UNIVERSITÀ DEGLI STUDI FIRENZE | DINFO DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE | DISIT DISTRIBUTED SYSTEMS AND INTERNET TECHNOLOGIES LAB

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KM4CITY

Exploiting Satellite Data in the Context of Smart City Applications

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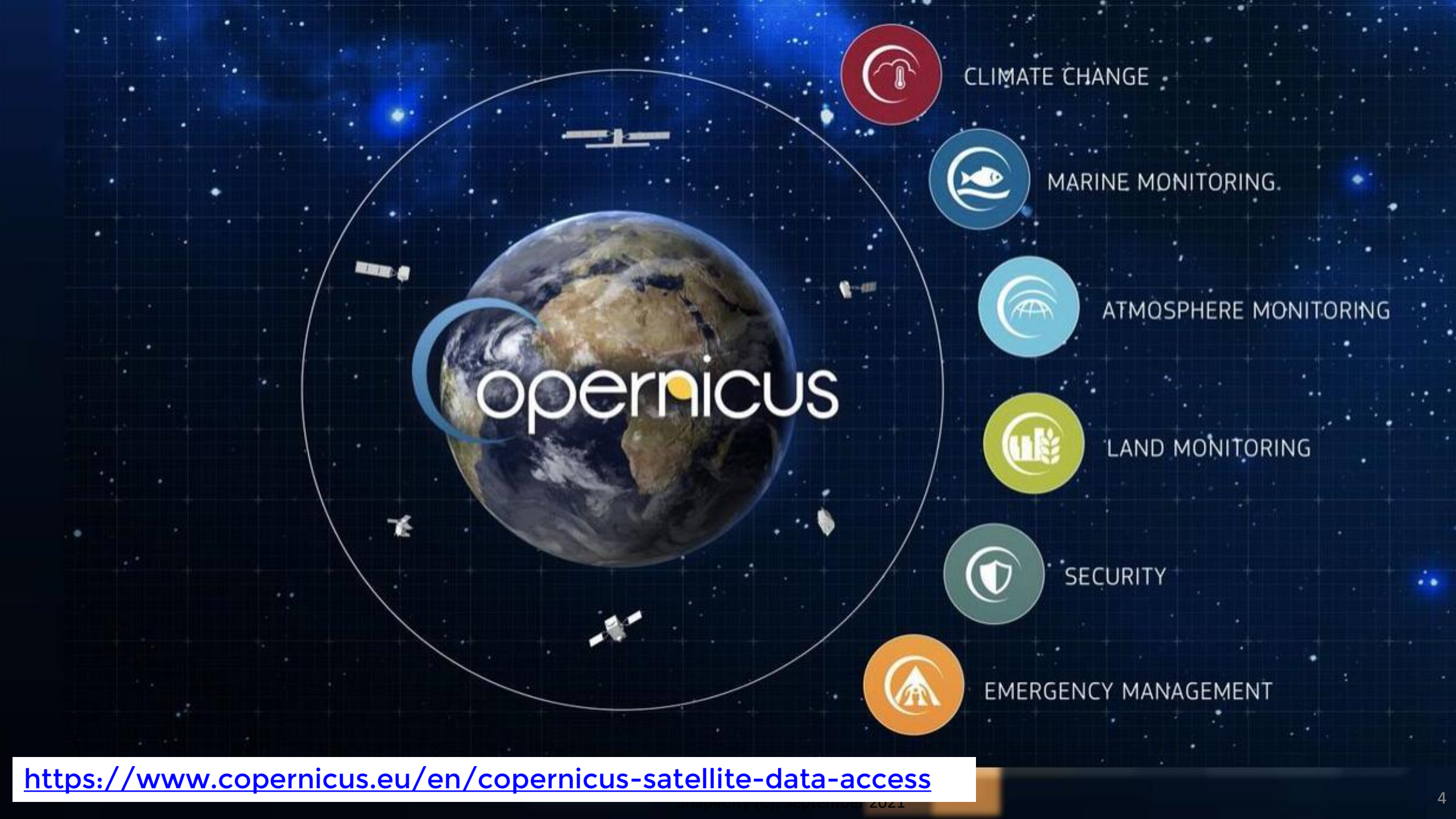
Needs

- In the Smart City context there is the needs of
  - **Accessible and affordable** data: spatially and temporally dense
  - **Reducing costs** for data gathering.
    - Sensors are good, but are scattered and very expensive
  - Reduce **costs for maintenance** of data gathering solutions
    - Sensors have high costs of maintenance: repairing, battery changes, calibrations, attacks, etc.
  - **Validation** of data.
- Satellite data may be a solution to some of those problems, while other have to be managed.

Smart City: Satellite Data vs Sensors Data

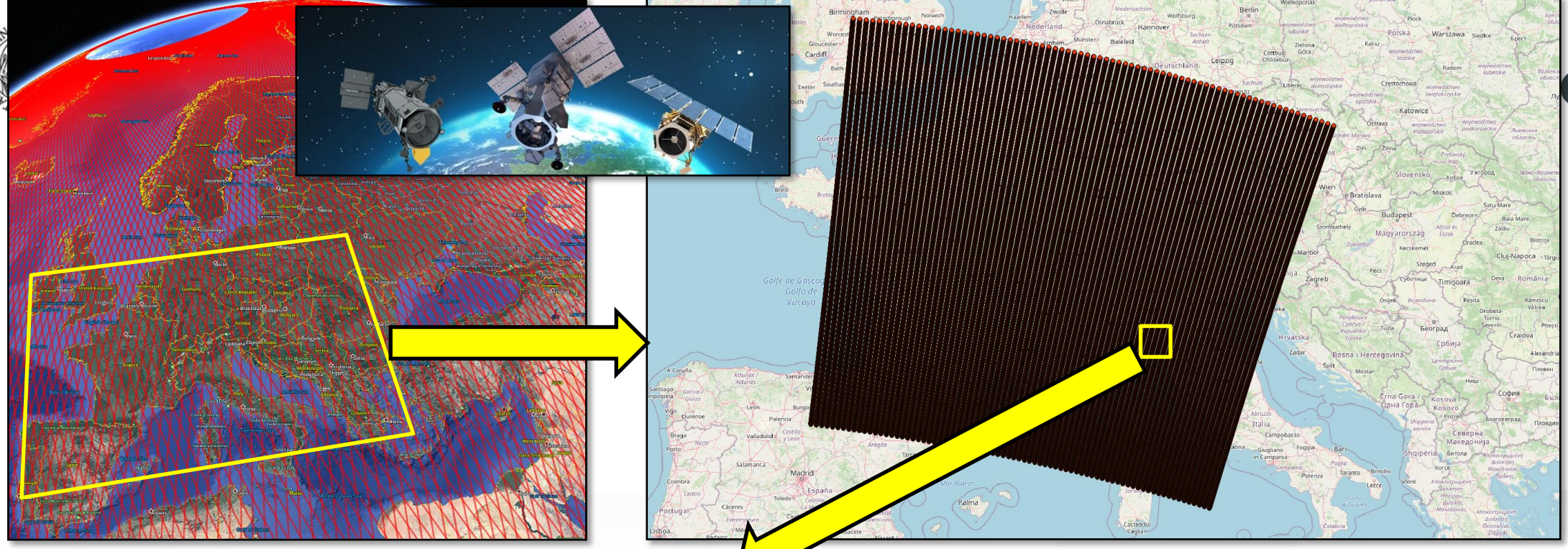
- **From Satellites, many sources, different resolutions, open/closed:**
  - Ozone, NO2, SO2, Aerosol, CO, etc.
  - Temperature, vegetation, land usage
    - Evolution of soil usage: with high seasonality, and weather impact
  - Air traffic derived data
  - Water traffic usage data
  - Many other technical measures….
  - Spatial and temporal resolution ???
- **From Sensors and other sources:**
  - Pollutant: PM10, PM2.5, NO2, NO, SO2, CO2, …
  - Weather: temperatures, humidity, wind, DEW, etc.
  - Other: Traffic flow sensors, people flow, parking, etc.
  - Air/lidar measures from flights: vegetation, land usage
  - Scattered data, specifically positioned, no dense data

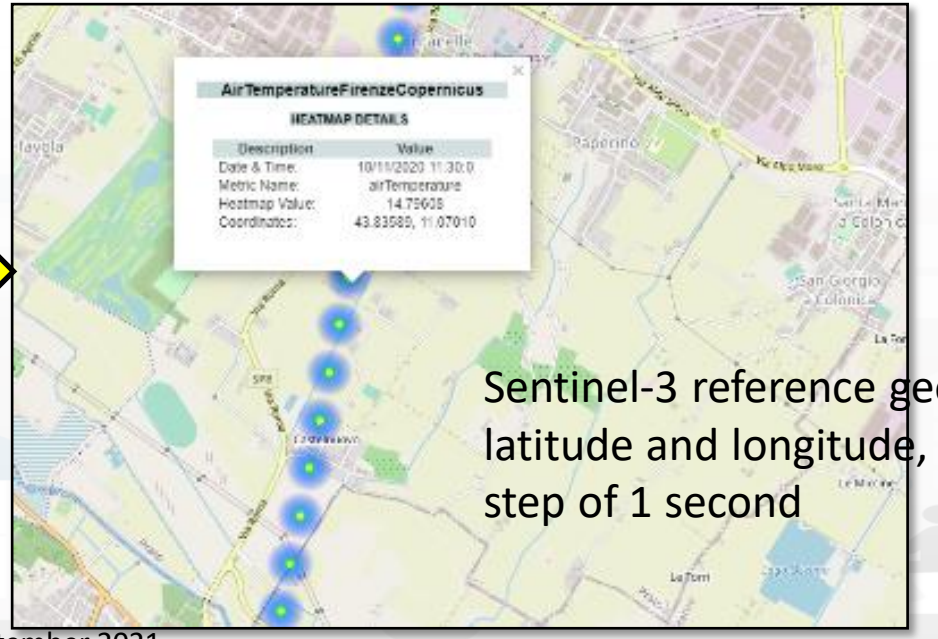


https://www.copernicus.eu/en/copernicus-satellite-data-access

Satellite data

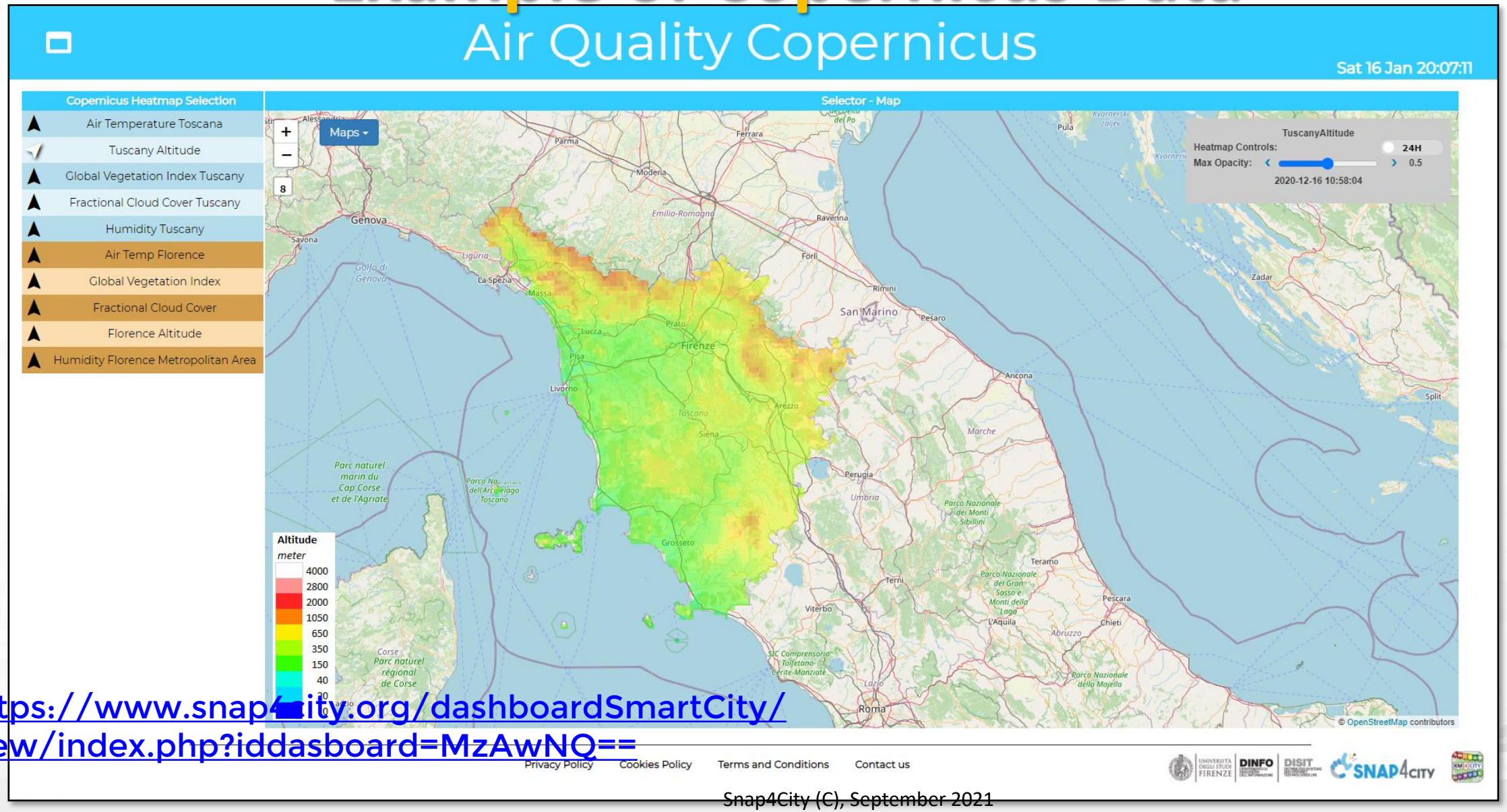
- **A large number of measures, not accessible from ground level sensors**
- **Complex data stream acquisition**
  - Data Transformation by knowing the satellite model is needed
  - Complex for small area since satellite products are typically large area
- **Temporal and spatial resolutions** (lat, lon)
  - They are not matrices actually
  - They are not always taken on the same places
  - Resolution may be not enough for specific city area analysis
  - No event driven data
- **View from the space**:
  - Affected by cloud and weather
  - Measures of the column of air and not at the ground level





Sentinel-3 reference geocentric latitude and longitude, time step of 1 second

Example of Copernicus Data

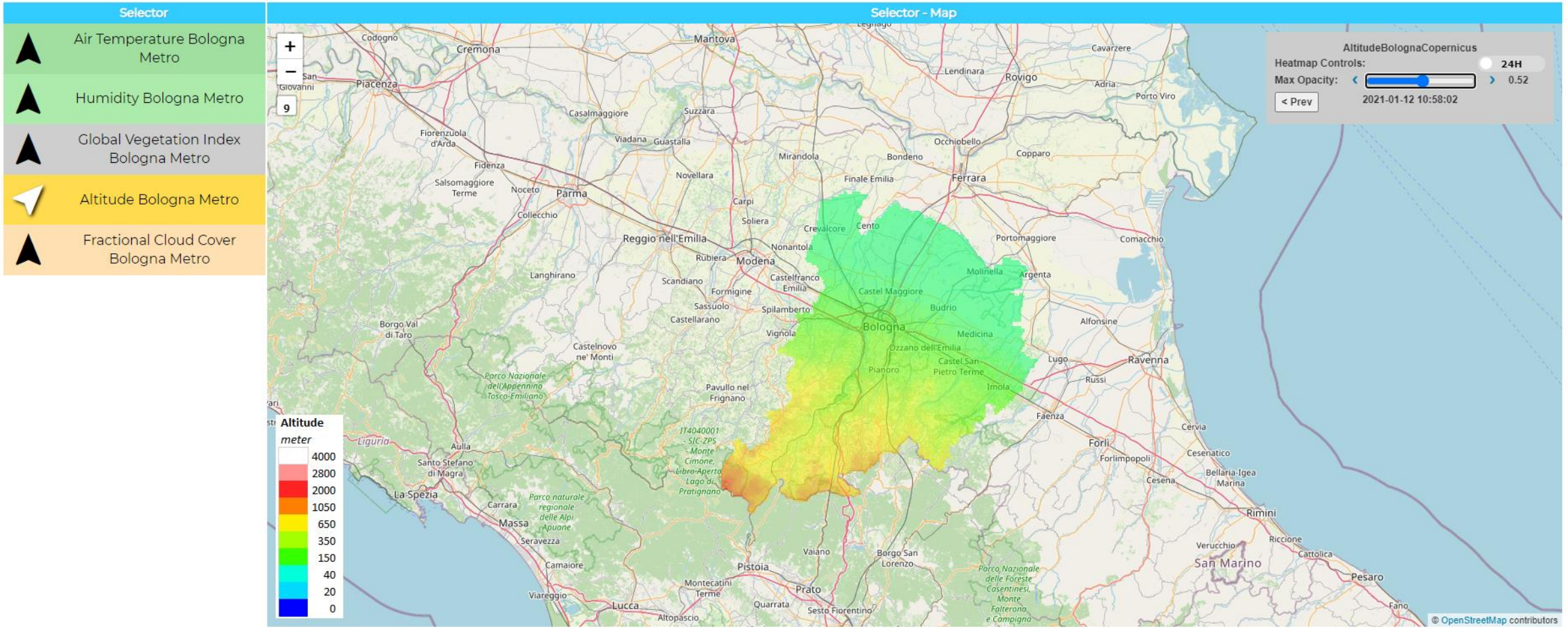


https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MzAwNQ==

Bologna Metro

Bologna Metropolian Area Copernicus Data

Sat 16 Jan 20:08:03



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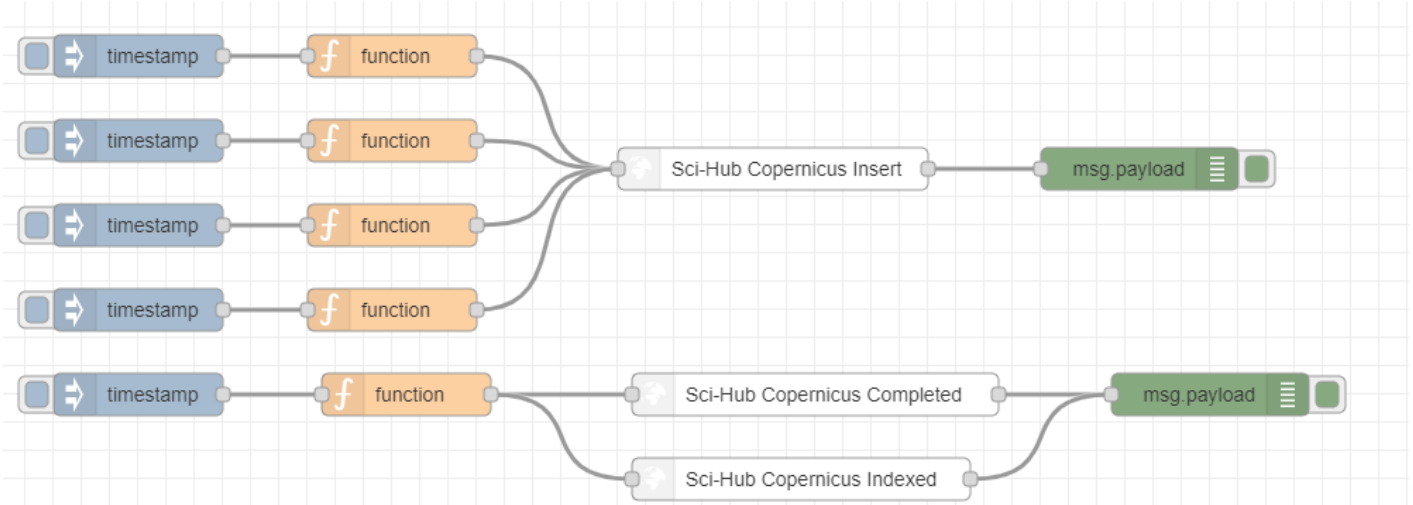
Satellite Data Harvesing and Preparation

Compernicus Data Request: Sci-Hub on Snap4City

https://www.snap4city.org/671

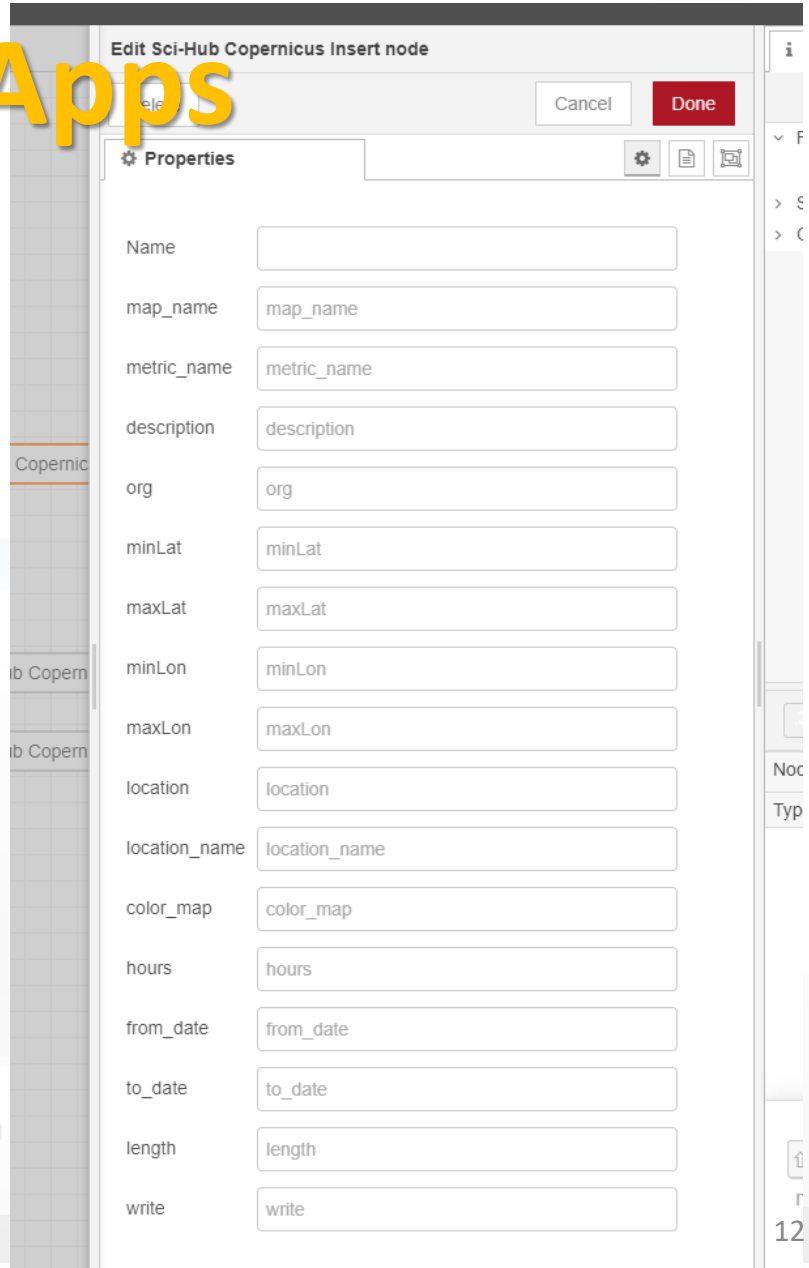
- **Map name**: ……..
- **Metric name**: AirTemperature, Humidity, Altitude, OLCI Global Vegetation Index, Cloud Fraction, etc.
- **Description**: a generic description;
- **Location**: select the level the data have to be taken and heatmap created. It is possible to specify one of the following: City, Country, State or Postal Code;
- **Location Name**: specify here the location: the name of a City or "Città Metropolitana di Firenze", or "Toscana" as State or "Italy" as Country, etc.;
- **Color Map**: color map visualization for example: airHumidity, ogvi, altitudeHQ, airTemperatureHQ, FractionalCloudCoverLQ, …. From those of Snap4City
- **Org**: specify the organization in Snap4City from the available list;
- **From Date - To Date**: use these to forms to specify the time period of the data to be downloaded. Please note that at least you have to specify at least 1 day period since satellite data are typically updated 1 times per day. If a longer period is specified, all data included in the period will be taken and, according to the available data, more date sets and heatmaps will be generated covering the time period;
- **Length**: specify here the dimension in meters of squared area, for example 700 for obtaining points values in a grid of 700x700 meters;
- **Write**: (1) to have data on piking and database, or (0) to do not have data thus obtaining only the heatmap
- You need to have a TOKEN to use the service ☺

Copernicus data request via IoT Apps



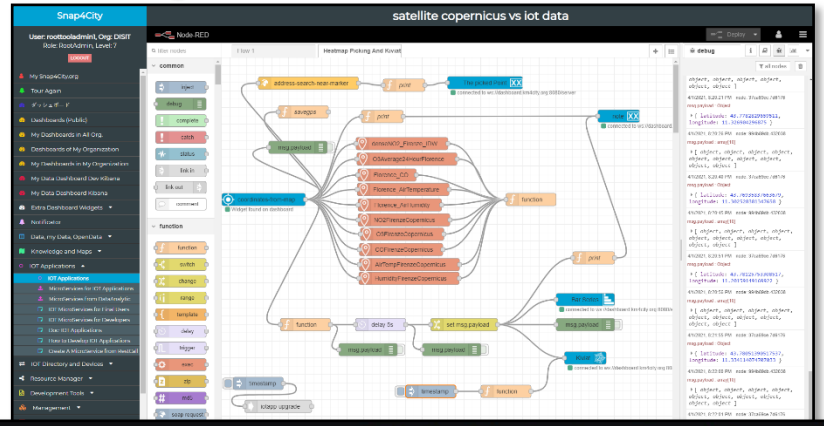
Setup | **Function** | Close

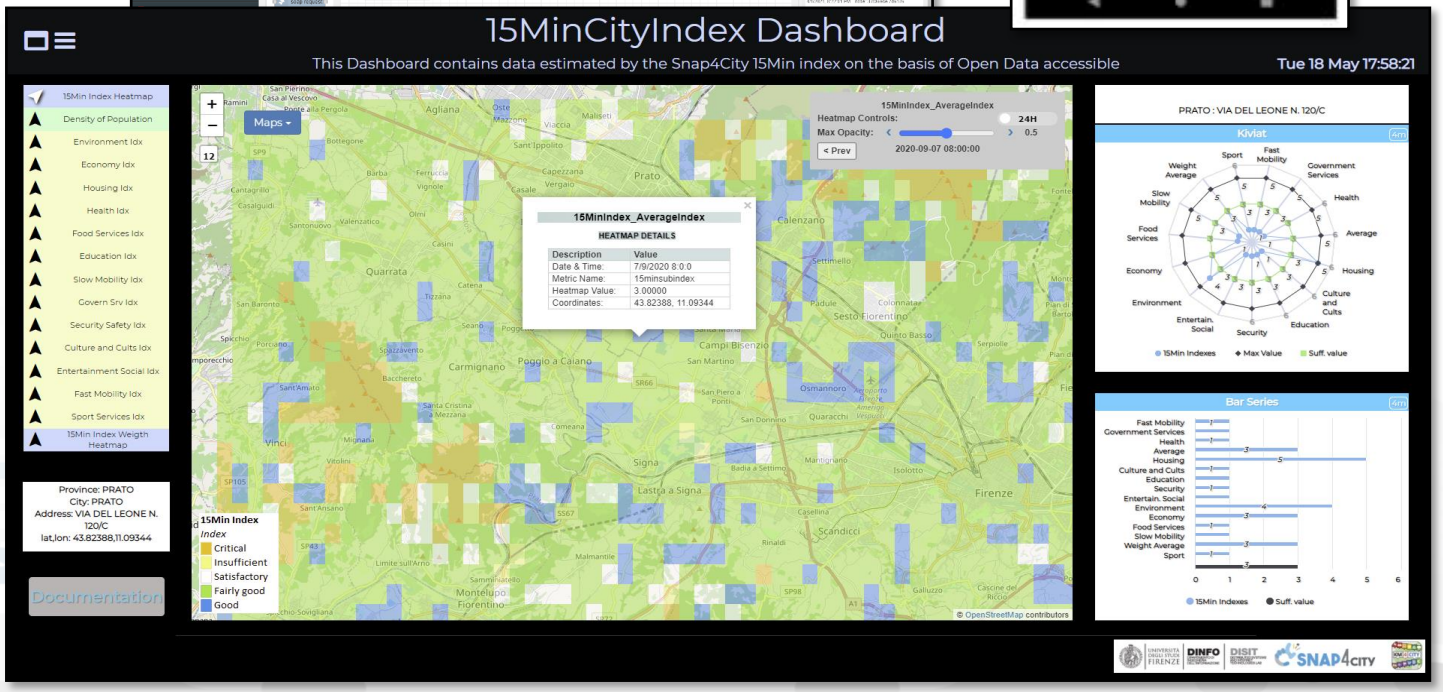
```
msg.payload = {
    "map_name": "AirTemperatureBolognaCopernicus",
    "description": "Air Temperature Bologna",
    "location": "city",
    "location_name": "Città metropolitana di Bologna",
    "color_map": "airTemperatureHQ",
    "org": "DISIT",
    "from_date": "2021-01-01T00:00:00",
    "to_date": "2021-01-01T23:59:00",
    "length": "700",
    "write": "1",
}
return msg;
```



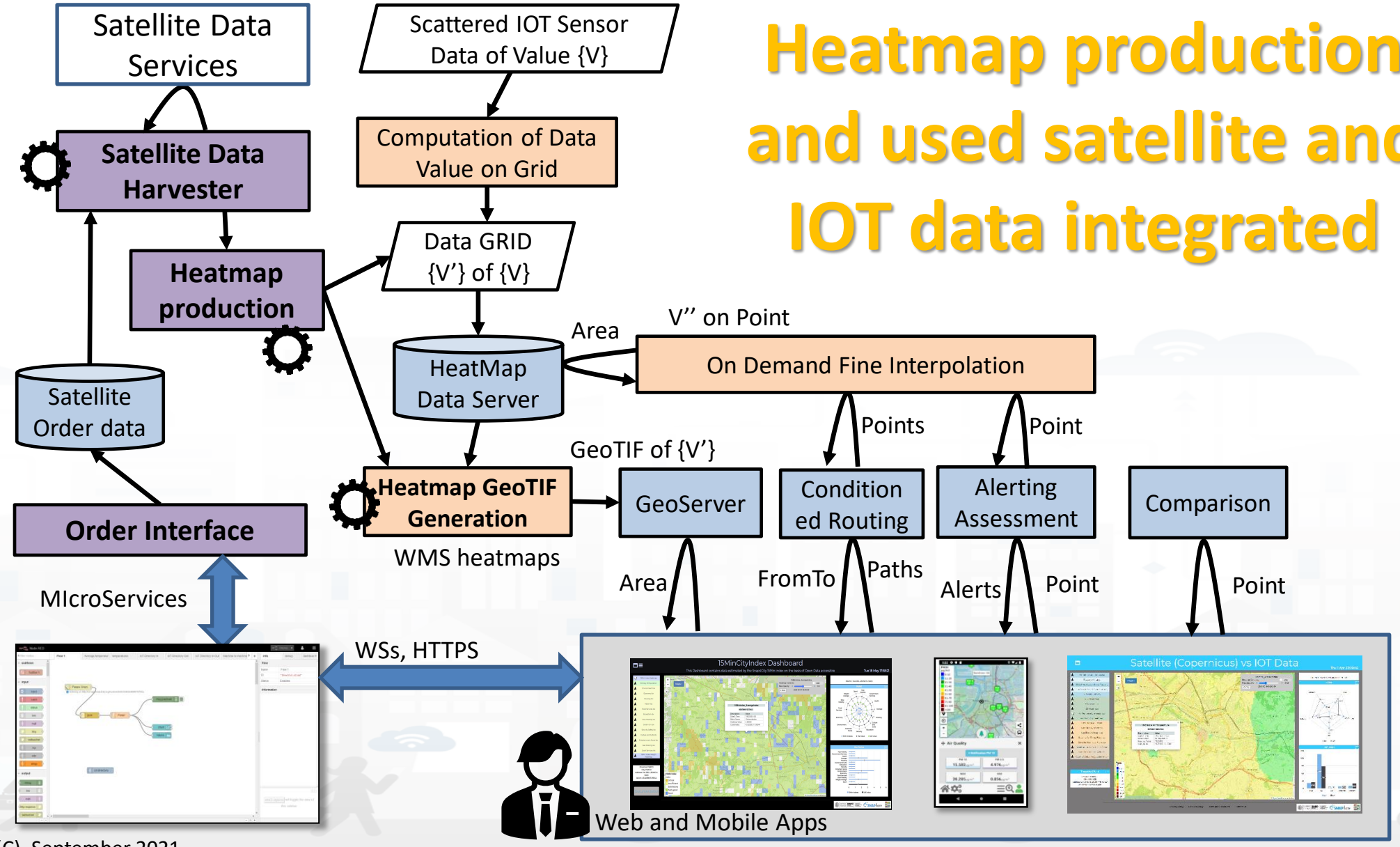
Once Generated can be exploited

- **Picking data on dense map and exploiting them on**
  - Assessing routing:
    - path of GPS points
  - Alerting specific users wrt specific locations.
    - One GPS position: park, garden, house, etc.
    - Alerting them
      - Via telegram
      - Email
- **Estimating city Indexes**
- **Comparison with sensors**





Heatmap production and used satellite and IOT data integrated



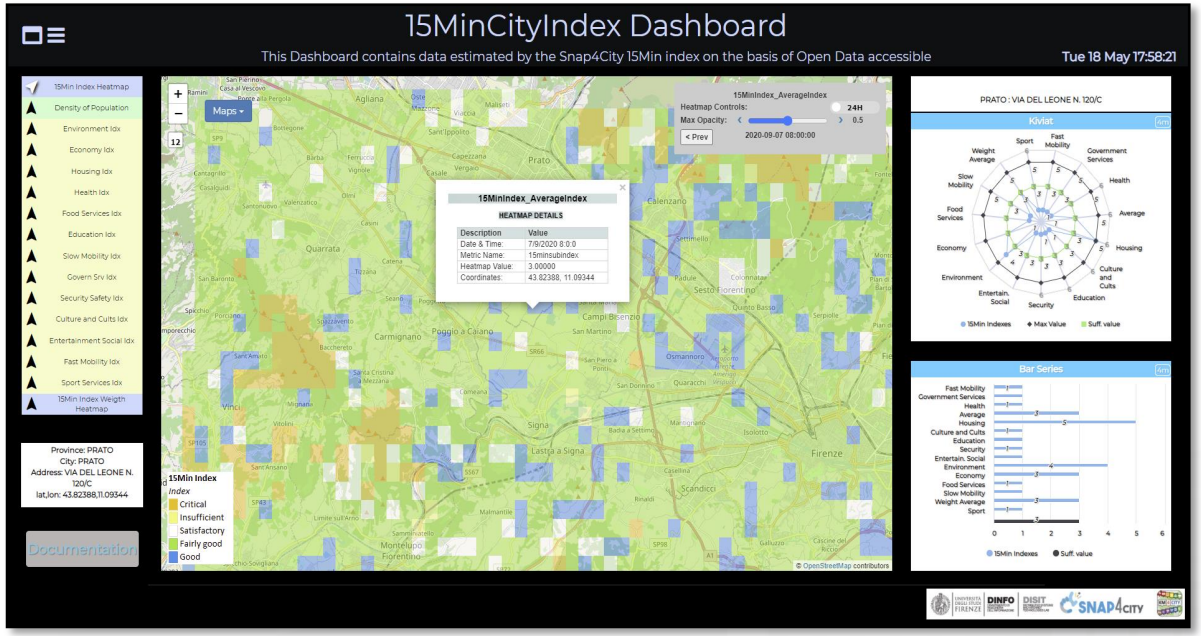
Concept 15MinIndex

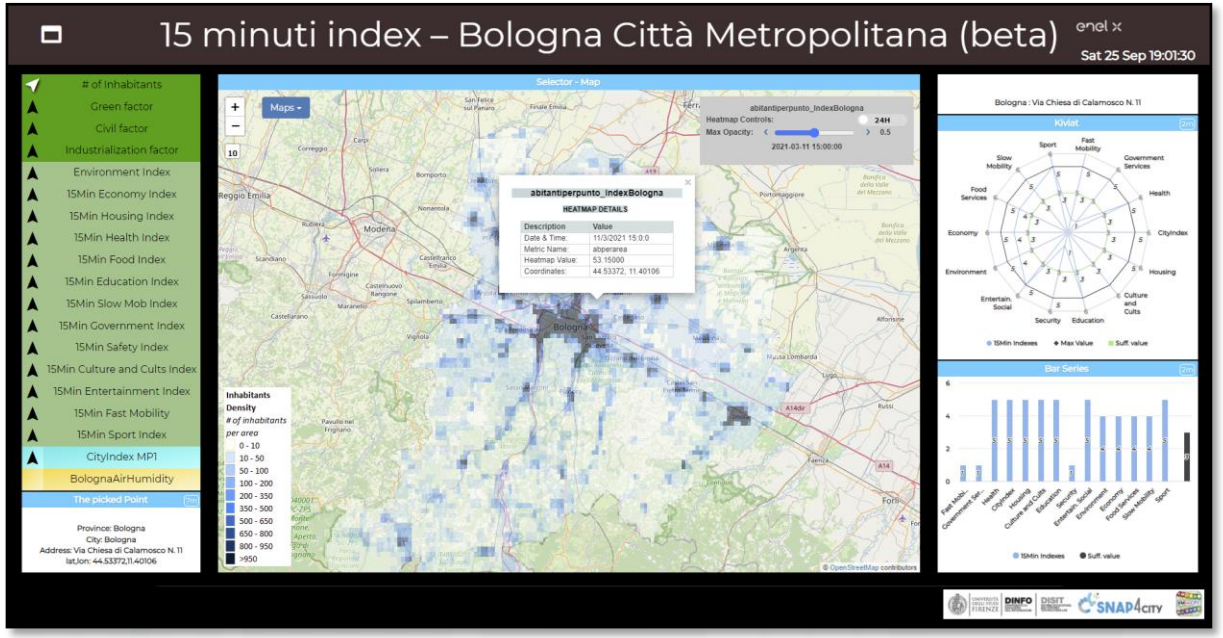
Assessing in each point of the area (city or rural) the capability of providing services ad 15 Min walking distance for the city users

- Several different approaches from early Carlos Moreno concept
- Several different subindexes

Carlos Moreno Functions	Li et al., 2019	15MinCityIndex subindexes
living		Housing viability
	Gov	Govern Services
		Safety Services
		Culture and Cults Services
		Environment Quality
	Roads	Slow Mobility Services
		Fast Mobility Services
	[Medical]	Sport Services
working		Economy/ sustainability
	pension	
commerce	commerce	
	dining	Food Services
healthcare	medical	Health Services
education	edu	Education Services
entertainment	entertainment	Entertainment Services

15MinCityIndex





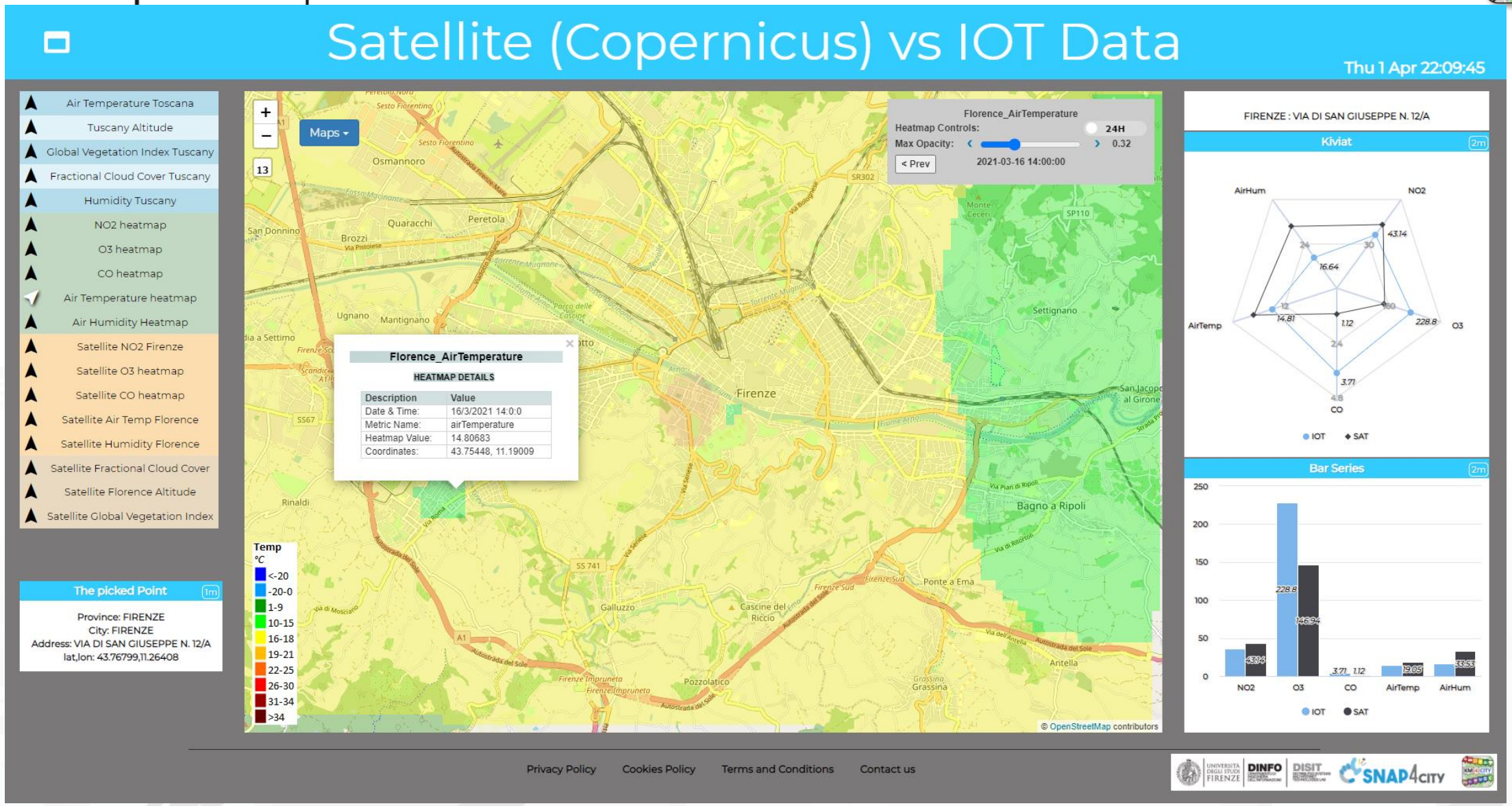
[FLORENCE metro city](https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MjkzOA=)

https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MjkzOA=

[Bologna metro city](https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MzA1OQ==)

https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MzA1OQ==

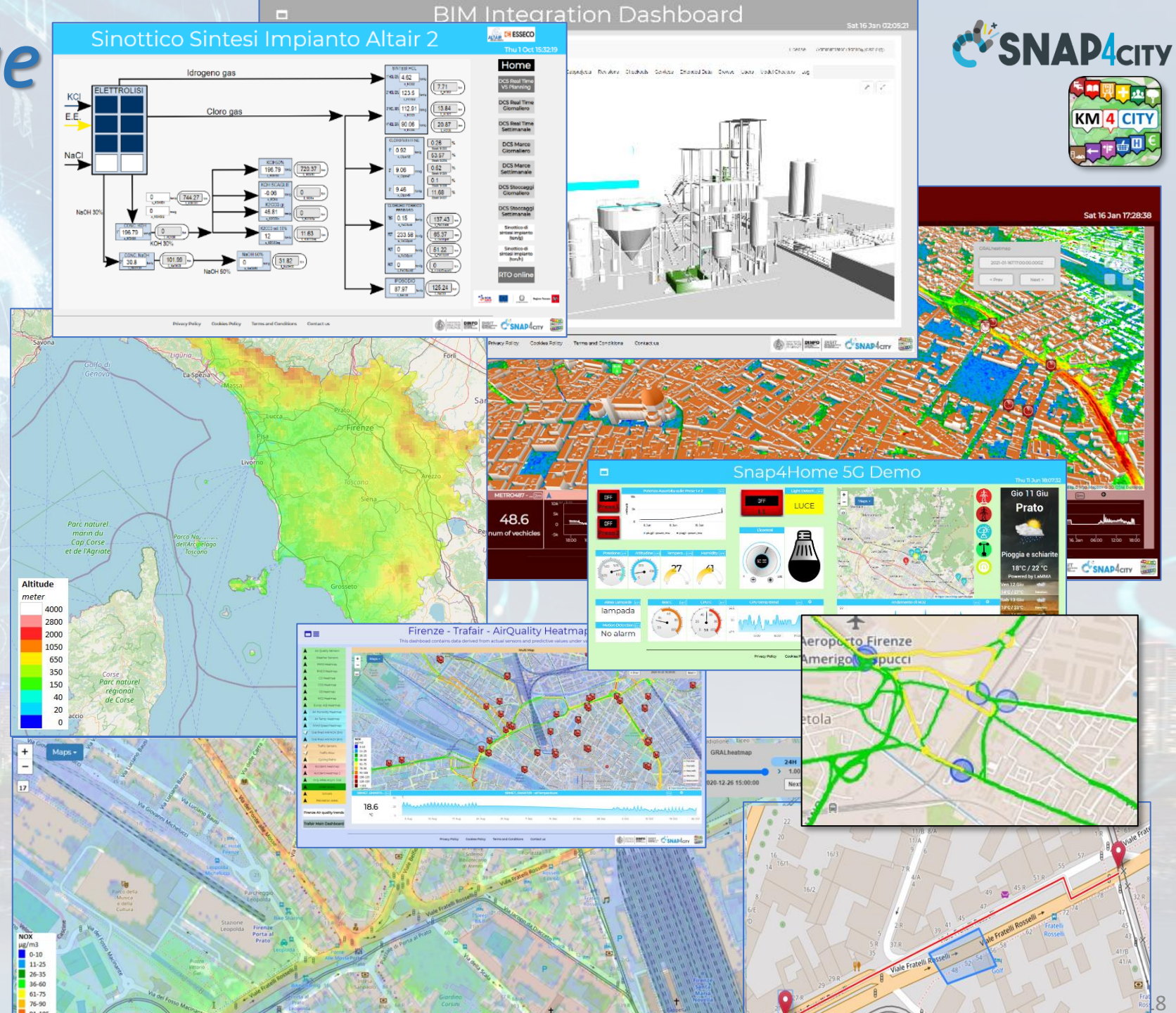
Satellite (Copernicus) vs IOT Data



https://www.snap4city.org/dashboardSmartCity/view/index.php?iddasboard=MzAwNQ==

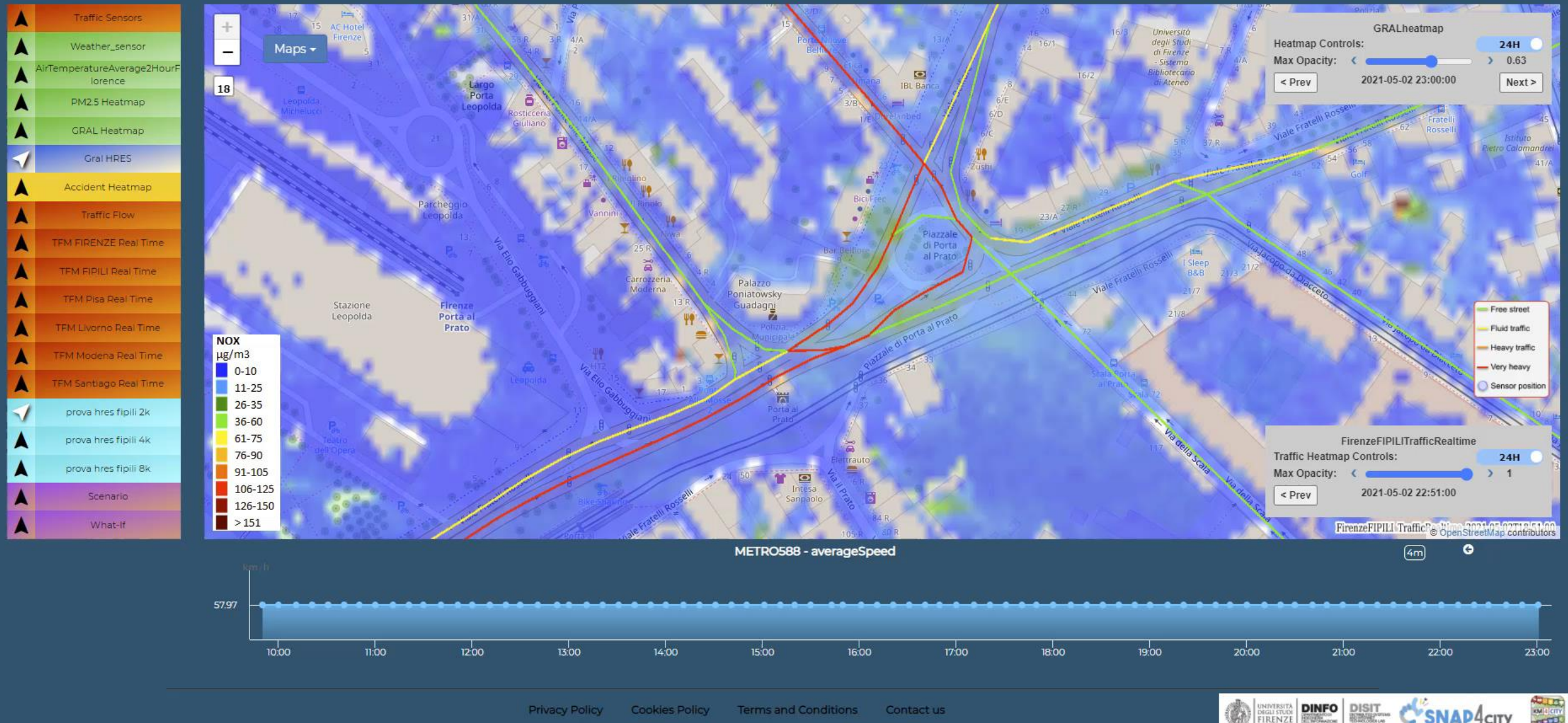
Data Type Coverage

- POI, IOT, shapes,..
- maps, orthomaps, GTFS, GIS WFS/WMS, GeoTiff, ..
- calibrated heatmaps, ..
- traffic flow, typical trends, ..
- trajectories, events, ..
- 3D, BIM, Workflow, ..
- Dynamic icons/pins, ..
- OD Matrices, scenarios, ..
- prediction models, ….
- decision support, ….
- Synoptics, animations, ..
- social media, Routing, ..
- Satellite data, ..
- KPI, personal KPI,..
- etc.



Traffic Flow Manager on multiple cities

Sun 2 May 23:16:31



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Tools for rapid implementation of sustainable Smart Solutions and Decision Support Systems

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PEN Test Passed

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Node-RED

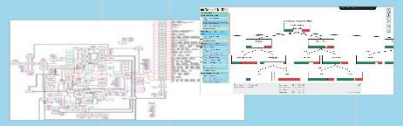
JS Foundation

E015 digital ecosystem

NVIDIA

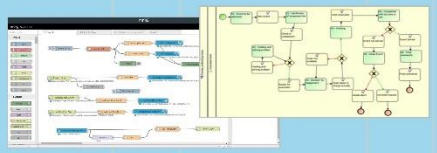
DASHBOARDS AND APPS - CONTROL ROOMS - DECISION SUPPORT SYSTEMS - WHAT-IF ANALYSIS - VISUAL ANALYTICS

PREDICTION - ANOMALY DETECTION - ENVIRONMENTAL MODEL - 3D MODEL
KPI - SIMULATION - EARLY WARNING - SYNOPTIC - DIGITAL TWIN - VIRTUAL REALITY



EXPERT SYSTEM
KNOWLEDGE BASE
STORAGE

BIG DATA ANALYTICS
EXPLAINABLE ARTIFICIAL INTELLIGENCE
BUSINESS INTELLIGENCE
MACHINE LEARNING



DATA FLOWS, DATA DRIVEN
WORKFLOWS, MICROSERVICES
PARALLEL DISTRIBUTED PROCESSING

METHODOLOGIES
COURSES AND COMMUNITY
LIVING LABS
DEVELOPMENT TOOLS

https://www.snap4city.org/577

On Line Training Material (free of charge)

	1st part (*)	2nd part (*)	3rd part (*)	4th part (*)	5th part (*)	6th part (*)	7th part (*)
what	General	Dashboards	IOT App, IOT Network	Data Analytics	Data Ingestion processes	System and Deploy Install	Smart City API: Web & Mob. App
PDF							
Inter active							
Video1							
Video2							
Video3							
Video4				none		none	none
duration	2:55	3:16	3:41	2:00	2:48	2:35	1:47

Conclusions

https://www.Snap4City.org

- IoT data have relevant costs for installation and maintenance.

- **The exploitation of satellite data in the context of Smart City**.
  - PROS: satellite data of the European Union's Earth observation program Copernicus can be used to
    - calibrate the values of large sensors network data and for new applications in which similar data cannot be recovered from the field.
    - develop new applications in which similar data cannot be recovered from the field.
  - CONS, satellite data are not easy to be managed
    - volume of the data obtained when requesting small regions;
    - complexity of the formats that need to be processed and converted;
    - computational time needed and difficulty in providing data in real time;
    - lack of spatial resolution in providing the data.
- **Tools and Dashboards have been provided and integrated into Snap4City suite to:**
  - perform a comparison of data coming from satellite with respect to those obtained from IoT devices.
  - Demonstrate that it is possible to create a real time solution by exploiting satellite data