e-shape

EuroGEOSS Showcases: Applications Powered by Europe

S6P3 – Test Site Data Requirements

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1 INTRODUCTION

S6P3 designed products require mandatory and auxiliary data to obtain successful analysis of the geohazards. This document provides the explanation about these datasets and their utility to the analysis.

2 PRODUCT 1: INSAR PROCESSING

Satellite radar differential interferometry (DInSAR) is a geodesic technique that allows to remote sense small displacements of the terrestrial surface by analysing the phase differences between pairs of SAR images. This product is focused on the obtention of the main monitoring data that is going to be analysed in order to obtain advanced products.

2.1 Sentinel-1 Data

Sentinel-1 data is considered as the core SAR data in this project due to the free availability of the SAR images, high temporal resolution and good spatial resolution. Also, these images can be processed using cloud computing platforms like GEP-TEP improving the accessibility to final InSAR results. Since InSAR results are the objective of this product, they could be obtained through collaboration with the EGS or National Geological Service, or hiring specialized InSAR processing companies to carry on this work.

SAR images from other Satellite platforms like ALOS, Cosmo-SkyMed, RADARSAT or TerraSAR-X are available options. X-band satellites are especially suitable for urban areas. Despite that, these data must be usually obtained under payment of the images or through research projects requests or calls.

Final product is the InSAR displacement dataset for a specific area and time span and is mandatory for further analysis.

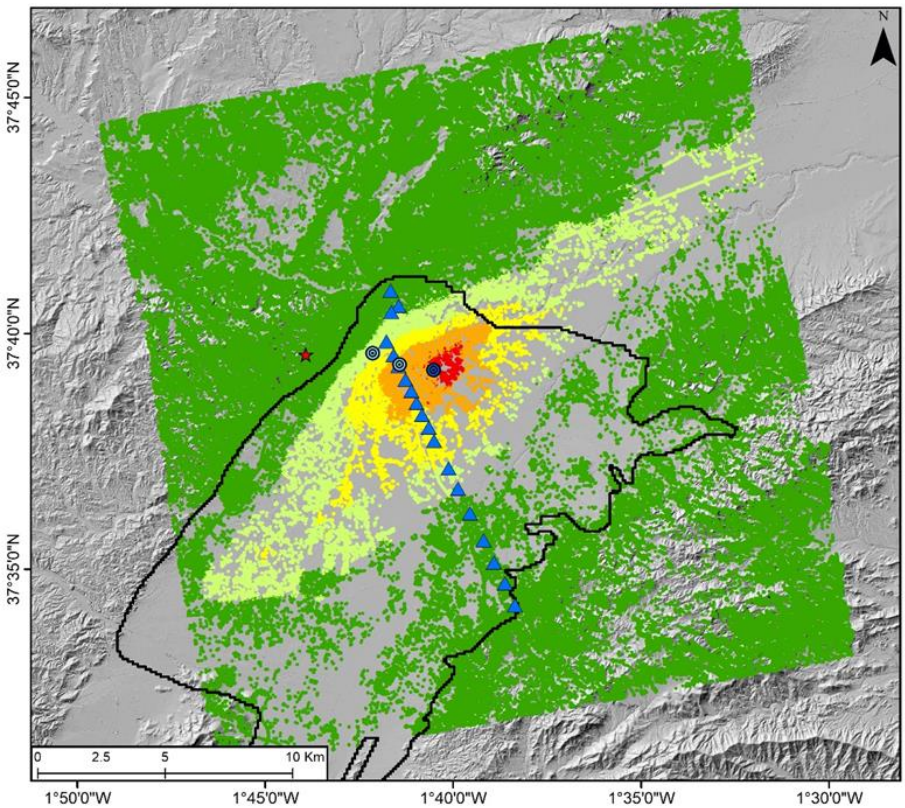


Fig. 1: Example of InSAR results[1]

2.2 Stability Knowledge

InSAR processing provide displacement results over valid scatterer points from a large area, but those results are relative. In order to obtain absolute values, a stable area must be set to refer the values. Since this information is not mandatory, the stable area ("seed") can be set "randomly" and refined during processing workflow, in-deep knowledge of the test site is useful to improve the results and reduce the processing time.

The information that must be presented to complete this requirement is the expected stable area (coordinates). If In-situ data that confirms the stability is available, they will help to support the processing and validation.

3 PRODUCT 2: INSAR VALIDATION REPORT

InSAR validation report is the second S6P3 product, designed for specialized users. This product aims to provide information about the performance and accuracy of the InSAR data. Depending on the test site, is difficult to obtain auxiliary monitoring data and two sides of validation are possible: Quatitative and Qualitative.

3.1 Quantitative Validation

Quantitative validation is based on the comparison of displacement data between InSAR main dataset and other kind of In-situ or remote sensing data. Usually, this kind of data are usually difficult to obtain and compare. In order to obtain a validation result, three levels of validation are described. Only one of the datasets on each level is mandatory to complete the requirements.

3.1.1 Full Validation

Compares the displacement time series of a similar time span.

- Secondary InSAR data

The information that must be presented to complete this requirement is a secondary InSAR dataset with time series from different software, acquisition geometry or satellite that covers similar study area and time span.

- GNSS Permanent Stations

The information that must be presented to complete this requirement are the post-processed GNSS data time series of all the available GNSS stations that covers located in the study area within the InSAR time span.

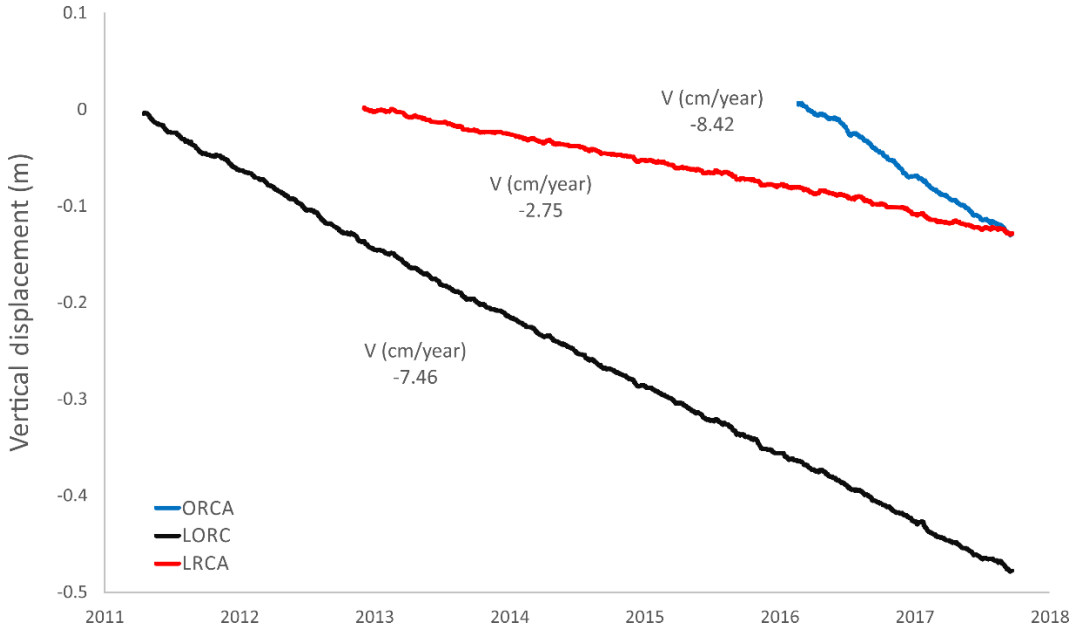


Fig. 2: Example of GNSS time series and velocities[1]

3.1.2 Trend Validation

Compares the displacement velocities at similar time span.

- Secondary InSAR data

The information that must be presented to complete this requirement is a secondary InSAR dataset with displacement velocities from different software, acquisition geometry or satellite that covers similar study area and time span.

- GNSS Data

The information that must be presented to complete this requirement are the post-processed GNSS data displacement velocities of all the available GNSS stations and campaigns that covers located in the study area within the InSAR time span.

- Levelling Campaigns

The information that must be presented to complete this requirement are levelling data displacement velocities of all the available benchmarks and campaigns that covers located in the study area within the InSAR time span.

3.1.3 Trend Comparison

Compares the displacement velocities at different time span.

- Secondary InSAR data

The information that must be presented to complete this requirement is a secondary InSAR dataset with displacement velocities from different software, acquisition geometry or satellite that covers similar study area but during a different period.

- GNSS Campaigns

The information that must be presented to complete this requirement are the post-processed GNSS data displacement velocities of all the available GNSS stations that covers located in the study area but during a different period.

- Levelling Campaigns

The information that must be presented to complete this requirement are levelling data displacement velocities of all the available benchmarks and campaigns that covers located in the study area but during a different period.

3.2 Qualitative Validation

When no monitoring data is available, a qualitative validation can be achieved if other spatial or temporal data related to the geohazard exists.

3.2.1 Spatial Validation

The spatial coincidence between InSAR active displacements and a possible geohazard trigger can be considered as a first kind of validation.

- Spatial Location of the Geohazard

Depending on the studied area and the expected geohazard this layer could be the extraction wells location, the extent of a landslide, the galleries of an underground mine, new buildings, etc.

The information that must be presented to complete this requirement is the location (point, line or polygon) of the geohazard at the most similar time span than the main InSAR data.

3.2.2 Temporal Validation

Also, the temporal correlation between InSAR active displacements and temporal data related to geohazard trigger can be used as a qualitative validation.

- Temporal evolution of the Geohazard

Depending on the studied area and the expected geohazard this layer could be the extraction rates, underground mining evolution, piezometric levels, evolution of lava flows, etc.

The information that must be presented to complete this requirement is the location (point, line or polygon) and temporal data of the geohazard at a comparable time span regarding the main InSAR data.

4 PRODUCT 3: ACTIVE GEOHAZARD AREAS REPORT

Active Geohazards Report is the main S6P3 product, designed to present the results in an understandable way to final stakeholders not used to InSAR data. This section is divided depending on the main geohazard of the studied area.

4.1 Land Subsidence due to Groundwater Changes: Influence area definition & Extraction rates response

Land subsidence is one of the most important geohazards, affecting large areas and generating several problems like damages to structures and infrastructures, loss of aquifer-system storage, etc. Main challenges on the analysis of this geohazards are the possible low-rate displacements near the detection range or the influence of the geology in the observed displacements. The following datasets are needed to carry on this task. Extraction rates are not mandatory but improves the knowledge of the aquifer-system.

- Piezometric Changes

Piezometric changes are the main driver to generate surface displacements and their evolution must be considered to understand the aquifer-system dynamics.

The information that must be presented to complete this requirement is the location (point) or map and temporal data of the groundwater position.

- Active Well location

The location of the active wells during an extraction campaign or period determines their area of influence in both groundwater and subsidence.

The information that must be presented to complete this requirement is the location (point) of the active wells and their activity period.

- Extraction Rates

Extraction rates can be useful to compare their influence on the detected subsidence and improve the knowledge of the hydrogeological and geomechanical properties.

The information that must be presented to complete this requirement is the location (point) of the active wells and the temporal evolution of the extraction rates.

- Hydrogeological Data

All the available knowledge about the aquifer-system is useful to understand the process and the influence of the different materials in the detected displacements.

The information that must be presented to complete this requirement is the thickness and hydrogeological properties of the different layers that compose the aquifer-system.

- Geological and Borehole Data

Extraction rates can be useful to compare their influence on the detected subsidence and improve the knowledge of the hydrogeological and geomechanical properties.

The information that must be presented to complete this requirement is the location (point) of the active wells and the temporal evolution of the extraction rates.

4.2 Landslides

Landslides mostly affect steep areas and are a geohazard that can generate severe damages to buildings and infrastructures. Due to their location and movement characteristics can be difficult to identify and understand using InSAR data. Two different analyses are designed. The following datasets are needed to carry on the different analysis of this kind of hazard.

4.2.1 3D Analysis

Since main displacement direction of a landslide is towards the maximum slope direction or the slide surface and the InSAR acquisition geometry is fixed, the landslide displacement can be distorted or masked by the geometry. The availability of InSAR data in other acquisition geometry allow to calculate E-W and Up-Down displacement components.

- Secondary InSAR Data

The information that must be presented to complete this requirement is a secondary InSAR dataset with displacement velocities from different acquisition geometry that covers similar study area at the same period.

4.2.2 Detection of Active Lobes

Large landslides use to be subdivided on different lobes, active or inactive depending on the time span. The evolution of those lobes' displacement can be useful to detect the most vulnerable areas or rank their vulnerability to take decisions and prioritize efforts

- High Resolution DEM

High resolution DEM allow to cartograph the different lobes and understand the geometry of the landslide.

The information that must be presented to complete this requirement is the DEM with a 5m pixel side.

- Geomorphological Interpretation

Geomorphological maps are the next step to understand the "history" of a landslide and provide valuable information about the different features that compose the landslide and can lead to different displacement behaviours.

The information that must be presented to complete this requirement are the geomorphological map or features.

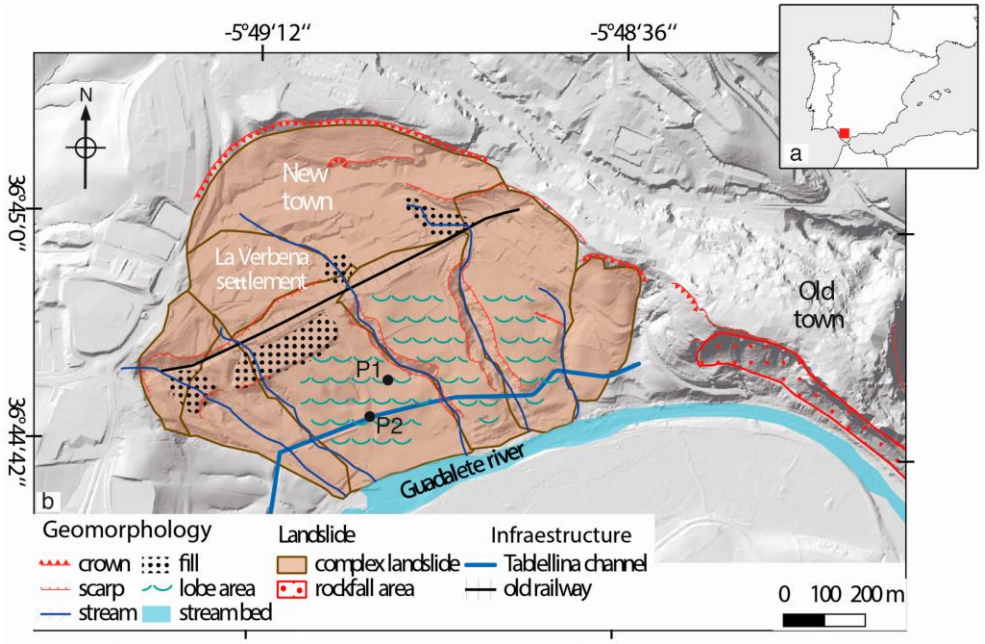


Fig. 3: Example of geomorphological map over an active landslide area[2]

4.3 Mining: Underground mining spatial correlation

Underground mining activities generate severe affection over land surface that are usually monitored and calculated to minimize the effects over urban areas. The evaluation of the mining influence can be studied in comparison with the mining activity.

- Evolution of Mining Activities

Annual or monthly data about the underground galleries progress, extracted material and its depth are key data to evaluate the evolution of their effect on the detected surface displacement.

The information that must be presented to complete this requirement are the location (point, line, polygon) of the progress and/or the amount of extracted resources.

- Complete map of the underground galleries

Sometimes, detailed information about the mining process is not available, but analysis can be carried on using the galleries map (especially useful in abandoned mines with collapsing problems) or the mining area.

The information that must be presented to complete this requirement are the features that define the underground mining area.

5 PRODUCT 4: URBAN VULNERABLE AREAS REPORT

Urban vulnerable areas product is the most specific one designed in the S6P3 which result provides detailed information about the vulnerability of an area to the studied geohazard. This product is very dependent on the available information, especially the existence of specifically designed campaigns to detect damages in the structures of the basin. Due to the problems to obtain that kind of information, part of the analysis can be done using specific displacement thresholds adapted to each test site.

5.1 Generation of dynamic fragility curves

Fragility curves provide information about the damage probability regarding each damage level, building typology, building age... They can also provide information about the value of the damages if enough information is available.

5.1.1 Damage Probability

First step uses the InSAR data, cadastral data and damage detection campaigns to calculate the fragility curves.

- Cadastral Data (Polygons)

The information that must be presented to complete this requirement is the cadastral data (Polygons). If more information about the building typology or age is available, more analysis can be performed.

- Damage Detection Campaign (Damage Level)

The information that must be presented to complete this requirement is the existence or not of damages on the inspected cadastral polygons. If more information about the damage level is available, more analysis can be performed.

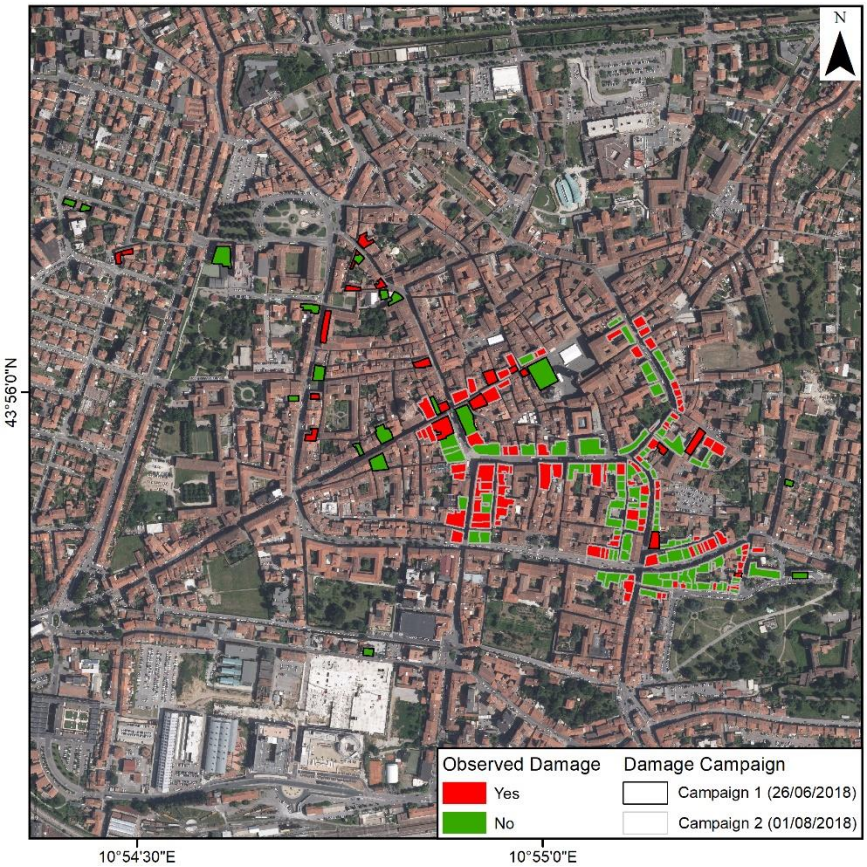


Fig. 4: Example of damage detection campaigns[3]

5.1.2 Economical Estimation

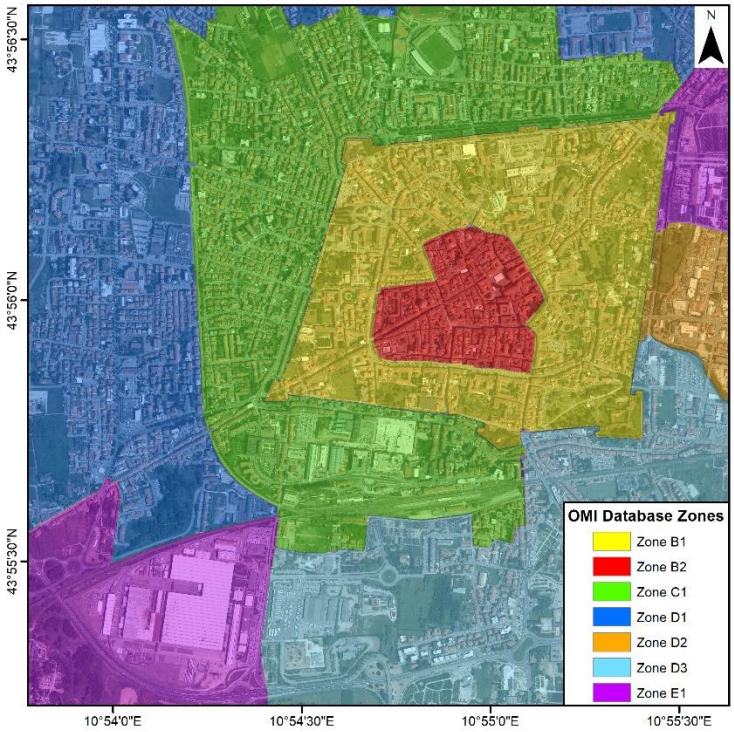
Using the economical data, more detailed cadastral data and the level of the expected damages, the expected economical impact can be estimated.

- Cadastral Data (Number of Floors, Economical Use)

The information that must be presented to complete this requirement is the cadastral data (Number of Floors, Economical Use) on each polygon.

- Economic data

The information that must be presented to complete this requirement is the economic value depending on the economic use and city neighbourhood.



Economical Use

District	Houses		Industry		Office		Shops		Warehouse	
	E/m2	%	E/m2	%	E/m2	%	E/m2	%	E/m2	%
B1	1525	26.5	800	13.7	1275	22.2	1450	24.8	750	12.8
B2	1810	31.3	0	0.0	1575	27.0	1675	28.8	750	12.9
C1	1510	25.1	800	13.6	1400	23.8	1450	24.7	750	12.8
D1	1590	26.7	825	14.2	1325	22.8	1375	23.7	775	12.5
D2	1425	23.0	760	14.4	1400	23.0	1575	25.5	875	14.0
D3	1440	24.8	775	14.3	1400	24.3	1450	24.3	725	12.2
E1	1460	25.2	635	13.9	1375	23.9	1425	25.7	625	11.3

Fig. 5: Example of economical zonation and data[3]

5.2 Identification of induced displacements

Simpler analysis can be performed if no damage campaigns are available using both cadastral data and specific information about the history of damages of the case study

- Cadastral Data (Polygons)

The information that must be presented to complete this requirement is the cadastral data (Polygons). If more information about the building typology or age is available, more analysis can be performed.

- Displacement Thresholds

Usually, urban areas affected by geohazards have specific normative related to the maximum tolerable accumulated or velocity displacements, moreover if they are caused by human activities (mining, pumping, …). They can be used to identify the most vulnerable areas relative to those thresholds.

The information that must be presented to complete this requirement is the agreed thresholds.

6 BIBLIOGRAPHY

1 Ezquerro, P., et al. “Upgrading groundwater model capabilities using Sentinel-1 and Cosmo-SkyMed data” Science of the Total Enviroment (2019)

2 Béjar-Pizarro, M. et al. “Mapping Vulnerable Urban Areas Affected by Slow-Moving Landslides Using Sentinel-1 InSAR Data” Remote Sensing (2017)

3 Ezquerro, P., et al., “Vulnerability Assessment of Buildings due to Land Subsidence Using InSAR Data in the Ancient Historical City of Pistoia (Italy)” Sensors (2020)

7 REQUIREMENTS SURVEY

Product		Level	Needed data	Is this data available?	Is this level applicable to your case study?	Is this product applicable to your case study?
InsSAR processing	-	-	InSAR data		-	-
InSAR Validation Report	Cuantitative	Full validation	Secondary InSAR dataset (TS&same dates) *			
			GNSS permanent station data (TS&same dates) *			
		Trend Validation	Secondary InSAR dataset (V&same dates) *			
			GNSS campaigns (V&same dates) *			
			Levelling campaigns (V&same dates) *			
		Trend Comparison	Secondary InSAR dataset (V&diff dates) *			
			GNSS data (V&diff dates) *			
			Levelling campaigns (V&diff dates) *			
	Cualitative	Spatial Validation	Spatial location of the Geohazard			
		Temporal Validation	Temporal evolution of the Geohazard			
Active Geohazard Areas Report	Subsidence	Influence area definition & Extraction rates response	Piezometric data			
			Position of active wells			
			Extraction rates **			
			Hydrogeological data			
			Geological and borehole data			
	Landslides	3D analysis	Secondary InSAR dataset (Opposite SAR geometry)			
		Detection of active lobes	High resolution DEM data			
			Geomorphological interpretation			
	Mining	Underground mining spatial correlation	Evolution of the mining activity			
			Complete map of the underground galleries			

Urban Vulnerable Areas Report	Generation of dynamic fragility curves	Damage probability	Cadastral data (polygons)			
			Damage detection campaigns (Damage level)			
			Cadastral data (Building typology) **			
		Economical Estimation	Cadastral data (number of floors)			
			Cadastral data (economical use) **			
			Economical data (market value)			
			Economical data (market value by economical use) **			
	Identification of induced displacements	Displacement Thresholds	Cadastral data (polygons)			

* Only one dataset is mandatory for the correct implementation of the tool level

** This data is not mandatory for the correct implementation of the tool but still important for better results