A geospatial intelligence application to support post-disaster inspections based on local exposure information and on co-seismic DInSAR results

The case of the Zagreb (Croatia) earthquake 22/03/2020

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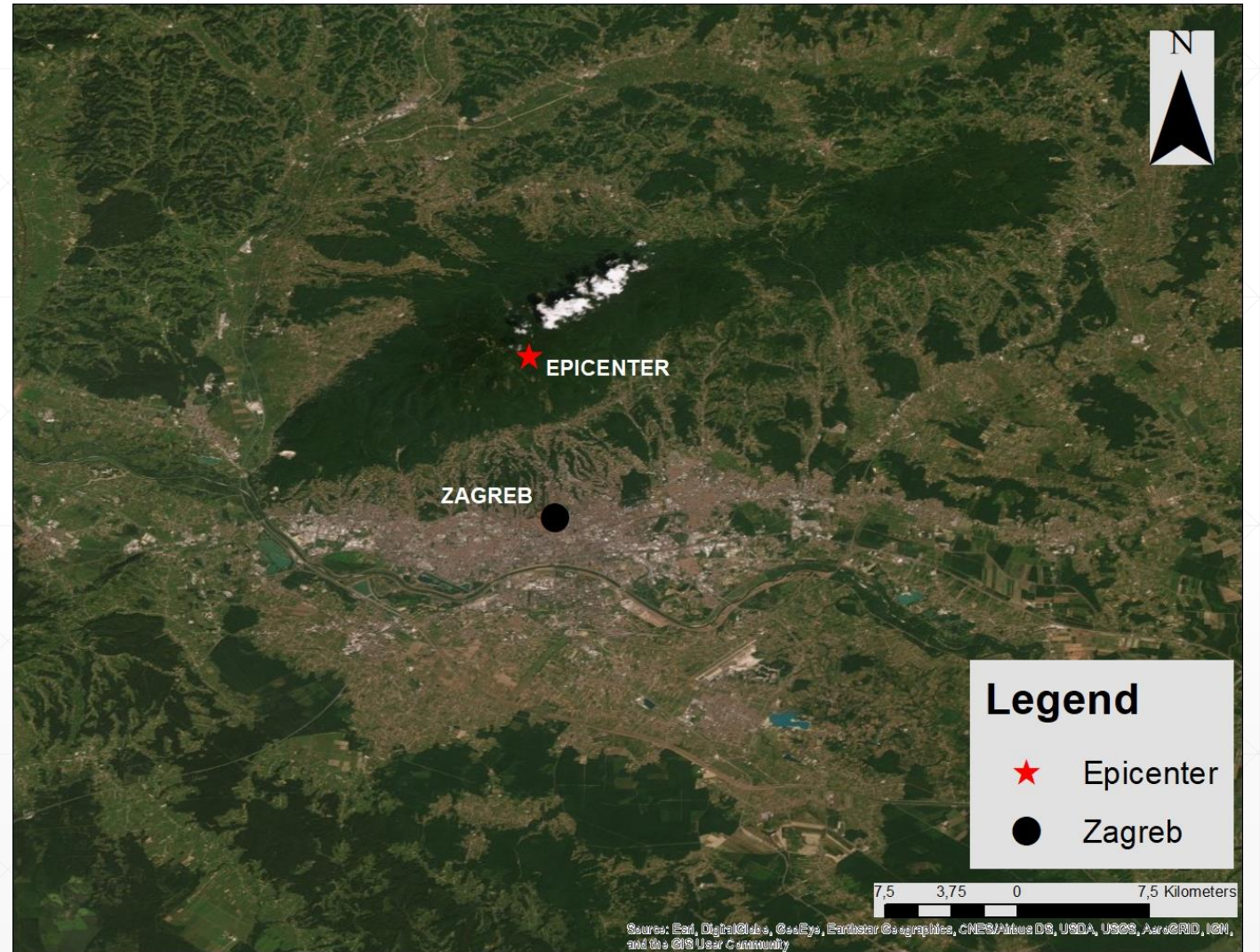
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Area of Interest

Seismic Event

- At the 22th of March 2020 at 5h24 UTC an earthquake of a M:5.4 (Epicenter Coordinates 45.897°N 15.966°E) magnitude hit an area about 9 kilometers north of Croatia's capital city, Zagreb.

Geospatial Intelligence (GEOINT)

Geospatial information   **+**   **Imagery intelligence**

The basic principle of geospatial intelligence (GEOINT) is to organize and combine all available data around a geographical location on Earth and then exploit it in order to prepare products that can be easily used by planners, emergency responders and decision makers (Richardson 2010).

Data

➢ The first of the five missions that ESA is developing for the Copernicus initiative.

➢ Sentinel-1 mission comprises a constellation of two polar-orbiting satellites, A & B operating day and night performing C-band SAR imaging, enabling them to acquire systematically imagery (especially over Europe) regardless of the weather.

➢ Copernicus Open Access Hub (Free) (https://scihub.copernicus.eu/) to download images

Number of Pair	Satellite	Type	Subswath Number	Sensing Day	Pass Direction
1st (master)	Sentinel-1A	SLC	IW2	17/03/2020	Ascending
1st (slave)	Sentinel-1B	SLC	IW2	23/03/2020	Ascending

Exposure Data

- ➤ Data from CORINE LAND COVER Inventory (map the main urban center boundary)
- ➤ Data from OpenStreetMap (mapping and geo-location of linear infrastructures)

Polygonal, linear and point import of exposure	Source
Roads	OpenStreetMap
Railway	OpenStreetMap
Airport	Identification through Google Earth
Castle	Identification through Google Earth
Hospital	OpenStreetMap
Bridges	Identification through Google Earth
Boundaries of the city of Zagreb	CORINE Land Cover (CLC) version 2018 / OpenStreetMap

Software

➢ Satellite Data Processing(open source software)

SNAP 7.0 (+ SNAPHU plugin)
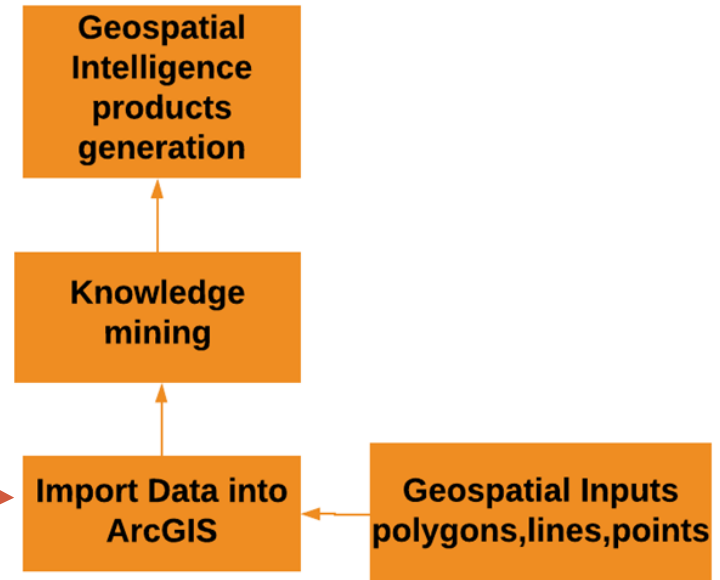in Linux Environment

➢ Manipulation and Visualization of Data

ArcGIS 10.6
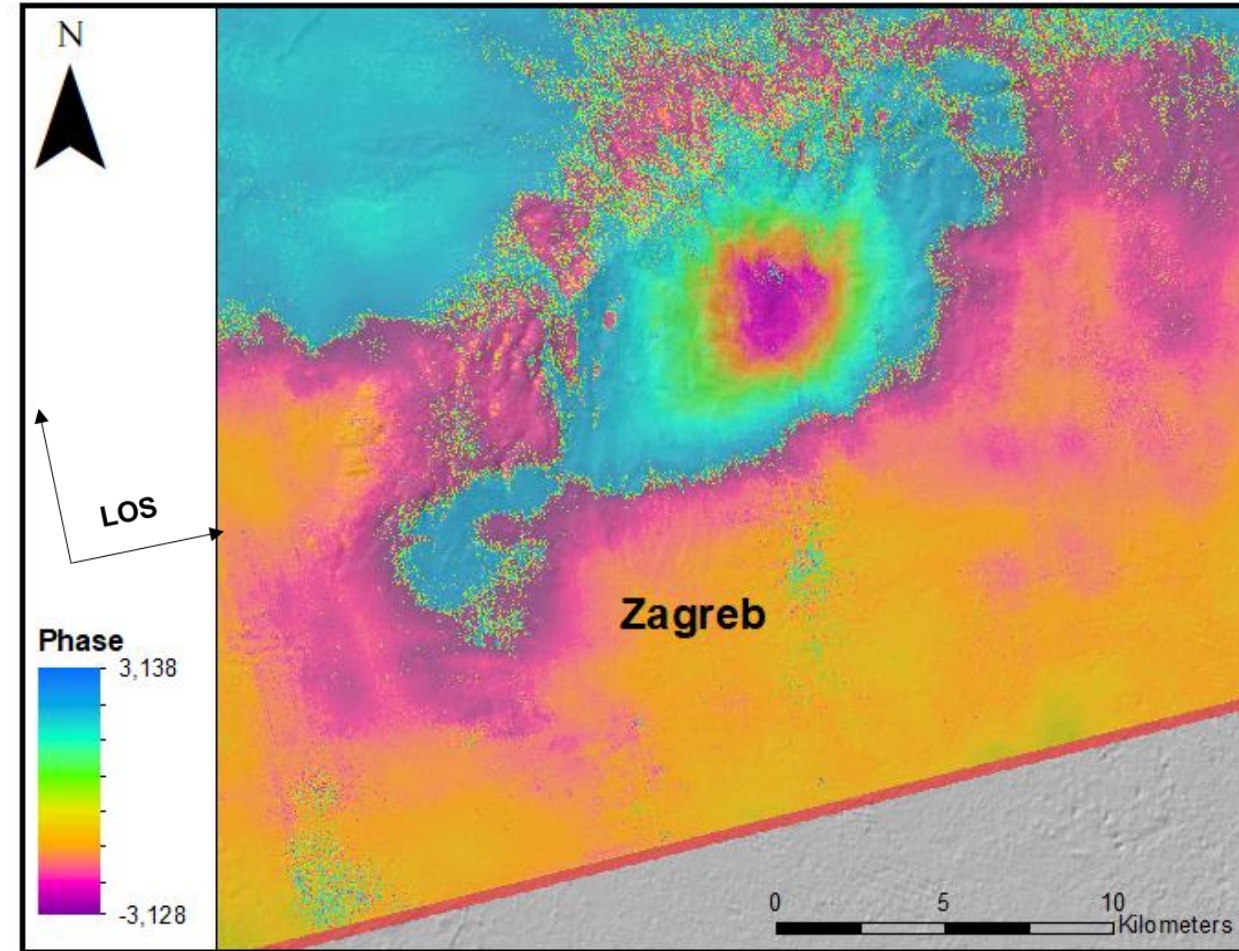
Methodology

SNAP Processing
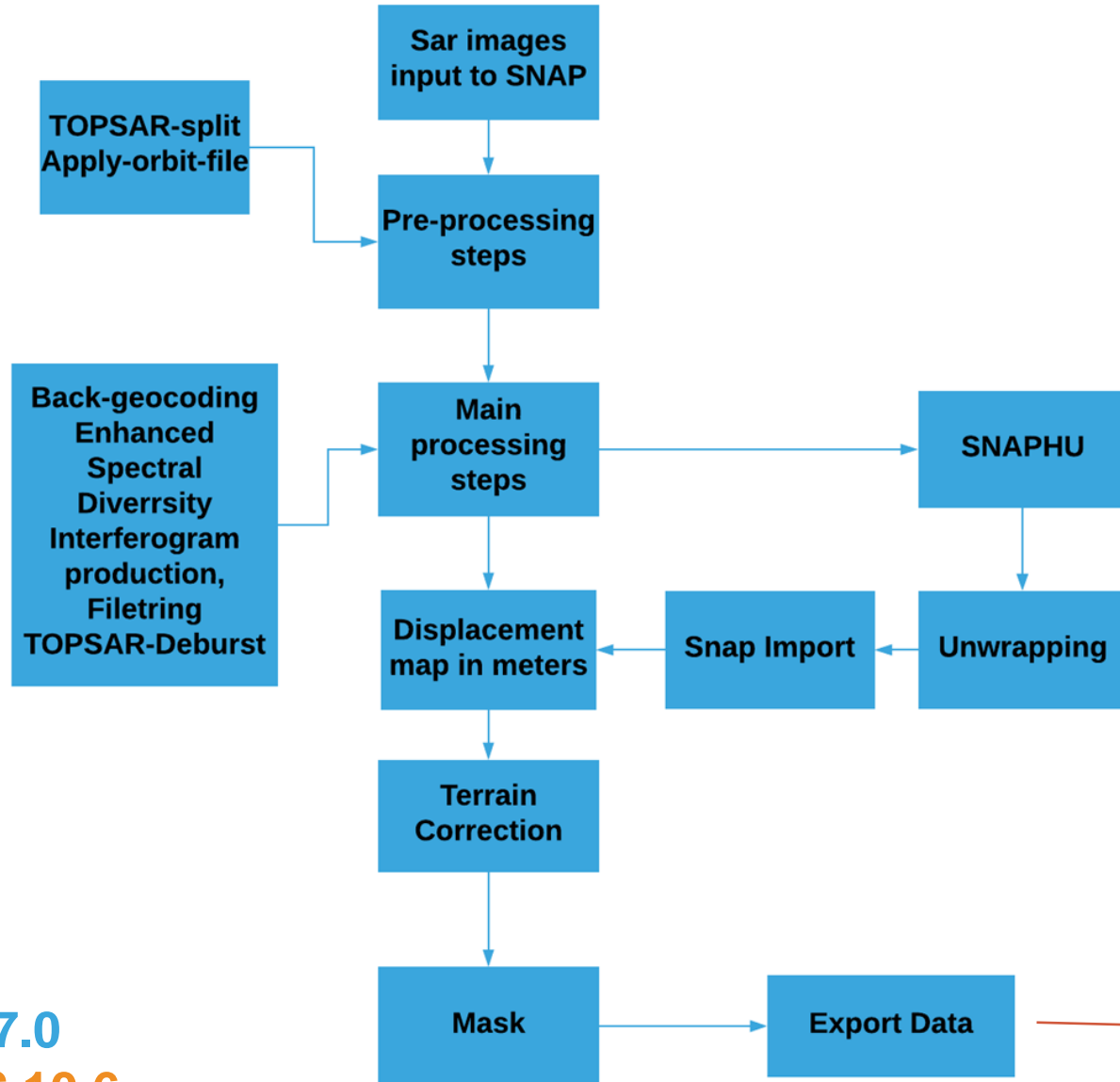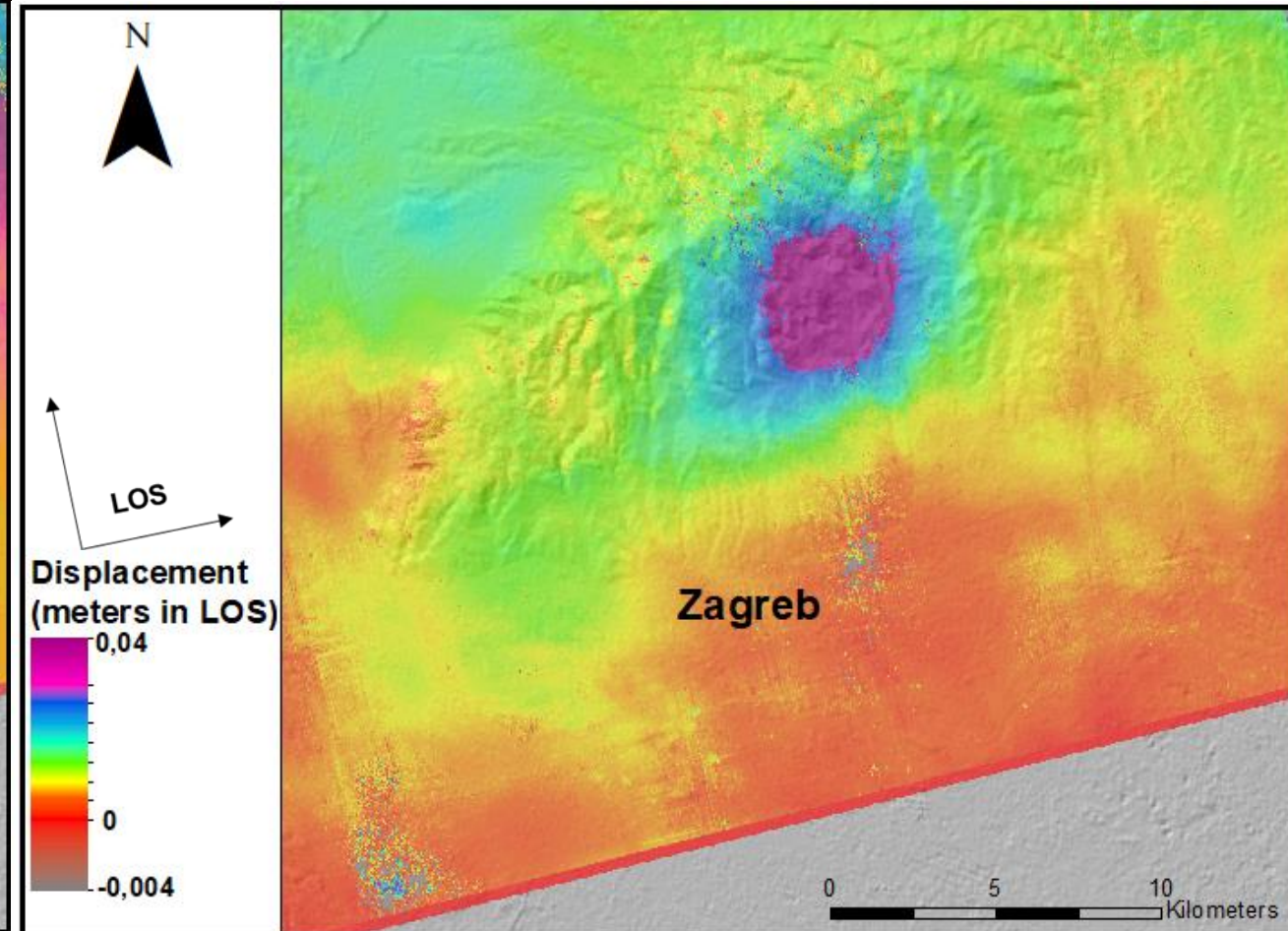
Sar images input to SNAP

TOPSAR-split Apply-orbit-file → **Pre-processing steps**

Back-geocoding Enhanced Spectral Diverrsity Interferogram production, Filetring TOPSAR-Deburst → **Main processing steps** → **SNAPHU**

ArcGIS Processing

Displacement map in meters ← **Snap Import** ← **Unwrapping**

Terrain Correction

Geospatial Intelligence products generation

Knowledge mining

Mask → **Export Data** → **Import Data into ArcGIS** ← **Geospatial Inputs polygons,lines,points**

SNAP 7.0
ArcGIS 10.6

Results

Wrapped interferogram (wrapped phase) after processing Sentinel 1 pair ascending SAR images (a).
Deformation map (meters in LOS) after unwrapping, Sentinel 1 pair ascending SAR images (b).
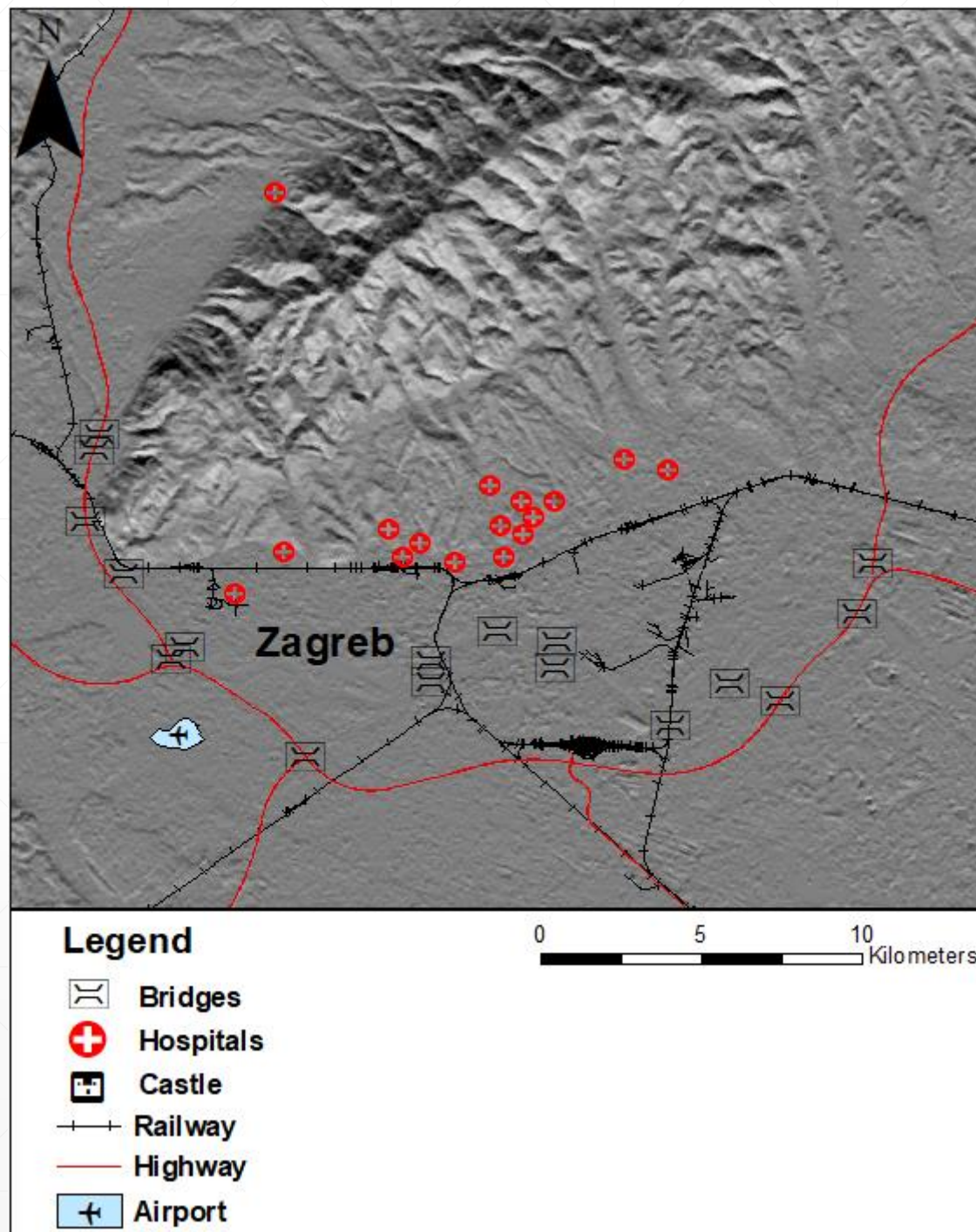
Results

a)

b)
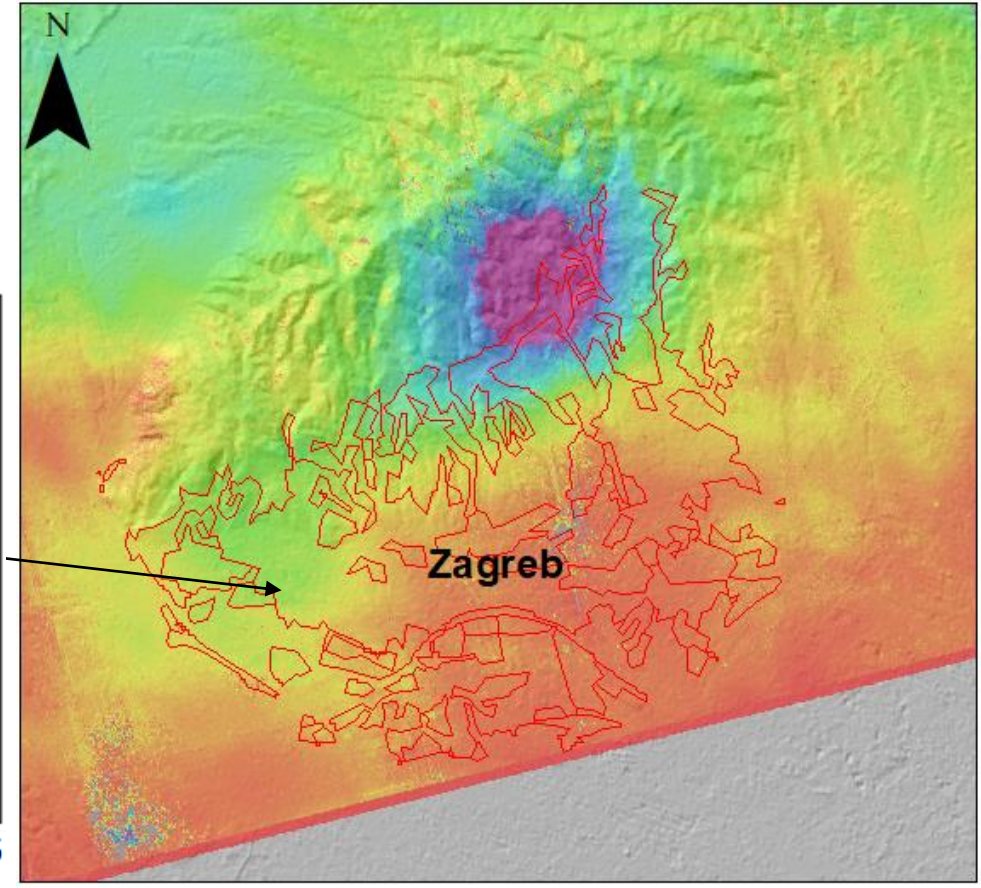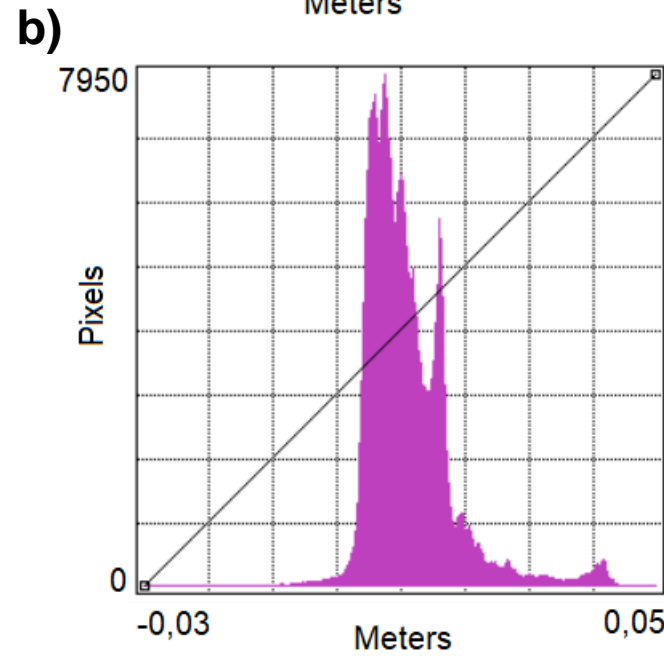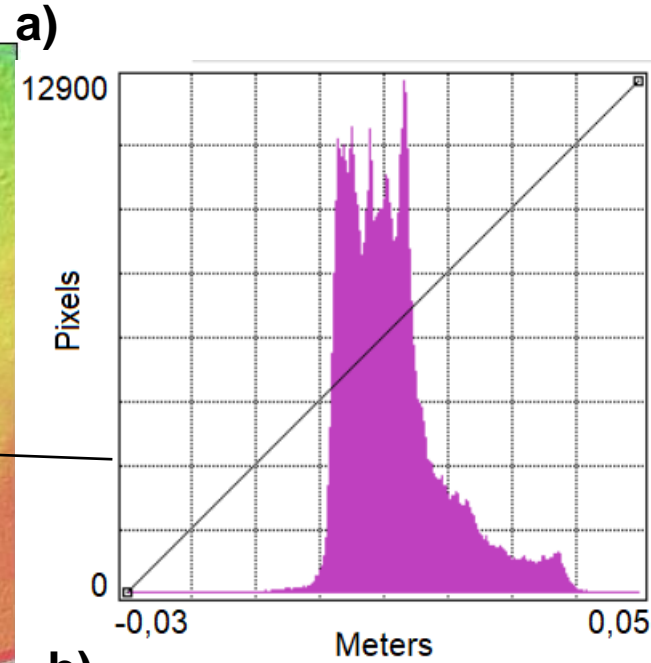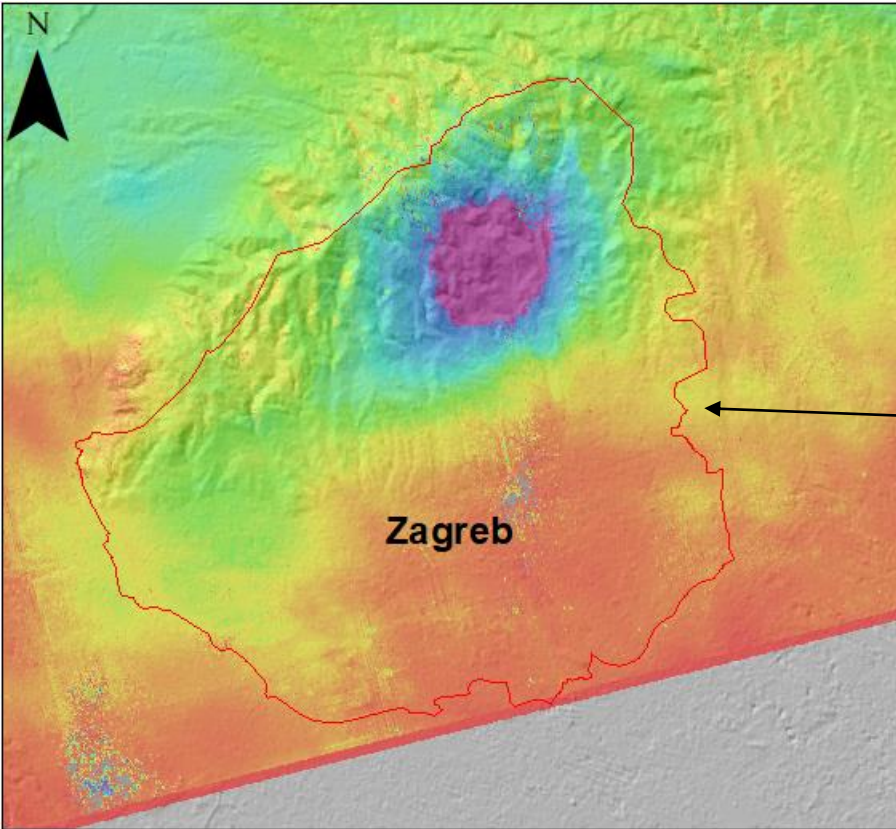
Histograms of deformation (in LOS) frequency of Zagreb city
a) Based on OpenStreetMap and b) Based on Corine 2018
(axis X : deformation in meters,
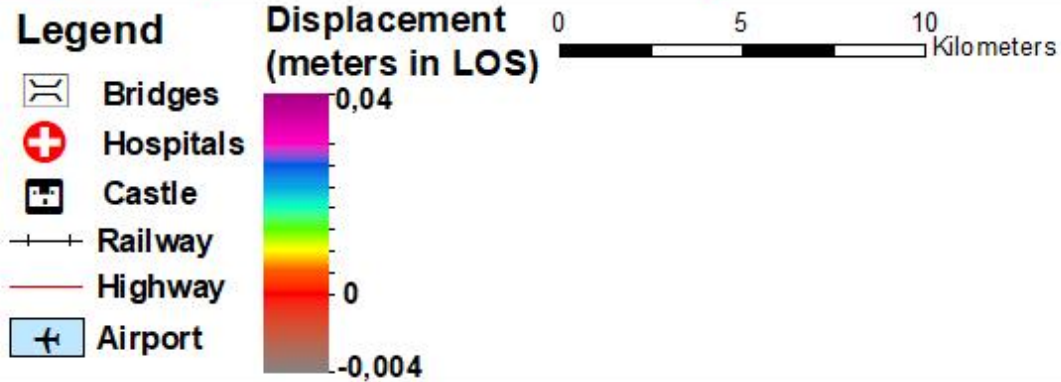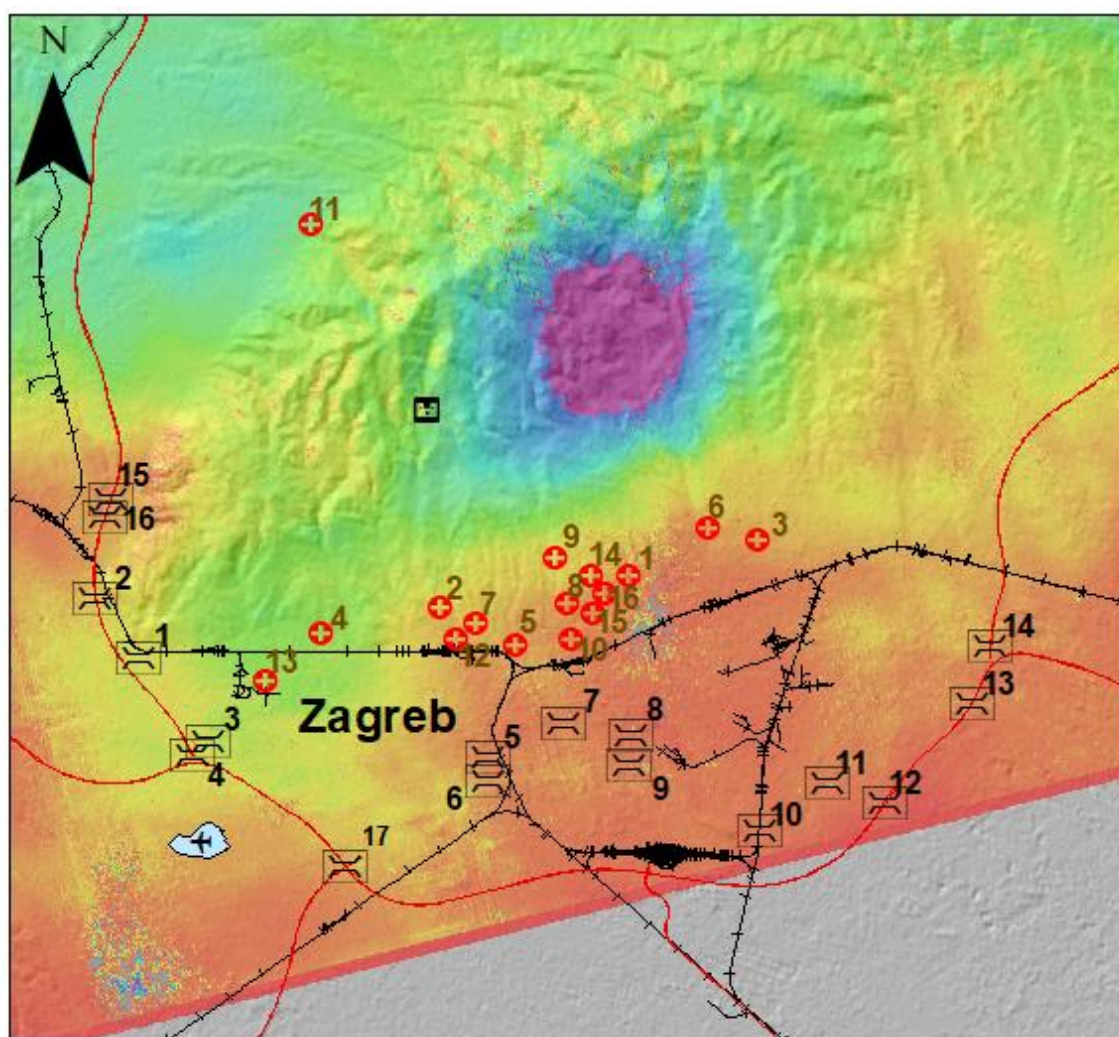axis Y: frequency in pixels)
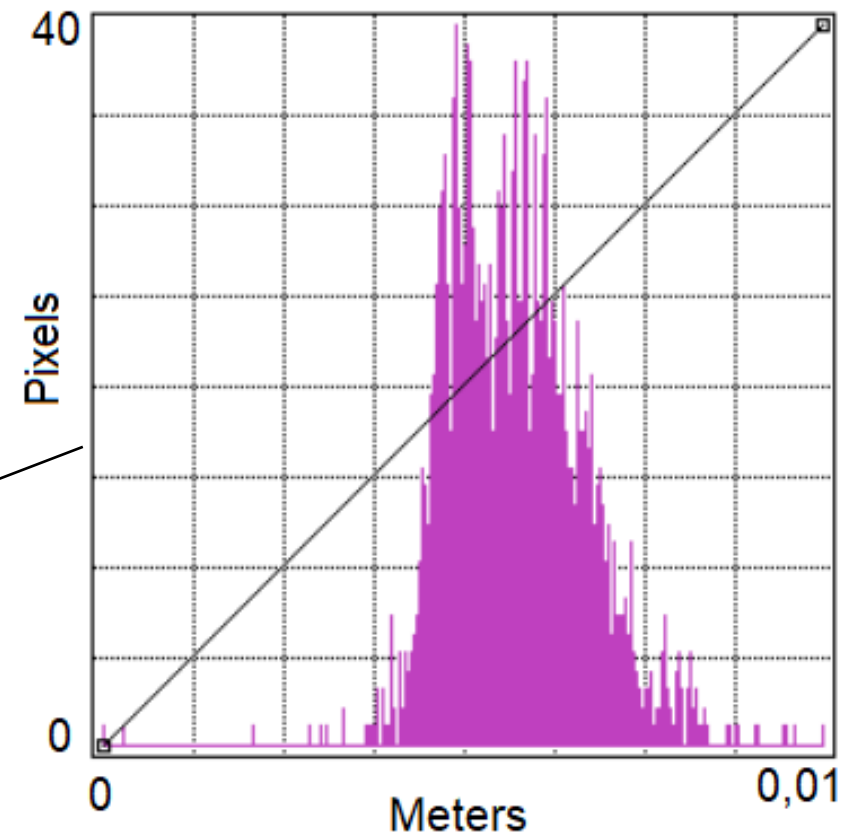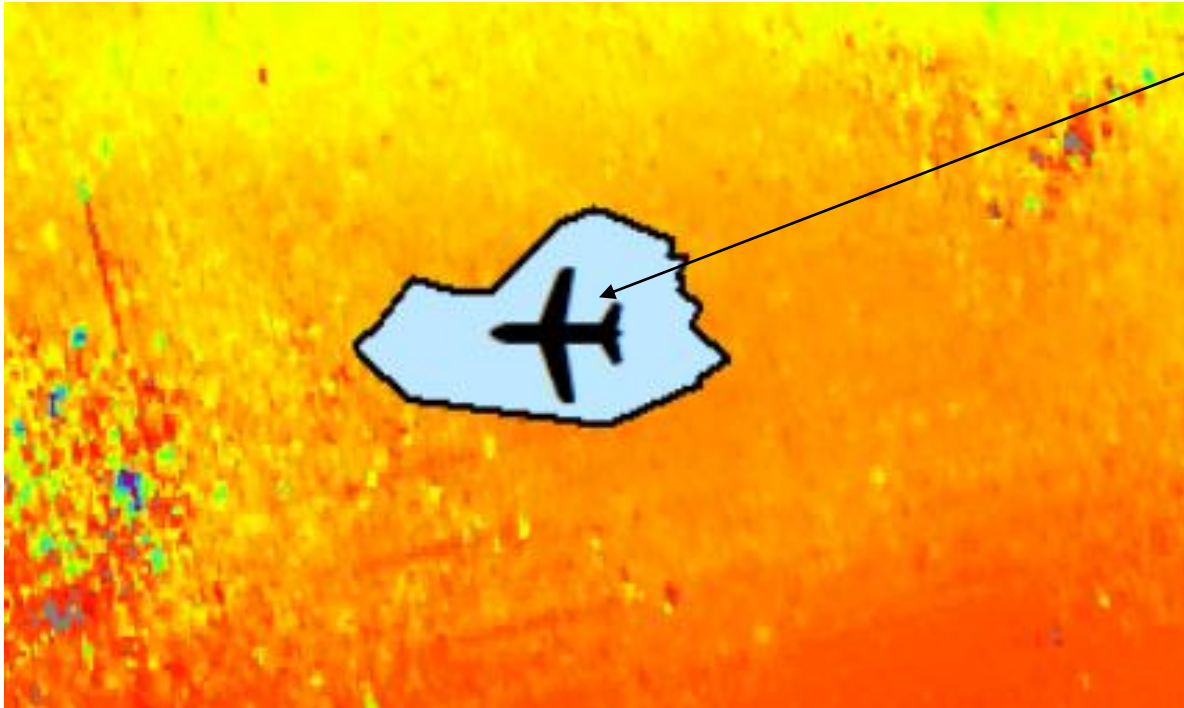
Results

Histogram of deformation (in LOS) frequency for Lucko Airport area (axis X: deformation in meters, axis Y: frequency in pixels).

Results

Local exposure data for the area of Zagreb

Results

| Infrastructures	Displacement (m in LOS)	Infrastructures	Displacement (m in LOS)
Hospital 1	0,005	Bridge 1	0,011
Hospital 2	0,01	Bridge 2	0,012
Hospital 3	0,007	Bridge 3	0,011
Hospital 4	0,014	Bridge 4	0,009
Hospital 5	0,007	Bridge 5	0,006
Hospital 6	0,005	Bridge 6	0,006
Hospital 7	0,008	Bridge 7	0,006
Hospital 8	0,006	Bridge 8	0,003
Hospital 9	0,009	Bridge 9	0,004
Hospital 10	0,006	Bridge 10	0,005
Hospital 11	0,016	Bridge 11	0,005
Hospital 12	0,006	Bridge 12	0,003
Hospital 13	0,013	Bridge 13	0,005
Hospital 14	0,008	Bridge 14	0,006
Hospital 15	0,006	Bridge 15	0,006
Hospital 16	0,006	Bridge 16	0,006
Castle	0,016	Bridge 17	0,007

Point-like infrastructures and deformation

Results

Histogram showing the deformation in LOS along linear transportation, **a)** national road (Blue Line) and **b)** railway road (Yellow Line) network
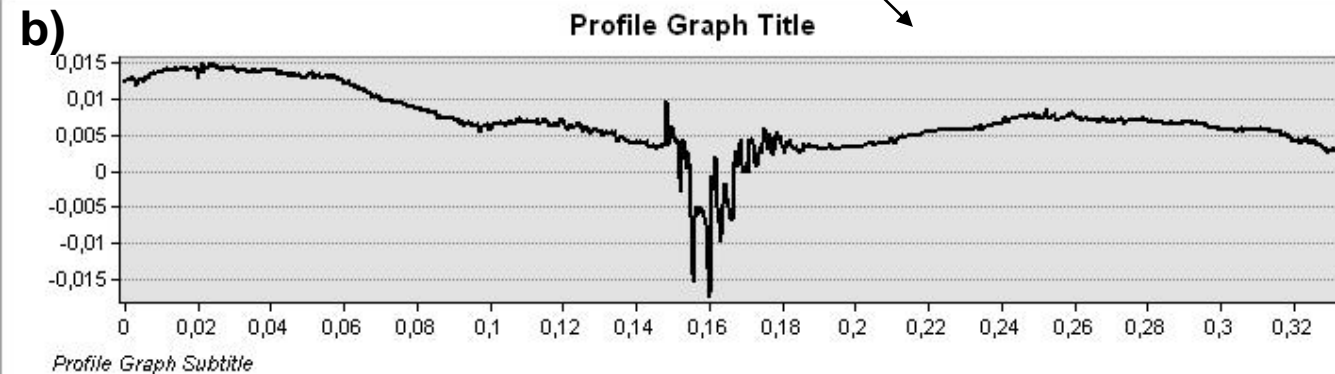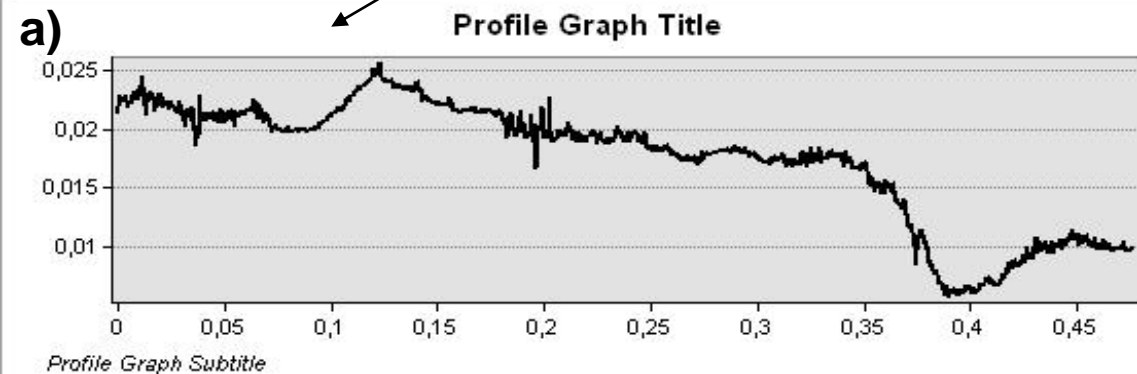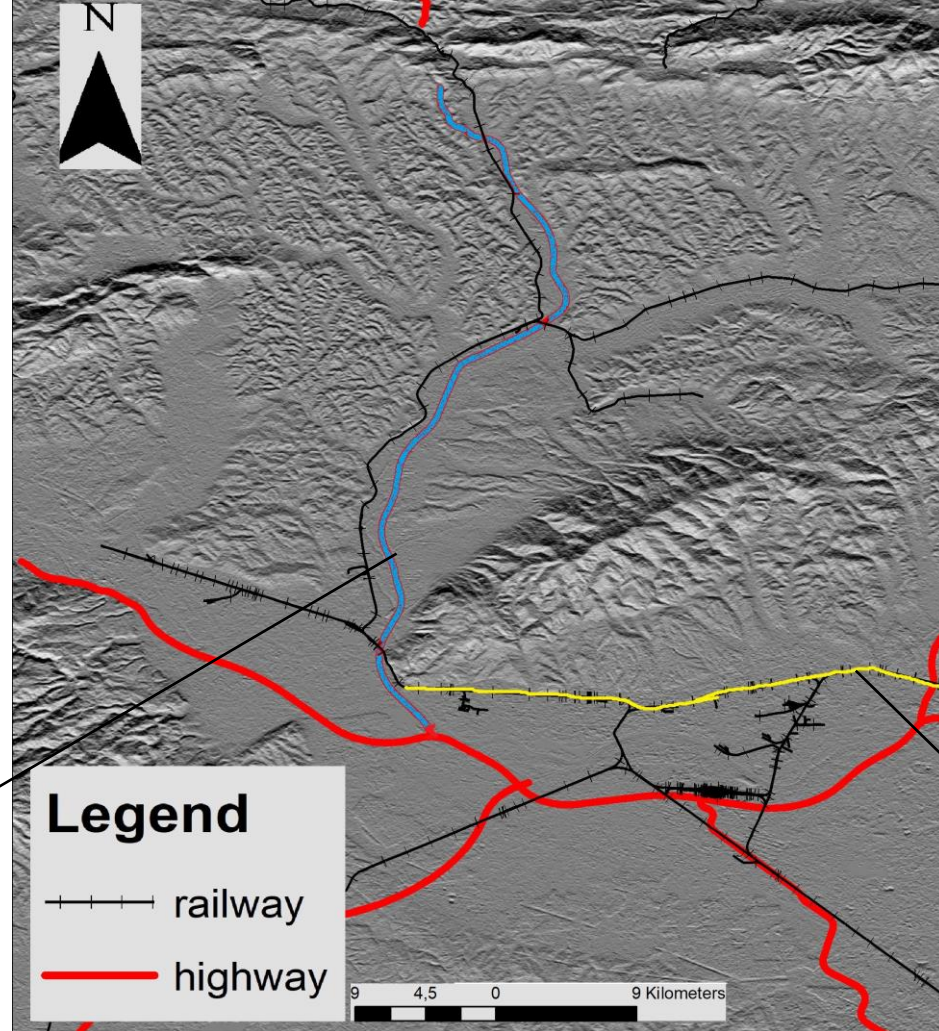
Results
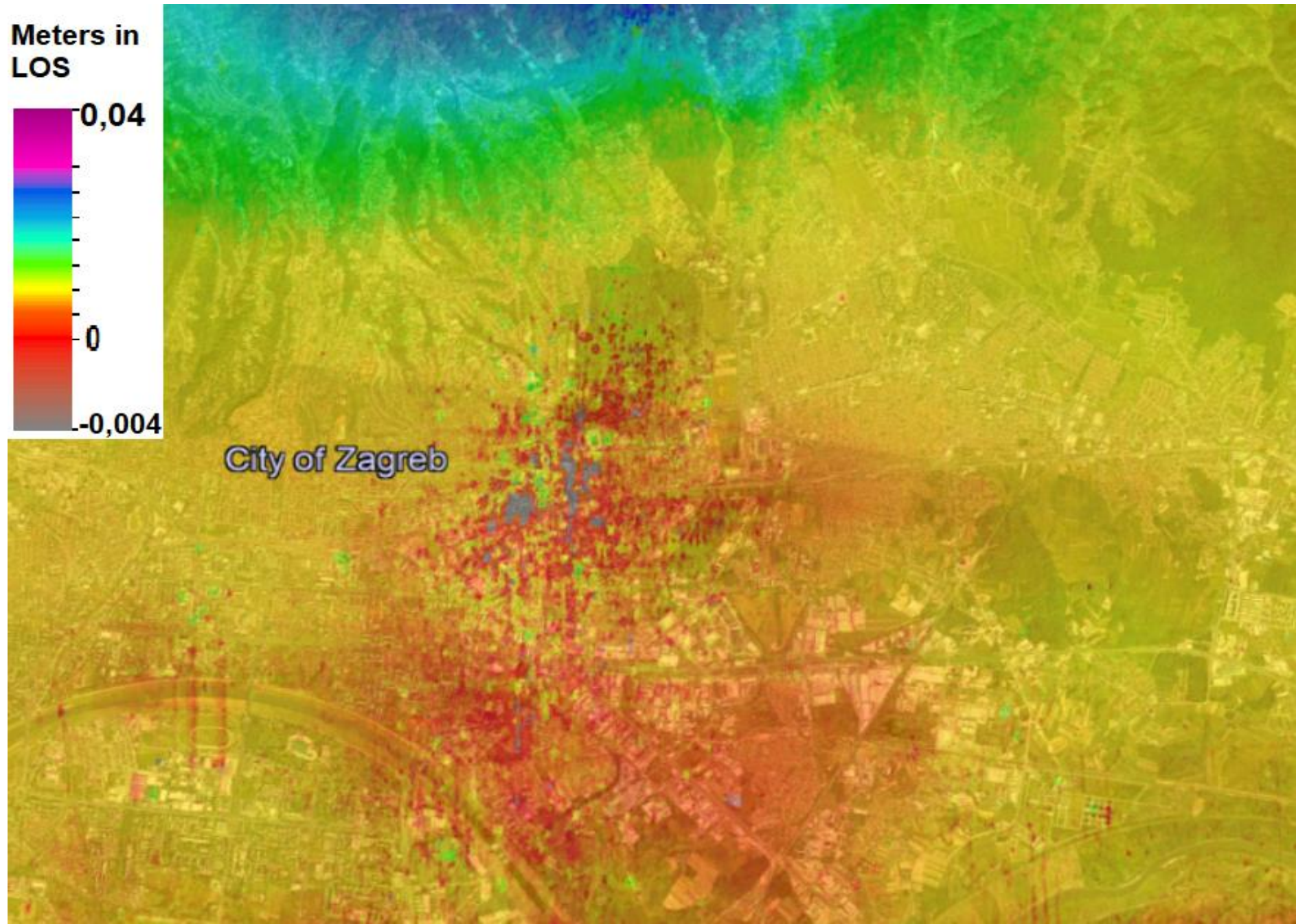
The Deformation inside the City of Zagreb (Deformation meters in LOS)