

Innovative approach for landslide vulnerability assessment using InSAR data at the regional scale

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UNIVERSITÀ
DEGLI STUDI
FIRENZE

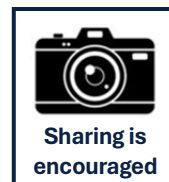
Da un secolo, oltre.

DST

DIPARTIMENTO DI
SCIENZE DELLA TERRA
ECCELLENZA 2023-2027



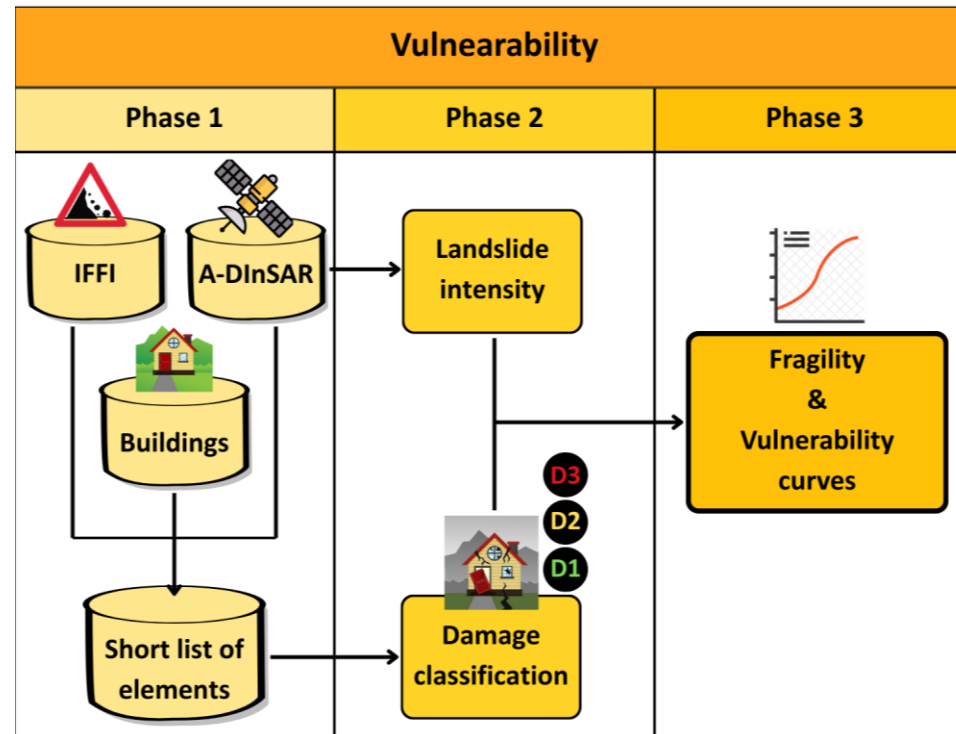
istituto per il rilevamento
elettromagnetico
dell'ambiente



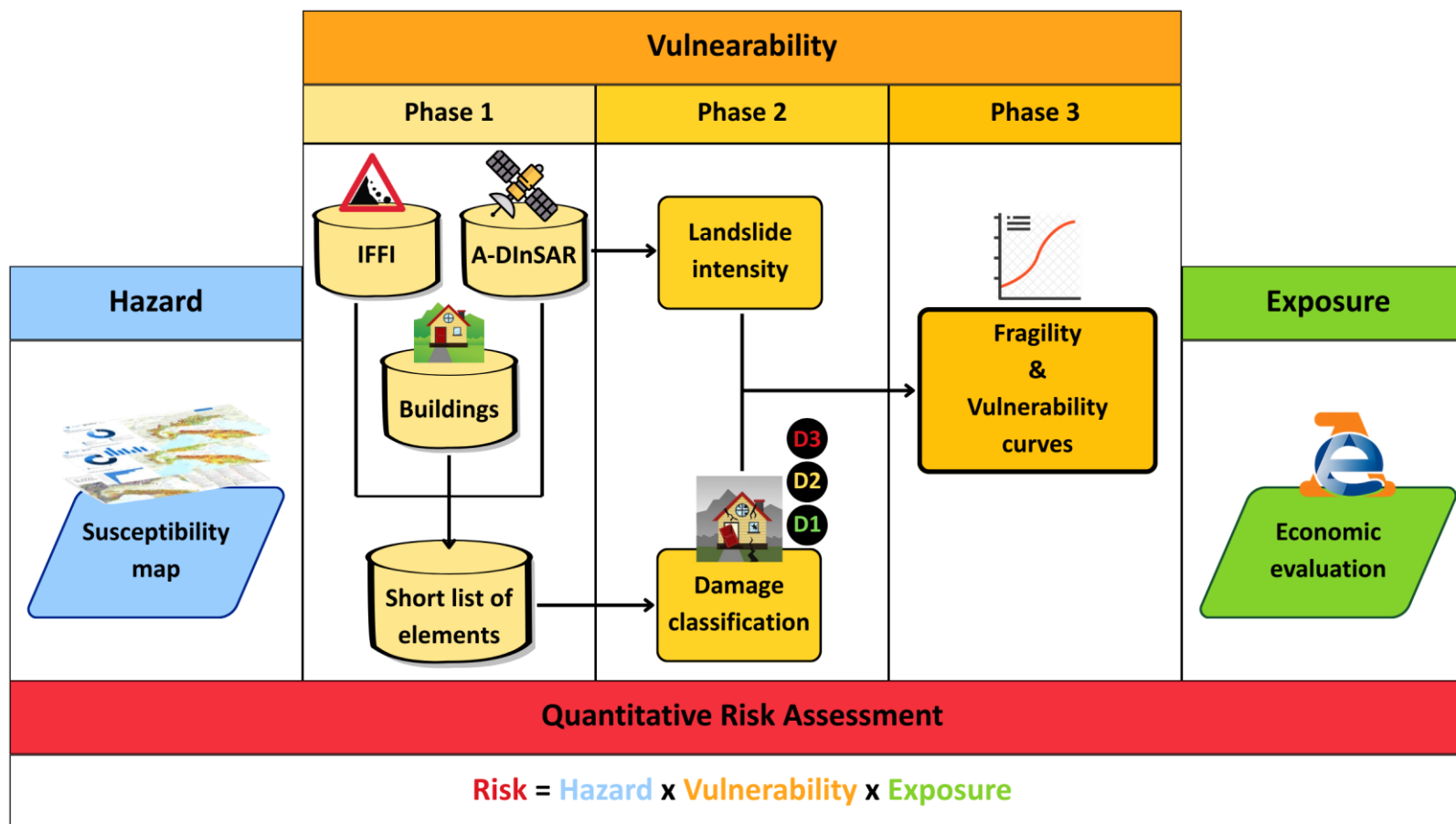
What does “Vulnerability” mean?

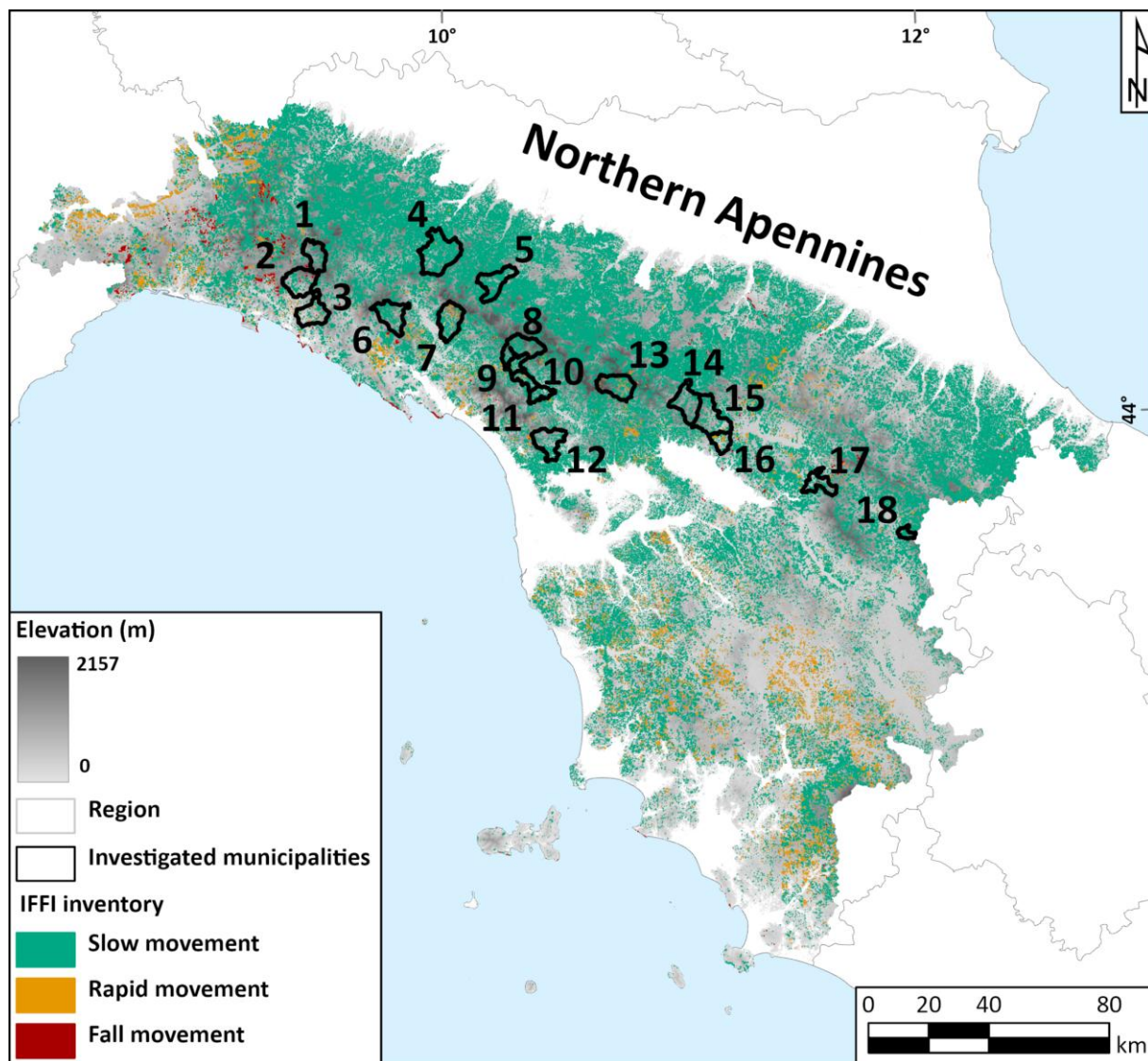
The potential loss of a specific element (or group of elements) exposed to the occurrence of an event (such as a landslide) of a given intensity (Fell 1994; Corominas et al. 2014)

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IFFI inventory

Slow movement	87.8 %
Rapid movement	8.4 %
Collapse	3.8 %

Cruden & Varnes, 1996

CLASSE DI VELOCITA'	DESCRIZIONE	VELOCITA' (mm/sec)	VELOCITA' TIPICA
7	Estremamente rapida	5×10^3	5 m / sec
6	Molto rapida	5×10^1	3 m / min
5	Rapida	5×10^{-1}	1.8 m / h
4	Moderata	5×10^{-3}	13 m / mese
3	Lenta	5×10^{-5}	1.6 m / anno
2	Molto Lenta	5×10^{-7}	16 mm/anno
1	Estremamente Lenta		

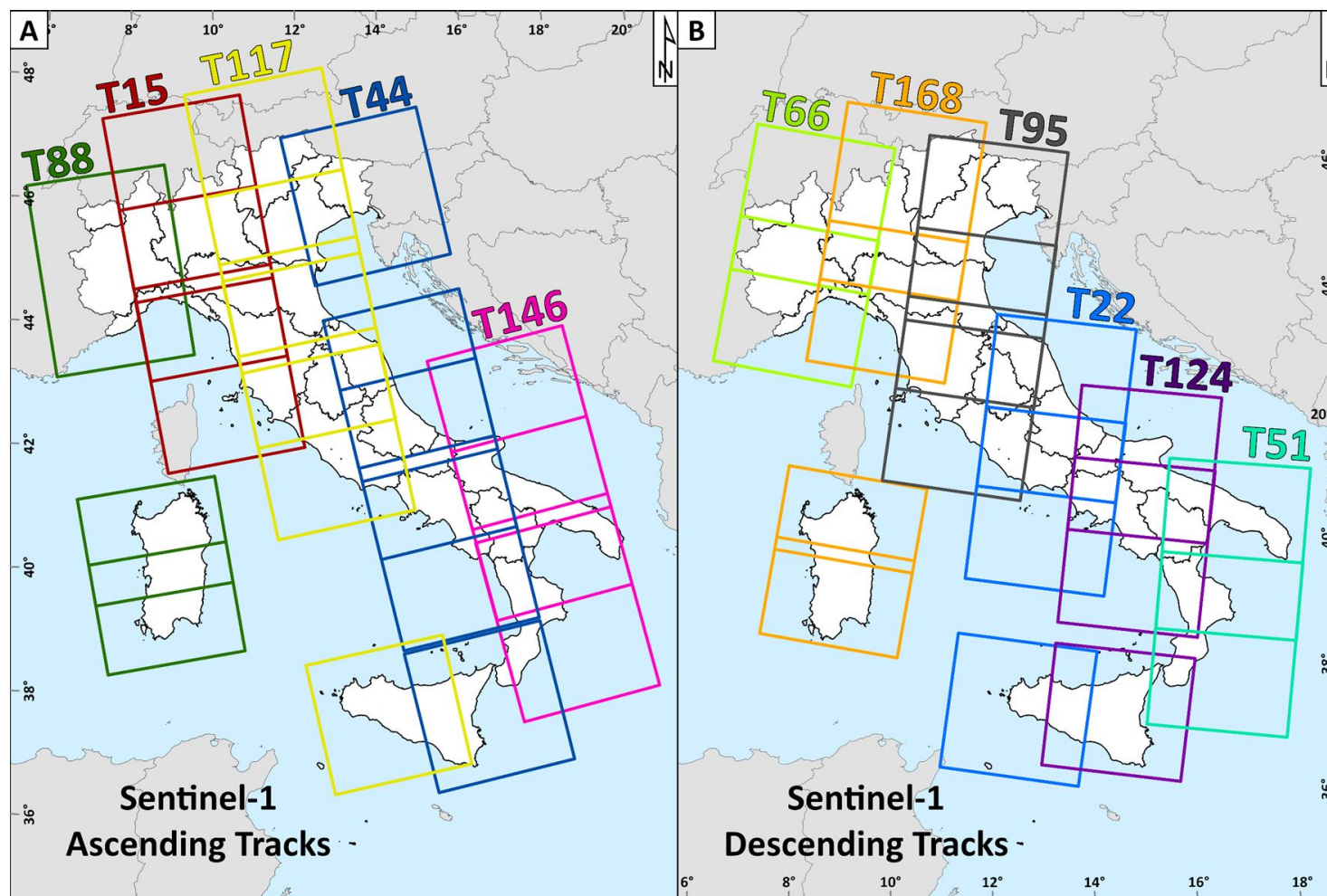
**Monitorable using
DInSAR techniques!**

A total of 18 municipalities are identified for surveys, and 4,306 buildings are investigated

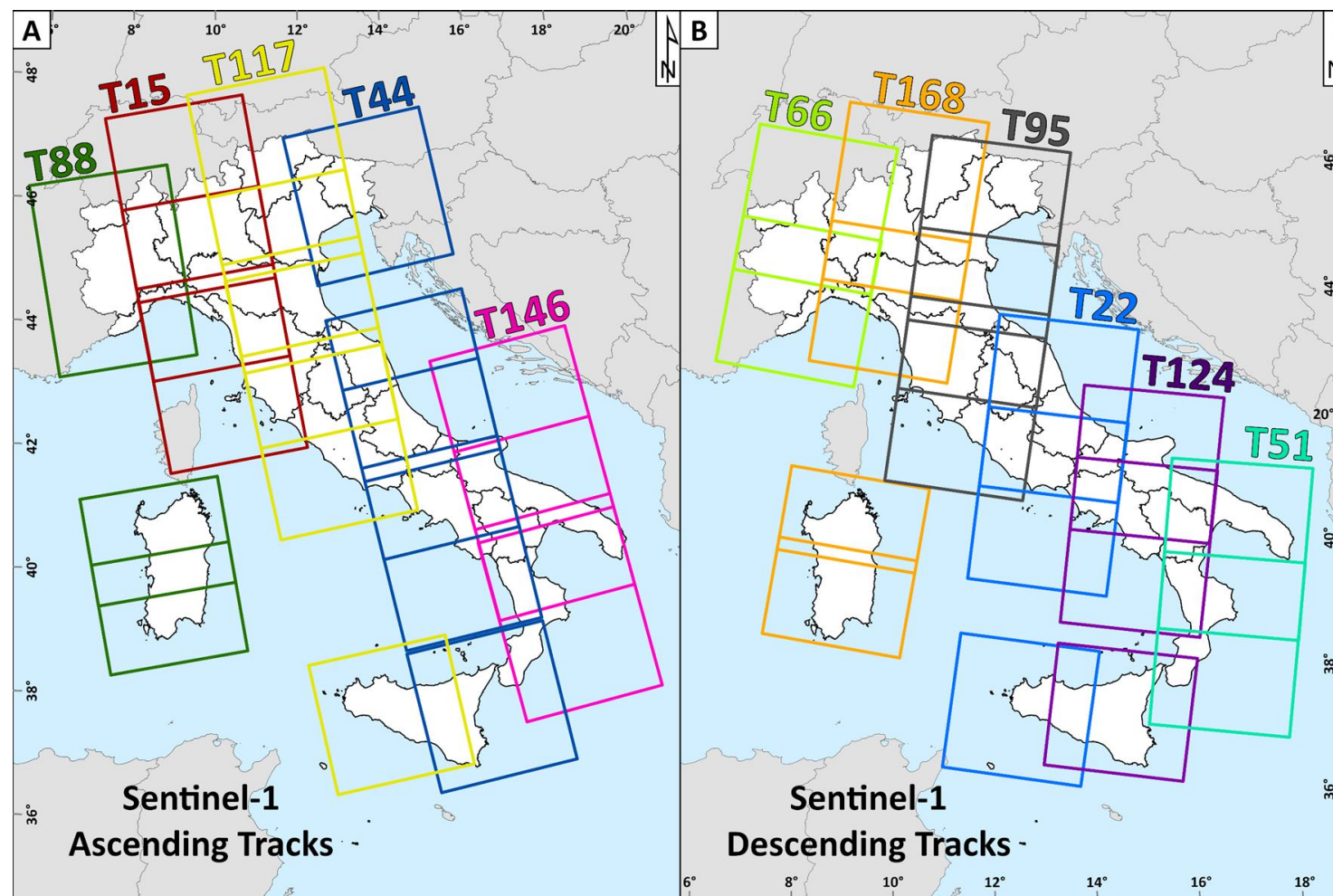
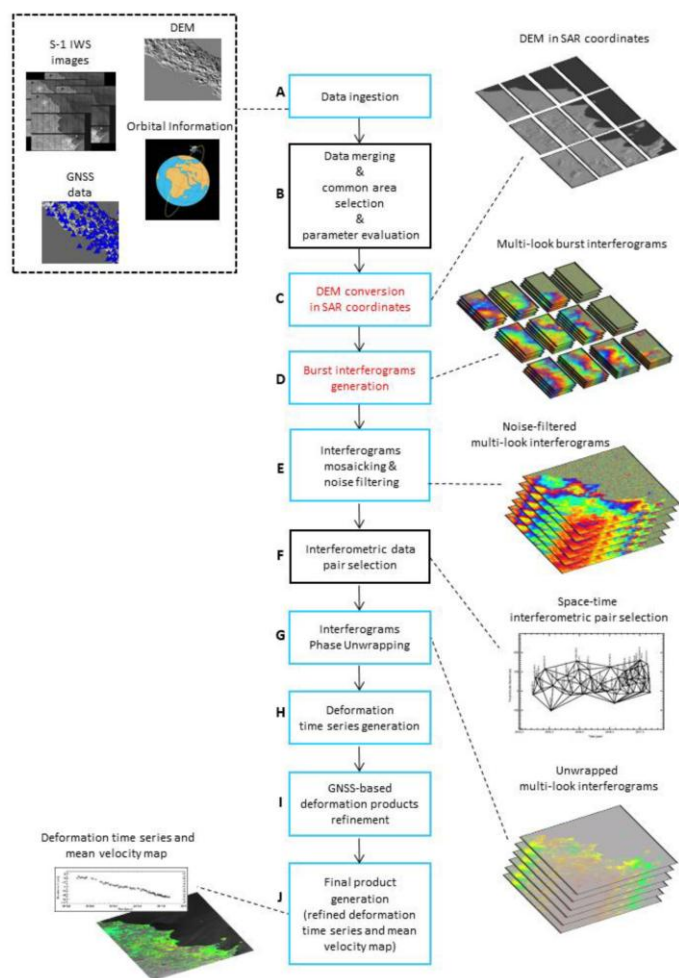
Investigated municipalities (number of buildings surveyed)

1 - Santo Stefano d'Aveto (177)	7 - Bagnone (77)	13 - Cutigliano (122)
2 - Borzonasca (173)	8 - Sillano (96)	14 - Sambuca Pistoiese (53)
3 - Ne (71)	9 - Piazza al Serchio (90)	15 - Cantagallo (101)
4 - Berceto (318)	10 - Camporgiano (410)	16 - Vaiano (169)
5 - Palanzano (64)	11 - Castelnuovo di Garfagnana (95)	17 - Rufina (63)
6 - Zeri (1668)	12 - Pescaglia (204)	18 - Chitignano (355)

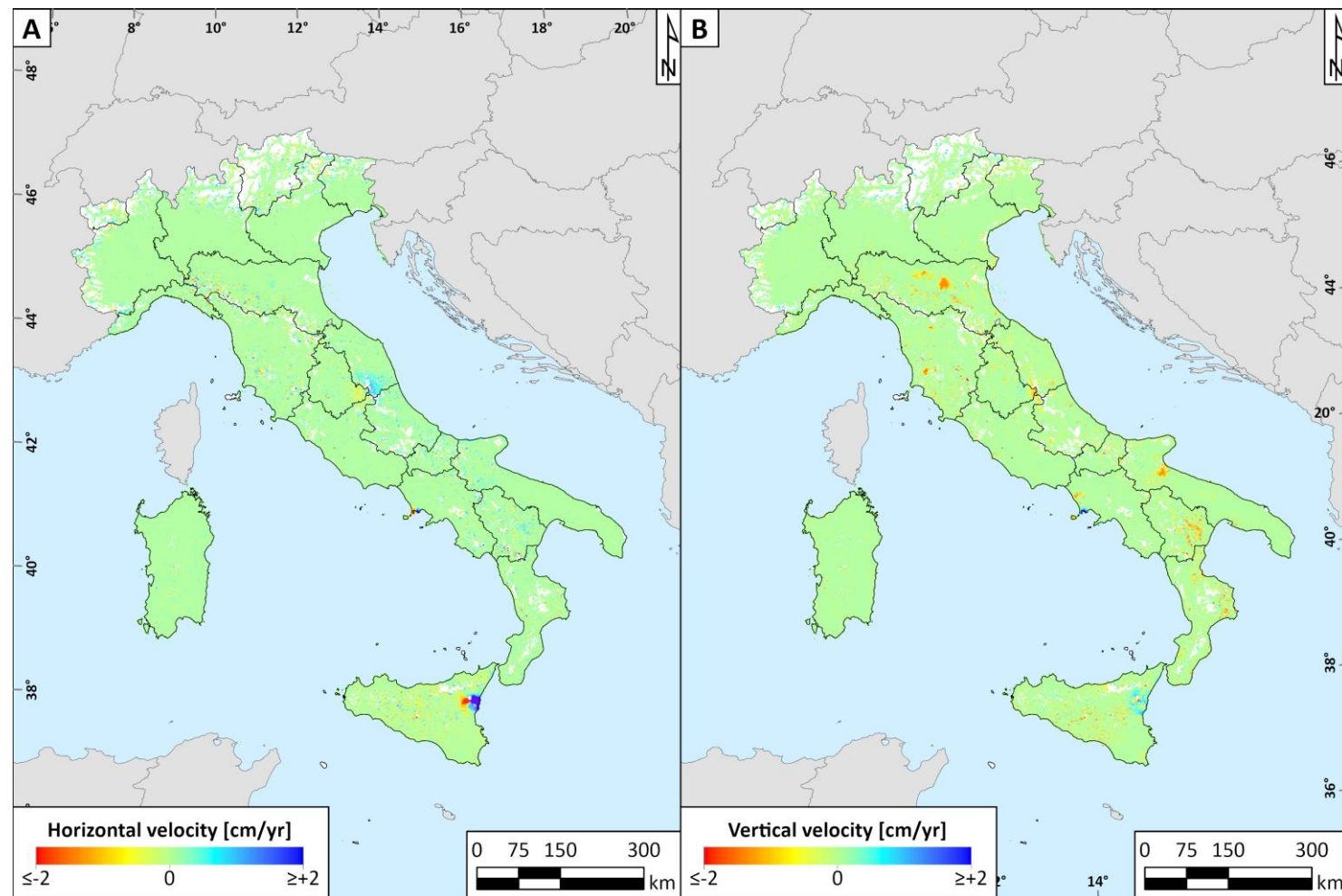
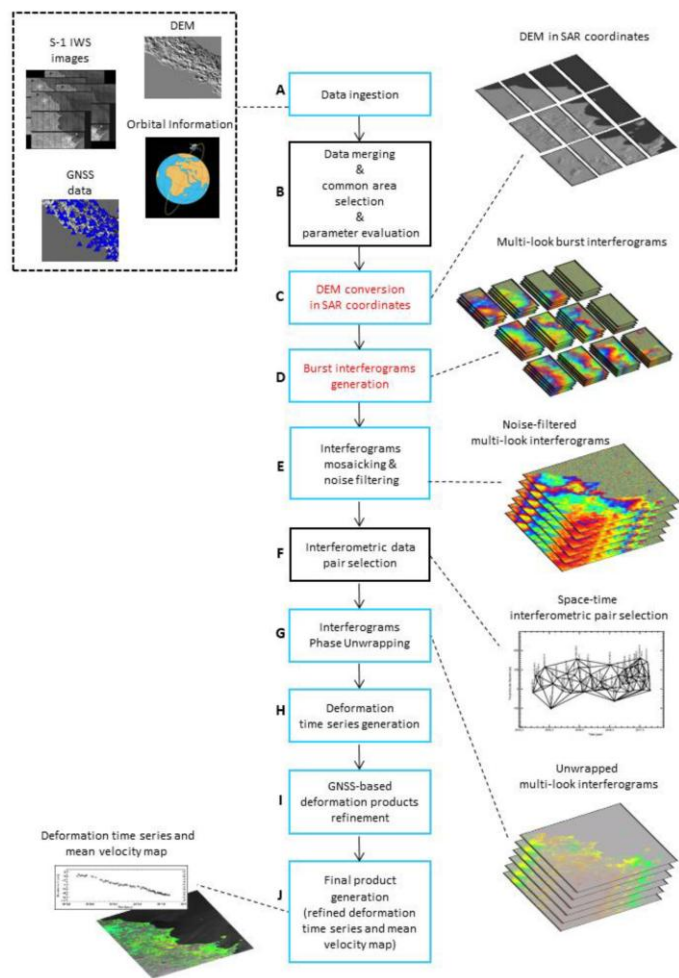
The Sentinel-1 tracks over the Italian territory

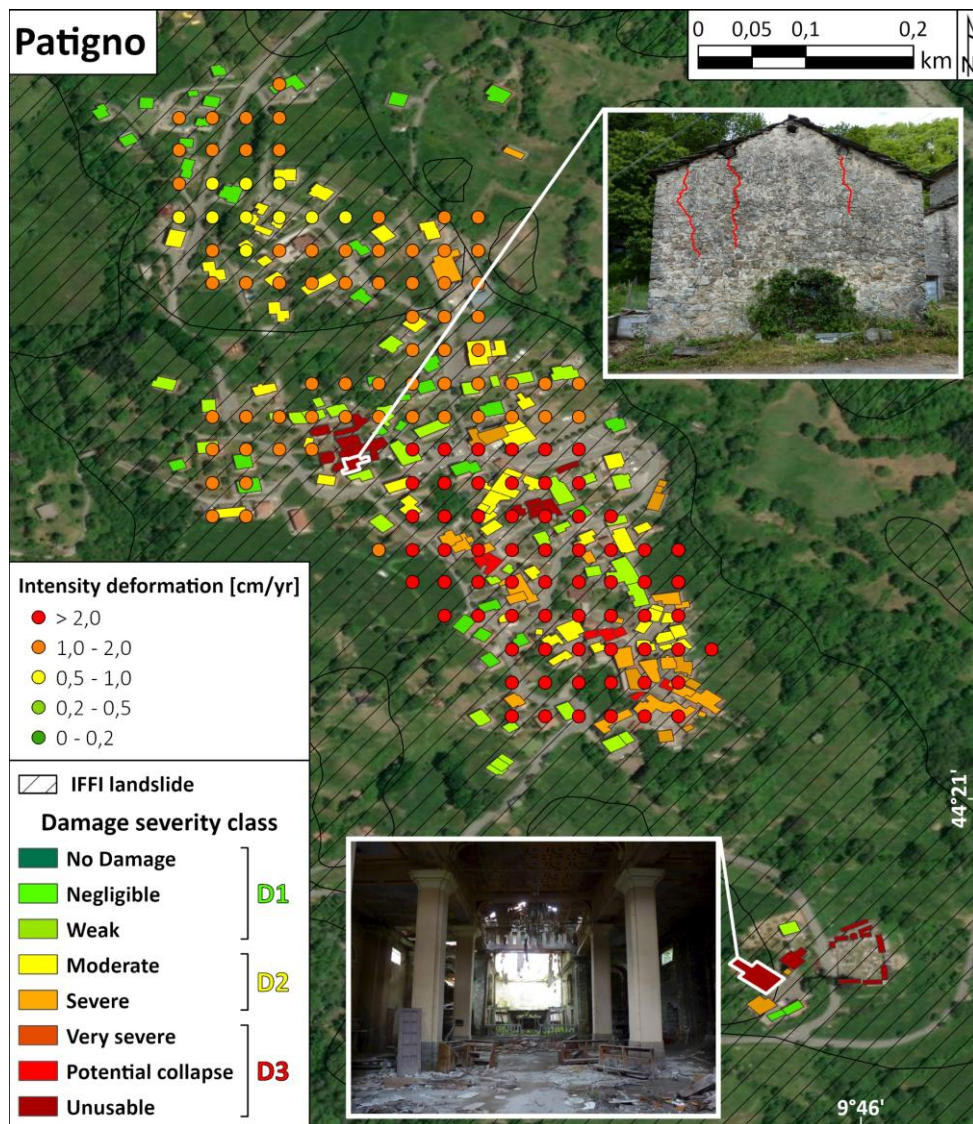


The P-SBAS algorithm developed by CNR-IREA



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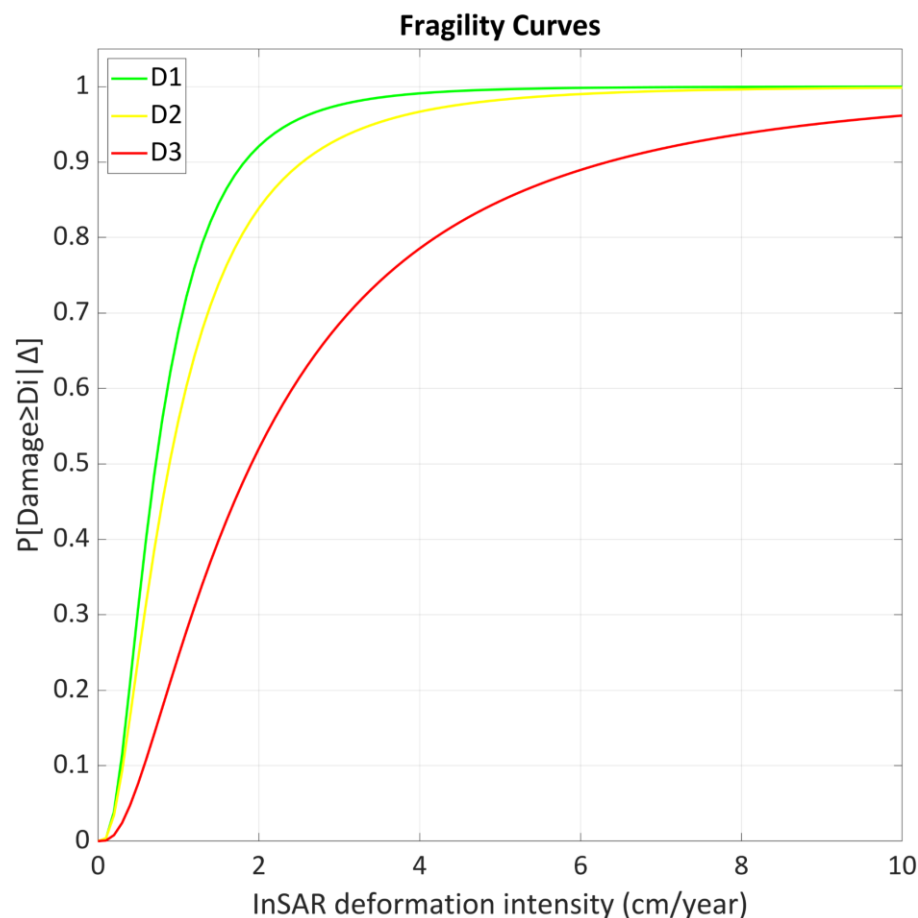
Intensity deformation from the DInSAR components:

$$V_r = \sqrt{V_{horizontal}^2 + V_{vertical}^2}$$

Damage severity class according to Del Soldato et al. 2017



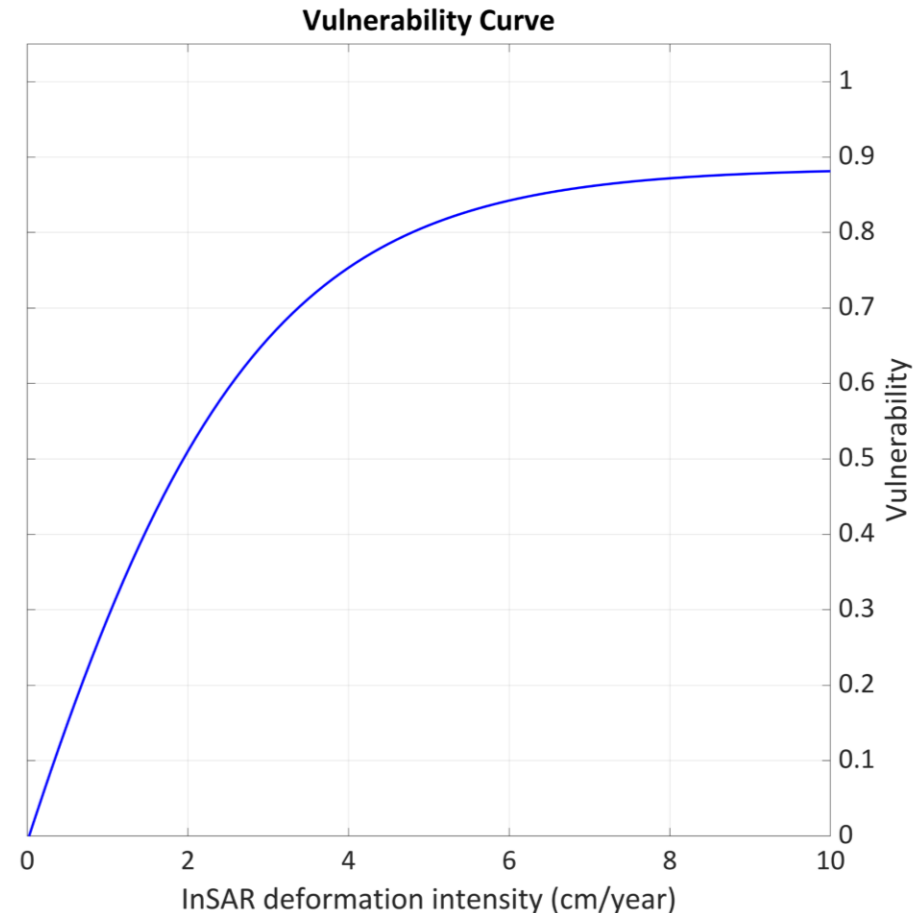
Generation of **fragility** and **vulnerability** curves for building affected by slow-kinematic landslide



Express the probability of
exceeding a given damage level
related to the intensity parameter

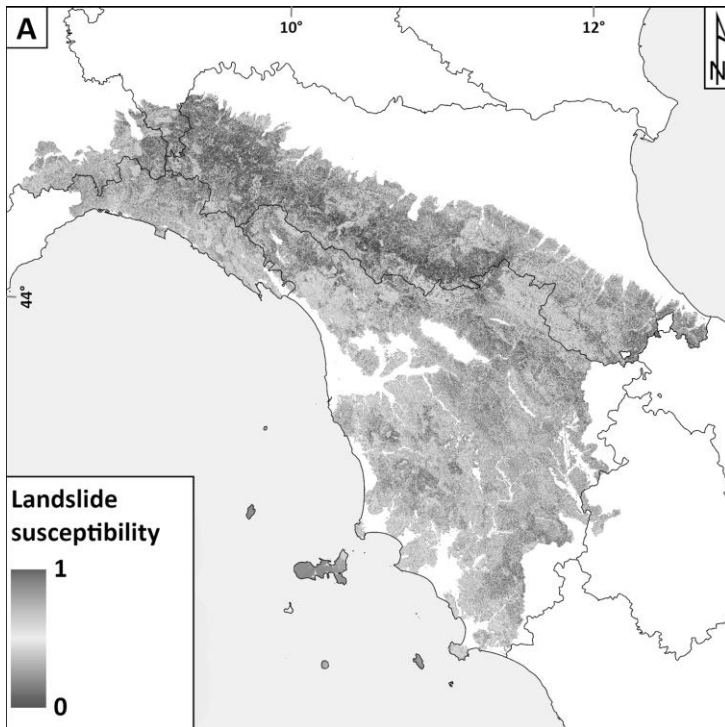
Generation of **fragility** and **vulnerability** curves for building affected by slow-kinematic landslide

Express the probabilistic relationship
between the intensity parameter
and the vulnerability value

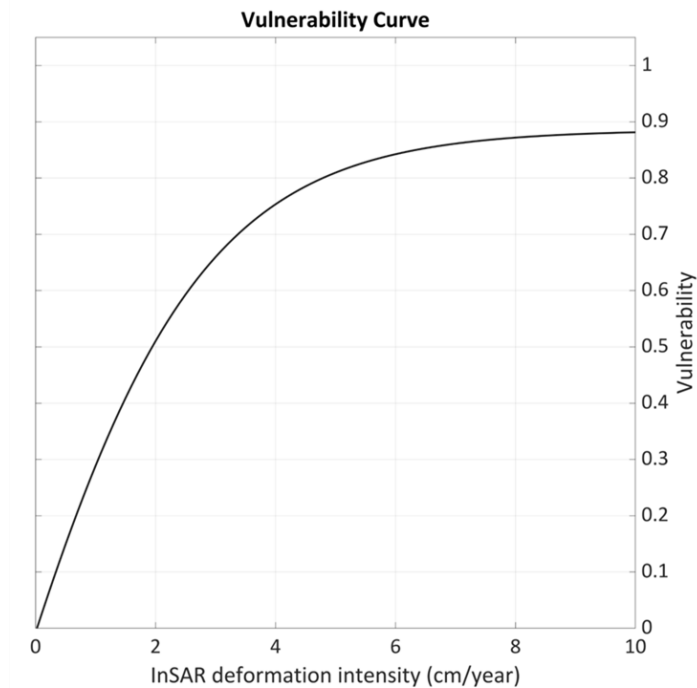


Quantitative Risk Assessment (QRA) procedure over the Northern Apennines

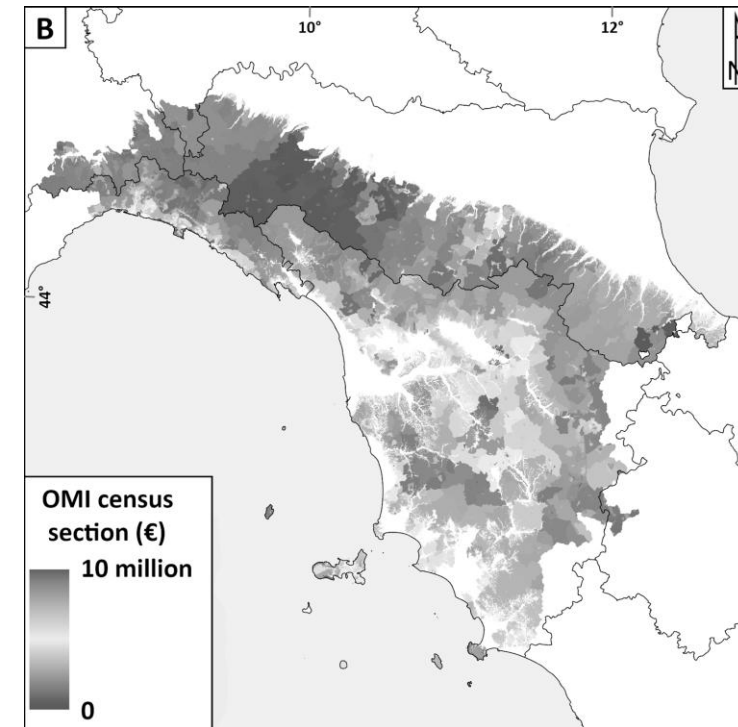
$$Risk = Hazard * Vulnerability * Exposure$$



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Introduction

Vulnerability procedure

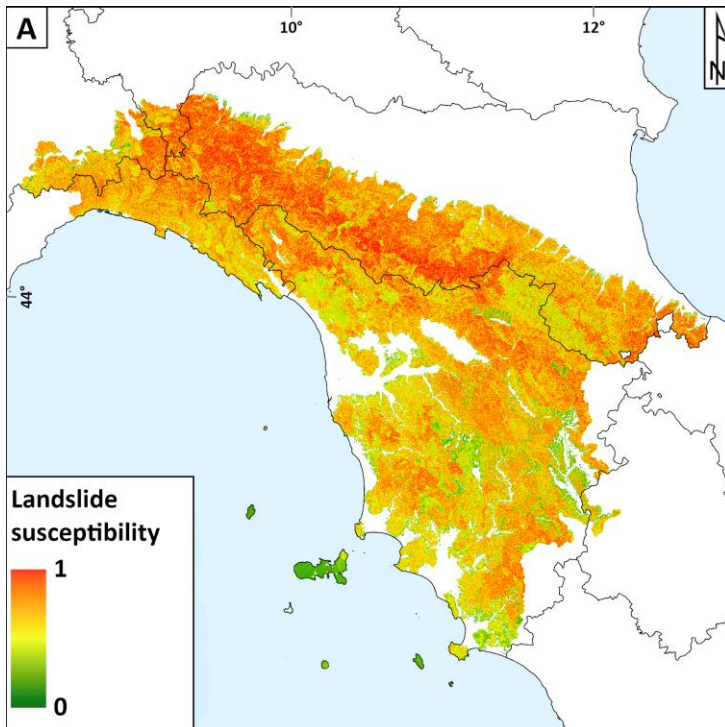
QRA application

Conclusion

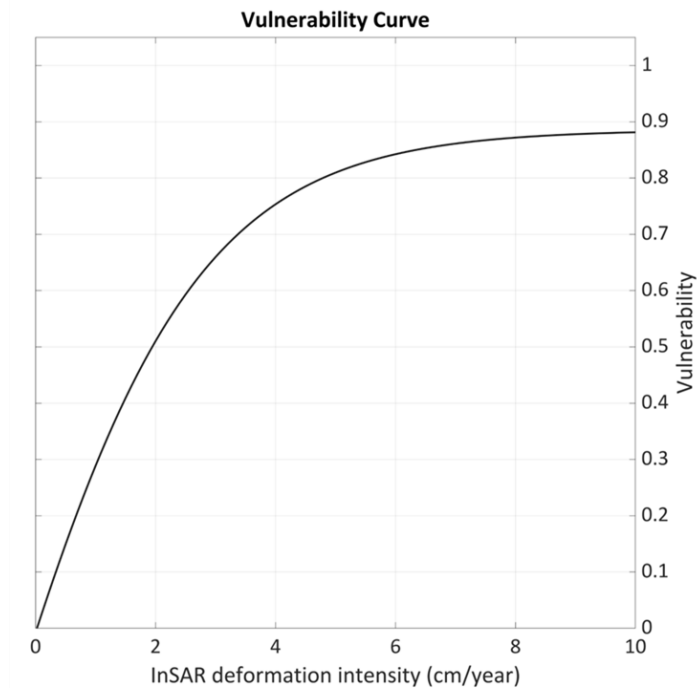
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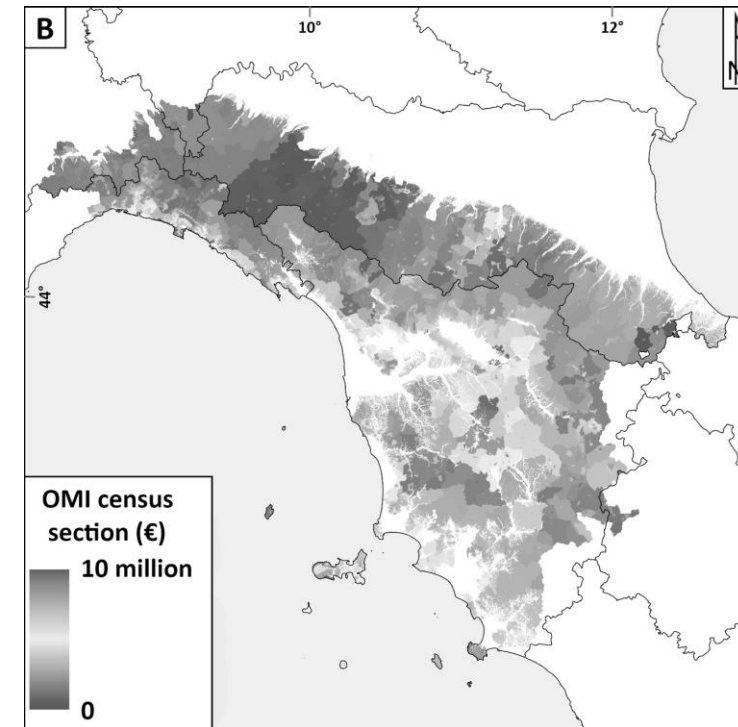
Landslide susceptibility



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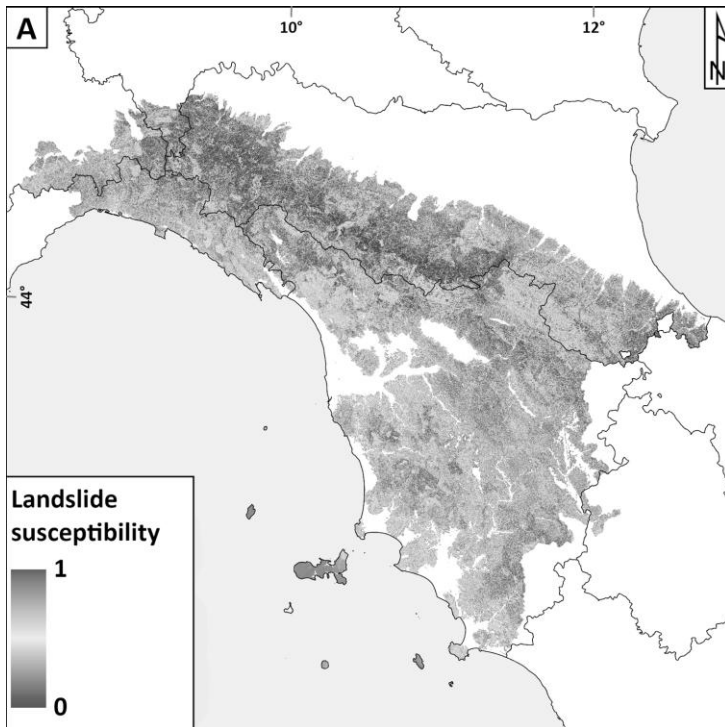
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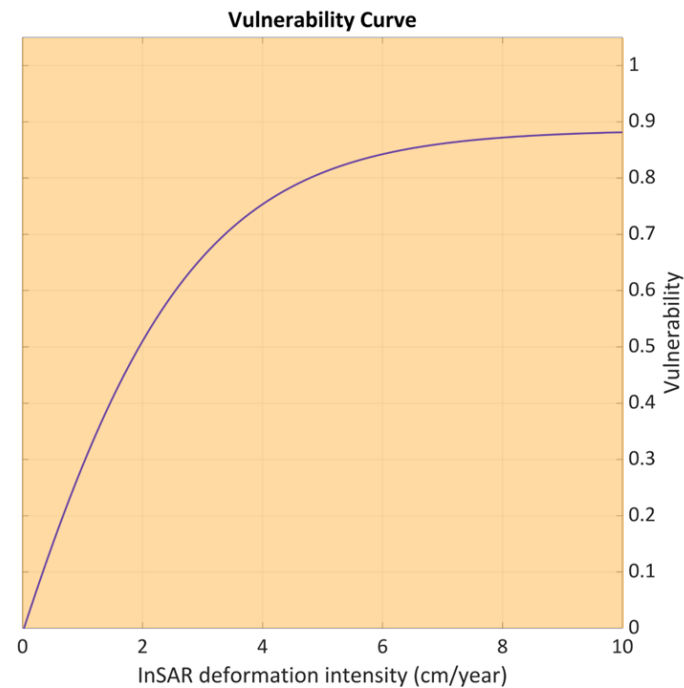
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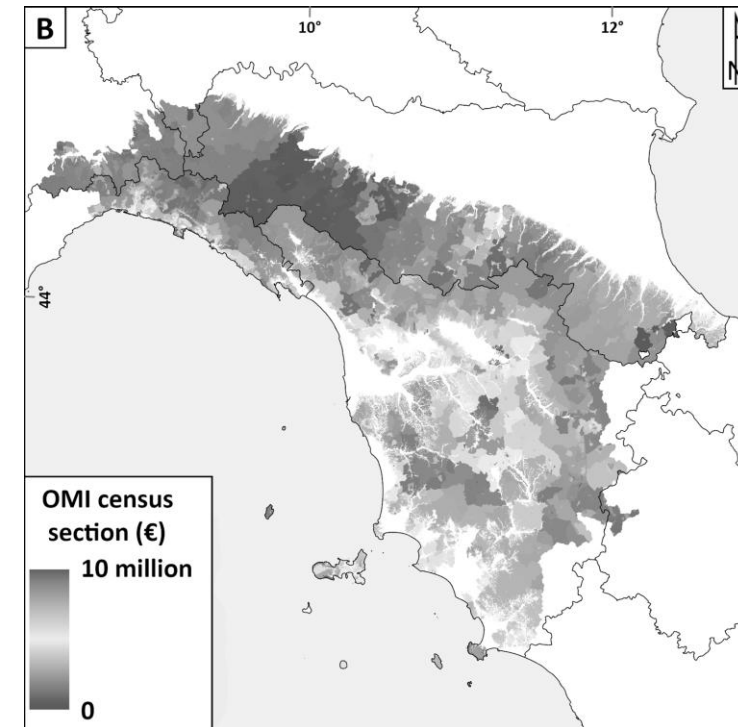
Vulnerability curve



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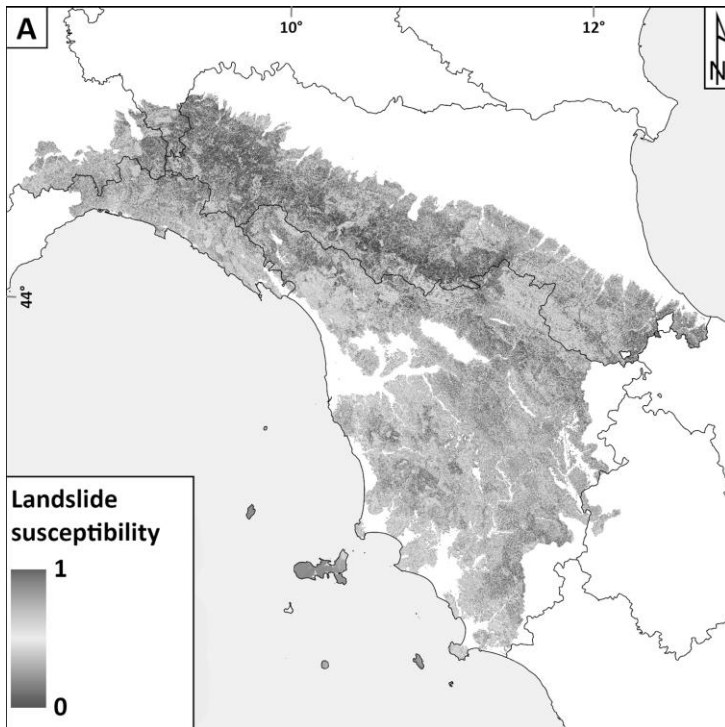
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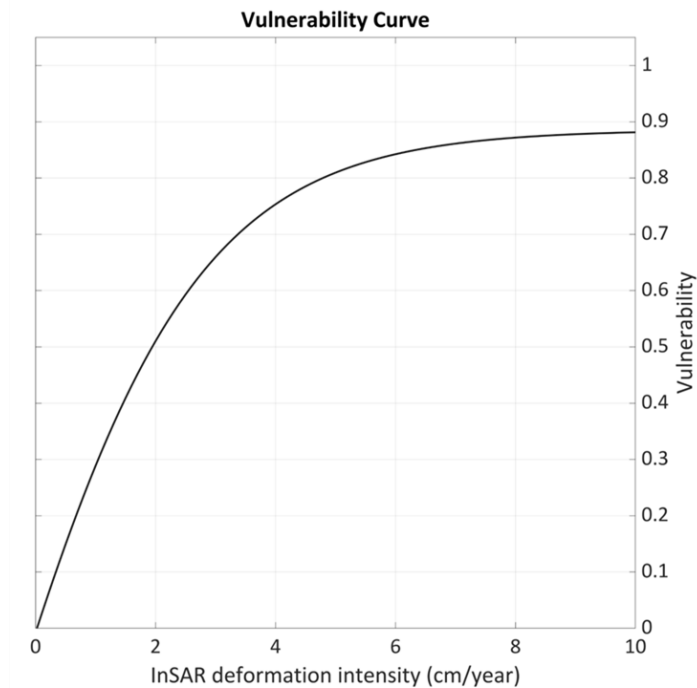
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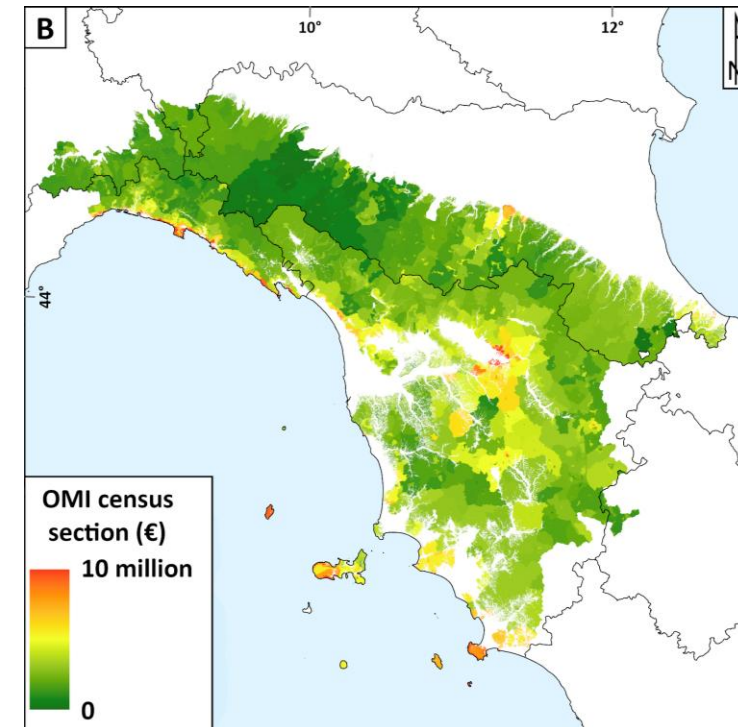
OMI inventory



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Vulnerability procedure

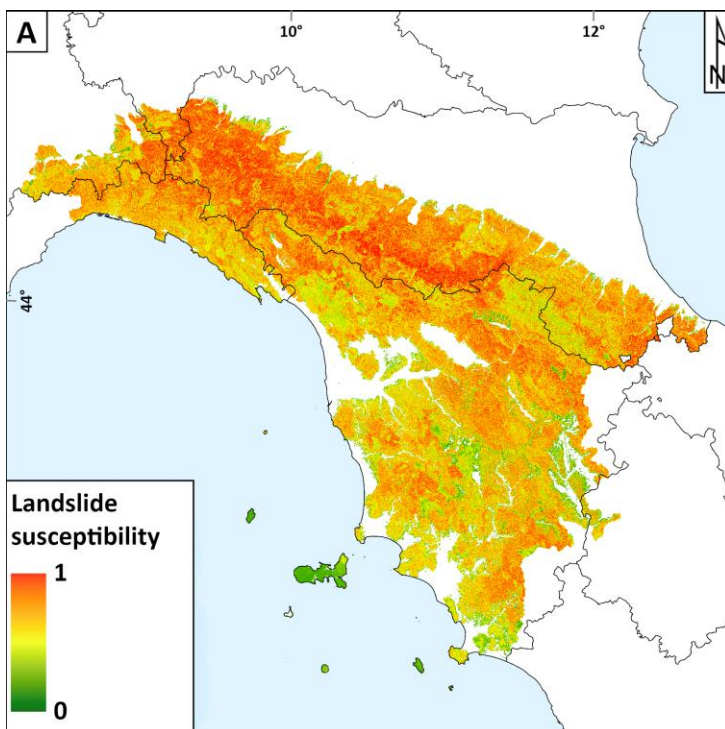
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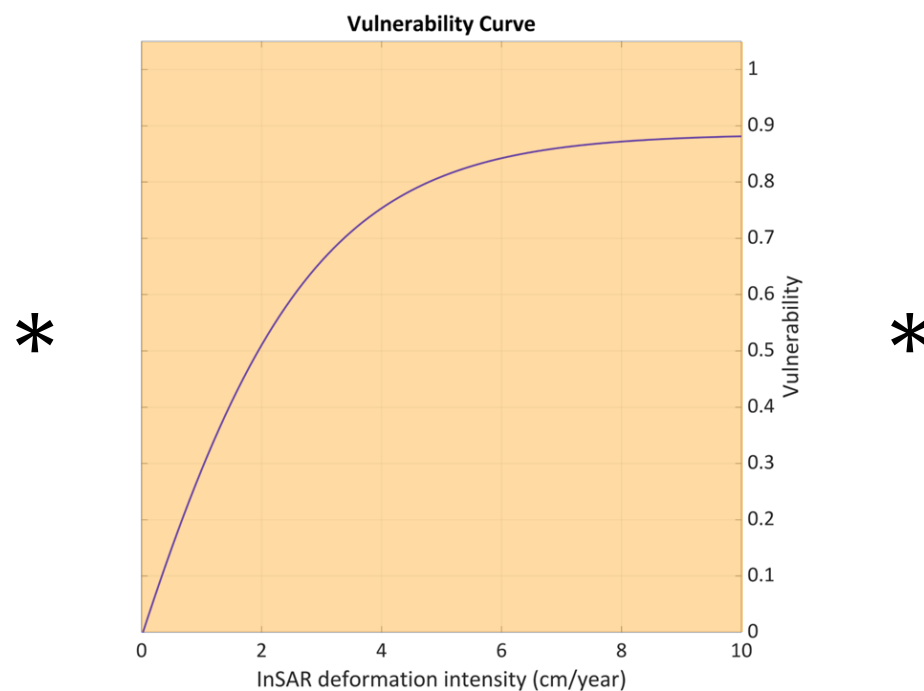
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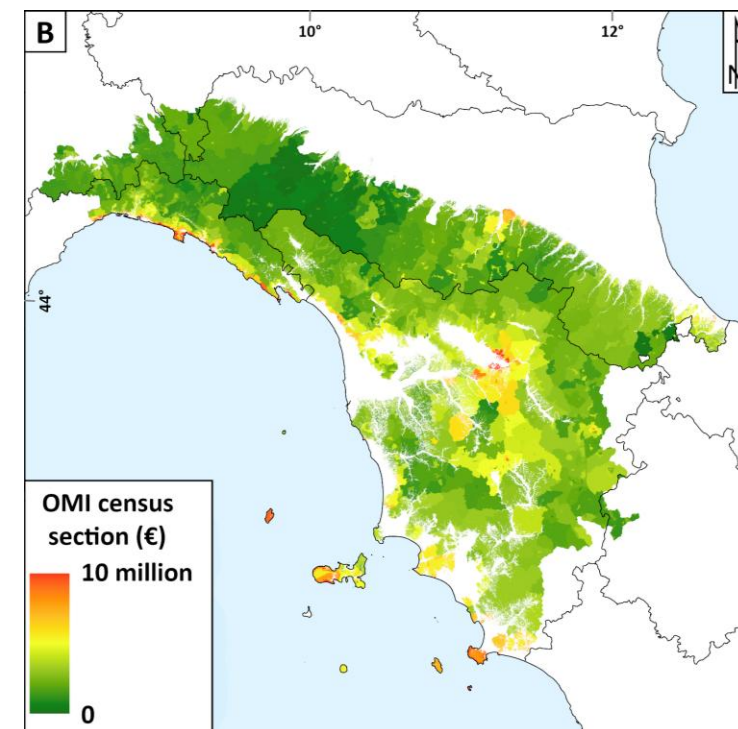
Landslide susceptibility

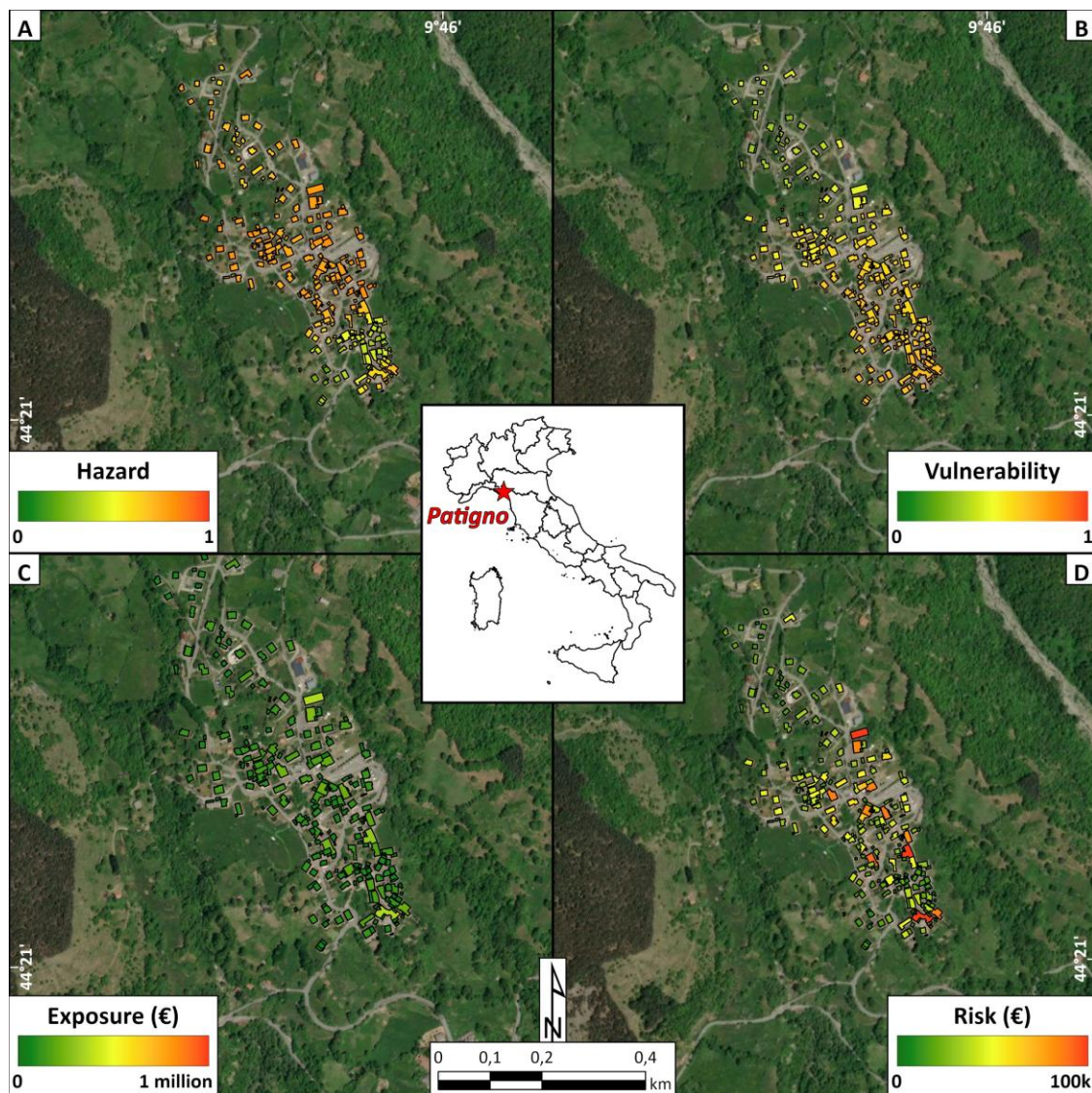


Vulnerability curve



OMI inventory

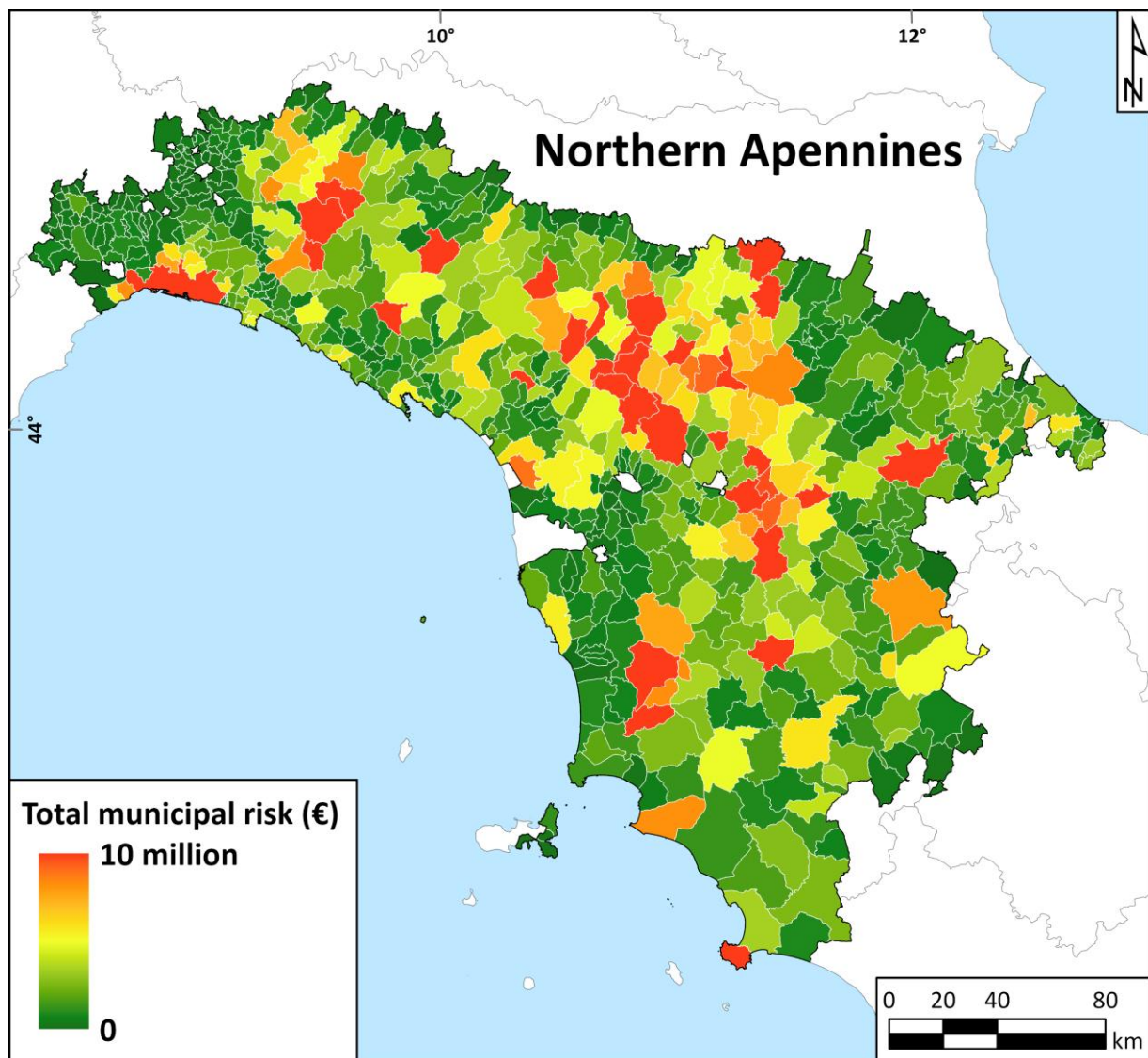




Quantitative Risk Assessment (QRA) procedure focus over Patigno hamlet (Zeri)

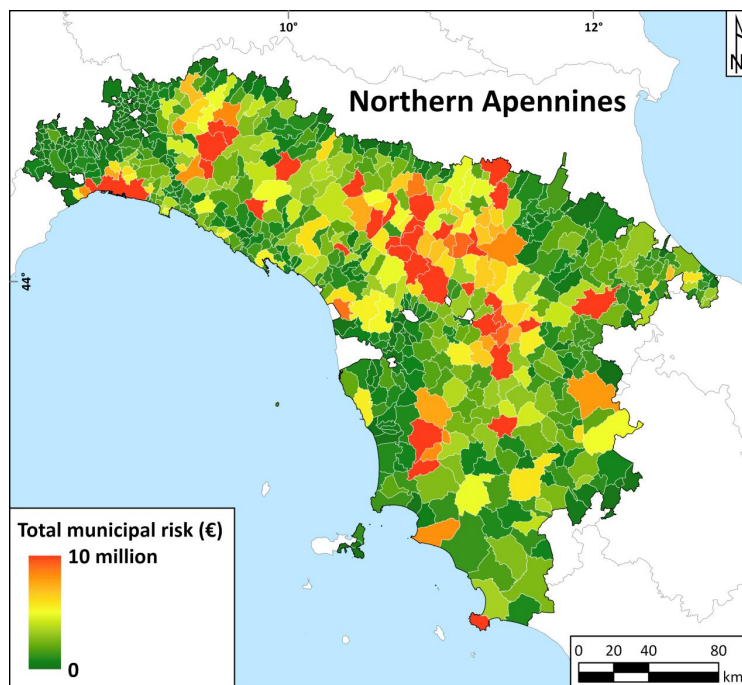
$$\text{Risk} = \text{Hazard} * \text{Vulnerability} * \text{Exposure}$$

Each parameter has been defined for each building in the Northern Apennines, with a total of over 700,000 buildings covered.

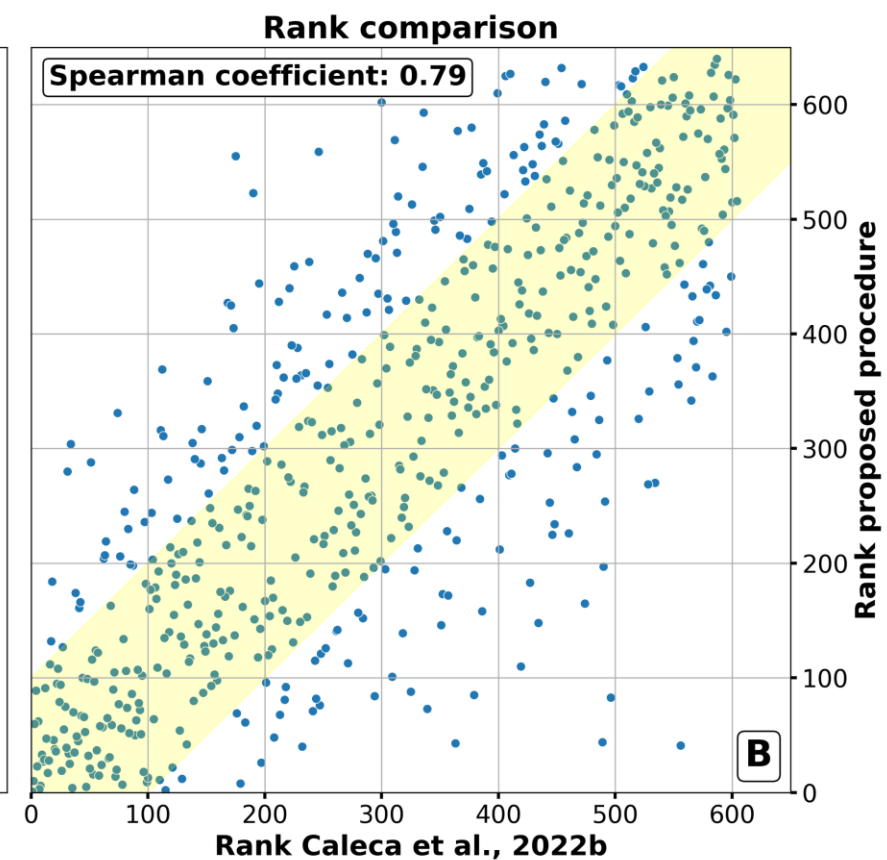
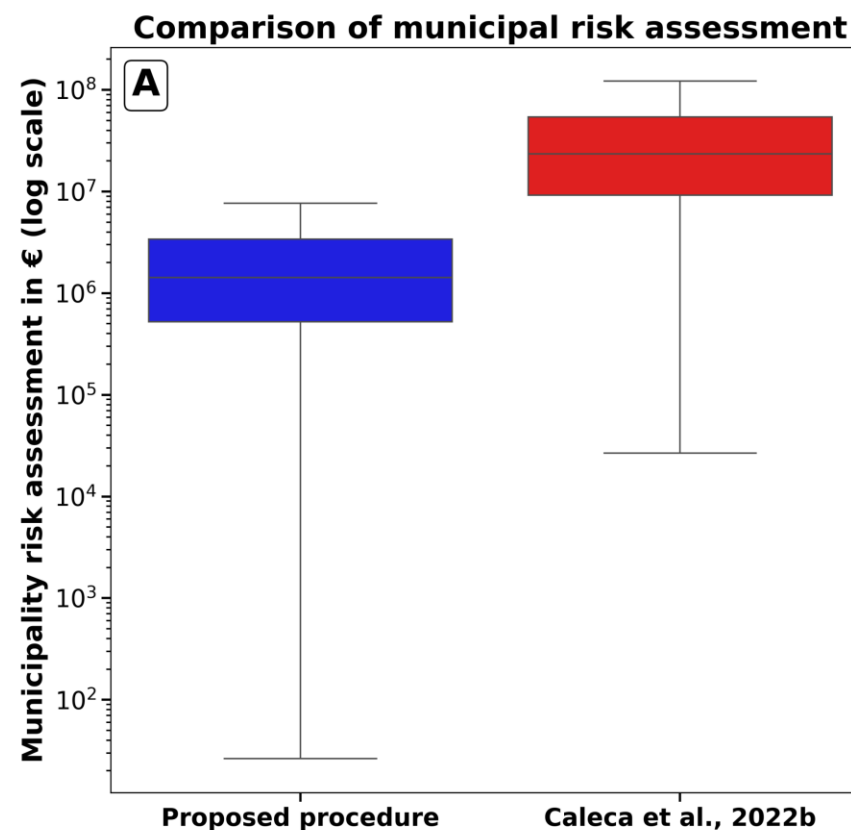


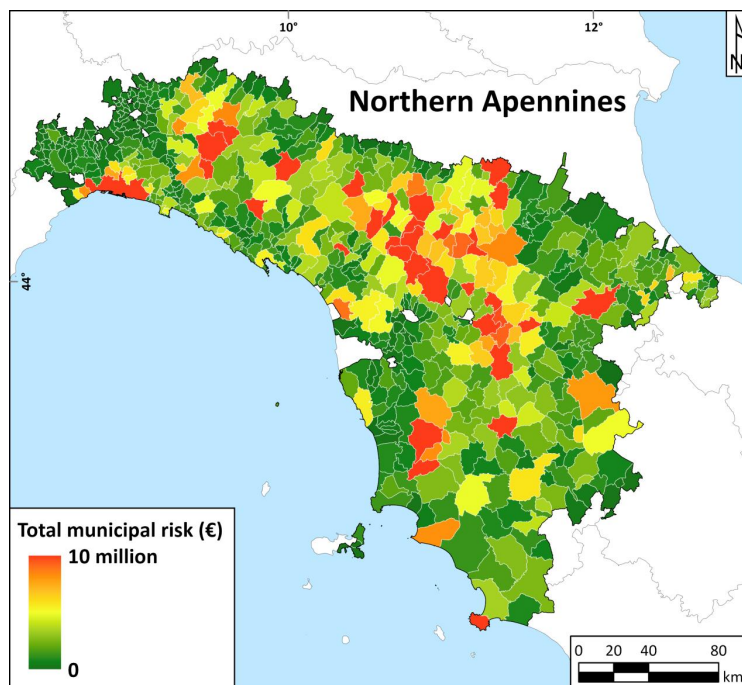
The ***risk assessment*** obtained from the QRA procedure over the Northern Apennines at the **municipal** level



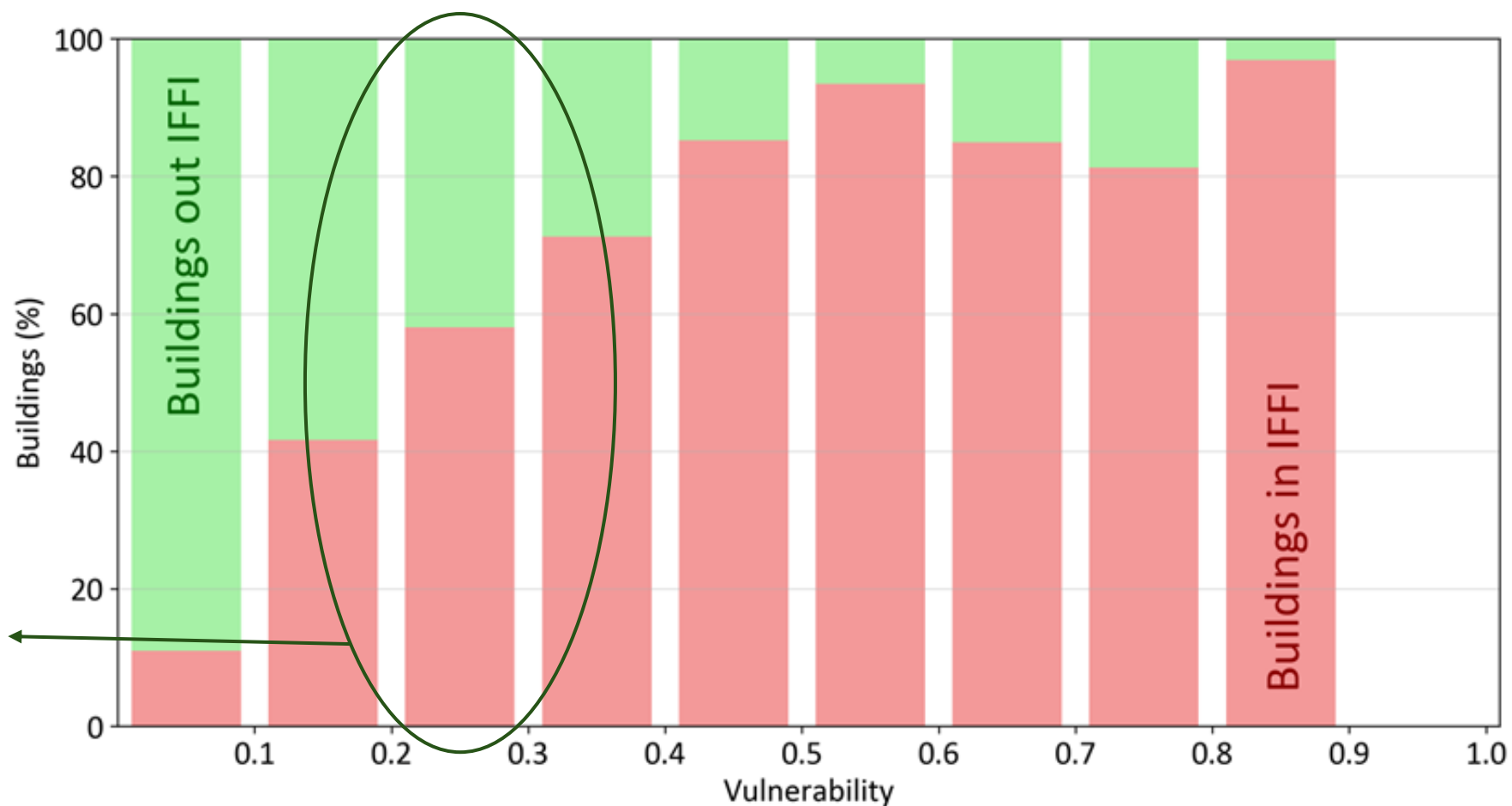


A comparison of the outcomes obtained by the proposed procedure and by **Caleca et al. 2022b**





A comparison of the outcomes obtained with the IFFI inventory



When the vulnerability value exceeded the 0.2-0.3, the majority of buildings are in a mapped landslide

Thank you for your attention!

You can find and read the research on
Remote Sensing of Environment

<https://doi.org/10.1016/j.rse.2025.115199>



Sentinel-1 imagery for wide-scale
quantitative landslide vulnerability
assessment of buildings ☆

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Matteo Del Soldato ^a✉, Claudio De Luca ^b✉, Francesco Casu ^b✉, Manuela Bonano ^b✉,
Riccardo Lanari ^b✉, Veronica Tofani ^a✉, Federico Raspini ^a✉

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