



Remote sensing techniques applied to seismic vulnerability assessment

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POLITÉCNICA

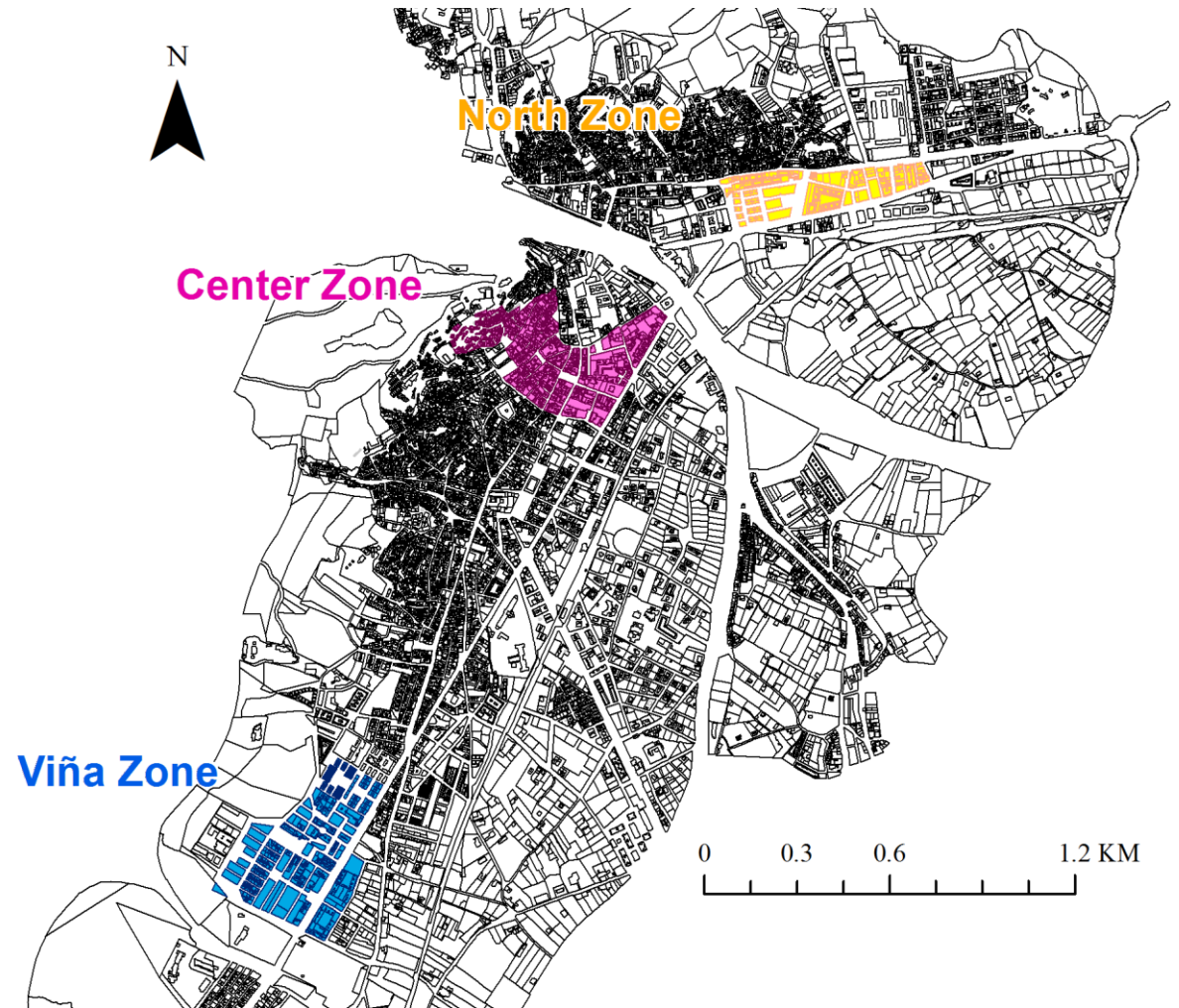


Goal

- To create an exposure and vulnerability database of buildings, useful for a seismic risk assessment, based on remotely sensed data analysis.
- Application in Lorca (Murcia, Spain)
 1. Definition of representative building typologies from the Lorca building stock
 2. From the analysis of aerial images and LiDAR:
 - a. Digitalization of building footprints
 - b. Characterization of buildings: parameters related to vulnerability, such as height, area and inclination of the roof
 - c. Vulnerability allocation
 3. Validation of the results by comparison with ground truth: Database of 816 buildings located in three representative areas

Data and resources

- Three different study areas:
- Software:
 - ArcGIS
 - ENVI
 - Google Street View
 - MDTopX



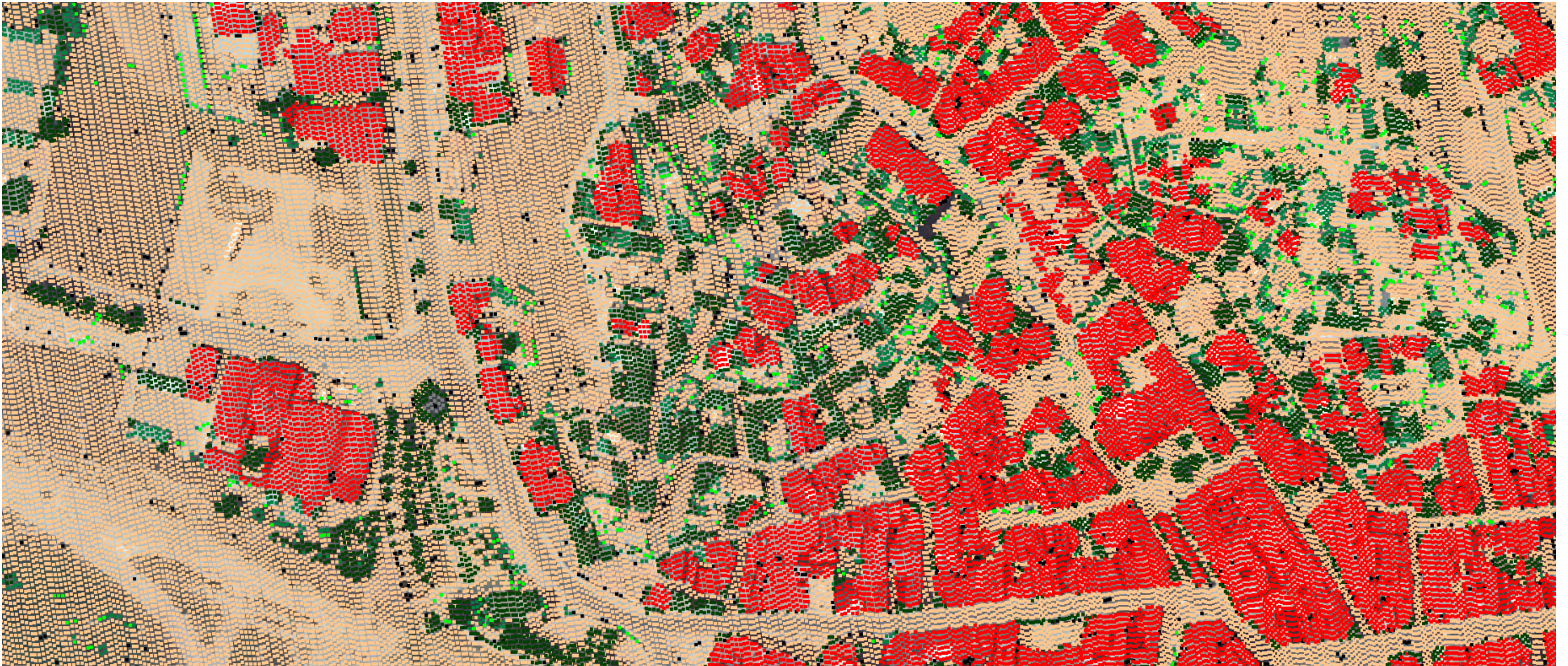
Data and resources

- Time series of orthophotos (2003-2011) from IGN (National Geographic Institute):



Data and resources

- LiDAR data and IR data from IGN (National Geographic Institute):



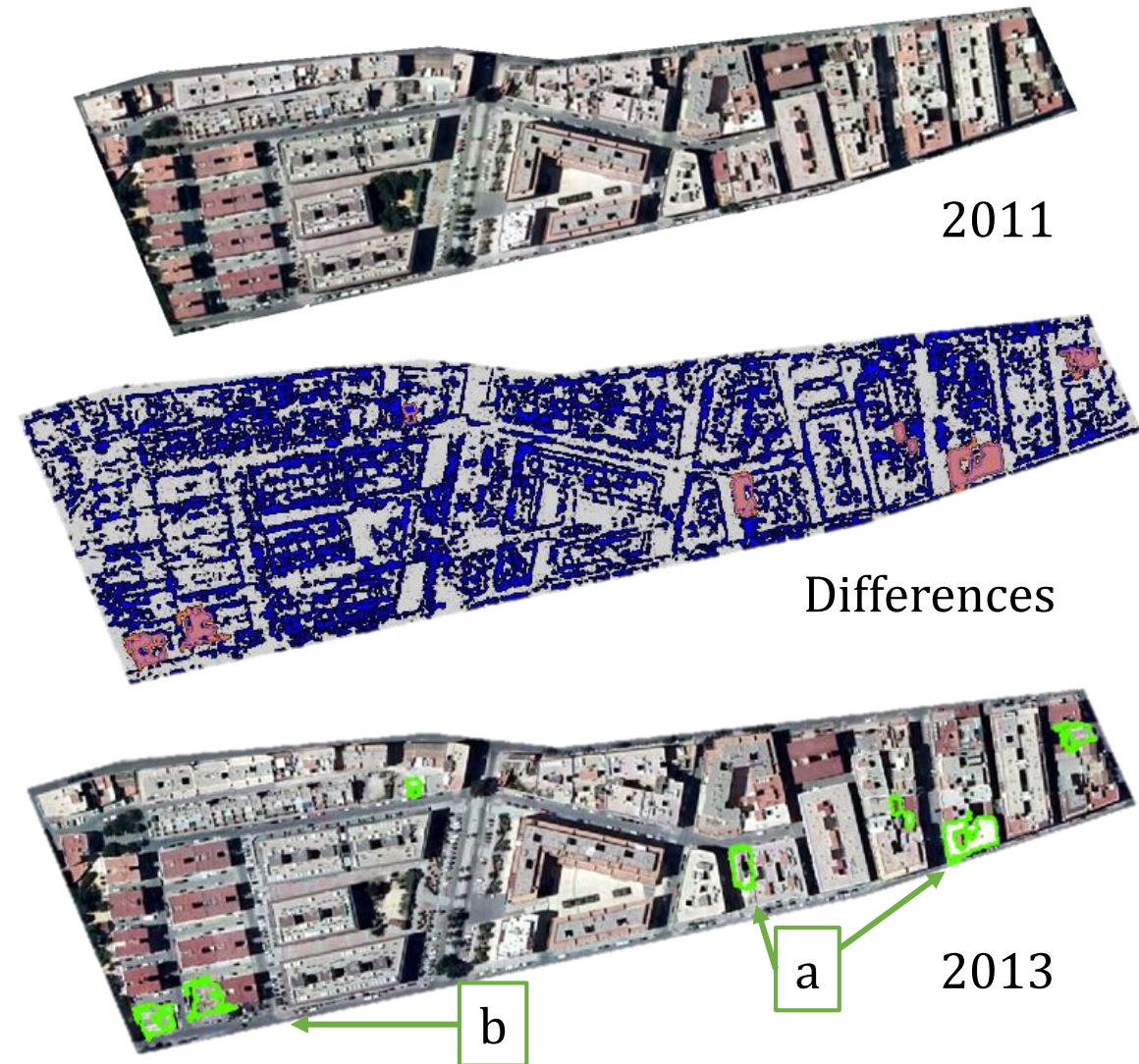
Methodology

1. Comparison of RGB images from different periods:

- a. Search for areas of change in the urban structure
- b. Identification of the time of construction of buildings

A new algorithm has been developed in MDTopX to find differences between georeferenced images. Small surfaces and slices are deleted

Changes found are renovations (a) and demolitions after 2011 earthquake (b)



Methodology

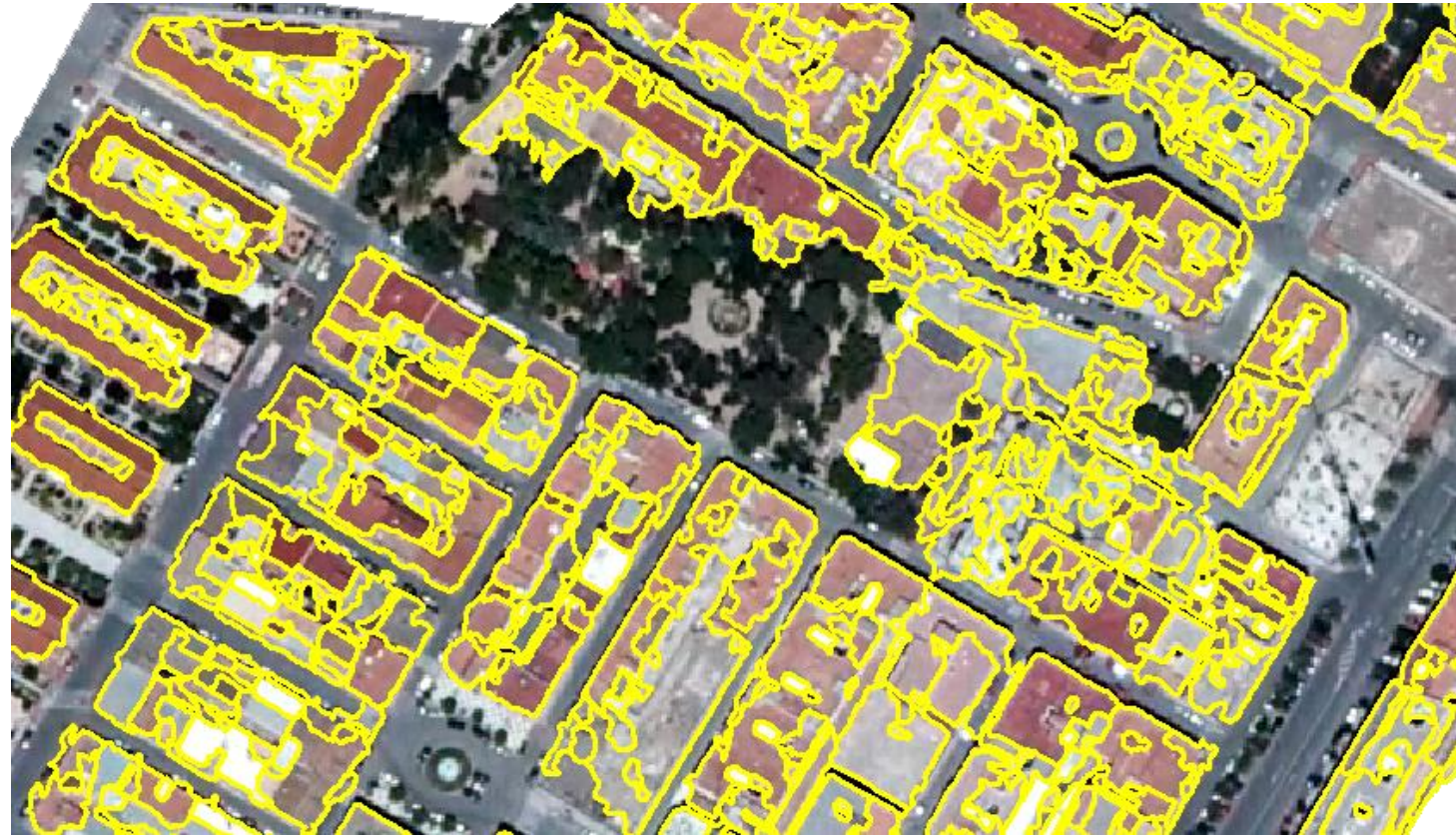
2. Fusion of the analysis of RGB image with LiDAR classification:
 - a. Integration of segmentation and classified point cloud
 - b. Differentiation of buildings and vegetation

A new algorithm has been developed in MDTopX to find vector boundaries in images. Sobel filter is used

Also, in order to choose footprints of buildings, another algorithm has been developed in MDTopX that projects vector boundaries onto LiDAR point cloud. In this way, only surfaces with points classified as building have been selected

Methodology

2. Fusion of the analysis of RGB image with LiDAR classification:
Viña zone:



Methodology

2. Fusion of the analysis of RGB image with LiDAR classification:
Centre zone:



Methodology

2. Fusion of the analysis of RGB image with LiDAR classification:
North zone:



Methodology

3. Improvements in the LiDAR classification using additional data: RGB + Infrared

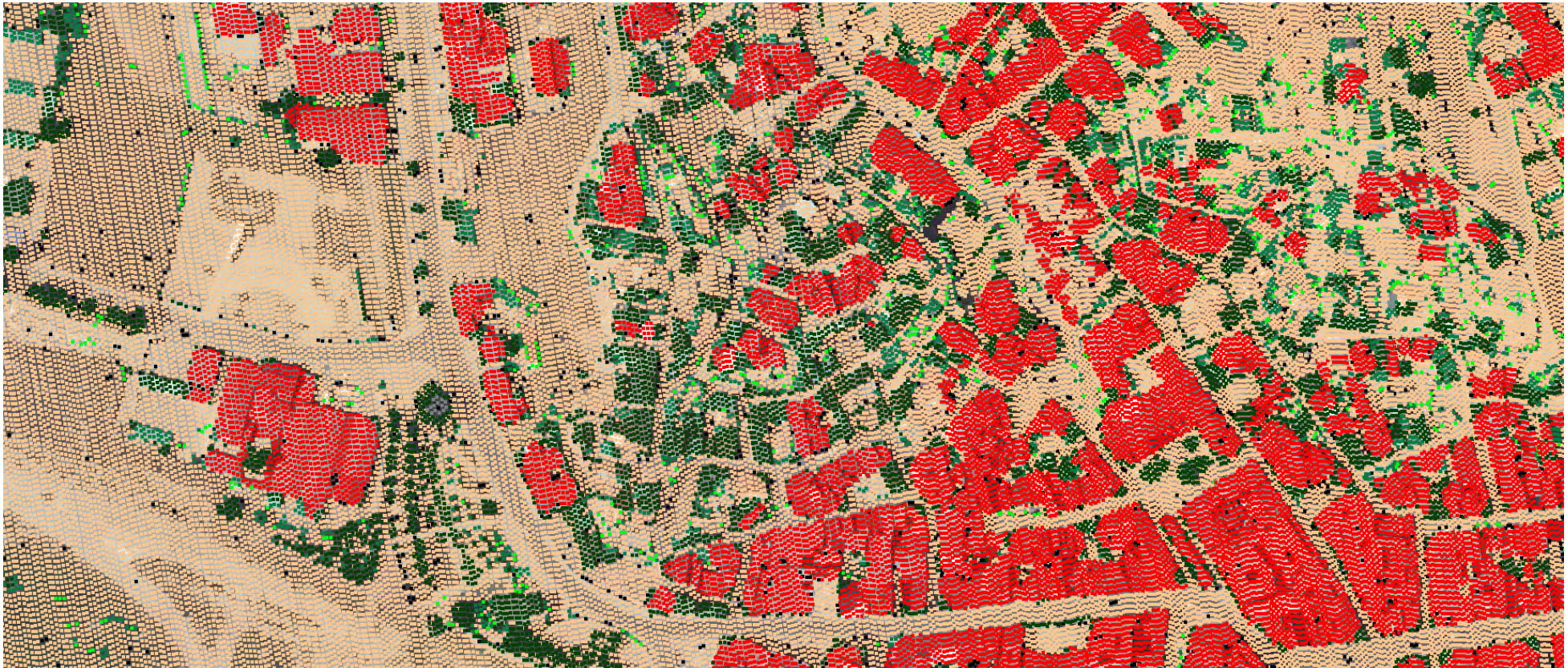
A new algorithm has been developed in MDTopX that used Infrared data and RGB data to classify LiDAR point cloud

Using infrared data, we can classify points over vegetation and over buildings

In this way, we obtain improved results

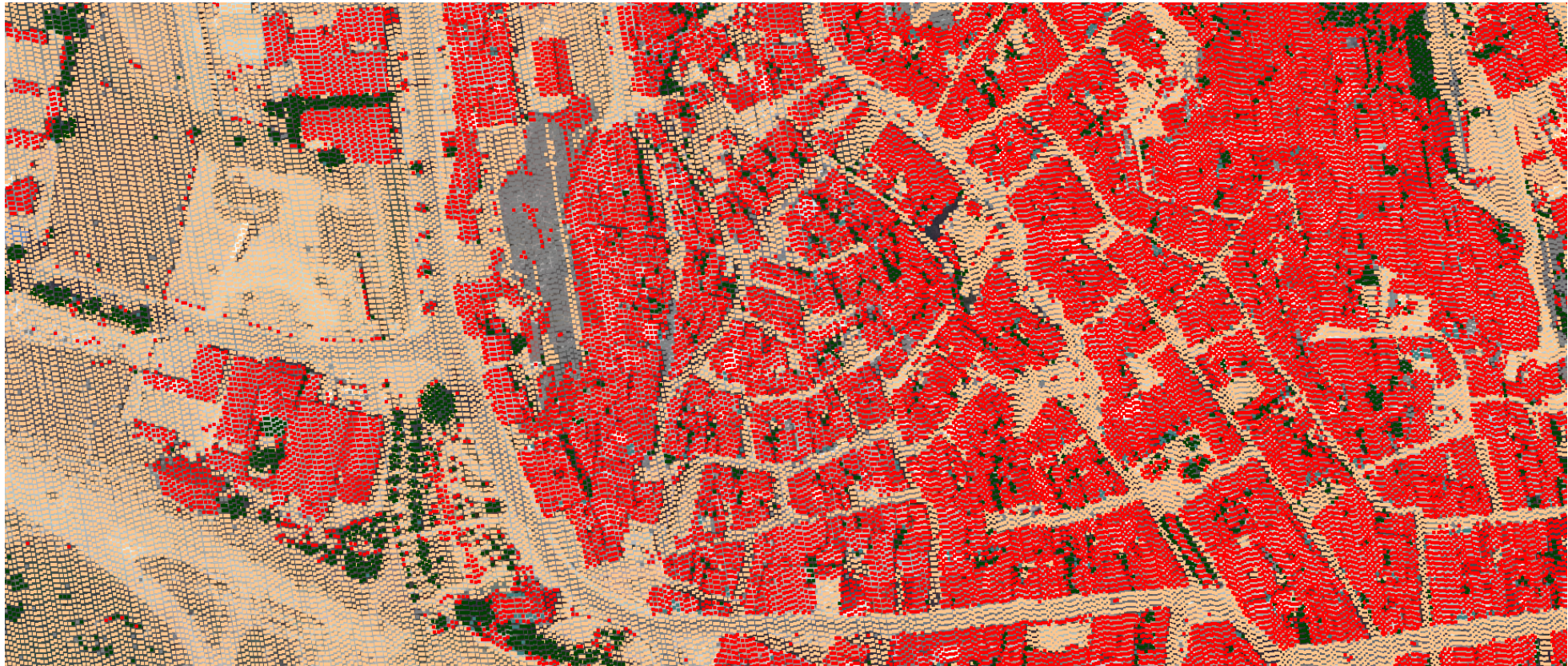
Methodology

3. Improvements in the LiDAR classification using additional data:
Source data:



Methodology

3. Improvements in the LiDAR classification using additional data:
Improved data:



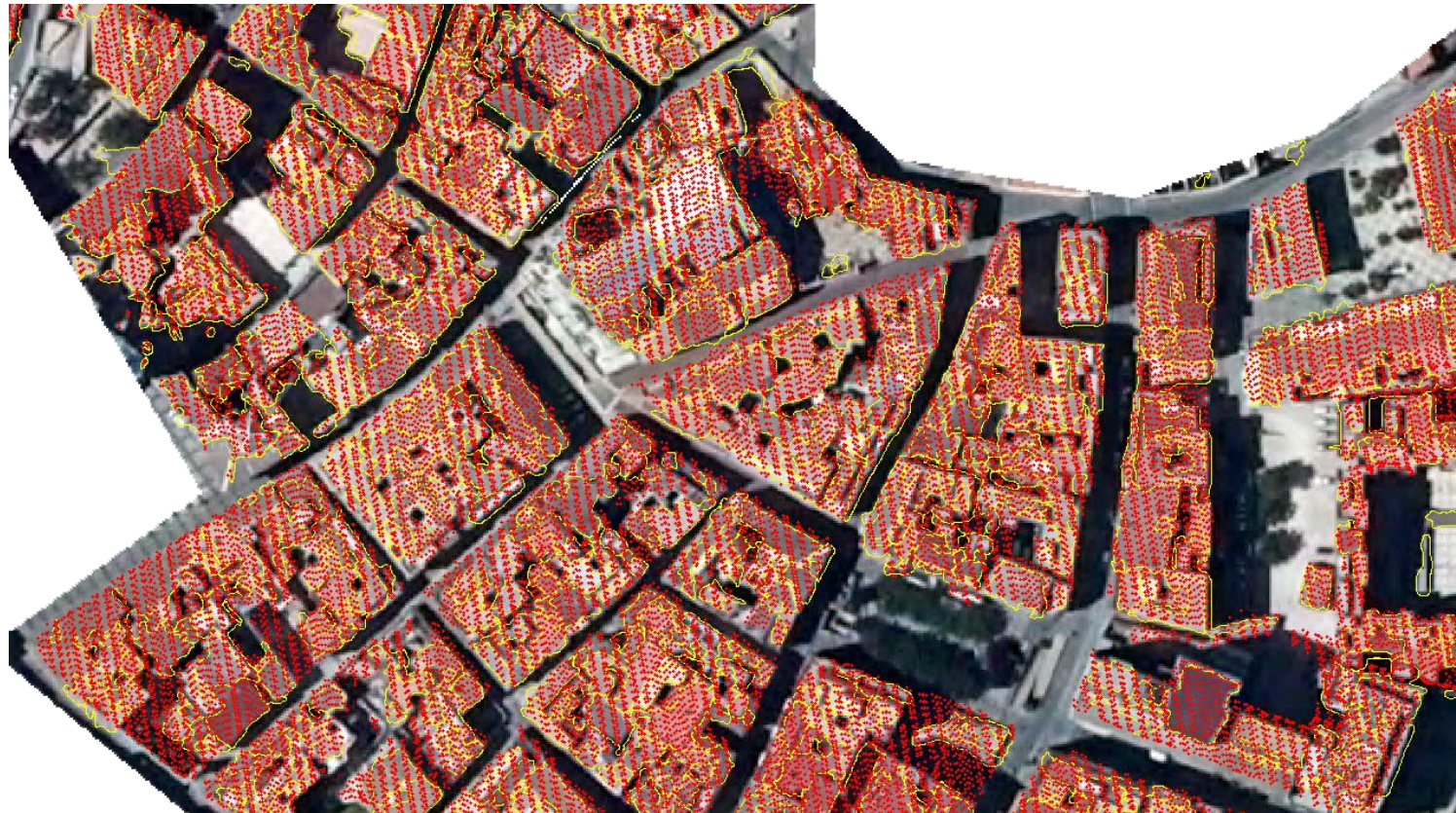
Methodology

4. Combination of surfaces from LiDAR and image segmentation
5. Selection of LiDAR points classified as buildings



Methodology

4. Combination of surfaces from LiDAR and image segmentation
5. Selection of LiDAR points classified as buildings



Methodology

4. Combination of surfaces from LiDAR and image segmentation
5. Selection of LiDAR points classified as buildings



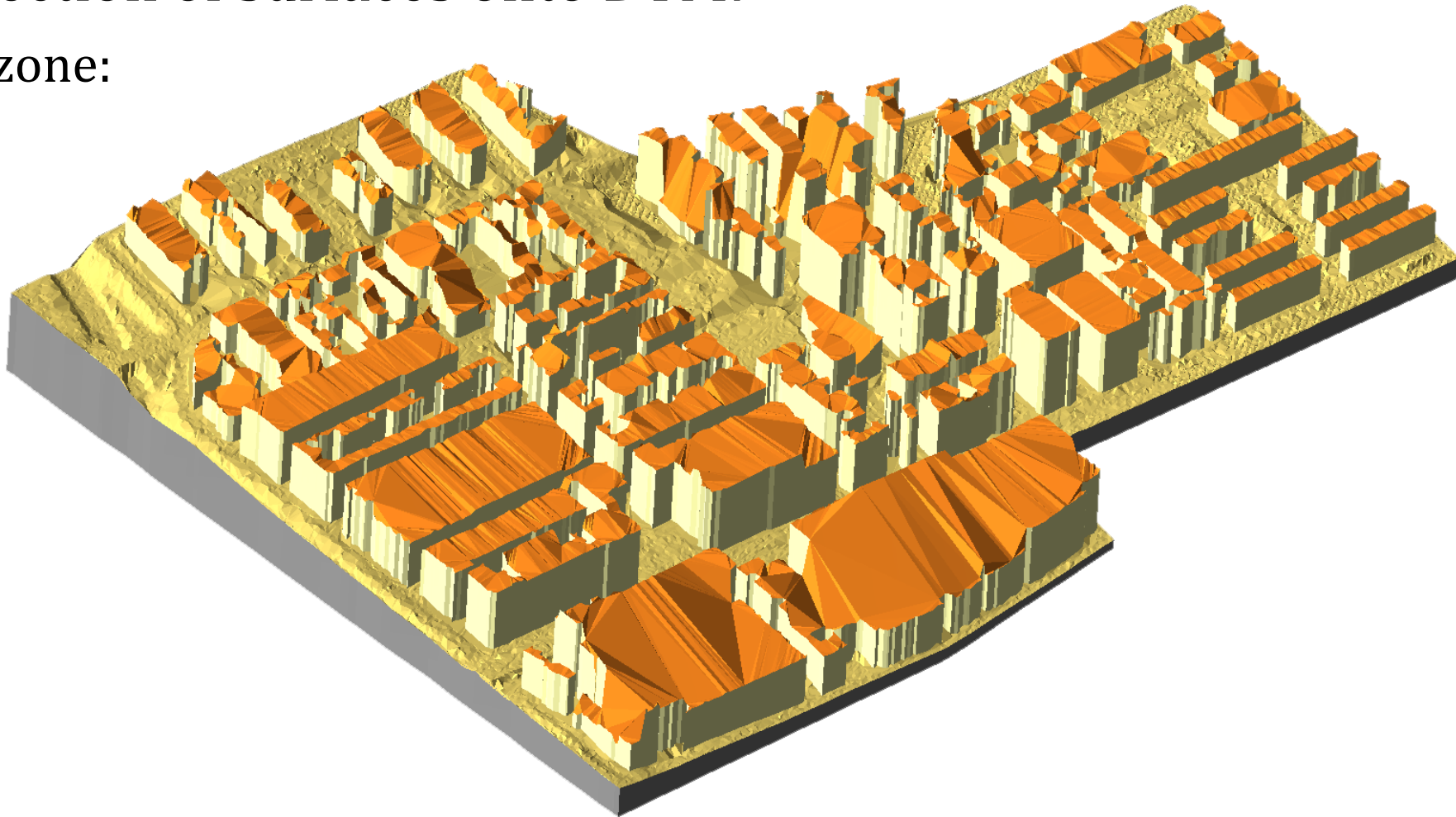
Methodology

6. Projection of surfaces onto DTM:
 - a. Elimination of minor segmented surfaces
 - b. Elimination of surfaces outside buildings
 - c. Extraction of main geometric and statistical values of each surface:
 - i. Average elevation
 - ii. Slope vector
 - d. Differentiation between two types of slope: gabled and flat
 - e. Union of surfaces with similar characteristics
 - i. Similar elevation
 - ii. Similar RGB

Methodology

6. Projection of surfaces onto DTM:

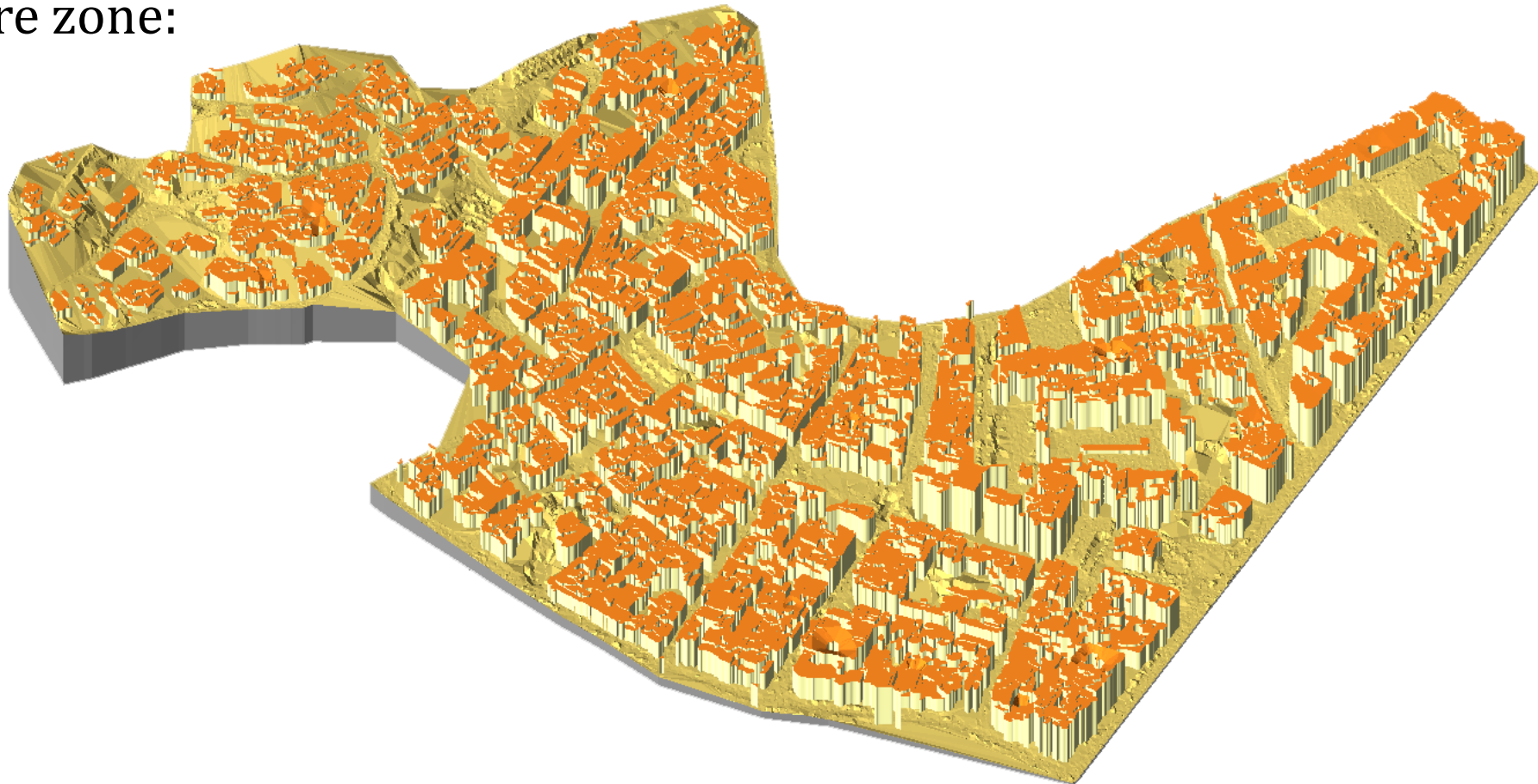
Viña zone:



Methodology

6. Projection of surfaces onto DTM:

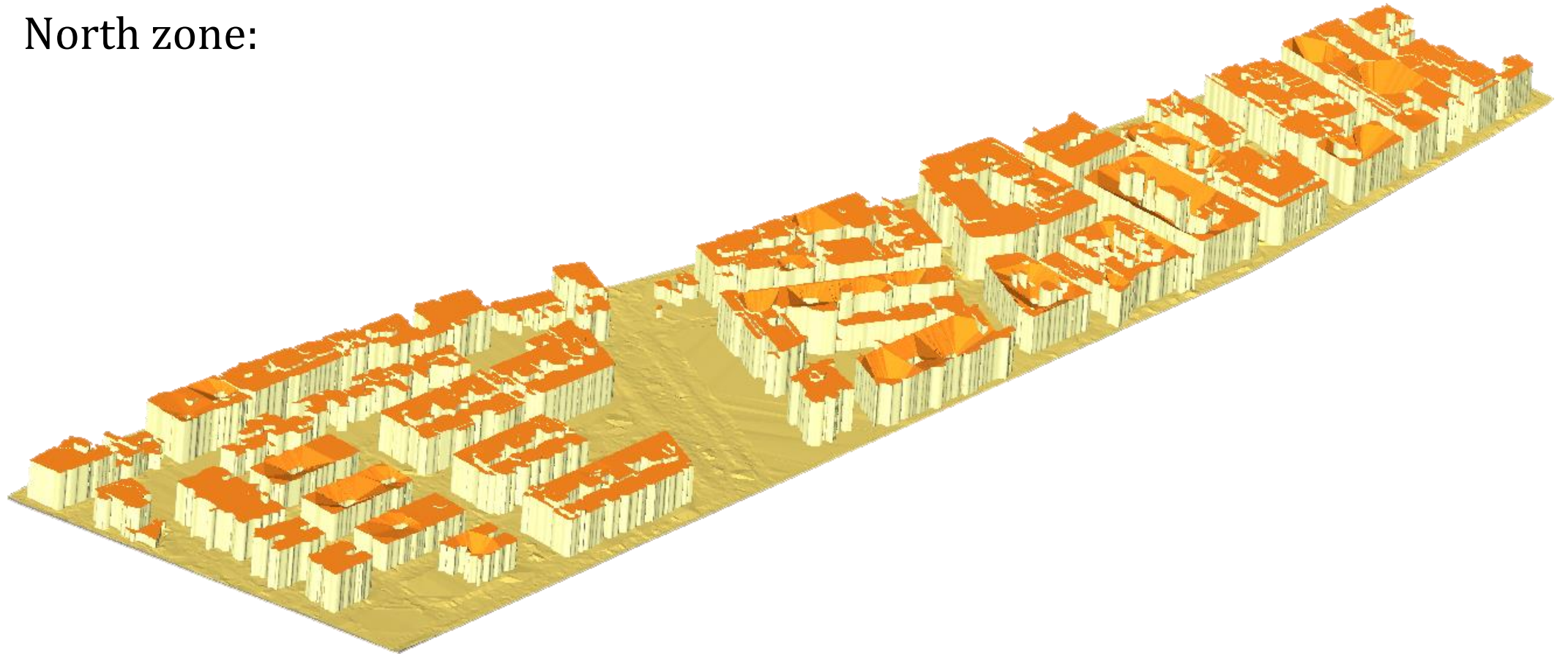
Centre zone:



Methodology

6. Projection of surfaces onto DTM:

North zone:

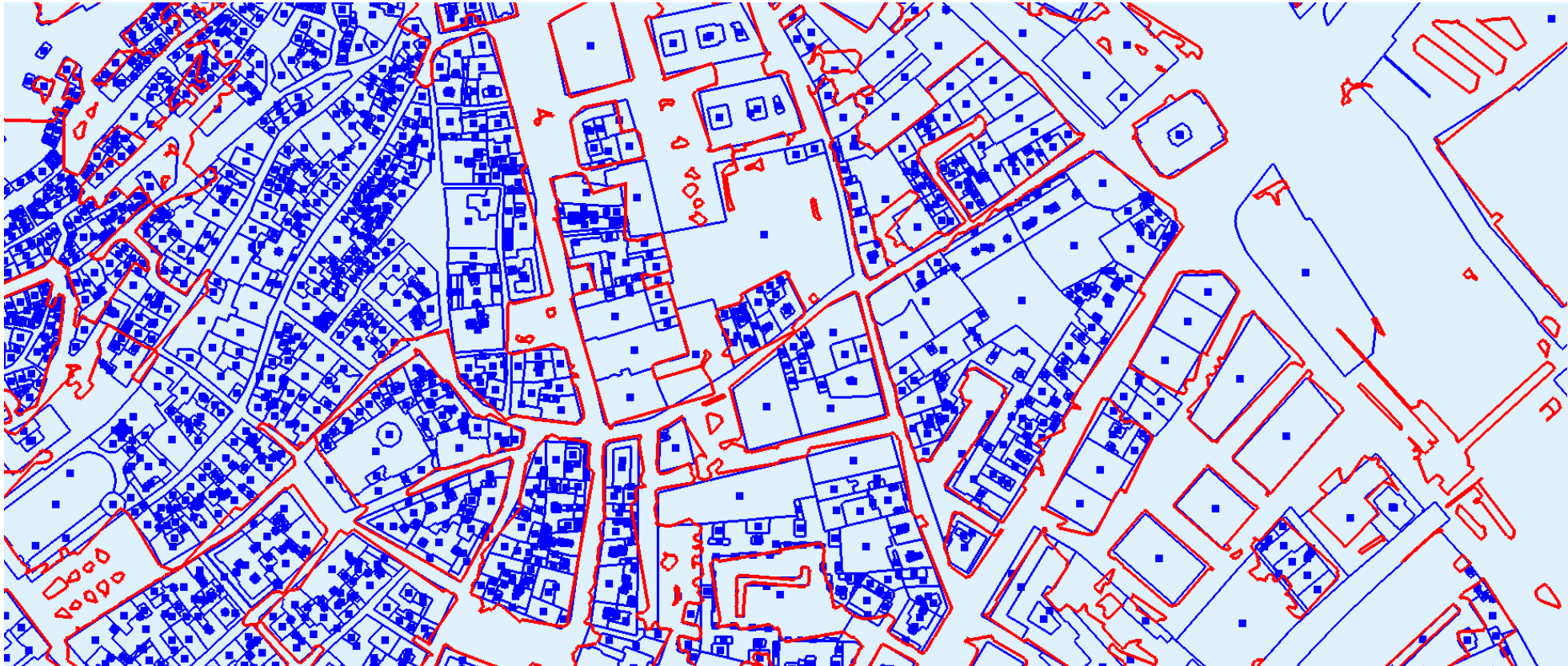


Methodology

7. Comparison of the results obtained with LiDAR+RGB+IR with cadastre:
 - a. Accuracy of results
 - b. Search for areas of change in the urban structure
 - c. Search for different buildings by their height (dividing walls)
 - d. Improvements in the cadastral data:
 - i. Flat roofs
 - ii. Sloping roofs
8. Data integration in GIS: The final database contains building footprints and four vulnerability-related attributes:
 - a. Year
 - b. Height
 - c. Area
 - d. Roof material

Methodology

7. Comparison of the results obtained with LiDAR+RGB+IR with cadastre:



Conclusions

- This research presents a more cost-effective process to create an exposure and seismic vulnerability database than traditional field surveys. Our new approach is based only on expert knowledge and remote sensing techniques
- The final database contains building footprints and four vulnerability-related attributes: year, height, area and roof material; all of them calculated using LiDAR points and HR orthophotos. Global accuracy measures:
 - Total built area: Overestimation 9%
 - Height: True positive rate 82%
 - Roof material: True positive rate 71%
- Calculating per-pixel differences between two consecutive orthophotos has proven to be a valuable change detection technique to locate and date new buildings at local scale, as well as to detect renovated roofs

Conclusions

- LiDAR point cloud classification improves when RGB and IR information from aerial images is also considered
- Current segmentation algorithms (Sobel filter and Watershed) do not perform well when applied to complex urban areas, such as historic city centre. New or complementary algorithms should be developed to avoid roof over-segmentation
- The combination of LiDAR points and HR images constitutes a powerful dataset to analyse urban environment, in terms of building detection and characterization
- GIS is the best tool to integrate and manage all this geo-spatial information