

# Towards Next-Generation Impact-Based Earthquake Early Warning

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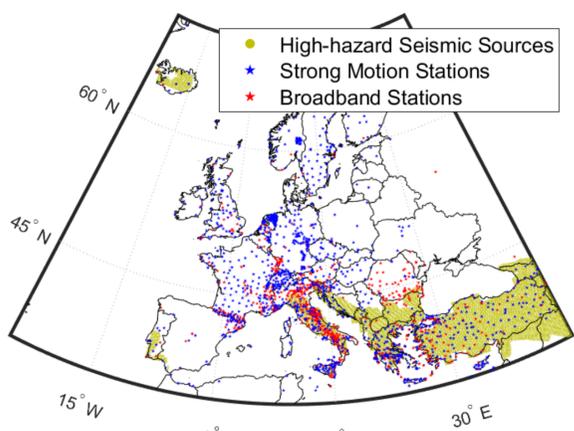
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## Introduction

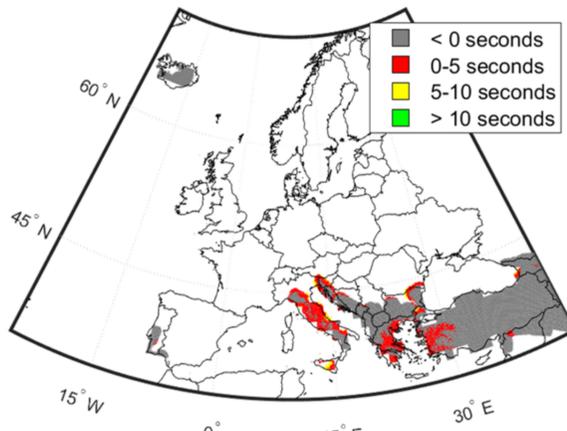
- Up to now, the most cutting-edge innovations in earthquake early warning (EEW) have been largely concentrated in the field of real-time seismology, e.g., the use of advanced probabilistic approaches for accurately predicting earthquake source parameters and ground-shaking intensities at target sites.
- To maximise the potential of EEW as a credible tool for seismic resilience promotion, there remains a strong need to develop next-generation decision-support systems and related computational tools that use interpretable probabilistic impact-based estimates and account for malfunctions of the system (i.e., false alarms).
- These advances can promote more informed stakeholder decision making on EEW installation/alert triggering.
- These challenges are addressed in the poster, which showcases a series of recent significant EEW contributions by the authors.**

## From installation ...

1. A feasibility study to identify the most promising locations for potential EEW installation across Europe, combining...



(1) High-hazard seismic sources and seismic stations



(2) Probabilistic lead times

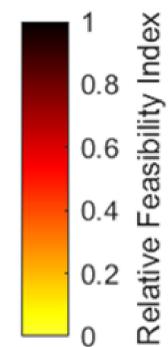
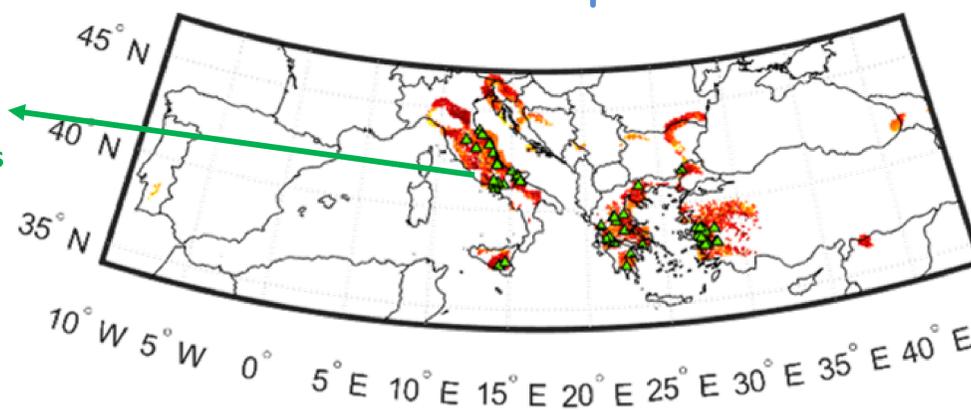


PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%)	<0.05	0.3	2.8	6.2	12	22	40	75	>139
PEAK VEL.(cm/s)	<0.02	0.1	1.4	4.7	9.6	20	41	86	>178
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Worden et al. (2012)

(3) Impact-oriented measures of exposure and earthquake intensity

▲ = site with one of the 50 highest Relative Feasibility Index values

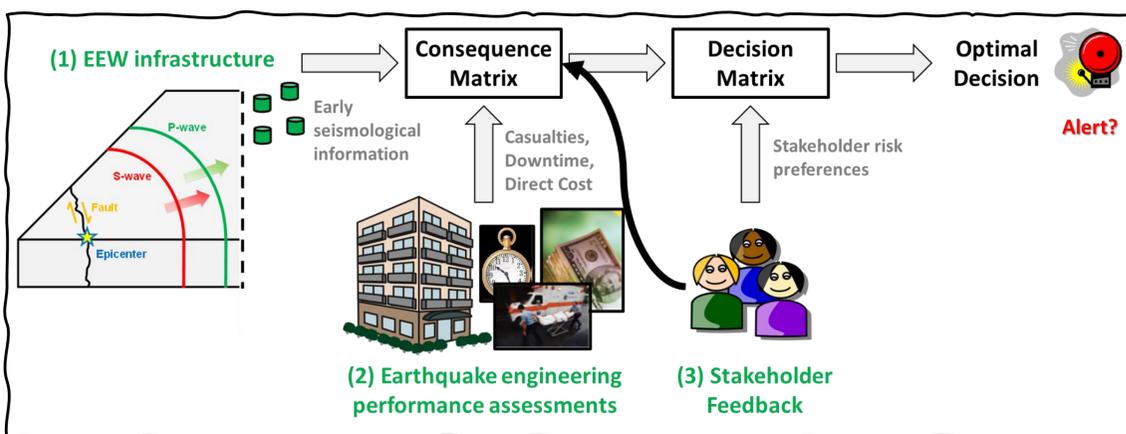


Relative Feasibility Index =  $f(\text{exposure, intensity, lead time, stakeholder risk preferences})$

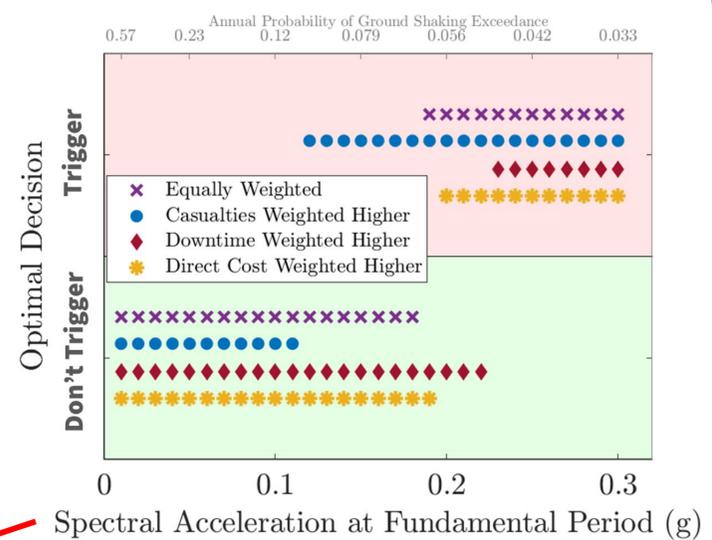
✓ EEW would be most useful for **Italy, Turkey, and Greece**

... To alert issuance

2. A decision-making methodology for people-centred, impact-based EEW that combines earthquake engineering procedures and multi-criteria decision making



Applied to a hypothetical school

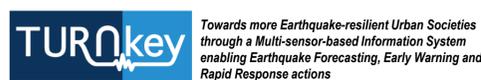


✓ The optimal decision can depend on stakeholder preferences, emphasising the importance of participatory approaches to EEW.

✓ Similar results are obtained for the Port of Gioia Tauro in Italy, one of Europe's largest seaports, and a railway bridge in France

## Summary

- We have presented the results of a state-of-the-art feasibility study for EEW conducted across the continent of Europe, which represents the only attempt of its kind in the literature to spatially combine traditional seismologically driven EEW decision criteria (i.e., lead time) with proxy risk-oriented measures for earthquake impact.
- We have also presented an innovative people-centred approach for risk-informed decision making on triggering EEW alerts, which integrates advanced earthquake engineering methods with tools for multi-criteria decision making.
- The work presented in this poster represents an important paradigm shift in current approaches to analysing and conducting earthquake early warnings.**



## Key References

- Cremen G., Galasso C., Zuccolo E. (2022) *Investigating the potential effectiveness of earthquake early warning across Europe*, Nature Communications, <https://doi.org/10.1038/s41467-021-27807-2>
- Cremen G., Bozzoni F., Pistorio S., Galasso C. (2022) *Developing a risk-informed decision-support system for earthquake early warning at a critical seaport*, Reliability Engineering & System Safety, <https://doi.org/10.1016/j.ress.2021.108035>
- Cremen G., Galasso C. (2021) *A decision-making methodology for risk-informed earthquake early warning*, Computer-aided Civil and Infrastructure Engineering, <https://doi.org/10.1111/micc.12670>
- Cremen G., Galasso C. (2020) *Earthquake Early Warning: Recent Advances and Perspectives*, Earth-Science Reviews, <https://doi.org/10.1016/j.earscirev.2020.10318>