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An operational tool for geo-hydrological scenario risk assessment and cascading effects evaluation

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Building multiple, complex risk scenarios is a priority for the improvement of the effectiveness of early warning systems and technical countermeasure designs to detect phenomena associated with severe weather events, such as floods and landslides.

This study introduces CERCA (Cascading Effects in Risk Consequences Assessment), a methodology for the characterisation of event scenarios that is consistent with the current Italian Civil Protection Guidelines on the national warning system for weather-related geo-hydrological and hydraulic risks.

The aim is to propose a simple, effective, multiscale operational tool that can be adapted to multiple purposes. Specifically, the methodology frames the problem as a typical scenario analysis through the assessment of possible cascading effects and consequences characterised by a cause/effect relationship produced by a triggering event. The proposed conceptual framework for 'cascade scenario' assessment consists of four stages, referring to the characterization of:

- Triggering Events,
- cascading effects in terms of Representative Elementary Phenomena,
- cascading effects in terms of Damaged Elements at Risk,
- Fatalities Circumstances.

The CERCA approach can be effective:

- in processing post-disaster information at the local level to identify site-specific dependencies based on local hazard proneness and exposure and vulnerability conditions as well as to prioritize countermeasures;
- in supporting efficient surveillance of the real-time evolution of critical situations, helping operative structures of civil protection to update the picture of occurring phenomena;
- in providing general dependency matrices to be used in the 'ex-ante' definition of scenarios and recurring cascading event trees, through analysis of several past events.

The methodology was assessed using a case study concerning a local event occurred in 2015 in the north-east of Calabria (Italy) and a back-analysis on 152 events in warning zones of the Italian

territory that occurred during the period 2004–2021.

The first application aimed at illustrating CERCA functionality in describing cascading effects based on a post-disaster survey at a local level for a heavy rainfall event that caused flooding of various streams and widespread shallow landslides.

The national-scale back-analysis offered an overview of the chains generated by triggering events. The analysis showed that in over 50% of investigated cases, more than one triggering event was observed (most of the time floods accompanied by landslides), confirming the necessity for multi-risk analysis. 'Pluvial flood', particularly affecting urban areas, was the most frequent triggering event with 30%, mainly causing damage to basement or ground floor/yards of public and private buildings and to transport infrastructure. A detailed characterisation of the circumstances of death for 52 fatalities, further specified that the majority were flood-related fatalities (82%). Numerous people were affected outdoors along roads (35%) and travelling in vehicles (37%). Dependency matrices based on a frequency analysis, provided an overall picture of relations between different elements of the chain that, although limited to the number and type of investigated events, offers a preliminary assessment for further studies that could explore also the dependency from the severity of the forcing rainfall.