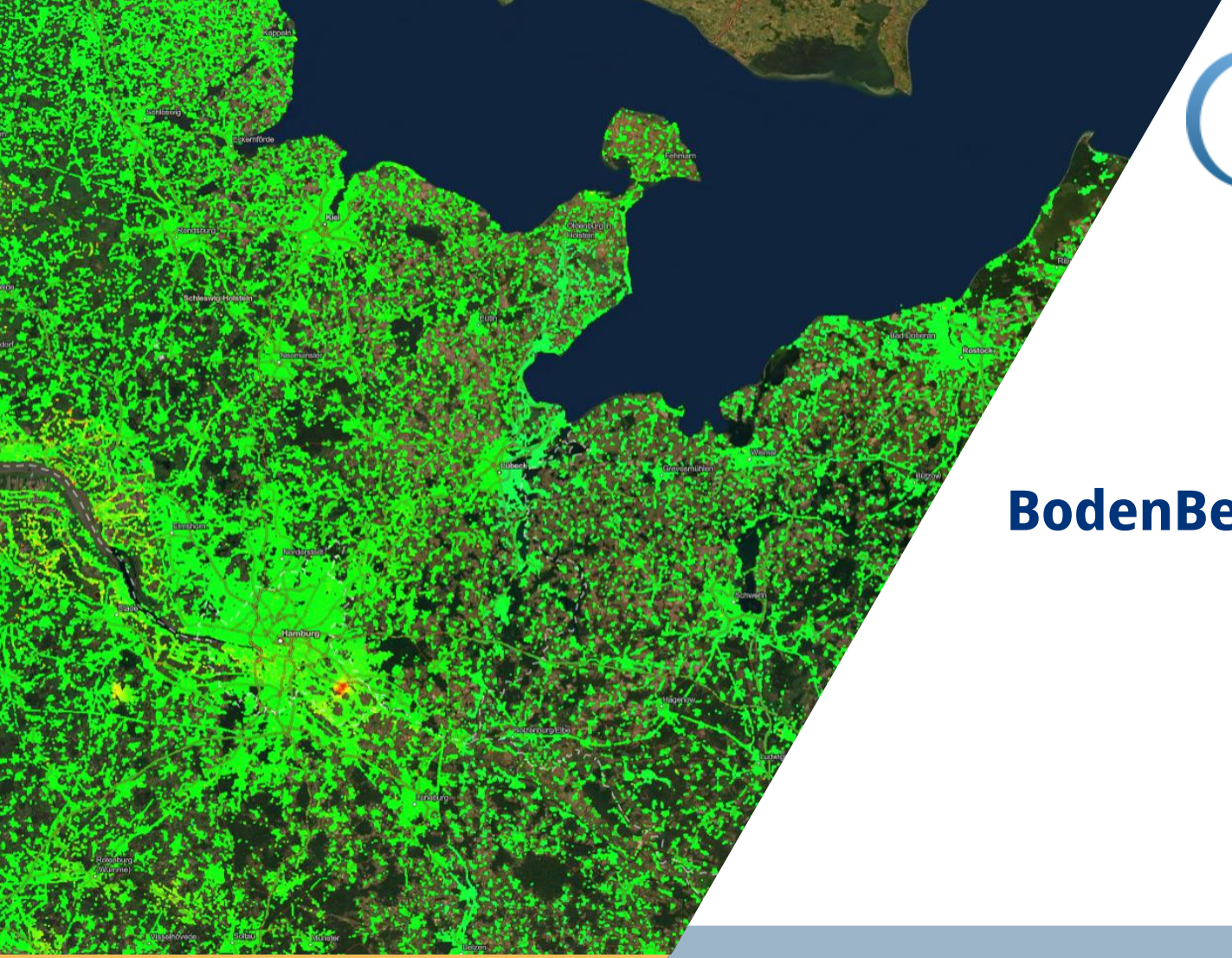


Aktuelle Entwicklungen im BodenBewegungsdienst Deutschland und im European Ground Motion Service

Andre Kalia, Michaela Frei, Thomas Lege

Hannover, 10.03.2023

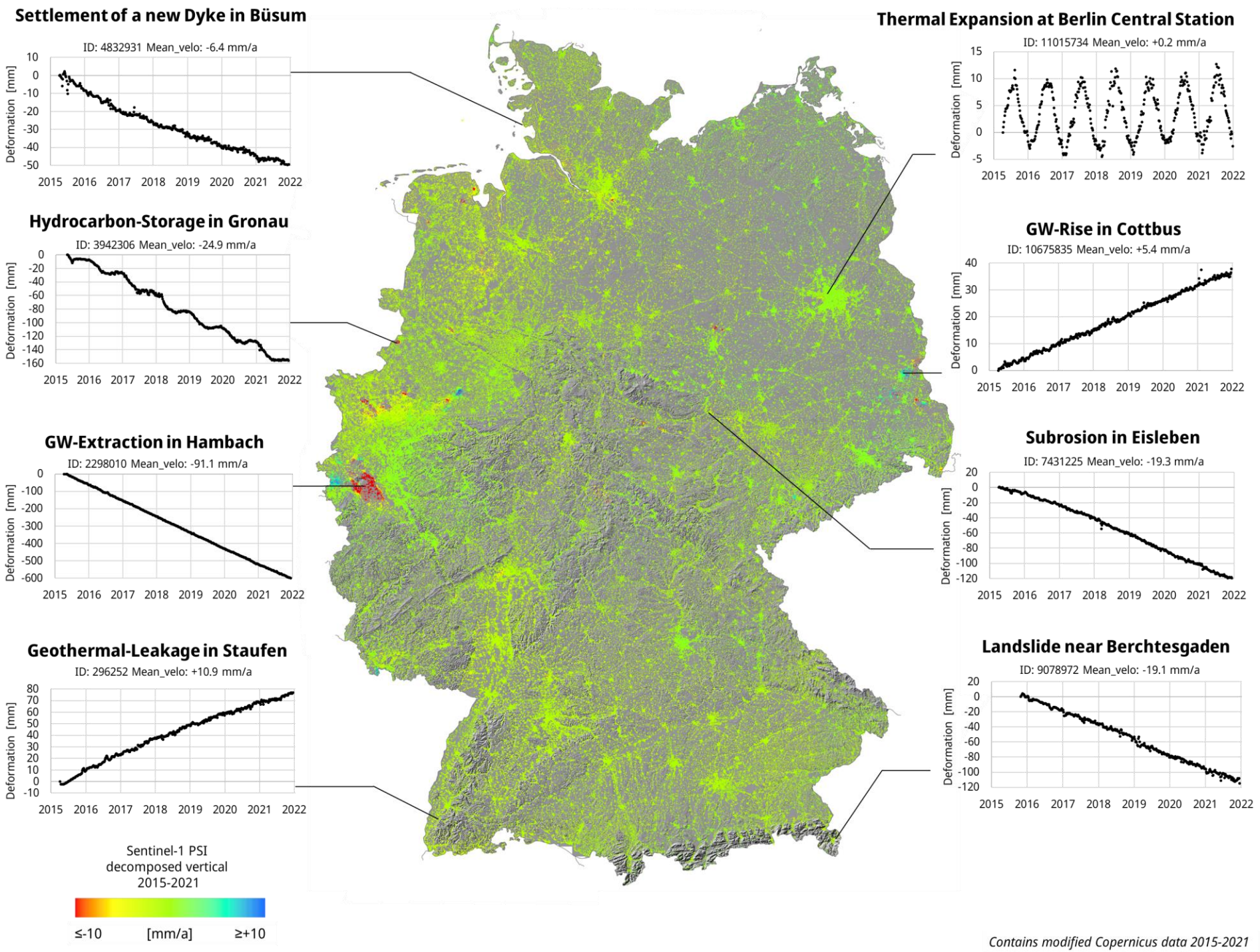
GeoMonitoring Tagung

Bundesanstalt für Geowissenschaften und Rohstoffe

www.bgr.bund.de

BBD Basisprodukt:

Bundesweite S-1 Persistent Scatterer Interferometrie Daten



Contains modified Copernicus data 2015-2021

Aktuelle Entwicklungen im BBD

A-DInSAR:

- **3. Update der bundesweiten S-1 PSI Datensätze**
  - **Zuwachs der Datenmenge**

- **Studie zur Distributed Scatterer Interferometrie**
  - **Hamburg**
  - **Gnarrenburger Moor**

- **Automatisierte Informationsextraktion / Data Mining**
  - **Mosel / Hangkriechen**
  - **Hamburg / Bodenkompaktion, Ölförderung, ehem. Gasspeicher**

Web-GIS:

- **Transekt-Tool zur Visualisierung**
- **WMTS-Dienste zur Integration in externe GIS**
- **Visualisierungstool für ArcGIS und QGIS**

Zuwachs der Datenmenge in der BBD Web-App

		LoS Asce.	LoS Desc.	Vertikal	Ost-West	Anzahl PS LoS [Mio.]	Anzahl vPS [Mio.]
Onlinegang Nov. 2019	2014 - 2018	✓	-	-	-	16,9	-
1. Update Sep. 2020	2014 - 2019	✓	✓	-	-	48,9	-
2. Update Apr. 2022	2015 - 2020	✓	✓	✓	✓	60,0	11,7
3. Update Okt. 2022	2015 - 2021	✓	✓	✓	✓	104,9	19,3

- Zuwachs der Datenlayer von einem auf vier
- Zuwachs der online verfügbaren Punktmengen von 16,9 Mio. auf 124,2 Mio.
- Zuwachs der Zeitreihen von ~118 auf ~322 Beobachtungen

Möglichkeiten und Grenzen der BBD Basisprodukte

Möglichkeiten

- Basisinformation für langsame Bodenbewegungen in ganz Deutschland
- Ausdehnung von ~100 m bis > 60 km (Hambach)
  - (Nach-) Bergbau
  - KW-Speicher
  - Setzungsempfindliche Böden
  - Erdrutsche
  - Tunnelbau
  - PV-Anlagen
  - etc.

Grenzen

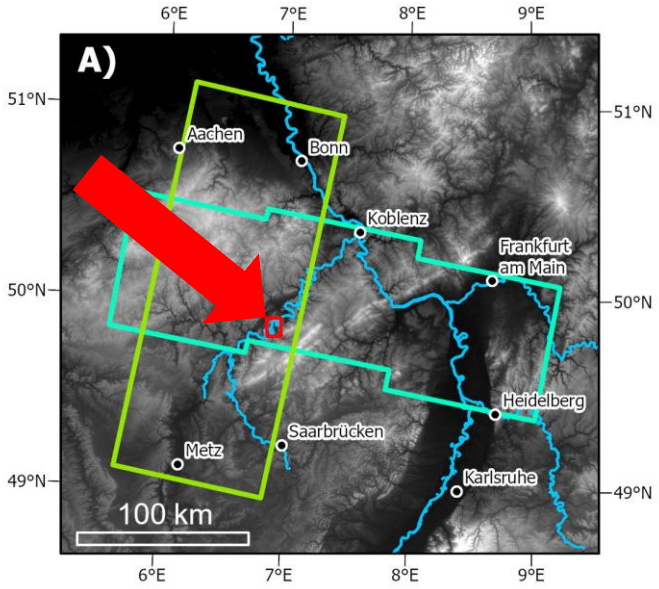
- Gebiete mit schneller/dynamischer Bewegung
- Ländliche Gebiete
- Gebiete mit starker Landbedeckungs-Änderung
- Kleinräumige Bewegungen
- Bewegungen in Nord-Süd Richtung

Aktuelle BBD Studien

- Gebiete mit schneller/dynamischer Bewegung
- Ländliche Gebiete

Automatisierte Detektion von Bewegungsgebieten

Lage des AOI

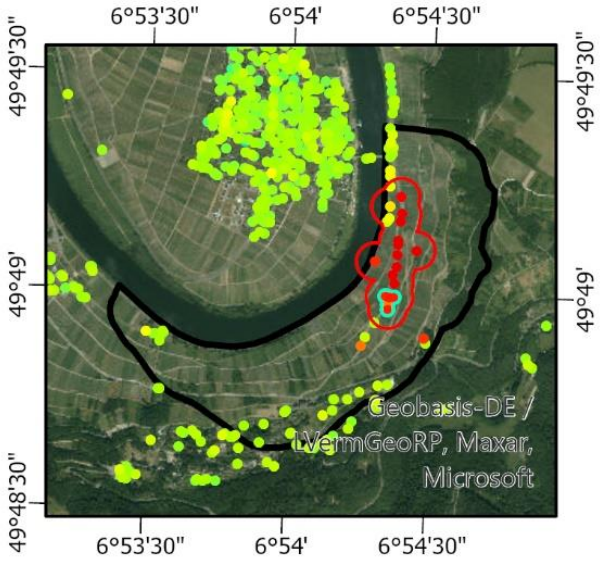


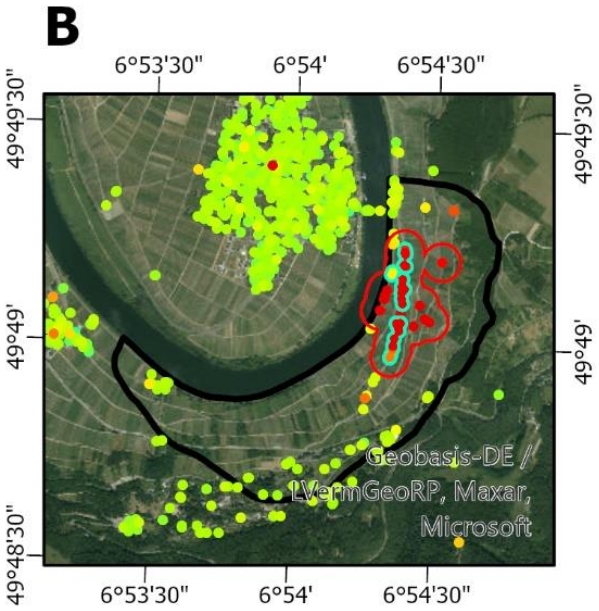
Ziel: Autom. Detektion von Gruppen von sich bewegenden Messpunkten

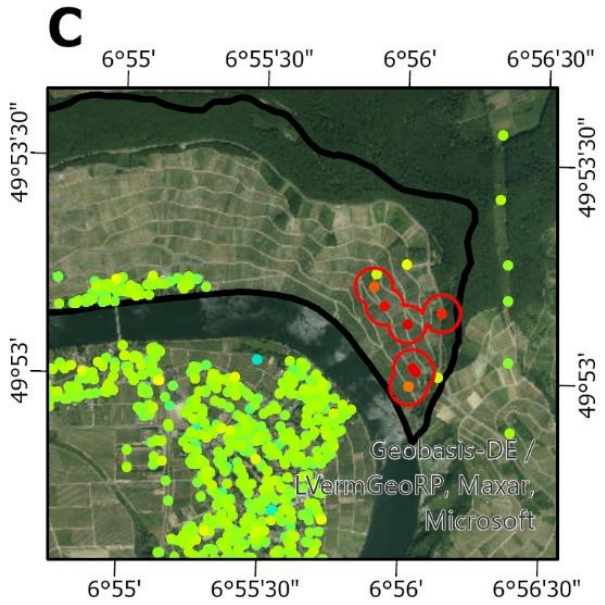
Ansatz: 1) Filterung der PS 2) Cluster-Analyse (verändert nach Barra et al., 2017)

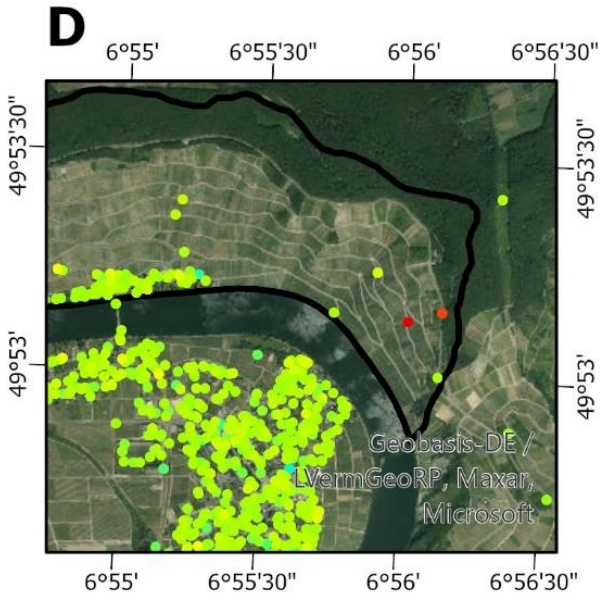
Eingangsdaten: BBD S1 PSI track 139 und 37 (Descending)

Ergebnis: Polygone die auf Bewegungsgebiete hinweisen



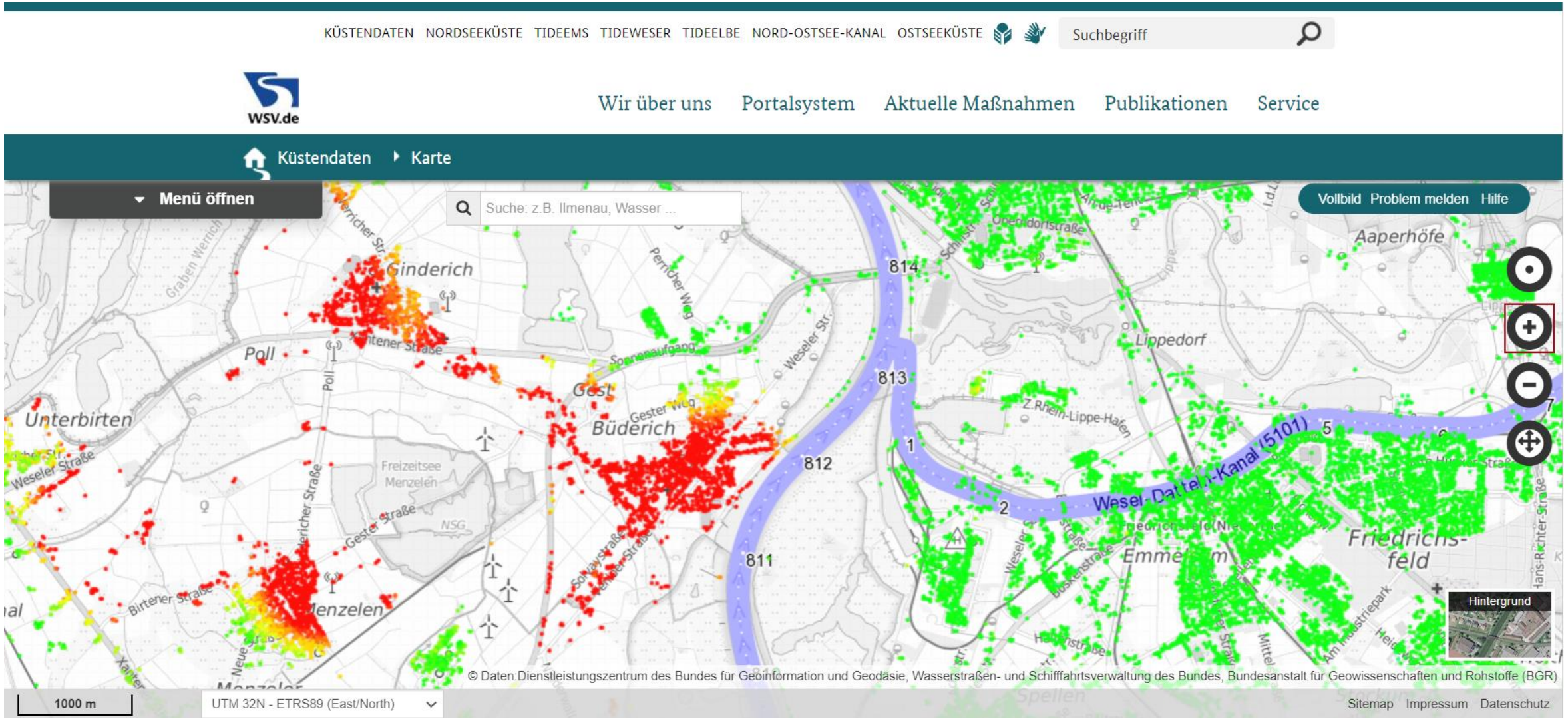




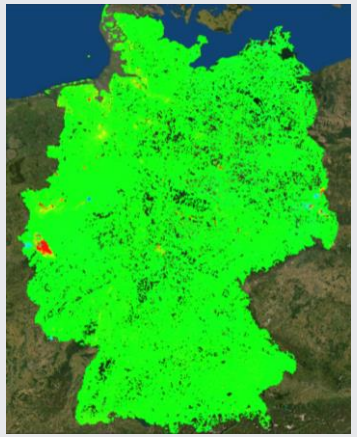
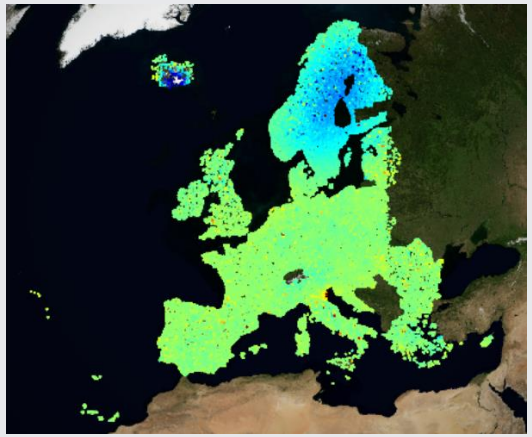


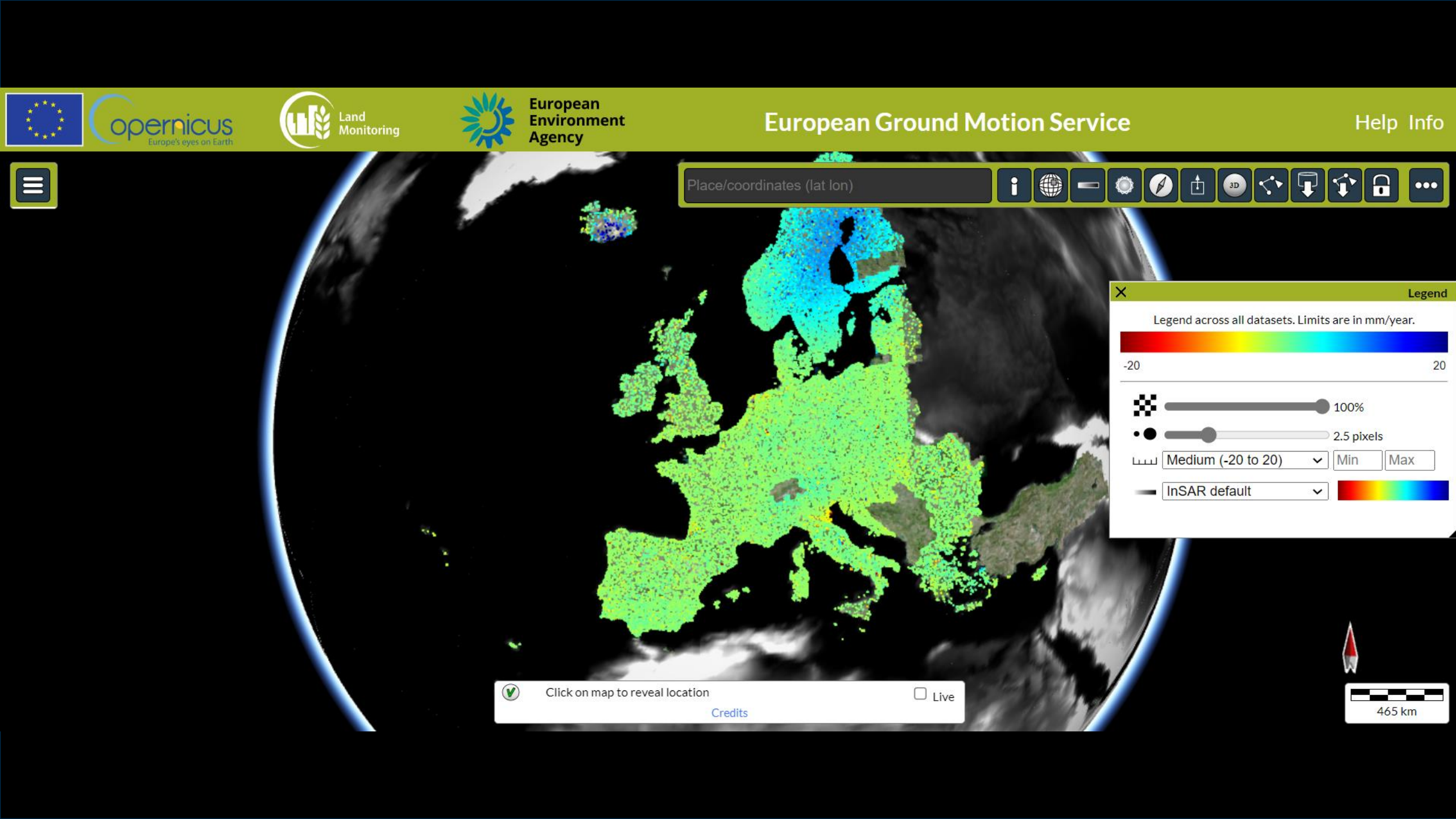
Transekt-Tool zur Visualisierung

Integration des BBD in andere (Web-)GIS via WMTS

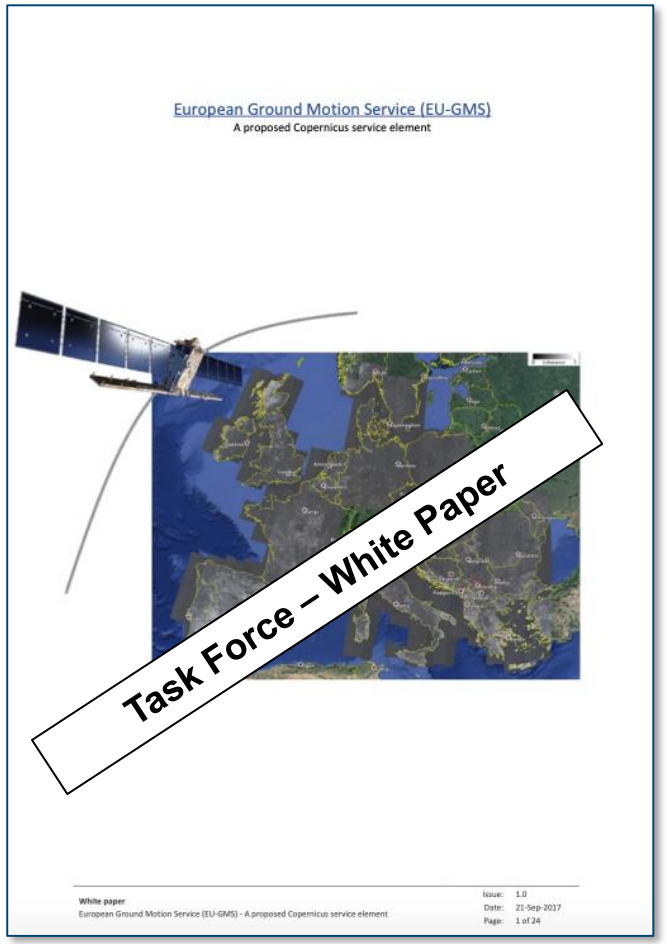


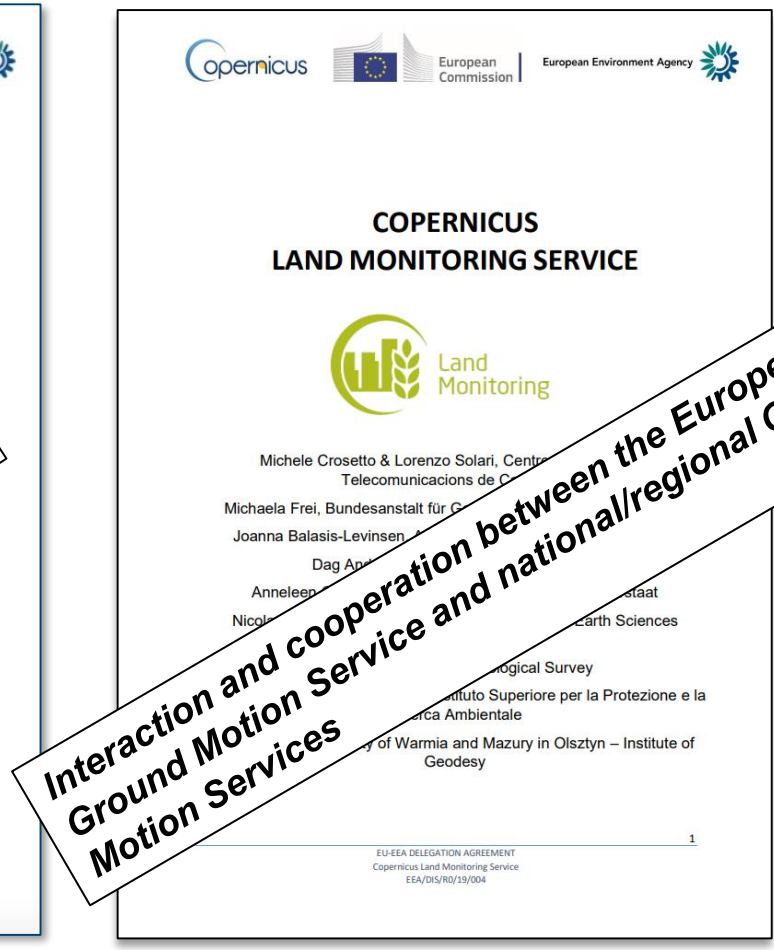
Eigenschaften von BBD und EGMS

	BBD	EGMS
Federführung	BGR	EEA
Im Betrieb seit	2019	2022
Räuml. Abdeckung	Deutschland	Europa
Zeitl. Abdeckung	Mär. 2015 – Dez. 2021	Jan. 2016 - Dez. 2021
Bezugssystem	ETRS89/DREF91	ETRS89/ETRF2000
L3 GSD	50 x 50 m^2	100 x 100 m^2
Kohärenzfilter	> 0,75	-
Web-App		


Copernicus
Europe's eyes on Earth
Land Monitoring
European Environment Agency
European Ground Motion Service
Help
Info
Place/coordinates (lat lon)
Legend
Legend across all datasets. Limits are in mm/year.
-20
20
100%
2.5 pixels
Medium (-20 to 20)
Min
Max
InSAR default
Click on map to reveal location
Live
Credits
465 km

EGMS Dokumentationen





EGMS Dokumentationen

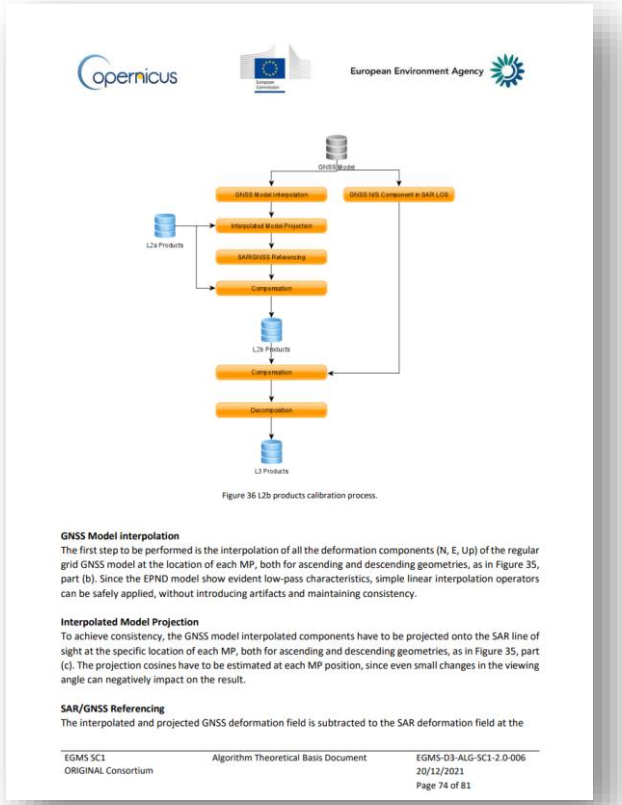


Figure 36 L2b products calibration process.

GNSS Model interpolation

The first step to be performed is the interpolation of all the deformation components (N, E, Up) of the regular grid GNSS model at the location of each MP, both for ascending and descending geometries, as in Figure 35, part (b). Since the EPND model show evident low-pass characteristics, simple linear interpolation operators can be safely applied, without introducing artifacts and maintaining consistency.

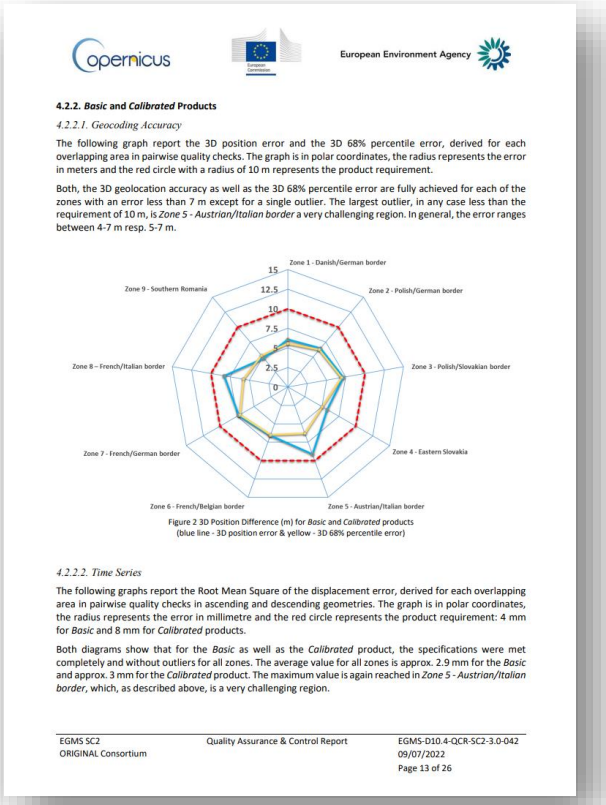
Interpolated Model Projection

To achieve consistency, the GNSS model interpolated components have to be projected onto the SAR line of sight at the specific location of each MP, both for ascending and descending geometries, as in Figure 35, part (c). The projection cosines have to be estimated at each MP position, since even small changes in the viewing angle can negatively impact on the result.

SAR/GNSS Referencing

The interpolated and projected GNSS deformation field is subtracted to the SAR deformation field at the

Algorithm Theoretical Basis Document



4.2.2. *Basic* and *Calibrated* Products

4.2.2.1. Geocoding Accuracy

The following graph report the 3D position error and the 3D 68% percentile error, derived for each overlapping area in pairwise quality checks. The graph is in polar coordinates, the radius represents the error in meters and the red circle with a radius of 10 m represents the product requirement.

Both, the 3D geolocation accuracy as well as the 3D 68% percentile error are fully achieved for each of the zones with an error less than 7 m except for a single outlier. The largest outlier, in any case less than the requirement of 10 m, is *Zone 5 - Austrian/Italian border* a very challenging region. In general, the error ranges between 4-7 m resp. 5-7 m.

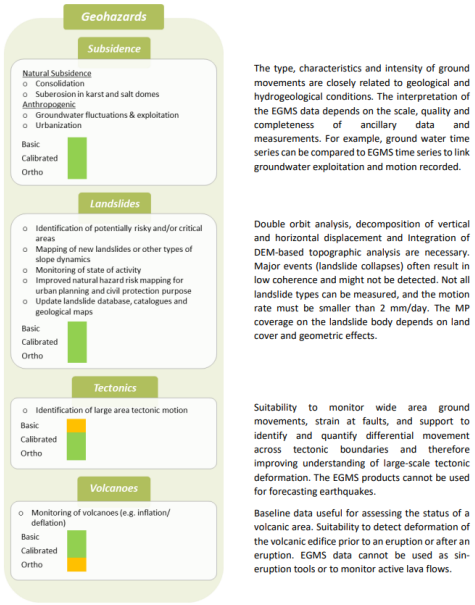
Figure 2 3D Position Difference (m) for *Basic* and *Calibrated* products
(blue line - 3D position error & yellow - 3D 68% percentile error)

4.2.2.2. Time Series

The following graphs report the Root Mean Square of the displacement error, derived for each overlapping area in pairwise quality checks in ascending and descending geometries. The graph is in polar coordinates, the radius represents the error in millimetre and the red circle represents the product requirement: 4 mm for *Basic* and 8 mm for *Calibrated* products.

Both diagrams show that for the *Basic* as well as the *Calibrated* product, the specifications were met completely and without outliers for all zones. The average value for all zones is approx. 2.9 mm for the *Basic* and approx. 3 mm for the *Calibrated* product. The maximum value is again reached in *Zone 5 - Austrian/Italian border*, which, as described above, is a very challenging region.

Quality Control Report



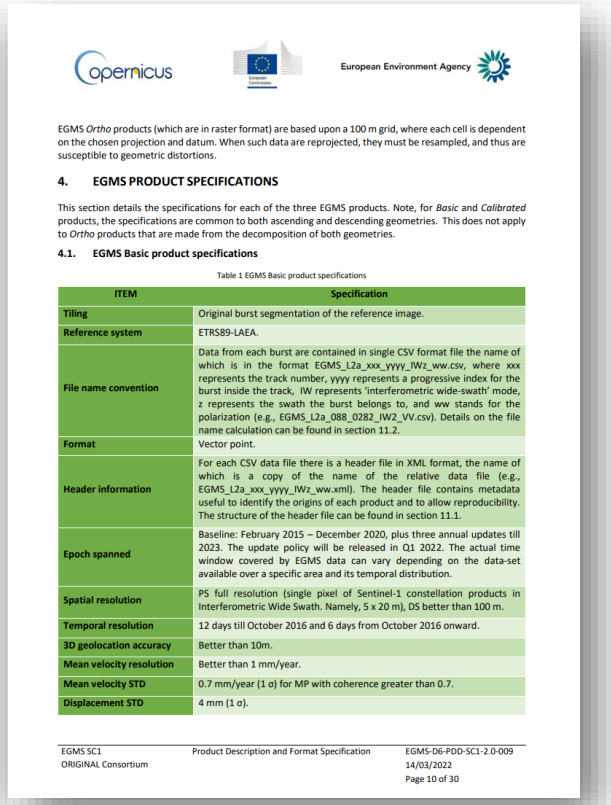
The type, characteristics and intensity of ground movements are closely related to geological and hydrogeological conditions. The interpretation of the EGMS data depends on the scale, quality and completeness of ancillary data and measurements. For example, ground water time series can be compared to EGMS time series to link groundwater exploitation and motion recorded.

Double orbit analysis, decomposition of vertical and horizontal displacement and Integration of DEM-based topographic analysis are necessary. Major events (landslide collapses) often result in low coherence and might not be detected. Not all landslide types can be measured, and the motion rate must be smaller than 2 mm/day. The MP coverage on the landslide body depends on land cover and geometric effects.

Suitability to monitor wide area ground movements, strain at faults, and support to identify and quantify differential movement across tectonic boundaries and therefore improving understanding of large-scale tectonic deformation. The EGMS products cannot be used for forecasting earthquakes.

Baseline data useful for assessing the status of a volcanic area. Suitability to detect deformation of the volcanic edifice prior to an eruption or after an eruption. EGMS data cannot be used as sin-eruption tools or to monitor active lava flows.

Product User Manual



EGMS *Ortho* products (which are in raster format) are based upon a 100 m grid, where each cell is dependent on the chosen projection and datum. When such data are reprojected, they must be resampled, and thus are susceptible to geometric distortions.

4. EGMS PRODUCT SPECIFICATIONS

This section details the specifications for each of the three EGMS products. Note, for *Basic* and *Calibrated* products, the specifications are common to both ascending and descending geometries. This does not apply to *Ortho* products that are made from the decomposition of both geometries.

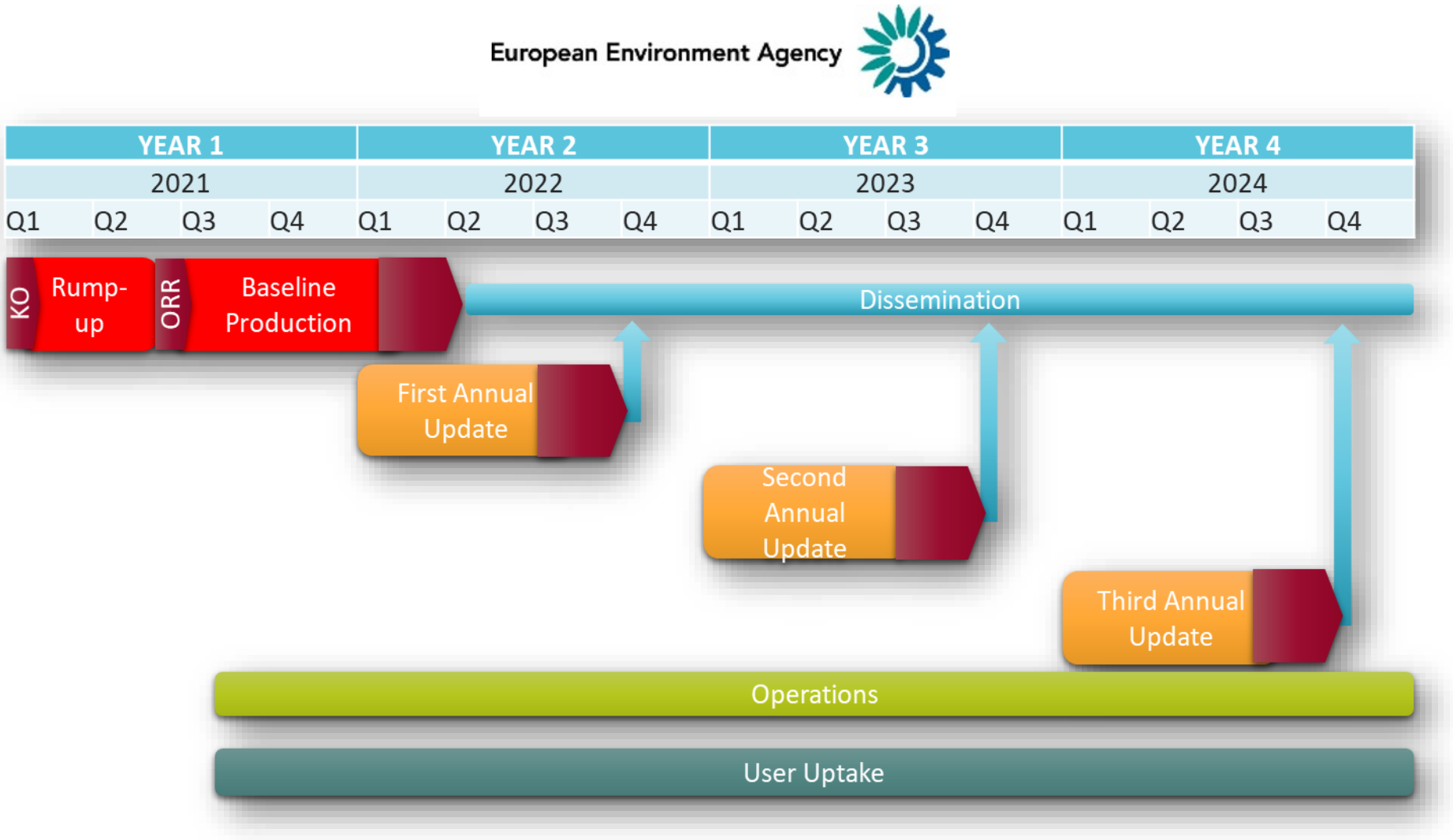
4.1. EGMS Basic product specifications

Table 1 EGMS Basic product specifications

ITEM	Specification
Tiling	Original burst segmentation of the reference image.
Reference system	ETRS89-LAEA.
File name convention	Data from each burst are contained in single CSV format file the name of which is in the format EGMS_L2a_xxx_yyyy_IWz_ww.csv, where xxx represents the track number, yyyy represents a progressive index for the burst inside the track, IW represents 'interferometric wide-swath' mode, z represents the swath the burst belongs to, and ww stands for the polarization (e.g., EGMS_L2a_088_0282_IW2_VV.csv). Details on the file name calculation can be found in section 11.2.
Format	Vector point.
Header information	For each CSV data file there is a header file in XML format, the name of which is a copy of the name of the relative data file (e.g., EGMS_L2a_xxx_yyyy_IWz_ww.xml). The header file contains metadata useful to identify the origins of each product and to allow reproducibility. The structure of the header file can be found in section 11.1.
Epoch spanned	Baseline: February 2015 – December 2020, plus three annual updates till 2023. The update policy will be released in Q1 2022. The actual time window covered by EGMS data can vary depending on the data-set available over a specific area and its temporal distribution.
Spatial resolution	PS full resolution (single pixel of Sentinel-1 constellation products in Interferometric Wide Swath. Namely, 5 x 20 m), DS better than 100 m.
Temporal resolution	12 days till October 2016 and 6 days from October 2016 onward.
3D geolocation accuracy	Better than 10m.
Mean velocity resolution	Better than 1 mm/year.
Mean velocity STD	0.7 mm/year (1 σ) for MP with coherence greater than 0.7.
Displacement STD	4 mm (1 σ).

Product Description and Format Specification

EGMS Zeitplan (Stand: 2022)



Zeitplan 2022:

Q2, 2022: Erste 5-Jahres-Baseline für den Zeitraum 2015 bis 2020.

Q4, 2022: Erste jährliche Aktualisierung mit Daten aus dem Jahr 2021.

Aktuelle Entwicklungen im EGMS

A-DInSAR:

- **1. Update der europaweiten PSI Datensätze im Februar 2023**

Web-GIS:

- **Downloadmöglichkeit seit November 2022**

Validierung

- **Konsortium hat nach Ausschreibung mit der Validierung begonnen**

Tutorials

- **Webinare beginnen ab März 2023**
  1. **EGMS, a general introduction (02.03.2023)**
  2. **EGMS and exploitation of natural resources (29.03.2023)**
  3. **EGMS and geological hazards (19.04.2023)**
  4. **EGMS and climate adaptation (16.05.2023)**
  5. **EGMS, urban areas and infrastructure (07.06.2023)**

EGMS und Regionale/Nationale Bodenbewegungsdienste

- Gegenseitiger Nutzen aus der Nutzung von nationalen/regionalen GMS- und EGMS-Aktivitäten und -Daten zu Validierungszwecken
- Integration von nationalen/regionalen GMS mit hochauflösenden interferometrischen Produkten
- Zusammenarbeit zwischen nationalem/regionalem GMS und EGMS, um die Akzeptanz der EGMS-Produkte durch die Nutzer zu gewährleisten und zu erhöhen und die Entwicklung nachgelagerter Aktivitäten zu erleichtern
- Einrichtung von nationalen EGMS-Kontaktstellen. Nationale Experten, die als Botschafter für die Einführung von EGMS auf nationaler Ebene dienen

Ausblick BBD

Integration der EGMS Daten in die BBD Web-App

- **Voraussichtlich: Ende 2023 (Zeitspanne 2016-2022)**

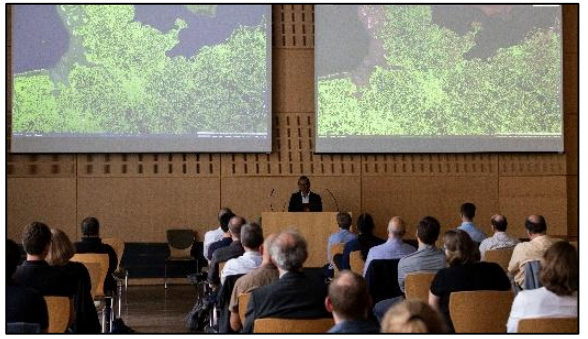
Weiterentwicklung BBD Web-App

- **z.B.: mobile Version, Tools zur Datenexploration**

➢ **Nächster BBD Workshop im November 2023 geplant**

Sentinel-1

BBD-Workshop 2022



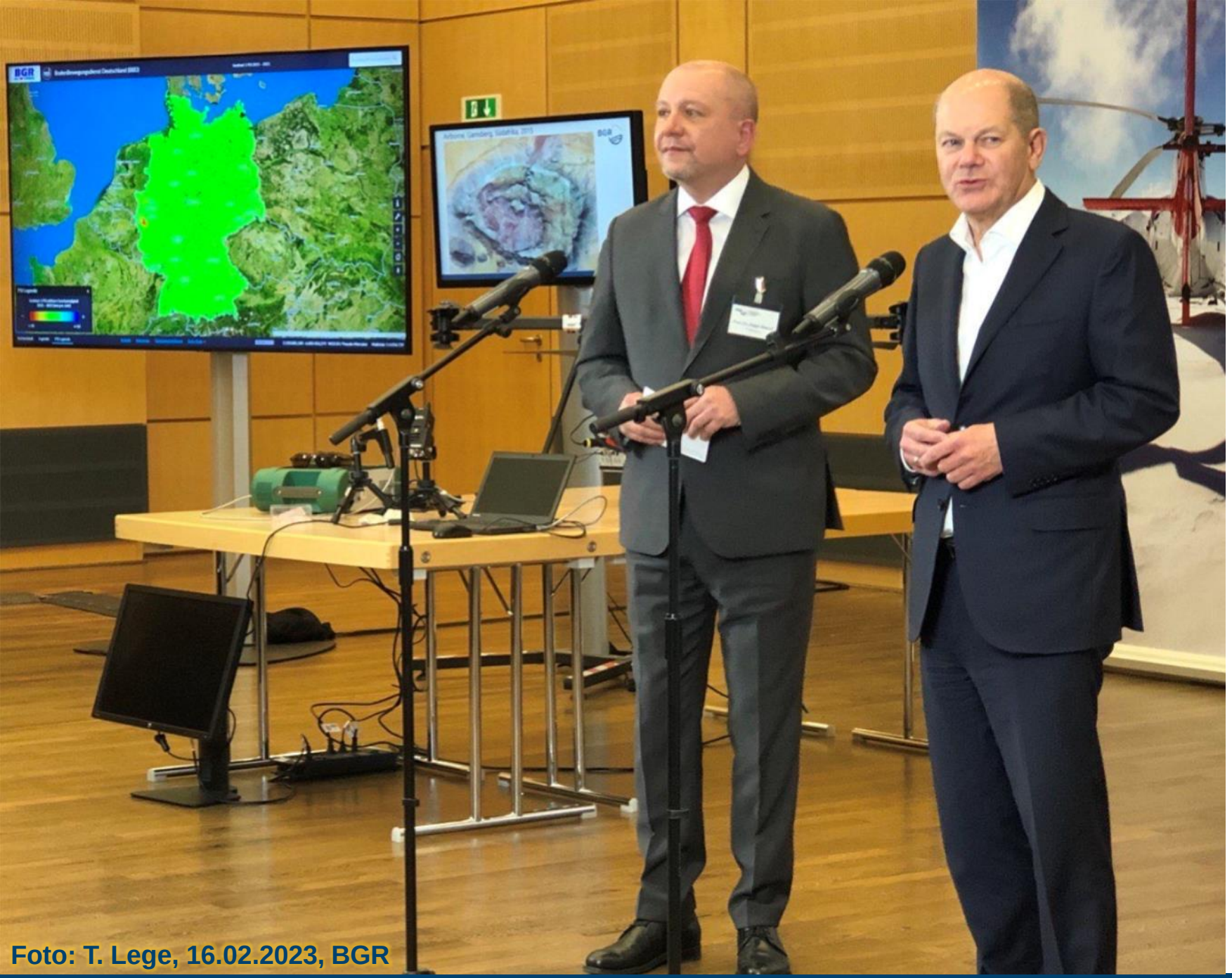


Foto: T. Lege, 16.02.2023, BGR

Vielen Dank für Ihre Aufmerksamkeit

Andre.Kalia@bgr.de