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Development of a Web Portal for Australian Ground-Motion Data

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Abstract

Earthquake recordings in Australia are a crucial input to a wide range of applications in seismology and earthquake engineering. In particular, earthquake recordings are critical for robust estimation of earthquake magnitudes, earthquake hazard assessment, and dynamic structural analysis. The expansion of permanent monitoring networks (e.g., Australian National Seismograph Network) and deployment of temporary seismic networks in Australia over the past few decades has resulted in a significant increase in the number of earthquake ground motion recordings, particularly for moderate magnitude events. The volume of new data means there is now a need to store these recorded data and metadata in standard format in a comprehensive, searchable, national ground motion database. Recently, we developed a ground-motion database for earthquakes in cratonic regions of western and central Australia, as well as non-cratonic southeastern Australia. We also developed an associated graphical user interface tool to process and visualise the ground-motion data. This tool can also store the processed waveforms in the database. Work is ongoing at Geoscience Australia to develop a web delivery portal to provide end-users direct access to Australian ground-motion data. This web-based portal would enable end-users to search the ground-motion database based on key earthquake, station, and waveform parameters in a user-friendly platform. Providing public access to these data will facilitate greater use of ground-motion recordings to inform various applications including seismic hazard assessment and dynamic structural analysis.

Keywords: ground-motion database, waveform processing, web service

1 Introduction

In Australia, earthquake ground motions are recorded by several permanent and temporary monitoring networks at regional and local scales across the continent. The backbone of the national monitoring system is the Australian National Seismograph Network (ANSN), a network of over 100 seismic stations across Australia, islands in the Pacific, Southern and Indian Oceans, and the Australian Antarctic Territory. The seismic data collected by the ANSN is complemented with data from other deployments such as seismic instruments deployed as part of the Australian Passive Seismic Array (AusArray) project (Gorbatov et al., 2018) and the Australian Seismometers in Schools (AuSIS) seismic network (Balfour et al., 2014), to name a few.

There is a wide range of applications in both seismology and earthquake engineering fields for ground motion data. For an example, the high-quality data acquired from Australian earthquakes have significant utility to enable more informed choices for ground motion models (GMMs) for future hazard assessments (Ghasemi and Allen, 2018) and will support the development of future empirical and simulated ground-motion models for the nation.

Digital strong- and weak-motion records from earthquakes occurring in Proterozoic and Archean (cratonic) regions of western and central Australia have been compiled (Ghasemi and Allen, 2021), together with a dataset for Phanerozoic (non-cratonic) regions of eastern Australia (Ghasemi and Allen, 2023). The time-series data are consistently processed to correct for the instrument response and to reduce the effect of background noise. The raw and processed waveforms are stored in a database together with the metadata (including recording station location, instrumentation, and earthquake information). A range of engineering ground-motion parameters in the time and frequency domains are also calculated and stored in the database. Consistent processing of ground-motion records is a time-consuming task, primarily because of the large volume of ground motions, and the necessity for individual processing of each record, as the optimal approach. Therefore, as detailed in this paper, we developed a web-based graphical user interface (GUI) tool to visualize and process ground-motion data. In Geoscience Australia, we have also developed a web delivery platform to enable users to search the ground-motion database, visualize and download the waveforms and engineering ground-motion parameters. This paper presents the key features of this web service.

2 Ground-Motion Processing Service

Ground-motion data are affected by broadband noise, which restricts the usable data range. Seismic noise levels at different frequencies are influenced by both the time and the recording location, showing variations from one record to another. Filtering of the time-series data is the most widely used and effective technique to reduce the high- and low-frequency noise (Boore and Bommer, 2005). For each record, the corner frequencies of the filter are often chosen based on the signal-to-noise ratio (SNR) of the record. At each frequency, the SNR is the ratio of the signal power to the pre-event noise power. The selection of the SNR threshold, above which the data are considered useful, is subjective, but it is typically set at 3.0. Besides considering SNR criteria, the shape of the Fourier amplitude spectra (FAS) and the presence of non-physical features in the displacement time-series can also provide guidance for selecting the corner frequencies of the filter. The FAS of an acceleration time-series exhibits a power-of-2 decay pattern at low frequencies, f, in accordance with theoretical models (Brune, 1970). Therefore, in practice, the frequency at which the FAS of acceleration record begins to diverge from the f^2 line can be regarded as the effective high-pass corner frequency of the filter.

In this study, we have developed an interactive web-based platform designed to simplify and accelerate the manual processing of ground-motion data. This platform is a wrapper around the U.S. Geological Survey's "gmprocess" software which is a python toolkit for retrieving and processing ground-motion waveform data and deriving various metrics from that data (Hearne et al., 2019). The platform developed in this study assists users in the subjective selection of filter corner frequencies for greater efficiency. Additionally, it enables the storage of both user-defined processing parameters and the processed waveforms in the database. Figure 1 illustrates the layout of this waveform processing tool. Users can upload unprocessed data for any earthquake and recording station directly from the database. Furthermore, for each unprocessed record, the platform also plots instrumentally corrected acceleration, velocity, and displacement time-series. The instrument amplitude response of the selected station is also displayed. Users can interactively select the signal and noise windows, which the tool utilizes to calculate and display the SNR and FAS of acceleration. These plots can serve as a visual aid for users in selecting the appropriate filter corner frequencies for the platform to apply to the time-series data. The filtered data will then be displayed accordingly. After processing, the user has the option to either reject the waveforms or accept and store them in the database.

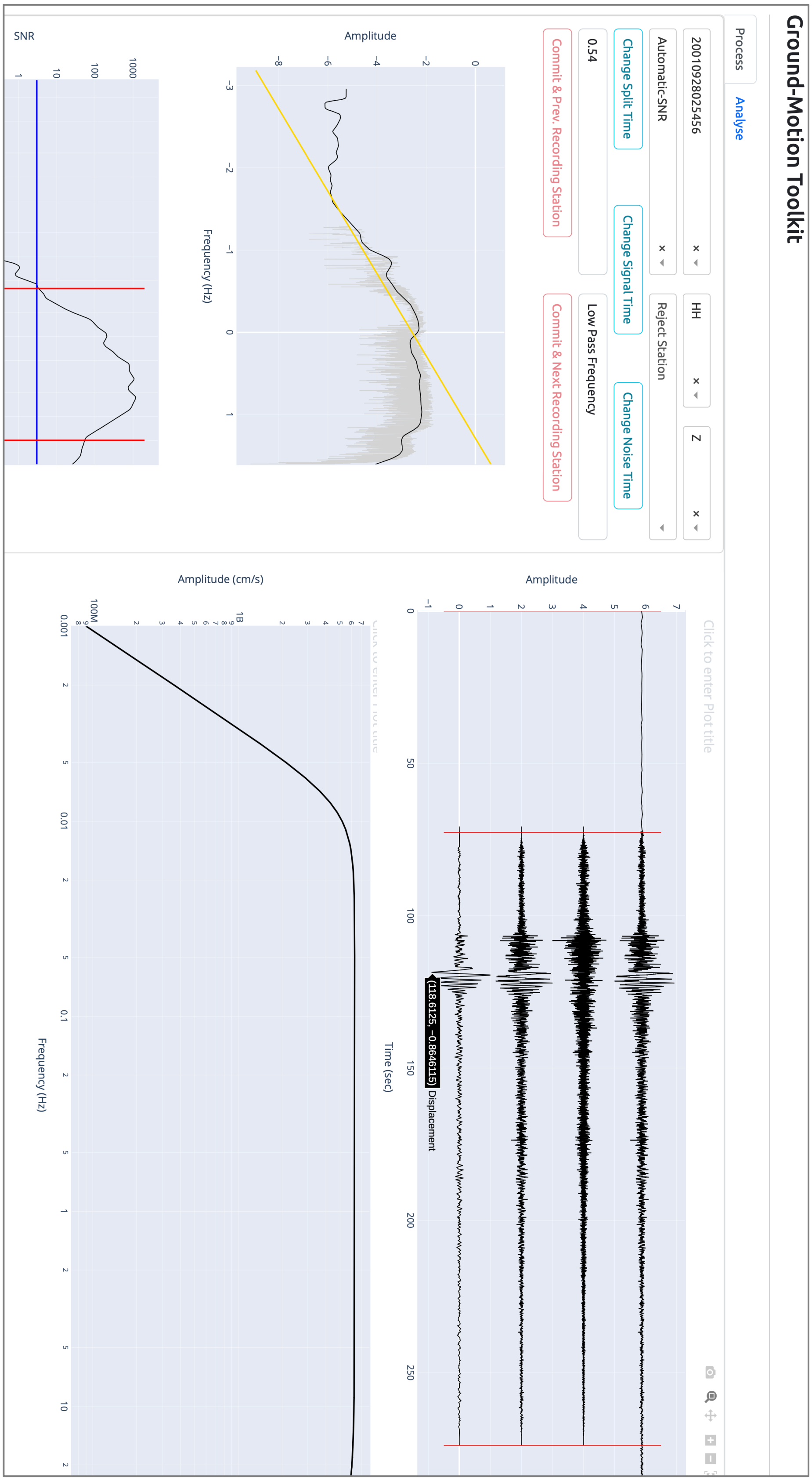

Figure 1. Screenshot of the main interface of the ground-motion review tool. It displays the raw and processed time-series for the selected event and recording station (top-right), instrument response of the sensor deployed at the station (bottom-right), FAS of acceleration and SNR plots (left panel)

3 Ground-Motion Web Delivery Service

We have developed a prototype web delivery portal to provide end-users direct access to Australian ground-motion data that are processed as part of this study. Upon loading, the web portal maps the spatial distribution of all earthquakes and recording stations included in the database. Users have the option to select a basemap from the gallery, which offers a variety of choices including topography, and streets. Additionally, they can overlay other useful features such as the Australian seismic site conditions map, the neotectonic domains model (Clark and McPherson, 2012), and several national-scale hazard maps, including Global Seismic Hazard Assessment Program (Giardini et al., 1999; McCue, 1999) and the 2018 National Seismic Hazard Assessment (Allen et al., 2020).

On the landing page, the earthquakes are mapped as color-coded circles, with the size of each circle corresponding to the magnitude of the event, while the colour indicates the earthquake's depth. The stations are plotted by colour-coded triangles, with each colour representing the network to which the station belongs. Information on each network is available by clicking on the "Legend" item in the toolbar at the top of the page. By clicking on any earthquake on the map, users can access earthquake parameters, a list of recording stations, and a sectional plot displaying the waveforms recorded during the earthquake. By clicking on any station on the map, users can access station parameters, as well as any available station images.

The web service (Figure 2) offers a range of tools, allowing users to search, select, and download processed ground-motion data and the associated engineering ground-motion parameters from a database compiled for Australian earthquakes. Users have the flexibility to retrieve data for any spatial region defined interactively on the map or based on their specific search criteria, whether it is related to ground motion or event metrics. The ground-motion parameters of engineering interest along with the corresponding event and recording station parameters, can be displayed in a table format, and be downloaded as a standard comma-separated value (csv) file. Users can also download the waveform data for each search result in standard COSMOS format (Consortium of Organizations for Strong-Motion Observation Systems, 2001). For each ground-motion record retrieved from the database, the corresponding ground-motion and earthquake parameters would be listed. Users have also the ability to generate plots for both waveforms and response spectra for each ground motion record. Furthermore, the displayed response spectra can be compared with the design spectra anchored to the hazard factor, *Z*, identified by the AS1170.4–2007 (Standards Australia, 2007).

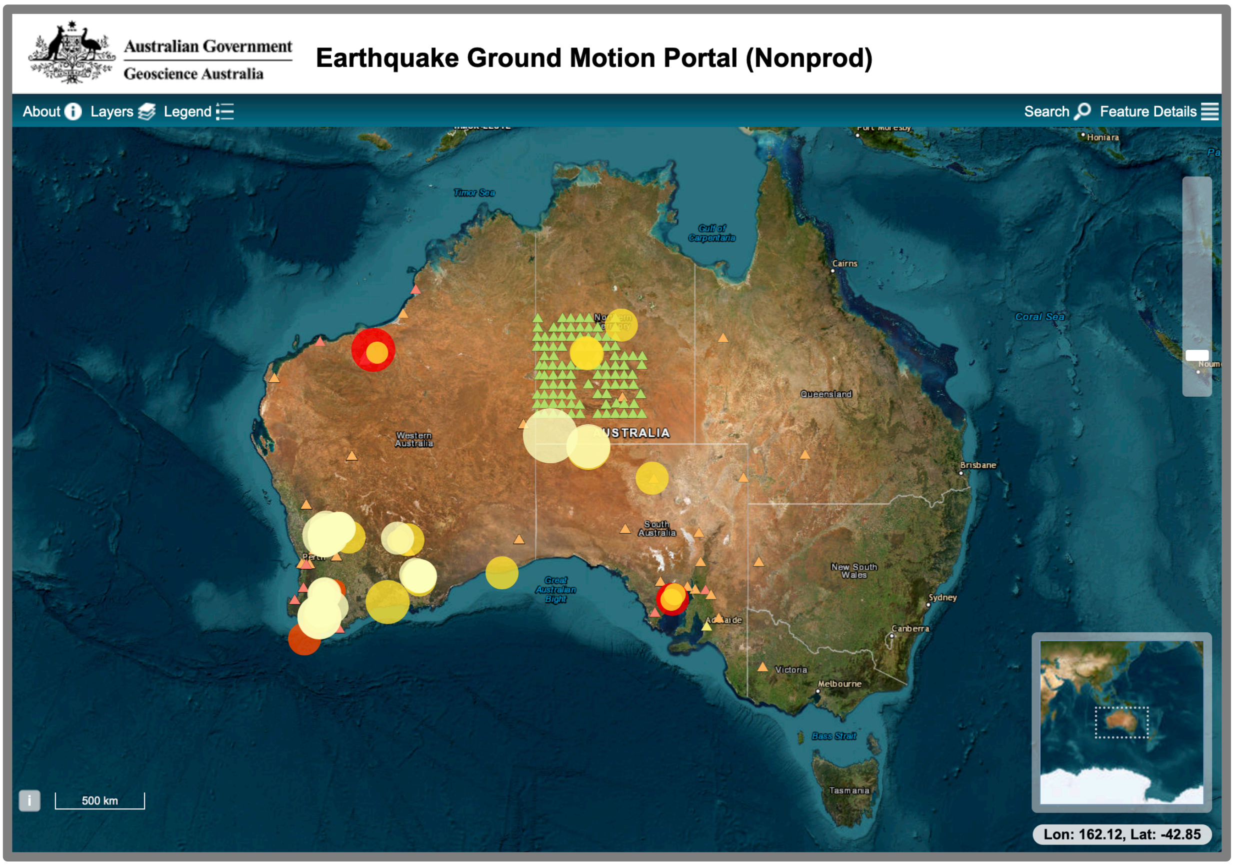

Figure 2. The landing page of earthquake ground-motion web portal.

4 Conclusions

This paper described the ongoing programme to assemble a comprehensive database of Australian ground-motion data and their associated ground-motion parameters relevant to engineering purposes. To facilitate this procedure and address the practical challenges of incorporating new data into the database, we have developed a user-friendly, web-based platform. This platform is designed to simplify and accelerate the manual processing of ground-motion data using USGS “gmprocess” toolkit. Additionally, it seamlessly interfaces with the database, allowing for data retrieval and efficient storage of the processed data.

Recognising the wide range of applications for Australian ground-motion data, we have developed a web delivery portal to provide access to a broad spectrum of stakeholders interested in using these data. This portal allows users to search, select, and download processed ground-motion data and the associated engineering ground-motion parameters from the database compiled for Australian ground-motion data.

We acknowledge that maintaining the compiled dataset and the developed services will require active participation from the community, including sharing recorded data by local networks, technical details on instrument metadata, and provision of feedback. Geoscience Australia is actively working with Australian network owners and operators to ingest additional new (e.g., Attanayake et al., 2023; Miller et al., 2023) and legacy (e.g., Peck, 2016) data into the database.

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