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Real-Time Shaking Maps of PGA and PGR in Greece

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The use of real-time in natural disasters is on the rise. Earthquake real-time applications have proved to be a useful tool for acquiring a rapid estimation of ground shaking immediately after an earthquake occurrence. USGS ShakeMaps (Wald *et al.*, 2005) and PAGER (Wald *et al.*, 2010) applications are two of the most known. In Greece, the Earthquake Planning and Protection Organization – Institute of Engineering Seismology and Earthquake Engineering (EPPO-ITSAK) provides PGA maps for moderate and large earthquakes using the ShakeMaps application within 30 minutes (Wald *et al.*, 2005). In 2015, the National and Kapodistrian University of Athens (NKUA) was the first institution in Greece that developed its own application, in Matlab environment, for creating rapid PGA maps in the case of earthquake occurrence (Kouskouna *et al.*, 2014). This application was further upgraded by Sakkas (2016) and Sakkas *et al.* (2018), taking into account modern GMPEs for calculating PGA and Peak Ground Rotations – torsion and rocking (PGR) – incorporating, in addition to moment magnitude (M_w), epicentral distance (R_{epi}) and focal depth (h), also the soil type (rock, stiff or soft soil) and focal mechanism type (normal and strike-slip or thrust). The real-time application is hosted by NKUA and publicly available online at http://macroseismology.geol.uoa.gr/realtime/ (the home page is presented in Figure 1). The application presents PGA and PGR maps in a user-friendly environment with google maps as base maps, zoom-in and zoom-out options, as well as activation and deactivation of the PGA and PGR thematic layers. Maps are created in a few seconds in a run-of-the-mill personal computer. The algorithm utilizes the internet, RSS feeds, XML DOM elements, HTML and Matlab mathematical, scripting and plotting capabilities.

Within the framework of HELPOS project, NKUA, as official partner, will host both its own application and ShakeMaps (Wald *et al.*, 2005). In this context, we present the Sakkas (2016) and Sakkas *et al.* (2018) upgrade. The latter incorporates the most recent regional GMPEs for Greece. Specifically, PGA and PGR maps are produced in real-time for both shallow and intermediate depth earthquakes with M≥4.0. More specifically, for shallow earthquakes, five (5) GMPEs (Skarlatoudis *et al.*, 2003; Danciu and Tselentis, 2007; Segou and Voulgaris, 2013; Sakkas, 2016; Chousianitis *et al.*, 2017) are used for the calculation of PGA in different thematic layers. For intermediate depth earthquakes, GMPEs proposed by Skarlatoudis et al. (2013) are applied. For the calculation of PGR, the GMPEs for shallow and intermediate depth earthquakes of Sakkas (2016) and Sakkas et al. (2018) are used. Soil types are based on the 1:500.000 Geotechnical map of Greece and focal mechanism type on Papazachos *et al.* (1998), Benetatos *et al.* (2004) and Giardini *et al.* (2013), taking also in account the interface and in-slab zones proposed in Kkallas *et al.* (2018). PGA values for all GMPEs adopted in this study are presented in Figure 2.

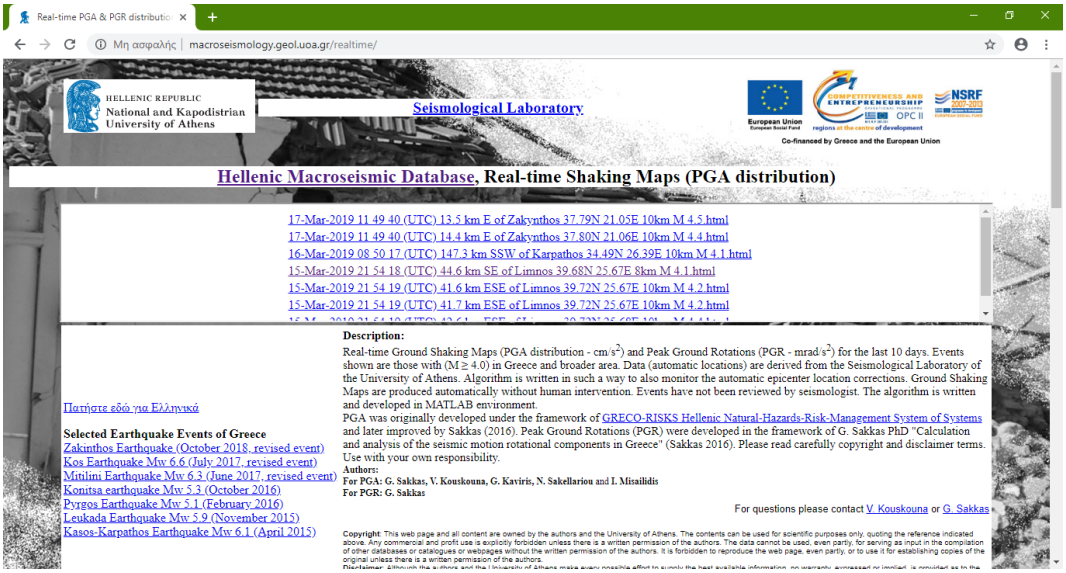

Figure 1. The home page of the real-time application hosted in NKUA.

Future development of the algorithm will incorporate real-time PGA measurements from accelerographs and seismographs, belonging to the national infrastructure of the HELPOS project. In addition, residuals of GMPEs compared to observed measurements will be embedded and open-source software and improved mapping capabilities of GIS software will be examined for better representation of PGA and PGR maps.

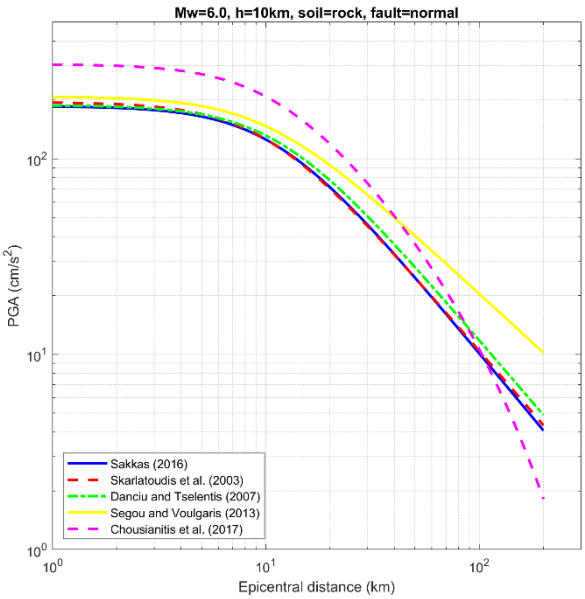

Figure 2. GMPEs for shallow earthquakes used in this study (M_w6.0, focal depth 10km, normal fault, rock soil type).

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