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EXTENDED ABSTRACT 041

The Greek Database of Seismogenic Sources (GreDaSS) version 3.0. A compilation of potential seismogenic sources (Mw> 5.5) in the Aegean Region

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The broader Aegean Region, including the Southern Balkans, is among the most tectonically active areas of the Mediterranean realm and has the highest seismicity both in terms of frequency of events and magnitudes. The principal aim of this note is to present the new release of the Greek Database of Seismogenic Sources (GreDaSS) corresponding to version 3.0 systematically revised in terms of sources and seismotectonic parameters and largely improved both qualitatively and quantitatively (Figure 1).

Background

The importance of a complete repository for active faults in the Aegean Region became clear since the late 1990's; however, the first efforts were primarily focused on tectonic structures associated to pre-instrumental and instrumental seismicity (e.g. Ambraseys and Jackson, 1998; Papazachos et al., 1999) and thus based almost entirely on historical and seismological data. This approach can be successful in studying recently activated seismogenic sources, but becomes inappropriate for sources without any seismological record (neither pre-instrumental nor instrumental) and characterized by a long recurrence period. The 13 May 1995 Kozani earthquake (Ms = 6.5; e.g. Pavlides et al., 1995; Meyer et al., 1996; 1998a; 1998b; Chiarabba and Selvaggi, 1997; Clarke et al., 1997, 1998; Hatzfeld et al., 1997; 1998) and the 7 September 1999 Athens earthquake (Mw = 6.0; e.g. Kontoes et al., 2000; Voulgaris et al., 2001; Ganas et al., 2004; Atzori et al., 2008; Foumelis et al., 2009) are emblematic examples of ruptures occurred in areas considered till that moment as aseismic or associated with low seismic activity. Although the subsequent works managed to include the geological records in the source identification process, most of them resulted to be too much descriptive, lacking in quantitative parameters information (e.g. Mountrakis et al., 2006; Pavlides et al., 2007; Karakaisis et al., 2010).

For these reasons, in the late '90ies on the track of the European FAUST Project and the Italian DISS, the GreDaSS Project was thus launched initially at the University of Basilicata and then permanently developed at the University of Ferrara (copyright owner) with an international working group. The financial support of this initiative was primarily provided by the Italian Ministry of University and the University of Ferrara.

The principal aim of the GreDaSS Project was indeed i) to overcome the above described critical issues , ii) to provide a complete and accurate repository of fully parametrized seismogenic sources and not simply, for example, a 2D map of (active) fault traces (Papazachos et al., 2001; Pavlides et al., 2008) and iii) to contribute to better and more realistic Seismic Hazard Assessment (SHA) analyses.

Since its beginning, GreDaSS was obviously populated by seismicity-related sources, but the preferred approach was intrinsically multidisciplinary (e.g. Caputo and Helly, 2008; Caputo et al., 2015) giving emphasis and exploiting as many as possible different sources of information digging any geological, structural, morphotectonic, geodetic, palaeoseismological, historical, archaeoseismological, geophysical, etc. data available in the literature or specifically collecting new data by the research group.

During the years and becoming a reference database for SHA analyses, the products of GreDaSS were included in several European projects, like the European Seismic Hazard Model (ESHM13; Woessner et al., 2015) and more recently the European Fault-Source Model 2020 (EFSM20; Basili et al., 2024).

Since its almost 30 years of research activity, the working group of the GreDaSS Project evolved in time and saw the collaboration and contribution of several PhD students, like Valkaniotis (2009), Sboras (2012), Maggini (2020) and Russo (2025) and colleagues. The authorship of this note is limited to the contributors of the new entirely revised and updated version 3.0 of GreDaSS, which is the object of the present note.

Method

For our purposes we used the well tested, time-proof, worldwide acknowledged database structure and method proposed by the Istituto Nazionale di Geofisica e Volcanologia (INGV) for the Italian Database of Individual Seismogenic Sources (DISS), which represents the result of almost twenty years research experience of its Working Group (Valensise and Pantosti, 2001). The DISS uses many basic levels of data that can be either independent or directly related. Among the most important ones are the Individual Seismogenic Sources (ISS), the Composite Seismogenic Sources (CSS) and the Subduction Sources (SDS); see also Basili et al. (2008) for a more detailed description of the informatic framework.

- "Individual Seismogenic Sources" (ISS) are obtained from geological and geophysical data and are characterized by a full set of geometric (strike, dip, length, width and depth), kinematic (rake) and seismological-palaeoseismological parameters (average displacement per event, magnitude, slip rate, return period) and by a rating of the associated uncertainties. ISSs are assumed to exhibit "characteristic" behaviour with respect to rupture length/width and expected mean and maximum magnitude. They are tested against worldwide databases for internal consistency in terms of length, width, average displacement and magnitude. This category of sources favours accuracy of the information supplied over completeness of the sources themselves. As such, they can be used for deterministic assessment of seismic hazard, for calculating earthquake and tsunami scenarios, and for tectonic and geodynamic investigations.

- "Composite Seismogenic Sources" (CSS) are still obtained from geological and geophysical data and characterized by geometric (strike, dip, width, depth) and kinematic (rake) parameters, but their length is more loosely defined and spans two or more Individual Sources. They are not assumed to be capable of a specific earthquake, but their potential can be derived from existing earthquake catalogues. A CSS is essentially inferred on the basis of regional surface and subsurface geological data, that are exploited well beyond the simple identification of active faults or youthful tectonic features. Opposite to the previous case, this category of sources favours completeness of the record of potential earthquake sources over accuracy of source description. In conjunction with seismicity and modern strain data, CSSs can thus be used for regional probabilistic seismic hazard assessment and for investigating large-scale geodynamic processes.

- "Subduction Sources" (SDS) are designed to include a simplified model of this complex tectonic environment. They represent the dipping slab at mantle depth, the interface between the two plates at crustal depth, and the detachment at the base of the accretionary wedge. In map view, a set of depth contour lines depicts the geometry of the subducted slab. At the upper end of the slab, a fault trace marks the boundary of the two plates. A set of basic parameters relative to the tectonic behavior, the possible segmentation of the Wadati-Benioff surface and the net convergence direction and rate are also added in the corresponding layers of information. This type of reconstruction is typically performed using data from geology, exploration geophysics, seismicity distribution, and seismic tomography.
The details about how faults are graphically represented in the database and what are the attributes of every information field can be found in the paper of Basili et al. (2008).

Informatic platform

Different from version 2.0 that is available as a Google Maps version or a downloadable KMZ version, Gredass 3.0 is hosted on "SEISMOFAULTS.EU" IT infrastructure (Basili et al, 2022) that provides access through standard web services protocols such as the Web Map Service (WMS), Web Feature Service (WFS), or Web Coverage Service (WCS), developed by the Open Geospatial Consortium (OGC; https://ogc.org). Through the OGC web services, data can also be downloaded as CSV (Comma-Separated Values), SHP (Esri shapefile), KML (Keyhole Markup Language), GeoJson, and many others.
The last release of GreDaSS (version 3.0) is also publicly available through a web GIS interface (Figure 1). Since the database structure remains consistent, we have chosen to adopt the same web interface designed and developed by DISS Working Group of INGV for the most recent version of Italian Database of Individual Seismogenic Sources (DISS Working Group, 2021). This interface is developed in JavaScript language, using the open-source library OpenLayers for mapping data directly querying the web services made available by the "SEISMOFAULTS.EU" infrastructure.

Results

Within the investigated area, we have already recognized, characterized and parametrized numerous CSSs and

ISSs. All ISSs show evidence of Late Pleistocene-Holocene activity and sometimes also the occurrence of past ‘linear morphogenic earthquakes’ (sensu Caputo, 2005) as inferred, for example, from palaeoseismological trenches, archaeoseismological investigations or detailed morphotectonic mapping. In some cases, a moderate to strong earthquake has occurred in the last few decades, therefore allowing us to investigate the re-activated fault with a great detail, based on a modern scientific approach, and especially exploiting a rich seismological information associated with the mainshock. In particular, available instrumental data commonly provide crucial constraints about focal depth, magnitude, focal mechanism (i.e. strike, dip and rake) and aftershock distribution. This additional ‘co-seismic’ information is obviously not available for all the other geologically-derived seismogenic sources (ISSs) where no historical or instrumental earthquakes have been recorded. Accordingly, these faults represent a crucial test for the database and especially for its possible applications in seismic hazard assessment analyses. They have been independently investigated according to the two approaches, in one case the available ‘co-seismic’ constraints of the principal seismotectonic parameters have been ignored and mainly the cumulative effects of Late Quaternary morphogenic events have been considered; in the other case this additional co-seismic information has been included (Caputo et al., 2015).

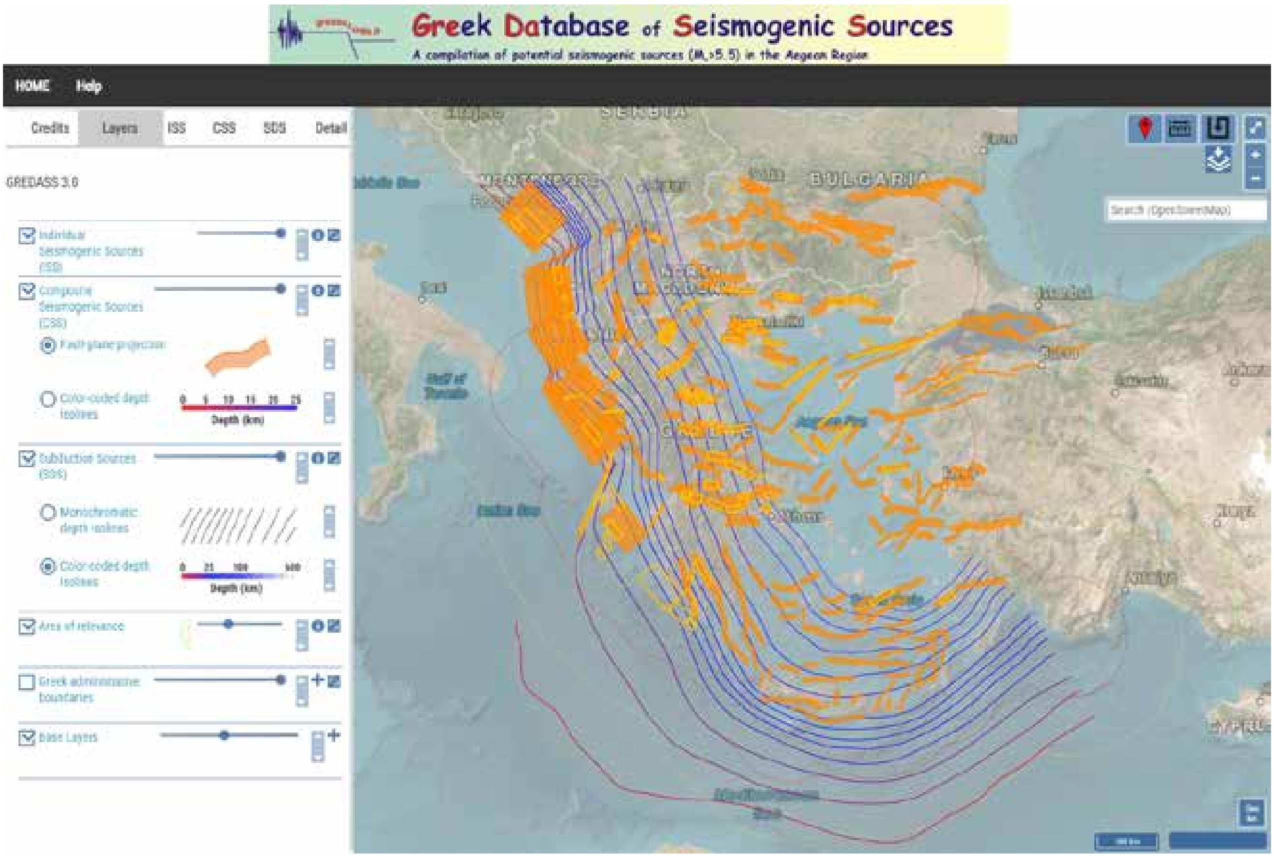

Figure 1. Screen capture of the last release of GreDaSS (version 3.0) available through the new web GIS interface.

It is worth noting that relative to the previous one (release 2.0; Caputo and Pavlides, 2013) the new version of GreDaSS (release 3.0) has been largely improved both qualitatively and quantitatively. In particular, all seismotectonic parameters have been systematically revised and most of the numerical fields have been completed and/or compiled where missing. This work produced an overall rough increase in the order of +70% of the information contained. It is worth noting the significant improvement that was achieved in better constraining the seismogenic layer all over the investigated area by applying the results of the 3D thermo-rheological model recently produced for the broader Aegean Region (Maggini, 2020; Maggini and Caputo, 2020; 2021; Maggini et al., 2023). Based on this model, a set of crucial seismotectonic parameters, like maximum depth, width, dip-angle and maximum credible magnitude of the seismogenic sources, have been systematically revised and/or better quantified.
Crustal faults (i.e. CSSs and ISSs) included in the database are at present 277 (instead of 267) and 117 (108), respectively. As concerns the other two informative layers (the graphical one and the relevant literature), the number

of figures associated with the sources are now 1667 (916) and references 853 (679), showing in both cases an important step forward the completeness and improvement of the database especially if compared to version 2.0.
When a seismogenic source is associated with secondary effects, especially liquefaction features, because of a recent or historical event, this information taken from DALO (Papathanassiou et al., 2010) has been systematically included in the descriptive layer of the new GreDaSS release.
A further major difference of the last release is represented by the reconstructed and modelled Wadati-Benioff zones that were not included in the previous version of GreDaSS. In version 3.0, they are actually two, the Hellenic Subduction Zone and the Adriatic Continental Collision (Figure 1), therefore better defining the seismotectonics of the active accretionary wedges surrounding the southern Balkan peninsula.
As a final comment, we want to stress the fundamental and intrinsic difference of GreDaSS with respect to other apparently similar catalogues and/or databases available or under construction for the broader Aegean Region. Indeed, GreDaSS with its philosophical approach, its informatic structure and especially the choice of including some crucial parameters is the only one that could be directly exported and easily used for performing seismic hazard assessment analyses, like for example, in the Seismic Hazard Harmonization in Europe Project (SHARE; http://www.share-eu.org/) or the TAP Project between the Greece-Turkey border and southern Italy (Slejko et al., 2021; Moratto et al., 2021).

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