



PROGRAMME OF
THE EUROPEAN UNION



Validation Data Collection and Description Document

SERVICES SUPPORTING THE EUROPEAN ENVIRONMENT AGENCY'S (EEA) IMPLEMENTATION OF THE COPERNICUS EUROPEAN GROUND MOTION SERVICE – PRODUCT VALIDATION.



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1. INTRODUCTION

This document is part the documentation connected to the European Ground Motion Service (EGMS) products validation as specified in the framework contract EEA/DIS/R0/21/009. The validation of the Interferometric Synthetic Aperture Radar open datasets at continental scale has the following goals and considerations:

- It verifies the **usability** of the data for different applications according to initial user requirements and with respect to the fields of application foreseen by the Validation of the EGMS Product Portfolio¹ and the EGMS End User Requirement² documents.
- It determines if the **quality** of the products is consistent with the technical specifications for different areas and applications. It is used to confirm the conclusions of the EGMS Quality Assurance and Control Reports.
- It addresses the **completeness** and **consistency** of the data products together with their **accuracy**.
- It is performed **independently** from the EGMS production. The validation datasets used, and the chosen procedures/criteria are documented in deliverables D3.1, D5 and D6.1.
- It is based on the comparison of data of different nature. Therefore, a complete agreement is most likely impossible, and differences may not be related to a quality issue.

In the following sections, the methods used for validation data collection, data sources and providers, data accessibility and license conditions are described.

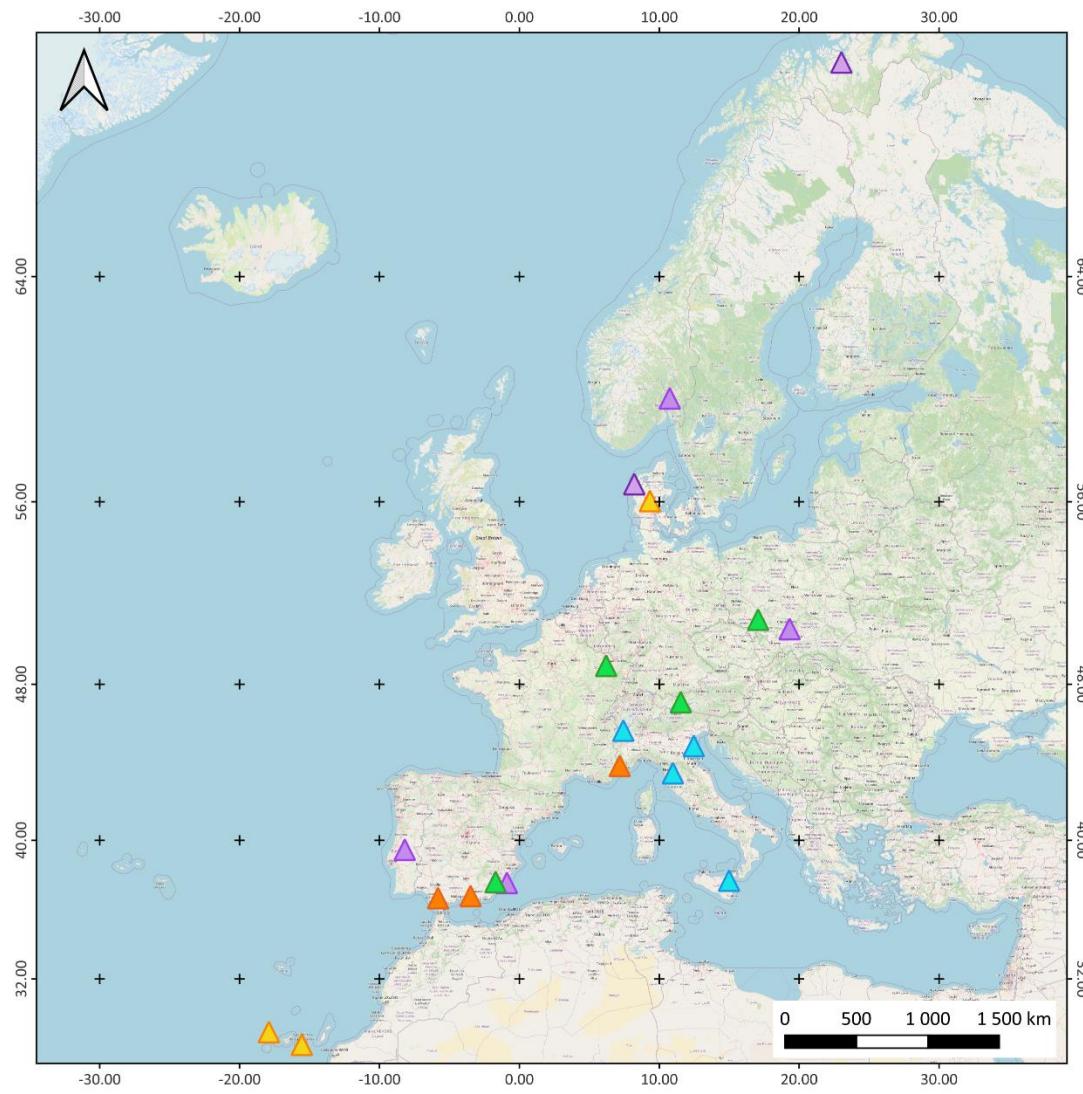
Moreover, this document provides the validation data technical specifications with a focus on spatial and temporal coverage, quality/accuracy requirements, data format, metadata, and uncertainty level.

¹ <https://land.copernicus.eu/user-corner/technical-library/egms-end-user-requirements-document>

² <https://land.copernicus.eu/user-corner/technical-library/validation-approach-of-the-egms-product-portfolio>

2. VALIDATION DATA COLLECTION

The following map presents a global overview of the approximative site location for each of the validation activities (Figure 1). The same overview can be consulted in a tabular format (Table 1) linking validation activity, site and data provider.



- ▲ Comparison with GNSS
- ▲ Comparison with in-situ
- ▲ Comparison with CRs
- ▲ Comparison with other GMS
- ▲ Comparison with inventories
- ▲ Comparison with geoinformation

Figure 1: Validation Activities (VA) and their validation sites (approximative).



Table 1: Summary of Validation sites grouped by Validation Activity

Validation Activity	Validation site ID - description	Data Provider
Point density check	VA1_1 – Urban area of Bologna, Italy	CLC Urban Atlas (EEA)
Point density check	VA1_2 – Urban area of Bucharest, Romania	CLC Urban Atlas (EEA)
Point density check	VA1_3 – Urban area of Stockholm, Sweden	CLC Urban Atlas (EEA)
Point density check	VA1_4 – Urban area of Barcelona, Spain	CLC Urban Atlas (EEA)
Point density check	VA1_5 – Urban area of Sofia, Bulgaria	CLC Urban Atlas (EEA)
Point density check	VA1_6 – Urban area of Warsaw, Poland	CLC Urban Atlas (EEA)
Point density check	VA1_7 – Urban area of Bratislava, Slovakia	CLC Urban Atlas (EEA)
Point density check	VA1_8 – Urban area of Brussels, Belgium	CLC Urban Atlas (EEA)
Point density check	VA1_9 – Rural area of Bolzano, Italy	CLC Urban Atlas (EEA)
Point density check	VA1_10 – Rural area of Las Palmas, Spain	CLC Urban Atlas (EEA)
Point density check	VA1_11 – Rural area Zilina, Slovakia	CLC Urban Atlas (EEA)
Point density check	VA1_12 – Rural area Tromso, Norway	CLC Urban Atlas (EEA)
Comparison with other GMS	VA2_1 – Mount Etna, Sicily Island, Italy	CNR/IREA
Comparison with other GMS	VA2_2 – Danish GMS, Thyborøn	DTU
Comparison with other GMS	VA2_4 – Valle d'Aosta/Italy GMS, Alps	Regional GMS
Comparison with other GMS	VA2_5 – Veneto/Italy GMS, Po delta	Regional GMS
Comparison with other GMS	VA2_6 – Tuscany/Italy GMS, north Apennines	Regional GMS
Comparison with Inventories of Phenomena	VA3_1 – National inventory (France)	BRGM
Comparison with Inventories of Phenomena	VA3_2 – Rules reservoir (Spain)	CSIC / IGME
Comparison with Inventories of Phenomena	VA3_3 – Post-mining area in Lorraine, France	BRGM
Comparison with Inventories of Phenomena	VA3_4 – Arcos de la Frontera, Spain	CSIC / IGME
Consistency check with Ancillary geo-information	VA4_1 – Municipal area of Oslo, Norway	NGI
Consistency check with Ancillary geo-information	VA4_2 – Cartagena-La Unión, Murcia (Spain)	CSIC / IGME
Consistency check with Ancillary geo-information	VA4_3 – Alto Guadalentín, Lorca, Spain	CSIC / IGME
Consistency check with Ancillary geo-information	VA4_4 – Silesia coal mine region, Czech Republic / Poland	CGS
Consistency check with Ancillary geo-information	VA4_5 – Lower Tagus Valley Fault System, Portugal	LNEG
Comparison with GNSS data	VA5_1 – Jutland, Denmark	DTU
Comparison with GNSS data	VA5_2 – Canary Islands, Spain	CNIG
Comparison with GNSS data	VA5_3 – Lorca, Spain	CNIG
Comparison with In-situ monitoring	VA6_1 – Lorca, Spain	CSIC / IGME
Comparison with In-situ monitoring	VA6_2 – Turow mine, Czech Republic / Poland	CGS
Comparison with In-situ monitoring	VA6_3 – Navis valley, Tyrol, Austria	GeoSphere
Comparison with In-situ monitoring	VA6_4 – Freyming-Merlebach, France	BRGM
Evaluation XYZ and displacements with ACR	VA7_1 – Thyborøn, Denmark	Geopartner
Evaluation XYZ and displacements with ACR	VA7_2 – Norway, various sites	NVE / NGU
Evaluation XYZ and displacements with ACR	VA7_3 – Calern, France	IGN

2.1 Point density check

Test site ID / Name

Eight different **urban** sites are proposed covering the different EGMS interferometric processing entities:

- VA1_1** – Urban area Bologna, Italy
- VA1_2** – Urban area Bucharest, Romania
- VA1_3** – Urban area Stockholm, Sweden
- VA1_4** – Urban area Barcelona, Spain
- VA1_5** – Urban area Sofia, Bulgaria
- VA1_6** – Urban area Warsaw, Poland
- VA1_7** – Urban area Bratislava, Slovakia
- VA1_8** – Urban area Brussels, Belgium

And four different **rural/mointaneous** sites are proposed covering the different EGMS production team providers:

- VA1_9** – Rural area Bolzano, Alps, Italy
- VA1_10** – Rural area Las Palmas, Canary Islands, Spain
- VA1_11** – Rural area Zilina, Tatras, Slovakia
- VA1_12** – Rural area Tromso, Norway

Data providers / sources

Open dataset downloaded directly from the CLMS website – Urban Atlas 2018 showing the different land cover classes/polygons. This dataset comes with metadata and quality information.

<https://land.copernicus.eu/local/urban-atlas/urban-atlas-2018>

Data collection methodology

The CLMS website offers a simplified download service per city or urban area. The result of the download is an SQLite Geopackage (.gpkg) with its associated legends and metadata. This vector format can easily be read by GeoPandas python package.

References:

https://land.copernicus.eu/user-corner/technical-library/urban_atlas_2012_2018_mapping_guide

Data accessibility and license conditions

INSPIRE compliant catalogue metadata for this dataset is available here:

<https://sdieea.europa.eu/catalogue/srv/eng/csw-copernicus?SERVICE=CSW&VERSION=2.0.2&REQUEST=GetCapabilities>



2.2 Comparison with other ground motion services

Test site ID / Name
VA2_1 – Mount Etna, Sicily, Italy
Data providers / sources
IREA-CNR (Institute for the Electromagnetic Sensing of the Environment - National Research Council)
Data collection methodology
For this activity the IREA-CNR has processed the Sentinel-1 (S-1) data archives following the temporal baseline of the EGMS service releases to perform the validation activities as effectively as possible.
Data accessibility and license conditions
The results are free to be redistributed in the provided format and without other modifications.

Test site ID / Name
VA2_2 – Danish GMS
Data providers / sources
The Danish Agency for Data Supply and Infrastructure (SDFI) / Technical University of Denmark (DTU)
Data collection methodology
Data acquisition by request to DTU/SDFI. Contact person at SDFI is Kristian Keller (krkel@sdfi.dk). Last update available until August 2020, further updates are not planned. For validation beyond 2020, DTU has carried out PSI processing specific for the validation site(s). Contact person at DTU is John Peter Merryman Boncori (jme@space.dtu.dk).
Data accessibility and license conditions
SDFI products: Open access (no data license specified) DTU products: CC BY + CCO

Test site ID / Name
VA2_4 – Valle d'Aosta, Italy GMS
Data providers / sources
Aosta Valley Geological Survey
Data collection methodology
Data can be accessed via the following web portal http://geologiavda.partout.it/ .



Data downloads have to be requested by email to Davide Bertolo at Regional Geological Survey of Valle d'Aosta: d.bertolo@regione.vda.it

Data accessibility and license conditions

The data is available under the CC BY-SA 4.0 license (<https://creativecommons.org/licenses/by-sa/4.0/deed.it>).

Test site ID / Name

VA2_5 – Veneto, Italy GMS

Data providers / sources

Regione del Veneto

Data collection methodology

Data is accessible via the web portal under:

<https://idt2.regione.veneto.it/idt/webgis/viewer?webgisId=185>. The web portal allows data-download of files with mean velocities for the entire area.

For download of full datasets with time-series, information is available under:

<https://www.regione.veneto.it/web/ambiente-e-territorio/monitoraggiops#dataset>

Data accessibility and license conditions

The data is available under the CC BY-SA 4.0 license (<https://creativecommons.org/licenses/by-sa/4.0/deed.it>).

Test site ID / Name

VA2_6 – Tuscany, Italy GMS

Data providers / sources

Consorzio Lamma - Regione Toscana

Data collection methodology

Data can be accessed via the following web portal:

https://geoportale.lamma.rete.toscana.it/difesa_suolo/#/viewer/openlayers/326.

The web portal allows data download for the entire area.

Data accessibility and license conditions

Data publicly available. Terms and conditions (in Italian) can be found under:

<https://www.regione.toscana.it/documents/10180/14985922/Termini+di+utilizzo+dei+dati+del+geoportale.pdf/76d8b222-f2fc-489e-91f7-fb25fb6e86f4>



2.3 Comparison with inventories of phenomena/events

Test site ID / Name
VA3_1 – National inventory (France)
Data providers / sources
BRGM. Data from the database on ground motions (BDMvT) completed by BRGM. database description/viewer available at https://www.georisques.gouv.fr
Data collection methodology
Data can be freely downloaded from https://www.georisques.gouv.fr/donnees/bases-de-donnees/base-de-donnees-mouvements-de-terrain as csv files including positions of landslides for the departments included in the area of interest (French Alps). The CSV files include point coordinates of different registered phenomena (erosion, rockfall, ...) related to recent (after year 2000) landslides.
References:
Théophile Lucas 2023. <i>Proposition d'une carte de susceptibilité glissement de terrain sur le département des Alpes-Maritimes (06) dans le cadre de la réalisation d'un système de vigilance</i> . Rapport de stage de Master GEE - GERINAT V1. BRGM, p.8.
Data accessibility and license conditions
Public data. Accessible online

Test site ID / Name
VA3_2 – Local inventory – Rules Reservoir (Spain)
Data providers / sources
IGME (Spanish Geological Survey)
Data collection methodology
The inventory combines DInSAR results with geomorphological analysis to examine three active landslides: Lorenzo-1, Rules Viaduct, and El Arrecife, including their types, evolution, and triggering factors.
References:
Reyes-Carmona et al. (2020) <i>Sentinel-1 DInSAR for Monitoring Active Landslides in Critical Infrastructures: The Case of the Rules Reservoir (Southern Spain)</i> . Remote Sens. 2020, 12, 809.
Data accessibility and license conditions
Shape files and/or csv files have been provided by IGME. Public data.

Test site ID / Name
VA3_3 – Post-mining area in Lorraine (Freyming-Merlebach), France
Data providers / sources



BRGM (Département Prévention et Sécurité Minière - DPSM)

Data collection methodology

Data to be provided by DPSM from its databases on the area of interest:

1. Limits of the ground motions derived from ground-based measurements. Data has been provided in Shapefile format.
2. Levelling time series (yearly) allowing quantitative estimates of the motion. In csv format.

Data accessibility and license conditions

Data is accessible from BRGM. DPSM and DREAL (Direction régionale de l'Environnement, de l'Aménagement et du Logement) granted use of this data in the framework of the EGMS validation project.

Test site ID / Name

VA3_4 – Arcos de la Frontera, Spain

Data providers / sources

IGME

Data collection methodology

IGME supplied a Shapefile database of slow-moving landslides, mapped through geomorphological fieldwork and stereoscopic aerial photo analysis.

References:

Béjar-Pizarro, M., Notti, D., Mateos, R.M.; Ezquerro, P., Centolanza, G., Herrera, G., Bru, G., Sanabria, M., Solari, L., Duro, J. and Fernández, J. (2017). *Mapping vulnerable urban areas affected by slow-moving landslides using Sentinel-1 InSAR data*. Remote Sensing, 9(9), 876; doi:10.3390/rs9090876

Data accessibility and license conditions

Database to be provided by IGME via data download.

2.4 Consistency check with ancillary geo-information

Test site ID / Name
VA4_1 – Urban area of Oslo, Norway
Data providers / sources
Copernicus Land Monitoring Service Norwegian Geological Survey (NGU) Norwegian Geotechnical Institute (NGI)
Data collection methodology
Data accessible via web portals: <ol style="list-style-type: none">1. Corine Land Cover: https://land.copernicus.eu/pan-european/corine-land-cover2. EU-DEM: https://land.copernicus.eu/imagery-in-situ/eu-dem3. Bedrock Map / Lithological Map: https://geo.ngu.no/kart/berggrunn_mobil/4. Quaternary Geology Map: https://geo.ngu.no/kart/losmasse_mobil/
Data provided by Oslo Kommune: <ol style="list-style-type: none">5. Depth to bedrock maps for parts of Oslo Municipal area
Data accessibility and license conditions
1 & 2: Full, open and free access by the Copernicus data and information policy regulation (EU) no. 1159/2013, 12 July 2013. This regulation establishes registration and licensing conditions for GMES/Copernicus users and can be found here: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32013R1159 . 3 & 4: Data is made available under the Norwegian Licence for Open Government Data (NLOD) 2.0. See https://data.norge.no/nlod/en/2.0/ for more details. 5: Depths to bedrock dataset is not freely available.

Test site ID / Name
VA4_2 – Cartagena-La Unión, Murcia (SE Spain)
Data providers / sources
Spanish Geological Survey (IGME) and Copernicus Land Monitoring Service
Data collection methodology
Data accessible via web portals: <ol style="list-style-type: none">1. Corine Land Cover: https://land.copernicus.eu/pan-european/corine-land-cover2. EU-DEM: https://land.copernicus.eu/imagery-in-situ/eu-dem
Data from IGME: <ol style="list-style-type: none">3. Geotechnical map from IGME4. La Union waste disposal facilities map



5. Fault lines

References:

Instituto Geológico y Minero de España. 1996. *Estudio Geotécnico para el Depósito de Residuos de la Bahía de Portman en Corte Minera, Madrid; Instituto Geológico y Minero de España*: Madrid, Spain, Unpublished report.

López-Vinielles, J.; Fernández-Merodo, J.A.; Ezquerro, P.; García-Davalillo, J.C.; Sarro, R.; Reyes-Carmona, C.; Barra, A.; Navarro, J.A.; Krishnakumar, V.; Alvioli, M.; et al., 2021. *Combining Satellite InSAR, Slope Units and Finite Element Modeling for Stability Analysis in Mining Waste Disposal Areas*. Remote Sens. 2021, 13, 2008. <https://doi.org/10.3390/rs13102008>.

Graus i March, L., 2005. *Delimitación de las áreas de riesgo e impacto ambiental mediante técnicas sig en la sierra minera de Cartagena-La unión*. Universidad Politécnica de Cartagena. Dissertation.

Herrera, G., Tomás, R., Vicente, F., Lopez-Sanchez, J. M., Mallorquí, J. J., & Mulas, J., 2010. *Mapping ground movements in open pit mining areas using differential SAR interferometry*. International Journal of Rock Mechanics and Mining Sciences, 47(7), 1114-1125. <https://doi.org/10.1016/j.ijrmms.2010.07.006>.

IGME, InfoIGME, 2002. *Catálogo de datos*, Inventario Nacional de Depósitos de Lodos (wms), <http://info.igme.es/catalogo/resource.aspx?portal=1&catalog=3&ctt=1&lang=spa&dlang=eng&llt=dropdown&q=balsas&master=infoigme&shdt=false&shfo=false&resource=18>.

Data accessibility and license conditions

1 & 2: Full, open, and free access by the Copernicus data and information policy regulation (EU) no. 1159/2013, 12 July 2013. This regulation establishes registration and licensing conditions for GMES/Copernicus users and can be found here: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32013R1159>.

Datasets from IGME:

3: Geotechnical map is publicly available in the article López-Vinielles et al. 2021 and provided by IGME as data download.

4: La Union waste disposal facilities map is provided by IGME as data download, not publicly available

5: Fault line data is publicly available in the article López-Vinielles et al. 2021 and provided by IGME as data download

Test site ID / Name

V4_3 – Alto Guadalentín, Spain

Data providers / sources

Spanish Geological Survey (IGME) and Copernicus Land Monitoring Service

Data collection methodology

Data accessible via web portals:

1. Corine Land Cover: <https://land.copernicus.eu/pan-european/corine-land-cover>
2. EU-DEM: <https://land.copernicus.eu/imagery-in-situ/eu-dem>

Data from IGME:

3. Ground water model
4. Aquifer System Geometry (soft soil thickness)
5. Active Well locations

References:

Béjar-Pizarro et al., 2016. *Interpolation of GPS and Geological Data Using InSAR Deformation Maps: Method and Application to Land Subsidence in the Alto Guadalentín Aquifer (SE Spain)*. Remote Sensing. doi: 10.3390/rs8110965.

Ezquerro et al., 2017. *Groundwater and subsidence modelling combining geological and multi-satellite SAR data over the Alto Guadalentín aquifer (SE Spain)*. Geofluids. <https://doi.org/10.1155/2017/1359325>.

Ezquerro, P., Tomás, R., Béjar-Pizarro, M., Fernández-Merodo, J.A., C. Guardiola-Albert, A. Staller, J.A. Sánchez-Sobrino, G. Herrera. G., 2020. *Improving multi-technique monitoring using Sentinel-1 and Cosmo-SkyMed data and upgrading groundwater model capabilities*. Science of the Total Environment, Vol. 703, 10 February 2020, 134757, <https://doi.org/10.1016/j.scitotenv.2019.134757-9697>, <https://doi.org/10.1016/j.scitotenv.2019.134757>.

Data accessibility and license conditions

1 & 2: Full, open and free access by the Copernicus data and information policy Regulation (EU) No 1159/2013 of 12 July 2013. This regulation establishes registration and licensing conditions for GMES/Copernicus users and can be found here: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32013R1159>.

Datasets from IGME:

3: Ground water model is publicly available in the articles Ezquerro et al. 2017, 2020 and provided by IGME as data download.

4: Aquifer System Geometry is publicly available in the article Béjar Pizarro et al. 2016 and provided by IGME as data download.

5: Active Well locations is publicly available in the articles Ezquerro et al. 2017, 2020 and provided by IGME as data download.

Test site ID / Name

VA4_4 – Silesia coal mine region, Czech Republic/Poland

Data providers / sources

Czech Geological Survey (CGS) and Copernicus Land Monitoring Service

Data collection methodology

Data accessible via web portals:

1. Corine Land Cover: <https://land.copernicus.eu/pan-european/corine-land-cover>
2. EU-DEM: <https://land.copernicus.eu/imagery-in-situ/eu-dem>

Data from CGS:

3. Mining related areas
4. Geology map
5. Fault lines

Data accessibility and license conditions

1 & 2: Full, open, and free access by the Copernicus data and information policy Regulation (EU) No 1159/2013 of 12 July 2013. This regulation establishes registration and licensing conditions for GMES/Copernicus users and can be found here: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32013R1159>.

3, 4, & 5: Datasets from CGS provided as data downloads and are provided as "open access".



Test site ID / Name

VA4_5 – Lower Tagus Valley Fault System, near Lisbon, Portugal

Data providers / sources

Laboratório Nacional de Energia e Geología (LNEG)

Lisbon Municipality

Portuguese Environment Agency

Copernicus Land Monitoring Service

Data collection methodology

Data accessible via web portals:

1. Corine Land Cover: <https://land.copernicus.eu/pan-european/corine-land-cover>
2. EU-DEM: <https://land.copernicus.eu/imagery-in-situ/eu-dem>
3. National geodatabases and others:
 - (a) Fault lines (geoERA-HIKE)
 - (b) Geological data layers

Data accessibility and license conditions

1, 2: Full, open, and free access by the Copernicus data and information policy Regulation (EU) No 1159/2013 of 12 July 2013. This regulation establishes registration and licensing conditions for GMES/Copernicus users and can be found here: <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32013R1159>.

3: <https://geoportal.lneg.pt/>

Open access INSPIRE compliant geology and faults

<https://sig.lneg.pt/server/services/CGP1M/MapServer/WMServer?request=GetCapabilities&service=WMS>



2.5 Comparison with GNSS data

Test site ID / Name
VA5_1 – Jutland, Denmark
Data providers / sources
The technical University of Denmark (DTU) is responsible for data processing and provides data from permanent and non-permanent GNSS stations. The permanent stations are owned by SDFI, the non-permanent ones are privately owned.
Data collection methodology
Permanent stations provide daily solutions referenced to the ETRF2000.
Data accessibility and license conditions
Accessible upon request. (DTU)

Test site ID / Name
VA5_2 – Canary Islands, Spain
Data providers / sources
The CNIG (Centro Nacional de Información Geográfica) in Spain provides data from permanent GNSS stations.
Data collection methodology
Permanent stations provide daily solutions referenced to the ETRF2000.
Data accessibility and license conditions
Accessible upon request only (CNIG). Some stations have open access, others have restrictions.

Test site ID / Name
VA5_3 – Alto Guadalentín, Lorca, Spain
Data providers / sources
The CNIG in Spain provides data from permanent GNSS stations coming from the spanish network managed by CNIG.
Data collection methodology
Permanent stations provide daily solutions referenced to the ETRF2000.
Data accessibility and license conditions
Accessible upon request (CNIG)



2.6 Comparison with in-situ monitoring data

Test site ID / Name
VA6_1 – Alto Guadalentín, Lorca, Spain
Data providers / sources
<p>The data provider for this site is the IGME. The main type of data requested to the IGME are piezometer measurements (expressed in underground water level height [m.a.s.l.]) spanning between 2011 and 2022 in the Alto Guadalentín Basin, near the city of Lorca, Spain. These data are accessible for viewing at the following website: https://www.chsegura.es/es/cuenca/redes-de-control/piezometria/series-piezometria/index.html and managed by Confederación Hidrográfica del Segura.</p> <p>The other primary data which has been used are three GNSS permanent stations. Two of them are managed by the Murcia Region Authority:</p> <p>One belongs to the MERISTEMUM (LORC, http://gps.medioambiente.carm.es/)</p> <p>The other to the REGAM (LRCA, http://sitmurcia.carm.es/web/sitmurcia/lorca).</p> <p>In 2016 a new GNSS permanent station (ORCA) was deployed by the IGME.</p> <p>The secondary data set are the levelling benchmarks.</p>
Data collection methodology
<ol style="list-style-type: none">1. Piezometers data as an ESRI shapefile for the geolocation and as excel file for the piezometric levels are stored time series.2. GNSS permanent station data (daily processes in three components) as an ESRI shapefile for the geolocation and as excel file for the time series 3D deformation.
Data accessibility and license conditions
<p>For the validation with the GNSS data, the IGME processed data of three stations (ORCA, LORC, LRCA) in the Alto Guadalentín Basin that have been used and made available via data download (of the shape file and excel) with open and free conditions to redistribute them.</p> <p>For the validation with Piezometer data only three stations have been used and have been made available by the IGME via data download (of the shape file and excel). They should be considered as open data.</p>

Test site ID / Name
VA6_2 – Turow mine, Czech Republic / Poland
Data providers / sources
<p>The data provider, for the Czech territory surrounding the Turow mine in Poland, is the Czech Geological survey (CGS). The main type of data requested to the CGS are piezometer measurement (expressed in water level height [m.a.s.l.]) spanning between 1997 and 2021.</p> <p>The other primary data are geodetic measurements.</p>
Data collection methodology
<p>In order to collect the data, the Czech Geological Survey has delivered:</p> <p>17 systematic groundwater level measurements (measuring the upper and lower aquifer).</p>
Data accessibility and license conditions



The 1997-2021 dataset has open access, the new measurements from 2020 onwards have been provided only for validation purposes of this project.

Test site ID / Name

VA6_3 – Navis valley, Tyrol, Austria

Data providers / sources

The key element of monitoring equipment is the Automatic Tracking Total Station (ATTS), which is positioned on the opposite slope. This device is used to record and measure approximately 69 survey prisms within the landslide area once a day.

These data can be viewed on the following website (<https://geoinformation.tirol.gv.at/client/?projekt=kerschbaumsiedlung>) and are managed by the Tyrol Geo-Information department (Province Tyrol Government).

A network of nine inclinometers detects deep movement. Eight are measured quarterly, and one continuously records displacement with a chain inclinometer. Sixty piezometers with data loggers monitor soil and rock water pressures. Only the ATTS system is used for monitoring from 2016 to 2020.

Data collection methodology

The only data that has been used for the validation is a selection of the still active ATTS stations. Part of these data have been obtained from the Tyrol Geo-Information department through a close operation with the WLV Torrent and Avalanches Control. Daily ATTS data from 6 stations covering the period 01.2017 - 12.2019 has been collected. Since 2020, two stations are not active anymore, that is why a request has been made to substitute them and extend the time series for all the stations between 2016-2023.

Data accessibility and license conditions

The data has been accessed via data download of excel files. The data is open for visualization via the geoinformation Tirol portal.

Test site ID / Name

VA6_4 – Post-mining area in Lorraine (Freyming-Merlebach), France

Data providers / sources

The data provider for the Lorraine coal region is the BRGM, through its post-mining department (DPSM). In 2004 the coal extraction activity was terminated in Freyming-Merlebach in France. Since 2006, DPSM is performing each year a monitoring campaign based on precise levelling.

Data collection methodology

In order to collect the data, BRGM which has delivered:

1. Ground level measurements: the position of the boreholes (6 in number) is in ESRI shapefile format whereas the database in excel contains the information about the time series (mainly monthly measurements) started mainly in 2012 and still ongoing.
2. Levelling data: The position of the benchmarks and the levelling data (around 1500 levelling points, their number may vary from one campaign to the other as some parts of the Western sector are measured only every 2 years) is in ESRI shapefile format



whereas the database in excel contains records of several campaigns since 2006 and is still ongoing.

To be more specific the levelling benchmarks cover 40 municipalities and consist of a total of 1500 points. The levelling paths cover the zones of influence of the mining operations and the points are materialized on the ground by survey nails along roads or paths.

Data accessibility and license conditions

The levelling dataset and piezometers datasets are accessible via data download.

2.7 Evaluation XYZ and displacements with Corner Reflectors

Test site ID / Name
VA7_1 – Thyborøn, Denmark
Data providers / sources
Geopartner, Agency for Data Supply and Efficiency
Data collection methodology
9 CR's located in Thyborøn. <ol style="list-style-type: none">1. CR XY displacements measured at/around CR with Real time kinematic GNSS positioning (3 5 cm accuracy)2. CRs Z displacements measured at the CR location was determined immediately after installation of the reflectors using precision levelling (sub millimetre accuracy). Measurements are repeated by precision levelling in 2021, 2022, 2023 and 2024.3. CRs (t) Time-series: exist at and around the CR? and the methods (and repetition times) are the same as described in 1 and 2.
Data accessibility and license conditions
Accessible upon request. (Geopartner) Campaigns from 2003 to 2021 were performed by the Agency for Data Supply and Efficiency. Geopartner can obtain access to these data and has clarified IPR issues with SDFI.

Test site ID / Name
VA7_2 – Norway
Data providers / sources
NVE
Data collection methodology
Indre Nordnes and Jettan are two unstable mountain ranges located on the east side of the Lyngenfjord. Gámanjunni is an unstable mountain section, or a compound slide, located on the east side of Manndalen. Because of the high risk of landslides at these locations, several measurements have been deployed through continuous, real-time measurements, or with periodic measurements with weekly intervals. Continuous monitoring is and based on a minimum of two independent measurements. Continuous monitoring measurement methods usually are GPS, InSAR, CRs on the surface of the unstable mountain parts, total-station, ground-based radar, laser, extensometers and tilt-meters. [NVE website, https://www.nve.no]. The three mountains, or test site, have in total five CRs installed with continuous GNSS measurements at or nearby the CR locations. The CRs deployed for C-band in 2014-2015 by The Norwegian Water Resources and Energy Directorate (NVE). All the CRs are in descending geometry.
Data accessibility and license conditions
Accessible upon request. (NVE)



Test site ID / Name

VA7_3 – Calern, France

Data providers / sources

The IGN (Institut national de l'information géographique et forestière) is the reference public operator for geographic and forest information in France. It is a public administrative establishment placed under the joint authority of the Ministries in charge of ecology and forestry. IGN is responsible for the Calern multitechnical geodetic observatory.

Data collection methodology

1 CR installed in December 2018.

1. CR XY displacements measured at the CR location by precise topometric survey immediately after installation and repeated every year (except year 2020). From 2022, measurements are repeated twice a year.
2. CR Z displacements measured at the CR location by precise levelling and precise topometric survey immediately after installation and repeated every year (except year 2020). From 2022, measurements are repeated twice a year.
3. CR (t) Time-series: exist at the CR and the methods are the same as described in 1 and 2.

Data accessibility and license conditions

Accessible upon request (IGN)

3. VALIDATION DATA DESCRIPTION

In this section the various technical data aspects of the Validation Data are described with a focus on spatial and temporal coverage, quality/accuracy requirements, data format, metadata, uncertainty level.

3.1 Point density check

Test sites ID / Name

Eight different **urban** sites are proposed covering the different EGMS interferometric processing entities:

- VA1_1** – Urban area Bologna, Italy
- VA1_2** – Urban area Bucharest, Romania
- VA1_3** – Urban area Stockholm, Sweden
- VA1_4** – Urban area Barcelona, Spain
- VA1_5** – Urban area Sofia, Bulgaria
- VA1_6** – Urban area Warsaw, Poland
- VA1_7** – Urban area Bratislava, Slovakia
- VA1_8** – Urban area Brussels, Belgium

And four different **rural/mointaneous** sites are proposed covering the different EGMS production team providers:

- VA1_9** – Rural area Bolzano, Alps, Italy
- VA1_10** – Rural area Las Palmas, Canary Islands, Spain
- VA1_11** – Rural area Zilina, Tatras, Slovakia
- VA1_12** – Rural area Tromso, Norway

Data spatial and temporal coverage

The land cover classes update was done with ESA-Sentinel-2 dual date and Landsat-8 covering until 2018. Data covers major urban areas in Europe (39 countries) and the selected sites including its surroundings.



Figure 2: Extension of Corine Land Cover urban data.



Data quality accuracy and uncertainty requirements

The spatial resolution is 10 m or less with a geometric accuracy better than 100 m. The thematic accuracy is higher than 85%. Each of the validation sites comes with a quality report included in the download of the CLC urban files.

Data and metadata format

The SQLite Geopackage (.gpkg) files are distributed in the standard European Coordinate Reference System defined by the European Terrestrial Reference System 1989 (ETRS89). Each file is a geodatabase of polygons with their associated classes.

INSPIRE compliant metadata for this dataset is available here:

<https://sdi.eea.europa.eu/catalogue/srv/eng/csw-copernicus?SERVICE=CSW&VERSION=2.0.2&REQUEST=GetCapabilities>

3.2 Comparison with other ground motion services

Test site ID / Name
VA2_1 – Mount Etna, Sicily, Italy
Data spatial and temporal coverage
Advanced DInSAR products relevant to the Etna volcano were generated by IREA-CNR, exploiting a proprietary algorithm known as Parallel Small Baseline Subset (P-SBAS) approach (Manunta et al., 2019; Lanari et al., 2020). The products are displacement time-series and mean deformation velocity maps, from both ascending and descending orbits (Line-of-Site/LOS geometry). In addition, the two LOS DInSAR products were combined to retrieve the vertical and horizontal (East-West) components of the measured displacements. The P-SBAS workflow is the same exploited for the routine production of the DInSAR products provided to the Italian Department of Civil Protection (DPC) for which IREA-CNR formally acts as Centre of Competence. IREA-CNR has produced the same type of data products for EGMS updates during the validation period. The produced data for this validation site covers the entire Etna volcano and surrounding areas. Available products for Mount Etna are Level 2a, Level 2b (tracks 44 and 124) and Level 3.
References:
Lanari R., et al. 2020. <i>Automatic generation of sentinel-1 continental scale DInSAR deformation time series through an extended P-SBAS processing pipeline in a cloud computing environment</i> . Remote Sensing 12.18: 2961. Manunta M., et al. 2019. <i>The parallel SBAS approach for Sentinel-1 interferometric wide swath deformation time-series generation: Algorithm description and products quality assessment</i> . IEEE Trans. Geosci. Remote Sens., vol. 57, no. 9, pp. 6259–6281. MPC-S1 report. 2021. <i>Phase Artefacts for InSAR Pairs Acquired Over Geographic Regions With Strong Variations of Terrain Height in Range Direction</i> . Accessed: Aug. 11, 2021. [Online]. Available: https://sar-mpc.eu/disclaimer/58/
Data quality accuracy and uncertainty requirements
The DInSAR analysis is based on Sentinel-1 data and has a resolution of 30 m x 30 m (in east-west and north-south directions). The P-SBAS displacement time series and the corresponding mean deformation velocity have 5 mm and 1mm/year accuracy, respectively (Manunta et al., 2019). The P-SBAS processing chain was specifically developed to analyse the Sentinel-1s TOPS acquisitions. Manunta et al. (2019) describe the specific quality assessment of the processing chain, carried out using data from ca. 500 GPS stations distributed over the entire Italian territory. This validation activity confirmed the accuracy values for the SBAS algorithm reported in Casu et al., 2006.
References:
Manunta M., et al., 2019. <i>The parallel SBAS approach for Sentinel-1 interferometric wide swath deformation time-series generation: Algorithm description and products quality assessment</i> . IEEE Trans. Geosci. Remote Sens., vol. 57, no. 9, pp. 6259–6281. Casu, F., Manzo, M., Lanari, R., 2006. <i>A quantitative assessment of the SBAS algorithm performance for surface deformation retrieval from DInSAR data</i> . REMOTE SENSING OF ENVIRONMENT. 102. 195-210. 10.1016/j.rse.2006.01.023.
Data and metadata format

The produced DInSAR results have been shared as csv file. The file contains the metadata and the data generated through the P-SBAS processing.

Test site ID / Name

VA2_2 – Thyborøn

Data spatial and temporal coverage

The ad-hoc processing is done by DTU on the area of interest Thyborøn. A PS workflow is used offering a similar resolution as for the EGMS and directly comparable with L2a products.

The calibrated products use ITRF2014 as a reference system, while the calibrated EGMS products use the ETRF2000 system. Therefore, these products are not compatible, and the validation has been done on Level2a products only.

Data quality accuracy and uncertainty requirements

InSAR data processed from Sentinel-1 data with resolution of approx. 5 m x 20 m (5 m east-west, 20 m north-south). Mean velocity precision approx. 1 mm/year. Precision of displacement time series approx. 5 mm.

The processing chain used by DTU is based on the commercial software "sarproz" (<https://www.sarproz.com/>), has been previously intercompared with the Danish GMS products, both in the Aarhus area (within an ESA project) and in the Copenhagen area (within the framework agreement between DTU and SDFI). In both cases DTU's own processing was found to be of comparable quality with rather less noise than the SDFI Danish GMS data.

Data and metadata format

CSV format (DTU products)

Reference System: EPSG:4326

Test site ID / Name

VA2_4 – Valle d'Aosta/Italy GMS

Data spatial and temporal coverage

The regional GMS of Valle d'Aosta covers the entire administrative region of Valle d'Aosta. The currently available dataset covers the period from April 2019 to January 2024. The availability of future updates is unknown at this stage. Only Level 2a products are available.

Data quality accuracy and uncertainty requirements

InSAR data processed from Sentinel-1 data with resolution of approx. 5 m x 20 m (5 m east-west, 20 m north-south). Mean velocity precision approx. 1 mm/year. Precision of displacement time series approx. 5 mm.

Data and metadata format

Format: Data is provided as zipped shapefiles

Reference System: EPSG:4326

**Test site ID / Name****VA2_5 – Veneto/Italy GMS****Data spatial and temporal coverage**

The regional GMS of Veneto covers the entire administrative region of Veneto. Focus has been on the area surrounding Venice and the Po delta area. The currently available dataset covers the period from January 2019 to July 2023. The availability of future updates is unknown at this stage. Only Level 2a products are available.

Data quality accuracy and uncertainty requirements

InSAR data processed from Sentinel-1 data with resolution of approx. 5 m x 20 m (5 m east-west, 20 m north-south). Mean velocity precision approx. 1 mm/year. Precision of displacement time series approx. 5 mm.

Data and metadata format

Format: Data is provided as zipped shapefiles. Reference System: EPSG:4326

Test site ID / Name**VA2_6 – Tuscany/Italy GMS****Data spatial and temporal coverage**

The regional GMS of Tuscany covers the entire administrative region of Tuscany. In this validation activity the provinces of Lucca, Massa-Carrara and Pistoia have been chosen as areas to focus the validation on. The currently available dataset covers the period January 2019 to August 2024. The availability of future updates is unknown at this stage. Only Level 2a products are available. Only Level 2a products are available.

Data quality accuracy and uncertainty requirements

InSAR data processed from Sentinel-1 data with resolution of approx. 5 m x 20 m (5 m east-west, 20 m north-south). Mean velocity precision approx. 1 mm/year. Precision of displacement time series is approx. 5 mm.

Data and metadata format

Format: Data is provided as zipped shapefiles

Reference System: EPSG:4326

3.3 Comparison with inventories of phenomena/events

Test site ID / Name

VA3_1 – National inventory (France)

Data spatial and temporal coverage

Motion point location analysis has been limited to French Pyrenees (~10000 km²), in the Department of Hautes Pyrénées and Atlantic Pyrénées addressed in V3_9 for the shape analysis. Temporal coverage including most of EGMS coverage. The capture below shows the extent of the inventory. Red squares indicate landslides.

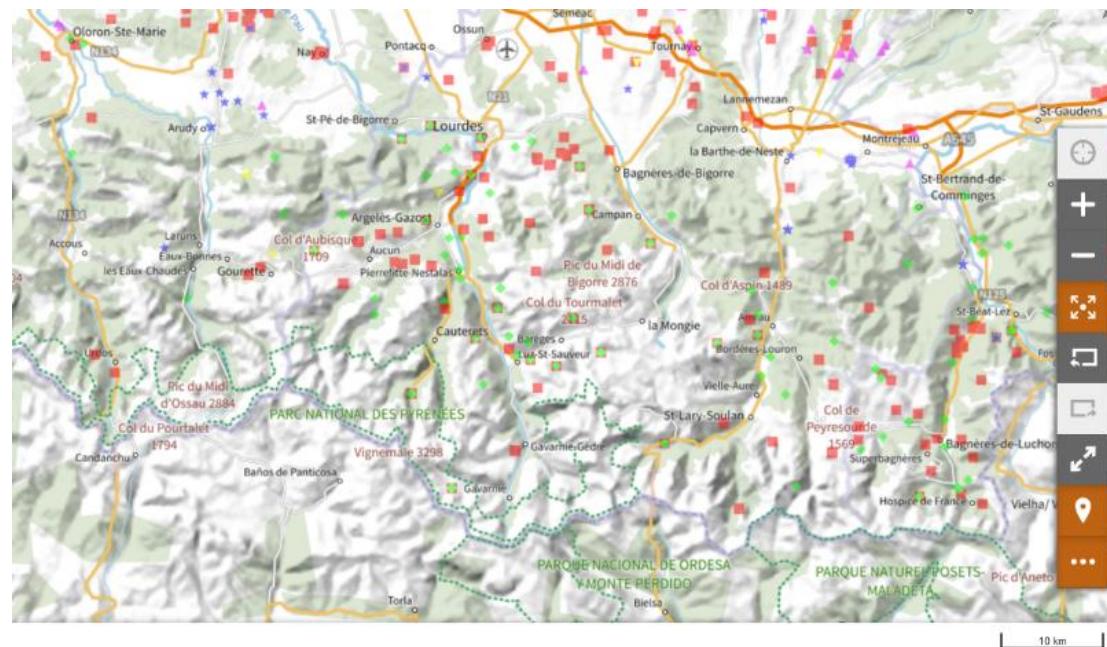


Figure 3: Extension of the French landslide inventory.

Data quality accuracy and uncertainty requirements

Uncertainty on location of centres of the landslide must be better than 100 m for small landslides.

Data and metadata format

Shape file for vector data. Shape file or CSV for point data. Text file for metadata when relevant.

Test site ID / Name

VA3_2 – National inventory (Spain)

Data spatial and temporal coverage

Spanish Pyrenees (~10000 km²). Temporal coverage including most of EGMS coverage. Temporal coverage including most of EGMS coverage. The capture below shows the excerpt of the inventory on the area of interest.

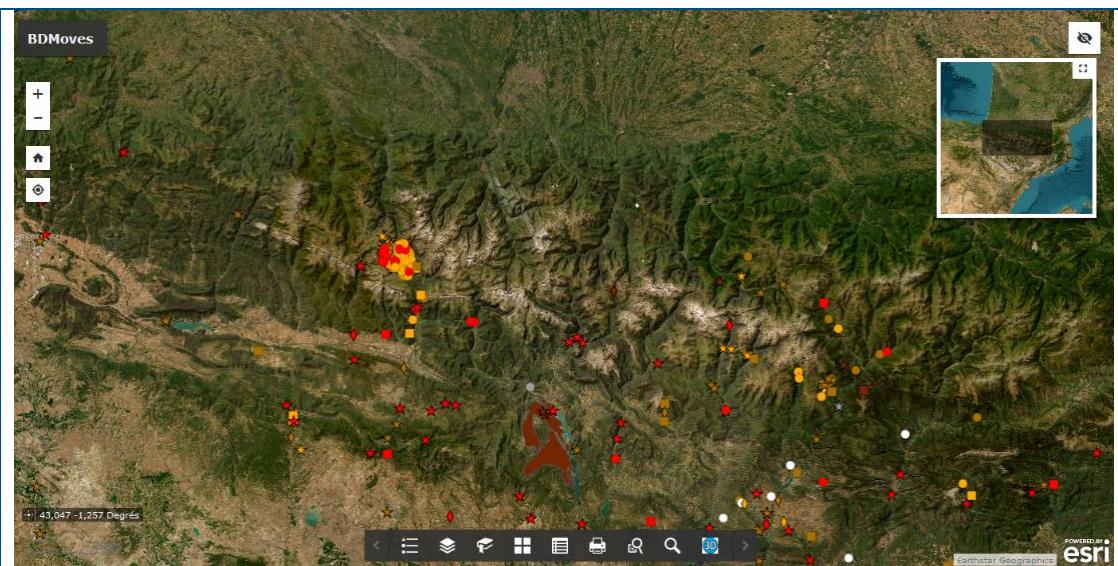


Figure 4: Landslide inventory over the Spanish Pyrenees area of interest.

Data quality accuracy and uncertainty requirements

Uncertainty on location of the phenomena better than 100 m.

Data and metadata format

Shape file for vector data. Shape file or CSV for point data. Text file for metadata when relevant.

Test site ID / Name

VA3_3 – Post-mining area in Lorraine, France

Data spatial and temporal coverage

Area of about 50 km² around the municipality of Freyming-Merlebach (Department of Moselle) affected by post-mining motion.

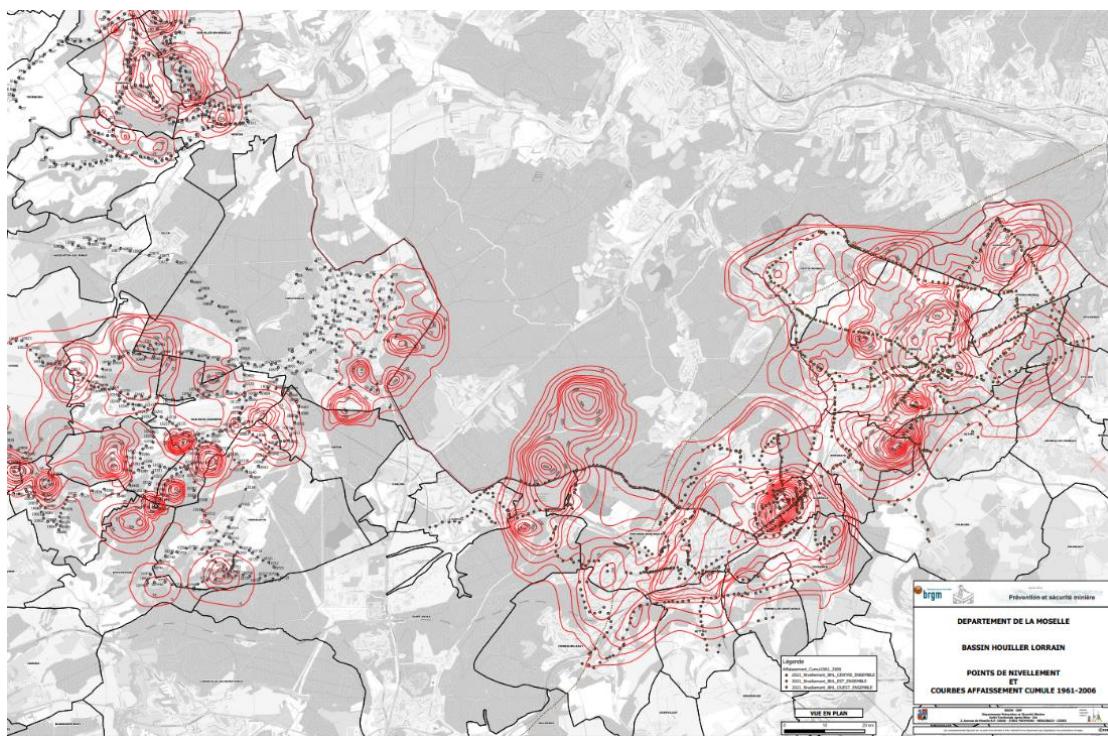


Figure 5: Levelling network (dots) and interpolated isocontours delimitating ground displacements.

Data quality accuracy and uncertainty requirements

Uncertainty on location of the uplift contour better than 100 m. Temporal coverage including all EGMS coverage.

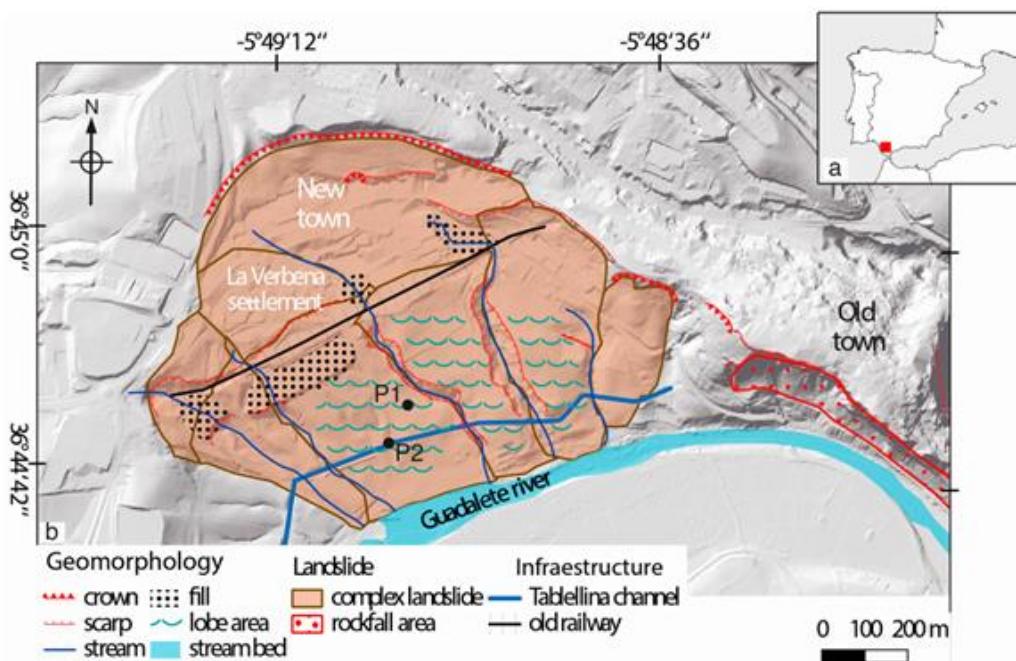
Data and metadata format

Shape file for vector data. Shape file or CSV for point data. Text file for metadata when relevant

Test site ID / Name

VA3_4 – Arcos de la Frontera, Spain

Data spatial and temporal coverage

Area of about 20 km² around the landslide/IGME (Figure 6).

Data quality accuracy and uncertainty requirements

Uncertainty on location of the phenomena better than 100 m. Temporal coverage includes most of EGMS coverage

Data and metadata format

Shape file for vector data. Shape file or CSV for point data. Text file for metadata when relevant

3.4 Consistency check with ancillary geo-information

Test site ID / Name
VA4_1 – Oslo, Norway
Data spatial and temporal coverage
Depending on the particular dataset and its spatial extend, certain areas of the Oslo municipal region have been targeted.
<ol style="list-style-type: none">1. Corine Land Cover: The land cover classes update was done with ESA-Sentinel-2 dual date and Landsat-8 covering until 2018. Data covers the entire European continent.2. EU-DEM: A digital elevation model and slope dataset with 25 m resolution covering the entire European continent.3. Datasets from NGU cover the entire target area. Representing geological background information, they are attributed to any specific time period.4. The depth to bedrock map is available for the area of the municipality of Oslo.
Data quality accuracy and uncertainty requirements
The spatial resolution of Corine Land Cover is 100 m or less with a geometric accuracy better than 100 m. The thematic accuracy is higher than 85%.
The spatial resolution of EU-DEM is 25 m with vertical accuracy of +/- 7 meters RMS (root mean square).
The NGU datasets are provided as vector data.
The depth to bedrock maps is provided as raster map, however, the data is based on borehole data varying density of boreholes and interpolation in between boreholes.
Estimates for the accuracy of these data are not available.
Data and metadata format
Copernicus data are distributed as SQLite Geopackage (.gpkg) files in the ETRS89-extended / LAEA Europe reference system.
EU-DEM available in GeoTiff format in ETRS89-extended / LAEA Europe reference system.
NGU and FKB data have been acquired in shape-file format in UTM Zone 33 (Euref89) reference system.

Test site ID / Name
VA4_2 – Cartagena - La Unión, Spain
Data spatial and temporal coverage
<ol style="list-style-type: none">1. Corine Land Cover: The land cover classes update was done with ESA-Sentinel-2 dual date and Landsat-8 covering until 2018. Data covers the entire European continent.2. EU-DEM: A digital elevation model and slope dataset with 25 m resolution covering the entire European continent.
Data from IGME:
<ol style="list-style-type: none">3. Geotechnical map: Carried out by the Spanish Geological Survey in 1996, the dataset includes the geo-



mechanical properties of dominant lithologies. The data were obtained through field surveys, geotechnical boreholes, and in situ and laboratory tests. Available for the La Union validation site.

4. La Unión waste disposal facilities map:

Inventory of waste disposal facilities elaborated through field surveys and aerial photo-interpretation. Available for the La Union validation site.

5. Fault Lines:

Available for the La Union validation site.

Data quality accuracy and uncertainty requirements

The spatial resolution of Corine Land Cover is 100 m or less with a geometric accuracy better than 100 m. The thematic accuracy is higher than 85%.

The spatial resolution of Urban Atlas is 10 m or less with a geometric accuracy better than 100 m. The thematic accuracy is higher than 85%.

The spatial resolution of EU-DEM is 25 m with vertical accuracy of +/- 7 meters RMS (root mean square).

Data from IGME:

The spatial resolution of the Geotechnical map is 5 m or less with a geometric accuracy better than 50 m. The thematic accuracy is higher than 85%.

Data and metadata format

Copernicus data are distributed as SQLite Geopackage (.gpkg) files in the ETRS89-extended / LAEA Europe reference system.

EU-DEM available in GeoTiff format in ETRS89-extended / LAEA Europe reference system.

IGME datasets are provided as shapefiles.

Test site ID / Name

VA4_3 – Alto Guadalentín, Spain

Data spatial and temporal coverage

1. Corine Land Cover: The land cover classes update was done with ESA-Sentinel-2 dual date and Landsat-8 covering until 2018. Data covers the entire European continent.
2. EU-DEM: A digital elevation model and slope dataset with 25 m resolution covering the entire European continent.

Data from IGME:

3. Ground water model: GW levels (m a.s.l.) over the Guadalentín basin in 1973, 1988, 1993 and 2012. Elaborated using a MODFLOW model from 1960 to 2012.
4. Aquifer System Geometry (soft soil thickness): Obtained through geostatistical analysis of boreholes and InSAR data.
5. Active Well locations: Elaborated analysing the activity of the basin wells available in the IGME sources of water database and data from Basin Water Management Authority.

Data quality accuracy and uncertainty requirements

1: The spatial resolution of Corine Land Cover is 100 m or less with a geometric accuracy better than 100 m. The thematic accuracy is higher than 85%.



2: The spatial resolution of EU-DEM is 25m with vertical accuracy of +/- 7 meters RMS (root mean square).

Data from IGME:

3: Ground water model: The spatial resolution is 100 m.

4: Aquifer System Geometry (soft soil thickness): The spatial resolution is 90 m.

5: Active Well locations: Point Vector file, no spatial resolution.

Data and metadata format

1: Copernicus data are distributed as SQLite Geopackage (.gpkg) files in the ETRS89-extended / LAEA Europe reference system.

2: EU-DEM available in GeoTiff format in ETRS89-extended / LAEA Europe reference system.

Data from IGME:

3: Ground water model: GeoTIFF format.

4: Aquifer System Geometry (soft soil thickness): ASCII file.

5: Active Well locations: Point Vector shapefile.

Test site ID / Name

V4_4 – Silesia coal mine region, Czech Republic/Poland

Data spatial and temporal coverage

1. Corine Land Cover: The land cover classes update was done with ESA-Sentinel-2 dual date and Landsat-8 covering until 2018. Data covers the entire European continent.
2. EU-DEM: A digital elevation model and slope dataset with 25 m resolution covering the entire European continent.

Data from CGS:

3. Mining related areas are available for the Czech Republic part of the Silesia region
4. Geology maps are available for the entire country of Czechia
5. Fault lines are available for the entire country of Czechia

Data quality accuracy and uncertainty requirements

The spatial resolution of Corine Land Cover is 100 m or less with a geometric accuracy better than 100 m. The thematic accuracy is higher than 85%.

The spatial resolution of EU-DEM is 25 m with vertical accuracy of +/- 7 meters RMS (root mean square).

Data from CGS are provided as vector data. No further information on accuracy available.

Data and metadata format

Copernicus data are distributed as SQLite Geopackage (.gpkg) files in the ETRS89-extended / LAEA Europe reference system.

EU-DEM available in GeoTiff format in ETRS89-extended / LAEA Europe reference system.

Data from CGS:

Vector data in shapefile format



Test site ID / Name

VA4_5 – Lower Tagus Valley Fault System, near Lisbon, Portugal

Data spatial and temporal coverage

1. Corine Land Cover: The land cover classes update was done with ESA-Sentinel-2 dual date and Landsat-8 covering until 2018. Data covers the entire European continent.
2. EU-DEM: A digital elevation model and slope dataset with 25 m resolution covering the entire European continent.
3. National geodatabases and others:
 - (a) Fault lines (geoERA-HIKE): Entire country
 - (b) geoERA-HIKE: Entire country
 - (c) Geological data layers: Entire country

Data quality accuracy and uncertainty requirements

The spatial resolution of Corine Land Cover is 100 m or less with a geometric accuracy better than 100 m. The thematic accuracy is higher than 85%.

The spatial resolution of Urban Atlas is 10 m or less with a geometric accuracy better than 100 m. The thematic accuracy is higher than 85%.

Fault data and geological maps provided as vector data. No further information on accuracy available.

Data and metadata format

Copernicus data are distributed as SQLite Geopackage (.gpkg) files in the ETRS89-extended / LAEA Europe reference system.

EU-DEM available in GeoTiff format in ETRS89-extended / LAEA Europe reference system.

Data from LNEG:

Fault data and geological maps provided as shapefiles.



3.5 Comparison with GNSS data

Test site ID / Name
VA5_1 – Jutland, Denmark
Data spatial and temporal coverage
7 permanent stations in west coast of Jutland with yearly updates since 2001. Plus 13 stations distributed over Denmark.
Data quality accuracy and uncertainty requirements
To be determined (DTU).
Data and metadata format
Data format: csv file with fields YYYYMMDD, X, Y, Z, stdX, stdY, stdZ, Lat, Lon, height Metadata are text files with at least the following information: <ol style="list-style-type: none">1. Dates of antenna and radome changes2. Dates of any other change or physical phenomena (for example volcanic eruption)

Test site ID / Name
VA5_2 – Canary Islands, Spain
Data spatial and temporal coverage
<ul style="list-style-type: none">• 3 stations in La Palma (an area of ~41kmx25km). With Daily samples since 2015 or earlier.• 6 stations in Gran Canaria (an area of ~41kmx41km. Most stations provide daily samples since 2015 or earlier (CNIG).
Data quality accuracy and uncertainty requirements
Several stations exhibited jumps attributed to changes in antennas, receivers, or other modifications. All stations were initially included in the analysis, but those with significant jumps in the time series were ultimately excluded from the final evaluation. For instance, station CRTG was removed due to large jumps caused by changes in the GNSS antenna across all displacement components. Other stations with minor jumps include: <ul style="list-style-type: none">• ALHA: Experienced a jump in 2017 due to unspecified changes in the north and up components and another jump in 2019 in the north and east components not associated with any reported shift.• CIEZ: Reported jumps in the up and east components.• CRVC: In 2017, detected 'other changes' affected the north and up components.• MUL1: Faced a jump in 2017 in the up component due to 'other changes,' in 2021, jumps occurred first in the receiver and then in the antenna.
Data and metadata format
Data format: csv file with fields YYYYMMDD, X, Y, Z, stdX, stdY, stdZ, Lat, Lon, height



Metadata are text files with at least the following information:

1. Dates of antenna and radome changes
2. Dates of any other change or physical phenomena (for example volcanic eruption)

Test site ID / Name

VA5_3 – Alto Guadalentín, Lorca, Spain

Data spatial and temporal coverage

17 stations for area of ~140kmx140km, with daily samples since 2015 or earlier. (CNIG)

Data quality accuracy and uncertainty requirements

Based on SINEX daily files, GNSS stations provide data with error inferior to 2mm. This is applicable to X,Y and Z.

Data and metadata format

Data format: csv file with fields **YYYYMMDD, X, Y, Z, stdX, stdY, stdZ, Lat, Lon, height**

Metadata are text files with at least the following information:

1. Dates of antenna and radome changes
2. Dates of any other change or physical phenomena (for example volcanic eruption)



3.6 Comparison with in-situ monitoring data

Test site ID / Name
VA6_1 – Alto Guadalentín, Lorca, Spain
Data spatial and temporal coverage
<ol style="list-style-type: none">1. The piezometers data are in ESRI shapefile format with the ETRS89 UTM30N as reference coordinate system. The piezometric levels time series are stored in an excel file. The database contains records of historical piezometers up to 2012. Additional data contains data from 2012 to 2022.2. The GNSS data are daily processes in three components (X, Y, Z). The position of the stations is in ESRI shapefile format, with the ETRS89 UTM30N as reference coordinate system. The GNSS time series are stored in an excel file. LORC station covers the period 2011-2022. LRCA station covers the period 2012-2022. ORCA station covers the period 2016-2022.3. The levelling data represents three campaigns in 2005, 2016 and 2017. The position of the benchmarks and the levelling data are in ESRI shapefile format, with the ETRS89 UTM30N as reference coordinate system. The database in excel contains records of 2005, 2016 and 2017. No further updates planned.
Data quality accuracy and uncertainty requirements
The GNSS stations are collecting 30 s rate data and daily RINEX files are being downloaded from the receivers to Spanish National Geographic Institute (IGN) data centre. All three stations are integrated in the IBERRED project, which consists of a network covering all the country and processed by the IGN (Ezquerro et al., 2020). The quality accuracy and uncertainty are not yet known for the piezometer's measurements. The instrument used for the two levelling campaigns was the LEICA SRINTER 100 digital level, which produce a maximum kilometric error of 3.5 mm and a maximum tolerance in the closure error of each ring of 5 mm. Levelling campaign guarantee the measurement of the vertical component of the benchmarks with an accuracy higher than 5 mm (Ezquerro et al., 2020).
Data and metadata format
The GNSS, the piezometers and the levelling data has been delivered as shape and excel file. No metadata present.

Test site ID / Name
VA6_2 – Turow mine, Czech Republic / Poland
Data spatial and temporal coverage
<ol style="list-style-type: none">1. The piezometers data are in ESRI shapefile format. The piezometric levels time series should be stored in an excel/csv file. The database contains records of historical piezometers from 1997 to 2021 (time frequency 6 time a year). Additional data contains time series from 2021 to today at 36 sites. The new measurements are taken continuously.2. The geodetic data cover a network built along the border between Czech Republic and Poland.



The position of the data should be in ESRI shapefile format. The measurements are taken annually, and the time series should be stored in excel/csv files.

Data quality accuracy and uncertainty requirements

The validation has been based mainly on the piezometric data which measure the underground water table height of three different aquifers (upper, middle and lower). The quality accuracy and uncertainty are not yet known for the piezometer's measurements.

Data and metadata format

No metadata available, data is made available as excel and shape file (for the delimitation of the mining area).

Test site ID / Name

VA6_3 – Navis valley, Tyrol, Austria

Data spatial and temporal coverage

The ATTS location are in MGI_Austria_GK_West coordinate system (EPSG 31258). They are covering spatially the entire village of Kerschbaumsiedlung the upper part and the bottom part of the Navis Landslide, located in Navis valley, Tyrol. The temporal coverage spans between 2013 and is still on going, the measurements (in X,Y,Z) are taken daily.

Data quality accuracy and uncertainty requirements

The data accuracy for the ATTS varies since it depends on the distance between the total station and the prism but a median of 5 mm accuracy in the horizontal and 7 mm accuracy in the vertical measurements are assured.

Data and metadata format

No metadata available, data is made available as excel file.

Test site ID / Name

VA6_4 – Freyming-Merlebach, France

Data spatial and temporal coverage

Since 2004, in the Freyming-Merlebach coal mine basin the extraction activity was interrupted in France. There are 3 mining sectors on the basin in the Western, Central and Eastern sectors. Altogether, the basin covers an area of approximatively 300 km². The available levelling measurements are taken yearly, and the first campaign started in 2006 and recurrent campaigns are still ongoing.

Data quality accuracy and uncertainty requirements

The uncertainty of a single levelling vertical measurement is ≤ 2 cm.

Data and metadata format

No metadata available, data is made available as excel and shape file (for the delimitation of the mining area).

3.7 Evaluation XYZ and displacements with Corner Reflectors

Test site ID / Name

VA7_1 – Thyborøn, Denmark

Data spatial and temporal coverage

The Thyborøn area has eight operationsl CR located in an area of ~5 km² since 2017. Five CR's were installed by Geopartner in 2020, and three CR's were installed by the Agency for Data Supply and Efficiency in 2017. All reflectors are of the type "Double geometry muse" or "Double trihedral reflector" (Figure 7 and Figure 8).



Figure 7: Permanent double geometry Muse, square plate deployed CR build in Aluminium/Iron with 60x60x120 cm dimensions.

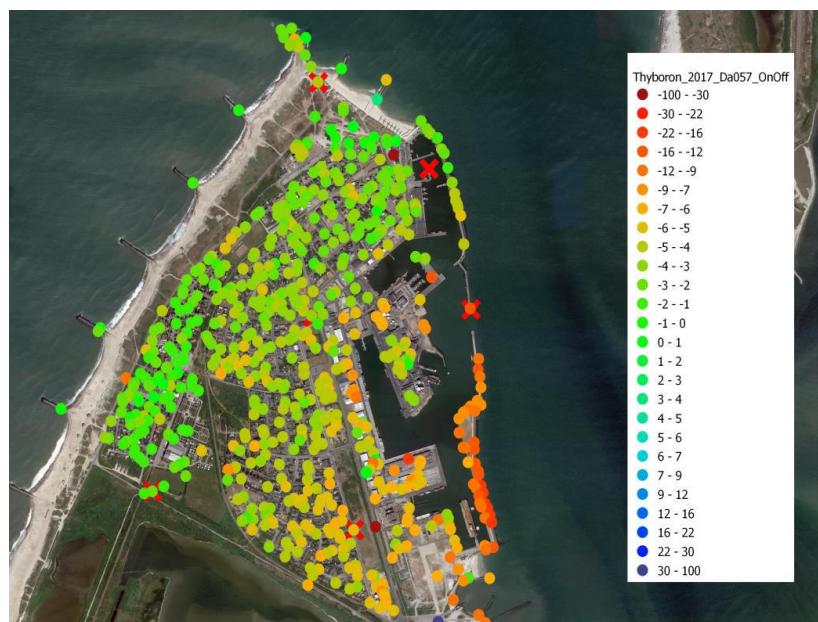


Figure 8: Surface displacements derived by InSAR where the red crosses locate five of the CR's.

Complimentary data: Real time kinematic GNSS positioning, and precision levelling measured yearly. Levelling campaigns have been performed every 3 years since 2003 with more than 60+ elevation benchmarks (Figure 9). The XY coordinates has been measured with Real time kinematic GNSS with positioning accuracy of 3-5 cm. The Z coordinate was determined

immediately after installation of the reflectors by precision levelling (sub millimeter accuracy). The measurements were carried out in 2021, 2022 and will continue in 2023 and 2024.

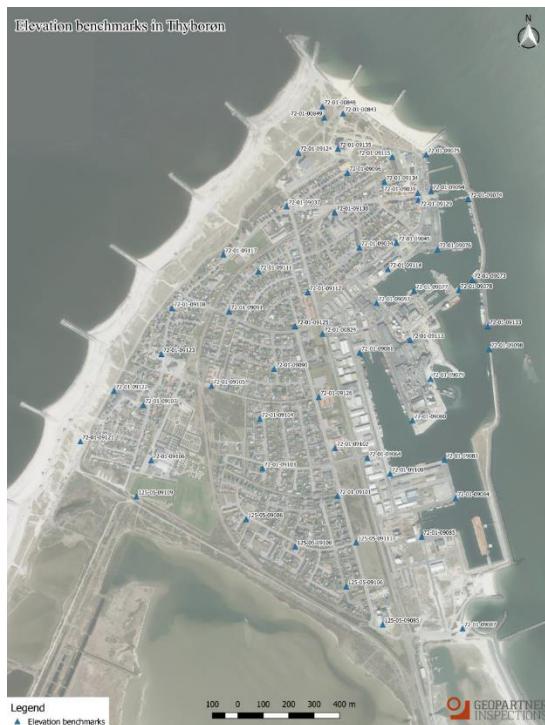


Figure 9: Precision levelling measurements of benchmarks evenly distributed throughout Thyborøn.

Data quality accuracy and uncertainty requirements

Real time kinematic GNSS positioning 3-5 cm accuracy

Precision levelling: submillimetre accuracy

The specifics of the CRs used are as follows:

- A total of 8 CRs, designed explicitly for C-band applications.
- CRs installed by the Agency for Data Supply and Infrastructure in 2017 are identifiable in the time series analysis.
- Additional CRs, deployed by Geopartner in 2020, are not included in the time series analysis.
- Each reflector follows the 'Double geometry muse' design.
- Precision levelling measurements to monitor changes were conducted in 2019 and 2021, with another scheduled for 2022.
- XY coordinates were precisely measured using real-time kinematic GNSS positioning, boasting an accuracy of 3-5 cm.
- The Z coordinates were determined through precision levelling after the installation of the reflectors, achieving sub-millimeter accuracy.

Data and metadata format

Data in csv file and metadata text file

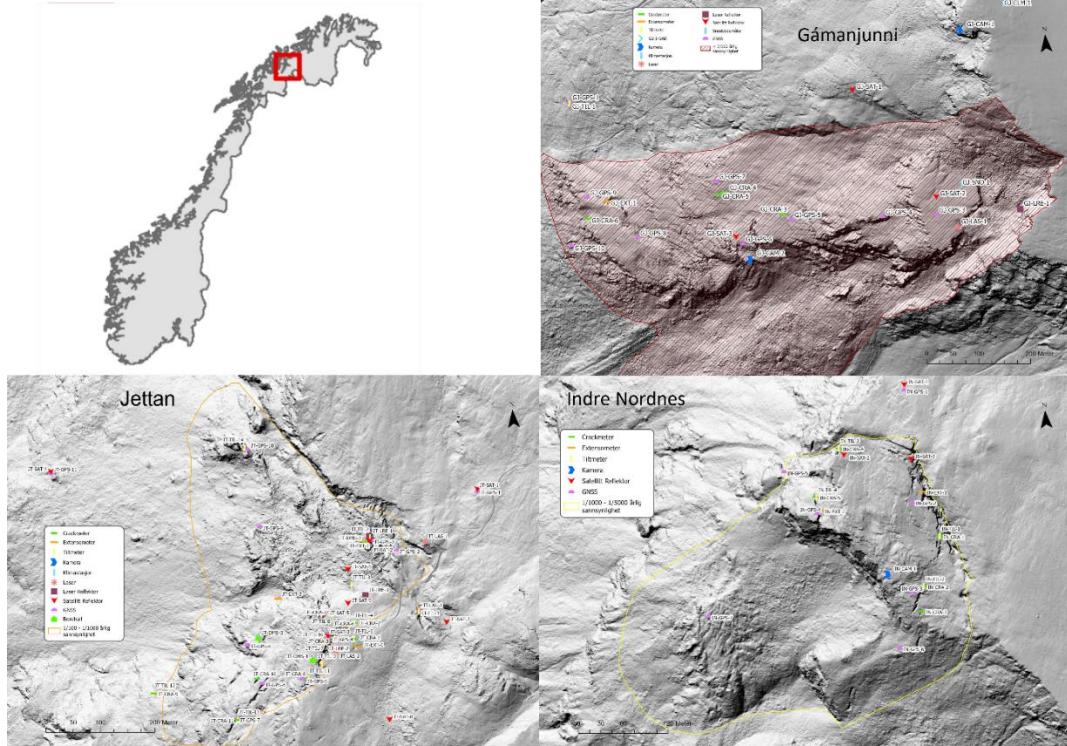
Test site ID / Name

VA7_2 – Norway

Data spatial and temporal coverage

Five CRs covering an area of approximately 6 by 5 km deployed for C-band in 2014-2015. Continuous GNSS stations are placed nearby each CR. The closest GNSS station is approximately 2m from the CR the farther GNSS station is approximately 60m.

The map below shows the location, in Norway of the test site together with a map of each of the mountain ranges and corresponding measurements. Jettan area has three CR's (JT-SAT-2, JT-SAT-3 and JT-SAT-4), Indre Nordnes has one CRs (IN-SAT-3) and Gámanjunní has one CR (GJ-SAT2).



Data quality accuracy and uncertainty requirements

Coordinates of the CR and heights should not be used to compare with EGMS products because accuracies are known. GNSS time series are also not provided with uncertainties.

Data and metadata format

CSV file with metadata .txt

Test site ID / Name

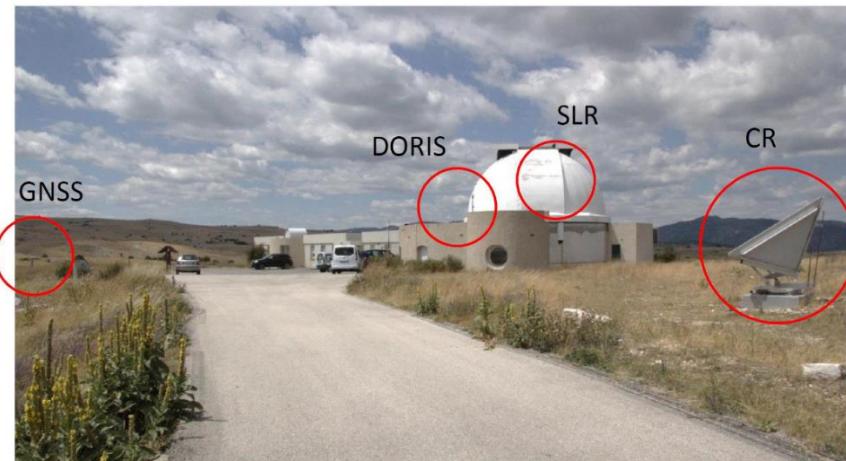
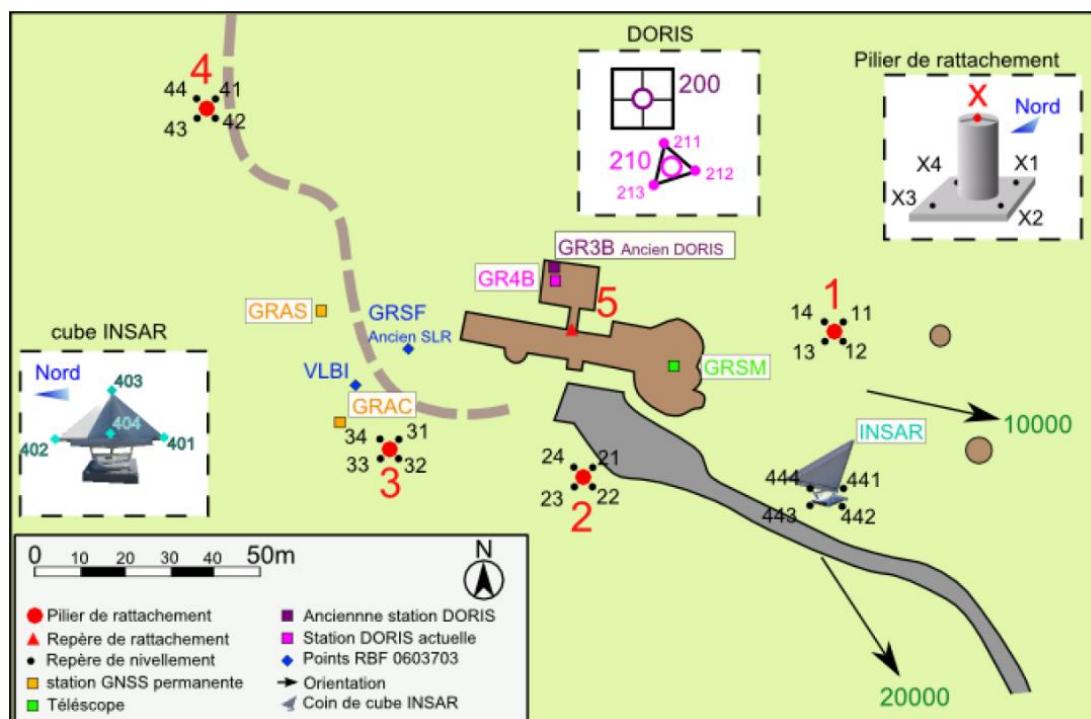
VA7_3 – Calern, France

Data spatial and temporal coverage

This area has a single Corner Reflector (CR) since 2018. The added value of this area is complimentary multitechnical geodetic observatory.

The CR has an incidence angle of 35 degrees oriented to relative orbit 88. The CR is made of aluminium plates with side length of 1,5m x 1,5 m with a thickness of 8 mm fixed on a 1m x 1m concrete slab. The depth of concrete slab is about 0,5m and fixed on bedrock.

As complimentary data, there are two nearby GNSS stations with daily measurements and yearly levelling and precise topometric survey.



The figures show a map and photo of the CR and the complimentary data locations as well as examples of levelling measurements on the CR, where 401 to 403 are the CR corners, 404 is the CR center and 441 to 444 are levelling benchmarks.



Data quality accuracy and uncertainty requirements

Precise topometric survey: millimetre accuracy

Precision levelling: submillimetre accuracy

Data and metadata format

Data in csv file and metadata text file



4. LIST OF ABBREVIATIONS

ASC	Ascending
ATTS	Automatic Tracking Total Station
CLC	Corine Land Cover
CLMS	Copernicus Land Monitoring Service
CNIG	Centro Nacional de Información Geográfica
CR	Corner Reflector
CRS	Coordinate Reference System
DEM	Digital Elevation Model
DESC	Descending
DPSM	Département Prévention et Sécurité Minière
DREAL	Direction régionale de l'Environnement, de l'Aménagement et du Logement
DTU	Technical University of Denmark
EEA	European Environment Agency
EGMS	European Ground Motion Service
GMS	Ground Motion Service
GNSS	Global Navigation Satellite System
InSAR	Interferometric Synthetic Aperture Radar
INPIRE	INfrastructure for SPatial InfoRmation in the European community
ITRF	International Terrestrial Reference Frame
NGI	Norwegian Geotechnical Institute
NGU	Norwegian Geological Survey
P-SBAS	Parallel Small Baseline Subset
TS	Time Series



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