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Towards an integrated framework for distributed, modular multi-risk scenario assessment

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A significant percentage of disasters qualify as complex, multi-hazard events. Either when extreme events trigger additional phenomena (for instance in the case of particularly strong earthquakes generating tsunamis and landslides), or when different compounded hazards significantly amplify their joint impact (e.g., if an earthquake would occur during a typhoon). Further cascading effects can also occur due to systemic interdependency in the exposed infrastructure, for example water or power distribution lines. The quantitative estimation of the consequences associated to such multi-hazard scenarios is referred to as multi-risk estimation and can be relevant in supporting civil protection authorities and decision makers to plan medium and long-term disaster risk reduction (DRR) and prevention measures.

Exploring the multi-risk associated to a complex event is challenging, partly due to the inherent model complexity, partly because is a strongly interdisciplinary matter, where skills and expertise from heterogeneous scientific and technical areas have to converge, and they rarely can be found in a single institutions nor managed by single-domain experts. In order to streamline this process, and at the same time unleash the potential of different institutions to bridge the gap between science and practice, an innovative conceptual and operational framework for multi-risk scenario assessment has been developed within the project RIESGOS (https://www.riesgos.de). The proposed solution is based on a dynamic, multi-hazard exposure and vulnerability model, which provides the geography-aware structural description of different types of assets (e.g. residential

buildings) compatible with vulnerability models related to different hazards.

A novel methodology for describing inter- and intra-hazard damage accumulation also allows the modelling of scenarios composed by sequences of hazardous events. The processing framework is based on processing modules that are implemented as distinct web-processing-services (WPS), possibly hosted remotely by different institutions. Each WPS is fully complying with the OGC WPS directives, and implemented in a flexible and scalable architecture based on Docker containers. The interoperability among the different services is ensured by a careful harmonization of input and output format and the use of on-the-fly converters. Standard and de-facto standards (e.g., community standards) are supported. Specific WPS provide the simulation of intensity maps for the considered hazards, either on the fly (e.g., for the earthquake shake-map generation) or by querying portfolios of pre-simulated events (e.g., for tsunami inundation maps).

The proposed framework can be used to explore the direct damage and loss to assets as a result of a sequence of consecutive events, and also includes a specific processing module for the analysis and simulation of cascading effects on extended infrastructure such as power lines. A graph-based topological model of the network along with the physics-inspired modelling of the load- shedding allows the estimation of potential outages caused by non-linear cascading effects triggered by damage accumulation during the events sequence.

The approach has been exemplified in several study areas in South America, considering a wide range of natural hazards including earthquakes, tsunamis and volcanic phenomena (lahar, ash-fall). The cases of Gran Valparaiso (Chile) and Cotopaxi region (Ecuador) are shown and discussed.