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Development of the NGA-Subduction Database

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Abstract

NGA-Subduction is a large multidisciplinary, multi-year research program to develop database resources and ground motion models (GMMs) for subduction-zone earthquakes. Coordinated by the Pacific Earthquake Engineering Research Center (PEER) and funded by FM Global, the project entails extensive technical interactions among many individuals and organizations from around the world. The ground motion database will include the processed recordings and supporting source, path, and site metadata from Japan, Taiwan, the Pacific Northwest and State of Alaska in the United States, and Central and South America, including Mexico, Peru and Chile.

The database spans ~740 earthquakes with magnitudes from 4 to 9 classified as interface, intraslab, or outer-rise events. Data from Japan and Taiwan comprise about 70% and 20% of the recordings, respectively. The database currently includes more than 60,000 three-component recordings, most of which are from digital accelerograms. Finite-fault models have been collected from the literature for about 80 earthquakes. Focal depths range from about 3 to > 600 km. Maximum PGA and PGV are > 2.0 g and > 90 cm/s, respectively.

The database includes pseudo-spectral acceleration for eleven damping values between 0.5% and 30%, Fourier amplitude spectra for frequencies from 0.1 to 100 Hz, and significant durations based on Arias Intensity. This paper provides an overview of the ongoing NGA-subduction database development effort.

Keywords: PEER-NGA; database; subduction; ground motion model; response spectra; Fourier spectra

1. Introduction

Next Generation Attenuation (NGA) ground-motion databases (http://ngawest2.berkeley.edu/, http://peer.berkeley.edu/ngaeast/) provide uniformly processed ground motion data, including time series and spectral data for earthquakes recorded in different tectonic settings and regions. Currently, the research program, referred to as the NGA-Subduction project, is being conducted by PEER to develop data resources and GMMs for subduction-zone earthquakes with technical interactions among many individuals and organizations around the world. The database contains ~740 events from subduction regions of Japan, Taiwan, the Pacific Northwest and State of Alaska in the United States, and South and Central America. The Central America dataset is currently under development. More than 60,000 three-component time series are already included from different data resources. The unprocessed waveforms were processed using a uniform set of instrument-correction, filtering, and baseline-correction algorithms developed by PEER to obtain acceleration time series, pseudo-spectral acceleration (PSa), Fourier amplitude spectra (FAS) and significant durations based on Arias Intensity (AI). These data will be used to guide the generation of new GMMs, which should significantly improve upon current models that rely on much more limited data sets, mainly from moderate magnitude events. We describe the database including the supporting source, path, and site metadata.

2. Earthquakes

Figure 1 plots the epicenters of events included in the NGA-Subduction database. In the development of the earthquake catalog, data from events having magnitudes greater than 5 are mainly collected and processed, however some events with magnitudes between 4 and 5 are also included for specific regions. We collect and process recordings mostly from digital instruments, but some important analog records are also included. The time period in the database is from the early 1970s to the present including recent significant earthquakes such as the 2010 Maule, Chile and the 2011 Tohoku, Japan earthquake. Figure 2 shows the distributions of the current database for each region. The total number of three-component recordings, events and stations are approximately 60,000, 740, and 5,500 respectively. Figure 2(a) shows that Japan and Taiwan provide the largest number of time series. Figure 2(b) shows that South and Central America is the region with the largest number of subduction events; however, they are recorded on a relatively small number of stations. Figure 2(c) shows that Japan, Taiwan and the Pacific Northwest in the U.S. have the largest number of recording stations in the current dataset.

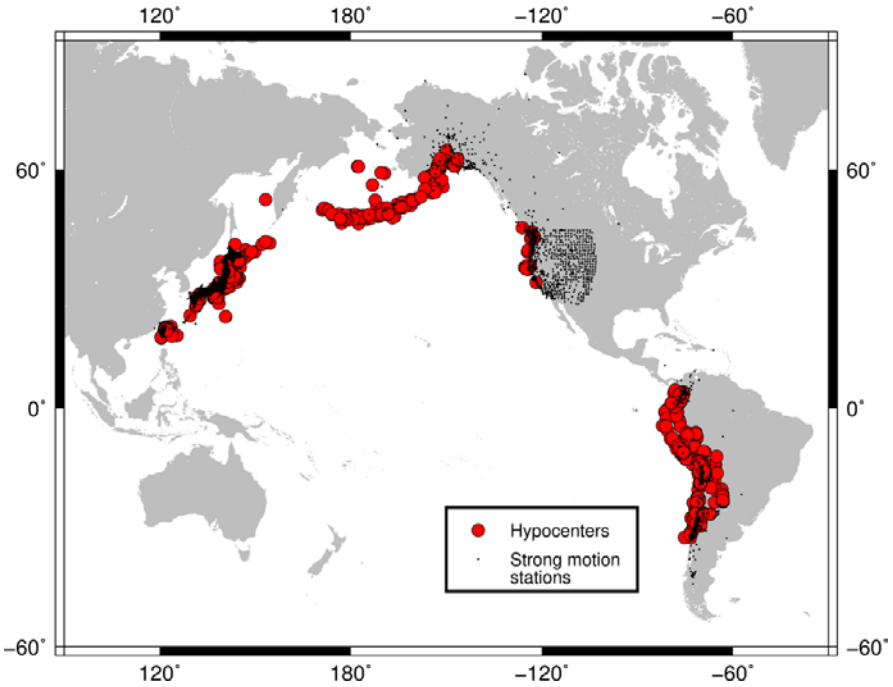

Figure 1. Hypocenter and station locations in NGA-Subduction database

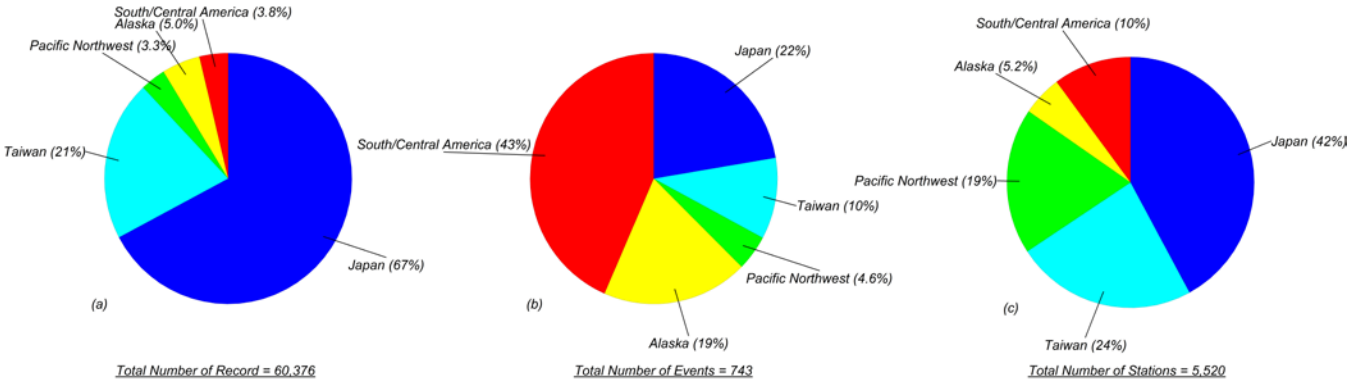

Figure 2. Regional distributions of the NGA-Subduction database, (a) number of recordings, (b) number of events, (c) number of stations

3. Database and Flatfile Overview

The NGA-Subduction database is a compilation of three databases, which are an earthquake ground motion database, an earthquake source database, and a site database. A "flatfile", which is a summary data file that can be used to develop GMMs, is developed by combining selected data from these three databases. This section provides an overview of these databases.

3.1 Ground Motion Database

Approximately 60,000 selected records have been processed and filtered following the standard PEER data processing methods [1, 2] to provide uniformly processed time series, PSa and FAS in the ground motion database. Records from sensors whose output is not directly proportional to acceleration are converted to acceleration time series using frequency domain adjustments. A time window for data processing is selected following the recommendations of previous studies [3, 4]. A 2% taper is applied to the start and end of the time window. An acausal Butterworth bandpass filter is applied after reviewing the FAS shape and the signal-to-noise ratio between the S-wave (or the entire time history) and the pre-event noise window (when available) on a component-by-component basis (e.g. [5]). PSa for 5% and other oscillator damping ratios, as well as FAS, are calculated at selected frequencies for all processed time histories following [2, 3]. The metadata from all the processing steps are also stored in the database such as record starting time, location of station, time window locations, and applied high-pass and low-pass filter corner frequency. The processed data are also reviewed by visual inspection (e.g. late-P and -S triggered flag), and through residual analyses (e.g. PSa and FAS quality flags) as described by [2]. The largest distance is approximately 2,000 km to capture the attenuation of large magnitude subduction events, which is critical in some probabilistic seismic hazard analyses (PSHA). However, the largest distances depend on the region due to the geological boundary, regional attenuation rates, and station distributions. Figure 3 shows the scatter plot of recordings between magnitude and epicentral distance.

Approximately 90% of the recordings are from accelerographs, and the remainder are from broadband seismographs. Table 1 shows the agencies that provided the time series used in the development of the database.

Table 1. Data resources of time series

Region	Data Source Agencies
Japan	K-NET, KiK-net, PARI, JMA, NOAA, Hi-net
Taiwan	CWB, IES
Pacific Northwest	CESMD, COSMOS, IRIS, NSMP, NCEDC, GSC
Alaska	CESMD, COSMOS, IRIS, GSC
South/Central America	CESMD, COSMOS, NOAA, IRIS, GFZ, RENADIC, CSN, CISMID, NORSAR, Other regional networks

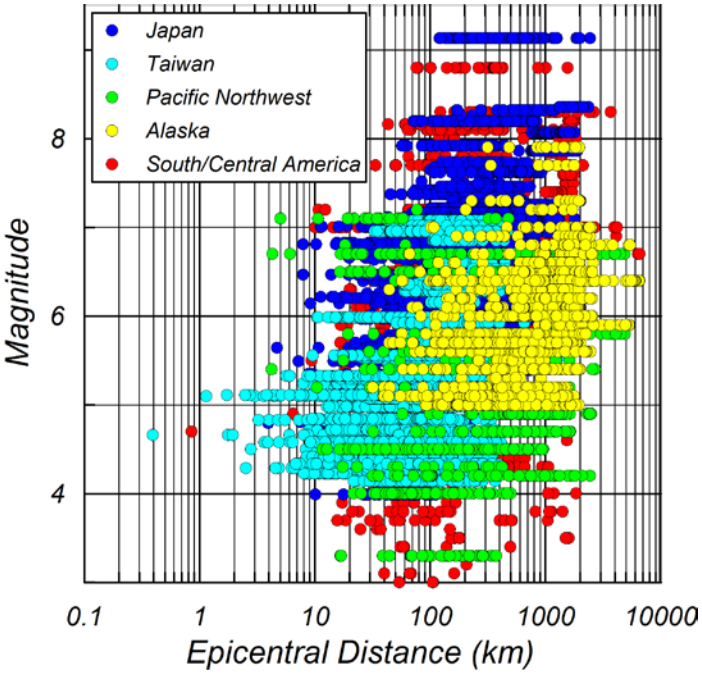

Figure 3. Scatter plot of epicentral distance versus magnitude

3.2 Earthquake Source Database

The earthquake source database consists of the event catalog and source parameters such as origin time, moment magnitude (**M**), hypocenter location and finite-fault model. The event catalog is developed by reviewing past studies (e.g. [6, 7, 8, 9]) with the inclusion of recent events. Regional studies and reports on subduction earthquakes are also reviewed along with interaction between multiple international experts to identify the earthquakes included in the dataset. Source parameters such as **M** and hypocenter locations are selected from several global and local data resources (e.g. [10, 11, 12]). Special studies for moment tensors and source inversions are given priority to determine **M** and its standard deviations when available. However, when **M** is not available, usually for smaller magnitude earthquakes, it is determined from values of local magnitude (M_L), surface-wave magnitude (M_S), and body-wave magnitude (m_b) using regional data. Figure 4(a) shows the distribution of magnitude types in the database. Most events have an estimate of **M** in the catalog, where the remainder have other magnitudes that will be converted to **M** for GMM development.

Earthquakes have also been classified as either interface, intraslab, outer-rise, or shallow crustal events by reviewing past studies. Figure 4(b) shows the event classification distribution in the database and that interface and intraslab events are evenly distributed. As a part of earthquake source database, finite-fault models have been collected by reviewing past studies and several data resources (e.g. [11, 13, 14, 15]). More than 80 events have finite-fault models documented in the database. Event classes (i.e. foreshock and aftershock flags) are also provided based on previous studies and the method described in [16].

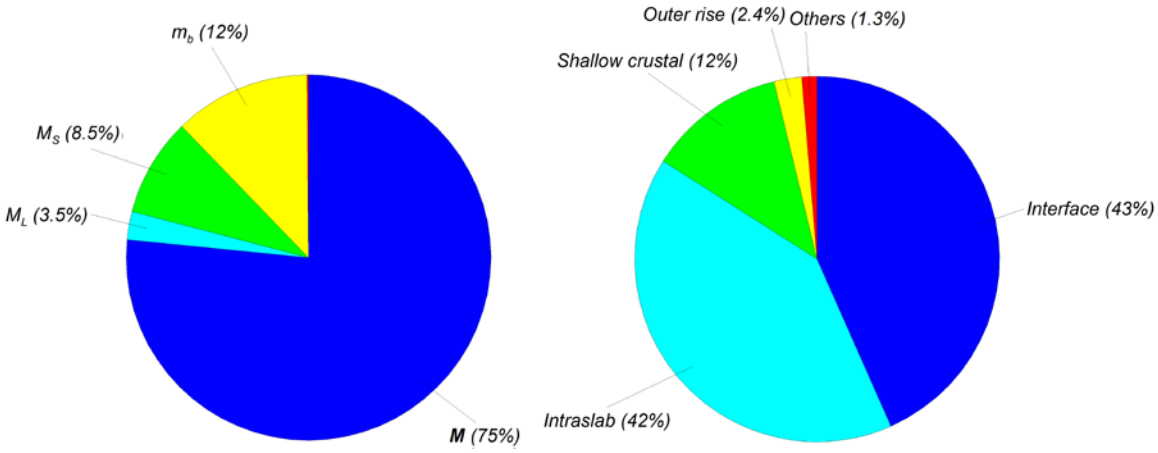

Figure 4. Distribution of parameters in the source database (a) magnitude type, (b) event classification

3.3 Site Database

Approximately 5,500 stations are included in this database. The site database includes, station name, station ID, recording network, coordinates, instrument location, geology/geomorphology information, and soil profile characteristics such as V_{S30} and depth to V_s horizons (z_{xx}). Details of the development of these data are described in the companion paper [17].

3.4 Flatfile

The flatfile is the summary table used to develop GMMs. It includes key metadata and ground motion parameters extracted from the aforementioned three databases. Ground motion parameters include PGA, PGV, PSa and FAS at selected frequencies and AI and significant durations between selected percentages of AI. PSa based on the different definitions (i.e. as-recorded and RotDnn) are provided following [18]. The current approach is similar to the past NGA databases [1, 2, 3], that are public and available through the PEER website [19].

4. Summary

The PEER NGA-Subduction database includes a ground-motion database that compiles engineering seismology resources for different regions. The database combines parameters from three databases; the ground motion database, earthquake-source database and site database. Moderate-to-large magnitude earthquakes are included for which time series were recorded by strong motion or broad-band seismograph stations. Time series were obtained from various agencies and were uniformly processed through the standard PEER data processing methodology. A variety of metadata is available to users, including uniformly processed time series, PSa, FAS, site condition and distance metrics. Earthquake source parameters such as moment magnitude, focal mechanisms, and finite-fault models are included after a review of different data resources, when available. The developed ground-motion data are useful for GMM development for subduction earthquakes.

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