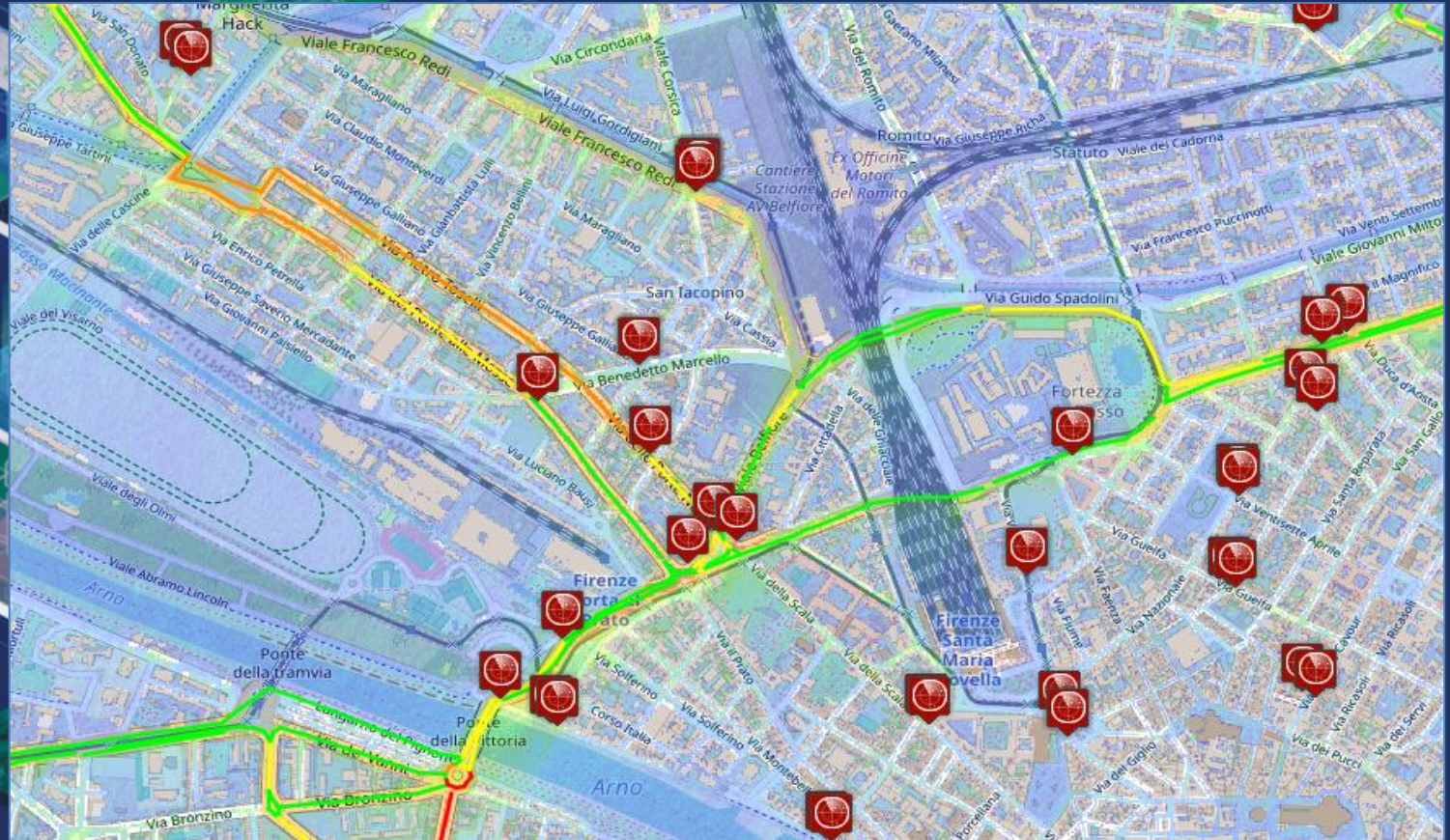




www.snap4city.org  
www.snap4solutions.org



www.km4city.org



Environmental overview

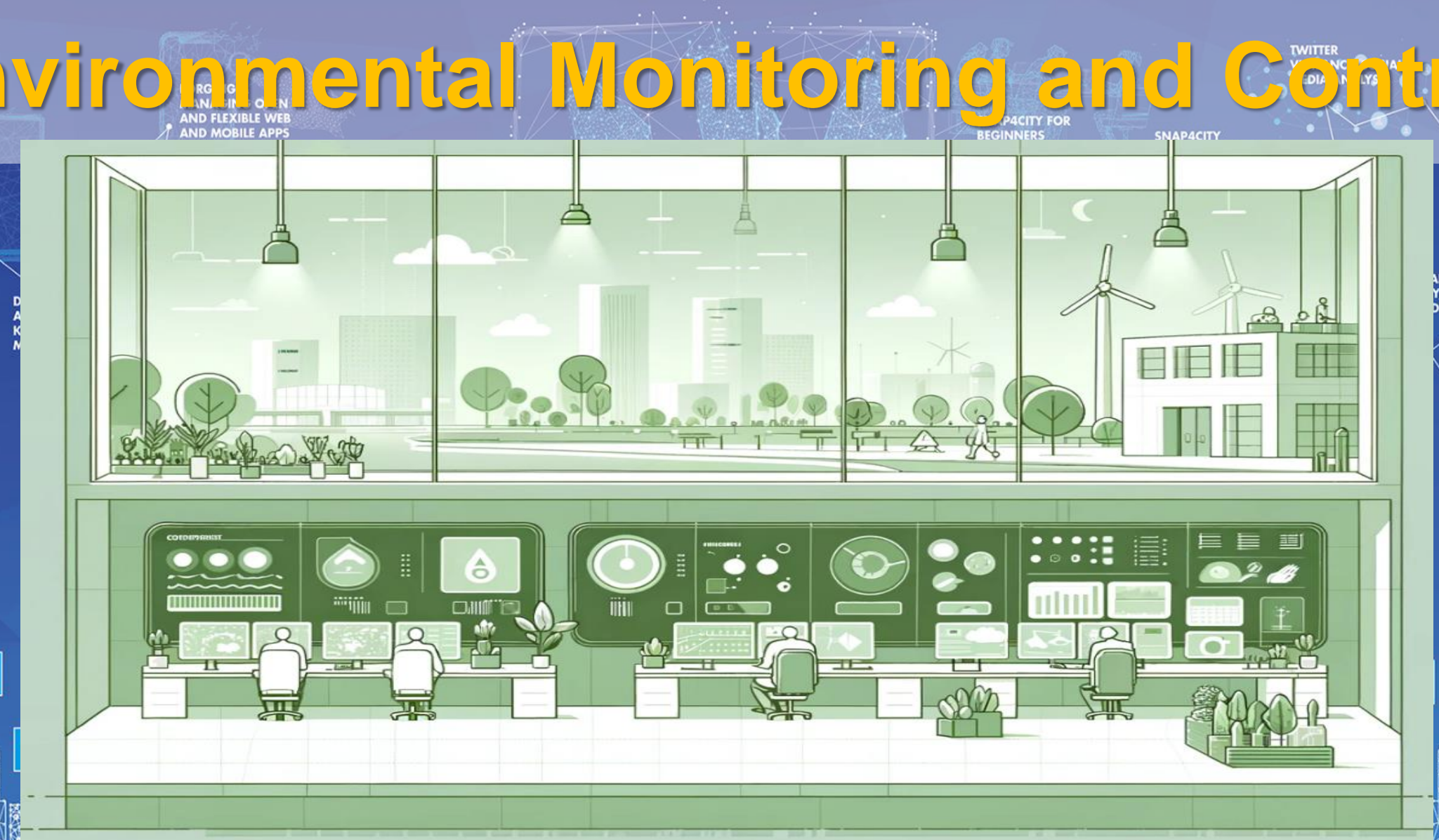
DIGITAL TWIN SOLUTIONS TO SETUP SUSTAINABLE DECISION SUPPORT SYSTEMS AND BUSINESS INTELLIGENCE



# Environmental Monitoring and Control

FROM CITY  
DASHBOARD TO  
APPLICATIONS

DATA



ORGANIZATION  
AND FLEXIBLE WEB  
AND MOBILE APPS

SNAP4CITY FOR  
BEGINNERS

SNAP4CITY

TWITTER  
ANALYTICS  
DIAGNOSTICS

SNAP4CITY  
AND KM4CITY  
PROJECTS

ADOPT  
AND  
MAP

SNAP4CITY THE  
VIEW OF THE  
ADMINISTRATORS





# Key Performance Indicators, KPI



- **United Nations Sustainable Development Goals, SDGs** (for which cities can do more to achieve some of the 17 SDGs, <https://sdgs.un.org/goals>);
- **15 minutes cities** (where primary services must be accessible within 15 minutes on foot);
- **objectives of the European Commission** in terms of pollutant emissions for: NO2, PM10, PM2.5 ([https://environment.ec.europa.eu/topics/air\\_en](https://environment.ec.europa.eu/topics/air_en));
- **SUMI: mobility and transport vs env**
  - <https://www.snap4city.org/951>
- **SUMP/PUMS: mobility and transport vs env.**
- **ISO indicators:** city smartness, digitization, tech level.
- **Low Level/Real Time:** global traffic, quality of service, betweenness, centrality, queue, time to travel, etc.

Global  
&  
Local  
  
Periodic  
&  
Realtime

Air Quality Directive				WHO guidelines	
Pollutant	Averaging period	Objective and legal nature and concentration	Comments	Concentration	Comments
PM <sub>2.5</sub>	One day			25 µg/m <sup>3</sup> (*)	99 <sup>th</sup> percentile (3 days/year)
PM <sub>2.5</sub>	Calendar year	Target value, 25 µg/m <sup>3</sup>	The target value has become a limit value since 1 January 2015	10 µg/m <sup>3</sup>	
PM <sub>10</sub>	One day	Limit value, 50 µg/m <sup>3</sup>	Not to be exceeded on more than 35 days per year.	50 µg/m <sup>3</sup> (*)	99 <sup>th</sup> percentile (3 days/year)
PM <sub>10</sub>	Calendar year	Limit value, 40 µg/m <sup>3</sup> (*)		20 µg/m <sup>3</sup>	
O <sub>3</sub>	Maximum daily 8-hour mean	Target value, 120 µg/m <sup>3</sup>	Not to be exceeded on more than 25 days per year, averaged over three years	100 µg/m <sup>3</sup>	
NO <sub>2</sub>	One hour	Limit value, 200 µg/m <sup>3</sup> (*)	Not to be exceeded more than 18 times a calendar year	200 µg/m <sup>3</sup> (*)	
NO <sub>2</sub>	Calendar year	Limit value, 40 µg/m <sup>3</sup>		40 µg/m <sup>3</sup>	



• **15 Minute City Index:**

- 13 subindexes: energy, slow mobility, fast mobility, housing, economy education, culture and cults, health, entertainment, gov, food, security...



- Monitoring and Prediction of energy consumption
- Stimulating: Bike sharing, e-bikes, car charge, etc.
- Community of Energy, planning energy plant



- Industry 4.0 integrated solutions
- Decisions Support Systems
- Process optimization, control
- Predictive maintenance



- Smart City infrastructure: monitoring and resilience, long terms predictions
- Effective and Low cost smart solutions
- What-if analysis, Simulations
- Origin Destination matrices computation



- business intelligence tools for decision makers
- Reduction production costs
- Monitoring resource consumption
- Optimization of Waste Collection



- Monitoring and Predicting: NO<sub>2</sub>, NO<sub>x</sub>, CO<sub>2</sub>, Traffic flow, pollutant, landslide, waste, etc.
- Traffic flow reconstruction
- Demand vs Offer of Mobility analysis



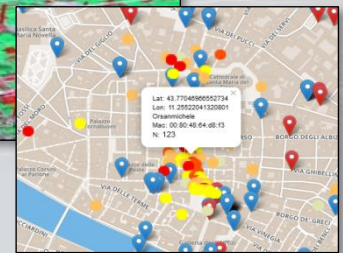
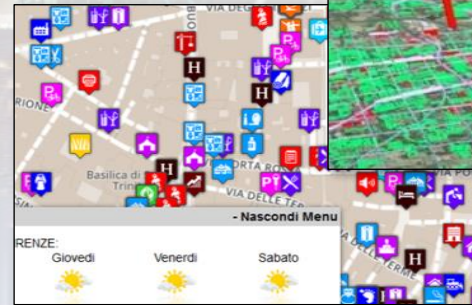
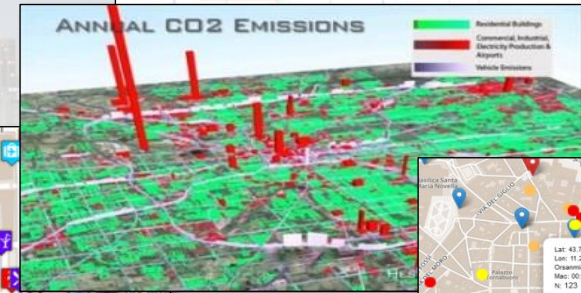
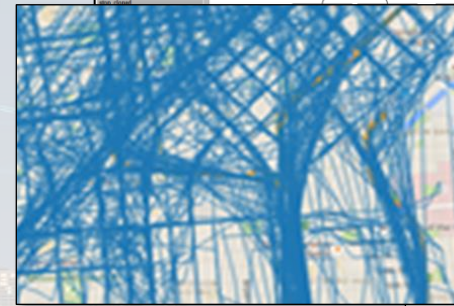
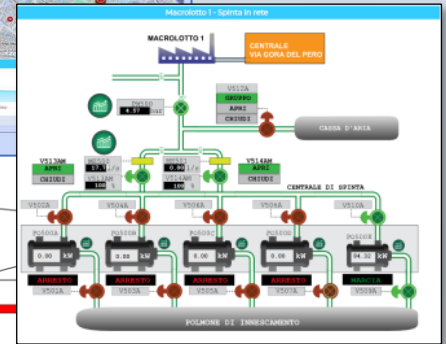
- Shortening justice time
- Anonymization and indexing legal docs.
- Prediction of mediation proneness
- Ethical Explainable Artificial Intelligence



# Data Driven Decision Support



- Decision Support system
- Assessment / Strategies
- Data Rendering,
  - visual analytics, business intel..
- Data Analytics, ML, AI
- Data aggregation, Storage, indexing
- Data Ingestion





# Public Spaces as Critical Infrastructures

- The City is a system of systems for city users
  - Cascading effects
- **Transport** networks
  - Main means for rescue teams, food, water, etc.
- **Communication**, ICT infrastructure
  - TV cam, switches, cyber,
- **Energy** networks
  - power supply for health, cyber systems, etc.
- **Hospitals** networks
- Aggregation areas



[https://www.snap4city.org/download/video/DPL\\_SNAP4SOLU.pdf](https://www.snap4city.org/download/video/DPL_SNAP4SOLU.pdf)



# 15MinCityIndex

**What would support my neighborhood to become a 15-Minute City?**

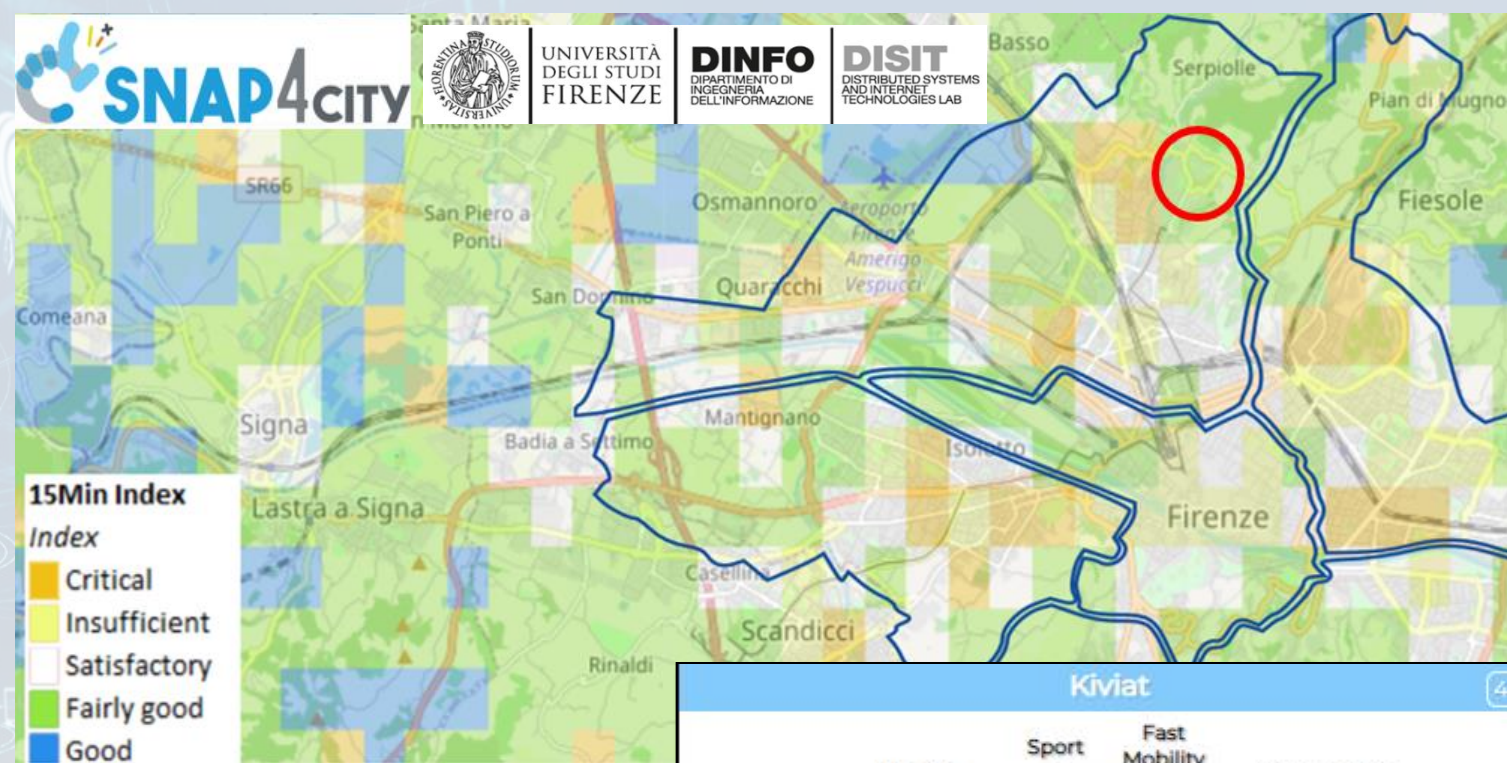
## Using the Open Data:

We developed a data analytic tool based on municipal and national open data to assess services adequacy for people living in each 15 minutes areas of the city.

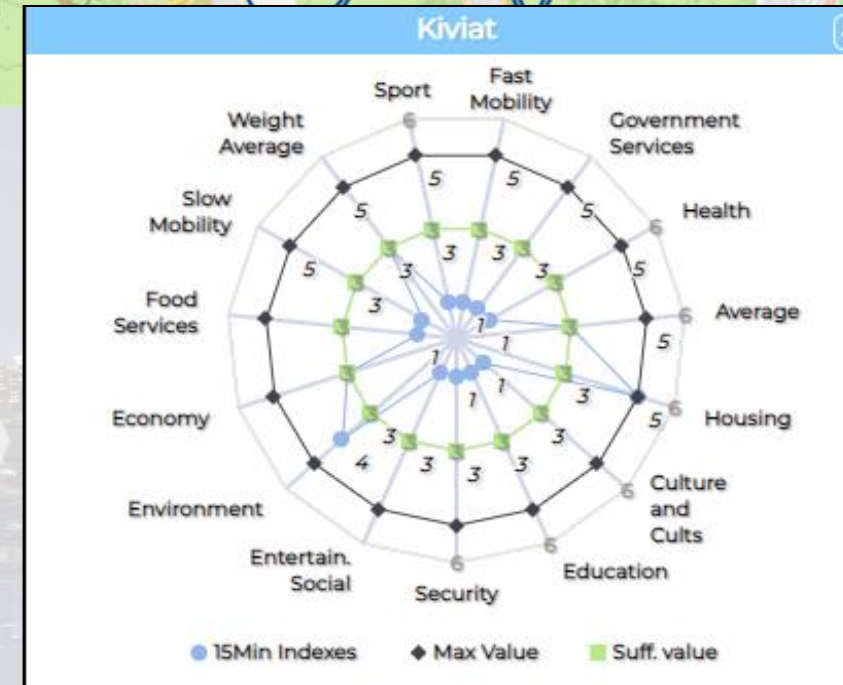
Good public transport services: bus, new tram line, train stations, cycle paths.



Careggi/Rifredi is a relevant district in Florence because of hosting the main Florence/Tuscany hospitals Careggi and Meyer, but also university headquarters and many other workplaces.



The tool supports the becoming of a 15-Minute city evaluating the service level in various domains.



<https://www.snap4city.org/dashboardSmartCity/view/index.php?iddashboard=MjkzOA==>



# 15MinCityIndex on Bologna

Ciao roottooladmin!

Tue 3 May 20:14:59

## 15 MINUTI INDEX BOLOGNA CITTÀ METROPOLITANA - NEWGUI

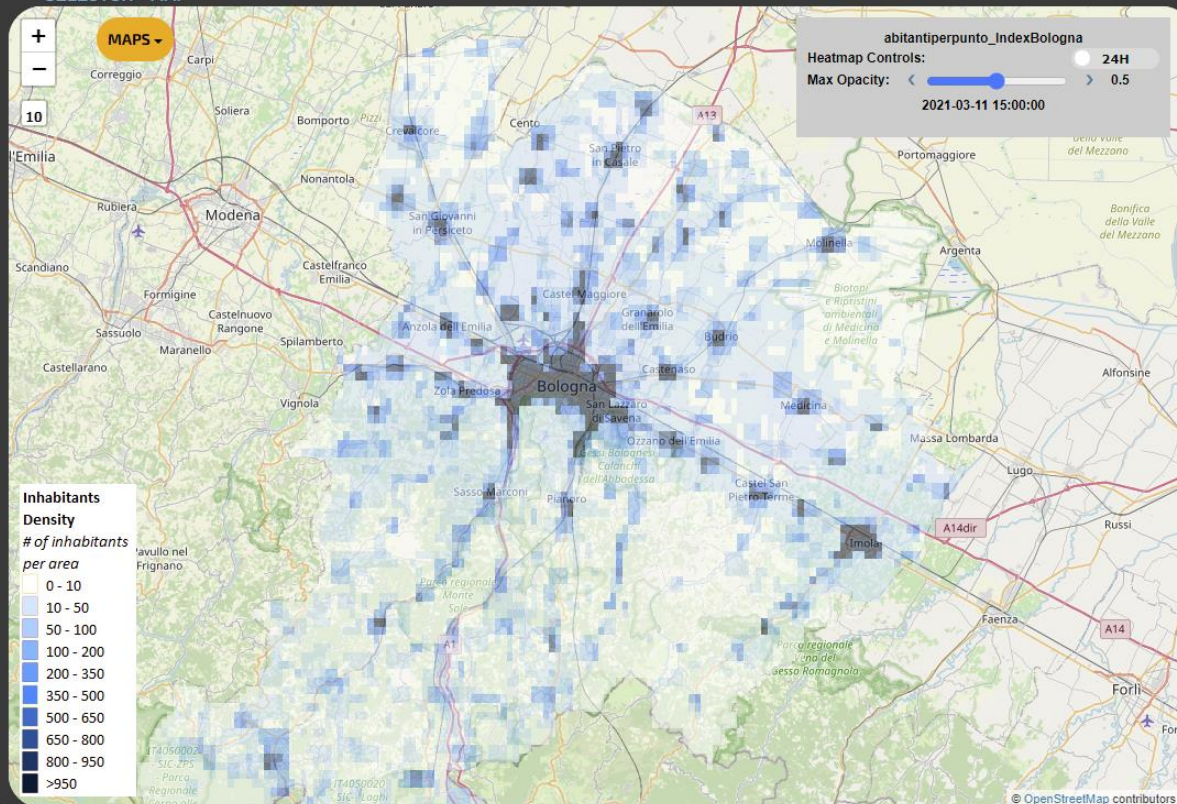
- # of Inhabitants >
- Green factor >
- Civil factor >
- Industrialization factor >
- Environment Index >
- 15Min Economy Index >
- 15Min Housing Index >
- 15Min Health Index >
- 15Min Food Index >
- 15Min Education Index >
- 15Min Slow Mob Index >

### THE PICKED POINT

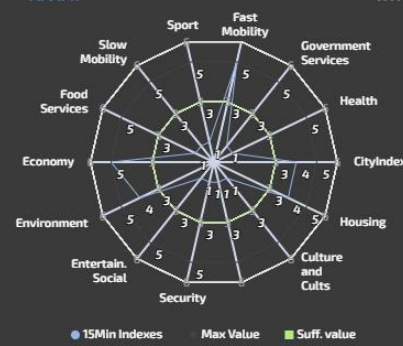
9m

City: Argelato  
Address: Via Casadio N. 1  
lat,lon: 44.61882,11.35437

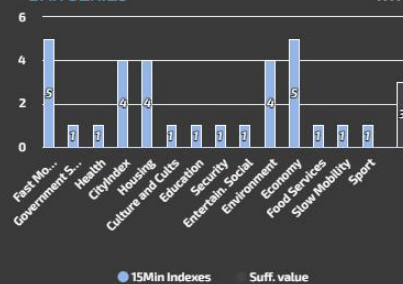
### SELECTOR - MAP



### KIVIAT



### BAR SERIES

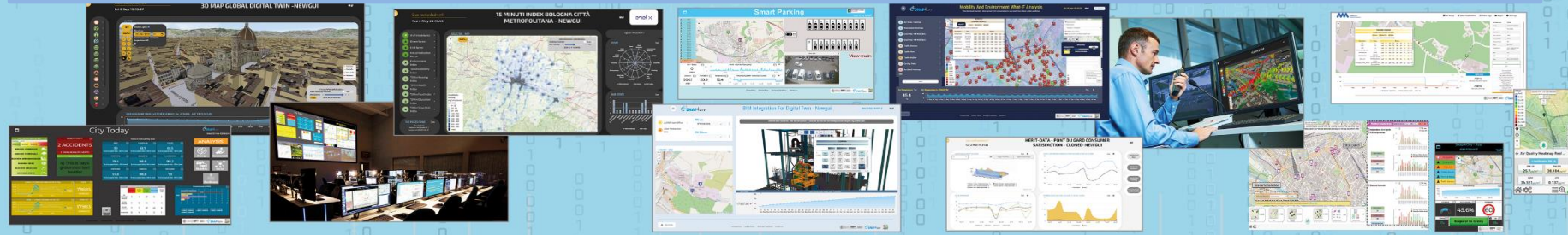




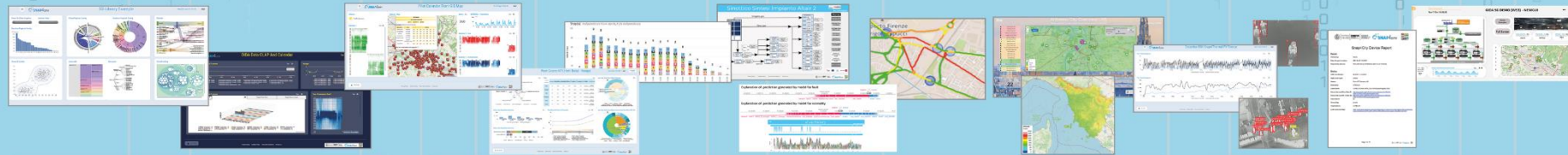


# Smart Solutions and Decision Support Systems

CONTROL ROOMS - DECISION SUPPORT SYSTEMS - WHAT-IF ANALYSIS - BUSINESS INTELLIGENCE - SIMULATIONS - SMART APPLICATIONS



DASHBOARDS - VISUAL ANALYTICS - SYNOPTICS - DIGITAL TWIN - GRAPHICAL WIDGETS - ANALYTICS - GUI CUSTOM STYLES - VISUAL PROGRAMMING



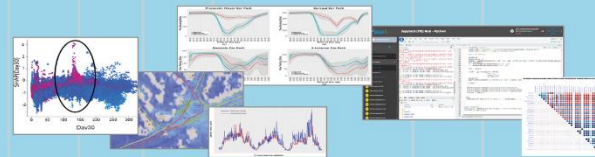
DASHBOARDS, WIDGETS  
TEMPLATES

PREDICTION - ANOMALY DETECTION - CLUSTERING - ROUTING - SENTIMENT NLP - TRAFFIC FLOW  
PEOPLE FLOWS - SDG - 15 MIN CITY INDEX - KPI - HEATMAPS - ORIGIN DESTINATION - ETC...

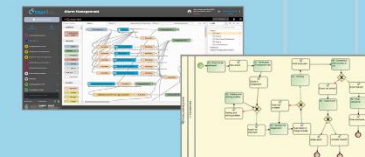
API - MICROSERVICES - GIS - BPM  
VIDEO - REPORTS - MAPS - 3D ...

ANY: DATA, BROKER, NETWORK AND VERTICAL

EXPERT SYSTEM, KNOWLEDGE BASE  
SEMANTIC REASONING  
SMART DATA MODEL  
IOT DEVICE MODELS, STORAGE



BIG DATA ANALYTICS, ARTIFICIAL INTELLIGENCE  
EXPLAINABLE AI, MACHINE LEARNING  
OPERATIVE RESEARCH, STATISTICS



VISUAL PROGRAMMING, ADAPTERS  
DATA FLOWS, WORKFLOWS  
PARALLEL DISTRIBUTED PROCESSING  
EVENT DRIVEN

Native and External  
Smart Applications

Mobility & Transport

Light & Energy

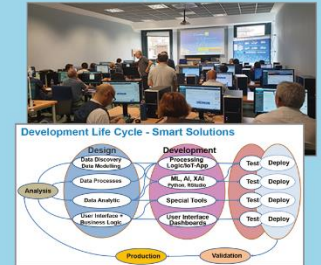
Waste | Environment

Building | Tourism

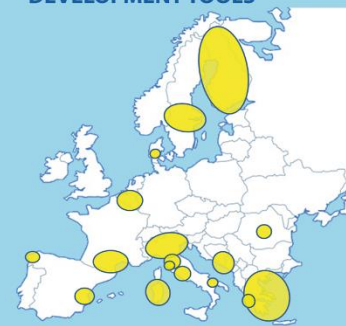
Asset Management

Security and Safety

Social Media



METHODOLOGIES  
LIVING LABS  
COURSES AND COMMUNITY  
DEVELOPMENT TOOLS



Powered by  
FIWARE

FREE  
TRIAL

PEN Test  
Passed

EU GDPR  
COMPLIANT

SNAP4  
Appliances and Dockers  
Installations

EUROPEAN OPEN  
SCIENCE CLOUD

Node-RED

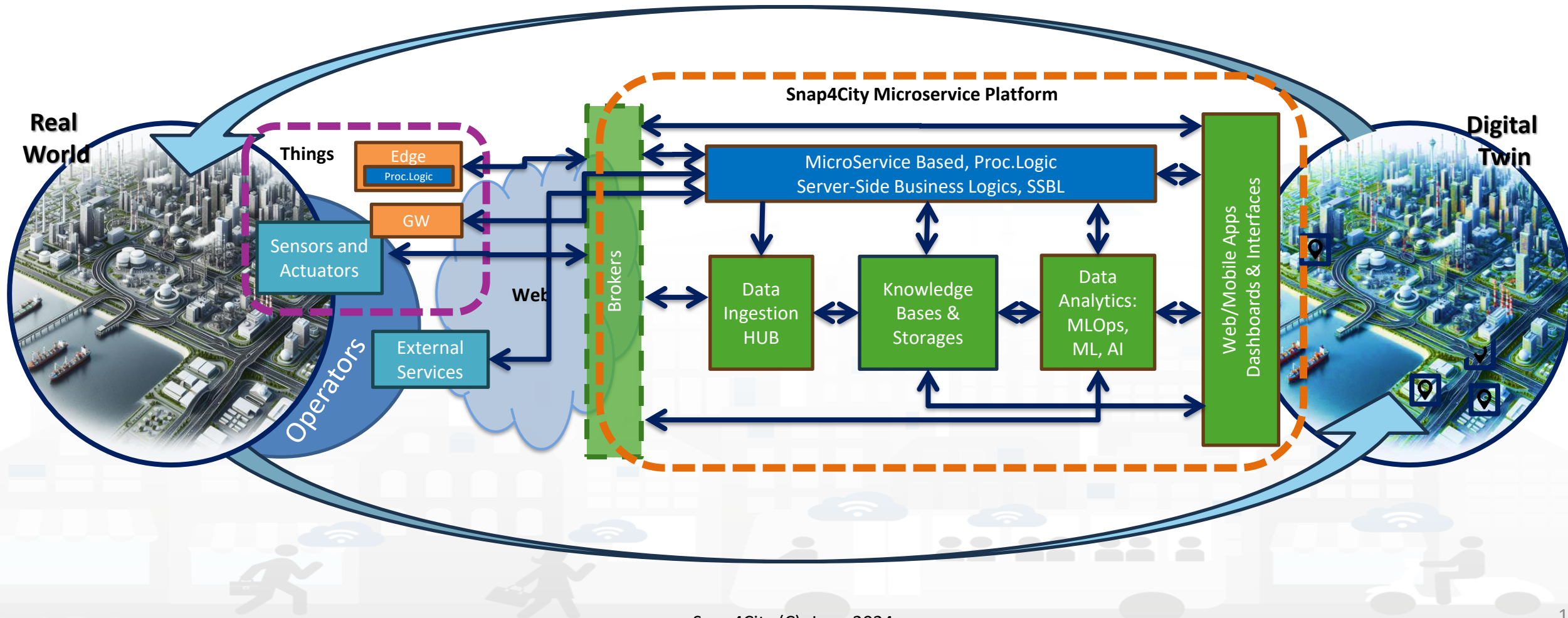
JS Foundation

E015  
digital ecosystem

NVIDIA



# Digital Twin Development Platform





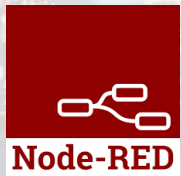
# Standards and Interoperability (6/2023)



## Compliant with:

- **IoT:** NGSI V2/LD, LoRa, LoRaWan, MQTT, AMQP, COAP, OneM2M, TheThingsNetwork, SigFOX, Libelium, IBIMET/IBE, Enocean, Zigbee, DALI, ISEMC, Alexa, Sonoff, HUE Philips, Tplink, BACnet, TALQ, Protocol Buffer, KNX, OBD2, Proximus, ..
- **IoT model:** FIWARE Smart Data Model, Snap4City IoT Device Models
- **General:** HTTP, HTTPS, TLS, Rest Call, SMTP, TCP, UDP, SOAP, WSDL, FTP, FTPS, WebSocket, WebSocket Secure, GML, WFS, WMS, RTSP, ONVIF, AXIS TVCam, CISCO Meraki, OSM, Copernicus, The Weather Channel, Open Weather, OLAP, VMS, ....
- **Formats:** JSON, GeoJSON, XML, CSV, GeoTIFF, OWL, WKT, KML, SHP, db, XLS, XLSX, TXT, HTML, CSS, SVG, IFC, XPDL, OSM, Enfuser FMI, Lidar, gITF, GLB, DTM, GDAL, Satellite, D3 JSON, ...
- **Database:** Open Search, MySQL, Mongo, HBASE, SOLR, SPARQL, ODBC, JDBC, Elastic Search, Phoenix, PostGres, MS Azure, ..
- **Industry:** OPC/OPC-UA, OLAP, ModBUS, RS485, RS232,..
- **Mobility:** DATEX, GTFS, Transmodel, ETSI, NeTEx, ..
- **Social:** Twitter, FaceBook, Telegram, ..
- **Events:** SMS, EMAIL, CAP, RSS Feed, ..
- **OS:** Linux, Windows, Android, Raspberry Pi, Local File System, AXIS, ESP32, etc.

<https://www.snap4city.org/65>

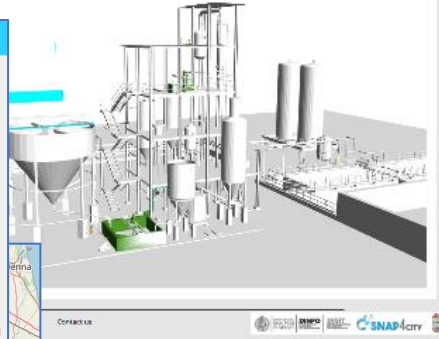
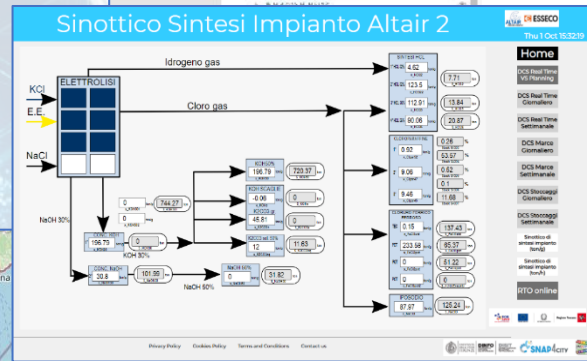
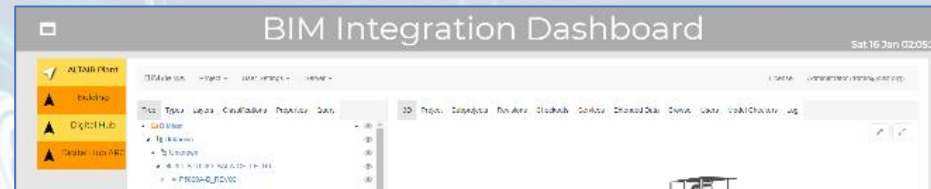




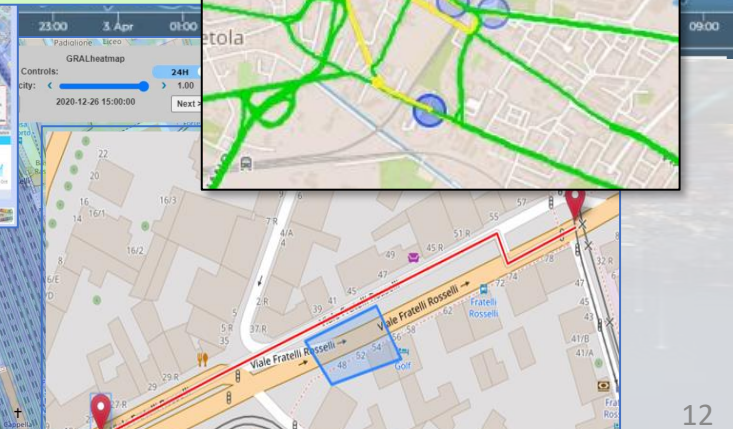
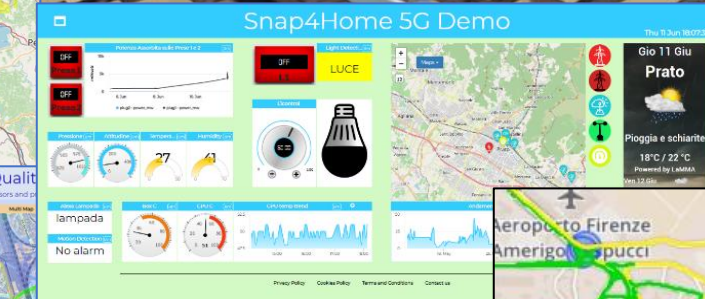
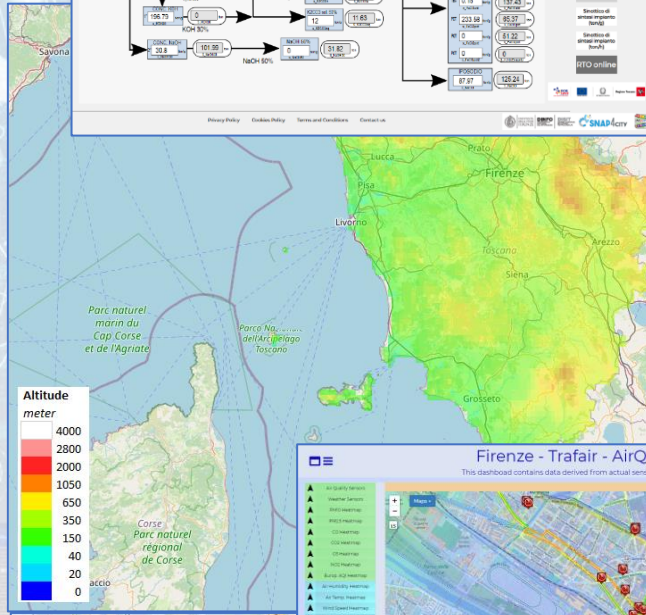
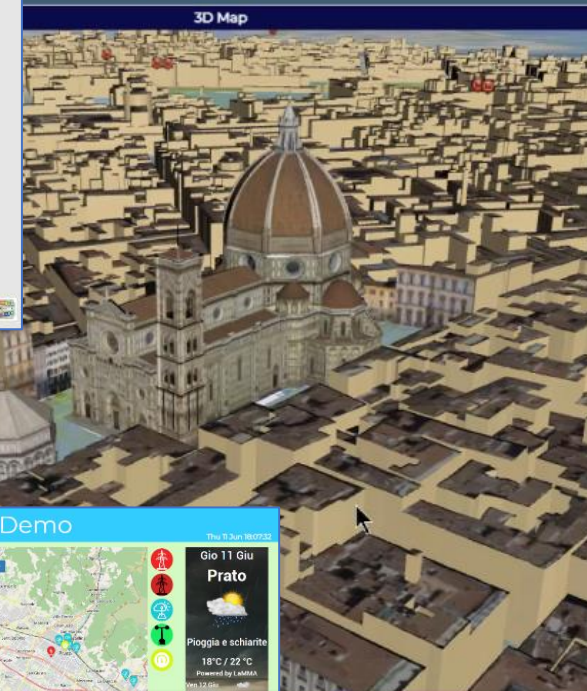
# High Level Types

Snap4City (C), June 2024

- POI, IOT Devices, shapes, ...
  - FIWARE Smart Data Models,
  - IoT Device Models
- GIS, maps, orthomaps, WFS/WMS, GeoTiff, calibrated heatmaps, ...
- Satellite data, ...
- traffic flow, typical trends, ...
- trajectories, events, Workflow, ...
- 3D Models, BIM, Digital Twins, ...
- OD Matrices of several kinds, ...
- Dynamic icons/pins, ...
- Synoptics, animations, ...
- KPI, personal KPI, ...
- social media data, TV Stream,
- routing, multimodal, constraints, ...
- decision scenarios, ....
- etc.



**SNAP4CITY**  
- Digital Twin Global - Fire  
demonstrator

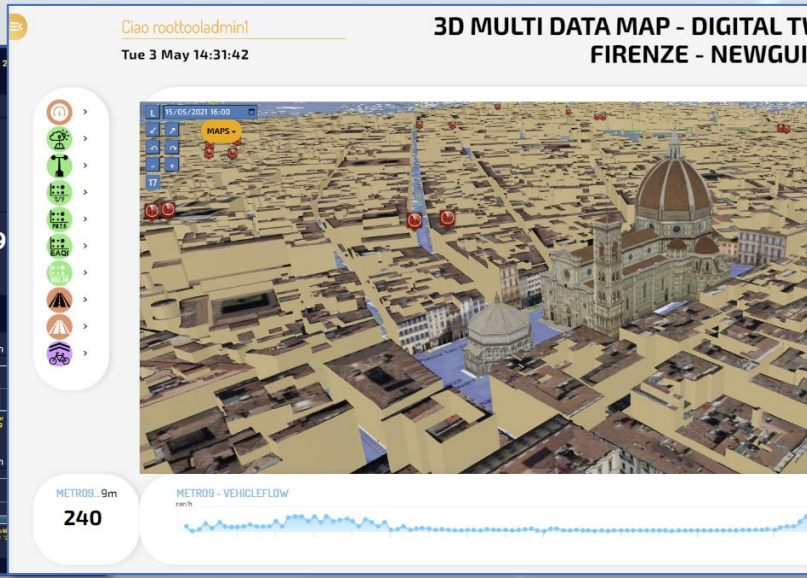
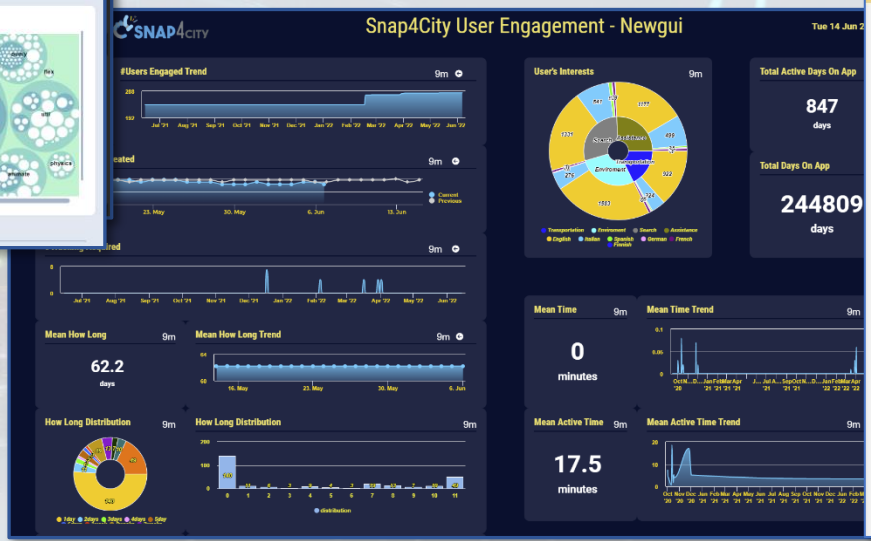
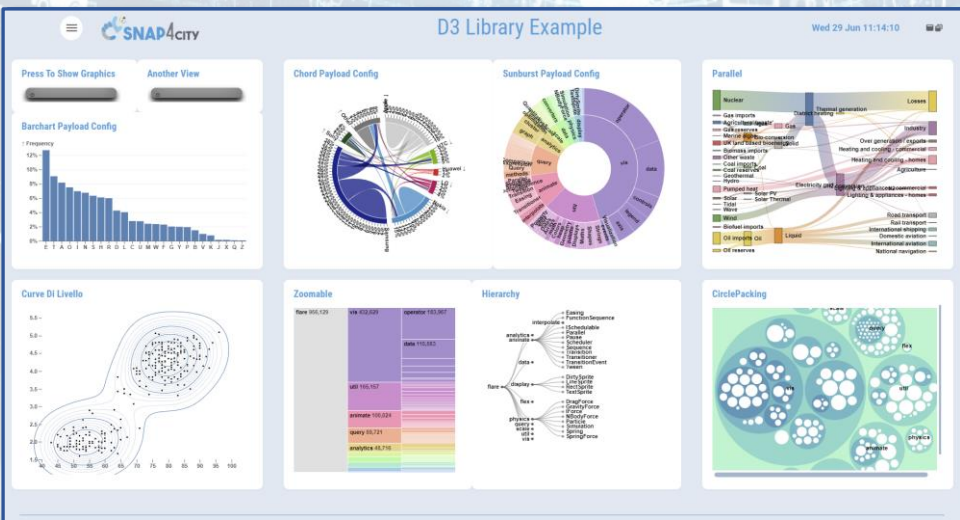
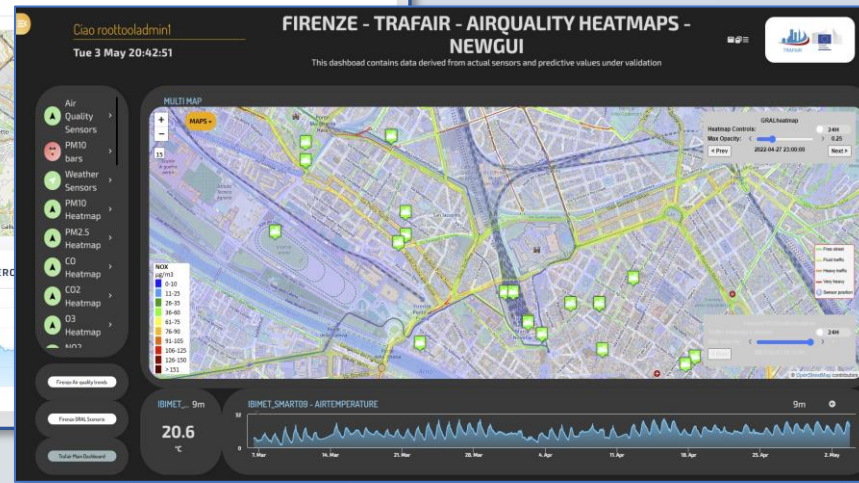
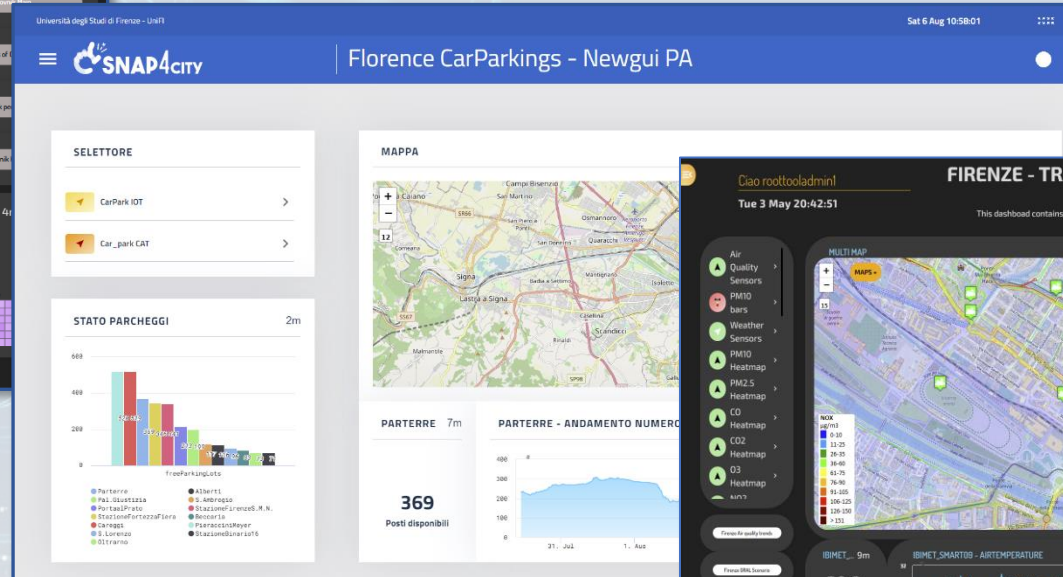
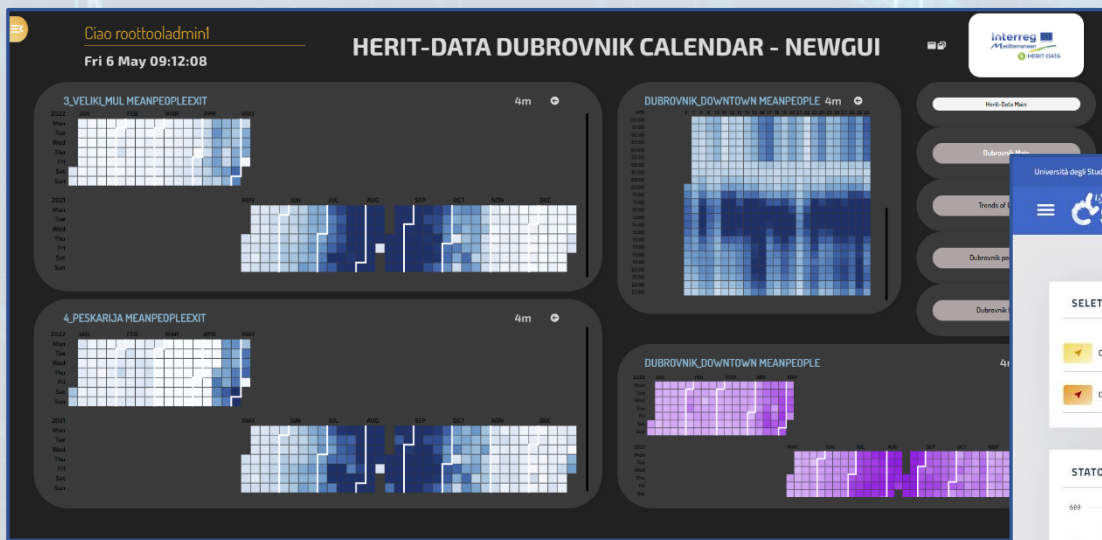








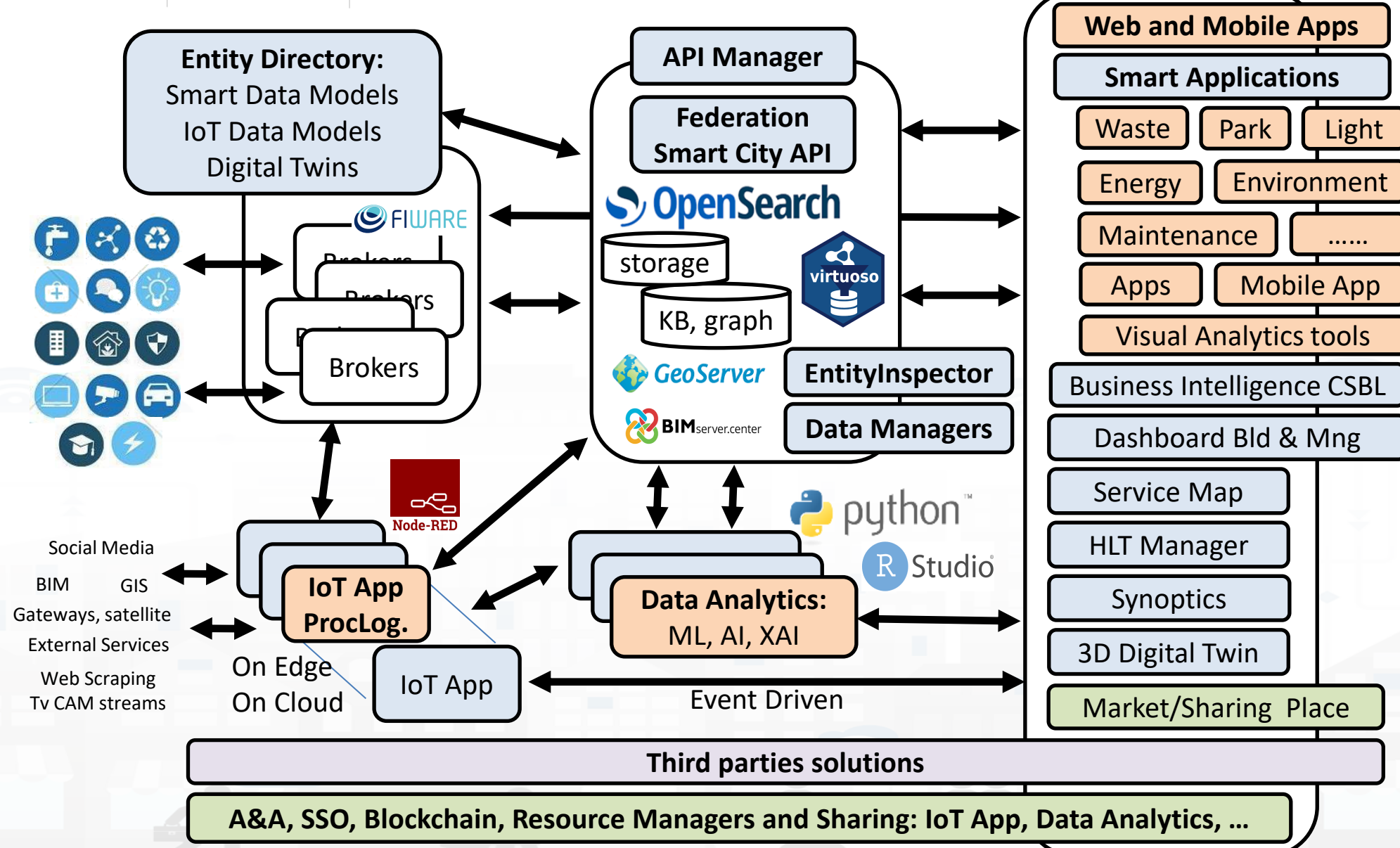
# Different Themes



New styles/themes can be developed by specializing a few files from open source

<https://www.snap4city.org/793>







TOP



# Monitoring and control short/long term predictions



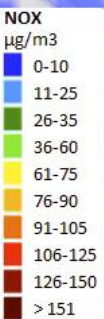
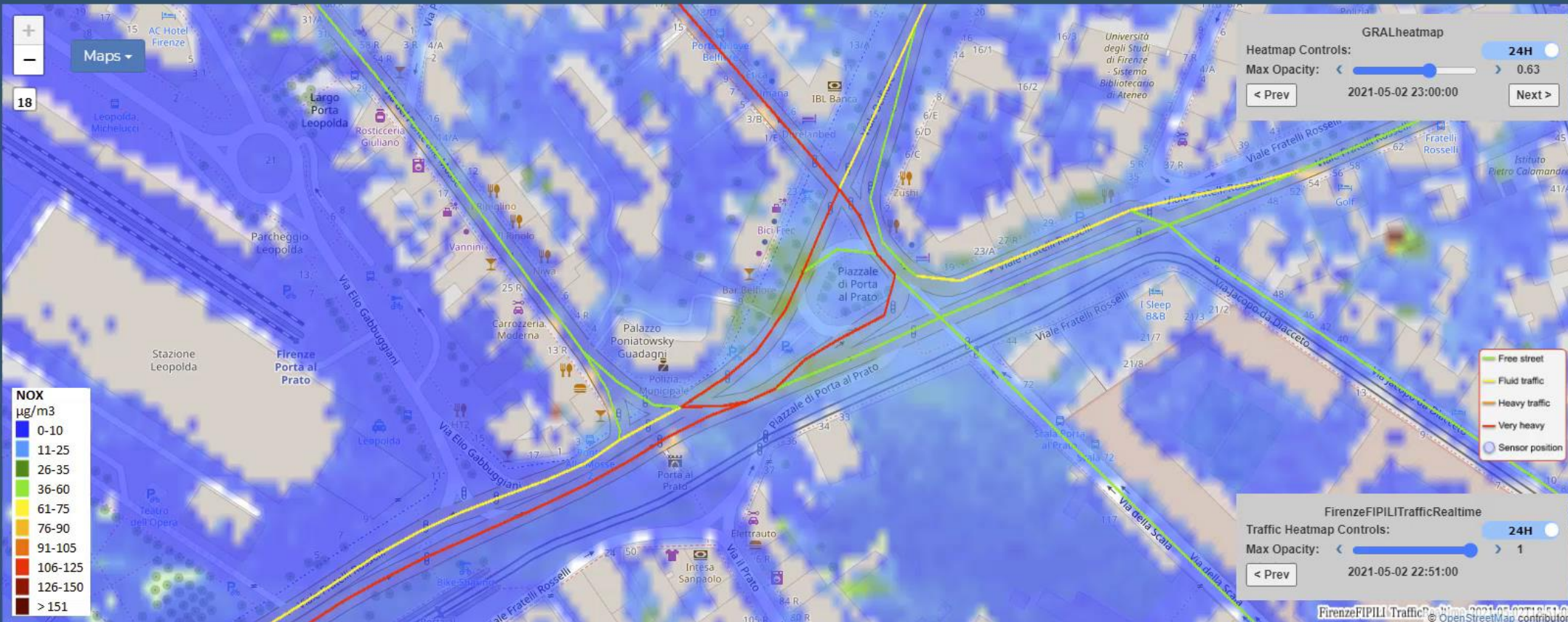




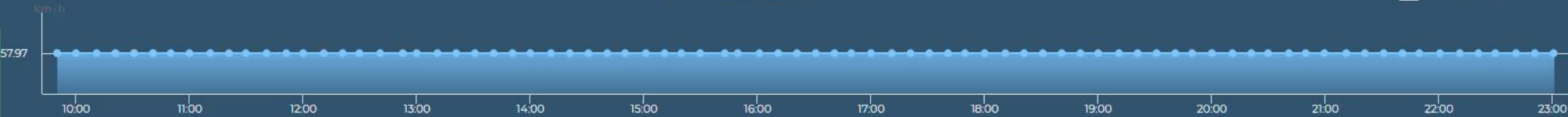
# Traffic Flow Manager on multiple cities

Sun 2 May 23:16:31

- Traffic Sensors
- Weather\_sensor
- AirTemperatureAverage2HourFlorence
- PM2.5 Heatmap
- GRAL Heatmap
- Gral HRES
- Accident Heatmap
- Traffic Flow
- TFM FIRENZE Real Time
- TFM FIPILI Real Time
- TFM Pisa Real Time
- TFM Livorno Real Time
- TFM Modena Real Time
- TFM Santiago Real Time
- prova hres fipili 2k
- prova hres fipili 4k
- prova hres fipili 8k
- Scenario
- What-if



METROS88 - averageSpeed



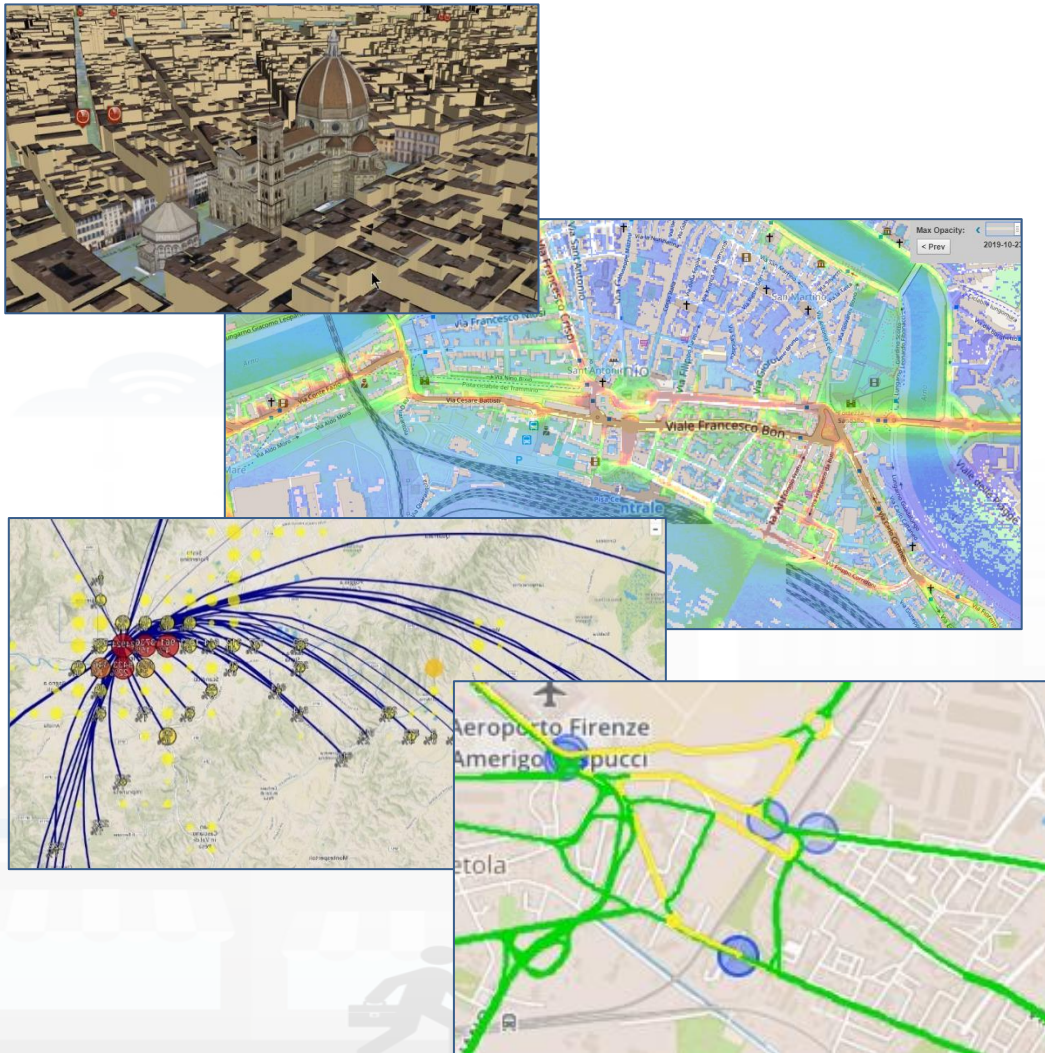
[Privacy Policy](#) [Cookies Policy](#) [Terms and Conditions](#) [Contact us](#)



<https://www.snap4city.org/dashboardSmartCity/view/index.php?iddashboard=MzEyNg==>



# Smart City Digital Twin City Digital Model with...



- Intuitive platform
- Any Data TYPE, any data source, any protocol
- Data storage seamless
- Data analytics → artificial intelligence, AI/XAI
- Data Ethics, AI Ethics, GDPR
- Data Representation, any kind
- Key Performance Indicators, any kind
- What-IF analysis – Simulation, prediction, 2D/3D
- Micro, Meso e macro scales
- Operation, planning tactic and strategic
- Collaborative and shared representation
- Sustainable, shared, open source 100%

## Complex and heterogeneous information, interoperability

- GIS, ITS, AVM, IoT, BIM, CKAN, etc.
- Satellite services
- MaaS, last-mile delivery HUBs
- etc.





Ciao roottooladmin!

Fri 2 Sep 19:13:07

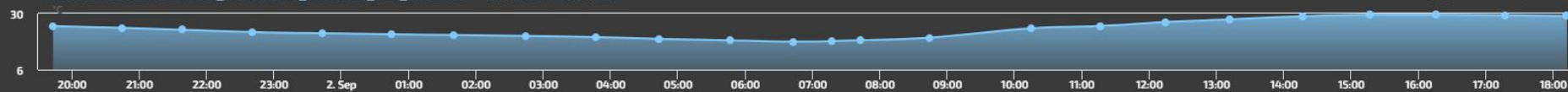
## 3D MAP GLOBAL DIGITAL TWIN - NEWGUI



3D MAP

3D MAP interface showing a 3D model of Florence, Italy. The map includes a settings panel on the left with options like "Enable Lights" (checked), "Datetime: 02/08/2022 10:11", and "Enable dynamic shadows (experimental)". A legend on the right identifies traffic levels: Free street (green), Fluid traffic (yellow), Heavy traffic (orange), Very heavy (red), and Sensor position (blue circle). A traffic heatmap control panel at the bottom right shows "FirenzeFIPILITrafficRealtime" with a "24H" duration and "Max Opacity: 1".

DISIT:ORIONUNIFI:TUSC\_WEATHER\_SENSOR\_OW\_3176959 - AIRTEMPERATURE





Ciao

Fri 13 Oct 18:29:18

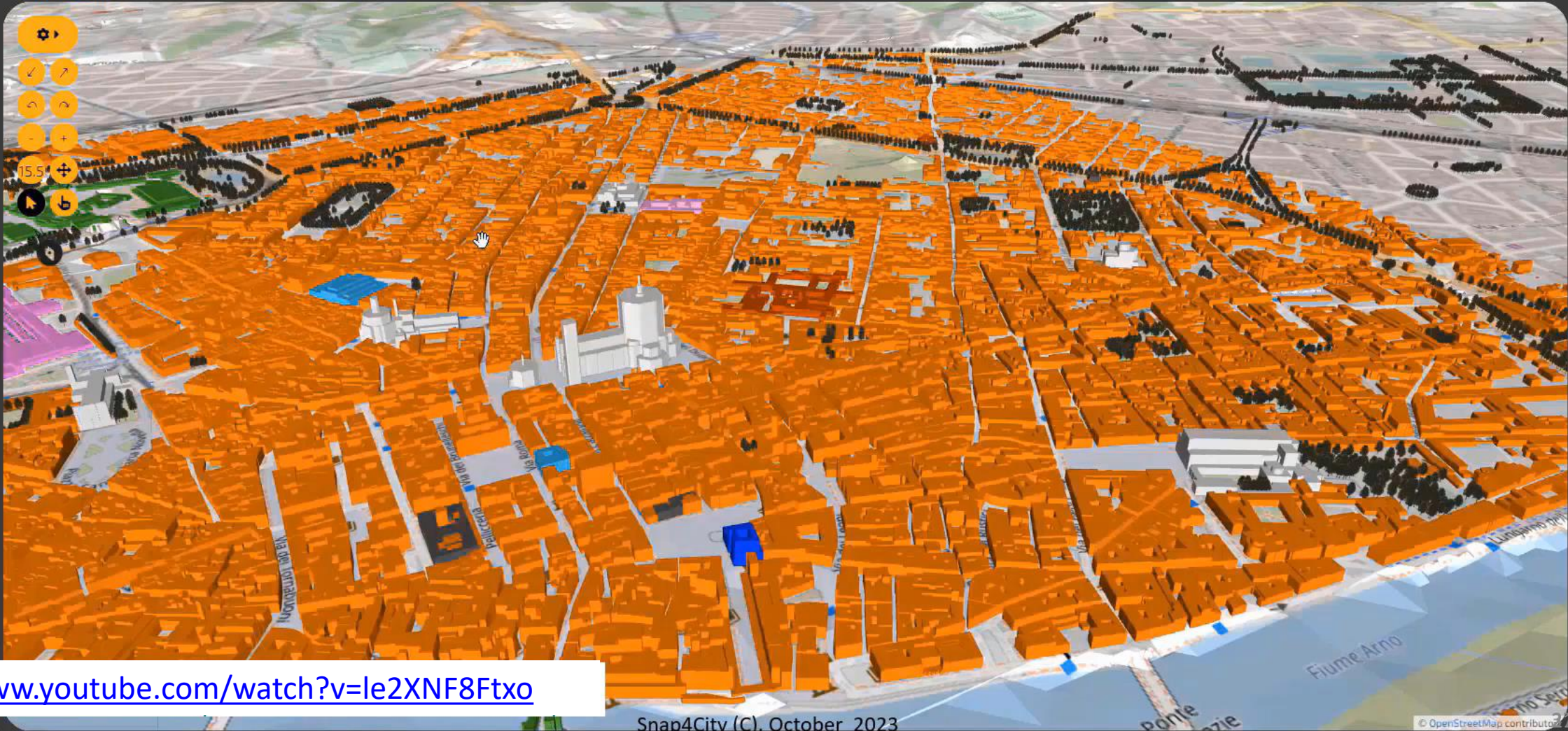
# FLORENCE SCDT

SELECT...

- GRAL HD
- NO 2
- 
- 
- 
- 
- 
- WHAT-IF
- 
- 

DOUBLE MAP

- 
- 
- 
- 
- 15.5
- 
- 



<https://www.youtube.com/watch?v=le2XNF8Ftxo>



TOP

# Decision Support Tactic and Strategic Plans What-if Analysis

FROM CITY DASHBOARD TO APPLICATIONS

DATA, THE AND CITY DATA KNOWLEDGE MANAGEMENT

FORGING & MANAGING CITY AND FLEXIBLE WEB AND MOBILE APPS

IoT APPLICATIONS VS IoT EDGE DEVICES

EDGE DEVICES AND NETWORKS

ADVANCE SMART CITY MICRO-APPLICATIONS

ENABLING FOR DEVELOPERS AND STAKEHOLDERS

SNAP4CITY ARCHITECTURE AND SYSTEM. OPENED TO DEVELOPERS AND STAKEHOLDERS

DATA ANALYTICS, BUSINESS INTELLIGENCE, WHAT-IF AND SIMULATION

TWITTER VIGILANCE SOCIAL MEDIA ANALYSIS

DECISION SUPPORT SYSTEM AND CITY RESILIENCE

SNAP4CITY AND KM4CITY PROJECTS

ROADMAP TO ADOPT SNAP4CITY, AND YOUR ROADMAP

SNAP4CITY THE VIEW OF THE ADMINISTRATORS

SNAP4CITY LIVING LAB FOR COLLABORATIVE WORK







# Available AI Solutions on Snap4City

- **Mobility and Transport**
- **Environment, Weather, Waste, Water**
- **City Users Behaviour and Social analysis**
- **Energy and Control, Security, .....**
- **Tourism and People**
- **Security and Safety**
- **High Level Decision Support Solutions**
  - **Asset management**
  - **Resilience and Risks Analysis**
- **Low level Techniques**



[https://www.snap4city.org/download/video/DPL\\_SNAP4SOLU.pdf](https://www.snap4city.org/download/video/DPL_SNAP4SOLU.pdf)

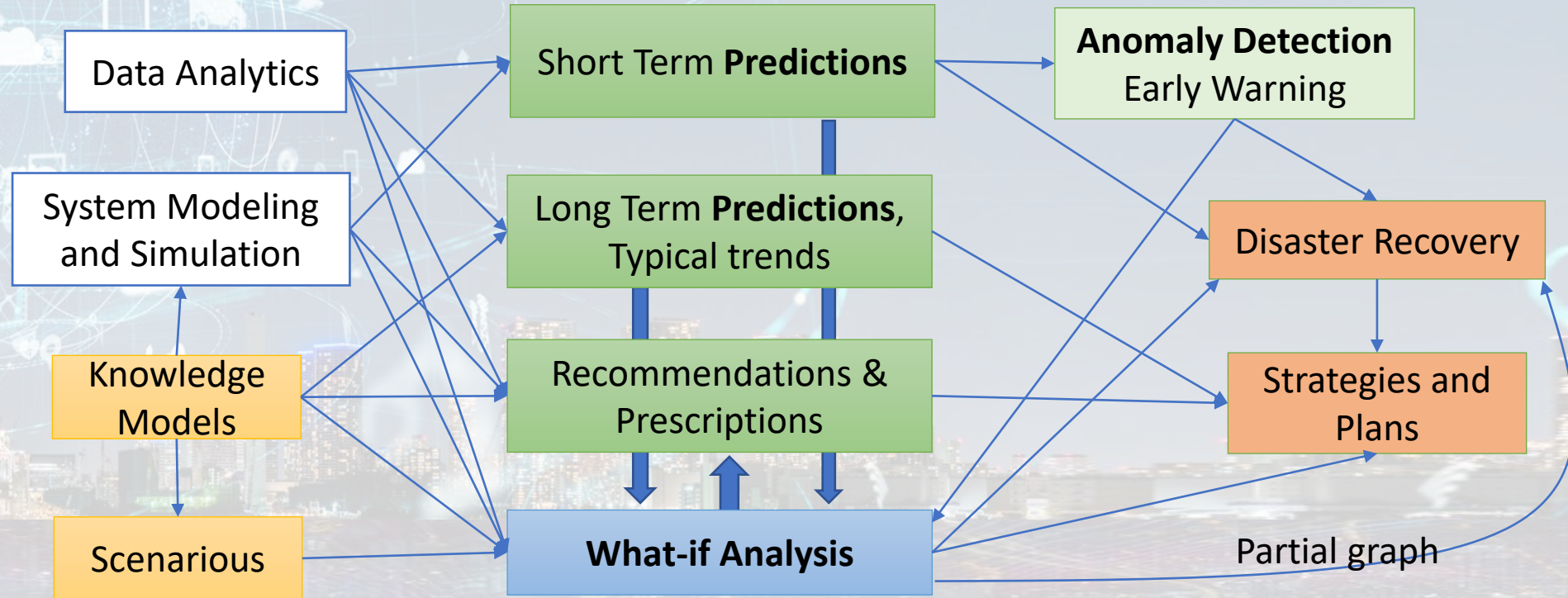
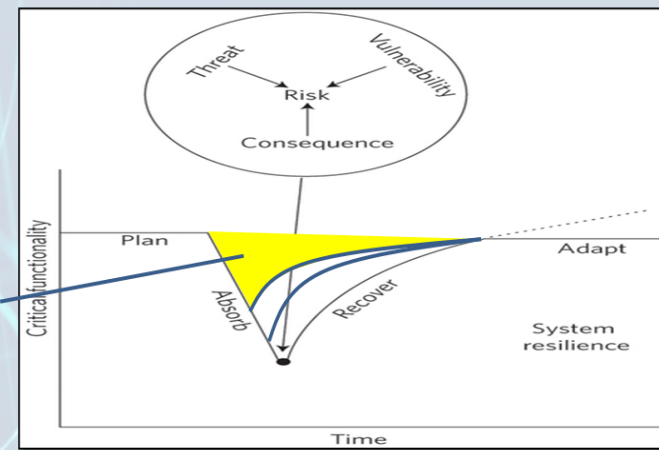
<https://www.snap4city.org/download/video/course/p4/>



# Snap4City What-If

- Decision support systems
- Improvement of life quality
- Sustainable Solutions
- Reduction of costs
- Risk Assessment
- Resilience

**P**repare  
**A**bsorb  
**R**ecover  
**A**dapt



**Decision Support System:** neuro-symbolic reasoning  
 targeting Indicators: Quality of Life, PUMS, SUMI, KPI, SDG, 15MinIndex,...



TOP

# Data Analytic Artificial Intelligence, XAI, Machine and Deep Learning

FROM CITY DASHBOARD TO APPLICATIONS

FORGING & MANAGING OPEN AND FLEXIBLE WEB AND MOBILE APPS

IoT APPLICATIONS VS IoT EDGE DEVICES

SNAP4CITY FOR BUSINESS

SNAP4CITY ARCHITECTURE AND ECOSYSTEM. OPENED TO DEVELOPERS AND STAKEHOLDERS

TWITTER VIGILANCE: SOCIAL MEDIA ANALYSIS

SNAP4CITY AND KM4CITY PROJECTS

DATA GATHERING AND CITY DATA KNOWLEDGE MANAGEMENT

IoT DEVICES AND NETWORKS

DATA ANALYTICS: INTELLIGENCE, WHAT-IF AND SIMULATION

HOW TO ADOPT SNAP4CITY, AND OUR ROADMAP

DECISION SUPPORT SYSTEM AND CITY RESILIENCE

APPLICATIONS LOGIC AND PARTNERSHIP

ADVANCED SMART CITY AND MICRO-SERVICE SNAP4CITY

SNAP4CITY THE VIEW OF THE ADMINISTRATORS

SNAP4CITY LIVING LAB FOR COLLABORATIVE WORK





# Environment, waste, land, etc., Domain (2024)

- **Goals:**
  - Reduction of pollutant emissions and EC taxations
  - Cost Reduction for waste collection, reduction of waste collection impact on mobility
- **Solutions for Operation (monitoring, managing, mobile apps, digital signages, control rooms)**
  - Monitoring emissions, weather, waste, water, etc.: sensors, traffic, flows, ....
  - Early detection/warning of critical conditions on *emissions, weather, waste, water, fire, animals, ...*
  - Early detection/warning of critical conditions for *landslides, water flooding, beach*
  - Managing Smart Waste: bins/lockers, waste collection daily plan, pay as you throw, PAYT, etc.
  - Short terms prediction of emissions: CO<sub>2</sub>, NO<sub>2</sub>, etc.
  - Production of suggestions, nudging
  - Computing and predicting long terms KPI indicators of the European Commission
- **Solutions for Planning (optimization and what-if analysis)**
  - Identification of main CO<sub>2</sub>/NO<sub>2</sub> emission locations in the city, total production from traffic
  - Reduction of Pollutant Emissions, via optimization: semaphore cycles, viability
- **Algorithms and computational solutions, see next slide**



# Tools: Environment and Weather (2024)

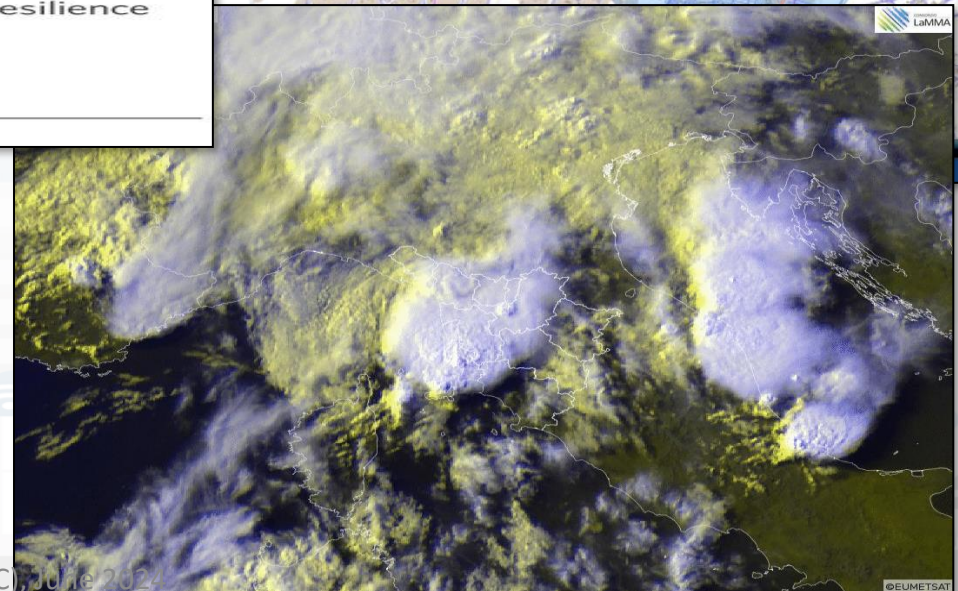
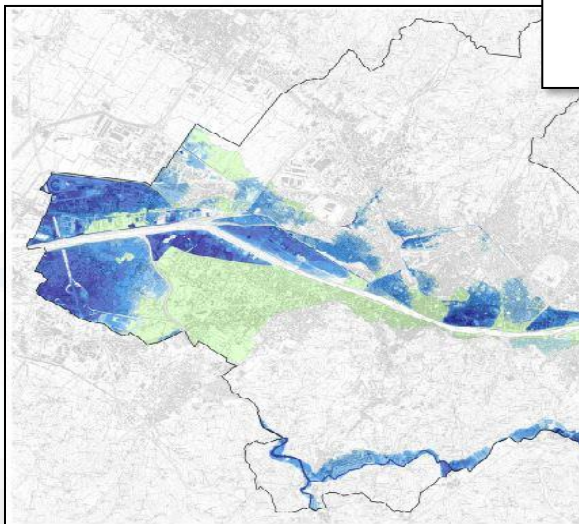
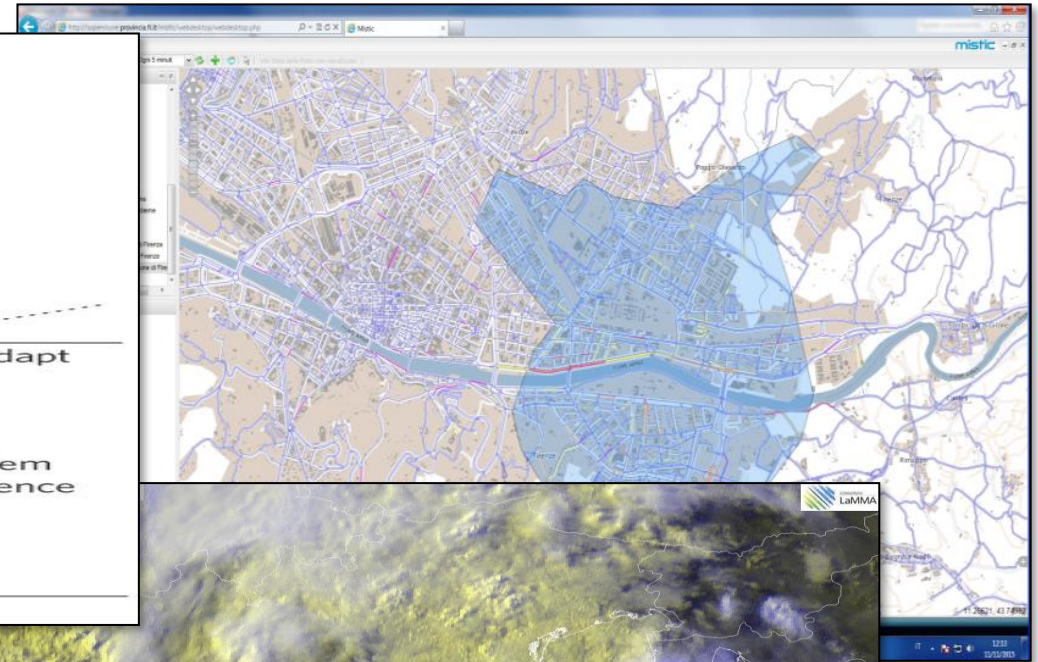
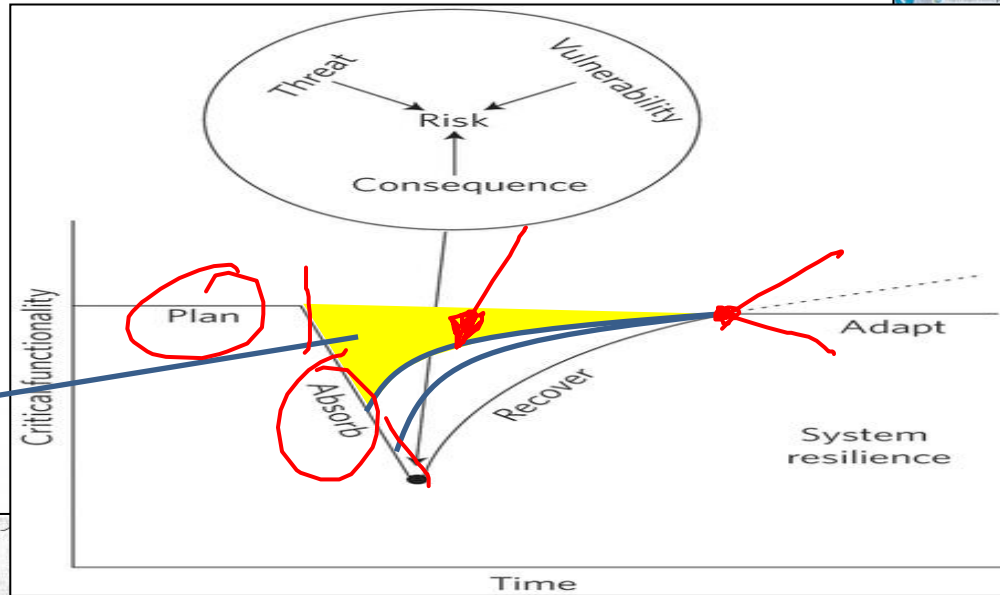
- **Pollutant Predictions:** short, long and very long term European Commission KPIs
  - NOX, PM10 pollution on the basis of traffic flow, 48 hours (ML, AI, DL)
  - Cumulated NO2 average value over the year, ..... (ML, AI, DL)
- **Computation of CO2** on the basis of traffic flows (DP), computing emission factor (DA)
  - each road for each time slot of the day
- **Prediction of MicroClimate** conditions for diffusion (ML, AI)
  - NO2, PM10, PM2.5, etc.
- **Prediction of landslides**, 24 hours in advance (AI, DL)
- **Heatmaps production**, dense data interpolation (DP) for
  - Weather conditions: temperature, humidity, wind, DEW
  - Pollutants and Aerosol: NO, NO2, CO2, PM10, PM2.5, etc.
- **Impact of COVID-19** on Environmental aspects (DP)
- Optimisation of **waste collection** schedule and paths (DP, ML)
- Computing **SDG, SUMI, PUMS**, .. (mainly DP)
- Etc.



# Early Warning, Detection

**P**repare  
**A**bsorb  
**R**ecover  
**A**dapt

damage





# Environment and Quality of Life

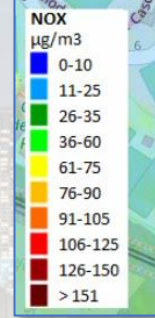
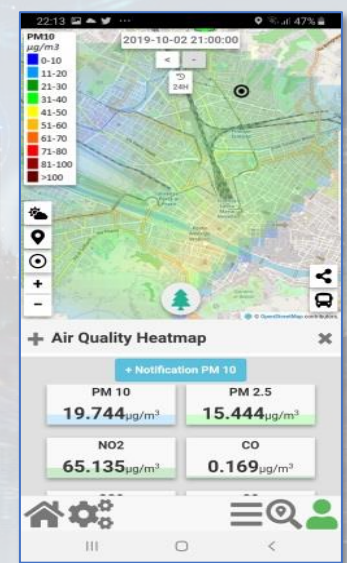
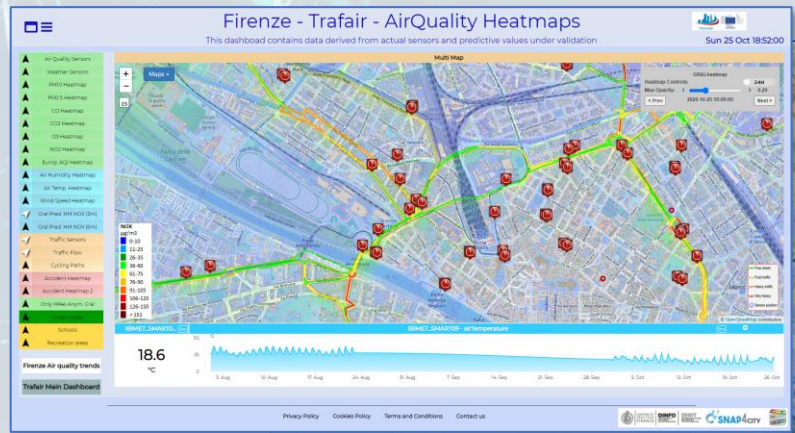
## Air Quality Predictions

Cities of: Firenze, Pisa, Livorno

reference



- **Multiple Domain Data**
  - Traffic Flow data, Pollutant: NOX, CO2, PM10, PM2.5, O3, ....
  - 3D City structure, weather, ...
- **Multiple Decision Makers**
  - Pollutant Predictions: NOX, NO2, ..
  - City officers, energy industries
  - Dashboards, What-IF analysis
  - Traffic Flow Reconstruction
- **Historical and Real Time data**
  - Billions of Data
- **Services Exploited on:**
  - Dashboards, Mobile App
- **Since 2020**

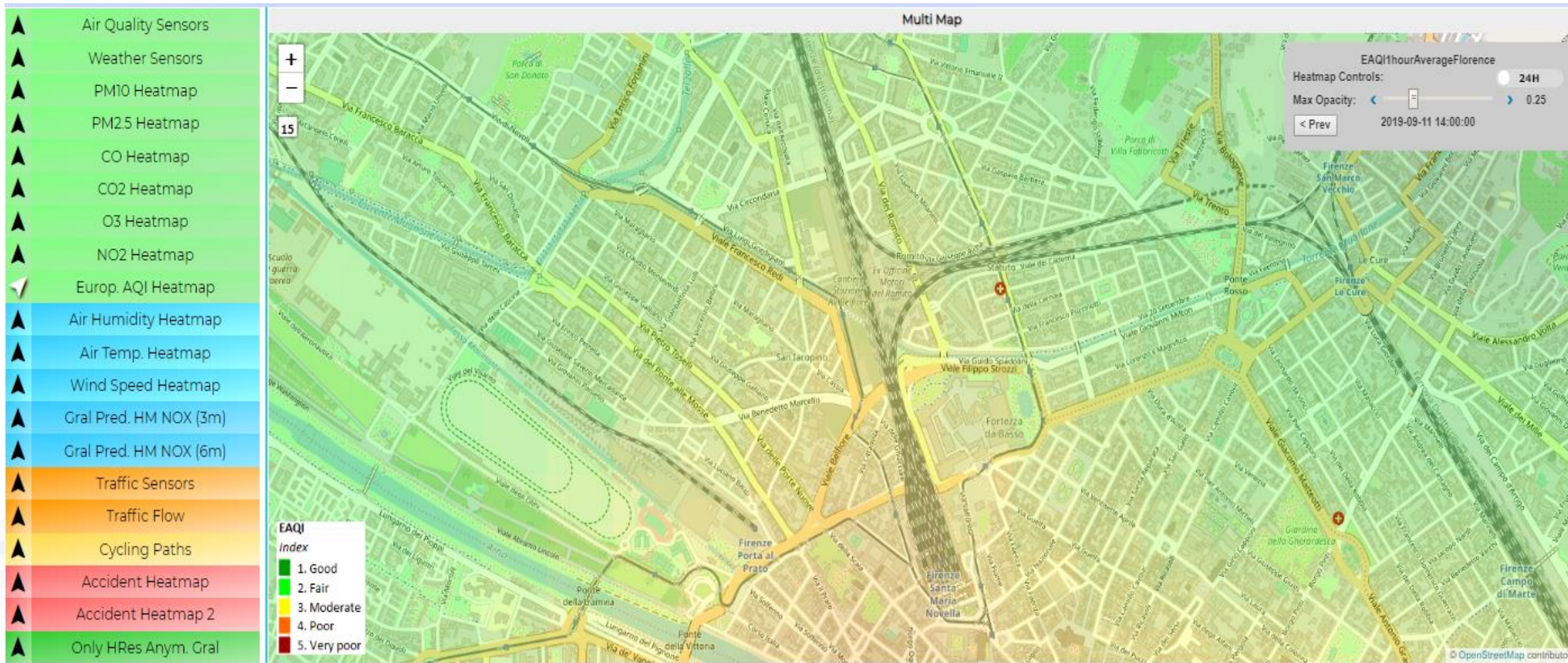


Pollutant	Averaging period	Air Quality Directive		WHO guidelines	
		Objective and legal nature and concentration	Comments	Concentration	Comments
PM <sub>2.5</sub>	One day			25 µg/m <sup>3</sup> (*)	99 <sup>th</sup> percentile (3 days/year)
PM <sub>2.5</sub>	Calendar year	Target value, 25 µg/m <sup>3</sup>	The target value should become a limit value by 2015	10 µg/m <sup>3</sup>	
PM <sub>10</sub>	One day	Limit value, 50 µg/m <sup>3</sup>	Not to be exceeded on more than 35 days per year.	50 µg/m <sup>3</sup> (*)	99 <sup>th</sup> percentile (3 days/year)
PM <sub>10</sub>	Calendar year	Limit value, 40 µg/m <sup>3</sup> (*)		20 µg/m <sup>3</sup>	
O <sub>3</sub>	Maximum daily 8-hour mean	Target value, 120 µg/m <sup>3</sup>	Not to be exceeded on more than 25 days per year, averaged over three years	100 µg/m <sup>3</sup>	
NO <sub>2</sub>	One hour	Limit value, 200 µg/m <sup>3</sup> (*)	Not to be exceeded more than 18 times a calendar year	200 µg/m <sup>3</sup> (*)	
NO <sub>2</sub>	Calendar year	Limit value, 40 µg/m <sup>3</sup>		40 µg/m <sup>3</sup>	

KPI of EC



# EAQI Heatmap and sequence





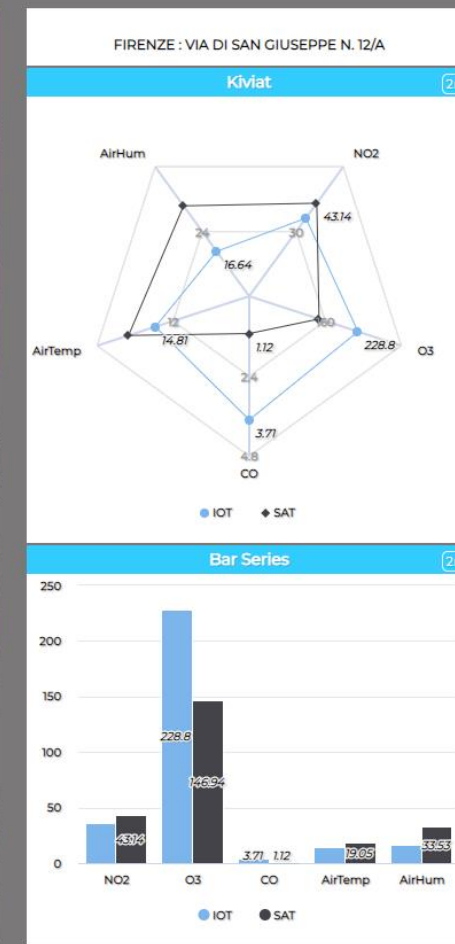
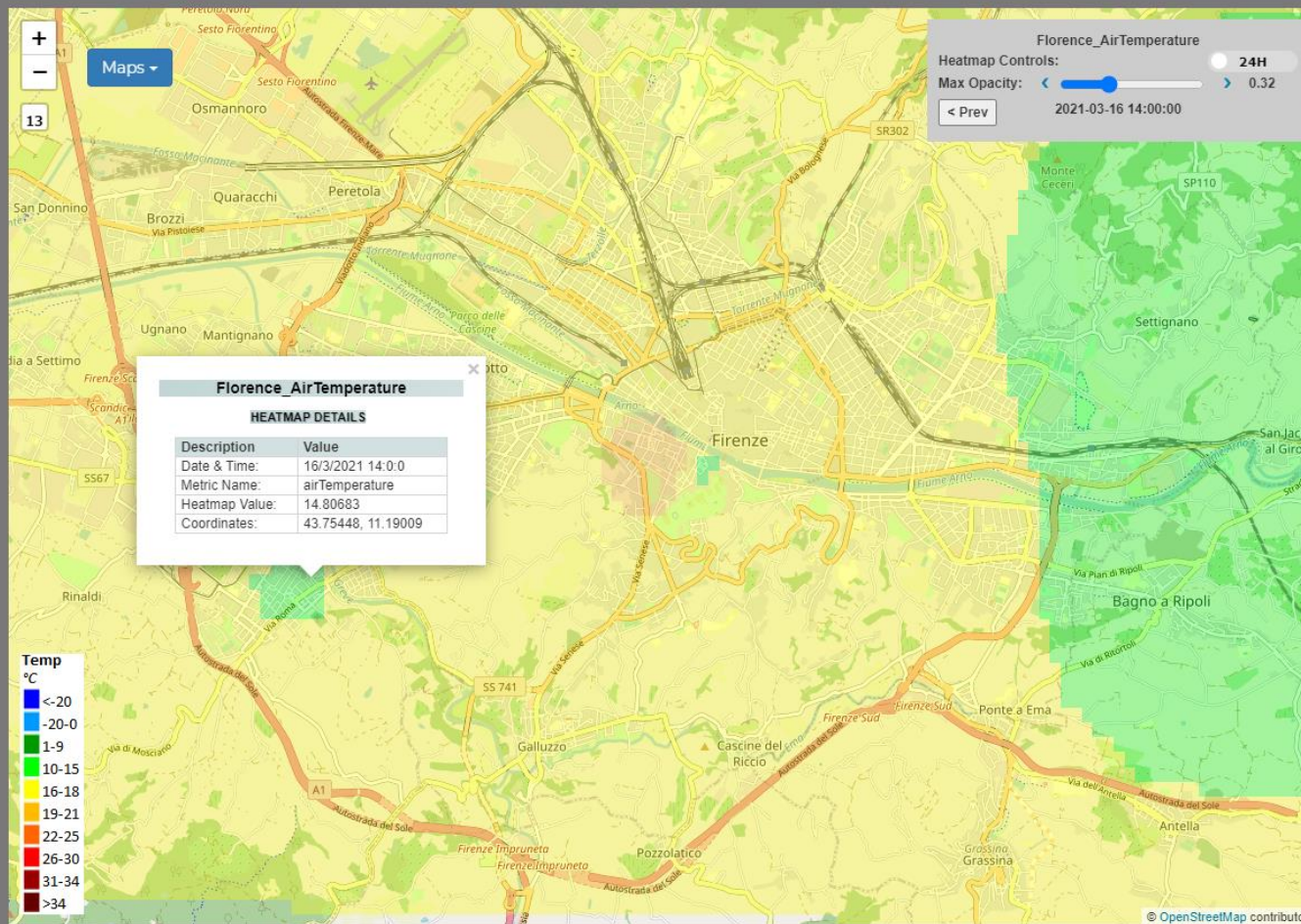
# Satellite (Copernicus) vs IOT Data

Thu 1 Apr 22:09:45

- ▲ Air Temperature Toscana
- ▲ Tuscany Altitude
- ▲ Global Vegetation Index Tuscany
- ▲ Fractional Cloud Cover Tuscany
- ▲ Humidity Tuscany
- ▲ NO2 heatmap
- ▲ O3 heatmap
- ▲ CO heatmap
- ▲ Air Temperature heatmap
- ▲ Air Humidity Heatmap
- ▲ Satellite NO2 Firenze
- ▲ Satellite O3 heatmap
- ▲ Satellite CO heatmap
- ▲ Satellite Air Temp Firenze
- ▲ Satellite Humidity Firenze
- ▲ Satellite Fractional Cloud Cover
- ▲ Satellite Firenze Altitude
- ▲ Satellite Global Vegetation Index

**The picked Point** (1m)

Province: FIRENZE  
 City: FIRENZE  
 Address: VIA DI SAN GIUSEPPE N. 12/A  
 lat,lon: 43.76799,11.26408

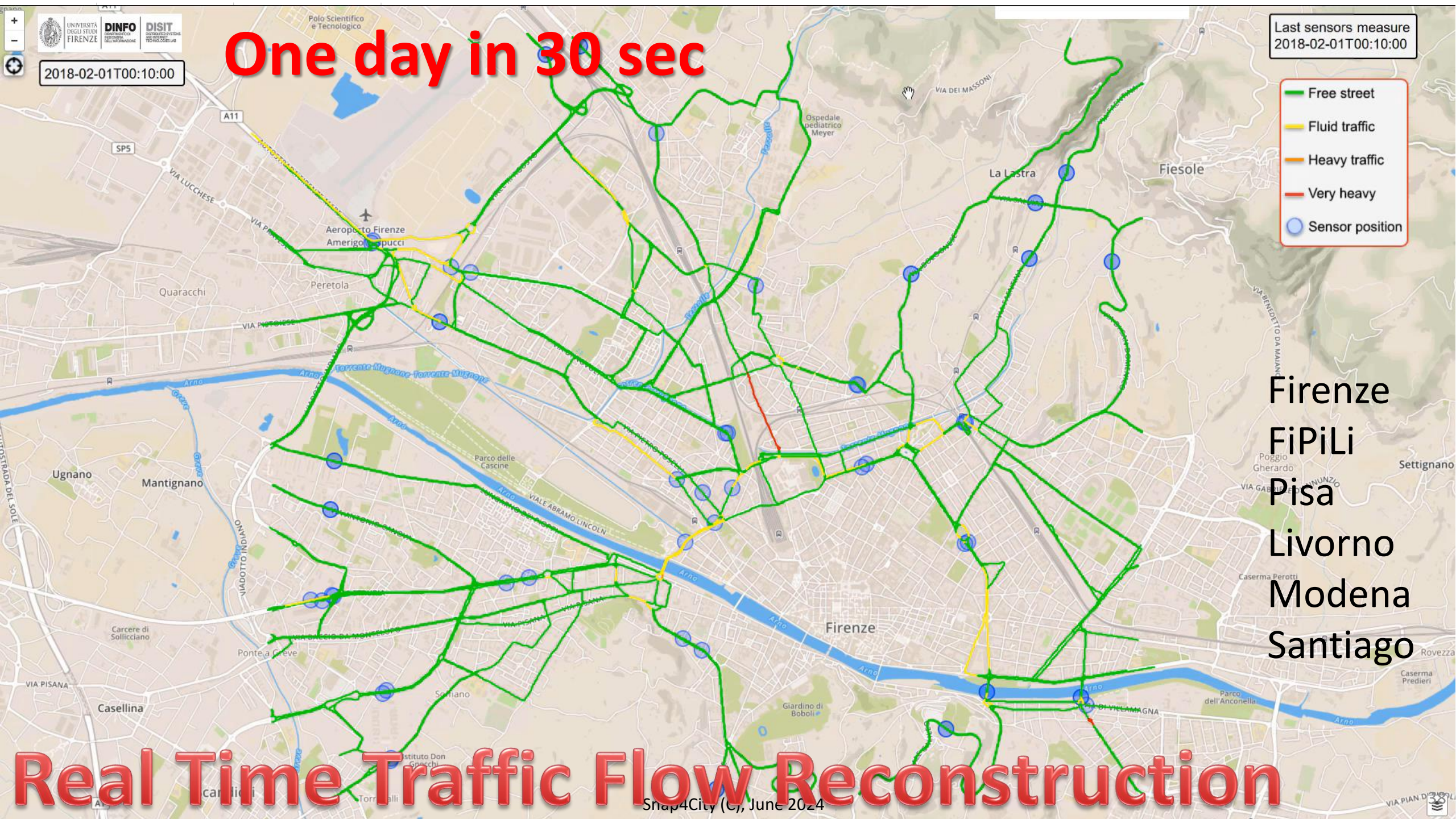




# One day in 30 sec

Last sensors measure  
2018-02-01T00:10:00

- Free street
- Fluid traffic
- Heavy traffic
- Very heavy
- Sensor position



Firenze  
FiPiLi  
Pisa  
Livorno  
Modena  
Santiago

# Real Time Traffic Flow Reconstruction



# 1-48 Hour prediction of NO<sub>x</sub>



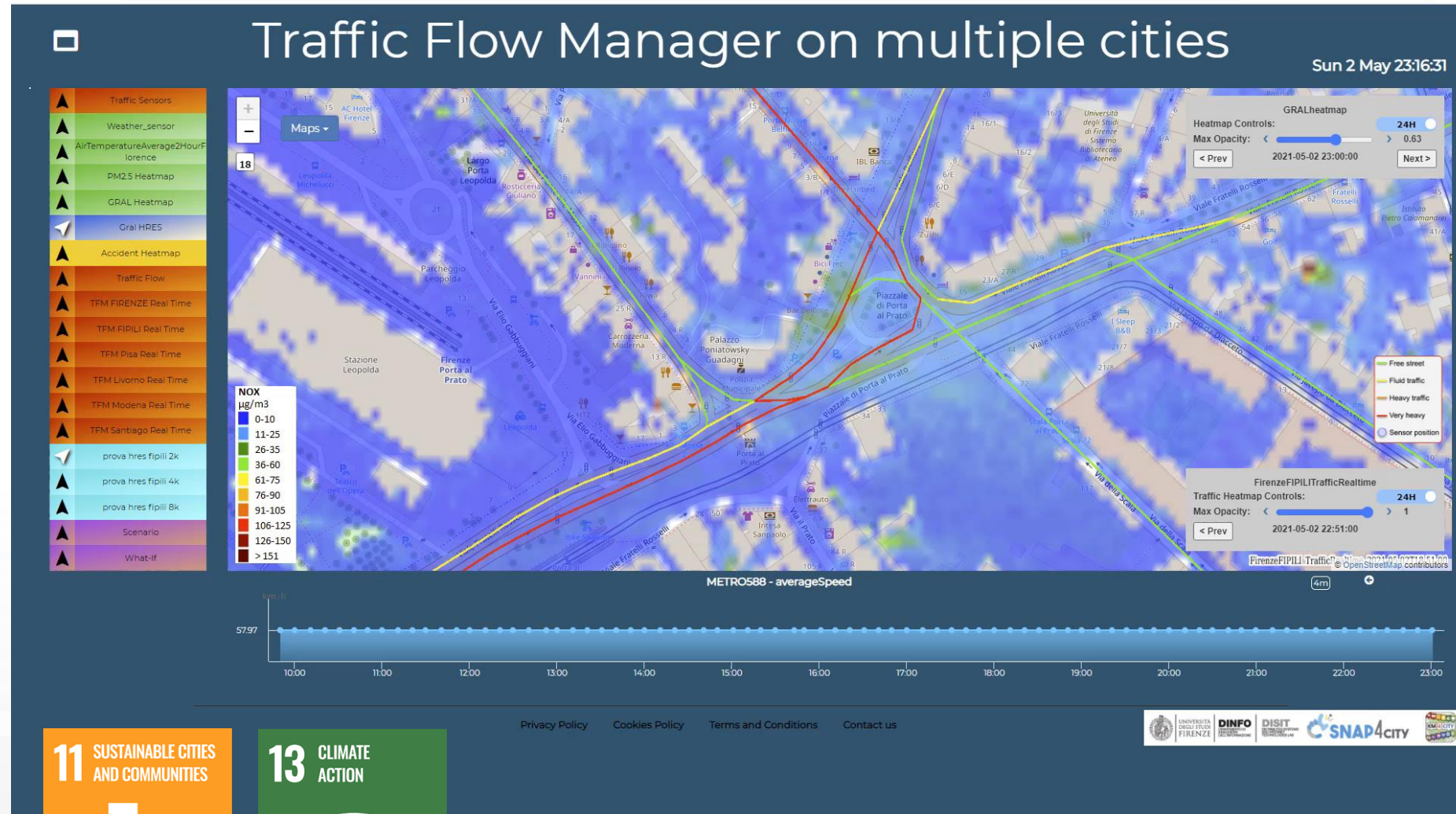


- **Prediction**

- **NOX** Pollutant diffusion on the basis of Traffic Flow (prediction), weather and 3D structure
- **NO2** progressive average (Long term)

- **Project:**

- Trafair CEF EC
- Mixed solutions of Fluidinamics modeling and AI





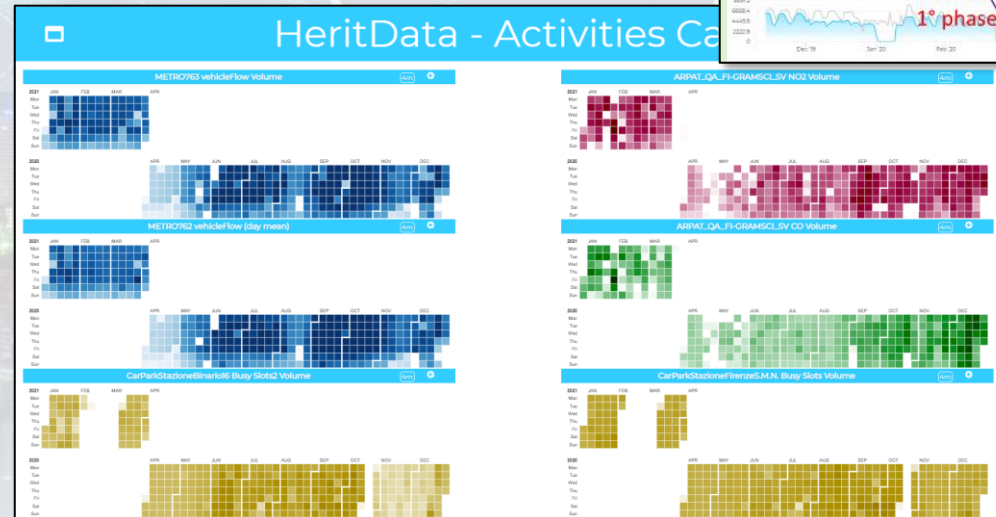
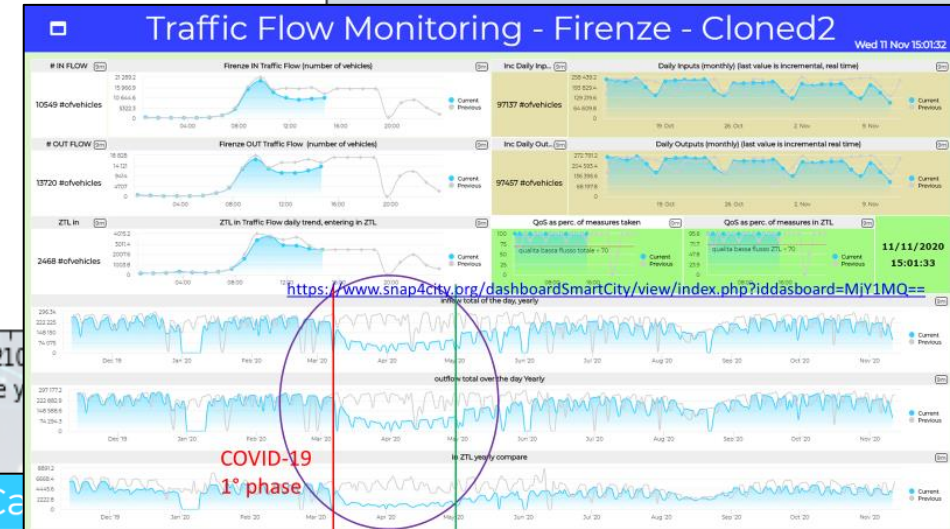
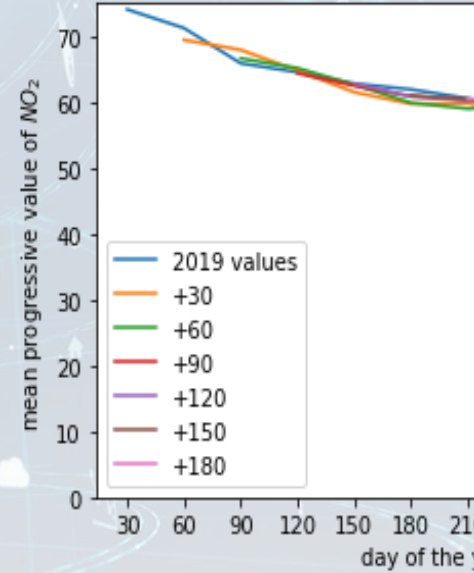
# Impact of COVID-19

Cities: Firenze, Pisa, Livorno, Toscana



- **Multiple Domains Data**
  - Traffic, environment, People, parking, stock options, Twitter, tc.
- **Decision Makers Multiple Locations**
  - NO2 long term predictions
  - Twitter analysis
- **Historical and Real Time data**
- **Services Exploited on:**
  - Dashboards
  - Social media,
  - Sentiment Analysis
- **Since 2019, 2020**

mean progressive NO<sub>2</sub> of 2019



metric	model30	model60	model90	model120	model150	model180
MAE	1.21	1.31	1.52	2.04	2.31	2.37
RMSE	2.16	2.61	4.18	6.77	7.83	7.93
MAPE	1.99	2.20	2.65	3.57	4.07	4.18
R2	0.91	0.83	0.80	0.54	0.45	0.14

Table 4. Assessment of the predictive models with respect to the actual values of the 2019.



# Computing CO2 from traffic Data

**11** SUSTAINABLE CITIES  
AND COMMUNITIES

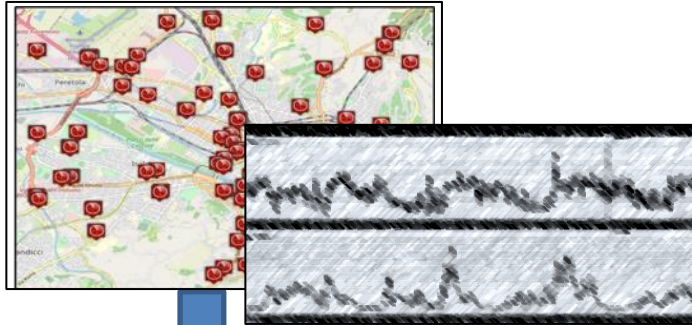


**13** CLIMATE  
ACTION

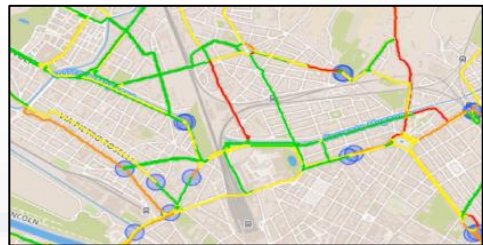




# Estimating City Local CO2 from Traffic Flow Data



Computing Traffic Flow  
into CO2 sensor area



Traffic Flow data

- Traffic Flow is one the main source of CO2 (**ton of CO2 x Km x Vehicle**)
  - **K1: Fluid Flow**
  - **K2: Stop and Go**
- **Dense estimation of CO2 into the city** is very useful to know to target EC's KPIs

Computing CO2 on the basis of  
traffic flow data



CO2 estimation



S. Bilotta, P. Nesi, "Estimating CO2 Emissions from IoT Traffic Flow Sensors and Reconstruction", Sensors, MDPI, 2022. <https://www.mdpi.com/1424-8220/22/9/3382/>



TOP

# Long Term Prediction of Annual Mean of $NO_2$ index of EC

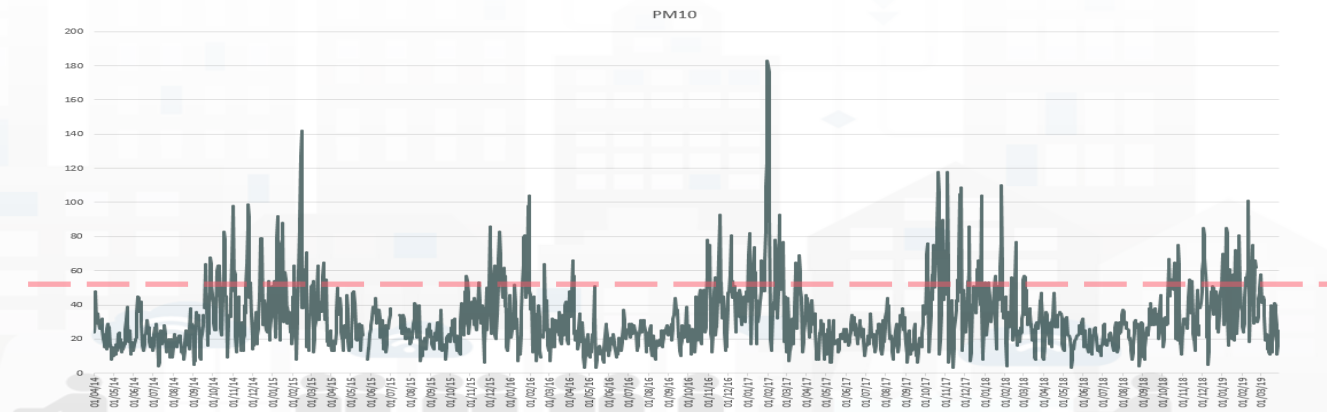




# Predicting Air Quality

- European Air Quality Directive
- Predicting critical days
  - PM10 with an accuracy of more than 90% and precision of 85%;
  - PM2.5 with an accuracy of 90% and precision greater than the 95%.
- Simulating Long terms values
  - For long terms predictions

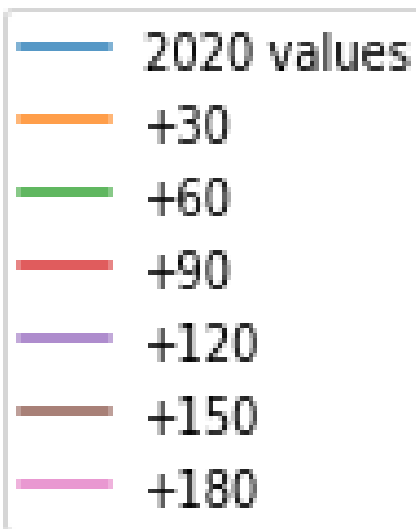
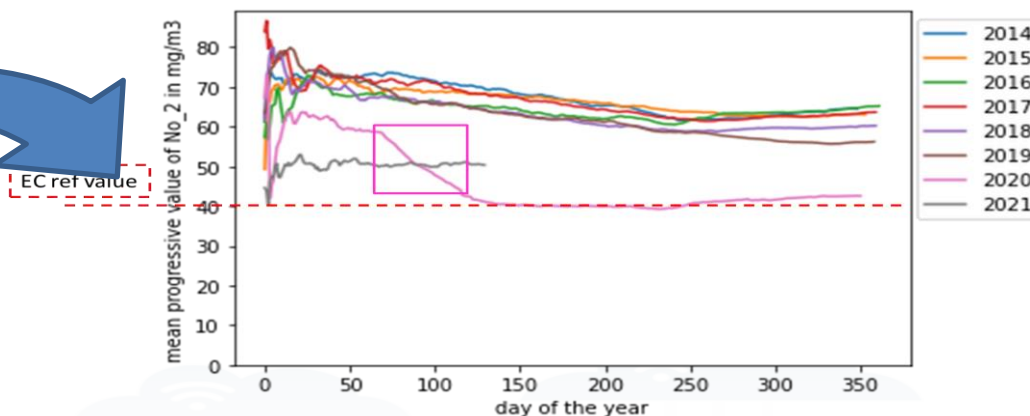
Air Quality Directive				WHOguidelines	
Pollutant	Averaging period	Objective and legal nature and concentration	Comments	Concentration	Comments
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PM <sub>10</sub>	One day	Limit value, 50 µg/m <sup>3</sup>	Not to be exceeded on more than 35 days per year.	50 µg/m <sup>3</sup> (*)	99 <sup>th</sup> percentile (3 days/year)
PM <sub>10</sub>	Calendar year	Limit value, 40 µg/m <sup>3</sup> (*)		20 µg/m <sup>3</sup>	
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NO <sub>2</sub>	Calendar year	Limit value, 40 µg/m <sup>3</sup>		40 µg/m <sup>3</sup>	





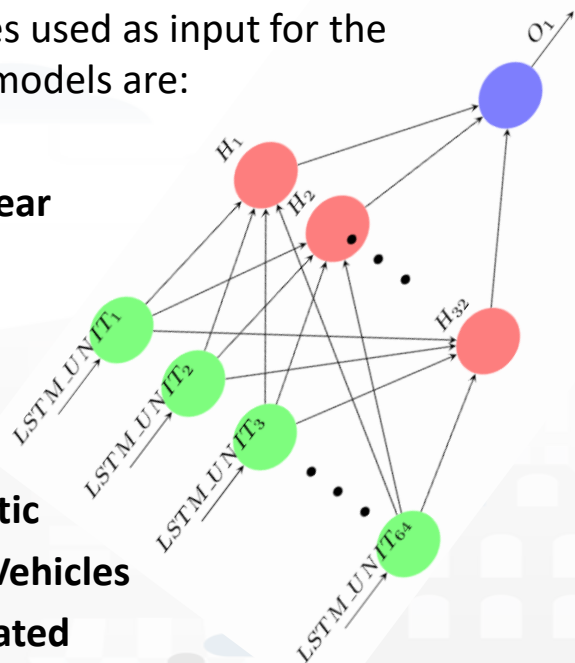
# Predicting EC's KPI on NO2 months in advance

Deep Learning Long Terms Predictions of NO2 mean values, From 30 to 180 days in advance



The features used as input for the predictive models are:

- Month
- dayOfTheYear
- NO2
- Tmean
- Humidity
- windMean
- NoxDomestic
- numberOfVehicles
- NO2cumulated
- NO2progesseveMean
- numberOfVehiclesCumulated



Pollutant	Averaging period	Air Quality Directive		WHOguidelines	
		Objective and legal nature and concentration	Comments	Concentration	Comments
PM <sub>2.5</sub>	One day			25 µg/m <sup>3</sup> (*)	99 <sup>th</sup> percentile (3 days/year)
PM <sub>2.5</sub>	Calendar year	Target value, 25 µg/m <sup>3</sup>	The target value has become a limit value since 1 January 2015	10 µg/m <sup>3</sup>	
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PM <sub>10</sub>	Calendar year	Limit value, 40 µg/m <sup>3</sup> (*)		20 µg/m <sup>3</sup>	
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NO <sub>2</sub>	One hour	Limit value, 200 µg/m <sup>3</sup> (*)	Not to be exceeded more than 18 times a calendar year	200 µg/m <sup>3</sup> (*)	
NO <sub>2</sub>	Calendar year	Limit value, 40 µg/m <sup>3</sup>		40 µg/m <sup>3</sup>	



TOP

# Predicting Land sliding









# Local Explainable AI - understanding the single event

- The local explanation puts in evidence the features which provided major contribution to the prediction
- For example considering Figure 10a, the value of VelMaxSIR, MaxTempSIR, Day3 and Humidity contributed significantly to the classification of the observation as a **landslide event**



**FIGURE 10. Local feature relevance via SHAP, as interpretation of events in terms of feature values: (a) and (b) are events with predictions of landslide, (c) a no landslide event.**





# Waste Optimisation

**11** SUSTAINABLE CITIES  
AND COMMUNITIES

**3** GOOD HEALTH  
AND WELL-BEING

Data Analytic



# Smart Waste – Map view



Smart Waste Management
Thu 5 May 11:14:28

Select the bins Kind, Fullness and Status from the dropdown below and press SUBMIT to see the results on the map.

Kind:  Status:

Fullness:

Address:

Group ID:

DESCRIPTION	VALUE	Buttons						
dateObserved	2022-02-28T12:46:12.899Z	Last value	Last 4 hours	Last 24 hour	Last 7 days	Last 30 days	Last 6 month	Last 1 year
generic	[SURI id]	Last value	Last 4 hours	Last 24 hour	Last 7 days	Last 30 days	Last 6 month	Last 1 year
glass	[SURI id]	Last value	Last 4 hours	Last 24 hour	Last 7 days	Last 30 days	Last 6 month	Last 1 year
metal	[SURI id]	Last value	Last 4 hours	Last 24 hour	Last 7 days	Last 30 days	Last 6 month	Last 1 year
organic	[SURI id]	Last value	Last 4 hours	Last 24 hour	Last 7 days	Last 30 days	Last 6 month	Last 1 year
paper	[SURI id]	Last value	Last 4 hours	Last 24 hour	Last 7 days	Last 30 days	Last 6 month	Last 1 year
plastic	[SURI id]	Last value	Last 4 hours	Last 24 hour	Last 7 days	Last 30 days	Last 6 month	Last 1 year

Smart waste bins status

ORGANIC	PAPER	METAL	PLASTIC	GLASS	GENERIC
89 %	100 %	100 %	62 %	83 %	65 %

Via\_Del\_Medici: ORGANIC fullness

Search bins on map by filtering per:

- **Kind** (All, generic, plastic, paper, glass, metal, organic)
- **Status** (Active, Not Active)
- **Fullness** (Full, Half-full, Empty)
- **Address**
- **Group of bins** (by GroupID)

- Reduction of costs for waste collection
  - Optimization of waste collection for the next day, forecast
  - Production of rides and paths for the drivers on waste collection
- Operator:
  - Refine a search by using the filters on the left side
  - Click on a waste bin pin on the map:
  - A popup with real time data is shown
  - The fullness status of the selected group of bins is shown in the synoptic below the map
  - Specific fullness weekly trends are shown below the map
  - Click on the «Table view» button to access the other dashboard







**Trajectorywaste2** Fri 17 May 18:34:15

DISIT:orionUNIFI:113043.960\_485172.926-Rest

Please select a date: 02/09/2020

Please select a ride among: 3

Selector - Map

DISIT-OrionUNIFI:114985.283\_488088.814-Rest - Weight 8m

**Trajectorywaste2** Fri 17 May 18:34:37

DISIT:orionUNIFI:113043.960\_485172.926-Rest

Please select a date: 02/09/2020

Please select a ride among: 3

Selector - Map

DISIT-OrionUNIFI:114985.283\_488088.814-Rest - Weight 7m

AMSTERDAM UNIVERSITY OF APPLIED SCIENCES  
DINPO  
DISIT  
SNAP4city

**Trajectorywaste2** Fri 17 May 18:30:58

DISIT:orionUNIFI:113043.960\_485172.926-Rest

Please select a date: 05/mm/yyyy

Please select a ride among: 3

Selector - Map

**116977.080\_488279.962-REST**

VALUE NAME: 116977.080\_488279.962-REST

DETAILS DESCRIPTION RT DATA

Last update: 2021-12-04 10:10:34.000+01:00

Description	Value	Buttons
dateObserved	2021-12-04T09:10:34.000Z	Last 4h 24h 7d 30d 6m 1y 2y 10y
weight	215	Last 4h 24h 7d 30d 6m 1y 2y <b>10y</b>

Keep data on target widget(s) after popup close:

Weight - 10 Year 9m

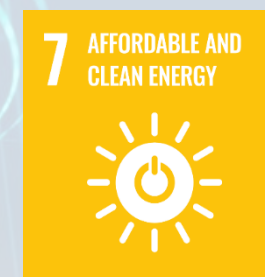
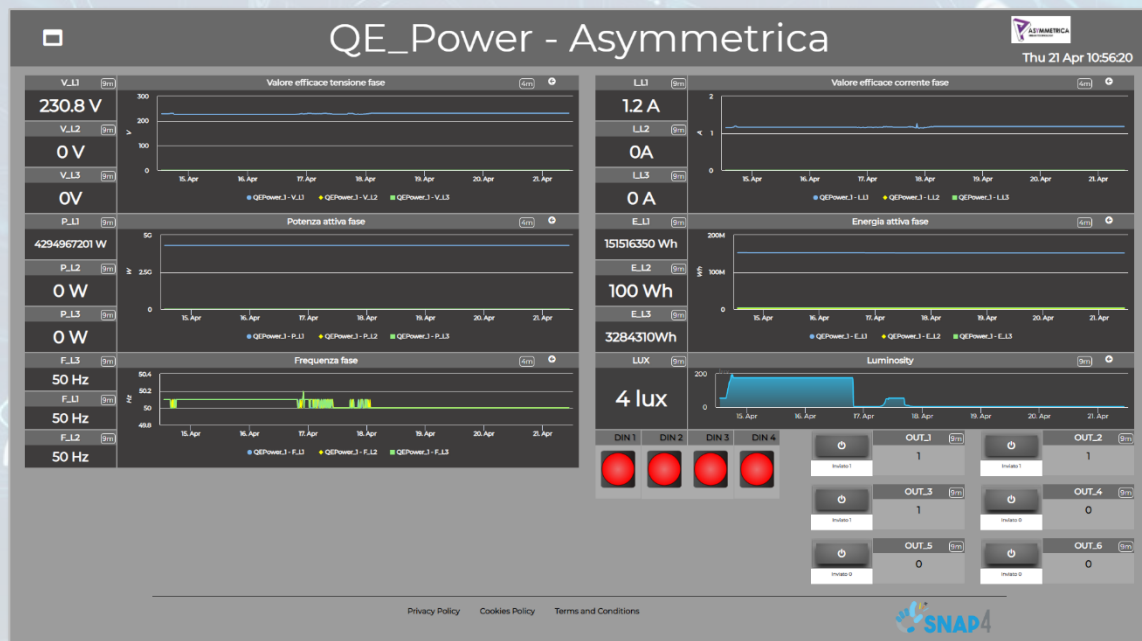




# others







- Environmental data
- Power meter Data
- Smart Light data are coming (in collaboration with a multinational company)

**Asymmetrica Alarms**  
Thu 21 Apr 10:56:49

Alarms

Variable	Status	Device	Date and Time
DIN_4	ALERT_H	DIGITAL_IN_Alarm_1	18/04/2022 3:24:40
DIN_3	ALERT_H	DIGITAL_IN_Alarm_1	18/04/2022 3:24:38
DIN_2	ALERT_H	DIGITAL_IN_Alarm_1	18/04/2022 3:24:35
DIN_2	ALERT_H	DIGITAL_IN_Alarm_1	18/04/2022 3:22:20
DIN_4	ALERT_H	DIGITAL_IN_Alarm_1	18/04/2022 3:19:39
DIN_3	ALERT_H	DIGITAL_IN_Alarm_1	18/04/2022 3:19:38
DIN_2	ALERT_H	DIGITAL_IN_Alarm_1	18/04/2022 3:19:37
DIN_4	ALERT_H	DIGITAL_IN_Alarm_1	18/04/2022 3:17:10
DIN_3	ALERT_H	DIGITAL_IN_Alarm_1	18/04/2022 3:17:07
DIN_2	ALERT_H	DIGITAL_IN_Alarm_1	18/04/2022 3:17:05
DIN_4	ALERT_H	DIGITAL_IN_Alarm_1	18/04/2022 3:14:40
DIN_3	ALERT_H	DIGITAL_IN_Alarm_1	18/04/2022 3:14:38
DIN_2	ALERT_H	DIGITAL_IN_Alarm_1	18/04/2022 3:14:36
DIN_4	ALERT_H	DIGITAL_IN_Alarm_1	18/04/2022 3:12:09
DIN_3	ALERT_H	DIGITAL_IN_Alarm_1	18/04/2022 3:12:08
DIN_2	ALERT_H	DIGITAL_IN_Alarm_1	18/04/2022 3:12:05
DIN_4	ALERT_H	DIGITAL_IN_Alarm_1	18/04/2022 3:09:39
DIN_3	ALERT_H	DIGITAL_IN_Alarm_1	18/04/2022 3:09:38
DIN_2	ALERT_H	DIGITAL_IN_Alarm_1	18/04/2022 3:09:37
DIN_4	ALERT_H	DIGITAL_IN_Alarm_1	18/04/2022 3:07:10

Showing 1 to 20 of 3,392 entries

Privacy Policy Cookies Policy Terms and Conditions

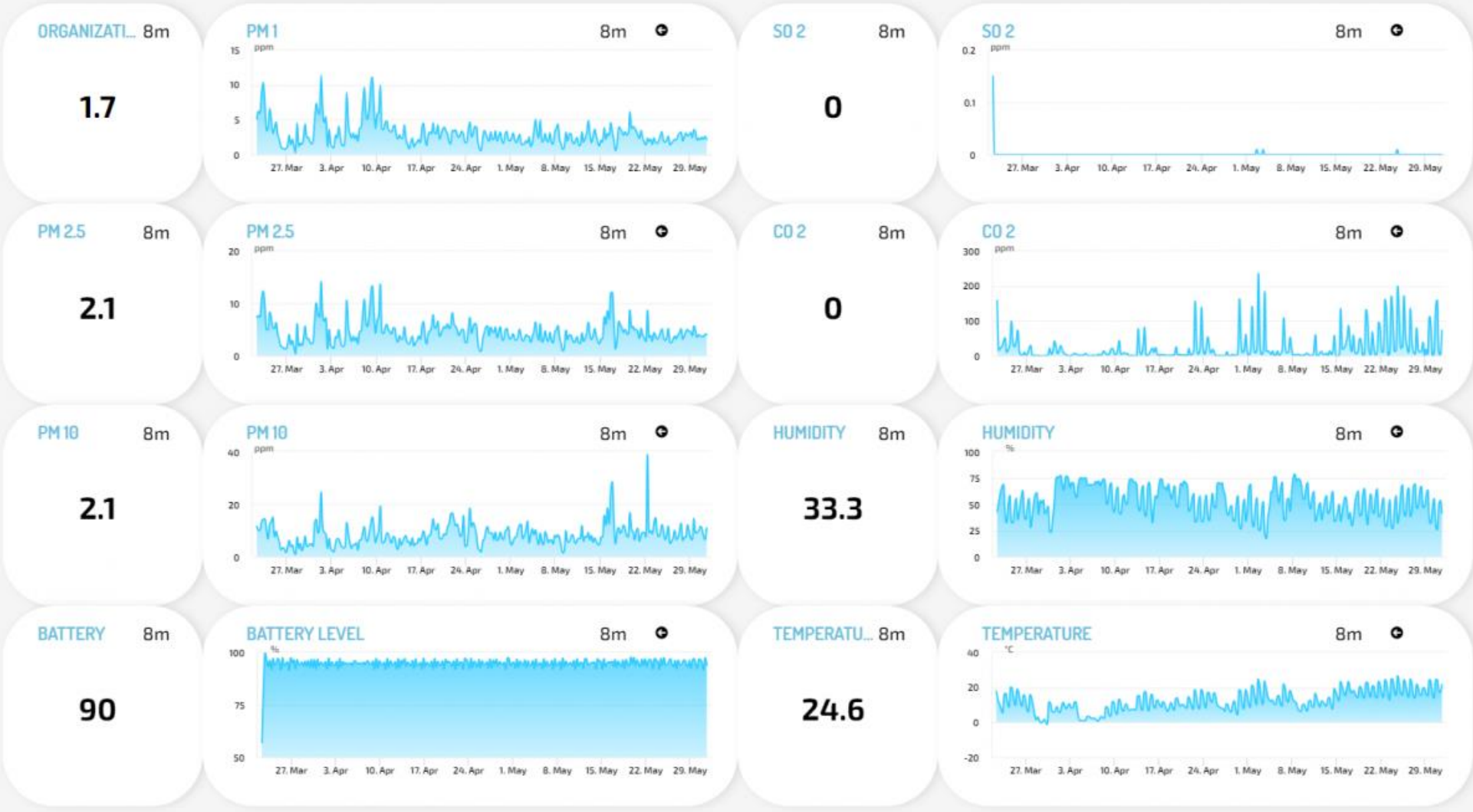


# TheLab.City LivingLab by ICEBERG, Romania



Ciao  
Wed 31 May 16:11:04

## ICEBERG AIR QUALITY AND PMX



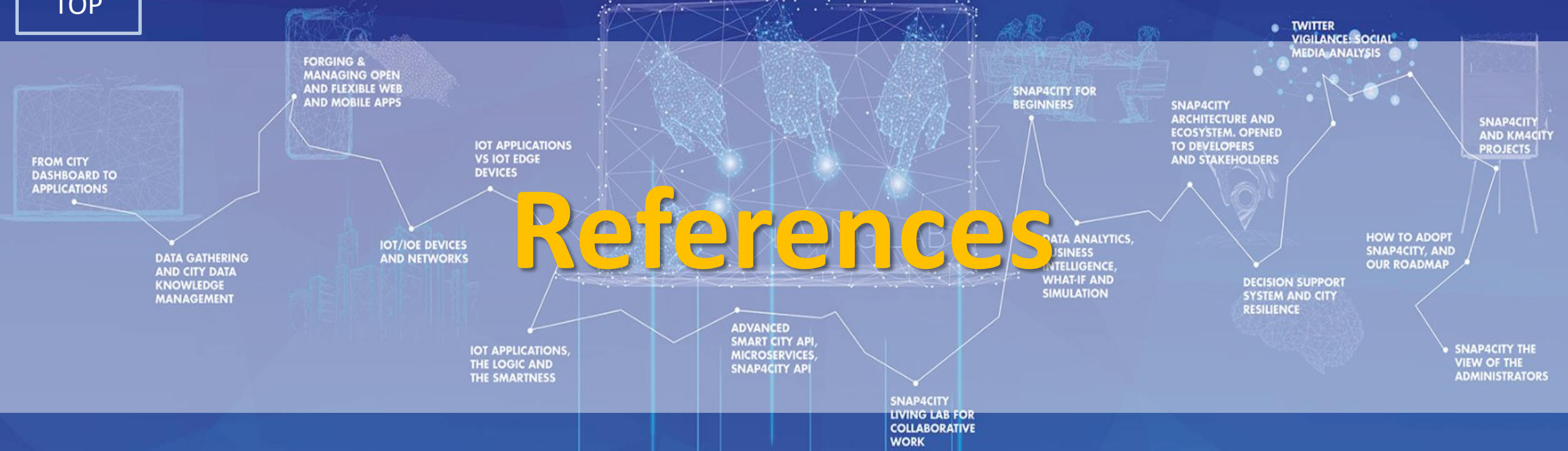
- Airquality
- Urban planning
- Parking
- Waste
- Etc.

<https://thelab.city/>



TOP

# References





# 2023 booklets



- Smart City



[https://www.snap4city.org/download/video/DPL\\_SNAP4CITY.pdf](https://www.snap4city.org/download/video/DPL_SNAP4CITY.pdf)

- Industry



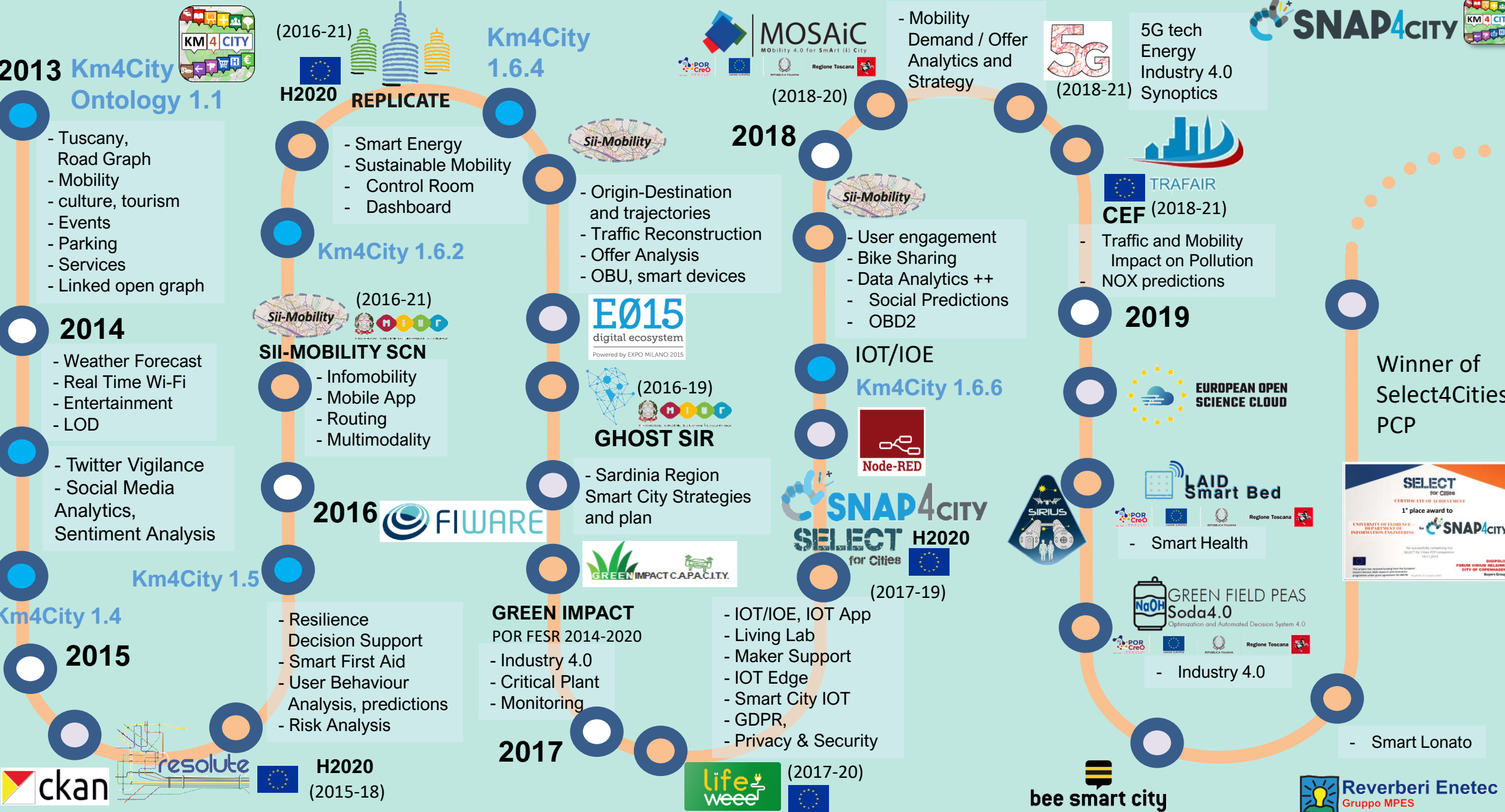
[https://www.snap4city.org/download/video/DPL\\_SNAP4INDUSTRY.pdf](https://www.snap4city.org/download/video/DPL_SNAP4INDUSTRY.pdf)

- Artificial Intelligence



[https://www.snap4city.org/download/video/DPL\\_SNAP4SOLU.pdf](https://www.snap4city.org/download/video/DPL_SNAP4SOLU.pdf)





**2013 Km4City Ontology 1.1**

- Tuscany, Road Graph
- Mobility
- culture, tourism
- Events
- Parking
- Services
- Linked open graph

**2014**

- Weather Forecast
- Real Time Wi-Fi
- Entertainment
- LOD

- Twitter Vigilance
- Social Media Analytics, Sentiment Analysis

**Km4City 1.4**

**2015**

- Resilience Decision Support
- Smart First Aid
- User Behaviour Analysis, predictions
- Risk Analysis

ckan, resolute, H2020 (2015-18)

**(2016-21) H2020 REPLICATE Km4City 1.6.4**

- Smart Energy
- Sustainable Mobility
- Control Room
- Dashboard

**Km4City 1.6.2**

(2016-21) Sii-Mobility, HIER

- SII-MOBILITY SCN**
- Infomobility
  - Mobile App
  - Routing
  - Multimodality

**2016 FIWARE**

**Km4City 1.5**

- GREEN IMPACT**  
POR FESR 2014-2020
- Industry 4.0
  - Critical Plant
  - Monitoring

**2017** life weee (2017-20)

- Sii-Mobility**
- Origin-Destination and trajectories
  - Traffic Reconstruction
  - Offer Analysis
  - OBU, smart devices

**E015** digital ecosystem  
Powered by EXPO MILANO 2015

(2016-19) HIER  
**GHOST SIR**

- Sardinia Region Smart City Strategies and plan

**GREEN IMPACT CAPACITY.**

- IOT/IOE, IOT App
- Living Lab
- Maker Support
- IOT Edge
- Smart City IOT
- GDPR,
- Privacy & Security

**2018** MOSAIC (2018-20)

**MOSAIC** Mobility 4.0 for Smart (II) City  
POR CreO, Regione Toscana

**2018**

- Sii-Mobility**
- User engagement
  - Bike Sharing
  - Data Analytics ++
  - Social Predictions
  - OBD2

**IOT/IOE Km4City 1.6.6**

**Node-RED**

**SNAP4CITY SELECT** H2020 for Cities (2017-19)

- Smart Waste

**bee smart city**

**5G** (2018-21)  
5G tech, Energy, Industry 4.0, Synoptics

**TRAFAIR CEF** (2018-21)

- Traffic and Mobility Impact on Pollution
- NOX predictions

**2019**

**EUROPEAN OPEN SCIENCE CLOUD**

**LAI Smart Bed**

- Smart Health

**GREEN FIELD PEAS Soda4.0**  
Optimization and Automated Decision System 4.0

- Industry 4.0

**Smart Lonato**

**Reverberi Enetec** Gruppo MPES

**SNAP4CITY** KM4CITY

Winner of Select4Cities PCP

**SELECT for Cities**  
1<sup>st</sup> place award to SNAP4CITY

**DISIT lab roadmap vs model and tools' usage**





**2020**



- Smart Tourism
- 6 Pilots
- Data Analytics
- Extended platform



- Smart Mobility
- PISA, PUMS
- Living lab



**Km4City 1.6.7**

Smart Ambulance (2021-22)

Enterprise (2021-22)  
Industry 4.0



**2021**

PC4City (2020-21)  
Monitoring Terrain



**CAPĒLON**

- Smart Light
- Sweden

Almafluida Industry 4.0 (2021-22)

AMPERE (2021-22)  
Industry 4.0

SYN-RG-AI  
SmartCity



Industry 4.0

uni.systems  
SmartCity, 2021-23



AXIS collab  
SmartCity

**2022**



Asymmetrica  
Smart City, 2022-23



Italferr, Smart City

**2023**



Contract, 2022-23



2022-2023



Security and Risk



Contract, 2022-23



CN MOST, 2022-26



EI THE, 2022-26



G. Agile, 2021-23



2023-26 Finanziato dall'Unione europea NextGenerationEU

Merano, smart light

OceanRace,  
Genova, AWS

Cuneo,  
smart city

**2024**



TOURISMO

ELLIE IA  
2024-2027



CAI4DSA



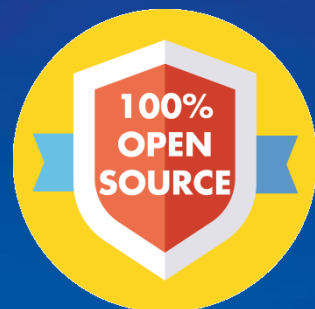
Rhodes,  
smart city

eShare  
UNIFI TUSS

AMMIRARE



TOP



*Be smart in a SNAP!*



**SMARTCITY**

EXPO WORLD CONGRESS

7-9 November 2023, Barcelona, Spain

Visit Snap4City in Hall 1

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