URBAN-GEO BIG DATA

PRIN PROJECT: *URBAN GEOmatics for Bulk Information Generation, Data Assessment and Technology Awareness*

Workshop on Volunteered Geographic Information

CNR, 16/04/2018

URBAN GEOmatics for Bulk Information Generation, Data Assessment and Technology Awareness

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MINISTERO DELL'ISTRUZIONE DELL'UNIVERSITA' E DELLA RICERCA

Project objective (2017-2020)

The project aims to develop innovative GIS methodologies and tools to exploit the integration of:

- traditional geomatic data,
- Earth Observations (EO)
- statistics data
- new user-generated contents

for promoting a more effective management of urban resources and infrastructures

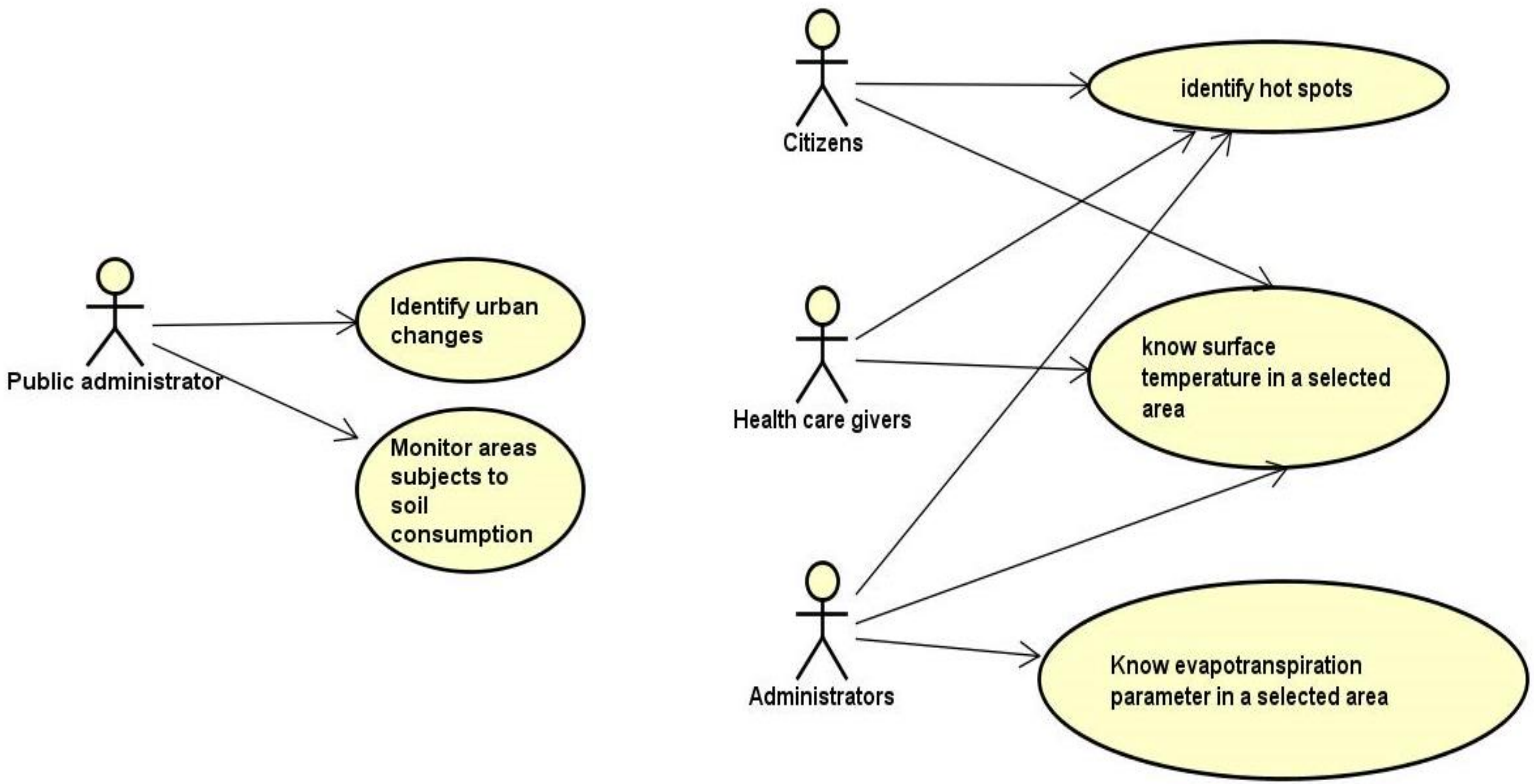
To evaluate the system practicability, two topical (**soil consumption and mobility**) issues and five cities (**Milan, Naples, Padua, Rome and Turin**) among all the possible urban topics and cities, will be considered as case studies:

Urban data census

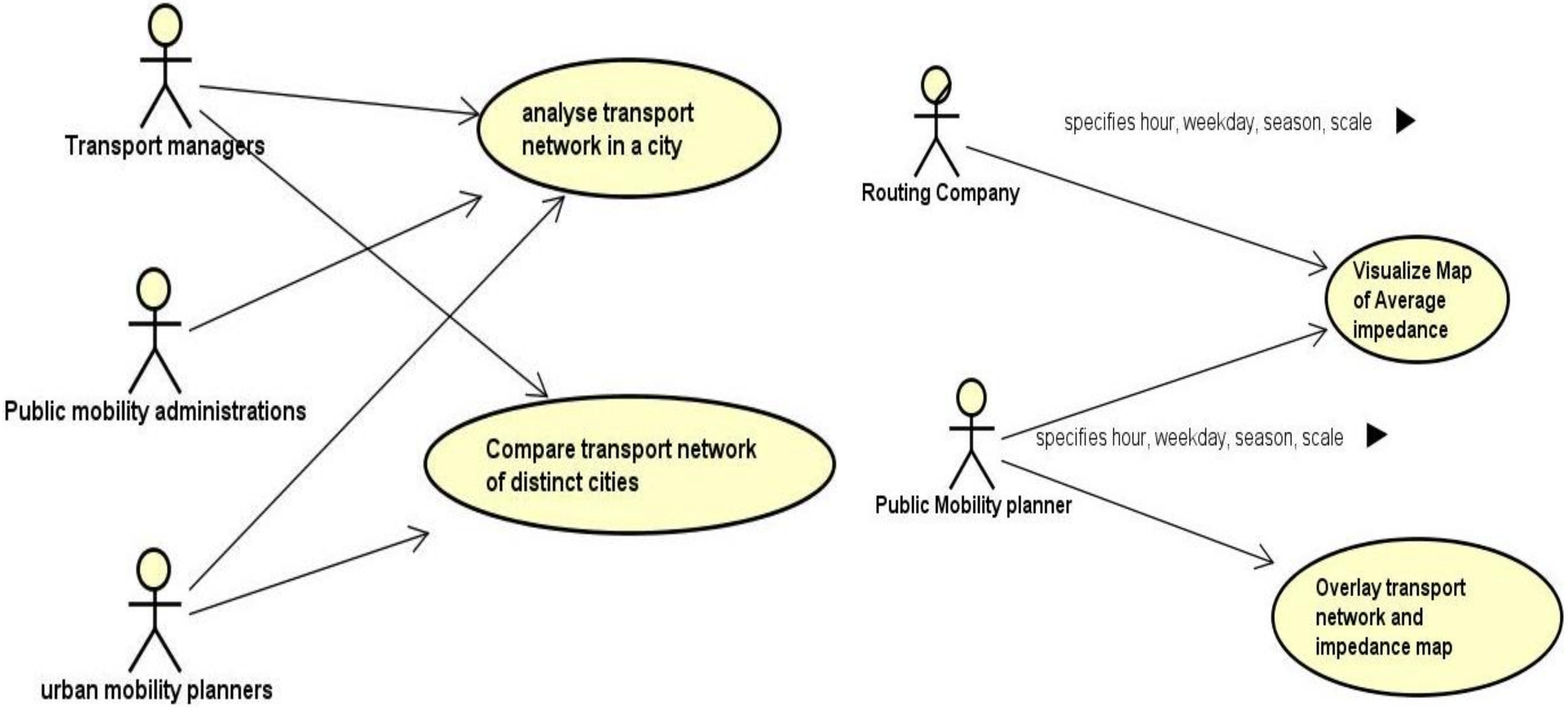
TARGET -> Soil consumption & Mobility

- **Open & city-owned data**
  - Earth Observations
  - Global and local LULC
  - Geoportals
  - Mobility portals
- **Volunteer GI**
  - OpenStreetMap
- **Crowdsourcing**
  - Social Media
  - User-generated content

Use Case1

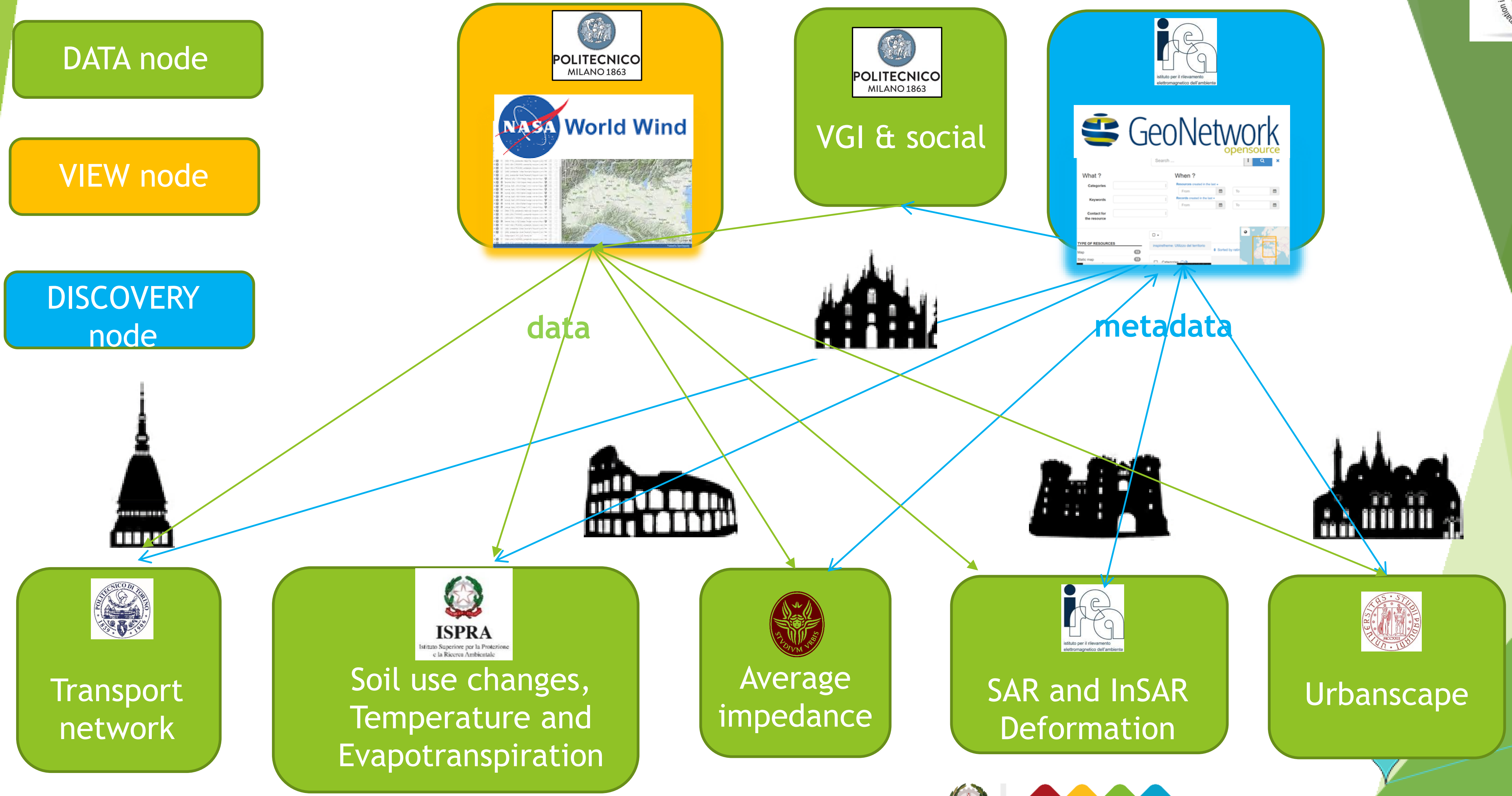

Public administrator
Identify urban changes
Monitor areas subjects to soil consumption
Citizens
Health care givers
Administrators
identify hot spots
know surface temperature in a selected area
Know evapotranspiration parameter in a selected area

Use Case2



Transport managers
Public mobility administrations
urban mobility planners
analyse transport network in a city
Compare transport network of distinct cities
Routing Company
specifies hour, weekday, season, scale
Visualize Map of Average impedance
Public Mobility planner
specifies hour, weekday, season, scale
Overlay transport network and impedance map

URBAN GEO SDI Architecture (INSPIRE compliant)



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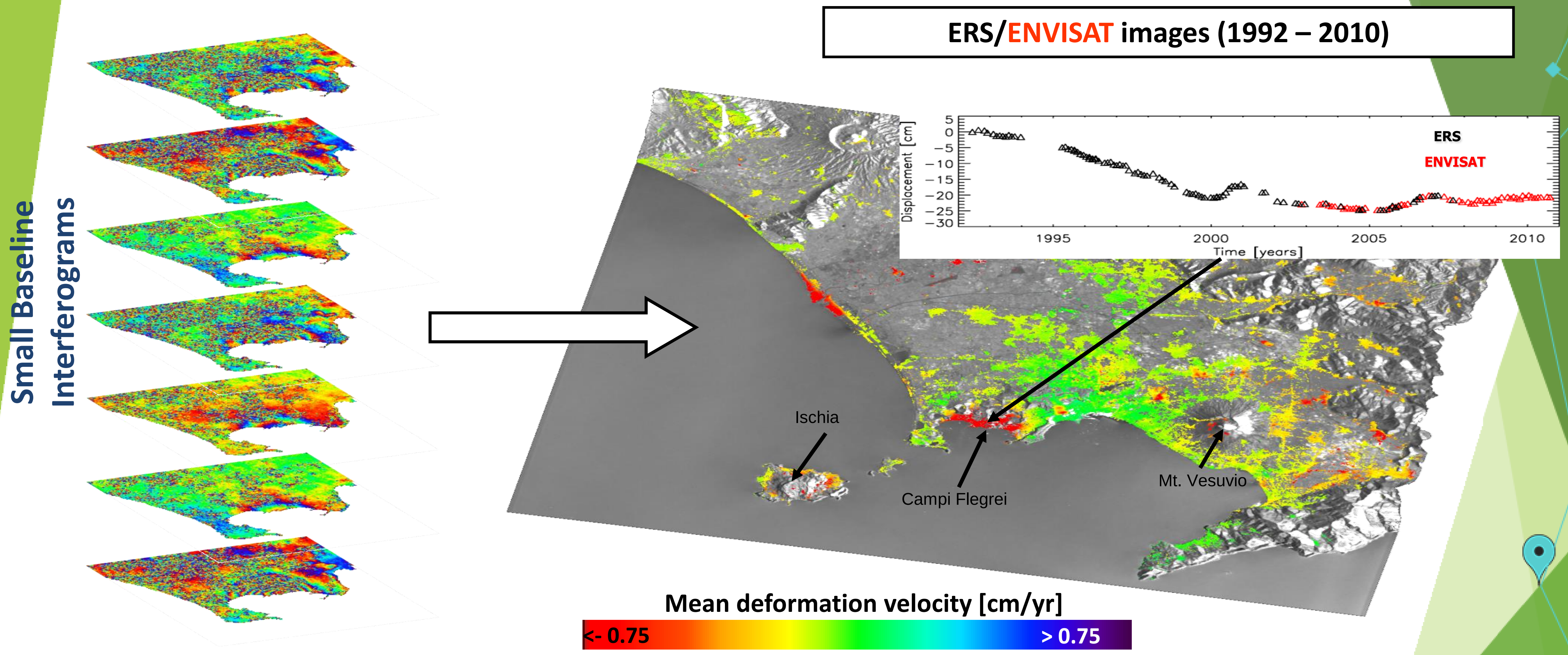
UrbanScape - CityGML

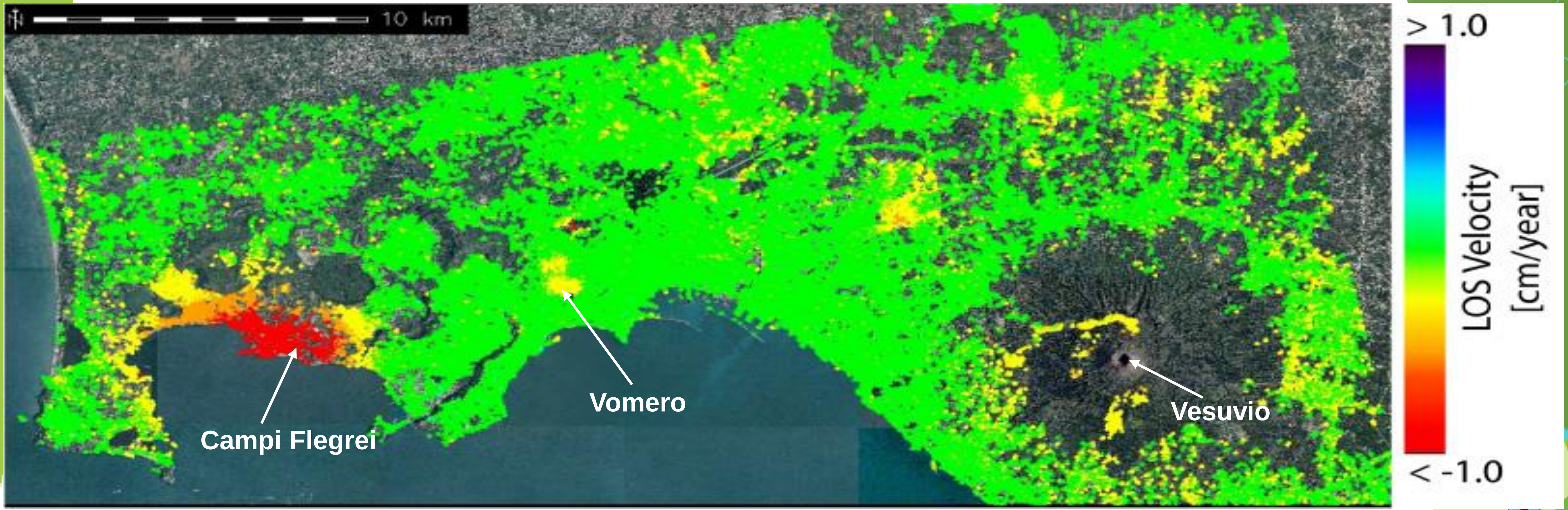
- **Focus**: city 3D model – implementation of extract-transform-load of spatial data, from topographic geodatabase to CityGML model
- New collaboration agreement between UR Padova with VSIX – “North East Neutral Access Point” for fast data transfer/access/process
- Online tool for ETL (Extract, Transform, Load) and sharing spatial data…
- http://217.146.204.139/sapps/zcitygml/

Online tool for ETL and sharing spatial data…

Example of Advanced DInSAR DATA



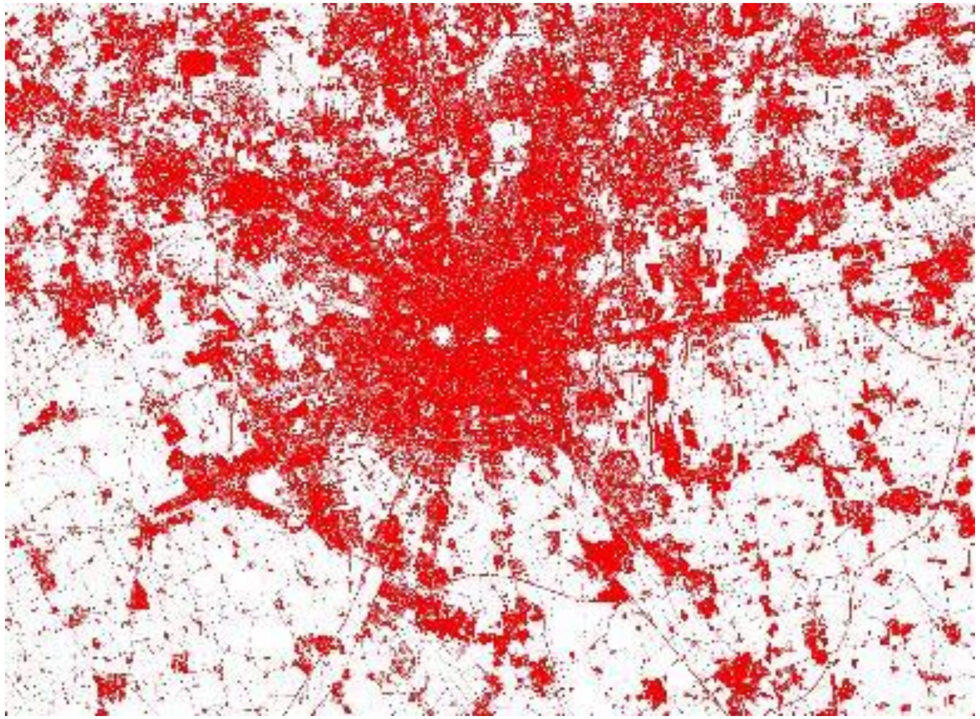
The Napoli Bay area



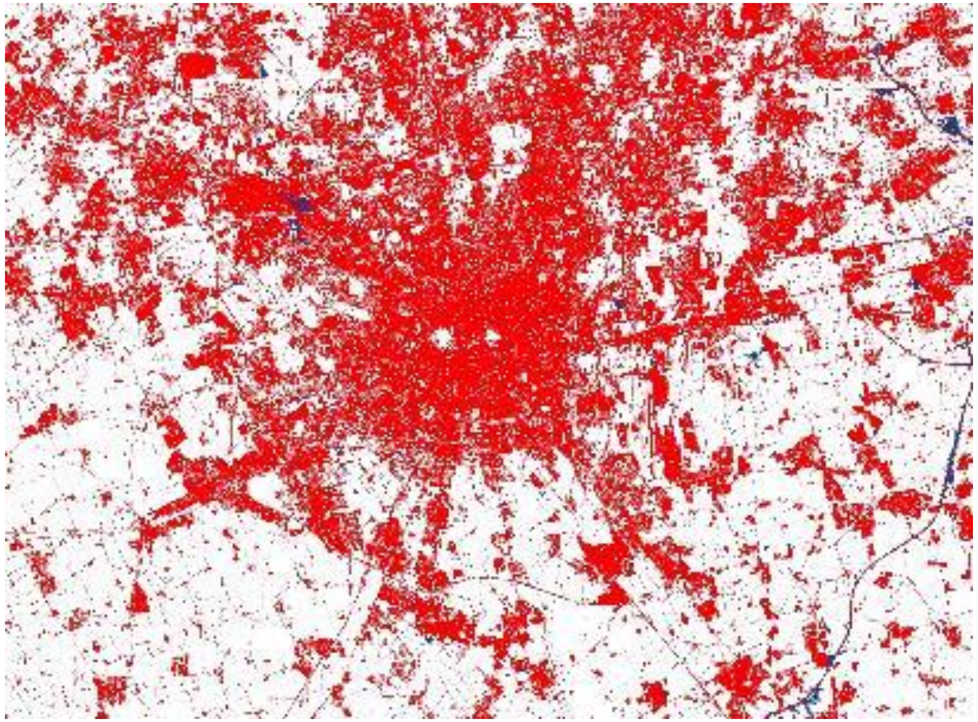
71 ERS-1/2 and 39 ENVISAT images acquired on ascending orbits (1993-2007)

197 ERS and 115 ENVISAT interferograms

Artificial land cover (soil consumption) classification and mapping



Classification 2012



Classification 2016 (changes in blue)

Mapping possible changes using Sentinel-2

Sentinel-2 images of 2016

Selection of images without shift issues

NDVI calculation for every image

Maximum NDVI calculation per pixel 2016

Sentinel-2 images of 2017

Selection of images without shift issues

NDVI calculation for every image

Maximum NDVI calculation per pixel 2017

Difference of max NDVIs (change if difference > 0,4)

Mapping possible changes using Sentinel-1

Sentinel-1 images of 2016

Selection of intensity images with polarization VV

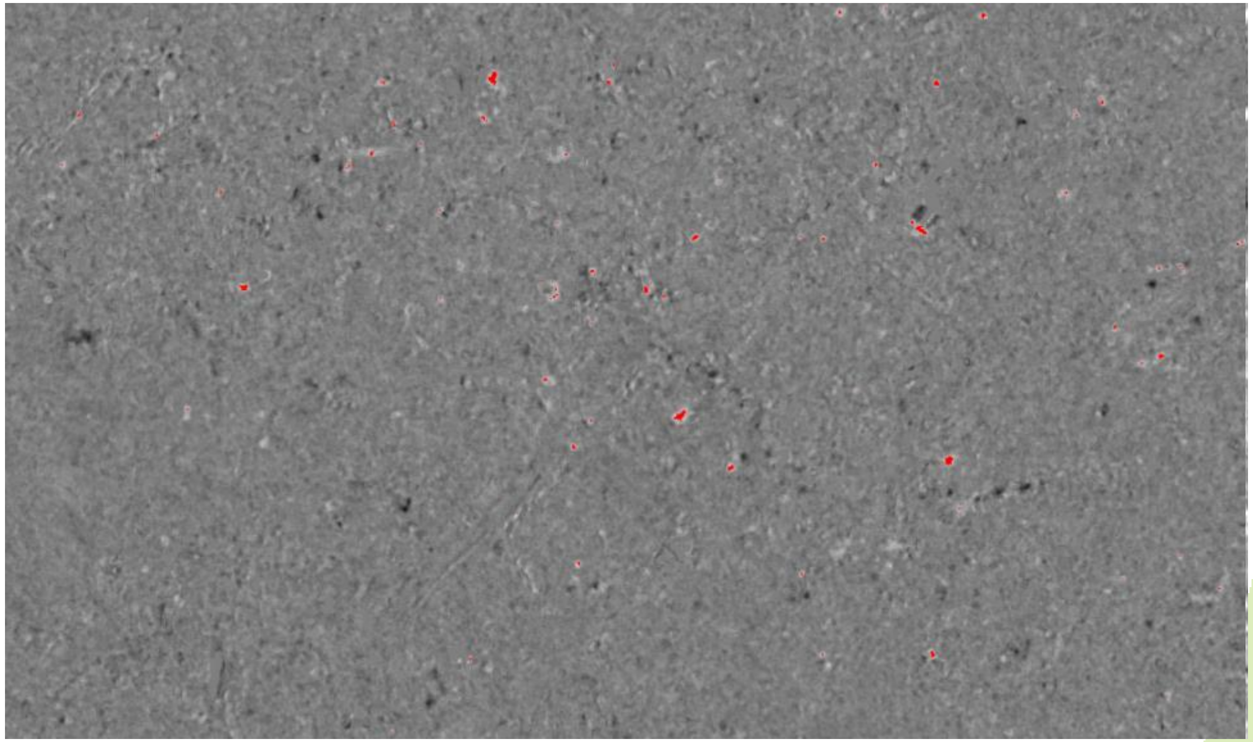
Calculation of the median per pixel

Sentinel-1 images of 2017

Selection of intensity images with polarization VV

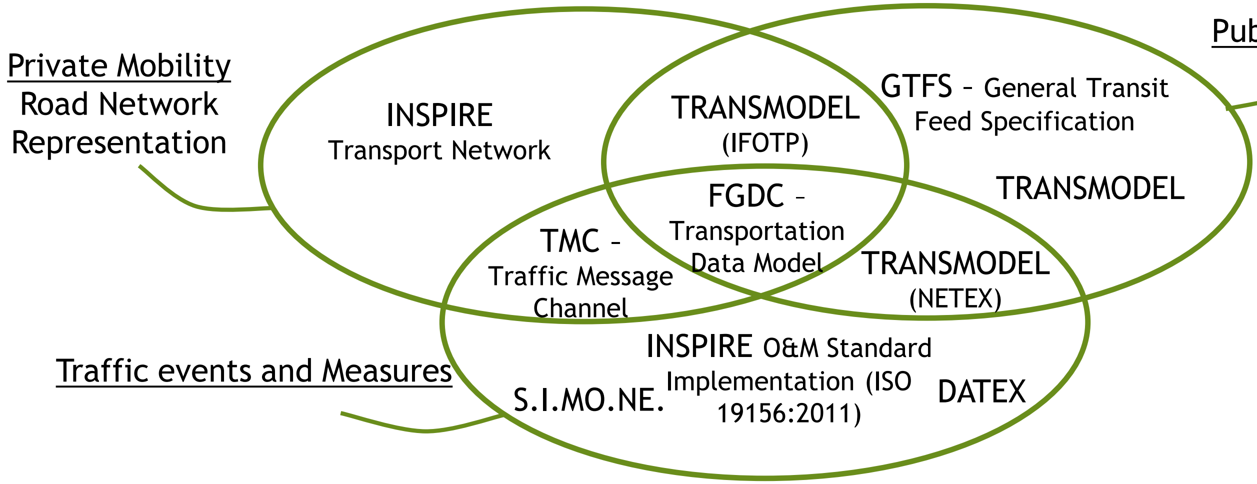
Calculation of the median per pixel

Difference of medians (change if difference > 5)



Spatial Data Model for Mobility Management

Main components and Standards analysis

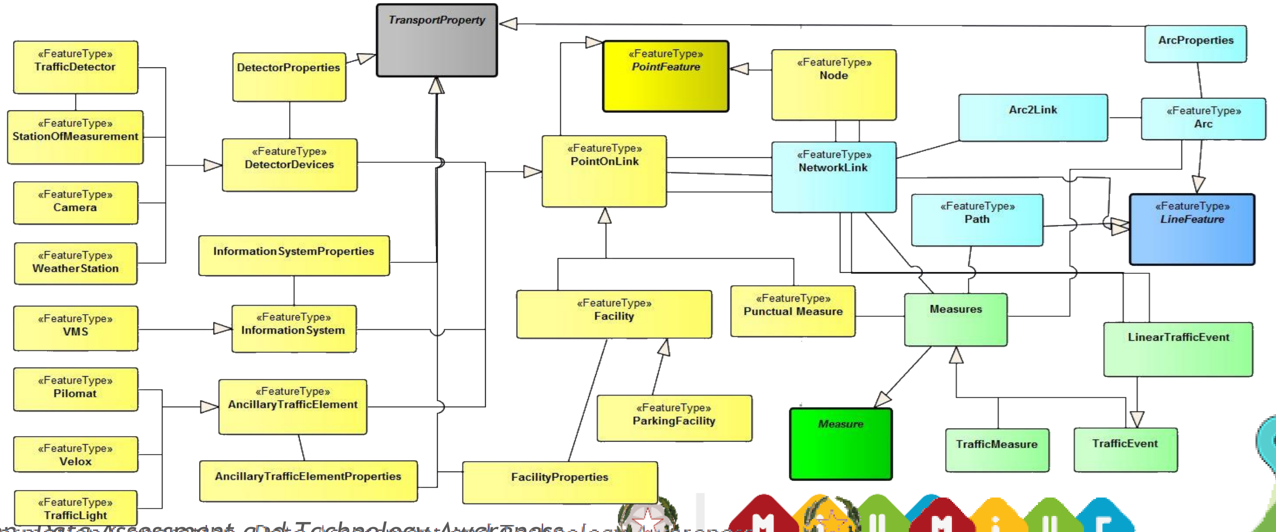


- Many standards to represent the road network elements;
- Many standards to represent the public transport elements (spatial and non-spatial aspects);
- Many standards for events and traffic measures management (spatial aspects and communication protocols);
- Lack of elements to spatial represent traffic detectors and other traffic ancillary elements.

Main results

A physical implementation tailored on 5T TOC of Turin, which allow visualization of available static elements and dynamic measures.

A logical data model, which can be applied to various mobility management contexts.



Further Developments

Restricted Access Area modelling

Implementation of Turin new strategy (extension of restricted access schedule, liberalization of the access to all vehicles via a fee payment + 2 hours of parking right).

Enabling factors: plate recognition + timestamp → need to reduce latency time in plate recognition

improve human efforts? deep learning for feature extraction? telepass or rfid technology?

Estimation of access fee: Modelling total cost of private mobility → Total costs = Owner cost + Collectivity costs

First results: 13 million of km driven in Turin area (owner cost = 8 million in a day).

450K of km driven in the Turin RAA (owner cost = 250 k in a day).

Connected vehicles

H2020 HPC proposal that aims to set up a test bed for connected vehicles, focused on proactive & early warning, in order to alert for preventive maintenance, emulated ECUs failure, etc. The HPC challenge:

- Real-time integration and processing of a continuous big data streams, supporting the driving environment and experience and providing information to assist driving and to guarantee car and people safety.
- HPC requirements, implementation and demonstration at one single location: generation of value added information (fully supported by HPC, being these flows big data) enabling new possible mobility services both from the driving environment point of view from the driving experience side.

Autonomous driving

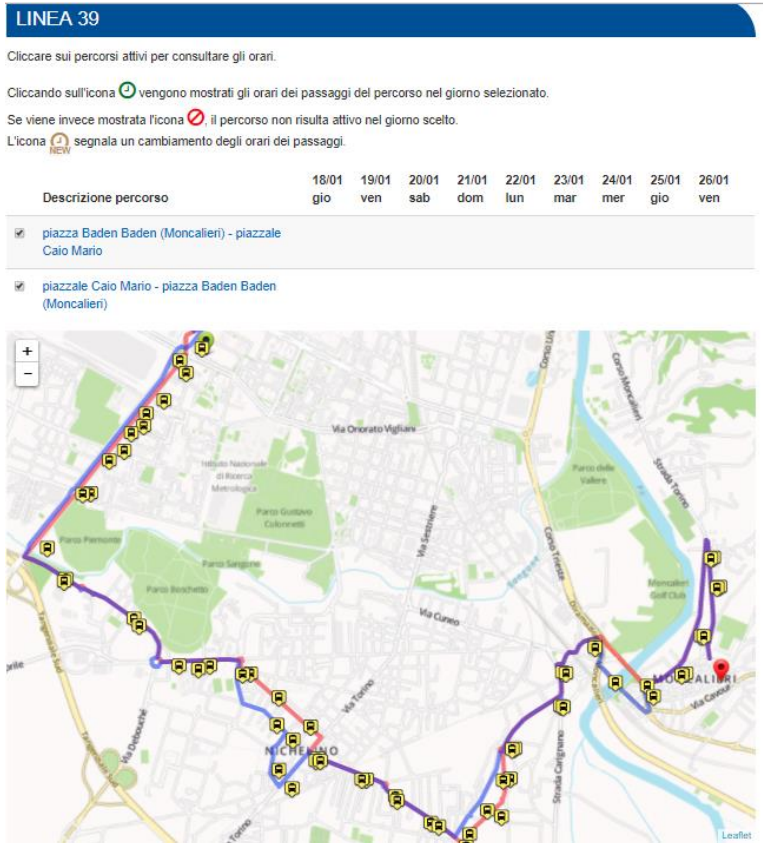
On Board Unit (OBU) and infrastructure connection, enabling new services such as “Electronic Horizon”.
Geospatial requirements: fully 3D model with a very high accuracy (derived from aerial/satellite stereo imageries) in order to allow real time matching between OBU (GPS + video camera) and 3D coordinates.

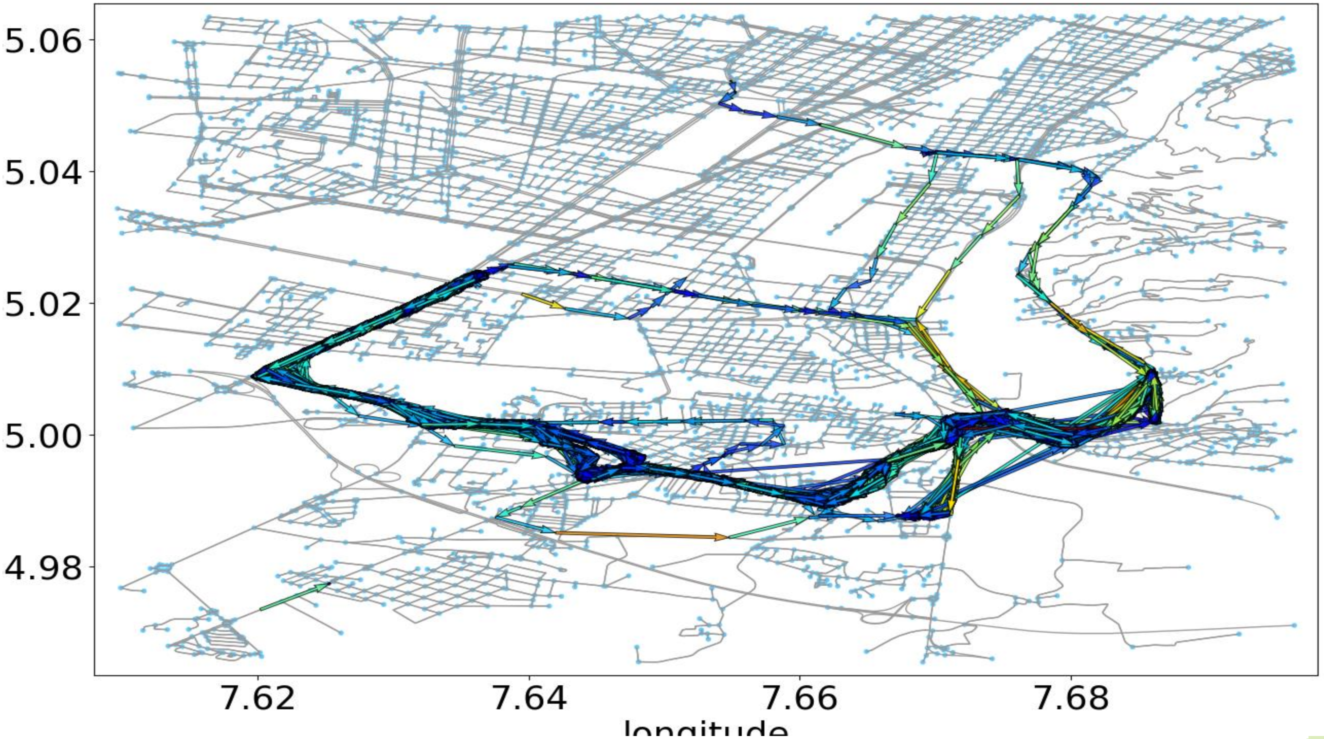
Floating Car Data: velocity analysis

- The **Floating Car Data** (**FCD**) of **Turin Public Transportation** system were acquired by every vehicle of the fleet through its On Board Unit in the **month** of **April 2017**, with a **variable time interval**
- The **FCD** are provided in the **CSV** format (2.19 GB, **30.000.000** records) and include the **geographical coordinates** along with a **set of attributes** (vehicle code, line code, turn, timestamp, etc.)
- The **FCD** were **organised** for **lines**, then for **vehicles** and finally they were **chronologically ordered**; for every line of the transportation network:
  - the *Vincenty* formula was used to compute the **planimetric displacement Δs** between **two positions** of the specific vehicle in two **consecutive time moments**
  - the **velocities** were computed as $v = \frac{\Delta s}{\Delta t}$
- The computed **velocities** were represented as **arrows** and plotted on top of the **Turin drive network graph**
- Before proceeding with the time analysis, the **outliers** were **removed** by eliminating all the records not statistically significant ($t > 99.5^{th}$ percentile & $t < 0.5^{th}$ percentile & $v > v_{mean}$)

Example: Line 39 velocities

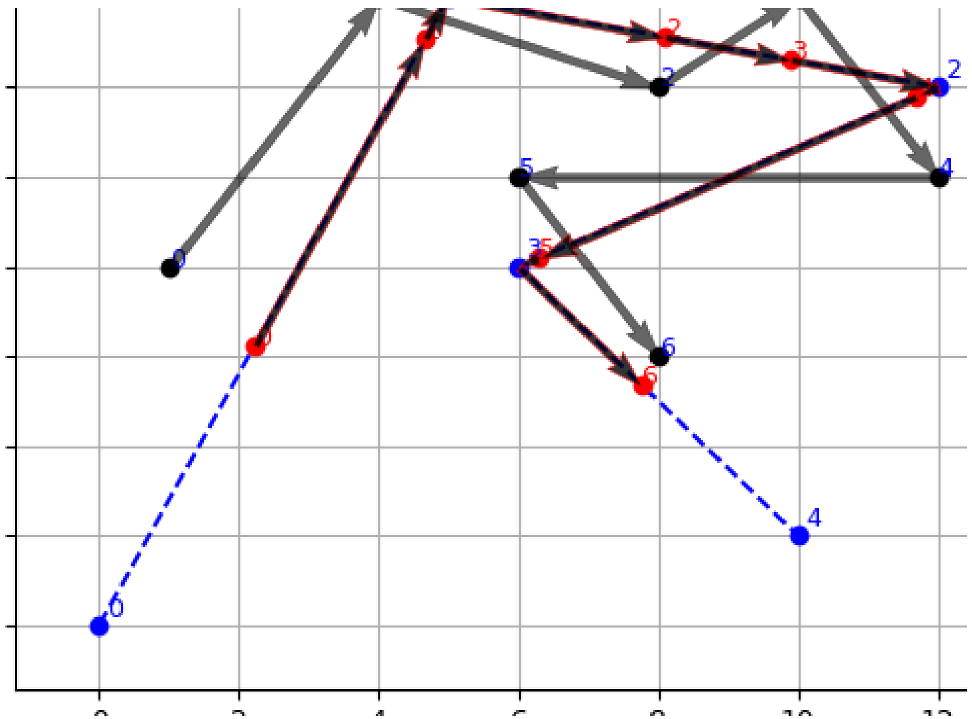
After the **outlier removal**, the reconstructed path follows more closely the actual line route: the **longest arrows**, probably due to the bus routes from and to the depot, are **eliminated**





Topological problem

- A **dedicated procedure was developed** to **assign** the **velocities** to the **line network topology**
- First tests on synthetic data



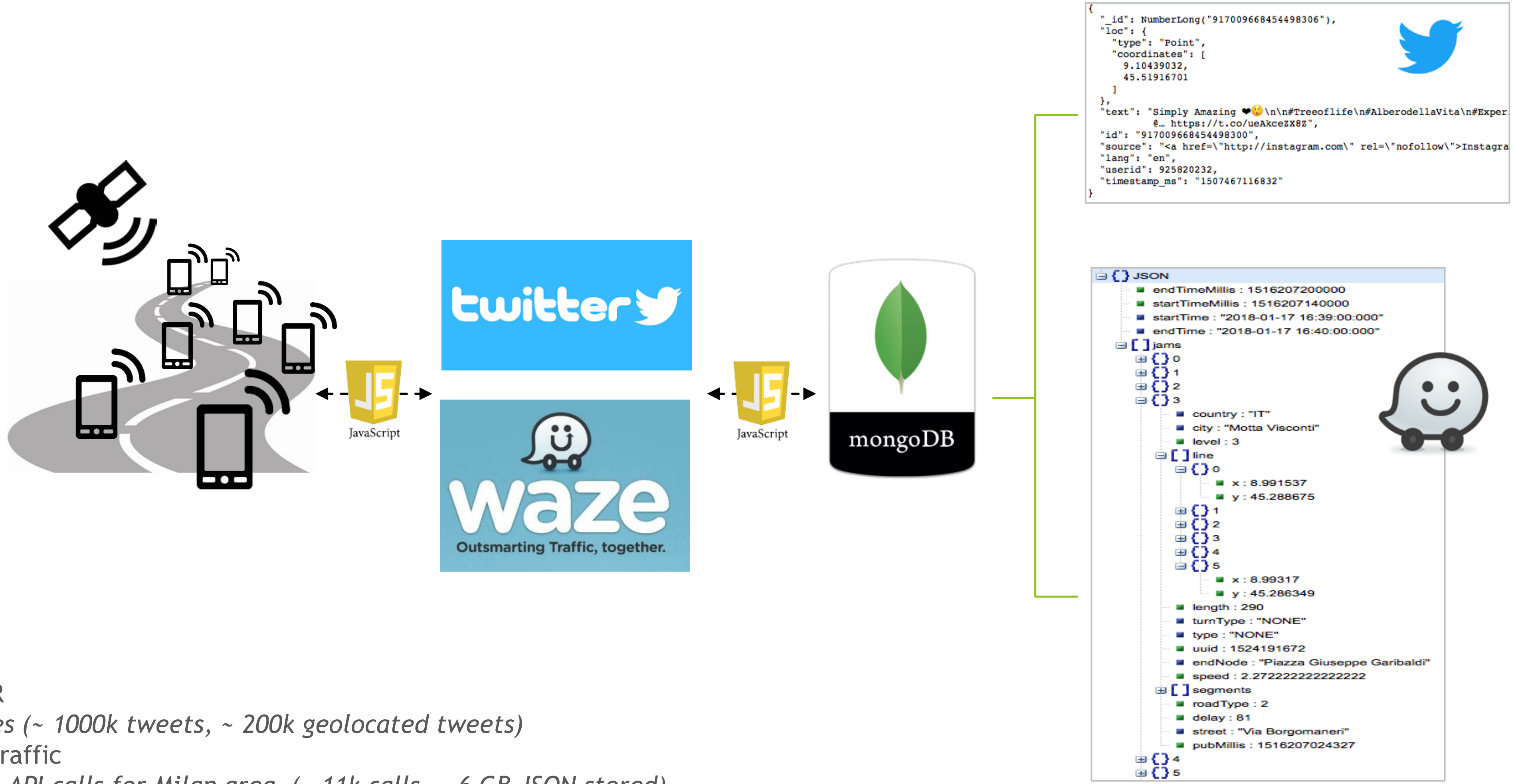
Conclusions and further developments

A **general methodology** able to **analyse** the huge amount of information contained in **Transport Big Data** has been developed

Necessary further developments:

- refine the outlier removal process in order to all the **velocities not referable** to the **actual path** of the **lines**
- to **test** the developed **topological procedure** on **all** the **velocity data**
- to **compute** the **impedence maps**

Crowdsourced data collecting and storing architecture



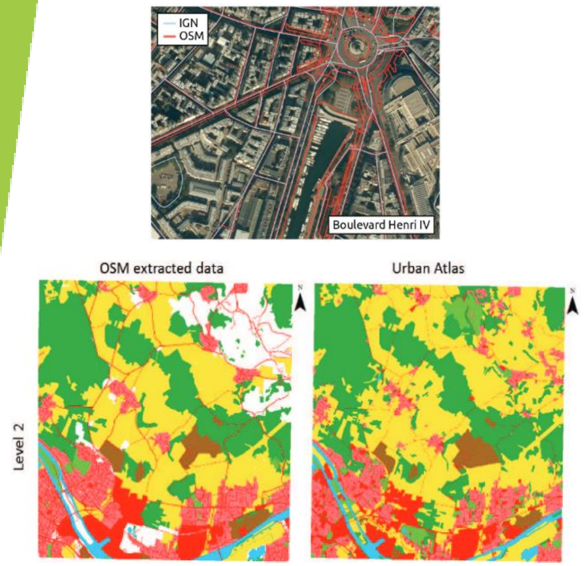
TWITTER

- *5 cities (~ 1000k tweets, ~ 200k geolocated tweets)*

WAZE - traffic

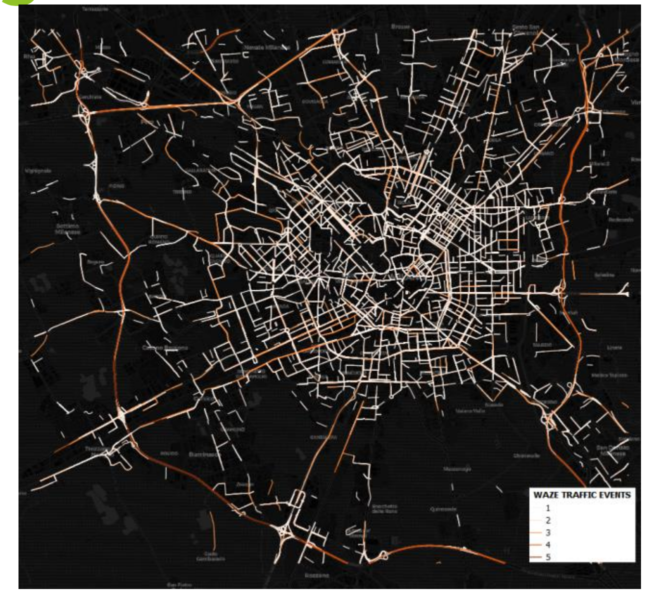
- *30min API calls for Milan area (~ 11k calls, ~ 6 GB JSON stored)*

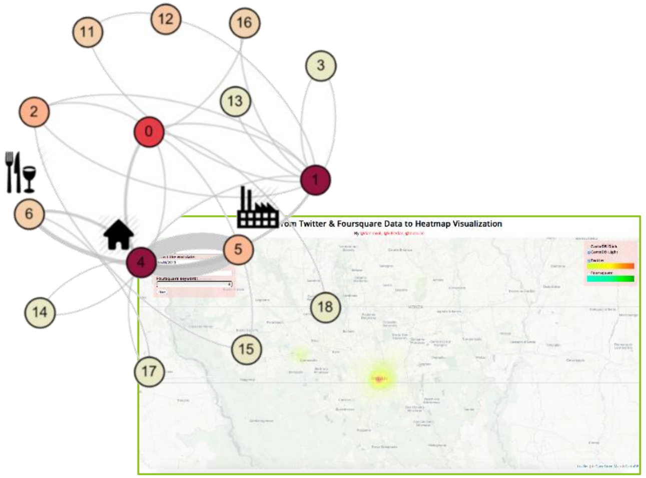
Data processing and analysis



- quality and accuracy check of OSM-derived data against authoritative data
- OSM-derived LULC and soil consumption maps

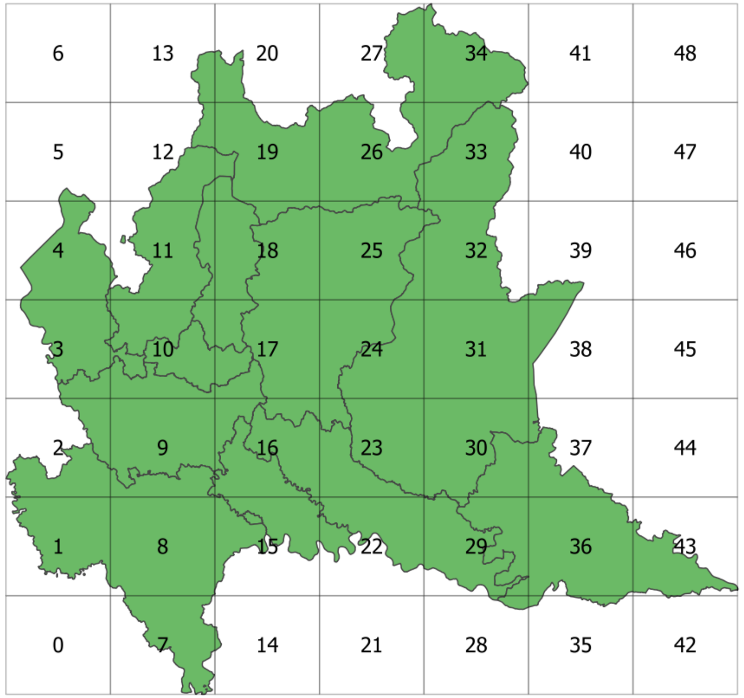
- Road network layers enrichment with crowdsourced mobility information and spatial/temporal pattern analysis





- Users-city spaces interaction and inter-city mobility demands investigation using social media data feeds

Positional Accuracy: mean and RMS of the distance between homologous pairs of OSM and the Authoritative Maps in case of building footprints



Building footprints in

- OSM
- Topographic Database DBT (scale: 1:1000→ 1:5000)

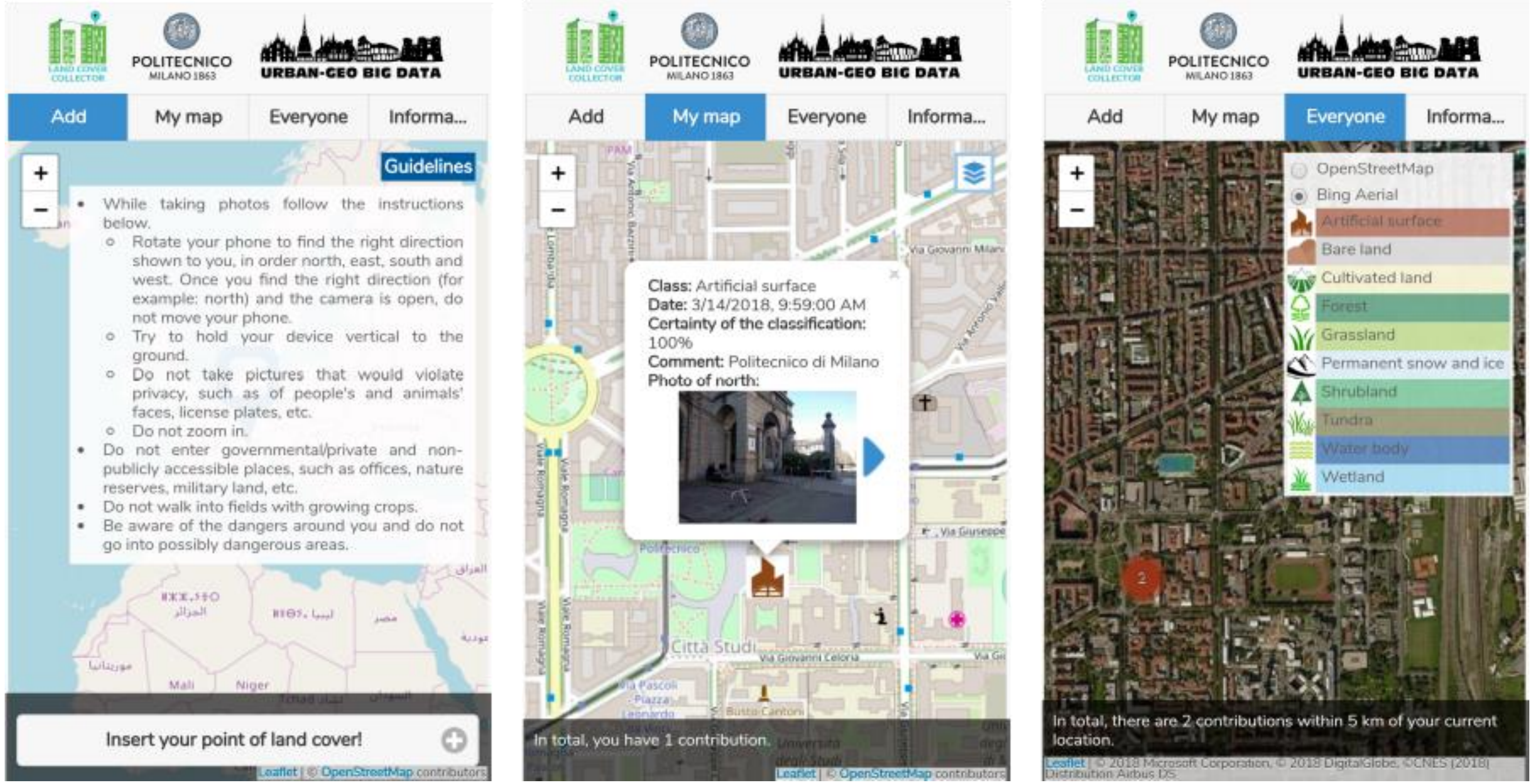
Area	DBT buildings	DBT points	OSM buildings	OSM points
23.844 Km^2	2794196	17604429	915696	7506851

TILE	Points	m(DX)	var(DX)	m(DY)	var(DY)	m(dist)	var(dist)	min(dist)	max(dist)	PtiDBT%)	PtiOSM(%)
1	2359	0,588	2,070	-0,151	1,644	1,669	1,296	0,014	7,340	84,6	44,7
2	33540	-0,107	1,549	-0,560	1,532	1,465	1,261	0,000	6,634	72,8	23,6
3	372232	-0,118	1,992	-0,645	1,599	1,680	1,200	0,000	6,841	83,5	48,9
4	152706	0,015	2,753	-0,817	2,414	2,076	1,526	0,000	7,159	82,3	37,2
5	1366	-0,544	1,988	-0,547	1,836	1,776	1,264	0,022	6,673	80,5	35,9
7	117271	0,542	2,836	-0,344	2,168	1,999	1,420	0,000	7,361	75,1	62,6
8	170223	-0,013	1,670	-0,348	1,107	1,363	1,039	0,000	6,704	79,6	70,8
9	354194	0,235	1,585	0,024	1,689	1,430	1,285	0,000	6,701	79,5	44,9
10	568039	0,229	2,285	-0,375	2,318	1,770	1,664	0,000	6,798	77,6	40,0
11	128766	-0,019	2,740	-0,751	2,927	2,075	1,925	0,000	7,318	77,9	34,6
12	27452	0,556	4,112	-0,970	3,667	2,539	2,580	0,014	7,906	78,0	40,1
13	2394	-0,252	3,270	-0,898	1,583	2,054	1,503	0,010	6,780	87,8	47,9
15	18347	0,215	1,388	-0,671	1,697	1,486	1,374	0,000	6,621	85,6	40,1
16	179028	0,070	1,490	-0,803	2,420	1,706	1,651	0,000	7,469	83,4	53,3
17	216559	0,325	2,656	-0,689	2,364	1,979	1,682	0,000	7,089	83,4	40,9
18	43736	-0,060	2,871	-0,776	2,765	2,076	1,933	0,000	7,460	82,4	21,7
19	72066	0,319	3,183	-0,514	2,027	1,998	1,583	0,000	6,857	82,4	39,9
20	1684	0,763	3,136	-0,234	2,407	2,147	1,570	0,051	6,862	85,6	39,6

TILE	Points	m(DX)	var(DX)	m(DY)	var(DY)	m(dist)	var(dist)	min(dist)	max(dist)	PtiDBT%)	PtiOSM(%)
22	20574	0,678	2,247	-0,214	1,654	1,597	1,854	0,000	7,312	78,6	42,4
23	34975	0,162	2,760	-0,780	3,646	2,216	2,129	0,000	7,784	78,7	50,1
24	133993	0,535	2,839	-1,254	3,324	2,436	2,085	0,000	7,641	81,5	42,3
25	17660	0,413	3,458	-0,739	3,309	2,395	1,747	0,010	7,567	83,1	36,2
26	52071	-0,281	3,291	-0,766	2,726	2,200	1,842	0,000	7,511	79,0	43,9
27	7840	0,559	4,841	-0,399	3,259	2,593	1,846	0,022	7,048	86,5	54,4
28	246	1,326	1,605	-0,228	0,980	1,836	1,019	0,054	7,112	80,4	51,7
29	5998	0,293	4,094	0,390	1,873	2,133	1,657	0,010	6,742	81,0	53,9
30	58863	0,406	3,169	-1,105	4,635	2,606	2,396	0,000	8,034	82,4	37,8
31	128898	0,578	3,696	-0,742	3,575	2,457	2,118	0,000	7,734	78,2	42,7
32	26561	0,427	4,010	0,270	2,987	2,343	1,761	0,014	8,081	81,4	50,1
33	15751	-0,253	2,943	-0,411	3,116	2,151	1,664	0,010	6,789	82,3	38,5
34	12746	-0,428	3,268	-0,460	3,291	2,304	1,645	0,014	7,562	85,0	38,5
35	109	-0,338	1,934	-0,114	1,044	1,342	1,287	0,000	5,237	58,3	0,9
36	21747	-0,214	2,473	0,131	2,078	1,761	1,513	0,000	6,427	71,0	35,5
37	6568	-0,330	3,765	0,961	2,611	2,381	1,739	0,022	8,133	79,1	47,9
38	11646	0,847	4,405	-0,037	2,632	2,413	1,931	0,000	9,533	76,6	40,3
39	2697	0,051	4,670	0,759	1,685	2,275	1,759	0,051	8,162	80,8	41,1
43	932	1,243	4,709	-0,128	1,405	2,227	2,713	0,000	8,623	59,1	1,8

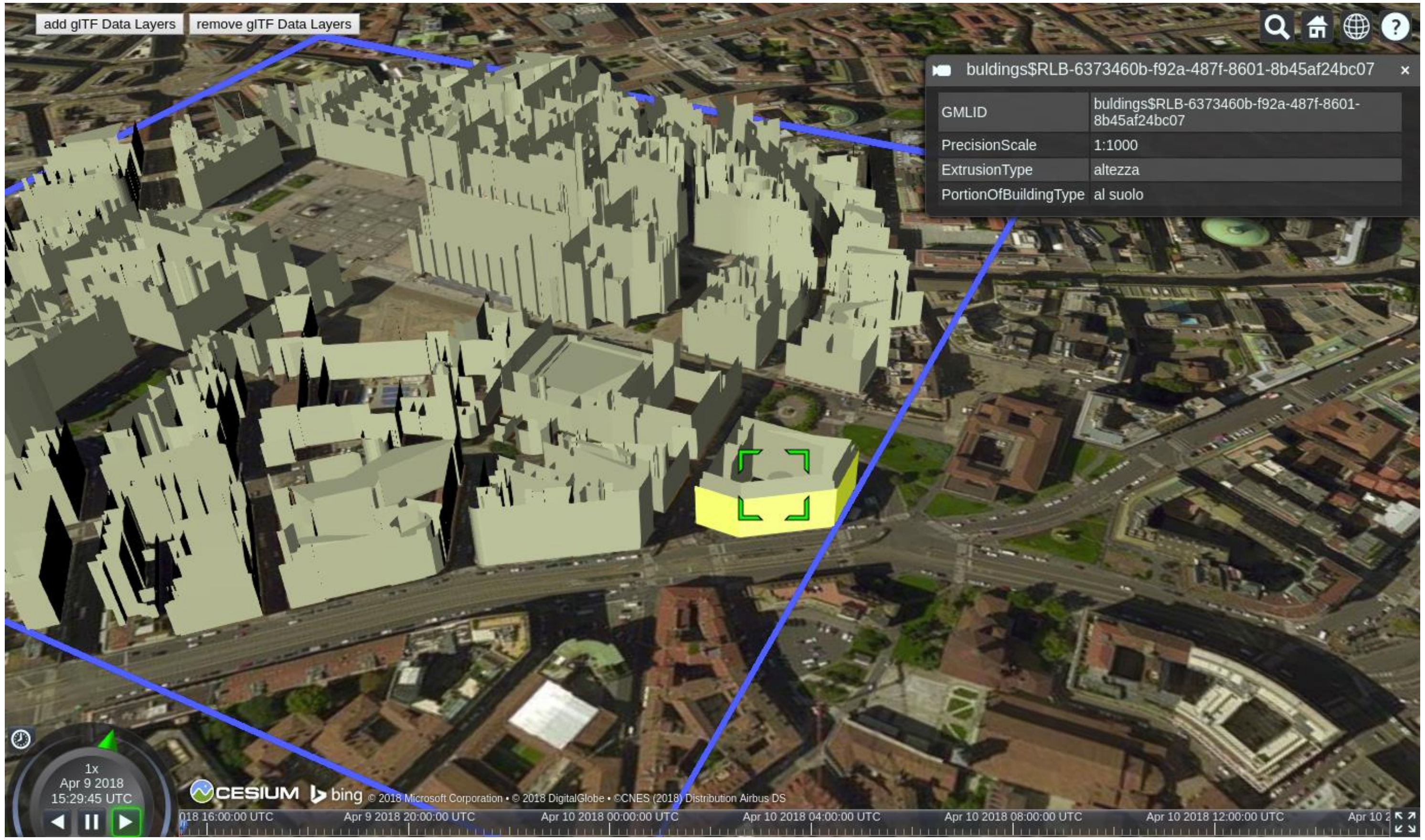
Land Cover Collector

- Crowdsourcing application available on browsers (https://landcover.como.polimi.it/collector/, so far tested on Google Chrome and Mozilla Firefox), and as Android and iOS applications (cross-platform).
- Data is stored in a NoSQL database, CouchDB, which in need can be set up to be distributed to support big data.
- The collected data will also be embedded in the 3D viewer.



3D City

- shapefile → CityGML (by University of Padova)
- CityGML → gltF (by 3D City Database Importer/Exporter)
- glTF in 3DCityDB-Web-Map-Client and Cesium virtual globe

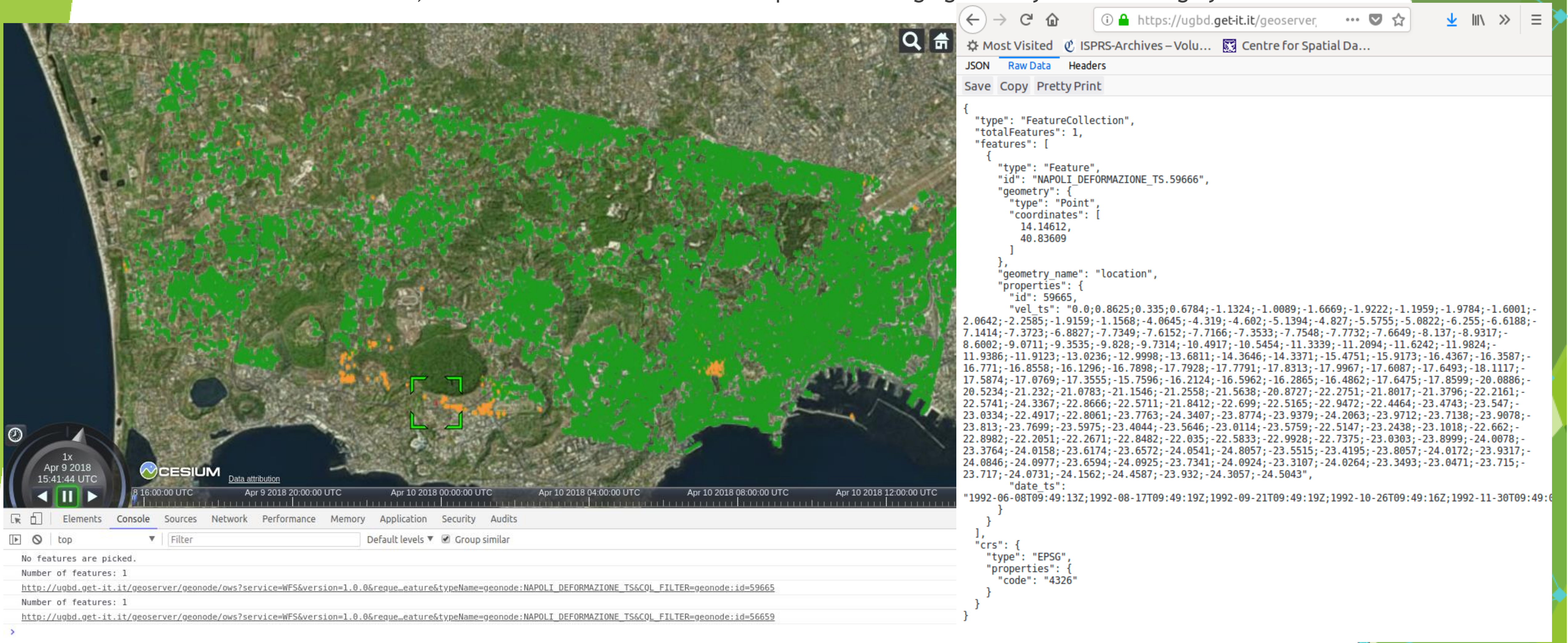


3D Buildings

- Using the plugin API developed for NASA Web WorldWind in 2017 GSoC project. Individual buildings' height can be set in different ways: manually (using LiDAR data and a suitable GIS software, editing GeoJSON), the height available in OSM can be used, the same value can be assigned to all. Find more info at https://github.com/kilsedar/3dosm.

Naples Displacement Map

- GeoServer and WMS is used, with GetFeatureInfo available to plot the changing velocity values through years.

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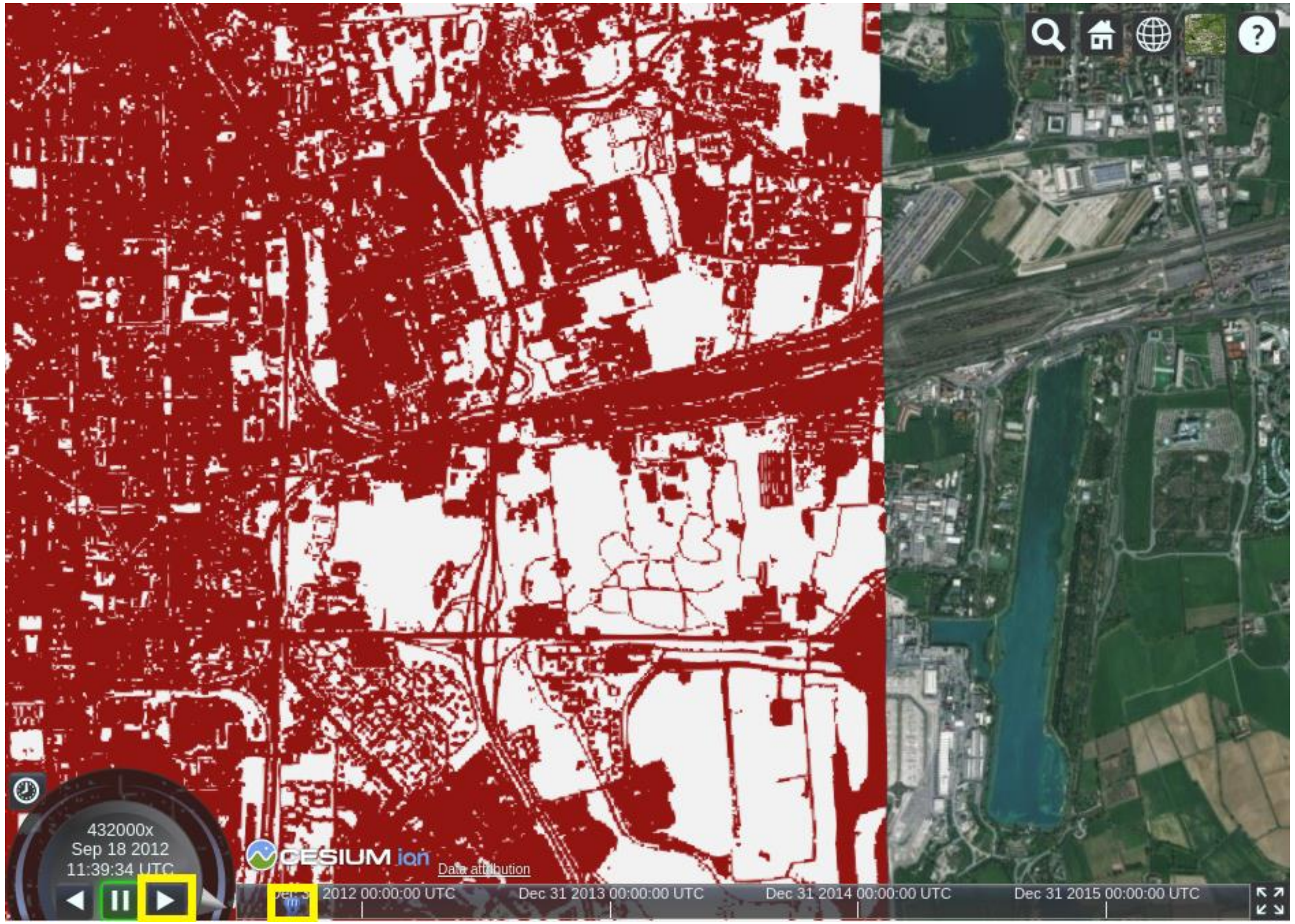
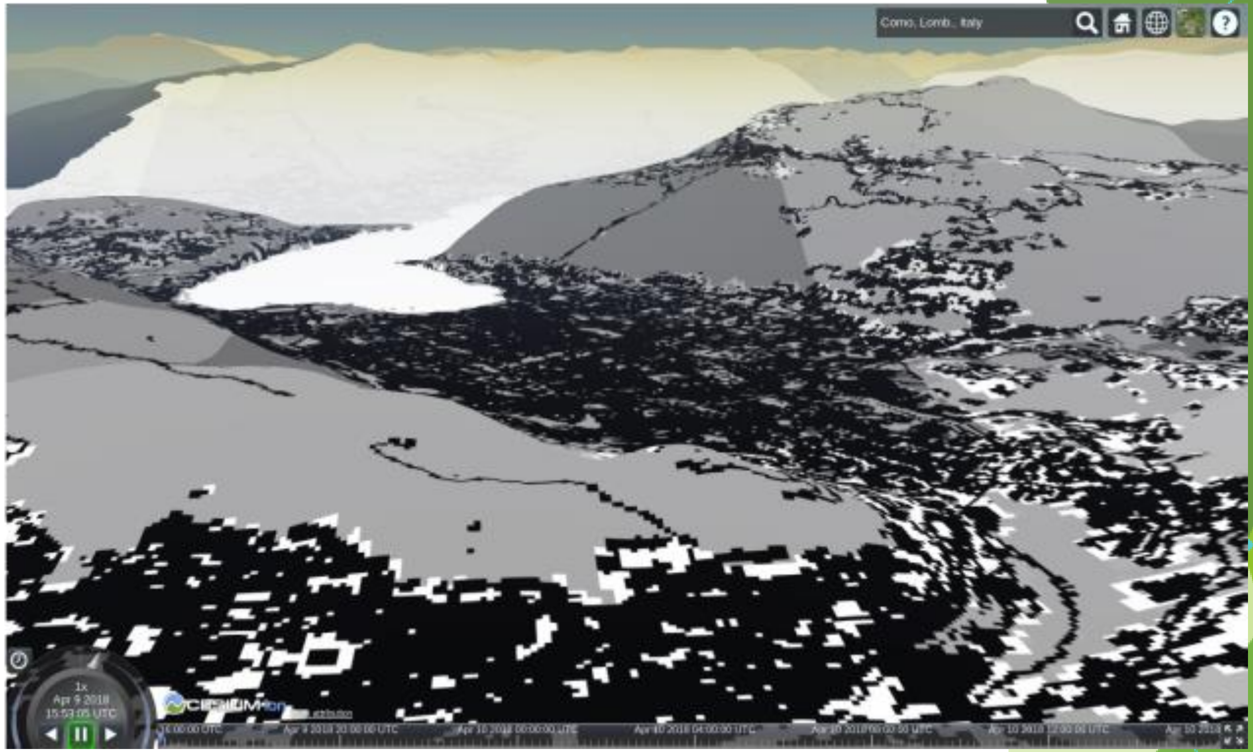
Big raster data of soil consumption

- WMTS with Time is implemented in GeoServer, animated using Cesium.
- Click on play button or move the cursor to animate the imagery through years. Watch the video at https://youtu.be/V94HpGhdCIE. It is also being implemented for Naples Displacement Map.



Big raster data of soil consumption

- Devoleped using WMTS (Web Map Tile Service), available in GeoServer. Style will be applied with a legend for multiple datasets.



- rasdaman (raster data manager) will be used to access and analyze parts of big data on the client side through WCPS queries. (e.g. difference of soil consumption between years for a specific region)

URBAN-GEO BIG DATA

PRIN PROJECT: *URBAN GEOmatics for Bulk Information Generation, Data Assessment and Technology Awareness*

Workshop on Volunteered Geographic Information

CNR, 16/04/2018

Thank You!

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