Investigating land subsidence drivers and socio-economic exposure to differential land subsidence in the Emilia-Romagna Region, Italy

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Enhancing our understanding of Subsidence RISK induced by groundwater exploitation towards sustainable urban development [2023-2026]

Italian Ministry of University and Research (MUR)'s "**PRIN 2022 PNRR" Call** to fund Research Projects of Significant National Interest (PRIN) in the framework of the National Recovery and Resilience Plan (PNRR)

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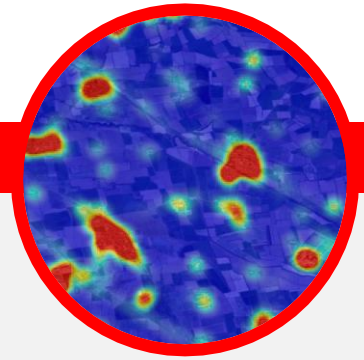
Research Objective

Discern ground deformation time series trends



Identify hot spots of subsidence

Understand the potential direct impacts of the land subsidence

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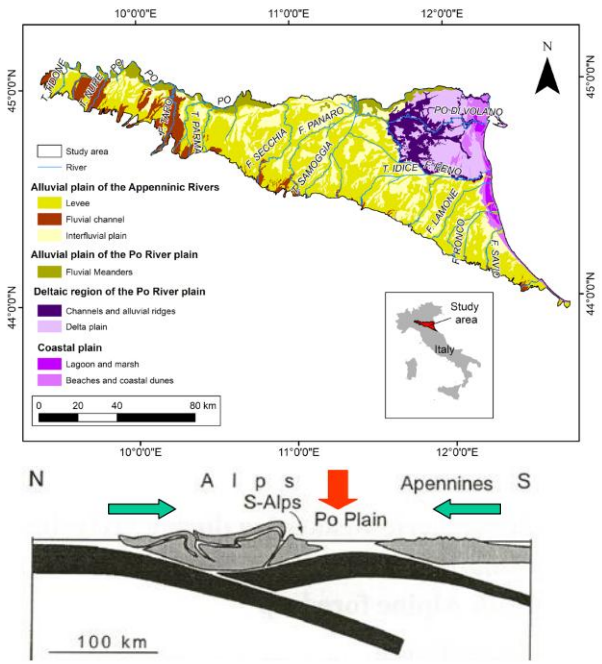
Study area



4.482.977 inhabitants
30% of Italian population

120.000 SMEs
40% of Italy's total productive activities

SMALL BUSINESS

MEDIUM BUSINESS

https://earthobservatory.nasa.gov/features/NightLights

Legislative measures adopted (Italian Law 10 December 1980, n. 845) to control subsidence

Area: 22,123 km²
The 6th largest Italian region by area

Economic losses ≅ 13.2 billion euros

Collapse in Concordia sulla Secchia (Modena) after the earthquake of May 20, 2012 (DPC)

2023 Emilia-Romagna flood (DPC)

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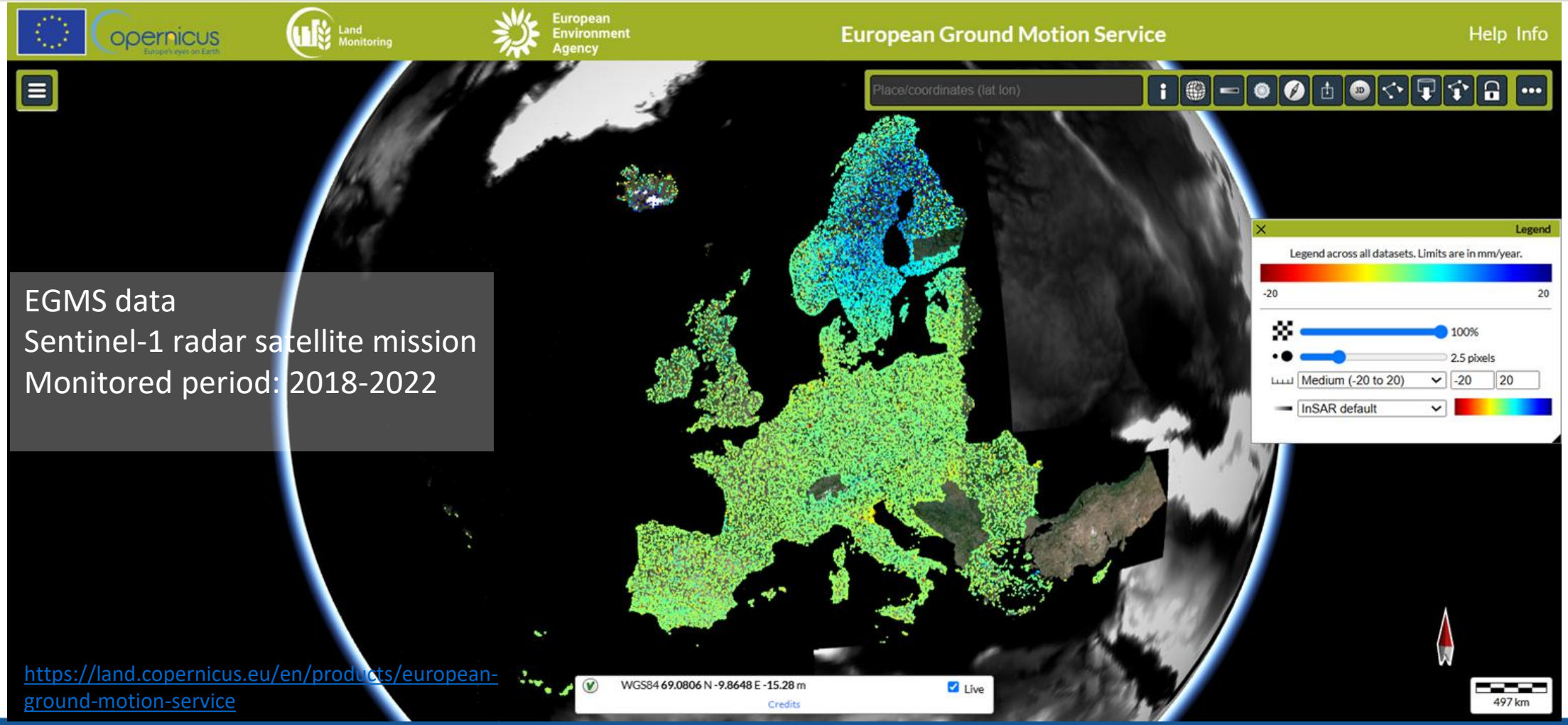
Data for hazard analysis



EGMS data
Sentinel-1 radar satellite mission
Monitored period: 2018-2022

https://land.copernicus.eu/en/products/european-ground-motion-service

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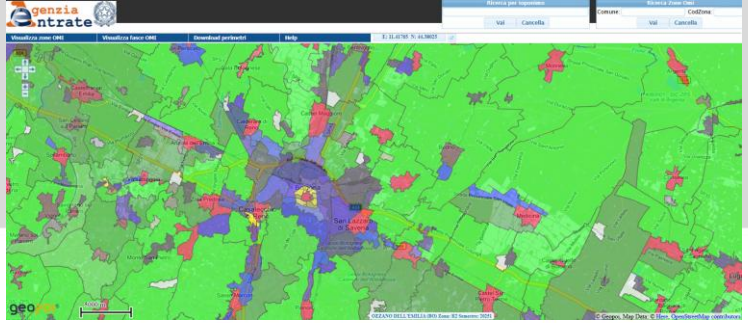
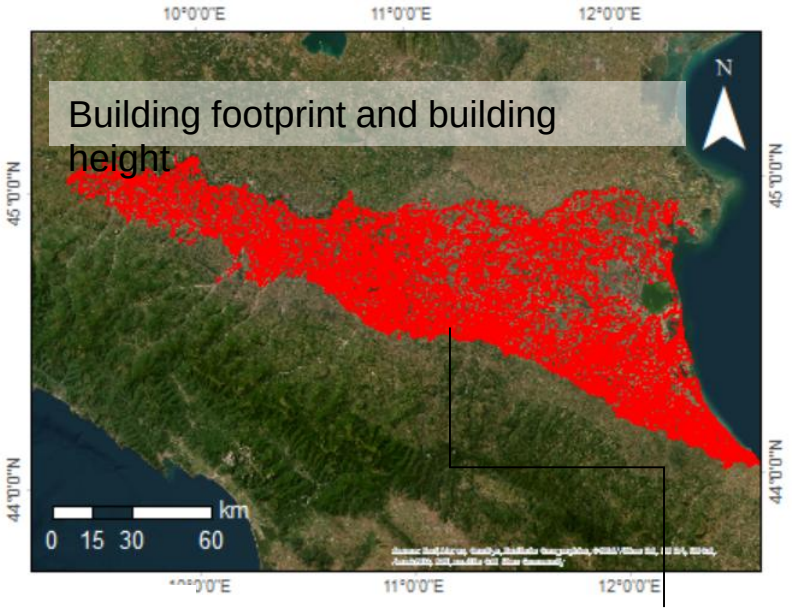
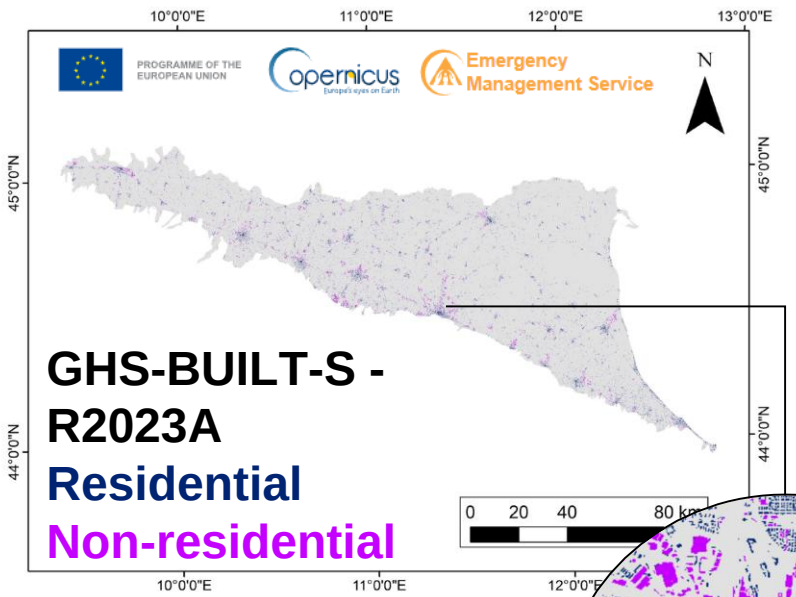
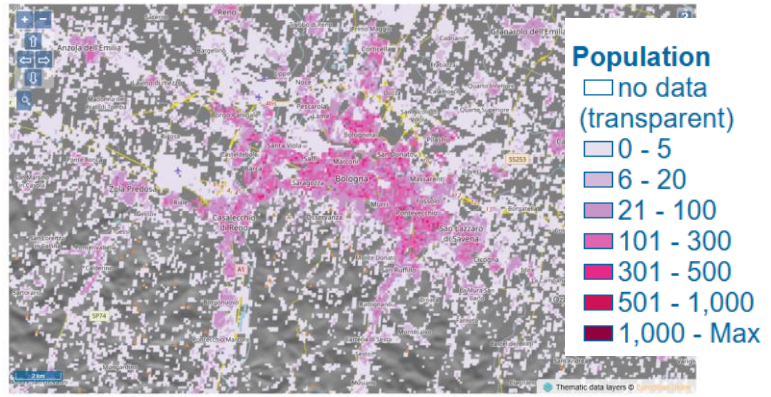
Data for exposure-vulnerability analysis

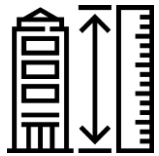




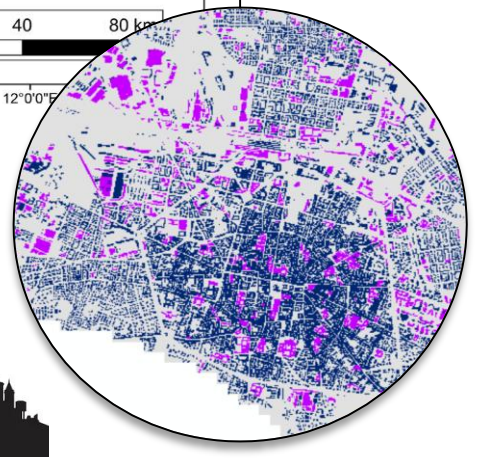




RegioneEmilia-Romagna



Bologna



GHS-POP

Resident population grid (inhabitants)

Epochs: 1975-2030;
Resolutions: 100m; 1km; 3 arcsec; 30 arcsec;
Coordinate systems: Mollweide; WGS84;

The spatial raster dataset depicts the distribution of population, expressed as the number of people per cell

GHS population grid (R2023) in 2020 at the resolution of 100 m

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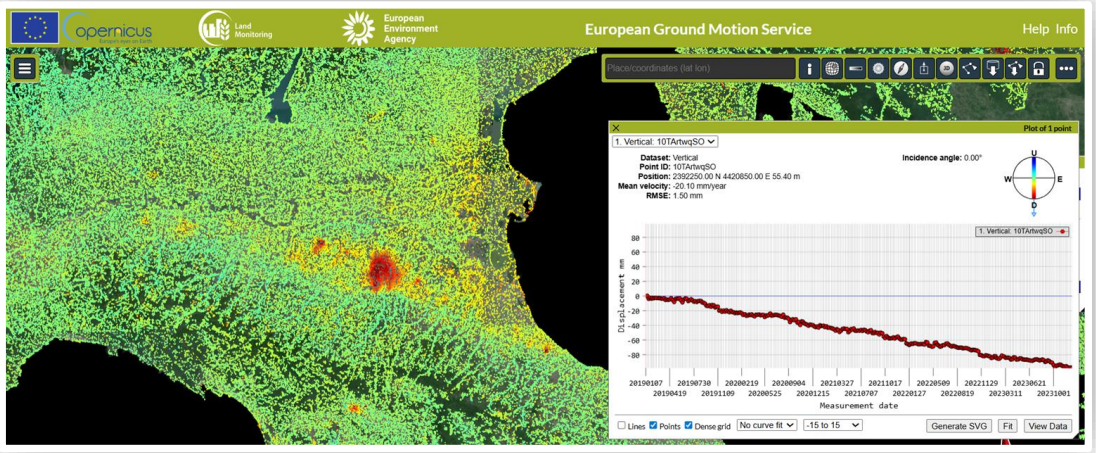
Methodology



InSAR-based
Ground displacement time series

PCA
Determine significant components

ICA
Extract Independent signals

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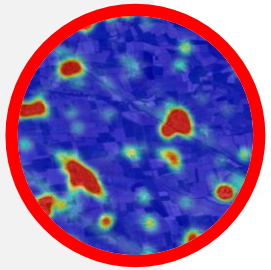
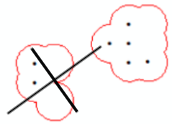


Land subsidence Hotspots identification

Spatial clustering of MP with similar temporal trends

Filter by N° measuring points

MP ≥5

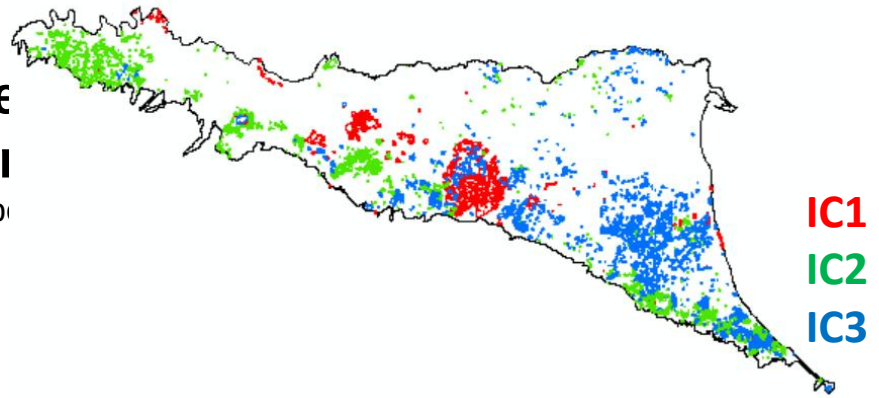


Filter by cluster size

Area ≥5000km^2

Final land subsidence Hotspots identificatio

Spatial clustering of MP with similar temp trends



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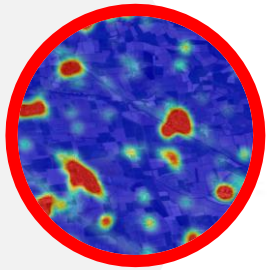

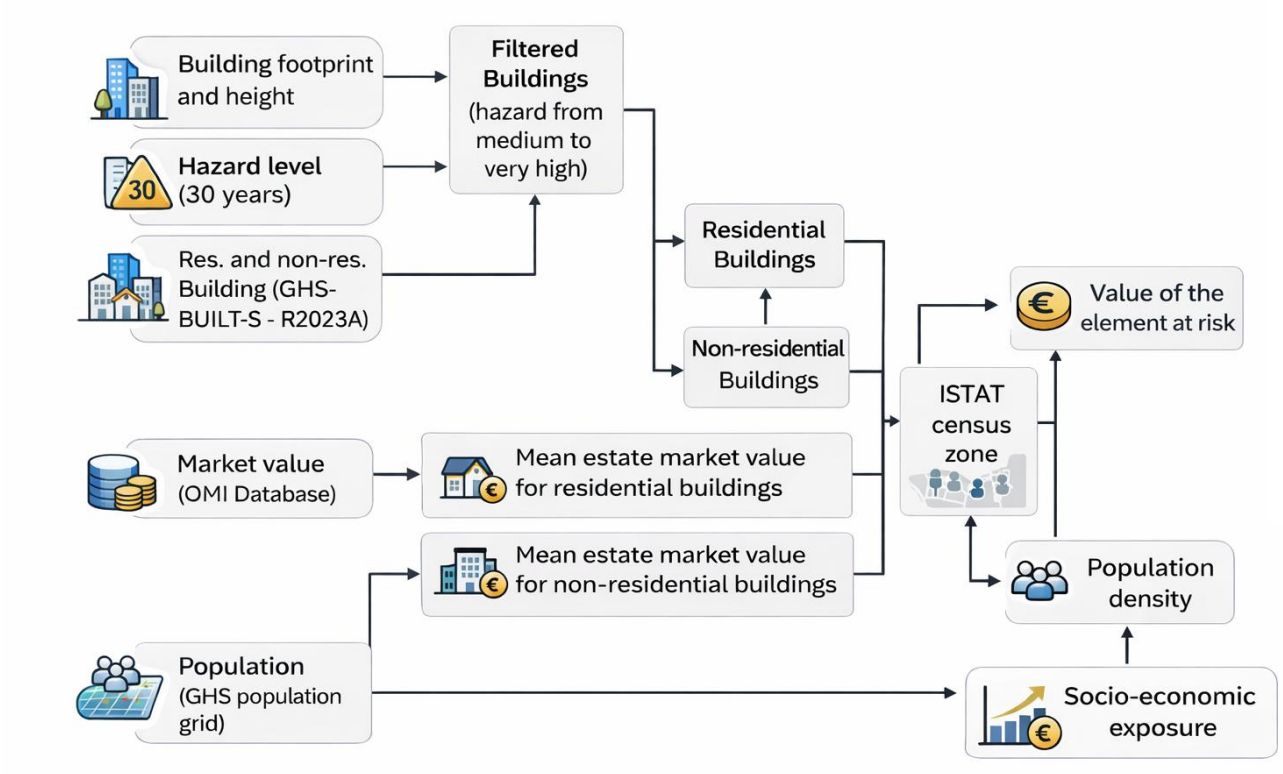

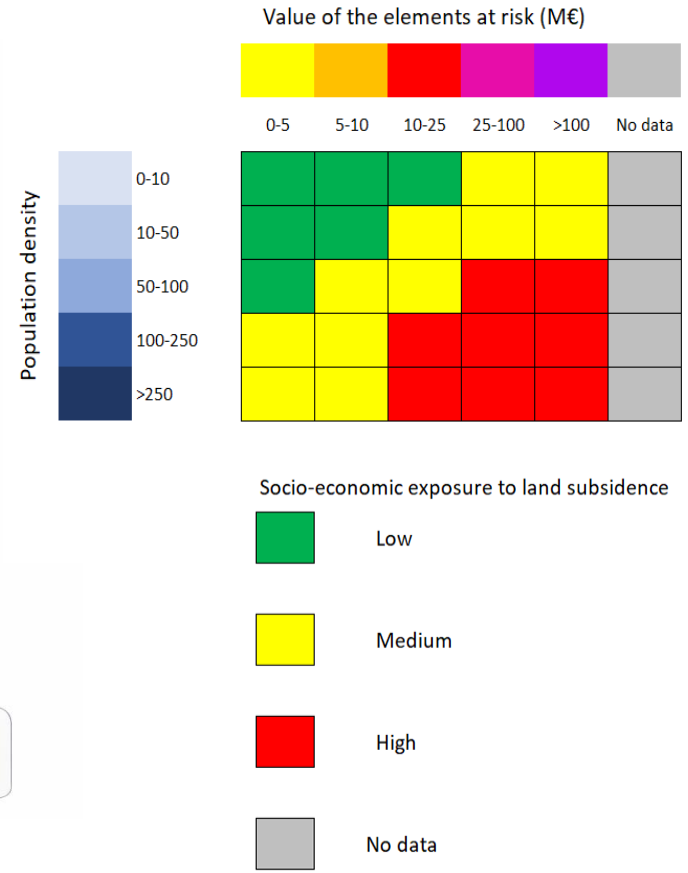

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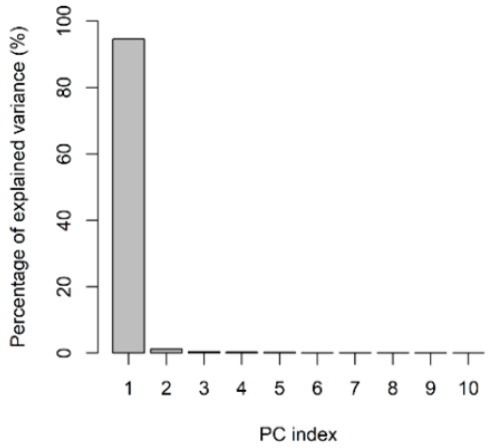
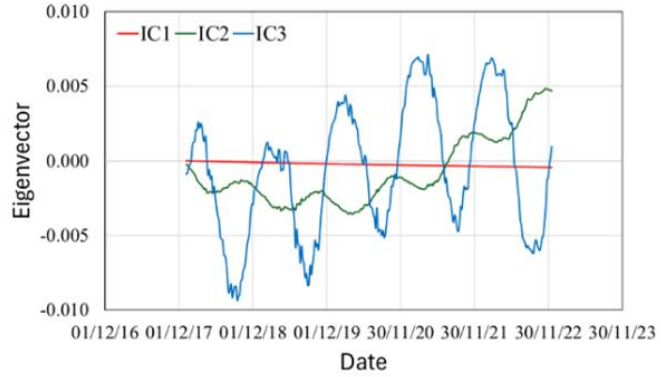
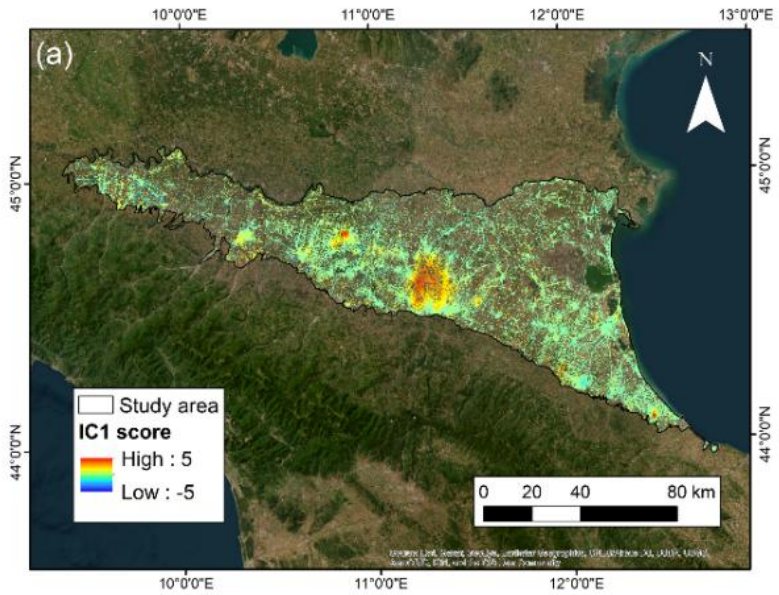
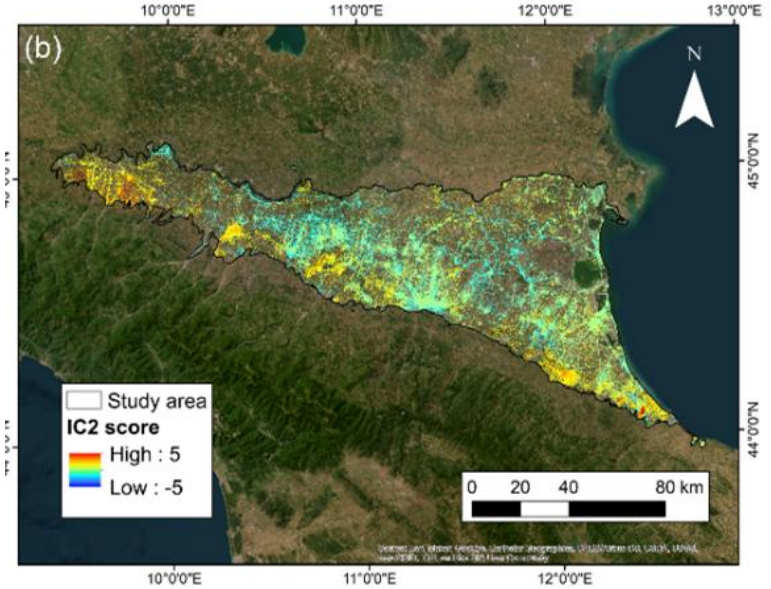
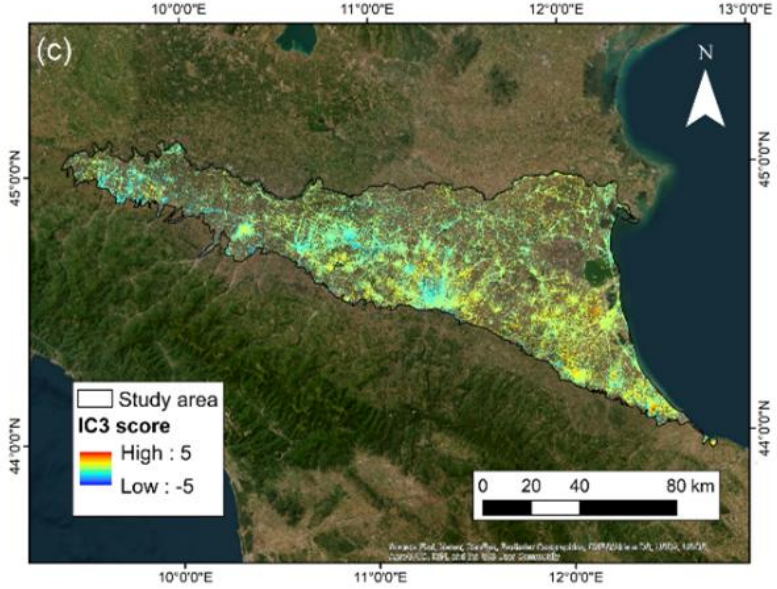
Results











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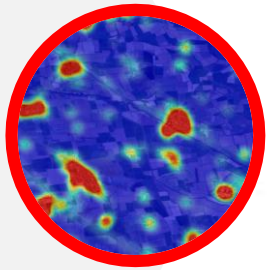

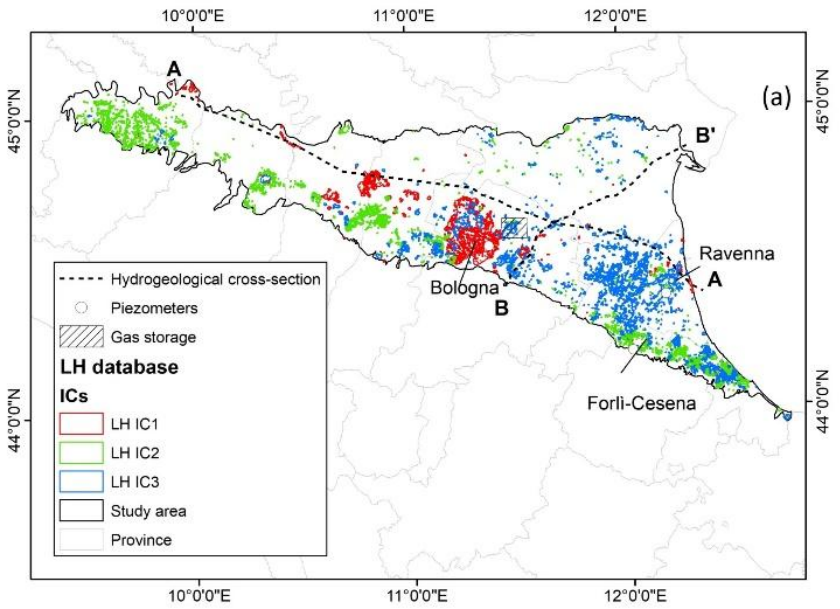

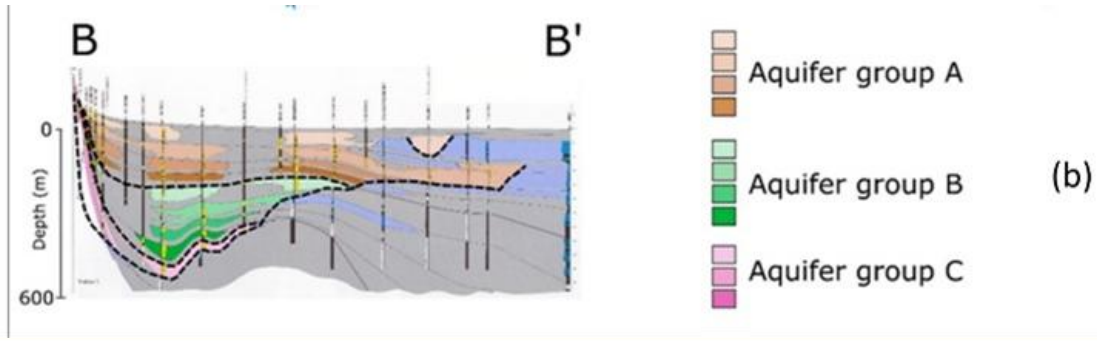

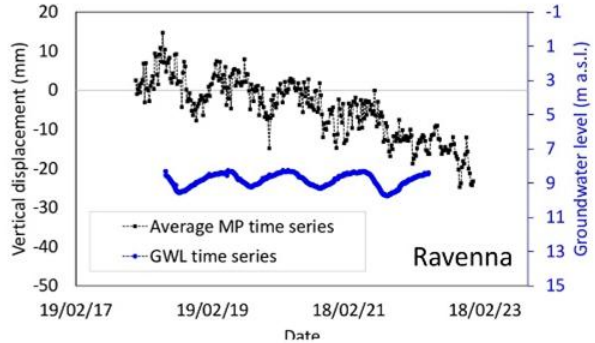

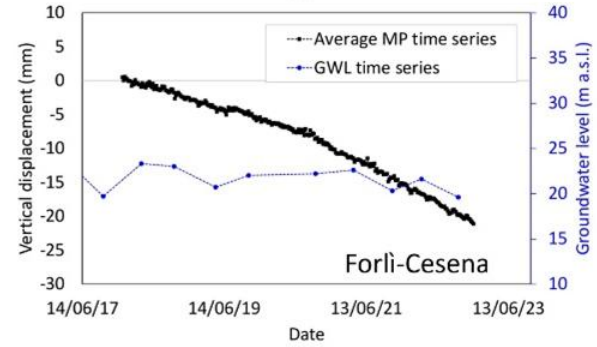

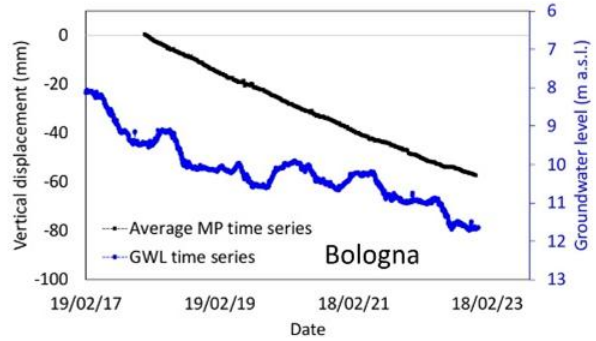

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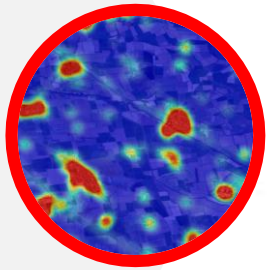
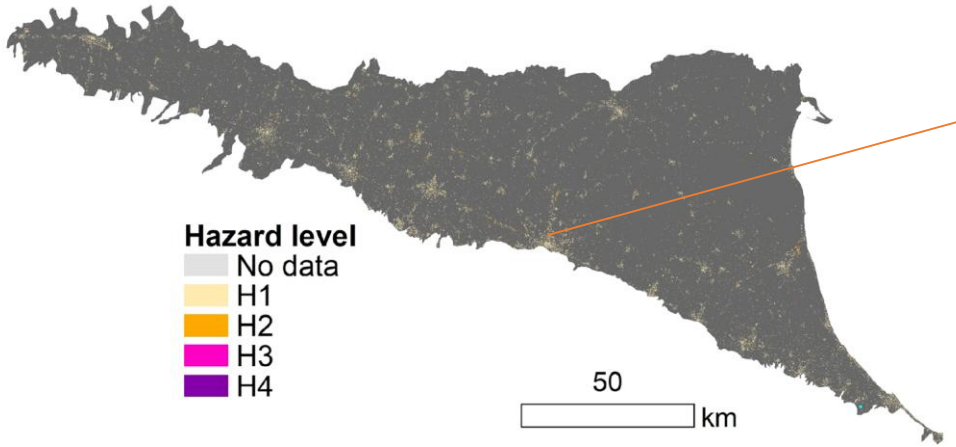
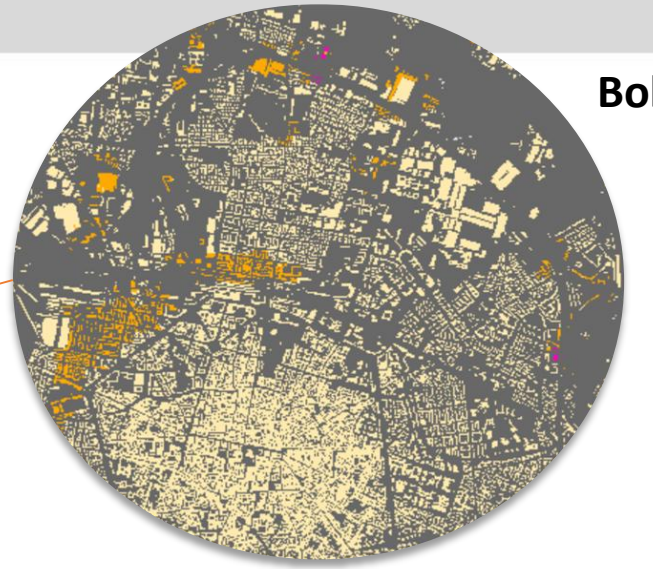


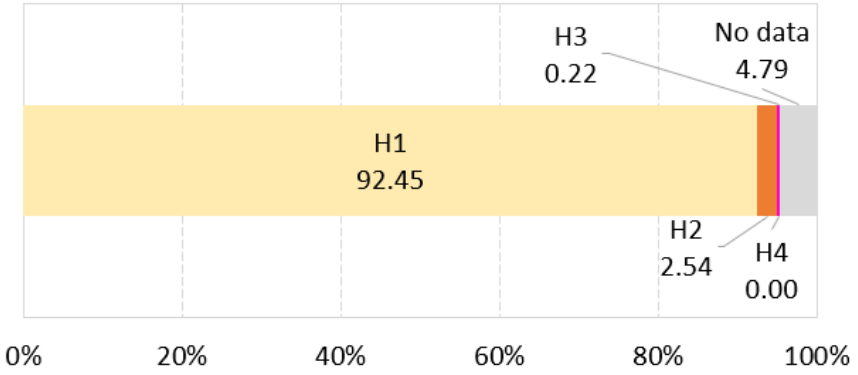




Bologna

Total: 1251715 buildings

49 buildings classified as H4



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Conclusions & future perspectives

- The **methodology** provides an **accessible perspective** on how **differential subsidence** could impact **urban regions**.
- Overall, the results highlight a pattern where inland provinces tend to have lower socio-economic exposure, while more urbanized or coastal areas, demonstrate a higher concentration of socio-economic assets.
- The developed tools serve as a valuable guide for preventing future damages and supporting informed urban planning decisions to enhance **urban resilience**.

Future development

- Future work will focus on evaluating the **indirect socio-economic impacts** of land subsidence (e.g., subsidence-induced flood risk).

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Regione Emilia-Romagna

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SubRISK+ references

- Bonì *et al.* 2024. Assessing and mapping of land subsidence risk at different scales in major urban areas in Italy. *EGU General Assembly 2024*, 14-19 April 2024, Vienna, Austria & online, id. EGU24-10558, doi:10.5194/egusphere-egu24-10558
- BONÌ R., GOLIRAEISI L., SAPIO S., TARAMELLI A., CIGNA F., PARANUNZIO R. & TEATINI P. (2025). PRIN 2022 PNRR SubRISK+ Deliverable DEL 5.2: Report on the current impacts at national, regional and local scales, Version 1.0, Issue date: 31/05/2025, pp. 53. Public Report. Available at: https://www.subrisk.eu/deliverables

Thanks for the attention

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