AUTOMATIC GROUND DEFORMATION AREA EXTRACTION FROM EUROPEAN GROUND MOTION SERVICE PRODUCTS

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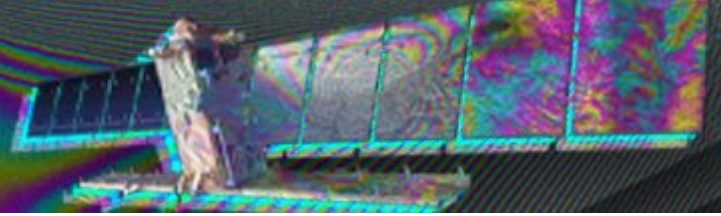
Introduction

- The work focuses on detecting ground motion phenomena from Persistent Scatterer SAR Interferometry (PSInSAR) data;
- Exposure of the built environment to geohazards has increased, due to the rapid and uncontrolled urbanization, man-induced environmental transformations leading to higher hydrogeological risk, and global climate change;
- InSAR allows characterising ground deformation trends with increasing accuracy that can be used to detect a wide variety of ground deformation events;
- The European Ground Motion Service (EGMS) is a new Sentinel-1 PSInSAR data source that can be exploited to generate wide-area databases of ground deformation phenomena;
- A **European dataset of active deformation areas** (ADAs) is the main output of this work;
- The work is funded by the ESA Living Planet Fellowship scheme (“Wide area Sentinel-1 deformation classification for advanced data exploitation”) and by the DG-ECHO project RASTOOL (“European ground motion risk assessment tool”).

Outline

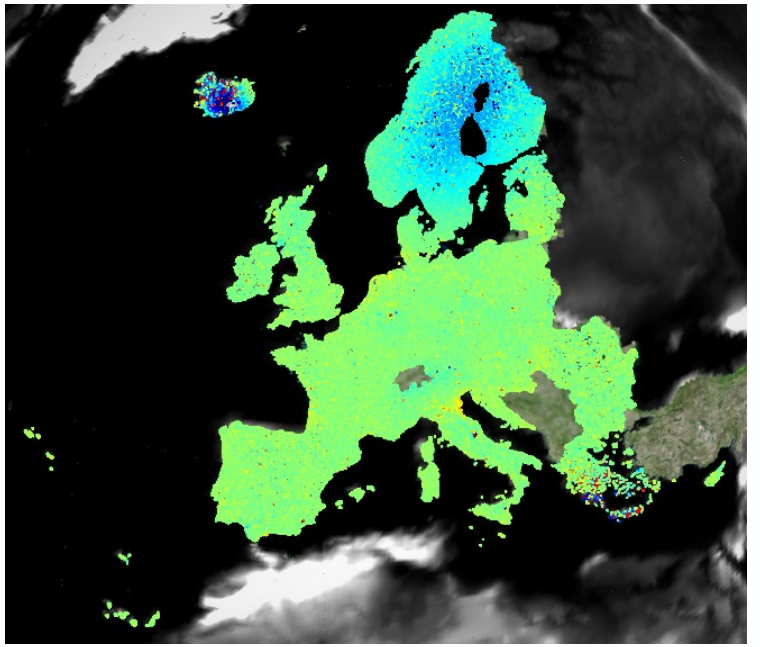


1. European Ground Motion Service (EGMS) overview
2. Active Deformation Area (ADA) Extraction: algorithm description
3. Results: European ADA Maps
4. Validation: Valle d'Aosta (Aosta Valley, Italy) case study
5. Towards a European labelled dataset of ground deformation areas

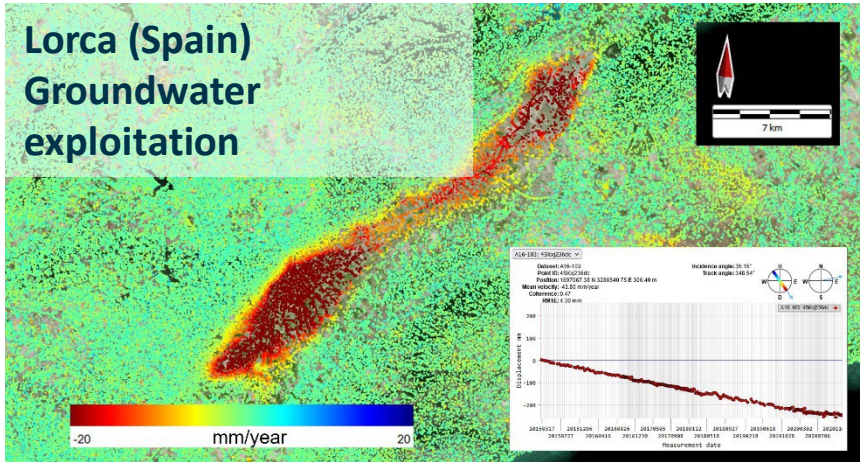
European Ground Motion Service

The European Ground Motion Service (EGMS) provides three product levels:

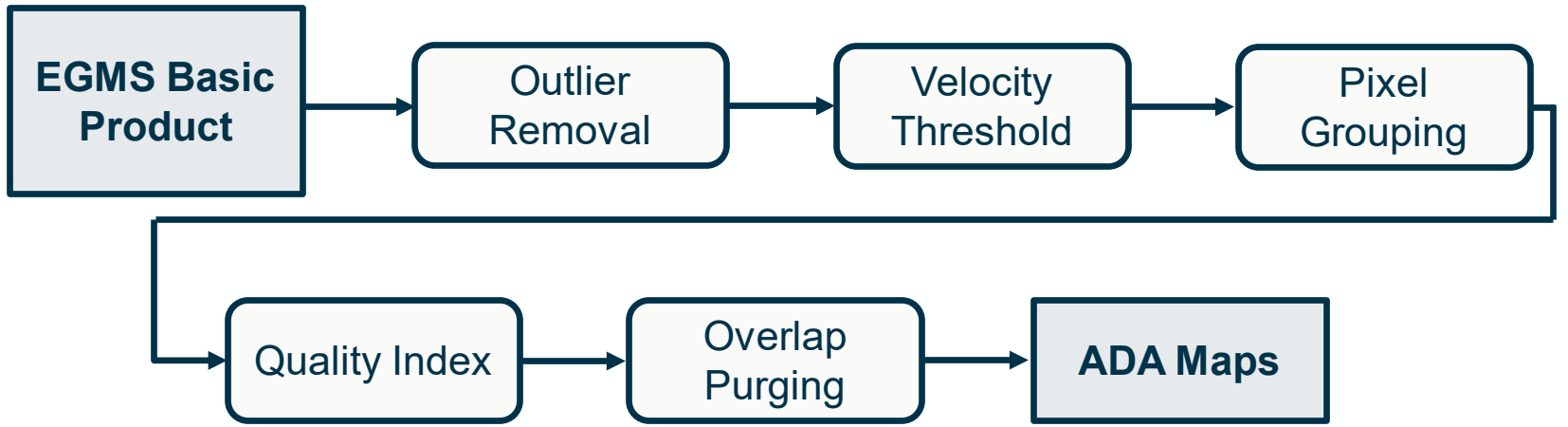
- **Basic**: line-of-sight (LOS) velocity maps in ascending and descending orbits referred to a local reference point;
- **Calibrated**, obtained by correcting the Basic product data using a model derived from Global Navigation Satellite Service (GNSS) data as reference;
- **Ortho:** vertical and horizontal (East-West) displacements computed from the Calibrated data.



- Obtained through PSInSAR processing of Sentinel-1 data
- Period: Feb 2016- Dec 2021 (with yearly updates)
- Dataset contains displacement time series and derived metrics



Algorithm - ADA Finder



ADA polygon

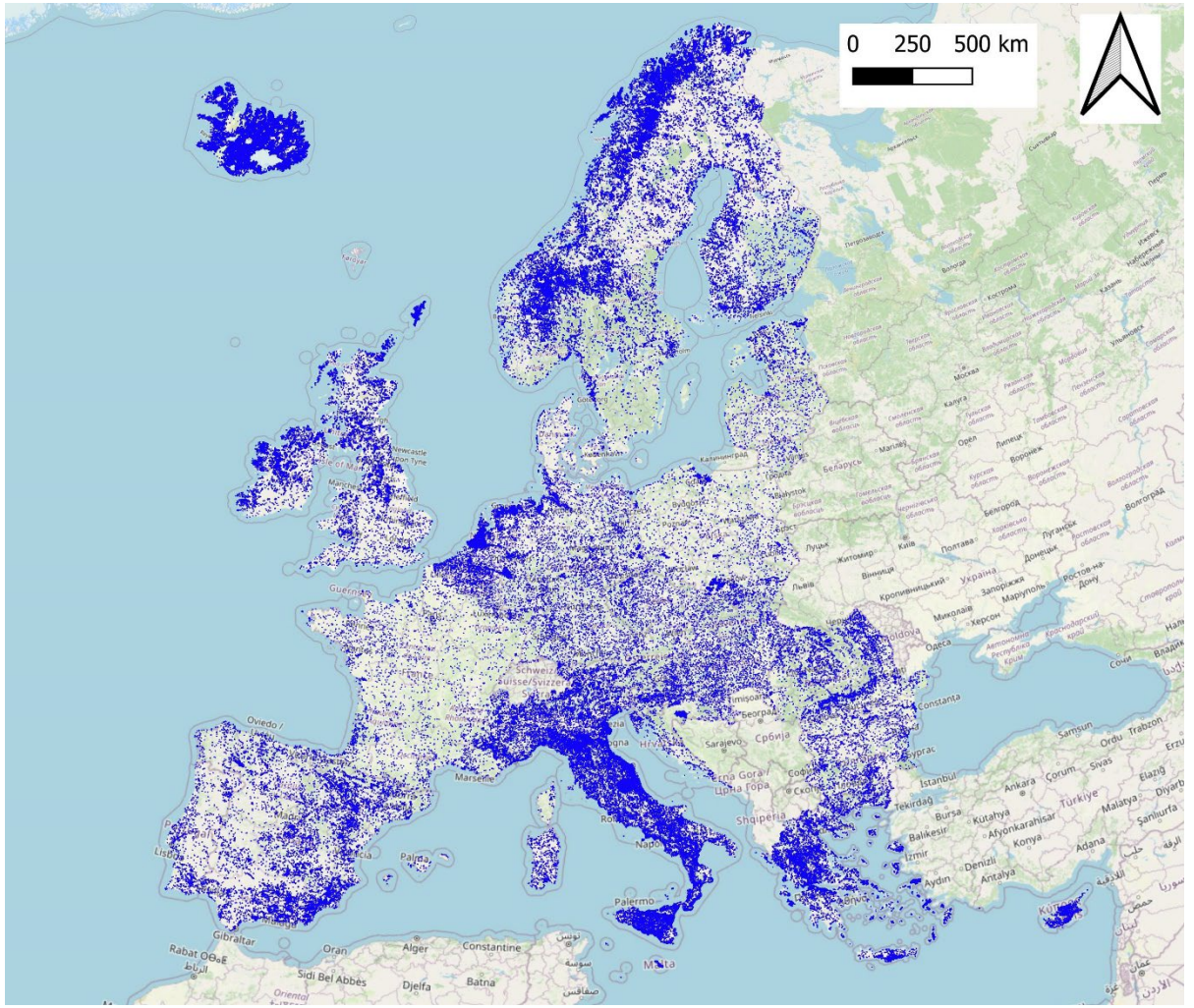
- Number of PSs
- Velocity statistics
- Quality Index

- The **ADA Finder tool** [*] was extended to process the EGMS Basic Product frames on a parallel processing implementation;
- ADA Finder detects active deformation areas using a **velocity threshold of 5 mm/year**;
- **overlap purging** selects the wider ADA between two overlapping ones (for overlapping regions between two Sentinel-1 frames/swaths)

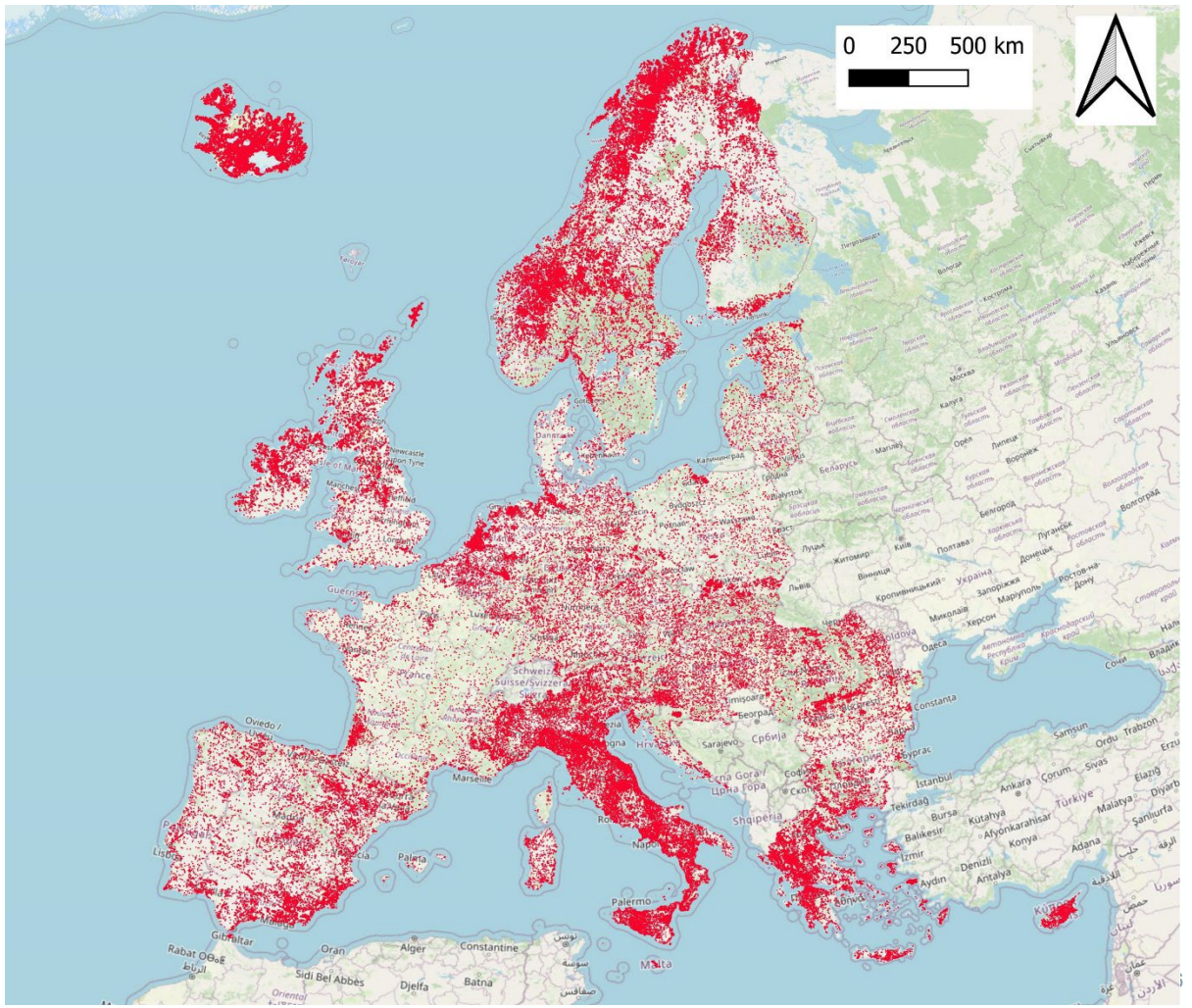
[*] A.Barra, L.Solari, M.Béjar-Pizarro, *et al*. "A methodology to detect and update active deformation areas based on Sentinel-1 SAR images", *Remote Sensing*, 9, 1002, 2017.

European ADA Maps

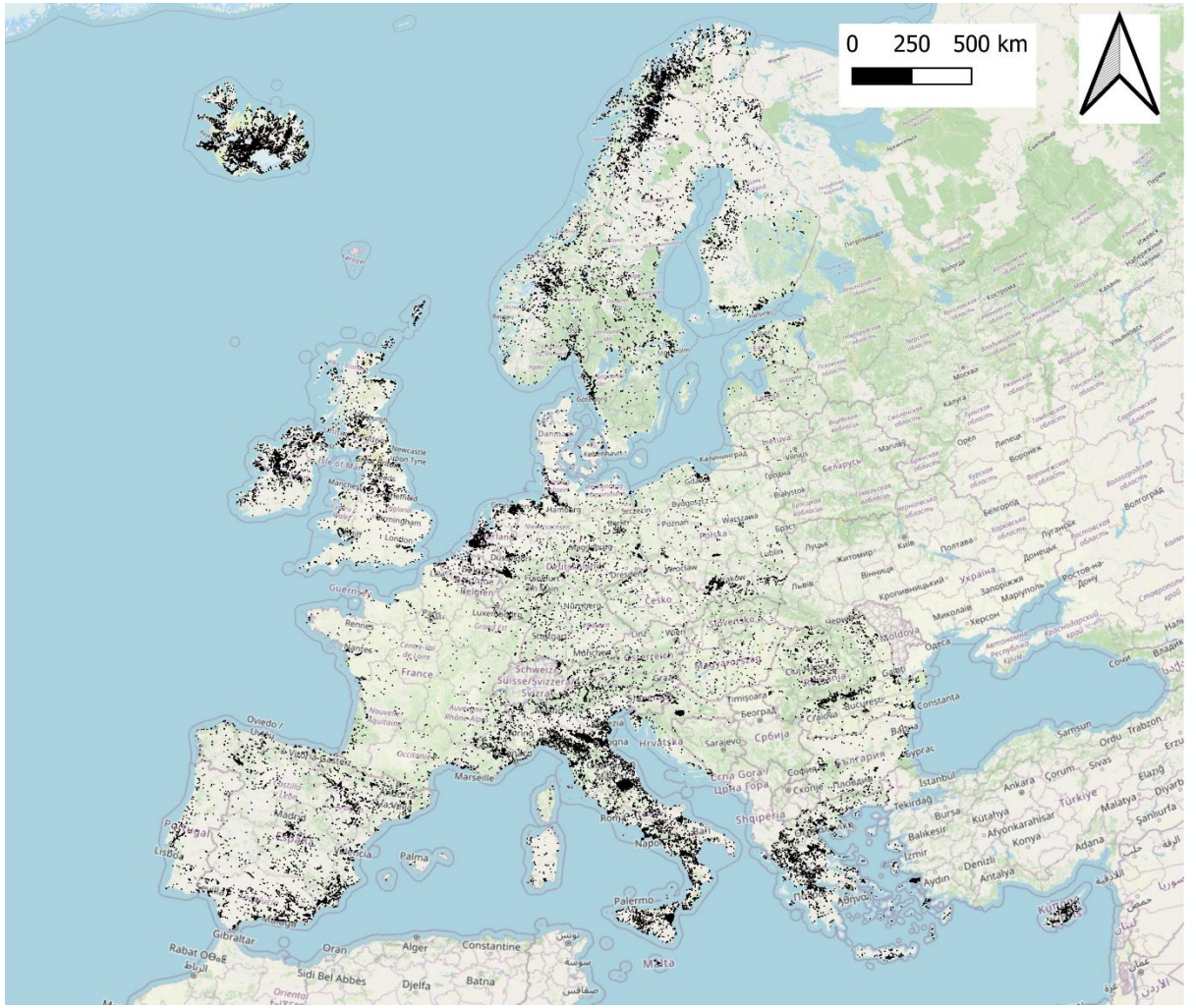
Ascending LOS – Nr ADAs ~351000



Descending LOS – Nr ADAs ~341000

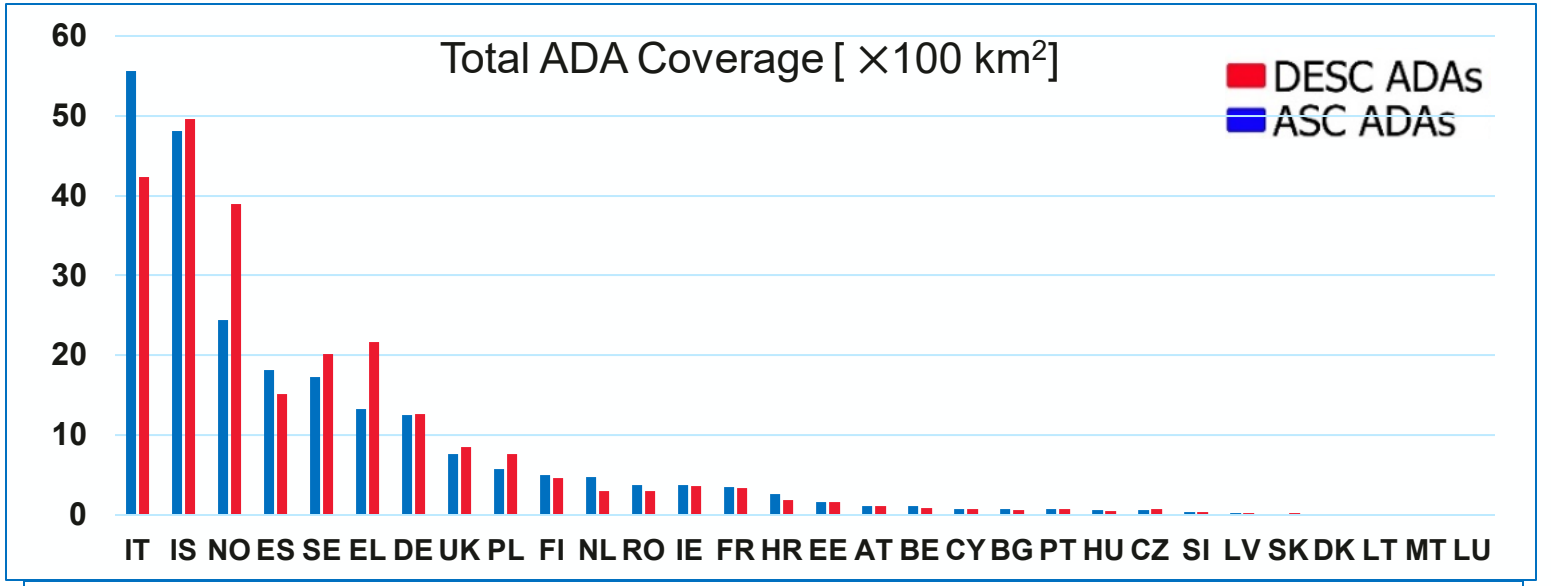


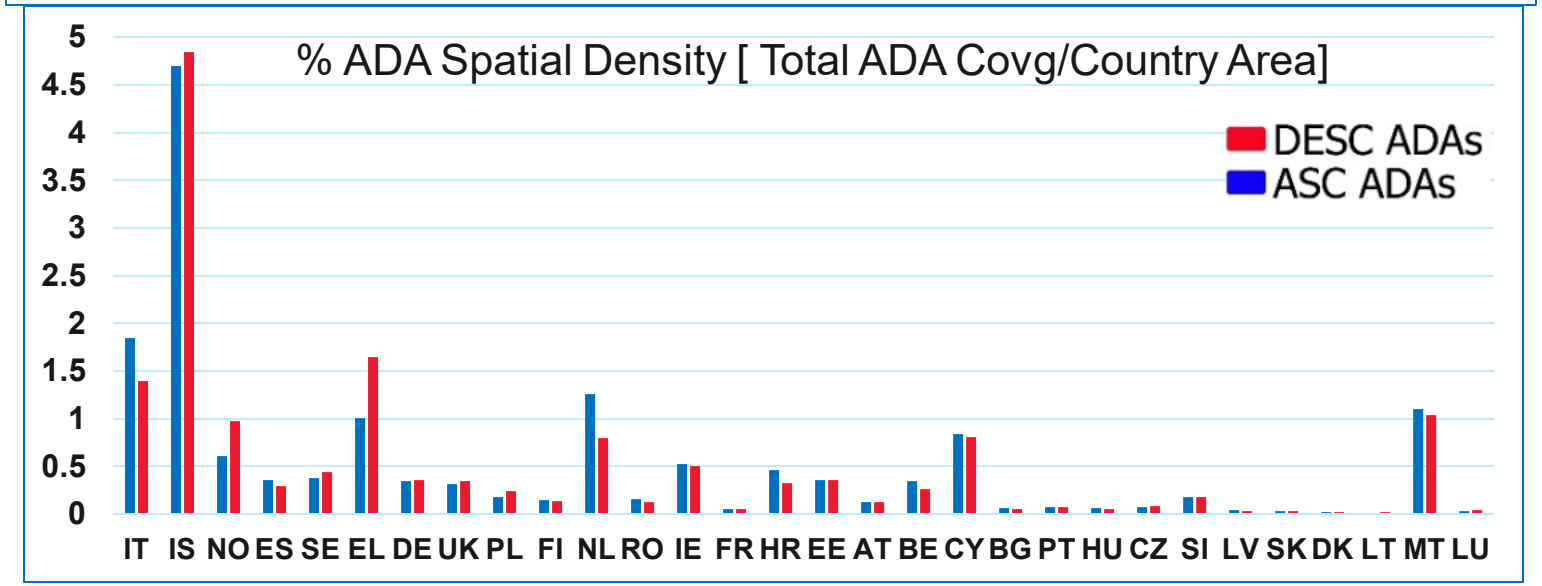
European ADA Maps



Asc/Desc intersection
~ 157000 polygons

European ADAs – Country Stats





ADA Quality Index

- The ADA Quality Index (QI) is calculated from the PS time series within one ADA polygon :
  - **Spatial Noise Index** (SNI) : mean spatial cross-correlation (i.e. over the PS pairs)
  - **Temporal Noise Index** (TNI): mean temporal autocorrelation
- The TNI and SNI values are **quantized** to four possible values [1,2,3,4] (high-> low quality)
- The QI values are computed using a **lookup table**
- Low Quality ADAs (QI=3,4) were discarded

		TNI			
		1	2	3	4
SNI	1	1	1	2	4
	2	1	2	3	4
	3	2	3	3	4
	4	4	4	4	4

European ADA Maps: 75% QI = 1, 25% QI = 2

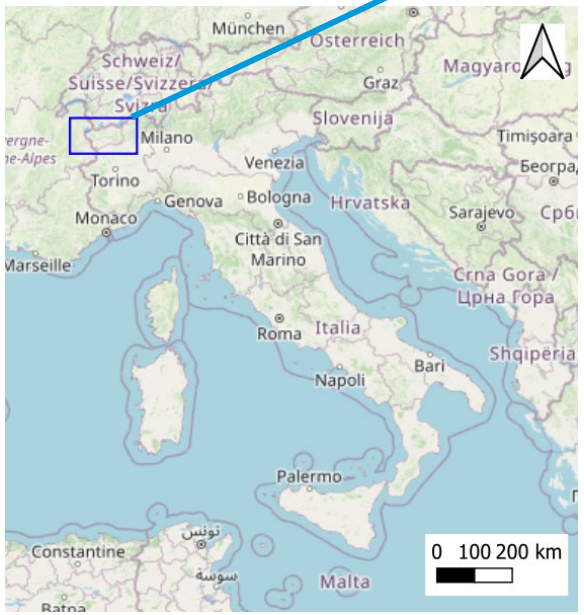
Percentages of ADAs for each QI/TNI and QI/SNI combination

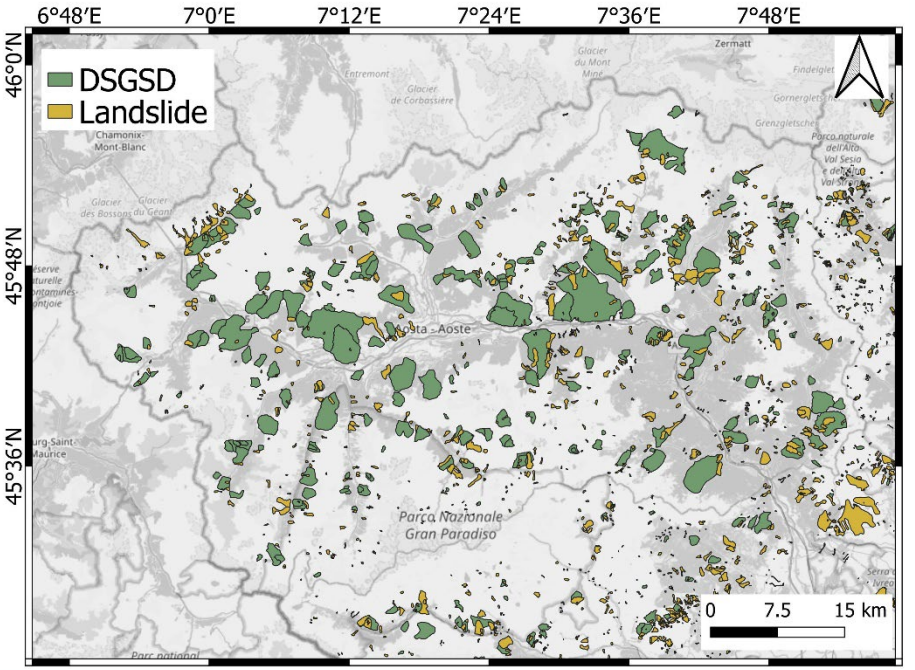
	QI = 1		QI = 2	
TNI	Asc	Desc	Asc	Desc
1	99.2	99.4	34.9	34.5
2	0.8	0.6	65.1	65.5
3	0	0	<0.01	<0.01

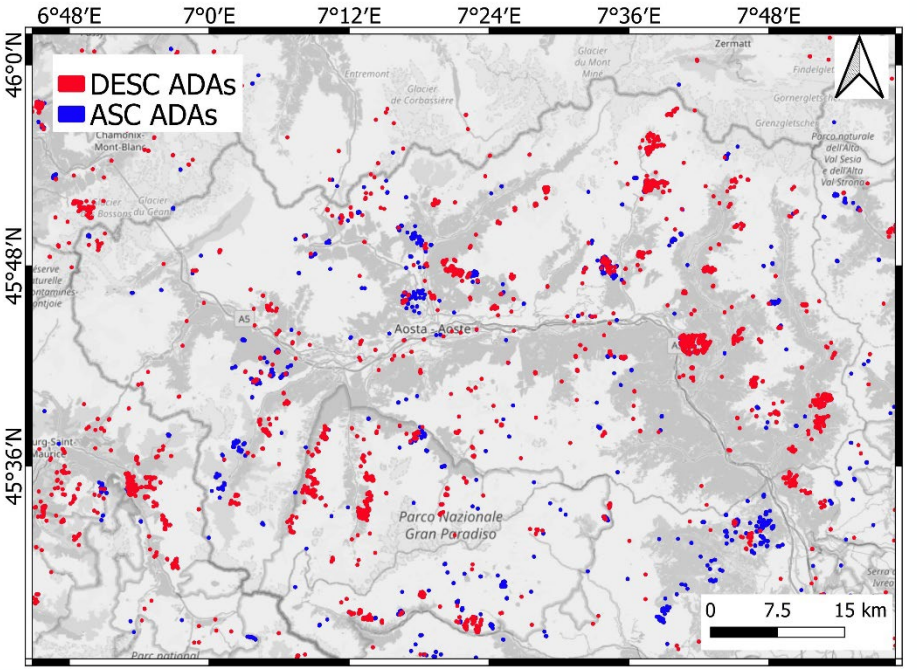
	QI=1		QI=2	
SNI	Asc	Desc	Asc	Desc
1	73.9	72.8	<0.01	<0.01
2	26.1	27.2	65.1	65.5
3	0	0	34.9	34.5

Case study – Valle d'Aosta

Valle d'Aosta region
(Aosta Valley, NW Italy)

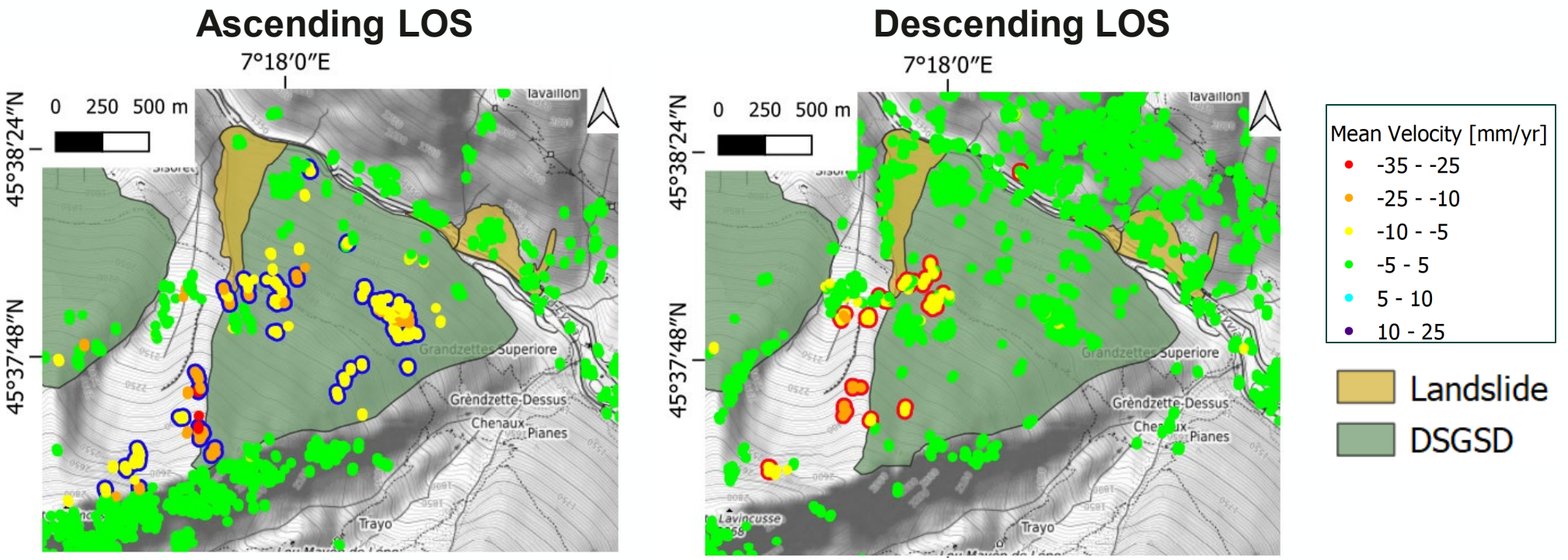






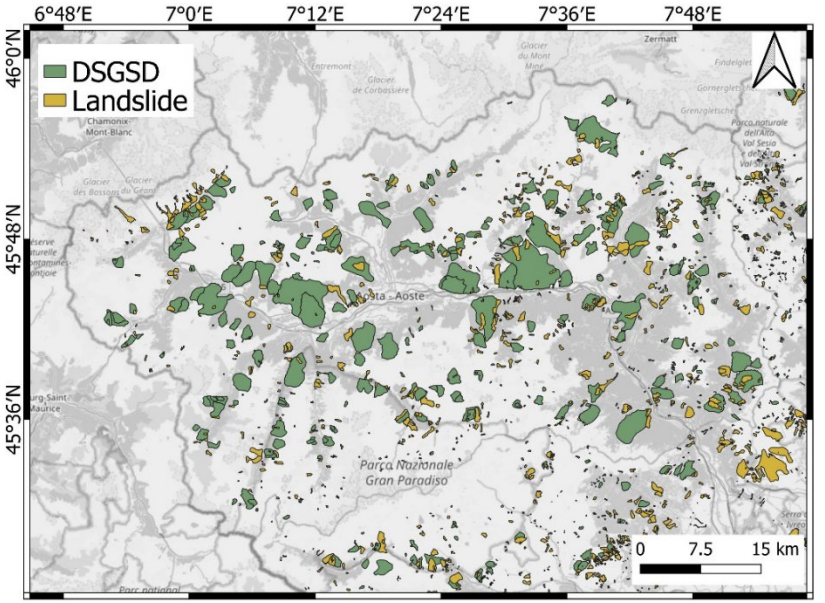
- Territory of Valle d'Aosta is almost totally subject to natural hazard
- The Italian National Landslide Inventory (IFFI) provides information about the presence of ground deformation phenomena, mainly landslides (various types) and Deep Seated Gravitational Slope Deformation (DSGSD)
- ∼ 1300 ADA polygons (Asc + Desc) detected

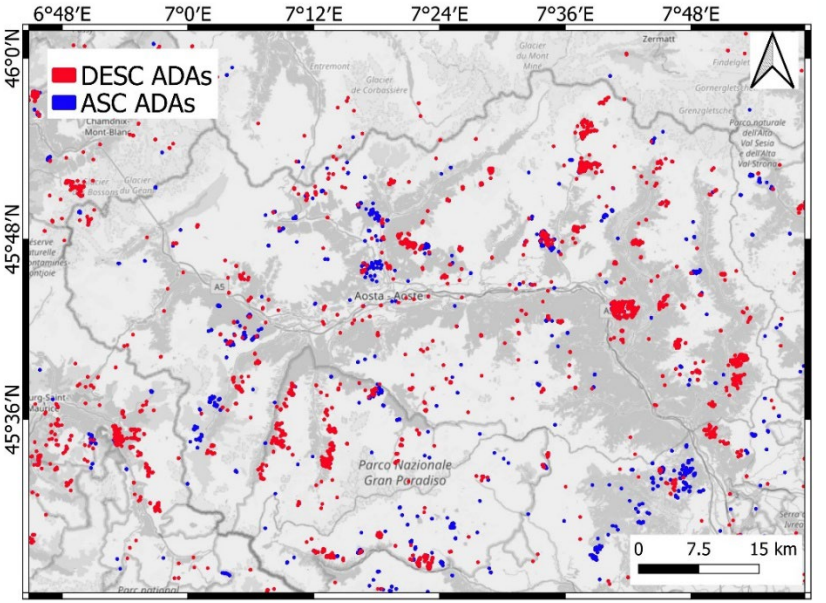
Case study – Valle d'Aosta (2)



Background: topographic map (OpenTopo)

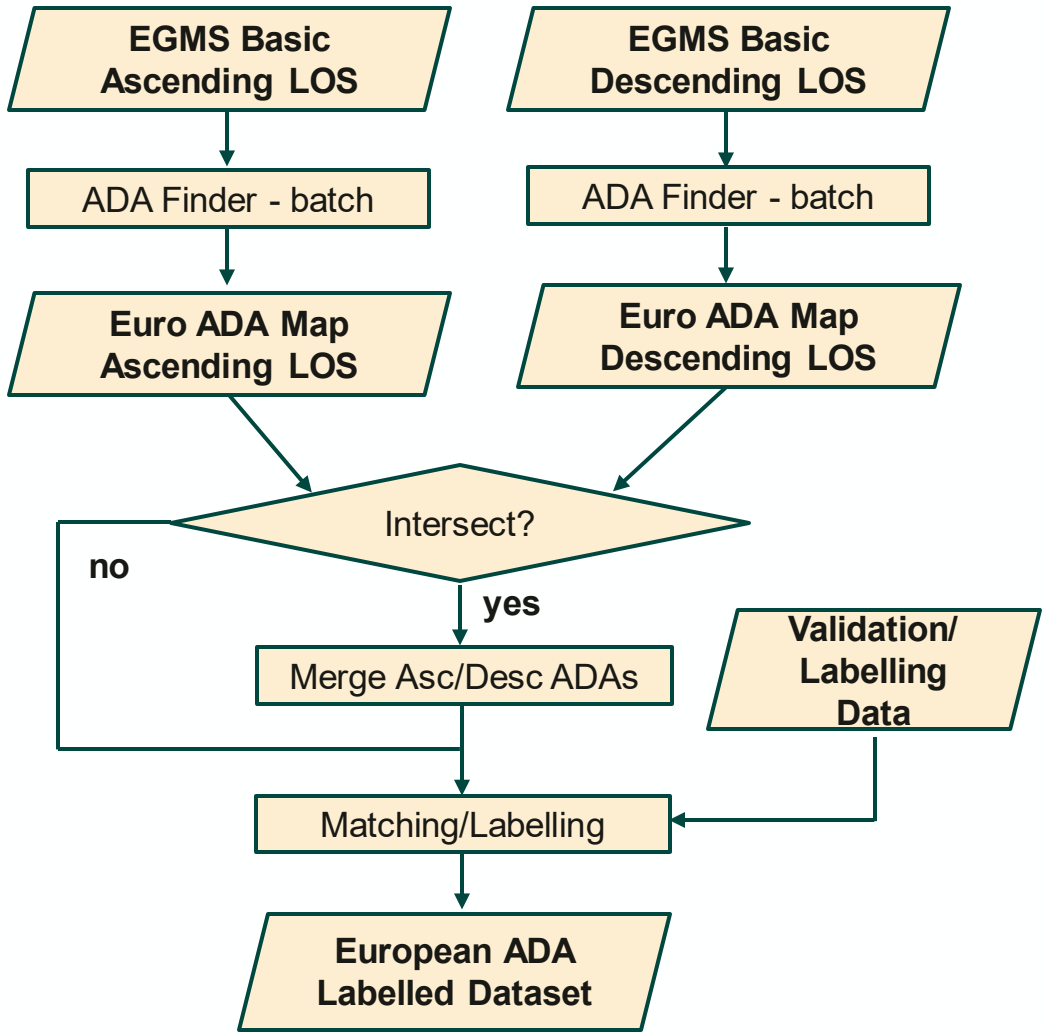
Validation





Ground motion class	Nr matching ADA polygons
DSGSD	675 (52.4%)
Landslide	132 (10.2%)
Landslide & DSGSD	166 (12.9%)
No match	313 (24.5%)
All classes	1286 (100%)

Training Dataset



ADA Labelled dataset over Valle d'Aosta (part of)

ADA_GLB_ID	INTERSECT	ADA_ASC_ID	ID_FILE_ASC	ADA_DSC_ID	ID_FILE_DSC	ADA_CLASS
20	1	101815	088_0269_IW2	76707	066_0804_IW3	noclass
21	1	101834	088_0269_IW2	170559	139_0803_IW1	DSGSD
22	1	101835	088_0269_IW2	76764	066_0804_IW3	DSGSD & Landslide
23	1	101838	088_0269_IW2	76787	066_0804_IW3	DSGSD
24	1	101843	088_0269_IW2	170596	139_0803_IW1	DSGSD
541	0	102063	088_0270_IW2	0	0	DSGSD
542	0	102064	088_0270_IW2	0	0	Landslide
543	0	102065	088_0270_IW2	0	0	Landslide

- Each global ADA is associated to a polygon and to spatio-temporal statistics extracted from the EGMS data;
- This method will be extended to other areas, affected by diverse ground motion phenomena (such as subsidence due to underground mining activity or ground-water extraction, settlement, …)

Conclusion

- An European map of active ground deformation areas obtained from the EGMS Data has been presented;
- Such map can be used for several applications: e.g. geological studies, or early identification of hazard exposure for infrastructure and buildings;
- Future work: use of AI tools to classify the ADAs included within the obtained map;
- Validation/labelling of the deformation areas using different types of ancillary data and developing classification performance indexes to support users' decisions;
- **Engaging with interested users to establish cooperation.**

THANK YOU FOR YOUR ATTENTION

Contact Information

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