiovisual production:
  - ✓ Short videos (local, national and foreign impacts)
  - ✓ Documentary (30')



### Socios

### Colaborador



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## Promotion of activities aimed at the general public

- Development of activities in related events
  - ✓ European Bicycle Day
  - ✓ World Environment Day
  - ✓ European mobility week ...
- Teaching unit on air quality, mobility and health
  - ✓ Didactic guide (primary education and ESO)
  - ✓ Workshops



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Find more information in: <http://liferespira.eu>

Foto ganadora: *En bici por la ciudad*



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