

**23rd International Conference on  
Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes  
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**A hybrid modelling system  
for high-resolution urban air quality assessment  
with integrated source apportionment**

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## Developing a modelling tool

**to obtain a complete and detailed assessment of the urban air quality  
at very high resolution in space and time**



Deep understanding of the complexity of the  
spatiotemporal distribution of pollutant concentrations



Hotspots identification

## Developing a modelling tool

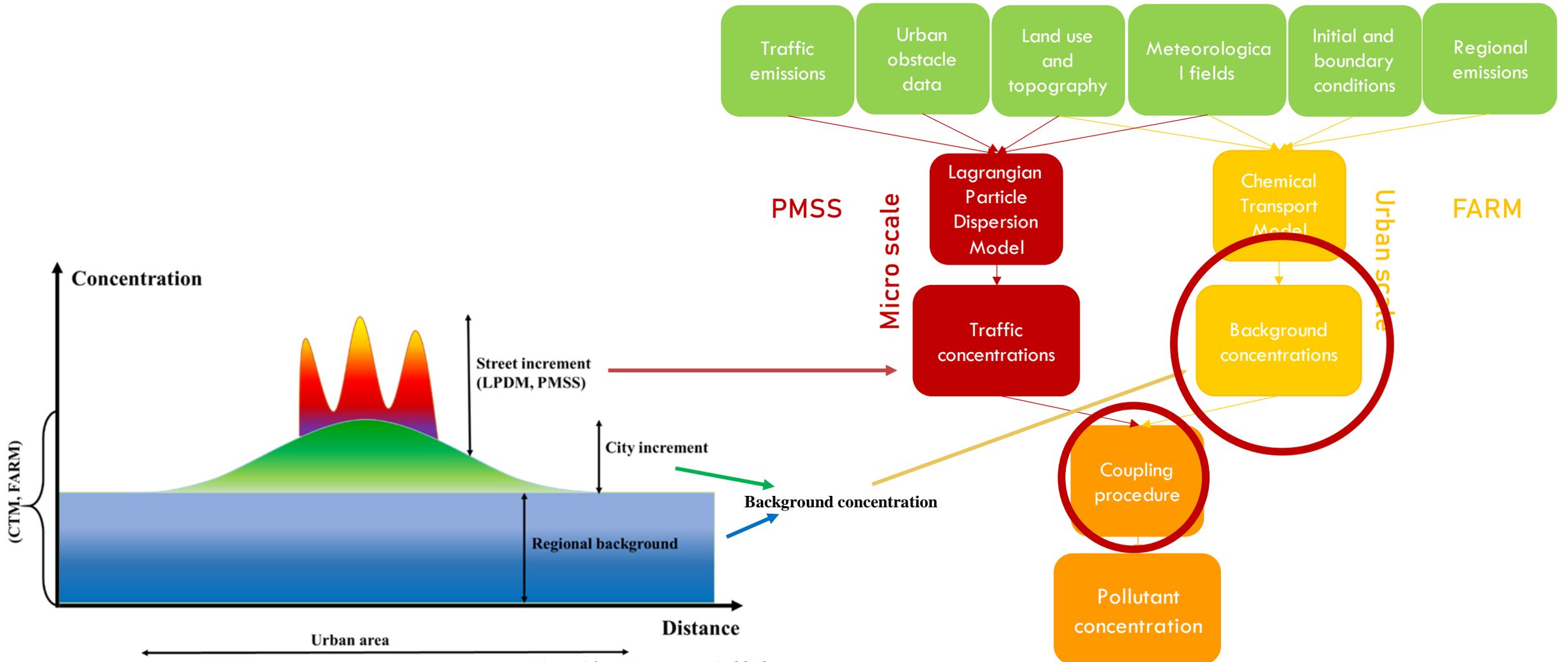
**to obtain a complete and detailed assessment of the urban air quality  
at very high resolution in space and time**

### KEY FEATURES

comprehensiveness  
high resolution  
flexibility  
scalability  
computational efficiency  
accuracy



# Conceptual Design of the tool: Hybrid Modelling System



Adapted from Harrison et al., 2018

# Conceptual Design of the tool: Hybrid Modelling System

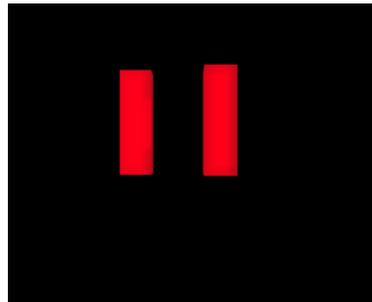
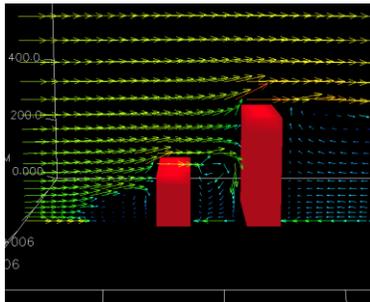
## PMSS

### PMSS: Parallel Micro Swift Spray

Terrain-following 3D diagnostic mass-consistent model +  
3D Lagrangian Particle Dispersion Model

#### Features:

- **Microscale:** buildings taken into account
- Suitable for complex meteorological conditions
- Large domains splitted in tiles
- **Parallelized**



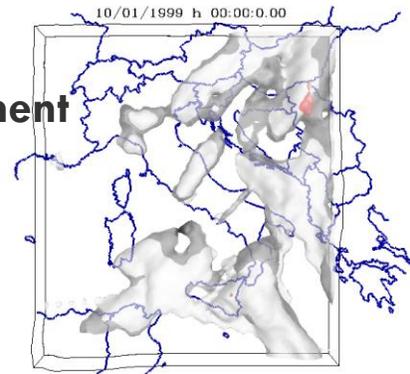
## FARM

### FARM: Flexible Air quality Regional Model

Multigrid **Eulerian grid model** for dispersion,  
transformation and deposition of inert and reactive  
pollutants (photochemistry and aerosols)

#### Features:

- Continental → national → regional → urban scales
- Observational data assimilation
- **On-line Reactive Source Apportionment**
- **Fully parallelized**

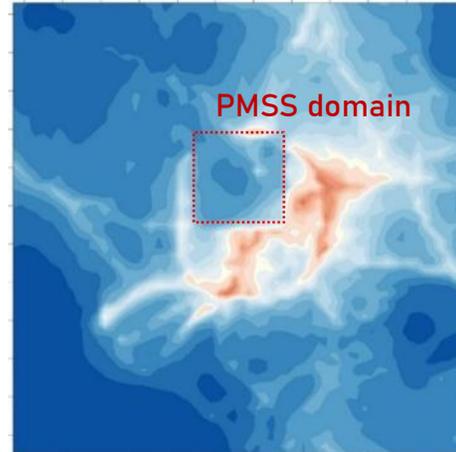


# First HMS design

## FARM – Background concentration

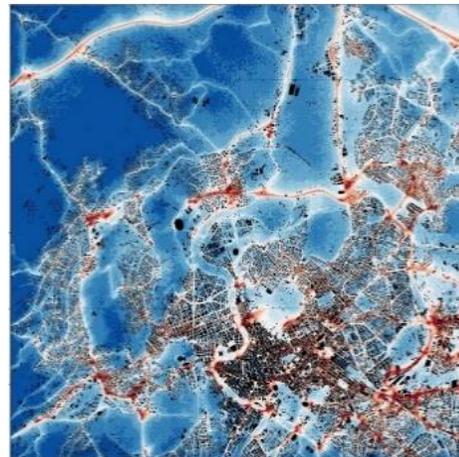
- **Primary and secondary pollutants emitted by all other sources**
- Simulated all the pollutants emitted by all the sources except traffic sources simulated with PMSS

Background from other sources (FARM)



## PMSS – Traffic concentration

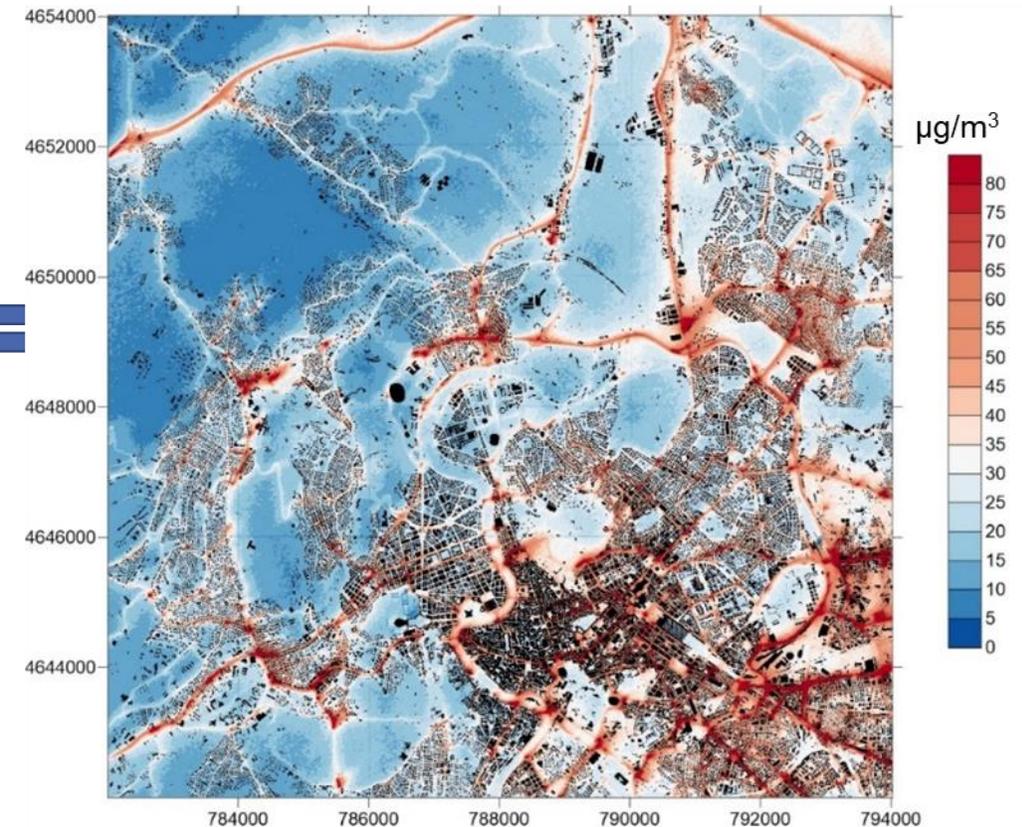
- **Primary pollutants emitted by traffic sources**
- Simulated only primary pollutants emitted by traffic sources
- Polynomial relationship to compute NO<sub>2</sub> from NO<sub>x</sub>



Traffic, street level (PMSS)

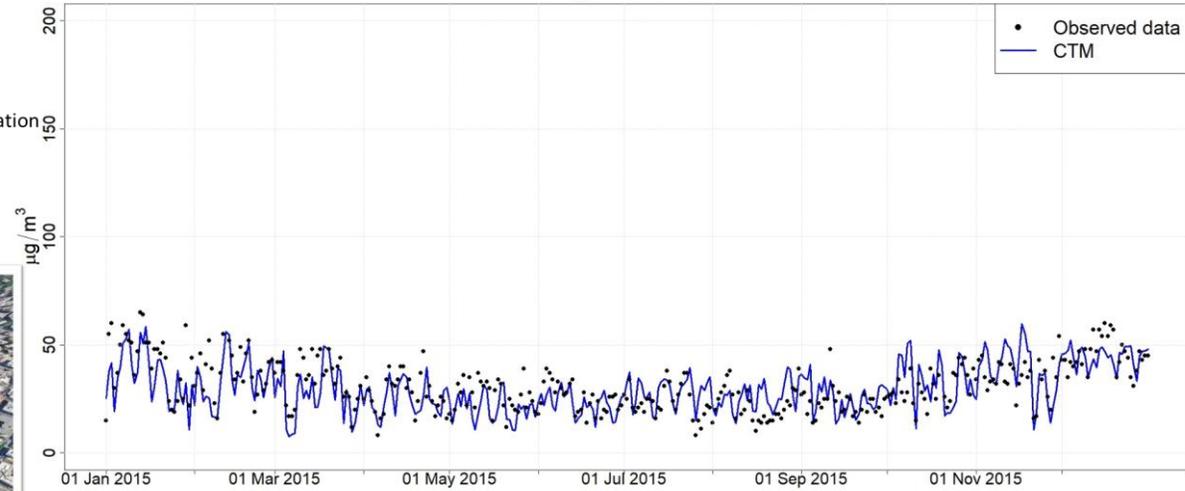
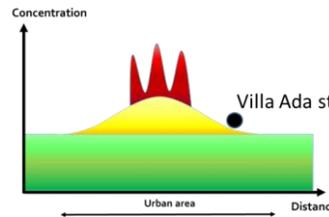
Coupling procedure based on **additivity**

$$\text{TOTAL} = \text{FARM} + \text{PMSS}$$

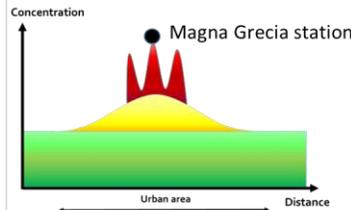
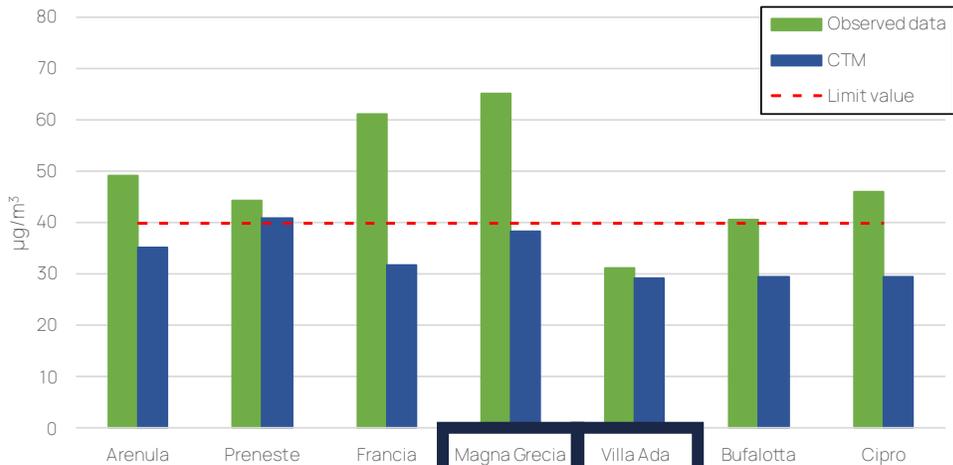


# First HMS design - Application

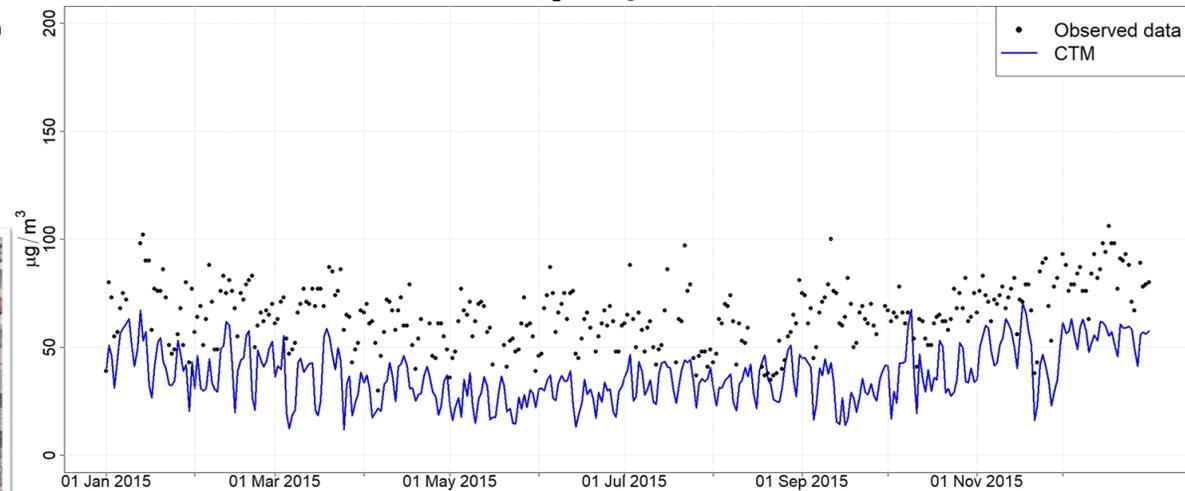
NO<sub>2</sub> - Villa Ada



NO<sub>2</sub> annual average

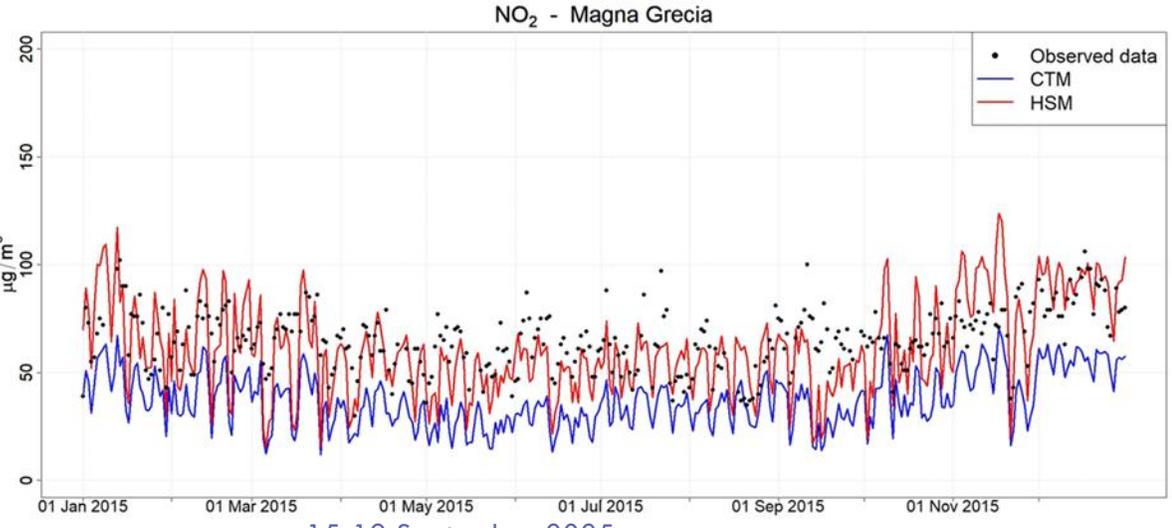
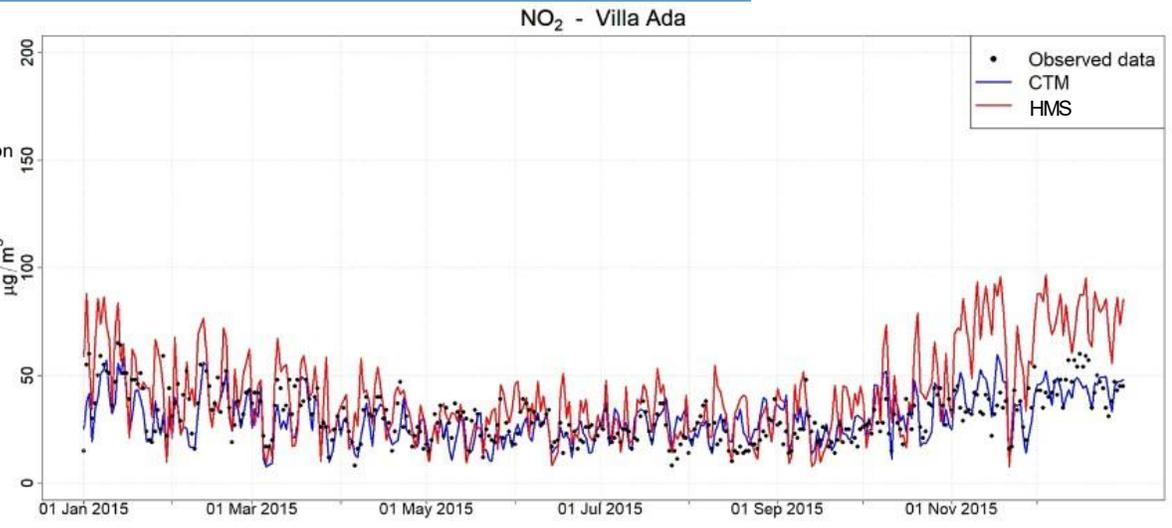
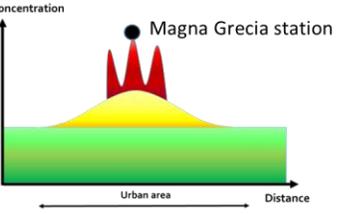
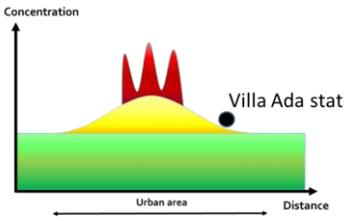
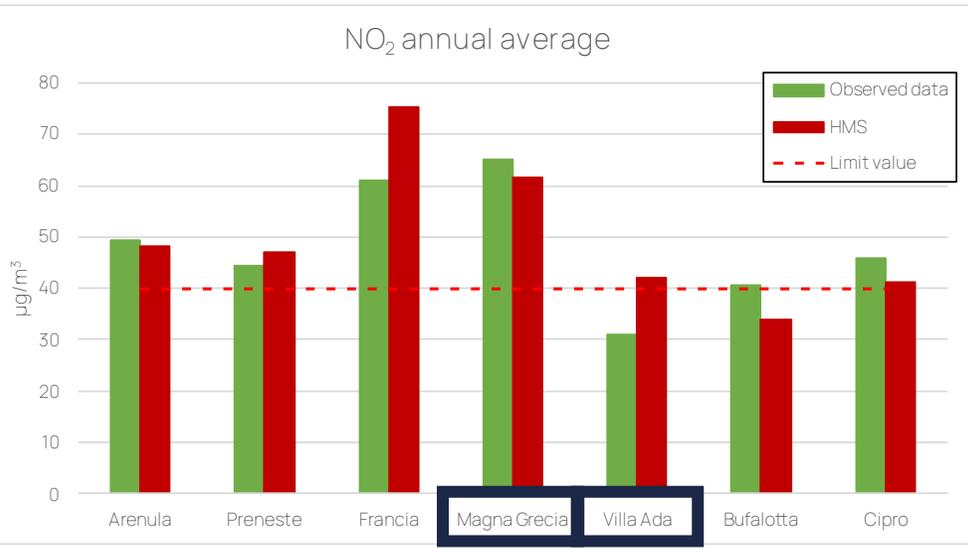


NO<sub>2</sub> - Magna Grecia



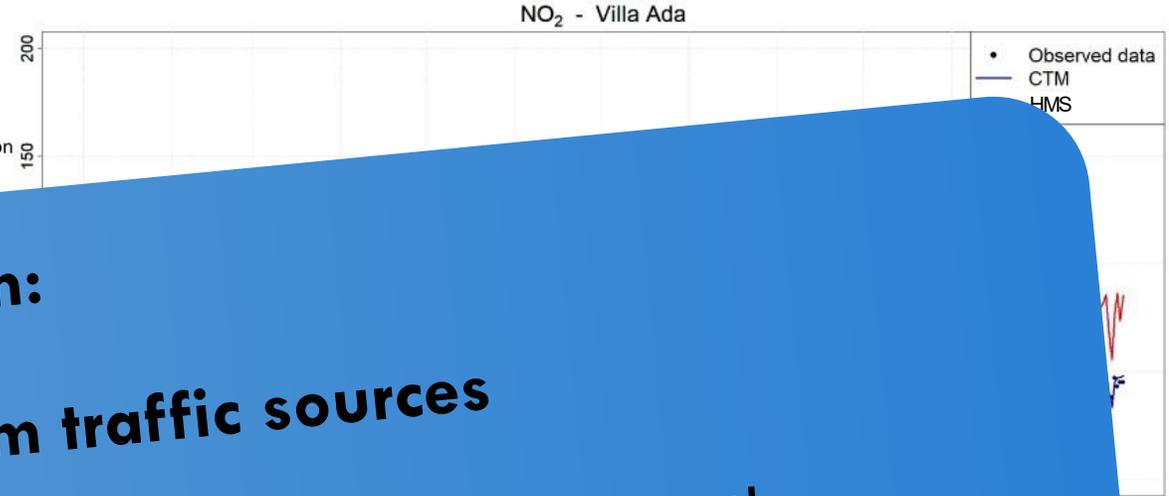
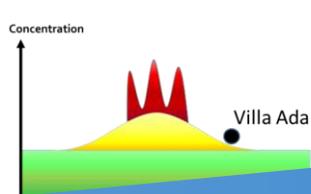
Barbero et al., 2021

# First HMS design - Application



Barbero et al., 2021

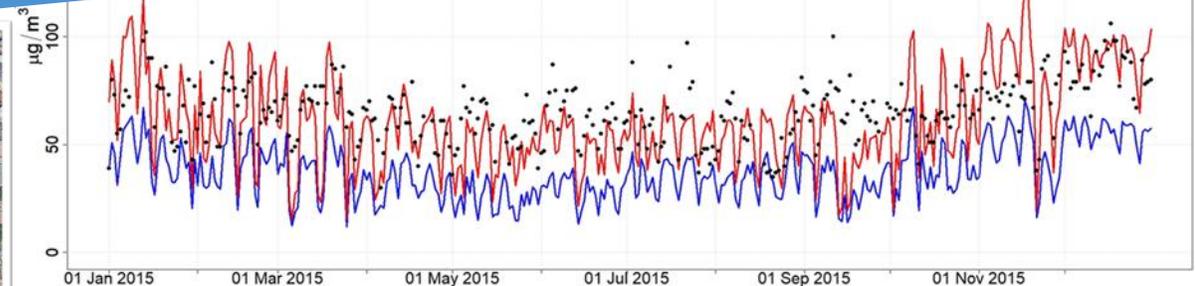
# First HMS design - Application



## Limitations of the first HMS configuration:

- Neglect of secondary pollution from traffic sources
- Disruption of chemical equilibrium in FARM simulation due to the removal of traffic sources

µg/m<sup>3</sup>



Barbero et al., 2021

# Advanced HMS design

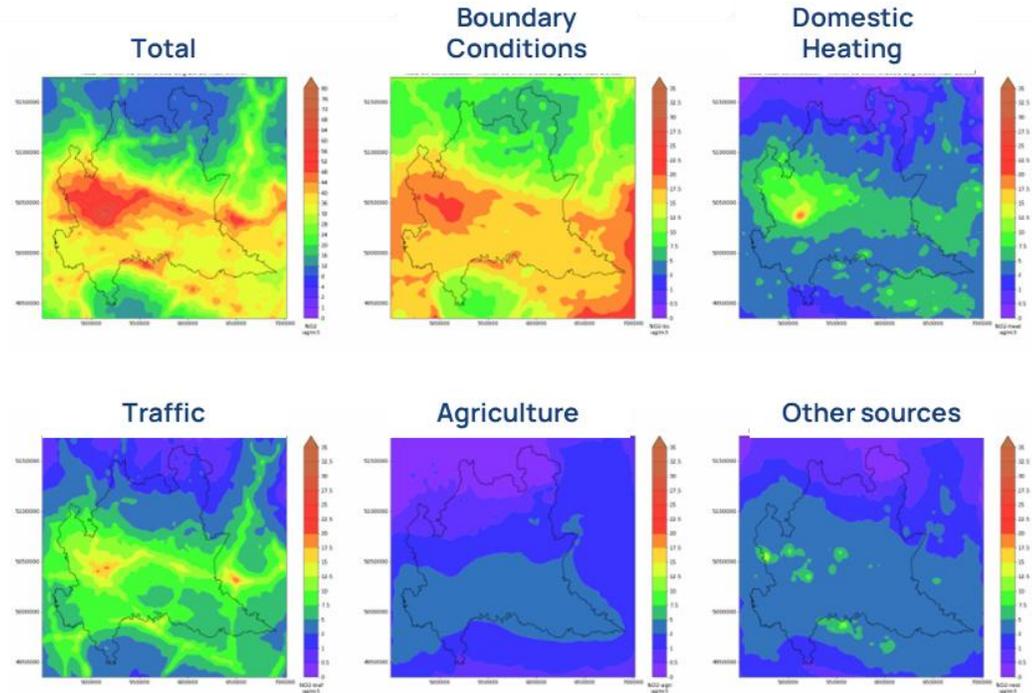
## FARM ORSA – Background concentration

- **Primary and secondary pollutants emitted by all other sources**
  - **Secondary pollutants of the traffic sources**
- Simulated all the pollutants emitted by **all the sources, tracking primary and secondary pollution of traffic sources**

## PMSS – Traffic concentration

- **Primary pollutants emitted by traffic sources**
- Simulated only primary pollutants emitted by traffic sources
- Polynomial relationship to compute NO<sub>2</sub> from NO<sub>x</sub>

Use of the **Online Reactive Source Apportionment (ORSA)** inside **FARM**



Coupling procedure based on **additivity**  
**TOTAL = FARM ORSA + PMSS**

# Test case on Milan

## Main target:

Comparison between the first and the advanced HMS configuration

## Statistical parameters of interest:

- Period average concentrations
- Hourly and daily concentrations

## Simulation specifics:

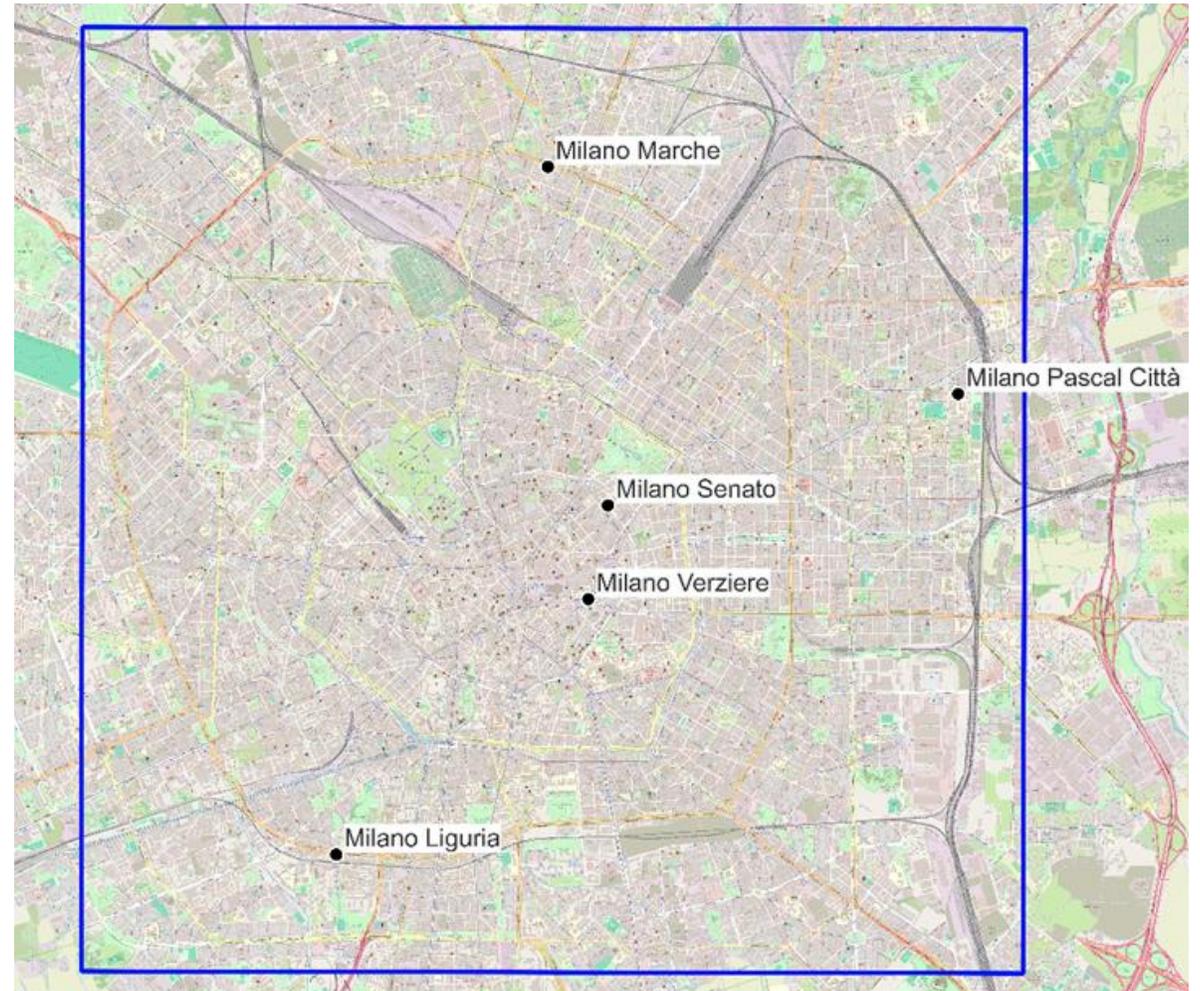
Domain: **8x8 km<sup>2</sup>**

Horizontal resolution: **5 meters**

Temporal resolution: **1 hour**

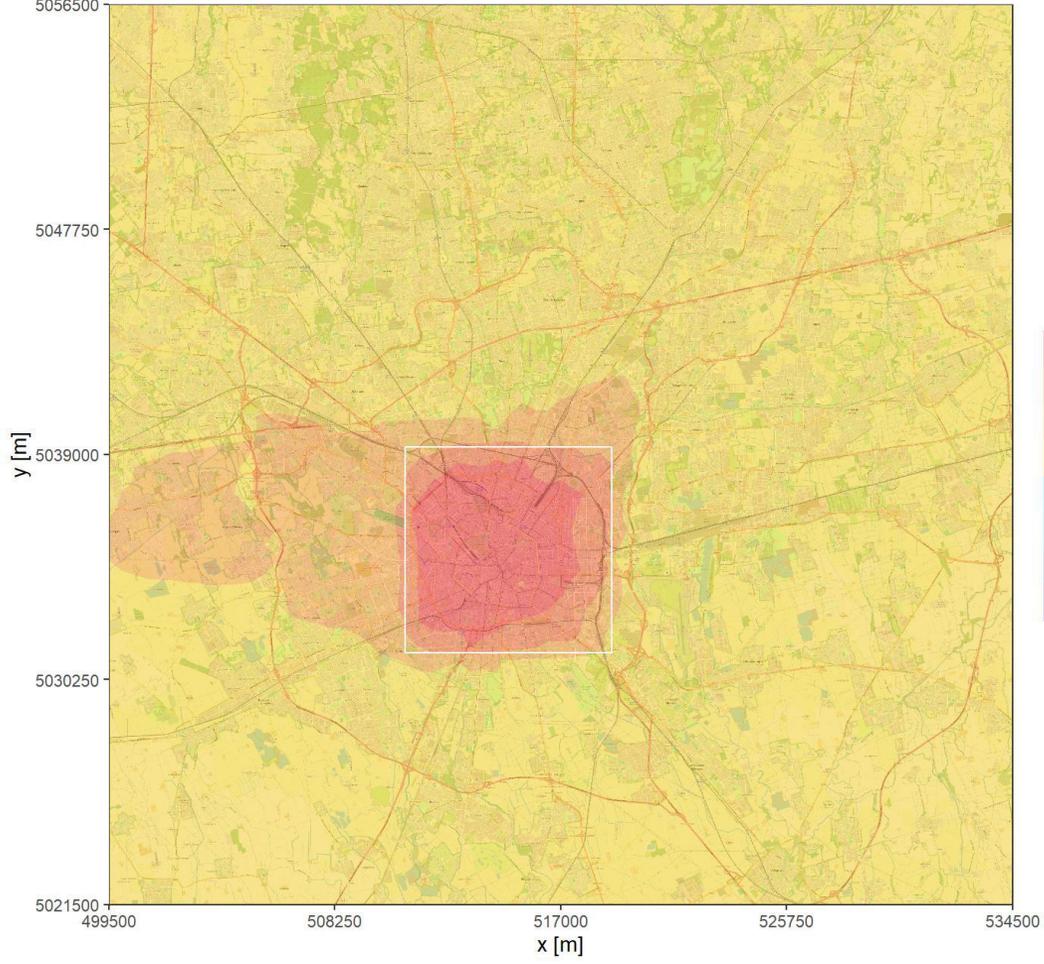
Temporal extension: **1 week**

**(27/06/2017-04/07/2017)**

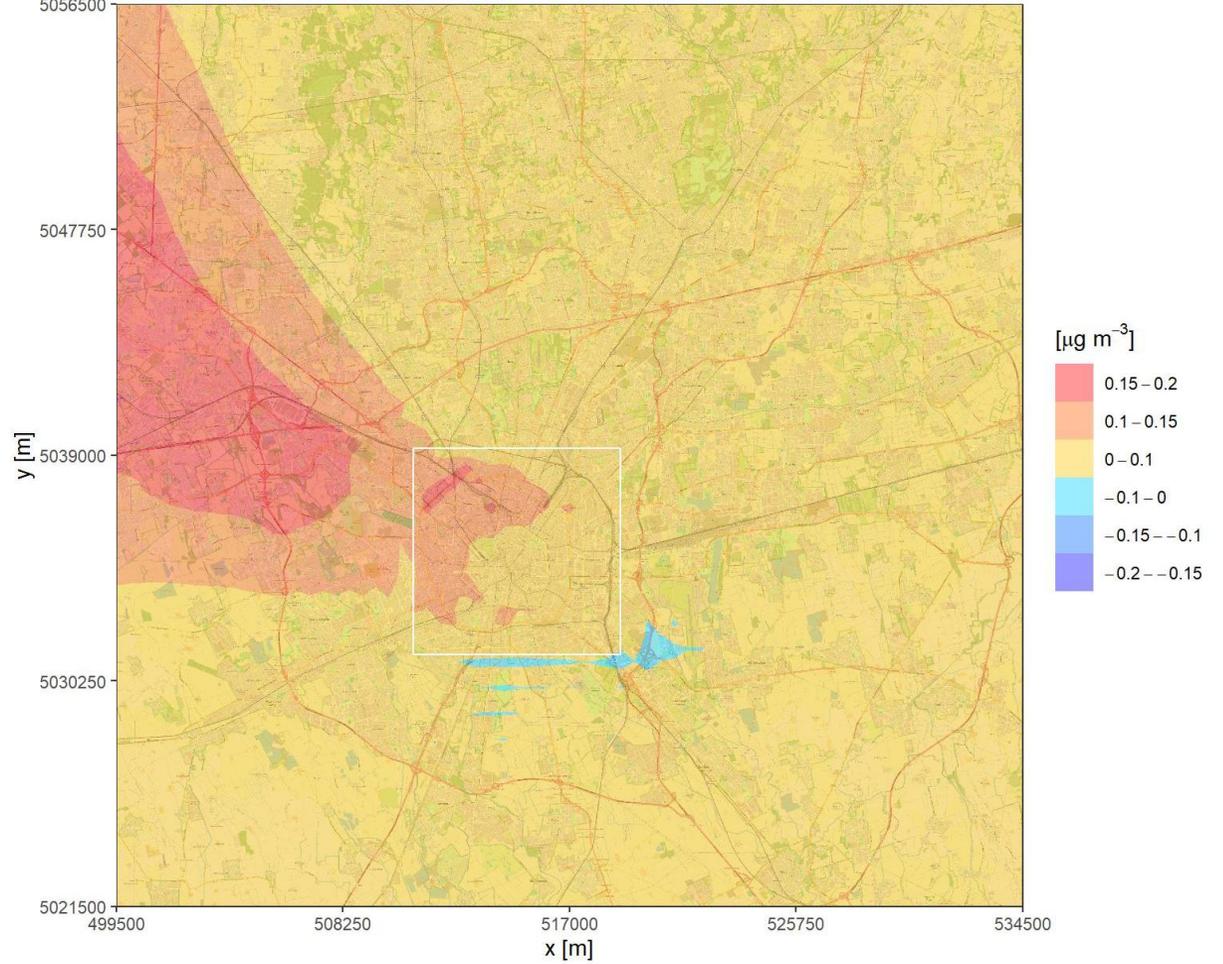


# Comparison between the two HMS configurations

NO<sub>2</sub> - Difference between Advanced HMS and HMS first configuration  
Average on target period



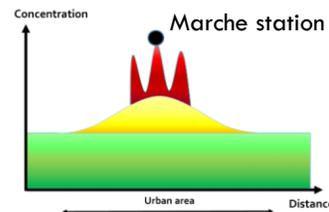
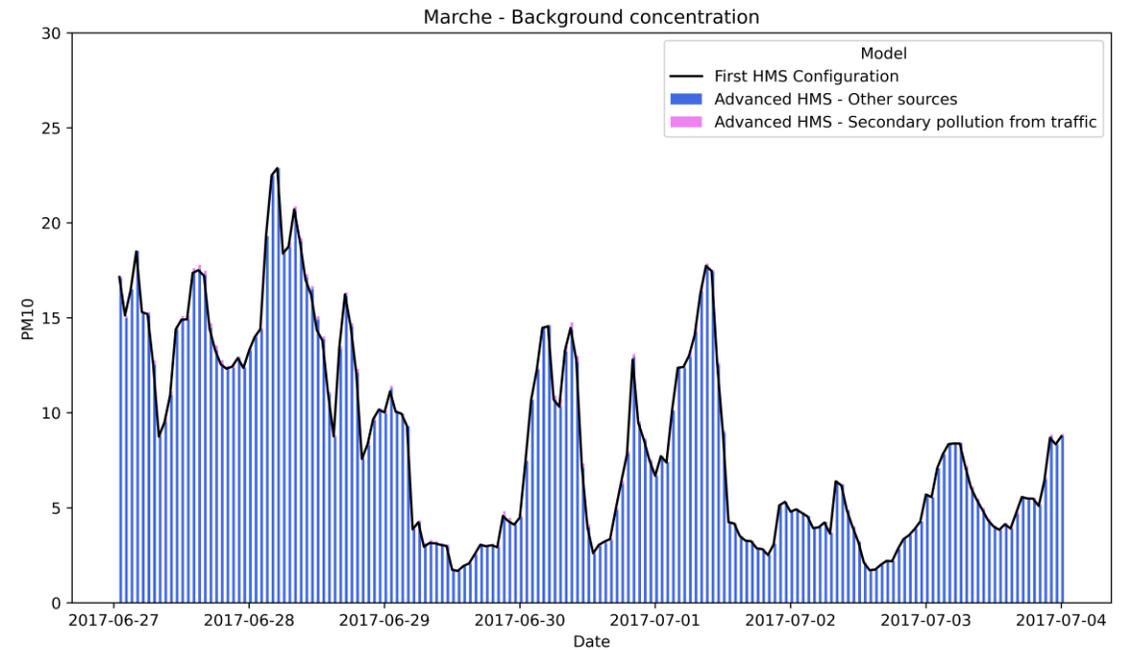
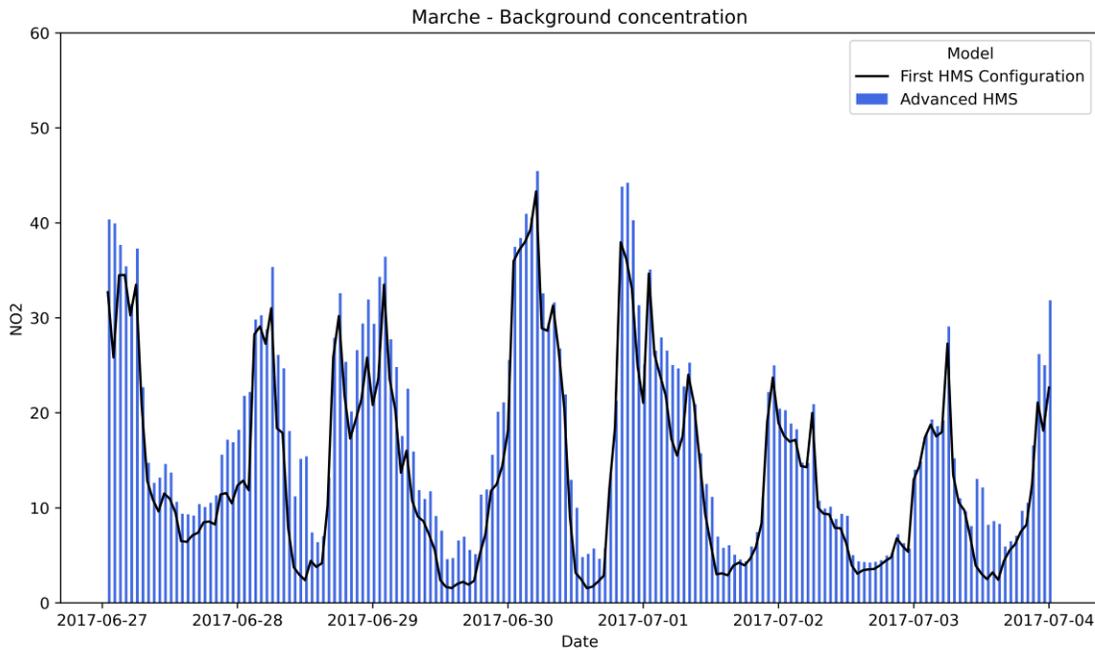
PM10 - Difference between Advanced HMS and HMS first configuration  
Average on target period



# Comparison between the two HMS configurations

## NO<sub>2</sub>

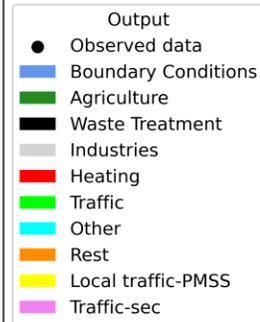
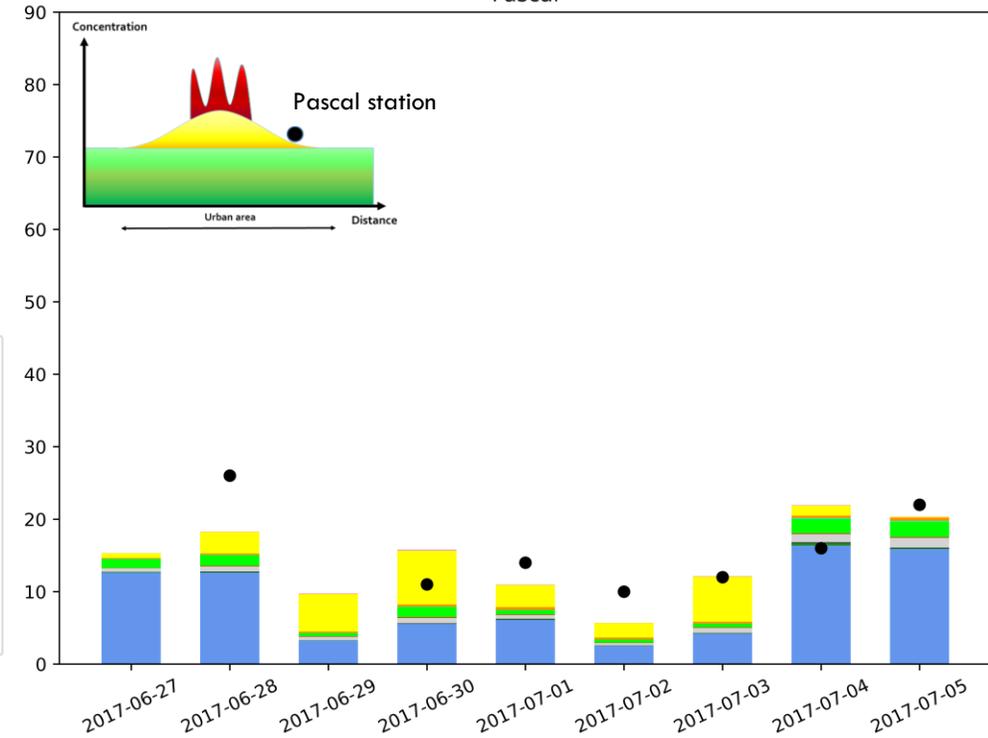
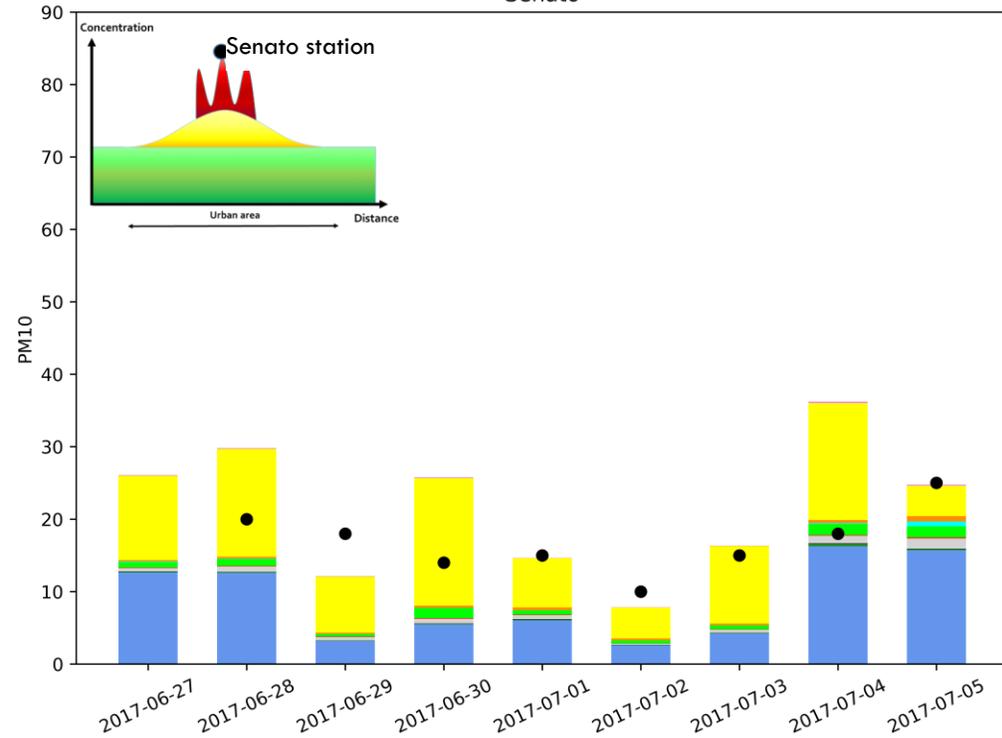
## PM10



# Comparison with observed data

Senato

Pascal



	n. data	Mean obs	Mean HMS	SD obs	SD HMS	IA	FAC2	FB
NO <sub>2</sub>	960	37.21	43.40	21.01	28.15	0.40	0.56	0.15
PM10	23	16.52	18.72	4.41	8.53	0.65	0.96	0.12

# CONCLUSIONS

- Comprehensiveness
- High resolution
- Flexibility
- Scalability
- Computational efficiency
- Accuracy
- Source apportionment

Advanced HMS design → more extensive testing and applications are needed

# Thank you for your attention!

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