Applications of AI in urban data spaces - the USAGE EU project -

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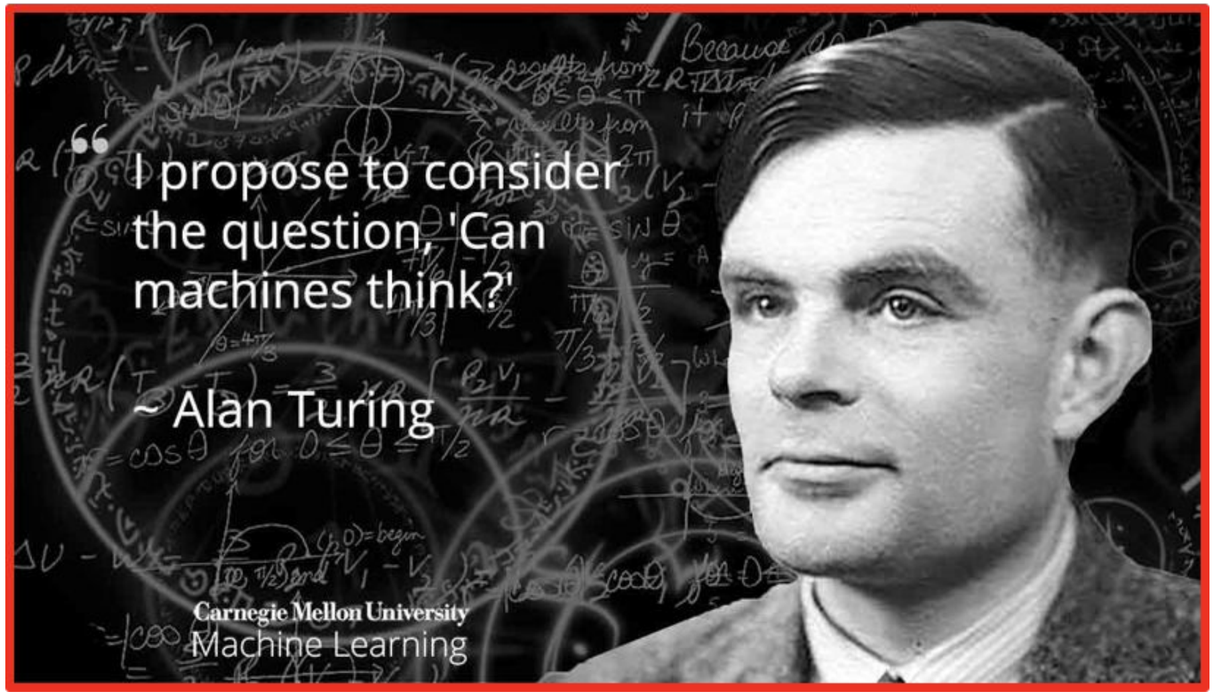
and contributions from the entire USAGE EU project

The EU USAGE project (2022-2025)

- Urban Data Space for Green Deal
- Call HORIZON-CL6-2021-GOVERNANCE-01-17 (IA)
- Support the implementation of the EU strategy for data and European Green Deal priority actions fostering the use of geospatial data and AI solutions
- 4 pilot cities: Ferrara (Italy), Graz (Austria), Leuven (Belgium), Zaragoza (Spain)
- https://www.usage-project.eu/

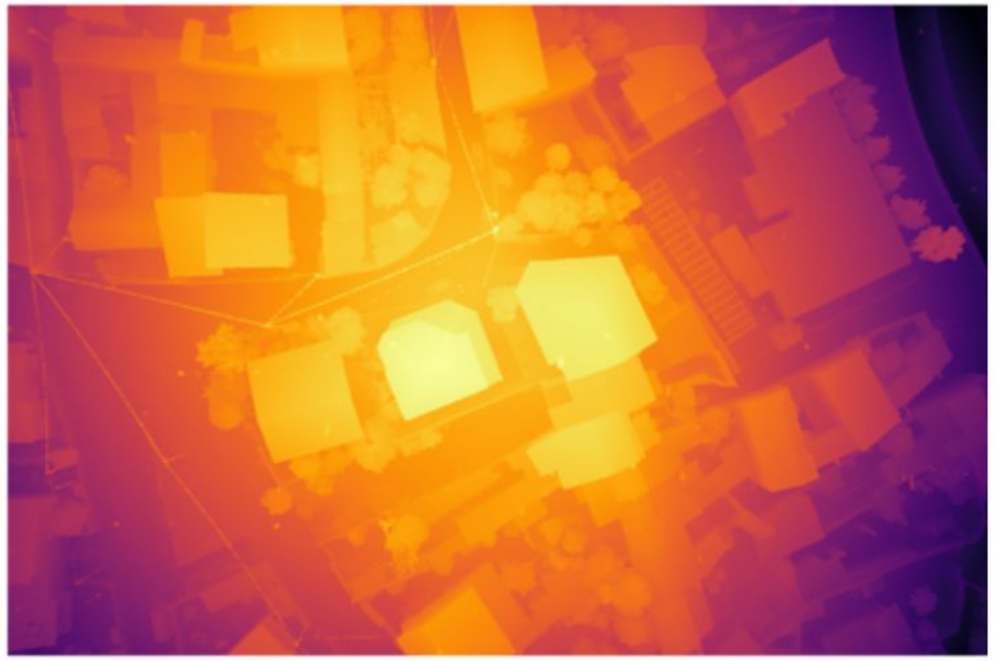
AI ….what?

- Artificial Intelligence or Absence of Intelligence?
- Sometimes used as a **Black Box**, sometimes you get lost into the **Black Box**
- Lack of explainability, replicability and generalization
- We need to move towards an Intelligent use of AI



AI for geospatial data

- Dream: extract meaningful information (2D or 3D) from geodata better and faster than humans
- Current: for *radiometric* data still not faster than human but for *geometric* data machines / algorithms are almost unbeatable



AI for geospatial data

- Image colorization
- Image segmentation / classification
- Tie points extraction / Image triangulation
- 3D reconstruction (monocular, stereo/MVS, NeRF)
- DSM inpainting / editing / cleaning / super-resolution
- Point cloud segmentation / classification
- Orthophoto correction
- Photovoltaic panel identification / counting
- Urban heat island prediction
- Detection of building footprints
- Tree identification / counting
- etc.

AI for image colorization

- Historical aerial images: AI to restore colors and improve interpretation and understanding
- Hyper-U-NET (https://github.com/3DOM-FBK/Hyper_U_Net)

[Farella, E.M., Malek, S., Remondino, F., 2022: ***Colorizing the past: Deep learning for the automatic colorization of historical aerial images***. Imaging, 8, 269]

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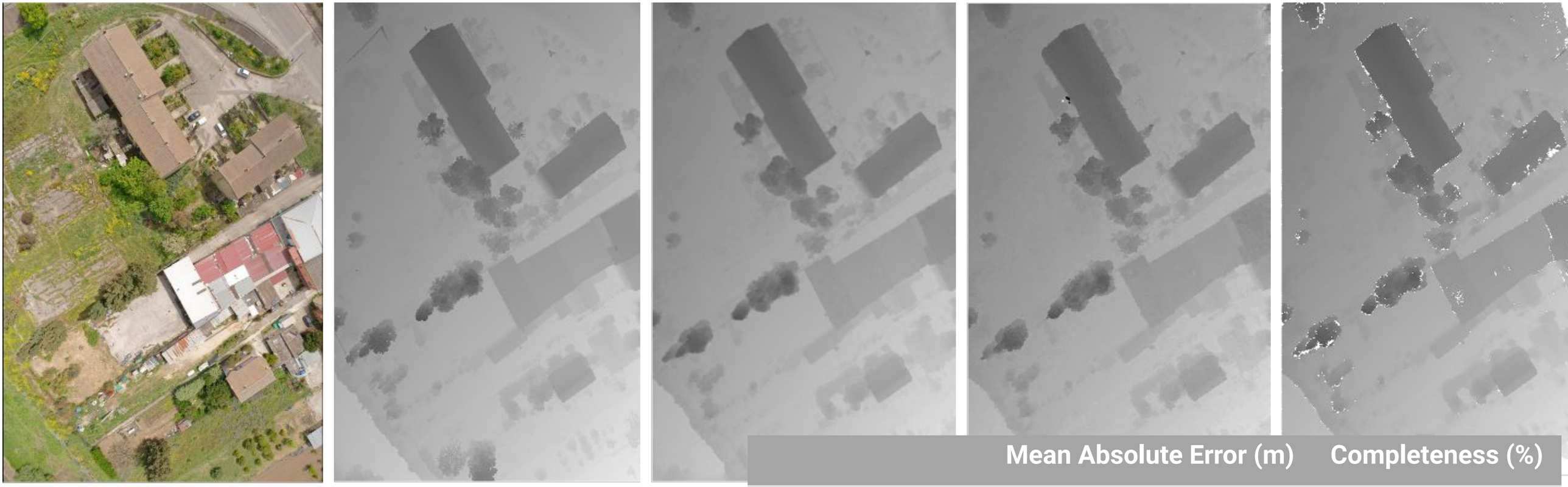
AI for Multi-View Stereo (MVS) 3D reconstruction

- Learning-based MVS methods complementary (?) to conventional approaches

UAV | LiDAR GT | MVSFormer | Unimvs | Conventional (SGM)



	Mean Absolute Error (m)	Completeness (%)
MVSFormer	0.48	98
Unimvs	0.485	97
Conventional	0.35	94

[Nex, F., Zhang, N., Remondino, F., Farella, E.M., Qin, R., Zhang, C., 2023. ***Benchmarking the extraction of 3D geometry from UAV images with deep learning methods.*** ISPRS Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLVIII-1/W3-2023.]

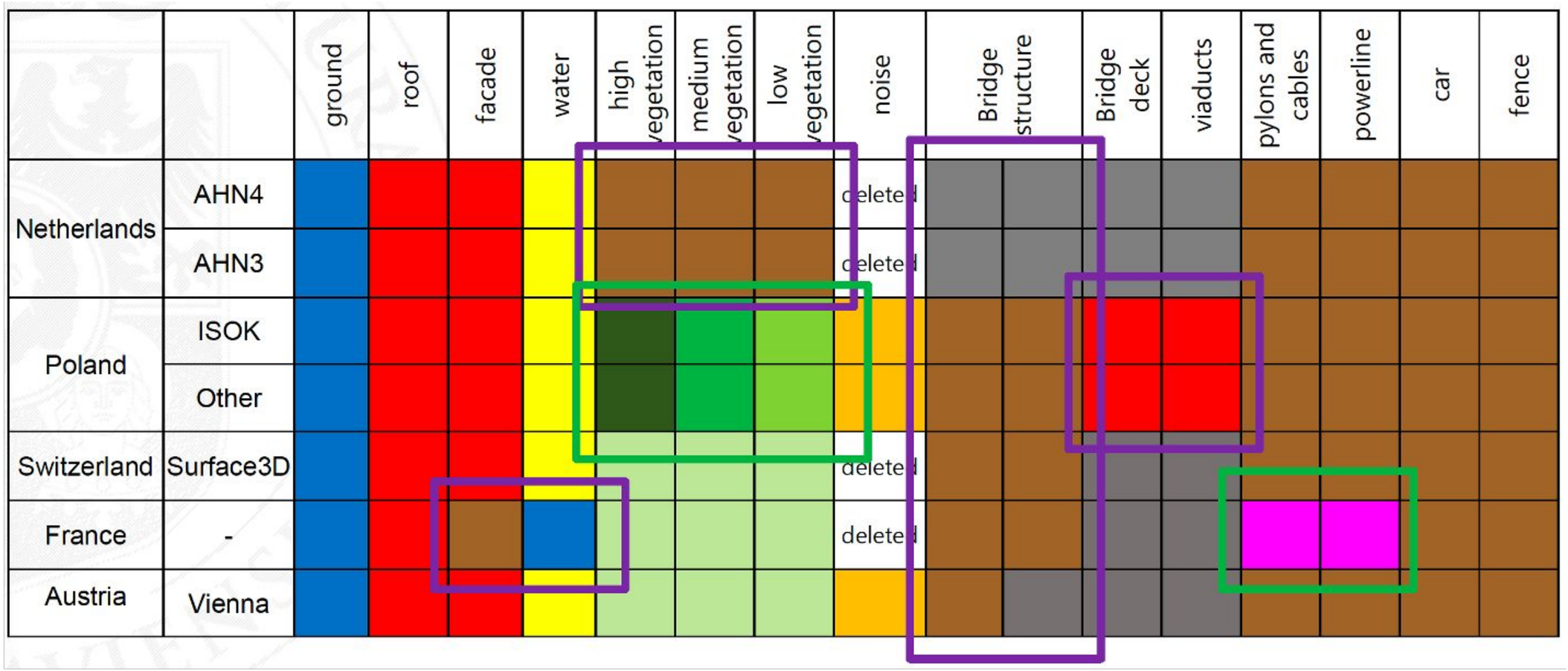
AI for point cloud segmentation / classification (1/2)

- Lack of generalization
- No standards in classes definition

Name	Reference	Year	Classes	Points (mil)	Spatial Size (m^2)	RGB	Sensor
ISPRS	Niemeyer et al. (2014)	2012	9	1.2	1.6×10^5	No	ALS / LiDAR
DublinCity	Zolanvari et al. (2019)	2019	13	260	2×10^6	No	ALS / LiDAR
DALES	Varney et al. (2020)	2020	8 (9)	505	10×10^6	No	ALS / LiDAR
LASDU	Ye et al. (2020)	2020	5	3.12	1.02×10^6	No	ALS / LiDAR
Campus3D	Li et al. (2020)	2020	24	937	1.58×10^6	Yes	UAV Photo
SensatUrban	Hu et al. (2022)	2020	13 (31)	2847	7.64×10^6	Yes	UAV Photo
Swiss3DCities	Can et al. (2021)	2021	5	226	2.7×10^6	Yes	UAV Photo
Hessigheim 3D	Kölle et al. (2021)	2021	11	73	8×10^4	Yes	UAV LiDAR
STPLS3D	Chen et al. (2022)	2022	6 (18)	-	6×10^6	Yes	Synthetic + UAV Photo
HRHD-HK	Li et al. (2023)	2023	7	273	9×10^6	Yes	UAV Photo

AI for point cloud segmentation / classification (2/2)

- Lack of generalization
- No standards in classes definition (task force for NMCAs?)



[Walicka, A., Pfeifer, 2023: ***Classification of point clouds for transnational data***. EuroSDR Workshop on Point Cloud Processing, Stuttgart, Jan 2023]

AI for solar panel identification (1/2)

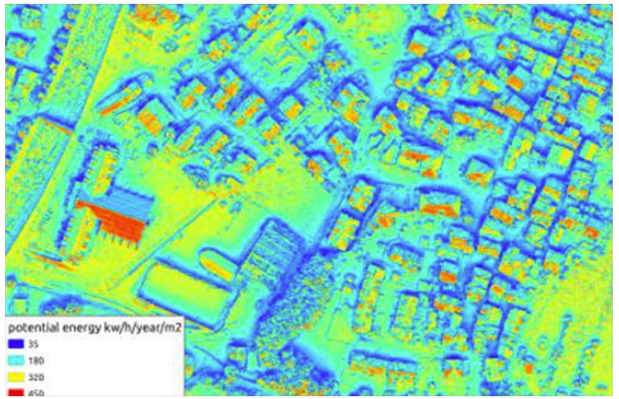
- Identification of existing solar panels to better estimate PV potential of buildings / ground

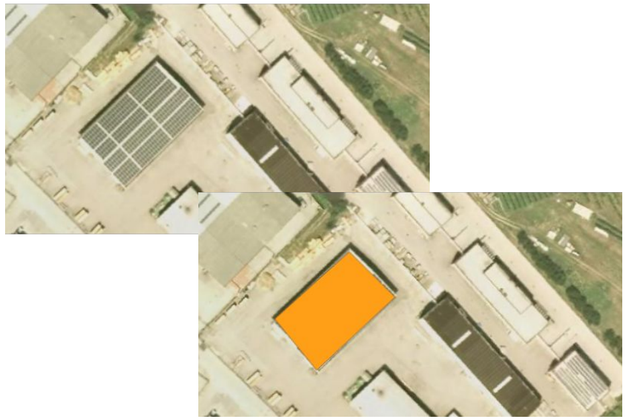
PV potential estimation using geospatial data and geometric methods

AI-based identification of the already installed PV panels

visibility analyses, DSM, vector data, municipal boundaries, buildings and other area of interest)

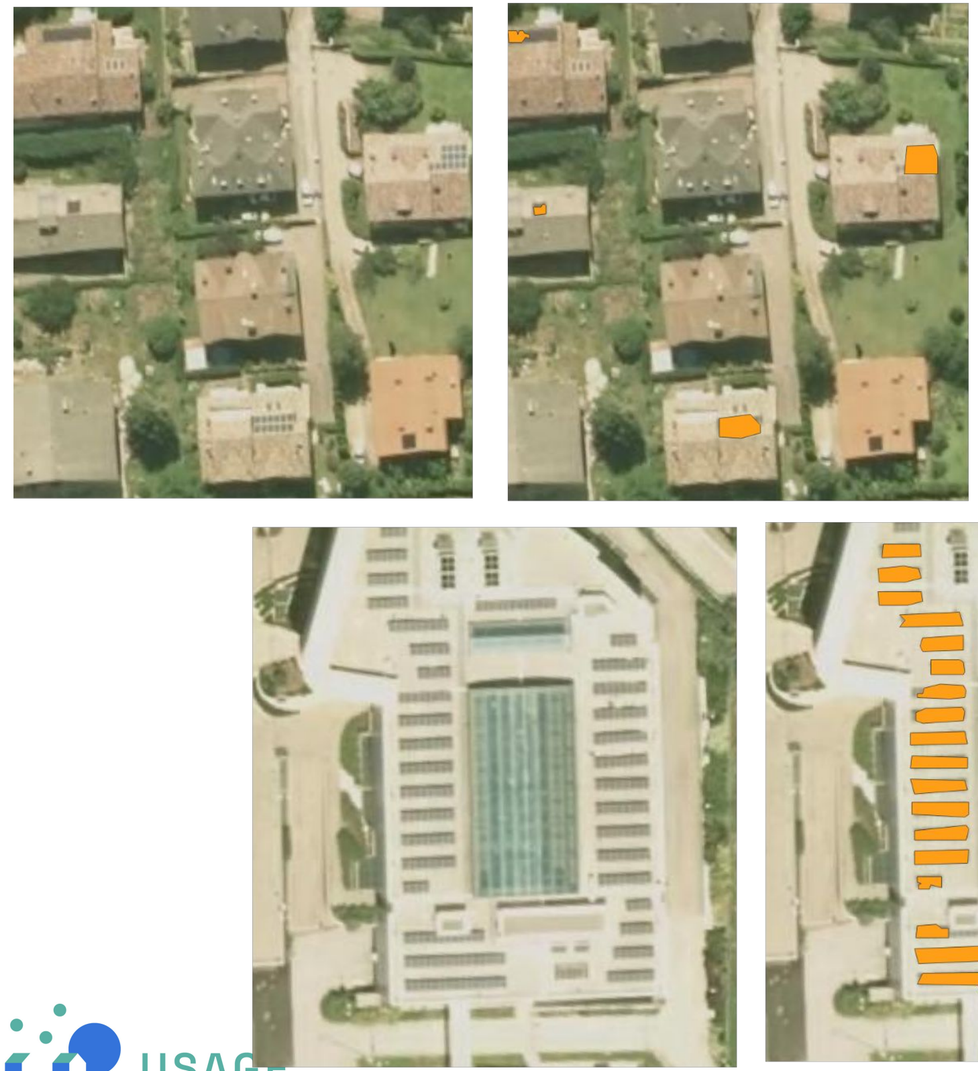
Orthophoto

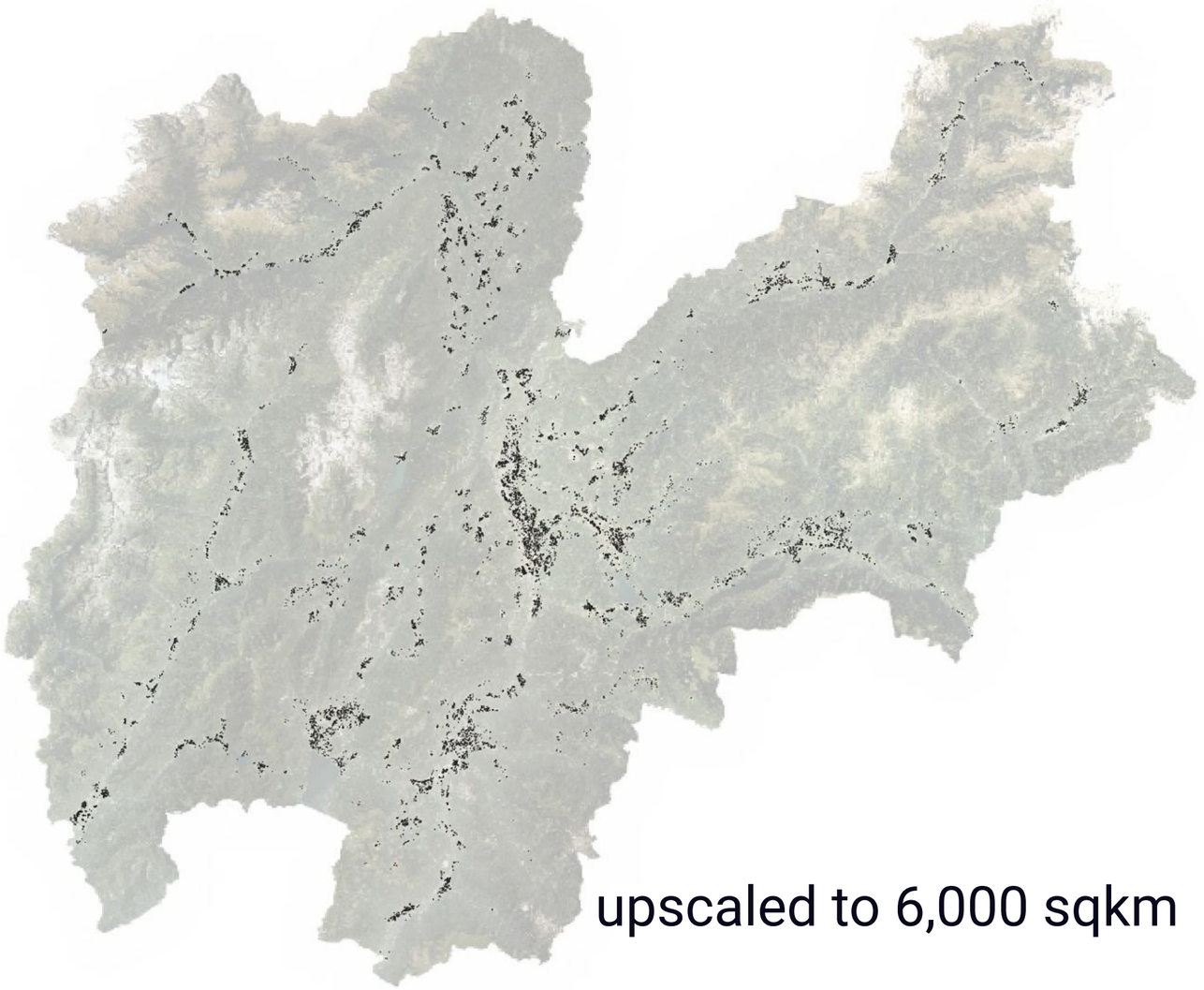




AI for solar panel identification (2/2)

- U-net-like network for panel identification





upscaled to 6,000 sqkm

AI for geospatial data within USAGE pilot activities

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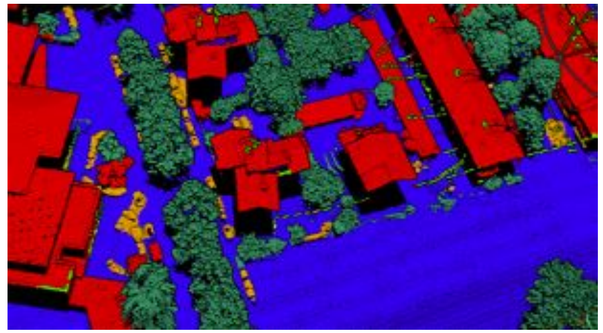
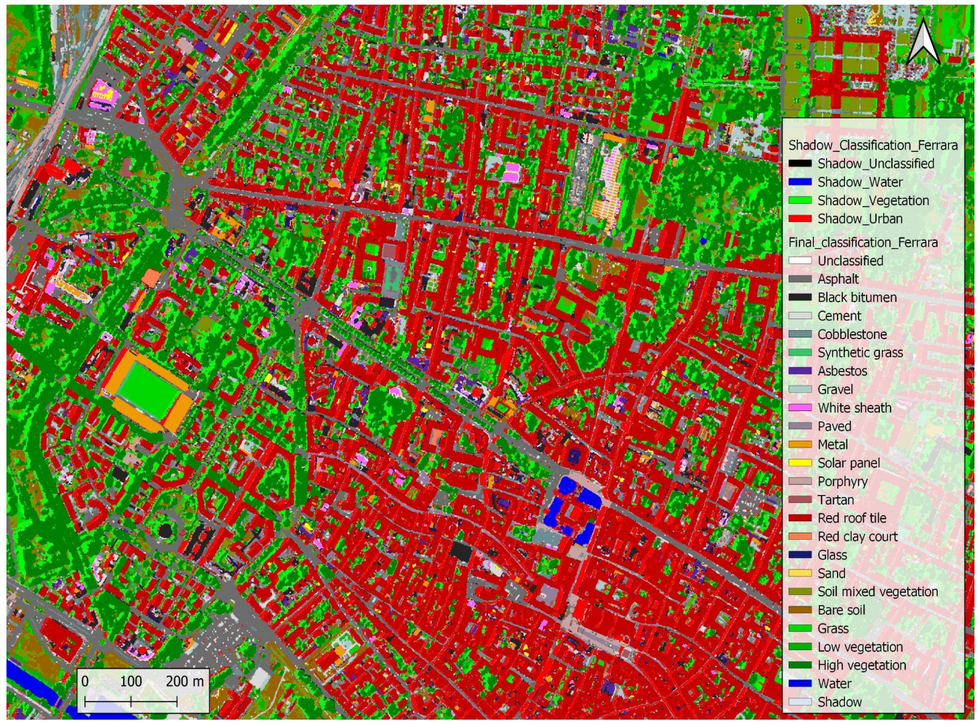
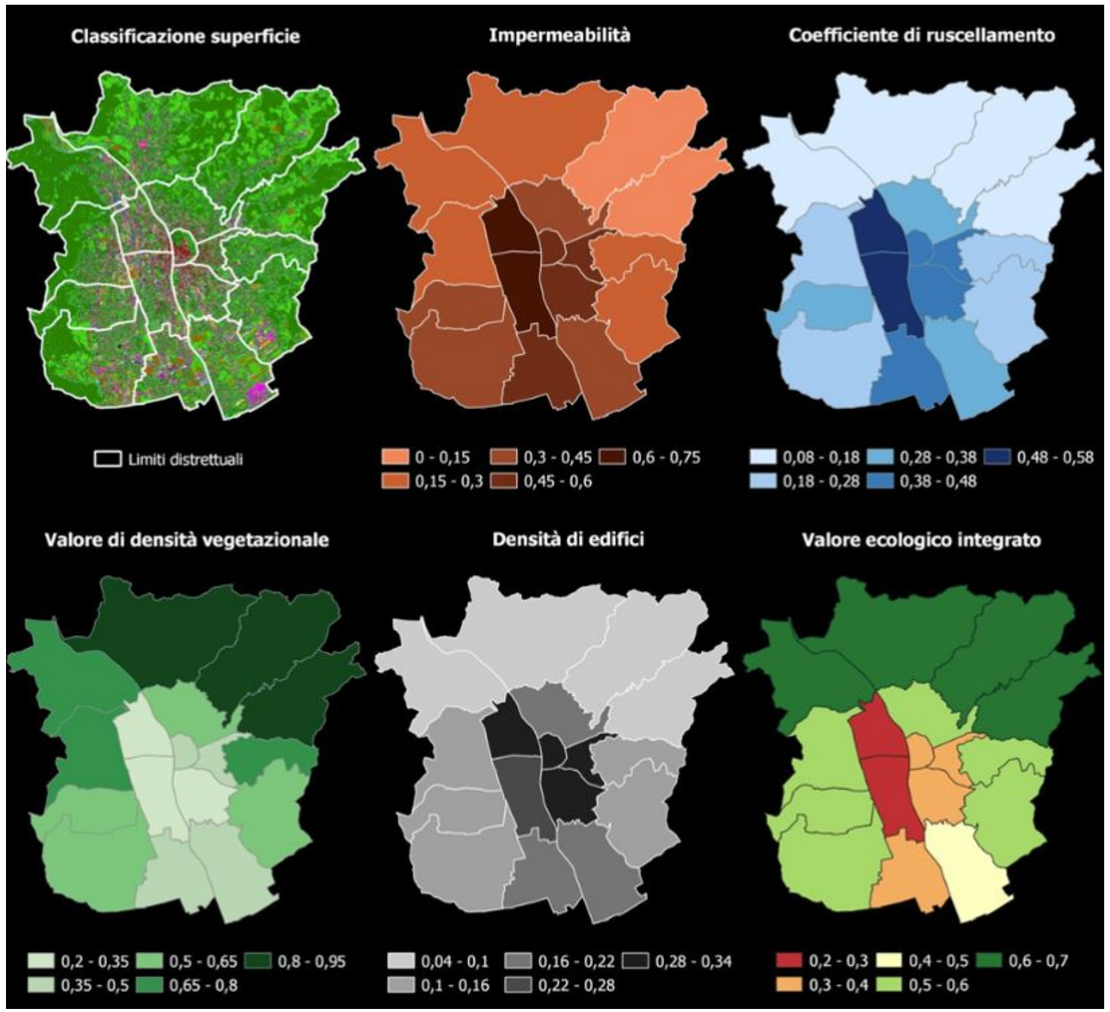


AI within USAGE pilot activities: image classification

- Hyperspectral images (AVT): 1m, 364 bands, VNIR and SWIR (0,4 - 2,5 µm) [AisaFENIX384 by Specim]
- AI-based supervised classification
- 26 classes

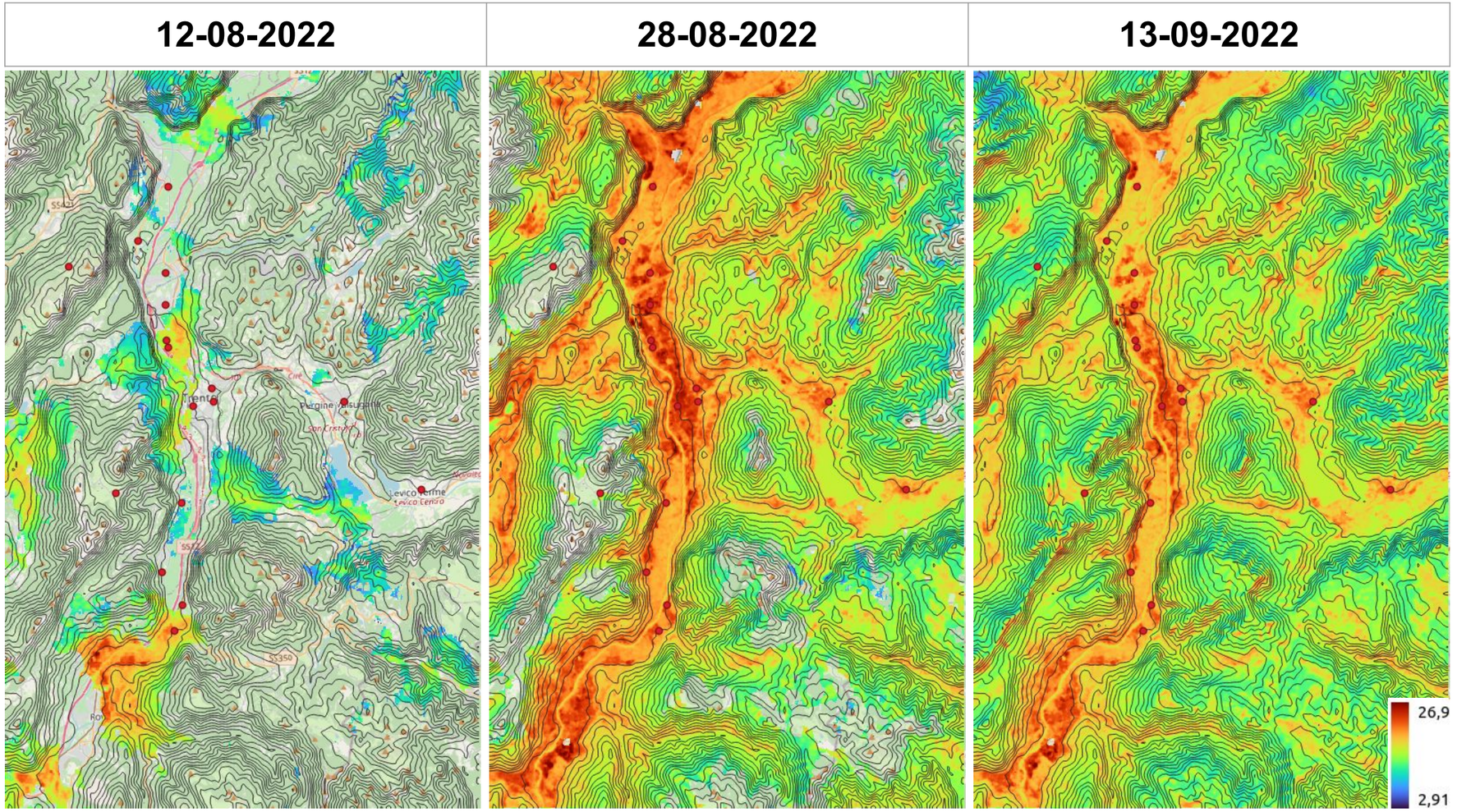




[Beber et al.,, 2023. ***Multi-modal geospatial and thematic data to foster green deal applications***. ISPRS Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLVIII-1/W3-2023.]

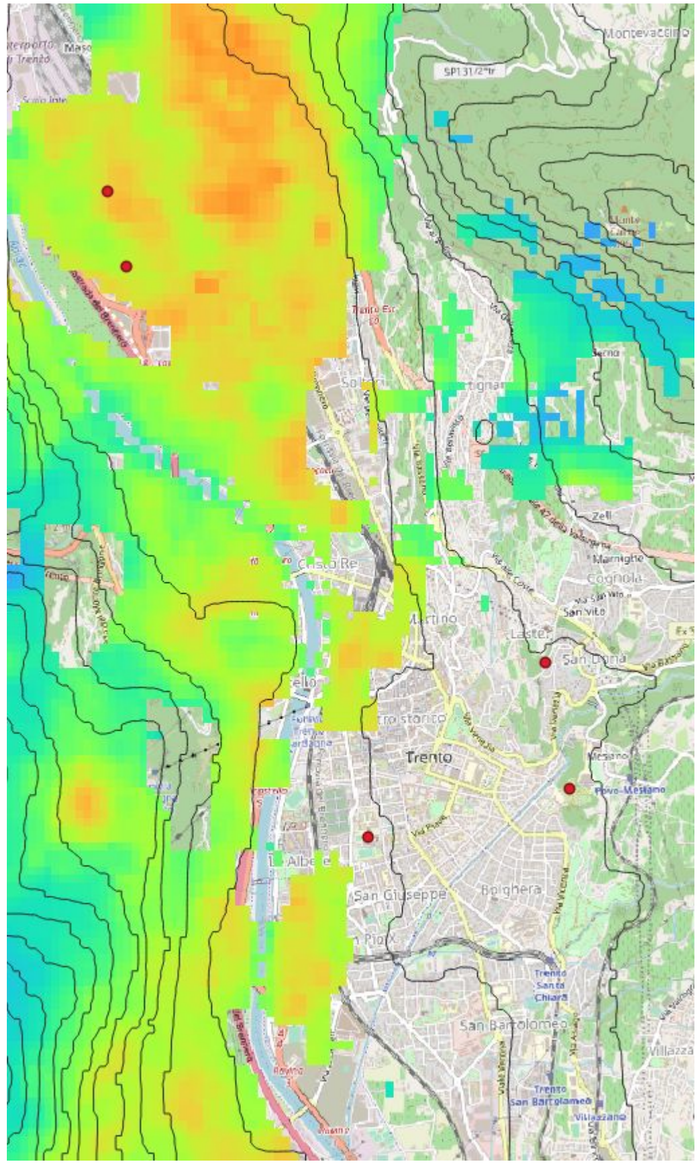
AI within USAGE pilot activities: urban heat island prediction

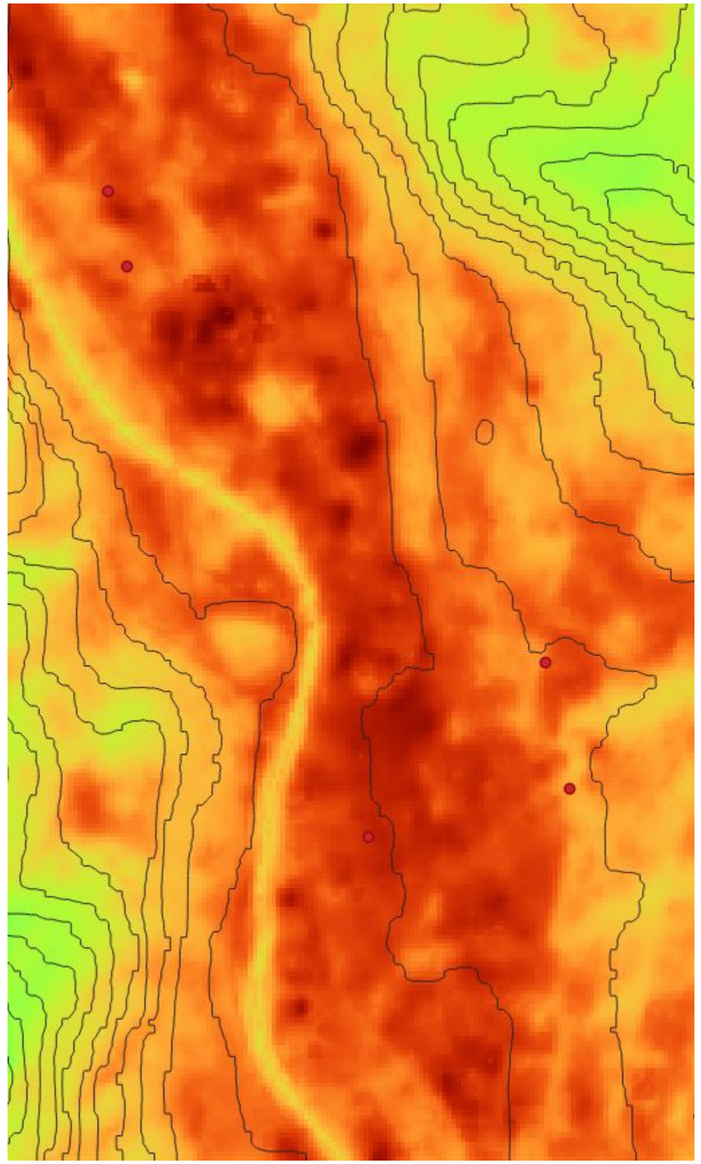
- **What: Air temperature** play an essential role in UHI prediction but is measured in few location (i.e. red dots)
- **With**: land cover properties, buildings morphology, detail vegetation volumes and satellite optical & thermal images
- **To:** City & neighborhood level *Comfort index & heat wave intensity* prediction 48h ahead.

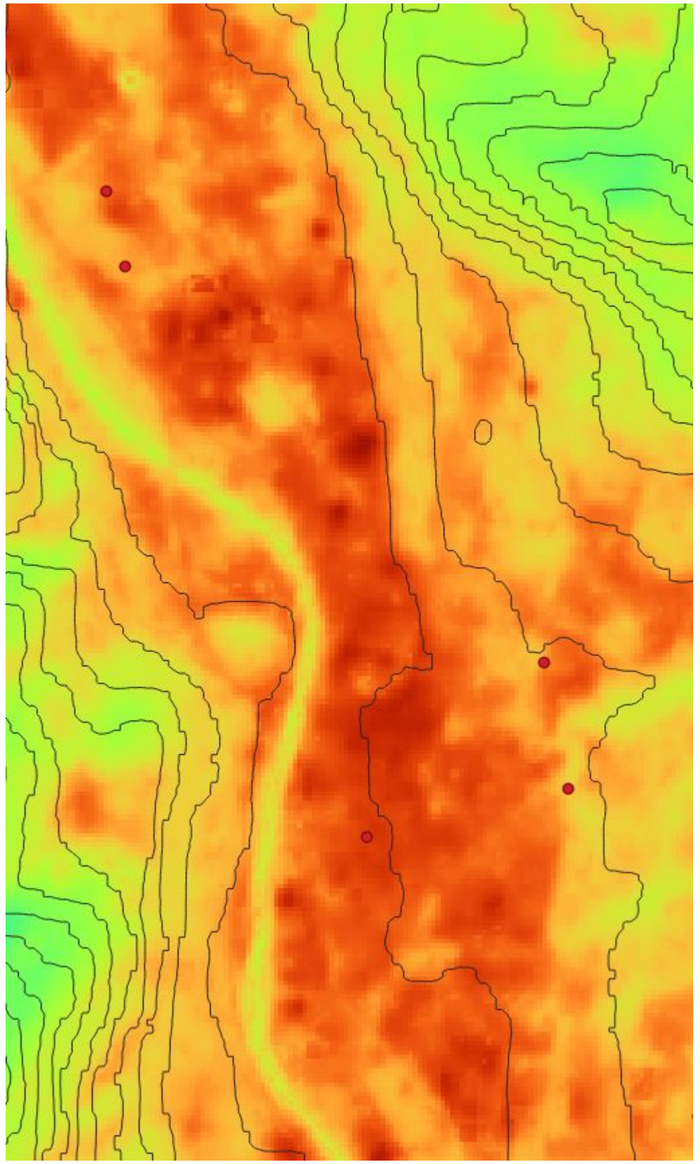


Fusion of weather stations *time-dense* & **spatially sparse** data with *resolute (30-70m)* LST satellite data that are **time sparse**

AI within USAGE pilot activities: urban heat island prediction

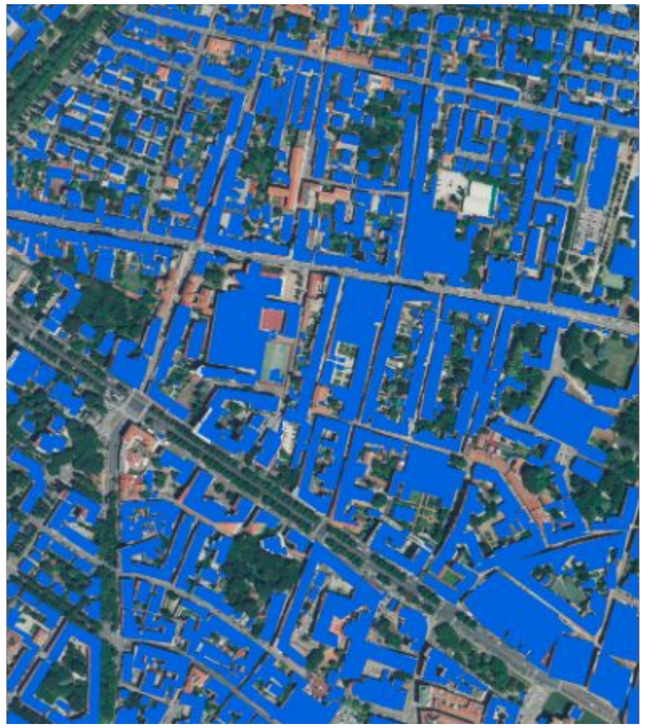






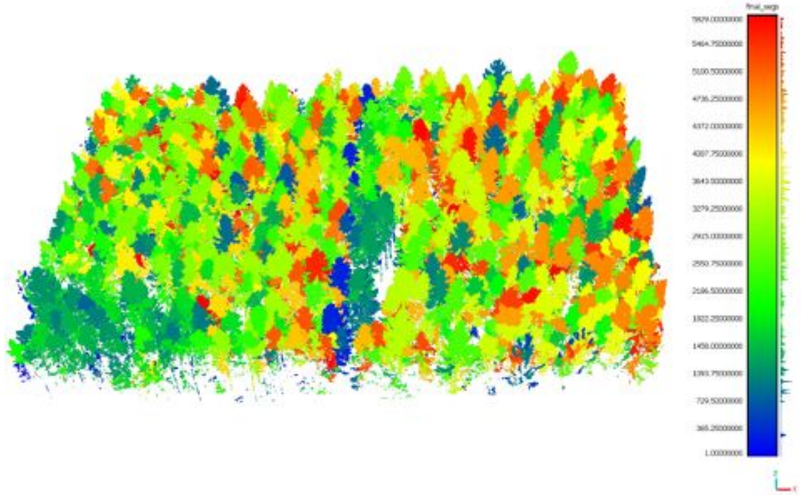
AI within USAGE pilot activities: building footprints detection

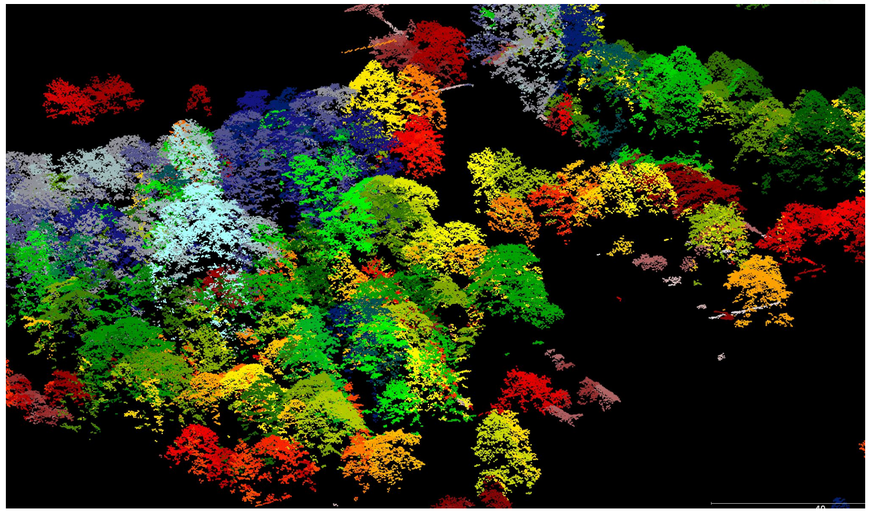
- Unet-like method
- Ferrara results

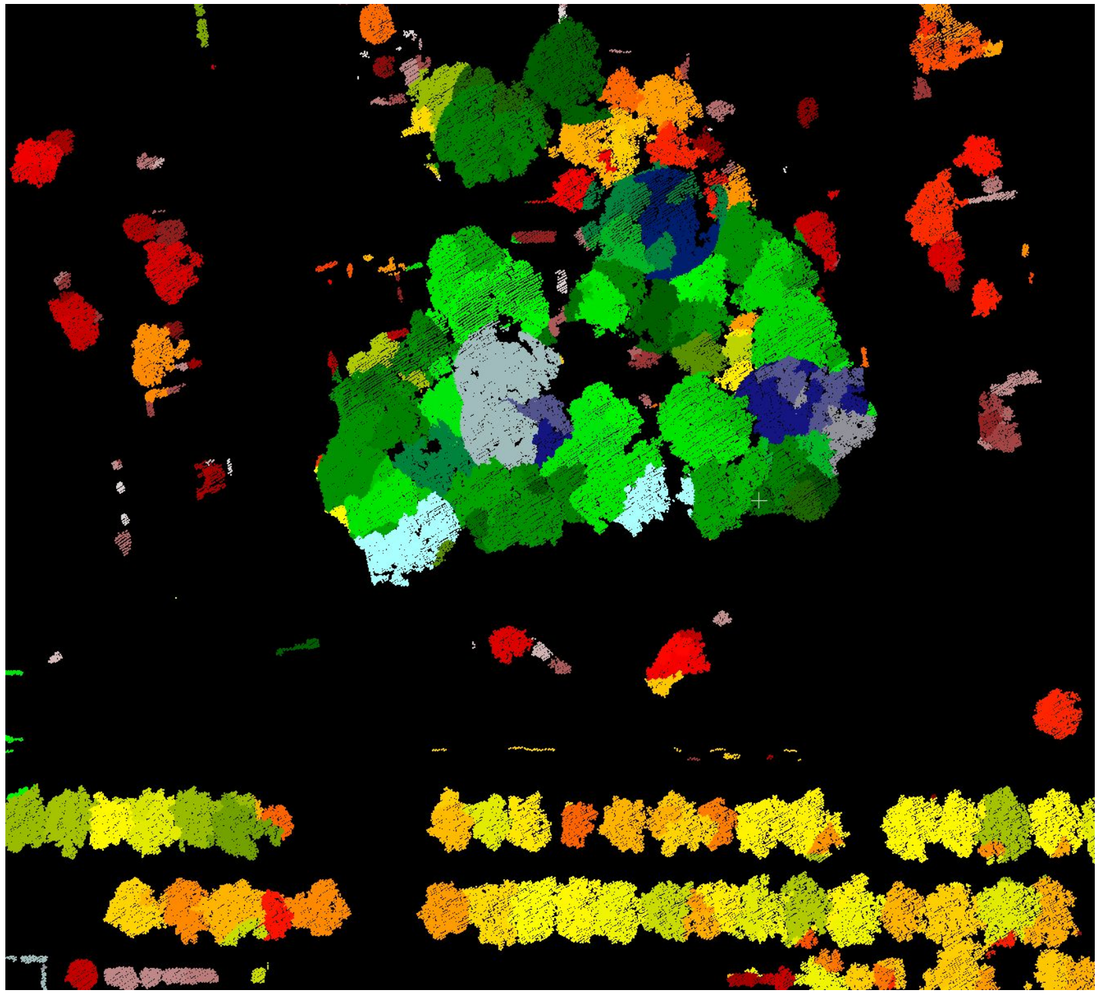


AI within USAGE pilot activities: individual tree segmentation

- color-coded ITS results from airborne LiDAR on Ferrara





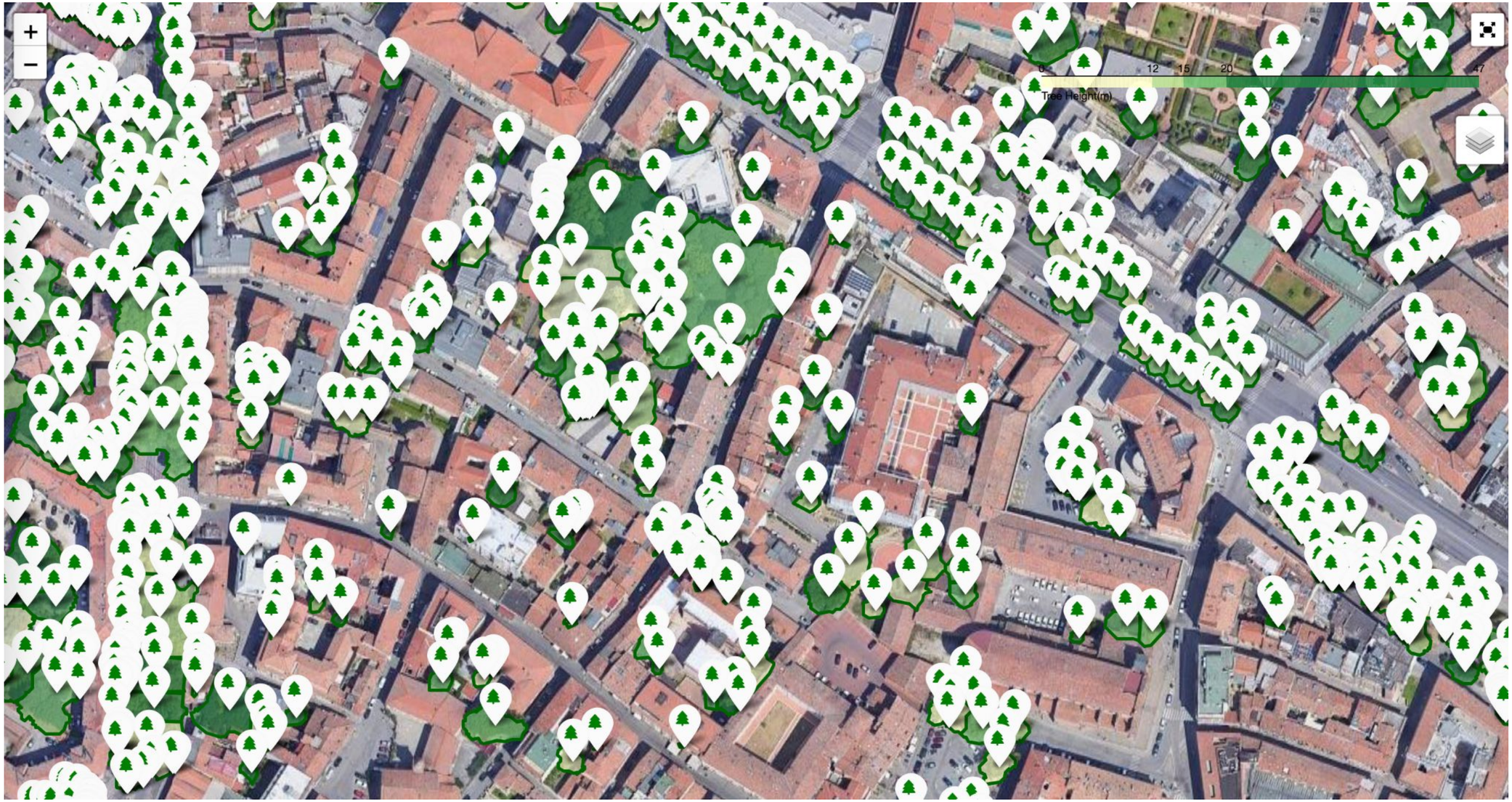


AI within USAGE pilot activities: individual tree segmentation

- GIS-based viz of ITS results from airborne LiDAR on Ferrara

AI within USAGE pilot activities: individual tree segmentation

- GIS-based viz of ITS results from airborne LiDAR + hyperspectral images on Ferrara



AI within USAGE pilot activities: individual tree segmentation

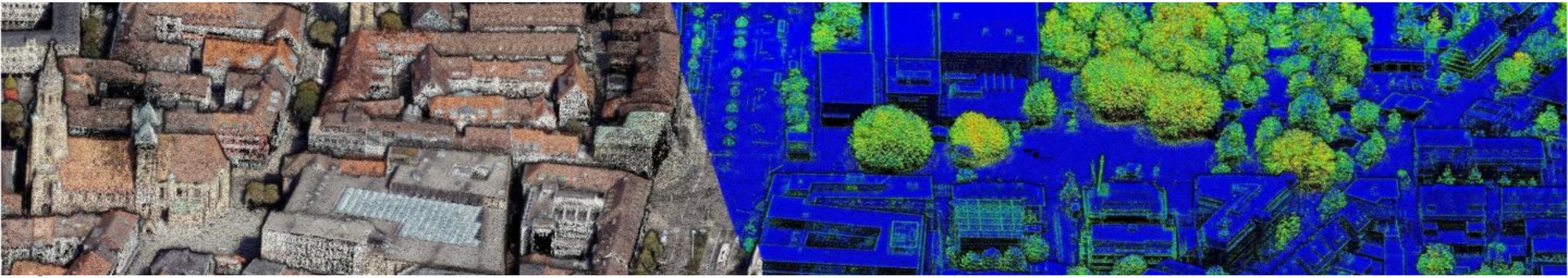
- GIS-based viz of ITS results from airborne LiDAR + hyperspectral images on Ferrara

Take away messages

- AI methods are surely boosting many tasks in geospatial data processing pipelines
- AI still suffers when dealing with large image resolutions and point clouds
- AI should not replace traditional (geometric) methods but should support them in order to speed up processes and improve results (complementarity)
- In the mapping field, the great variety of datasets from different sensor types (terrestrial, multi-head aerial cameras, multi/hyperspectral images, LiDAR, SAR, etc.) and scales (terrestrial, UAV, aerial, satellite), leads to poor availability of training / labelled samples
- AI methods are rapidly changing but lack of generalization, hence it is important for us to have our feet grounded and use common sense, while selecting these technologies

Take away messages

- AI will offer more valuable solutions for the geospatial field in the near future, inspiring and impacting research in our field through collaboration with colleagues in neighboring disciplines
- NMCAs are carefully monitoring new AI-based solutions and gradually adopting them as their potential is huge
- For sure, fully automated general image understanding and geometric processing remain an elusive problem for many years to come

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