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A GIS platform for Rapid Seismic Risk Assessment in Greece – Case study Cephalonia Isl.

I. Kassaras1, D. Kazantzidou-Firtinidou[1], V. Kapetanidis[1], G. Sakkas[1], S. Vassilopoulou[1], D. Theodorakatou[1], S. Hadjiefthymiades[2], P. Papadimitriou[1]

(1) Department of Geophysics & Geothermics, NKUA, Panepistimiopolis, 15784 Athens, Greece, kassaras@geol.uoa.gr
(2) Department of Informatics & Telecommunications, NKUA, Panepistimiopolis, 15784 Athens, Greece

The term Seismic Risk Assessment (SRA) is defined as the combination of a specified level of ground motion at a site (seismic hazard), the degree of damage expected to occur in its structures after an earthquake (seismic fragility) and the assets exposed (economic exposure). Given that the issue of the accurate prediction of earthquakes is strongly argued at present and physical limitations of Earthquake Early Warning Systems (EEWS) often impose restraints on their feasibility (Thelen et al., 2016), implementation of Rapid Seismic Risk Assessment (RSRA), highlighting urban regions prone to damage within the affected area, may crucially facilitate targeted emergency actions to be taken immediately after a disaster. To this aim, a GIS computer platform for semi-automatic deterministic RSRA is under development in the frame of HELPOS project, with the prospect to be linked to the near-realtime ShakeMap application of the Seismological Laboratory of NKUA towards acquiring an efficient, site-tailored, structural RSRA system. Herein we present its basic structure and an offline application on Cephalonia (Ionian Islands) that will be used as a baseline scenario of the platform's validation at a later stage. Computational tasks within the system consist of Deterministic Seismic Hazard Assessment (DSHA) for a given earthquake taking into account site-effects and a combination of the derived Intensity Measures (IMs) with a predefined macroseismic EMS-98 vulnerability model (Grünthal, 1998). The output product includes spatial models (maps) of EMS-98 Damage Grades (DGs) and their probability to occur at the building block level. Key-point the platform is stressed to, is short delay in producing output, reduction of error-prone conversions and adaptations between modules/systems and a fully automated workflow (Fig. 1).

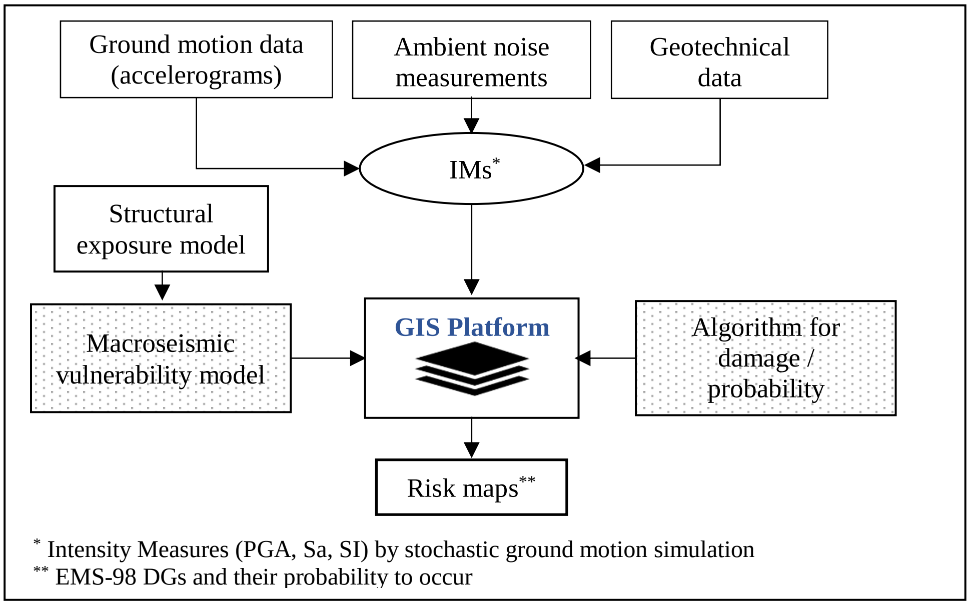

Figure 1. Basic design of the GIS platform.

As mentioned above, platform output is fully localized, which requires site-specific parameterization regarding seismic sources, Ground Motion Prediction Equations (GMPEs), soil conditions and buildings taxonomy. Seismic source, i.e. its location, geometry, kinematics and its magnitude is the only variable in the workflow, input to a DSHA based on stochastic ground motion simulation implemented through the EXSIM module (Motazedian & Atkinson, 2005). Prior to automatic simulations, the appropriate GMPEs and soil conditions have been pre-determined by applying synthetic IMs generated by considering historical, instrumental and nearest Maximum Credible Earthquakes (MCEs), after validation with real damage observations. Path-effects are assumed after empirical GMPEs; site effects are approximated by experimental Horizontal to Vertical Spectral Ratios - HVSRs (Nakamura, 1989) and geotechnical borehole data. Hence, the platform's EXSIM parameterization is considered to accurately resolve DSHA's IMs, i.e. Peak Ground Acceleration (PGA), Velocity (PGV) or

Displacement (PGD), Spectral Acceleration (Sa), Seismic Intensity (SI), defined as equivalent Modified Mercalli Intensity - MMI), however only by neglecting near-source effects and non-linear soil response.

Vulnerability is input as indices, integrated into the platform in tabular form, linked to specific building classes and characteristics, and consists of a static component of the risk assessment application. This architecture allows flexibility for the input of different exposure files, renders the platform extendable to other areas and provides guidelines for structural data collection and exposure modelling in a standardized way. The structural vulnerability method selected to be implemented in the platform is the macroseismic semi-empirical method proposed by Giovinazzi & Lagomarsino (2004) that takes into account the EMS-98 classification (Grünthal, 1998) and additional typological-specific and seismic behavior modifiers, i.e. height, irregularities, building position, etc. The final outcome includes risk maps, in terms of collapse maps, distribution of number of buildings per EMS-98 DGs with maximum probability of occurrence. Consistently with international scientific practices for risk assessment studies at territorial level, the lowest tract at which the end product is provided, is seismic risk at building-block scale, because of the numerous uncertainties risk assessment is related to and also social privacy issues.

The components that we put together have demonstrated good performance in the past when operated individually into several target sites in the Greek territory, i.e. Lefkada (Kassaras et al., 2015), Kalamata (Kassaras et al., 2018), Aigion (Giannaraki et al., 2018), Fira-Santorini (Kazantzidou-Firtinidou et al., 2018), yielding good agreement with real damage observations. Herein, we showcase seismic risk assessment of W. Cephalonia, pivotal for the platform's validation, by exploiting damage observations due to the 26.1.2014 (Mw=6.1) and 3.2.2014 (Mw=5.9) earthquakes, ambient noise measurements during a post-seismic campaign and geotechnical data. Regarding the buildings' inventory it was available by EPANTYK (2009) at building scale for the towns of Argostoli and Lixouri and aggregates per municipal district for the rest of the island. The derived IMs by the EXSIM scheme were found consistent with observed MMIs. Scenario DGs derived from the macroseismic approach were compared to the accumulated damage of the 2014 events, manifesting a satisfactory behavior of the constructions throughout the island, and a successful stress testing of the intended approach.

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